CHAPTER 6. PORT PLAN

6.1. Scale of Port Development

6.1.1. Berth Requirements

1) Cargo Volume by Commodity Handled at the Port

As shown in the previous chapter, in analyzing the port situation it is important to breakdown the total cargo volume by commodity and into the two categories of foreign and domestic trade.

Another important factor to take into consideration in analyzing the port situation is the "Gateway Port Policy".

In planning port facilities for foreign trade, it is especially important to consider whether each foreign trade commodity will be directly imported/exported or first transhipped from/to a gateway port. Each major type of commodity is classified with reference to this Gateway Port Policy as shown in Table 6.1.1.

Table 6.1.1 Cargo Volumes by Trade Type

(000 t)

Commodity	Trade Type	1985	1990	2000
Palm Oil	Direct export	110	487	1,438
	Domestic transport	47	209	616
Forestry Products	Direct export	71	125	225
	Domestic transport	8	14	25
Fertilizer	Via gateway port or direct import	107	157	268
	Domestic transport	90	114	170
Rice	Direct import	45	56	87
	Domestic trade in	36	46	71
	Domestic trade out	16	20	31
Palm Kernel & Rubber	Direct export	13	83	285
	Domestic trade out	9	43	137
General Cargo	Import via gateway port	45	69	145
	Export via gateway port	1	1	3
	Domestic trade in	25	39	81
	Domestic trade out	13	19	40
Construction Materials	Direct import	35	35	35
Total		671	1,517	3,657

2) Ship Size for Port Planning

In formulating a port plan, assumptions must be made concerning the size of ships calling at the port, port cargo handling capacity, etc.

The question of ship size in the planning of port facilities is dealt with here.

(1) Size of ships presently calling at Dumai Port

According to an analysis of Dumai Port shipping records for the years 1979 to 1981, the number of ship calls and the average tonnage of ocean going vessels by commodity is shown in Table 6.1.2.

Table 6.1.2 Number of Ship Calls and Average Tonnage of Ocean Going Vessels

	1979		1980		1981		Average DWT
Commodity Transported	Ship Calls	Average DWT	Ship Calls	Average DWT	Ship Calls	Average DWT	
Rice	9	8,202	11	8,519	7	8,022	8,284
Log	64	6,934	51	6,647	26	6,251	6,704
Sawn Timber	15	4,489	33	3,878	38	5,070	4,511
GC and others	18	12,422	13	12,187	29	16,155	14,175
Pile	3	2,598	11	8,881	26	8,045	7,866

Source: Dumai Port Administration

Tables 6.1.3 and 6.1.4 show the frequency of ship calls the average tonnage of ocean going vessels and interinsular ships respectively.

This data relating to ocean going vessels indicates that the average tonnage of ships calling at Dumai Port was about 8,000 DWT and that ships up to 15,000 DWT represent 91% of all ocean going vessels. As for inter island transportation, this study assumes that the average tonnage of ships is approximately 1,000 DWT.

(2) Ship Size by Commodity

a) Palm Oil Carrier Ship Size

Vessels that carry palm oil fall into a category of vessels called chemical tankers. These vessels are built for transporting any liquid cargo except for crude oil, water, liquefied gas and substances classified as product carrier cargo. Chemical cargo carried by such vessels are mainly classified into six types, named according to the AB code; petrochemical products (A); coal tar products (B); carbohydrate derivatives including molasses, alcohols and wines (C); vegetable oils including animal fats and oils, fish oils, palm oils and oils derived from a variety of seeds (D); heavy chemicals (E); and molten sulphur (S). Fig. 6.1.1 shows the distribution pattern for vessels that carry type D cargo. Such vessels include not only chemical tankers, but also bulk carriers and cargo ships that have facilities such as deep tanks for carrying chemical cargo.

Table 6.1.3 Ocean Going Vessels that called at Dumai Arranged by Ship Size

Year / Classification	1979		1980		1981		Average	
	Number of Ships	Average Tonnage DWT	Number of Ships	Average Tonnage DWT	Number of Ships	Average Tonnage DWT	Composition %	Tonnage DWT
~ 3,000 DWT	6 (6.0)	1,568	16 (13.6)	1,753	20 (16.9)	1,939	12.5	1,815
3,001 ~ 5,000 DWT	12 (12.0)	3,734	11 (9.3)	4,151	10 (8.5)	3,975	9.9	3,946
5,001 ~ 10,000 DWT	68 (68.0)	6,504	77 (65.3)	6,674	62 (52.5)	6,417	61.6	6,571
10,001 ~ 15,000 DWT	7 (7.0)	11,283	9 (7.6)	11,371	8 (6.8)	11,300	7.1	11,322
15,001 ~ 20,000 DWT	3 (3.0)	16,313	1 (0.1)	17,110	5 (4.2)	15,880	2.7	16,161
20,001 ~ 30,000 DWT	4 (4.0)	22,700	4 (3.4)	23,323	13 (11.0)	22,249	6.2	22,539
Total	100 (100%)	7,152	118 (100%)	6,783	118 (100%)	7,980	100	7,623

Source: Dumai Port Administration

Table 6.1.4 Inter-Insular Vessels that called at Dumai Arranged by Ship Size

Year / Classification	1979		1980		1981		Average	
	Number of ships	Average Tonnage	Number of ships	Average Tonnage	Number of ships	Average Tonnage	Composition	Tonnage
		DWT		DWT		DWT	%	DWT
~ 500 DWT	17 (27.4)	340	9 (14.3)	410	6 (9.2)	460	16.8	380
501 ~ 1,000 DWT	24 (38.7)	730	27 (42.8)	590	42 (64.2)	560	48.9	610
1,001 ~	21 (33.9)	1,550	27 (42.9)	1,620	16 (26.2)	1,540	34.3	1,580
Total	62 (100%)	900	63 (100%)	1,000	65 (100%)	780	100.0	890

Source: Dumai Port Administration

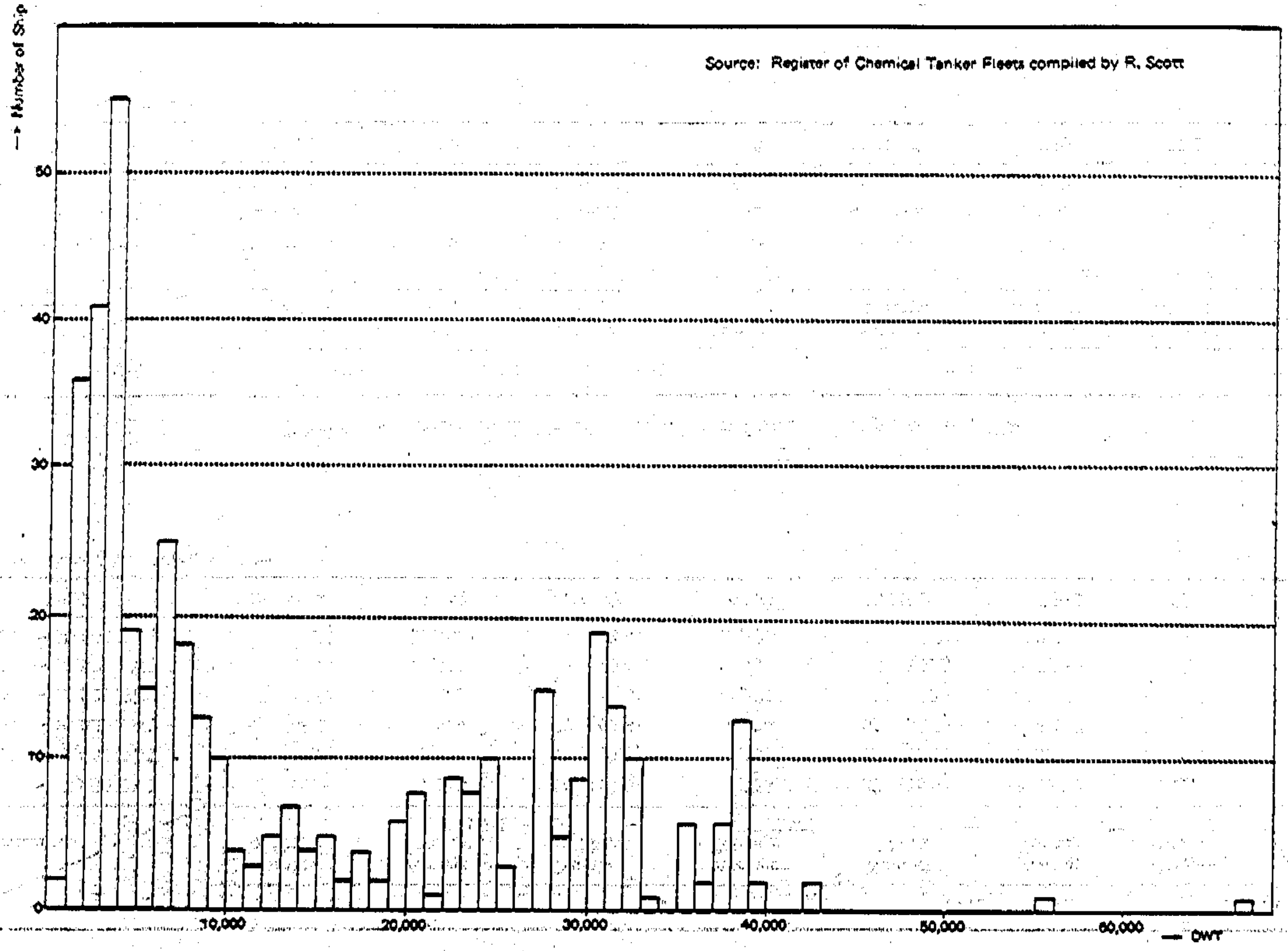


Fig. 6.1.1 Ship Size Distribution of Chemical Carrier enable to carry Palm Oil

Fig. 6.1.1 shows that there are basically two sizes of ship: those less than 10,000 DWT which are found on coastal lines or adjacent sea lines, and ships between 20,000 ~ 30,000 DWT which are found on ocean going lines. Vessels that call at Southeast Asian ports and that take on palm oil cargo are large scale parcel tankers, belonging to the larger class of vessels.

Parcel tankers generally provide liner type and operate according to services, regular trading patterns.

Table 6.1.5 shows the principal operators and their large-scale parcel tankers. Based upon Fig. 6.1.1, the average tonnage of oceangoing vessels that are larger than 10,000 DWT and that carry palm oil can be roughly estimated at 26,000 DWT. 86% of such vessels are less than 35,000 DWT.

As for interinsular transportation, Table 6.1.6 shows sample dimensions for the type of small parcel tankers that are engaged along coastal lines in Indonesia. Average tonnage is about 2,300 DWT. As for general cargo vessels equipped with deep tanks for vegitable oil their average tonnage is estimated at roughly 11,000 DWT, as shown in Table 6.1.7.

It can be assumed that palm oil is shipped out in vessels listed in Table 6.1.8.

Table 6.1.5 Principal Operators of Large-Scale Parcel Tankers

Operators	Existing		Under construction	
	No.	DWT	No.	DWT
Iver Bugge (Norway)	2	58,678	2	80,000
Ditler-Simonsen (Norway)	2	60,818		
Eurochem (U.K.)	2	59,602		
Gotaas-Larsen (U.S.A.)	4	127,216		
Marine Transport Lines	2	61,355		
J.O. Odfjell	1	33,000		
Odfjell Johnson	2	77,200	2	77,200
Odfjell Westfal-Larsen (Norway)	18	518,839	7	191,000
C. Haaland	2	63,004		
O.B. Sorenson	—	—	2	76,000
Panocean-Anco (U.K.)	14	347,360		
Pemex (Mexico)	2	61,592		
Petrobras (Brazil)	2	46,935		
Steuber (U.S.A.)	1	20,381		
Ole Schroder (Norway)	4	135,804		
Stolt-Nielsen* (U.S.A.)	25	706,510		
Mowinckels	1	32,514		
Total	84	2,410,808	13	424,200

Note: *includes 4 ships of 18,421 tons dwt.

Source: The Bolletin of Japan Maritime Research Institute No. 201, 1983.3 & Chemical Tanker, Fairplay 2nd Edition 1981

Table 6.1.6 Dimensions of Palm Oil Carriers Engaged in Domestic Transportation

	DWT	Overall Length	Draft	Tank Capacity	No. of Tanks
	ton	m	m	m^3	
1	1,779	71.70	5.00	1,958	8
2	1,340	61.15	4.50	1,570	8
3	1,329	60.00	4.45	1,566	8
4	1,526	65.68	4.50	1,775	8
5	2,600	77.49	5.00	2,695	8
6	6,062	101.78	7.02	5,248	8
7	1,158	57.25	4.29	1,274	8
8	2,700	77.60	5.15	2,787	10
9	2,139	72.37	5.10	2,605	10
10	2,552	77.24	5.03	2,706	10
11	1,557	63.90	6.49	1,790	8
12	2,762	81.25	5.40	2,296	8
13	2,700	73.99	5.38	2,713	10
Average	2,323	82.06	5.18	2,383	

Table 6.1.7 Distribution of General Cargo Ships with Deep Tanks carrying Vegitable Oil

Ship Size (DWT)	General Cargo Ships with Deep Tanks	Cumulative ratio
1,000 ∿ 2,000	3	0.41
2,000 ∿ 3,000	3	0.82
3,000 ∿ 4,000	8	1.92
4,000 ∿ 5,000	14	3.83
5,000 ∿ 6,000	11	5.34
6,000 ∿ 7,000	27	9.03
7,000 ∿ 8,000	50	15.87
8,000 ∿ 9,000	40	21.34
9,000 ∿ 10,000	77	31.87
10,000 ∿ 11,000	70	41.45
11,000 ∿ 12,000	72	51.30
12,000 ∿ 13,000	132	69.35
13,000 ∿ 14,000	76	79.75
14,000 ∿ 15,000	60	87.96
15,000 ∿ 16,000	31	92.20
16,000 ∿ 17,000	29	96.17
17,000 ∿ 18,000	12	97.81
18,000 ∿ 19,000	2	98.08
19,000 ∿ 20,000	4	98.63
20,000 ∿ 21,000	6	99.45
21,000 ∿	4	100.00

total number of ship 731

Source: Register of Ships, 1980-81

Table 6.1.8 . Ships for Palm Oil Transportation

	Type of Ship	Tonnage	Lot Size
		DWT	t/ship
Export	Parcel Tanker	26,000	26,000
	Deep Tank	10,000	2,200
Domestic	Parcel Tanker	2,300	2,200

Table 6.1.9 Ship Size Distribution of Conventional Ship for Timber in Japan

Ship Size (DWT)	Number of Ship	Aceumulative Percentage
4,001 ∿ 5,000	2	3.63
5,001 ∿ 6,000	14	29.09
6,001 ∿ 7,000	7	41.82
7,001 ∿ 8,000	3	47.27
8,001 ∿ 9,000		
9,001 ∿ 10,000	2	50.91
10,001 ∿ 11,000		
11,001 ∿ 12,000		
12,001 ∿ 13,000		
13,001 ∿ 14,000		
14,001 ∿ 15,000	1	52.73
15,001 ∿ 16,000	4	60.00
16,001 ∿ 17,000	6	70.91
17,001 ∿ 18,000	2	74.55
18,001 ∿ 19,000	6	85.45
19,001 ∿ 20,000	1	87.27
20,001 ∿ 21,000	1	89.09
21,001 ∿ 22,000		
22,001 ∿ 23,000		
23,001 ∿ 24,000		
24,001 ∿ 25,000		
25,001 ∿ 26,000		
26,001 ∿ 27,000		
27,001 ∿ 28,000	2	92.73
28,001 ∿ 29,000		
29,001 ∿ 30,000		
30,001 ∿ 35,000	1	94.55
35,001 ∿ 40,000	3	100.00

[total number of ship 55
average size; 12,700DWT]

Table 6.1.10 Full Load Draft Distribution of Conventional Ship for Timber in Japan

Full Load Draft of Ship (m)	Number of Ship	Accumulative percentage
6.01 ∿ 6.50	5	9.09
6.51 ∿ 7.00	18	41.82
7.01 ∿ 7.50	4	49.09
7.51 ∿ 8.00	1	50.91
8.01 ∿ 8.50		
8.51 ∿ 9.00	8	65.45
9.01 ∿ 9.50	12	87.27
9.51 ∿ 10.00	1	89.09
10.01 ∿ 10.51	1	90.91
10.51 ∿ 11.00	2	94.55
11.01 ∿ 12.00		
12.01 ∿ 13.00	3	100.00

total number of ship 55

b) Rice

It is estimated that ocean going rice cargo ships will average 8,000 DWT, based upon daily shipping records as shown in Table 6.1.2. Inter-insular rice cargo vessels are estimated at 1,000 DWT, as shown in Table 6.1.4. Redistribution feeder service ships are estimated at 500 DWT.

c) Sawn Timber

According to the daily shipping records at Dumai Port, the average tonnage of ships carrying sawn timber was 5,000 DWT. Reference works from Samarinda and Japan however, suggest that 12,000 DWT is a more accurate value for average ship tonnage. Table 6.1.9 and Table 6.1.10 show respectively, the ship size distribution and the full load draft distribution of timber carriers in Japan. The average ship tonnage for domestic transportation has been estimated at 1,000 DWT.

d) Fertilizer

Domestically produced fertilizer such as urea can be economically transported to Dumai by sea from the present factory at Palembang and/or the factory now under construction at Lhokseumawe. According to shipping records for bagged fertilizer products, 126,000 tons were shipped from Palembang in 1979. Also, according to a supply/demand forecast for East Java which is one of the largest fertilizer consuming areas in Indonesia, the East Java area will reach a level of self-sufficiency in fertilizer production by 1988. Therefore, the Palembang factory will be able to provide sufficient quantities of fertilizer to meet the needs of Sumatra, shipping the reqired amount of bagged fertilizer through Dumai Port. It is estimated that average ship size will be 5,000 DWT, with an average lot size of 4,000 tons. This estimation is based upon shipping records for "Khusus", which in the future as well are expected to have a major role in fertilizer transportation.

As for imported fertilizer, potassium and phosphate, these will be shipped to Dumai from a gateway port that has a bagging plant within its port area. It is anticipated that these goods will

Table 6.1.11. NUMBER of SHIPS for SPECIAL LINE PURPOSE (KHSUS), 1980

TYPE	OWNERSHIP								TOTAL	
	PRIVATELY OWNED		HIRE PURCHASE		NATIONAL SHIP CHARTERED		FOREIGN SHIP CHARTERED			
	UNIT	DWT	UNIT	DWT	UNIT	DWT	UNIT	DWT	UNIT	DWT
(1)	(2)	(3)	(4)	(4)	(6)	(7)	(8)	(9)	(10)	(11)
1. General	4	16,055	–	–	–	–	–	–	–	16,055
	9	3,283 *)	–	–	–	–	–	–	–	3,283 *)
	6	1,920 **)	–	–	–	–	–	–	–	1,920 **)
2. Log carrier	60	400,664	42	293,263	–	–	–	–	102	693,927
3. Tanker	38	424,695	37	737,758	12	26,534	48	1,481,801	135	2,670,788
4. Off shore	164	86,085 *)	30	19,848 *)	80	47,568 *)	139	184,026 *)	413	337,527 *)
	140	88,757 **)	22	19,540 **)	25	19,749 **)	57	115,533 **)	244	243,579 **)
5. Industrial Carrier	4	87,092	–	–	–	–	–	–	4	87,092
	192	103,744 *)	–	–	–	–	–	–	192	103,744 *)
	114	32,439 **)	–	–	–	–	–	–	114	32,439 **)
	38	13,568 ***)	–	–	–	–	–	–	38	13,568 ***)
6. Estates	3	86,577	–	–	–	–	–	–	3	86,577
	14	5,323 *)	–	–	–	–	–	–	5	5,323 *)
	1	108 **)	–	–	–	–	–	–	1	108 **)
Mining	1	515	–	–	–	–	–	–	1	515
	165	67,905 *)	–	–	–	–	–	–	165	69,905 *)
	113	32,331 **)	–	–	–	–	–	–	113	32,331 **)
	38	13,568 ***)	–	–	–	–	–	–	38	13,568 ***)
Salt	8	8,038 *)	–	–	–	–	–	–	8	8,038 *)
Fertilizer	3	22,448 *)	–	–	–	–	–	–	3	22,448 *)
Cement	2	30 *)	–	–	–	–	–	–	2	30 *)
7. Fishery	302	34,293 *)	–	–	–	–	–	–	302	34,293 *)
8. Forestry	197	43,325 *)	–	–	–	–	–	–	197	43,325 *)
	158	31,025 **)	–	–	–	–	–	–	158	31,025 **)
	103	31,018 ***)	–	–	–	–	–	–	103	31,018 ***)
9. Others	5	7,059	–	–	–	–	–	–	5	7,059
	12	2,137 *)	–	–	–	–	–	–	12	2,137 *)
	1	150 **)	–	–	–	–	–	–	1	150 **)
TOTAL	111	935,565	79	1,031,021	12	26,534	48	1,481,801	250	3,474,921
	876	272,867 *)	30	19,848 *)	80	47,568 *)	139	184,026 *)	1,125	524,309 *)
	419	154,291 **)	22	19,540 **)	25	19,749 **)	57	115,533 **)	523	309,113 **)
	141	44,586 ***)							141	44,586 ***)

Source: Directorate General of Sea Communication

*) B.R.T. = Gross Registered Ton. **) H.P. = Horse Power. ***) M^3

Source: CBS, Statistical Year book of Indonesia 1980/1981 be shipped by conventional carriers of 6,000 ~ 10,000 DWT.

Judging from the volume of fertilizer, that is forecast to pass through Dumai Port, it can be assumed that this bagged sector fertilizer will be carried in ships that have an average dead weight of 8,000 tons. Maximum ship size for fertilizer carrier owned by Khusus can be estimated at 13,000 DWT according to Table 6.1.11.

e) General Cargo

According to Dumai Port's daily shipping records, general cargo was transported mainly by large size vessels. Importation of various materials necessary for Riau's industrial development was carried out mainly by ships chartered by contractors. It is assumed that such ships are mainly of the 10,000 DWT class, and that lot size is 5,000 tons per ship. As for inter-insular transportation, average ship size is assumed to be 5,000 DWT. Feeder route ships calling at Dumai are an average 300 DWT.

f) Palm Kernel and Rubber

Palm kernel and rubber will be shipped out in vessels that are comparable in size to general cargo vessels. These commodities are largely for export, so average ship size is estimated at 10,000 DWT. As for domestic transportation average ship size is estimated at 1,000 DWT, based upon daily shipping records as shown in Table 6.1.4.

3) Cargo Handling Productivity

The annual loading/unloading rate by commodity per unit berth length has been estimated as follows.

(1) Palm Oil

Palm oil will be loaded onto ships at Dumai Port for both export and domestic use. According to the results of the cargo forecast, 70% of the palm oil handled at Dumai Port will be for export. Of this export bound palm oil, it has been estimated that 60% will be carried by parcel tankers, and that the rest will be carried by conventional cargo vessels with deep tanks. Share of all palm oil transport (both domestic and export bound) by ship type is shown in the following table.

	Type of Ship	Transportation Share
Export	Parcel Tanker	42%
	Deep Tank	28%
Domestic	Parcel Tanker	30%

The loading rate for palm oil will depend upon the pump capacity at the storage tank yard. According to the palm oil storage tank construction plan for PTP IV at Dumai Port, the pipe diameter for palm oil loading will be 20 cm. Judging from this diameter and from the loading rate at the existing palm oil loading facility at Belawan Port, it can be estimated that the rate at Dumai will be 250 t/h for small parcel tankers. Since large parcel tankers for palm oil export have several manifolds on deck, it can be estimated that the loading rate for these large tankers will be 1,200 t/h.

Table 6.1.12 shows loading rates by ship type as estimated in this study.

