shifted southwards compared with that in the Western Backwater Scheme shown in Fig. III-4-12. In fact, should the berth be constructed more upwards, the dredging cost will be raised considerably by involving the hard layer dredge. The hard layer N>150 appears, for example, at the level of -5m at an immediate westside of the fishery harbour. On the other hand, the southern most berth should be so located that the future access channel to a further inner berth may be excavated between the berth and Baba Island.
Out of six berths planned for the Master Plan, the two central berths shall be constructed at the stage of the Urgent Plan by taking a soil balance and soil condition into account.

4-6 Approach channel

The approach channel and turning basin are allocated as shown in Fig. III-4-10 and Fig. III-4-11.

4-6-1. Dimensions of approach channel

(1) Channel Width

According to the Japanese standard of port engineering, the channel width should be taken wider than 1/2 ship length for a one-way traffic when a ship traffic is not heavy and wider than 1.0 ship length for a two way traffic.

The statistic of length of container ship in use in 1979 is given in Table III-4-11. As shown, about 50% of container ships falls in the class shorter than 170m and 90% shorter than 245m and about 3% or 42 ships have the lengths between 285–290m.
The existing channel is 180m in width which is designed for 75000 DWT tanker and this allows a two way traffic for ships shorter than 180m or 53% of total number of container ships and a one way traffic for bigger ones. The ship sizes other than container carrier calling Karachi Port at present are shown in Fig. III-3-11 and 88% of ships calling Karachi is under the size of LOA 180m. As for the frequency of ship call, it is counted at about 4.5 ships/day in 1979–80 and this is not expected to increase in proportion to the total throughput of the port because the maximum tanker size has been increased and the majority of freighter will be replaced by a container ship. Considering all the aspects mentioned above, the present channel is not to be widened from the viewpoint of future container traffic, but the navigation aids system is to be reinforced to secure a safe ship operation.

(2) Channel Depth

The water depths along the existing channel and the proposed channel are shown in Fig. III-4-13. It is proposed that the existing channel from the frontage of Oil Pier No. 4 to the new basin be dredged to the depth of 37′ from 34′ at present. Then the channel follows the branch course to the fishery harbour upto the turning basin where the depth is to be dredged to 40′ below datum. The middle portion of the channel is planned shallower as at present by about one meter than the remainder because of no significant wave agitation.

The proposed channel is to cause a big ship to wait a high tide and the navigational conditions of the planned channel are analyzed and shown in Tables III-4-12 to III-4-14, and Fig. III-4-14 and III-4-15. Table III-4-12 shows a full load draft of container ships in the world in 1979 and in Table III-4-13 shown in an actual midship draft of Japanese container ships. It is shown that, if a container ship navigates at a 80% of full load draft (average actural draft), a 90% of container ships draw the actual draft of less than 9 m. Fig. III-4-14 shows the draft acceptable in the proposed channel. Table III-4-14 gives the average navigable time by ship's draft in the proposed channel for two cases; cautal drafts of 0.8 and 1.0 x full load draft. Fig. III-4-15 shows typical tidal variations in Karachi and Qasim and are taken into consideration in compiling the table above. From the analysis, it can be said that the navigational condition of the proposed channel is acceptable. The cost of dredging work for another one meter over the entire reach of the channel is estimated at about 5 million $ (assuming the sea bed is not so hard). From the consideration above, the channel depth is proposed as shown in Fig. III–4-13.

The depth of quay wall is designed to be 12m deep based on the Japanese standard of full-fledged container berth. If a trend of ship building is towards a bigger container carrier in future, two southern berths can be redesigned to have a depth of 13 m or more.

4-6-2. Sedimentation caused by the construction of the container berths

Followings are sedimentation caused by both the construction of the container berths and the dredging of the access channel inside the port:

1) In case tidal volume decreases by the reclamation, sedimentation might happen at the Lower Harbour, west of Keamari Groyne. However, in the case of this study, water mass which will increase by the dredging and water mass which will decrease by the reclamation are almost equal. Therefore, this sort of sedimentation will not occur.

