Table 3.3.11 Apparent Steel Consumption through 1990

		Apparent steel consumption								Per capita ASC (crude base)	
		Finished rolled products base						Crude base *			
		Flat	%	Non-flat	%	Total	%	* 1,000 tonnes	G.R. %		G.R. %
Actual	1966	181	35.2	333	64.8	514	100	651	–	21kg	
	1967	231	43.3	303	56.7	534	100	685	5.2	21	
	1968	248	36.4	434	63.6	682	100	865	26.3	26	
	1969	268	36.7	463	63.3	731	100	930	7.5	27	
	1970	327	41.3	465	58.7	792	100	1,066	14.6	29	
	1971	276	36.6	478	63.4	754	100	1,017	▲ 4.6	27	
	1972	413	44.1	523	55.9	936	100	1,269	24.8	33	
	1973	525	45.3	635	54.7	1,160	100	1,572	23.9	40	
	1974	462	45.1	563	54.9	1,025	100	1,395	▲11.3	34	
	1975	400	43.5	519	56.5	919	100	1,256	▲10.0	30	
	1976	694	51.6	652	48.4	1,346	100	1,842	46.7	43	
	1977	757	49.0	787	51.0	1,544	100	2,103	14.2	48	
	'77/'66	13.9		8.1		10.5			11.3		
	'77/'70	12.7		7.8		10.0			10.2		
Projection	1985	1,201	49.0	1,249	51.0	2,450	100	3,266		61	
	1990	1,758	49.5	1,795	50.5	3,553	100	4,734		79	
	'85/'77	5.9		5.9		5.9			5.7		
	'90/'77	6.7		6.6		6.6			6.4		

(Source: Provided by Study Mission)

* Crude steel = finished products x

Bars, sections	=	1.271
Plates	=	1.420
Sheets	=	1.395
Hoops	=	1.228
Tin plates	=	1.359
Wire rod	=	1.271
Pipe	=	1.470

(JISF "Statistical Handbook" '78)

3.4 Steel Demand Forecast II (1995 and 2000)

(1) Methods of Forecast

As referred to already, steel demand forecast has been made for 1985 and 1990. The methods employed include sectoral accumulation by end use, analysis of GDP correlated with capital formation, steel intensity analysis, etc. In adopting the findings of these studies, due consideration has been given to the characteristics inherent in the methods of forecasting. It was after going through all these procedures that estimates have been determined for final adoption.

In working out the steel demand forecast for the year 2000, that is 20 years away, the approach of sectoral accumulation will not be viable, because it by nature better suited to short-term and medium term forecasts and because long-term uncertainties surrounding the activities of the end user sectors will not afford a clear insight into these activities that form the basis on which to work out forecasts. It is a characteristic of long-term forecast that it has to rely on macroeconomic approaches.

The year 2000 was selected as the goal year of this forecast. As a means to work out forecast for this distant future, the historical cross-sectional approach was adopted to serve the purpose.

This approach basically calls for the comparison of the long-term past performance of steel consumption among the nations in the fairly advanced stage of economic development and for the comparison of data on the current state of steel consumption among the nations in different stages of economic development. The method will offer an insight into changes in the structural pattern of steel consumption by type of product through the collection of data concerned with the volume of steel consumption, structural pattern of steel consumption by type of product, level of economic development of a given nation at various points in time. If the picture of future economic development in the region or of that nation is forecast, it will be possible to identify the possible level of steel consumption and structure of steel consumption by type of products on the basis of a careful analysis of data for the past and the present.

The adoption of this approach requires a particular attention. That is, it is quite probable that the relation, which exists now and is considered to be existent as a matter of course in future also, between a certain stage of economic development and steel consumption may not be justified any more as a result of some drastic changes in production technology affecting significantly the structure of steel consumption by type of products.

While due attention should be paid to the factor mentioned above, this approach is considered useful for the forecast of steel consumption in the distant goal year. It goes without saying, however, that the findings are of use only to the extent that they offer a basis on which to judge the adoption of estimates produced by other methods of forecast.

(2) Forecast Based on Correlation with GDP

GDP, a variable, was assumed to register a 7.0 percent growth rate through 1990. Stable growth was presumed for agriculture from thereafter through the year 2000. Also, assuming that it would achieve relatively high growth comparable to the levels of the latter half of the 1970's, the GDP growth rate was estimated at 7.3 percent for 1990–1995 and 7.5 percent for 1995–2000. Thus, the GDP performance for 1995 and 2000 would be as shown in Table 3.4.1.

Table 3.4.1 Estimated GDP until 2000 at 1972 Prices

(Unit: millions of bahts)

Year	GDP	Remarks	
1978	257,127	78/70	7.0%
1985	412,890	85/78	7.0
1990	579,099	90/78	7.0
1995	823,479	95/90	7.3
2000	1,182,516	2000/1995	7.5

Apparent steel consumption was calculated for 1995 and 2000 by using the correlation equation employed for the 1990 forecast:

Y (apparent steel consumption) = 0.007431 x GDP – 331.67

For 1995 0.007431 x 823479 – 331.67 = 5,788,000 tonnes

For 2000 0.007431 x 1182516 – 331.67 = 8,456,000 tonnes

The figures thus obtained have been modified by the micro/macro ratio for 1985 as was the case for 1990:

For 1995 $5{,}788{,}000 \text{ tonnes} \times \frac{2450}{2737} (\fallingdotseq 0.9) = 5{,}209{,}000 \text{ tonnes}$

For 2000 $8{,}456{,}000 \text{ tonnes} \times \frac{2450}{2737} (\fallingdotseq 0.9) = 7{,}610{,}000 \text{ tonnes}$

Crude steel equivalent was calculated by the use of a conversion coefficient which, in the absence of the itemized breakdown, was obtained by dividing the 1990 consumption of crude steel equivalent by the 1990 consumption of steel equivalent.

(4,734,000 tonnes ÷ 3,553,000 tonnes = 1.33)

Thus, the crude steel equivalent is:

5,209,000 tonnes x 1.33 = 6,928,000 tonnes for 1995

7,610,000 tonnes x 1.33 = 10,121,000 tonnes for 2000

It is presumed that the consumption of high grade steel will increase from 1995 through 2000 accompanying chages in the structure of steel consumption, with the result that the conversion coefficient will turn higher. It is also possible in the meantime that a higher ratio of continuous casting and technological progress will improve the yield. However, it was assumed that these consequences would cancel each other.

(3) Forecast Based on Steel Intensity

Apparent steel consumption is obtained by multiplying steel intensity (tonne per million dollars) by GDP. The steel intensity was assumed to be 128 for 1995 and 135 for 2000. The dollar equivalent of GDP is as shown in Table 3.4.2.

Table 3.4.2 GDP and Steel Intensity (1977 ~ 2000)

Year	GDP (mill.$)	S.I (t/mill.$)
1977	11,593	133.18
1985	20,303	120.67
1990	28,477	124.77
1995	40,494	128.0
2000	58,154	135.0

From the table will be calculated as follows:

For 1995:

Apparent steel consumption

128 x 40494 = 5,183,000 tonnes

Crude steel equivalent

5,183,000 tonnes x 1.33 = 6,890,000 tonnes

For 2000:

Apparent steel consumption

135 x 58154 = 7,851,000 tonnes

Crude steel equivalent

7,851,000 tonnes x 1.33 = 10,440,000 tonnes

(4) Forecast Based on Historical Cross-sectional Approach

The forecast of the stage of economic development and the size of the national economy of Thailand both for 1995 and 2000 constitutes a prerequisite for this forecast.

No official data are published which foresee the performance of the Thai economy into the year 2000. Only relevant data available are the estimates of petroleum products by economic sector through 2000 published by the National Energy Administration, Office of the Prime Minister, and the estimates of population through 2000 by NESDB.

Accordingly, in the prediction of the future scale of the economy and the future level of development in Thailand a reasonable level of development was estimated by analyzing the information and data collected by the Survey Team while on visit to Thailand and by examining the patterns of economic development during the 1970's and the possible trends of development in the first half of the 1980's, with the result the following economic pattern was assumed.

Table 3.4.3 Predicted Scale of Thai Economy in 2000

			1985	1990	1995	2000
Population (1,000)			53,710	59,800	66,380	73,680
GDP (1972 prices)			412,890 (Million B)	579,099 (Million B)	823,479 (Million B)	1,182,516 (Million B)
Composition	Industry	(%)	42.2	47.0	49.5	53.0
	Agriculture	(%)	23.4	21.0	20.5	20.0
	Others	(%)	34.4	32.0	30.0	27.0
Per capita GDP (1972 prices)			7,687 Bahts (378$)	9,683 Bahts (476$)	12,406 Bahts (611$)	16,050 Bahts (791$)
Steel consumption	(Crude steel) Steel consumption (1,000 tonnes)		3,266	4,734		
	Per capita consumption (kg)		61	79		

The indicators of economy and steel consumption in the Republic of Korea and Spain, shown in Table 3.4.4 represent historical cross-sectional data that concern developing nations. As far as the population and the industrial components of GDP in Thailand in 2000 are concerned, they bear similarity to those in advanced nations. No developing nations show such similarity to Thailand in their historical data.

Though not similar, what comes close to the predicted picture of Thailand in 2000 is found in the 1977 data for the Republic of Korea and the 1969 data for Spain, which are advanced among the developing nations. In this sense, any prediction or interpretation by this approach may not be natural in the case of Thailand. What it offers is simply a clue to the ratio of flat and non-flat products in steel consumption, the scale of GDP and the level of steel consumption.

Thus, the findings by this approach are given here only for the purpose of reference. Estimates by other methods have been adopted instead.

Table 3.4.4 Economic and Steel Consumption Indicators for Korea in 1977 and Spain in 1969

		Korea (1977)	Spain (1969)	Thailand (2000)
Population (million)		37.02	33.43	73.68
GDP (million $)		25,237.6 (1975 prices)	21,478.6 (1964 prices)	58,280.7 (1972 prices)
Composition	Industry (%)	28.9	28	53
Composition	Agriculture (%)	21.4	14	20
Composition	Others (%)	49.7	58	27
Per capita GDP ($)		682 (1975 prices)	642 (1964 prices)	791 (1972 prices)
Steel consumption (1,000 t)		5,900	8,513	(10,400)
	Per capita consumption (kg)	159	258	(142)
Product (%) composition	Steel plates	52.5	45	(47.0)
Product (%) composition	Long products	47.5	55	(53.0)

Sources: Monthly Bulletin of Statistics UN.
Yearbook of National Accounts Statistics 1976 (Vol II)
ECE Quarterly Bulletin of Steel Statistics for Europe, UN.
Handbook of Steel Statistics, Korean Iron and Steel Association

Note:
1 Exchange rates Korea 1$: 484 Won, Spain 1$: 69.93 Pesetas
2 Product composition for Korea on domestic demand basis: plates and sheets 2,413 (1,000 t) long products 2,186 (1,000 t).
3 Products composition for Spain on domestic Shipment basis as of 1970: Plates and sheets 2,245 (1,000 t), long products 2,749 (1,000 t).

Table 3.4.5 Historical Data on Steel Consumption in Selected Countries

Country	Calendar year	Population (1,000)	Per capita GDP (nominal US $)	Apparent steel consumption: Apparent crude steel consumption (1,000 t)	Apparent steel consumption: Per capita (kg)	Apparent steel product consumption: Plates (%)	Apparent steel product consumption: Long products (%)	Apparent steel product consumption: Total (%, 1000 t)
Mexico	1968	45,690	553	3,525	77	50.3	49.7	100 (2,761)
	1974	58,120	1120	6,111	105	52.9	47.1	100 (4,486)
	1979			8,544		55.6	44.4	100 (6,329)
	1980 (estimated)			9,489		55.8	44.2	100 (7,081)
Brazil	1975	106,230	1019	11,241	106	52.2	47.8	100 (8,904)
	1974	103,350	952	12,799	124	56.3	43.7	100 (9,842)
	1973	100,560	774	9,513	95	52.3	47.7	100 (7,066)
	1972	97,850	609	7,662	78	49.4	50.6	100 (5,609)
	1971	95,170	530	7,386	78	50.9	49.1	100 (5,338)
	1970	92,520	497	6,088	66	49.3	50.7	100 (4,229)
	1969	90,070	334	5,532	61	49.9	50.1	100 (3,954)
	1968	87,620	283	4,879	56	48.9	51.1	100 (3,556)
Venezuela	1975	11,990	2415	2,352	196	51.6	48.4	100 (1,983)
Argentina	1975	25,580	1935	4,287	172	56.4	43.6	100 (3,440)
	1973	24,720	1478	4,126	167	58.6	41.4	100 (2,858)
	1972	24,390	1076	3,739	156	56.1	43.9	100 (2,994)
	1971	24,070	1245	3,708	157	53.1	46.9	100 (2,673)
	1967	22,800	–	2,036	88	54.3	45.7	100 (1,719)
Spain	1977	36,670	2897	9,052	249	58.5	41.5	100 (7,479)
	1976	35,970	2663	10,983	305	55.0	45.0	100 (7,409)
South Africa	1975	25,500	1339	7,506	263	54.7	45.3	100 (4,123)
	1974	24,940	1300	6,494	232	51.2	48.8	100 (3,961) *
	1973	24,310	1095	5,636	213	49.7	50.3	100 (4,117)
Iran	1976	33,590	1988	4,919	147	–	–	–
	1975	33,020	1635	5,382	163	–	–	–
	1974	32,140	1427	2,973	93	–	–	–
Turkey	1976	41,090	963	3,701	94	–	–	–
	1975	40,350	910	3,078	80	–	–	–

*: Shipment basis

(5) Final Figures of Demand Forecast

The estimates of steel consumption by the above-mentioned approach are summarized in Table 3.4.6. The figures shown in the table can be considered close to ceiling values rather than mean values.

Since agro-business centered industrial development is expected to lead the national economy together with the modernization of agriculture, the future structure of steel consumption in Thailand will be such that: flat rolled products will occupy 47.0 percent and non-flat products 53 percent.

Table 3.4.6 Summary of Steel Demand Forecasts 1995 – 2000

(unit: 1,000 tonnes)

		1995	2000
Forecasts I	Steel products	5,209	7,610
	Crude steel	6,928	10,121
Forecasts II	Steel products	5,180	7,850
	Crude steel	6,890	10,440
Forecasts III	Steel products	---	7,890
	Crude steel	---	10,490
Adopted values	Steel products	5,200	7,800
	Crude steel	6,900	10,400

3.5 Steel Prices and Price Performance in ASEAN Nations

Any attempt to grasp steel prices not only in ASEAN nations but also in the world at large, without due regard to the pricing system and the distribution system in each respective country, is prone to arrive at a false conclusion. A close examination of actual going domestic prices in each respective country will reveal that prices vary depending on business practices, amount of transaction, size and standard of products, place of delivery, etc.

(1) Pricing System and Distribution Channels in ASEAN Nations

i. Malaysia

In Malysia the price of steel bars, the principal steel product, is controlled by the government and it is subject to government approval. Steel prices are ex base point and set under date of the receipt of orders. When it concerns the distribution of domestic steel products from steel makers to end users, 95 percent are distributed by way of warehouses, while 5 percent are distributed directly.

As to imported steel products, 5 percent fo directly to users, 50 percent to warehouses, and 45 percent to steel makers. The steel makers distribute 95 percent of their share of steel imports to warehouses and 5 percent to users, just the way they do their own steel products. The import of steel products which can be supplied by domestic production is subject to government approval. Import duties are raised and a surtax imposed depending on the demand and supply on the home market on those domestically producible products.

ii. Singapore

Warehouses handle 90 percent of domestic steel products and 50 percent of imported steel products for distribution to end users. Domestic steel products are ex factory as a rule and invoiced under date of the receipt of orders, an exception being steel bars which are franco domicile at delivered prices. Warehouses and steel makers each handle 50 percent of imported steel products. Steel makers distribute 10 percent of their share directly to users.

No transaction tax is levied either on domestic steel products or on imported steel products. Being an island nation, the domestic transport cost is small. Thus, domestic and imported steel products are both available to end users at almost similar prices.

iii. Indonesia

No direct government controls are exercised on steel prices. However, administrative guidance by the Ministry of Industry is in force through the machinery of product-by-product sub-committees created under GAPBESI. Whenever domestic steel makers are affected by steel products imports, the ministries of industry and commerce intervene with protective measures such as the imposition of an import ban and the raising of import duties. Domestic steel products are ex factory and priced at the date of the receipt of orders. As for distribution channels, the majority of domestic products go through the hands of wholesalers. Users can import directly, too. However, depending on the prices, they purchase by way of domestic wholesalers to suit their convenience. Plates and hot coils are imported through wholesalers, while plates for GI sheets are imported directly by GI sheet makers. Shapes are mainly handled by wholesalers. Project-related shapes are imported directly by users, however.

It is the policy of the Indonesian government to reduce as much as possible steel products imports keeping pace with the domestic production of these products. Thus, the import of GI sheets supplied by domestic production is banned. Prohibitive import duties are imposed on imported steel bars from time to time.

iv. The Philippines

As a chain of measures to fight domestic prices, ceiling prices are set for GI sheets, tin plates, nails, steel bars by the government's Price Control Committee. Domestic steel products are ex base point and priced at the receipt of orders. End users are making direct purchases, and the share of wholesalers in the market is extremely small.

The import of hot coils for cold rolling and for welding pipes used to be handled exclusively by NASCO, a state-run steel corporation, in the past. Steel makers, such as Pasig Steel Co., make direct imports now, however.

The emphasis of NASCO is on cold rolled sheets rather than on hot rolled sheets. NASCO supplies GI sheet makers. It used to import hot rolled coils on behalf of pipe makers. The task is now taken over by Pasig Steel Co., as a result of the reorganization of domestic steel makers.

As to the distribution of imported steel products, 15 percent go directly to users, while 35 percent go by way of wholesalers and 50 percent by way of steel makers.

v. Thailand

As part of anti-inflation measures to bring soaring prices under control in Thailand, ceiling prices are set by the Ministry of Commerce on the retail of steel bars, wire rods, nails and wires. Thus, the performance of steel prices is under surveillance. Domestic steel products are ex factory as a rule, except for certain GI sheets and tin plates which are ex base point. It is the general practice to set prices at the receipt of orders.

All domestic steel products and 70 percent of imported steel products are distributed to end users by way of warehouses.

High import duties are imposed from time to time on steel bars, pipes and wire rods to protect domestic producers, and the import license system is adopted to ban imports when it is deemed necessary.

(2) Steel Prices in Five ASEAN Nations

As noted earlier, it is no easy task to summarize the trends in steel prices in the ASEAN nations since the pricing system and the distribution system are by no means uniform. On the contrary, various patterns are observed.

The ASEAN steel industry is characterized by the production of non-flat products. Thus, the supply of flat products and, above all, hot rolled and cold rolled sheets are dependent on imports, the only exception being the Philippines which produces cold rolled sheets.

For this reason, the prices of flat products are affected by the export prices of major steel exporters, such as Europe, the United States and Japan. Thus, the performance of the domestic price of flat products is generally in parallel with the trends in these exporting nations. The export prices of steel products quoted by these exporting nations fluctuate keeping pace with the demand and supply of these steel products in their own domestic markets. Nevertheless, they are basically geared to the demand and supply situation in the world market. One of the typical indicators of export prices is FOB Antwerp.

The price mirrors the actual trends in exports as of the date quoted. Thus, it serves as a major indicator to look into the trends.

The import prices (CIF) in the ASEAN nations are as shown in Table 3.5.3. Only 1977 figures are available because of the technical difficulties associated with statistical compilation. The case of Thailand is as presented in Table 3.5.2, 3.5.4 together with the trends in the domestic prices.

The end users of flat steel products in the ASEAN nations are mainly secondary steel products makers who process those steel products into pipes, GI sheets and tin plates. They are mostly assisted both in capital and technology by steel makers of developed nations and are dependent on long term supply of hot and cold rolled products at stable prices.

As such, the contracted prices are not necessarily uniform. Any attempt to understand the general trends in steel price movements will have to take into consideration these special features along with the trends in general.

Table 3.5.1 Trends in European Export and Domestic Steel Prices

	Continental Europe			USA		West Germany		France		UK	
	Actual export prices			Domestic prices		Domestic prices		Domestic prices		Domestic prices	
	HR coils	CR coils	GI sheets (17 ~ 20G undulated)	HR strip	CR strip	HR sheets (NPO)	CR sheets (SPO)	HR sheets (NPO)	CR sheets (SPO)	HR sheets	CR sheets
				June 19, 1977	June 19, 1977	July 1, 1977	July 1, 1977	July 1, 1977	July 1, 1977	July 10, 1977	July 10, 1977
1977 June 28	*	250/255+	290+	325.2	461.9	323.5	343.4	244.5	345.2	256.2	308.9
1978 June 30	275	315/315+	370	July 30	July 30	July 1	July 1	July 3	July 3	July 9	July 9
				348.3	500.0	374.7	396.6	326.7	412.7	319.6	403.5
Dec. 29	300	350+/350	410								
1979 Jan. 30	300	350~360	435	Jan. 1	Jan. 1	Jan. 1	Jan. 1	Jan. 1	Jan. 1	Jan. 21	Jan. 21
				366.0	546.7	454.2	454.2	351.1	445.4	334.7	422.6
April 27	300	360	420	April 1	April 1	April 1	April 1	April 1	April 1	April 2	April 2
May 25	300	370	425	366.0	546.7	440.9	440.9	340.8	432.2	347.4	438.7
June 1	305	370	425	end of June	end of June	end of June	end of June	end of June	end of June	end of June	end of June
				366.0	546.7	453.7	453.7	344.9	437.5	359.6	454.1
June 22	305	370+/370~375	430*								

1 Base prices as quoted by European steel makers indicative of current values according to Metal Bulletin survey.
Unless otherwise remarked, prices are for standard Thomas Steels.
+: Includes 2½ commission
*: Nominal
No marking: Net price
Source: Metal Bulletin

2 USA FOB (ex factory) quoted by leading steel mill.
Source: Iron Age

3 West Germany Ex Essen price quoted by ATH (base price minus provisional rebate)
NPO–Standard quality, not pickled
SPO–Standard quality, pickled
Source: ECSC

4 France Ex Thionville price quoted Sacilor
(base price minus provisional rebate)
NPO, SPO same for Germany.
Source: ECSC

5 U.K BSC New Port
Ex New Port
Source: ECSC

Table 3.5.2 Trends in Unit Price of Steel Imports in Thailand

(Unit: US$/t)

	Shape	Plate	Medium plate	Sub total	Sheet	Tin plate	GI sheet	Hoop & strip	Welded pipe	Total
1970	164	147	143	146	152	191	231	150	217	159
1971	131	148	143	147	254	222	191	162	239	203
1972	–	–	–	–	–	–	–	–	–	–
1973	229	206	441	230	210	215	271	245	374	225
1974	339	325	651	347	314	332	341	374	679	343
1975	246	275	487	294	270	327	358	414	827	294
1976	252	374	819	434	261	309	335	370	525	276
1977	245	320	320	328	301	375	365	302	499	307

Source: Annual Statement of Foreign Trade of Thailand

Table 3.5.3 Import Price of Steel Products in Four ASEAN Nations in 1977

(Unit: US$/t)

Country	Malaysia		Singapore		Indonesia		Philippines	
Volume unit price / types of product	Volume	Unit price	Volume	Unit price	Volume	Unit price	Volume	Unit price
Shape	65,119	226	172,760	237	113,545	286	29,558	302
Plate (A)	64,441	226	185,732	244	73,143	284	37,078	264
Medium plate (B)	31,760	245	20,783	253	25,815	258	1,099	834
(A) + (B)	96,201	232			98,958	278	38,177	281
Sheet	159,390	281	116,964	331	388,255	299		•
of which HR							76,527	274
of which CR							11,442	298
Tin Plate	68,067	462	81,727	364	72,599	393	54,074	491
GI sheet	20,113	331	33,434	380	5,119	408	12,625	320
Hoop & strip	8,458	465	28,772	396	43,954	335	29,696	291
of which H.R								
of which C.R								
Welded pipe	3,135	411	184,378	376	16,951	526	1,753	370
Total (Including others)	346,369	380	827,794	308	755,452	313	255,960	335

Source: Customs clearance statistics of 4 countries surveyed

Table 3.5.4 Price Trends in Selected Steel Products in Thailand

		Import prices (US$)		Domestic prices (Bahts)	
		1977	1978	1977	1978
Plate	1 Q	245	260	5,000 ~ 5,350	5,500 ~ 6,500
	2 Q	235	270	5,200 ~ 5,500	6,000 ~ 6,500
	3 Q	245	320	5,600 ~ 6,200	6,200 ~ 6,600
	4 Q	250	340	5,200 ~ 5,500	6,100 ~ 6,500
C.R coil	1 Q	260	280	6,000 ~ 6,500	6,500 ~ 7,300
	2 Q	275	310	6,300 ~ 6,500	7,000 ~ 8,400
	3 Q	270	350	6,200 ~ 6,500	8,000 ~ 8,300
	4 Q	275	365	6,000 ~ 6,500	8,300 ~ 8,500
H.R coil	1 Q	220	233	5,000 ~ 5,300	5,500 ~ 6,500
	2 Q	222	270	5,200 ~ 5,500	5,800 ~ 6,500
	3 Q	228	294	5,400 ~ 6,000	6,000 ~ 6,700
	4 Q	231	306	5,150 ~ 5,400	6,500 ~ 6,700
GI sheet	1 Q	365		3,700	3,870
	2 Q			3,870	3,870
	3 Q			3,870	4,120
	4 Q			3,870	4,120
Welded pipe	1 Q	499			
	2 Q				
	3 Q				
	4 Q				
Sheet	1 Q	301			
	2 Q				
	3 Q				
	4 Q				

Note: a) Import prices: CIF Bangkok per tonne L/C, 150 days after sight
b) Domestic prices per tonne (franco domicile) on 90 days' Credit

Table 3.5.5 Export Prices by Steel Products in Selected Countries

Country		Plate	H R coil	C R coil	G I coil	D – bar	Structural	Wire rod
Belgium	1979 Feb.	US$ 319	US$ 305	US$ 370	US$ 415	US$ 325	US$ 325	US$ 315
	Mar.	306-312	302-306	360-367	425	335	312	316
	Apr.	307-310	300	351-363	425	335	317-320	327-333
	May	310-315	300	360	420	325	325	330
	Jun.	310-315	305	370-375	430	325	315	330
	Jul.	310-320	310-315 (NOMINAL)	370	425	320-325	315	330 (NOMINAL)
	Aug.	310	305	375	415	330	315	345
	Size/Spec.	ST 37 4 high 10-25 mm 2,000 x 800 mm	ST 33-1 2-10 mm x 2,000 x C	SPCC or SPO 1 mm – 2.99 x 1,500 x C	ASTM A525-65 Coating G90, GSC xC 916x24	ASTM 615 GR 60 6-32 mm	WFB	SAE 1008 5.5 mm
Germany, Fed. Rep. of	1979 Feb.	US$ 310	US$ 300	US$ 345	US$ 420	US$ 320	US$ 310	US$ 315
	Jul.	310	300-305	375	420-430	315-320	320	325
	Aug.	315	310	375	420	330	320	345
	Size/Spec.	ST 33	SAE 1008	ST 12 03	ST 01Z	ASTM A615	ST 33	SAE 1008
Italy	1979 Feb.	US$ 310	US$ 305-310	US$ 350	US$ 420	US$ 305	US$ 320	Unquoted
	May	300-310	300-305	360-365	420-430	310-315	320	Unquoted
	Jun.	300-310	300-305	360-365	420-430	310-315	320	Unquoted
	Jul.	300-310	300-305	360-365	420-430	310-315	320	Unquoted
	Aug.	300-310	300-305	360-365	420-430	310-315	320	Unquoted
	(Offer prices in the 4Q)	(320-325)	(315)	(365)	(430-440)	(315-320)	(325-330)	(Unquoted)
	Size/Spec.						WFB	
United Kingdom	1979 Feb.	–	–	–	–	US$ 300-305	US$ 320	US$ 315
	Mar.	–				350	390	350
	Apr.	–				350	390	350
	May	US$ 410				310-320	320	365-390
	Jun.	410				310-330	320	365-330
	Jul.	–	–	–	–	360	–	–
	Aug.	(325) (Offer prices in the 4Q)					(350)	(340)
	Size/Spec.	(BSC's List Price) BS 43A					WFB BS 43A	Low Carbon
Spain	1979 May	US$ 280	US$ 280	US$ 340	US$ 420	US$ 300	US$ 310	US$ 300
	Jun.	290	290	350	430	300	315	310
	Jul.	290	290	350	430	300	315	319
	Aug.	300-310	Unquoted	360-370	430	310-315	320	330-335
	Size/Spec.	LLOYD'S GRADE-A 7 mm up x 2,000 x 4,000 mm	SAE 1008 2 mm up x 1,200 mm x coil	COMMERCIAL QLTY, 0.5 mm up x 1,200 x coil	ASTM A-525/527 0.5 mm up x 1,200 x coil	BS 4449 DIA 8 mm up	COMMERCIAL QLTY, 80 x 80 x 6,000 mm	SAE 1008 DIA 5.5 mm up
Republic of Korea	1979 Feb.	US$ 295	–		–	US$ 340	–	–
	Mar.	295	–	US$ 360-365	US$ 525	340	–	US$ 310
	Apr.	300-305	–	360-365	525	340	–	310
	May	295	–	365	440	NONE	–	320
	Jun.	295	–	365	440	NONE	–	320
	Jul.	295	US$ 300	365	433	–	–	315
	Aug.	295	293	352	438	–	–	320
	Size/Spec.	6 mm ≤						

Unit: FOB prices (US$ per tonne)

Note: 1. Belgium: FOB main Ports
2. Germany: FOB main ports
3. Italy: FOB stowed Italian ports
4. U.K: FOB U K port
–: Fhis products are not available
5. Korea: Plate: FOB Pohang
D-bar: FOB Busan
Commission and handling charge excluded.

3.6 Possibility of Exporting Flat Products

The study into the possiblity of exporting steel coils and sheets produced by the proposed integrated steel plant in Thailand to the ASEAN markets will have to wait until various associated factors will have been duly considered.

Generally speaking, international competitiveness is defined by four major elements, namely cost of raw materials, cost of labour, capital cost, technological standards. When it concerns the international competitiveness of steel products, it is measured by international cost comparisons as well as by international price comparisons. After all, it boils down to whether steel products of a given country are more expensive or less expensive compared with those in other countries after taking into consideration the aspect of quality. It is also closely related to the value of money and the par value of exchange of the currency in question. A rough idea will be obtainable by a relative comparison between the export prices worked out on the basis of production costs at the projected integrated steel plant and the CIF export prices quoted by other countries.

The steel industry in the ASEAN nations has been developed on a backward integration basis. As witnessed by this historical background, the production of galvanized iron sheets, tin plates, welded pipes, etc. carries great weight, and the plates and sheets needed for the production of these are supplied by imports. It is similar to the structural pattern of demand for hot and cold rolled coils and sheets in Thailand. In fact, this is a common feature.

Incidentally, the steel companies in the ASEAN nations are mostly operated either with technological cooperation by steel makers in advanced steel producing nations or in joint capital venture with them. And the plates and sheets they process are mainly supplied by these affiliated steel makers abroad.

It is a common practice among the ASEAN nations to control or ban the imports of competitive steel products from third countries either under the Industrial Promotion Law or under the Investment Law. With the implementation of steel coils and sheets production plans in the ASEAN nations, it is expected that the imports of these products will decline sharply. The cases in point concern the hot strip mill project being undertaken by P.T. Krakatau Steel in West Java, Indonesia (1,500,000 tonnes per year), a cold strip mill project which is under study, the hot strip mill project in northern Mindanao in the Philippines, of which feasibility studies have been completed and which is being planned as a part of an integrated steel plant.

