7.4 Unit Price of Major Construction Materials

Unit prices for construction materials are determined on the basis of "Construction price List 29, Jan. 93" issued by the Ministry of Commerce. However, according to our survey, the actual market prices are a little higher than these prices. Therefore the prices of our survey were adopted for the following unit prices in Table 7-4-1.

Table 7-4-1 Unit Prices of Major Materials

Major Material	Unit	Baht	Remarks
Fuel (Gasoline)	lit	9	Import
Fuel (Diesel)	lit	8	Import
Soil (Fill Material)	cu.m	150	
Sand (Fill Material)	cu.m	170	
Coarse Aggregate	cu.m	250	
Fine Aggregate	cu.m	200	
Mixed Stone	cu.m	170	
Ready Mixed Concrete			
140 kg/sq.cm	cu.m	1210	
180 kg/sq.cm	cu.m	1260	
210 kg/sq.cm	cu.m	1300	
240 kg/sq.cm	cu.m	1350	
280 kg/sq.cm	cu.m	1390	
320 kg/sq.cm	cu.m	1440	
Asphalt Concrete (Hot-Mix)	ton	1200	
Interlock Paving Block (t=6cm)	sq.m	152	
Hollow Concrete Block (19x39x9)	each	13	
Reinf. Concrete Pipe			
300mm x 1m	piece	235	
500mm x 1m	piece	460	
1000mm x 1m	piece	1200	
PC Pile (Hollow Core)			
300 x 21000	piece	5900	
500 x 21000	piece	14150	
Cement	ton	1560	
Reinf. Deformed Ber			
SD 30	ton	10250	Import
SD 40	ton	10350	Import
P.V.C Pipe 4'x4m	piece	950	
Plywood (Fiber Solid)			
10mm x1200mm x2400mm	sheet	160	
Hard-wood 1'x6'x3.5m	sq.ft	480	
Structural Steel (General)	ton	12000	Import
H - Beam I - Beam	ton	25000	Import
Steel Pipe Pile	ton	25000	Import
Steel Sheet Pile (IV)	m	1200	Import
Steel Pipe (General)	ton	20000	Import
Temporary Materials			
Steel Sheet Pile	ton day	20	Rental
Steel plate (19mm)	sq.m.day	3	Rental
Metro Deck	sq.m.day	10	Rental

These prices for materials will be adjusted for inflation based on "Wholesale price Index" shown in Table 7-4-2 and Fig. 7-4-1.

Table 7-4-2 Wholesale Price Index

(Upper: Index 1985=100 Lower: Increase Rate(%)

Description	1986	1987	1988	1989	1990	1991	1992	1993 FEB
Synthesis	99.6	105.4	114.2	119.4	123.5	132.0	132.4	131.7
	-0.4	5.9	8.3	4.6	3.4	6.9	0.3	
Agricultual Products	102.8	115.4	128.0	135.4	138.2	154.3	159.8	151.2
	2.8	12.3	10.9	8.5	-0.1	9.2	3.5	
Articles of Food	103.0	106.0	117.0	126.9	126.8	138.5	140.7	140.5
	3.0	2.9	10.4	8.5	-0.1	9.2	1.6	
Construction Material	98.8	102.8	113.9	127.6	138.9	146.2	146.0	144.5
	-1.2	4.1	10.8	12.0	8.9	5.3	-0.1	
Fiber	99.8	106.3	109.1	112.2	117.8	124.8	127.6	127.9
	-0.2	6.5	2.6	2.8	5.0	5.9	2.2	
Oil Products	88.9	84.5	85.2	82.9	92.8	106.1	100.0	102.2
	-11.1	-4.9	0.8	-2.7	11.9	14.3	-6.1	
Machine	101.7	105.2	117.0	122.6	124.7	128.2	128.4	129.8
	1.7	3.4	11.2	4.8	1.7	2.8	0.1	

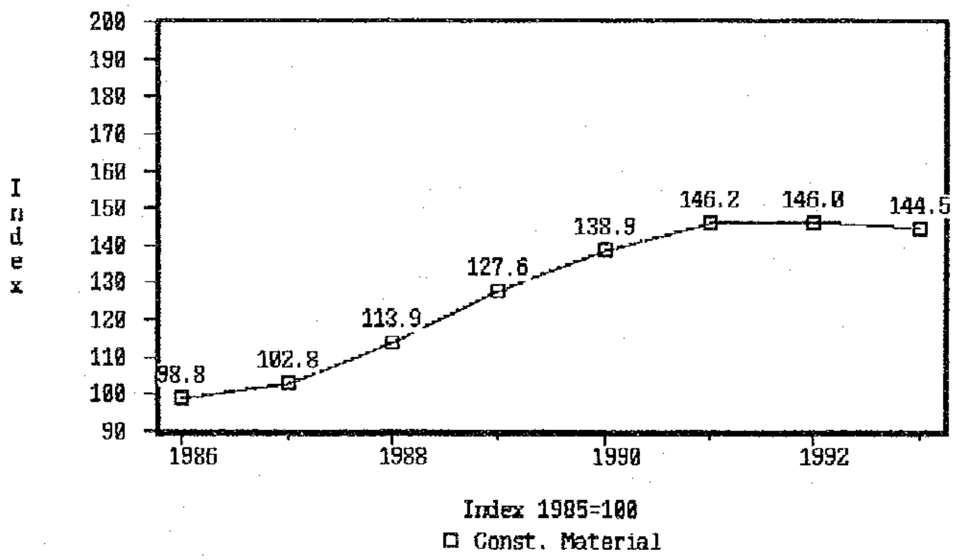


Fig. 7-4-1 Construction Material Wholesale Price Index

According to the above mentioned, the prices of construction materials in the future are surmised to increase at a a rate of 4.5% every year.

7.5 Unit Rate of Major Construction Equipment

Unit rate of equipment is determined on the basis of our survey for major rental equipment firms in Bangkok, as shown in Table 7-5-1.

Table 7-5-1 Unit Price for Major Equipment

(Without Operator and Fuel)

Equipment/ Machinery	Baht/Hour
Dump Truck (10t)	285
Trailer Truck (30t)	500
Pick-up Truck (1t)	100
Bulldozer (D6)	450
Bulldozer (D8)	600
Wheel Loader (1.5 cu.m)	800
Excavator (0.4 cu.m)	360
Excavator (0.7 cu.m)	500
Excavator (1.0 cu.m)	700
Truck Crane (25t)	950
Truck Crane (50t)	1250
Truck Crane (100t)	3000
Crawler Crane (50t)	1100
Generator (50KVA)	400
Generator (125KVA)	450
Generator (200KVA)	550
Moter Grader (100HP)	700
Macadam Roller (12t)	550
Tyre Roller (12t)	550
Piling Machine 1Unit	3500
Air Compressor(17 cu.m/min)	350

These rates for equipment will be adjusted for inflation based on "Wholesale Price Index of Machine" shown in Fig. 7-5-1.

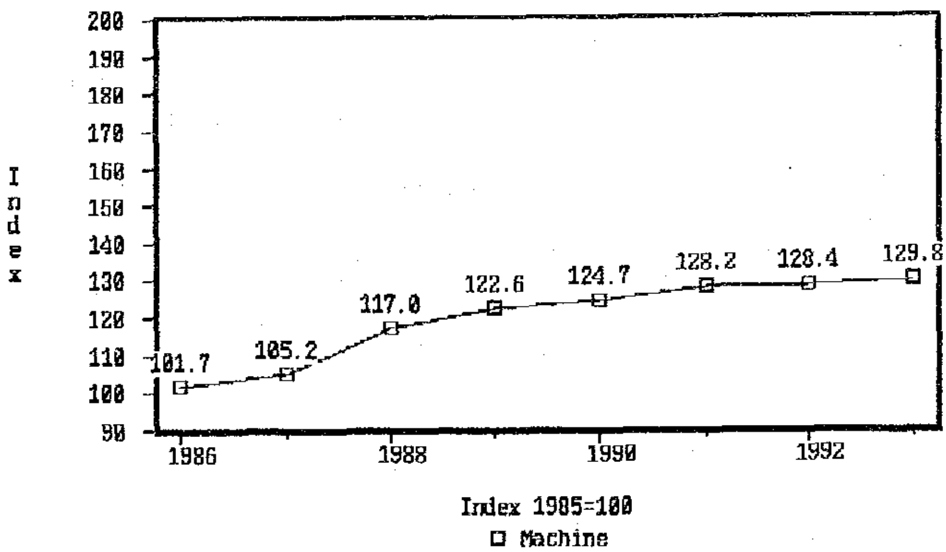


Fig. 7-5-1 Wholesale Price Index of Machine

According to the above figure, the rates of equipment in the future are surmised to increase at a rate of 2.0% every year.

7.6 Combined Cost for Major Work

Combined costs for major works based on the required materials, labours and equipment are estimated, as shown in Table 7-6-1.

Table 7-6-1 Combined Cost for Major Work

	Year	1993	
Work Item	Unit	Baht	Remarks
Land Excavation	cu.m	23	Without Transportation Cost
Back Filling	cu.m	27	Without Filling Material Cost
Concrete Piling Work (450mm)	m	1050	R.C Pile= 450mm x 450mm
Steel Sheet Piling Work	m	111	Without Pile Cost
Concrete Work Placing	cu.m	1542	Concrete= 210kg/sq.cm
Concrete Formwork	sq.m	216	
Re-Bar Work	ton	15200	Re-Bar= SD30
Asphalt Pavement (Light Duty)	sq.m	369	AS t=0.06m
Asphalt Pavement (Heavy Duty)	sq.m	880	AS t= 0.05m+0.15m
Concrete Pavement	sq.m	980	Concrete t=0.25m
Concrete Pavement (Container)	sq.m	1120	Concrete t=0.35m
Concrete Block Pavement	sq.m	750	Block t=0.12m
Marsonry Work	sq.m	150	
Structural Steel Work	ton	17000	
Plastering Work	sq.m	110	
Painting Work	sq.m	65	
Roofing Work	sq.m	150	
General Construction Cost			
Office Building	sq.m	12000	
Shed Building	sq.m	8500	
Ware House	sq.m	8500	

Notes

* Cost estimation of each items is shown in Appendix 11.
* Structural Steel Work, Plastering Work, Painting Work, Roofing Work and General Construction Cost were adopted on the basis of our survey for major construction firms in Bangkok.

Chapter 8 Demand Forecast

8.1 Socioeconomic Frame for the Target Year

8.1.1 Population

National Economic and Social Development Board estimates that the population of Thailand will reach 62 million in 1997 and 68 million in 2005. These data for future population are used for the estimates.

8.1.2 Economy

According to the future target values of gross domestic product (GDP) by the seventh national economic and social development plan, the average growth rate of GDP during 1992-1996 is 8.2%, and those in the sectors of Agriculture, Manufacture and Construction are 3.4%, 9.5% and 8.9% respectively. Annual growth rates from 1992-1997 are assumed to be the same as above. After 1998, annual growth rate is estimated at 5.5%, while growth rates in the sectors of Agriculture, Manufacture and Construction are 3.4%, 5.7% and 6.2% respectively by using the average rate from 1981 to 1986 considering past stable growth.

Based on these assumptions, the forecasted growth rate of GDP in 1997 and 2005 is given in Table 8-1-2.

Table 8-1-1 Population Forecast

	1991	1997	2005
Population (1000 persons)	56,933	62,000	68,000
Increase over the base year (times)		1.09	1.19

Table 8-1-2 GDP (at 1988 Prices) Forecast

Unit: Million of Baht

	1991	annual growth rate	1997	annual growth rate	2005
GDP	2,108,249	8.2%	3,382,871	5.5%	5,191,647
Agricultural sector	278,063	3.4%	339,834	3.4%	444,049
Manufacturing sector	606,763	9.5%	1,045,933	5.7%	1,629,685
Construction sector	135,240	8.9%	225,565	6.2%	364,980

8.2 Methodology for Demand Forecast

Two methods are used to forecast the cargo volume handled at Bangkok Port (Klong Toei), Laem Chabang Port and private container terminals within the limits of Bangkok Port. One is a macro forecast which estimates the cargo volume as a group including entire commodities, regardless of the volume of each commodity. The other is a micro forecast which estimates the cargo volume of each commodity individually.

For the macro forecast, two methods are used. One is to grasp the trend of cargo handling volume from the past data and forecast the future volume by a time series analysis. The other is to relate the past cargo handling volume to national, social or economic indices such as GDP or population, and to forecast the future cargo volume using future estimates of these national figures.

In the micro forecast, the future volumes of major commodities are projected individually based on the correlation analyses between the respective cargo volumes and the historical trends, and correlative economic and social indices such as GDP and population.

The micro forecast is applied to the cargo projection of only Klong Toei Wharf because historical statistics of breakdown by commodity in other ports are not available.

When forecasting the cargo volume handled at Bangkok Port (Klong Toei), it might be desirable to handle the entire throughput (for both Klong Toei Wharf and Klong Toei Dolphins) as one port. But in this study, demand forecast was conducted separately for Klong Toei Wharf and for Klong Toei Dolphins because breakdown of the cargo volume by commodity at Klong Toei Dolphins is not available as mentioned above.

In the forecast of the volume of container cargo through the ports of Bangkok (Klong Toei Wharf) and Laem Chabang in the target year of the Master Plan, the total volume through the two ports was projected in the first step. Then was broken down to the respective volumes in the next step, because the duplication of their respective hinterlands in container transportation.

In the forecast of the volume of container cargo through the ports of Bangkok (Klong Toei Wharf) and Laem Chabang, the historical data of Klong Toei Wharf was solely used because up to the year 1992, which is the last year of the statistics adopted in the forecast in this study, achievement of the volume of cargo through Laem Chabang was still negligible.

8.3 Macro Forecast

8.3.1 Time Series Analysis

(1) Method

Table 8-3-1 Handling volume of Bangkok Port (Klong Toei Wharf) and GDP and Population

Year	G D P Million Baht	Population Thousand People	Export Tons	Import Tons
1982	1,019,501	48,709	1,436,664	3,282,758
1983	1,076,432	49,681	1,538,299	4,078,788
1984	1,138,353	50,637	1,850,256	4,353,222
1985	1,191,255	51,579	2,222,736	4,118,275
1986	1,257,177	52,511	2,909,318	3,771,574
1987	1,376,847	53,425	3,668,511	4,683,921
1988	1,559,804	54,325	4,588,677	5,858,231
1989	1,751,515	55,213	5,731,847	6,253,117
1990	1,954,229	56,083	5,996,831	7,837,512
1991	2,108,249	56,933	7,186,272	8,185,775

Table 8-3-1 shows the volume of cargo handled at Bangkok Port (Klong Toei Wharf). The volume of cargo handled at the target year of the Master Plan was forecast by using a time series analysis.

(2) Result of Forecast

The cargo volume is assumed to be expressed as the following liner equation:

$V = a + bT$

where V: Handling volume at the port of Bangkok

a,b: Constants

T: Year

The constants are determined by the linear regression method. The resulting figures are a=668007.0727, b=-1.32E+09 in export and, a=521635.8242, b=-1.03E+09 in import. Under the above assumptions, the forecast volume of container cargo to be handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang and conventional cargo through Bangkok Port as a total is given as follows:

Unit: Thousand Tons

		1997	2000
Volume of Cargo	Export	14,010	19,354
	Import	11,707	15,880
	Total	25,717	35,234

8.3.2 Correlation with Economic Indices

The total volume of cargo handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang is forecasted based on the correlation between the respective historical trends of the total cargo volume and GDP or the population (as shown in Table 8-3-1).

(1) Correlation with GDP

The correlation between the cargo volume and GDP from 1982 to 1991 is expressed by the following equations:

Export:

$V=5.341766455 \times GDP - 3997023 \ (r=0.9827492)$

Import:

$V=4.380547380 \times GDP - 1080285 \ (r=0.9561472)$

When GDP in the target year mentioned in 8.1.1 is input into the above equation, the forecast volume of cargo to be handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang is given as follows:

Unit: Thousand Tons

Volume of cargo	Export	1997	2000
	Import	14,073	23,736
	Total	13,739	21,661
		27,812	45,397

(2) Correlation with Population

The correlation between the cargo volume and the population from 1982 to 1991 is expressed by the following equations:

Export:

$V=727.7013093 \times Population - 34789444 \ (r=0.9521788)$

Import:

$V=566.4237014 \times Population - 24726934 \ (r=0.8346226)$

When the population in the target year mentioned in chapter 8.1.1 is input into the above equations, the forecast volume of cargo to be handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang is given as follows:

Unit: Thousand Tons

		1997	2000
Volume of cargo	Export	10,328	14,694
	Import	10,391	13,790
	Total	20,719	28,484

(3) Result of Macro Forecast

The result of the macro forecast in target years is shown below.