2) Since current velocity is high in the channel between the Lower Harbour and the southern end of the container berth, expected sedimentation volume there will be negligible.

3) An area between the container berth and West Wharf will be relatively calm, so fine suspended silt will be trapped and deposited there. According to the calculation of the Danish Institute of Applied Hydraulics (DIAH)[(1)], expected sedimentation rate is 0.06 m per year in the case of a similar layout to that of this study. Therefore, total sedimentation volume will be 0.06 m x 600 m x 450 m (Area of this calm zone is 270 thousand square meters), that is 16 thousand cubic meters per year.

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(1) Port of Karachi Expansion Feasibility study, Appendix Ea, 1973 August

4-7 Access road and railway

4-7-1. Access road

(1) Forecast of Traffic Volume

A traffic volume generated in a port is forecasted by a cargo volume using the formula given below. The future traffic volume at the container terminal is assumed to be of a similar pattern as that in Japan and will be estimated using the same formula.

Hourly traffic volume – Annual cargo volume (freight ton/year) $\times \alpha/\omega \times \beta/12 \times \gamma/30 \times (1 + \delta)/\epsilon \times \sigma$

where
- α : Automobile share = Automobile transport/Whole transport;
- ω : Actual truck loading (ton/truck);
- β : Monthly variation = Peak monthly cargo volume/Mean monthly cargo volume;
- γ : Daily variation = Peak daily cargo volume/Mean daily cargo volume;
- δ : Related vehicle rate = Number of related vehicles/Number of trucks;
- ϵ : Loaded truck rate = Number of loaded trucks/Number of trucks; and
- σ : Hourly variation = Peak hourly traffic volume/Daily traffic volume

For the above coefficients, the following values are standardly used in Japan at present.

$\omega = 10t$, $\beta = 1.2$; $\gamma = 1.5$; $\delta = 2.0$; $\epsilon = 0.5$; and $\sigma = 0.12$

(2) Number of Lane

Similarly, according to the standard used in Japan, the 2 lanes road is enough when the traffic volume is of a value less than those listed below.

Type of Road	Hourly Traffic Volume
Road connecting the port with highway, etc.	650 Vehicles/hour
Other roads	500

The traffic volume generated at the container terminal in 1999–2000 is calculated at about 700 vehicles/hour. Therefore, a road of 4 lanes is considered to be enough, however, a tolerance for a heavy traffic concentration as shown in Fig. III-4-2 should be taken into consideration and an access road of 6 lanes is recommended. The access road is connected to Mauripur Road by fly-over and then to State Avenue, RCD Highway, and Super Highway. The access road of 4 lanes is enough at the stage of the Urgent Plan.

4-7-2. Access railway

The major portion of export/import cargo handled at the berth are to be transported by rail. The rail line alignment is shown in detail in Fig. III-4-4 and it is necessary to provide stand-by lines. A container transportation by rail is calculated for the Urgent and Master Plan by following equations.

o $CT = (DS + LS) \times (1 + \frac{s}{100-s}) \times u$

Where:

CT : Annual through put of CNTRS (TEU) transported to and from new port CNTR terminal by unit train.
DS : Total number of CNTR (TEU) discharged from ships per year.
LS : Total number of CNTR (TEU) loaded to ships per year.
s : Percentage of CNTR (TEU) discharged and loaded by semi and RORO CNTR ship at present Karachi port,
Urgent plan = 20% Master plan = 15%
u : Ratio of transportation by unit train, 0.427

o $MC = CT \times t \div WD \times \rho$

MC : Maximum handling units of CNTR per day
t : Conversion factor from TEU to units, 0.75
WD : Annual working days, 365 – 65 = 300 days
ρ : Peak day factor of transportation (Peak day/ordinary day), 1.25

o $MR = CT \div 2 \div WD \times p \div CU$

MR : Maximum number of round trips per day
CU : Number of CNTR (TEU) carried by one unit train, 75 TEU

The figures of CT, MC and MR are give for both port and inland container terminals as below.