Table 6.3.12 Loading Rates for Palm Oil by Ship Type

Route	Ship Type	Loading Rate
Export	Parcel Tanker	1,000 t/h
	Convensional ship with deep tank	250 t/h
Domestic	Parcel Tanker	250 t/h

(2) Forestry products

a) Actual loading rates at Samarinda Port

Samarinda Port is one of the major ports of East Kalimantan Province. The total volume of forestry products exported from Samarinda in 1981 was 703,000 tons, which accounted for 43 percent of all foresty product exports from East Kalimantan. Actual loading rates recently in effect at the port for sawn timber and plywood are shown in Table 6.1.13.

Table 6.1.13 Loading Rates at Samarinda

	Commodity	Number of Ships	Mean Ship Size	Overall Length	Loading Time	Cargo Volume	Loading rate	Remarks
Export	Sawn Timber Plywood	12	12,800 DWT (38,600)	123 m (195)	58 days	57,500 m³	991 m³/day (2,700)	( ): max. value
Domestic	Plywood	12	765 (2,100)	49 m (70)	43	8,150	190 (435)	

b) Loading Rates at Dumai

Although the average loading rate for ocean-going vessels at Samarinda Port is about 1000 m³/day, judging from the port's maximum recorded loading rate, if cargo packing and packaging were standardized, it seems likely that the average loading rate could be raised.

Accordingly, a loading rate for forestry products can be determined by examing the loading rate for similar types and sizes of cargo, such as bagged cement and fertilizer. For example, the loading rate for bagged cement is 1,600 tons/day ~ 1,750 tons/day. For conventional vessels in service on oceangoing routes, the current loading rate per gang per hour is currently 25 t/g/h by normal loading/unloading methods.

From these facts, the cargo handling rate for oceangoing vessels in Dumai is estimated to be 1,500 tons/day or at least 25 tons/gang/hour assuming a quaywall with sufficient handling facilities and yard space. The loading rate for domestic shipment remains at 18 tons/gang/hour.

c) Cargo Handling Efficiency

90% of the total amount of sawn timber will be exported. The lot sizes for export and domestic transportation are 9,000 tons and 800 tons respectively. Table 6.1.14 shows the composition of ships, by size, taking into account that the overall length of ships used for domestic transportation is shorter than that for oceangoing vessels and that two of the smaller ships can berth at the same time.

Table 6.1.14 Percentage of Ship Type by Size (Forestry products)

	Percentage of Cargo	DWT	Lot Size	Percentage of Ships
Export	90%	12,000	9,000 ton	62%
Domestic	10%	1,000	800	38%

On the basis of the assumptions that the average number of gangs per ship is 4 for oceangoing ships and 1 for domestic ships, and that the coefficient of cargo handling efficiency is 0.7, including idle time and rest time, the time required to load each ship can be calculated as follows:

$$\text{12,000 DWT (for export):} \quad \frac{9{,}000 \text{ t}}{25 \text{ t/g/h} \times 4 \times 0.7} = 128 \text{ hr}$$

$$\text{1,000 DWT (for domestic):} \quad \frac{800 \text{ t}}{18 \text{ t/g/h} \times 1 \times 0.7} = 63 \text{ hr}$$

A berth occupancy time can be obtained by adding the time for berthing and unberthing to the loading time. Table 6.1.5. shows berth occupancy time by ship size, assuming an additional 12 hours for berthing and unberthing.

Table 6.1.15 Berth Occupancy Time for Timber Carrier

	Ship Size	Berth Occupancy time
Export	12,000 DWT	140 hrs.
Domestic	1,000 DWT	75 hrs.

The total number of ships (N) can be calculated as follows:

$$\frac{0.62 \times 140 \times N + 0.38 \times 75N}{335 \times 24} = 0.6$$

$$\therefore N = 42$$

The number of ships per year which load sawn timber from one berth is shown in the following table.

	Ship Size	Number of ships
Export	12,000 DWT	26
Domestic	1,000 DWT	16

Annual sawn timber loading quantity (w) per berth can be calculated as follows:

w = 26 ships x 9,000 ton/ship + 16 ships x 800 ton/ship x2
= 259,600 tons

The required berth length for a ship is 185 m.

The annual loading rate (T) per unit length of a berth is calculated as follows:

T = 259,600 t/185m ≒ 1,400 t/m/y

By the year 2000 the coefficient of cargo handling efficiency will increase to 0.8. At this time T will be as follows:

T = 1,570 t/m/y

The cargo handling rate at the existing jetty type berth is assumed to be 90% of this estimate.

(3) Rice

20% of the total amount of rice unloaded in Dumai will be distributed by inter insular vessels. According to daily shipping records the average tonnage of ocean going vessels is estimated at 8,000 DWT. (See Table 6.1.3). The average size of inter-insular vessels is estimated at 1,000 DWT.

A rice per gang loading rate can be calculated as follows,

Weight of rice per sling:	10 bags x 100 kg/bag = 1.0 ton
Loading/Unloading cycle rate:	20/hour
Loading/Unloading rate:	1.0 x 20 = 20 t/g/h
On the following assumptions,	
Average number of gangs per ship:	3.0 for 8,000 DWT
	1.0 for 1,000 DWT
Lot size per ship:	6,400 ton for 8,000 DWT
	500 ton for 1,000 DWT
Coefficient of cargo handling efficiency (including idle and rest time):	0.7

The loading/unloading time can be calculated as follows,

8,000 DWT (for Import): $\frac{6{,}400\ t}{20\ t/g/h \times 3.0\ g \times 0.7} = 152\ h$

1,000 DWT (for Domestic): $\frac{500\ t}{20\ t/g/h \times 1.0\ g \times 0.7} = 36\ h$

The berth occupancy time can be obtained by adding 12 hours for berthing and unberthing to the above values. Table 6.1.16 shows the berth occupancy time, by ship size.

Table 6.1.16 Berth Occupancy Time per Ship (Rice)

	Ship Size	Loading Time	Berthing and Unberthing Time	Berth Occupancy Time
Import	8,000 DWT	152 hours	12 hours	164 hours
Domestic	1,000 DWT	36 hours	12 hours	48 hours

The composition of ships by ship size, follows from the cargo volume of each type and the cargo lot sizes, and is shown in the following table.

	Ship Size	Percentage of Ships
Import	8,000 DWT	45%
Domestic	1,000 DWT	55%

The total number of ships (N) can be calculated as follows,

$$\frac{0.45 \times 164 \text{ h} \times N + 0.55 \times 48 \text{ h} \times N}{305 \text{ days} \times 24 \text{ hours/day}} = 0.6$$

$$\therefore N = 44$$

Here, berth occupancy rate is assumed to be 0.6 and effective number working days per year 305. It was assumed that 30 days each year are lost due to rain.

The quantity of rice loaded/unloaded (W) per berth annually can be calculated as follows,

$$W = 20 \text{ ships} \times 6{,}400 \text{ t/ship} + 24 \text{ ships} \times 500 \text{ t/ship}$$
$$= 140{,}000 \text{ t}$$

The required berth length for an 8,000 DWT ship is 165 m. The annual loading/unloading rate (T) per unit length of a berth is calculated as follows,

$$T = 140{,}000 \text{ t}/165\text{m}$$
$$\fallingdotseq 850 \text{ t/m/y}$$

By the year 2000 the coefficient of cargo handling efficiency will increase to 0.8. In this case T will be as follows,

$$T \fallingdotseq 970 \text{ t/m/y}$$

The cargo handling rate at the existing jetty type berth is assumed to be 90% of this estimate. These cargo handling rates are shown in the following table.

Year	1990	2000
New Berth	850 t/m	970 t/m
Existing Berth	770	870

(4) Fertilizer

An unloading rate per gang for fertilizer can be calculated as follows,

Weight of fertilizer per sling:	20 bags x 50 kg/bag = 1.0 ton
Unloading cycle rate:	20/hour
Unloading rate:	1.0 x 20 = 20 t/g/h

On the following assumptions,

Average number of gangs per ship:	3.0 for 8,000 DWT
	2.0 for 5,000 DWT
Lot size per ship:	6,000 ton for 8,000 DWT
	4,000 ton for 5,000 DWT
Coefficient of cargo handling efficiency:	0.75 for 8,000 DWT
	0.7 for 5,000 DWT

The unloading hours can be calculated as follows,

for 8,000 DWT: $$\frac{6{,}000\ t}{20\ t/g/h \times 3.0\ g \times 0.75} = 133\ h$$

for 5,000 DWT: $$\frac{4{,}000\ t}{20\ t/g/h \times 3.0\ g \times 0.7} = 95\ h$$

The berth occupancy time can be calculated by adding 12 hours for berthing and unberthing to the above values. Accordingly, the berth occupancy time is 145 hr and 107 hr for 8,000 DWT and 5,000 DWT ships respectively, since the ratio of large ships to small ships is 48:52.

The total number of ships (N) can be calculated as follows,

$$\frac{0.48 \times 145 \times N + 0.52 \times 107 \times N}{305\ \text{days} \times 24\ \text{hours}} = 0.6$$

$$\therefore N \fallingdotseq 36$$

Where the berth occupancy rate is assumed to be 0.6 and the effective working days per year 305.

The annual quantity (W) of fertilizer unloaded at the port can be calculated as follows,

W = (36 x 0.48) x 6,000 ton/ship + (36 x 0.52) x 4,000 ton/ship
= 179,000 t

The required berth length for 8,000 DWT ships is 165 m.

The annual loading/unloading rate (T) per unit length of a berth is calculated as follows,

T = 179,000 t/165m ≒ 1,100 t/m/y

By the year 2000 the coefficient of cargo handling efficiency will increase to 0.8. In this case T will be as follows,

T ≒ 1,140 t/m/y

The cargo handling rate at the existing jetty type berth is assumed to be 90% of this estimate. The cargo handling rates are shown in the following table.

Year	1990	2000
New Berth Existing Berth	1,100 t/m 990	1,170 t/m 1,050

(5) Palm Kernels and Rubber

Palm kernels and rubber will be exported by ships of the same size as general cargo vessels. The lot size is assumed to be 3,000 tons.

The loading rate per gang for palm kernels and rubber can be calculated as follows:

Weight of cargo per sling:	Palm kernels 20 bags x 50 kg/bag	≒ 1.0 ton
	Rubber	= 1.0 ton
Loading cycle rate:	20/hour	
Loading rate:	1.0 x 20 = 20 t/g/h	

On the following assumptions,

Average number of gangs per ship:	3.0
Lot size per ship:	3,000 ton
Coefficient of cargo handling efficiency:	0.7

The loading time can be calculated as follows:

$$\frac{3{,}000\ \text{t}}{20\ \text{t/g/h} \times 3.0\ \text{g} \times 0.7} = 71\ \text{h}$$

The berth occupancy time can be calculated by adding 12 hours for berthing and unberthing to the above value.

Berth occupancy time: 83 h

The total number of ships (N) can be calculated as follows:

$$\frac{83\ \text{h} \times N}{335\ \text{days} \times 24\ \text{hours/day}} = 0.6$$

$$\therefore N \fallingdotseq 58$$

Here it is assumed that the berth occupancy rate is 0.6 and the effective number working days per year 335.

The annual palm kernel and rubber loading quantity (W) per berth can be calculated as follows:

W = 58 ships x 3,000 t
  = 174,000 t

The required berth length for a 10,000 DWT ship is 165 m. The annual loading rate (T) per unit length of a berth is calculated as follows;

$T = 174,000\ t/165\ m$

$\fallingdotseq 1,050\ t/m/y$

By the year 2000 the coefficient of cargo handling efficiency will increase to 0.8. In this case T will be as follows:

$T \fallingdotseq 1,150\ t/m/y$

The cargo handling rate at the existing jetty type berth is assumed to be 90% of this estimate. The cargo handling rates are shown in the following table.

Year	1990	2000
New Berth Existing Berth	1,050 t/m 950	1,150 t/m 1,040

(6) General Cargo

Although lot size is small, the daily shipping records at Dumai Port show that general cargo is imported in large vessels. (see Table 6.1.2)

We assume that the size of a general cargo vessel is 10,000 DWT and that the lot size is 5,000 tons per ship.

The loading rate per gang of general cargo can be calculated as follows:

Weight of general cargo per sling:	1.0 ton
Loading/Unloading cycle rate:	15/hour
Loading/Unloading rate:	1.0 x 15 = 15 t/g/h

On the following assumptions,

Average number of gangs per ship:	3.0
Lot size per ship:	5,000 tons
Coefficient of cargo handling efficiency:	0.7

The loading/unloading time can be calculated as follows:

$$\frac{5,000\ t}{15\ t/g/h \times 3.0\ g \times 0.7} = 159\ h$$

The berth occupancy time can be calculated by adding 12 hours for berthing and unberthing to the above value.

Berth occupancy time: 171 h

The total number of ships (N) can be calculated as follows:

$$\frac{171\ h \times N}{305\ days \times 24\ hours/day} = 0.6$$

Here it is assumed that the berth occupancy rate is 0.6 and the effective working days per year 305.

The annual general cargo loading/unloading quantity (W) per berth can be calculated as follows:

$$W \fallingdotseq 26 \text{ ships} \times 5{,}000\ t$$
$$= 130{,}000\ t$$

The required berth length for a 10,000 DWT ship is 165 m.

The annual loading/unloading rate (T) per unit length of a berth is calculated as follows:

$$T = 130{,}000\ t/165\ m$$
$$\fallingdotseq 800\ t/m$$

By the year 2000 the coefficient of cargo handling efficiency will increase to 0.8. In this case T will be as follows:

$$T \fallingdotseq 910\ t/m$$

The cargo handling rate at the existing jetty type berth is assumed to be 90% of this estimate. The cargo handling rates are shown in the following table.

Year	1990	2000
New Berth	800 t/m	910 t/m
Existing Berth	720	820

(7) Summary

The cargo handling rates, by commodity, are summarized in Table 6.1.17.

Table 6.1.17 Loading/Unloading Rate by Commodity

Commodity	Ship Type and Size		Lot Size	Loading Rate	Handling rate of Berth
Palm Oil	For Export				
	Parcel Tanker	26,000 DWT	26,000 tons	1,000 t/h	
	Deep Tank	10,000 DWT	2,200 tons	250 t/h	
	For Domestic Use				
	Parcel Tanker	2,300 DWT	2,200 tons	250 t/h	
Sawn Timber	For Export	12,000 DWT	9,000 tons	25 t/g/h	1,400 t/m/y
	For Domestic Use	1,000 DWT	800 tons	18 t/g/h	
Rice	For Import	8,000 DWT	6,400 tons	20 t/g/h	850 t/m/y
	For Domestic Use	1,000 DWT	500 tons	20 t/g/h	
		500 DWT	200 tons	20 t/g/h	
Fertilizer	For Domestic	8,000 DWT	6,000 tons	20 t/g/h	1,100 t/m/y
	For Domestic Use	5,000 DWT	4,000 tons	20 t/g/h	
Palm Kernels & Rubber	For Export	10,000 DWT	3,000 tons	20 t/g/h	1,050 t/m/y
	For Domestic Use	1,000 DWT	800 tons	20 t/g/h	
General Cargo	For Import	10,000 DWT	5,000 tons	15 t/g/h	800 t/m/y
		5,000 DWT	4,000 tons	15 t/g/h	
	For Domestic Use	3,000 DWT	2,000 tons	15 t/g/h	
		300 DWT	100 tons	15 t/g/h	

4) Berth Allotment

Based on the cargo handling capacity, the number of berths was determined as shown in Table 6.1.18 and Table 6.1.19

Table 6.1.18 Berth Allotment in 1990

Commodity	Cargo Volume (000t) (A)	Vessel Size (DWT)	Depth (m)	Handling Capacity (t/m) (B)	Required Berths	
					m (A/B)	Number of Berths
(New Berth)						
Palm Oil	427	26,000 10,000	−12			1 (exclusive berth)
Sawn Timber	139	12,000	−10	1,400	100	3 (multi-purpose berth) 545 m
Fertilizer	271	8,000		1,100	247	
Palm Kernels & Rubber	126	10,000		1,050	120	
General Cargo	45	10,000		800	56	
Sub Total	1,008				523	4
(Jetty Berth)						
Palm Oil	269	2,300	−6.5 ∼−10		165	3 (multi-purpose berth) 500 m
General Cargo	118	3,000		720	164	
Rice	122	8,000		765	159	
Total	1,517				1,011	4 (planned) 3 (existing)

Table 6.1.19 Berth Allotment in 2000

Commodity	Depth of Berth (m)	Handling Volume per Year (t)	Remarks
(New Berth)			
Palm Oil	−12 −10	1,524,000	2 Dolphin Berths (exclusive berth)
Sawn Timber	−10	250,000	6 (multi-purpose berth) 1,045 m
Fertilizer		438,000	
Rubber		79,000	
Palm Karnels		343,000	
General Cargo		223,000	
Sub Total		2,857,000	8
(500 m Jetty Berth)			
Palm Oil	−6.5	530,000	3 (multi-purpose berth) 500 m
General Cargo	−10	81,000	
Rice		189,000	
Grand Total		3,657,000	11 8 (planned) 3 (existing)

5) Quaywall for Small Ships

Port related offices such as navigation, harbour master, pilots and coast guard (KPLP) have their ships as shown in the Table 6.1.20.

At present a large number of these ships anchor in the harbour area but berth at quaywalls. In order to allow the port related offices to more effectively carry out their duties, these ships should be moored alongside the quaywalls.

There is a large passenger traffic between Dumai Port and the ports of Bengkalis, Selat Panjang and Bagan Siapi-api. The statistical report of BPP Dumai shows that the passenger numbers will increase considerably by the year 1990. Fig. 6.1.2 shows the passenger forecast which has been carried out in the light of the past trends in passenger numbers. According to the result, the number of passengers for 1990 is forecast at about 100 thousand. Table 6.1.21 shows the required berth length and water depth for small ships by around 1990.

Table 6.1.20 List of Small Ships in Dumai Port

	No. of Ships	Tonnage	Overall Length	Draft	Remarks
Navigation Office	1	553 DWT	50 m	3.5 m	Bouy tender
	1	404 DWT	50 m	3.65 m	Supply vessels
	3	60 DWT	21 m	1.9 m	Small vessels
Harbour Master Office	1		14.3 m	1.2 m	Patorol (220 HP)
	(3)		(20 m)	(2.0 m)	Purchase plan
Pilot Office	3		(15 m)	(1.5 m)	Pilot boat (140 – 160 HP)
	1		(20 m)	(2.0 m)	Pilot boat 250 HP
	1		(27 m)	(2.5 m)	Pilot boat 700 HP
	4	(340 GT)	(30.7 m)	(3.7 m)	Tug boat not owned by Dumai Port Administration (3,200 HP)
	3		(15 m)	(1.5 m)	Mooring boat (82 HP)
	1		(15 m)	(1.5 m)	Mooring boat (110 HP)
Coast Guard Office (KPLP)	1	33.6 BRT	18.9 m	(2.0 m)	Patorol (200 HP)
	1	26.5	16.0 m		(150 HP)
	1	31.1	18.0 m		(200 HP)
	1	163	12.0 m		(210 x 2 HP)
	1	8.7	14.0 m		(24 HP)
	1	11.8	14.0 m		(36 HP)
	1	10.5	10.0 m		(60 HP)
	1	10.9	8.9 m		(36 HP)
	1	1.5	8.2 m		(50 HP)
		(50.0)	(20.0 m)		Purchase plan
Passenger	1		42 m	(3.5 m)	
	1		25 m		
	(5)		(15 m)		Estimation
	1	(500)	(50 m)	(4.0 m)	(Ferry boat)

Note: Number in parenthesis is by estimation.

Table 6.1.21 Required Berth Length and Water Depth for Small Ship in 1990

	Berth Length	Water Depth	Remarks
	m	m	
Navigation Office	70 ~ 100	−5.0	
Harbour Master Office	30 ~ 40	−3.5	
Pilot Office	100 ~ 140	−5.0	
Coast Guard (KPLP)	50 ~ 80	−3.5	
Passenger wharf	100 ~ 140	−5.0	
Total	350 ~ 500 m		

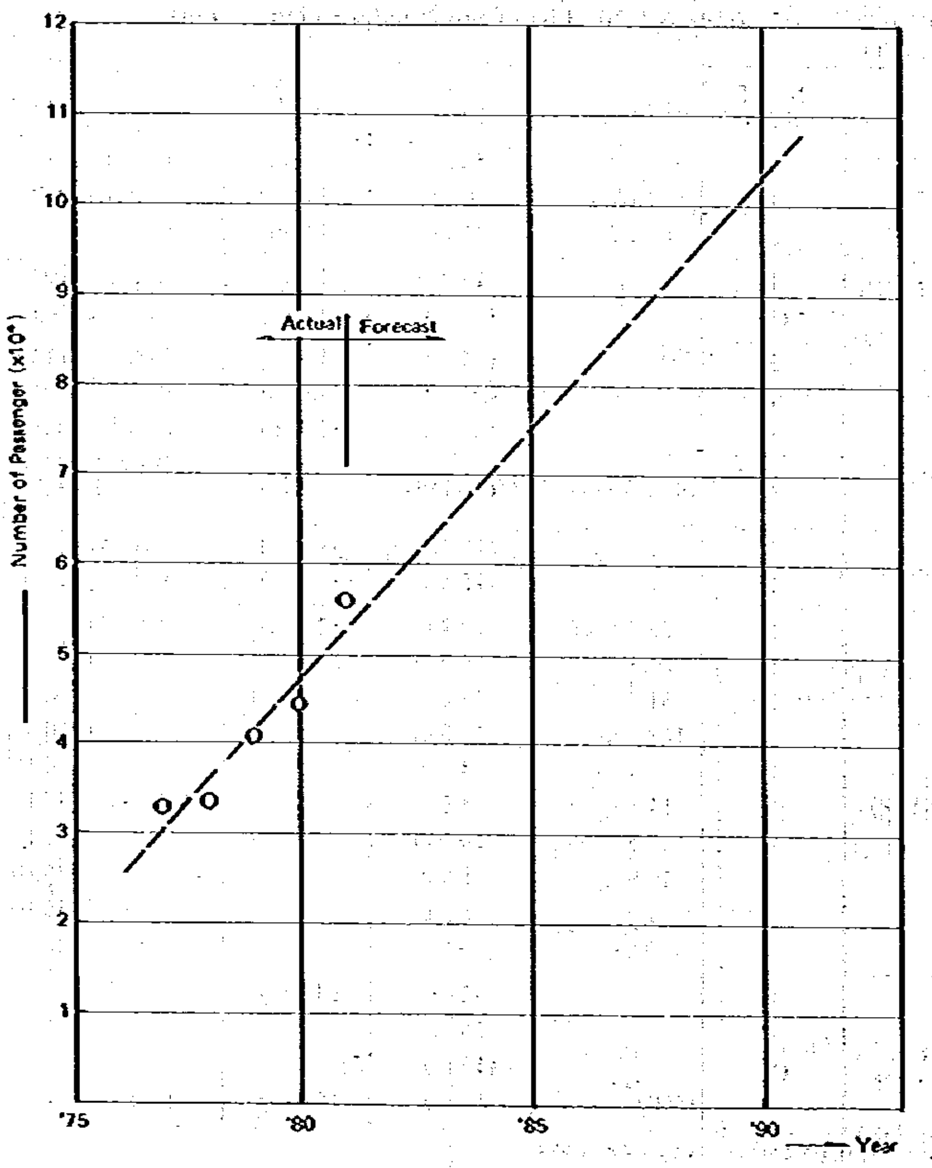


Fig. 6.1.2 Passenger Forecast

6.1.2. Area Required for Transit Sheds, Open Storage and Other Facilities

1) Cargo Volume Handled at Transit Shed, and Open Storage

Cargo can be devided into three groups depending on how it is handled before loading or after as shown in Table 6.1.20.