ASEAN nations' requirements for coils and sheets are mainly supplied by advanced steel producing nations, such as Japan, Europe and the United States. Import prices (CIF customs clearance basis) are roughly as shown in Table 3.5.3.

Also, the trends in the current values of FOB Antwerp for exports to European countries, an indicator of steel export prices in the world, are as shown in Table 3.5.5. The CIF import prices can be obtainable by adding freight, marine insurance and usance interest to the FOB price.

The CIF price thus obtained will provide a criterion for the judgment of the competitiveness of the ASEAN nations vis-a-vis their competitors.

At the same time, whether to import or not will be decided upon due consideration of the price competitiveness, quality, standard of domestic products, adaptability to user requirements, demand and supply on the home market, etc.

The ASEAN nations will continue to seek to promote both on government and private level transformation of the ASEAN markets into what amount to a regional common market. When the expansion of preferential treatment accorded mutually and the gradual elimination of restrictive trade barriers are extended to steel products, the conditions of competition with non-ASEAN nations will assume different proportions through the specialization and division of work among the steel markers in the ASEAN region. The attainment of the anticipated result depends solely on the availability of such environment.

In view of the current situation in which about 70 percent of the total steel demand is supplied by non-ASEAN sources, the ASEAN Iron and Steel Federation (AISIF), a non-governemnt organization, at its meeting held in October 1978, underlined the importance of efforts for the promotion of regional selfsufficiency and regional exchanges, agreed to lose no time in promoting step by step product trade among the existing steel makers in the region and also in eliminating trade restrictions within the region so as to facilitate this move, and enumerated steel products exportable as of that date. Transport capability centering on shipping will also have to be strengthened at the same time, however. Accordingly, the ASEAN-CCI WG on Industrial Complementation (WGIC) was created to support the development and expansion of the ASEAN steel industry and is now working on the ways and means of materializing this into reality. The export of Thai steel products will find a new orientation when such move in ASEAN arrives at concrete and effective decisions.

Until such environment is provided, Thai steel exports will have to compete with major steel exporters of the world. And it will be difficult to hope for an expansion of steel exports unless drastic measures are taken to assist and promote these.

Be that as it may, should the future world supply of steel turn tight, there will be room for exports as the price competitiveness improves. Yet, it is difficult to look into the possible direction of the world demand and supply of steel, because a decline in the world steel demand is also possible depending on the OPEC strategies which at this moment are not predictable.

According to the data furnished by the ASEAN Steel Club, the steel supply in ASEAN will continue to fall short or the requirements for some time, while the ASEAN steel markets continue to expand. (See Table 3.6.1 & 3.6.2). The case of the Philippines can be cited here as reference. As shown in Table 3.6.2, the demand and supply by product is off balance in that country, relying heavily on imports. It is particularly so for plates and sheets. This characteristic is common among other ASEAN nations, suggesting the necessity of joint action for mutual cooperation in the region.

Table 3.6.1 Steel Demand in ASEAN Nations from 1975 to 1985

(Crude steel; 1,000 t)

	1975	1980	1985	1985/1975
Indonesia	1,788	3,115	4,867	11.0
Malaysia	1,204	2,041	3,439	11.0
Philippines	1,324	2,264	3,901	11.5
Singapore	1,678	2,641	4,177	9.0
Thailand	1,536	2,191	3,060	7.4
Total	7,530	12,252	19,444	10.1

Source: ASEAN Steel Club

Table 3.6.2 Gap between Demand and Supply of Steel in ASEAN Nations in 1980 and 1985

(Crude steel; 1,000 t)

	Demand in 1980 (A)	Capacity of production in 1975 (B)	A – B	Demand in 1985 (C)	Capacity of production in 1975 (D)	C – D
Indonesia	3,115	100	3,015	4,867	100	4,767
Malaysia	2,041	320	1,721	3,439	320	3,119
Philippines	2,264	458	1,806	3,901	458	3,443
Singapore	2,641	400	2,241	4,177	400	3,777
Thailand	2,191	731	1,460	3,060	731	2,329
Total	12,252	2,009	10,243	19,444	2,009	17,435

Source: ASEAN Steel Club

Table 3.6.3 Demand and Supply of Steel in the Philippines in 1974, 1977 and 1978

(Unit: 1,000 t, %)

Products	Item / Years	Production (A)			Imports (B)			Domestic demand (A) + (B)			Ratio of imports ($\frac{B}{A+B}$, %)		
		1974	1977	1978	1974	1977	1978	1974	1977	1978	1974	1977	1978
Cold rolled products	Galvanized iron sheets	83.5	102.5	104.8	5.7	12.9	21.7	89.2	115.4	126.5	6.4	11.2	17.1
	Tin plates	80.1	87.8	69.9	36.6	56.9	92.8	116.7	144.7	162.7	31.4	39.3	57.0
	Cold rolled sheets	28.5	28.2	45.7	29.1	17.9	41.5	57.6	46.1	87.2	50.5	38.9	47.6
Hot rolled products	Medium plates	–	3.6	27.0	71.8	58.9	90.8	71.8	62.5	117.8	100.0	94.3	77.1
	Sheets and coils	19.6	11.6	21.3	27.7	75.5	74.0	47.3	87.1	95.3	58.6	86.7	77.6
	Pipes	32.3	40.0	47.3	19.0	31.3	24.7	51.3	71.3	72.0	37.0	43.9	34.3
Long products	Bars	250.9	389.0	391.4	35.8	29.2	40.0	286.7	418.2	431.4	12.5	7.0	9.3
	Wire rods and wires	34.0	82.5	68.5	37.9	15.3	22.8	71.9	97.8	91.3	52.7	15.6	25.0
	Shapes	–	–	–	40.0	30.5	19.0	40.0	30.5	19.0	100.0	100.0	100.0
	Total	528.9	745.2	775.9	303.6	328.4	427.3	832.5	1073.6	1203.2	36.5	30.6	35.5

Source: Compiled from data of the Philippine government

CHAPTER 4

BASIC PLAN FOR THE NEW STEEL PLANT

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4.1 Basic Concept

As is described in the preceding chapter, the current steel consumption in Thailand is approximately a little more than 1.5 million tonnes annually, of which 600,000 tonnes are locally produced and the remainder of about 900,000 tonnes are imported as either finished steel products or semi-finished steel to be fabricated. In other words, those engaged in manufacturing of steel products such as bars, rods and wires from crude steel are small sized electric arc furnace steel manufactures and galvanized sheets, tin plates, welded pipes and light gauges are manufactured from imported steel materials.

Of the total imported steel, flat products account for 72 per cent. And this ratio of flat products import represents a higher growth rate. Both the 1985 and the 1990 forecasts indicate the continuance of similar tendency as previously mentioned in the preceding chapter. Table 4.1.1 shows the results of these demand forecasts.

Table 4.1.1 Demand Forecasts

(Unit: tonnes)

	Total of steel products	Flat products	Non-flat products
1985	2,450,000	1,200,000	1,250,000
1990	3,550,000	1,760,000	1,790,000

The Royal Thai Government contemplates the construction of an integrated steel plant for flat products, and has requested the Japanese Government to conduct a feasibility study thereof. By virtue of the request, the study was planned to work out for the pursuit of the integrated flat steel plant of a size and content compatible with the domestic demand for flat products, for the years 1985 and 1990. The pursuit will also include consideration for future expansion of the proposed steel plant.

The project to construct the integrated steel plant is the first of its kind in Thailand. It is well expected that the completion of the steel plant, will promote the employment at home and will lead the domestic steel industry in respect of technologies and techniques, and will play a significant role for the fostering and prosperity of Thai industries, including steel associated industries as well as society and economy overall.

This project, when compared with the existing steelworks in Thailand, is far greater in its scale, and as a matter of course, will require higher technical levels.

What is necessary as a basic concept for the proposed project lies in that primarily, based on the demand forecast given in the preceding chapter, the effective use of the national resources of Thailand for the production of flat products to fulfill the domestic demand for steel, and secondarily, an establishment of a modern steel plant with low equipment cost, putting an emphasis on ensuring the balancing of promoted employment and modernization of the steel plant with securing stable operation.

Three proposed sites for the new steel plant are designated by the Royal Thai Government; two sites in the Sattahip district and one in the Laem Chabang district. This study will be conducted to select one optimum site out of the three. In the study, the equipment plan for the project will include the consideration of environmental protection and pollution control measures.

To carry out the construction and operation of the proposed steel plant smoothly in accordance with the trend of Thai future demand, the project is divided into two stages: the 1st stage to meet the 1985 demand and the 2nd stage for the 1990 demand. As will be described later in this report, the 1st stage assumes 1,295,000 tonnes/year and the 2nd stage 2,044,000 tonnes/year both on a molten steel basis.

4.2 Type of Products and the Outputs.

As shown in the preceding chapter, the demand forecast indicates that the cold rolled and hot rolled products share major part of flat products. Considering the above condition, the hot rolled and cold rolled products for general use are planned to be produced by the new steel plant.

Based on the product demand by mills which is given in the preceding chapter, the production schedule for different types of products at the 1st and 2nd stages are designed as shown in Table 4.2.1.

In designing the above mentioned outputs, assumptions are made for the following items.

a. As most of the plate required in demand forecast can be manufactured by the hot strip mill, provision of a plate mill is not considered.

b. A portion of the strip materials for tin plates require a continuous annealing process. Manufacturing of this material will be included in the 2nd stage when the manufacturing techniques will have been stabilized and production scale will have been expanded. In other words, 50% of the strip material for tin plates will be excluded in the 1st stage.

c. In addition, for tin plates and galvanized sheets, only the cold rolled material will be supplied.

Table 4.2.1 Production Plan by Types of Products

(Unit: 1,000 tonnes)

			1st stage		2nd stage	
			Cold rolled product	Hot rolled product	Cold rolled product	Hot rolled product
For light gauges				48		72
For general use	Heavy and Medium plate	Heavy plate		127		169
		Medium plate		50		66
		Sub-total		177		235
	Sheet	Hot rolled		239		408
		Cold rolled	122	(131)	172	(185)
		Sub-total	122	239	172	408
		Total	122	416	172	643
For tin plate			80	(89)	255	(282)
For galvanized sheet			224	(246)	305	(334)
For welded pipe		Hot rolled		160		222
		Cold rolled	53	(55)	72	(75)
Flat products total			479	624 (521)	804	937 (876)

Note: 1. Product base
2. Figures in ( ) are those converted to hot product base.

Summarizing the results, the relationship between the production schedule and the demand for the products to be produced by the new steel plant will be as shown in Table 4.2.2.

Table 4.2.2 Demand and Production by Mills

(Unit: tonnes)

	1985		1990	
	Demand	Production	Demand	Production
Cold strip mill	581,000	479,000	832,000	804,000
Hot strip mill	1,260,000	1,145,000	1,845,000	1,813,000

4.3 Comparison between BF/BOF Route and DR/EAF Route

(1) Classification of the Making of Iron and Steel

There are a number of process routes for the making of iron and steel, and these can be classified into four typical process routes as follows:

Route A: Blast furnace – Basic oxygen furnace (BF/BOF)

Route B: Electric pig iron process – Basic oxygen furnace (EPIP/BOF)

Route C: Scrap based electric arc furnace (Scrap/EAF)

Route D: Direct reduction – Electric arc furnace (DR/EAF)

When the most suitable route for the project is selected from these four routes, a thorough consideration must be given to the following domestic situation:

a. Domestic natural gas as reductant must be available in abundant quantities and obtainable at a low pirce.
b. Occurrence of coal for metallurgical purpose has not been reported in Thailand.
c. Local scrap supply is not sufficient.

As for Route B, though it has been advantage of not requiring high quality metallurgical coke, it demands a large amount of electric power, i.e. about 2,000 kWh per tonne of molten pig iron. Therefore, Route B is suitable only for countries where sufficient electric power is available at a low price. For this reason, Route B is not recommendable for the project. Route C is not recommended neither for the project, since scrap price varies sharply, and the supply of scrap itself is expected to be more and more difficult to obtain on the international market in the future.

Therefore, comparison between Route A and Route D, is made in the following sections.

(2) **Characteristics of BF/BOF Route**

This route is usually adopted for large scale production. Accordingly, most of the modern integrated steel plants using this route have a large production capacity ranging from 3 to 10 million tonnes per year. Because of this large capacity production, BF/BOF route shows a very high productivity, and commercial effect is favourably recongnized.

When an integrated steel plant having an annual capacity of 2 million tonnes has to be newly constructed, two blast furnaces each of 1 million tonnes capacity should be installed to assure a stable continuous operation of BOF and to avoid the risk of "single lung" operation. In this case, the production per blast furnace is made comparatively smaller, which requires a larger capital investment per blast furnace. It naturally leads to a higher production cost of molten steel.

The BF operation requires high quality metallurgical coke. Since domestic metallurgical coke is not available in Thailand, high grade coal must be imported. The import of coal requires additional supporting facilities such as a port accommodating bulk carriers, unloading facilities, a coal stockyard, coke ovens and coke storage facilities.

Further, a sintering plant must be installed, since sinters are more desirable for blast furnace burden from the viewpoint of raw materials.

In addition to these facilities, a power plant and pollution prevention facilities are required for effective use of BF and coke oven gas. As stated above, in case of installation of BF including supporting facilities the total investment is not only higher than in DR/EAF route, but also a large plant site area is required comparing to DR/EAF route.

It is technically difficult to operate BF at a low level of production, and also to adjust the production counterbalancing the need of succeeeding processes. However, once BF operation stops, it will take a long time and require a large expense to restart BF operation. This is the difference of BF fróm DR plant operation.

(3) Characteristics of DR/EAF Route

In DR/EAF route, iron ores (iron ore lump and/or pellets) are reduced in a solid form to become DRI, which is used as the main raw material for EAF. Therefore, one advantage is that stock level of DRI can be adjusted freely, that is, DR/EAF route has a higher flexibility of operation as DR plant can be controlled at a low level of production.

High grade iron ores (66% Fe or more), which are raw materials for DR processes, can be procured at the international market as well as iron ores for BF burden.

(4) Comparison of Cost between BF/BOF Route and DR/EAF Route

i. Direct construction cost

Table 4.3.1 shows the description of major equipment and facilities up to the steelmaking process, and direct construction cost at the second stage of the project with an eventual capacity of 2 million tonnes per year of molten steel.

It can be seen from the table that the direct construction cost for the DR/EAF route is approximately 35% less than that for the BF/BOF route.

Table 4.3.1 Comparison of Construction Cost between BF/BOF and DR/EAF

(Unit: mill.dollars)

Name of facility	BF/BOF		DR/EAF	
	Capacity	Cost	Capacity	Cost
1) Port & raw material preparation facilities		159		83
2) Coke oven and by-products facilities	1 mill. t/y	150	—	—
3) Sinter plant	2 mill. t/y	60	—	—
4) BF or DR plant	1.8 mill. t/y	173	1.912 mill. t/y	176
5) BOF or EAF plant	2.0 mill. t/y	128	2.044 mill. t/y	131
6) BF blower and generating facilities	360,000 Nm^3/h 90,000 kW	58	—	—
Power generating plant (outside)	—	—	250,000 kW*	130
7) Flicker compensation facility	—	—	—	29
8) Oxygen plant	26,000 Nm^3/h	38	8,000 Nm^3/h	19
Total		766		568

*: Capacity is only for DR plant and EAF plant

ii. Operation cost

Table 4.3.2 and 4.3.3 show the operation cost based upon the unit consumption rate and unit cost of steelmaking on each equipment.

It would be generally accepted that the production cost of molten steel in BF/BOF route is a little higher than that of DR/EAF at this scale of operation, as observed from these data.

(5) Conclusion

In comparison with BF/BOF route, DR/EAF route based on natural gas as a reductant has the following advantages:

DR/EAF route;

a. does not require coal for metallurgical purpose,

b. can use domestic natural gas as a reductant,

c. is flexible in operation and easy to control,

d. can be built with less equipment cost,

e. is operated at lower cost,

f. requires less plant area, and

g. has less environmental pollution control problems.

In consideration of the advantages mentioned above, DR/EAF route is advisable to be employed for this project.

Table 4.3.2 Comparison of Production Cost between DRI and Pig Iron

Items	Unit	Unit price	BF		DR	
			Q'ty	Cost	Q'ty	Cost
Variable cost		$		$		$
Sinters	tonnes	38.0	1.134	43.09	—	—
Pellets	tonnes	39.52	—	—	1.156	45.69
Lump ore	tonnes	24.21	0.566	13.70	0.301	7.30
Coke	tonnes	120.00	0.520	62.40	—	—
Natural gas	Nm^3	0.062	—	—	340.13	21.04
Heavy oil	kg	0.09	50	4.50	—	—
Electric power	kWh	0.036	20	0.72	142.03	5.07
Oxygen	Nm^3	0.078	12	0.94	—	—
Nitrogen	Nm^3	0.078	—	—	0.25	0.02
Water	m^3	0.035	45	1.58	32.78	1.13
Steam	kg	0.010	15	0.15	—	—
BF & cock oven gas	—			5.60	—	—
BF blower cost	—			5.5	—	—
Chemicals	—		—	—		0.41
Transportation	—			2.0		0.17
Raw material preparation	—			5.0		4.94
Others	—			3.0		3.50
By-products	—			−15.0		−1.48
Fixed cost						
Employee	—			0.25		0.12
Maintenance	—			12.0		2.02
Depreciation	—			7.1		7.2
Others	—			5.0		0.06
Total				$157.53		$97.19

Table 4.3.3 Comparison of Molten Steel Production Cost

Items	Unit	Unit cost	BOF		EAF	
			Q'ty	Cost	Q'ty	Cost
Variable cost		$		$		$
Pig iron	tonnes	157.53	0.880	138.63	——	——
DRI	tonnes	97.19	——	——	0.935	90.88
Scrap	tonnes	156.24	0.220	34.37	0.213	33.30
Sub-raw material	—	——	——	12.30	——	9.09
Natural gas	Nm^3	0.062	——	——	12	0.741
Electric power	kWh	0.036	25	0.90	756	26.99
Water	m^3	0.035	15	0.53	67.95	2.36
Oxygen	Nm^3	0.078	55	4.29	5.02	0.392
Air	Nm^3	0.01	8	0.08	8.08	0.084
Brick	kg	0.555	10	5.55	17.8	9.88
Dolomite clinker	kg	0.268	3	0.80	10	2.68
Electrode	kg	2.15	——	——	7	15.04
Transportation	—			0.81		0.81
Raw material preparation	—			1.01		1.01
Others	—			6.2		2.83
By-product (Scrap)	—			−0.97		−0.965
Fixed cost						
Employee	—			0.29		0.225
Maintenance	—			3.50		1.41
Depreciation	—			4.68		4.79
Total				$212.97		$201.54

4.4 Production Plan and Flow

(1) Production Plan

Based on the various conditions referred to in the preceding paragraphs, the basic concept in respect of the production by the new steel plant is designed as follows.

i. Production process

a. The DR/EAF process should be employed.

b. The slab manufacturing process should be the continuous casting process employed worldwide, from the viewpoints of yield, quality, productivity and cost.

c. Hot strip mill and cold strip mill should be provided.

d. The new steel plant should mainly consist of the above equipment.

ii. Main raw materials

a. Imported pellets and lump ores should be used as the raw materials for the direct reduction plant.

b. In principle, the raw materials used for the electric arc furnace should consist of 80 per cent of direct reduced iron (DRI) which is manufactured by the DR process, and 20 per cent of scraps. Scrap should mainly consist of return scrap generated from the new steel plant, and the balance should be purchased from overseas.

iii. Production scale

a. Annual 1.3 million tonnes of molten steel at the 1st stage and annual 2 million tonnes of molten steel at the 2nd stage.

b. The outputs from the main plants should be as shown in Table 4.4.1

Table 4.4.1 Annual Outputs from Main Facilities

(Unit: tonnes)

Plant	1st stage		2nd stage	
Direct reduction	DRI	1,211,000	DRI	1,912,000
Steelmaking	Molten steel	1,295,000	Molten steel	2,044,000
Hot strip mill	(Rolled)	1,169,000	(Rolled)	1,846,000
Cold strip mill	(Rolled)	500,000	(Rolled)	841,000

iv. Types of products

Types of products should include plates, hot coils and sheets, cold coil and sheets, cold rolled materials for tin plates and galvanized sheets, sheets and plates for welded pipe, and for light gauges.

v. Product outputs by size – Product-mix

a. With consideration given to the domestic demand structure in Thailand relating to steel products and to the characteristics of steel products by use, the product outputs by size are designed as shown in Tables 4.4.2 and 4.4.3.

Table 4.4.2 Product-mix in Hot Strip Mill

Nominal product width	1st stage		2nd stage	
	Tonne/year	%	Tonne/year	%
2.5 feet	196,000	16.8	268,000	14.5
3.0	126,000	10.8	332,000	18.0
4.0	801,000	68.5	1,177,000	63.8
5.0	46,000	3.9	69,000	3.7

Table 4.4.3 Product-mix in Cold Strip Mill

Nominal product width	1st stage		2nd stage	
	Tonne/year	%	Tonne/year	%
2.5 feet	188,000	38.0	257,000	30.0
3.0	121,000	24.0	319,000	38.0
4.0	191,000	38.0	265,000	32.0

b. For reference, the typical sizes of hot strip mill products are shown in Table 4.4.4, and those of cold strip mill product in Table 4.4.5.

Table 4.4.4 Typical Sizes of Hot Strip Mill Products

			Thickness (mm)	Width (mm)
Hot strip mill	Coil		3.2	1,240
	Sheet		6.0	1,240
For cold strip mill	For general use	Coil	3.8	1,240
		Sheet	2.8	1,240
	For galvanized sheets		1.8	785
	For tin plates		2.0	835

Table 4.4.5 Typical Sizes of Cold Strip Mill Products

		Thickness (mm)	Width (mm)
For general use	Coil	1.6	1,219
	Sheet	0.8	1,219
For galvanized sheets	Coil	0.2	762
For tin plate		0.23	810

c. Based on the above data, range of product size from hot and cold strip mills are established as follows.

Table 4.4.6 Range of Product Size

	Thickness (mm)	Width (mm)
Hot strip mill product	1.2 ~ 12.7	600 ~ 1,600
Cold strip mill product	0.15 ~ 3.2	50 ~ 1,300

(2) Production Flow

The production flow from the products backward to raw materials in the new steel plant, will be as shown in Fig. 4.4.1 for the 1st stage and in Fig. 4.4.2 for the 2nd stage.

(3) Process Flow

The process flow in the new steel plant is shown in Fig. 4.4.3.

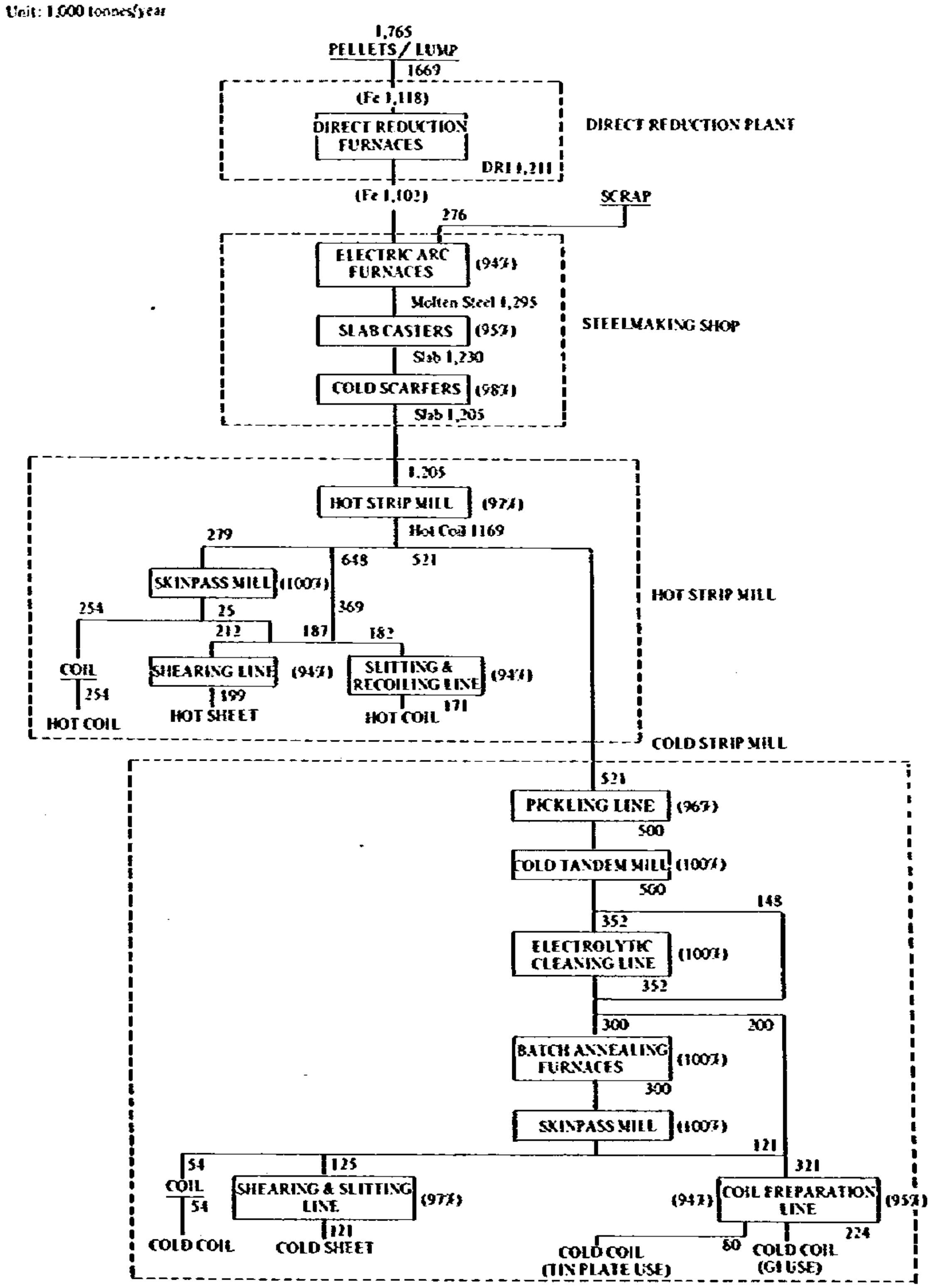


Fig. 4.4.1 Production Flow – 1st Stage

(Molten Steel 1,295,000 t/y)

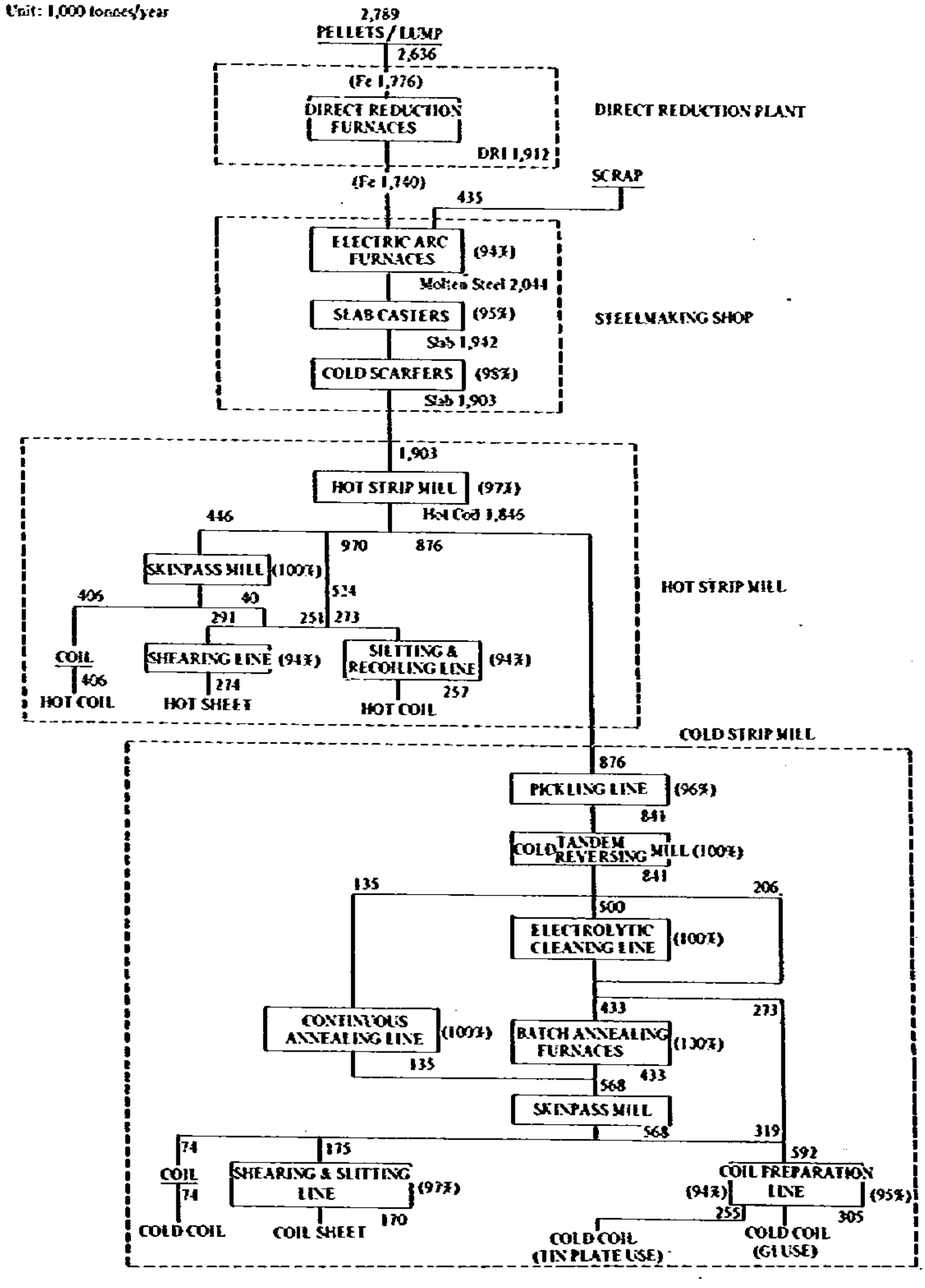


Fig. 4.4.2 Production Flow – 2nd Stage

(Molten Steel 2,044,000 t/y)

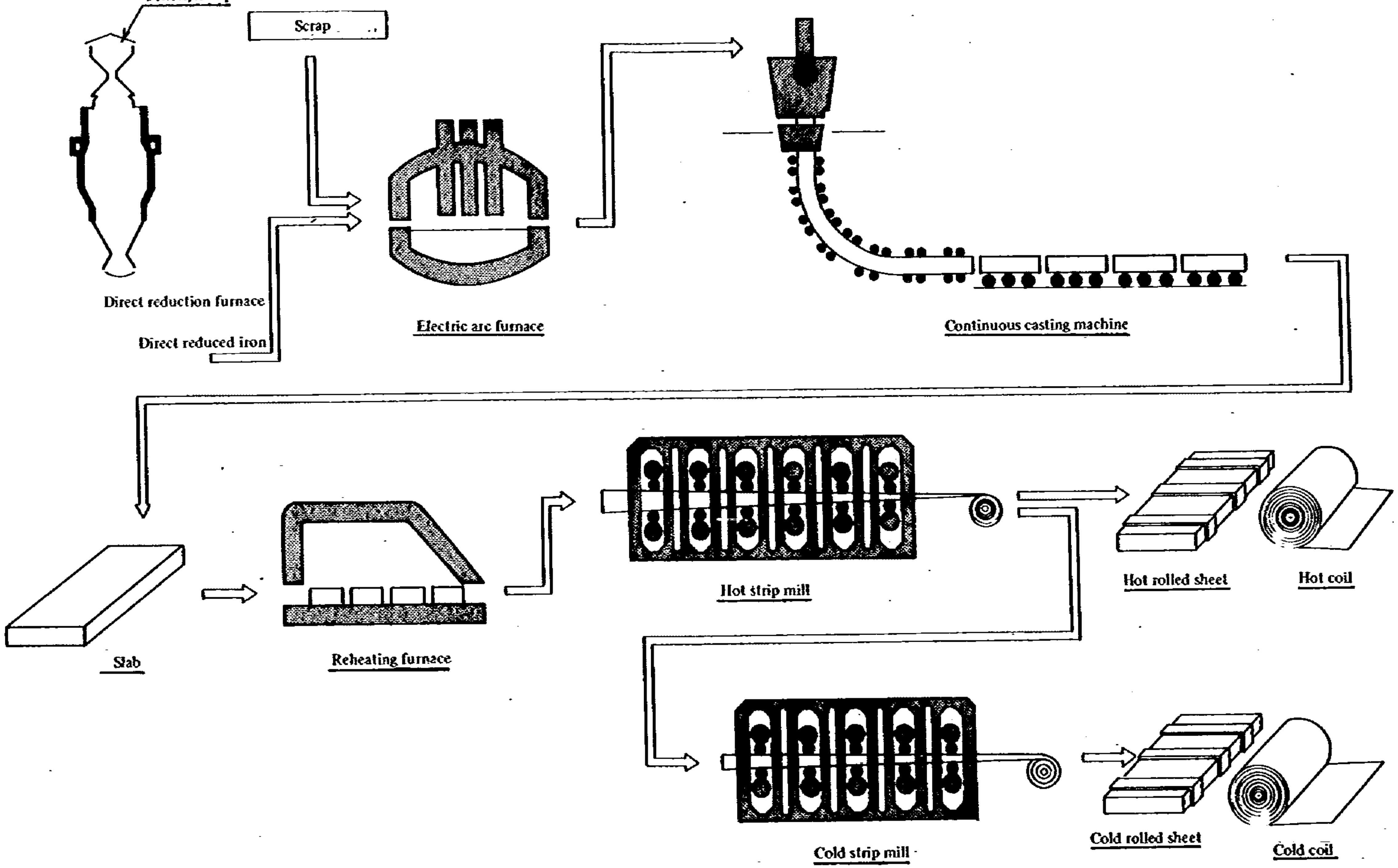


Fig. 4.4.3 Process Flow of the Integrated Steel Plant

4.5 Main Production Equipment

Of the equipment plan based on the outputs at the 1st and 2nd stages, the main production equipment plan is designed as shown in Table 4.5.1.