1. Urgent plan (1987–1988)
   a. Port container terminal
      CT = (84,642 + 84,642) x 0.427 = 72,284 TEU
      MC = 72,284 x 0.75 ÷ 300 x 1.25 = 226 units
      MR = 72,284 ÷ 2 ÷ 300 x 1.25 ÷ 75 = 2.0 round trips
   b. Inland container freight station
      $CT = (84,642 + 84,642) \times (1 + \frac{20}{80}) \times 0.427 = 90,355$ TEU
      MC = 90,355 x 0.75 ÷ 300 x 1.25 = 282 units
      MR = 90,355 ÷ 2 ÷ 300 x 1.25 ÷ 75 = 2.5 round trips

2. Master plan (1999–2000)

a. Port container terminal

$CT = (338,007 + 338,007) \times 0.427 = 288,658$ TEU

$MC = 288,658 \times 0.75 \div 300 \times 1.25 = 902$ units

$MR = 288,658 \div 2 \div 300 \times 1.25 \div 75 = 8.0$ round trips

b. Inland container freight station

$$CT = (338,007 + 338,007) \times (1 + \frac{15}{85}) \times 0.427 = 339,598 \text{ TEU}$$

$MC = 339,598 \times 0.75 \div 300 \times 1.25 = 1,061$ units

$MR = 339,598 \div 2 \div 300 \times 1.25 \div 75 = 9.4$ round trips

In order to handle the volume of railway traffic calculated above, it is necessary to provide to stand-by lines for the Master Plan and 5 for the Urgent Plan.

departure line	1
arrival line	1
waiting line	4
classification line	4
Total	10 lines.

For the section between Wazir Mansion and Karachi Station, an additional one line for an exclusive use of container traffic is included in the Master and Urgent Plans.

Table III-4-1 Traffic Forecast

('000 M/T)

	1979-80			1987-88				1999-00			
Types of Cargo	Export	Import	Total	Export	Import	Total	87-88/1979-80	Export	Import	Total	99-00/1979-80
Liquid Bulk	1,302 (38%)	6,046 (54%)	7,348 (50%)	1,167 (21%)	6,396 (59%)	7,563 (46%)	1.03	643 (100%)	13,096 (60%)	13,739 (49%)	1.87
Dry Bulk	1,202 (35%)	2,852 (25%)	4,054 (28%)	2,910 (52%)	1,620 (15%)	4,530 (28%)	1.12	3,360 (52%)	3,280 (15%)	6,640 (23%)	1.64
General Cargo	894 (27%)	2,361 (21%)	3,255 (22%)	1,510 (27%)	2,820 (26%)	4,330 (26%)	1.33	2,420 (38%)	5,495 (25%)	7,915 (28%)	2.43
Total:	3,394	11,259	14,657	5,587	10,836	16,423	1.12	6,432	21,851	28,274	1.93

Table III-4-2 Container Cargo Forecast

('000 ton)

	1987 - 88		1999 - 2000	
	Export	Import	Export	Import
Containerizable Cargo	Rice 1,860 Sugar 200 Cotton 300 Other Dry 1,210	Other Dry 2,820	Rice 2,590 Sugar 200 Cotton 300 Other Dry 2,120	Iron/Steel 550 Other Dry 4,945
Total	3,570	2,820	5,210	5,495
Containerized Cargo	890	857	2,655	3,221
Percentage of Containerization	25%	30%	51%	59%

Table III-4-3 Share of CNTR Carrier and 20'/40' (TEU) Ratio by Route (Actual record of Japanese CNTR trade in 1980)

