deep draft vessels seems to be 4 vessels per high tide.

Neglecting the lock entrance restriction, the queuing model for determination of the number of berths is as follows.

Queue Size

The average queue length Lq can be calculated by the following formula.

$$Lq = \frac{S^S \rho^{S+1}}{S!(1-\rho)^2} p_0$$

where

Lq : Average Queue Length

S : Number of Berths

ρ : Utilization Factor $\left(\rho = \frac{\lambda}{S\mu}\right)$

where λ : Average Number of Arriving Vessels

μ : Average Number of Serving Vessels

p_0 : Probability Berths are Empty.

$$\left(p_0 = 1 \Big/ \left\{ \sum_{n=0}^{s-1} \frac{a^n}{n!} + \frac{a^s}{(S-1)!(S-a)} \right\}, \quad \text{where} \quad a = \frac{\lambda}{\mu} \right)$$

The average waiting time Wq can be calculated by the following formula.

$$Wq = Lq/\lambda$$

The calcuated average queue length is presented in **Appendix 11-1-5.**

11-1-2 Planning Premises

(1) Projected Cargo Volume

As started in Chapter 8, the forecast cargo volume of respective cargo types is as follows.

	in 1994/95	in 2004/05
① Liquid Bulk Cargo		
	x1000Tons	x1000Tons
Import POL (Products)	900	1,945
Export POL (Products)	90	195
Total POL (Products)	990	2,140
Import Edible Oil	190	285
Other Liquid Cargo	30	70
Grand Total	1,210	2,495
② Dry Bulk Cargo		
Import Food Grain	200	400
Import Fertilizer	20	30
Import Raw Materials for Fertilizer	380	630
Import Salt	10	10
Grand Total	610	1,070
③ Container Cargo		
Grand Total	1,110	2,235

	in 1994/95	in 2004/05
	x1000TEUs	x1000TEUs
Loaded Containers	87	175
Empty Containers	23	93
Total Containers	110	268

	in 1994/95	in 2004/05
④ Other General Congo		
	x1000Tons	x1000Tons
Import Other General Congo	1,780	2,475
Export Other General Congo	430	435
Grand Total	2,210	2,910

The coal which has been handled at No. 20 coal berth will be handled at the Haldia Dock System. The food grains which have been handled at No. 23 berth will continue to be handled at the Calcutta Dock System.

(2) Projected Vessel Size

As stated in **Appendix 11-1-1**, the current vessel size of respective cargo types is as follows.

① Liquid Bulk Cargo

Average Vessel Size = 6,717 GRT

② Dry Bulk Cargo

Average Vessel Size = 6,917 GRT

③ Container Cargo

Average Vessel Size = 3,786 GRT

④ Other General Cargo

Average Vessel Size = 5,961 GRT

According to the relationship between the registered gross tonnage (GRT) and the dead weight tonnage (DWT) of the standard vessels, the vessel size can be estimated as follows as stated in **Appendix 11-1-6**.

① Liquid Bulk Cargo

	Length overall	Breadth	Maximun Draft
6,717 GRT ≒ 10,258 DWT	136.9m	17.9m	7.9m

② Dry Bulk Cargo

6,917 GRT ≒ 10,288 DWT	136.9m	17.7m	7.9m

③ Container Cargo

3,786 GRT ≒ 5,560 DWT	110.9m	17.7m	6.3m

④ Other General Cargo

5,961 GRT ≒ 9,361 DWT	133.8m	18.2m	7.8m

The present lock restriction for vessels is as follows

	Length	Width	Depth
KPD	157 m	21.9 m	9.15 m
NSD	172 m	24.4 m	9.15 m

So long as there is no improvement of the respective locks, the vessels which can be accommodated at the Calcutta Dock System will be limited to within the following dimensions as shown in **Appendix 11-1-7.**

① As for KPD lock:	ⓐ Length Limitation	ⓑ Width Limitation	ⓒ Maximum Vessel Size
ⓐ Liquid Bulk Carriers	16,154 DWT	19,077 DWT	16,154 DWT
ⓑ Dry Bulk Carriers	16,535	18,964	16,535
ⓒ Comtainer Vessels	13,800	11,367	11,367
ⓓ General Cargo Vessels	16,034	18,664	16,034
② As for NSD lock:			
ⓐ Liquid Bulk Carriers	21,852 DWT	26,577 DWT	21,852 DWT
ⓑ Dry Bulk Carriers	22,699	25,896	22,699
ⓒ Comtainer Vessels	17,518	16,280	16,280
ⓓ General Cargo Vessels	21,801	27,813	21,801

The current cargo size per ship is as follows according to the Administration Report of CPT.

① Liquid Bulk Cargo	4,605 tons
② Dry Bulk Cargo	5,924 tons
③ Container Cargo	2,745 tons
④ General Cargo	3,645 tons

Acconding to CPT's draft improvement scheme, the available draft in the shipping channel is as follows.

① Present 6.8 m
② in 1995 7.4 m
③ in 2005 7.9 m

Thus the present maximum size of vessels which are accessible to in full load is as follows. The calculation method is presented in **Appendix 11-1-8.**

	ⓐ DWT	ⓑ Length overall	ⓒ Width	ⓓ Full load draft
① Liquid Bulk Carriers	5,844 tons	116 m	14.9 m	6.8 m
② Dry Bulk Carriers	5,428	114	14.2	6.8
③ Container Vessels	7,083	122	19.0	6.8
④ General Cargo Vessels	5,640	115	15.8	6.8

The maximum size of vessels which will be accessible to in full load in 1995 and 2005 is as follows.

		ⓐ DWT	ⓑ Length overall	ⓒ Width	ⓓ Full load draft
① Liquid Bulk Carriers	in 1995	8,077 tons	127 m	16.3 m	7.4 m
	in 2005	10,318	137	17.9	7.9
② Dry Bulk Carriers	in 1995	7,686	126	16.0	7.4
	in 2005	10,060	136	17.6	7.9
③ Container Vessels	in 1995	9,130	134	20.5	7.4
	in 2005	11,110	145	21.7	7.9
④ General Cargo Vessels	in 1995	7,743	126	17.3	7.4
	in 2005	9,883	136	18.4	7.9

The locks of KPD and NSD can accomodate all these vessels.

The vessel size is gradually increasing as shown in **Appendix 11-1-9,**

and the full load draft of the average liquid bulk, dry bulk and general cargo vessels which called at Calcutta in 1986/87 was similar to the maximum draft which can be accommodated in 2005. When the draft is improved from 6.8m to 7.9m, the full load draft of the average vessels will be more than 7.9m. As statistics regarding the vessel size distribution of Calcutta Dock System are not available, it is difficult to forecast the vessel size directly. Then, we suppose the average vessel size will not change in the future, and project the parcel size per vessel based on the effect of increased draft limitations.

(3) Basic Concepts to Formulate Alternative Master Plans

As stated in Chapter 9, the Calcutta Dock System will mainly handle break bulk cargo and container cargo in the future. But liquid cargo and dry bulk cargo will also be handled so long as the present users continue to use the Calcutta Dock System. We consider that the sites for handling liquid bulk cargo and dry bulk cargo will not be changed. The alternative Master Plans will mainly consider the container cargo terminal as follows.

① Conservative Alternative (Trend Case)
② Rather Radical Alternative (Shifting to Haldia Case)

1) Conservative Alternative

This alternative is to handle all potential container cargoes at the Calcutta Dock System. That is the total forecast container cargo in 2004/05, 2,235,000 tons or 268,000 TEUs, will be handled at the Calcutta Dock System.

2) Rather Radical Alternative

This alternative is to restrict the container cargo handling at some level, such as the capacity of Berth D NSD is estimated as 75,000 TEUs by CPT. The cargo volume which was handled at Calcutta Dock System excluding D NSD was about 35,000 TEUs in 1986-87. This alternative is to restrict the container cargo handling at this level. The cargo volume is Just the same as the projected container cargo volume in 1994-95. In other words, this alternative is to limit the increase of container cargo at the 1994-95 level.

The forecast container volume in 2004-05 is 268,000 TEUs. Then

158,000 TEUs would be transferred to Haldia Dock System, and only 110,000 TEUs would be handled at Calcutta Dock System.

11-1-3 Alternative Formulation

(1) Liquid Bulk Cargo Berth

Liquid bulk cargo is now handled at 5 berths of BB and No. C berth of NSD. The characteristics of vessel size, productivity, etc. are as follows.

1) Average vessel size : 6,717 GRT
2) Cargo size per ship : 4,605 tons
3) Total number of departed vessels : 151 vessels
4) Mean arrival time : 2.41 days
5) Average total time at berth : 2.39 days
6) Average lost time at berth : 1.11 days
7) Average working time at berth : 1.28 days
8) Productivity per working time : 4,595 tons/day
9) Productivity per total time at berth : 2,471 tons/day

The forecast cargo volume is 1,180,000 tons in 1994/95 and 2,425,000 tons in 2004/05.

When the available draft is improved from 6.8m to 7.4m and 7.9m in the future, the parcel size which the average vessel can carry will increase.

As stated in **Appendix 1-1-10**, the average parcel size is as follows.

	in 1986/87	in 1994/95	in 2004/05
Average Parcel Size	4,605 tons	6,405 tons	7,905 tons

As stated in **Appendix 11-1-1** the liquid cargo was handled at BB jetties and No. C NSD.

The cargo volume handled at No. C NSD was almost constant recently. As stated in **Appendix 11-1-2** the pumping capacity of respective jetties will change in accordance with the change of cargo handling. The actual pumping capacity of No. 3 jetty can work independently from POL product handling. On the other hand, the actual pumping capacities of No. 1, No. 2, No. 5 and No. 8 were respectively, 20%, 20%, 23% and 23%. So the actual

total capacity of No. 1, No. 2, No. 5 and No. 8 was only 86% of the actual capacity of No.3 jetty. From this result, we assume that one-half of the cargo volume of vegetable oil and other liquid cargo will be handled at No. 3 berth and the other half will be handled at 4 jetties -- No. 1, No. 2, No. 5 and No. 8.

In accordance with the above assumption, the allocation of liquid bulk cargo is as follows.

		in 1994/95 x1000TEUs	in 2004/05 x1000TEUs
ⓐ at BB (No.1, No.2, No.5, No.8)			
POL products	Import	781	1,826
	Export	90	195
	Sub total	871	2,021
Vegetable oil and other liquid cargo		110	177
Sub total		981	2,198
ⓑ at No.3 BB		110	177
ⓒ at C NSD		119	119
Total		1,180	2,425

As stated in **Appendix 11-1-11**, by using the present level of productivity, viz 150 tons/hour, the average waiting time will be asfollows.

ⓐ at BB (No.1, No.2, No.5, No.8)

	In 1994/95	In 2004/05
Wg	0.0766	2.9557

ⓑ at No.3 BB

	In 1994/95	In 2004/05
Wg	0.6127	1.3982

ⓒ at C NSD

	In 1994/95	In 2004/05
Wg	0.6989	0.8585

By using the actual pumping capacity, viz 270 tons/hour, the average time will be as follows.

ⓐ at BB (No.1, No.2, No.5, No.8)

	In 1994/95	In 2004/05
Wg	0.0047	0.1114

ⓑ at No.3 BB

	In 1994/95	In 2004/05
Wg	0.1708	0.3557

ⓒ at C NSD

	In 1994/95	In 2004/05
Wg	0.1928	0.2302

The waiting time at No.1, No.2, No,5 and No.8 berths BB is too long compared with the pre-berthing detection time in 1986-87, but by using the actual pumping capacity, the situation can be improved greatly. In order not to make liquid bulk carriers wait more than the present level, the present pumping capacity mast be utilized fully in the future, but it is not necessary to construct additional berths or to increase the pumping capacity. So the required number of liquid bulk cargo berths will be 1 in NSD and 5 in BB.

(2) Dry Bulk Cargo Berth

Dry bulk cargo is now handled at No. 23 berth and No. 20 berth of KPD2 and at various other berths. At No. 8 of KPD1 and No. A of NSD, fertilizer and raw materials for fertilizer are handled. The characteristics of vessel size, productivity, etc. are as follows.

1) Average vessel size : 6,917 GRT
2) Cargo size per vessel : 5,924 tons
3) Total No. of departed vessels : 66
4) Mean arrival time : 5.53 days
5) Average total time at berth : 12.71 days
6) Average lost time at berth : 5.04 days
7) Average working time at berth : 7.67 days

8) Productivity per working time 772 tons/day

9) Productivity per total time at berth 466 tons/day

The forecast cargo volume is 610,000 tons in 1994/95 and 1,060,000 tons in 2004/05. The cargoes are fertilizer, and raw materials for fertilizer, food grain and salt.

As stated in **Appendix 11-1-10**, the average parcel size is as follows.

	in 1986/87	in 1994/95	in 2004/05
Average Parcel Size	5,924 tons	8,024 tons	9,259 tons

As stated in **Appendix 11-1-11**, the required number of berths and the average waiting time in accordance with the respective productivities are as follows.

ⓐ In the case of using the productivity in 1986-87

	in 1994/95	in 2004/05
Required No. of Berths	8	11
Average Waiting Time	0.4185 day	0.8958 day
Total Time at Berth	17.2 days	19.9 days

ⓑ In the case of using the present productivity per working time at berths and reducing the lost time at hearth

	in 1994/95	in 2004/05
Required No. of Berths	7	10
Average Waiting Time	0.4601 day	0.5709 day
Total Time at Berth	14.55 days	16.70 days

ⓒ In the case of using the Indian average productivity per total time at berth

	in 1994/95	in 2004/05
Required No. of Berths	4	6
Average Waiting Time	0.5898 day	0.3859 day
Total Time at Berth	6.98 days	8.05 days

ⓓ In the case of using the Indian average productivity per working time at berth and reducing the lost time at berth

	in 1994/95	in 2004/05
Required No. of Berth	4	5
Average Waiting Time	0.4289 day	0.9818 day
Total Time at Berth	6.5 days	7.47 days

(3) Container Cargo Berth

Container cargo is now handled at various berths, but mainly at No. D berth and No. 5 berth of NSD and No. 3 berth of KPDl. The characteristics of vessel size, productivity, etc. are as follows.

1) Average vessel size : 3,786 GRT
2) Cargo size per ship : 2,745 tons/ship
3) Total No. of departed vessels : 173
4) Mean arrival time : 2.11 days
5) Average total time at berth : 3.32 days
6) Average lost time at berth : 0.97 day
7) Average working time at berth : 2.35 days
8) Productivity per working time : 1,168 tons/day (2,745÷2.35)
9) Productivity per total time at berth : 826.8 tons/day (2,745÷3.32)
10) Average weight per loaded export container : 12.8 tons/TEU
11) Average weight per loaded import container : 13.2 tons/TEU
12) Average weight per loaded container : 13.0 tons/TEU
13) Ratio of total import containers to loaded export containers : 1.12
14) Ratio of total import containers to loaded export containers : 1.80
15) Ratio of total containers to total loaded containers : 1.38
16) Productivity per working time of loaded containers
: 89.2 TEUs/day (1,168÷13.0)
17) Productivity per total time at berth of loaded containers
: 63.6 TEUs/day (8,268÷13.0)
18) Productivity per working time of total containers (89.2 x 1.38)
: 123.1 TEUs/day (5.1 TEUs/hour)
19) Productivity per total time at berth of total containers (63.6 x 1.38)
: 87.8 TEUs/day (3.7 TEUs/hour)
20) Ratio of 40 Ft containers to total TEUs : 0.318
21) Productivity per working time (No. of containers) : 20Ft 84.1 + 40Ft 19.6 /day

22) Productivity per total time at berth (No. of containers) :

20Ft		40Ft	
59.9	+	14.0	/day

The forecast cargo volume of the conservative alternative is 2,235,000 tons and the forecast total number of containers is 268,000 TEUs in 2004/05.

The forecast volume of the rather radical alternative is 917,000 tons and 110,000 TEUs in 2004/05.

In 1994/95, the cargo volume is forecast to be 1,110,000 tons and the total number of containers is forecast to be 110,000 TEUs.

CPT reported that the maximum number of containers shipped and discharged by a particular vessel was 555 TEUs, and the maximum number of loaded containers shipped by a vessel was 253 TEUs during 1986-87.

The cargo size per ship was 2,745 tons/ship and the average weight per loaded container was 13.0 tons/TEU, and the ratio of total containers to total loaded containers was 1.38, then the average number of containers per vessel can be calcuated as folows.

Average No. of containers per vessel = 2,745 / 13.0 x 13.8 = 291 TEUs/ship

The proportion of import containers is about 50% of total containers, then the average volume of import containers by TEU per vessel is 145 TEUs/vessel and that of export containers by TEU pervessl is also 145 TEUs/vessel.

The average full load draft of container vessels which called at Calcutta Port in 1986/87 was 6.6m. This type of vessel is a 300 TEU type container vessel and can handle 300 TEUs of import containers and 300 TEUs of export containers. Accordingly the average number of containers per vessel in 1986/87 was less than the carrying capacity of the average size container vessel.

As the average size of calling container vessels in 1986/87 was similar to the present available draft, when the draft is improved up to 7.4m in 1995 and up to 7.9m in 2005, the average vessel size calling Calcutta Port will increase in accordance with the vessel size as shown in **Appendix 11-1-9.** But because of the lack of statistics regarding vessel

size distribution, it is very difficult to project the vessel size directly. So we project the average parcel size per vessel instead of the vessel size.

As stated in **Appendix 11-1-10**, the average parcel size is as follows.

	in 1986/87	in 1994/95	in 2004/05
Average Parcel Size	2,745 tons	3,885 tons	4,835 tons
	291 TEUs	385 TEUs	580 TEUs

As stated in **Appendix 11-1-11**, the required number of berths and the average waiting time in accordance with the respective productivities and the forecast cargo volume are as follows.

ⓐ In the case of using the productivity in 1986/87 for the conventional alternative

	in 1994/95	in 2004/05
Required No. of Berths (at least)	4	9
Average Waiting Time	11.77 days	17.8 days
Productivity per Working Time at Berth	5.1 TEUs/hour	5.1 TEUs/hour

ⓑ In the case of using the improved productivity for the conventional alternative

① Productivity per Working Time at Berth: 10 TEUs/hour

	in 1994/95	in 2004/05
Required No. of Berths	4	7
Average Waiting Time	0.1255	0.1736

② Productivity per Working Time at Berth: 15 TEUs/hour

	in 1994/95	in 2004/05
Required No. of Berths	3	5

Average Waiting Time	0.1266	0.1962

③ Productivity per Working Time at Berth: 20 TEUs/hour

	in 1994/95	in 2004/05
Required No. of Berths	2	4
Average Waiting Time	0.3398	0.1936

© In the case of using the improved productivity for the rather radical alternative

① Productivity per Working Time at Berth: 10 TEUs/hour

	in 2004/05
Required No. of Berths	4
Average Waiting Time	0.1860

② Productivity per Working Time at Berth: 15 TEUs/hour

	in 2004/05
Required No. of Berths	3
Average Waiting Time	0.1883

③ Productivity per Working Time at Berth: 20 TEUs/hour

	in 2004/05
Required No. of Berths	3
Average Waiting Time	0.06085

(4) General Cargo

General cargo is now handled at various berths. The characteristics of vessel size, productivity, etc. regarding general cargo are as follows.

1) Average vessel size : 5,961 GRT
2) Cargo size per ship : 3,645 tons/ship
3) Total No. of departed vessels : 509

4) Mean arrival time : 0.717 day

5) Average total time at berth : 10.88 days

6) Average lost time at berth : 4.64 days

7) Average working time at berth : 6.24 days

8) Productivity per working time : 584 tons/day

9) Productivity per total time at berth : 335 tons/day

The forecast general cargo volume is as follows.

	in 1986/87	1994/95	2004/05 (Unit: 1,000 tons)
Calcutta	1956	2210	2910

	in 1995 (x 1,000 tons)	in 2005 (x 1,000 tons)
Import	(2,360)	(3,935)
Iron, Steel & Machinery	260	465
Cement	150	230
Other Cargo	1,950	3,240
Export	(960)	(1,210)
Iron, Steel & Machinery	65	80
Jute	265	195
Tea	100	120
Cast Iron Goods	125	245
Other Cargo	405	570
Imp. Container	580	1,460
Exp. Container	530	775
Imp. Break Bulk	1,780	2,475
Exp. Break Bulk	430	435
Total Break Bulk	2,210	2,910

The parcel size per vessel was 3,645 tons/vessel in 1986/87. The average vessel size was 5,961 GRT (9,361 DWT), the length overall was 133.8m, and the width was 18.2m. The full load draft of this type vessel was 7.8m.

From the dimensional limitations of the locks at NSD and KPD, the maximum size of the vessels which can be accommodated at NSD and KPD is as follows.

Maximum vessel size.

NSD	21,801 DWT
NPD	16,034 DWT

The proportion of the vessels between 500 DWT and 15,000 DWT to all the working general cargo vessels around the world is 71%, and that between 500 DWT and 15,000 DWT is 81.2%. The trend of each proportion is as follows.

age	500 ~ 15,000 DWT	500 ~ 20,000 DWT
0 ~ 5 years	58.0%	70.0 %
~10	66.8	76.8
~15	76.6	85.1
~20	84.1	96.1
~25	83.5	91.3
~30	83.9	92.6

Then, the proportion of vessels which can be accommodated at NSD and KPD is gradually decreasing. But there are a lot of vessels which can use the facilities.

By improving the available draft from 6.8m to 7.4m and 7.9m, the average vessel size will surely increase, but due to the limitation of the available statistics regarding average vessel size, it is diificult to project the average vessel size in 1995 and 2005. Then we suppose the vessel size will be similar to the size of the vessels which used Calcutta Port in 1986/87.