4.6 Material Flow and Associated Data

The material flow covering the main raw materials and products for the project is shown in Figs. 4.6.1 and 4.6.2.

Summarized data associated with the new steel plant in respect of the outputs, raw materials, utilities and by-products yielded from or used by respective production section and auxiliary sections under the new steel plant project, are shown in Tables 4.6.1 and 4.6.2.

Table 4.5.1 Main Facilities

	Main equipment	No. of equipment		Remarks
		1st Stage	2nd Stage	
Direct reduction plant	Direct reduction furnace	2	3	DR Plant: 600,000 t/y
	Briquetting facilities	1	2	
	Desulphurization equipment	1	2	
Steelmaking shop	Electric arc furnace	4	6	EAF: 150 t/heat, UHP
	Continuous casting machine	2	3	C.C.: Radius type, 2 strand
	Cold scarfing machine	2	3	Slab size: 200mm thickness x 1,600mm width
Hot strip mill plant	Reheating furnace	2	3	Size of hot rolled products
	Vertical scale breaker	1	1	thickness: 1.2 ~ 12.7 mm
	4 Hi reversible roughing mill	1	2	width: 1,600mm max.
	Crop shear	1	1	
	68-in. 6 stands finishing mill	1	1	
	Down coiler	2	3	
	68-in. 2 Hi skinpass mill	1	1	
	Shearing line	1	1	
	Recoiling & slitting line	1	1	
Cold strip mill plant	Pickling line	1	1	
	56-in. 6 stands tandem mill*	1	1	*5 stands at 1st stage
	56-in. reversing mill	0	1	
	Cleaning line	2	2	Size of cold rolled products
	Batch annealing furnace	1 set	expansion	thickness: 0.15 ~ 3.2 mm
	Continuous annealing line	0	1	width: 1,300 mm max.
	56-in. 4 Hi skinpass mill	0	1	weight of coil: 8,000 kg max.
	56-in. 2 stands skinpass mill	1	1	
	Coil preparation line	1	2	
	Shearing & slitting line	1	2	

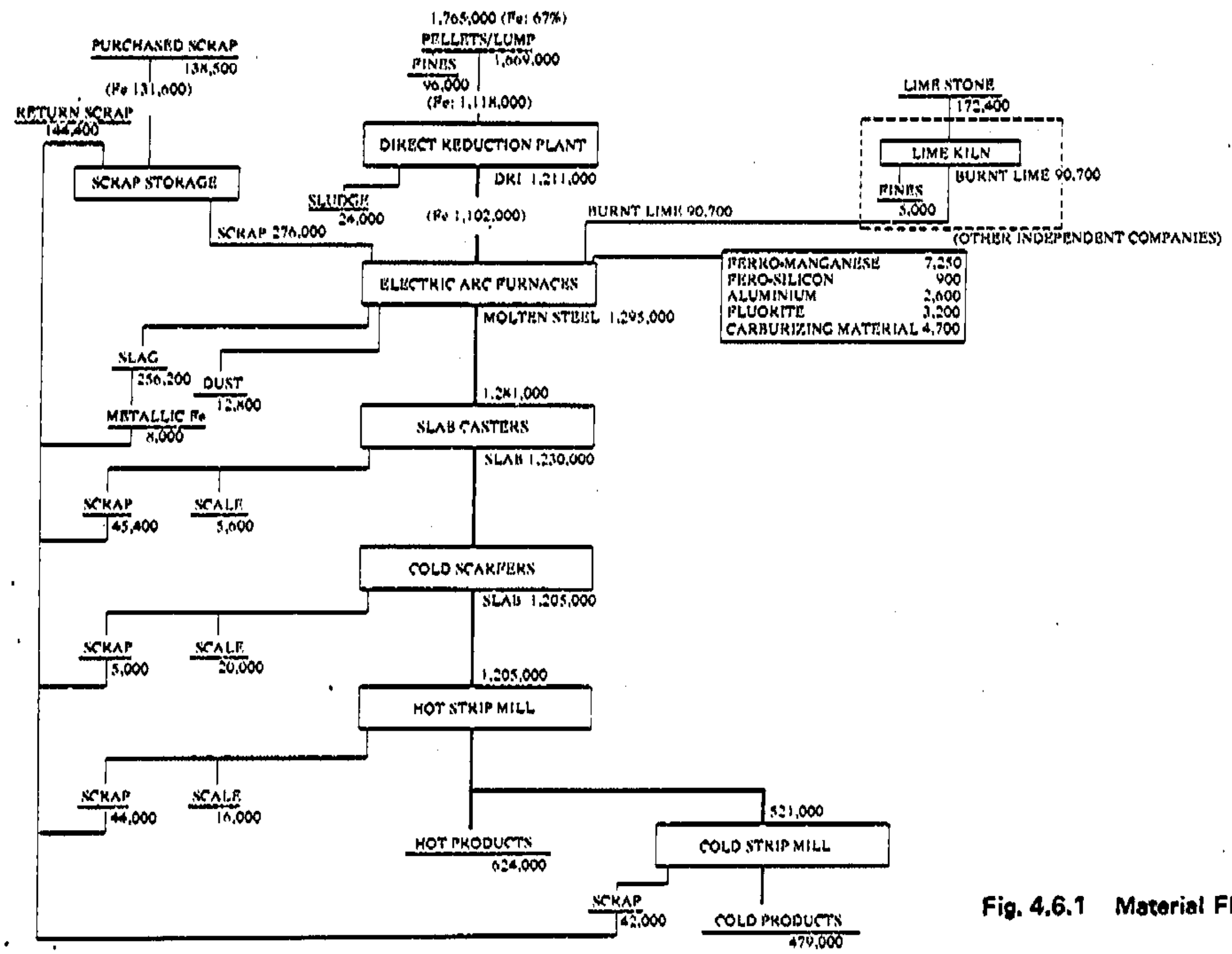


Fig. 4.6.1 Material Flow — 1st Stage

Unit: tonnes per year

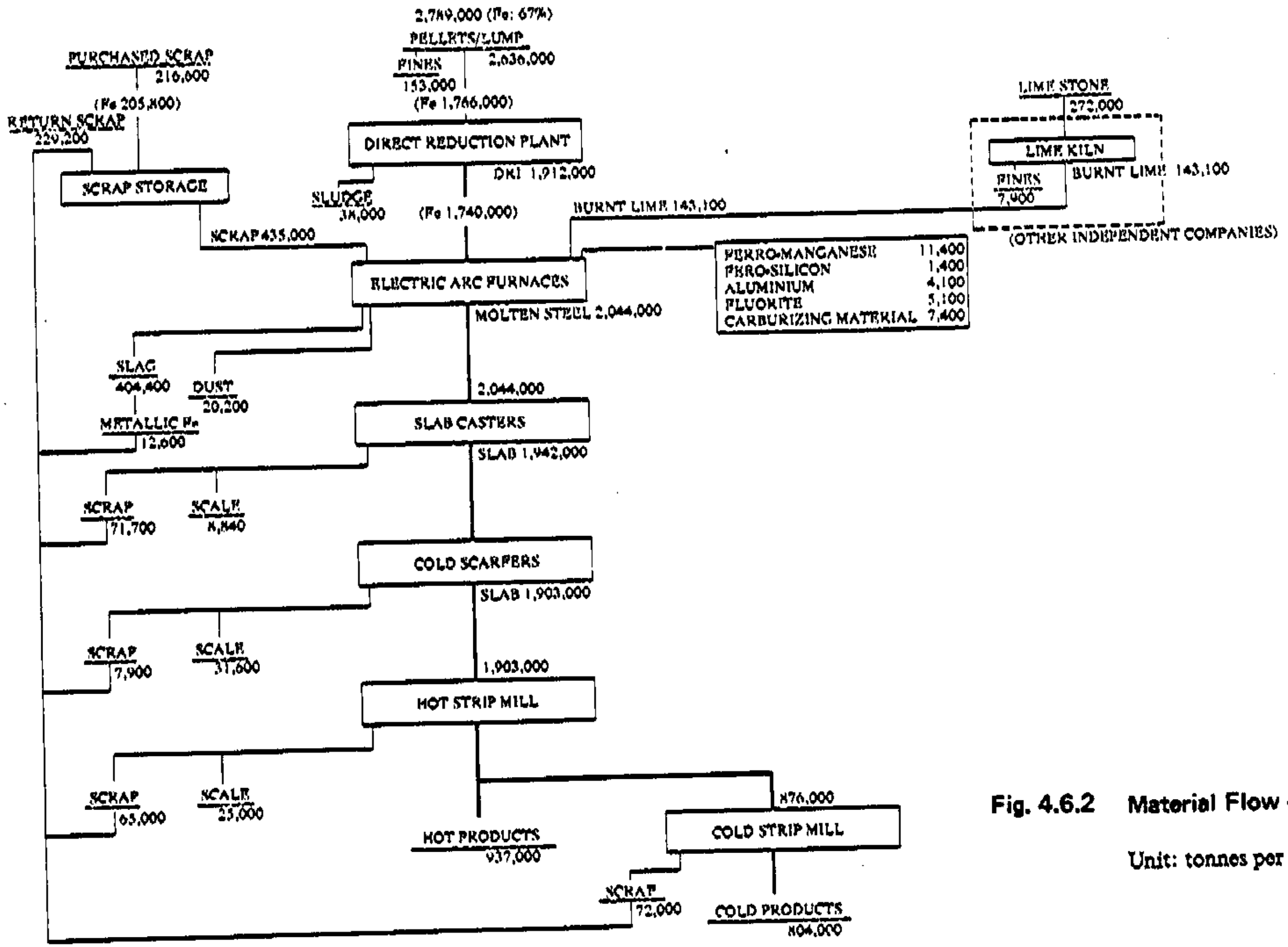


Fig. 4.6.2 Material Flow — 2nd Stage

Unit: tonnes per year

Table 4.6.1 Summary of Consumption and Generation — 1st Stage

	Production	Raw materials			Utilities			By-products			Remarks
		Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	
Raw Material					Electric power		1,800 x 10^3 kWh				
DR plant	DRI 1,211,000 t	Pellet/Lump		1,765,000 t	Natural gas	340.1 Nm^3/t	411,900 x 10^3 Nm^3				
					Electric power	142 kWh/t	172,000 x 10^3 kWh				
					Plant air	9 Nm^3/t	10,900 x 10^3 Nm^3				
					Nitrogen, argon	0.25Nm^3/t	300 x 10^3 Nm^3				
					Circulated water	32.8 m^3/t	39,700 x 10^3 m^3				
					Make-up water	1.5 m^3/t	1,790 x 10^3 m^3				
					Fresh water	1.5 m^3/t	1,790 x 10^3 m^3				
Electric arc furnace	Molten steel 1,295,000 t	DRI	935 kg/t	1,211,000 t	Natural gal	12 Nm^3/t	15,500 x 10^3 Nm^3	EAF slag	198 kg/t	256,200 t	
		Scrap	213 kg/t	276,000 t	Electric power	756 kWh/t	979,000 x 10^3 kWh	Recovered iron from slag	6.2 kg/t	8,000 t	
		Burnt lime	70 kg/t	90,700 t	Plant air	8 Nm^3/t	10,400 x 10^3 Nm^3				
		Fluorite	2.5 kg/t	3,200 t	Oxygen	5 Nm^3/t	6,500 x 10^3 Nm^3				
		Ferroalloys	6.3 kg/t	8,200 t	Circulated water	68 m^3/t	88,000 x 10^3 m^3	Dust	9.8 kg/t	12,800 t	
		Alluminium	2 kg/t	2,600 t	Make-up water	3.1 m^3/t	3,960 x 10^3 m^3				
		Carburizing Material	3.6 kg/t	4,700 t	Fresh water	3.1 m^3/t	3,960 x 10^3 m^3				
Continuous casting	Slab 1,205,000 t	Molten steel		1,295,000 t	Natural gas	4.7 Nm^3/t	5,600 x 10^3 Nm^3	Scrap	41.8 kg/t	50,400 t	
					Electric power	14.2 kWh/t	17,100 x 10^3 kWh	Scale	21.2 kg/t	25,600 t	
					Plant air	20 Nm^3/t	24,100 x 10^3 Nm^3				
					Oxygen	18.3 Nm^3/t	22,100 x 10^3 Nm^3				
					Nitrogen, argon	2.8 Nm^3/t	3,400 x 10^3 Nm^3				
					Circulated water	48.8 m^3/t	58,800 x 10^3 m^3				
					Make-up water	2.2 m^3/t	2,650 x 10^3 m^3				
					Fresh water	2.2 m^3/t	2,650 x 10^3 m^3				
Hot rolling mill	Coil 1,169,000 t (for cold rolling 521,000 t)	Slab		1,205,000 t	Natural gas	56.4 Nm^3/t	65,900 x 10^3 Nm^3	Scrap	37.6 kg/t	44,000 t	
					Electric power	101.2 kWh/t	118,300 x 10^3 kWh	Scale	13.7 kg/t	16,000 t	
					Steam	12.4 kg/t	14,500 t				
					Plant air	36.7 Nm^3/t	42,900 x 10^3 Nm^3				
					Circulated water	61.8 m^3/t	72,300 x 10^3 m^3				
					Make-up water	2.8 m^3/t	3,250 x 10^3 m^3				
					Fresh water	2.8 m^3/t	3,250 x 10^3 m^3				
Cold rolling mill	479,000 t	Hot rolling coil		521,000 t	Natural gas	27.8 Nm^3/t	13,300 x 10^3 Nm^3	Scrap	87.7 kg/t	42,000 t	
					Electric power	191.6 kWh/t	91,800 x 10^3 kWh				
					Steam	288.7 kg/t	138,300 t				
					Plant air	93.7 Nm^3/t	44,900 x 10^3 Nm^3				
					Nitrogen,	9.4 Nm^3/t	4,500 x 10^3 Nm^3				
					Circulated water	35.9 m^3/t	17,200 x 10^3 m^3				
					Make-up water	1.6 m^3/t	780 x 10^3 m^3				
					Once through water	2.8 m^3/t	1,340 x 10^3 m^3				
					Fresh water	4.4 m^3/t	2,120 x 10^3 m^3				

Table 4.6.1 (cont'd)

		Production	Raw materials			Utilities			By-products			Remarks
			Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	
Utilities	Oxygen					Electric power Circulated water Make-up water Fresh water		22,900 x 10^3 kWh 2,900 x 10^3 m^3 130 x 10^3 m^3 130 x 10^3 m^3				
Utilities	Electric power					Electric power		27,100 x 10^3 kWh				
Utilities	Steam					Electric power Fresh water Natural gas Once through water		3,100 x 10^3 kWh 180 x 10^3 m^3 15,200 x 10^3 Nm^3 180 x 10^3 m^3				
Utilities	Plant air					Electric power Circulated water Make-up water Fresh water		18,600 x 10^3 kWh 3,500 x 10^3 m^3 160 x 10^3 m^3 160 x 10^3 m^3				
Utilities	Water					Electric power		122,900 x 10^3 kWh				
Maintenance						Electric power		700 x 10^3 kWh				
Product handling						Electric power		500 x 10^3 kWh				
Warehouse						Electric power		100 x 10^3 kWh				
General						Electric power Potable water		700 x 10^3 kWh 660 x 10^3 m^3				
Head quarter						Electric power Potable water		400 x 10^3 kWh 60 x 10^3 m^3				

Table 4.6.2 Summary of Consumption and Generation — 2nd Stage

	Production	Raw materials			Utilities			By-products			Remarks
		Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	
Raw material handling					Electric power		2,900 x 10^3 kWh				
DR plant	D.R. Iron 1,912,000 t	Pellet/Lump		2,789,000 t	Natural gas	340.1 Nm^3/t	650,300 x $10^3 Nm^3$				
					Electric power	142 kWh/t	271,500 x 10^3 kWh				
					Plant air	9 Nm^3/t	16,400 x $10^3 Nm^3$				
					Nitrogen, argon	0.25 Nm^3/t	500 x $10^3 Nm^3$				
					Circulated water	31.1 m^3/t	59,500 x $10^3 m^3$				
					Make-up water	1.4 m^3/t	2,680 x $10^3 m^3$				
					Fresh water	1.4 m^3/t	2,680 x $10^3 m^3$				
Electric arc furnace	Molten steel 2,044,000 t	DRI	935 kg/t	1,912,000 t	Natural gas	12 Nm^3/t	24,500 x $10^3 Nm^3$	EAF slag	198 kg/t	404,400	
		Scrap	212 kg/t	435,000 t	Electric power	756 kWh/t	1,545,300 x 10^3 kWh	Recovered iron from slag	6.2 kg/t	12,670 t	
		Burnt lime	70 kg/t	143,100 t	Plant air	8 Nm^3/t	16,400 x $10^3 Nm^3$				
		Fuorite	2.5 kg/t	5,100 t	Oxygen	5 Nm^3/t	10,200 x $10^3 Nm^3$	Dust	9.8 kg/t	20,200 t	
		Ferroalloys	6.3 kg/t	12,800 t	Circulated water	65 m^3/t	132,000 x $10^3 m^3$				
		Aluminium	2 kg/t	4,100 t	Make-up water	2.9 m^3/t	5,940 x $10^3 m^3$				
		Carburizing Material	2.3 kg/t	7,400 t	Fresh water	2.9 m^3/t	5,940 x $10^3 m^3$				
Continuous casting	Slab 1,903,000 t	Molten steel		2,044,000 t	Natural gas	4.7 Nm^3/t	8,900 x $10^3 Nm^3$	Scrap	41.8 kg/t	79,000 t	
					Electric power	14.2 kWh/t	27,000 x 10^3 kWh	Scale	21.2 kg/t	40,440 t	
					Plant air	20 Nm^3/t	38,100 x $10^3 Nm^3$				
					Oxygen	18.3 Nm^3/t	34,800 x $10^3 Nm^3$				
					Nitrogen, argon	2.8 Nm^3/t	5,400 x $10^3 Nm^3$				
					Circulated water	44 m^3/t	83,800 x $10^3 m^3$				
					Make-up water	1.98 m^3/t	3,770 x $10^3 m^3$				
					Fresh water	1.98 m^3/t	3,770 x $10^3 m^3$				
Hot rolling mill	Coil 1,846,000 t (for cold rolling 876,000 t)	Slab		1,903,000 t	Natural gas	56.4 Nm^3/t	104,000 x $10^3 Nm^3$	Scrap	35.2 kg/t	65,000 t	
					Electric power	101.0 kWh/t	186,400 x 10^3 kWh	Scale	13.8 kg/t	25,000 t	
					Steam	12.4 kg/t	22,800 t				
					Plant air	28.3 Nm^3/t	52,200 x $10^3 Nm^3$				
					Circulated water	51.6 m^3/t	95,200 x $10^3 m^3$				
					Make-up water	2.3 m^3/t	4,280 x $10^3 m^3$				
					Fresh water	2.3 m^3/t	4,280 x $10^3 m^3$				
Cold rolling mill	804,000 t	Hot rolled coil		876,000 t	Natural gas	30 Nm^3/t	24,100 x $10^3 Nm^3$	Scrap	89.5 kg/t	72,000 t	
					Electric power	193.5 kWh/t	155,600 x 10^3 kWh				
					Steam	344.6 kg/t	277,100 t				
					Plant air	77.7 Nm^3/t	62,500 x $10^3 Nm^3$				
					Nitrogen,	21.1 Nm^3/t	17,000 x $10^3 Nm^3$				
					Circulated water	38.2 m^3/t	30,700 x $10^3 m^3$				
					Make-up water	1.7 m^3/t	1,380 x $10^3 m^3$				
					Once through water	3.6 m^3/t	2,930 x $10^3 m^3$				
					Fresh water	5.3 m^3/t	4,310 x $10^3 m^3$				

Table 4.6.2 (cont'd)

		Production	Raw materials			Utilities			By-products			Remarks
			Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	Material	Unit consumption	Annual consumption	
Utilities	Oxygen					Electric power Circulated water Make-up water Fresh water		36,000 x 10^3 kWh 4,500 x 10^3 m^3 200 x 10^3 m^3 200 x 10^3 m^3				
	Electric power					Electric power		42,800 x 10^3 kWh				
	Steam					Electric power Natural gas Once through water Fresh water		6,000 x 10^3 kWh 29,800 x 10^3 Nm^3 360 x 10^3 m^3 360 x 10^3 m^3				
	Plant air					Electric power Circulated water Make-up water Fresh water		23,500 x 10^3 kWh 4,400 x 10^3 m^3 200 x 10^3 m^3 200 x 10^3 m^3				
	Water					Electric power		178,700 x 10^3 kWh				
Maintenance						Electric power		1,100 x 10^3 kWh				
Product handling						Electric power		800 x 10^3 kWh				
Warehouse						Electric power		200 x 10^3 kWh				
General						Electric power Potable water		1,100 x 10^3 kWh 1,000 x 10^3 m^3				
Head quarter						Electric power Potable water		600 x 10^3 kWh 60 x 10^3 m^3				

4.7 Construction and Operation Schedules

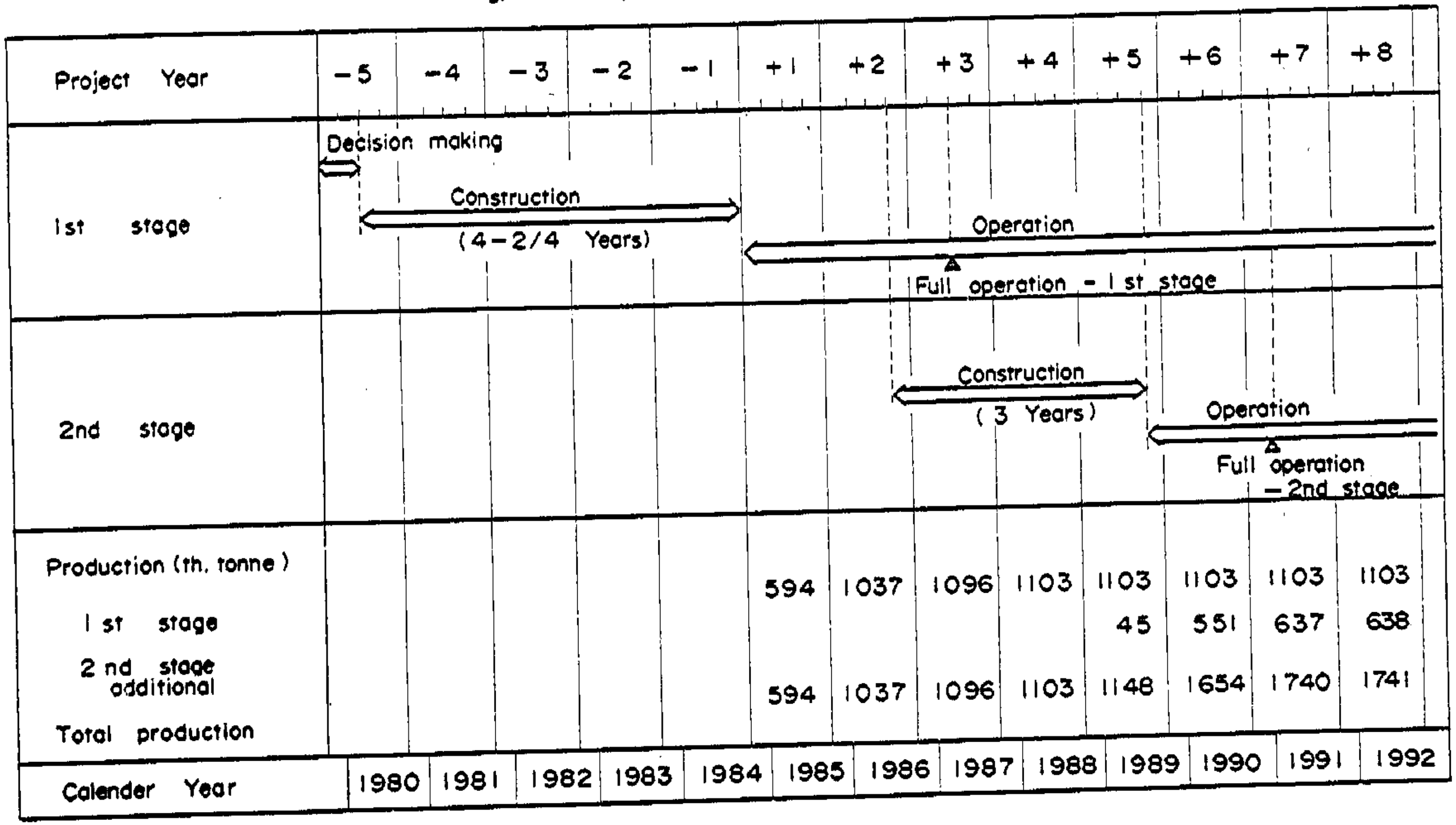
Construction schedule and start-up operation schedule are designed as shown in Fig. 4.7.1. Detailed implementation schedules will be described in the other chapter. Table 4.7.1 shows the main schedule of main items as orderly classified.

Table 4.7.1 Critical Periods for Construction and Operation

	Item	Period
1st stage	Construction period	54 months from commencement of construction
	Operation start-up	54th month from commencement of construction
	Full operation	30th month from operation start-up (or 84th month from commencement of consturction)
2nd stage	Commencement of construction	21st month from 1st stage operation start-up (or 75th month from commencement of 1st stage construction)
	Construction period	36 months from commencement of construction
	Operation start-up	36th month from commencement of 2nd stage construction (or 111th month from commencement of 1st stage construction)
	Full operation	18th month from operation start-up (or 129th month from commencement of 1st stage construction)

In respect of the commissioning which will be referred to in the item "Implementation Schedule", Fig. 4.7.1 also provides some explanation on it.

Fig. 4.7.1 Implementation Plan of Steel Project



4.8 Relationship between Production and Demand

A relationship between the production amount of the flat products in the new steel plant and its demand in Thailand, as provided that the production activities progresses based on the schedule so far described, is expected to be as shown in Fig. 4.8.1.

Although there is a difference between Table 4.2.2. "Production and Demand Schedule by Mills" given in paragraph 4.2 titled "Type of Products and the Outputs" and the figures given in Fig. 4.8.1, it is due to the fact that the former figures are theoretically planned while the latter figures have taken into consideration the operation rates in the gradual building up process after the commissioning.

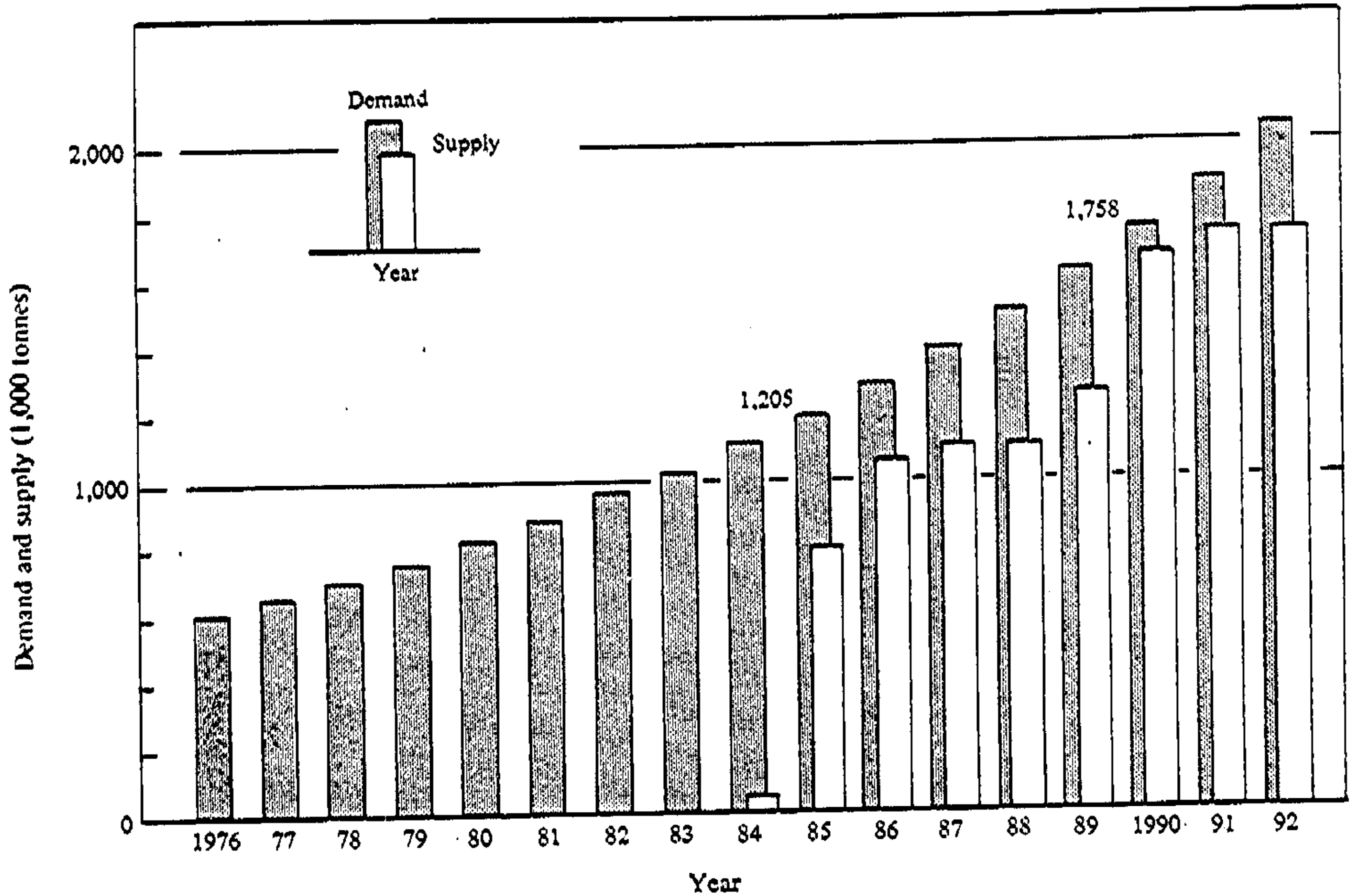


Fig. 4.8.1 Demand and Supply of Flat Rolled Products

CHAPTER 5

SITE SELECTION AND RELATED INFRASTRUCTURES

Chapter 5

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5.1 Basic Conditions for Site Selection

The following six basic conditions have to be satisfied when selecting a site for an integrated steel plant. It is because these conditions greatly affect the construction and operation cost of an integrated steel plant.

a. Proximity to a labour force supply area.

b. Fewer natural disasters and good meteorological, marine meteorological and subsoil conditions.

c. A vast area of land is needed. The site should have flat land, or a wide water basin with a shoaling beach which can be reclaimed. Further, the site should have access to land preparation materials.

d. The site should have port facilities permitting easy entry to and exit from a port of large and medium size ships for transport of main and auxiliary raw materials, equipment and materials, and products. Loading and unloading of these goods should be assured of smootheness. Alternatively, the site possesses a space suitable for building a new port which fulfills the foregoing requirements.

e. The site should be rich in water resources.

f. Traffic and communication means is adequately available to hinter-lands such as a market for products distribution, and material and equipment procurement.