Carrier's type	Share (%)	Trade	Share (%)	Ratio (%) in TEU	
				20'	40'
Full CNTR (LOLO)	78		(100)	49	51
		U.S.A. & Canada	44	38	62
		Europe & Mediterranean	21	41	59
		Australia (RORO)	14	83	17
		New Zealand	5	62	38
		Red sea & Arabian Gulf	9	53	47
		Far East	7	58	42
Feeder	7	Far East	(100)	59	41
Semi CNTR & RORO	15		(100)	78	22
		Africa	60	79	21
		Central & South America	19	84	16
		Oceania	9	81	19
		Red sea & Mediterranean	6	75	25
		Arabian Gulf	6	38	62
		Others	-	100	-
Total	(100)			54	46

Table III-4-4 (I) FCL/LCL & 20'/40' Classification of Containerizable Cargo Imported from Far East (1979—1980)

Ports of loading	Density under 0.5 MT per CM									Density over 0.5 MT per CM																		Total		
	Under 25.6 CM per B/L			more 25.6 CM less 52.8 CM per B/L			Over 52.8 CM per B/L			Under 25.6 CM per B/L									More 25.6 CM per B/L								
										Density Under 0.7 MT			Density over 0.7 MT, Under 18 MT per B/L			Density over 0.7 MT, Over 18 MT per B/L			Density Under 0.7 MT			Density Over 0.7 MT					
	ⓐ 20' M. LCL			ⓑ 20' M.FCL/ 40' M.LCL			ⓒ 40' M. FCL			ⓓ 20' M. LCL			ⓔ 20' W. LCL			ⓕ 20' W. FCL			ⓖ 20' M. FCL			ⓗ 20' W. FCL					
	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM	No.of B/L	TL MT	TL CM
Japanese																											
6 main ports	3,401	6,472	26,101	308	2,657	10,828	226	16,914	63,787	641	1,237	2,085	983	4,767	4,078	51	1,277	339	83	4,776	8,990	96	8,168	7,224	5,789	46,268	123,432
FCL/LCL = 70/30 %					20'	212																			20'	2,454	2,454
20'/40' = 48/52 %		20'	1,020		40'	103		40'	1,208		20'	81		20'	265		20'	71		20'	351		20'	454	40'	1,311	2,622
9' KT per TEU																											5,076
Busan	73	191	794	12	94	404	5	125	465	7	58	89	14	166	191	-	-	-	10	618	1,112	6	315	343	127	1,567	3,398
FCL/LCL = 70/30 %					20'	8																			20'	111	111
20'/40' = 81/19 %		20'	31		40'	4		40'	9		20'	3		20'	9					20'	43		20'	17	40'	13	26
11.4 KT per TEU																											137
Hongkong	739	888	3,253	43	474	1,610	21	627	1,808	151	336	578	206	906	869	2	54	8	28	1,189	1,942	14	807	860	1,204	5,281	20,928
FCL/LCL = 55/45 %					20'	31																			20'	356	356
20'/40' = 78/22 %		20'	127		40'	15		40'	34		20'	23		20'	51		20'	3		20'	76		20'	45	40'	49	98
11.6 KT per TEU																											454
Singapore	173	519	1,699	26	271	860	3	41	232	95	480	814	89	474	574	-	-	-	20	1,447	2,320	7	251	299	413	3,483	6,798
FCL/LCL = 54/46 %					20'	17																			20'	246	246
20'/40' = 90/10 %		20'	66		40'	8		40'	5		20'	32		20'	26					20'	91		20'	14	40'	13	26
12.8 KT per TEU																											272
Total	4,386	8,070	31,847	389	3,496	13,702	255	17,707	66,292	894	2,111	3,566	1,292	6,313	5,712	53	1,331	347	141	8,030	14,364	123	9,541	8,726	7,533	56,599	144,556
FCL/LCL = 68/32 %					20'	268																			20'	3,167	3,167
20'/40' = 53/47 %		20'	1,244		40'	130		40'	1,256		20'	139		20'	351		20'	74		20'	561		20'	530	40'	1,386	2,772
9.5 KT per TEU																											5,939