As stated in **Appendix 11-1-10**, the average parcel size is as follows.

	in 1986/87	in 1994/95	in 2004/05
Average Parcel Size	3,645 tons	4,785 tons	5,735 tons

As stated in **Appendix 11-1-11**, the required number of berths and the average waiting time are as follows.

ⓐ In the case of using the productivity in 1986/87

	in 1994/95	in 2004/05
Required No. of Berths (at least)	25	27
Average Waiting Time	0.6776 day	8.4522 day

ⓑ In the case of using the Indian average productivity

	in 1994/95	in 2004/05
Required No. of Berths	18	22
Average Waiting Time	0.5972 day	0.9271 day

ⓒ In the case of using the improved productivity up to 600 tons/vessel・day

	in 2004/05
Required No. of Berths	19
Average Waiting Time	0.6316 day

(5) Berths Allotment for Respective Types of Cargo

At present, the number of working berths at NSD, KPD1 and KPD2 is 27. Before considering new berth construction at Calcutta we will examine the full utilization of existing berth facilities.

The following table shows the relationship between the number of berths and the lost cost in 2004/05 for the conventional alternative derived from **Appendix 11-1-11.**

① In 2004/05

ⓐ Dry bulk cargo

(i) Using the Indian average productivity per total time at berth (1,150 tons/day)

No. of berths	6	5	4	3
Lost cost (MY)	42	160	652	4,570

(ii) Using the Indian average productivity per working time at berth and reducing lost time at berth (1,728 tons/day)

No. of berths	6	5	4	3
Lost cost (MY)	27	107	440	2,581

ⓑ Container cargo

(i) Using the productivity of 10 TEUs/hour

No. of berths	7	6	5	4
Lost cost (MY)	52	168	606	4,628

(ii) Using the productivity of 15 TEUs/hour

No. of berths	6	5	4	3
Lost cost (MY)	15	59	242	1,515

(iii) Using the productivity of 20 TEUs/hour

No. of berths	5	4	3
Lost cost (MY)	13	58	295

ⓒ General cargo

(i) Using the Indian average productivity (492 tons/day)

No. of berths	23	22	21	20	19	18	17
Lost cost (MY)	239	440	813	1,525	2,995	6,567	20,244

(ii) Using the productivity of 600 tons/day

No. of berths	23	22	21	20	19	18	17	16
Lost cost (MY)	19	39	78	154	300	585	1,155	2,385

Berth C NSD will handle liquid bulk cargo, so the usable number of berths will be 26.

The following table shows the combination of respective cargo berths and the total lost cost.

ⓘ Container 4 berths

Productivity :	20 TEUs/hour	15 TEUs/hour	10 TEUs/hour
Lost cost (MY):	58	242	4,628

Dry bulk berth No. of berths	Dry bulk berth Lost cost (MY)	General cargo berth No. of berths	General cargo berth Lost cost (MY)	Both Lost cost (MY)	Total lost cost (20TEUs)	Total lost cost (15TEUs)	Total lost cost (10TEUs)
6	27	16	2,385	2,412	2,470	2,654	7,040
5	107	17	1,155	1,262	1,320	1,504	5,890
4	440	18	585	1,025	1,083	1,267	5,653
3	2,581	19	300	2,881	2,939	3,123	7,509
	(in case ii)		(in case ii)				

② Container 5 berths

Productivity :	20 TEUs/hour	15 TEUs/hour	10 TEUs/hour
Lost cost (MY):	13	59	606

Dry bulk berth No. of berths	Dry bulk berth Lost cost (MY)	General cargo berth No. of berths	General cargo berth Lost cost (MY)	Both Lost cost (MY)	Total lost cost (20TEUs)	(15TEUs)	(10TEUs)
6	27	15	5,518	5,545	5,558	5,604	6,151
5	107	16	2,288	2,495	2,508	2,554	3,101
4	440	17	1,155	1,595	1,608	1,654	2,201
3	2,581	18	585	3,166	3,179	3,225	3,772
(in case ii)		(in case ii)					

The althernatives of berth combination are as follows.

In 2004/05 (Conservative Plan)

	Container Berth			Dry Bulk Berth			General Cargo Berth			Lost Cost due to vessel waiting	
Cargo Volume	x 1,000 tons 2,235			x 1,000 tons 1,070			x 1,000 tons 2,910				
No. of Vessel	(268 x 1,000 TEUs) 462			116			507				
	1,266			0,317			1,389				
	No. of B	Prod. TEUs/hour	$\overline{Wg}$ day	No. of B	Prod. tons/hour	$\overline{Wg}$ days	No. of B	Prod. tons/hour	$\overline{Wg}$ days		
Alternative 1	4	20	0.2	4	1,728	4.0	18	600	1.2	1,083	Long Waiting Time for Dry Bulk Carriers
2	4	15	0.8	4	"	"	18	"	"	1,267	
3	4	20	0.2	5	"	0.98	17	"	2.4	1,320	Long Waiting Time for General Cargo Carriers
4	4	15	0.8	5	"	"	17	"	"	1,504	
5	5	20	0.2	4	"	4.0	17	"	"	1,608	Long Waiting Time
6	5	15	0.8	4	"	"	17	"	"	1,654	

The average waiting time of dry bulk carriers of alternatives 1 and 2 seems to be too long, and the average waiting time of general cargo vessels of alternatives 3 and 4 seems to be too long. The average waiting time of both vessels of alternatives 5 and 6 seems to be too long. Accordingly, if it is impossible to increase the productivity of respective berths, it would be necessary to construct some new berths.

From the calculated results in **Appendix 11-1-11**, the relationship between the number of berths and the lost cost in 2004/05 for the rather radical alternative is as follows.

In the case that the number of container berths is 3, the relationship

between the productivity and the lost cost is as follows.

Container : 3 berths

productivity :	20 TEUs/hour	15 TEUs/hour	10 TEUs/hour
Lost cost (MY):	8	23	122

The combination of respective cargo berths is as follows.

Dry bulk berth No. of berths	Dry bulk berth Lost cost (MY)	General cargo berth No. of berths	General cargo berth Lost cost (MY)	Both Lost cost (MY)	Total lost cost (20TEUs)	(15TEUs)	(10TEUs)
7	7	16	2,388	2,395	2,403	2,418	2,517
6	27	17	1,155	1,182	1,190	1,205	1,304
5	104	18	585	689	697	712	811
4	440	19	300	740	748	763	862
3	2,581	20	154	2,735	2,743	2,758	2,857
(in case ii)		(in case ii)					

In 2004/05 (Conservative Plan)

	Container Berth			Dry Bulk Berth			General Cargo Berth			Lost Cost due to vessel waiting
Cargo Volume	x 1,000 tons 917,351			x 1,000 tons 1,070			x 1,000 tons 2,910			
No. of Vessel	(110 x 1,000 TEUs) 190			116			507			
λ	0.5198			0.317			1.389			
	No. of B	Prod. TEUs/hour	$\overline{Wg}$ day	No. of B	Prod. tons/hour	$\overline{Wg}$ day	No. of B	Prod. tons/hour	$\overline{Wg}$ day	
Alternative 1	3	20	0.06	5	1,728	0.98	18	600	1.2	697
2	3	15	0.19	5	"	"	18	"	"	712 ◎
3	3	10	0.98	5	"	0.98	18	"	2.4	811 ○

Although the lost cost of alternative 1 is the lowest, a productivity of 20 TEUs/hour without gantry cranes is not so easy. Then alternative 2 is the best selection.

The berth allottment is summarized as follows.

① Container Berth

In 2004/05 110×10^3 TEUs 3B 10 or 15 TEUs/hour + Barge

190 vessels

② Dry Bulk Cargo Berth
In 2004/05 1,070 x 10^3 TEUs 5B 1,728 tons/day
116 vessels Persent Indian Average
(per working time at berth
+ lost time reduction)

③ General Cargo Berth
In 2004/05 2,910 x 10^3 TEUs 18B 600 tons/day
507 vessels

④ Liquid Cargo Berth
In 2004/05 119 x 10^3 TEUs 1B 1,924.5 tons/day
15 vessels (per total time at berth)

The berths shall be allotted taking into consideration the present berth utilization as follows.

At present, the liquid bulk cargo is handled at No. C berth of NSD. As the necessary number of berths is one, No. C berth of NSD will continue to be used for liquid bulk in 2004/05.

No. A berth of NSD is now frequently used for dry bulk cargo, so No. A berth of NSD will be used for dry bulk cargo in 2004/05. And No. 23 of KPD2 is now alloted to food grains so it will be used for dry bulk cargo in the future. Other necessary berths, 3 berths in 2004/05, should be allocated to some parts of existing facilities. In order to provide good measures to prevent pollution, this types of berths should be contiguous. On the other hand, the lock dimension of NSD is greater than that of KPD and the vessel size of dry bulk carriers seems to be greater than that of general cargo vessels. Considering this situation, A and B of NSD and 6 and 8 were allocated for dry bulk cargo berths.

For container cargoes, No. D berth should be used. The other 2 necessary berths should be located in NSD or KPD2 by considering the availability of land use.

In the above examination, we do not consider the possibility of new berth construction. But if we do not think about the possibility of a new container berth, the conservative plan would not be feasible. If we think about the construction of 1 berth, some alternatives of the conservative plan would be feasible as follows.

The berth allottment of this case 4 would be as follows.

	No. of berths	Productivity	$\overline{Wg}$
Container berth	4 (old 3 + new 1)	15 TEUs/hour	0.8 day
Dry bulk berth	5	1,728 tons/day	0.98 day
General cargo berth	18	600 tons/day	1.2 days
Liquid bulk berth	1	1,924.5 tons/day	0.86 day
	28		

IWT container transport demand is estimated as follows:

(Unit: TEUs)

Year	Alternative	Estimate	Dutch Estimate
2004/05	Conservative	44,700	-
	Rather Radical	62,000	51,600

According to the Dutch Report on IWT, the handling capacity of one IWT berth (75m long) is as follows.

31,800 TEUs (1 container quay crane)
76,300 TEUs (2 container quay crane)

Therefore, 1 IWT container berth, with 2 quay cranes is required in 2004-05. The site of the IWT would be at Garden Reach Jetty.

(6) Alternative Formulation

According to the planning premises and the calculated No. of berths, we formulated the following alternative plans.

1) *Alternative Master Plans*

In 2004/05, we formulate the following Alternative Master Plans.

ⓐ Conservative Alternative 1 (Fig. 10-1-4)

① Liquid Bulk Cargo	1B	1,925 tons/day	at C of NSD
② Dry Bulk Cargo	5B	1,728 tons/day (per working time at berth)	at A, B of NSD and 6, 8 of KPD1 and 23 of KPD1
③ International Container Cargo	4B	15 - 20 TEUs/Hour	at D of NSD and 28, 29 of KPD2 and 1 New Berth

④ Inland Water Way Container Cargo	1B		at Gerden Reach Jetty
⑤ General Cargo	18B	600 tons/day (per working time at berth)	at other berths

ⓑ Conservative Alternative 2 (Fig. 10-1-5)

① Liquid Bulk Cargo	1B	1,925 tons/day	at C of NSD
② Dry Bulk Cargo	5B	1,728 tons/day	at A, B of NSD and 6, 8 of KPD1 and 23 of KPD2
③ Container Cargo	4B	15 - 20 TEUs/Hour	at D and 4, 5 of NSD and 1 New Berth
④ Inland Water Way Container Cargo	1B		at Garden Reach Jetty
⑤ General Cargo	18B	600 tons/day	at other berths

ⓒ Rather Radical Alternative 1 (Fig. 10-1-6)

This alternative is to restrict the container cargo handling to the volume of 110,000 TEUs. The rest of the containers, 158,000 TEUs, would be transferred to the Haldia Dock System, but a volume of 62,000 TEUs containers would have to be carried by barges back to the hinterland of the Calcutta Dock System. If the retransferred cargo were handled at the Calcutta Dock System, it would be necessary to prepare a Container Terminal for the Inland Water Way transport. The site of the Inland Water Way Terminal could not be inside NSD and KPD according to the above plan. Then the IWT terminal would be located at Garden Reach Jetty.

① Liquid Bulk Cargo	1B	1,925 tons/day	at C of NSD
② Dry Bulk Cargo	5B	1,728 tons/day (per working time at berth)	at A, B of NSD and 6, 8 of KPD1 and 23 of KPD2
③ International Container Cargo	3B	10 - 15 TEUs/hour	at D of NSD and 28, 29 of KPD2

④	Inland Water Way Container Cargo	1B	at Garden Reach Jetty
⑤	General Cargo	18B 600 tons/day	at other berths

ⓓ Rather Radical Alternative 2 (Fig. 10-1-7)

①	Liquid Bulk Cargo	1B 1,925 tons/day	at C of NSD
②	Dry Bulk Cargo	5B 1,728 tons/day	at A, B of NSD and 6, 8 of KPD1 and 23 of KPD2
③	International Container Cargo	3B 10 - 15 TEUs/hour	at D, 5 and 4 of NSD
④	Inland Water Way Container Cargo	1B	at Garden Reach Jetty
⑤	General Cargo	18B 600 tons/day	at other berths

Fig. 11-1-1 Present Land Use within Part of CPT Land Estate

Fig. 11-1-2 Alternative 1 of Berth Allocation in 2005

Fig. 11-1-3 Alternative 2 of Berth Allocation in 2005

Fig. 11-1-4 Alternative 3 of Berth Allocation in 2005

Fig. 11-1-5 Alternative 4 of Berth Allocation in 2005

(7) Examination of Lock Entrance Capacity

The number of each type of vessel is as follows.

	in 1986/87	in 1994/95	in 2004/05
	(119÷4.605)		
① Liquid bulk carrier (C of NSD)	26	19	15
② Dry bulk carrier	66	76	116
			(190)
③ Cotainer cargo vessel	173	286	462
④ General cargo vessel	509	462	507
			(638)
Total	774	843	1,100

The mean arrival time and the average arrival number of vessels are as follows.

	in 1986/87	in 1994/95	in 2004/05
			(0.572)
① Mean arrival time ($1/\lambda$)	0.472	0.433	0.332
			(1.75)
② λ	2.12	2.31	3.01

The necessary time to use the lock is not certain, so we suppose that 30 minutes would be necessary. And also we suppose the available time to use the lock would be 2 hours per one high tide. In order to use the queueing model, we introduce the following situation.

① One day is supposed to be 2 hours.
② Vessels are supposed to call at Calcutta during only this period.
③ The average service rate per one day is supposed to be 4.
④ The number of locks is 2.
⑤ Departing vessels are supposed to use another high tide.

Then the queueing calculation results are as follows.

① in 1986/87

S	λ	μ	ρ	Lq	Wq	
2	2.14	4	0.2675	0.0412	0.0193	= 2 minutes
(1	2.14	4	0.5350	0.6155	0.2876)	

② in 1994/95

S	λ	μ	ρ	Lq	Wq	
2	2.31	4	0.2888	0.0525	0.0227	= 3 minutes
(1	2.31	4	0.5775	0.7894	0.3417)	

③ in 2004/05

S	λ	μ	ρ	Lq	Wq	
2	3.01	4	0.3763	0.1241	0.0412	= 5 minutes
(1	3.01	4	0.7525	2.2879	0.7601)	
2	1.75	4	0.2188	0.0220	0.0126	= 1.5 minutes
(1	1.75	4	0.4375	0.3403	0.1944)	

According to the above examination, in all cases the locks have sufficient capacity.

If only one tide is used for entrance and departure, the queueing calculation results are as follows.

① in 1994/95

S	λ	μ	ρ	Lq	Wq	
2	2.31	2	0.5775	0.5779	0.2502	= 15 minutes
(1	2.31	2	1.1550	∞	∞)	

② in 2004/05

S	λ	μ	ρ	Lq	Wq	
2	3.01	2	0.7525	1.965	0.6528	= 39 minutes
(1	3.01	2	1.505	∞	∞)	
2	1.75	2	0.4375	0.2071	0.1184	= 7 minutes
(1	1.75	2	0.8750	6.1250	3.5000)	

In all cases, the locks have sufficient capacity.

The allottment of berths to NSD and KPD is as follows.

	NSD					KPD			
In 2004/05	LB	DB	CB	BB	Total	DB	CB	BB	Total
Alternative 1	1	2	2	5	10	3	2	13	18
2	1	2	4	3	10	3	0	15	18
3	1	2	1	5	9	3	2	13	18
4	1	2	3	3	9	3	0	15	18
In 1994/95									
Alternative 1	1	2	1	5	9	2	2	14	18
2	1	2	3	3	9	2	0	16	18

We do not introduce different productivities among the berths which are used for the same kind of cargo, so the number of vessels can be calcuated as follows.

	NSD					KPD			
In 2004/05	LB	DB	CB	BB	Total	DB	CB	BB	Total
Alternative 1	15	46	231	141	433	70	231	366	667
2	15	46	462	85	608	70	0	422	492
3	15	46	63	141	265	70	127	366	563
4	15	46	190	85	336	70	0	422	492
In 1994/95									
Alternative 1	19	38	95	122	274	38	191	340	569
2	19	38	286	73	416	38	0	389	427

The mean arrival time and the average arrival number of vessels are as follows.

	NSD		KPD	
In 2004/05	Mean arrival time	λ	Mean arrival time	λ
Alternative 1	0.843	1.186	0.547	1.827
2	0.600	1.666	0.742	1.348
3	1.377	0.726	0.648	1.542
4	1.086	0.921	0.742	1.348
In 1994/95				
Alternative 1	1.332	0.751	0.641	1.559
2	0.877	1.140	0.855	1.170

If the service rate μ is 4, the queueing calculation of a single lock would be as follos.

NSD

In 2004/05	λ	μ	ρ	Lq	Wq	
Alternative 1	1.186	4	0.2965	0.1249	0.1054	= 13 min.
2	1.666	4	0.4165	0.2973	0.1784	= 21
3	0.726	4	0.1815	0.0402	0.0554	= 7
4	0.921	4	0.2303	0.0689	0.0748	= 9

KPD

Alternative 1	1.827	4	0.4568	0.3841	0.2103	= 25
2	1.348	4	0.3370	0.1713	0.1271	= 15
3	1.542	4	0.3855	0.2418	0.1568	= 19
4	1.348	4	0.3370	0.1713	0.1271	= 15

NSD

In 1994/95	λ	μ	ρ	Lq	Wq	
Alternative 1	0.751	4	0.1878	0.0450	0.0599	= 7 min.
2	1.140	4	0.2850	0.1136	0.0997	= 12

KPD

Alternative 1	1.559	4	0.3898	0.2490	0.1597	= 19
2	1.170	4	0.2985	0.1209	0.1034	= 12

In all cases, each lock has a sufficient capacity. In considering that the lock of NSD is better than that of KPD, we should think about using the NSD lock more, so the alternative which concentrates containers at NSD is better.

(8) Evaluation of alternatives

In 2004/05, we formulated 4 alternative Master Plans.

The merits and demerits of the respective plans are as follows.

11-1-4 Cargo Handing System

The purpose of this section is not to plan the cargo handling equipment for the increased cargo volume to be handled in the target year but to plan mainly the improvement of the cargo handling system at Calcutta Dock System.

(1) General Cargo (except bulk)

The cargo handling at port has to be considered as a unified system and not in a piecemeal fashion, and it can not really be divided into individual stages (from/to ship, at apron, between apron and storage area and loading/unloading to/from truck or trailer). The handling at each stage is only one step in the total handling system. If we hope maintain high throughput at the port, the cargo passing through the port must flow smoothly.

Ideally, the cargo handling unit at each stage should be the same to maintain a smooth flow.

In general the handling unit at each stage is the same as that handled by ship gear or quay-side crane. Thus it is necessary to introduce a unit load system.

1) From/to ship

The best handling method is a combination of quay-side cranes, ship gear and mobile cranes (for smaller ships). However, the existing quay-side cranes have three big problems:

a. Too old
b. Too many
c. Fixed on rails

The recommendations are as follows.

a. A half (1/2) or a third (1/3) of the existing quay-side cranes should be disposed of. The remaining cranes should be moved by power cable to berths where quay-side cranes will be required from time to time and two or three berths should be covered by three or four quay-side cranes.

b. The necessary quay-side cranes should be replaced as necessary.

c. Upon increasing the ground load restrictions mobile cranes will be used.

2) At apron

In general the cargo handling at apron is carried out manually with the help of hand trucks at present.

After the unit load system is introduced, the manual handling at apron will not be needed because the cargo which will be transported over a long distance will be loaded directly to track or trailer by ship gear or quay-side crane or by forklift. However, it is necessary to clarify the following items before the unit load system is introduced.

a Labor and system adjustment to accommodate the changes

b To prepare the necessary ground surface condition.

3) Between apron and storage area

The manual handling for short-distance transport will be eliminated by introducing the unit load system. The long-distance transportation will not be changed greatly, and it will be carried out by trucks and trailers.

4) At the open storage yard

There are 20 yard cranes at the open storage yard and the handling is mostly carried out using these cranes.

The theoretical features of the yard crane handling system at the open storage yard are as follows.

a Large stacking height

b Large stacking area

c Large initial investment

However, the yard cranes are not actually used in accordance with the planned system. The crans have limited mobility, and the stacking height is low.

The consultant recommends changing the handling system at the some open storage yard from the yard crane system to the mobile crane system.