In Japan, more than 90% of integrated steel plants have sought sites in seaside areas and have procured flat land by reclaiming to meet the foregoing six conditions.

The Royal Thai Government, on the other hand, is planning an socio-economic development programme, selecting a coast area between Chon Buri and Sattahip, south of Bangkok, as a site for an integrated steel plant that would satisfy the foregoing six conditions.

In undertaking the present study, a comparison and evaluation was made regarding three alternative locations, which are from north to south Laem Chabang, Sattahip A (Hat Yao) and Sattahip C (Ban Nam Tok) as proposed locations for the site.

Fig. 5.1.1 shows the geographical positions of these three alternative locations. The selection of the site will have a significant bearings on the master plans to be formulated and undertaken by the Royal Thai Government such as industrial development, regional development, and energy development and distribution programmes. These programmes must be studied in parallel in selecting the site.

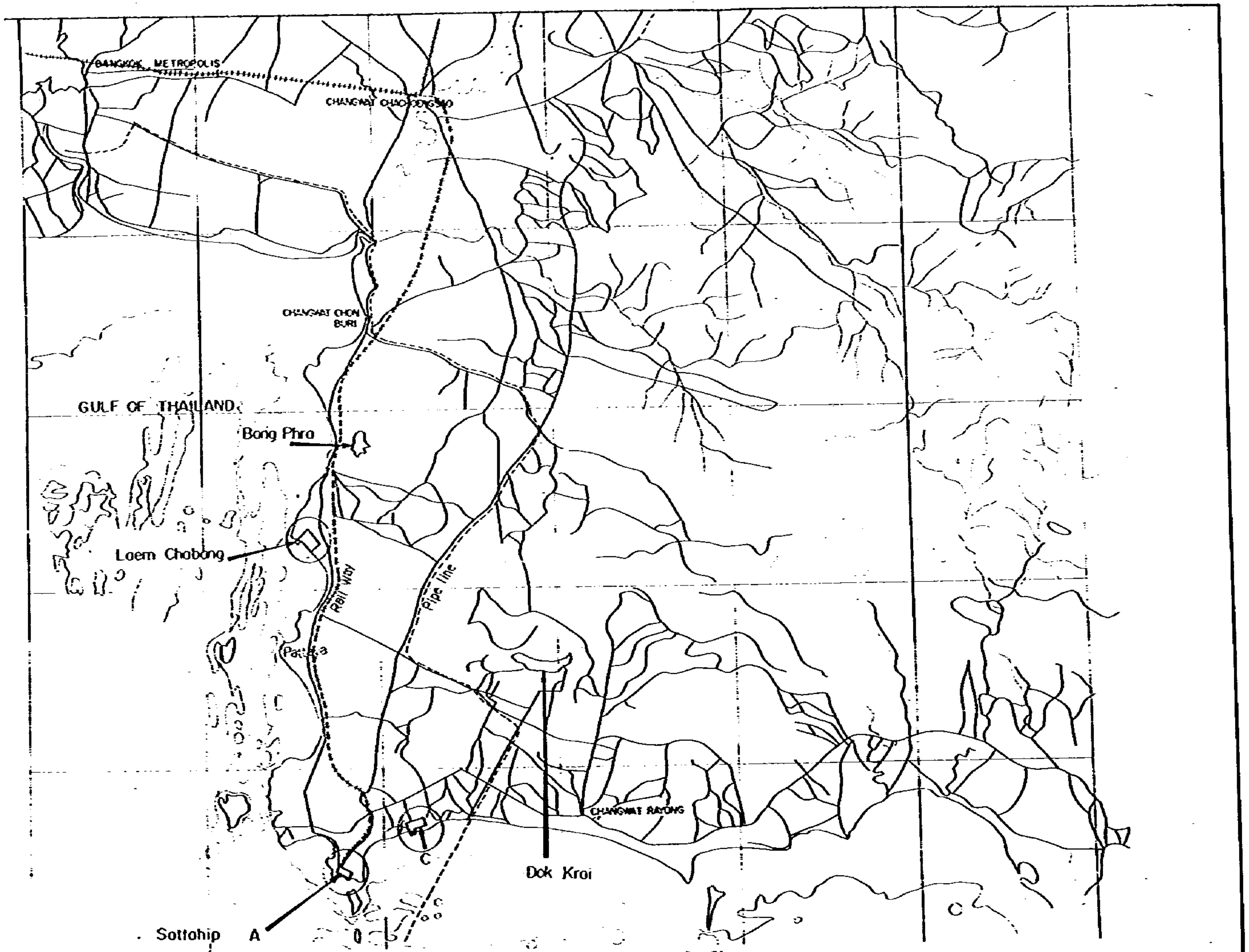


Fig. 5.1.1 General Location Map of 3 Alternative Sites

5.2 Natural Conditions at Three Proposed Sites

(1) Meteorology

Both Laem Chabang and Sattahip areas are situated on the coast of the Gulf of Thailand, so-called Eastern Seaboad Area, between lat. 12°30′ to 13°15′ N. and long. 100°45′ to 101°15′ E. in southeast of Thailand near Bangkok. Both areas belong to a tropical monsoon climate.

In both areas, light sea-land breezes blow throughout the year. The temperature on land is warmer than on sea in the day, and it is reversed during the night. Sea breezes start four hours after noon. Land breezes start in the evening and stop before the sun rises, peaking four hours after sunset. The foregoing phenomena intensify when the southwest monsoon season starts.

Tables 5.2.1 and 5.2.2 show typical values of meteorological data in 25 years between 1951 and 1975 in Laem Chabang (Koh Sichang) and Sattahip.

i. Temperature

The following was extracted from Tables 5.2.1 and 5.2.2, and the temperature difference in a day shows a variance of about 10°C.

	Laem Chabang	Sattahip
Annual Average (°C)	28.5	27.9
Past Maximum (°C)	36.9	40.5
Past Minimum (°C)	15.0	12.3

ii. Precipitation

Fig. 5.2.1 shows a probability distribution of precipitation for one year in Bangkok. The precipitation distribution in the diagram shows that the rainy season is between May and October.

Table 5.2.1 Climatological Data for the Period 1951–1975, Laem Chabang

Station: Laem Chabang (KOH SICHANG)
Index Station: 48 460
Latitude: 13° 10' N
Longitude: 100° 48' E

Elevation of station above MSL. 24.90 meters
Height of barometer above MSL. 26.09 meters
Height of thermometer above ground 1.20 meters
Height of wind vane above ground 20.00 meters
Height of raingauge 0.80 meters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Pressure (+ 1000 or 900 mbs)													
Mean	12.54	11.43	10.42	09.02	07.23	06.78	06.77	06.82	07.63	09.72	11.37	12.23	09.59
Ext. MAX.	22.25	20.21	17.94	17.05	13.58	12.99	13.05	13.73	13.94	16.50	18.98	20.65	22.25
Ext. Min.	05.56	05.00	03.42	01.89	99.68	98.19	98.60	00.51	98.79	01.95	04.62	04.34	98.19
Mean daily range	4.23	4.33	4.41	4.37	4.00	3.35	3.13	3.42	4.00	4.21	4.10	4.12	3.97
Temperature (°C)													
Mean	26.7	28.0	29.1	30.3	29.9	29.6	29.1	29.0	28.3	27.7	27.4	26.7	28.5
Mean Max.	29.6	30.7	31.7	33.0	32.3	31.9	31.3	31.3	30.7	30.3	30.1	29.7	31.0
Mean Min.	22.3	24.5	25.7	26.9	26.6	26.7	26.2	25.9	25.1	24.5	23.8	22.6	25.0
Ext. Max.	33.6	34.4	35.8	36.9	36.2	35.4	34.5	33.7	34.8	33.0	33.0	33.2	36.9
Ext. Min.	15.2	18.4	20.0	21.2	22.5	23.8	21.6	21.9	21.8	19.8	15.5	15.0	15.0
Relative Humidity (%)													
Mean	65.0	71.0	72.0	71.0	74.0	73.0	74.0	74.0	78.0	73.0	71.0	65.0	72.0
Mean Max.	78.8	84.1	84.2	82.7	83.7	80.6	82.1	81.1	87.4	83.1	81.3	76.9	82.8
Mean Min.	55.8	60.7	63.0	61.7	65.8	65.3	66.6	66.6	69.9	70.2	62.9	55.9	63.7
Ext. Min.	29.0	31.0	31.0	33.0	43.0	52.0	54.0	51.0	43.0	43.0	34.0	29.0	29.0
Dew Point (°C)													
Mean	19.3	21.9	23.3	23.8	24.6	24.1	23.9	24.0	24.0	23.6	21.4	19.4	22.8
Evaporation (mm)													
Mean-Piche						No Observation							
-Pan													
Cloudiness (0-8)													
Mean	3.5	3.5	3.6	4.3	5.9	6.4	6.6	6.8	6.6	5.8	4.4	3.6	5.1
Visibility (Km)													
0700 L.S.T.	7.9	7.3	7.7	9.1	10.3	10.7	10.3	10.4	10.0	9.2	9.3	8.8	9.3
Mean	9.5	9.1	9.5	10.8	11.8	12.2	11.8	11.9	11.6	10.9	11.1	10.6	10.9
Wind (Knots)													
Prevailing wind	W	W	SW	SW	SW	W	W	W	W	NE	NE	NE	-
Mean Wind Speed	7.9	7.5	7.5	7.5	7.4	8.2	7.9	7.6	6.3	6.4	8.5	8.6	-
Max. Wind Speed	30 NE	27 NE	33 N/NW	35 SW	35 SW/NE	45 W	50 W	50 W	43 W	30 E	28 NNE	32 E	-
Rainfall (mm)													
Mean	6.0	24.7	37.5	35.6	193.1	89.7	104.1	124.5	284.1	259.9	55.6	14.5	1229.3
Mean rainy days	1.2	3.0	3.5	5.1	14.2	11.4	14.3	15.1	18.6	16.5	6.4	2.2	111.5
Greatest in 24 hr	25.8	52.1	63.5	57.2	101.5	33.3	93.5	68.5	158.6	135.3	122.7	71.7	196.3
Day/Year	19/75	24/63	18/74	26/61	25/64	2/66	4/60	23/64	18/65	9/74	30/70	1/70	9/74
Number of days with													
Haze	20.6	16.1	15.1	12.2	1.4	0.6	0.4	0.4	0.4	2.5	8.9	15.8	94.4
Fog	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	1.2	4.3	8.3	15.7	17.6	8.4	8.4	8.7	15.5	16.4	6.1	1.1	122.2
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Remark: Date for 1958-1975

Table 5.2.2 Climatological Data for the Period 1951–1975, Sattahip

Station SATTAHIP
Index Station 48 477
Latitude 12° 41' N
Longitude 100° 59' E

Elevation of station above MSL. 16.00 meters
Height of barometer above MSL. 18.00 meters
Height of thermometer above ground 1.35 meters
Height of wind vane above ground 12.00 meters
Height of raingauge 0.73 meters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pressure (+ 1000 or 900 mbs)													
Mean	12.81	11.79	10.93	09.59	07.93	07.66	07.74	07.89	08.49	10.20	11.59	12.59	09.93
Ext. Max	21.37	20.27	18.04	17.97	14.62	13.84	13.64	13.77	14.63	16.84	18.67	20.27	21.37
Ext. Min.	06.17	05.47	04.68	02.02	01.54	00.27	00.93	00.76	00.67	99.64	96.52	05.69	96.52
Mean daily range	3.74	3.83	3.93	3.95	3.66	3.09	2.99	3.22	3.84	3.99	3.74	3.71	3.63
Temperature (°C)													
Mean	26.7	27.9	28.9	29.7	29.2	28.9	28.4	28.4	27.9	27.1	26.5	26.1	27.9
Mean Max.	33.2	33.6	34.1	34.6	33.3	32.7	32.4	32.5	32.2	31.9	32.2	32.4	32.9
Mean Min.	22.1	24.2	25.6	26.5	26.2	26.4	25.7	25.6	25.0	24.0	22.6	21.6	24.6
Ext. Max.	33.0	39.4	39.5	40.5	40.5	37.2	37.8	37.2	37.4	36.2	37.4	33.3	40.5
Ext. Min.	12.3	16.8	18.7	21.0	21.5	20.9	19.0	21.5	19.0	19.5	15.0	12.8	12.3
Relative Humidity (%)													
Mean	70.0	75.0	76.0	77.0	79.0	76.0	77.0	77.0	81.0	83.0	75.0	70.0	76.9
Mean Max.	84.2	88.2	87.6	87.3	88.8	86.0	87.4	97.6	90.7	93.3	83.0	84.7	87.9
Mean Min.	51.2	57.0	59.9	61.1	66.6	65.5	74.2	65.9	69.3	69.1	60.7	53.0	61.9
Ext. Min.	25.0	17.0	29.0	33.0	43.0	43.0	47.0	49.0	45.0	38.0	28.0	21.0	17.9
Dew Point (°C)													
Mean	20.2	22.7	24.0	24.9	24.9	24.3	24.0	23.9	24.2	23.8	21.9	20.0	23.2
Evaporation (mm)													
Mean-Piché	98.0	75.9	84.2	83.6	73.1	73.4	77.7	76.6	59.9	47.2	73.9	97.1	926.6
-Pan						No Observation							
Cloudiness (0-8)													
Mean	3.9	4.1	4.3	4.9	6.4	6.5	6.8	6.9	6.9	6.0	4.8	3.7	5.4
Visibility (Km)													
0700 L.S.T.	7.8	7.8	8.1	9.6	10.6	11.2	10.9	10.8	10.6	9.3	9.3	9.3	9.7
Mean	8.6	8.3	8.6	10.0	11.0	11.4	11.1	11.3	11.0	10.4	10.4	9.9	10.2
Wind (Knots)													
Prevailing wind	N	S	S	S	S.SW	SW	SW	WSW	WSW	E	N	N	-
Mean Wind Speed	6.0	6.8	7.4	7.2	7.2	9.8	9.4	9.1	7.4	5.8	6.8	7.1	-
Max. Wind Speed	35 N	36 SE	48 SE	46ESE	57 NW	55[illegible]	52 W	52 W	49[illegible]	53 W	73[illegible]	40 N	-
Rainfall (mm)													
Mean	28.4	56.8	65.2	90.9	205.5	76.4	95.8	93.7	226.1	288.4	93.7	17.1	1351.0
Mean rainy days	2.7	4.7	5.0	7.8	13.8	10.9	13.8	13.5	16.6	17.5	8.8	2.0	117.1
Greatest in 24 hr	53.2	117.6	116.1	103.7	170.0	62.8	155.0	69.7	107.7	302.7	319.6	87.0	319.6
Day/Year	26/73	27/69	22/70	28/71	4/71	17/71	22.51	25/69	25/63	22/53	30/70	1/70	30/70
Number of days with													
Haze	20.6	15.6	16.1	8.6	0.9	1.0	1.8	2.2	1.1	4.3	8.8	16.1	97.1
Fog	5.8	4.9	3.4	2.0	0.5	0.8	0.7	0.6	0.7	1.3	1.9	3.4	26.0
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Thunderstorm	0.7	1.4	3.5	7.7	10.3	3.8	3.9	3.7	8.3	10.2	4.8	1.0	59.3
Squall	0.0	0.1	0.2	0.4	0.2	0.4	0.4	0.2	0.2	0.1	0.1	0.0	2.3

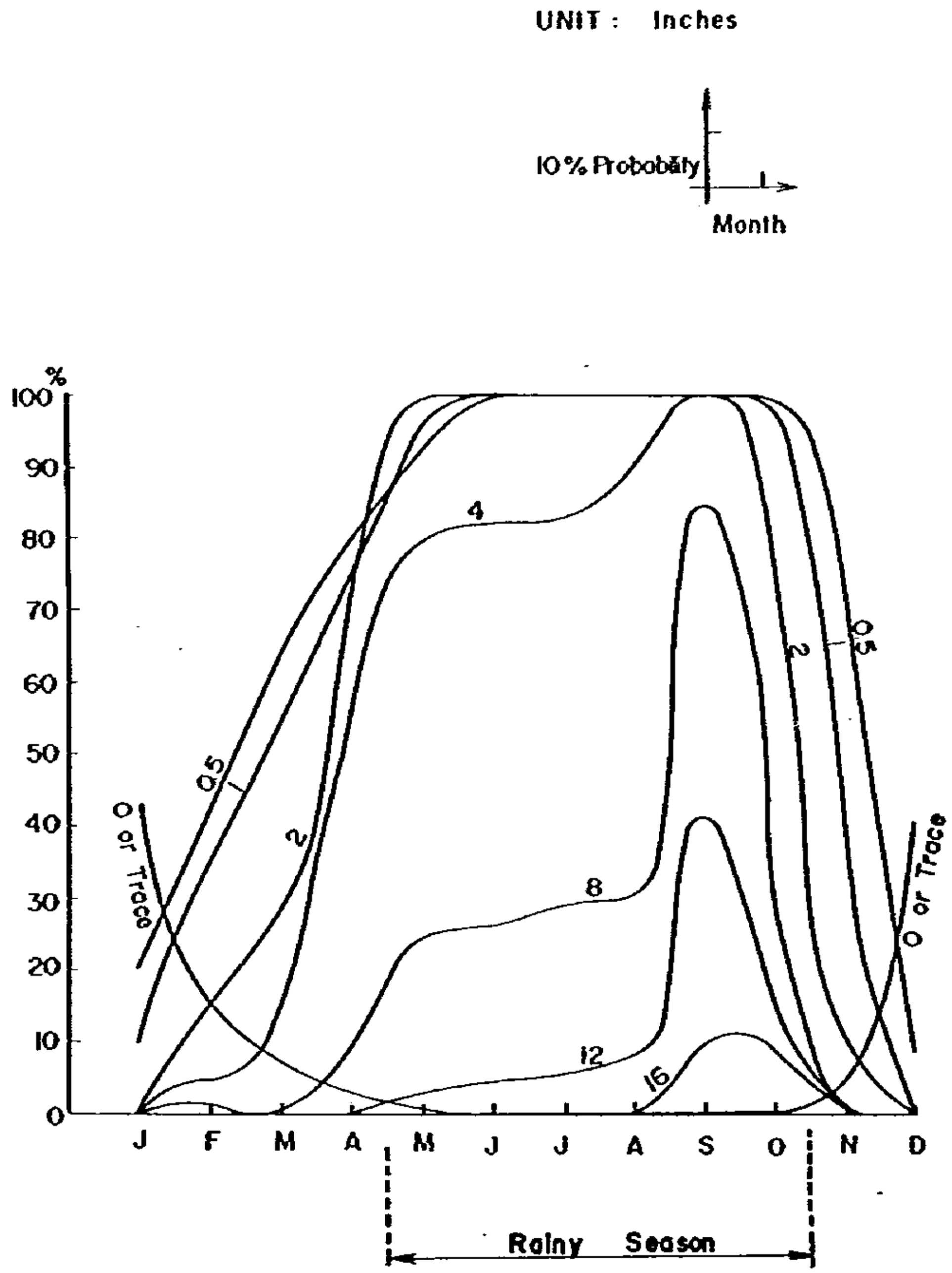


Fig. 5.2.1 Probability Distribution of Precipitation in Bangkok

The annual precipitation in Laem Chabang is 1,229.3 mm and in Sttahip, 1,351.0 mm. The maximum precipitation per day (24 hours) was recorded on October 9, 1974 when 196.3 mm of rain fall in Laem Chabang, and 319.6 mm on November 30, 1970 in Sattahip. Squalls hit the areas for 1 to 2 hours a day during the rainy season. According to records in Bangkok, the following maximum precipitation intensities were observed.

In 30 minutes	72.0 mm	April 22, 1951
In 1 hour	108.0 mm	April 22, 1951
In 2 hours	131.0 mm	April 23, 1939
In 3 hours	135.0 mm	April 23, 1939
In 6 hours	135.0 mm	April 23, 1939
In 12 hours	145.2 mm	April 26, 1950
In 24 hours	152.5 mm	April 23, 1939

This observation indicates that precipitation during the rainy season concentrates in 1 to 2 hours.

iii. Wind

Tables 5.2.1 and 5.2.2 show wind direction and frequencies by wind velocity in 25 years between 1951 and 1975. Figs. 5.2.2 and 5.2.3 show wind rose.

W, SW and NE winds prevail in the Laem Chabang area, and winds at a speed 6 to 9 knots (3 to 5 m/sec.) blow regularly. The maximum wind velocity in the past is 50 knots (26 m/sec.).

SW, S and N winds prevail in the Sattahip area, on the other hand, and winds regularly blow at a speed of 5 to 10 knots (3 to 5 m/sec.). The maximum wind recorded is 73 knots (38 m/sec.).

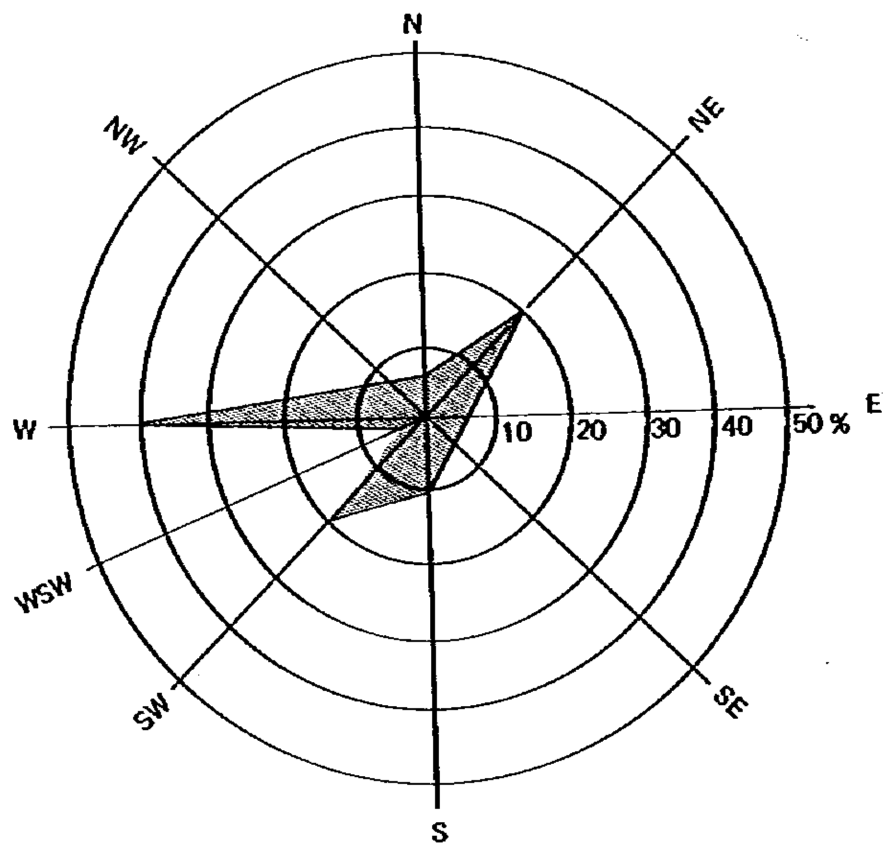


Fig. 5.2.2 Wind Rose (Laem Chabang)

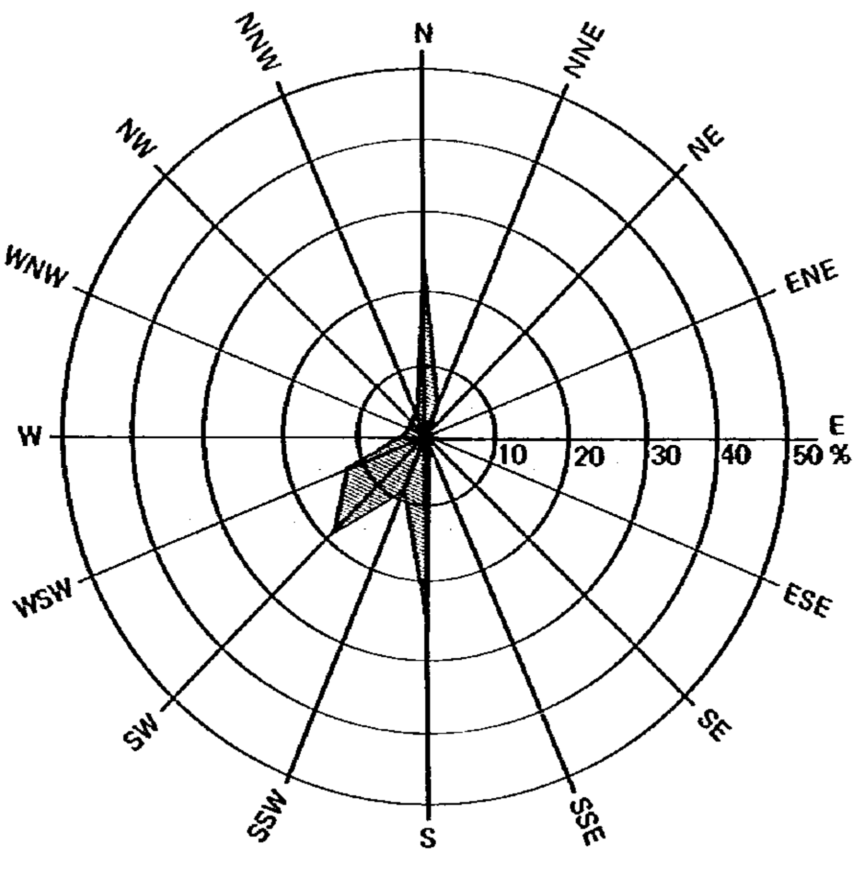


Fig. 5.2.3 Wind Rose (Sattahip)

(2) Marine Meteorology

i. Tide

Figs. 5.2.4 and 5.2.5 relate to tides in the Laem Chabang and Sattahip areas. The tide ranges in Laem Chabang and Sattahip are 4.25 m and 3.40 m, respectively.

ii. Tidal Current

Tidal currents measured off Laem Chabang and Sattahip were 0.25 to 0.35 and 0.25 to 0.50 knots, which are relatively slow. Tidal currents about 1.4 knots (0.7 m/sec.) are considered maximum. Wind driven currents are very small from a topographical standpoint.

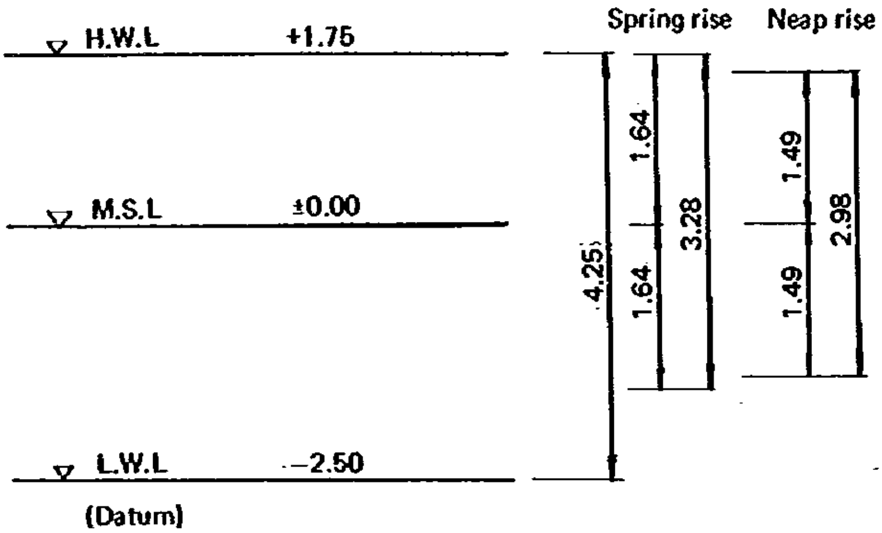
iii. Wave

Fig. 5.2.6 is the observation data of wave heights in the Laem Chabang and Sattahip areas. Maximum wave heights of 1.0 and 1.9 m have been observed in Laem Chabang and Sattahip, respectively. Considering effects by waves, Laem Chabang is attractive as this area is not directly facing an ocean and is free from swells.

(3) Special Natural Conditions

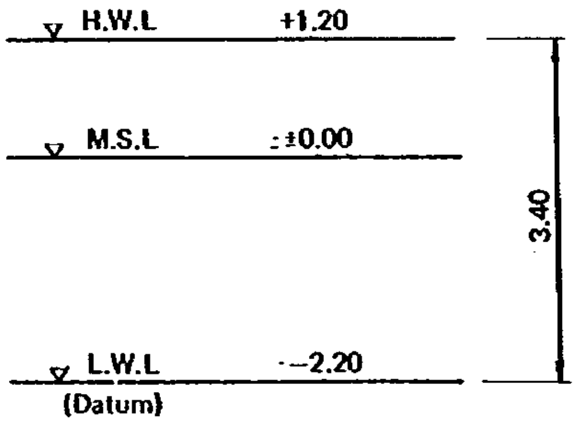
Topography and subsoil conditions will be taken up in 5.3, and no discussion will be made here regarding these subjects. There are neither earthquakes nor high waves.

Typhoons occasionally pass through the northern part of Thailand.