LCL ratio by cargo weight (MT): [ⓐ + ⓑ ÷ 2 + ⓓ + ⓔ] ÷ [ⓐ + ⓑ + ... + ⓗ]

Table III-4-4 (2) Classification of FCL/LCL Cargo

Cargo quantity by BL lot				Class	
Density under 0.5 MT	Less than 25.6 CM/BL			a	20′ Measurement cargo LCL
Density under 0.5 MT	More than 25.6 CM/BL but less than 52.8 CM/BL			b	20′ Measurement cargo FCL OR 40′ Measurement cargo LCL
Density under 0.5 MT	More than 52.8 CM/BL			c	40′ Measurement cargo FCL (OR LCL)
Density over 0.5 MT	Less than 25.6 CM/BL	Density under 0.7 MT		d	20′ Measurement cargo LCL
Density over 0.5 MT	Less than 25.6 CM/BL	Density over 0.7 MT	Less than 18 MT/BL	e	20′ Weight cargo LCL
Density over 0.5 MT	Less than 25.6 CM/BL	Density over 0.7 MT	More than 18 MT/BL	f	20′ Weight cargo FCL (OR LCL)
Density over 0.5 MT	More than 25.6 CM/BL	Density under 0.7 MT		g	20′ Measurement cargo FCL (OR LCL)
Density over 0.5 MT	More than 25.6 CM/BL	Density over 0.7 MT		h	20′ Weight cargo FCL (OR LCL)

Condition 1. Class b . . . Each 50% of cargo will be stacked in to 20′ and 40′ CNTR.
2. Class c f g h . . . All cargo will be stacked as FCL.

20′ container
Interior capacity: 32 CM
Measurement of cargo: 32 CM × 80% = 25.6 CM
Pay load: 18 MT
Density: 18 ÷ 25.6 = 0.7 MT per CM

40′ container
Interior capacity: 66 CM
Measurement of cargo: 66 × 80% = 52.8 CM
Pay load: 27.5 MT
Density: 27.5 ÷ 52.8 = 0.5 MT per CM

Table III-4-5 Cargo Weight Forecast per Container

(MT per TEU)

	1987/1988			1999/2000		
	Import	Export	Total	Import	Export	Total
Total cargo quantity (MT)	857,000	890,000	1,747,000	3,221,000	2,655,000	5,876,000
Total No. of container (TEU)	96,706	82,293	178,999	345,035	253,401	598,436
Cargo weight (MT) per TEU	8.9	10.8	9.8	9.3	10.5	9.8

CONCLUSION

Import: 9 MT per TEU
Export: 11 MT per TEU
at 1987–1988 & 1999–2000

Table III-4-6 (1) Transport Share by Rail/Road, FCL/LCL (1999/2000)

		Import				Export			
		KT	%	TEU	%	KT	%	TEU	%
Rail	FCL	1,297,741	47.4	144,329	42.7	1,056,159	46.8	95,989	28.4
	LCL	169,747	6.2	18,590	5.5	106,067	4.7	9,801	2.9
	TL	1,467,488	53.6	162,919	48.2	1,162,226	51.5	105,790	31.3
Road	FCL	632,443	23.1	70,305	20.8	487,458	21.6	44,276	13.1
	LCL	637,919	23.3	70,982	21.0	607,066	26.9	55,093	16.3
	TL	1,270,362	46.4	141,287	41.8	1,094,524	48.5	99,369	29.4
Total	FCL	1,930,184	70.5	214,634	63.5	1,543,617	68.4	140,265	41.5
	LCL	807,666	29.5	89,572	26.5	713,133	31.6	64,894	19.2
	TL	2,737,850	100	304,206	90	2,256,750	100	205,159	60.7