Table 6.1.22 Cargo Volume at Transit Shed and Open Storage

($\times 10^3$ ton)

Commodity	1990				2000			
	Total	Transit Shed	Open Storage	Direct	Total	Transit Shed	Open Storage	Direct
Palm Kernel	107	75	(32)		343	178	(165)	
Rubber	19	19			79	16	(63)	
Fertilizer	271	250.6		20.4	438	403.5		34.5
Rice	122	55.2	(28)	38.8	189	64.4	(69)	55.6
General Cargo	163	98.4	(42)	22.6	304	126.2	(127)	50.8
Sawn Timber	139		139		250		250	
Palm Oil	696			696	2,054			2,054
Total	1,517	498.2	(102) 139	777.8	3,657	788.1	(424) 250	2,194.9

Note: ( ) indicates containerizable cargoes.

2) Area Required for Transit Sheds

The area required for the transit sheds is calculated by the following formula:

$$A = \frac{C}{R \cdot \alpha \cdot q}$$

where: A: area required for sheds (m^2)

C: annual cargo volume through the shed (ton/year)

R: rotation rate of cargo per year (times/year)

q: average storage capacity (ton/m^2)

α: coefficient of shed utilization

Judging from the tariff system at Dumai Port, the rotation rate of cargo can be calculated on the assumption that the average transit time is 15 days.

$$A\ 1990 = \frac{498,200}{24 \times 0.5 \times 2.0} = 20,760\ m^2$$

$$A\ 2000 = \frac{788,100}{24 \times 0.5 \times 2.0} = 32,830\ m^2$$

In applying this formula, we must pay an attention to the fact that it does not take into account the fluctuations of cargo volume. Therefore, a strict application of this formula will lead to an estimation that is lower than the actual required area. We shall introduce a coefficient β (β=1.10 ~ 1.15), to make allowance for absorbing the fluctuation. Thus the required transit shed area is as follows,

$$A_{1990} \times \beta = 20,760 \times 1.12 = 23,300$$
$$A_{2000} \times \beta = 32,830 \times 1.12 = 36,000$$

There exist four sheds in the back yard behind the existing 500 m jetty berth. Their total area is 12,590 m^2. Accordingly, the area required for new transit sheds by 1990 is,

$$\Delta A_{1990} = 23,300 - 12,590 \fallingdotseq 10,800 \ m^2$$

Two transit sheds of 45 m x 120 m are needed to meet this requirement.

The area required by 2000 is,

$$\Delta A_{2000-1990} = 36,000 - (12,590 + 10,800) \fallingdotseq 12,000 \ m^2$$

To make cargo handling more convenient, the cargo handling area will be constructed in front and back of the transit sheds. Taking account of the space needed for vehicles and a passage way, the total width of the area is planned to be 45 m.

3) Required Open Storage Area

The area required for open storage can be obtained from the same formula used for the transit sheds.

The volume of cargo making use of open storage by 1990 and 2000 will be 139,000 tons, 250,000 tons respectively excluding containerizable cargos. The area required for open storage for conventional cargo is,

$$A_{1990} = 139,000/20 \times 0.5 \times 2.0 = 6,950 \ m^2$$
$$A_{2000} = 250,000/20 \times 0.5 \times 2.0 = 12,500 \ m^2$$

The average weight of a 20′ container is estimated at 7 metric tons per TEU. Therefore, the number of containers in the years 1990 and 2000 is calculated to be about 14,500 and 60,500 respectively. We assume that the rotation rate of containers is approximately 20, in case of handling transhipped containers. Accordingly, the number of ground slots required for containers can be calculated by a formula of the same type as that used for the area of open storage as follows:

$$Ac = \frac{N}{Rc \cdot \alpha c \cdot t}$$

where,
- Ac: Number of ground slots for containers (TEU)
- N: Number of containers (TEU)
- Rc: Rotation rate of containers
- αc: Net stacking container ratio, excluding the operational allowance for slot availability due to reservation, shifting or congestion. (0.5 ~ 0.9)
- t: Number of stacking tiers of containers ($t = 1 \sim 3$)

Consenquently,

$$Ac_{1990} = \frac{14,500}{20 \times 0.9 \times 1} \fallingdotseq 800 \text{ TEU}$$

$$Ac_{2000} = \frac{60,500}{20 \times 0.9 \times 2} \fallingdotseq 1,680 \text{ TEU}$$

The required open storage area is estimated to be 23,000 m² for the year 1990 and 48,000 m² for the year 2000.

4) Area for Palm Oil Storage Tank

The tentative design estimates the storage tank capacity required for shipments of palm oil to be 9% of the yearly handling volume. The volume of this cargo to be handled through Dumai Port in 1990 will be more than 696,000 m^3/year.

Calculation shows it will be necessary to reserve storage tank volume of about 63 thousand tons. According to tentative calculations, the area required for the storage tanks is about 30,000 m^2. In addition to this area, more than 5,000 m^2 will be required to build various operational facilities. Thus the total required area is more than 35 thousand square meters. Due to future expansion, more than 3 times this estimated area will have to be reserved to meet the needs of the cargo volume forecast for the year 2000.

5) Area Required for Warehouses

The area required for warehouses is determined by using the same formula as used in estimating the area of the transit sheds. The rotation rate used in this formula is between 8 to 12 in Japan. The coefficient of accommodation is about 0.7 and the average storage capacity is estimated at 3 ton/m^2.

Accordingly, the area required for warehouses is,

$Aw_{1990} \fallingdotseq 19{,}000\ m^2$

$Aw_{2000} \fallingdotseq 46{,}000\ m^2$

An area sufficient to build the warehouses is to be secured in the second zone behind the quaywall.

6) The Passenger Terminal

As for the passenger terminal, the required area is allocated in the western most part in accordance with the future plans of Passenger Liner Service. They plan to make use of 5,000 ~ 8,000 GT liners, for which the full load draft and over all length are −7.8 m and 150 m respectively. The required berth dimensions are shown in the following table:

Ship Size	Berth Length (m)	Depth
8,000 GRT	215 (max)	−8.5 m

The parking lot area required for the ferry terminal is estimated by the following formula;

$$Sp = a \times n \times \alpha \times B$$

Where: Sp: parking area

a: area required per vehicle (82m² ~ 93m² for 8 ton track)

n: vehicle capacity for a ferry (8000 GT: 200 vehicles)

α: utilization of capacity 0.8

B: coefficient of concentration (1.6 ~ 3.0)

Accordingly,

$S = 82 \times 200 \times 0.8 \times 1.6 = 20,992$

$= 21,000\ m^2$

The area required for the passenger terminal may be calculated from the following formula.

$St = a \times n \times N \times \alpha \times B$

where,
- St: area required for the passenger terminal (m^2)
- a: area required per person ($1.2m^2$)
- n: legal passenger limit per ship
- N: number of ships starting simultaneously
- α: peak ratio
- B: coefficient of seasonal variation

Accordingly, the area required for the passenger terminal in 2000 may be obtained:

$St = 1.2 \times 1,200 \times 1 \times 1.2 \times 1.2 = 2073$

$\fallingdotseq 2100\ m^2$

7) Roads

Roads are one of the most important of the port backup facilities. In view of the expected growth in the port's cargo volume, it is indespensable, for the activities of both the port and the local citizenry, that well specified roads be secured to meet the needs of future development. In the case of insufficient roads, not only may port generated traffic interfere with the daily lives of the citizens, but congestion of private vehicles may hinder port activities, as well. It is therefore proposed to reserve as much space as possible for future road development.

The necessary number of road lanes is determined by the following formula:

$$\text{Design traffic volume (vehicles/hour)} = z \times \frac{\alpha}{w} \times \frac{\beta}{12} \times \frac{\gamma}{\zeta} \times \frac{1+\delta}{\epsilon} \times \sigma$$

- z: annual cargo volume (tons)
- w: average real loadage of a truck (tonnage/truck)
- α: share of modal split by trucks
- β: monthly variation (peak month/ordinary month)
- γ: daily fluctuation (peak day/ordinary day)
- δ: ratio of related vehicles (related vehicles/all trucks)
- ϵ: real load ratio (loaded trucks/all trucks)
- σ: hourly fluctuation (traffic volume of peak hour/traffic volume of peak day)
- ζ: average number of days operated per month

- The scale of future traffic volume will be estimated by adopting the following empirical values for the parameters:

	w	β	γ	ζ	δ	ϵ	σ	α
1990	2.5	1.2	1.5	25	0.5	0.5	0.16	1
2000	3.5	1.2	1.5	25	0.5	0.5	0.16	1

The annual cargo volume in 1990 and in 2000 is 1,517 thousand tons and 3,657 thousand tons respectively. The design traffic volume may be estimated as follows:

$$N_{1990} = 1{,}439{,}000 \times \frac{1}{2.5} \times \frac{1.2}{12} \times \frac{1.5}{25} \times \frac{1+0.5}{0.5} \times 0.16$$

$$= 1{,}657 \fallingdotseq 1{,}700 \text{ v/hr}$$

$$N_{2000} = 3{,}515{,}000 \times \frac{1}{3.5} \times \frac{1.2}{12} \times \frac{1.5}{25} \times \frac{1+0.5}{0.5} \times 0.16$$

$$= 2{,}892 \fallingdotseq 2{,}900 \text{ v/hr.}$$

The necessary number of lanes is determined on the basis of a perlane traffic capacity of 600 vehicles/hour.

From this estimation, the extension of the main road into the west side of the port is sufficient to provide the road capacity needed by 1990. However, by the year 2000 another access road connecting the port to the hinterland will be required, as bypass, in order to avoid traffic congestion in the town area.

6.1.3. Analysis of Port Congestion

A simulation test has been carried out in order to forecast future congestion at the port, so as to ascertain whether planned berth allotment is sufficient.

1) Premises

The simulation test was carried out under the following conditions:

(1) Ships can enter and leave at any time.

(2) Ship sizes are equivalent to those used for determining the required number of berths, as shown in Table 6.1.17.

(3) It is assumed that the distribution of berthing time for ships will be equivalent to Erlang's distribution.

(4) Domestic and oceangoing palm oil carriers will have exclusive use of the dolphin wharf. If the dolphin wharf is occupied, then domestic carriers up to 2,300 DWT will be assigned to the general cargo wharf (–6.5m).

(5) Ships under 3,000 DWT have priority at –6.5m wharves.
However, if such wharves are occupied, they may in that case use wharves for oceangoing vessels.

(6) The simulation ceases to be applicable for cases where more than 200 ships are in the port area.

2) Phases

The simulation test has been carried out at the following phases:

Phase 1 – 500m jetty has been completed. (1985)
Phase 2 – dolphin wharf has been completed. (1987)
Phase 3 – 2 quaywalls have begun operation. (1988)
Phase 4 – the last quaywall has begun operation. (1989)

3) Input data

In general, simulation tests that employ queuing theory are based on data concerning arrival distribution patterns and service distribution patterns. It is naturally best to obtain such data directly from actual shipping records of the port where development is to take place. However, actual records of cargo handled at Dumai are not available for determining the two abovementioned distribution patterns. Therefore, in order to estimate ship arrival distribution, it will be necessary to assume the validity of applying exponential distribution of shipping records from similar Japanese ports.

Next in order to estimate ship berthing time, it is assumed valid to apply the previously estimated loading/unloading rate to the figure for average lot size by ship size. Another type of required input data for the simulation test is the number of ships.

This value can be calculated from the average lot size for each ship size and from the cargo volume that is forecast for each commodity.

4) Simulation Test Results

Two of the main uses of the simulation method are to evaluate port operation efficiency in terms of (A): port congestion and ship waiting time, and in terms of (B): the influence of ship

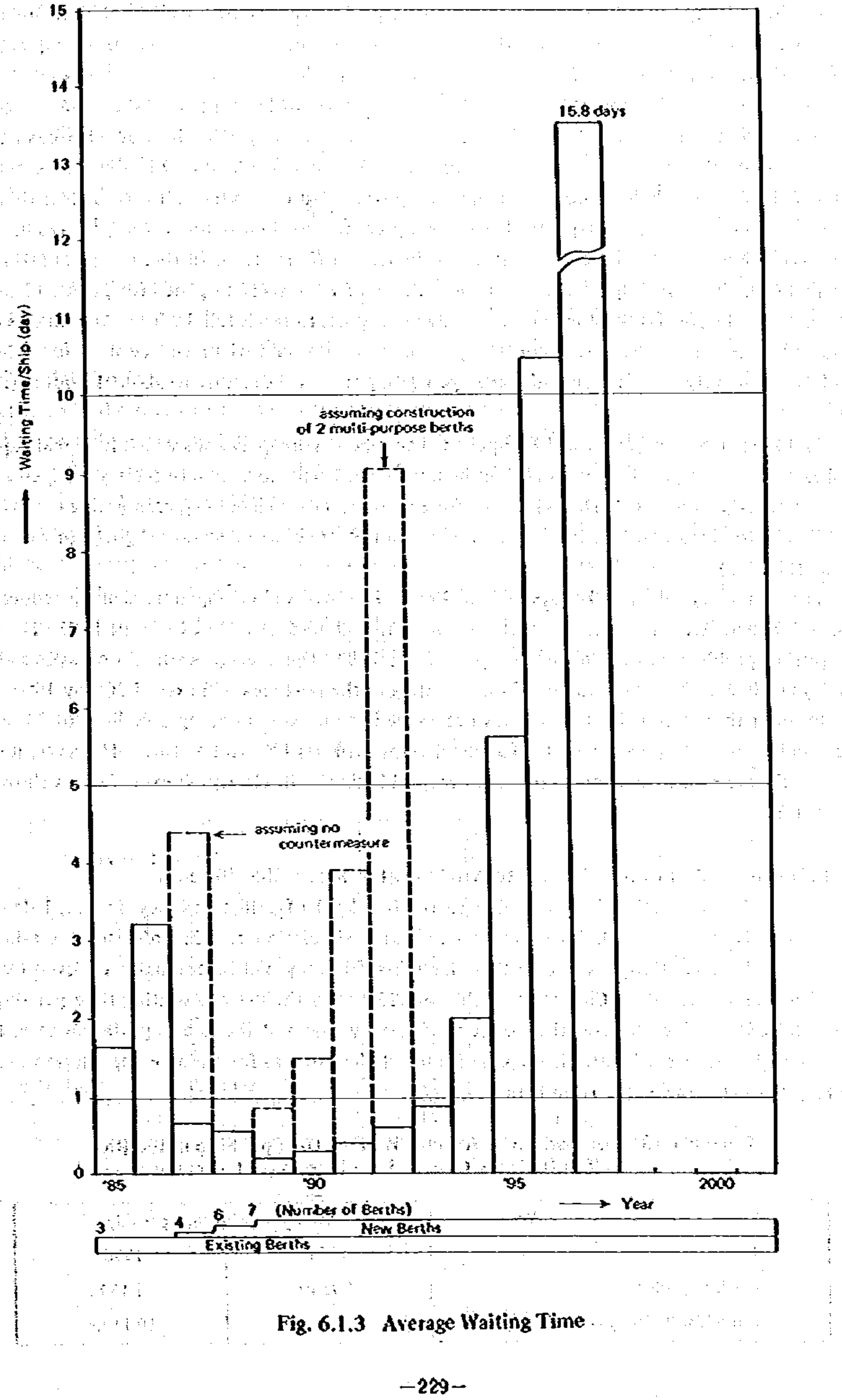


Fig. 6.1.3 Average Waiting Time

arrival irregularity and berthing time irregularity. The results of such simulation are more sophisticated than results based on the berth allotment method making use of a simple berth occupancy ratio. The results of simulation are as follows:

The average waiting time for all ships using the wharves of Dumai Port is shown in Fig. 6.1.3. According to the results of simulation phase 1, average waiting time is about 1.6 days upon completion of the 500m jetty wharf. In this simulation, it is assumed that loading/unloading by barge is still an available option – an option equivalent to one extra berth. It is clear that the construction of the 500m jetty wharf will greatly contribute to a reduction in port congestion. However, average waiting time will continue to increase if there are no further measures taken.

In 1987, the new dolphin berth, having a depth of 12m, will be opened for palm oil loading, allowing the 35,000 DWT percel tankers, used for export, to reach full draft loading. In this case, loading/unloading by barge will continue, because the dolphin whalf will be used for palm oil loading exclusively. Accordingly, the average waiting time will decrease to about 16 hours (Phase 2).

In 1988, two new berths will be opened. These berths are quaywalls which have wide aprons and large handling yards. This will bring the number of berths to a total of 5 quaywalls, counting the 500m jetty berth as 3. This will allow for economical cargo handling, eliminating the need to use barges for loading/unloading. The average waiting time will decrease slightly to about 14 hours (Phase 3).

The 3rd quaywall will be opened in 1989. The average waiting time will be reduced to about 6 hours. After that, the average waiting time will gradually increase until 1993. The port congestion problem will begin to grow again from 1994. The average waiting time will be about 16 days in 1997. The total number of ships waiting in the port area will exceed 200 by 1998.

In order that ship waiting time does not exceed the maximum acceptable limit of 24 hours, the number of multi-purpose berths for short term plan has been set at three. However, if only two berths are built, then this maximum acceptable limit will clearly be exceeded, as shown in Fig. 6.1.3.

5) Influence on Port Congestion due to Attainment of Rice Self-Sufficiency.

Indonesia has a national plan aiming to reach a level of self-sufficiency in rice, balancing annual supply and demand. We have carried out a simulation test in order to ascertain the resulting port congestion in the case that rice self-sufficiency will be gradually achieved by the year 2000 as described in Chapter 5. Table 6.1.23 shows the average waiting time per ship in 1989 and 1990 for each case: the rice self-sufficiency case and the rice importation case. Port congestion in the rice self-sufficiency case is almost the same as for the rice impottation case at the target year for the Short Term Plan.

Table 6.1.23 Comparison of Average Waiting Time per Ship in the Rice Self-Sufficiency Case and the Rice Importation Case

Case \ Year	Average waiting time per ship	
	1989	1990
rice is imported	5.95 hr	6.45 hr
rice self sufficiency is under way	6.81 hr	10.15 hr

6.1.4. Containerization

Containerization has become widespread because it holds various merits for both shipping companies and the owners of goods. There has been a trend whereby containerization of sea routes between southern and northern countries has progressed in accordance with the level of industrialization of countries in both areas. As for the developing countries, they generally import many kinds of heavy industrial and petro-chemical products that can usually be shipped in full container loads. An increasing percentage of such cargo will in the future likely be containerized. Containerizable cargo are also relatively expensive. It is assumed that containerized imports will consist only of general dry cargo. Use of containers for other cargo is unlikely. Accordingly, the volume of cargo assumed suitable for container transport is equal to the volume of foreign trade general dry cargo, as shown in Table 6.1.24. Containerized cargo volume is calculated on the assumption that only 50% of containerizable cargo will in fact be containerized within three to five years after container ships have started calling at the port. Then, it is assumed that it will take seven to ten years for the containerization rate to reach 80%. Furthermore, it is not expected that complete containerization of all cargo suitable for containers will ever be achieved. Therefore, it is assumed here that containerization rates will reach 50% by the year 1990 and 80% by the year 2000.

Table 6.1.25 shows calculations of containerizable cargo volumes. Based on these figures, it will be necessary to prepare an open storage area for containers in the back area. It should be kept in mind that achievement of full scale containerization will depend not only on facilities for containers at the port but also on a fully developed land transportation system as well as systems and procedures for regulating, inspecting and measuring the flow of goods.

Table 6.1.24 Containerizable Cargo Volume

(10^3 tons)

Type of Cargo		1990 Forecast	1990 Containerizable	2000 Forecast	2000 Containerizable
General Dry Cargo	General Cargo	163	289	304	726
	Rubber	19		79	
	Palm Kernel	107		343	
Dry Bulk Cargo	Swan Timber	139	532	250	877
	Fertilizer	271		438	
	Rice	122		189	
Bulk liquid	Palm Oil	696		2,054	
Total		1,517	821	3,657	1,603

Table 6.1.25 Estimation of Containerized Cargo

(ton)

Foreign Trade	1990	2000	Remarks
Import	32,000	165,000	General cargo
Export	41,500	228,000	Palm Kernel Rubber
Total	73,500	393,000	

6.1.5. The possibility of Direct Importation of Fertilizer

In the future Indonesia is expected to become self-sufficient in nitrogenous fertilizer, as domestic supply and demand become balanced. However, phosphatic and potash fertilizer will continue to be imported, as mentioned in Chapter 5. The total volume of fertilizer imported into Indonesia in 1980 was approximately 388 thousand tons, of which 367 thousand tons were manufactured fertilizer and the rest crude fertilizer. This is shown in Table 6.1.26.

Table 6.1.26 Fertilizer Volume Imported in 1979 and 1980

Commodity	1979		1980	
	Volume (t)	$ (x10³)	Volume (t)	$ (x10³)
Crude Fertilizer	18,693	1,128	20,415	2,751
Manufactured Fertilizer	398,118	55,985	367,644	71,915
Total	416,811	57,113	388,059	74,666

Source: Import (1980), Central Bureau of Statistic

The imported volume of phosphatic and potash fertilizers, is broken down by type, and listed by country in Table 6.1.27.

The major, phosphate exporting countries are R.F. Germany, Jordan, United Arab Rep., U.S.A. and Canada. For potash fertilizer, the major exporters are Canada, U.S.A. and both East and West Germany.

These two types of fertilizer acount for a total volume of about 283 thousand tons, or 73% by volume of all fertilizers imported into Indonesia. The volume of bagged fertilizers is very small, only 2,713 tons. Due to the future development of large scale plantation agriculture, the demand for potassium and phosphate fertilizer in Riau will increase.

This fertilizer could not be unloaded in Dumai Port given the present lack of facilities for bulk cargo. To be practical for Dumai Port to directly import these fertilizers, two conditions must be met as follows:

1) It must be possible to import bagged fertilizer.

Table 6.1.27 Imported Potash and Phosphatic Fertilizer in Indonesia

(Ton)

Country	Potassium					Phosphate					Total
	Potassium Salts Crude, net	Potassium Sulphate	Min/Chem Fertiliz Potassic	Magn-Potassium Pack =10 kg	Sub-Total	T.S.P.	Double Supper Phosphate	Min/Chem Fertiliz Phosphate	Diam Phosphate Pack > 10 kg	Sub-Total	
W Germany	1	4,519	74,656		79,176			39,694	2,250	41,944	121,120
Singapore			5,133		5,133	900	2	2		904	6,037
Jordan				170	170	550		41,396		41,946	42,116
U.S.A.			11,038		11,038	21,000		-0-		21,000	32,038
Canada		1,333	23,735		25,068			5,025		5,025	30,093
Japan			1		1	1,500				1,500	1,501
Spain			2,019		2,019				356	356	2,375
Switzerland			12		12				6	6	18
Netherlands			725		725			1,010		1,010	1,735
Denmark			1,200		1,200			720		720	1,920
Belgia & Luxemburg	100				100			725		725	825
United Arab Rep.								10,000		10,000	10,000
Australia								6,778		6,778	6,778
United Kingdom								751		751	751
Rep. of China								7,300		7,300	7,300
Poland								85		85	85
China			1,390		1,390						1,390
France			603		603						603
German Dem. Rep.			15,800		15,800						15,800
Total	101	5,852	136,312	170	142,435	23,950	2	113,686	2,612	140,250	282,685

Source: Imports by commodity and contry of origin 1980, Central Bureau of Statistic

2) It must be more economical to import directly through Dumai Port, as compared with importation via the gateway port of Belawan.

The small lot size of bags and the powdered nature of this type of fertilizer, make it most desirable for the end consumer. Therefore, it must be required that the supplier bag the fertilizer at some point in the distribution process. Thus countries that either possess existing bagging plants, or in which it is reasonable to build new ones are the best prospects to supply the future needs of Indonesia.