Unit: Thousand Tons

		1997	2000
Volume of cargo	Export	10,328-14,073	14,694-23,736
	Import	10,391-13,739	13,790-21,661
	Total	20,719-27,812	28,484-45,397

8.4 Micro Forecast

8.4.1 Selection of Major Commodity Groups

The cargo handled at Bangkok Port is classified into the following major commodity groups for the micro forecast:

(Export)

Agricultural Product, Food Product & Frozen Good, Textile Yarn Leather Product, Kenaf Cotton Kappok, Metal Machinery Electrical, Chemical Product, Plastic Product & Other Rubber Article, Mineral, Wood Product Others

(Import)

Vehicle, Car spare part, Machinery & Used Engine, Electric Equipment, Metal & Steel, Chemical Products, Pharmaceutical Products, Fertilizer, Paper, Plastic & Rubber products, Lubricating Oil-Soap-Wax, Textile-Filament-Clothing, Jute-Cotton-Kapok, Fresh & Frozen Food, Animal Food, Other Food Stuff, Others

8.4.2 Result of Micro Forecast

The results of the micro forecast, showing export and import cargo volumes by major commodity groups, are shown in Table 8-4-1 and Table 8-4-2. The detailed process is described in Appendix 10.

Table 8-4-1 Forecast by Major Commodity Group (Export)

Unit: Tons

Commodity	1997	2005
1. Agricultural Product Food Product & Frozen Good	7,453,302	12,570,029
2. Textile Yarn Leather Product	433,039	651,876
3. Kenaf Cotton Kapok	416,609	675,649
4. Metal Machinery Electrical	403,138	571,764
5. Chemical Product	80,758	80,758
6. Plastic Product & Other Rubber Article	547,481	547,481
7. Mineral	74,651	74,651
8. Wood Product	86,556	86,556
9. Others	1,399,651	2,285,044
Total	10,895,185	17,543,808

Table 8-4-2 Forecast by Major Commodity Group (Import)

Unit: Tons

Commodity	1997	2005
1. Vehicle	216,426	390,998
2. Car spare part	626,858	1,056,182
3. Machinery & Used Engine	957,005	1,627,541
4. Electric Equipment	446,507	791,568
5. Metal & Steel	2,717,371	3,534,582
6. Chemical Products	1,100,121	1,720,341
7. Dangerous Chemical Products	388,389	584,702
8. Pharmaceutical Products	25,961	37,996
9. Fertilizer	62,193	62,193
10. Paper	975,871	1,558,646
11. Plastic & Rubber Products	670,438	1,086,070
12. Lubricating Oil-Soap-Wax	133,859	211,925
13. Textile, Filament, Clothing	347,602	576,619
14. Jute-Cotton-Kapok	293,973	391,945
15. Fresh & Frozen Food	100,016	128,422
16. Animal Food	220,139	361,560
17. Other Food Stuff	409,659	616,481
18. Others	2,001,990	2,001,990
Total	11,694,378	16,739,761

8.4.3 Cross check with the Results of Macro Forecast

Table 8-4-3 shows a comparison of cargo volumes obtained by the macro and micro forecast methods described in Section 8.3 and 8.4.

The result of the micro forecast almost corresponds with that of the macro forecast. Herein, the cargo volumes handled at the ports of Bangkok (Klong Toei) and Laem Chabang for the target years will be forecasted as those obtained by the micro forecast method.

Table 8-4-3 Forecast of Total Cargo Volume in Target Years

Unit: Thousand Tons

		1997	2005
Export	Macro method	10,328-14,073	14,694-23,736
	Micro method	10,895	17,544
Import	Macro method	10,391-13,739	13,790-21,661
	Micro method	11,694	16,740
Total	Macro method	20,719-27,812	28,484-45,397
	Micro method	22,589	34,284

8.5 Forecast on the Volume of Container Cargoes

8.5.1 Trend of Containerization at Bangkok Port (Klong Toei Wharf)

The percentage of containerization by loaded/unloaded cargoes is shown in Table 8-5-1. The percentage of containerization is the ratio of the volume of container cargoes to the volume of containerizable cargoes. The volume of containerizable cargoes was estimated by their suitability for containerization from the statistical data and O/D survey conducted by the study team. The greater part of categories of goods are suitable for containerization, but most of steel & metal and fertilizer have been pronounced unsuitable for containerization.

Table 8-5-1 Percentage of containerization at Bangkok Port

Unit: Thousand Tons

	1987	1988	1989	1990	1991	1992
(Loaded)						
Container cargo	3,666	4,587	5,398	5,795	7,166	8,163
Containerizable cargo	3,669	4,589	5,732	5,997	7,186	8,163
Percentage of containerization	99.9%	100.0%	94.2%	96.6%	99.7%	100.0%
(Unloaded)						
Container cargo	2,180	2,813	3,340	3,917	4,374	4,594
Containerizable cargo	3,487	4,355	4,634	6,121	6,162	5,958
Percentage of containerization	62.5%	64.6%	72.1%	64.0%	71.0%	77.1%

8.5.2 Estimation of Volume of Container Cargoes in the Target Years

The percentage of containerization in the target years is estimated by using the logistic curve in Figure 8-5-1. Then, the volume of container cargoes in the target years can be obtained by multiplying the volume of containerizable cargoes by the percentage of containerization. Table 8-5-2 shows the estimated volume of container cargoes at the study ports of Bangkok (Klong Toei Wharf) and Laem Chabang obtained by application of logistic curve (see Fig.8-5-1).

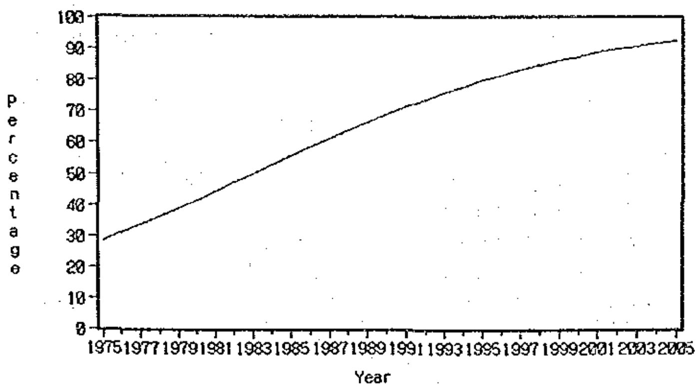


Fig. 8-5-1 Estimation of future percentage of containerization of imports by application of logistic-curve-fitting

Table 8-5-2 Forecast Volume of Container Cargo at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang

Unit: Thousand Tons

	1997	2005
(Loaded)		
Container cargo	10,895	17,544
Containerizable cargo	10,895	17,544
Percentage of containerization	100.0%	100.0%
(Unloaded)		
Container cargo	7,884	12,831
Containerizable cargo	9,465	13,856
Percentage of containerization	83.3%	92.6%

Considering that the volume of exports exceeds that of imports at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang, the number of containers is estimated as follows:

$$N = \frac{Vexp}{W} \times \frac{1}{(1 - Ep)} \times 2$$

N : Number of containers (TEUs/year)
Vexp : Container export volume (tons/year)
W : Cargo weight per loaded 20ft. container (tons/year)
Ep : Ratio of empty container

The average weight of container cargo is set as 12.5 tons/TEU based on the average in the last three years. Ratio of empty containers is set as 5% based on the actual data. Using the cargo weights and the above export volume, the number of containers to be handled in the target years are calculated to be 1.84 million TEUs in 1997 and 2.95 million TEUs in 2005 respectively.

On the other hand, the following number of containers has been handled at the private container terminals within the limits of Bangkok Port.

1989	1990	1991	1992
11,613 TEUs	78,672 TEUs	88,249 TEUs	138,442 TEUs

Considering the above trend of the container flow through the private terminals, the total number of containers to be handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang, and private container terminals within the limits of Bangkok Port is shown in Table 8-5-3.

Table 8-5-3 Number of containers to be handled at the ports of Bangkok (Klong Toei Wharf) and Laem Chabang, and private container terminals

Unit: Thousand TEUs

	1997	2005
Ports of Bangkok (Klong Toi) & Laem Chabang and Private container terminal	2,120	3,470

8.6 Forecast Volume of Conventional Cargoes at Bangkok Port (Klong Toei Wharf)

The forecast volume of conventional cargo at Bangkok Port (Klong Toei Wharf) in the target years is obtained by deducting container cargo volume from the total cargo volume. The results are shown in Table 8-6-1.

Table 8-6-1 The volume of conventional cargo through Bangkok Port (Klong Toei Wharf)

Unit: Thousand Tons

	1997	2005
Export	0	0
Import	3,810	3,909
Total	3,810	3,909

8.7 Forecast Volume of Conventional Cargoes at Klong Toei Dolphins

The volume of import conventional cargoes to be handled at Klong Toei Dolphins in the target years is obtained by the following equation.

$$V = Vb \times (1 + E \times G)^n$$

- V = Volume of cargo at Klong Toei Dolphins
- Vb = Volume of cargo at Klong Toei Dolphins in 1991 = 2,334,000 Tons
- E = Modulus of elasticity = 0.43
- G = Annual growth rate of GDP — 1997: 0.082; 2005: 0.065
- n = Years counted from the first year (1991) — 1997: 6; 2005: 14

The results are shown in Table 8-7-1.

Table 8-7-1 Forecast of Import Cargo Volume at Klong Toei Dolphins

Unit: Thousand Tons

	1997	2005
Import	2,880	3,450

It seems unlikely that the volume of export cargoes to be handled at Klong Toei Dolphins will increase considerably from the present level judging from that the total volume of export cargoes handled at the Mid-Stream Dolphins and private wharves has fluctuated historically along a narrow range without showing an upward trend and from the limitation of the cargo-handling capacity of Klong Toei Dolphins which is already almost saturated.

Chapter 9 Functional Allotment of Port Activities Between the Ports of Bangkok and Laem Chabang

9.1 Container-handling

9.1.1 Hinterlands of the Ports of Bangkok and Laem Chabang

According to the analysis of the import manifests and entry permission for export cargoes mentioned above, as to the import container cargoes, 74% and 15% of the total in terms of the cargo volume were destined to Bangkok Metropolis and the Central region, respectively, totaling 89%. On the other hand, as to the export container cargoes, 82% and 8% of the total originated from Bangkok Metropolis and the Central region, respectively, totaling 90%. The percentages of other regions including the East region (less than 1%) are very small.

9.1.2 Trade Partners of Thailand

Concerning the origin/destination ports of the container vessels that called at the east quay in 1991/1992, Singapore takes the largest share of 63% of the total in terms of the number of containers loaded/discharged at Bangkok Port. Singapore is followed by Japanese ports (19%) and Hongkong (17%). Those ports which receive feeder vessels from Bangkok Port are referred to as mother ports.

With respect to the origin countries of import container cargoes discharged at Bangkok Port, Japan ranks the first (19.7% of the total imports) followed by Singapore (17.6%), the USA (15.4%), Netherlands (6.9%), Germany (6.4%), Hongkong (5.8%), Taiwan (4.1%), Australia (2.5%), Canada (2.2%), England (2.2%), Korea (2.0%).

On the other hand, as to the origins of export container cargoes loaded from Bangkok Port, Japan again ranks the first (20% of the total exports) followed by the USA (16%), Hongkong (12%), Singapore (6%), Australia (5%), England (5%), France (4%), Taiwan (4%), Netherlands (3%), Korea (2%), Germany (2%).

Trading partners and their origin/destination shares are grouped into the following regions:

	Import		Export	
- South East Asia:	20.4%		10.3%	
- Singapore:		17.6%		6.8%
- Others:		2.8%		3.5%
- South and West Asia:	3.6%		3.3%	
- Europe:	21.2%		20.1%	
- Netherlands:		6.9%		3.0%
- Germany:		6.4%		2.0%
- England:		2.2%		4.9%
- Italy:		1.5%		1.1%
- France:		1.2%		4.5%
- Others:		3.0%		4.6%
- Africa:	0.9%		1.1%	
- Oceania:	3.5%		5.8%	
- Australia:		2.5%		5.3%
- Others:		1.0%		0.5%
- South America:	0.3%		0.1%	
- East Asia:	32.5%		40.8%	
- Japan:		19.7%		21.2%
- Hongkong:		5.8%		12.6%
- Taiwan:		4.1%		4.5%
- Korea:		2.0%		2.1%
- China:		0.9%		0.4%
- North America:	17.6%		18.5%	
- USA:		15.4%		17.0%
- Others:		2.2%		1.5%

9.1.3 Shipping Routes to/from Thailand

The representative shipping routes for container transport between Thailand and the above origin/destination countries at present are categorized as follows (see Chapter 5, Section 5.2):

Kind of Services	Shipping Routes	Share of Trade	
(Feeder/Direct Services)		Import	Export
Feeder services with transhipment at Singapore	South East Asia	2.8%	3.5%
	South and West Asia	3.6%	3.3%
	Europe	21.2%	20.1%
	Africa	0.9%	1.1%

	Oceania	3.5%	5.8%
	South America	0.3%	0.1%
	Subtotal	32.3%	33.9%
Direct services with Singapore Shuttles	Singapore	17.6%	6.8%
Feeder services with transhipment mainly at the ports in East Asia such as Tokyo, Yokohama, Hongkong, Kaohsiung and to a lesser degree at Singapore	North America	17.6%	18.5%
Direct services connecting Thailand and the ports in East Asia such as Tokyo, Yokohama, Kobe, Hongkong, Kaohsiung, Keelung, Busan	East Asia	32.5%	40.8%

9.1.4 Functional Allotment between the Ports of Bangkok and Laem Chabang

As shown in Chapter 8, the volume of containers to be handled at the ports of Bangkok (Klong Toei) and Laem Chabang including private container terminals within the limits of Bangkok Port in 2005 is estimated to be 3,470,000 TEUs. Taking account of the container-handling capacities of Klong Toei wharf (see Chapter 10, Section 10.1.4) and private terminals within the limits of Bangkok Port, the total number of 3,470,000 TEUs is allocated to each port/terminal as follows:

- Bangkok Port (Klong Toei Wharf):	1,000,000 TEUs	(28.8%)
- Private terminals:	280,000 TEUs	(8.1%)
- Laem Chabang Port:	2,190,000 TEUs	(63.1%)
Total:	3,470,000 TEUs	(100.0%)

Since a great portion of containers originate from or are destined for in and around the Bangkok Metropolis, and the container-handling capacity of Bangkok Port is restricted due to the limitation of available space and necessity of reducing road traffic generated from its port activities, a considerable portion of containers must be diverted to Laem Chabang Port, a deep sea port that has recently opened. Presently most containers are transported through Bangkok Port and the portion through Laem Chabang Port is still small.

In this Section, it was analyzed whether such diversion of container flow from Bangkok to Laem Chabang will be accomplished smoothly according to the market mechanism, or will be forced with conflicts of interests among port users. The total costs of transporting containers through Bangkok Port and Laem Chabang were compared by the representative shipping route. The total transport costs include terminal costs at the origin/transhipment/destination ports. Moreover, in case of transporting containers through Laem Chabang Port, land transport costs between Bangkok Metropolis and Laem Chabang Port are included. The results of the comparison are summarized as follows:

Case No.	Kind of Services	Shipping Route	Ship Size (TEUs)	Index of the Total Cost
- Europe (France) -				
1-1	Feeder services	BKK-Singapore- Marseille	500 3,000	100
1-2	Direct services	LCCP-Marseille	2,000	92
- Singapore -				
2-1	Direct services	BKK-Singapore	500	100
2-2	Direct services	LCCP-Singapore	500	117
- North America (USA) -				
3-1	Feeder services	BKK-Hongkong- Los Angeles	500 3,000	100
3-2	Direct services	LCCP-Los Angeles	2,000	89
3-3	Feeder services	LCCP-Hongkong- Los Angeles	2,000 3,000	103
- East Asia (Japan) -				
4-1	Direct services	BKK-Yokohama	500	100
4-2	Direct services	LCCP-Yokohama	2,000	95
- East Asia (Hongkong) -				
5-1	Direct services	BKK-Hongkong	500	100
5-2	Direct services	LCCP-Hongkong	2,000	108

As mentioned in Section 9.1.2, the major trade partners of Thailand are Japan, the USA, European countries and Hongkong. Except for Hongkong, the distances of the shipping routes connecting Thailand and the partners are long. Hence, in case of the routes for the USA and Europe, direct shipping services with larger container ships of up to around 2,000 TEUs in capacity which can be accommodated by Laem Chabang Port (see Cases 1-2, 3-2, 4-2) are more economical than feeder services with small ships (see Cases 1-1, 3-1, 4-1) employed by Bangkok Port, thereby compensating for costly 130km-long trucking between Laem Chabang Port and Bangkok Metropolis as shown in the above comparison between the alternative cases.