(Unit: m)

Fig. 5.2.4 Tidal Range (Laem Chabang)



(Unit: m)

Fig. 5.2.5 Tidal Range (Sattahip)

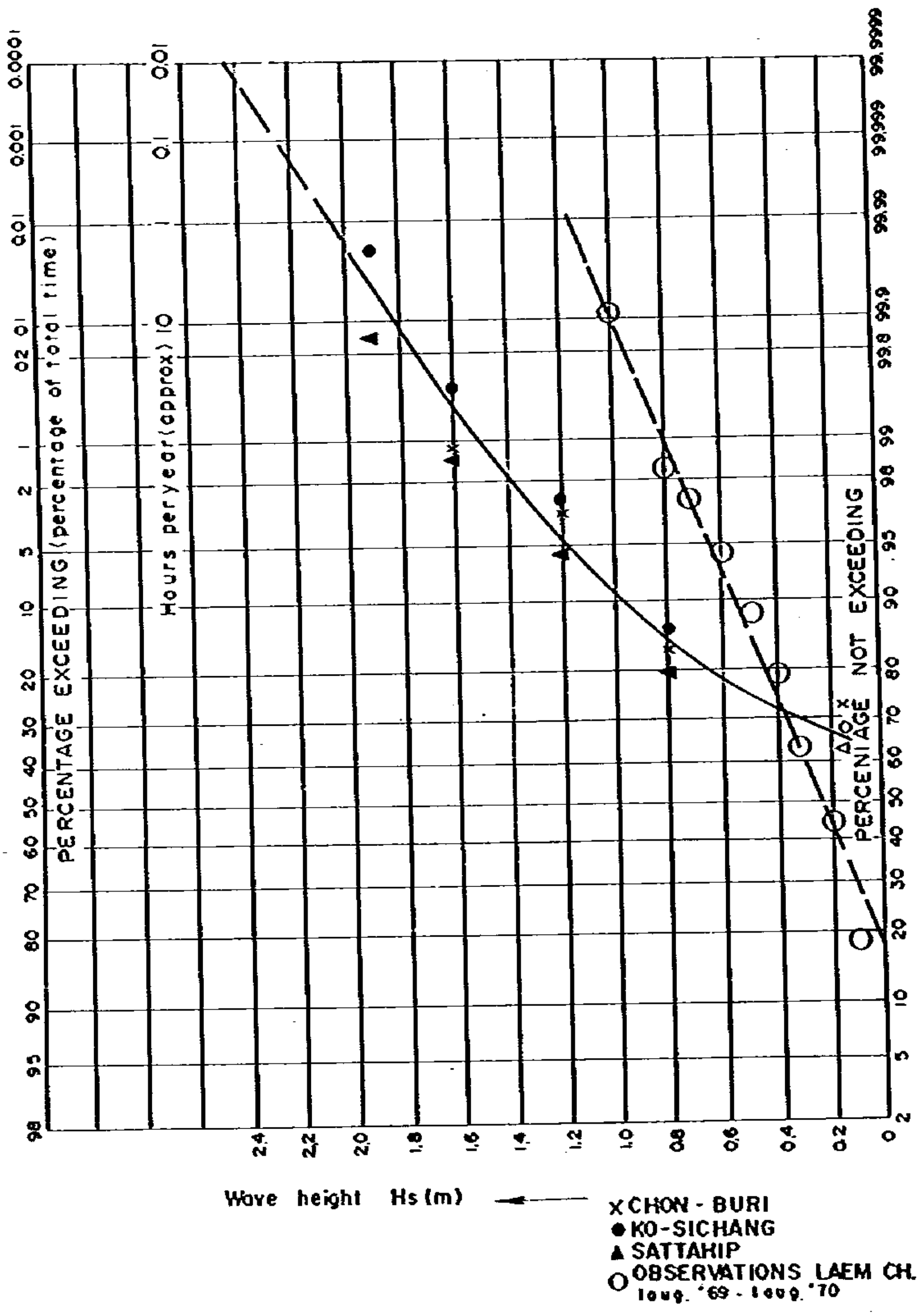


Fig. 5.2.6 Wave Heights and Frequencies in Laem Chabang (after NEDECO)

5.3 Comparison of Three Proposed Sites

In the present study, the following annual production capacities of molten steel are considered for hot and cold rolled flat products.

1st stage (1985)	1.3 million tonnes/year
2nd stage (1990)	2.0 million tonnes/year

The study takes into consideration a room for additional production of non-flat products in the future. In other works, a comparative study was made on the three proposed sites based on the integrated steel plant with a production scale of 2.6 million tonnes a year.

(1) Land, Topography and Subsoil

As stated in 5.1, the construction of the integrated steel plant requires a vast area of land. Fig. 5.3.1 studies required land space differentiated on annual production scales.

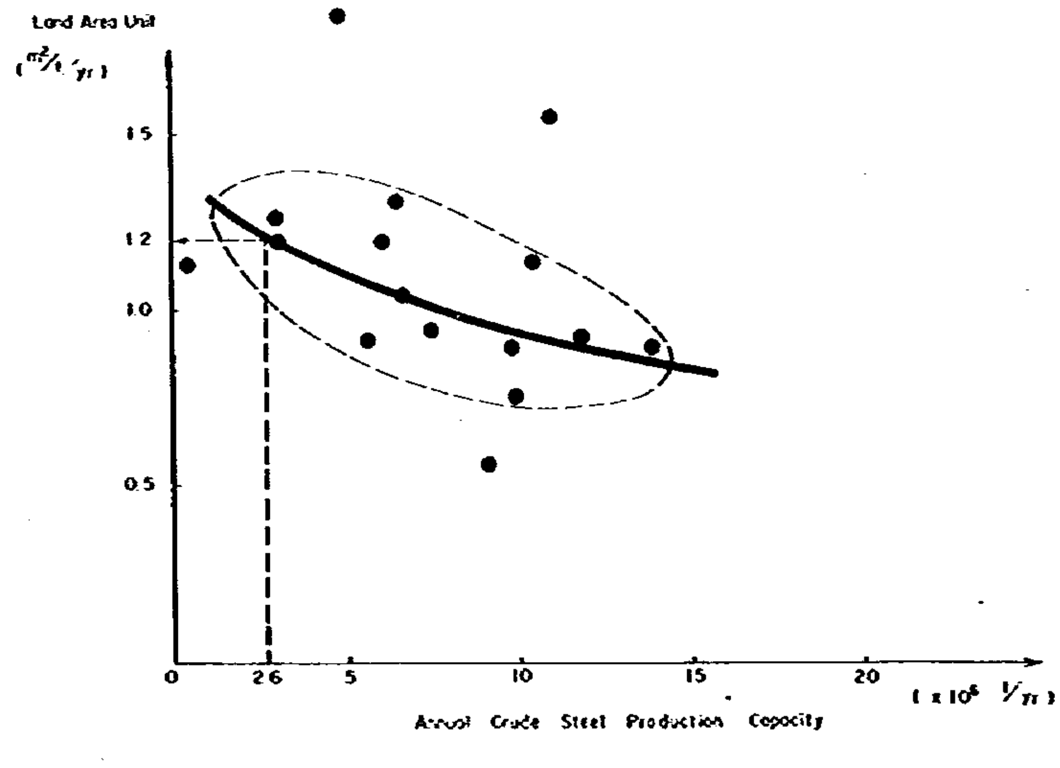


Fig. 5.3.1 Production Capacity and Required Unit Land Space Relationship

In general,

a. The smaller the annual production scale, the higher is the unit land space.

b. In the BF/BOF method, the larger the annual production scale the smaller the unit land space required. (an apparent scale merit). The DR/EAF method lacks a scale merit of this nature.

c. The unit land space will be higher, the higher the processing degree of a plant (e.g., a manufacturing plant for hot and cold rolled products).

Considering that the DR/EAF method will be employed this time, a unit land space of 1.20 has been used. This means that land area of

$$2,600 \times 10^3 \text{ tonnes/year} \times 1.20 = 3,120 \times 10^3 \text{ m}^2$$

will be required as a minimum requirement.

This land area includes land for roads, a railway, environment conservation facilities, offices and others, which directly relate to production. However, land for schools, hospital and other welfare, sports, or recreation facilities is not included. Therefore, a desirable area of land for a full-fledged integrated steel plant will be 3.5 million to 4 million m^2 (350 to 400 ha).

Both Laem Chabang and Sattahip C (Ban Nam Tok) sites are flat in topography and are wide enough to provide land for an area of 350 to 400 ha. Fig. 5.3.2 is an example of a plot plan for the integrated steel plant with an annual production capacity of 2.6 million tonnes/year for both sites. The land area will be 4,175,000 m^2 (417.5 ha, 2,600 Rai), and Fig. 5.3.3 is generated by matching to the topography and water front of Laem Chabang. It is clear that Laem Chabang area offers an advantage of being able to layout by meeting to the master plan of constructing a deep-sea port near a deep sea. Out of the required land area of 4,175,000 m^2, land equivalent to about 1,060,000 m^2 (25.4%) will be prepared by reclaiming a water front.

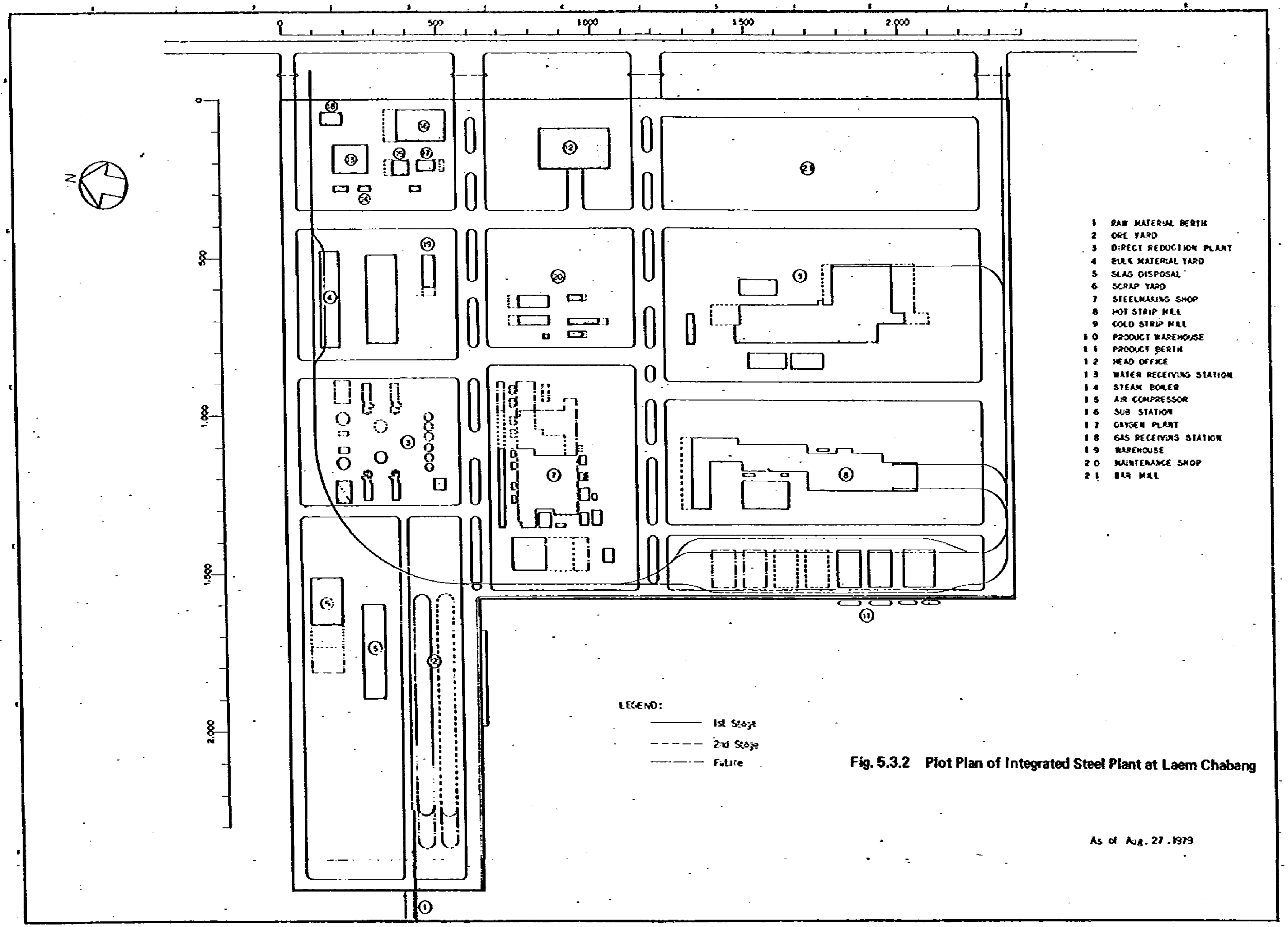


Fig. 5.3.2 Plot Plan of Integrated Steel Plant at Laem Chabang

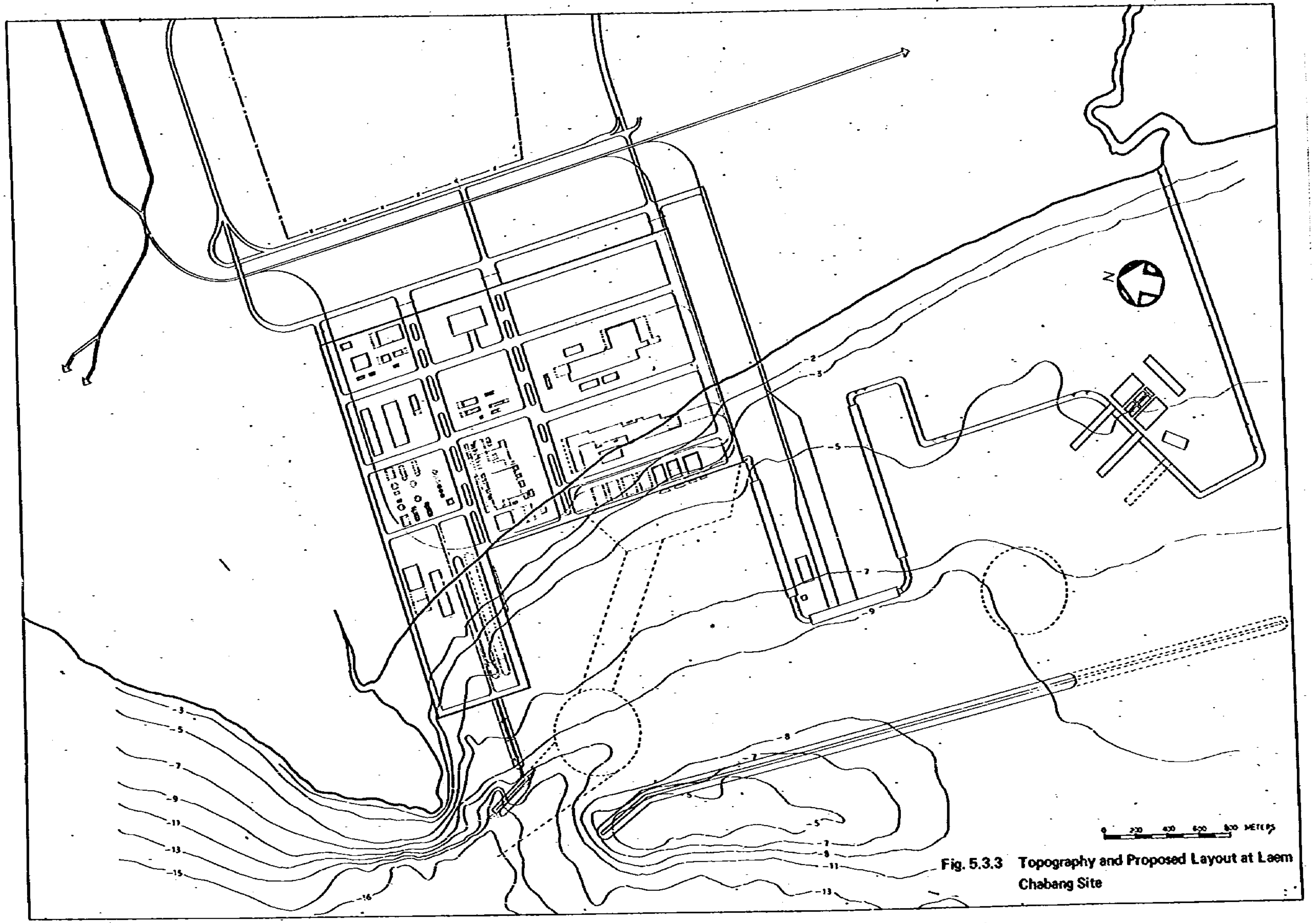


Fig. 5.3.3 Topography and Proposed Layout at Laem Chabang Site

However, this site, too, will face the problem of moving and compensating for existing schools and temples and the necessity of deviating the Huai Yai River.

Fig. 5.3.4 derives when making a plot plan for the integrated steel plant with an annual production capacity of 2.6 million tonnes/year at the Sattahip C site. A huge amount of money will be needed for constructing port facilities and dredging berths and long sea channels for ships, and a number of difficult problems as such are anticipated.

The Sattahip A (Hat Yao) site will be discussed next. The north and west sides of the site are surrounded by small mountains and hills 72 to 169 m high, and its south side is a coastline. The site has land of about 2 million m^2 in area. If a minimum 3.12 million m^2 land area is required, reclamation of

$$3{,}120 \times 10^3 - 2{,}000 \times 10^3 = 1{,}120 \times 10^3 \text{ m}^2$$

will be required. Figs. 5.3.5 and 5.3.6 are a plot plan and layout matching to the topography for the integrated steel plant with an annual production capacity of 2.6 million tonnes/year at the Sattahip A site. The land area is 3,149,000 m^2, and part of hills on the north, west and east sides will have to be graded. The land is topographically narrow, and it will be difficult to secure land for welfare, sports and recreation facilities and for steel related industries. Examining the layout, the land for a non-flat product plant to be built in the future has to be obtained by reclaiming the sea. Of the 3,149,000 m^2 land required, 1,160,000 m^2 (36.8%) will have to be reclaimed.. A future problem with this site is that it will be a little narrow for the integrated steel plant.

The next question is acquisition of land. The Laem Chabang site is located in the Export Processing Zone inside the Eastern Industrial Estate Project at Laem Chabang undertaken by the Royal Thai Government. A number of incentives are expected to be given. The requisition of land is also being pushed by the Royal Thai Government.

The Sattahip site A is inside a military district, so-called Naval Zone, used by the Royal Thai Navy as a drill field. The Ministry of Communications (MOC) is pushing commercialization of the present Sattahip port. However, the transformation of military land into industrial land would involve a number of difficulties and restrictions in legal procedures.

There are no definite industrial development programmes made by the Government agencies at present for the Sattahip C site, and the area remains in a clean slate state.

The question of subsoil will be taken up at the end. There is almost no data regarding subsoil, and it will be necessary to do detailed boring and soil investigations in the basic engineering stage. A recommendation will be submitted separately on this item, and the discussion in this report will be confined to an assessment made based on the existing ambient data.

Fig. 5.3.7 relates to data of boring near the coastline of Laem Chabang performed by NEDECO in 1969.

There is a loose sand layer down to about 10 m from the ground level, underneath which another firm sand layer exists for a thickness of 15 to 20 m. Granite forms underneath these two sand layers. The soil engineering property of the loose sand surface layer for 10 m leaves questions that require a further detailed study. However, in general, the site has good subsoil to construct a steel plant on it.

No boring data is available for the Sattahip site, and the only data available is by an observation. It is estimated that the surface layer is almost an arenaceous soil layer. However, the topography is complex, and as reefs are exposing on the coastline, rocks may possibly appear in a relatively shallow place underground. A detailed boring and soil investigations will be imperative.

Fig. 5.3.4 Topography and Proposed Layout at Sattahip C Site (BAN NAM TOK)

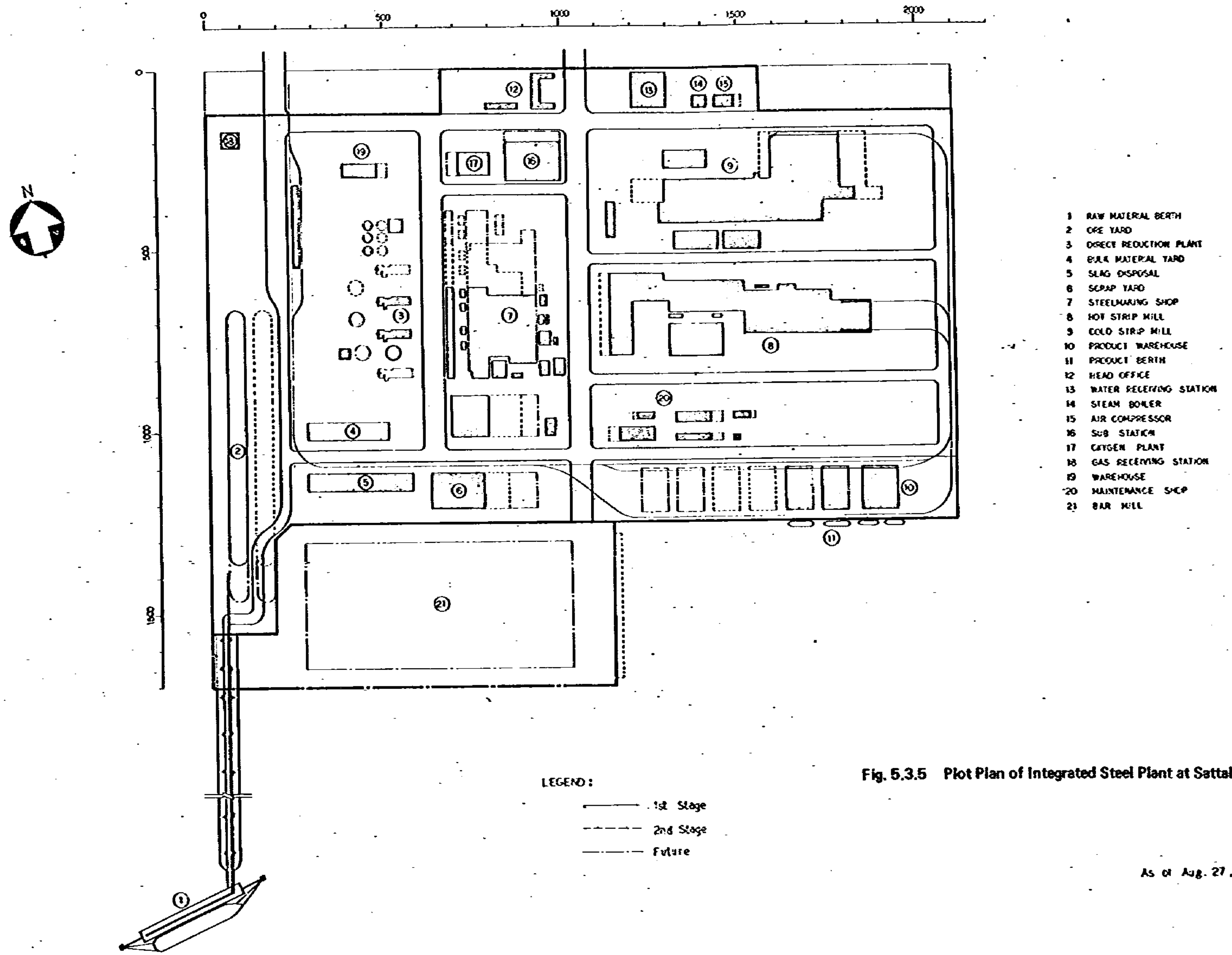


Fig. 5.3.5 Plot Plan of Integrated Steel Plant at Sattahip A

As of Aug. 27, 1979

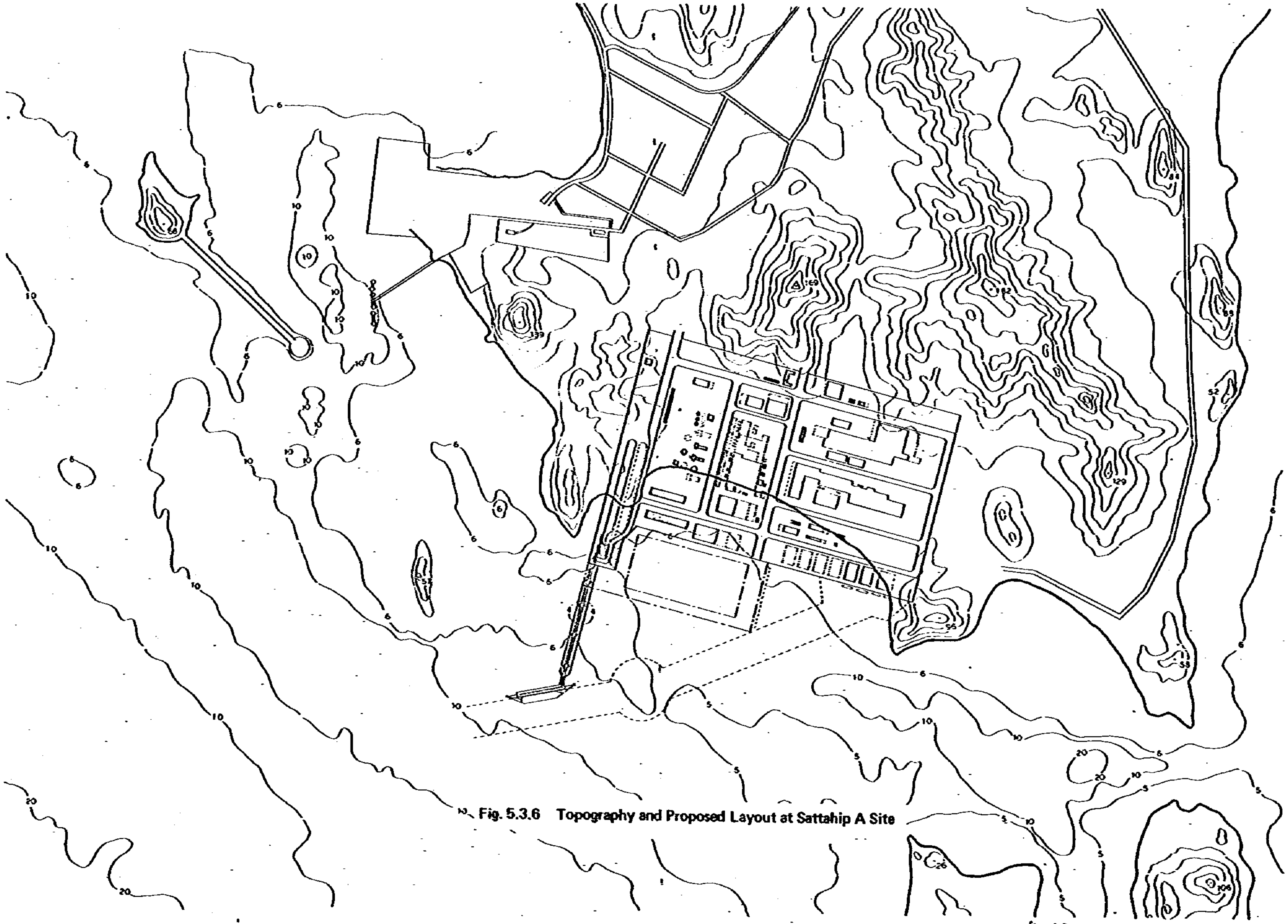


Fig. 5.3.6 Topography and Proposed Layout at Sattahip A Site

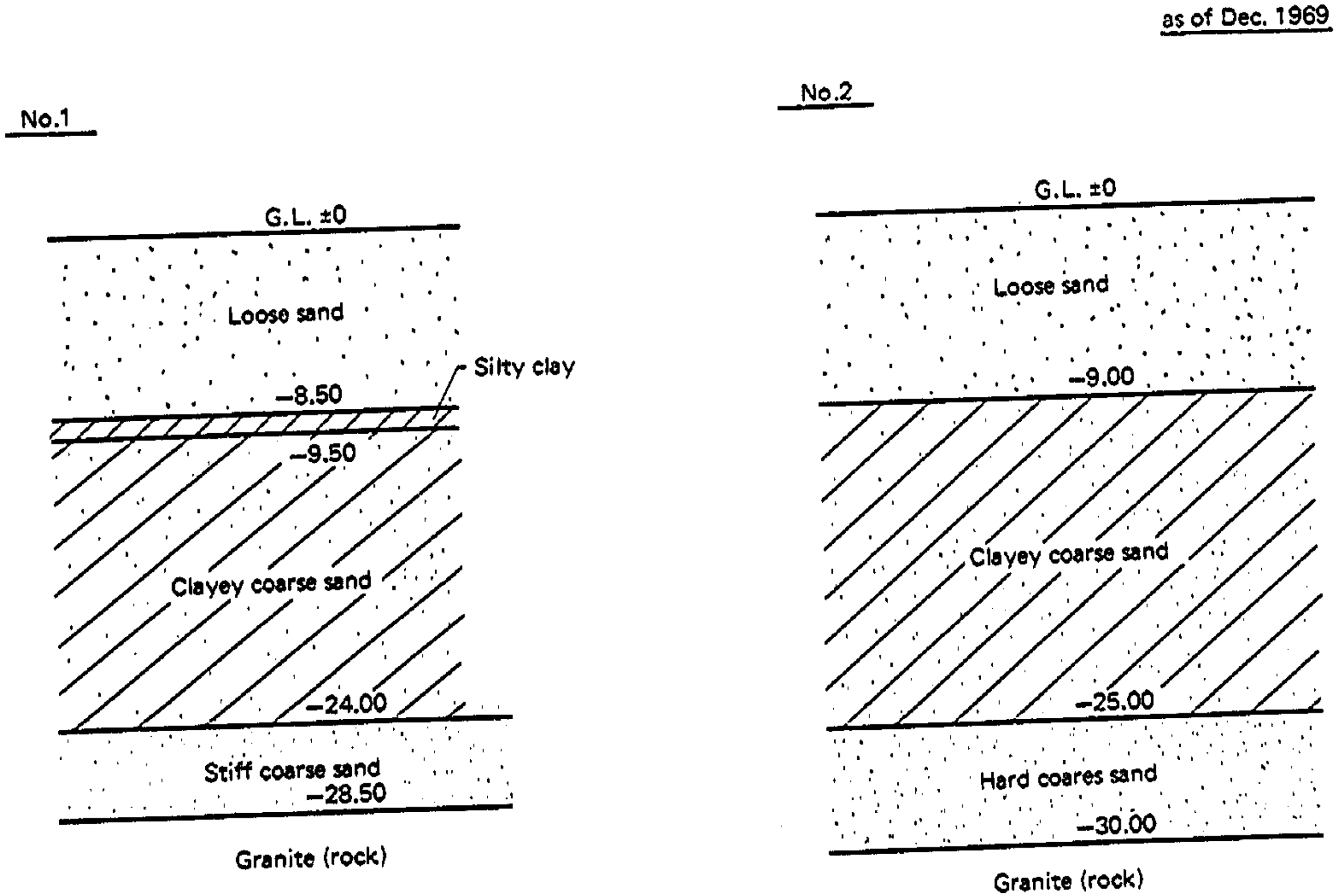


Fig. 5.3.7 Soil Profile at Laem Chabang (after NEDECO)

(2) Port

i. Laem Chabang Site

Engineering of the deep sea port programme in Laem Chabang dates back to December, 1972 when NEDECO submitted a four-part report on the engineering work done by it to the Royal Thai Government. It is believed that this programme is still being studied after experiencing various changes. At this point in time, Figs. 5.3.8 and 5.3.9 are representative examples as port development plans. It will be important for the Laem Chabang site to be included in these deep sea port programmes undertaken by MOC, when a plan to construct the integrated steel plant in the Laem Chabang site is considered. Fig. 5.3.3 is one layout example for the integrated steel plant matching to these deep sea port programmes. From a port engineering point of view, the advantages of Fig. 5.3.3 are:

a. A deep sea area is available in the shortest distance, and it will be convenient for large vessels to come in and go out.
b. Marine meteorological conditions are relatively good.
c. The sea-bottom soil is believed to be sandy, and it will be easy to construct quays and to dredge basin for small and medium ships.
d. Port facilities necessary for the integrated steel plant can be designed without drastically modifying the present deep sea port programmes.