In general the location of new bagging plants is chosen following strategic consideration of which countries are expected to become future consumers, and from the view point of worldwide distribution.

According to Table 6.1.27, west and east Germany combined supplied 67% of all potash fertilizer imported into Indonesia in 1980. Since these two countries can utilize the large (3,000 ton per day) bagging plant in Antwerp, they can comply with condition 1), to deliver bagged fertilizer.

Jordan is the major phosphatic fertilizer supplier for Indonesia and has a bagging plant processing 100,000 tons per annum. In the future Canada will be large supplier of potash fertilizer. However as the bagging cost in Canadian ports is prohibitively expensive, an appropriate location for bagging at lower cost is being sought in Far-East Asia, possibly Formosa, the Philippines, etc. Accordingly, potash and phosphatic fertilizer will likely continue to be imported in bags.

A cost analysis of importing bagged fertilizer is complicated by the difficulty in estimating the respective costs of bagged and bulk types. In general, the cost of importing by bag is clearly higher than the cost of bulk importation and in the case of Indonesia the difference between these two costs is estimated at between 16 and 22 US$ per ton including freight costs. In the case of bulk importation, the additional bagging cost must be included along with the standard C. and F. (cost and freight) figures. Based upon the assumption that the bagging cost at the gateway port, Belawan will be roughly 15 ~ 20 US$ per ton, while the cost of bagging in Philippines is 17 US$ Per ton, and estimating the freight cost of transhipment to Dumai Port, including loading cost at Belawan Port, at 6.8 US$, the total cost after transhipment to Dumai would probably be higher than the cost of direct bagged importation.

Therefore, in making a choice between these two methods, cost is not a conclusive factor and the decision can be based on the effects these plans have on local employment.

6.2. Port Construction Site

Several different factors must be considered in selecting a site for port construction: the present condition of an area and possible future developments there; socio economic conditions; natural conditions; and property boundaries that may affect or obstruct development.

6.2.1. Present Location of Dumai Port

The present area of Dumai Port is located directly to the west of Caltex's wharves, and extends along the waterfront for 3km. The width of the area used for port activities is about 150m at its narrowest, and 300m at its broadest. Therefore, port development will be confined to a rather narrow strip of land unless there is expansion of the port's land area. The west end of the present port area is bordered by the Dumai River where it flows into the Rupat Strait. Further west beyond the river lies an unoccupied 800m strip of land that extends as far as the area reserved for and owned by Pertamina.

6.2.2. Selection of the Site for Expansion

1) Factors

With an eye towards resolving the present limitations of Dumai Port, let us now evaluate possible alternative sites for future development. In making a selection of one of the alternatives, we must take into the consideration the following factors:

(1) Present situation of the water front area.
  a) Present land use
  b) Room available along the water front for future expansion
  c) Accessibility to the port area
  d) Major landowners
(2) Present use of the water surface and proposed plan.
  a) Existing facilities
  b) Plan for port facilities
(3) Natural conditions
  a) Distance from the shoreline to the required sea depth
  b) Existing rivers and sedimentation
  c) Soil
(4) Construction Work

2) Characteristics of the Proposed Area and Site Selection of the Site

Based on the evaluation of factors listed above, three areas can be proposed for the port development project, as shown in Fig. 6.2.1.

Area 1. West side area adjacent to the reserved area of Pertamina

Area 2. Area where the present port exists between Caltex's wharf area and the reserved area owned by Pertamina

Area 3. Area on the east side of Caltex's wharves

The characteristics of each area are described as follows:

Area 1.

This area extends from the west side of the area owned by Pertamina to the River Mesjid. It is not included in the city's future planning. Recently, however, plans have been drawn up to convert this area into an industrial area. About 6km length of shoreline is available for port development, with ample room left for additional future development. However, at present, the infrastructure of this area is still quite undeveloped in comparison to areas closer to the center of Dumai City.

Area 2.

The distance from the shoreline to the −10m water depth line is rather long compared with Area 1. This is due to the slight, though long-term influence of the Dumai River. Even so, construction of new wharves is considered feasible. In addition, the waters in this area are calm. There are already several jetty wharves in use by the Harbor Master, Coast Guard,

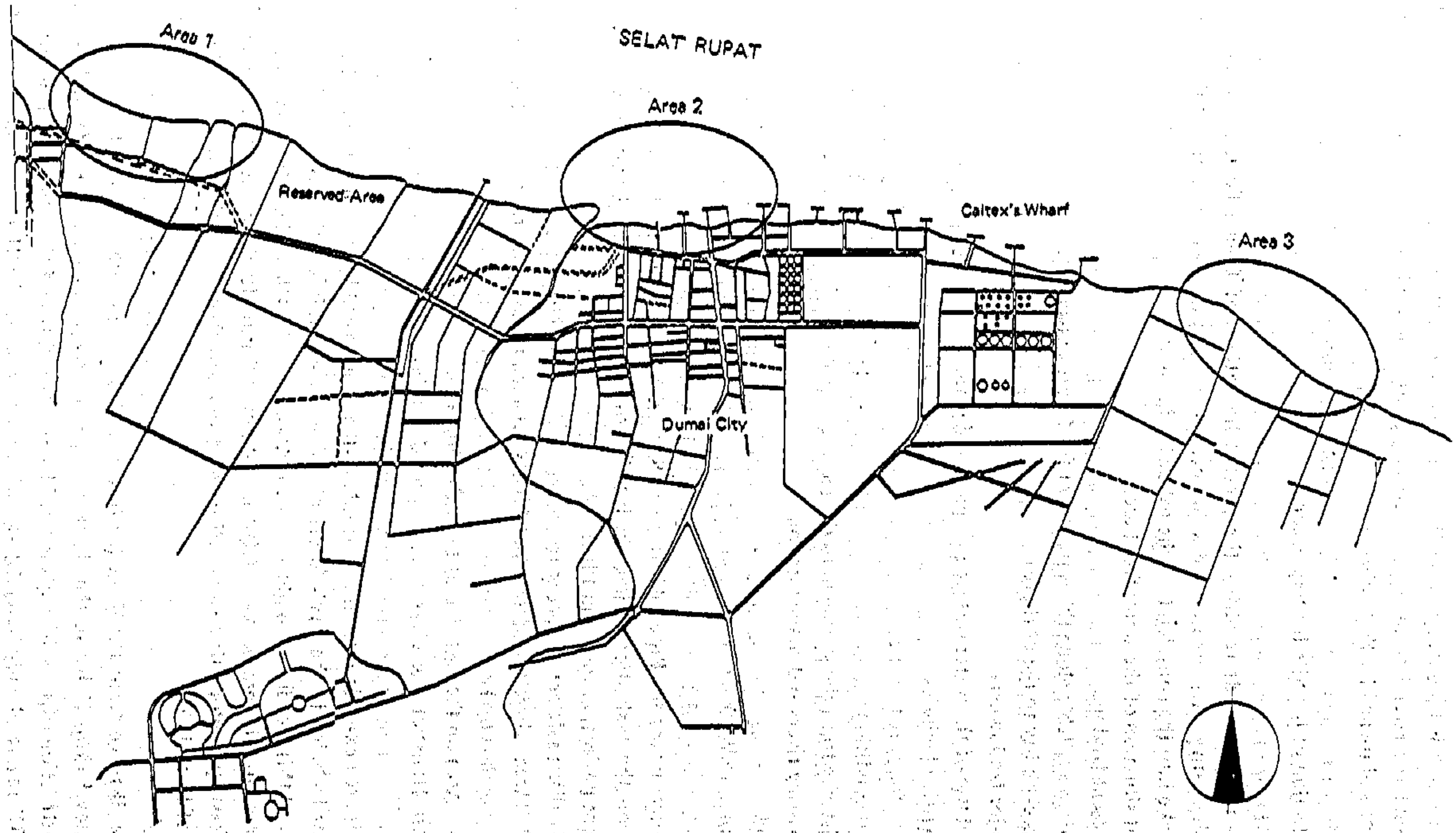


Fig. 6.2.1 Selection of Construction Site

Pilotage and Fishery. The main advantage of this area is its proximity to the town area. An existing 25m road is partially available as an access road. Almost every part of this area is classified for use as a port under Dumai's city planning.

Area 3.

This area like Area 1, is located at a distance from the town and completely cut-off from the town by the hydrocracking plant area. The required sea depth is not sufficient for construction of a quaywall. Furthermore, the coordination with existing port facilities cannot readily be carried out so that the greater efficiency usually associated with larger scale facilities will not be possible.

This area is therefore not considered suitable for development.

Area 2 has been selected for use under the master plan.

6.2.3. Land Use Plan for Dumai City

Port planning must be carried out in accordance with the master plan for Dumai City, especially as regards planned land use and the land transportation system.

1) Land Use Plan

The latest city plan for the year 2000 was formulated in 1981 by BIEC International Inc. as part of the city's existing master plan. Fig. 6.2.2 shows the land use plan for Dumai City. The land use plan for the waterfront area is also in this same figure.

As can be seen ample space has been reserved for future port development and port related activities industries.

2) Plans for the Transportation Network

Effective land use must be supported by a road network. At the same time port activities must be carried out in connection with a land transportation system to provide high accessibility to the hinterland. In order not to disturb intra-city traffic by heavy port generated traffic, it is necessary to construct a network of trunk roads as well as a loop road surrounding the city area. In addition, railways can also contribute to improvement of the future land transportation situation. In the Basic Policy Report on Transportation System Designs for Riau and North Sumatra Provinces, railways are regarded as a possible option for strengthening the basis of city and port activities. Fig. 6.2.3 shows the future road network for Dumai City as well as a tentative railway route.

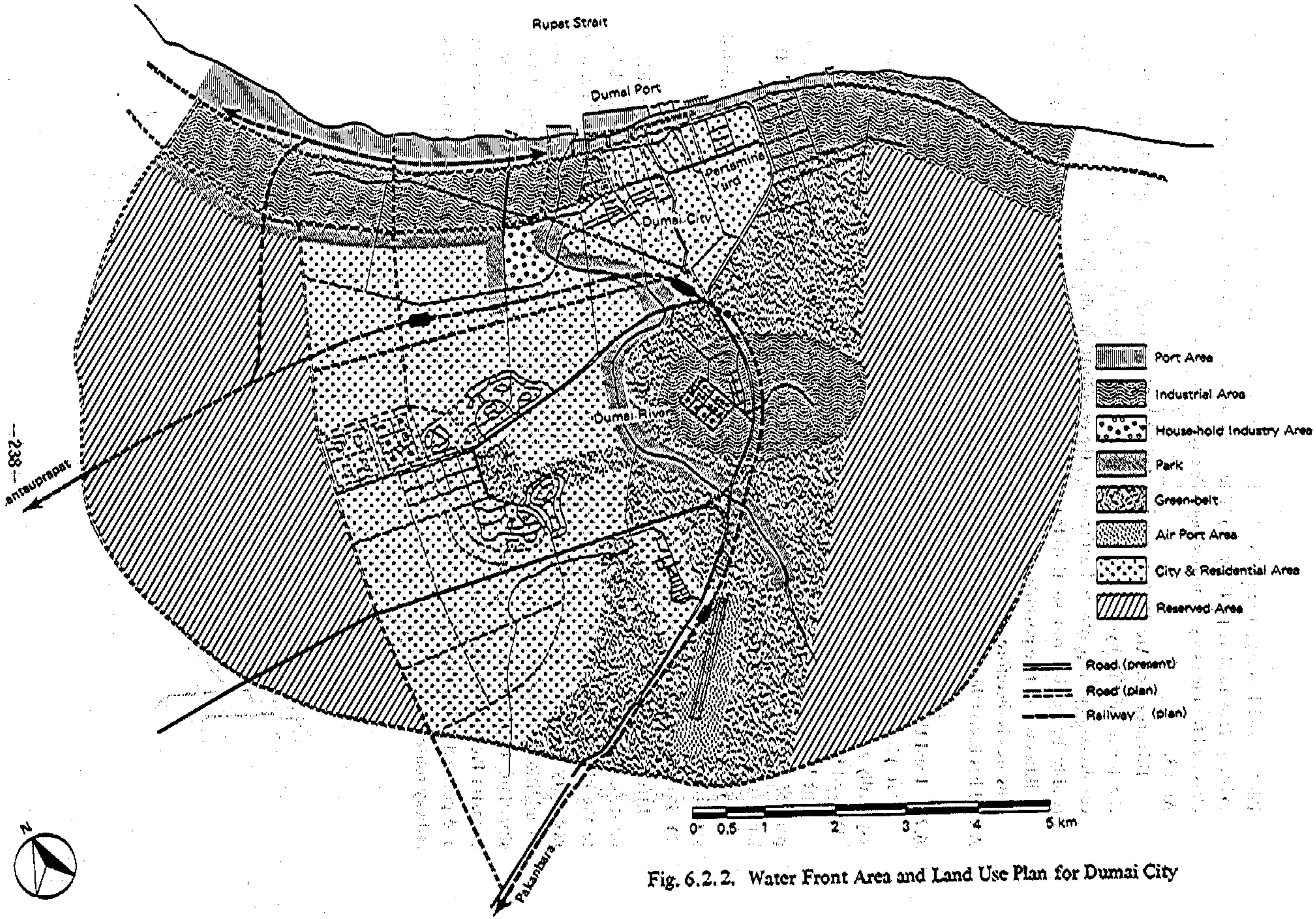


Fig. 6.2.2. Water Front Area and Land Use Plan for Dumai City

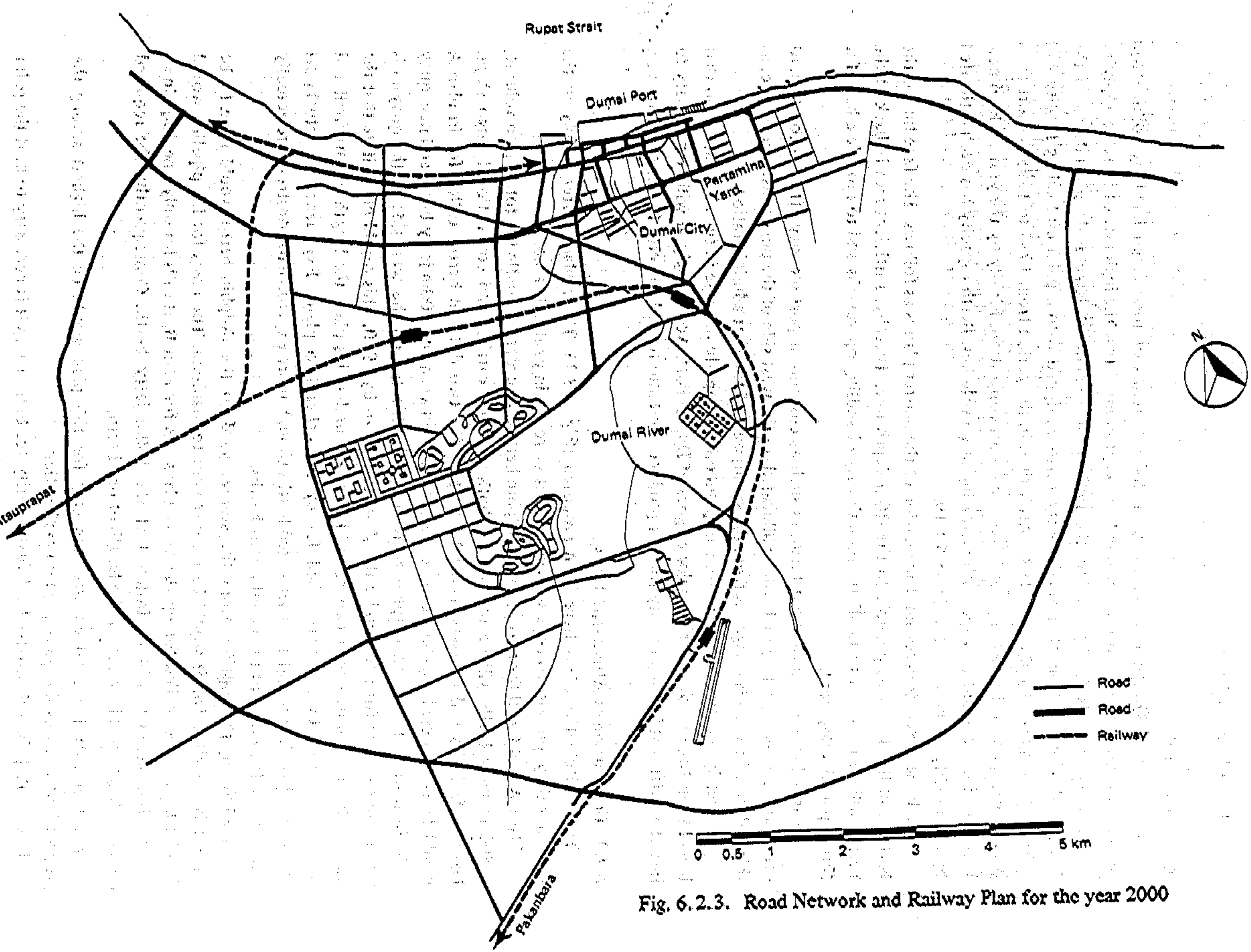


Fig. 6.2.3. Road Network and Railway Plan for the year 2000

6.3. Master Plan for 2000

6.3.1. Basic Thinking

The scale of Dumai Port in the year 2000 in terms of total cargo handling volume will amount to 3,657 thousand tons. It should be kept in mind that the high rate of increase applying to cargo volumes is largely due to the rapid development of large scale plantations in the hinterland. Construction of a 500 m jetty berth equipped with a palm oil loading facility will initially be required by the year 1985. After that, in the period from 1987 to 1995, a short term project will play an important role in reducing port congestion. Finally by the year 2000, 4 new berths will be required to cope with increasing cargo volumes. Berth capacity has been estimated by commodity as shown in the Table 6.1.19.

The basic conception for implementation of the master plan is as follows. The face line of the berths will lie as near as possible to the -10m depth line. Thereby, sufficient area in back of the berths will be obtained to facilitate smooth cargo handling operations and to provide a basis for future port development.

An area for port management facilities such as customs, a port security office, a coast guard office and a passenger terminal will be allocated on the west side of the port construction site, as this is deemed most advantageous from the standpoint of the port administration.

As already mentioned, the volume of palm oil will rapidly increase in the near future, so that it will soon become one of the major cargoes of Dumai Port. Accordingly, it will be necessary to install an efficient loading facility for this product, and also to build a berth for its exclusive use.

6.3.2. Comparison of Alternative Plans

Three alternative plans have been proposed (Fig. 6.3.1). These plans differ mainly in the measures they propose to cope with significant increases in palm oil cargo.

Plans A and C call for two palm oil dolphin berths. In order to handle the total cargo volume, a 500 m jetty berth will be utilized for both palm oil carriers and conventional cargo ships. Loading facilities will be constructed by DGSC. The two dolphin berths called for in plan A would be constructed adjacent to one another and between the 500m jetty berth and new quay wall. In plan C, the secon dolphin berth would be located on the west side of the quaywalls which are to be constructed under the short term plan by 1990. This would necessitate that the quaywalls be separated into two parts. Therefore, under this plan, the length of quaywall and revetment would exceed that called for by the other two plans. Experience in actual port operations has shown that such separated berths though more expensive to construct are actually functionally less efficient than continuous berths.

In addition, the pipeline from the storage yard to the dolphin berth would have to be separately installed and it would be inconvenient to maintain. The costs for his pipeline would thus be higher than called for by the other plans. As for Plan B, it calls for only one dolphin so that loading facilities will be installed at the 500m jetty berth. Consequently, the required quaywall length will increase by the length of one berth.

The fact that the total construction cost for this plan would be the highest among the proposed alternatives should require no explanation.

In case B, palm oil carriers have first priority for berthing, as it is necessary to heat the palm oil before loading. Conventional ships unloading their cargo under this plan would have to be transferred to the new berth, and transit sheds used for general cargo and for rice cargo would have to be located at a distance from the wharves. This would naturally cause a reduction in the loading rate.

In selecting the best plan from among the alternatives, it is important to consider conditions that will actually prevail when construction is fully completed. From this viewpoint, Plans A and B are superior to Plan C.

In terms of management and utilization of the port upon completion of construction Plan A is considered superior to Plan B. Plan A is therfore recommended for the master plan (Fig. 6.3.2). Table 6.3.1 compares the three plans.