The fact, however, does not mean that the above direct shipping services for the USA and Europe are already viable at present because the direct shipping services need a flow of a considerable sum of containers on a route between Laem Chabang and a specified port, and the principal container ports are widely scattered in the USA or Europe (see Section 9.1.2); the result being that the number of containers to/from Thailand and loaded/discharged at each port seems to be too small to open the direct services as long as it remains at its present level.

On the contrary, the direct shipping services with large container vessels on the route for the principal container ports in Japan seem to be promising, because the number of those ports are small; those ports are closely located to one another; the number of containers transported on the route has already reached a considerable sum; and the direct shipping services are already in operations on the route between Laem Chabang Port and the ports in Japan, though the size of vessels used for the services is still small to implement double calls at the ports of Laem Chabang and Bangkok at present.

In the meantime, as to the medium haul route between Laem Chabang Port and Hongkong/Kaohsiung, the larger container vessels that can be accommodated by Laem Chabang Port have an advantage over the small vessels acceptable to Bangkok Port in terms of shipping costs. Considering the total transport cost by adding land transport costs between Bangkok Metropolis and Laem Chabang Port, however, the advantage by using the larger vessels seems unlikely to fully compensate costly trucking costs (compare Case 5-1 and Case 5-2). APL which is a main user of Terminal III is managing to operate feeder services with the large container vessels of around 1,700 TEUs in capacity on the Hongkong/Kaohsiung route and with land transport by railway between the Bang Sue terminal and Laem Chabang Port which is comparatively cheaper than trucking, though the capacity of railway transport is presently limited due to a single track.

As to the short haul route between Laem Chabang/Bangkok and Singapore, the container vessels of small size commonly used at present are the most economical in shipping costs. Hence, in case of using Laem Chabang Port for the Singapore route, costly land transport cost between Bangkok Metropolis and Laem Chabang Port cannot be compensated by shipping costs in the least (compare Case 2-1 and Case 2-2).

Thus, Laem Chabang Port has an advantage over Bangkok Port and potentials for diversion from Bangkok Port to Laem Chabang Port on the following shipping routes:

Laem Chabang	Shipping Route	Share	
		Import	Export
Advantage	Japan, Korea	21.7%	23.3%
Potential	East Asia (Hongkong, Taiwan, China)	10.8%	17.5%
	North America	17.6%	18.5%
	Total	50.1%	59.3%

Thus, the combined percentage of the above import and export accounts for 55% of the total containers, and is nearly equal to the percentage of the number of containers allocated at Laem Chabang Port in 2005, accounting for around 60% as mentioned in Section 9.1.4. Such portion of containers could be smoothly diverted from Bangkok to Laem Chabang by improving infrastructures of land transport including roads and railways between Bangkok Metropolis and Laem Chabang,aiming at the reduction of land transport costs.

On the other hand, the portion of containers transported on other shipping routes such as those for Europe, South East Asia, South and West Asia are expected to be transported through Bangkok Port even in the stage of the Master Plan as they are at present.

Furthermore, the other hand, the containers transported on the following shipping routes are expected to be transported through Bangkok Port in the stage of the Master plan as they are at present due to the advantage of Bangkok Port over Laem Chabang Port:

Bangkok Port	Shipping Route	Share	
		Import	Export
Advantage	South East Asia, South and West Asia, Europe, Africa, Oceania, South America	49.9%	40.7%

9.2 Handling Conventional Cargo

Presently, heavy, bulky or less valuable cargoes such as steel products, vehicles and fertilizer are mainly discharged from conventional vessels at the west quay of Bangkok Port. On the other hand, at Laem Chabang Port, the major conventional cargoes are also heavy, bulky or less valuable cargoes such as cement, steel products, vehicles and grains as shown in Appendix4, A.4.1. Those cargoes are suitable for water-borne transport and after discharging at the ports, they are delivered to consignees located around the respective ports mainly by trucks or lighters/barges so as to achieve economical transport and avoid the restricted road transport as much as possible.

In the stage of the Master Plan, they are expected to be still the major conventional cargoes despite the progress of the containerization, since those cargoes are generally not suitable to be containerized. Thus, with respect to the handling of the conventional cargoes, the ports of Bangkok and Laem Chabang are expected to serve the respective local users as they do at present.

Chapter 10 Master Plan for Bangkok Port

10.1 Master Plan for Container-Handling

10.1.1 The Basic Concept of Modernization of Bangkok Port

The Purpose of the Master Plan (target year 2005) is to serve as a target and guideline for phase plans including the Short-Term Plan (target year 1997). The Master Plan shall be an integrated plan covering the layout plans for modernization plans for existing facilities and effective management and operation systems. In making the Master Plan for Bangkok Port, the following various aspects concerning the port modernization are recognized:

- Serious Port Congestion in Container-Handling
  Since the start of containerization in Thailand in 1977, along with the development of the Thai economy, especially in the export-oriented industries, the number of containers through Bangkok Port has continuously increased. In the last five years, from 1988 to 1992, the number shows a sharp increase, indicating an average growth rate of 14% per annum. In 1992, the number of containers handled at Klong Toei Wharf of Bangkok Port reached around 1.3 million TEUs. In 1991/1992, the average berth occupancy rate of seven berths of the east quay reached a high value of 75%, and consequently the west quay, which is basically allocated to conven-tional vessels, also received container vessels which overflowed from the east quay and accounted for 8% of the total in terms of the vessel number. In the same year, the berth occupancy rate of ten berths at the west quay which received mainly conventional vessels (87% of the total number at the west quay) and partly container vessels (13%) reached also a high value of 78%.

- Present System of Terminal Operations
  Notwithstanding that machines specialized for container-handling were introduced and containers of more than one million TEUs per annum are already passing through the port, the container terminal in Bangkok Port is still remaining an open type terminal where operations are not controlled by a terminal operator that takes the responsibility of receipt, storage and delivery of containers at the terminal by conducting yard planning and inventory control of containers, but performed by an individual shipping agency inde- pendently with the permission of the PAT by each operation. Hence, the marshaling yard in the east quay is left in a chaotic condi-tion.

- Shortage of Marshaling Yard Space
  In addition to the above fact, the marshaling yard in the east quay can only rarely afford to prepare necessary stacking space for outbound containers before ship arrivals due to shortage of yard area which exacerbates the chaotic condition at the yard.

- Long Berthing Hours due to Direct Loading and Long Hauls
  The shipping agencies are often forced to do costly direct loading of containers onto ships from the open yard behind sheds Nos 15-17 in the west quay or off-dock CYs outside the port due to the present operation system and the shortage of the marshaling yard mentioned previously. When conducting the direct loading, resulting traffic jams in and around the port cause unpredictability of boxes' arrivals to ships, and even in the port, it sometimes takes over one hour to get from the west quay to the east quay. In addi-tion to the direct loading, long hauls of outbound boxes once stacked within the marshaling yard from stacking places to dockside are often found due to lack of proper yard planning. Thus, the actual gross container-handling productivity per dockside gantry crane is small. As a result, costly container ships are forced to berth for long periods (33 hours per vessel on average) to discharge/load 580 boxes on average in 1991/1992.

- Tendency of Decrease of On-dock CFS Cargoes (LCL)
  Since shippers/consignees try to take full advantage of container transport of so-called door-to-door transport, generally, stuffing/unstuffing operations on-dock yards show a continuous de crease year by year in the leading container ports. The fact is unexceptional in Bangkok Port. With respect to unstuffing operations in 1992/93 (March of 1992-Feb. of 1993), 42% of inbound container cargoes were unstuffed in the port area, showing a sharp drop from 69% in 1988/89. On the other hand, as for stuffing opera-tions in the same period, 63% of outbound cargoes were stuffed in the port area, showing a decrease from 80% in 1988/89. Such cargoes are categorized as LCL by the definition of PAT's tariff. Large portion of such LCL cargoes in the sense of PAT's definition, however, is potential FCL cargoes in the sense of the international definition, in which cargoes belonging to one shipper/consignee are laden more than one boxes. Conversely, the portion of real LCL cargoes in the sense of international definition in which cargoes belonging to more than one shippers/consignees are consolidated in mixture in one box is very small. According to interviews with the major shipping agencies and the analysis of import manifests in one month of 1992, the volume of real import LCL cargoes does not exceed 20% of the total imports.

As to export container cargoes, according to interviews with the major shipping agencies, the volume of real export LCL cargoes does not exceed 20% of the total exports, as well. Thus, it seems to be possible to further reduce stuffing/unstuffing operations inside the port to the level of the real LCL from the present level by getting the potential FCL cargoes stuffed/unstuffed at shippers'/consignees' premises, off-dock CYs/CFSs or Inbound Container Depots (ICDs) as much as possible to utilize the limited port space efficiently.

- Functional Allotment between the Ports of Bangkok and Laem Chabang
  As mentioned in Chapter 9, the number of containers through Laem Chabang Port is expected to steadily increase after this on the specific routes, and consequently proper functional allotment between the ports of Bangkok and Laem Chabang will be achieved. That will be beneficial to both ports; congestion at Bangkok Port will be resolved and Laem Chabang Port will be promoted. That process might be accelerated by containers overflowing from Bangkok Port which is already saturated and cannot expand its container-handling capacity due to the limitation of available space and necessity of reducing road traffic generated from its port activities.

Based on the above situation of Bangkok Port, the following concept of modernization of Bangkok Port is proposed for the purpose of achieving safe, efficient and reliable operations for the customers:

- Introduction of a Closed Container Terminal System
  It is advisable to introduce a closed container terminal system controlled by a terminal operator that takes the responsibility of receipt, storage and delivery of containers at the terminal by conducting yard planning and inventory control of containers which is indispensable for a modernized container terminal.

- Introduction of Closing Time
  It is advisable to introduce closing time so as to be able to make a loading sequence plan before ship arrivals.

- Increase of Container Stacking Capacity of the Marshaling Yard in the East Quay
  It is advisable to increase container stacking capacity of the marshaling yard in the east quay to reduce berthing hours of con-tainer ships by making a loading sequence plan before ships' arrivals. For that purpose, it is necessary

to demolish sheds No.11 and No.12. Actual stacking capacity considering operational efficiency will be increased to around 10,000 TEUs from the present capacity of around 6,200TEUs. All exported containers should be received at the marshaling yard before ship arrivals even during peak conditions so as to achieve efficient operations. As to imported containers, at least laden containers must be stacked on the marshaling yard after discharging from ships. The resulting container-handling capacity of the terminal based on the above-mentioned operational system to be newly introduced is estimated to be one million TEUs per annum (see Section 10.1.5). In that case, berthing hours of container ships are expected to be reduced remarkably from the present level, generating benefits from the savings of ship staying costs.

- Rationalization of the Container Yard in the West Quay
  It is advisable to rationalize container-handling operations in the west quay which are conducted somewhat disorderly at present. First, the movements of ordinary trucks from outside to CFSs should be separated from the movements of tractor-chassis units/containers so as to reduce the present traffic congestion inside the port. It is proposed to install new Import CFSs in Area II and Export CFSs in Zone 1 facing the outside highway running along the port area. The CFSs are planned to be laid out parallel to the outside road. By laying out truckside at outer side of CFSs, and container side at inner side of the CFSs, interference of trucks and containers will be completely avoided. It is proposed that all of ondock-CFS cargoes (LCL) be received at CFSs, thus, stuffing operations for exported container cargoes will be separated from the empty container stacking yards; presently stuffing operations for exported containers are inconveniently done on some spots of the empty container stacking yards.

  In the open yard behind the Import CFS to be installed in Area II, an empty container storage yard will be allocated to deliver or receive empty boxes to or from the Import and Export CFSs. Additionally, the empty container yard will also receive imported empty containers from ships berthing at the east quay.

10.1.2 Land Preparation for Future Port Activities

The land under the jurisdiction of the PAT extends beyond the existing customs fences. A great part of the land beyond the customs fences is used for various activities such as residential areas that have no direct linkage with port activities. To resolve the present congestion at Bangkok Port and upgrade the level of the services for port users, the PAT intends to convert Area II, Zone 1, the area facing the Phra Kanong Canal and the area behind the planned storage yard for dangerous cargo into the areas for port activities collaborating with the Housing Authority.

10.1.3 Layout of the Main Facilities for Container-Handling

(1) General

The main facilities for container-handling are arranged so as to embody the basic concept of the modernization shown in Section 10.1.1.

(2) Marshaling Yard

The marshaling yard is arranged at the east quay as it is at present. To increase container-stacking capacity of the marshaling yard, it is proposed to prepare an additional marshaling yard behind Berths E, F and G by demolishing Sheds No.11 and No.12, and Cargo Warehouse No.25. Actual stacking capacity considering an operational factor will increase to around 10,000TEUs from the present capacity of around 6,200 TEUs.

To introduce a closed container terminal system and closing time, gates with the required number of lanes must be prepared at the entrance of the marshaling yard. A gate (referred to as Gate 2) is under construction at the entrance of the existing marshaling yard. It is necessary to prepare an additional gate (referred to as Gate 3) corresponding to the above-mentioned additional marshaling yard. In this case (referred to as Case 1), the two gates will be totally prepared. As to the gate preparation, another alternative case when the third gate (referred to as Gate 1) will be prepared near the existing control tower is considered. In this case (referred to as Case 2), the three gates will be totally prepared.

As to the possibility of divided control of the marshaling yard, in Case 1, the marshaling yard can be divided into two yards and controlled independ-ently by two sections of a terminal operator through the respective gate operations. On the other hand, in Case 2, the marshaling yard can be divid-ed into three yards and controlled independently by three units of a terminal operator through the respective gate operations. Such divided control of the marshaling yard corresponding to the number of gates enables simple and easy operations as compared with the case when the marshaling yard is wholly controlled by a single section without the divided control. In the cases of the divided control, however, the required areas for container-stacking increase proportional to the number of division, because the respective peaking conditions of container movements at the divided yards must be added together despite the fact that those peak conditions general-ly do not occur simultaneously.

According to the results of a computer simulation, in Case 2 when the number of containers handled per annum is one million TEUs and the marshal-ing yard is divided into three yards with three gates and controlled independently by three units, the resulting number of containers dwelling at the marshaling yard is 9,570 TEUs during peak conditions (see Section 10.1.4). The number is almost the same as the stacking capacity of the marshaling yard, and therefore, containers of one million TEUs can be handled per annum and the yard can be divided into three yards if larger RTGs are partly used at Terminal No.3. In other words, the container-handling capacity of the marshaling yard is estimated to be one million TEUs per annum under the divided control system, namely Case 2, which enables simple and easy operations.

In the divided control system, several alternatives are considered in terms of the type of RTGs and the layout of reefer yards. As to RTGs at the west yard of the marshaling yard (referred to as Terminal No.3) to be newly procured, introduction of large RTGs (six rows and one lane, four high stacking and five high over) is compared with that of the small RTGs (four rows and one lane, three high stacking and four high over) which are presently used at the existing marshaling yard.

On the other hand, as to a layout of reefer yards at the marshaling yard of the east quay, the following alternatives are considered:

- Case-A: A single reefer yard will be allocated west of the marshaling yard.
- Case-B: Reefer yards will be separately placed west and east of the marshaling yard. The west yard will be located at the same places as Case-A. The east yard is the existing one along the customs fences.