Table 11-1-4 Quay-Side Crane

No.	Name	Location	Capacity (t)	Year of Purchase	Conditions	Scrap		Built		Final	Remarks
						M / P	S / P	M / P	S / P		
1	200t CANTILEVER	NSD 1	200	1957		x					* Recommended by C.P.T. for condemnation
2	Q/C - 8	〃 2	2	1928	*	x	x				
3	Q/C - 11	〃 2	2	1928	*	x	x				
4	Q/C - 13	〃 2	2	1929	*	x	x				
5	Q/C - 16	〃 3	2	1928	*	x	x				
6	Q/C - 17	〃 4	2	1921	*	x	x				
7	Q/C - 43	〃 5	5	1963/64		x	x				
8	Q/C - 44	〃 5	5	1963/64		x	x				
9	Q/C - 45	〃 5	5	1963/64		x	x				
10	Q/C - 46	〃 5	5	1963/64		x	x				
11	Q/C - 47	〃 5	5	1963/64	To be shifted to NSD	x	x				
12	Q/C - 48	〃 5	5	1963/64		x	x				
13	Q/C - 38	〃 B	3	1958/59		x	x	○	○	○	These cranes will be installed for dry bulk
14	Q/C - 39	〃 B	3	1958/59		x	x	○	○	○	cargo handling at A N.S.D.
15	Q/C - 40	〃 B	3	1958/59		x	x	○	○	○	
16	Q/C - 41	〃 B	3	1958/59		x					
17	Q/C - 42	〃 B	3	1958/59		x					
18	Q/C - 32	〃 D	3	1958/59		x	x				
19	Q/C - 33	〃 D	3	1958/59		x	x				
20	Q/C - 34	〃 D	3	1958/59		x	x				
21	Q/C - 35	〃 D	3	1958/59		x	x				
22	Q/C - 36	〃 D	3	1958/59		x	x				
23	K 1 / J 1	KPD 1	3/5	1962/63		x		○		○	
24	K 1 / J 2	〃 1	3/5	1962/63		x					
25	K 1 / J 3	〃 1	3/5	1962/63		x		○		○	
26	K 1 / J 4	〃 1	3/5	1962/63		x	x				
27	K 3 / J 5	〃 3	3/5	1962/63		x		○		○	
28	K 3 / J 6	〃 3	3/5	1962/63		x		○		○	
29	K 3 / J 7	〃 3	3/5	1962/63		x	x				
30	K 3 / J 8	〃 3	3/5	1962/63	*	x	x				
31	K 3 / J 9	〃 3	3/5	1962/63		x					
32	K 5 / J11	〃 5/7	3/5	1962/63		x	x	△	△	○	
33	K 5 / J12	〃 5/7	3/5	1962/63		x	x				
34	K 5 / J13	〃 5/7	3/5	1962/63		x	x	△	△	○	
35	K 5 / J14	〃 5/7	3/5	1962/63	*	x	x				
36	K 9 / J15	〃 9	3/5	1962/63		x	x				
37	K 9 / J16	〃 9	3/5	1962/63		x	x	△	△	○	
38	K 9 / J17	〃 9	3/5	1962/63		x	x	△	△	○	
39	K9 / J18	〃 9	3/5	1962/63	*	x	x				
40	K 9 / J19	KPD 9	3/5	1962/63		x	x				
41	K11 / J20	〃 11	3/5	1962/63		x	x				
42	K11 / J21	〃 11	3/5	1962/63		x	x				
43	K11 / J22	〃 11	3/5	1962/63		x	x	△	△	○	
44	K11 / J23	〃 11	3/5	1962/63		x	x	△	△	○	
45	K11 / J24	〃 11	3/5	1962/63		x	x				
46	K 4 / J16	〃 4	3/5	1962/63	*	x	x				
47	K 4 / J17	〃 4	3/5	1962/63		x					
48	K 4 / J18	〃 4	3/5	1962/63		x	x				
49	K 4 / J19	〃 4	3/5	1962/63		x					
50	K 4 / J20	〃 4	3/5	1962/63		x	x				
51	K 6 / J12	〃 6	3/5	1962/63		x					
52	K 6 / J13	〃 6	3/5	1962/63		x	x				
53	K 6 / J14	〃 6	3/5	1962/63		x					
54	K 6 / J15	〃 6	3/5	1962/63		x					
55	K 8 / J 9	〃 8	3/5	1962/63		x					
56	K 8 / J10	〃 8	3/5	1962/63		x					
57	K 8 / J11	〃 8	3/5	1962/63		x					
58	K10 / J 5	〃 10	3/5	1962/63		x	x				
59	K10 / J 6	〃 10	3/5	1962/63		x		○		○	
60	K10 / J 7	〃 10	3/5	1962/63		x		○		○	
61	K10 / J 8	〃 10	3/5	1962/63		x					
62	K12 / J 1	〃 12	3/5	1962/63		x		○		○	
63	K12 / J 2	〃 12	3/5	1962/63	*	x	x				
64	K12 / J 3	〃 12	3/5	1962/63	*	x	x				
65	K12 / J 4	〃 12	3/5	1962/63		x		○		○	
66	K20 / J 1	20 CB	5	1963/64	To be shifted to KPD 1	x					
67	K20 / J 2	〃	5	1963/64	〃	x					
68	K20 / J 3	〃	5	1963/64		x					
69	K20 / J 4	〃	5	1963/64		x					
70	K20 / J 5	〃	5	1963/64		x					
71	K27 / J1A		3	1986		△	△				
72	K27 / J2A		3	1986		△	△				
73	K28 / J1A		3	1986		△	△				
74	K28 / J2A		3	1986		△	△				△ : Re-deployment
75	K29 / J1A		3	1986		△	△				
76	K29 / J2A		3	1986		△	△				
Total		76 Nos				78	x 42	○ 11	○ 3	17	

Table 11-1-5 Yard Crane

	Yard Crane				M / P			S / P				Remarks	
	Name	Capacity	Age	Location	Dispose	Built	Final	Dispose	Year	Built	Final		
KPD-II	YC- 1	15 t	45	Between 26&27	x	○	○				○	20 t	
	YC- 2	6 t	45	Between 27&28	x			x	93/94				
	YC- 3	6 t	45	Between 27&28	x	○	○	x	〃	○	○	20 t	
	YC- 5	6 t	45	Between 28&29	x			x	91/92				
	YC- 6	30 t	45	Between 28&29	x	○	○	x	〃	○	○	30 t	
	YC- 7	6 t	45	Between 28&29	x			x	〃				
	YC- 8	6 t	45	29	x								
NSD	YC- 3	2 t	58	A	x	△	○	x	91/92	△	○	5 t	From Between NSD 4 & 5
	YC- 7	3 t	30	Between A & B	x	△	○	x	〃	△	○	5 t	From Between NSD 3 & 4
	YC- 5	3 t	30	B	x			x	〃			30 t	
	YC- 8	3 t	30	B	x			x	〃				
	YC- 4	4 t	45	1	x	○	○				○	30 t	
		200 t	31	1	x						○		
	YC- 1	3 t	25	3	x						○		
	New	5 t	3	Between 3 & 4	△			△					To Between NSD A & B
	YC- 2	3 t	25	4	x						○		
	New	5 t	3	Between 4 & 5	△			△					To NSD A
	YC- 6	3 t	25		x			x	91/92				
	YC- 9	3 t	25		x			x	〃				
	YC-10	3 t	25		x			x	〃				
Total													
Existing		20											
Condemnation					18			12					
Re-deployment					2	2		2		2			
Replacement						4				2			
Final							6				10		
												△ : Re-deployment	

	Merits	Demerits
Alternative 1	① On the back side of container berth in KPD2, sufficient land for container yard is available. ② It is easy to convert general cargo berths to container berths.	① One new berth must be constructed ② Container berths are allocated separately, and the operation control must be divided. ③ The location of container berths at KPD2 is the most inner side of KPD2, and container vessels must pass through 2 bridges and narrow water ways. ④ The width of the channel in front of 27-29 KPD is only 100m, but as the container berths have comparatively high productivity and the frequency of berthing becomes rather high, the width of the channel is rather narrow in comparison with the average vessel length over all. ⑤ The proportion of the vessels which use KPD will be more than that at NSD. ⑥ Some difficulty of connecting IWT and the container vessel terminal is likely. ⑦ The increase of traffic to the hinterland is projected.
Alternative 2	① It is easy to convert general cargo berths to container berths. ② It is easy to connect the IWT with the container vessel terminal. ③ Operation control is easy because container berths are concentrated in NSD.	① Same as 1 of alternative 1. ② Same as 7 of alternative 1. ③ The available area for the container yard is small. ④ In order to get a sufficient area for the container yard, the labour house at the back of the boundary wall must be removed.
Alternative 3	① Effect to decrease traffic load to hinterland is expected. ② Same as 1 of alternative 1. ③ Same as 2 of alternative 1. ④ Effective use of existing facilities.	① Same as 2 of alternative 1. ② Same as 3 of alternative 1. ③ Same as 4 of alternative 1. ④ Same as 5 of alternative 1. ⑤ Same as 6 of alternative 1.
Alternative 4	① Same as 1 of alternative 3. ② Same as 4 of alternative 3. ③ Same as 1 of alternative 2. ④ Same as 2 of alternative 2. ⑤ Same as 3 of alternative 2.	① Same as 3 of alternative 2. ② Same as 4 of alternative 2.

Taking into consideration the above merits and demerits, alternative 4 seems to be recommendable.

5) At shed

Most of the handling at the shed is carried out manually.

Thus the stacking height is limited and the handling capacity is small. The consultant recommend's the use of forklifts for the handling at the shed.

(2) Containers

1) From/To ship

Two different handling systems will be used to and from container ships: the roll-on, roll-off method and the lift-on, lift-off method.

However, the roll-on, roll-off method will be used only in special cases.

The lift-on, lift-off method will basically be adopted at the port. The handling from/to ships will use ship gear, and the reasons for this are as follows.

a Most of the container ships which call at Calcutta Dock System are 1st and/or 2nd generation ships.

b These ships are not so large, and most of them don't have any special facilities for roll-on, roll-off cargo handling.

2) At terminal

There are many handling methods at container terminals including the transfer crane system (rail, rubber tyred), chassis system, straddle carrier system, forklift system, front loader system, mobile crane system, and others.

The most suitable handling system for the terminal will be adopted. The items to be considered include:

a The size and shape of the available container yard.

b The estimated cargo volume.

c Flexibility of the adopted handling system.

d Cost (initial cost, running cost, maintenance cost).

e Operation system and number of operators at the container terminal.

f Others

The consultant recommends the rubber tyred transfer crane system for

Calcutta. The reasons are as follows.

The rubber tyred transfer crane system is already used for handling containers at the partially constructed container berth.

The size of the available container yard is limited. This handling system provides great flexibility. The initial investment is lower than that of the rail transfer crane system.

11-1-5 Required Scale or Cargo Handling Equipment

The development plan for the cargo handling equipment except container handling equipment is not the equipment to cope with the forecast increased cargo volume but rather the equipment to promote the proposed handling system and to replace the old equipment.

(1) Equipment for general cargo (except bulk)

1) Quay-side cranes

No new or replacement equipment is planned, and the old cranes are to be disposed of.

2) Minor handling equipment

The minor handling equipment will be expanded to increase the throughput at berth. However, it will not be increased drastically. The conditions for this plan are as follows.

a Average service life

Mobile crane 15 years

Fork lift 5 years

b The rule of replacement

Equipment will be replaced one year after the average service life.

c The minor handling equipment to be used in the target years (1994/95, 2004/05) will be increased as follows:

	At present	in 1994/95	in 2004/05
Fork lift	47	70 (47 x 1.5)	105 (70 x 1.5)
Mobile crane	43	47 (43 x 1.1)	52 (47 x 1.1)

d The capacity of the minor handling equipment is as follows:

Fork-lift

10t	5%	of the total number
5t	25%	"
3t	70%	"

Mobile crane

45t	5%	of the total number
30t	20%	"
16t	20%	"
10t	30%	"
6t	25%	"

e The handling of logs at apron and in the storage yard will be done by log loader in principle. However, the existing handling equipment will also be used for log handling until it is disposed of.

(2) Container Equipment

1) Number of containers and berths

	1994/95	2004/05
Containers	110,000 TEUs	110,000 TEUs (A1-2)
Berths	3	3

2) The required minor handling equipment

Figures in parentheses indicate the values in 2004/05.

a Rubber tyred transfer cranes

The required number of rubber tyred transfer cranes is usually calculated by the following expression.

$NT = 2N + 1$ or 2

NT : Required number of rubber tyred transfer cranes

N : Number of quay-side container cranes

However, the above formula is used for the quay-side crane system and in this case the containers will be handled by ship gear. Thus, the cycle time will be slower than it would be using quay-side cranes.

On the other hand two (2) quay-side container cranes are usually provided at one container berth and the containers are handled by 2 gangs in general.

However, in this case the containers will be handled by 3 gangs per berth sometimes.

The consultant recommends four (4) rubber tyred transfer cranes (including one crane for the land side) per berth.

b Chassis

For carriage between ship gear and transfer cranes

Two chassis will be required per gang and six (6) chassis will be required per berth.

For C.F.S

The required number of chassis for the C.F.S is usually calculated by the number of gangs stuffing and unstuffing cargoes. The containers which are stuffed/unstuffed within the port area are L.C.L (less than container load) cargo only and F.C.L (full container load) cargo does not pass through the C.F.S in general.

Some F.C.L containers move through the C.F.S at present because of special local conditions.

However this practice should be discontinued as it is contrary to the goal of door-to-door service.

The volume of F.C.L cargo which passes through the C.F.S will be reduced to zero in 2004/05.

The ratio of containers via the CFS is assumed to be 50% (20%) in the target years.

Number of gangs; Ng

$$Ng = \frac{0.5(0.2) \times 110{,}000\ (110{,}000) \times 1.3 \times 2}{350 \times 24 \times 0.6}$$

$$= 28.4\ (11.3)$$

$$29\quad (12)$$

Required number of chassis

Nca = 1.5 Ng

= 44 (18)

Total required number of chassis

Nc = 69 (40) (including 10% spare)

c Tractors

Nt = 25 (20) (including 10% spare)

d Fork lifts

For C.F.S 1.5t

NF = Ng + 1 = 30 (13)

For C.F.S 3t

NF' = 16 (7)

For Empty 5t

$$NE = \frac{110,000 \times 1.3 \times 0.2}{30,240\ (350 \times 24 \times 0.6 \times 6)}$$

= 1

For General service 45t

Ng = 1

However, some of the handling equipment will be procured by C.P.T with A.D.B Funds.

The remaining necessary equipment will be considered in this paper.

(3) Floating cranes (For general and heavy cargo)

The maximum unit load to be handled by quay-side cranes is less than 5t. The cargo with a packaged load over 5t is shown in Table 11-1-4.

However, most of the cargo with a unit load of less than 10t will be handled by ship gear.

The percentage of the cargo to be handled by floating cranes is assumed as follows.

Unit load	by ship gear	by floating cranes
5t ~ 10t	80 %	20 %
10t ~ 20t	40 %	60 %
20t ~ 30t	20 %	80 %
30t ~ 50t	10 %	90 %
50t~100t	0	100 %
100t over	0	100 %

The cycle time of the floating cranes for each unit load is assumed as follows.

Unit load	cycle time (hours)
5t ~ 10t	5/60
10t ~ 20t	1/ 6
20t ~ 30t	1/ 3
30t ~ 50t	2
50t~100t	4
100t over	8

The required handling hours of the floating cranes is estimated in the following table.

	No. of pieces	No. of pieces to be handled by F.C	Required hours
5t ~ 10t	14,556	2,911	243
10t ~ 20t	1,486	891	149
20t ~ 30t	194	155	52
30t ~ 50t	26	24	48
50t~100t	50	50	200
100t over	34	34	272
Total			964

CPT currently has three floating cranes (FC) with a lifting capacity of 60t (2nos.) and 30t (1no.).

Out of the three FC, one 60t capacity is over aged being 65 years old and the other two are over 25 years old.

Moreover, for loading/unloading of heavy cargoes over 60t, the Port of Calcutta has to depend on the only 200t capacity canti-lever fixed crane and great inconvenience is caused in case the 200t crane is out of commission at the time of actual demand.

To increase the demand, the overaged FC should be replaced by a suitable higher capacity FC.

It will be desirable therefore to procure one 60t capacity FC in the Short-term Plan period and one 150t capacity FC within the Master Plan period in addition to the 60t FC.

Type of floating crane

There are two kinds of floating crane (self-propulsion and non-propulsion) and their features are as follows.

Self-propulsion

a. Can work alone
b. Easy to move at narrow space
c. High capital cost

Non-propulsion

a. Low capital cost
b. Reduced operational cost

Moving distance is very short except to go to Haldia Dock System where one exclusives FC will be provided.

Judging from the above working conditions, one non-propulsion type FC and one self-propulsion type FC should be adopted at Calcutta Dock System.

Whenever the non-propulsion type FC is required to be moved, it would be towed by tug boat.

Table 11-1-6 Profile of Heavy Cargo Handling at Calcutta

Unit Weight	Name of Commodity	Volume	Weight	Remarks
5 ~ 10t	Open machines/Parts/vehicles	650pkgs	3,096t	
	Cases/Packages/Iron Packages	3,873	24,360	
	Coils/Coil strips/Coiled Sheets	6,444	43,408	
	Structural members	732	5,046	
	Steel plate/Sheets/Billets	8,766	15,210	
	Skids	91	483	
		14,556	91,603	(6.3)
10 ~ 20t	Machinery/Parts/Vehicles	171	2,051	
	Pack cages/Iron/Materials	450	9,035	
	Coil strips/sheets	591	6,767	
	Structural member	227	3,401	
	Steel plates/sheets	47	599	
		1,486	21,853	(14.5)
20 ~ 30t	Machinery/Parts/Vehicles	31	876	
	Cases/Packages/Iron Packages	120	3,198	
	Structural members	23	535	
	Plate	20	780	
		194	5,389	(27.8)
30 ~ 50t	Machinery parts	26	917	(35)
50~100t	Machinery & Machinery parts	50	3,437	(68.7)
100	Machinery parts/Iron packages	21	2,385	
	Iron packages/cases/Boilers	13	1,879	
		34	4,262	(125.4)
			127,461	

(4) The crane for container handling from/to container barge

1) In 1995

The floating crane (self-propulsion swing type, 60t) in item (3) will be used temporarily for container handling from/to container barge.

2) In 2005

Two (2) quay-side container cranes for container barge should be prepared.

List of Minor Handling Equipment at Calcutta

	Exist	For General Cargo						For Container						A.D.B. Planed	Total Procurement	
		1994 / 1995			2004 / 2005			1994 / 1995			2004 / 2005					
		Required	Procu (Initial)	Procu (Replace)	Required	Procu (Initial)	Procu (Replace)	Required	Procu (Initial)	Procu (Replace)	Required	Procu (Initial)	Procu (Replace)		94/95	04/05
Transfer crane(rubber)	0	0	0	0	0	0	0	12	9	0	12	0	0	3	9	0
Fork-lift 2.0 t	12	0	0	0	0	0	0	30	0	0	13	0	26	32	0	26
3.0 t	35	49	14	35	74	25	88	18	14	0	7	0	14	0	63	127
5.0 t	0	18	18	0	26	8	36	1	1	0	1	0	2	0	19	46
10.0 t	0	3	1	0	5	2	6	0	0	0	0	0	0	2	1	8
45.0 t	0	0	0	0	0	0	0	1	1	0	1	0	2	0	1	2
Mobile crane 6.0 t	27	23	0	0	14	0	14	0	0	0	0	0	0	0	0	14
10.0 t	12	12	0	4	15	3	12	0	0	0	0	0	0	0	4	15
16.0 t	0	5	5	0	10	5	0	0	0	0	0	0	0	0	5	5
30.0 t	4	5	1	2	10	5	4	0	0	0	0	0	0	0	3	9
45.0 t	0	2	2	0	3	1	0	0	0	0	0	0	0	0	2	1
Chassis	0	0	0	0	0	0	0	69	33	0	40	0	80	38	33	80
Tractor	0	0	0	0	0	0	0	25	8	0	20	0	40	17	8	40

Replacement of Minor Handling Equipment (Calcutta)

Description	Capa.	Require at 94/95	Existing Equipment			No. of Replacement					Remarks
			No.	M.Y.	End Y.	90/91	91/92	92/93	93/94	94/95	
Fork-lift	3 t	65	3	1980	1985(89)	3					
			5	1981	1986(89)	5					
working life-time; 5 Y.			22	1982	1987(89)	22					
			5	1987	1992			5			
		total	35			30		5			35
		Initial Procu.	65-35- 2 = 28 ADB				10		18		28
											63 (Total Procurement)
Mobile crane	6 t	23	4	1974	1989						
			5	1980	1995						
working life-time; 15 Y.			1	1981	1996						No replacement
			10	1982	1997						
			1	1983	1998						
			6	1988	2001						
		total	27								
	10 t	12	1	1964	1979(89)	1					
			3	1967	1982(89)	3					
			2	1981	1996						
			3	1984	1999						
			1	1986	2001						
			2	1987	2002						
		total	12			4					4 (Total Procurement)
	30 t	5	2	1964	1979(89)	2					
			1	1982	1987						
			1	1985	2000						
		total	4			2					2
		Initial Procu.	5-4=1							1	1
											3 (Total Procurement)

11-1-6 Required Scale of Storage Facilities

(1) Classification of Cargoes by Storage Facility Type

The classification by storage facility type was made by CPT in 1987/88 as shown in **Appendix 11-1-12.**

From this analysis, the following findings become clear.

1) Import Cargoes

① Import cargoes are classified into the following four items.

(a) Cargoes which use transitsheds

(b) Cargoes which use open-storage yards

(c) Cargoes which use transitsheds and/or open-storage yards

(d) Cargoes which are directly transferred to outside of the wharves

② Major commodities of the above-items are as follows.