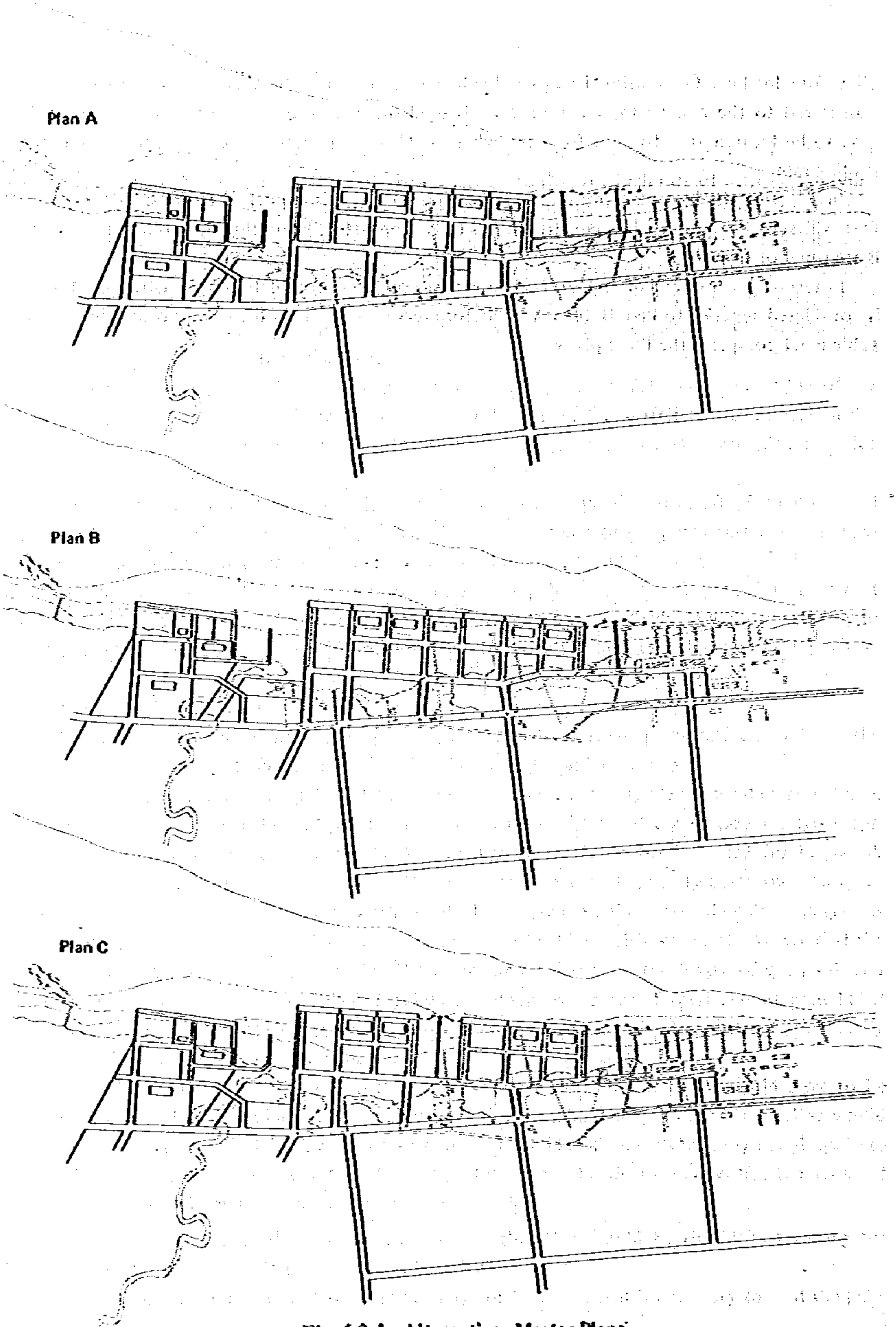


Fig. 6.3.1 Alternative Master Plans

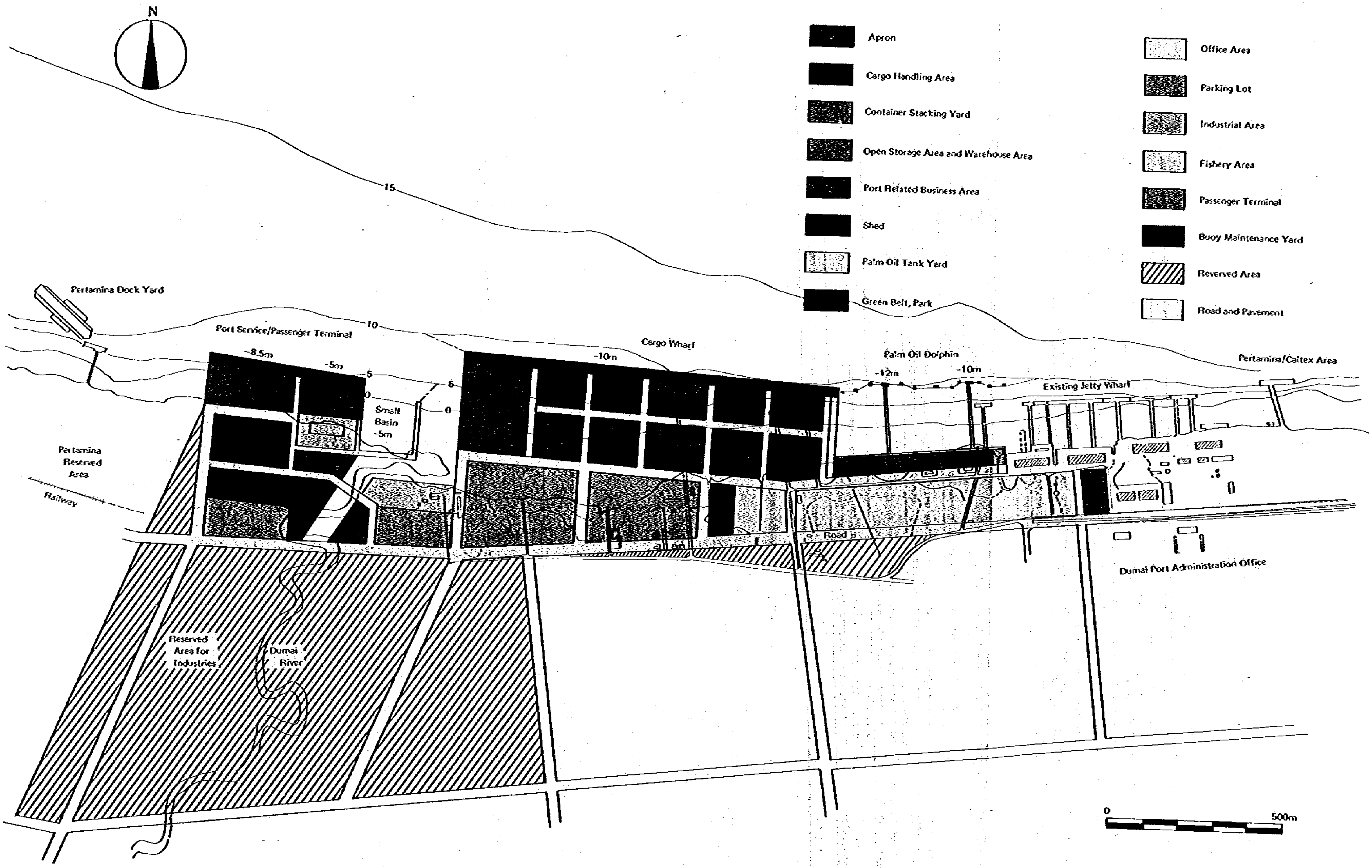


Fig. 6.3.2 Master Plan of Dumai Port (2000)

Table 6.3.1 Comparison of Alternative Plans

Item	Important Points of Comparison	Plan(A)	Plan(B)	Plan(C)
Maintenance of Facilities	Is it easy to maintain the constructed facilities? In this project, allocation of wharf is feared to pose problems in maintenance.	○	○	×
Management and Utilization of Port	Is it easy to manage and use the port? Comparison should be made both at an initial stage and upon completion of the project.	○	○	△
Coordination with Existing Pier	If the use of the existing pier and the new berth may be incorporated at the beginning stage, will the scale merits of the facilities be gained.	○	△	△
Utilization of Past Investment	May the existing port road and transit shed be effectively utilized?	○	○	○
Future Prospects	Is the project flexible enough to cope with new development plans after 2000?	△	△	△
Calmness within Port	Is the port sufficiently calm without breakwaters?	○	○	○
Soil Conditions	Is the site suitable for the construction of port structures?	△	△	△
Manipulation of Ships	Can the ships enter and leave the port without difficulty? Are berthing and unberthing easy?	○	○	○
Utilization of Land	Is the Port Development Plan in line with the land utilization scheme of the area? Are the storage areas and green zones in harmony with the surrounding environment?	○	○	○
Environmental Protection	Are port activities and port construction work so carried out that they are not destructive to the surrounding social and natural environment?	○	○	○
Workability	Is the construction of each facility easy? Is the gradual execution from planning to completion smooth?	○	○	○
Investment	Comparison of construction cost of basic port facilities.	○	×	△

Note: ○: Excellent △: Some Problems ×: Poor

6.4. Short-Tenn Port Development Plan for 1990

6.4.1. Construction Site for the New Berth

Arrangement of the short-term port development plan within the framework of the Master Plan is an important matter. In 1985, a new 500 m jetty berth will go into operation thereafter playing a major role at the port. New wharves that are required as time goes on should be located as near this jetty berth as possible in order to increase the efficiency of port facilities by concentrating them close together. In this way, port administration can be limited to a comparatively small area. The new palm oil dolphin berths will eventually be constructed along the waterfront between the new quaywall and the 500 m jetty berth. The left dolphin berth connected to the new quaywall will be constructed under the short-term plan. This will permit a shorter pipeline than if construction of the right dolphin berth were given priority. Additionally, the proposed pipeline route can be easily extended when the second dolphin berth is built. Fig. 6.4.1 shows Short-Term Development Plan up to 1990.

6.4.2. Selection of Berth Type

The selection of berth type is basically a technical matter. However, operational efficiency of the berth type is also a major selection criterion. There are two main methods of construction: constructing the whole profile on soft ground with sand; and constructing structures of the jetty type without improving the upper part of ground as shown in Fig. 6.4.2. With the former method, since the apron and the transit shed are continuous, cargo handling is quite efficient.

On the other hand, employing the latter (jetty type) construction method, the apron and the transit shed must be connected by one or two access bridges therby decreasing the cargo handling capacity.

In our previous report, we wrote that the cargo handling rate of a jetty type wharf is assumed to be 90% of the rate for a quaywall type wharf. Therefore, the length of a jetty wharf should be extended in order to compensate for its deficient handling efficiency. However, cargoes handled at an extended jetty wharf would probably overwhelm the capacity of a single access bridge. Consequently, another access bridge would be required. But this would be almost equivalent to requiring construction of anan additional berth simply to recover the same cargo handling capacity as a continuous quaywall wharf. Under these circumstances, a quaywall is clearly preferable in terms of an overall assessment, including assessment of wharf utilization as well as other factors.

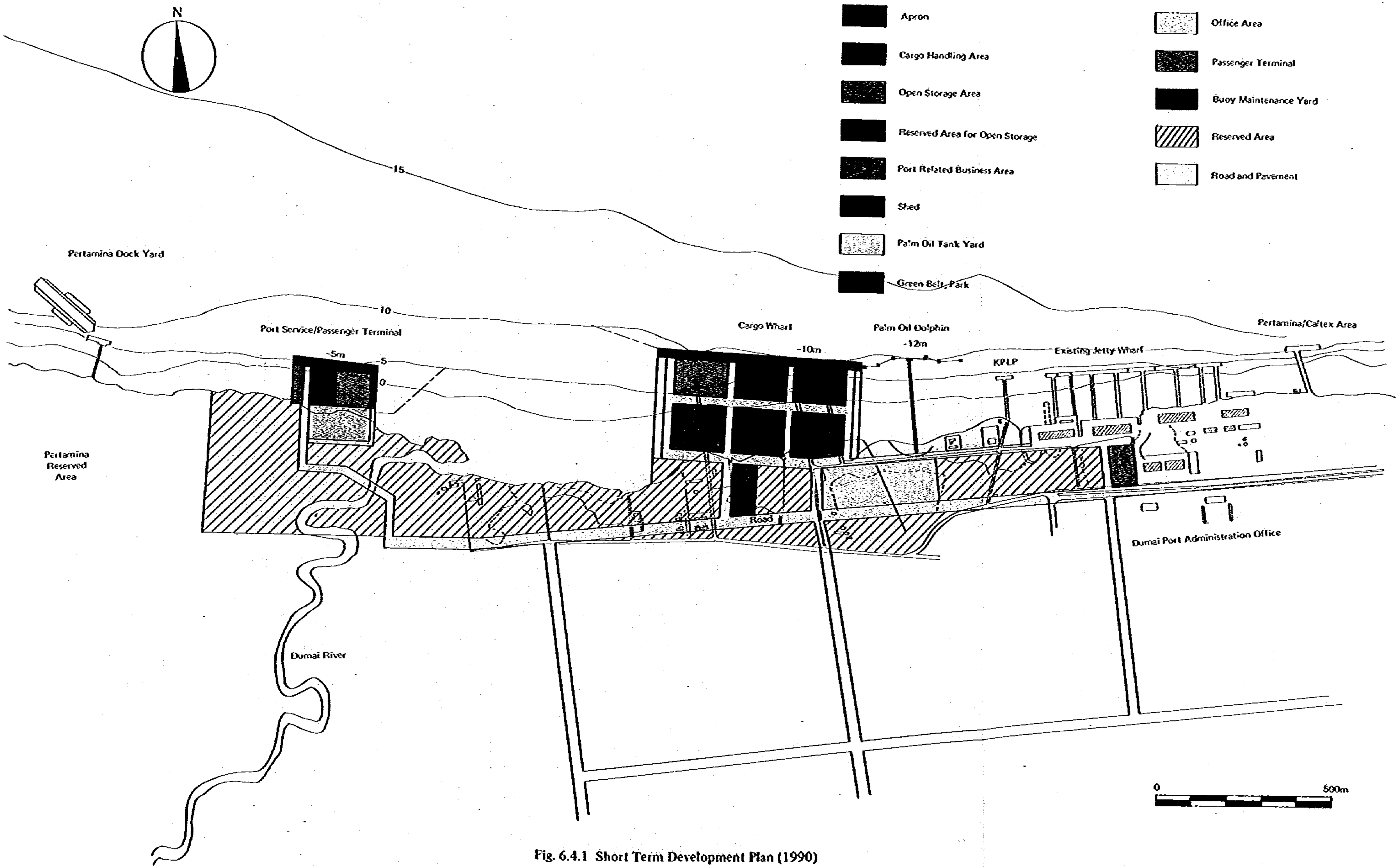
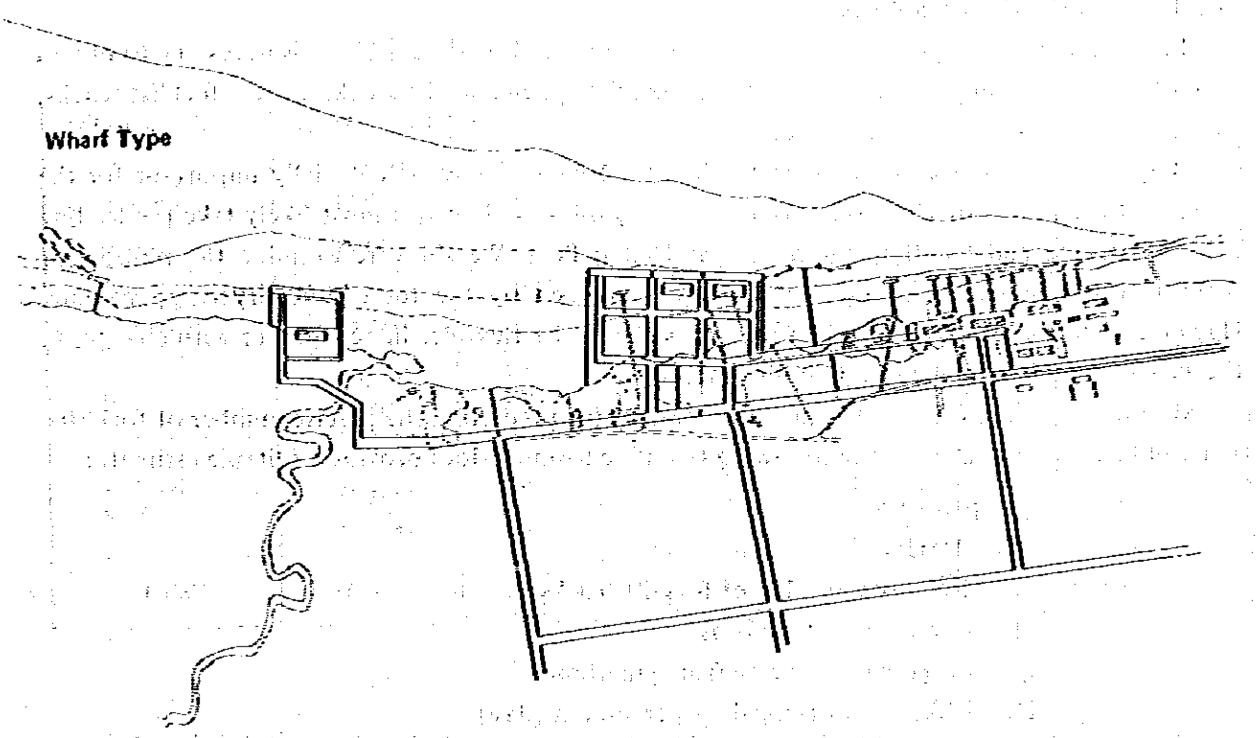


Fig. 6.4.1 Short Term Development Plan (1990)



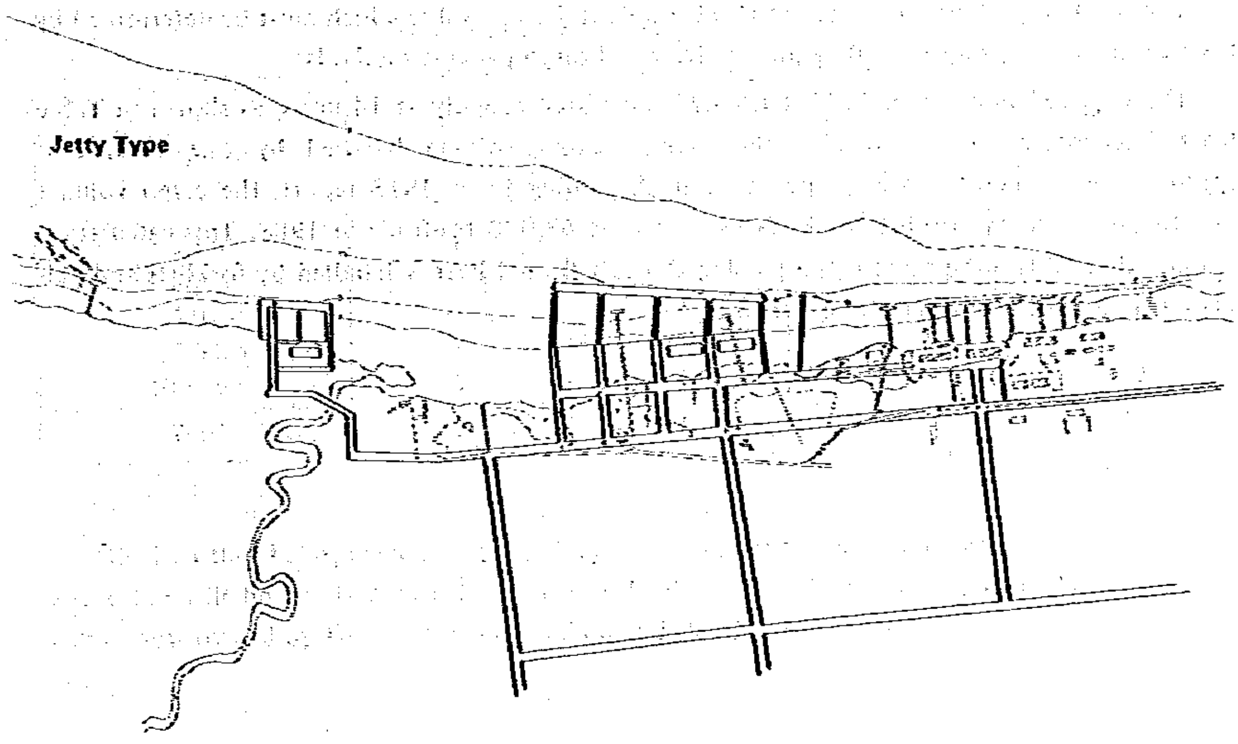


Fig. 6.4.2 Comparison of Berth Type

6.4.3. Cargo Handling Facilities

In order that loading/unloading be carried out as speedily as possible, it is necessary to obtain cargo handling machines to carry cargo between the apron and the stocking area: forklift trucks, mobile cranes and supplementary tools.

Acquisition of a fleet of forklift trucks at the new wharves is especially important for the maximal functioning of the large cargo handling yard and they will most likely take the leading role in carrying and handling cargo here at Dumai Port. We therfore examine the number of forklift trucks necessary to meet the requirements set by the total 1990 dry cargo volume. However selection of cargo handling machines should be flexible, in accordance with changes in the types of packing and cargo handling methods.

Although an exact formula has not been devised for predicting the precise number of forklifts that will be needed at Dumai, the following tentative formula does provide a suitable estimate:

$$N = \frac{p \cdot n \cdot Q/q}{D \cdot H \cdot w}$$

in which
- N: Required number of forklift trucks
- Q: Cargo volume (in tons)
- q: Cargo handling rate (ton/gang/hour)
- D: Effective working days per annum (day)
- H: Cargo handling hours per day (hour)
- p: Peak day factor, $p = 1.0 \sim 1.5$ $(p = 1.2)$
- w: Coefficient of cargo handling efficiency
- n: Number of forklift trucks per hatch (unit)

The most important parameter of this formula is the n – value which must be determined by taking into account cargo handling productivity and cargo packing methods.

The required number of forklift trucks is estimated roughly at 14 units, as shown in Table 6.4.1. According to the results, the average cargo volume handled by one forklift is approximately 58,000 ton/units per annum. According to an ISTS report, the cargo volume handled annually by forklift trucks is estimated at 63,000 ton/unit in 1988. This calculation assumes that all transhipment cargo passing through Dumai Port is handled by forklifts and pallets via transit sheds or open storage areas.

Table 6.4.1 Required Number of Forklift Trucks in 1990

Commodity	Cargo volume	q (t/g/m)	D (day)	n	N (unit)	Remarks
Forestry Products	125,000 14,000	25 18	335 335	2.0 1.0	2.13 0.16	Mainly banded products
Fertilizer	271,000	20	305	1.5	4.76	Bagged goods
Palm Kernel & Rubber	83,000 43,000	20 20	335 335	1.5 1.0	1.33 0.46	Bagged goods
Rice	56,000 66,000	20 20	305 305	1.5 1.0	0.98 0.77	Bagged goods
General Cargo	35,000 69,000 59,000	15 15 15	305 305 305	1.5 1.5 1.0	0.82 1.62 0.92	Carton and other types
Total	821,000	19.7 (mean)			13.95	

Table 6.4.2 shows the purchase plan for forklift trucks. The Dumai Port Administration already owns 6 forklift trucks, and a private company at the port, Samdra Indonesia, owns 5 forklifts. Therefore, four additional units must be acquired to efficiently handle the cargo load.

Table 6.4.2 Purchase Plan of Forklifts

Equipment	Number of Units			Total
	port-administration owned		privately owned	
	present units	required units	present units	
~2.5 ton	1			1
3.0 ton		1	1	2
5.0 ton	3	2	4	9
7.0 ton	1			1
10 ~ ton	1	1		2
Total	6	4	5	15

On the other hand, there is a possibility that some of the general cargo will be containerized and some will be handled as a heavy cargo. In these cases it is possible to make use of mobil cranes now owned by Dumai Port as listed up in Table 2.2.3.

CHAPTER 7.

DESIGN, CONSTRUCTION AND COST ESTIMATE

CHAPTER 7. DESIGN, CONSTRUCTION AND COST ESTIMATE

7.1. Fundamental Conditions for Design, Construction and Cost Estimate

In this section, the fundamental conditions for the design, construciton and cost estimate of the port facilities under the Master Plan and the Short Term Plan will be described.

7.1.1. Design Conditions

1) Object Vessels

General Cargo Wharf:	15,000 DWT
Palm Oil Berth:	35,000 DWT (This is the maximum value. The berth is designed to be utilized even for the small vessels.)
Passenger Wharf:	8,000 G.T.

2) Water Depth

General Cargo Wharf:	-10m
Palm Oil Berth:	-12m, -10m
Passenger Wharf:	-8.5m
Wharf for Small Vessels:	-5m

3) Wharf Crown Height: +4.5m

4) Tidal Range: 3.0m

5) Height of Residual Water: +2.0m

6) Surcharge

General Cargo Wharf:	Ordinary Condition	3.0 ton/m²
	Particular Condition	1.5 ton/m²
Breasting Dolphin:	0.2 ton/m²	
Mooring Dolphin:	0.2 ton/m²	
Loading Platform:	1.0 ton/m²	
Wharf for Small Vessels:	Ordinary Condition	1.0 ton/m²
	Particular Condition	0.5 ton/m²

7) Seismic Coefficient

Horizontal Coefficient (Kh):	0.05
Vertical Coefficient (Kv):	0.0

In Riau Province, earthquakes are very rare, therefore the lowest values have been selected for the seismic coefficients.

8) Berthing Velocity: 0.15 m/sec

9) Fender System

Materials:	rubber
Capacity of Energy Absorption:	10 ton·m
Reaction Force:	70 ton

10) Tractive Force: 70 ton

This value is rather conservative, but is sufficient for design of structures at Dumai Port, because the Port is well protected by Rupat Island and heavy storms in this area are uncommon. Thus, the above value is considered reasonable as the tracting force for Dumai Port.

11) Wave Force: not considered

As mentioned above, the port is well protected by Rupat Island and the sea is usually very calm. Therefore, it is not necessary to take the wave force into consideration.

12) Life Time: 50 years

13) Corrosion Control

The steel materials will be protected from corrosion by cathodic protection, concrete coating and an increase in material thickness.

14) Soil Conditions

Based on geotechnical conditions surveyed by the DGSC in November 1982 as well as other related data, the soil conditions used for wharf design are determined as shown in Table 7.1.1.

Table 7.1.1 Soil Conditions

Depth (m)	Soil Classification	N Value	Unit Weight (ton/m^3)	Angle of Internal Friction (Degree)
Surface – –23.0	Silt or Clay	0 – 2	1.4 – 1.5	–
–23.0 – –33.0	Silty Sand	16	1.8	30
–33.0 –	Clay	22	1.8	–

15) Allowable Stress

Compressive Stress for Reinforced concrete: 80 kg/cm^2

Steel: 1,400 kg/cm^2

These values are multiplied by 1.5 to meet seismic conditions.