By combining the above alternatives of RTGs and reefer yards, the following three alternatives are considered and compared with each other (see Fig 10-1-1-Fig. 10-1-3):

	Location of reefer yard	Reefer-handling system	Handling of dry containers at No.3 Ter-minal
- Case 1	A single reefer yard will be allocated west of No.3 Terminal	3 small RTGs	9 large RTGs
- Case 2	Reefer yards will be separated placed at No.1, No2 and No3 Terminals.	1 large RTG	10 large RTGs
- Case 3	Reefer yards will be separated placed at No.1, No2 and No3 Terminals.	1 small RTG	13 small RTGs

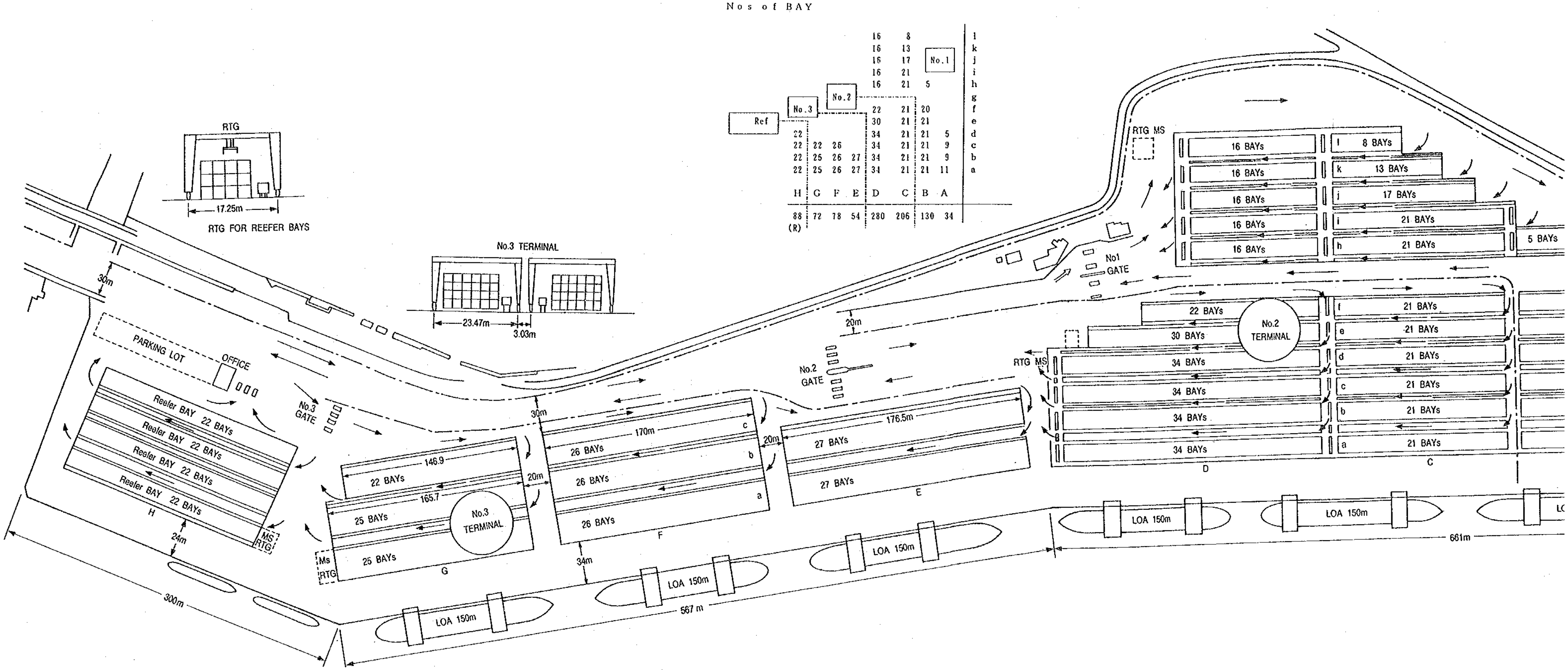


Fig. 10-1-1 Alternative Modernization Plan of the East Quay (Case 1)

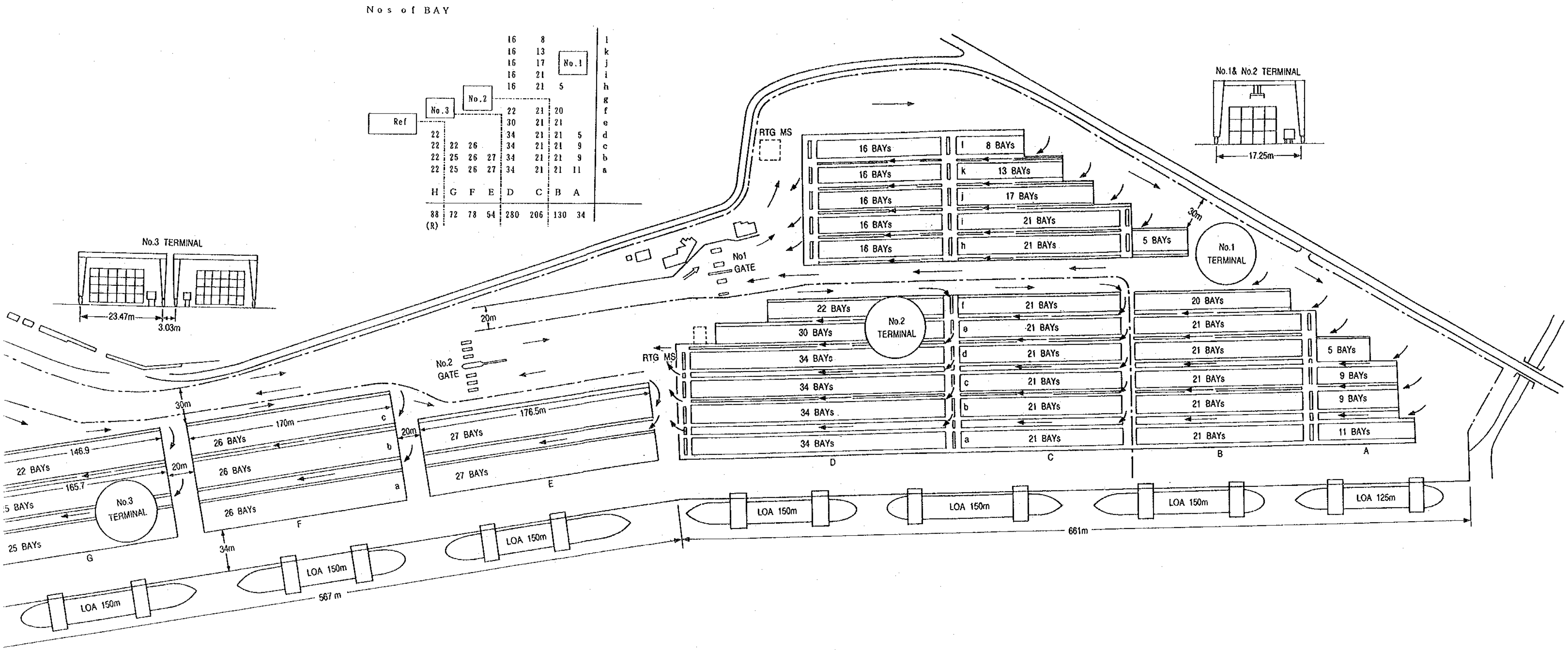


Fig. 10-1-1 Alternative Modernization Plan of the East Quay (Case 1)

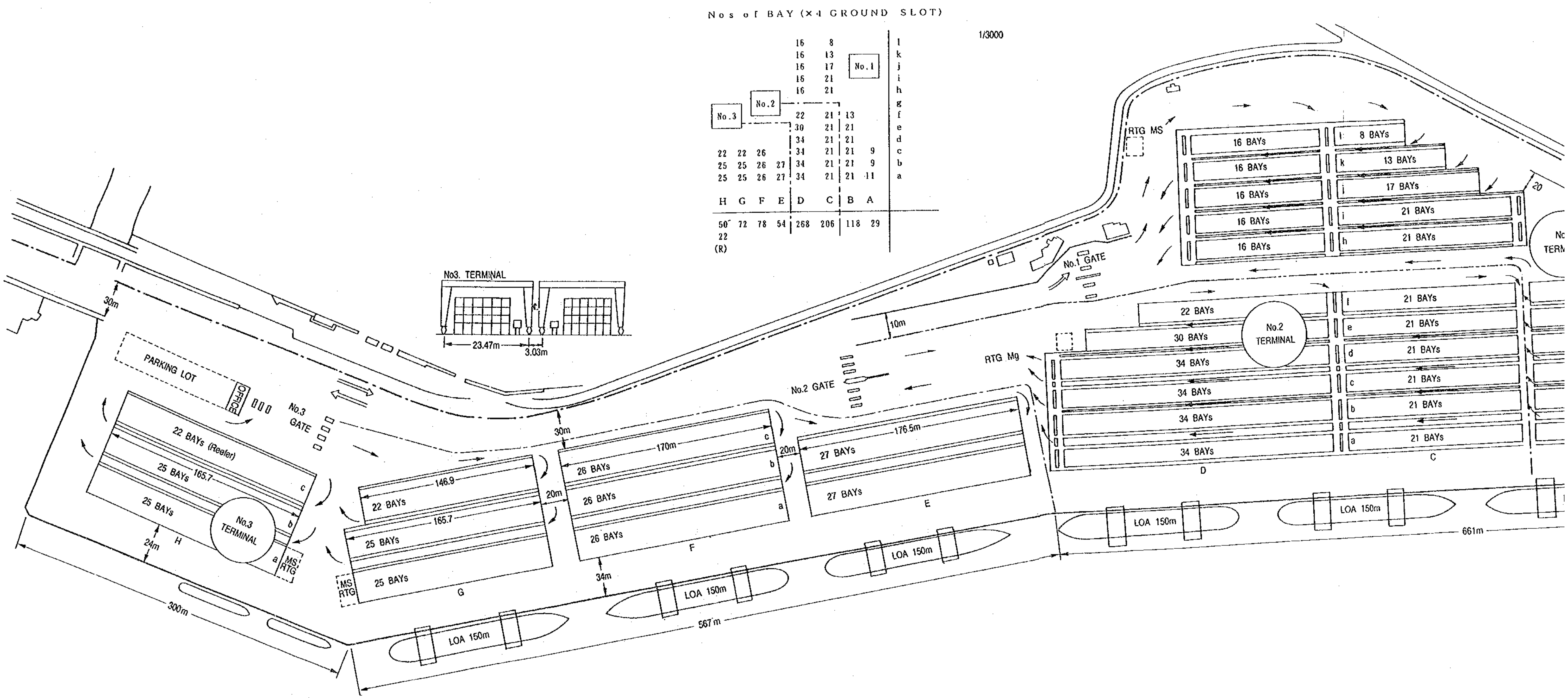


Fig. 10-1-2 Alternative Modernization Plan of the East Quay (Case 2)

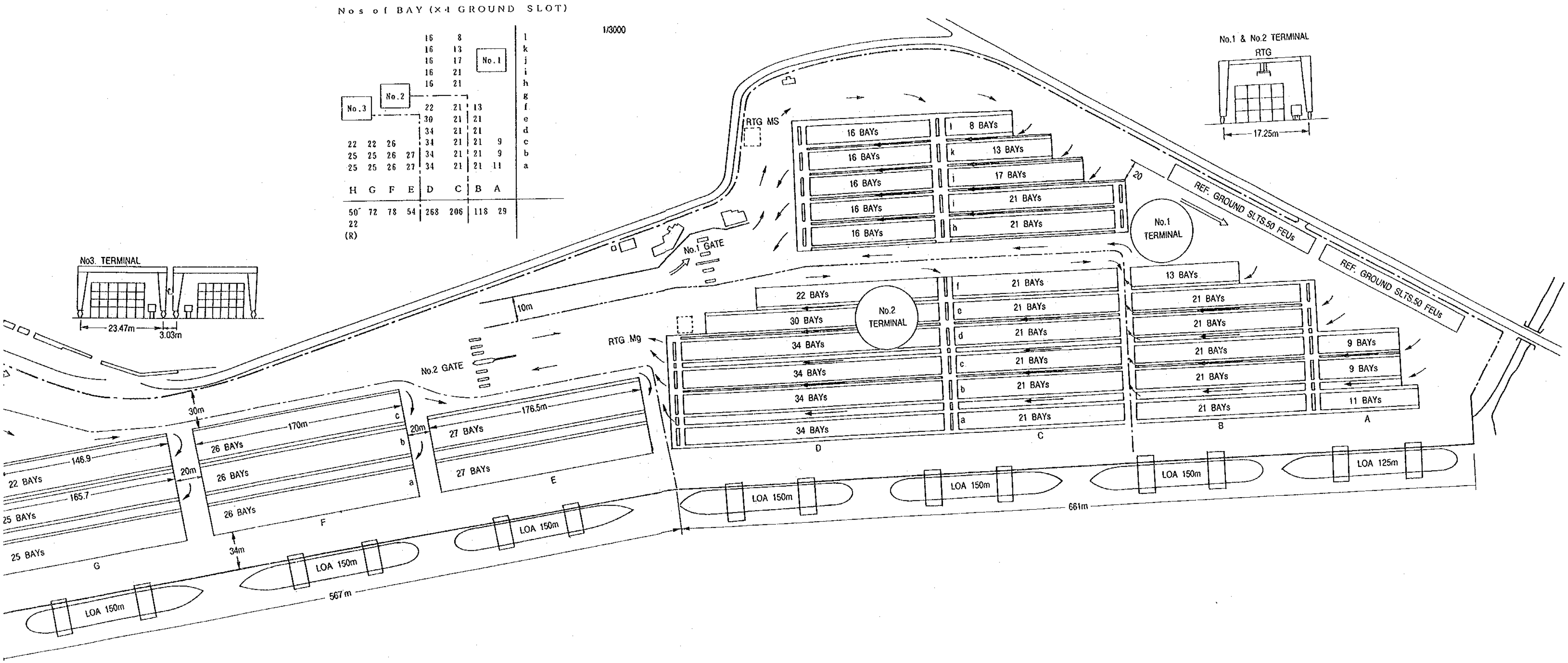


Fig. 10-1-2 Alternative Modernization Plan of the East Quay (Case 2)

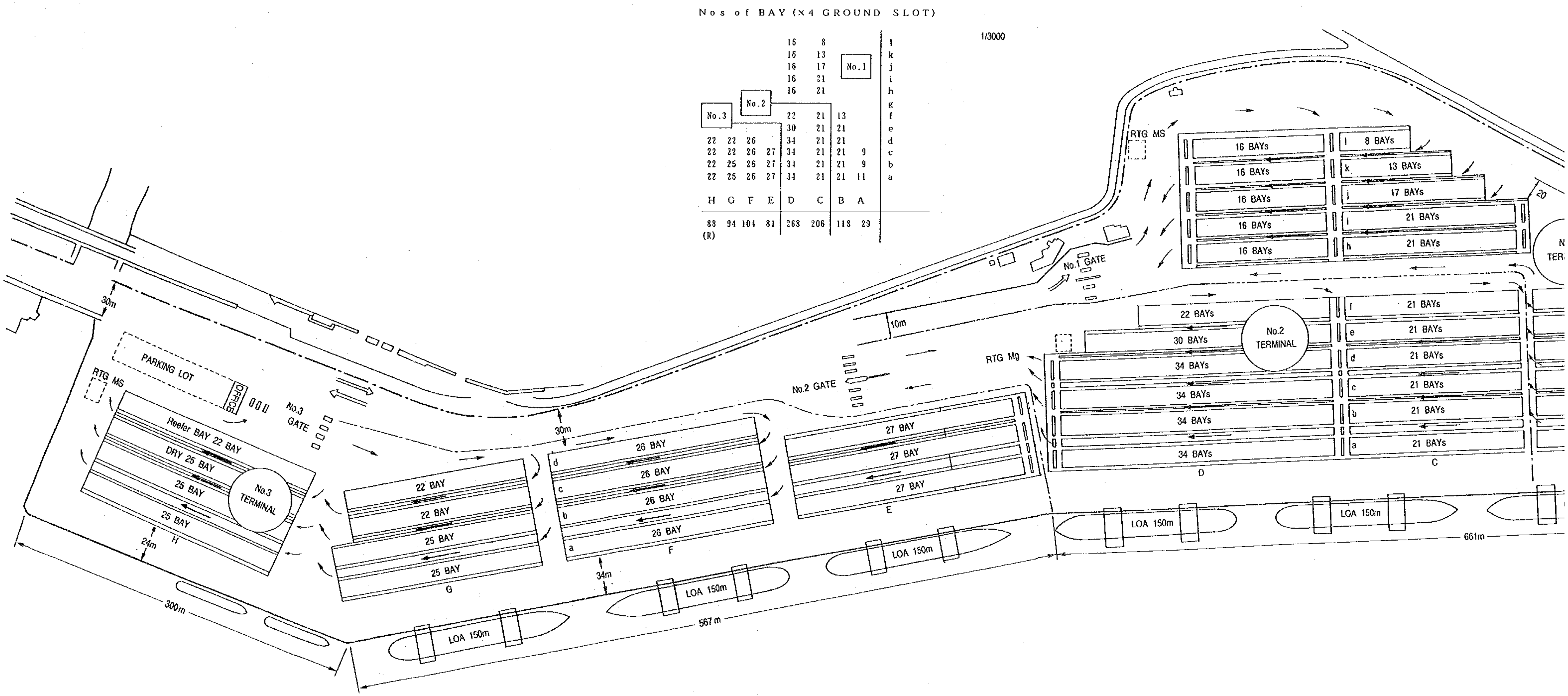


Fig. 10-1-3 Alternative Modernization Plan of the East Quay (Case 3)