(a) Cement, Sugar, Foodgrains

(b) Iron and Steel, Machinery, Fertilizer/Rew Materials

(c) Chemicals, Others

(d) Salt, Oil

③ The cargo volume of the respective classified items is as follows.

Item	Cargo Volume	%	Note
(a)	404,034 tons	12	S : Shed
(b)	771,871	23	Y : Yard
(c)	1,173,664	35	SY: Shed Yard
(d)	1,006,870	30	NA: Not App.
Total	3,356,439	100	

④ The volume of the break bulk cargoes handled in 1987/88 was 2,115,000 tons (218,000 + 1,897,000 tons).

⑤ Among the commodities which belong to items (a) to (c), the commodities which are not break bulk are as follows.

ⓐ Foodgrains, ⓑ Fertilizer, ⓒ Raw Materials for Fertilizer

(Salt belongs to the commodities of item (d))

⑥ Excluding the volume of commodities ⓐ to ⓒ from the cargo volumes which belong to items (a) to (c), the volume of the break bulk cargo classified to items (a) to (c) is so follows.

Item	Cargo Volume	%
(a)	360,748 tons	18.5
(b)	434,521	22.3
(c)	1,154,950	59.2
Total	1,950,219	100.0

⑦ If we assume that half of the item (c) cargoes belong to item (a) and the item (b) respectively, the share of the break bulk cargoes which belong to items (a) and (b) becomes as follows.

Item	%	Cargo Volume
(a)	48.1	938,223 tons
(b)	51.9	1,011,996
Total	100.0	1,950,219

⑧ On the other hand, by the analysis of containerized cargoes, it becomes clear that 70 % of the import containerized cargos belong to item (a).

⑨ Then the actual classification of the import break bulk cargoes in 1987/88 is estimated as follows.

Item	Total break bulk cargoes		Containerized	Actual break bulk cargoes	
	Share	Volume	Cargo Volume	Volume	Share
	%	x 1,000tons	x 1,000tons	x 1,000tons	%
Total Volume	100.0	2,115	218.0	1,897.0	100.0
(a) Shed	48.1	1,017.3	152.6	864.7	35.6
(b) Yard	51.9	1,097.7	65.4	1,032.3	54.4

⑩ If we assume that the classification pattern does not change in the future, the break bulk cargo volume which will use the transhitsheds

and the open storage yards respectively can be calculated by the following formulae.

$Ws = 0.481 \times W$

$Wy = 0.519 \times W$

$Ws' = 0.7 \times W'$

$Wy' = 0.3 \times W'$

$Vs = Ws - Ws'$

$Vy = Wy - Wy'$

where

W : Total break bulk cargo volume at the target year

W' : Total containerized cargo volume at the target year

Ws : Break bulk cargo volume which can use transitsheds

Wy : Break bulk cargo volume which can use open-storage yards

Ws' : Containerized break bulk cargo volume which can use transhitsheds as break bulk cargoes

Wy' : Containerized break bulk cargo volume which can use open-storage yards as break bulk cargoes

Vs : Forecast break bulk cargo volume which actually use transhitsheds at the target year

Vy : Forecast break bulk cargo volume which actually uses open-storage yards at the target year

⑪ The forecast volume (W) of import break bulk cargoes in 1994/95 is 2,360,000 tons.

⑫ The forecast volume (W') of import container cargoes in 1994/95 is 580,000 tons.

⑬ Then, the respective break bulk cargoes can be calculated as follows.

Ws = 1,135,160 tons

Wy = 1,224,840 tons

Ws' = 406,000 tons

Wy' = 174,000 tons

Vs = 729,160 tons

Vy = 1,050,840 tons

⑭ The forecast volume (W) of import break bulk cargoes in 2004/05 is 3,935,000 tons, but this volume is obtained in accordance with 268,000 TEUs of containers. So the volume of import break bulk cargoes in accordance with 110,000 TEUs of containers must be changed as follows.

The volume of break bulk cargoes in accordance with 268,000 TEUs is 1,460,000 tons. So the volume of break bulk cargoes in accordance with 110,000 TEU is as follows.

$$W' = 1,460,000^{tons} \times \frac{110,000}{268,000} = 599,000^{tons}$$

The total break bulk cargo volume accordingly can be calculated as follows.

$$W = 3,935,000^{tons} - 1,460,000^{tons} + 599,000^{tons} = 3,074,000^{tons}$$

⑮ Then, the respective break bulk cargoes can be calculated as follows.

Ws = 1,478,594 tons

Wy = 1,595,406 tons

Ws' = 419,300 tons

Wy' = 179,700 tons

Vs = 1,059,294 tons

Vy = 1,415,706 tons

2) Export Cargoes

① Export cargoes are classified into the following four items

(a) Cargoes which use transitsheds

(b) Cargoes which use open-storage yards

(c) Cargoes which use transitsheds and/or open-storage yards

(d) Cargoes which are directly transferred to outside of the wharves

② Major commodities of the above-items are as follows.

(a) Mica, Tea

(b) Iron and Steel, Machinery

(c) Others

(d) Jute/Jute Products, Oil

③ The cargo volume of the respective classified items is as follows.

Item	Cargo Volume	%	Note
(a)	252,666 tons	33.3	S : Shed
(b)	59,418	7.8	Y : Yard
(c)	92,798	12.3	SY: Shed Yard
(d)	352,534	46.6	NA: Not App.
Total	757,416	100.0	

④ The volume of the break bulk cargoes handled in 1987/88 was 795,000 tons (269,000 + 526,000 tons).

⑤ Among the commodities which belong to items (a) to (c), the commodity which is not break bulk is as follows.

ⓐ Coal

⑥ Excluding the volume of coal from the cargo volume which belongs to items (a) to (c), the volume of the break bulk cargo classified to items (a) to (c) is so follows.

Item	Cargo Volume	%
(a)	252,666 tons	63.7
(b)	50,931	12.8
(c)	92,798	23.5
Total	369,395	100.0

⑦ If we assume that half of the item (c) cargoes belong to item (a) and the item (b) respectively, the share of the break bulk cargoes which belongs to items (a) and (b) becomes as follows.

Item	%	Cargo Volume
(a)	75.4	299,065 tons
(b)	24.6	97,330
Total	100.0	396,395

⑧ The jute and jute products belong to item (d), so we must exclude the cargo volume of the jute and jute products 276,000 tons, from the total volume of the break bulk cargoes as follows.

⑨ On the other hand, by the analysis of containerized cargoes, it becomes clear that 90 % of the export containerized cargos excluding containerized jute and jute products belong to item (a).

⑩ Then the actual classification of the export break bulk cargoes in 1987/88 is estimated as follows.

Item	Total break bulk cargoes		Containerized	Actual break bulk cargoes	
	Share	Volume	Cargo Volume	Volume	Share
	%	x 1,000tons	x 1,000tons	x 1,000tons	%
Total Volume	100.0	519	205.0	314.0	100.0
(a) Shed	75.4	391.3	184.5	206.8	65.9
(b) Yard	24.6	127.7	20.5	107.2	34.1

⑪ If we assume that the classification pattern does not change in the future, the break bulk cargo volume which will use the transhitsheds and the open storage yards respectively will be calculated by the following formulae.

$W = W_1 - W_2$

$Ws = 0.754\ W$

$Wy = 0.246\ W$

$W' = W_1' - W_2'$

$Ws' = 0.9\ W'$

$Wy' = 0.1\ W'$

$Vs = Ws - Ws'$

$Vy = Wy - Wy'$

where

W_1 : Total break bulk cargo volume at the target year

W_2 : Total cargo volume of jute and jute products at the target year

W : Total break bulk cargo volume excluding jute and jute products

Ws : Break bulk cargo volume which can use transitsheds

Wy : Break bulk cargo volume which can use open-storage yards

W_1' : Total containerized cargo volume at the target year

W_2' : Containerized jute and jute products volume

W' : Total containerized cargo volume excluding jute and jute products

Ws' : Containerized break bulk cargo volume which can use transhitsheds as break bulk cargoes

Wy' : Containerized break bulk cargo volume which can use open-storage yards as break bulk cargoes

Vs : Forecast break bulk cargo volume which actually use transhitsheds at the target year

Vy : Forecast break bulk cargo volume which actually uses open-storage yards at the target year

⑫ The forecast volume (W_1) of export break bulk cargoes in 1994/95 is 960,000 tons (530,000 tons + 430,000 tons).

⑬ The forecast volume (W_2) of jute and jute products in 1994/95 is 276,000 tons.

⑭ The forecast volume (W_1') of export containerized cargoes in 1994/95 is 530,000 tons.

⑮ The forecast volume (W_2') of containerized jute and jute products in 1994/95 is 135,000.

⑯ Then, the respective break bulk cargoes can be calculated as follows.

W = 684,000 tons

Ws = 515,736 tons

Wy = 168,264 tons

W' = 395,000 tons

Ws' = 355,500 tons

Wy' = 39,500 tons

Vs = 160,236 tons

Vy = 128,764 tons

⑰ The forecast volume W_1 of export break bulk cargoes in 2004/05 is 1,220,000 tons (775,000 tons + 435,000 tons).
But this volume is in accordance with 268,000 TEUs of containers. The containerized break bulk cargo volume in accordance with 110,000 TEUs of containers must be changed as follows.

$$W_1' = 775{,}000^{tons} \times \frac{110{,}000}{268{,}000} = 318{,}000^{tons}$$

The total break bulk cargo volume, accordingly can be calculated as follows.

$$W_1 = 318{,}000^{tons} + 453{,}000^{tons} = 753{,}000^{tons}$$

⑱ The containerized jute and jute products volume W_2' is 125,000 tons in accordance with 268,000 TEUs of containers in 2004/05.
Then the containeried jute and jute products volume in accordance with 110,000 TEUs of containers must be changed as follows.

$$W_2' = 125{,}000^{tons} \times \frac{110{,}000}{268{,}000} = 51{,}000^{tons}$$

The total jute and jute products volume W_2 is obtained from the following formula.

$$W_2 = 51{,}000^{tons} + 195{,}000^{tons} - 125{,}000^{tons} = 121{,}000^{tons}$$

⑲ Then, the respective break bulk cargoes can be calculated as follows.

W = 632,000 tons

Ws = 476,528 tons

Wy = 155,472 tons

W' = 267,000 tons

Ws' = 240,300 tons

Wy' = 26,700 tons

Vs = 236,228 tons

Vy = 128,772 tons

⑳ Accordingly, the classification of cargoes by storage facilities can be summed up as follows.

(at Presetn) x 1,000 tons

	Shed Use	Yard Use	Container
Import	864.7	1,032.3	218.0
Export	314.0	206.8	205.0
Total	1,178.7	1,239.1	423.0

(in 1994/95) x 1,000 tons

	Shed Use	Yard Use	Container
Import	729.2	1,050.8	580.0
Export	160.2	128.8	530.0
Total	889.4	1,179.6	1,110.0

(in 2004/05) x 1,000 tons

	Shed Use	Yard Use	Container
Import	1,059.3	1,415.7	599.0
Export	236.2	128.8	318.0
Total	1,295.5	1,544.5	917.0

(2) Allocation of Cargoes by Storage Facilitiy Type to Districts of Ports

① The berth allocation at the target year is as follows.

(in 1994/95) Alternative-2

District	Liquid Cargo	Dry Bulk Cargo	Container Cargo	Break Bulk Cargo
NSD	1	2	3	3
KPD1		1		9
KPD2		1		7
Total	1	4	3	19

(in 2004/05) Alternative-4

District	Liquid Cargo	Dry Bulk Cargo	Container Cargo	Break Bulk Cargo
NSD	1	2	3	3
KPD1		2		8
KPD2		1		7
Total	1	5	3	18

② According to the berth allocation of each district, the volume of break bulk cargoes is allocated as follows.

(in 1994/95)

ⓐ NSD:

		tons		tons
Shed Use Cargo Volume	=	889,400	$\times \frac{3}{19}$ =	140,432
Import	=	729,000	$\times \frac{3}{19}$ =	115,105
Export	=	160,200	$\times \frac{3}{19}$ =	25,295
Yard Use Cargo Volume	=	1,179,600	$\times \frac{3}{19}$ =	186,253
Import	=	1,050,800	$\times \frac{3}{19}$ =	165,916
Export	=	128,800	$\times \frac{3}{19}$ =	20,337

ⓑ KPD1:

Shed Use Cargo Volume	=	889,400	$\times \frac{9}{19}$ =	421,295
Import	=	729,000	$\times \frac{9}{19}$ =	345,316
Export	=	160,200	$\times \frac{9}{19}$ =	75,884
Yard Use Cargo Volume	=	1,179,600	$\times \frac{9}{19}$ =	558,758
Import	=	1,050,800	$\times \frac{9}{19}$ =	497,747
Export	=	128,800	$\times \frac{9}{19}$ =	61,011

ⓑ' Westside of KPD1

Shed Use Cargo Volume	=	374,484	$\times \frac{4}{8}$ =	187,242
Import	=	307,032	$\times \frac{4}{8}$ =	153,516
Export	=	67,452	$\times \frac{4}{8}$ =	33,726
Yard Use Cargo Volume	=	496,674	$\times \frac{4}{8}$ =	248,337

Import = 442,442 x $\frac{4}{8}$ = 221,221

Export = 54,232 x $\frac{4}{8}$ = 27,116

ⓑ" Eastside of KPD1

Shed Use Cargo Volume = 374,484 x $\frac{5}{8}$ = 234,052

Import = 307,032 x $\frac{5}{8}$ = 191,895

Export = 67,452 x $\frac{5}{8}$ = 42,157

Yard Use Cargo Volume = 496,674 x $\frac{5}{8}$ = 310,421

Import = 442,442 x $\frac{5}{8}$ = 276,526

Export = 54,232 x $\frac{5}{8}$ = 33,895

ⓒ KPD2:

Shed Use Cargo Volume = 889,400 x $\frac{7}{19}$ = 327,674

Import = 729,000 x $\frac{7}{19}$ = 268,653

Export = 160,200 x $\frac{7}{19}$ = 59,021

Yard Use Cargo Volume = 1,179,600 x $\frac{7}{19}$ = 434,589

Import = 1,050,800 x $\frac{7}{19}$ = 387,137

Export = 128,800 x $\frac{7}{19}$ = 47,452

(in 2004/05)

ⓐ NSD:

Shed Use Cargo Volume = 1,295,500 x $\frac{3}{18}$ = 215,917

Import = 1,059,300 x $\frac{3}{18}$ = 176,550

Export = 236,200 x $\frac{3}{18}$ = 39,367

Yard Use Cargo Volume = 1,544,500 x $\frac{3}{18}$ = 257,417

Import = 1,415,700 $\times \frac{3}{18}$ = 235,950

Export = 128,800 $\times \frac{3}{18}$ = 21,467

ⓑ KPD1:

Shed Use Cargo Volume = 1,295,500 $\times \frac{8}{18}$ = 575,778

Import = 1,059,300 $\times \frac{8}{18}$ = 470,800

Export = 236,200 $\times \frac{8}{18}$ = 104,978

Yard Use Cargo Volume = 1,544,500 $\times \frac{8}{18}$ = 686,444

Import = 1,415,700 $\times \frac{8}{18}$ = 629,200

Export = 128,800 $\times \frac{8}{18}$ = 57,244

ⓑ' Westside of KPD1

Shed Use Cargo Volume = 503,806 $\times \frac{3}{7}$ = 215,917

Import = 411,950 $\times \frac{3}{7}$ = 176,550

Export = 91,856 $\times \frac{3}{7}$ = 39,367

Yard Use Cargo Volume = 600,639 $\times \frac{3}{7}$ = 257,417

Import = 550,550 $\times \frac{3}{7}$ = 235,950

Export = 50,089 $\times \frac{3}{7}$ = 21,467

ⓑ" Westside of KPD1

Shed Use Cargo Volume = 503,806 $\times \frac{5}{7}$ = 359,861

Import = 411,950 $\times \frac{5}{7}$ = 294,250

Export = 91,856 $\times \frac{5}{7}$ = 65,611

Yard Use Cargo Volume = 600,639 $\times \frac{5}{7}$ = 429,028

Import = 550,550 $\times \frac{5}{7}$ = 393,250

Export = 50,089 x $\frac{5}{7}$ = 35,778

© KPD2:

Shed Use Cargo Volume = 1,295,500 x $\frac{7}{18}$ = 503,806

Import = 1,059,300 x $\frac{7}{18}$ = 411,950

Export = 236,200 x $\frac{7}{18}$ = 91,856

Yard Use Cargo Volume = 1,544,500 x $\frac{7}{18}$ = 600,639

Import = 1,415,700 x $\frac{7}{18}$ = 550,550

Export = 128,800 x $\frac{7}{18}$ = 50,089

(3) Calculation Methodology of Required Area

① The required area of transhitsheds and open storage yards can be calculated by the following formula.

$$A = \frac{N \times C}{R \times w \times \alpha}$$

where

A: Required area of transitsheds

N: Cargo volume which use transitsheds

C: Peak rate

R: Average number of usage of transhitsheds per year

($R = \frac{365}{da}$ where da: Average dwell time)

w: Unit cargo weight per m^2

α: Available area rate

② Usually the following values are used to calcuate the above required area.

c = 1.3

α = 0.6 for transitsheds

0.7 for open storage yards

w = 1.3

③ The average dwell time of import break bulk cargoes was 15 days and that of export break bulk cargoes was 9 days. So the average numbers of usage of import and export break bulk cargoes are as follows.

R = 24.3 for import break bulk cargoes

= 40.6 for export break bulk cargoes

(4) Calculation of Required Area

① As for the total volume of cargoes, the required area can be calculated as follows.

(in 1994/95)

Area for transitsheds

$$As = \frac{729,200 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{160,000 \times 1.3}{40.6 \times 1.3 \times 0.6} = 50,014+6,576 = 56,590m^2$$

Area for open storage yards

$$As = \frac{1,050,800 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{128,800 \times 1.3}{40.6 \times 1.3 \times 0.7} = 61,775+4,532 = 66,307m^2$$

(in 2004/05)

Area for transitsheds

$$As = \frac{1,059,300 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{236,200 \times 1.3}{40.6 \times 1.3 \times 0.6} = 72,654+9,696 = 82,350m^2$$

Area for open storage yards

$$As = \frac{1,415,700 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{128,800 \times 1.3}{40.6 \times 1.3 \times 0.7} = 83,169+4,532 = 87,701m^2$$

② As for the respective districts, the required areas can be calculated as follows.

(in 1994/95)

ⓐ NSD district

Area for transitsheds

$$As = \frac{115,105 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{25,295 \times 1.3}{40.6 \times 1.3 \times 0.6} = 7,895+1,038 = 8,933m^2$$

Area for open storage yards

$$As = \frac{165,916 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{20,337 \times 1.3}{40.6 \times 1.3 \times 0.7} = 9,754+716 = 10,470m^2$$

ⓑ KPD1 district

Area for transitsheds

$$As = \frac{345,316 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{75,884 \times 1.3}{40.6 \times 1.3 \times 0.6} = 23,684+3,115 = 26,799m^2$$

Area for open storage yards

$$As = \frac{497,747 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{61,011 \times 1.3}{40.6 \times 1.3 \times 0.7} = 29,262+2,147 = 31,409m^2$$

ⓑ' Westside of KPD1

Area for transitsheds

$$As = \frac{153,516 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{33,726 \times 1.3}{40.6 \times 1.3 \times 0.6} = 10,529+1,384 = 11,914m^2$$

Area for open storage yards

$$As = \frac{221,221 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{27,116 \times 1.3}{40.6 \times 1.3 \times 0.7} = 13,005+ 954 = 13,959m^2$$

ⓑ" Eastside of KPD1

Area for transitsheds

$$As = \frac{191,895 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{42,157 \times 1.3}{40.6 \times 1.3 \times 0.6} = 13,162+1,731 = 14,893m^2$$

Area for open storage yards

$$As = \frac{276,526 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{33,895 \times 1.3}{40.6 \times 1.3 \times 0.7} = 16,257+1,193 = 17,450m^2$$

ⓒ KPD2 district

Area for transitsheds

$$As = \frac{268,653 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{59,021 \times 1.3}{40.6 \times 1.3 \times 0.6} = 18,426+2,423 = 20,849m^2$$

Area for open storage yards

$$As = \frac{387,137 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{47,452 \times 1.3}{40.6 \times 1.3 \times 0.7} = 25,285+1,670 = 26,955m^2$$

(in 2004/05)

ⓐ NSD district

Area for transitsheds

$$As = \frac{176,550 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{39,367 \times 1.3}{40.6 \times 1.3 \times 0.6} = 12,109+1,616 = 13,725m^2$$

Area for open storage yards

$$As = \frac{235,950 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{21,467 \times 1.3}{40.6 \times 1.3 \times 0.7} = 13,871+ 755 = 14,626m^2$$

ⓑ KPD1 district

Area for transitsheds

$$As = \frac{470,800 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{104,978 \times 1.3}{40.6 \times 1.3 \times 0.6} = 32,291+4,309 = 36,600m^2$$

Area for open storage yards

$$As = \frac{629,200 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{57,244 \times 1.3}{40.6 \times 1.3 \times 0.7} = 36,990+2,014 = 39,004m^2$$

ⓑ' Westside of KPD1

Area for transitsheds

$$As = \frac{176,550 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{39,367 \times 1.3}{40.6 \times 1.3 \times 0.6} = 12,109+1,616 = 13,725m^2$$

Area for open storage yards

$$As = \frac{235,950 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{21,467 \times 1.3}{40.6 \times 1.3 \times 0.7} = 13,871+ \ 755 = 14,627m^2$$

ⓑ" Eastside of KPD1

Area for transitsheds

$$As = \frac{294,250 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{65,611 \times 1.3}{40.6 \times 1.3 \times 0.6} = 20,182+2,693 = 22,875m^2$$

Area for open storage yards

$$As = \frac{393,250 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{35,778 \times 1.3}{40.6 \times 1.3 \times 0.7} = 23,119+1,259 = 24,378m^2$$

ⓒ KPD2 district

Area for transitsheds

$$As = \frac{411,950 \times 1.3}{24.3 \times 1.3 \times 0.6} + \frac{91,856 \times 1.3}{40.6 \times 1.3 \times 0.6} = 28,254+3,771 = 32,025m^2$$

Area for open storage yards

$$As = \frac{550,550 \times 1.3}{24.3 \times 1.3 \times 0.7} + \frac{50,089 \times 1.3}{40.6 \times 1.3 \times 0.7} = 32,366+1,762 = 34,128m^2$$

③ The calculated requiring area is summed up on the following table.