16) Safty Factors

Safty factors are shown in Table 7.1.2.

Table 7.1.2 Safty Factors

Condition	Safty Factor	
	Ordinary	Particular
Circular Slip	1.3	1.0
Sliding	1.2	1.0
Overturning	1.2	1.1
Bearing of Pile	2.5	2.0
Pulling of Pile	3.0	2.5
Penetration of Sheet Pile	1.5	1.2

7.1.2. Construction

Port construction at Dumai is impeded by several conditions not present at ports like Tanjung Priok or Surabaya on the island of Java. Therefore, in selecting construction methods, these special conditons must be given due consideration.

1) Natural Conditions

Most of the construction at Dumai Port will be carried out off shore, by craft especially fitted for at-sea construciton. Therefore, sea conditions will be of critical importance. Although there is no reliable wave observation data, based on existing wind data, it is thought that sea conditions at the port are good throughout the year. However, the work efficiency may decrease during the rainy season, a possibility that should be taken into account when formulating the construction schedule.

2) Scale of Construction

It will be necessary for a contractor from outside the area to execute the construction, as there are no nearby contructors with sufficient capacity to carry out the project. Many skilled laborers will be required on a temporary basis. However, as there are insufficient numbers in the vicinity of the construction site, they will have to be brought in from outlying areas.

3) Construction Equipment

Large construction craft (a pile driving barge, a pump dredger, etc.) are not available at the site. They must be brought in from Tanjung Priok, Singapore or Japan. The cost of bringing in these craft could constitute a significant proportion of the total cost. Thus, the construction program includes plans to reduce the required number of large craft as much as possible. Land-based construction equipment (bulldozers, power shovels and mobil cranes, etc.) are for the most part procurable at the site, though some will have to be brought in from Java or other areas.

4) Construction Materials

The only construction materials available directly at the site or in its vicinity are timber, sand and stone. Standard construction materials, including cement and steel, that are used in great quantity will be brought in from other areas.

Consequently, construction costs will be relatively higher than would be the case on Java or in other regions.

5) Construction Base

The public wharf is suitable for bringing in construction materials via sea transportation. However, the temporary storage yard area is limited. Consequently, it will be necessary to allocate an additional temporary storage yard near the construction site.

6) Construction Schedule

According to the construction program, the natural condition surveys (soil, hydrographic, and land investigations) and the engineering study will be conducted in 1984. Actual construction work will commence in 1985 and will be completed before the end of 1988.

7) Cost Estimate Factors

The most basic factors involved in the cost estimate are explained above in the sections on facilities and conditions. Presented below are additional factors.

(1) Prices are expressed in U.S. dollars, based on December 1982 prices.

(2) The exchange rate is 680 RP = 1 USD = ¥250.

(3) Customs duties on imported construction materials and equipment are not included.

(4) A 5% sales tax in local currency is assumed.

(5) The physical contingency of 15% is assumed, though not applicable to the natural conditions survey, the engineering study and supervision.

(6) A price contingency has not been assumed.

(7) The following costs will be met in foreign currency:

i) The cost of construction materials imported from abroad.

ii) Rentals of large construction craft and equipment which cannot be easily procured in Indonesia.

iii) Wages for skilled foreign labour.

7.2 Design of Main Facilities

7.2.1. Comparative Design

Three alternative plans for the general cargo wharf (water depth: -10m) were mutually compared.

Plan A: Sheet Pile Quaywall (Fig. 7.2.1.)
Plan B: Open Type Wharf with Vertical Piles (Fig. 7.2.2.)
Plan C: Caisson Type Quaywall (Fig. 7.2.3.)

1) Alternative Plan A (Sheet Pile Quaywall)

This alternative requires very deepwater, and in addition, as the section modulus of the steel sheet piles is not sufficient the use of steel sheet pipe piles is indicated for the quay wall. The steel pipe piles are continuously driven and connected with sheet pile anchorages by tie ropes, thus forming a wall.

As soil conditions at the wharf construction site are relatively poor, the sea bed should be replaced by sand material down to −23m. The depth and width of the replaced area have been determined in accordance with calculation of a circular slip.

The outside diameter of the sheet pipe piles is 812.8mm and the central interval of driven piles is 888.0mm. T and L shape bars are welded along the sheet piles to chuck the piles and prevent the outflow of back fill. The sheet pile length is 27.0m and the penetration length is 14.0m.

The dimensions of the sheet pile anchorages are 400mm in width, 150mm in height and 13.1mm in thickness.

Considering settlement of the ground, tie ropes are used for connecting the sheet pipe piles and anchorages. A tie rope is set for every two pipe piles, that is, at intervals of 1,776mm.

2) Alternative Plan B (Open Type Wharf with Vertical Piles)

The outside diameter of the piles is 812.8mm and the thickness is 14.0mm. The piles are protected from corrosion by cathodic protection, concrete coating and increased thickness. The base of the pile is driven down to −25m in order to obtain axial bearing capacity and pulling resistance. The embeded length of the piles is 15m and the total length is 28.5m. The block size for the wharf is 25m square. The width of a block of wharf has been determined by considering the cargo handling efficiency.

In addition to the piled jetty wharf as an apron, access bridges are needed to connect the apron and the transit sheds. Furthermore, in order to obtain a sufficient back area so as to facilitate as smooth a cargo handling operaton as possible, it is necessary to construct a bulkhead for reclamation along the 0 m depth line, as shown in Fig. 6.4.2. A replaced sand foundation is required for this bulkhead construction. Sheet piles will then the driven into this foundation.

3) Alternative Plan C (Caisson Type Quaywall)

As mentioned before, soil conditions are not good, so soil stabilization is necessary for constructing a gravity type quaywall such as a caisson. As shown in Fig. 7.2.3, the sea bed will be replaced by sand material down to −23m. The replacement depth has been determined in accordance with stability analysis against a circular slip.

The rubble mound foundation should be 3.5m thick, in consideration of the bearing capacity of the ground. The fundation must be excavated down to −13.5m.

Caisson dimensions are 7.0m wide, 13.0m long and 14.0m high. Dry weight is approximately 1,000 tons. Sand materials are filled into the installed caissons, and rubble stones are piled behind them. Mats are placed on the joints of the caissons to prevent reclaimed sand from spilling out.

Soil replacement and drainage work should be carried out in the reclaimed area used for open storage and wharehouses, in alternative plan A,B and C.

As a result of comparing the economy and workability of these plans (see Table 7.2.1), it has decided to adopt Alternative Plan A (Sheet Pile Type Quaywall).

Table 7.2.1 Comparison of Economy and Workability

Item \ Type	Plan A Sheet pile type quaywall		Plan B Open type wharf with vertical piles		Plan C Caisson type quaywall	
Large construction craft	Pile driving barge Sand drain barge Pump dredger		Pile driving barge Sand drain barge Pump dredger		Floating dock Sand drain barge Pump dredger	
Workability at sea	Very easy	◎	Very easy	◎	Not so easy	△
Construction Control	Very easy	◎	Very easy	◎	Not so easy	△
Amount of work	Small	◎	Small	◎	Much	△
Adaptability to change in ground	Good	◎	Good	◎	Adaptable	○
Requirement of corrosion prevention	Required	△	Required	△	Not required	◎
Reclamation area (m^2)	164,000		93,000		164,000	
Construction cost ratio (Plan A = 1.0)	1.00		1.12		1.08	

7.2.2 New Wharf and Other Facilities

As result of the comparison, Althernative A was chosen as the wharf structure. In this section, the main facilities for the project are described.

1) General Cargo Wharf (−10m Berth)

A standard cross section of the general cargo wharf is shown in Fig. 7.2.1

2) Wharf for small vessels (−5m Wharf)

The standard cross section of the wharf is shown in Fig. 7.2.4. The wharf is comprised of steel sheet piles and sheet pile anchorages, which are connected by 22mm diameter tie ropes. The dimensions of the sheet piles are 400mm in width, 150mm in height and 13.1mm in thickness. Anchorages are 400mm wide, 85mm high and 8.0mm thick. The penetration length of piles is 9.5m and the total length is 17.5m.

As with the −10m berth, the sea bed should be replaced with sand materials down to −15m to prevent circular slips from occurring.

3) −12m Palm Oil Dolphin Berth

The berth layout is determined in consideration of ship size, water depth, sea current direction, loading workability, etc. Fig. 7.2.5 shows the berth layout. Palm oil tankers of 5,000 to 35,000 DWT will be able to berth at the dolphins.

Fig. 7.2.6 ~ Fig. 7.2.7 show standard cross sections of breasting dolphin and mooring dolphin for the palm oil berth.

The breasting dolphin is used for berthing by oil tnakers. The structure of the breasting dolphin is designed so as to withstand a berthing force of 130 tons, which can be calculated by considering ship size, berthing velocity and the fender system. The breasting dolphin covers an area of 10m square. The outside diameter of the piles is 812.8mm and its thickness is 16.0mm.

The mooring dolphin is designed to withstand a mooring force of 150 tons. It covers an area of 10m square, and its piles have an outside diameter of 812.8mm and a thickness of 19.0mm.

4) −10m Palm Oil Dolphin Berth

The berth is designed to allow use by 20,000 DWT oil tankers.

The principal dimensions of the berth structure are the same as for −12m palm oil dophin berth, except that the dimensions of piles differ. The diameter and thickness of piles used for the mooring dolphin are respectively 711.2mm and 16.0mm. The dimensions for the breasting dolphin are the same as for the mooring dolphin. The piles for the loading platform are 609.6mm in diameter and 14.0mm in thickness. The penetration length of each pile is 13.0m.

5) Passenger Wharf (-8.5m Berth)

The structure type for this wharf is steel pile quaywall. The standard cross section is shown in Fig. 7.2.8.

The dimensions of the sheet piles are 400mm in width, 367mm in height and 21.9mm in thickness. The piles are of Z shape. The length of sheet piles is 23.0m and their penetration length is 11.5m. The dimensions of the sheet pile anchorages are 400mm in width, 125mm in height and 13.0mm in thickness. In anticipation of settlement of the ground, tie ropes are used for connecting the sheet pipe piles and anchorages. Tie ropes are applied for every two piles, that is, at intervals of 800mm.

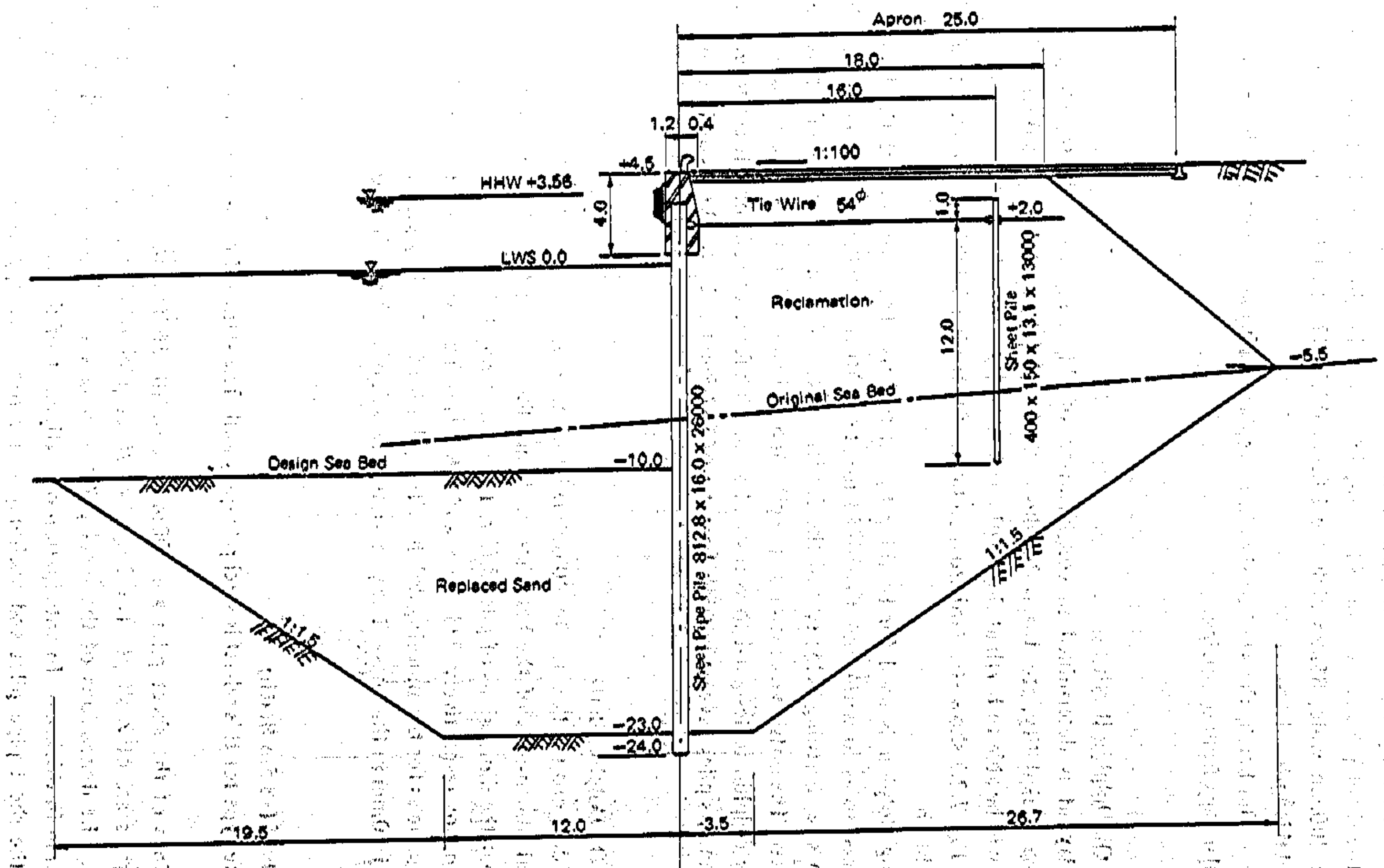


Fig. 7.2.1 Standard Section of Alternative Plan-A (Sheet Pile Type Quaywall : -10m Berth)

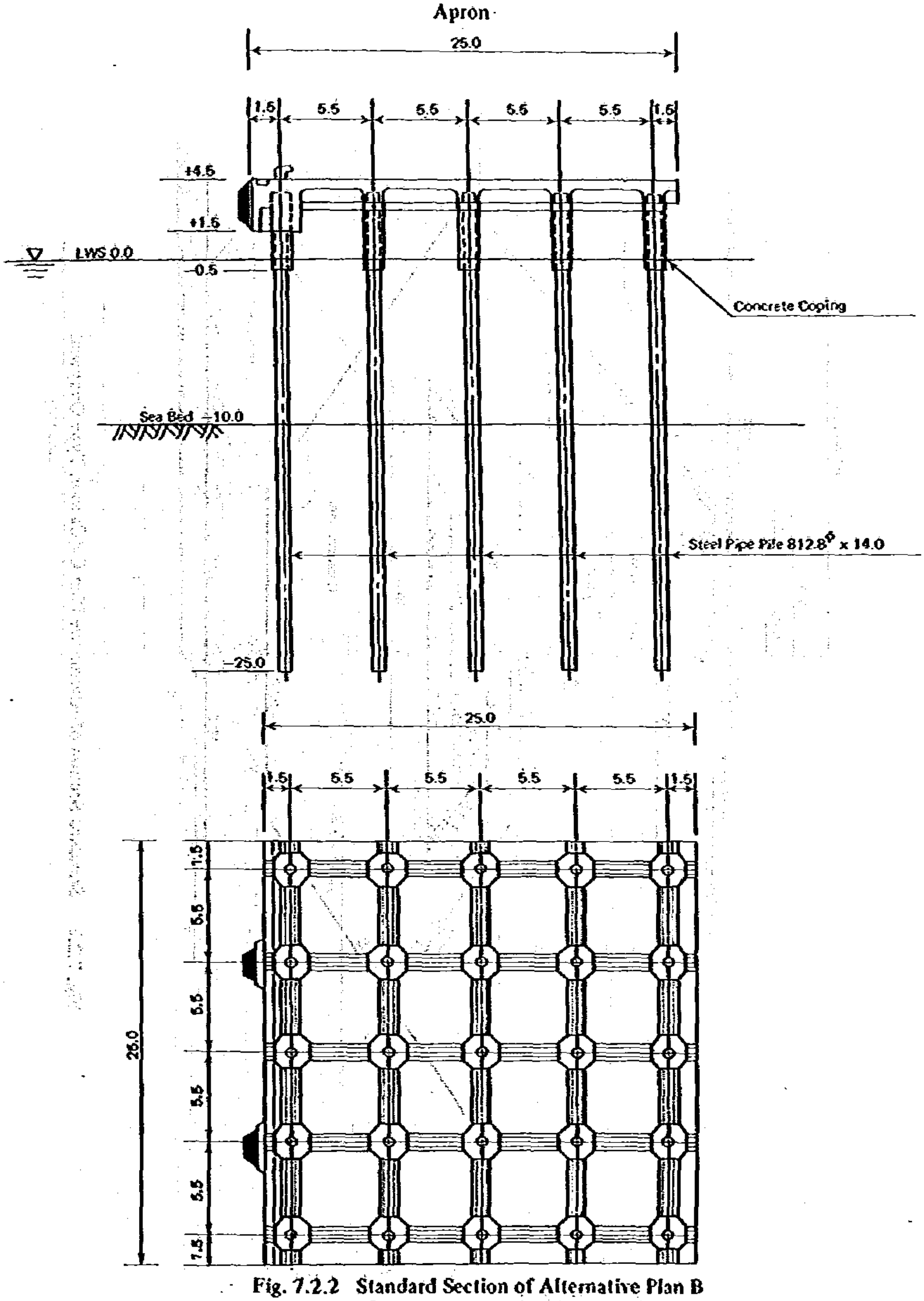


Fig. 7.2.2 Standard Section of Alternative Plan B (Open-Type Wharf with Vertical Piles)

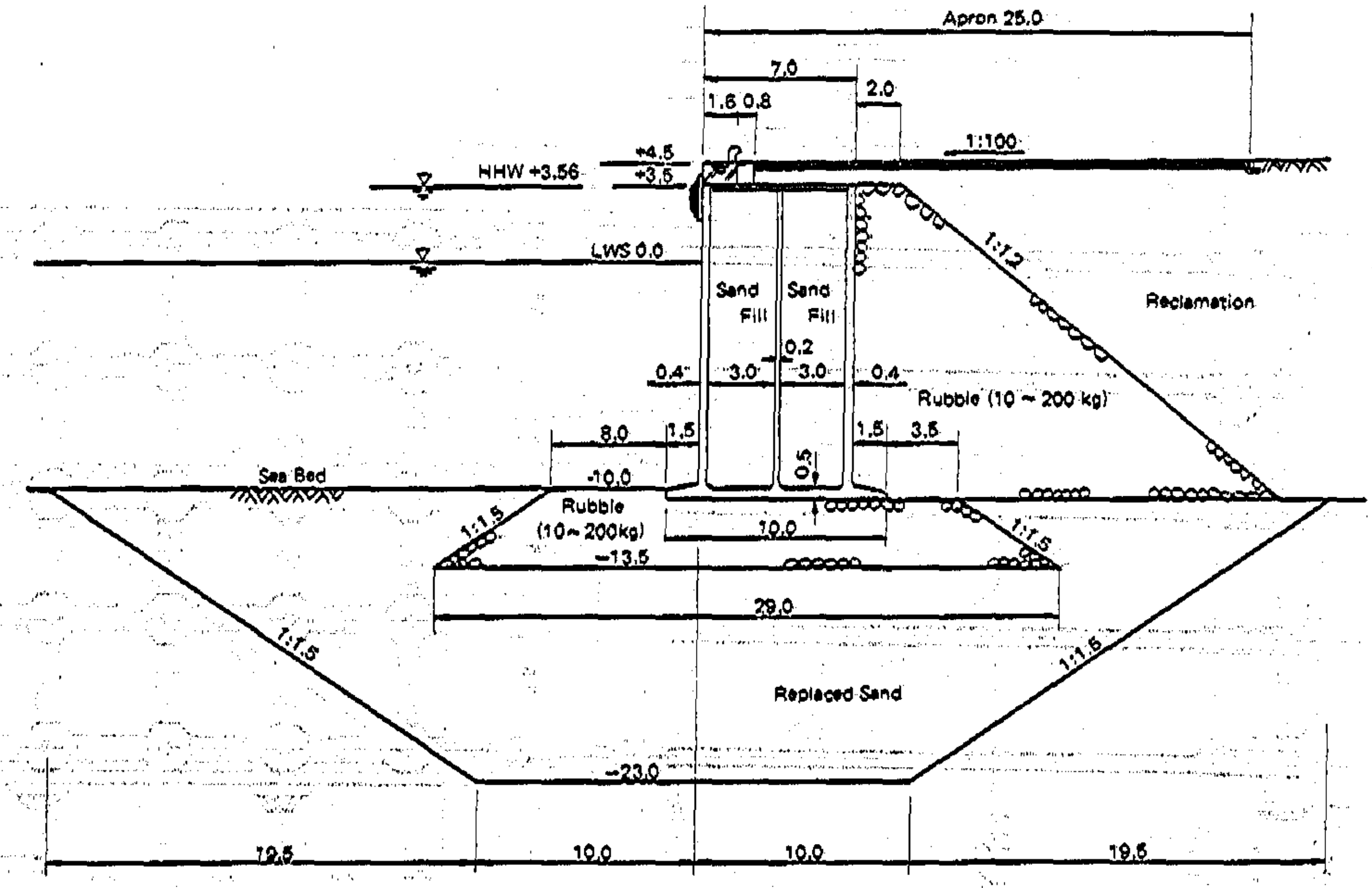


Fig. 7.2.3 Standard Section of Alternative Plan C (Caisson Type Quaywall)

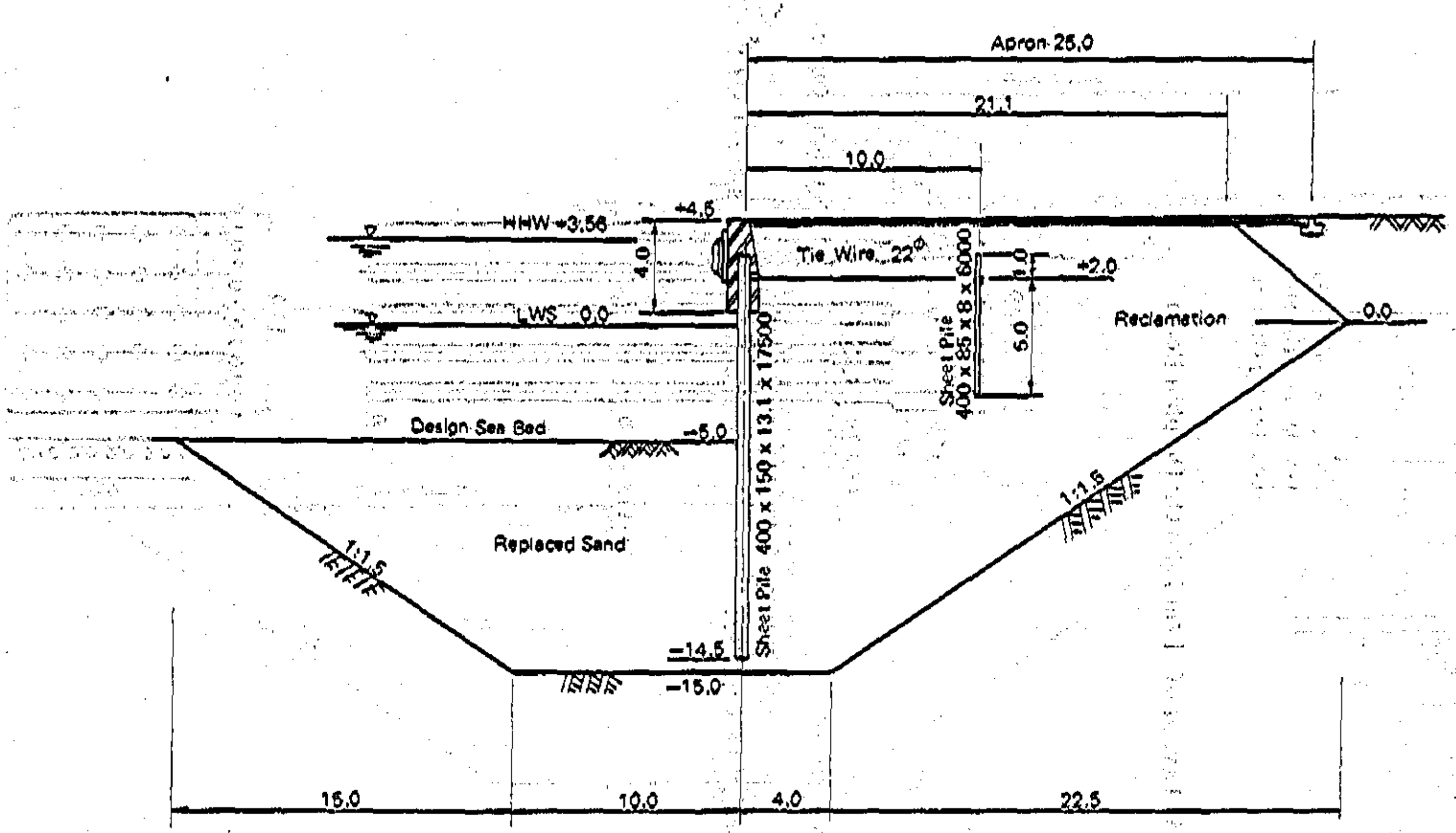


Fig. 7.2.4 Standard Section of -5m Wharf (Wharf for Small Vessels)