Nos of BAY (×4 GROUND SLOT)

	H	G	F	E	D	C	B	A
	No.3				No.2		No.1	
l					16	8		
k					16	13		
j					16	17		
i					16	21		
h					16	21		
g								
f					22	21	13	
e					30	21	21	
d	22	22	26		34	21	21	
c	22	22	26	27	34	21	21	9
b	22	25	26	27	34	21	21	9
a	22	25	26	27	34	21	21	11
	88 (R)	94	104	81	268	206	118	29

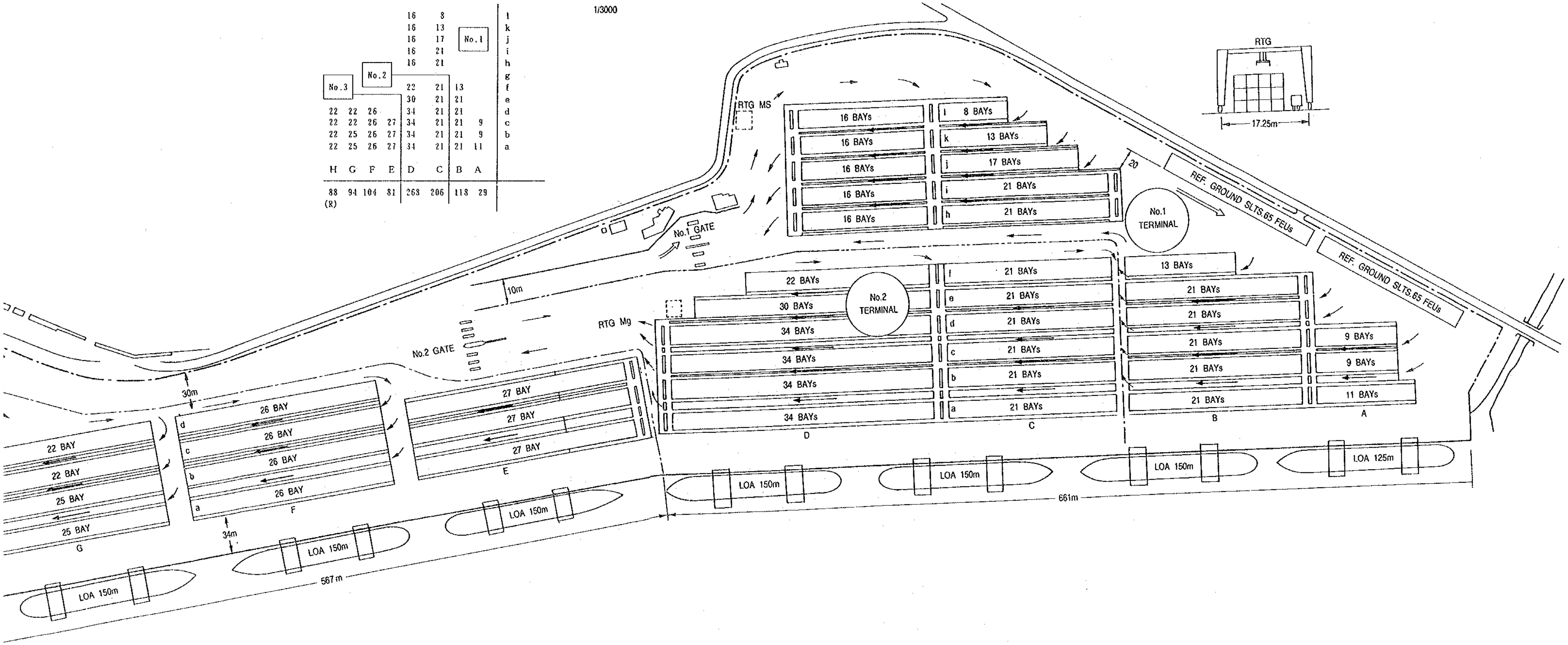


Fig. 10-1-3 Alternative Modernization Plan of the East Quay (Case 3)

In all cases, 19 small RTGs each will be used at Terminals No1 and No.2. The above three alternative plans are compared with each other from the following points:

a. Maintenance of reefer containers

Laden reefer containers must be stored with care at reefer yards without electric trouble. This matter must be given the first priority in reefer-handling. In Case 1 where a single reefer yard is utilized, reefer con-tainers could be maintained much easier than in Case 2 and Case 3 where the reefer yards are scattered throughout the area. From this point of view, Case 1 has a great advantage over Case 2 and Case 3.

b. Safety of operations

In Case 2 and Case 3, top loaders are used at the east reefer yard along the customs fences. The area where top loaders lift reefer containers will also be used as a passage for tractor-chassis units. Therefore, top loaders and tractor-chassis units might interfere with each other, resulting in dangerous conditions. On the contrary, in Case 1, there is no such fear. Therefore, from the standpoint of operational safety, Case 1 has an advantage over Case 2 and Case 3.

c. Haul distance of reefer containers within the marshaling yard

The average haul distance of reefer containers in Case 2 and Case 3 is shorter than that in Case 1 due to the difference in the locations of the reefer yards between the two alternative cases. The difference in haul distances within the marshaling yard, however, does not seem to be an important factor because the number of reefer containers is projected to be small compared with dry containers even in the future; and in both cases reefer containers will be hauled by tractor-chassis units which renders the small difference in the haul distances between the two cases insignificant.

d. Storage capacity of containers

Storage capacities of containers at Terminal No.3 in Cases 1, 2 and 3 are 9,942 TEUs, 10,659 TEUs and 9,297 TEUs. The capacity of Case 3 is less than the required capacity of 9,750 TEUs for the divided control system as mentioned above. The breakdown of the capacities are summarized as follows:

- Case 1 Unit: TEUs

		Terminal No.1	Terminal No.2	Terminal No.3	Total
Ground slots	Dry	1,296	1,256	1,224	3,776
	Reefer			352	352
				(352 plugs)	(352)
	Total	1,296	1,256	1,576	4,128
Capacity	Dry	2,916	2,826	3,672	9,414
	Reefer			528	528
Total		2,916	2,826	4,200	9,942

- Case 2 Unit: TEUs

		Terminal No.1	Terminal No.2	Terminal No.3	Total
Ground slots	Dry	1,228	1,256	1,524	4,008
	Reefer	100	100	132	332
		(100 plugs)	(100 plugs)	(132 plugs)	(332)
	Total	1,328	1,356	1,656	4,340
Capacity	Dry	2,763	2,826	4,572	10,161
	Reefer	150	150	198	498
	Total	2,913	2,976	4,770	10,659

- Case 3 Unit: TEUs

		Terminal No.1	Terminal No.2	Terminal No.3	Total
Ground slots	Dry	1,228	1,256	1,416	3,900
	Reefer	130	130	88	348
		(130 plugs)	(130 plugs)	(88 plugs)	(348)
	Total	1,358	1,386	1,504	4,248
Capacity	Dry	2,763	2,826	3,186	8,775
	Reefer	195	195	132	522
	Total	2,958	3,021	3,318	9,297

e. Project costs

The project costs of Cases 1, 2 and 3 are estimated to be 635 million Baht, 626 million Baht and 572 million Baht, respectively. Though, the cost of Case 3 is the lowest among the three cases, the storage capacity of Case 3 is short of the required capacity for divided control as mentioned above. The difference in cost between Case 1 and Case 2 is only 9 million Baht. Thus, there is no decisive difference in costs between the two cases. Breakdown of the costs is as follows:

- Case 1

Cost Item

1) Demolition of existing reefer facilities and pavement after the demolition:
3,090,000 Bahts

2) Preparation of the new reefer yard west of Terminal No.3 (4 blocks for reefers, small RTGs are used):
25,373,000 Baht

3) Preparation of the new yard for dry containers at Terminal No.3 (8 blocks for dry containers, large RTGs are used):
85,713,000 Bahts

4) Procurement of 3 small RTGs and 9 large RTGs 32,500,000 x 3 + 47,000,000 x 9 = 520,500,000 Bahts

Total 634,676,000 Baht

- Case 2

Cost Item

1) Demolition of existing reefer facilities and installation of renewed reefer facilities:
3,931,000 Bahts

2) Preparation of the new yard west of Terminal No.3 (1 block for reefers and 2 blocks for dry containers, large RTGs are used):
19,287,000 Baht

3) Preparation of the new yard for dry containers at Terminal No.3 (8 blocks for dry containers, large RTGs are used):
85,713,000 Bahts

4) Procurement of 11 large RTGs (6 rows + 1 lane):
47,000,000 x 11 = 517,000,000 Baht

Total 625,931,000 Bahts

- Case 3

Cost Item

1) Demolition of existing reefer facilities and installation of renewed reefer facilities:
3,931,000 Baht

2) Preparation of the new yard at Terminal No.3 (1 block for reefers and 14 blocks for dry containers):
113,200,000 Baht

3) Procurement of 14 small RTGs (4 rows + 1 lane):
32,500,000 x 14 = 455,000,000 Bahts

Total 572,131,000 Baht

From the above comparison, Case 1 where a single reefer yard is allocated and large RTGs are used for dry containers at Terminal No.3 is the optimum plan.

(3) Container Freight Stations (CFSs)

Import CFSs are arranged at the west quay. The existing Sheds No.13 and No14 are planned to be used for Import CFSs as they are at present. In addition to them, new Import CFSs are planned to be prepared in Area II. On the other hand, the new Export CFSs are planned to be prepared in Zone 1 at the west quay (see Fig 10-1-4). Required dimensions of the new CFSs are shown in Section 10.1.5.

(4) Storage Yard for Empty Containers

A storage yard for empty containers is planned to be prepared at the open yard behind and west of the existing Sheds No.15-No.17 and adjacent to the Import CFSs planned in the stage of the Master Plan. Required slot number to store empty containers is shown in Section 10.1.5.

As to the gate preparation, three gates, i.e. the first gate is near the CFSs, the second gate is the opposite side of the first gate and the third gate is west of sheds Nos 15-17 will be prepared (see Fig. 10-1-4 and 10-1-5).

(5) Parking Lots for Container Chassis

A parking lot with the capacity of 210 container chassis and 100 tractors will be prepared behind sheds Nos. 15-17. The total required number of container chassis are estimated as 210 and 110 in the stage of the Master Plan (see Section 10.1.6 (3)). Thus, most of the chassis and tractors can be parked at the above parking lot.

(6) LCL Reefer Yard

In addition to the concentrated reefer yard at the east quay, present reefer yard with 100 plugs east of shed No.17 at the west quay will be kept intact for handling LCL reefer containers.

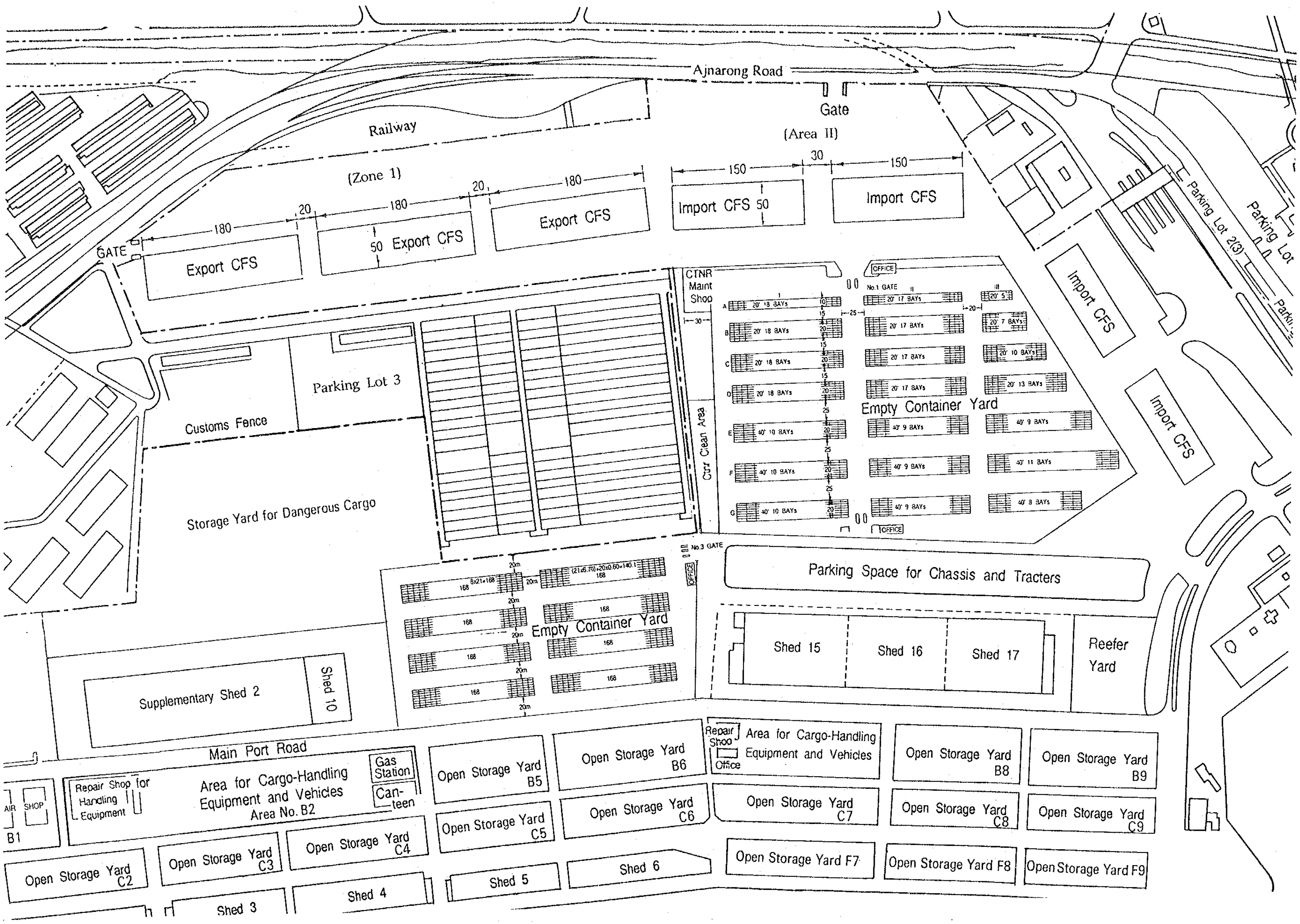
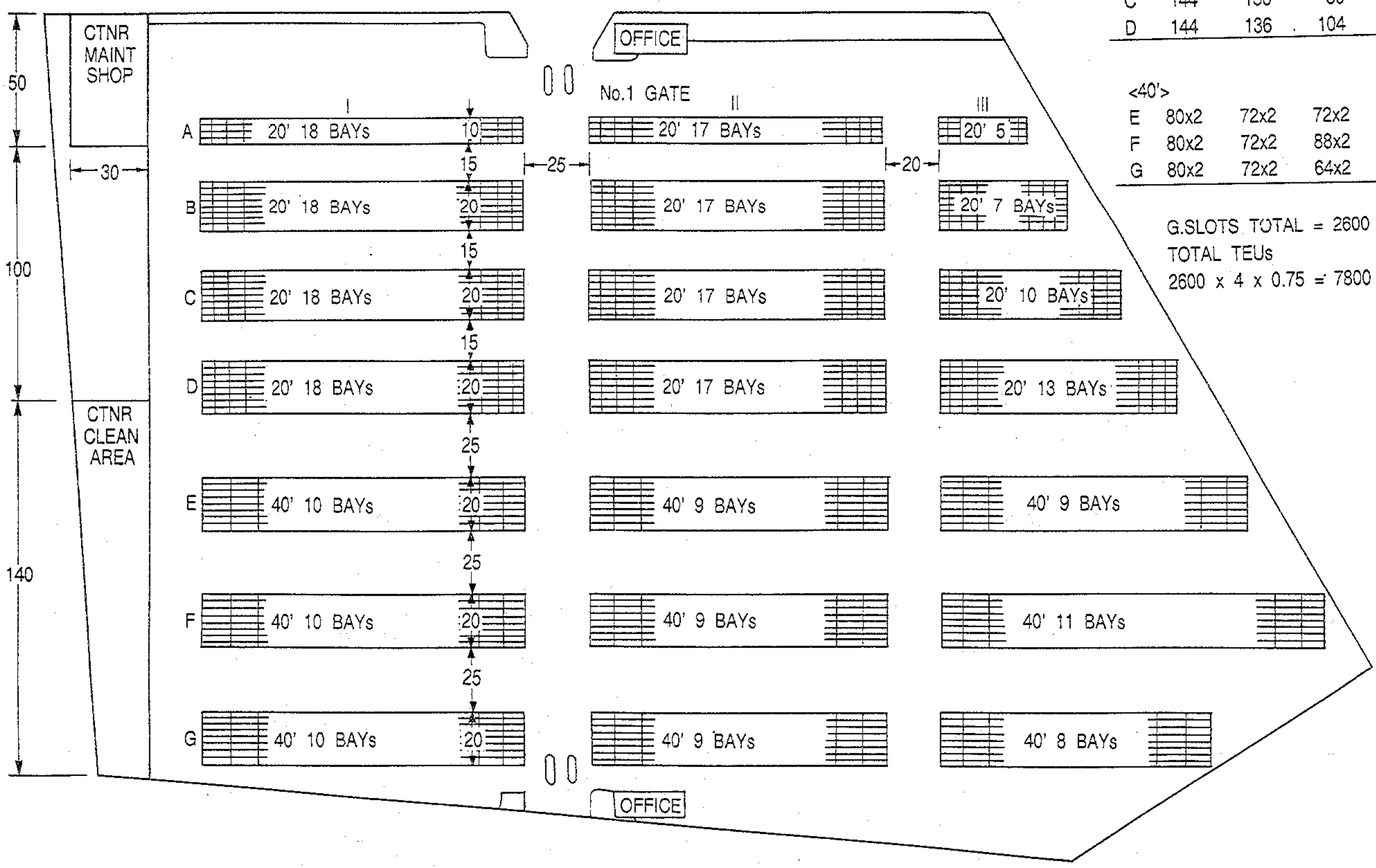