(unit: m2)

	District	Sheds	Yards	Total
1994/95	NSD	8,933	10,470	19,403
	KPD1	26,799	31,409	58,208
	Westside	11,914	13,959	25,873
	Eastside	14,893	17,450	32,343
	KPD2	20,849	26,955	47,804
	Total	56,589	73,486	130,075
2004/05	NSD	13,725	14,626	28,351
	KPD1	36,600	39,004	75,604
	Westside	13,725	14,629	28,354
	Eastside	22,875	24,378	47,253
	KPD2	32,025	34,128	66,153
	Total	82,346	87,758	170,104

(5) Improvement Plan of Respective Districts

1) KPD2 District

① The required storage area on the east side of KPD2 is as follows.

	in 1994/95	in 2004/05
Sheds	20,849m^2	32,025m^2
Yards	26,955m^2	34,128m^2
Total	47,804m^2	66,153m^2

② The existing shed area is as follows.

	Total Area	Ground Floor
At the back side of berths 22 and 23	17,838m^2	8,919m^2
At the back side of berths 24, 25 and 26	26,871m^2	13,435.5m^2
At the back side of berths 27, 28 and 29	21,738m^2	10,869m^2
Pie Shed	5,537m^2	5,537m^2
Total	71,984m^2	38,760.5m^2

③ The existing open storage yard area is as follows.

	Yard Area
At the back side of berths 22 and 23	2,808m^2
At the back side of berths 24, 25 and 26	6,550m^2
At the back side of berths 27, 28 and 29	11,193m^2
Total	20,543m^2

④ The existing total ground area used for storage space is as follows.

$38,760.5m^2 + 20,543m^2 = 59,303.5m^2$

⑤ The existing total ground area which is used for storage space is more than the total required area in 1994/95, but is less than the total required area in 2004/05.

⑥ In order to handle cargoes by machines, it is convenient to use only the first floor, and the apron width at berths 22 to 26 must be expanded.

⑦ The existing yard area is 20,453m2 and the required yard area is $26,955m^2$ in 1994/95 and $34,128m^2$ in 2004/05. So the open storage area must be expanded by the following amount.

in 1994/95 $26,955 - 20,543 = 6,412m^2$

in 2004/05 $34,128 - 20,543 = 13,585m^2$

⑧ The existing shed area on the ground floor is $38,760.5m^2$ and the required shed area is $20,849m^2$ in 1994/95 and $34,128m^2$ in 2004/05. So it is possible to demolish the following shed areas.

in 1994/95 $38,760.5 - 20,849 = 17,911.5m^2$

in 2004/05 $38,760.5 - 34,128 = 4,632.5m^2$

⑨ It will be impossible to provide the required yard area by converting sheds to yards in 2004/05.

⑩ So, we propose the expansion of the present dock area as shown on the following figure in 2004/05. In order to expand these parts it is necessary to demolish the residential buildings.

⑪ In 1994/95, it is not necessary to expand the dock area by demolishing the residential buildings. If we convert the pie shed to an open storage yard, the applicable ground area will be as follows in 1994/95.

Shed area	Total Area	Ground Floor
At the back side of berths 22 and 23	$17,838m^2$	$8,919m^2$
At the back side of berths 24, 25 and 26	$26,871m^2$	$13,435.5m^2$
At the back side of berths 27, 28 and 29	$21,738m^2$	$10,869m^2$
Total	$66,447m^2$	$33,223.5m^2$

⑫ The open storage yard area will be as follows in 1994/95.

	Yard Area
At the back side of berths 22 and 23	2,808m^2
At the back side of berths 24, 25 and 26	6,550m^2
At the back side of berths 27, 28 and 29	11,193m^2
Converted yard area	5,537m^2
	26,080m^2

⑬ The required yard area in 1994/95 will be 26,955m2 and the applicable area will be 26,080m^2, accordingly it will be short of 875m^2 in 1994/95. But this amount of ground may be obtainable at the south side of the pie shed.

⑭ In 2004/05, the dock area should be expanded and the road system shall be rearranged as shown in Fig. 11-1-6.
The west side of No. 22, 23, 24, 25 and 26 sheds shall be demolished in order to obtain 25m apron width. And at the east side of these sheds, cover shall be constructed to obtain the required shed area.

⑮ By the above measures, the shed area and the open-storage area shall be as follows in 2004/05.

	Shed Area	Yard
At the back side of berths 22 and 23	9,442m^2	1,400m^2
At the back side of berths 24, 25 and 26	14,218m^2	6,700m^2
At the back side of berths 27, 28 and 29	10,869m^2	27,600m^2
Total	34,529m^2	35,700m^2

Then the required area of respective facilities will be obtained.

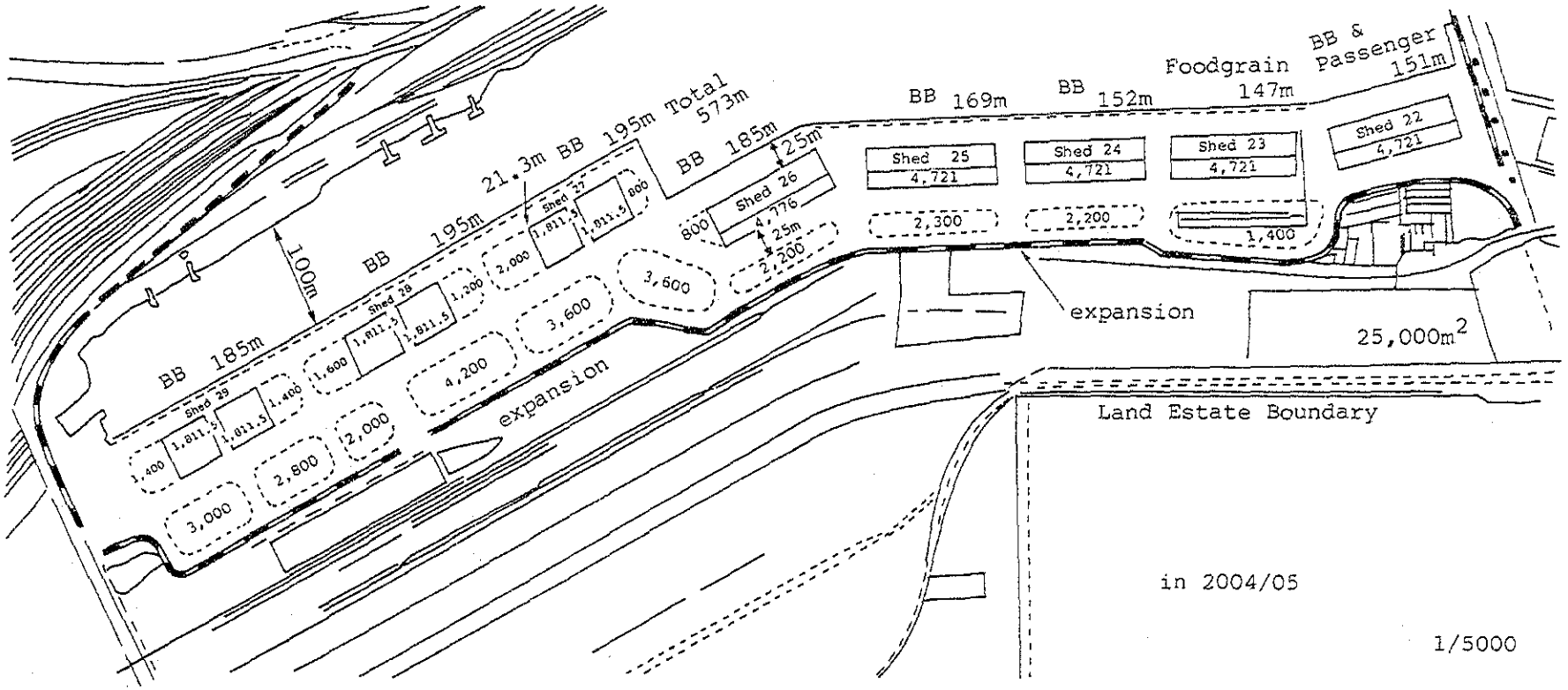


Fig. 11-1-6 Improvement Plan of East Side of KPD2 in 2004/05

2) KPD1 East Side District

① The required area at the east side of KPD1 is as follows.

	in 1994/95	in 2004/05
Sheds	14,893m^2	22,875m^2
Yards	17,450m^2	24,378m^2
Total	32,343m^2	47,253m^2

② The existing storage facilities are as follows.

		Area			Area
Transitshed	1	3,345m^2	Open Yard	1	1,830m^2
"	5/7	6,689m^2	"	3	911m^2
"	9	3,345m^2			3,344m^2
"	11	3,344m^2	"	5/7	1,560m^2
"	A	6,200m^2	"	9	650m^2
Total		22,923m^2		11	892m^2
			Total		9,187m^2

③ The required area in 2004/05 is 47,253m2, but the existing storage area is 32,110m^2, so it is necessary to obtain the following area in 2004/05.

47,253m^2 - 32,110m^2 = 15,143m^2

④ The required shed area in 2004/05 is 22,875m^2, and the existing shed area is 22,923m^2, so it is not necessary to construct new sheds even in 2004/05. Accordingly, only additional yard area must be obtained.

⑤ In 1994/95, the following area must be obtained for open storage.

17,450m^2 - 9,187m^2 = 8,263m^2

⑥ In 2004/05, the following area must be obtained for open storage.

24,378m^2 - 9,187m^2 = 15,191m^2

⑦ By the demolition of the railway system and the rearrangement of the road system, we can obtain the required area of open storage yards as shown in the following figure.

⑧ The open storage area obtained by the above measures, will be as follows in 2004/05.

At the back side of No. 1 berths	2,493m^2
At the back side of No. 3 berths	9,594m^2
At the back side of No. 5/7 berths	8,015m^2
At the back side of No. 9 berths	5,824m^2
At the back side of No. 11 berths	2,125m^2
Total	28,051m^2

⑨ Accordingly, we can obtain the required open storage area in 2004/05.

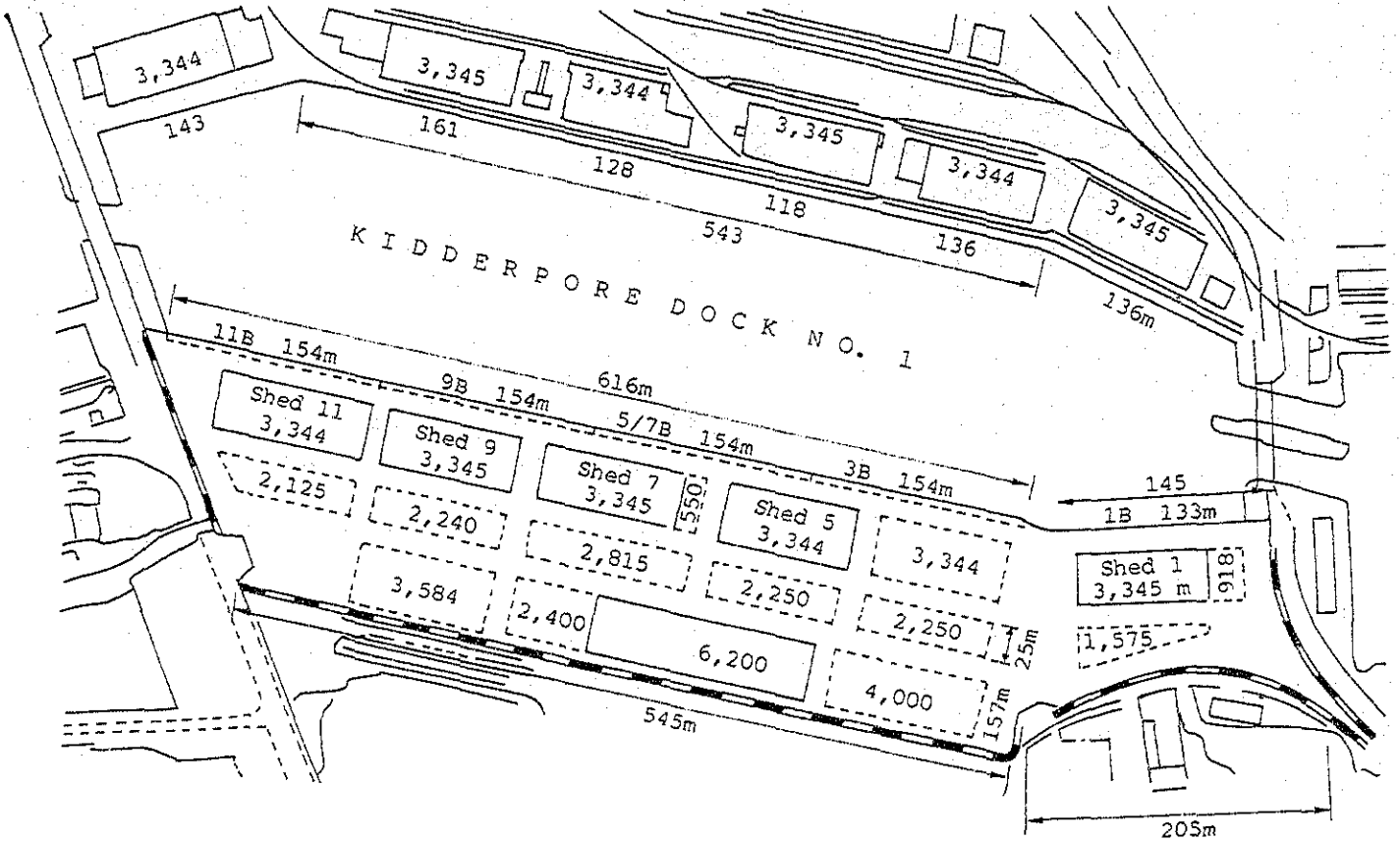


Fig. 11-1-7 Improvement Plan of East Side of KPD1 in 2004/05

3) KPDl West Side District

① At this site, dry bulk cargoes will be handled in the future.

② Salt is delivered directly from the apron and fertilizer and raw materials for fertilizer in bulk use the open storage yards. The forecast cargo volume of fertilizer and raw materials for fertilizer area as follows.

	in 1994/95	in 2004/05
Fertilizer	20,000 tons	30,000 tons
Raw Materials for Fertilizer	380,000 tons	630,000 tons
	400,000 tons	660,000 tons

③ The dwell time at the open storage yard is estimated as 4 days in 1986/87. If this dwell time does not change in the future, the average usage of yards per year will be as follows.

$$Ry = \frac{365}{4} = 91.3 \text{ times}$$

④ The dwell time at the transitsheds is estimated as 5 days in 1986/87. If this dwell time does not change in the future, the average usage of sheds per year will be as follows.

$$Rs = \frac{365}{5} = 73 \text{ times}$$

The required shed area for fertilizer is calculated as follows.

in 1994/95 $$As = \frac{20,000 \times 1.3}{73 \times 1.3 \times 0.6} = 457m^2$$

in 2004/05 $$Ay = \frac{30,000 \times 1.3}{73 \times 1.3 \times 0.6} = 685m^2$$

The required open storage yard area for raw materials for fertilizer is calculated as follows.

in 1994/95 $$Ay = \frac{380,000 \times 1.3}{91.3 \times 1.3 \times 0.7} = 5,946m^2$$

in 2004/05 $$Ay = \frac{630,000 \times 1.3}{91.3 \times 1.3 \times 0.7} = 9,858m^2$$

⑤ The number of berths utilized for this commodity is 3 in 1994/95 and 4 in 2004/05. And the number at this district is 1 in 1994/95 and 2

in 2004/05.

⑥ So the required open storage yard and shed area for dry bulk cargoes is calculated as follows.

in 1994/95 $Ay = 5,946 \times \frac{1}{3} = 1,982m^2$

in 2004/05 $Ay = 9,858 \times \frac{2}{4} = 4,929m^2$

in 1994/95 $As = 457 \times \frac{1}{3} = 152m^2$

in 2004/05 $Ay = 685 \times \frac{2}{4} = 229m^2$

⑦ The required storage area for break bulk is as follows.

	Sheds	Yards
in 1994/95	$11,914m^2$	$13,959m^2$
in 2004/05	$13,725m^2$	$14,629m^2$

⑧ Accordingly, the required storage area for all commodities is as follows.

	Sheds	Yards
in 1994/95	$12,066m^2$	$15,941m^2$
in 2004/05	$13,954m^2$	$19,558m^2$

⑨ The existing storage facilities area as follows.

No. of berths	Transitshed Area	Open Storage Area
2	$3,345m^2$	
4	$3,344m^2$	$892m^2$
6	$3,345m^2$	$780m^2$
8	$3,344m^2$	$1,450m^2$
10	$3,345m^2$	
12	$3,344m^2$	
(B)	$5,287m^2$	
Total	$25,354m^2$	$3,122m^2$

⑩ The required shed area is less than the existing shed area. So the following area can be demolished in the future.

in 1994/95 $25,354 - 12,066 = 13,288m^2$

in 2004/05 25,354 - 13,954 = 11,400m2

⑪ So it is possible to demolish the sheds No. 4, and B. After demolishing these sheds, the area of existing transitsheds becomes as follows.

As = 16,723m^2

⑫ By the rearrangement of the road system, the open storage yard area at the back side of respective berths will be as follows.

	Yard Area
At the back side of berths 2, 4, and 6	12,700m^2
At the back side of berths 8, 10, and 12	10,610m^2
	23,310m^2

⑬ Accordingly, we can obtain the required open storage yard area in 2004/05.

⑭ As fertilizer berth will need to be able to handle cargo amount of road traffic, so the road network in dock area should be rearranged as well as the improvement of roads around the dock area.

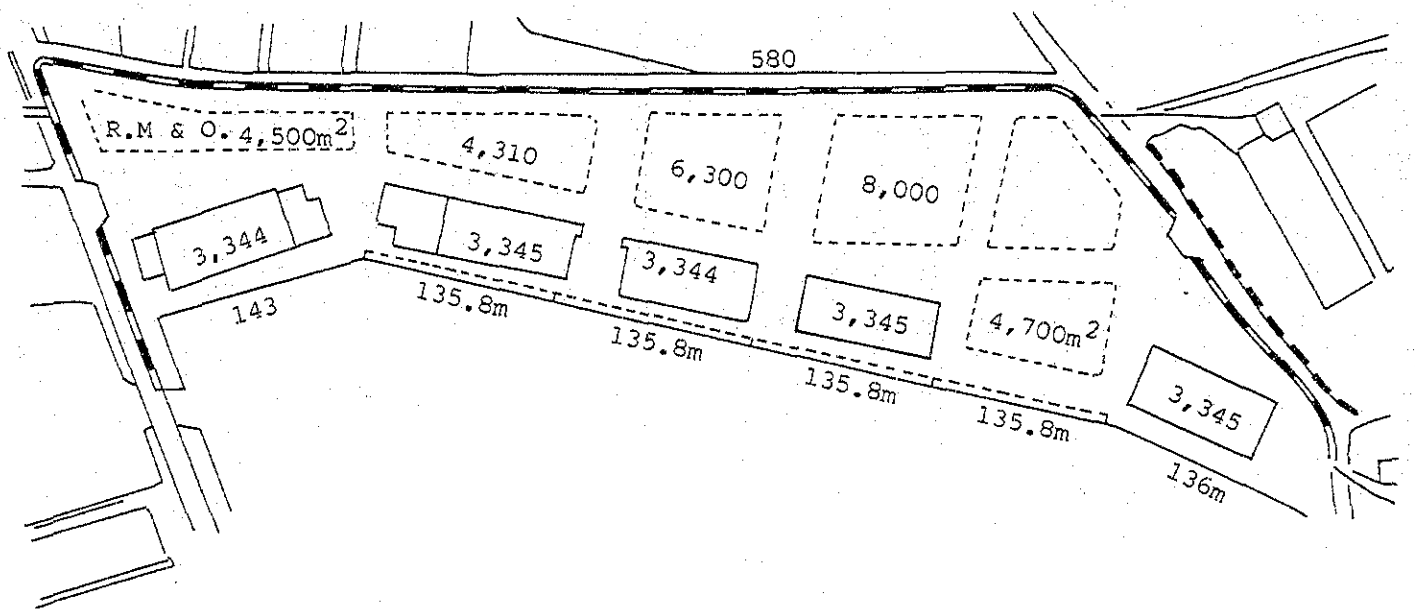


Fig. 11-1-8 Improvement Plan of East Side of KPD1 in 2004/05

4) NSD District

① The forecast container volume is as follows.

	in 1994/95	in 2004/05
Import	55,000 TEUs	55,000 TEUs
Loaded	45,000	46,400
Empty	10,000	8,600
Export	55,000	55,000
Loaded	42,000	25,400
Empty	13,000	29,600
Total	110,000	110,000
IWT	20,000	62,000

(Required CFS Area)

② The container volume which will be handled at CFS will be 50 % in 1994/95 and 20 % in 2004/05 of the total loaded container volume. Then the container volume via the CFS is as follows.

in 1994/95 87,000 TEUs x 0.5 = 43,500 TEUs

in 2004/05 76,000 TEUs x 0.2 = 15,200 TEUs

③ The required area of the CFS is calculated by the following formula.

$$S = \frac{C \times D}{w \times r \times K}$$

where S : Required Area of CFS (m^2)

C : Cargo Volume of Total Containers via CFS (ton)

D : Dwell Time in CFS (days)

w : Unit Weight of Cargoes in CFS (tons/m^2)

r : Effective Area Ratio of CFS

K : Working Days per Year

Usually, the unit weight 'w', the effective area ratio of CFS 'r' and the working days p.a. 'K' are as follows.