On the other hand, as disadvantages, the following items can be considered:

e. It will not be easy to coincide the timing with the implementation of the deep sea port programmes. The construction of port facilities for

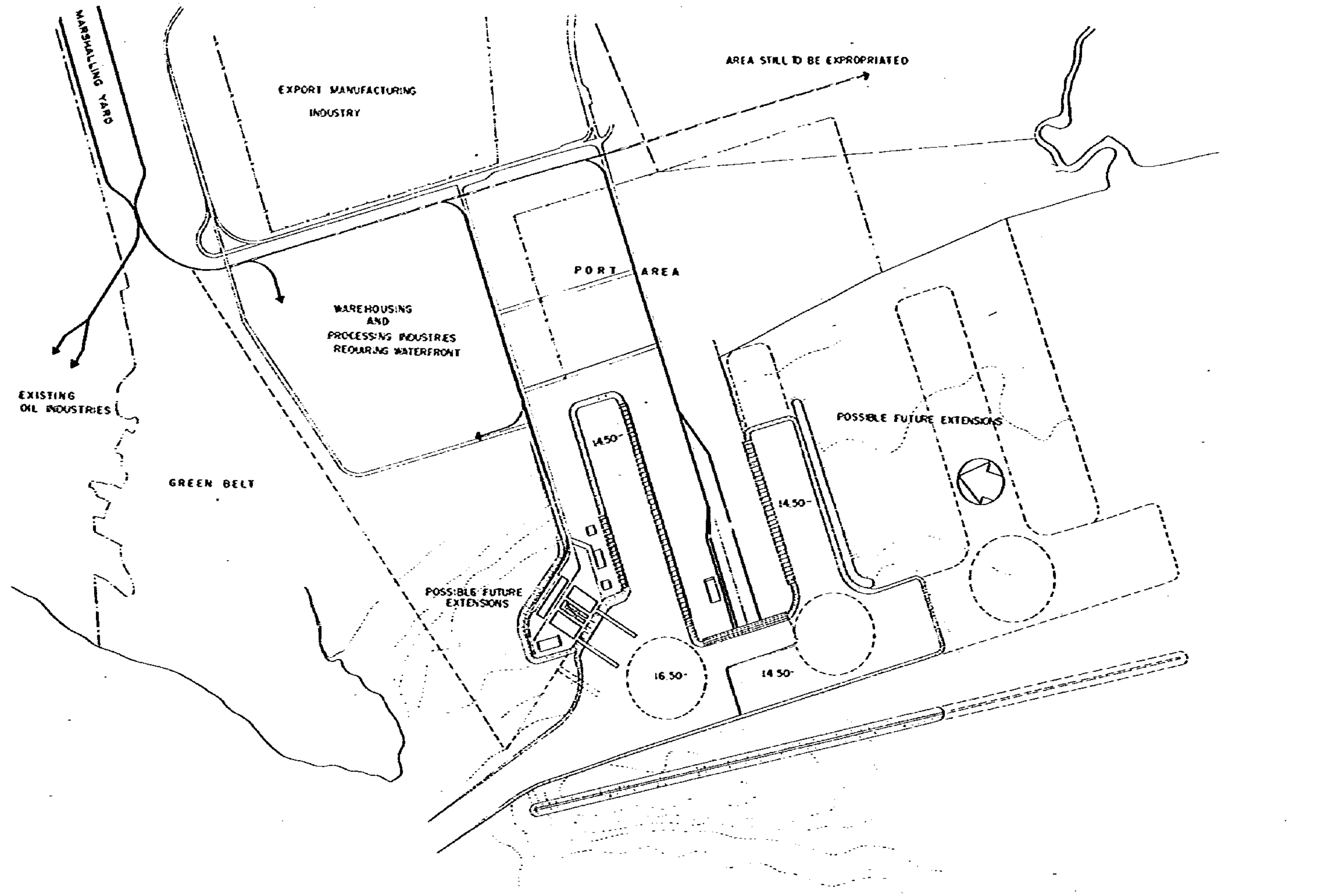


Fig. 5.3.8 Deep Sea Port of Laem Chabang (After NEDECO)

(Layout 2000)

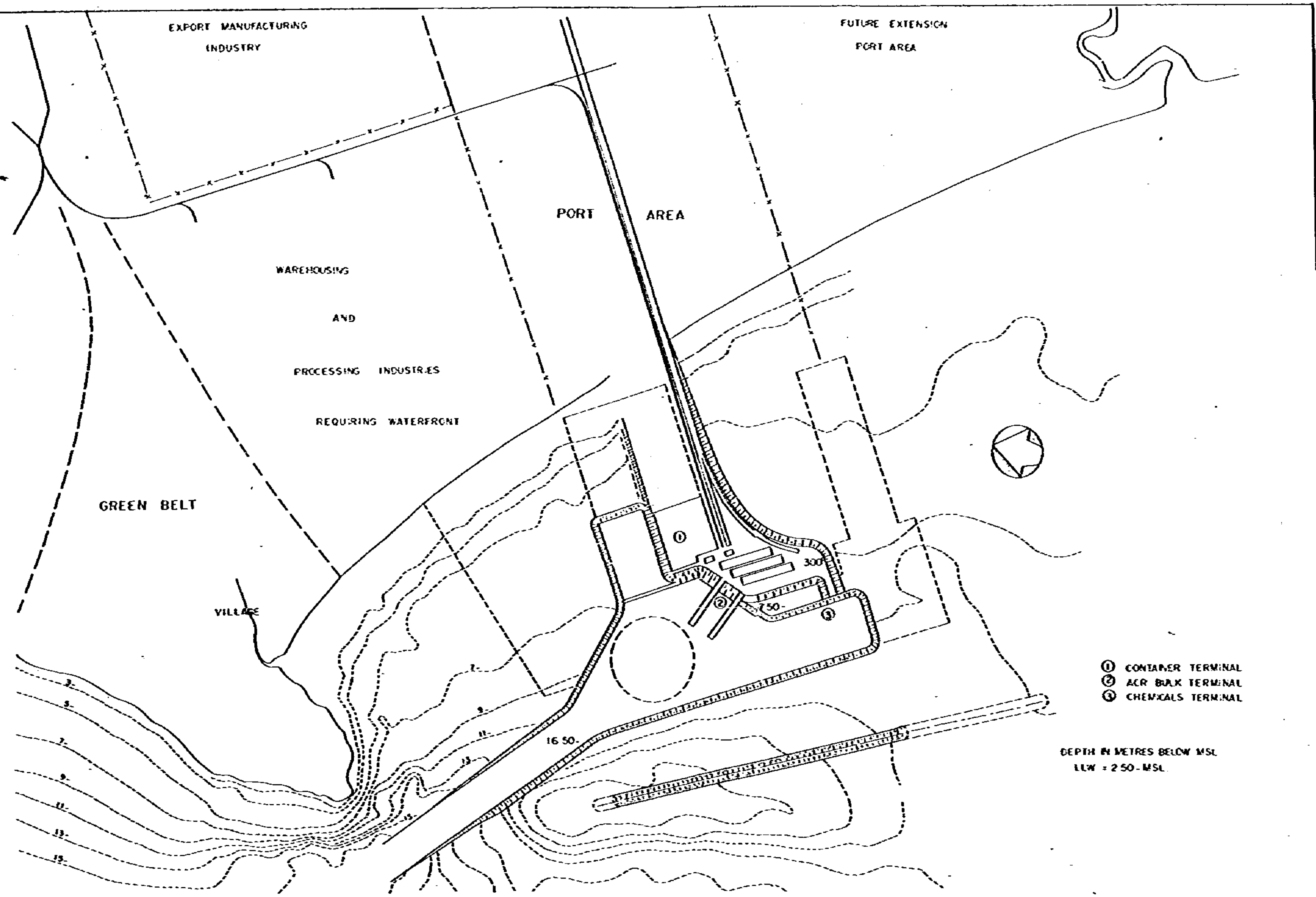


Fig. 5.3.9 Deep Sea Port of Laem Chabang (After NEDECO)

the integrated steel plant will be required sooner.

f. The site lacks in currently available port facilities near it, and a quay for unloading of construction materials and equipment and imported machinery will be required. A quay has to be constructed anew, or the cargo will have to be unloaded at the existing Sattahip port and transported on land.

ii. Present Sattahip Port

Fig. 5.3.10 shows the existing port facilities in the Sattahip port including sea channel, berths, quays, and breakwater, and the position of the Sattahip A site. The Fig. 5.3.11 is a detailed layout of the quay. The quay facilities are as follows:

Sea Channel Depth:	L.L.W. – 9.6 m (32 ft.) to – 10.8 m (36 ft.)
Sea Channel Width:	200 m (656 ft.)
Sea Channel Length:	800 m (2,720 ft.)
North Quay:	10,000 DWT class, –8.5 m deep
	2 berths x 150 m = 300 m
West Quay:	20,000 DWT class, –9.6 m deep
	3 berths x 180 m = 540 m
Gantry Cranes:	2 units Max. hoisting capacities 40 and 23 tons.
Storage Yard:	18,000 m^2, 3 warehouses 10,000 m^2
Forklifts:	About 20
Tug Boats:	1,200 HP X 4
Oil Pier:	20,000 DWT class, –9.6 m deep
	1 berth x 65 m

A breakwater with a length of 1,000 m protects the port against the monsoons which spawn in May to November, and the berths in the port are calm throughout the year. The port of Sattahip was completed in 1968. However, as of 1979, the port is not available for commercial transportation except for shipment of agricultural produce such as tapioca, for which the port is open for one or two ships a month. MOC is studying a plan to turn the port into a commercial port and for its improvements.

iii. Sattahip Site A

When the maximum utilization of the present Sattahip port is considered, first, it will be usefull in unloading construction materials and equipment and imported machinery during the construction. The existing quays and unloading facilities (excluding unloading of large and heavy cargo) can be used, and this will be a considerable advantage.

However, the integrated steel plant requires berths to import and unload main and auxiliary raw materials and quays to ship out products. When this is taken into consideration, the layout shown in Fig. 5.3.6 derives. A sea deeper than −18 m can only be found on a chart more than 3.0 km away from the site. Under the circumstances, a sea berth capable of accommodating a 150,000 DWT ore carrier has been planned by dredging a sea channel for an aggregate length of about 2.0 km, as shown in Fig. 5.3.6. Quays for ships of 500 to 2,000 DWT to load products should preferably be near the product warehouses. Therefore, dredging for an additional 2.0 km sea channel will further be required. The volume of the dredged soil material would total 6.5 million m^3, or more, and a plan has been made to utilize this dredged soil material by reclaiming land needed for preparing a plant for non-flat products in the future (See Fig. 5.3.6).

It is clear from the foregoing that the advantages and disadvantages considered for the Sattahip A site almost reverse in the case of Laem Chabang. The advantages of Fig. 5.3.6 are:

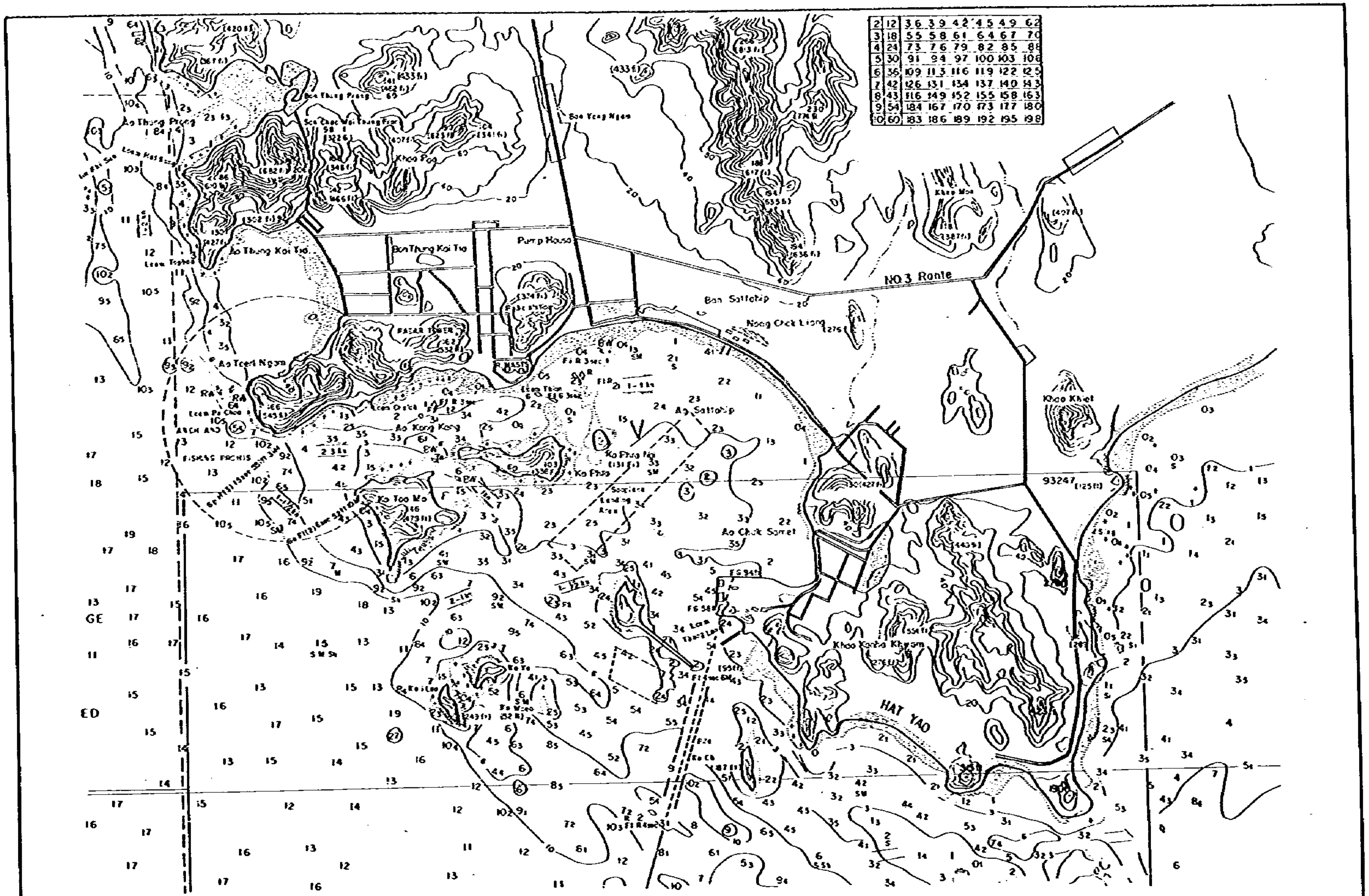


Fig. 5.3.10 Port of Sattahip

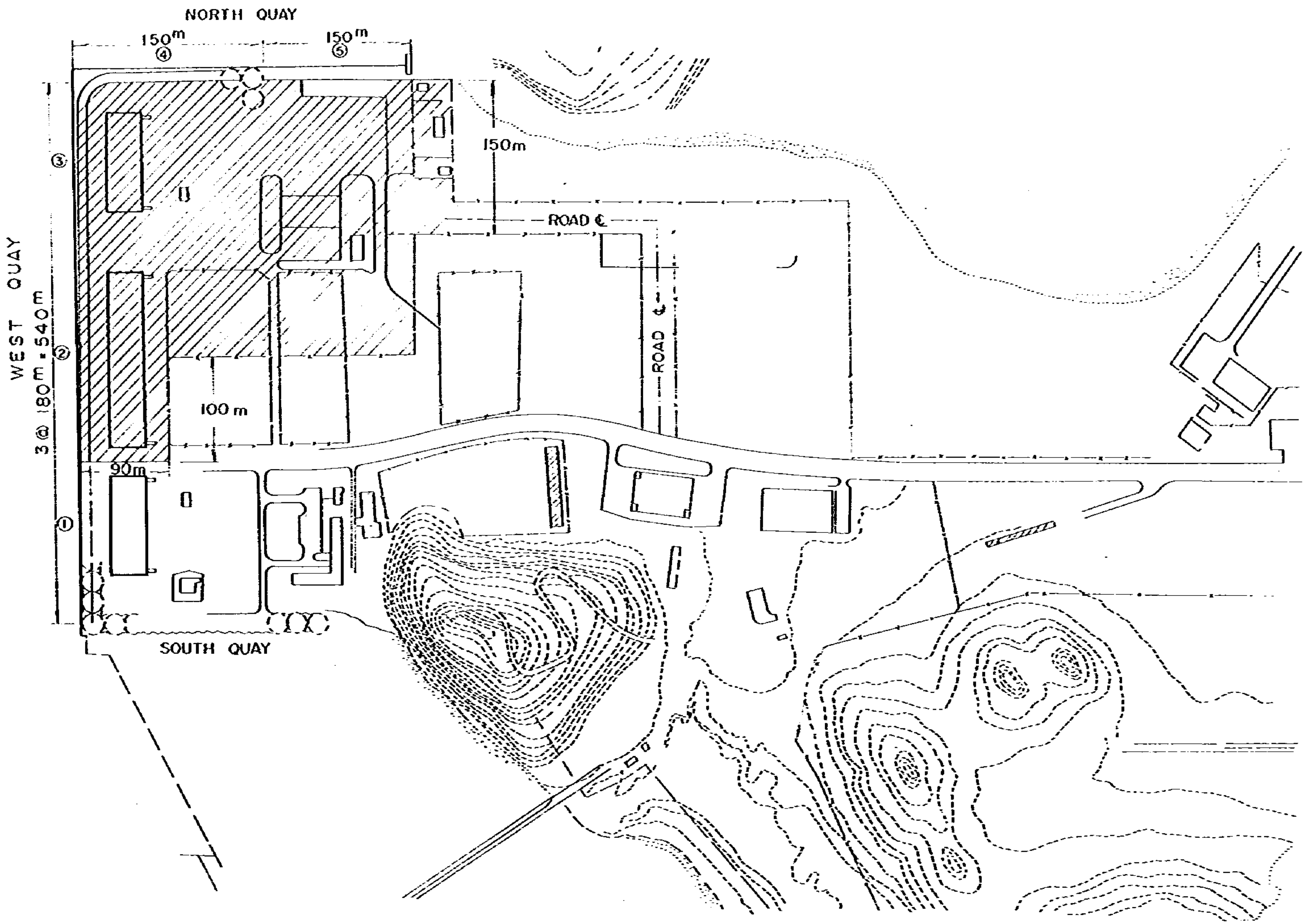


Fig. 5.3.11 Pier Layout of Sattahip Port

a. The existing Sattahip port can be greatly utilized for construction works and other purposes.

b. A port plan can be made independently for the integrated steel plant without regard to other industrial development programmes.

The disadvantages conceivable for Fig. 5.3.6 will be:

c. The distance to water areas sufficiently deep for large vessels is considerably far, and sea channels and berths will have to be dredged.

d. The volume of dredged soil material will be large (more than 6.5 million m^3).

e. The construction of a breakwater against marine meteorology, particularly against high waves from ocean, cannot be considered for the future also.

f. Basic data regarding sea-bottom boring and tidal currents is not suffcient.

iv. Sattahip Site C

This site has a number of advantages such as a free selection of a vast area of land and geographical proximity to the gas pipeline landing point. As far as what can be determined from sea charts is concerned, the shore is a shoaling beach and is totally unsuitable to construct port facilities to permit entry and exit of large vessels. For further information, a sea channel for a distance of more than 20 km, or a trestle, will be necessary to secure a water depth of –18 m. The cost to construct it will be prohibitive. It can said that the site offers fewer advantages from the port engineering standpoint.

(3) Industrial Water

The integrated steel plant under study will require a large volume of industrial water (fresh water), as follows:

1st Stage (1985, 1.3 million tonnes/year)

50,000 m^3/day, 14 MMm^3/year

2nd Stage (1990, 2.0 million tonnes/year)

70,000 m^3/day, 22 MMm^3/year

As a reservoir being capable of supplying such a large volume of fresh water, the following reservoirs can be considered:

Laem Chabang site — Bang Phra Reservoir

Sattahip sites A and C — Dok Krai Reservoir

Fig. 5.1.1 shows their locations.

The Bang Phra Reservoir is an artificial lake completed in 1975 by building an earth-fill dam. Its area is about 6 km^2 and is capable of holding 100 Mm^3 water. Fig. 5.3.12 shows its plan.

The Dok Krai Reservoir is also an artificial lake completed in 1975 by closing the upper stream of the Khlong Dok Krai river by an earth-fill dam (height 24.6 m, length 1,500 m). Its catchment river area is 291 km^2, and storage capacity, 58 Mm^3. The precipitation used in the calculation is 1,700 mm/year. The actual discharge volume in February, 1979 prior to entering the rainy season was 3 m^3/sec. (=260,000 m^3/day).

Water is taken from these reservoirs for agricultural and tourism purposes at present. These reservoirs have not yet been developed for industrial purposes, and strong back-up support by both the Royal Thai Government and the Royal Irrigation Department is desired.

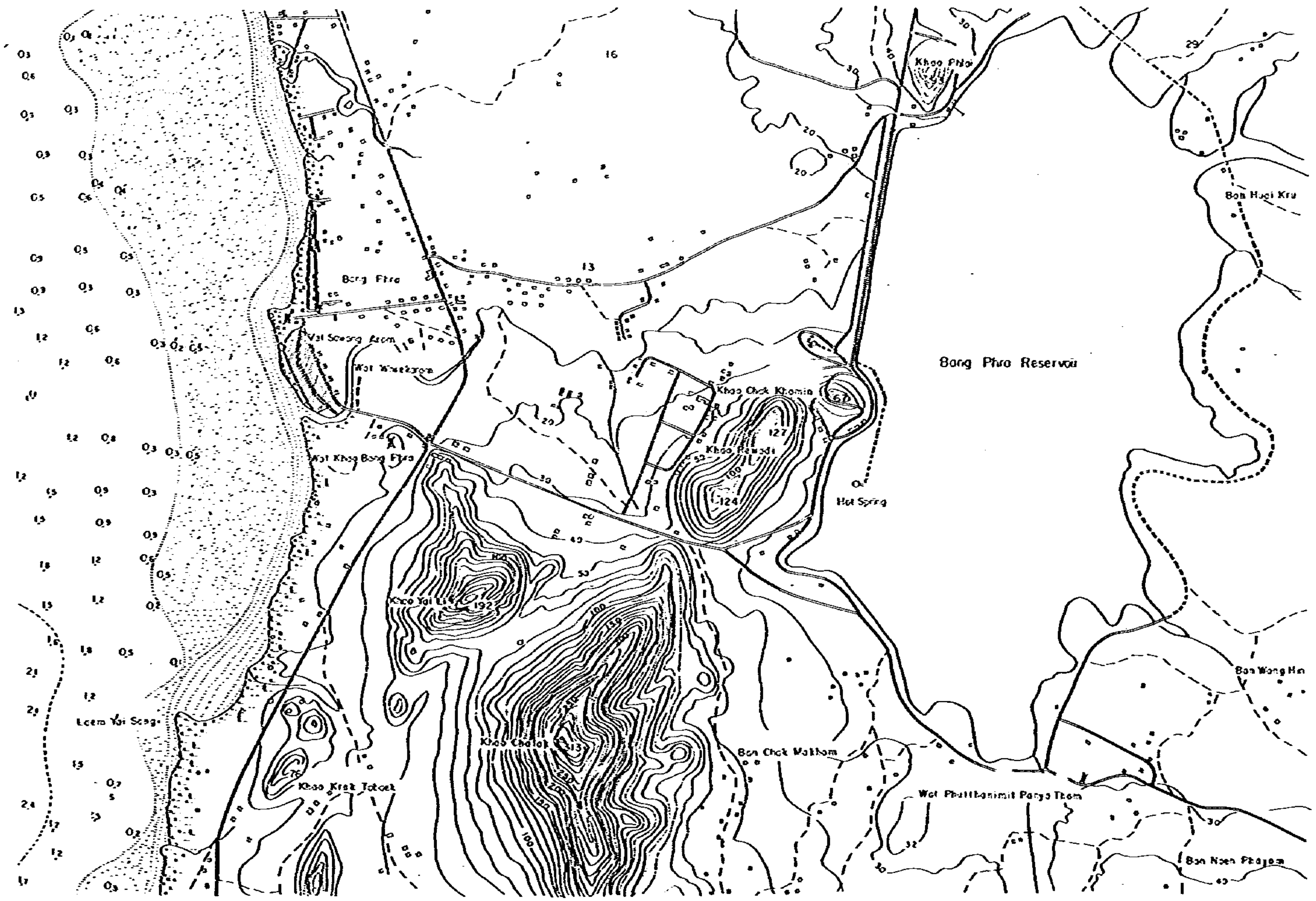


Fig. 5.3.12 Plan of Bang Phra Reservoir

No detailed quality analysis of the water in these reservoirs has been made yet. There should be no problem in terms of Cl_2 and total hardness, and the reservoirs are considered sources for good quality industrial water.

Water pipeline will now be discussed about. The total lengths of the pipeline needed are:

Bang Phra – Laem Chabang	20 km
Dok Krai – Sattahip A	54 km
Dok Krai – Sattahip C	40 km

As far as water pipeline is concerned, Laem Chabang is advantageous. The outside diameter of the pipe, steel pipe, used for the water pipeline is assumed to be 900 mm.

(4) Gas and Electric Power

The steel plant under present study will be of a direct reduction route to use natural gas to be produced in the Gulf of Thailand. Gas measuring 54 MMSCFD will be used in the 1st stage and 86 MMSCFD, in the 2nd stage. For this reason, it will be necessary to install a 20-inch branching pipe from the gas transport line, which extends from the pipeline landing point 30 km east of the Sattahip port to the South Bangkok P.S. via the Bang Pakong P.S., to the steel plant site. The Sattahip C site is closest to the gas transport pipe, and the length of the branching pipe will be 6 km.

Both Laem Chabang site and Sattahip A are slightly remote from the gas transport pipe, and the lengths of branching pipes will be 31 and 30 km, respectively.

Thai Carbon Black Co. and several other plants near Laem Chabang, which are now in production, are expected to use some gas, and gas can be supplied to them by branching out from the gas pipeline for the steel plant.

At present, there are no consumers to use gas in the Sattahip area except for the steel plant. If an ammonia plant is to be built in this area in future, a 20-inch or larger branching pipe should be installed.

Whichever site is selected, there will basically be no problem in obtaining supplies of gas, although there will be some differences in the length of the braching pipe.

Laem Chabang will be the most advantageous site for steel plant in terms of supplies of the electric power.

The steel plant will use DR/EAF route and will consume large amounts of electricity – 240 MW in the 1st stage and 360 MW in the 2nd stage. The electric power requirements in Thailand will principally be supplied by hydroelectric generation in the northern and western parts and thermal-power generation in south Bangkok. The Bang Pakong Thermal-Power Generation Plant will be able to supply the power in future. There is no plan to build a power plant in the southeastern section, and the power must be supplied to the steel plant by the Bank Pakong Thermal-Power Plant. The power should be supplied to the steel plant by a 230 kV extrahigh voltage transmission line. The present EGAT plan calls for the construction of a 230 kV transmission line to Si Racha, slightly north of Laem Chabang, and it will be necessary to build transmission lines (230 kV, 450 kVA X 2 lines) from there to the steel plant site. From this standpoint, Laem Chabang is most desirable as a site for the steel plant.

Variation of power load in a steel plant causes voltage variation in the transmission system, leading to the so-called "flicker" problem. An antiflicker facility is installed inside the steel plant to prevent this problem. When the steel plant is close to the power supply, voltage variation is negligible, and an anti-flicker facility can be small in capacity, costing less for building. This in turn lowers the construction cost of the steel plant slightly. From this point also, Laem Chabang is desirable as a construction site.

(5) Road and Railway

The National Highway Route No. 3 completed by the Department of Highways (DOH), is an excellent 4-lane highway, and one can drive a distance of 170 km along Bangkok – Laem Chabang – Pattaya – Sattahip in about three hours. All of the three alternative sites are located in excellent locations, and only an access road has to be built anew or widened for a distance of 4 to 7 km.

The Royal State Railway of Thailand (SRT) is already implementing a plan to extend the existing railway between Bangkok and Changwat Chachoengsao to Sattahip by extending 144 km. This new line has been planned to connect both Laem Chabang and Sattahip and has been given a goal of opening for service in October, 1982. Therefore, a line can be installed anew in parallel for about 9 to 31 km for connection with the railway inside the steel plant.

At any rate, it can be said that the backup by the Royal Thai Government regarding roads and railway is sufficient.

(6) Labour Force

Table 5.3.1 compares Chon Buri and Rayong Provinces in labour force. Compared with Rayong, Chon Buri is larger in GDP, population and working age population. It is noted that the weight of manufacturing industries in Chon Buri is relatively high, partly because it is close to Bangkok.

Both Laem Chabang and Sattahip belong to Chon Buri Province. Laem Chabang is situated in the centre of Chon Buri Province, whereas Sattahip is located rather close to Rayong Province.

Considering the foregoing situation, Laem Chabang seems slightly advantageous for the following reasons when Laem Chabang and Sattahip are compared on the supply of labour force.

Table 5.3.1 Comparison of Working-age Population – in Chon Buri and Rayong

	Chon Buri	Rayong
GDP (Basis: 1972 Price Index) (1977)	(100%) 8,598 M bahts	(100%) 2,252 M bahts
Agriculture, forestry, fishery	(24%) 2,055	(53%) 1,198
Manufacturing	(46%) 3,930	(16%) 367
Population (end 1978)	696,855	345,841
Working-age population (1970) (11 years and older)	250,875	128,834
Agriculture, forestry, fishery	149,947	94,665
Manufacturing	18,650	5,593

a. Unskilled and semiskilled workers have to be recruited from neighbouring locations. There is a difference in industrial structure between Chon Buri and Rayong. However, the degree of industrial development in both provinces is still low, and there will be no problems for Laem Chabang or Sattahip insofar as surplus supply capacity of labour force is concerned.

b. Laem Chabang seems superior regarding foremen and skilled workers because of its location. Laem Chabang is located in the centre of Chon Buri Province, where the weight of manufacturing industries is relatively high, and is near Bangkok. Another reason making Laem Chabang advantageous is that industrial development projects are being planned for this area.

c. Managers, supervisors and engineers have to be recruited mostly from Bangkok. There are no universities or professional training schools nearby. Laem Chabang, which is close to Bangkok and which has a health resort, Pattaya, in its back, is considered relatively advantageous.

(7) Environment

The population distribution (population density) near the steel plant will probably be smaller in Sattahip than in Laem Chabang. Therefore, it may look as if Sattahip causes lighter effects to the ambient environment when a steel plant is build. In fact, however, the steel plant will be equipped with of dust collectors and waste water processing facilities to prevent causing effects to nearby environment. As a result, the effects caused by it to nearby environment are extremely slight, as explained in Chapter 13. This does not change at all wherever the steel plant is to be built. As stated, the three alternative sites are comparable as far as effects on ambient environment are concerned.