Fig. 10-1-4 Modernization Plan of the West Quay for Container-Handling

West Quey Empty Storage Yard I (2005)



GROUND SLOT

<20'>

	I	II	III	TTL
A	72	68	20	160
B	144	136	56	336
C	144	136	80	360
D	144	136	104	384
				1240

<40'>

E	80x2	72x2	72x2	224x2
F	80x2	72x2	88x2	240x2
G	80x2	72x2	64x2	216x2
				680x2

G.SLOTS TOTAL = 2600

TOTAL TEUs

2600 x 4 x 0.75 = 7800 TEUs

Each lane length

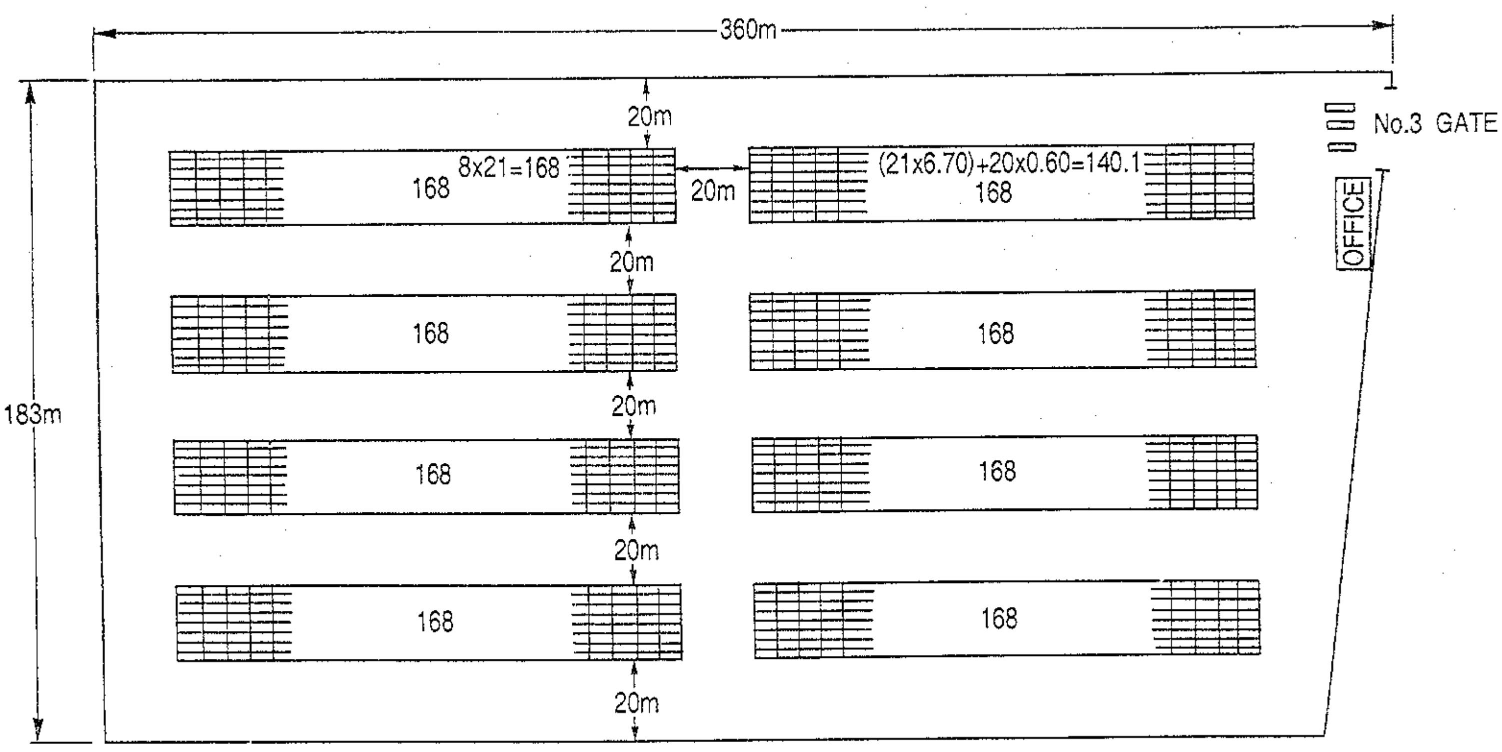
20' e = n x 6.1 + (n-1) x 0.6

40' e = n x 12.2 + (n-1) x 0.6

OPERATED BY 23 UNITS
OF THE LIFTER (FOR EMPTY)

West Quey Empty Storage Yard II

$\frac{1}{2000}$



(168 x 8 = 1344 G.SLOTs
1344 x 4 x 0.75 = 4032 TEUs)

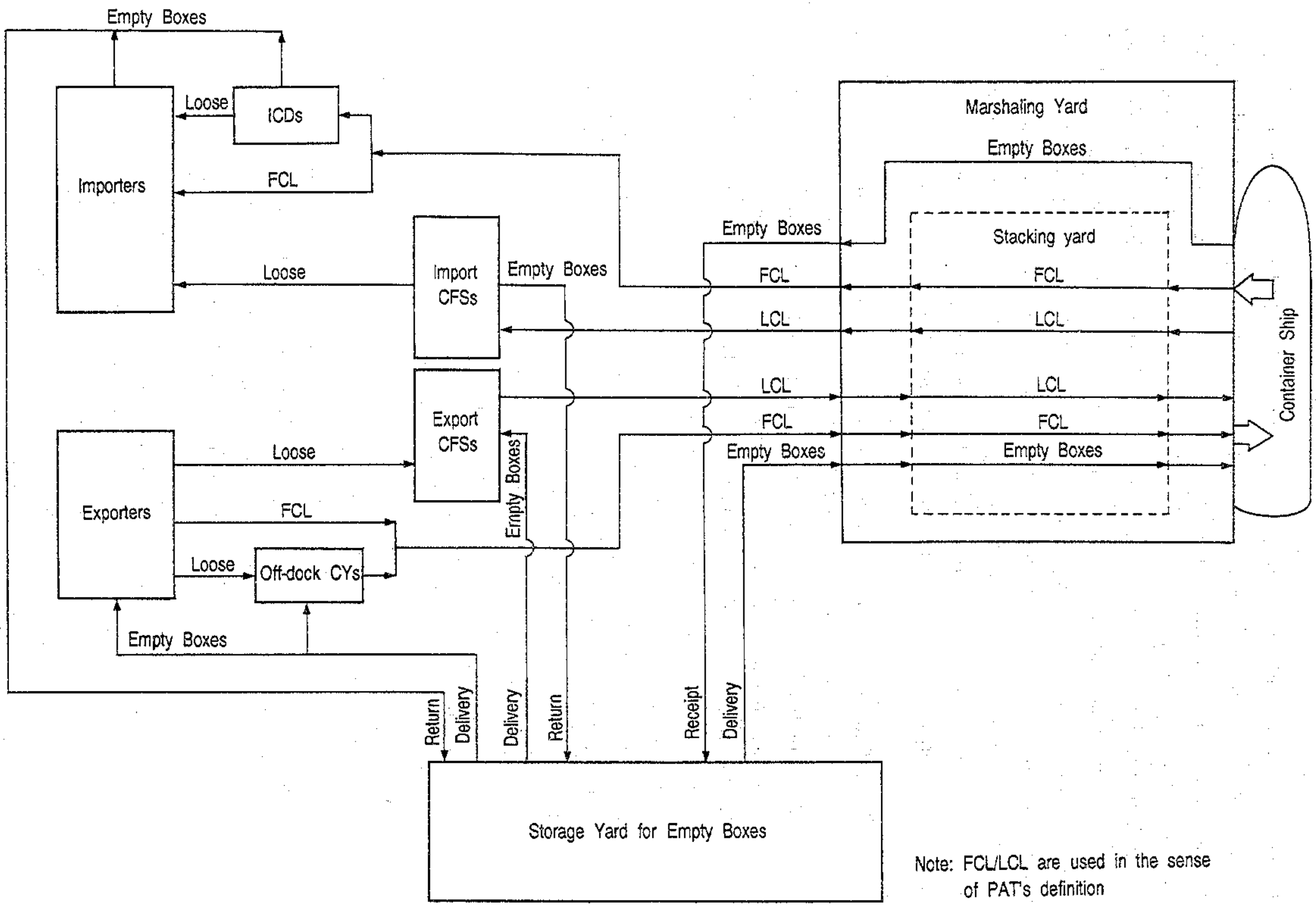
OPERATED BY 10 UNITS
OF TOP LIFTER (FOR EMPTY)

Fig. 10-1-5 Modernization Plan of the West Quay for Container-Handling (Empty Container Storage Yard)

10.1.4 Container Movements within the Port in the New Operational System

Container movements within the port are outlined in Fig. 10-1-6. To reveal container movements in the new operational system proposed in this study, a computer simulation was conducted. The resulting figures of the simulation are used to estimate container-handling capacity per annum that is one of the prerequisites of the functional allotment between the ports of Bangkok and Laem Chabang. The container-handling capacity per annum is determined according to the container-stacking capacity of the marshaling yard in the east quay. In the next step, the resulting figures of the simulation are used to estimate required scale of the main facilities for container-handling such as the number of lanes of the terminal gates, floor space of CFSs and the number of slots at the storage yard for empty containers corresponding to the container-handling capacity mentioned above. The conditions for the simulation are as follows:

- Arrival times of container ships: the actual arrival record in 1991/1992 was used (see Chapter 6, Section 6.4).
- The number of containers discharged/loaded per ship: the actual container-handling record was used (see Chapter 6, Section 6.4).
- Gross container-handling productivity at the dockside: 21 boxes/hr (referred to the actual record of the new terminal at Laem Chabang Port)
- The percentage of 20 ft. boxes: 48%
- The percentage of export CFS cargoes (LCL): 20% of laden containers
- The percentage of import CFS cargoes (LCL): 20% of laden containers
- The percentage of empty export containers: 5%
- The percentage of empty import containers: 20%
- Annual working days: 365 days
- Daily working hours: 24 hours
- Closing time: 24 hours before a ship arrival
- Arrival distribution of FCL containers:
  - Export:
    - 35%: 24-48 hours (2 days) before a ship arrival
    - 35%: 48-72 hours (3 days) before a ship arrival
    - 15%: 72-96 hours (4 days) before a ship arrival
    - 15%: 96-120 hours (5 days) before a ship arrival
  - Import:
    - 30%: 24-48 hours (2 days) after final loading
    - 30%: 48-72 hours (3 days) after final loading
    - 14%: 72-96 hours (4 days) after final loading
    - 13%: 96-120 hours (5 days) after final loading
    - 13%: 120-144 hours (6 days) after final loading



Note: FCL/LCL are used in the sense of PAT's definition

Fig. 10-1-6 Outline of Container Movements within the Port

(referred to the leading container terminals in the world)

- Dwelling time of LCL containers at the marshaling yard: 24 hours

In the simulation, the number of containers passing through Bangkok Port per annum must be a given condition. Hence, several alternative cases with different numbers of containers were considered, and the corresponding simulations were conducted. According to the results of the simulation, in the case (Case 2 in Section 10.1.3 (2)) when the number of containers handled per annum is one million TEUs (the number of calling vessels per annum is 1,141) and the marshaling yard is divided into three yards and controlled independently by three units of a terminal operator, the resulting number of containers dwelling at the marshaling yard is 9,750 TEUs during peak conditions (see Fig. 10-1-7). Thus, the required storage capacity of the marshaling yard is 9,750 TEUs. Compared to the above required storage capacity with the stacking capacity of 9,900 TEUs of the marshaling yard (see Section 10.1.3 (2)), the container-handling capacity of the marshaling yard at the east quay can be said to be approximately one million TEUs per annum as mentioned in Section 10.1.3 (2).

The resulting average berth occupancy rate of the seven berths of the east quay is 25.6%.