$w = 1.3$ tons/m^2

$r = 0.5$

$K = 350$ days

The dwell time of containerized break bulk cargoes is as follows.

Import 15 days

Export 9 days

④ The cargo volume per container is estimated as follows.

in 1994/95

Import 580,000 tons / 45,000 TEUs = 12.89 tons/TEU

Export 530,000 tons / 42,000 TEUs = 12.62 tons/TEU

in 2004/05

Import 1,460,000 tons / 113,000 TEUs = 12.92 tons/TEU

Export 775,000 tons / 62,000 TEUs = 12,50 tons/TEU

⑤ The cargo volume via the CFS is as follows.

in 1994/95

Import 45,000 x 0.5 x 12.89 = 290,025 tons

Export 42,000 x 0.5 x 12.62 = 265,020 tons

in 2004/05

Import 46,400 x 0.2 x 12.92 = 119,898 tons

Export 25,400 x 0.2 x 12.50 = 63,500 tons

⑥ Accordingly, the required area of CFS can be obtained as follows.

in 1994/95

$$S = \frac{290,025 \times 15}{1.3 \times 0.5 \times 350} + \frac{265,020 \times 9}{1.3 \times 0.5 \times 350} = 29,607m^2$$

in 2004/05

$$S = \frac{119,898 \times 15}{1.3 \times 0.5 \times 350} + \frac{63,500 \times 9}{1.3 \times 0.5 \times 350} = 10,417m^2$$

⑦ At the back side of D berth of NSD, the area of $9,040m^2$ of CFS is now under construction. Even if we plan another CFS at the back side of 4 and 5 berth of NSD, it is not possible to obtain sufficient CFS area in 1994/95. This is because the CFS cargo ratio in 1994/95 will still be 50 %. The ratio will soon be reduced to 20 % in 2004/05 and 2 CFS will surely be sufficient to handle the CFS cargoes in 2004/05. The existing transitshed area at the back side of container berths is as follows.

	Shed Area	Ground Floor
At the back side of D berths	$12,263m^2$	$6,132m^2$
At the back side of 4 berths	$17,758m^2$	$5,919m^2$
Total	$30,021m^2$	$12,051m^2$

If we use these sheds also as CFS, the total usable area in 1994/95

will be as follows.

New CFS 2 x 9,040 = 18,080m^2

Sheds = 12,051m^2

30,131m^2

When we utilize the existing shed as CFS and construct 2 New CFS, it is possible to obtain a sufficient CFS area in 1994/95.

But there is an opinion that the shed at the back of berth D is physically not usable. And the plan is to demolish this shed, as soon as the CFS, now under construction, becomes operational. In this case, the usable shed as CFS is only the shed at the back of berth 4. Then the total usable area will be as follows.

New CFS 2 x 9,040 = 18,080m^2

Sheds = 5,919m^2

Total 23,999m^2

On the other hand, the required area of CFS in 1994/95 is 29,607m^2, so the shortage area of CFS in 1994/95 is as follows.

Shortage Area of CFS = 29,607 - 23,999m^2 = 5,608m^2

As the required CFS area in 2004/05 is 10,417m^2, so it is not economical to construct another CFS.

At present, CPT stuff and devan containers on open yards. Accordingly, some amounts of cargoes must be handled tentatively in the same way in 1994/95.

(Required Container Yard Area)

⑧ The required container slots can be calculated by the following formula.

$$L = \frac{My}{Dy} \times Ds$$

where L : Required Container Volume

My: Container Volume p.a

Dy: Total Working Days p.a

Ds: Average Dwell Time of Containers

⑨ The international container volume of loaded containers is as follows.

in 1994/95 87,000 TEUs x 0.5 = 43,500 TEUs

in 2004/05 71,800 TEUs x 0.8 = 57,440 TEUs

⑩ From the empty container ratio, the volume of the loaded containers and the volume of the empty containers for IWT are as follows.

	Total	Loaded	Empty
in 1994/95	20,000 TEUs	14,140 TEUs	6,060 TEUs
in 2004/05	62,000 TEUs	46,500 TEUs	15,000 TEUs

⑪ The required stacking yard areas for IWT are as follows.

in 1994/95

$$\text{Loaded} \quad A = \frac{14{,}100 \times 10 \times 1.3}{365 \times 180 \times 2.5} \times 10{,}000\text{m}^2 = 11{,}200\text{m}^2$$

$$\text{Empty} \quad A = \frac{6{,}060 \times 20 \times 1.3}{365 \times 490 \times 3} \times 10{,}000\text{m}^2 = 2{,}900\text{m}^2$$

in 2004/05

$$\text{Loaded} \quad A = \frac{46{,}500 \times 8 \times 1.3}{365 \times 180 \times 2.5} \times 10{,}000\text{m}^2 = 29{,}400\text{m}^2$$

$$\text{Empty} \quad A = \frac{15{,}500 \times 20 \times 1.3}{365 \times 490 \times 3} \times 10{,}000\text{m}^2 = 7{,}500\text{m}^2$$

⑫ The required stacking slots for IWT are as follows.

in 1994/95 Loaded Slots = 1.12 x 180 = 202 Slots

in 2004/05 " = 2.94 x 180 = 529 Slots

These slots are preferably provided for IWT itself in the long run.

⑬ The average dwell time of containers is estimated as 20 days for international containers. So, the required container volume can be calculated as follows.

in 1994/95

$$L = \frac{43{,}500 \times 20}{350} = 2{,}486 \text{ TEUs}$$

in 2004/05

$$L = \frac{57{,}440 \times 20}{350} = 3{,}282 \text{ TEUs}$$

⑭ If we assume the average stacking height of international containers is 1.5, the required slots will be as follows.

	International	IWT	Total
in 1994/95	1,657 slots	202 slots	1,859 slots
in 2004/05	2,188 slots	529 slots	2,717 slots

⑮ The present container yard capacity at the back side of D berth of NSD is 1,152 slots, so the following capacity must be provided at the back side of berths 4 and 5 of NSD.

1,859 - 1,152 = 707 slots

Therefore we will provide 800 slots at the back side of berths 4 and 5 of NSD.

⑯ In 2004/05, there will be 1,692 slots at the back side of D berth of NSD, and 1,200 slots at the back side of 4 and 5 berths of NSD, and 540 slots at Gorden Reach Jetty. So the total slots will be as follows.

Total Slots = 1,150 + 1,200 + 540 = 2,892 slots

Therefore there will be sufficient slots in 2004/05.

⑰ The required area of storage facilities for break bulk cargoes is as follows.

	Sheds	Yards	Total
in 1994/95	8,933m^2	10,470m^2	19,403m^2
in 2004/05	13,725m^2	14,626m^2	28,351m^2

⑱ The existing storage facilities at the back side of 1, 2 and 3 berths of NSD are as follows.

	Shed Area	Ground Floor	Yard
At the back side of 2 berth	17,757m^2	5,919m^2	3,831m^2
At the back side of 3 berth	17,758m^2	5,919m^2	1,487m^2
At the back side of 1 berth			4,300m^2
Total	35,515m^2	11,838m^2	9,618m^2

⑲ In 1994/95, the existing shed area on the Ground floor will provide the required shed area, but the following shortage of open storage area will occur.

10,470m^2 - 9,618m^2 = 852 m^2

⑳ In 2004/05, the following shortage of shed area and open storage area will occur.

Shed 13,725m^2 - 11,838m^2 = 1,887m^2

Yard 14,626m^2 - 9,618m^2 = 5,008 m^2

⑵ Accordingly, in 2004/05, we must expand the existing shed area from 5,919m^2 to 7,000m^2, and develop the folowing yard area.

At the back side of 1 berth	7,400m^2
At the back side of 3 berth	500m^2
	15,900m^2

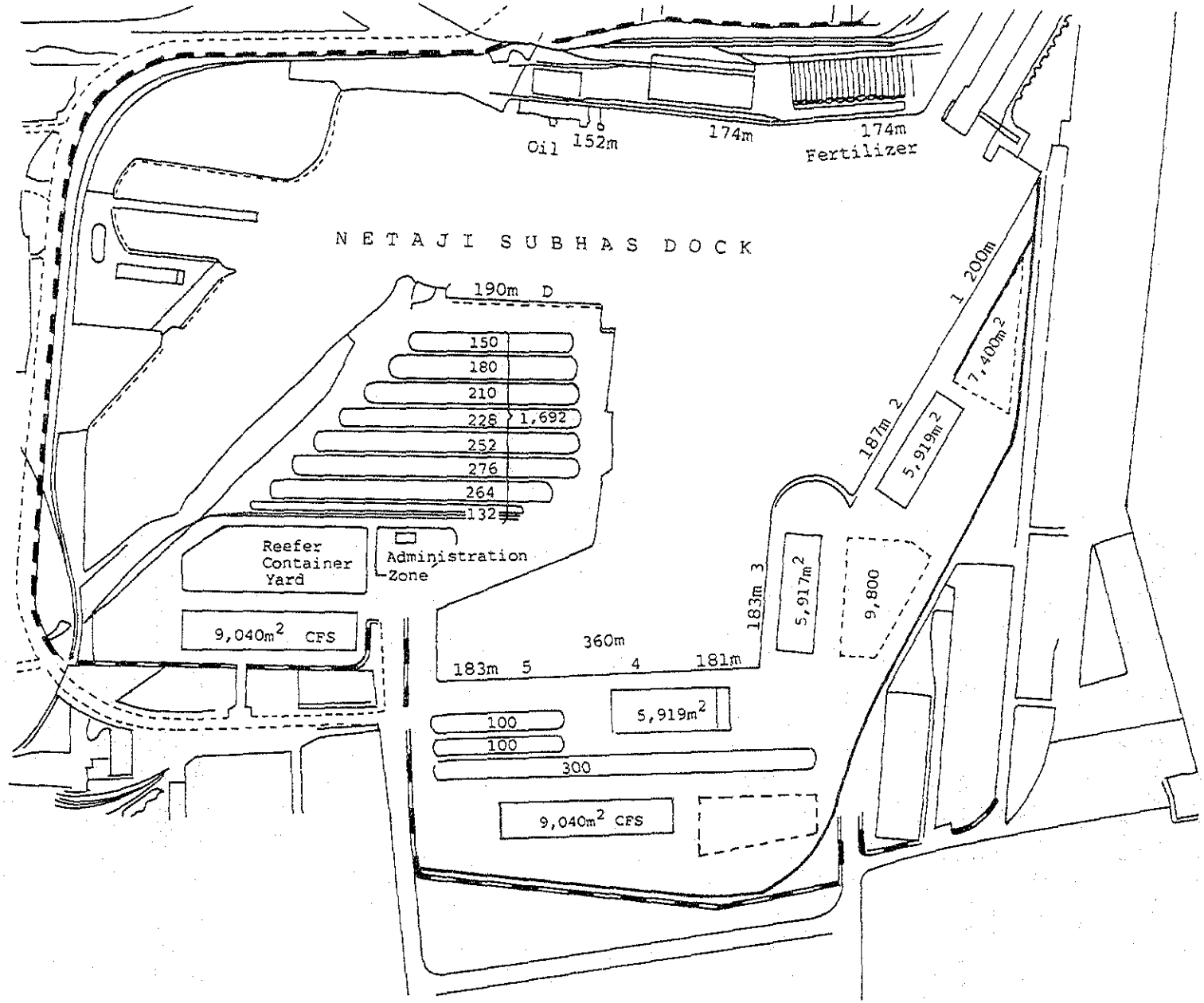


Fig. 11-1-9 Improvement Plan of NSD in 1995

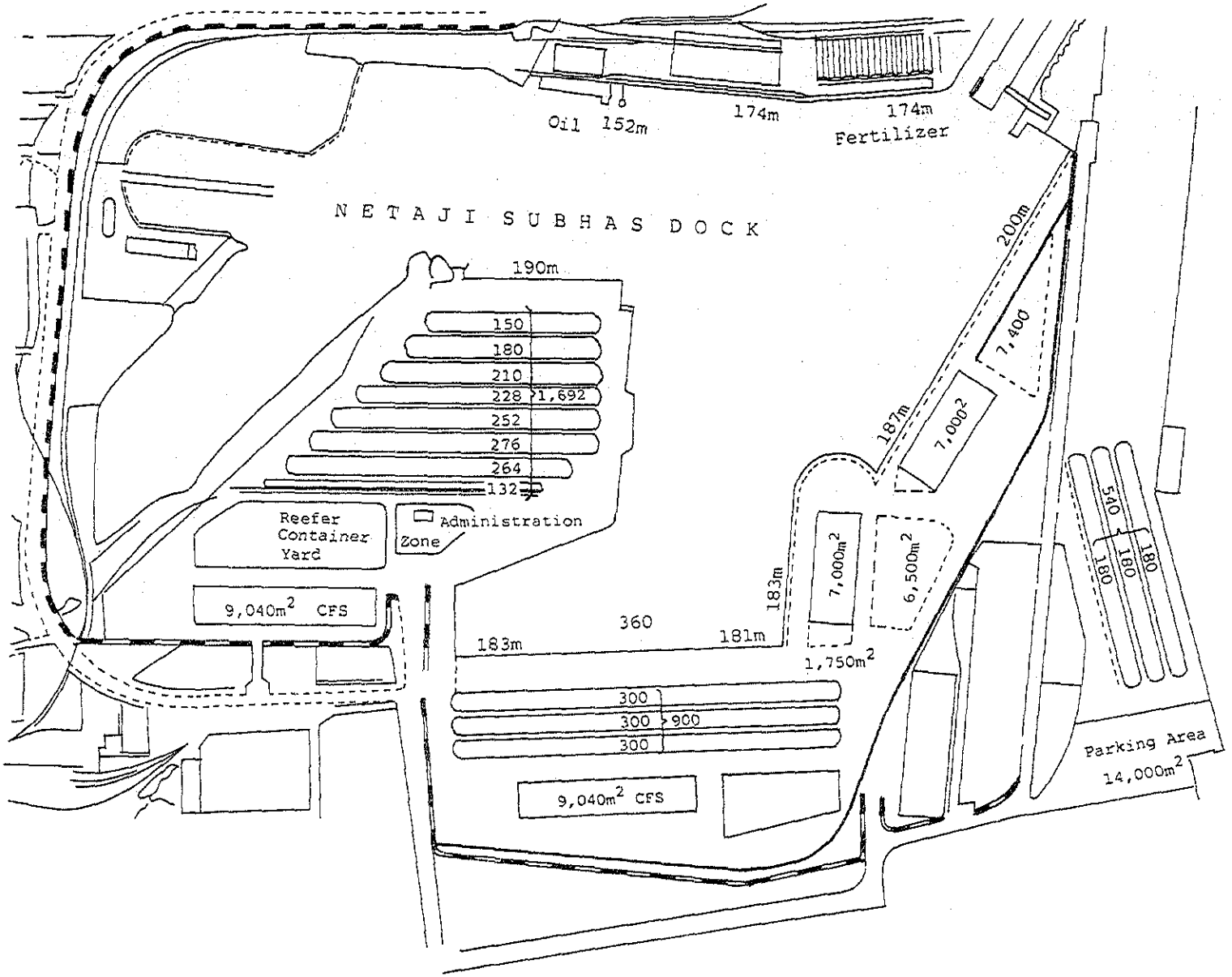


Fig. 11-1-10 Improvement Plan of NSD in 2005

11-1-7 Port Traffic Facilities

(1) Railway System in Calcutta Port

At present, GCD subsidiary yard has 21 tracks. It seems necessary to reduce the size of this yard because of the decline of the cargo volume handled at the quay side lines. The required number of tracks at present may be 10 - 12 tracks.

As the cargo volume to and from quay side lines is forecast to remain stable through 1995, 10 -12 tracks at GCD yard shall remain through 1995. However, by 2005, to improve the railway operation, most railway cargo will be shifted to a new loading terminal which will be located at EJC yard and most quay side lines will be eliminated. On the other hand, new tracks shall be constructed for container rakes along side the GCD yard.

It is also necessary to remove tracks at EJC yard, which presently has 50 tracks. Of these, 7 fully electrified arrival tracks, 7 top electrified departure tracks, 3 sorting tracks, and 2 tracks for loco movement shall remain through 1995.

As mentioned above the requirement for the quay side tracks is expected to gradually decrease. It would be better to construct a full rake loading terminal behind the quay side sheds to improve operational efficiency. However it seems that KPD and NSD dock do not have enough space for these additional facilities. Therefore, a loading terminal which will receive empty block rakes from Indian Railways directly and transfer rakes to reception lines without any repeated shunting operations is required. Container movement by rail will increase in the case of Alternative-1 (2005). Therefore, additional railway facilities for the container movement shall be developed up to 2005. The location of these railway facilities and the required number of tracks are discussed below.

1) Block Rake Loading Terminal

The required number of reception tracks, departure tracks and loading tracks are calculated for the Short-term and Master plan by the following equations on the assumption that the arrival rate of the rakes follows a poisson distribution and the service rate follows an exponential distribution.

$$Lq = \frac{S^S \rho^{S+1}}{S! (1-\rho)^2} Po$$

$$Wq = \frac{S^{S-1} \rho^S}{S! \mu (1-\rho)^2} Po$$

$$Po = 1 / \left\{ \sum_{n=0}^{S-1} \frac{a^n}{n!} + \frac{a^S}{(S-1)! (S-a)} \right\}$$

where,

Lq : Required number of reception tracks = Number of rakes waiting at the reception tracks

Wq : Average waiting time at the reception tracks (days)

S : Number of loading/unloading tracks

λ : Average number of arrival rakes per day

$$\lambda = \left(\frac{A}{T} \times \frac{1}{V} \times k\right) / t$$

where,

A : Cargo handling volume per year

T : Yearly working days

v : Actual wagon loading volume (tonnes/wagon)

k : Empty wagon rate

t : Average number of wagons per rake

For the above coefficients, the following values are used.

T = 350 days, v x t = 2,000 tons, k = 1.0

μ : Number of rakes loaded/examined at the loading terminal per day.

$\frac{1}{\mu}$: Required time for loading/examining at the loading terminal per rake.

a : $\frac{\lambda}{\mu}$

ρ : a/S

As shown above, the required number of reception tracks and loading tracks depends on the loading operational efficiency. The relation between $\frac{1}{\mu}$ and Lq, Wq are as shown in Table 11-1-7 for the short-term plan in 1995.

A = 200,000 tonnes

λ = 0.2857

Table 11-1-7 Required No. of Reception Tracks in 1995

$1/\mu$ (hrs)	No. of loading/unloading tracks	ρ	Lq	Wq	Required no. of reception tracks
24	1	0.2857	0.114	0.400	1
36	1	0.4286	0.322	1.125	1
48	2	0.2857	0.051	0.178	1

As shown in Table 11-1-7, two loading/unloading tracks will be necessary through 1995 at over 90% reliability. In addition, one reception track will be used for the block rakes.

The required number of reception tracks and loading tracks for the Master Plan in 2004/05 when cargo handling volume will be 0.50 million tonnes at the loading terminal is calculated in the same way as for the short-term plan and presented in Table 11-1-8.

A = 500,000 tonnes

T = 350 days

$v \times t$ = 2,000 tonnes

λ = 0.714

Table 11-1-8 Required No. of Reception Tracks in 1995

$1/\mu$ (hrs)	No. of loading/unloading tracks	ρ	Lq	Wq	Required no. of reception tracks
24	2	0.3570	0.104	0.146	1
36	3	0.3570	0.060	0.084	1
48	3	0.4760	0.192	0.269	1

Considering the improvement of loading operation through 2005, Three loading tracks will be enough for the estimated cargo volume. In addition, one reception track shall be used for this terminal.

There are two alternative locations for the block rake loading terminal viz. the northern part of EJC and the southern part of EJC. Considering the construction cost, the northern part of EJC seems preferable to the southern part. It would consist of only the track removal cost and the paving cost. In the case of the southern part of EJC,

a new road would be necessary and there would be additional cost for reclaiming a small canal.

However, the southern part of EJC has some advantages. It has a vacant lot for the expansion of the terminal. In 2005, this block rake loading terminal will have to handle around 0.5 million tonnes and three full rake lines which can handle three rakes at the same time. Considering the above and the necessity of the linkage between Oil Installation Road and Remount Road which will cross the northern part of EJC and will have to share a large part of the total traffic in the port area, it seems reasonable to construct the loading terminal at the southern part of EJC.

Fig. 11-1-11 show the conceptual plan of the block rake loading terminal to be located at EJC yard in 1995 and 2005.

Before developing the block rake loading terminal, operational problems in loading/unloading trucks and wagons and transportation in the port area should be identified and carefully considered. Therefore, we recommend conducting a trial. Considering the least cost, the northern part of EJC may be proposed as the trial site.