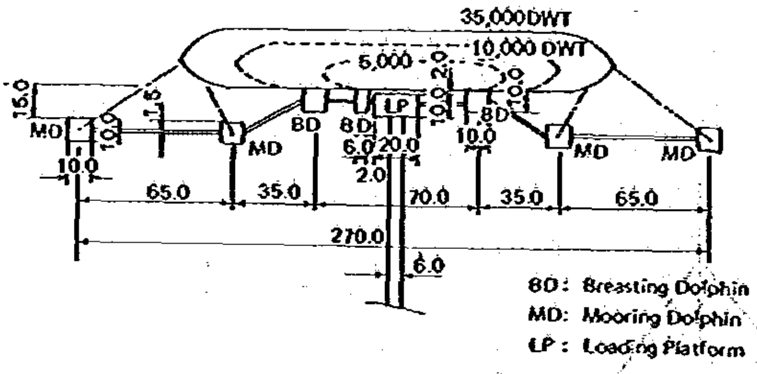
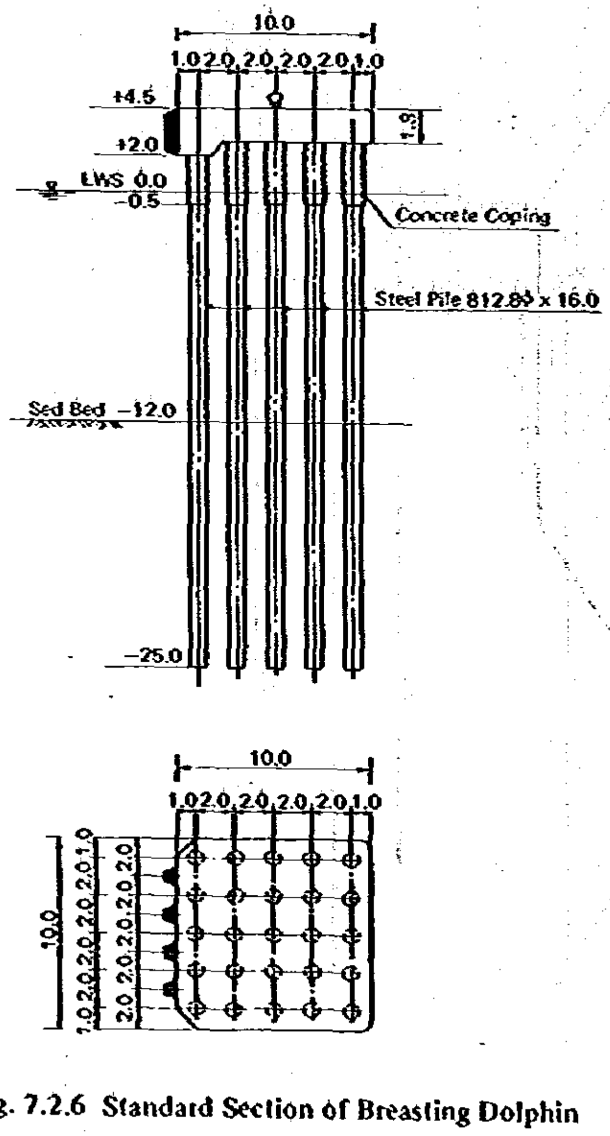


Fig. 7.2.5 Layout of -12m Palm Oil Dolphin Berth



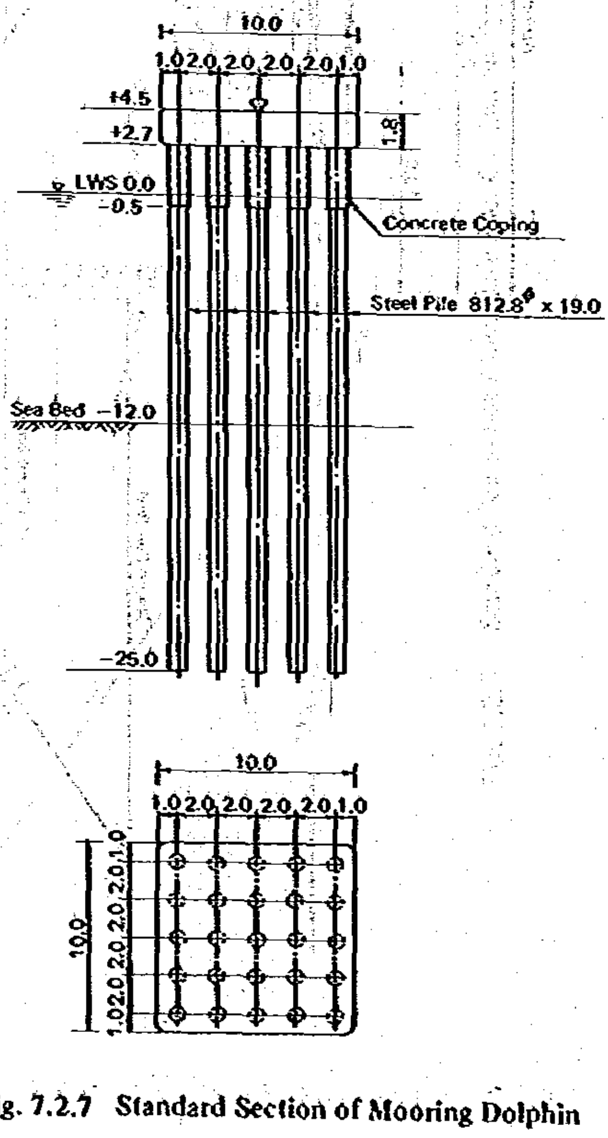


Fig. 7.2.6 Standard Section of Breasting Dolphin

Fig. 7.2.7 Standard Section of Mooring Dolphin

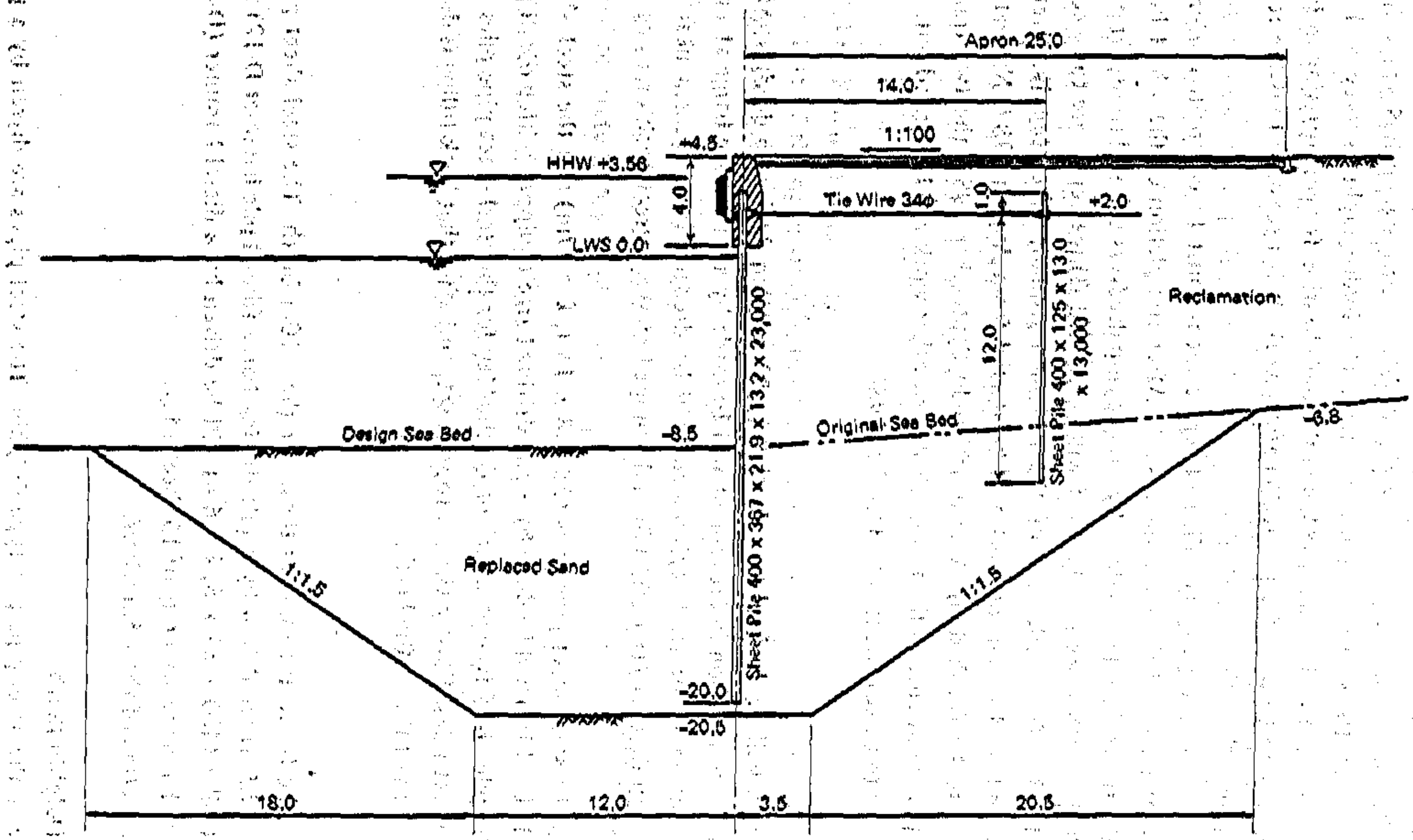


Fig. 7.2.8 Standard Section of –8.5m Wharf

7.3. Construction Planning

7.3.1. Construction Schedule

The construction schedule for the short term development program under the Master Plan is shown in Table 7.3.1. The construction period for this development program is 5 years, from January 1984 to September 1988. The soil investigation, the hydrographic survey and the engineering study will be started in January 1984, and the mobilization for construction in June 1985. As a pump dredger is to be used for the reclamation work, it is necessary that the revetments be completed before reclamation is started.

The wharf being a sheet pile type quaywall, soil replacement must be compelted prior to driving the steel sheet pipe piles and the sand drain work. After completion of the wharf bulkhead and the revetments, the reclamation is done by using pymp dredgers and soil transportation barges, following which the earth work for the road will be started. Three berths are to be completed by September 1978. After settlement of the reclamed ground, water supply, electric power supply, drainage and road pavement work will be started from August 1987. Navigation aid construction work is to be finished by August 1978. In September 1988, the two transit sheds, the building, the pavement around the transit sheds and other work will be carried out.

The palm oil dolphin is to be constructed by October 1986.

7.3.2. −10m Berth

Unsuitable soil material will be dredged to a depth of −23m by an 8m³ grab dredger. After dredging the sand piles for foundation improvement will be made by a sand drain barge at a rate of 40 sand piles/day. The sand for sand replacement will be dredged from the sea near the Pulau-Payung using a pump dredger (D 1,200 PS) and dumped at the correct position using soil transportation barges.

The work of driving the steel sheet pipe piles (ϕ812.8 x 16 t, ℓ = 27m) and the steel sheet piles (400 x 150 x 13.1, ℓ = 13m) will be done by a pile driving barge equipped with a diesel pile hammer (D-40, 12). The pile are driven at a rate of 6 piles/day for the steel sheet pipe piles and 18 sheets/day for steel sheet piles. Finally tiewire rope is set, and after that back filling is done. Fig. 7.2.1. shows the section of the −10m berth.

7.3.3. −5m Wharf

The construction methods are the same as those for the −10m berth. The steel sheet piles (400 x 150 x 13.1, ℓ = 17.5m) are driven by a pile driving barge (diesel pile hammer D-12) and the buttress steel sheet piles (400 x 85 x 8, ℓ = 6m) will be driven by a diesel hammer (D-12) mounted on a 35 ton crawler crane, at a rate of 15 sheets/day.

Fig. 7.2.4 shows the section of the −5m wharf.

7.3.4. −12m Palm Oil Dolphin Berth

The berth structure is the steel pipe pile type dolphin. The steel pipes are driven by a pile driving barge equipped with a diesel pile hammer (D-40), which will be brought from Japan. Fig. 7.2.5 ~ 7. shows the plan of the −12m palm oil dolphin berth.

7.3.5. Reclamation

The total volume of reclamation is 1,350,000 m^3, the area of reclamation is about 230,000m^2. The sand for reclamation will be dredged from the sea near Pulau-Payung by two pump dredgers (D 4,000 PS, D 1,200 PS), supported by three soil transporation barges (2,000m^3) and two pusher boats (2,000 PS).

7.3.6. Revetment

The revetment is of the rubble mount type. Rubble (50 – 100 kg) is deposited by the end-on system using dump trucks and bulldozers. The total length of the revetment as follows: ℓ = 480 + 74 = 554 m.

7.3.7. Roads

The roads are paved with asphalt. The total road area is about 143,500m^2, which breaks down as follows:

30m road x 2,150 = 64,500 m^2
25m road x 1,280 = 32,000 m^2
20m road x 2,350 = 47,000 m^2

7.3.8. Pavement (Asphalt)

Part of the open storage, the car park and the space around the transit shed are paved with asphalt concrete. The total area is 61,750m^2

7.3.9. Transit sheds

Two transit sheds (120 m x 45 m) with steel frames, roofs of corrugated asbesto cement slate, and concrete floors are planned.

7.3.10. Building

The building is made of reinforced concrete. The total floor space is 4,900m^2. The port facilities plan is shown in Fig. 7.3.1.

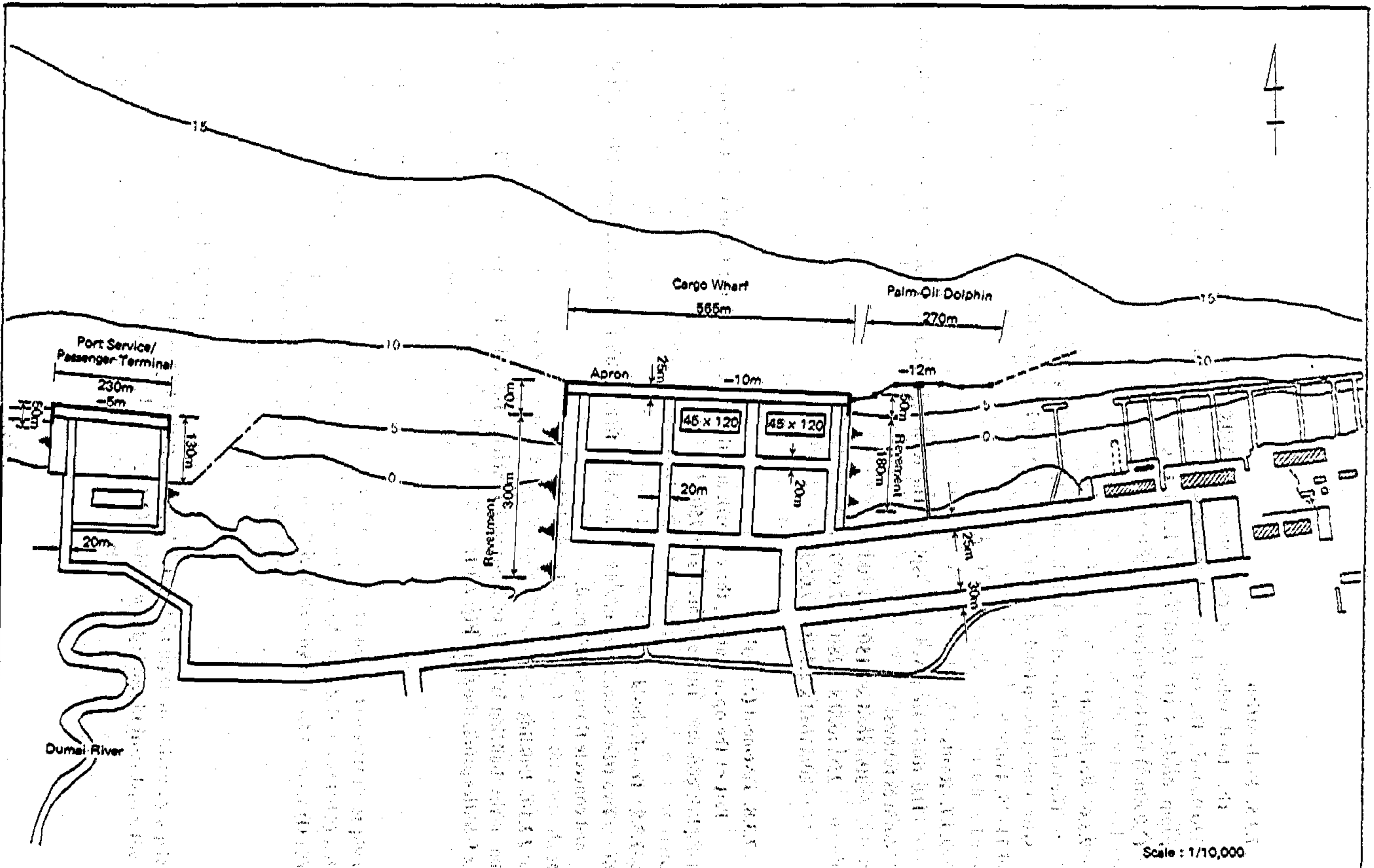


Fig. 7.3.1 Plan of Port Facilities for Short Term Development Program

Table 7.3.1 Construction Schedule for Short Term Development Program

No.	Item: Description	Unit	Quantity
1	Dredging	m^3	600,000
2	Sand Pile	m^2	78,000
3	Replacing	m^3	410,000
4	-10m wharf	m	685
5	-5m wharf	m	410
6	Palm Oil Dolphine	sum	1
7	Revetment	m	554
8	Reclamation	m^3	1,350,000
9	Road	m^2	143,530
10	Pavement	m^2	61,750
11	Transit Shed	m^2	10,800
12	Building	m^2	4,900
13	Drainage	sum	1
14	Water Supply	sum	1
15	Electric Supply	sum	1
16	Cargo Handling Equipment	sum	1
17	Navigation Aids	sum	1
18	Others	sum	1
19	Mobilization/Demobilization	sum	1
20	Engineering Study	sum	1
21	Supervision	sum	1

7.4. Cost Estimate

The required quantities of materials are calculated for the structural forms determined by comparative design and for the other facilities. The most economical construction method is employed over other practical methods. Based on the unit cost obrained through the field survey, the construction costs are estimated by summing up the costs of each individual work.

The project cost under the Master Plan has been estimated at 124,938 thousand US$ as shown in Table 7.4.1, of which 55,820 thousand US$ is appropriated for the construction of the Short Term Plan targetted for 1988.

Table 7.4.2 and Table 7.4.3 show respectively the construction cost of the Short Term Plan and its breakdown by year, from 1985 to 1988.

Table 7.4.1 Construction Cost of Master Plan

Item	Description	Unit	Quantity	Unit Price (US$)	Amount ('000 US$)
1	−10.0 m Wharf	m	1,190	18,710	22,265
2	−8.5 m Wharf	m	280	11,817	3,309
3	−5.0 m Wharf	m	440	6,022	2,650
4	Palm Oil Dolphin (−12 m)	sum	1		2,540
5	Palm Oil Dolphin (−10 m)	sum	1		2,209
6	Small Basin Jetty	sum	1		1,493
7	Dredging	m^3	1,200,000	2.1	2,520
8	Sand Pile	m^2	193,000	16.5	3,185
9	Replacing	m^2	766,000	2.5	1,915
10	Reclamation	m^3	2,820,000	2.5	7,050
11	Revetment	m	1,840	1,986	3,654
12	Road	m^2	255,000	36	9,180
13	Pavement	m^2	320,000	30	9,600
14	Pavement (Container)	m^2	52,000	48	2,496
15	Green Area	m^2	49,000	6.5	319
16	Transit Shed	m^2	22,800	326	7,433
17	Building	m^2	6,000	343	2,058
18	Drainage	sum	1		955
19	Water Supply	sum	1		1,142
20	Electric Supply	sum	1		1,123
21	Cargo Handling Equipment	sum	1		580
22	Navigation Aids	sum	1		102
23	Port Service Vessels	sum	1		1,162
24	Others	sum	1		1,360
25	Mobilization/Demobilization	sum	1		11,821
	Total				102,121
	Sales Tax (5%)				2,170
	Physical Contingency (15%)				15,643
	Engineering Fee				5,004
	Grand Total				124,938

Table 7.4.2 Construction Cost of Short Term Development Program

Item	Description	Unit	Quantity	Unit Price (US$)			Amount ('000 US$)		
				Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
1	Dredging	m^3	600,000	0.7	1.4	2.1	420	840	1,260
2	Sand Pile	m^2	78,000	3	13.5	16.5	234	1,053	1,287
3	Replacing	m^3	410,000	0.5	2	2.5	205	820	1,025
4	−10 m wharf	m	685	7,350	11,360	18,710	5,034	7,782	12,816
5	−5 m wharf	m	410	2,232	3,790	6,022	915	1,554	2,469
6	Palm Oil Dolphin	sum	1				1,060	1,480	2,540
7	Revetment	m	554	1,394	592	1,986	772	328	1,100
8	Reclamation	m^3	1,350,000	0.5	2	2.5	675	2,700	3,375
9	Road	m^2	143,530	32.4	3.6	36	4,650	517	5,167
10	Pavement	m^2	61,750	19	11	30	1,173	679	1,852
11	Transit Shed	m^2	10,800	99	227	326	1,069	2,451	3,520
12	Building	m^2	4,900	96	247	343	470	1,210	1,680
13	Drainage	sum	1				415	0	415
14	Water Supply	sum	1				175	367	542
15	Electric Supply	sum	1				202	276	478
16	Cargo Handling Equipment	sum	1				0	120	120
17	Navigation Aids	sum	1				5	39	44
18	Others	sum	1				151	319	470
19	Mobilization/Demobilization	sum	1				1,532	3,939	5,471
	Total						19,157	26,474	45,631
20	Sales Tax (5%)						957	0	957
21	Physical Contingency (15%)						3,017	3,971	6,988
22	Engineering Study	sum	1				376	690	1,066
23	Supervision	sum	1				234	944	1,178
	Grand Total						23,741	32,079	55,820
							(42.5%)	(57.5%)	(100%)

Table 7.4.3 Construction Cost of Short Term Development Program by Each Year (1984 – 1988)

(Unit: 1,000 US$)

Item				1984			1985			1986			1987			1988			Grand Total		
No.	Description	Unit	Quantity	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
1	Dredging	m^3	600,000				420	840	1,260										420	840	1,260
2	Sand pile	m^2	78,000				117	516	643	117	527	644							234	1,053	1,287
3	Replacing	m^3	410,000							205	820	1,025							205	820	1,025
4	-10m wharf	m	685							2,819	4,358	7,177	2,215	3,424	5,639				5,034	7,782	12,816
5	-5m wharf	m	410							165	279	444	750	1,275	2,025				915	1,554	2,469
6	Palm Oil Dolphin	sum	1				180	251	431	880	1,229	2,109							1,060	1,480	2,540
7	Revetment	m	554				255	108	363	517	220	737							772	328	1,100
8	Reclamation	m^3	1,350,000							493	1,971	2,464	182	729	911				675	2,700	3,375
9	Road	m^2	143,530							837	93	930	2,558	284	2,842	1,255	140	1,395	4,680	517	5,167
10	Pavement	m^2	61,750										656	381	1,037	517	298	815	1,173	679	1,852
11	Transit Shed	m^2	10,000													1,069	2,451	3,520	1,069	2,451	3,320
12	Building	m^2	4,900													470	1,210	1,680	470	1,210	1,680
13	Drainage	sum	1										278	0	278	137	0	137	415	0	415
14	Water Supply	sum	1										117	246	363	58	121	179	175	367	542
15	Electric Supply	sum	1										135	185	320	67	91	158	202	276	478
16	Cargo Handling Equipment	sum	1										0	60	60	0	60	60	0	120	120
17	Navigation Aids	sum	1										5	39	44				5	39	44
18	Others	sum	1				151	319	470										151	319	470
19	Mobilization/Demobilization	sum	1				260	670	930	459	1,182	1,641	459	1,182	1,641	354	905	1,259	1,532	3,939	5,471
20	Sales Tax (5%)	sum					69	0	69	324	0	324	367	0	367	197	0	197	957	0	957
21	Physical Contingency (15%)	sum	1				217	407	624	1,022	1,602	2,624	1,158	1,171	2,329	620	791	1,411	3,017	3,971	6,988
22	Engineering Study	sum	1	376	690	1,066													376	690	1,066
23	Supervision	sum	1				35	141	176	70	283	353	70	283	353	59	237	296	234	944	1,178
	Total			376	690	1,066	1,704	3,262	4,966	7,908	12,564	20,472	8,950	9,259	18,209	4,803	6,304	11,107	23,741	32,079	55,820

CHAPTER 8.
ECONOMIC ANALYSIS

CHAPTER 8. ECONOMIC ANALYSIS

8.1. General

8.1.1. Outline

The Dumai Port Development Project is part of the 3rd 5 year plan. The goal of the project is to raise the export capacity of the port's facilities in order to expand the export of agricultural goods produced in Riau Province and in the southeastern part of North Sumatra Province.