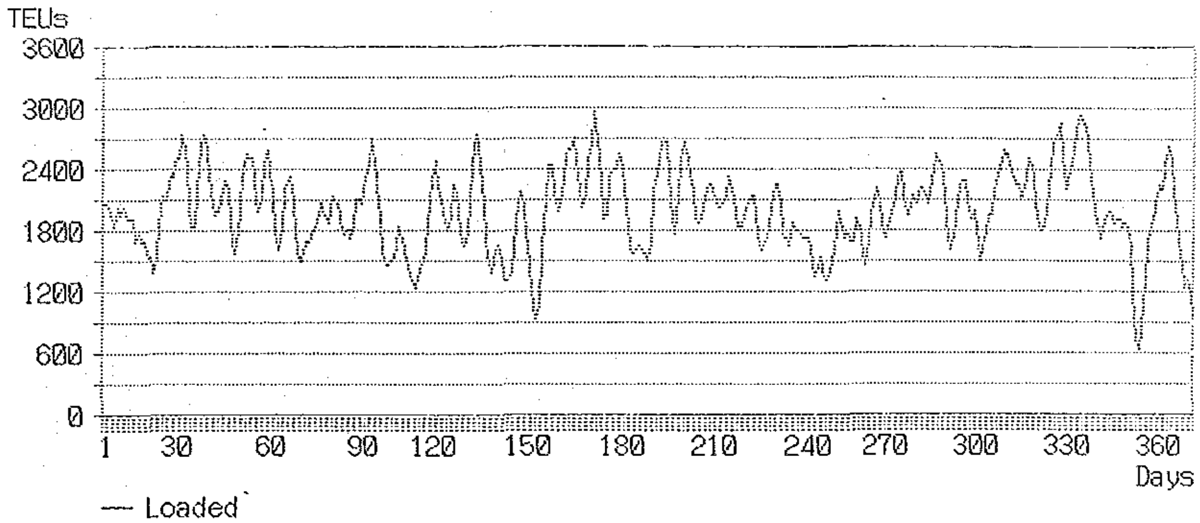


Fig. 10-1-7-(a) Number of Containers Dwelling at the Marshaling Yard (1st Unit)

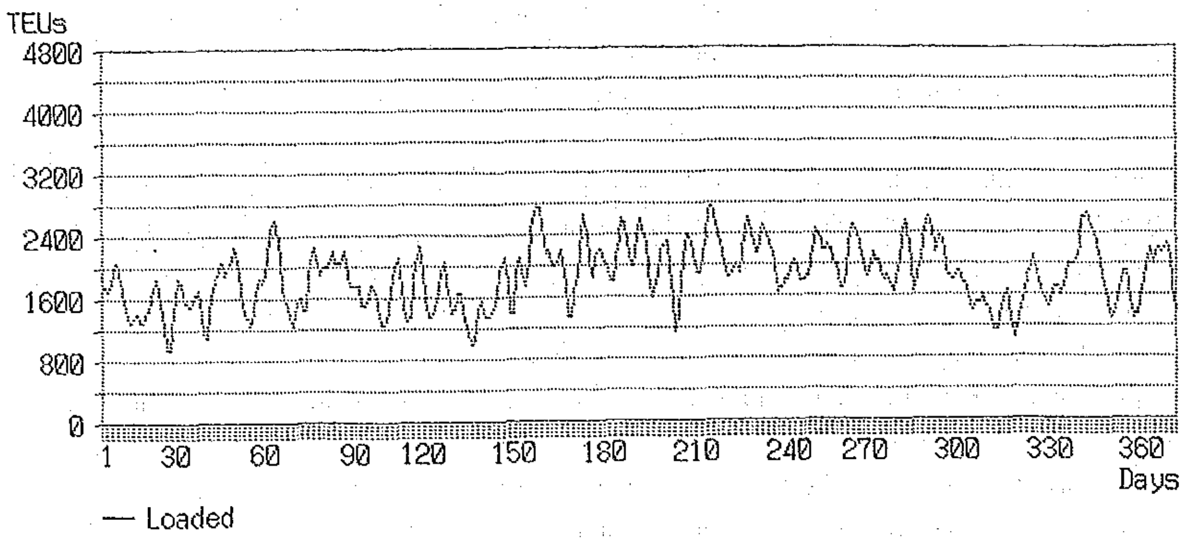


Fig. 10-1-7-(b) Number of Containers Dwelling at the Marshaling Yard (2nd Unit)

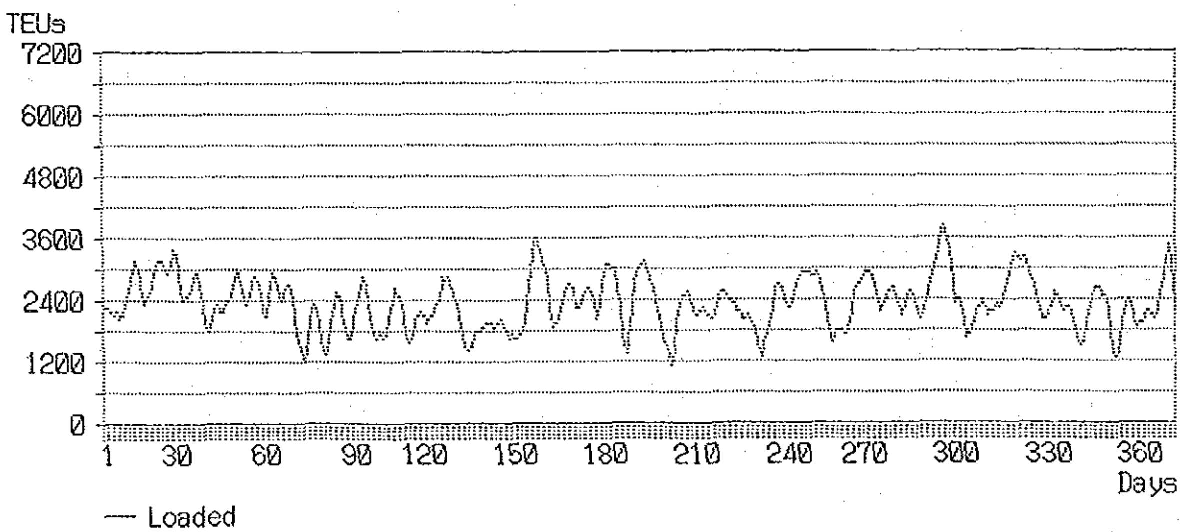


Fig. 10-1-7-(c) Number of Containers Dwelling at the Marshaling Yard (3rd Unit)

10.1.5 Required Scale of the Main Facilities for Container-Handling

(1) Container Freight Stations (CFSs)

As mentioned in Section 10.1.4, the container-handling capacity is estimat-ed to be one million TEUs per annum, and therefore Import and Export CFSs need to be prepared to meet the container movements corresponding to each case. According to the result of the simulation, the volume of container cargoes dwelling at Import CFSs is estimated to be 13,610 tons during peak condition (see Fig 10-1-7). To store the volume, the existing Sheds No13 and No14 are planned to be used as they are at present taking account of the advantage that those sheds are located adjacent to the main gate. The storage capacity of the two existing sheds are estimated to be 4,880 tons. Hence, additional Import CFSs with a storage capacity of 8,730 tons need to be prepared. The required dimensions of the new CFS are shown as follows:

- Required floor area: 14,550 sq.m
- Total length: 300 m
- Width: 50 m
- Total required number of bays on each side: 45

Taking account of a suitable size of one CFS building, two CFSs each with a length of 150 m are arranged at Area II.

On the other hand, as to Export CFSs, the volume of container cargoes dwelling at Export CFSs is estimated to be 15,880 tons during peak condition. To store the volume, new Export CFSs needs to be prepared. The required dimensions of the new CFS are shown as follows:

- Required floor area: 26,450 sq.m
- Total length: 540 m
- Width: 50 m
- Total required number of bays on each side: 60

Taking account of a suitable size of one CFS building, three CFSs each with a length of 180 m are arranged at Zone 1.

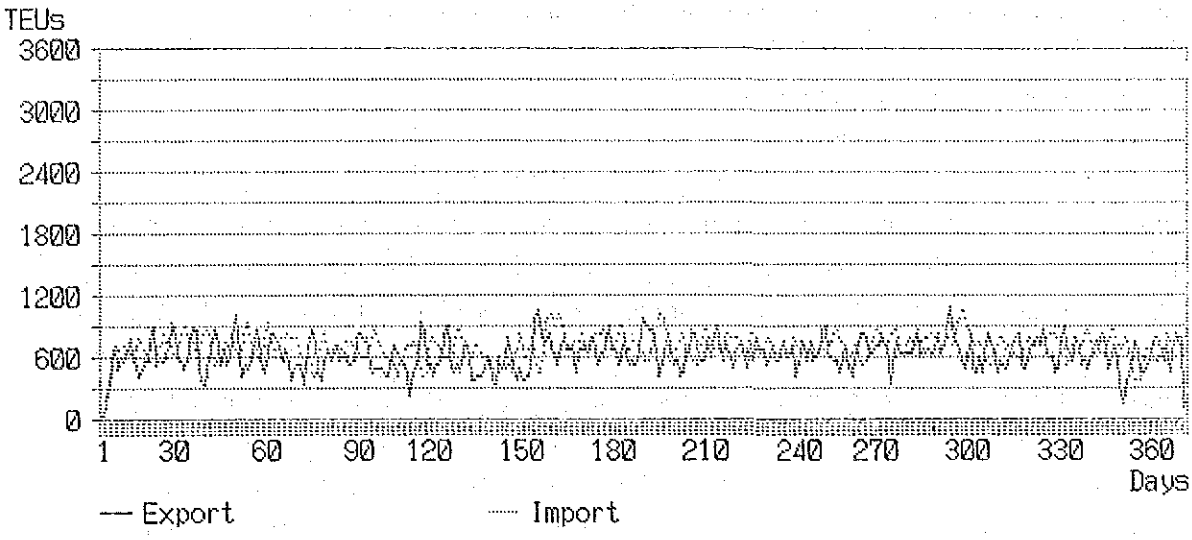


Fig. 10-1-8 Volume of Cargo Dwelling at CFSs Equivalent to TEUs

(2) Storage Yard for Empty Containers

According to the result of the simulation, the total required volume of empty containers to be stacked at storage yard is estimated to be approxi-mately 12,000 TEUs during peak condition, and therefore, storage yard with a capacity of the figure is planned to be prepared at the west quay.

(3) Required Number of Lanes of the Terminal Gates

According to the result of the simulation, daily traffic volume through the terminal gates and corresponding required number of lanes at the marshal-ing yard of the east quay in the condition of a hourly peaking factor of 1.5 (refer to the traffic survey conducted by the study team) are shown as follows:

Unit: Vehicles/day

	Receipt			Delivery			Number of
Gate	Laden	Empty	Chassis	Laden	Empty	Chassis	Lanes
Gate No.1	500	30	530	430	110	530	7
Gate No.2	560	30	550	440	110	590	7
Gate No.3	610	30	710	570	140	640	7

The required number of lanes at the storage yard for empty containers at the west quay is shown as follows:

Unit: Vehicles/day

Gate	Receipt Empty	Receipt Chassis	Delivery Empty	Delivery Chassis	Number of Lanes
Gate No.1	220	280	280	220	4
Gate No.2	750	760	760	750	2
(to/from the east quay)	(200)		(60)		
(to/from outside of the port)	(550)		(700)		
Gate No.3	250	250	250	250	2
(to/from the east quay)	(70)		(20)		
(to/from outside of the port)	(180)		(230)		

(4) Reefer Plugs

The required number of reefer plugs is shown as follows:

- The percentage of reefer containers to the total laden containers:
  Import: 1.5%
  Export: 7.0%
- The percentage of 20 ft. containers among reefer containers: 30%
- Operational factor: 0.75
- Required number of reefer plugs: 340

(5) Repair Shop and Cleaning Area

A repair shop for damaged containers is planned at the storage yard for empty containers at the west quay. The dimensions are as follows:

- Site area for a building: 50 m x 30 m = 1,500 sq.m

Cleaning area is also allocated at the same yard.

(6) Terminal Office

It is necessary to prepare a new terminal office at Gate No.3. The dimensions are as follows:

- Stories: 3
- Site area for a building: 20 m x 10 m = 200 sq.m
- Floor space: 600 sq. m

10.1.6 Container-Handling System

(1) Selection of Container-Handling System

There are four representative container-handling systems, namely transfer crane system, straddle carrier system, chassis control system and toplifter (toploader, forklift) system. As to container-handling system adopted at the marshaling yard of the east quay whose space is narrow and is difficult to be expanded, the chassis system is inappropriate to be adopted because the system requires a spacious yard. The toplifter system is also inappropriate because most containers handled at the marshaling yard are laden containers, and therefore the system needs a spacious yard.

The transfer crane system (RTG system falls under the transfer crane system), taking account of container-handling operations at the narrow space of the marshaling yard of the east quay, enables safe, clear and noiseless operations. Furthermore, maintenance of transfer cranes is easier than that of straddle carriers. Although the transfer crane system has a general disadvantage in terms of speedy yard operation compared with the straddle carrier system, it can be overcome by supplying sufficient number of transfer cranes.

Thus, the transfer crane system is selected as the most appropriate system to be adopted at the marshaling yard of the east quay in the stage of the Master Plan as it is at present.

On the other hand, as to container-handling system adopted at the storage yards for empty containers of the west quay, toplifters can move empty containers speedily from chassis on to stacking yards or vice versa com-pared with other systems such as the transfer crane system (RTG system). Moreover, even in the toplifter system, empty containers can be stacked in blocks like the transfer crane system because the percentage of digged empty containers is generally low by being stacked by size, type and ship-ping line, resulting in space-saving. And not only toplifters perform swift operation, the unit price of a toplifter is much cheaper than a transfer crane or a straddle carrier. Other advantages of the toplifter system include the low cost of paving or repairing yards and flexibility in the layout of ground slots. Thus, the toplifter system is selected as the optimum system at the storage yards for empty containers of the west quay.

(2) Divided Control System at the Marshaling Yard (See Fig.10-1-1)

At most leading container terminals, one unit of a terminal operator gener-ally controls 1,000-2,000 ground slots. The total number of ground slots at the marshaling yard in the stage of the Master Plan is around 4,100. Considering the above fact, the marshaling yard of the east quay is planned to be divided into three yards, Terminals No1-No.3 which are independently controlled by three units. Each terminal has its own gate with seven lanes to check container's condition and status. Each gate to receive or deliver containers is connected with a control section by computer system. In dividing the marshaling yard into three yards, movements of RTGs must be considered so as to ensure effective movements of RTGs. For example, shifting between different lanes takes a long time, and therefore, such shifting must be avoided as much as possible. Although the marshaling yard is planned to be divided into the three yards and controlled independently, RTGs are required to be flexibly used in dockside operations, especially in peak conditions.

In the meantime, as to a reefer yard, a single reefer yard will be allocat-ed west of Terminal No.3 as mentioned in Section 10.1.3 (2).

(3) Required Numbers of Container-Handling Machines to be Used at Bangkok Port

Required number of container-handling machines to be used at Bangkok Port in the stage of the Master Plan is estimated according to the following conditions:

1) Number of containers to be handled at Bangkok Port: one million TEUs
2) Storage capacity for empty containers at the yard: 12,000 TEUs

The resulting numbers are summarized as follows:

- Storage yards for empty containers

1) Toplifters of 4-high-stacking (10 tons): 27 units

- Number of empty containers to be received from outside the yard in peaking conditions:
  1,955 TEUs/day; 1,286 Boxes/day (peaking factor: 1.60 from a simulation)
- Number of empty containers to be delivered to outside the yard in peaking conditions:
  1,854 TEUs/day; 1,220 Boxes/day (peaking factor: 1.60 from a simulation)
- Daily working hours: 16.5 hours

- Gross cargo-handling productivity in normal conditions: 20 boxes/hour
- Operational factor: 0.5
- Percentage of dug containers: 10%
- Average handling times when containers being digged: 9 times
- Typical operation: a. Receiving empty containers from the marshaling yard, Import CFSs or outside the port
  b. Delivery of empty containers to the marshaling yard, Export CFSs or outside the port

(1,286 + 1,220)boxes/16.5hr/(20 boxes/hr/unit)/0.5 x (0.9 + (0.1) x 9) = 27 units

- Export CFSs

1) Yard tractors for delivery of Export LCL containers to the marshaling yard at the east quay: 23 units

- Number of LCL containers in peaking conditions:
  655 TEUs/day;431 Boxes/day (peaking factor: 2.71 from a simulation)
- Daily working hours: 16.5 hours
- Average velocity of a tractor within the port: 15 km/hr
- Average haul distance between the CFSs and the marshaling yard: 1.5 km in one way; distance between the CFSs and the empty container yards: 0.5 km in one way
- Cycle time of lift on and lift off: 6 minutes
- Gate in and out: 2 minutes
- Connection with and disconnection from chassis: 2 minutes
- Total cycle time of the operation: 26 minutes
- Number of container boxes hauled by tractors: 2.3 boxes/hr/unit
- Operational factor: 0.5

431 boxes/16.5hr/(2.3 boxes/hr/unit)/0.5 = 23 units

2) Chassis for delivery of Export LCL containers to the marshaling yard at the east quay: 77 units

- Number of LCL containers in peaking conditions:
  655 TEUs/day;431 Boxes/day (peaking factor: 2.71 from a simulation)
- Daily working hours: 16.5 hours
- Average velocity of a tractor within the port: 15 km/hr