2) Container Terminal

The required number of reception tracks, departure tracks and loading/unloading tracks are calculated using the same method as for the block rake loading terminal.

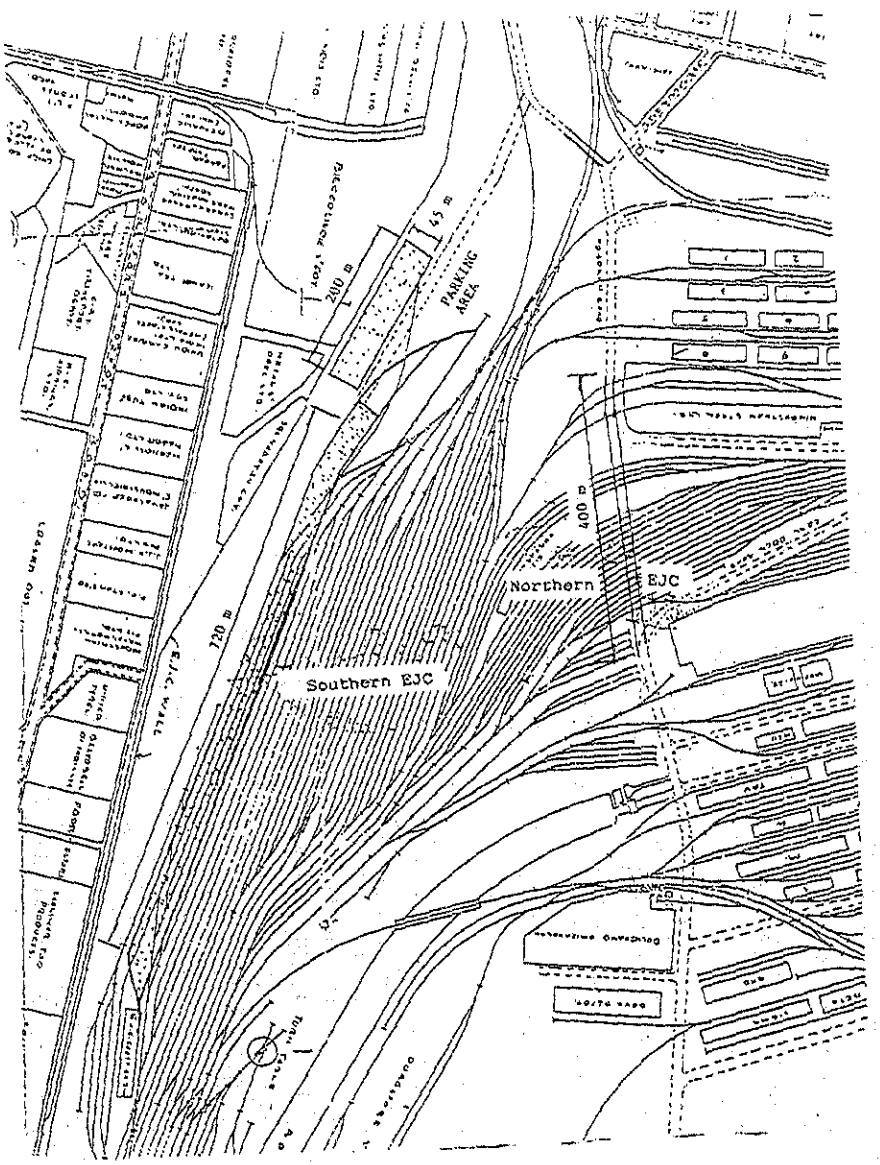
The number of containers (TEUs) to be handled by Calcutta railway system will be 58,500 TEUs (Alternative-1), 14,100 TEUs (Alternative-2) in 2004/05 and 22,000 TEUs in 1995 (see 8-4-4).

The average number of arrival rakes per day (λ) is calculated by the following equation.

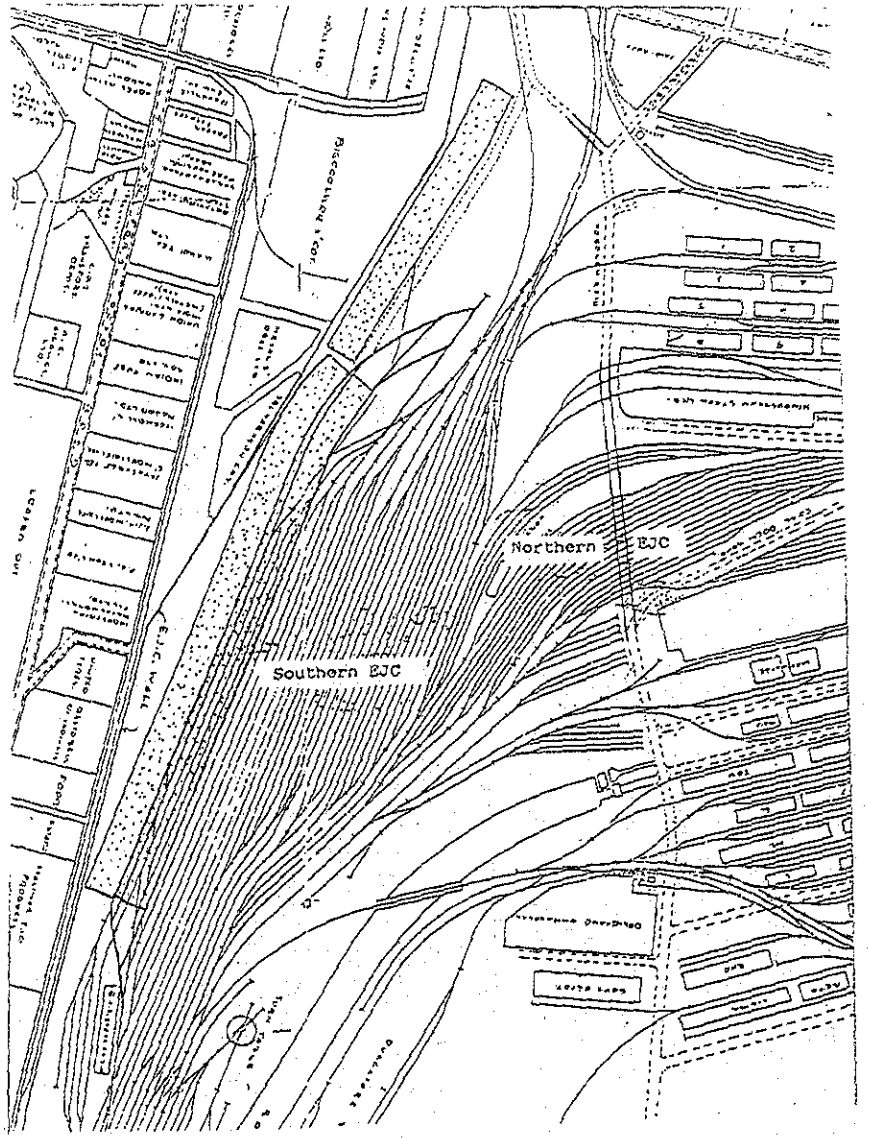
$$\lambda = \frac{A}{T} \times \frac{1}{t} \times k \times \frac{1}{2}$$

where A : Number of TEUs to be handled per year including empty containers
T : Working days per year
t : Average number of containers (TEUs) per rake
k : Empty wagon rate

As mentioned above, the required number of reception tracks,



SHORT TERM PLAN (1995)



MASTER PLAN (2005)

Fig. 11-1-11 Block Rake Loading Terminal

loading/unloading tracks and departure tracks depends on the operational efficiency.

The average staying periods of container rakes at each of the tracks at Haldia are as follows.

Reception Tracks : 3 hrs
ICD (loading/unloading tracks) : 18 hrs
Departure Tracks : 9 hrs

a) NSD Container Terminal

The required number of reception tracks shall be examined considering that waiting of incoming rakes at the trunk line should be strictly avoided and the required number of reception tracks depends on the number of loading/unloading tracks and the operational efficiency.

The required number of departure tracks shall be set considering that outgoing rakes should not wait at the loading/unloading tracks for departure tracks.

The required number of reception tracks, departure tracks and loading/unloading tracks in 1995 and 2005 (Alternative-2) are calculated on the condition that all railborne containers will be handled at the NSD container terminal, and are presented in Table 11-1-9.

The arrival rate is calculated by the equation below.

$$\lambda = \frac{A}{T} \times \frac{1}{t} \times k \times \frac{1}{2}$$

where, T = 350 days
t = 80 TEUs/rake
k = 1.2

Table 11-1-9 Required Number of Tracks at NSD Container Terminal

	Handling Volume A (TEUs)	λ	μ	Required Number of Tracks		
				Reception	Loading/ unloading	Departure
1995	22,000	0.4714	8 (Reception)	1	-	-
			1.33 (loading/ unloading)	1	1	-
			2.67 (Departure)	-	-	1
2005 Alter-native -2	14,100	0.3021	8 (Reception)	1	-	-
			1.33 (loading/ unloading)	1	1	-
			2.67 (Departure)	-	-	1

b) Second Container Terminal

In 2005 (Alternative-1), second container terminal will be constructed at KPD or NSD to cater to the increased container volume. The number of containers which the new container terminal will handle will be 36,500 TEUs. In the case of Alternative-2, no additional containers will be handled at the second container terminal. The required number of tracks are calculated in Table 11-1-10.

Table 11-1-10 Required Number of Tracks at the Second Container Terminal

	Handling Volume A (TEUs)	λ	μ	Required Number of Tracks		
				Reception	Loading/ unloading	Departure
2005	36,500	0.7821	8 (Reception)	1	-	-
			1.33 (loading/ unloading)	1	2	-
			2.67 (Departure)	-	-	2

3) General improvement plan of Calcutta railway system

Fig. 11-1-12 and Fig. 11-1-13 show the general plan of Calcutta railway system in 1995 and in 2005 (Alternative-2) respectively. Through 1995, most quayside tracks shall be eliminated. On the other hand, the container terminal at NSD and the block rake terminal at EJC shall be developed and the quay side tracks at KPD-2 and NSD A, B would remain. The block rake terminal shown in Fig. 11-1-13 shall handle not only bulk cargo but also general cargo. Therefore, it may include an elevated loading/unloading platform to facilitate stuffing.

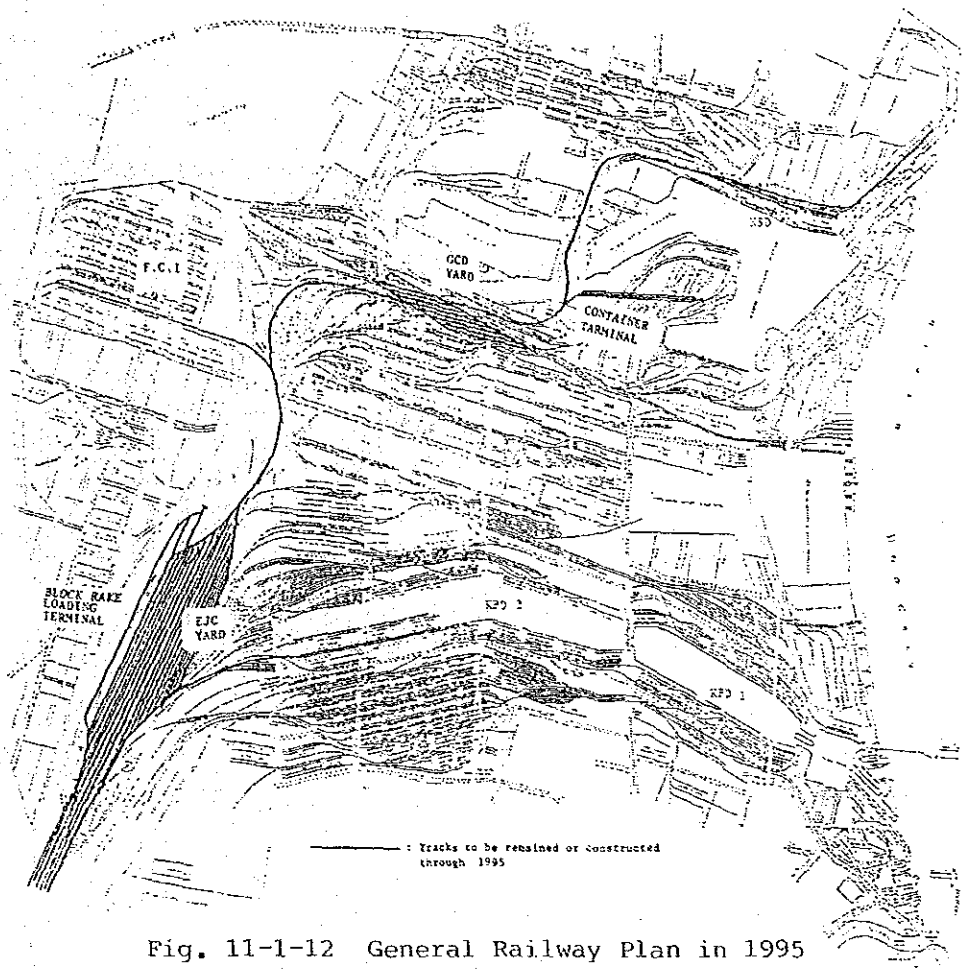


Fig. 11-1-12 General Railway Plan in 1995

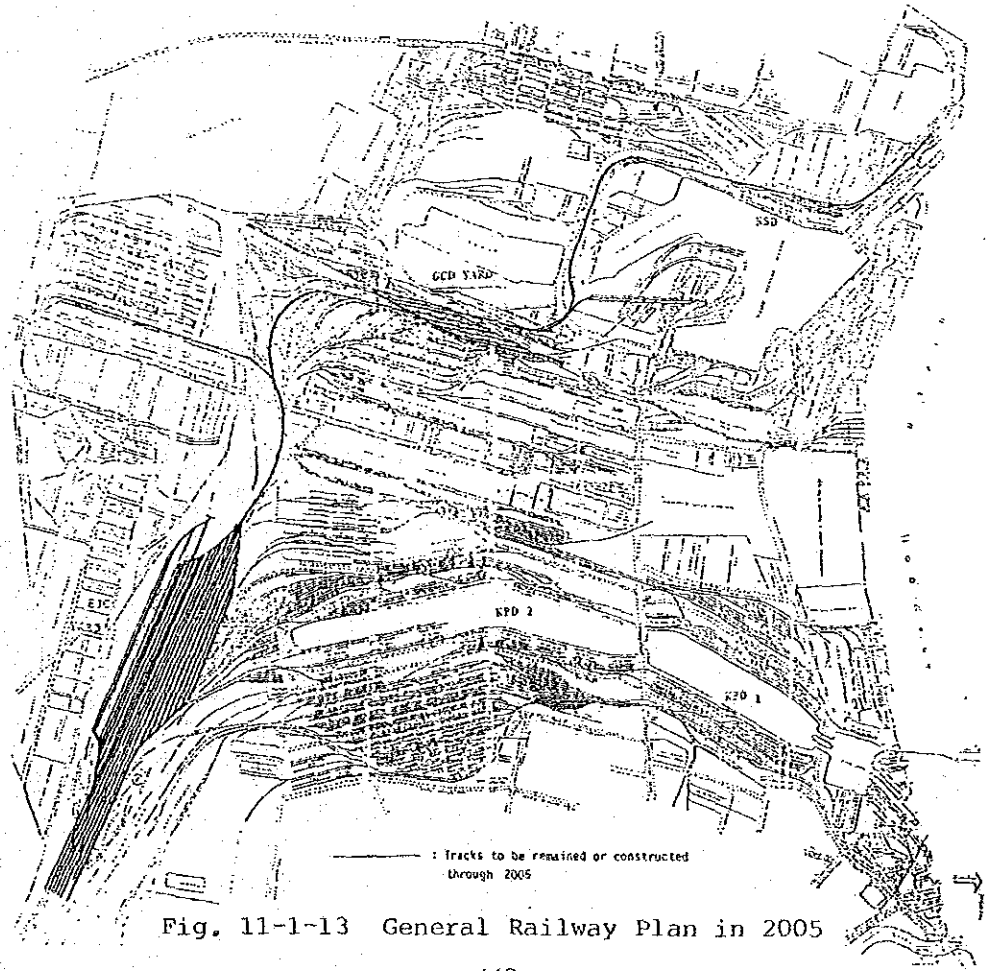


Fig. 11-1-13 General Railway Plan in 2005

(2) Road System in Calcutta

1) Traffic volume

The traffic volumes (loaded) generated from each dock in 1995 and 2005 (Alternative-2) are calculated from the cargo volume and presented in Table 11-1-11 ～13.

Table 11-1-11 Estimated Number of Trucks Per Day (in 1995)

Dock	Commodity	Cargo Volume by truck (,000 tonnes, TEU)		Loaded Traffic Volume (No. of trucks)	
		Import	Export	Import	Export
KPD-1 (East)	General Cargo	428	72	127	21
KPD-1 (West)	Dry Bulk	257	-	76	-
	General Cargo	257	43	76	13
KPD-2	Dry Bulk	129	-	38	-
	General Cargo	599	101	178	30
NSD	Dry Bulk	129	-	38	-
	General Cargo	634	213	189	63
	Container	12,510	12,510	33	33
GRJ	Container	3,055	3,055	8	8
	General Cargo	32	30	10	9

Note: (1) Yearly working days = 350
(2) Loaded Traffic Volume = Cargo Volume by truck/Average load (9.6t)
(3) Conversion factor for container = 1.1

Table 11-1-12 Estimated Number of Trucks Per Day (in 2005, Alternative-1)

Dock	Commodity	Cargo Volume by truck (,000 tonnes, TEU)		Loaded Traffic Volume (No. of trucks)	
		Import	Export	Import	Export
KPD-1 (East)	General Cargo	627	67	187	20
KPD-1 (West)	Dry Bulk	535	-	159	-
	General Cargo	251	27	75	8
KPD-2	Dry Bulk	178	-	53	-
	General Cargo	877	93	261	28
NSD	Dry Bulk	178	-	53	-
	General Cargo	793	208	236	62
	Container	67,000	67,000	174	174
GRJ	Container	5,700	5,700	15	15
	General Cargo	62	33	18	10

Note: (1) Yearly working days = 350
(2) Loaded Traffic Volume = Cargo Volume by truck/Average load (9.6t)
(3) Conversion factor for container = 1.1

Table 11-1-13 Estimated Number of Truck Per Day
(in 2005, Alternative-2)

Dock	Commodity	Cargo Volume by truck (,000 tonnes, TEU)		Loaded Traffic Volume (No. of trucks)	
		Import	Export	Import	Export
KPD-1 (East)	General Cargo	627	67	187	20
KPD-1 (West)	Dry Bulk	535	-	159	-
	General Cargo	251	27	75	8
KPD-2	Dry Bulk	178	-	53	-
	General Cargo	877	93	261	28
NSD	Dry Bulk	178	-	53	-
	General Cargo	621	117	185	35
	Container	23,550	23,550	61	61
GRJ	Container	10,775	10,775	28	28
	General Cargo	118	63	35	19

Note: (1) Yearly working days = 350
(2) Loaded Traffic Volume = Cargo Volume by truck/Average load (9.6t)
(3) Conversion factor for container = 1.1

2) Parking space at the exit gates

The queuing of trucks at the exit gates causes congestion by occupying road space. The numbers of queueing trucks during rush hour at KPD-1 and 2 in 1995 and 2005 for Alternative-2 are estimated on the assumption that the arrival rate of the trucks at the exit gates follows a poission distribution and the service rate follows an exponential distribution. The estimation is presented in Tables 11-1-14 and 15. Here, the arrival rate (λ) is estimated as follows.

$$\lambda = N \times \beta \times \gamma \times (1 + \delta) \times \sigma$$

Where,

λ = Arrival rate per hour (in peak hour)

N = Number of loaded trucks as shown in Table 11-1-11 ~ 13

β = Monthly variation

γ = Daily variation

δ = Related vehicle rate

σ = Hourly variation

For the above coefficients, the following values are used.

β=1.2, γ=1.2, δ=0.5, σ=0.12,

Service rate/gate is assumed as 50 trucks/hour for general cargo/bulk cargo.

Considering the results shown in Tables 11-1-14 and 15, it seems reasonable that each gate have two exits and parking spaces (queueing lanes) for 5-10 trucks.

Similary, parking spaces for the trucks waiting for entry should be provided outside the gates.