(8) Comparison of Three Proposed Sites and Evaluation Results

Prior to undertaking detail work of the present study, a conceptual comparison and study of the proposed three alternative sites was made. The sites are the following three locations:

Laem Chabang

Sattahip A (Hat Yao)

Sattahip C (Ban Nam Tok)

Their locations are shown in Fig. 5.1.1. The following seven grades were used as evaluation criteria:

A^+, A, A^-, B^+, B, B^-, C

Best ←————————→ Good

The evaluation results are shown in Table 5.3.2. As a overall evaluation, the following results have been obtained:

Laem Chabang .... A to A^-

Sattahip A (Hat Yao) .... B^+ to B

Sattahip C (Ban Nam Tok) .... B to B^-

Table 5.3.3 shows a conversion of investments related to the infrastructures required for these three alternative sites, respectively. According to this table, investments in infrastructures are expected to total 118 to 210 million dollars. In both monetary and technical considerations, Laem Chabang can be recommended as the best site.

Please note that the present study has been conducted on the assumption that Laem Chabang will be the selected site.

Table 5.3.2 Preliminary Comparative Study on Three Sites

Items \ Sites	Laem Chabang	Sattahip A	Sattahip C	Remarks
I Vital items				
1 Land				
(1) Acquiring land	A Easy by the Government	A⁻ Inside of the navy base	A Easy by the Government	
(2) Land shape and expansion space	A⁺ 418 ha and more	B Limited to 315 ha	A⁺ 418 ha and more	
(3) Land preparation (incl. reclamation)	B⁺ Reclamation area 1,060,000 m^2 (25.4 %)	B Reclamation area 1,160,000 m^2 (36.8 %) Hill cutting to be required	B Reclamation area 1,080,000 m^2 (25.9 %)	
2 Port				
(1) Master plan	A Deep sea port plan by NEDECO Industrial estate plan by IEA	B The best use of the existing Sattahip port facilities by MOC	C No plan	
(2) Sea berth for large vessel (150,000 DWT class)	A Very near to deep water zone (500 m)	B 3 km far from deep water zone	C 20 km far from deep water zone	

Table 5.3.2 (cont'd)

Items \ Sites	Laem Chabang		Sattahip A		Sattahip C		Remarks
(3) Products loading and scrap unloading berth (up to 30,000 DWT)	B	To be constructed newly	B^+	1st stage: The existing Sattahip port facilities to be used 2nd stage: To be constructed	C	Difficult to construct new berth	
(4) Discharging import equipment and construction materials	B^+	Small quaywall to be constructed ahead or on land transportation	A	At the existing Sattahip port facilities	C	On land transportation	
3 Natural gas & power							
(1) Gas pipeline	A	Necessary to install 30 km long gas pipeline	A	Necessary to install 31 km long gas pipeline	A^+	Necessary to install 6 km long gas pipeline	First stage 2500×10^6 BTU/h Second stage 3600×10^6 BTU/h
(2) Power transmission	A^-	To be distributed well	B^+	To be distributed	B	To be distributed	First stage 240 MW (230 kV) Second stage 360 MW (230 kV)

Table 5.3.2 (cont'd)

Items \ Sites	Laem Chabang	Sattahip A	Sattahip C	Remarks
4 Industrial water				
(1) Reservoir	B^+ Bang Phra 100 MMm^3	B Dok Krai 53 MMm^3	B Dok Krai 53 MMm^3	First stage 50,000 m^3/D – 14 MMm^3/Yr Second stage 70,000 m^3/D – 22 MMm^3/Yr
(2) Water pipeline	B^+ Necessary to install 22 km long water pipeline	C Necessary to install 54 km long water pipeline	B Necessary to install 40 km long water pipeline	
II Items to be studied				
5 Topography	A Flat	B A little hilly and rocky	A Flat	
6 Soils	A To be investigated more in detail	A Same as left	A Same as left	No boring data
7 Climatology and oceanography	A In the future break-water to be con-structed	A^- To be sheltered by small islands	B^+ No shelter	

Table 5.3.2 (cont'd)

Items \ Sites	Laem Chabang		Sattahip A		Sattahip C		Remarks
8 Highway & rail way							
(1) Access road	A^-	New road 6 km from No. 3 national highway route to be required	A^-	New road 7 km from No. 3 national highway route to be required	A	New road 4 km from No. 3 national highway route to be required	
(2) Railway extension from planned new line	A	Easily to be connected	A^-	Necessary to extend 1 km additionally	B	Necessary to extend 11 km additionally	
9 Approach to sea berth	A	0.5 km coaseway or trestle to be required	B	1.5 km coaseway or trestle to be required	C	8 to 10 km coaseway or trestle to be required	
10 Availability of labour force	A	Near to Si Racha and Chon Buri	A^-	Near to navy base	B	Near to Rayong	

Table 5.3.3 Comparative Study on Infrastructure Investment Costs at Three Sites

(unit: 1,000 USD)

Items	Unit price	Laem Chabang		Sattahip A		Sattahip C	
1. Survey, investigation			530		550		800
2. Site preparation & reclamation		417 ha	* 37,030	315 ha	30,400	417 ha	24,730
3. Port facilities			* 28,570		41,720		112,300
4. Access road	150 USD/m	6 km	900	7 km	1,050	4 km	600
5. Railway	340 USD/m	9 km	3,060	11 km	3,740	31 km	10,540
6. Water pipeline	300 USD/m	22 km	6,600	54 km	16,200	40 km	12,000
7. Gas pipeline	320 USD/m	30 km	9,600	31 km	9,920	6 km	1,920
8. Power transmission	300 USD/m	20 km	6,000	70 km	21,000	70 km	21,000
9. Housing			* 25,500		25,500		25,500
Total:			117,790 (100)		150,080 (127)		209,390 (178)

Note: Applicable only for the intergrated steel plant
* ..... Pertaining investment costs are included in Table 10.2.1 "Direct Construction Cost for the 1st Stage"

5.4 Layout for the Integrated Steel Plant

In the present study, the layout of the integrated steel plant, whether at Laem Chabang or Sattahip, has been planned with utmost emphasis on eliciting the maximum from the sea front advantages of the location.

Namely, major engineering considerations are given to the following points.

a. Mass transportation by sea of pellets and scrap for cost reduction; installation of port and harbour facilities near as deep waters as possible.
b. Interconnection of DR, EAF, CC, hot strip mill and cold strip mill plants with the shortest path for the minimization of the costs of handling the semi-finished products.
c. Sale of the majority of flat products (hot and cold rolled flat products) by transportation by sea, and installation of products warehouses near the products delivery quay.
d. Transportation by road and rail of the balance of the products, sub-materials, equipment and materials for operation, etc.
e. Centralized reception and control of such utilities as electricity, industrial water and natural gas for improved efficiency of energy distribution.
f. Capacious road network arranged functionally within the premises for high efficiency commutation of workers and smooth transportation of materials and equipment between plants and maintenance shop.

Fig. 5.4.1 is a schematic view of the layout. Figs. 5.3.2 and 5.3.3 is a layout worked out with all the efforts of the engineers of the survey team. According to this layout, detailed installation plan, cost estimation for construction and operation, and construction schedule have been made.

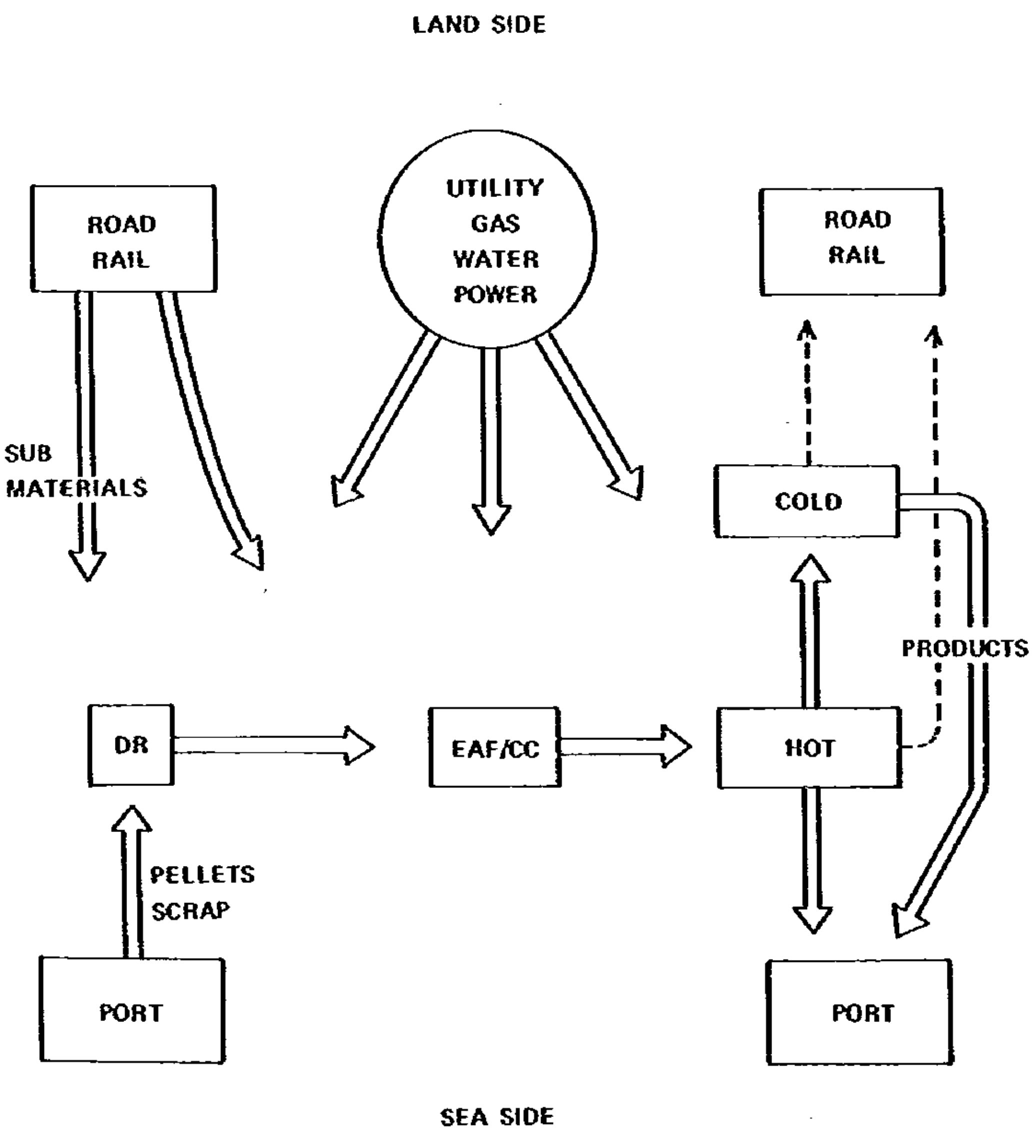


Fig. 5.4.1 Conceptual Flow Chart on Layout

5.5 Land Preparation

(1) Land for the Integrated Steel Plant

A number of steel mills in Japan and in many other countries of the world are built on reclaimed land along shores. By reclaiming sea fronts, sufficient port facilities and vast areas of land can be prepared.

Next, the land for the integrated steel plant has to be prepared flat. This is necessary to make transportation of heavy semi and fully finished products by roads and rail tracks inside the steel plant to be carried out easily and at low cost. Therefore, a site should be desirably a flat land with fewer ups and downs, and land with unevenness in height should be leveled.

The land for the integrated steel plant has to be elevated to certain level in view of the tides from the sea, effects by waves and underground water, draining of rain water, and other problems. The site ground level should be decided in such a manner that it will not hinder the operation.

Land preparation is the base for constructing the steel plant and is undertaken ahead of all other construction works. To effectively implement the land preparation works, which consist of disposal of top soil (bad soil), cutting, banking, dredging, reclaiming, revetment, access roads, drainage canals and other works, a full prerequisite topographical and marine surveys are essential.

a. A survey and measurements of topography of the land including, trees, farms, drainage canals, roads, buildings, etc.
b. A survey and measurements of water depths from the shoreline to open sea.
c. A soil investigation in the compounds and in sea areas.
d. Collection of aerial photographic survey maps.

The foregoing items are absolutely necessary preliminary step in making a basic engineering.

(2) Land Preparation Programme for Laem Chabang Site

Figs. 5.3.2 and 5.3.3 are considered as a basis. As stated, the required land area is 4,175,000 m², of which the land section is 3,115,000 m² (74.6%) and the sea section, 1,060,000 m² (25.4%). A rubble-mound revetment will be built along the outer side of the sea section for a length of 3,940 m. Inside of this revetment will be reclaimed with dredged sand. The volume of sand soil is 5.3 million m³ for minimum reclamation which is large. When designing the ground level height of the land to be:

Mean Sea Level (MSL) + 4.00 m;

an additional 10.2 million m³ of soil material will be required. This soil material is collected form around the site and the sea bottom nearby.

Inside the land prepared to a height of +4.00 m, roads are planned as shown in Fig. 5.3.2, and drainage ditches and culverts are built underneath main roads. About 27% of roads will be paved in the 1st stage.

The foregoing is our conceptual thinking prior to undertaking a detailed field survey. It goes without saying that work to increase accuracy will be needed based on concrete survey and measurement results.

5.6 Planning and Construction of Port Facilities

(1) Sea Berth for Receiving Raw Materials

The present study has suggested importation of pellets, as noted below, as a premise:

1st stage	1,765,000 tonnes/year
2nd stage	2,789,000 tonnes/year

Planning of port facilities is very important in considering the location for the integrated steel plant. The steel industry is referred to as the transport industry. The criteria for an efficient steel plant is how best it can reduce the overall transportation cost: raw materials – semifinished products – finished products. This principle also applies to raw materials centering on pellets. It is customary throughout the world to utilize large ore carriers to reduce the ocean transportation cost.

A sea berth for receiving raw materials as shown in Fig. 5.3.3 has been planned for the Laem Chabang site. At southwest of the site, a sea area with a sufficiently deep water depth has been recognized. By arranging the raw materials receiving sea berth at this point, the work of dredging sea channels and berths can be minimized.

The following vessel types were envisaged as large ore carriers:

1st stage	80,000 DWT class or over
2nd stage	up to 150,000 DWT class

A large vessel was considered from the beginning to reduce the ocean transportation cost of pellets to the lowest possible level. Therefore, a water depth of −18.5 m was made a design criterion for the sea berth structure, sea channels and berths. Fig. 5.6.1 shows the relations between the vessel size and berth depth.

To organically connect this raw material receiving sea berth and hinterland facilities, a causeway having a width of 12 m and a length of 400 m shall be constructed. A belt conveyor, road and cable will be built and installed on this causeway.

A 1,500-t/h large unloader shall be operated on the raw material receiving sea berth, and this must have a structure with sufficient strength. It shall have a foundation piled with large-diameter steel pipes to withstand impact by vessels

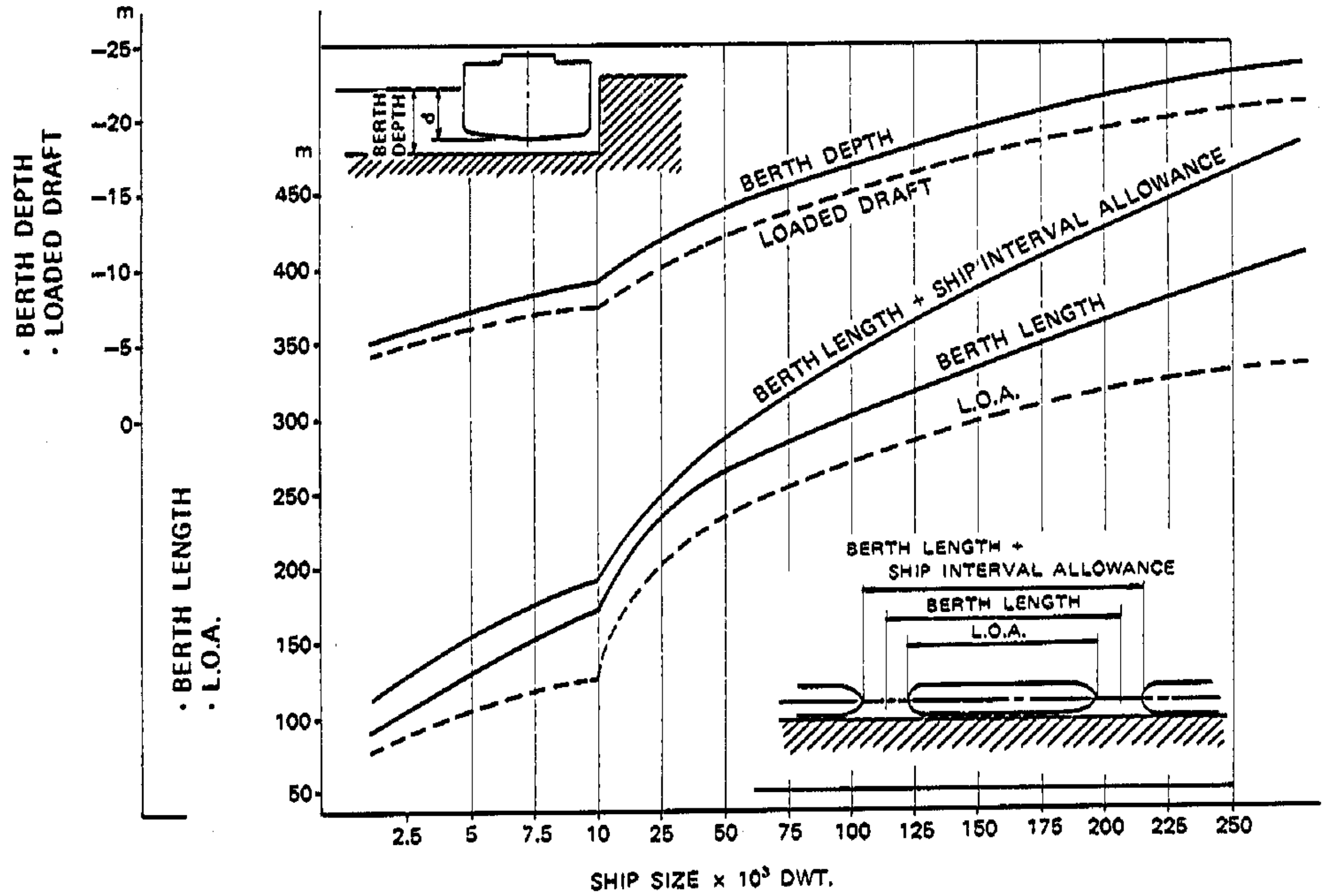


Fig. 5.6.1 Ship Size and Berth Depth

and the horizontal force of the unloader.

The present study has been made without making detailed surveys of sea-bottom topography and subsoil. Therefore, it should be subjected to review after implementing these studies. It will be necessary to implement: (a) a seabottom topographic survey, (b) soil investigation, and (c) tidal current and coastal current.

(2) Quay for Product Shipping

In the present study, the shipment of the following products has been envisaged:

1st stage	Hot rolled products	624,000 t/y
	Cold rolled products	479,000 t/y
Total		1,103,000 t/y
2nd stage	Hot rolled products	937,000 t/y
	Cold rolled products	804,000 t/y
Total		1,741,000 t/y

Two transportation methods can be considered for transport of these products. One is sea transportation by barges and small vessels. The other is land transportation by trucks/trailers and railways. The proportion of sea transport must be estimated in determining the necessary length of the product shipping quay. This will be a difficult decision making to face. Fig. 5.6.2 shows these relations, and

Total product shipping volume → ratio of sea transport → length of the quay, the number of berths

can be obtained. In the present study, the following numbers were taken into consideration:

200 to 1,000 DWT class 2 berths X 75 m = 150 m

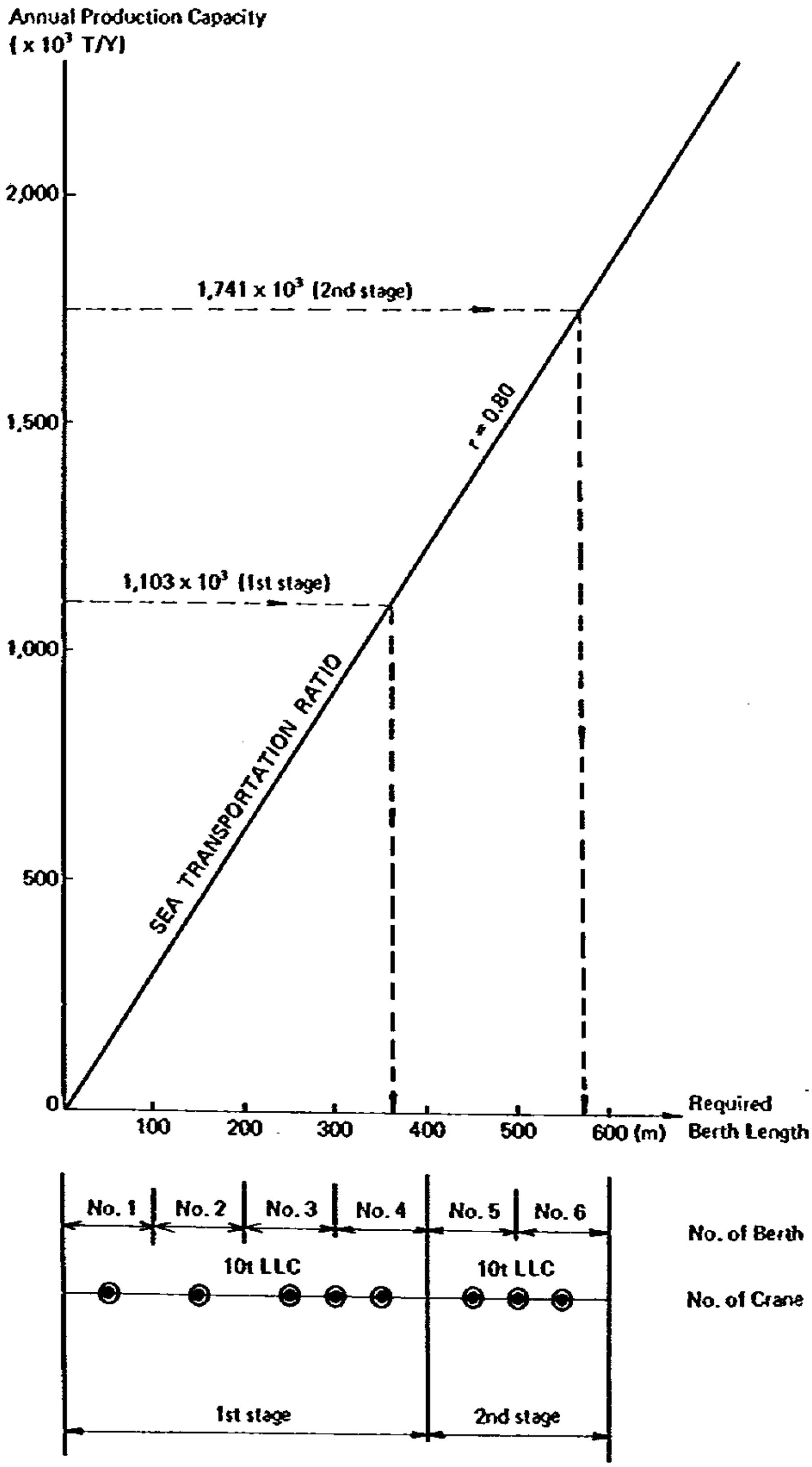


Fig. 5.6.2 Annual Production Capacity and Berth Length Relationship

1,000 to 2,000 DWT class	2 berths X 100 m =	200 m
	Total	350 m

The berth water depth is −5.0 to −6.0 m, and 5 units of 10-t LLC will be used. Assuming a sea transport ratio of 80%, the quay occupancy rate of 64% shall derive.

According to an example of a steel plant in Japan, more than 87% of ships shipping products for the market in Japan are below 1,000 DWT in size. A quay capable of accommodating ships of 2,000 DWT class has been considered for Thailand.

The location of the product shipping quay is shown in a layout presented in Fig. 5.3.3. The location has been chosen to make the transportation distance by cranes and trucks/trailers between the warehouses and quay to the minimum by locating product warehouses near the hot and cold strip mills. Presuming that the subsoil nearby is sand of relatively good quality, the quay will be structured by using steel sheet-piles. As stated in (1), it is important to implement various basic studies and surveys.

Small vessels and barges come alongside the product shipping quay and are subjected to waves. It is hoped that construction of a breakwater shown in the Deep Sea Port Programme studied by the Royal Thai Government will be completed as soon as possible. It is shown in Fig. 5.3.3 for reference.

(3) Scrap Unloading Quay

The scrap requirements for the 1st stage is 283,000 t/y and for the 2nd stage, 446,000 t/y, according to the present study. About 50% of these scrap requirements will be supplied by return scraps produced inplant. The remaining 139,000 t/y and 217,000 t/y will be imported. A special quay to accommodate a vessel of the 25,000-DWT class to import scraps of this quantity will be required. This will be left as a future problem (at the 2nd stage), and a berth on the rear side (northeast side) of the raw materials receiving sea berth will be used for the time being for unloading of scraps in the 1st stage. The reasons for this are that the occupancy rate of the raw materials (incl. scrap) receiving sea berth will be 40 to 60% in the 1st stage and to minimize the initial investment amount in the total construction cost. The transport distance by trucks will unavoidably be longer.

(4) Unloading of Equipment and Materials during Construction

During the construction of the steel plant for the 1st stage, large quantities and volumes of materials and equipment for construction and plant facilities will be required. Two methods can be considered for this purpose, as shown below:

a. To unload at the existing Sattahip port and to transport by trucks/ trailers.

b. To construct part of the products shipping quay (for 1 to 2 berths) in advance and effectively utilize it.

In the present study, the mission would like to recommend the method b. The detailed procedure for this purpose can be solved in the stage of detailed engineering. It is important to complete it within 1.5 years after receiving "GO" notice. However, the method a. will unavoidably be used until this quay is completed and operative.

5.7 Prerequisite Preparation Programme for Infrastructure Related Facilities

(1) Land

As stated in 5.4, a topographical survey and soil investigation are required to be implemented as early as possible.

A scale of 1/1,000 (or 1/2,000) shall be required for topographical maps to be made.

The soil investigation shall be conducted at a total of 20 locations:

Land	10 locations
Sea	10 locations

Approximate soil profiles, their properties have to be determined.

It will absolutely be essential that purchases and acquisition of land and compensations to residents and landlords are settled by the Royal Thai Government prior to the basic survey of the land.

Dredging, reclamation and land preparation works will start after implementing detail engineering and going through these procedures. At the same time, an access road to the National Highway Route No. 3 will be constructed.

(2) Port

It is also important that the Deep Sea Port Programme in Laem Chabang is made into an implementation programme in a policy decision by the Royal Thai Government. The site for the integrated steel plant should be selected closer to the north side where a deep water depth is available, Fig. 5.3.3.

As sea berth and quays, raw material receiving berth (310 m) with a depth of −18.5 m and products shipping quays (400 m) with a −6.0 m water depth are planned. Very extensive dredging works will be required to secure sea channels and berths. It is important that these large marine works be perfectly coincided with the implementation of the Deep Sea Port Programme as the works will require an investment of large amount of money. A construction investment of about 28.6 million dollars is anticipated for the case of Laem Chabang. See Table 5.3.3.

(3) City Planning

More than 7,000 employees and suppliers related to the steel industries will reside near the site when the new integrated steel plant is completed; When their family members, people who will work for stores, people related to schools, a hospital, public organizations, recreational and religious facilities are added, a community with a population of nearly 100,000 people will emerge. In other words, a medium city with a population of about 100,000 will at least be required to smoothly operate the integrated steel plant.

This medium city must be equipped with city water and drainage facilities, transmission and distribution of electric power, city gas and other facilities for utilities, traffic networks such as roads and railways, and communication networks such as telephone, radio and TV broadcasting in addition to various public facilities. Further, city disaster prevention and city police will have to be made available. It is important that comprehensive and long-range city planning programmes will be drafted by the Royal Thai Government.

(4) Utilities for the Steel Plant

The three largest utilities, electric power, industrial water and gas are needed for an integrated steel plant. In the case of Laem Chabang site, extensions have to be obtained for utilities from the trunk lines the Royal Thai Government is now implementing:

Electric Power	20 km
Water	22 km
Gas	30 km

As shown in Table 5.3.3, an investment of about 22.2 million dollars is estimated. It is strongly advised that electric power and water be made available within 1 to 1.5 years and gas, within 4 years, after "GO" notice has been received.

(5) Railway for the Steel Plant

A total railway length of 9 km is included in the present study as a railway inside the Laem Chabang site. Fig. 5.3.3 shows one example of this route. The plan calls for jointing the steel plant railway with the trunk line of SRT on the east side of the integrated steel plant. Calcined lime and fluorite are the materials that are principally transported to the steel plant by railway. Also, about 5 to 10% of the finished hot and cold rolled products will be shipped on rail. Locomotives, freight cars and other rolling stock will be made available by SRT in a sufficient quantity. Detail engineering will show types, numbers, times required, and other information.

An investment of approximately 3.06 million dollars will be required. See Table 5.3.3.

CHAPTER 6

IMPLEMENTATION PROGRAMME

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6.1 Construction Schedule

Fig. 6.1.1 is a construction scheduling chart used in the present study, where it is assumed that a period of 4.5 years or 54 months is required from a "Go" notice to start-up of operation.

The 54 months is divided as follows:

the first half of the period (18 ~ 30 months) is for site preparation, procurement of construction equipment, basic engineering and conclusion of contracts with equipment syppliers;

the second half of the period (21 ~ 33 months) is for civil and construction works, fabrication, delivery and erection of equipment; and

the remaining period (3 ~ 6 months) is for commissioning, and preoperation tests; totalling 54 months.

It is assumed that the steel plant related infrastructure be completed timely along with the construction schedule. To effect the timely completion, therefore, it is preferable that the basic surveys and designs of the infrastructure such as site preparation, port and harbour construction, electric power, waterworks and road construction be initiated 3 months prior to the date of the "Go" notice. Upon receipt of a "Go" notice, a construction headquarters should be organized.