- Average haul distance between the CFSs and the marshaling yard: 1.5 km in one way; distance between the CFSs and the empty container yards: 0.5 km in one way
- Cycle time of lift on and lift off: 6 minutes
- Gate in and out: 2 minutes
- Connection with and disconnection from chassis: 2 minutes
- Unit weight: 12.5 tons/TEU
- Average weight per lift by a forklift at Export CFSs: 0.7 ton
- Productivity of a forklift: 20 lifts per hour
- Stuffing time by forklift: 0.77 hour/TEU: 70%
- Stuffing time by laborer: 1.50 hour/TEU: 30%
- Total cycle time of the operation: 116 minutes
- Number of container boxes hauled by tractors: 0.52 boxes/hr/unit
- Operational factor: 0.5: hauled by hustler
- Operational factor: 0.8: at a container side
- Average operational factor: 0.7

431 boxes/16.5hr/(0.48 boxes/hr/unit)/0.7 = 77 units

3) Forklifts (3 tons) used at Export CFSs: 82 units

- Number of Export LCL dry containers per annum: 88,350 TEUs
- Number of LCL containers in peak conditions:
  655 TEUs/day;431 Boxes/day (peaking factor: 2.71 from a simulation)
- Daily working hours: 16.5 hours
- Unit weight: 12.5 tons/TEU
- Cargo volume in peak conditions: 7,074 tons per day
- Average weight per lift by a forklift at Export CFSs: 0.7 ton
- Productivity of a forklift: 20 lifts per hour
- Cargo-handling productivity of a forklift: 14 tons per hour
- Operational factor: 0.6
- Percentage of forklift's use: 70%

8,188 tons x 0.7/16.5hr/(14 tons/hr/unit)/0.6 x 2 = 82 units

- Import CFSs

1) Yard tractors for receiving Import LCL containers from the marshaling yard at the east quay: 18 units

- Number of LCL containers in peaking conditions:
  512 TEUs/day;337 Boxes/day (peaking factor: 2.37 from a simulation)
- Daily working hours: 16.5 hours
- Total cycle time of the operation: 26 minutes
- Number of container boxes hauled by tractors: 2.3 boxes/hr/unit
- Operational factor: 0.5

337 boxes/16.5hr/(2.3 boxes/hr/unit)/0.5 = 18 units

2) Chassis for receiving Import LCL containers from the marshaling yard at the east quay: 56 units

- Number of LCL containers in peaking conditions:
  512 TEUs/day;337 Boxes/day (peaking factor: 2.37 from a simulation)
- Daily working hours: 16.5 hours
- Number of container boxes hauled by tractors: 0.52 boxes/hr/unit
- Average operational factor: 0.7

337 boxes/16.5hr/(0.52 boxes/hr/unit)/0.7 = 56 units

3) Forklifts (3 tons) used at Import CFSs: 56 units

- Number of Import LCL dry containers per annum: 78,800 TEUs
- Number of LCL containers in peak conditions:
  512 TEUs/day;337 Boxes/day (peaking factor: 2.37 from a simulation)
- Daily working hours: 16.5 hours
- Unit weight: 10.8 tons/TEU
- Cargo volume in peak conditions: 5,530 tons per day
- Average weight per lift by a forklift at Export CFSs: 0.7 ton
- Productivity of a forklift: 20 lifts per hour
- Cargo-handling productivity of a forklift: 14 tons per hour
- Operational factor: 0.6
- Percentage of forklift's use: 70%

5,530 tons x 0.7/16.5hr/(14 tons/hr/unit)/0.6 x 2 = 56 units

- Marshaling yard at the east quay

1) Small RTGs: 22 units

- Number of containers received or delivered through the gates in peak conditions:
  5,389 TEUs/day; 3,545 Boxes/day (peaking factor: 1.97 from a simulation)
- Dry containers excluding imported empty containers: 3,052 boxes
  - Terminals No1 and No2: 1,896 boxes
    (Percentage of Import FCL containers: 37%
  - Terminals No3: 1,155 boxes
- Reefer containers: 139 boxes
  (Percentage of Import FCL containers: 15%
- Daily working hours: 24 hours
- Gross cargo-handling productivity in normal conditions: 20 boxes/hour
- Operational factor: 0.7
- Percentage of dug containers when being lifted: 50%
- Average handling times when containers being digged:
  - Dry containers at Terminals No1 and No2: 2 times
  - Reefer containers at Terminals No3: 1.5 times

- Dry containers at land side of Terminals No.1 and No.2

1,896 boxes/24hr/(20 boxes/hr/unit)/0.7 x(1-0.37+(0.5+(0.5) x 2) x 0.37) = 7 units

- Reefer containers at land side of Terminal No.3

139 boxes/24hr/(20 boxes/hr/unit)/0.7 x(1-0.15+(0.5+0.5 x 1.5)x 0.15) = 1 unit

- Dry containers at dock side of Terminal No.1 and No.2

1.5 RTGs / dock-side crane x 8 dock-side cranes = 12 RTG units

- Reefer containers at dock-side of Terminal No.3: 1 RTG unit
- Considering the layout of reefer lanes at Terminal No.3, one RTG unit is added.

2) Large RTGs: 9 units

- Number of containers received or delivered through the gates in peak conditions:
  5,389 TEUs/day; 3,545 Boxes/day (peaking factor: 1.97 from a simulation)
- Dry containers excluding imported empty containers: 3,052 boxes

- Terminals No1 and No2: 1,896 boxes
  (Percentage of Import FCL containers: 37%
- Terminals No3: 1,155 boxes

- Daily working hours: 24 hours
- Gross cargo-handling productivity in normal conditions: 25 boxes/hour
- Operational factor: 0.7
- Percentage of dug containers when being lifted: 50%
- Average handling times when containers being digged:
  - Dry containers at Terminals No1 and No2: 2 times
  - Reefer containers at Terminals No3: 1.5 times
- Dry containers at land side of Terminals No.1 and No.2

1,155 boxes/24hr/(25 boxes/hr/unit)/0.7 x(1-0.37+(0.5+0.5x2)x 0.37) = 3 units

- Dry containers at dock side of Terminal No.3
  1 RTG / dock-side crane x 6 dock-side cranes = 6 units

3) Yard tractors working at dock side: 70 units

- Average velocity of a tractor within the port: 15 km/hr
- Average haul distance per cycle within the marshaling yard: 1.62km
- Cycle time of lift on and lift off: 4 minutes
- Total cycle time of the operation: 10 minutes
- Cycle time of a dock-side crane: 3 minutes
- Operational factor: 0.7
- Number of dock-side cranes: 14

14 dock-side cranes x 10 min/3min/0.7 = 70 units

4) Chassis used at dock side: 80 units

- 70 units the same number as tractors
- 10 units for damaged or over-size containers

Thus, the required numbers of container-handling machines in the stage of the Master Plan are summarized as follows:

	Required Nos.
- Dockside gantry cranes	14
- RTGs (Rubber tired gantry cranes)	
- Small RTGs	22
- Large RTGs	9
- Toplifters (10 tons)	27
- Forklifts (3 tons)	
- Export CFSs	82
- Import CFSs56	
- Total	138
- Tractors	
- Export CFSs	23
- Import CFSs	18
- Dockside	70
- Total	111
- Chassis	
- Export CFSs	77
- Import CFSs	56
- Dockside	80
- Total	213

(4) Safety in Container-Handling Operations

As mentioned in Sections 6-9-5 and 6-9-6 of Chapter 6, presently, operational congestion and subsequent dangerous conditions confronting staff, cargo and machines are found at the container yards of both the east and west quays. Those dangerous conditions are summarized as follows:

a. Intricate movements of many heavy machines such as toplifters and forklifts due to the shortage of RTGs at the marshaling yard of the east quay,

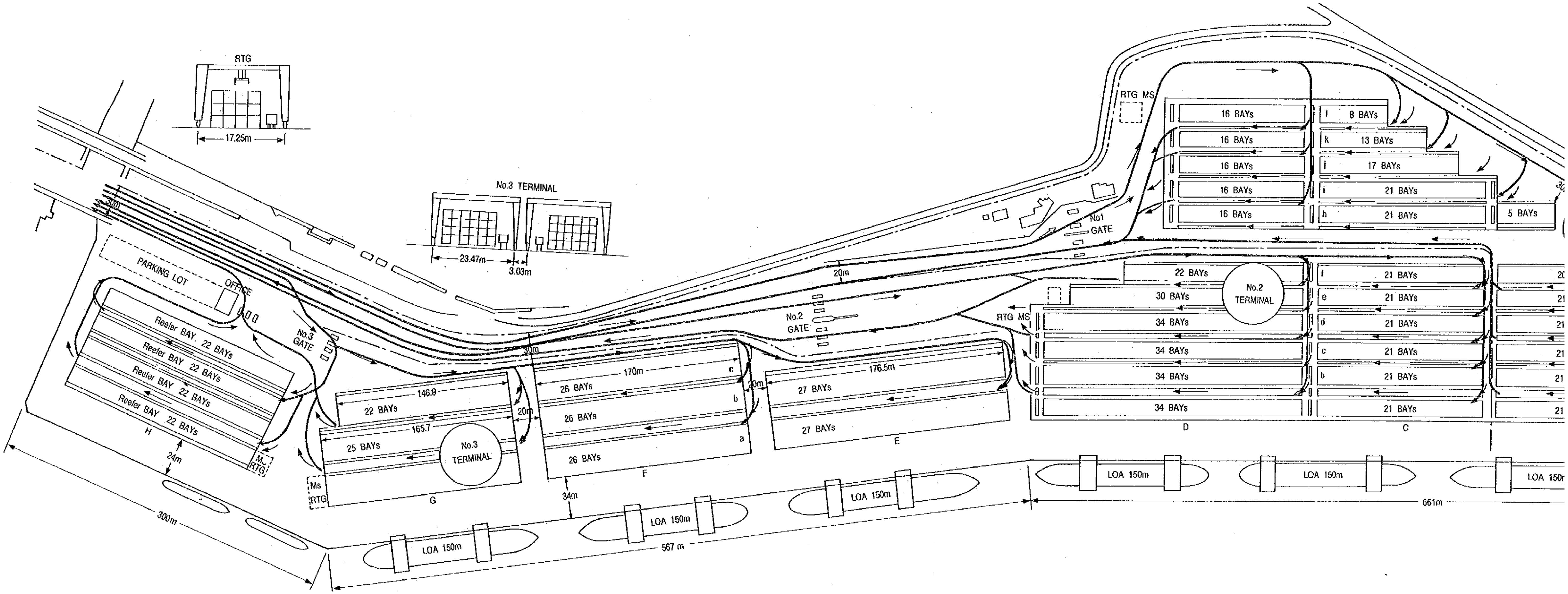
b. Many people are working on ground of the marshaling yard together with heavy machines due to the fact that the closed system has not yet introduced at the container terminal of Bangkok Port,

c. RTGs are repaired at the places where RTGs are in operation, creating a dangerous situation both for mechanics and other mobile machines,

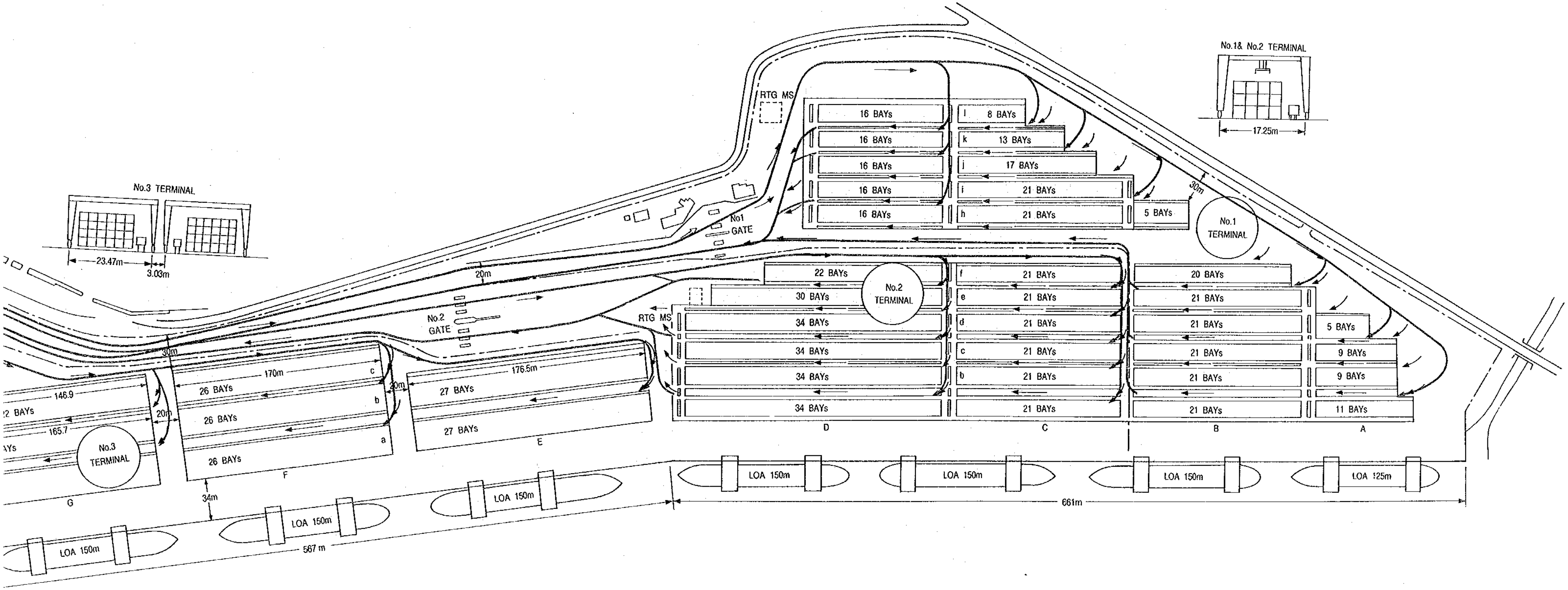
d. At the open yards behind and west of the sheds Nos. 15-17 of the west quay, stuffing operations of export cargoes and stacking operations of empty containers are conducted in mixture, creating a dangerous situation both for the people working on ground and mobile machines within the yards.

The dangerous conditions listed above will be removed by adopting the following countermeasures proposed in this study:

a. Procurement of the required number of RTGs at the marshaling yard,
b. Introduction of the closed system at the container terminal,
c. Preparation of repair areas specialized for RTGs within the marshaling yard,
d. Preparation of the Export CFSs at Zone 1 and the yards specialized for stacking empty containers behind and west of the sheds Nos. 15-17



RTG
17.25m
No.3 TERMINAL
23.47m
3.03m
RTG MS
16 BAYs
f 8 BAYs
k 13 BAYs
j 17 BAYs
i 21 BAYs
h 21 BAYs
5 BAYs
No1 GATE
PARKING LOT
OFFICE
No.3 GATE
Reefer BAY 22 BAYs
H
24m
M. RTG
300m
30m
20m
No.2 GATE
22 BAYs
30 BAYs
No.2 TERMINAL
RTG MS
34 BAYs
f 21 BAYs
e 21 BAYs
d 21 BAYs
c 21 BAYs
b 21 BAYs
D
C
146.9
22 BAYs
165.7
25 BAYs
No.3 TERMINAL
G
Ms RTG
20m
170m
26 BAYs
F
c
b
a
176.5m
27 BAYs
E
34m
LOA 150m
567 m
661m


No.1& No.2 TERMINAL
17.25m
No.3 TERMINAL
23.47m
3.03m
RTG MS
16 BAYs
16 BAYs
16 BAYs
16 BAYs
16 BAYs
l 8 BAYs
k 13 BAYs
j 17 BAYs
i 21 BAYs
h 21 BAYs
5 BAYs
30m
No.1 TERMINAL
No1 GATE
20m
No.2 GATE
RTG MS
22 BAYs
30 BAYs
No.2 TERMINAL
34 BAYs
34 BAYs
34 BAYs
34 BAYs
f 21 BAYs
e 21 BAYs
d 21 BAYs
c 21 BAYs
b 21 BAYs
21 BAYs
20 BAYs
21 BAYs
21 BAYs
21 BAYs
21 BAYs
21 BAYs
5 BAYs
9 BAYs
9 BAYs
11 BAYs
D
C
B
A
30m
170m
176.5m
146.9
165.7
20m
20m
26 BAYs
26 BAYs
26 BAYs
27 BAYs
27 BAYs
c
b
a
No.3 TERMINAL
F
E
G
34m
LOA 150m
LOA 150m
LOA 150m
LOA 150m
LOA 150m
LOA 150m
LOA 150m
LOA 125m
567 m
661m