Table 11-1-14 Number of Queueing Trucks at the Exit Gates (in 1995)

Gate	Arrival rate	Service rate per gate	Average number of trucks queueing	Required no. of parking spaces in terms of truck No. at over 90 % reliability	Number of gates
KPD-1 Gate 3	38	50	1	2	2
KPD-1 Gate 4	43	50	1	2	2
KPD-2 Gates	64	50	1 1	6 1	2 3

Table 11-1-15 Number of Queueing Trucks at the Exit Gates (in 2005, Alternative-2)

Gate	Arrival rate	Service rate per gate	Average number of trucks queueing	Required no. of parking spaces in terms of truck No. at over 90 % reliability	Number of gates
KPD-1 Gate 3	54	50	1	3	2
KPD-1 Gate 4	63	50	1	6	2
KPD-2 Gates	89	50	7 1	over 30 5	2 3

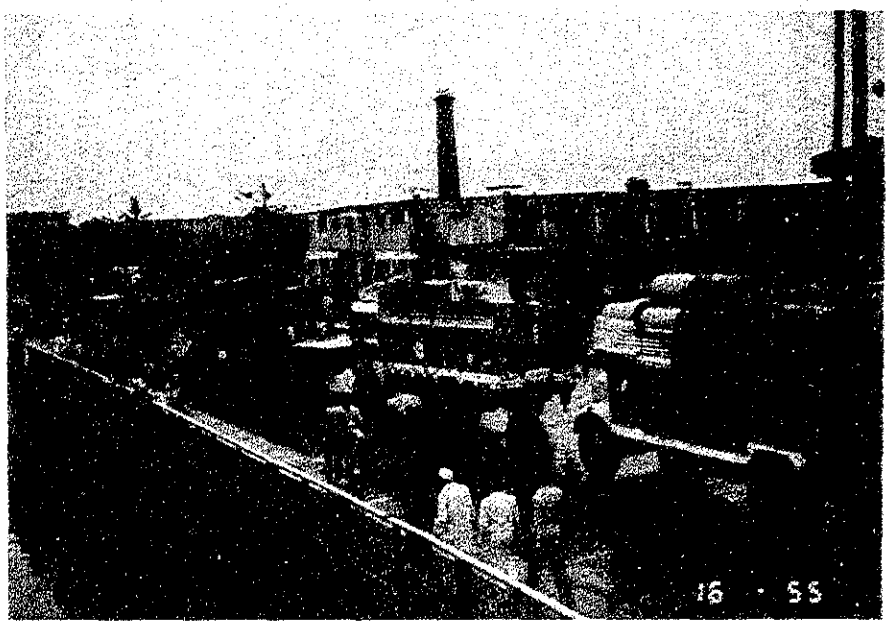


Photo 11-1-(1)

3) Projected traffic volume

The design hourly traffic volumes (M) for 1995 and 2005 are calculated by the following equation and presented in Figures 11-1-14 ~ 16.

$$M = N \times \beta \times \gamma \times \frac{(1+\delta)}{\varepsilon} \times \sigma$$

M : Hourly traffic volume

$N, \beta, \gamma, \delta, \sigma$: Refer to 2)

ε : Loaded truck rate (0.5)

According to Fig. 11-1-14 ~ 16. With only present network the hourly traffic volume on Circular Garden Reach Road would be over 300 trucks per hour even in 1995. Even with the present level of road traffic, Calcutta Port, Circular Garden Reach Road and especially Bascule Bridge, Kidderpore intersection and Kidderpore Bridge are very congested. As shown in Fig. 4-3-5, not only port related trucks but also buses and cars run on Bascule Bridge. At around 300 trucks/hour the bridge is at a standstill as shown in Photo 11-1-(1) due to the traffic Jam at Kidderpore intersection.

In order to ease the congestion on Circular Garden Reach Road, three measures are proposed, namely,

a) In order to reroute some heavy vehicles from Circular Garden Reach Road to Garden Reach Road, Swing Bridge should be replaced or reinforced and opened to heavy vehicles. Hasting Bridge on Garden Reach Road should also be expanded.

b) In order to avoid passing through Diamond Harbour Road and Kidderpore intersection and reroute the cargo traffic on Diamond Harbour Road from the industrial/commercial area in the port, Kantapukur Road, Eastern Boundary Road and Satya Doctor Road should be improved.

c) In order to reroute the traffic on Circular Garden Reach Road from NSD dock, Remount Road and Sonapore Road Should be linked.

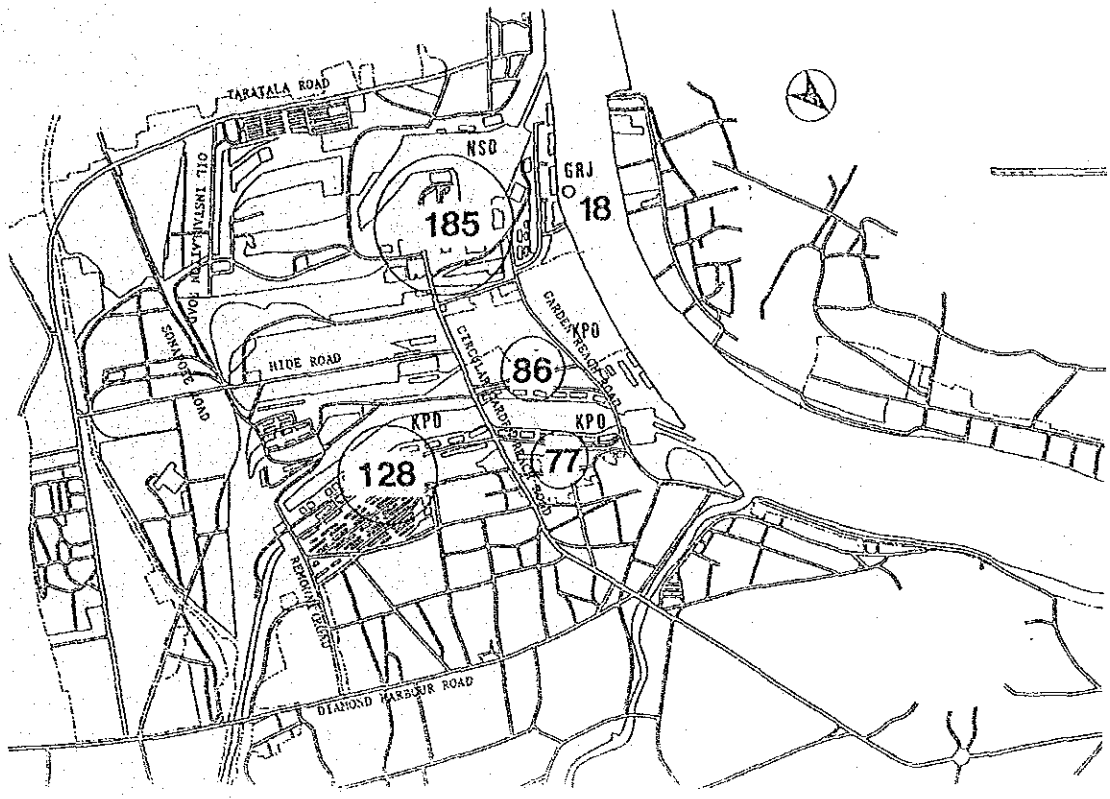


Fig. 11-1-14 Hourly Traffic Volume in 1995

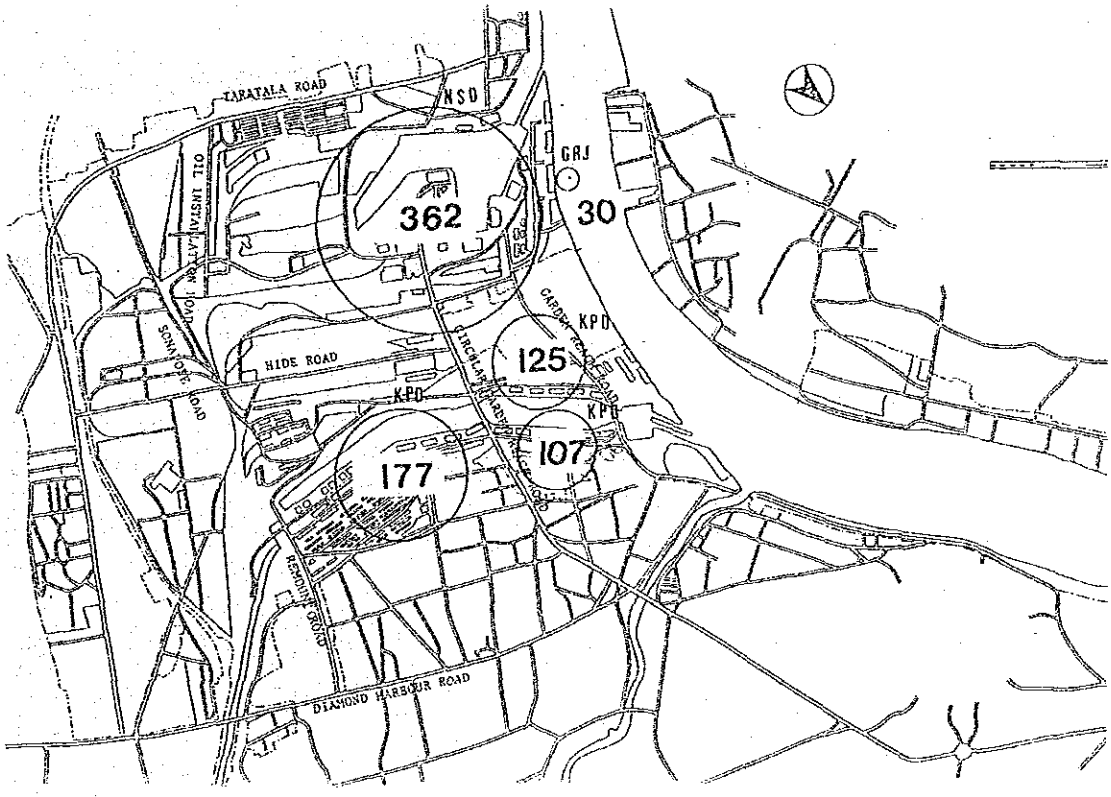


Fig. 11-1-15 Hourly Traffic Volume in 2005 Alternative-(1)

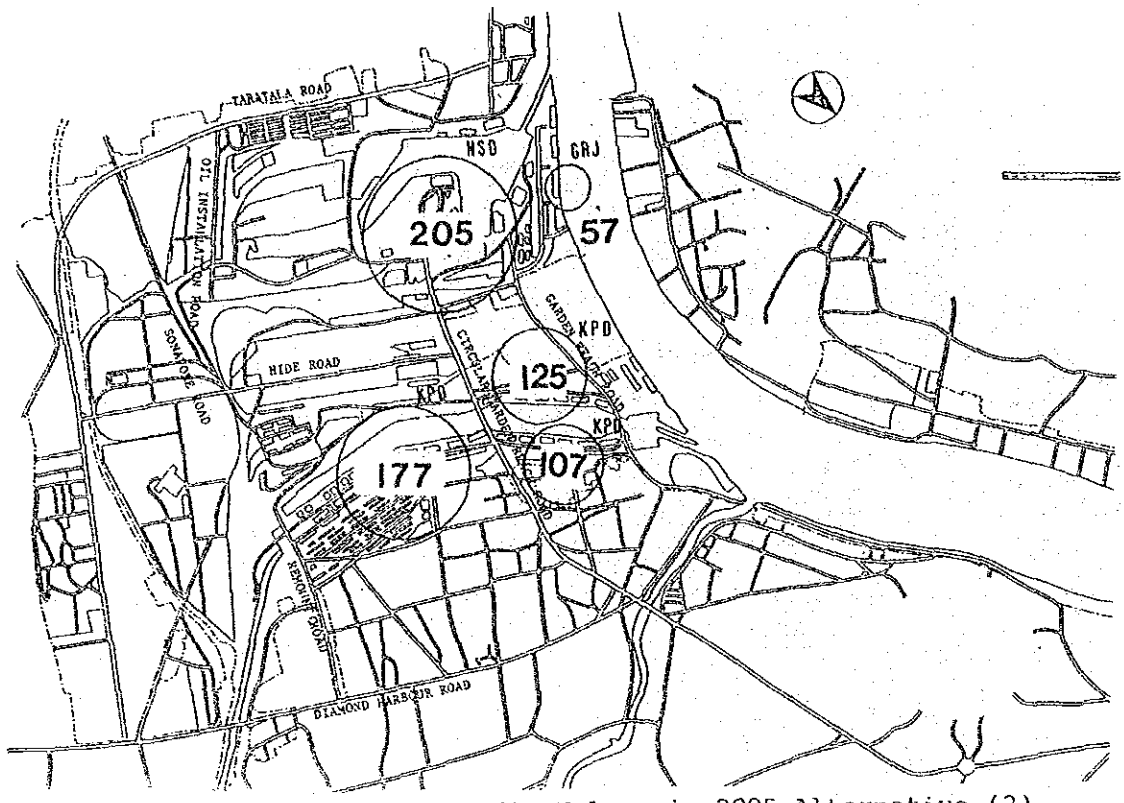


Fig. 11-1-16 Hourly Traffic Volume in 2005 Alternative-(2)

4) General improvement plan of Calcutta port road system

a) Major roads to be improved (ref. Fig. 11-1-18)

In order to ease the congestion on the roads, especially on Circular Garden Reach Road, we propose following improvement.

Up to 1995 : New roads

1) Linkage between NSD (conversion of the C.G.R.R) and Sonapore Road
2) Linkage between Sonapore Road and Remount Road

: Widening/improvement

1) Swing Bridge on Garden Reach Road
2) Hasting Bridge on Garden Reach Road
3) Sonapore Road and Hoboken Road
4) Hide Bridge

Up to 2005 : Widening/improvement

1) Kantapukur Road
2) Eastern Boundary Road
3) Satya Doctor Road
4) Hide Road
5) Flyover bridge on Hoboken Road
6) Replacement of Bascule Bridge on Circular Garden Reach Road

b) Parking facilities and road network within the docks

As mentioned in 2), queueing trucks on the road within the docks and around the gates cause traffic congestion.

The general layout of parking facilities and the road nework within the docks is planned so as to improve the cargo handling efficiency as shown in Fig. 11-1-17.

c) Parking facilities for trucks in the port area.

Not only port-related trucks but also local trucks travelling to and from the industrial/commercial area are parking on the roads viz. Hide road, Circular Garden Reach Road, and Garden Reach Road, causing traffic jams. Some parking spaces shall be provided in order to streamline the traffic flow on these roads. Fig. 11-1-18 shows the likely parking areas around the port.

For the port-related trucks, two parking areas shall be developed, one for KPD and one for NSD. For the non-port-related trucks one parking area shall be developed to ease the traffic congestion on Hide Road. This is proposed to be located at the EJC yard to be released.

Parking capacity is calculated considering the average parking duration (hours) and the average number of arrival trucks per hour. Presently, parking duration/truck is estimated as 0.9 hour and arrival rate is calculated refering to Fig. 11-1-14 and 16.

The required space for these parking area in 1995 and in 2005 (Alternative-2) is presented in Table 11-1-16. In addition, we propose the provision of refreshment stalls, rest rooms etc. at each truck parking area.

Table 11-1-16 Required space for parking areas

	Arrival rate (trucks/hour)	Service rate (trucks/hour)	Required capacity (No. of trucks)	Required space (m^2)
K P D	146 (1995)	1.11	150	15,000
	205 (2005)		225	22,500
N S D	102 (1995)	1.11	105	10,500
	131 (2005)		140	14,000

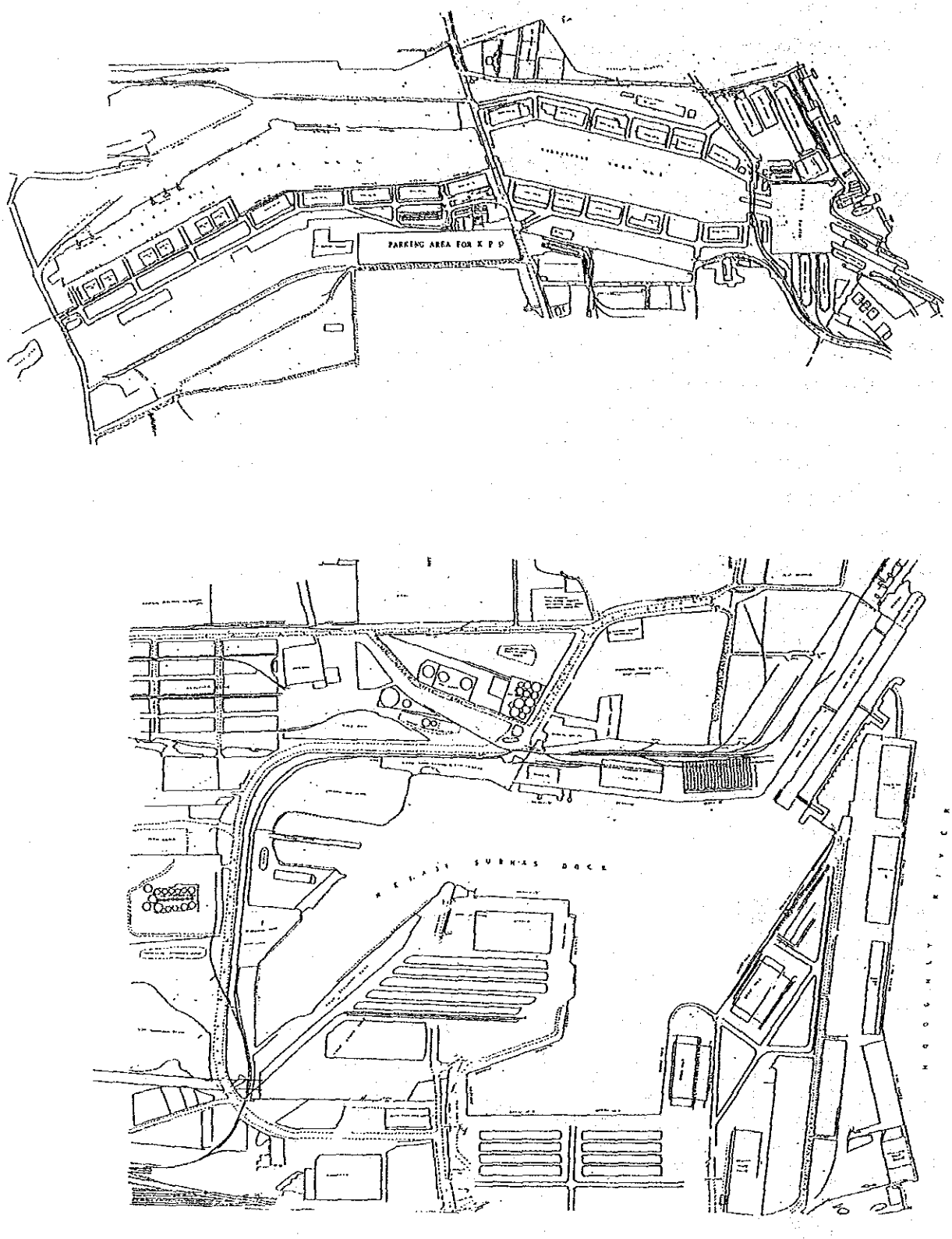


Fig. 11-1-17 General Layout of Road Network Around Docks

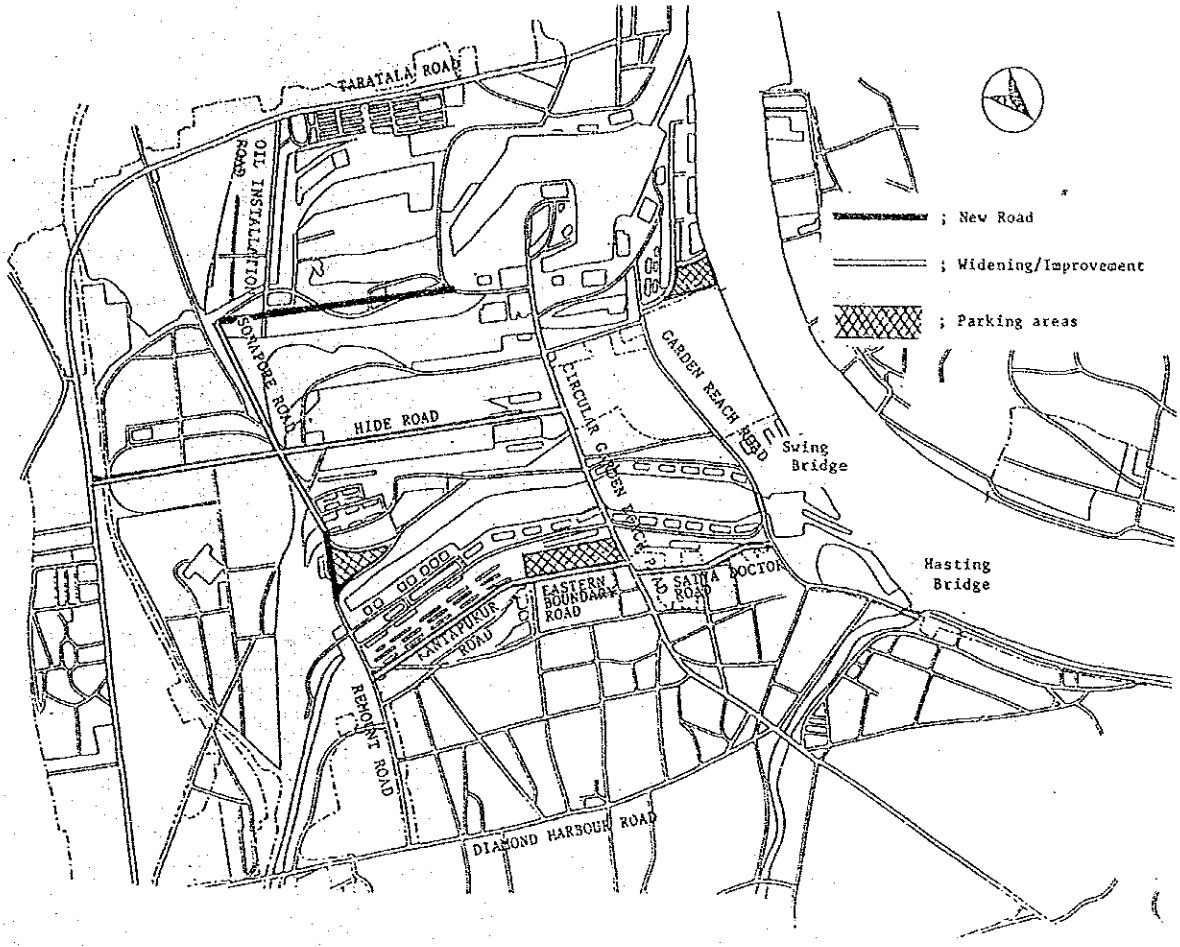


Fig. 11-1-18 Major Roads and Parking to be Improved/developed