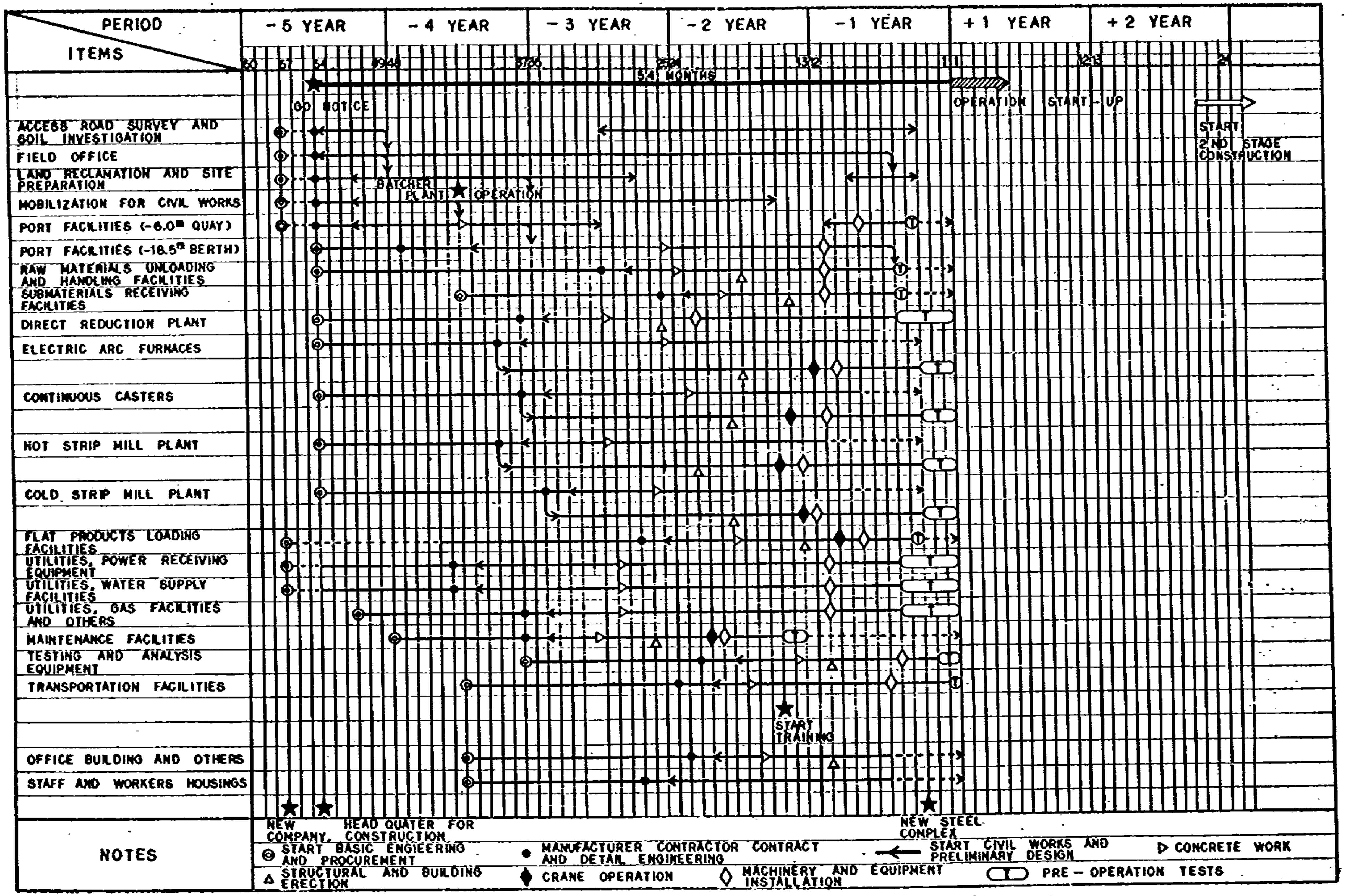

Fig. 6.1.1 Construction Scheduling Chart

6.2 Preparation before the Project Implementation

The shortest possible schedule to complete the construction of the steel plant is expected to be 54 months as mentioned in the preceding paragraph. It will need a certain period of time before the decision on the implementation of the steel plant is made. The types of work to be performed during the decision-making period, and the critical dates for the types of work definitely affecting the progress of the entire project unless the requirements are met by certain times, will be as follows.

(1) Preparation before the Project Implementation

In implementing the project, the following items will have to be identified or determined by the Royal Thai Government.

i. Types of products

Emphasis should be placed on the production of hot and cold rolled flat products to substitute current import. For non-flat products, no prior investment should be made although consideration should be given for the future addition.

ii. Selection of site

Either Laem Chabang or Sattahip should be selected as the site where the steel plant is to be built. With the present study, the former is recommended on the ground as discussed in Chapter 5.

iii. Fund raising

Fund of about 1,400 million dollars will be required to complete the 1st stage portion of the steel plant. In addition, about 1,600 million dollars which will have to be used for improvements and provision of the infrastructure will be required. The Royal Thai Government should, therefore, manage to work out how to raise those funds.

iv. Determination of implementation organization

The project has the national importance from the view point of providing economic fundamentals in Thailand as it has a preinvestment character for the national prosperity of Thailand while it is considered the biggest project in Thailand from the amount of money involved. The project is therefore of the magnitude which will draw a wide public attention.

Therefore, while consideration is being given to such circumstances, a study should be made as to establishing the most effective, suitable implementation organization. Although it is the responsibility of the Royal Thai Government to determine such implementation organization (or a type of enterprise) at the earliest possible time in near future, it is generally conceivable that the type of enterprise includes either a government authority or a private company. In this study, an assumption was made to establish a new company.

v. Selection of consultant

In implementing the project, it will be effective and important to select a competent engineering service advisor. The services which must be performed by the consultant selected will include the provision of assistance to the implementation organization of Thailand in the preparation of equipment plans, the placing of purchase orders for the equipment, the planning and implementation of infrastructures, supervision of infrastructure construction, and the transfer of operational technologies and management techniques for the project to be made feasible and implemented smoothly. A consultant or engineering company to be selected must be fully qualified and must have sufficient volition to complete the services referred to above. As to these requirements, further description will be made later in this report.

vi. Land acquisition

The land on which the steel plant is to be built must be acquired timely in accordance with overall area development plan.

vii. Basic surveys for harbour civil work

Including boring, on-site surveys must be conducted urgently, as the result of such surveys may necessitate a change in the layout of the steel plant.

viii. Provision of infrastructure

It is necessary that the Royal Thai Government conclude a policy to improve or newly provide waterworks, electric power, gas supply, roads, railways, communication facilities, and prepare for urgent implementation of such infrastructure. It is also important and recommendable that the government will study and implement the infrastructure in perspective of the overall area development plan including the steel plant.

(2) Key Dates

Key dates for main utility and service items are shown in the following table.

Table 6.2.1 Key Dates for Main Items

Item	From the start-up date of DR, hot and cold strip mills
Receipt of large incoming power for operation	–6 months
Receipt of natural gas	–6 months
Receipt of industrial water	–6 months
Receipt of raw material vessel	–4 months
Opening of railway	–5 months

6.3 Organization during Construction Stage

A feasibility of the project must be carefully evaluated at the special committee consisting of government officials, academic scholars, and experts from private industries. Upon decision on implementing the project, a new company should be established wherein a steel plant construction plan should be initiated, and contacts with associated organs should be started for the selection of engineering companies, provision of infrastructure, and fund raising, etc. All these are assumed to be commenced 57 months prior to the start-up operation of the steel plant.

Three months later of the establishment of the new company (or 54 months prior to the start-up operation), construction of the new steel plant will start. As referred to in Fig. 9.1.2 of Chapter 9 which describes a new company organization during construction stage, the construction group is given an unusual authority, to carry out the construction of a large-sized steel plant very efficiently and systematically. Based on such concept, it is strongly recommended that the construction headquarters is established as shown in Fig. 6.3.1. There are many engineering companies both at home and abroad, but the one to be selected must be of a first-rated company in terms of technical and management experience in the construction of an integrated steel plant and in terms of staff availability including their competence and quality.

Construction Headquarters

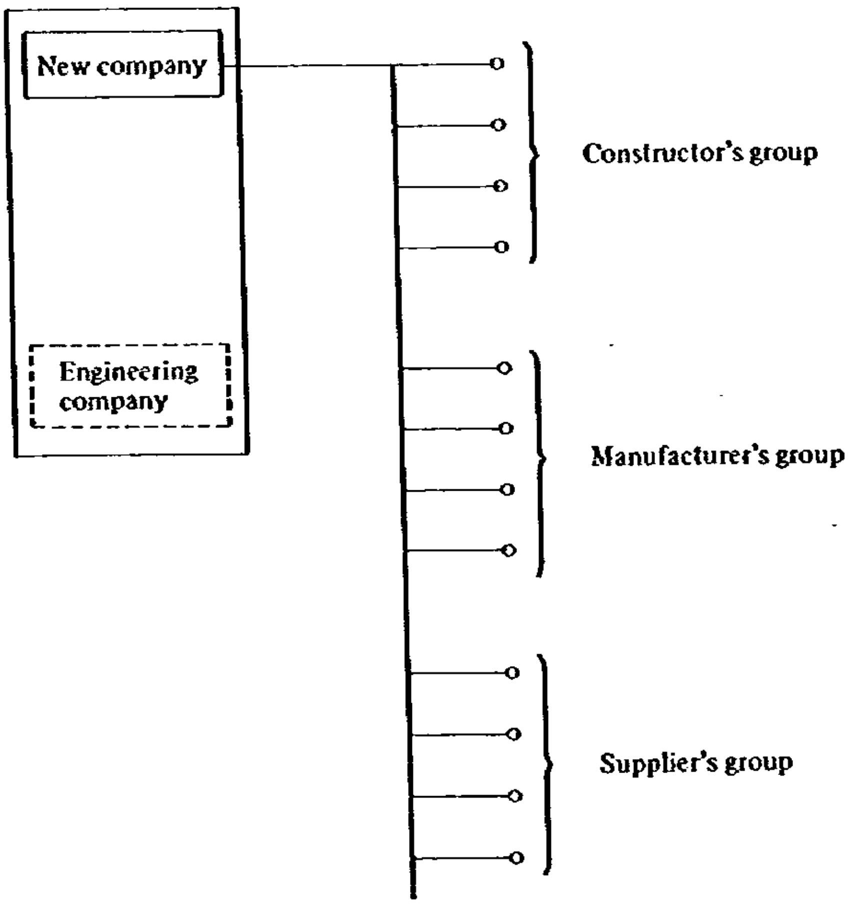

Fig. 6.3.1 Construction Headquarters Organization

6.4 Recruitment and Training Programme

(1) Recruitment

Table 6.4.1 shows recruitment for the steel plant covering a period from the preparation stage to the start-up operation.

The new company will be started with a small group of 19 members including the president. 3 months later when the construction headquarters as shown in Fig. 6.3.1 is organized, the new company will add 29 more members to have 48 members in total. The 48-member new company is still small in scale, but it should be enough because the actual execution of construction works will be undertaken by an engineering company so that the major roles that the new company has to play will be to supervise the engineering company and provide coordination and liaison with outside sectors.

This new organization will exist continuously for a subsequent period of 54 months until the steel plant reaches the start-up. Even after the start-up of the steel plant, the members of the new company engaged in the construction management are intended to be assigned to positions of key divisions and play a role as a core in the management of the steel plant.

The steel company must begin recruiting 18 months prior to its start-up. At an early stage the personnel will consist mainly of managers and engineers, but one year before the start-up, skilled workers will have to be employed on a full-fledged basis. Employment of unskilled workers can be much delayed timingly, but they will have to be all employed at least 3 months before the start-up.

(2) Training

All employed personnel must be fully trained and well prepared for a satisfactory start-up. Training must be carefully and sufficiently provided for as the operation of the steel plant requires high-level, complicated work.

First of all, key personnel such as managers, engineers, foremen, etc should be despatched overseas to developed countries where they will be trained at proper steel plant on an on-the-job training basis. It is considered reasonable that overseas despatch for training should be started 12 to 15 months prior to the start-up.

The key personnel who have received training in developed countries will be the back-bones for the steel plant operation, but still the steel plant will absolutely need technical assistance by experts from developed countries to expect a satisfactory start-up.

Table 6.4.1 Recruitment at Various Stages

	Preparation stage			Construction stage (54 months)				Operation start		Total
	–57 months	–54	–18	–15	–12	–9	–6	–3	0	
Management	3		7							10
Sup't/ or manager	4	9	2	1	2	5				23
Ass't Sup't or engineer	12	20	31	39	101	25	16			244
Clerk				55	20	9	100	61		245
Foreman				69	93	15	12			189
Skilled worker				33	432	245	116	8		834
Semi-skilled worker					6	509	367	93		975
Un-skilled wroker					6		172	1045		1,223
Total	19	29	40	197	660	808	783	1207	0	3,743

Note: Management consists of a managing director, deputy managing directors and general managers.

6.5 Preparation for Construction Facilities

Upon release of a "Go" notice, surveys and soil investigations will be initiated simultaneously. Before commencement of these works, the following must be urgently provided, and they include;

a. Camps for construction-related personnel, vehicles and roads,

b. Field offices and communication facilities,

c. Electric power and water supply facilities for construction use,

d. The construction materials storage yard and their security organization, and

e. Safety and medical facilities.

Subsequently, the mobilization for civil works will have to be started with;

f. Local surveys on aggregates, cements, earth, sands and stones, surveys on other construction materials, and establishment of a supply system,

g. Selection of contractors to use dredgers, dump trucks, bulldozers and other large-sized civil work equipment, and commencement of civil works,

h. Initiation of constructing crusher plants, concrete plants, and unloading berth for construction materials,

i. Provision of on-site workshops, and

k. Mobilization of construction workers, including provision of their camps.

Taking the case of a quantity of concrete to be used, it will be totalled 537,000 m^3 while concrete placing schedule will be as shown in Fig. 6.5.1. This will be a large scale civil work wherein at the peak, approximately 40,000 m^3 of concrete must be placed in one month, and will entail a great deal of jobs in procurement and supply of construction materials, mobilization of labour, and construction equipment, so a project manager who will have to command the construction works must be the one fully experienced and well qualified.

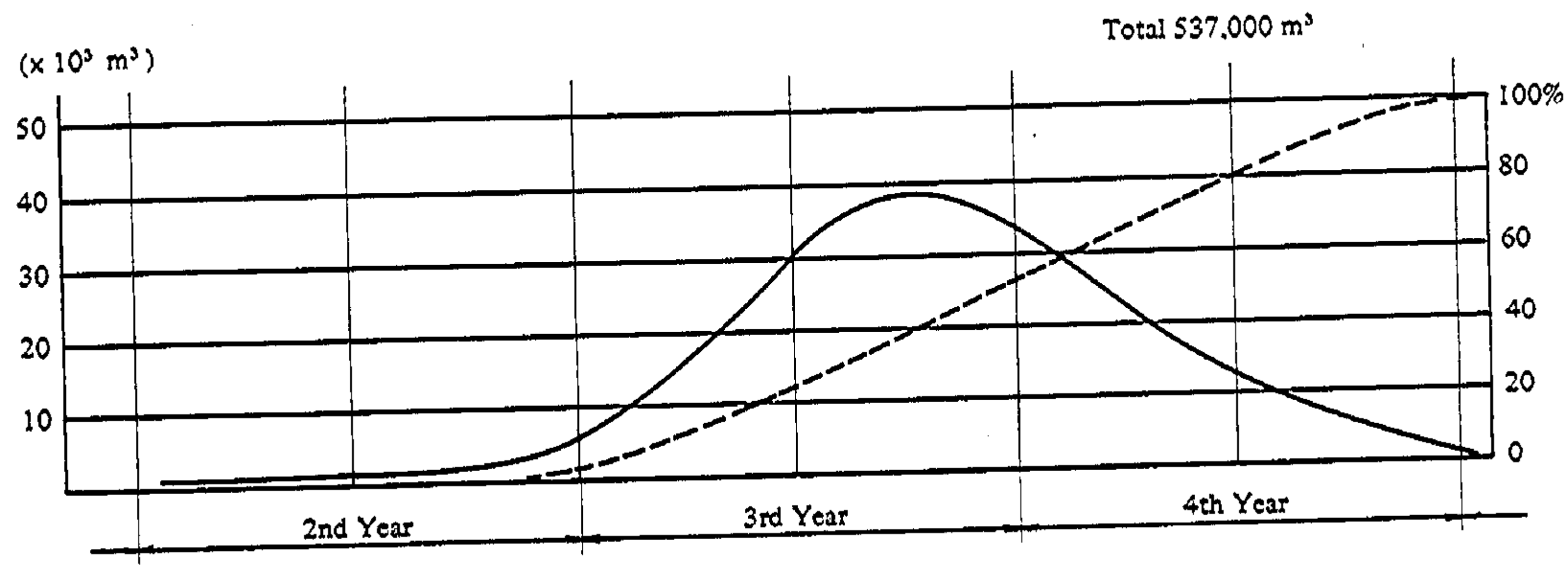

Fig. 6.5.1 Monthly Concrete Work Progress (To be performed)

Brief calculations indicate that at the peak of construction, more than 20,000 workers will be required per day to digest their respective works, more than 600 high-level engineers and more than 2,000 medium-level engineers and office staff will participate. Through these figures, significance of a community creation could be recognized.

Next, during the construction stage, a vast quantity of construction materials and equipment will be brought into the site, so their transportation, storage and related services will require competent staff.

The weights of equipment, machines, facilities, and fabricated steel materials for construction use which will be brought into Thailand during construction stage are as shown below. They will be shipped timely from various countries all over the world and delivered to the construction site in accordance with the progress of construction work.

	(In gross tonne)
Treatment facilities of raw and sub-materials	6,503
Direct reduction furnace and its associated equipment	18,147
Electric arc furnace and its associated equipment	14,000
Continuous casting machine and its associated equipment	19,000
Hot strip mill and its associated equipment	75,270
Cold strip mill and its associated equipment	54,776
Product shipping facilities	5,841
Utility, its related equipment and facilities	15,071
Maintenance facilities	4,091
Fabricated steel materials for construction use	63,677
Total	276,376 tonnes

6.6 Start-up Production Plan

(1) Start-up

As already mentioned, a construction period of 4.5 years or 54 months will be required from the date of a "Go" notice until the start-up of the steel plant. The time for start-up will fall in the autumn of 1984 provided that a decision-making on the steel plant is drawn immediately after the submission of the feasibility study report, and thereafter all construction works are progressed on schedule.

(2) Commissioning of Various Facilities

With consideration given to the facts that the proposed project is a large scale integrated steel plant which Thailand experiences for the first time in its history and that the facilities and plants provided will be of large-size, most up-to-date types, and that the work-in-process inventories must be adjusted during commissioning period, the commissioning of the respective plants in the steel plant is set as shown in Table 6.6.1.

Table 6.6.1 Commissioning Period for Major Facilities

Facilities	Period
Direct reduction plant	21 months
Electric arc furnace	24 months
Continuous casting machine	24 months
Hot strip mill	24 months
Cold strip mill	30 months

Where the commissioning of an integrated steel plant is to be performed, generally the blow-in of DR plant is started first and then other down-stream facilities and plants are put in order to firm the production system. For this project, however, it is designated that operation of the steelmaking shop (consisting of electric arc furnaces and continuous casting machines) be allowed to precede the other production facilities by 3 months. During this period, training of engineers and technicians will also take place. This action is required because steelmaking operation, particularly continuous casting operation depends more directly on the skillfulness of operators than in the cases with other operations and therefore the operators concerned must be fully trained so that this will not become a bottleneck in the commissioning of the entire steel plant.

During this period, the electric arc furnace will be operated with only scrap as main raw material.

(3) **Production Plan at Commissioning**

The rate of operation for a period from the start-up and during commissioning stage is established as shown in Fig. 6.6.1. Giving the production plan and the estimated quantities of products to be sold in the respective commissioning years, they will be as shown in Table 6.6.2.

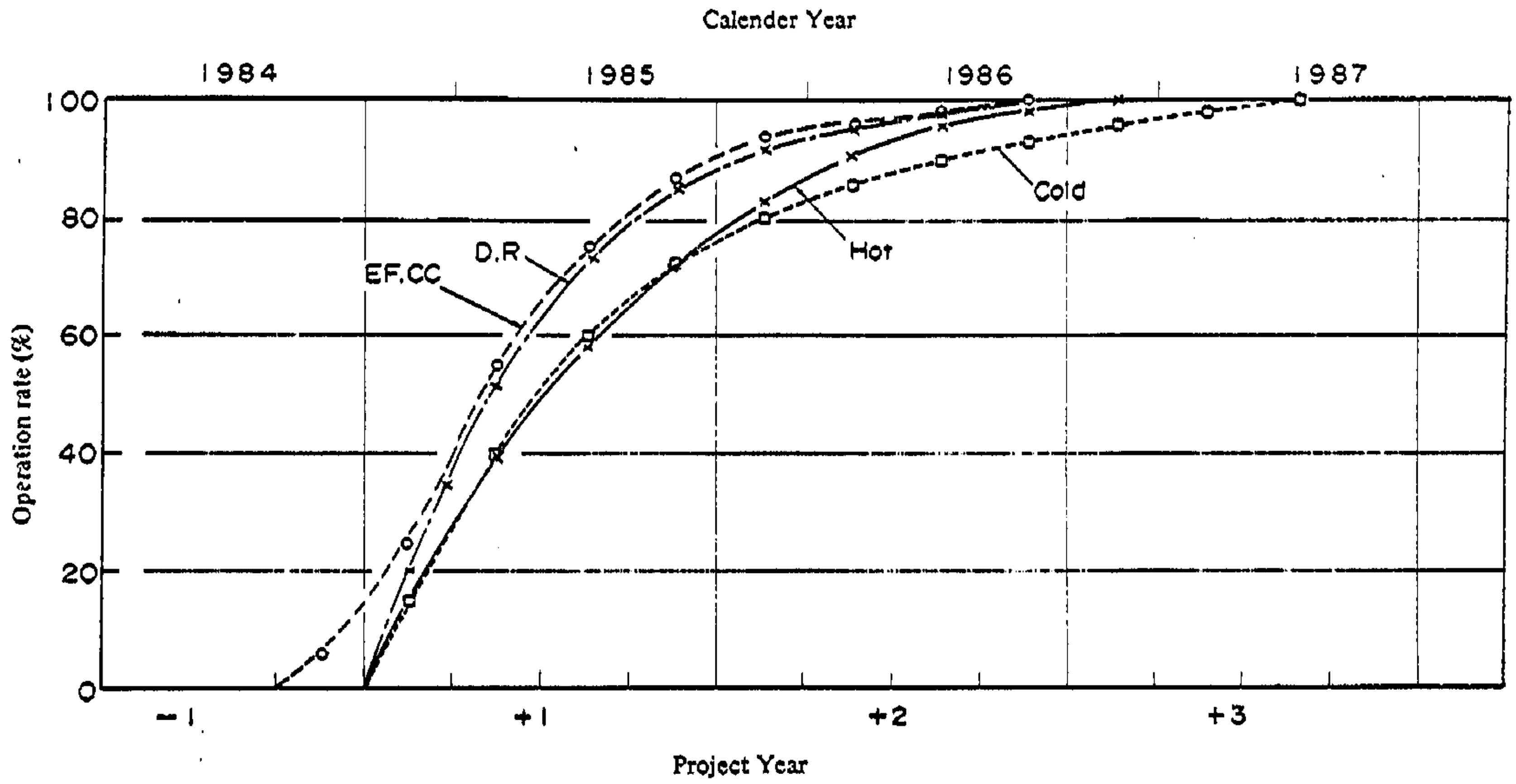

Fig. 6.6.1 Start-up Plan — 1st Stage

Table 6.6.2 Production Plan – 1st Stage

Project Year	–1	+1	+2	+3	+4
DR plant					
Operation rate (%)		46	92	100	100
Production (1,000 tonnes)		560	1,114	1,211	1,211
Steelmaking shop					
Operation rate (%)	2	60	97	100	100
Production (1,000 tonnes)	18	729	1,169	1,205	1,205
Hot strip mill					
Operation rate (%)		57	96	100	100
Production (1,000 tonnes)		672	1,122	1,169	1,169
Cold strip mill					
Operation rate (%)		47	87	99	100
Production (1,000 tonnes)		225	418	472	479
For selling (1,000 tonnes)					
Hot rolled products		380	623	624	624
Cold rolled products		214	414	472	479
Total		594	1,037	1,096	1,103
Calendar Year	1985	1986	1987	1988	1989

(4) Construction and Operation at the 2nd Stage

The equipment and facilities to be added at the 2nd stage will be as shown in Table 6.6.3.

Table 6.6.3 Equipment to be added at the 2nd Stage

	Equipment	No. of Unit
Direct reduction plant	Direct reduction plant	1
	Briquetting system	1
	Desulphurization system	1
Steelmaking shop	150-tonne electric arc furnace	2
	Continuous slab casting machine	1
	Cold scarfer for slab conditioning	1
Hot strip mill	Heating furnace	1
	4-Hi reversing type roughing machine	1
	Down coiler	1
Cold strip mill	56-in. reversing mill	1
	Batch type temper furnace	Expansion
	Continuous temper mill	1
	56-in. 4-Hi skin pass mill	1
	Coil preparation line	1
	Shear line	1

In addition, the construction and operation schedules at the 2nd stage are as previously shown in Fig. 4.7.1. In detail, construction will be initiated on the 21st month after the start-up of the 1st stage operation, and will last for a period of 36 months. Consequently, the start-up of the 2nd stage operation will fall on the 57th month following the start-up of the 1st stage operation or, as previously mentioned, in the mid-1989 assuming that everything from decision-making on the part of the steel plant to the 1st and 2nd stage construction and operations, is carried out on schedule. Based on this literature, the end of 1990 will be the time when the 2nd stage operation can reach its designed full capacity.

Giving the relationship between the commissioning schedule at the 2nd stage and the production schedule at the 1st stage, it can be programmed as shown in Table 6.6.4.

Table 6.6.4 Start-up Production Programme

Year / Assumed year		+1	+2	+3	+4	+5	+6	+7	+8
	(1984)	(1985)	(1986)	(1987)	(1988)	(1989)	(1990)	(1991)	(1992)
1st stage	44	799	1059	1101	1103	1103	1103	1103	1103
2nd stage						160	574	638	638
Total	44	799	1059	1101	1103	1263	1677	1741	1741

(5) Raw Materials Procurement Schedule

The raw materials supply and demand schedule based on the commissioning and production schedules is established as shown in Table 6.6.5.

Table 6.6.5 Quantities of Purchase, Consumption and Inventory

(Unit: t/y)

Year		0			1			2			3			4			5~		
Materials		P	C	I	P	C	I	P	C	I	P	C	I	P	C	I	P	C	I
Iron oxides	Pellets	50,000	–	50,000	100,000	64,000	86,000	1,250,000	983,000	353,000	1,400,000	1,514,000	239,000	1,400,000	1,400,000	239,000	1,400,000	1,400,000	239,000
	Lump	–	–	–	–	–	–	120,000	110,000	10,000	365,000	207,000	168,000	365,000	365,000	168,000	365,000	365,000	168,000
Scrap	Imported	50,000	–	50,000	25,000	65,000	10,000	333,000	273,000	70,000	135,000	155,000	50,000	139,000	139,000	50,000	139,000	139,000	50,000
	(Return)	–	–	–	(10,000)	–	(10,000)	(110,000)	100,000	(20,000)	(140,000)	140,000	(20,000)	(144,000)	144,000	(20,000)	(144,000)	144,000	(20,000)
Ferro-alloys	Fe-Mn	200	–	200	600	600	200	6,800	5,600	1,400	7,500	7,100	1,800	7,300	7,300	1,800	7,300	7,300	1,800
	Fe-Si	100	–	100	100	100	100	800	700	200	900	900	200	900	900	200	900	900	200
Burnt lime		–	–	–	7,600	7,000	600	70,400	70,400	600	89,300	89,300	600	90,700	90,700	600	90,700	90,700	600
Fluorite		100	–	100	250	250	100	2,900	2,500	500	3,000	3,200	300	3,200	3,200	300	3,200	3,200	300
Aluminium		100	–	100	200	200	100	2,400	2,000	500	2,800	2,600	700	2,600	2,600	700	2,600	2,600	700
Carburizing M.		100	–	100	360	360	100	4,400	3,600	900	4,900	4,600	1,200	4,700	4,700	1,200	4,700	4,700	1,200

Legend

P: Purchase

C: Consumption

I: Inventory

(6) Other Preparations

Prior to the start-up of operation, the following preparations will be required.

a. Provision of operational materials (lubricant, electrodes, refractories, castables, hydrochloric acid for pickling, rolling oil, packing materials, furnishings, fixtures, and supplies.)

b. Provision of materials and equipment for maintenance and repair use.

c. Laying of the groundwork for marketing and sales to potential customers.

d. A large amount of burnt lime is going to be used at electric arc furnaces and it will not be manufactured at the on-site plant in the steel plant, but will be produced at the mines. It will be necessary to provide a proper measure in burnt lime manufacturing to meet the steelmaking shop schedule. Detailed description of this item will be given later.

e. Fostering of related and supporting industries.

6.7 Effect of One Year Delay of the Start-up

As previously described, it is of the utmost importance that all schedules covering from decision-making of the steel plant implementation to the 1st and 2nd stage construction and operations are carried out as planned, and should any of the schedules delay in its implementation, the concequential effect is substantial. For exmaple, the relationship between the demand and production in the case of delay in the implementation of the project will be aggregated as shown in Fig. 6.6.2.

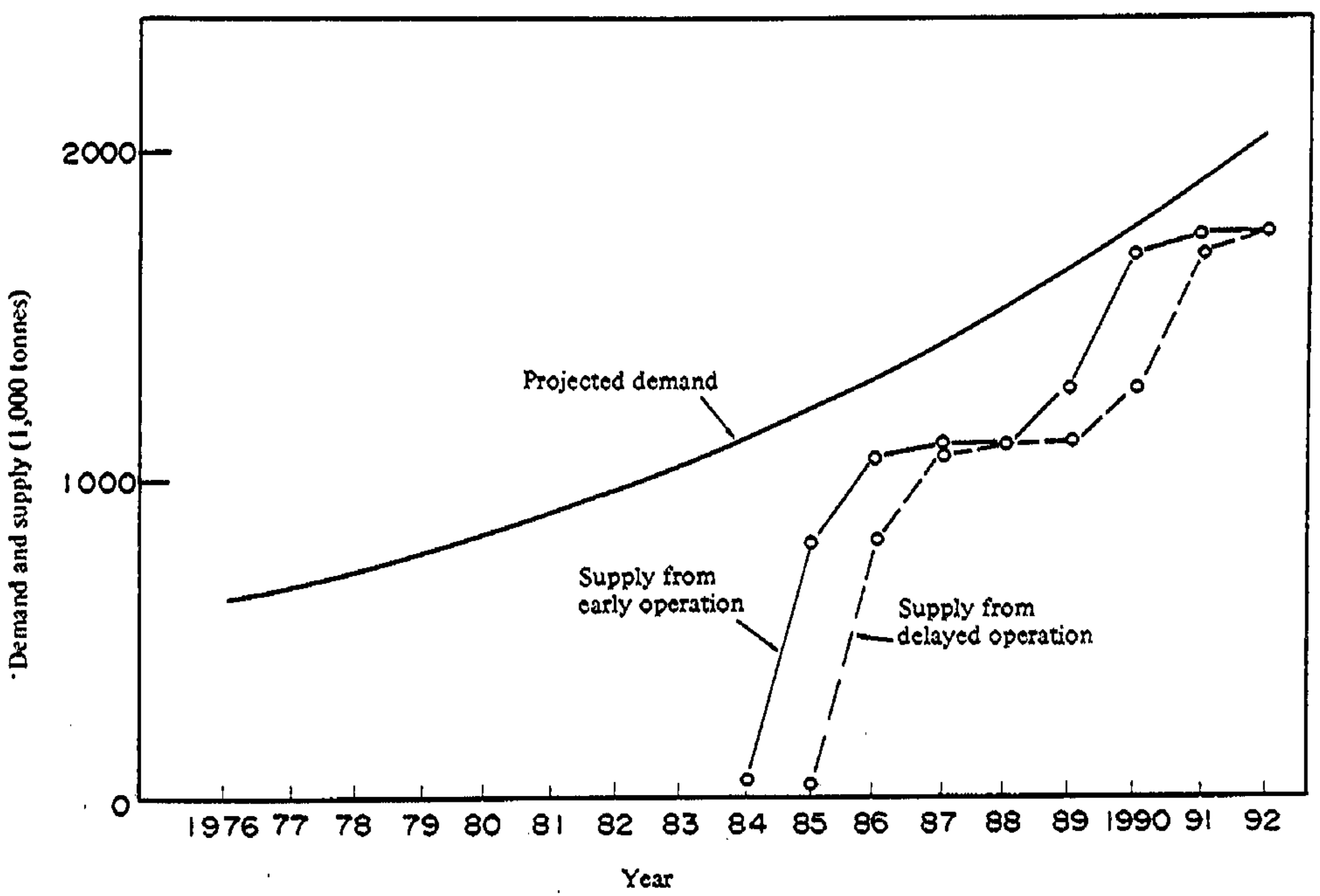

Fig. 6.6.2 Effect of Delayed Start-up