The Dumai Port Development Project is also expected to stimulate development of economic activities in Dumai City, as well as Riau and the southeastern part of North Sumatra Province. The expanded and modernized facilities will provide great benefits to the industries and municipal functions of Dumai City and its surrounding area.

Plans for this development project call for a final target year of 2000, while an economic analysis has been made for the short term plan extending up to 1990.

8.1.2. Method for the Economic Analysis

Two methods of economic analysis have been used for this project. One method employs market prices that were in effect at the time of the survey of October – December, 1982. The other method uses "calculated prices" based upon "international prices" for the same period. As for this latter method, sufficient statistical data was not always available so rough estimates of the calculated prices were at times used.

The evaluation method for economic earning power is based on internal rate of return (IRR) and on benefit cost ratio (B/C ratio). As for the discount rate used in calculating the benefit cost ratio, a value of 12% has been applied.

8.1.3. Hypothetical Proposal for the Purpose of Comparison

The hypothetical proposal calls for adoption of several "without" cases, whereby it is assumed that investments are not made in certain cases. Cost/benefit analyses can then be made by comparing the differences between the "with" and "without" cases.

Although off-shore cargo handling through the use of barges will in principle not be introduced in this project, it has been assumed for the hypothetical "without" case that barges will be utilized for this purpose. Without new port development, ship waiting time would become so lengthy that the use of barges for cargo handling would undoubtedly become necessary. This "without" case has been assumed that the number of barges currently owned by the port would suffice, so that investment in additional barges would not be needed.

Estimated cargo volume to be handled at the port is the same for both "with" and "without" cases. Both cases also assume that construction of the 500m jetty berth and the Dumai-Duri highway will be completed on schedule.

8.2. Cost

8.2.1. Cost Estimate

Costs dealt with in the project economic analysis include, construction, maintenance and operating costs.

Construction costs have been estimated at US$55,820,000 – 1982 prices. The economic analysis has deducted sales tax from this sum to arrive at a value that can be compared to international standards. The construction costs thus arrived at amount to US$ 54,863,000.

Maintenance and operating costs of Dumai Port will count towards maintenance and operating of wharves, sheds, open storage, loading equipment, as well as towards provision of power, water, fuel, salaries, and miscellaneous expenses.

8.2.2. Construction Costs

Construction costs from 1984 to 1988 will total US$54,863,000. These costs by year are shown in Table 8.2.1.

Table 8.2.1 Construction Costs Used for Economic Analysis

(Unit: '000 US$)

Year	Construction Costs
1984	1,066
1985	4,897
1986	20,148
1987	17,842
1988	10,910

8.2.3. Maintenance and Operating Costs

Maintenance and operating costs dealt with in the economic analysis for this project include expenses for personnel, administration, and facility maintenance and operation.

The estimate for personnel expenses has been based upon the 1981 average personnel expense for all trades, and amounts to US$2,111.76/man/year, in accordance with the 1981 financial data for Dumai Port.

As for administrative expenses, it has been established that these amount to 22% of total personnel expenditures.

As for maintenance and operating costs, these have been estimated as a fixed proportion of the original construction cost. The proportion (percentage) applying to each facility is shown in Table 8.2.2. An annual breakdown of maintenance and operating costs based upon a calculation of the above items is shown in Table 8.2.3.

Table 8.2.2 Maintenance and Operating Costs

Facilities	Rates (%)
Wharf	1.0
Revetment	0.3
Navigation Aids	2.0
Shed	1.0
Building	1.5
Road/Pavement	1.0
Water Supply	3.0
Electric Supply	3.0
Cargo Handling Equipment	10.0

Table 8.2.3 Maintenance and Operating Costs Used in the Economic Analysis

(Unit: '000 US$)

Year	Maintenance and Operating Costs
1987	327
1988	979
1989	1,218

8.3. Benefit

8.3.1. Categories of Benefits

The following benefits are expected from this project.

1) Reduction of ship waiting costs
2) Improved cargo handling efficiency and reduced cargo handling costs
3) Positive effect on regional development
4) Increased employment opportunities and incomes

Benefits 1) and 2) can readily be quantitatively analyzed. However, 3) and 4) are difficult to quantify, so only a qualitative analysis will be undertaken.

8.3.2. Reduction of Ship Waiting Costs

If the increased volume of cargo is handled only by existing facilities, then the number of ships waiting for berth space will increase to the point where port congestion becomes a serious problem. Investment in improved port facilities can avoid this problem by reducing waiting time for ships. Monetary benefits that will accrue from such improved facilities can be calculated by comparing the case where investment is carried out against the case where it isn't – with case vs without case.

1) Lowered Costs due to Reduced Waiting Time

Calculation of waiting time for berths will be based on the results of simulation in accordance with Queuing Theory. In order to avoid overestimation of waiting time, the distribution of ship arrival has been assumed to be random. Total waiting time for all ships is as per Table 8.3.1.

Table 8.3.1 Total Waiting Time for All Ships

Year	Without-Case Ship-Day (Total)	With-Case Ship-Day (Total)	Difference between Cases Ship-Day (Total)
1987	1,006	412	594
1988	2,150	367	1,783
1989	7,582	215	7,367

There are two methods for calculating the cost incurred by ships when waiting for berths. One method is to sum up all of the various expenses incurred during the wait. The other method, which reveals the "international market price" for expenses sustained through ship waiting, is based on the fixed period charter rates for a vessel. This latter method has been adopted in this report.

Table 8.3.2 shows international charter rates (one year) for dry cargo. Table 8.3.3 shows domestic charter rates charged by Indonesian shipping companies. The domestic charter rate is set at US$5,000/day for 10,000 DWT ocean going vessels (source: Indonesian Shipping Company). However, during the three years from 1980 ~ 1982, Table 8.3.2 reveals that the average (international market price) charter rate for 12,000 DWT ships was US$4,152/day, so that the above mentioned price of US$5,000/day for a 10,000 DWT ocean going vessel, though corresponding more or less to actual market prices, is somewhat on the high side due to fluctuations in charter rates.

The economic benefit that results from reducing berth waiting expenses does not necessarily accrue to Indonesia.

From the viewpoint of this economic analysis, only savings related to Indonesian ships will be re-cycled into the Indonesian economy. Therefore, only savings pertaining to Indonesian ships will be considered as benefits in this economic analysis.

At present, the percentages of cargo carried by Indonesian vessels bound for the following destinations are: 50% for Europe; 43% for Japan; and 40% for South Korea (source: DGSC). It is expected that in the future, the percent of Indonesian vessels engaged in import/export at Indonesian ports will rise to 50%. Thus 50% of the savings gained from berth waiting reductions will accrue to Indonesia.

Table 8.3.2 Changes Over Time in Average Charter Rates for Dry Cargo

(Unit: US$/DWT・Month)

Year	12,000–19,999 DWT	20,000–34,999 DWT	35,000–49,999 DWT	50,000–84,999 DWT	85,000 over DWT
1980					
Jan. – Mar.	11.74	9.67	8.32	6.50	3.99
Apr. – Jun.	12.96	12.41	10.04	7.24	4.07
Jul. – Sep.	13.31	9.91	8.46	6.10	2.91
Oct. – Dec.	12.20	10.31	8.42	6.63	3.76
1981					
Jan. – Mar.	12.35	10.24	8.55	6.80	2.96
Apr. – Jun.	12.15	9.37	7.11	5.09	3.03
Jul. – Sep.	10.57	7.45	–	4.07	–
Oct. – Dec.	11.63	6.57	4.05	3.13	1.47
1982					
Jan. – Mar.	7.18	4.87	4.22	2.66	1.30
Apr. – Jun.	7.39	5.78	5.84	2.80	1.24
Jul. – Sep.	6.17	3.23	4.41	1.48	1.19
Oct. – Dec.	6.89	3.63	2.72	1.66	0.99
Average	10.38	7.79	6.56	4.51	2.45

Source: GCBS

Table 8.3.3 Coastal Charter Rates for Indonesian Shipping Companies

(Unit: US$/DWT・Month)

DWT	US$
200	54.90
750	39.00
1,000	34.80
1,500	32.10
2,300	24.00
4,200	19.80

2) Reductions in Berthing Time through Improved Cargo Handling

In the event that the "with case" is implemented, then the type of wharf to be constructed will be a reclaimed type wharf. Through the higher efficiency of this type wharf as compared to the existing jetty type, ships will be able to reduce their berthing time by 10%. The higher efficiency of reclaimed type wharves is considered due to the fact that they are furnished with mechanized chargo handling equipment.

Benefits, in terms of waiting time, that are derived from utilization of a reclaimed type wharf are calculated by first estimating the cargo handling volume and cargo handling time of vessels berthing at the reclaimed type wharf. Then, these estimated values are multiplied by shipping costs. The benefit is regarded as the difference between the cost thus calculated and a corresponding cost based on calculations for the jetty type wharf.

Table 8.3.4 indicates the projected savings due to reduced berth waiting time.

Table 8.3.4 Saving in Expenses due to Reduced Berth Wating Time

(Unit: '000 US$)

Year	Reductions due to reduced waiting time	Savings due to improved cargo handling	Total
1987	332	–	332
1988	2,151	182	2,333
1989	9,288	238	9,526

Another benefit of the reclaimed type wharf, though difficult to quantify, is that damage to cargo will be considerably reduced by eliminating the need to load and unload cargo onto trucks so as to transport it from wharf to transit shed and vice versa.

8.3.3. Reduction in Cargo Handling Expenses

1) Elimination of Off-shore Cargo Handling Expense

In the event that the "without case" is implemented, it is assumed that a certain percent of cargo will first be handled off-shore by barges, as the existing facilities will not be sufficient to handle the increasing volume of cargo. On the other hand, implementation of the "with case" will in principle obviate the necessity for cargo handling by barges, especially after completion of the wharf streamlining project in 1988. Therefore, the absence of cargo handling expenses involving barges is rated as a benefit of the "with case".

In order to calculate the amount of this cargo handling benefit, a calculation of costs involved in off-shore cargo handling for the "without case" is first required. This calculation is based on the estimte that half of all cargo will be handled via barges. Table 8.3.5 shows projections for cargo handling by barges. In addition to expenses directly related to the barges, the "without case" also requires expenses for stevedoring, for three mobile cranes, and for one 200 HP class tugboart. Taking all these expenses into account, per ton expenses for cargo in the "without case" have been calculated at US$4.36. This figure was then multiplied by the barge handled cargo volume to arrive at the "with case" cargo handling benefit.

Table 8.3.5 Volume of Cargo handled by Barges (without case)

(Unit: '000 ton)

Year	1988	1989
Alongside berth	778	979
Barge	358	361
Total	1,136	1,340

Table 8.3.6 Reductions in Expenses for Cargo Handling by Barges

(Unit: '000 US$)

Year	Amount of savings
1988	1,562
1989	1,574

2) Reduction of On-shore Cargo Handling Expenses

Implementation of the "with case" will make possible construction of transit sheds directly behind the berth. This, in turn, will make it suitable to operate forklifts for cargo handling between the ships and the transit sheds.

On the other hand, the "without case" specifies that a jetty type wharf be connected to transit sheds via a long, narrow 110 m bridge. Forklifts would be unsuitable for cargo handling over this distance, thus necessitating the use of trucks for cargo handling. The purchase price and operating expenses of these trucks are an added difference in cost between the "with" and "without" cases, and as such are regarded as another benefit of the "with case".

The amount of this on-shore cargo handling benefit is calculated by multiplying the number of required trucks (6) by their purchase price and yearly operating cost (US$23,330/year/truck). Results are indicated in Table 8.3.7.

Table 8.3.7 Reduction in On-Shore Cargo Handling Expenses through Construction of Reclamation Type Wharf

(Unit: '000 US$)

Year	Amount of savings
1988	140
1989	140

8.3.4. Positive Effect on Regional Development

The development of Riau Province lags far behind that of the other provinces of Sumatra. While the petroleum sector has been fully developed, the development of the agricultural sector has only recently been begun and as yet its products are not shipped for export. However, in the future the exportation of these products is expected to grow steadily until it is comparable to the quantities presently shipped from North Sumatra. Construction work on new roads in Riau Province, in the areas around Dumai and Duri should be completed by 1978. This will greatly facilitate transportation between Dumai Port and the plantation, increasing the effect of the development on this region.

8.3.5. Employment Opportunities and Incomes

With the development and expansion of the commercial facilities at Dumai Port, employment opportunities for the local population are expected to increase due to increased industrialization and development in the region. Furthermore, as the growth of primary industries and the subsequent advance of secondary and thirtiary industries increases the value of produced goods, the income of the local population is expected to rise.

8.4. Shadow Pricing

8.4.1. Calculation Method for Shadow Princing

"Shadow Princing" here means the appraisal of benefits and costs in terms of international prices (border prices).

In the calculation of shadow princing the following methodology will be used:

(1) all benefits and costs will be divided into the categories of trade goods, labour and non-trade goods;

(2) trade goods will be appraised in terms of border prices, while CIF prices and FOB prices will apply respectively to imported goods and exportable goods;

(3) labour will be divided into skilled labour and unskilled labour; skilled labour costs will be estimated based on local market wages; and unskilled labour costs will be estimated on the value of lost marginal products. Border prices will then be arrived at by multiplying these costs by the conversion factor for consumption; and

(4) as border prices cannot be directly applied in the case of non-trade goods (goods of local origin), a second level analysis is made of the items required for the production of non-trade goods. These items are, in their turn, divided between the categories of trade goods, labour and other remaining non-trade goods.

The standard conversion factor is then applied to the remaining value of non-trade goods.

8.4.2. Calculation of the Conversion Factors

1) The Standard Conversion Factor

Import duties and export subsidies create a price differential between the domestic market and the international market. For the purpose of analysing benefits and costs incured within the domestic market, the standard conversion factor is applied in order to convert to international market prices.

The standard conversion factor (SCF) is obtained by the following formula:

$$SCF = \frac{\text{Total amount of imports} + \text{Total amount of exports}}{(\text{Total amount of imports} + \text{Total amount of import duties} + \text{Total amount of exports} - \text{Total amount of export duties})}$$

The standard conversion factors, for the five years from 1976/77, are listed in Table 8.4.1.

Table 8.4.1 Standard Conversion Factor

(Unit: US$ Million)

Item	1976/'77	1977/'78	1978/'79	1979/'80	1980/'81	Mean
Import (C.I.F.)	5,673.1	6,230.3	6,690.4	7,202.3	10,834.4	7,344.1
Export (F.O.B.)	8,546.5	10,852.6	11,643.2	15,590.1	21,908.9	13,708.3
Import Duties and Sales Tax on Import	866.5	967.5	673.3	726.6	1,017.6	850.3
Export Duties	148.7	691.3	265.9	622.6	482.6	549.2
S. C. F.	0.952	0.984	0.978	0.996	0.984	0.986

In the present calculations the mean value for this five year period was used. Thus the standard conversion factor has a value of 0.986.

2) Conversion Factor for Consumption

This factor is used for converting the prices of consumer goods from domestic prices to international prices. Particularly, this will be required to convert labour costs measured in domestic prices to the corresponding international prices.

The conversion factor for consumption (CFC) will be calculated in the same manner as the standard conversion factor, replacing total imports and total exports by imports and exports of consumer goods only.

However, due to the lack of required data, such as duty revenue figures, the conversion factor for consumption could not be directly calculated. While, it's value can be assumed to the nearly the same as the standard conversion factor, usually higher duties are imposed on imported consumer goods than on the producer's exported goods, therefore a slightly lower figure of 0.950 was chosen.

3) Shadow Wage Rate

Labour cost will be measured by its opportunity cost (value of lost marginal products for other purposes arising from additional employment of a labourer for this project).

For skilled labour costs, assuming that the market meachanism is functioning, the actual market wages will be used. As data are in recieved domestic prices, they will be converted to international prices by multiplying by the conversion factor for consumption. Thus the conversion factor for skilled labour = (Local market wage rate) x (CFC) = 1 x 0.950 = 0.950

Unskilled labour costs, will also be evaluated by their *opportunity cost*. Generally, wages paid to unskilled labour by the project are above its opportunity cost, the corrected price will be obtained by multiplying by the ratio between the shadow wage rate and market wages.

The shadow wage rate is obtained by the following formula.

$$SWR = C - (C-m)/S$$

Here, SWR = Shadow wage rate
C = Market wages
m = Opportunity cost
S = Premium for saving (or investment)

Here, we will assume that when the premium part of the savings premium is 0, then S = 1, and thus SWR = m. Opportunity cost will be estimated by calculating the per-head-GDP of workers in the agriculture, forestry and fishery sectors. The total GDP for the agriculture, forestry and fishery sectors in Indonesia in 1978 was US$9.86 billion. The number of workers in these sectors was 31,545,000. By division, the per head daily wage comes to US$1.04, assuming 25 working days in a month. Extrapolating, at the average annual growth rate; 23.8% (mean growth rate of GDP in these sectors during the three years from 1978 to 1980), the per head daily wage in 1982 is expected to be US$2.45.

On the other hand, the nominal wage for unskilled labourers in Dumai (construction labourers and other labourers employed for construction work in this project) is US$3.68. Thus the wage rate in the agriculture, forestry and fishery sectors in 66.6% of the nominal wage. The conversion factor for unskilled labour = Nominal wage x 0.666 x CFC = 1 x 0.666 x 0.950 = 0.633

8.4.2. Shadow Prices of Cost Items

1) Construction Costs

The breakdown of construction cost by facility type and currency (foreign and local currencies) is shown in Tables 7.4.1 and 7.4.2. As imported materials for the project will be exempted from payment of import duties, the foreign exchange portion will be in CIF prices.

On the other hand, the conversion factor for the portion of construction cost paid for in local currency will be calculated in the manner described in 8.4.1. This conversion factor is 0.940. (Table 8.4.2) Calculated cost of construction based on this factor is shown in Table 8.4.3.

2) Maintenance and Operating Costs

These costs mainly consist of personnel expenditures, maintenance, operation and repair, and administrative expenses. These will be divided by facility type and currency, in the same manner used for construction cost, to obtain the value for the conversion factor. The conversion factor for maintenance and operating cost is 0.910.

Maintenance and operation costs calculated using this factor are shown in Table 8.4.4.

Table 8.4.2 Conversion Coefficients of Construction Cost

Type of work	Division component	Foreign current	Domestic currency					Total Conversion factor	① x ②
			Portion corresponding to trade goods	Skilled labour	Unskilled labour	Non trade goods	Balance		
	Composition ratio (%) ① \ Conversion factor	1.000	1.000	0.950	0.633	0.986	0	②	
Revetment and reclamation	20	(71) 0.710	(11) 0.110	(5) 0.048	(3) 0.019	(10) 0.099	–	(100%) 0.986	0.197
Wharf	44	(60) 0.600	(2) 0.020	(6) 0.057	(8) 0.051	(24) 0.237	–	(100%) 0.965	0.425
Road and pavement	17	(17) 0.170	(14) 0.140	(12) 0.114	(43) 0.272	(14) 0.138	–	(100%) 0.834	0.142
Building	13	(70) 0.700	(5) 0.050	(4) 0.038	(16) 0.101	(5) 0.049	–	(100%) 0.938	0.122
Cargo handling equipment and others	6	(54) 0.540	(8) 0.080	(8) 0.076	(24) 0.152	(6) 0.059	–	(100%) 0.907	0.054
Total	100	–	–	–	–	–	–	General conversion factor 0.940	

Note: Figure in ( ) is composition ratio (%) by component of each type of work.

Table 8.4.3 Construction Costs (Shadow Price)

(Unit: '000 US$)

Year	Costs
1984	1,002
1985	4,603
1986	18,939
1987	17,065
1988	11,134

Table 8.4.4 Maintenance & Operating Cost (Shadow Price)

(Unit: '000 US$)

Year	Costs
1987	298
1988	891
1989	1,108

8.4.3. Shadow Prices of Benefit Items

1) Reductions in Expenses due to Ships Waiting for Berths

Calculation is based on the charter rate, in international prices; this figure is the shadow price.

2) Reductions in Cargo Handling Expenses

The conversion factor for personnel expenditures is as follows:

- o The conversion factor for skilled labour = 0.950
- o The conversion factor for unskilled labour = 0.633

As detailed figures are unavailable, the following assumptions are made; per ton expenses are used in connection with cargo handling by barges, skilled labour costs are assumed for cargo handling by barges, stevedoring is performed by both skilled labour and unskilled labour, 50% each, and finally the consumption conversion factor will be used as the conversion factor in the cases of mobile cranes and tug boats. The conversion factor for cargo handling by barges under the above assumptions will be 0.906. The conversion factor for trucking will be the conversion factor for consumption (0.950) as statistical data on machinery is not available.

Reductions in cargo handling expenses converted into shadow prices using the above conversion factors are shown in Table 8.4.5.