Remark: Import LCL by rail = 43.9% of Multan & Quetta = 14.1 x 0.439 = 6.2%
Import LCL by road = 40% of Karachi + 56.1% of Multan & Quetta = 38.5 x 0.4 + 14.1 x 0.561
= 23.3%
Export LCL by rail = 27.4% of Multan & Quetta = 17.2 x 0.274 = 4.7%
Export LCL by road = 40% of Karachi + 72.6% of Multan & Quetta = 36.0 x 0.4 + 17.2 x 0.726
= 26.9%

Table III-4-6 (2) Transport Share by Rail/Road, FCL/LCL (1987/88)

		Import				Export			
		KT	%	TEU	%	KT	%	TEU	%
Rail	FCL	324,974	47.4	36,142	42.7	329,656	46.3	29,952	35.4
	LCL	42,507	6.2	4,740	5.6	39,160	5.5	3,554	4.2
	TL	367,481	53.6	40,882	48.3	368,816	51.8	33,506	39.6
Road	FCL	158,374	23.1	17,606	20.8	144,536	20.3	13,115	15.5
	LCL	159,745	23.3	17,690	20.9	198,648	27.9	18,106	21.4
	TL	318,119	46.4	35,296	41.7	343,184	48.2	31,221	36.9
Total	FCL	483,348	70.5	53,748	63.5	474,192	66.6	43,067	50.9
	LCL	202,252	29.5	22,430	26.5	237,808	33.4	21,660	25.6
	TL	685,600	100	76,178	90	712,000	100	64,727	76.5

Remark: Import LCL by rail = 43.9% of Multan & Quetta = 14.1 x 0.439 = 6.2%
Import LCL by road = 40% of Karachi + 56.1% of Multan & Quetta = 38.5 x 0.4 + 14.1 x 0.561
= 23.3%
Export LCL by rail = 27.4% of Multan & Quetta = 19.9 x 0.274 = 5.5%
Export LCL by road = 40% of Karachi + 72.6% of Multan & Quetta = 33.8 x 0.4 + 19.9 x 0.726
= 27.9%

Table III-4-7 General Comparison of Terminal Operation System

Item \ Operation system		Rail mounted transfer crane and chassis feed	Rubber tired transfer crane and chassis feed	All straddle carrier	Combined system of transfer crane and straddle carrier	All chassis and transter crane	Toplifter and chassis feed
Initial cost of equipment		×	○	◎	△	×	◎
Running cost		○	○	△	△	×	△
Reliability on equipment		◎	○	△	△	○	○
Storage capacity		◎	◎	○	○	×	△
Productivity of	Systematic Operation (Ship, Rail, CFS)	◎	◎	○	○	△	△
	Randam Operation (Road)	×	△	○	○	◎	○
Elaboration to Control system		△	×	◎	△	◎	△
Difficulty to drive equipment		◎	○	×	△	◎	○
Restriction of service area		×	○	◎	×	◎	△
Accidental ratio to personnel and container		◎	○	×	△	○	△
Adoptability to 40 footer and over dimention container		◎	◎	○	○	◎	×
Pavement (included rail) per unit area		×	○	△	△	◎	△
Automation of equipment		◎	○	×	△	×	×

Judgement : Excellent ◎ Good ○ Fair △ Poor ×

Table III-4-8 Comparison of Equipment on Each System (1999–2000)

Unit: 1,000 US$

Description of equipment	Unit Cost	Railmounted transfer crane and chassis feed		Rubble tired transfer crane and chassis feed		All straddle carrier		Combined system of rubble tired transfer crane and straddle carrier		All chassis and shifter		Top lifter and chassis feed	
		Q'ty	Total Cost	Q'ty	Total Cost	Q'ty	Total Cost	Q'ty	Total Cost	Q'ty	Total Cost	Q'ty	Total Cost
(Ship's operation)													
Container crane	3,095	12	37,140	12	37,140	12	37,140	12	37,140	12	37,140	12	37,140
Yard tractor	37	48	1,776	48	1,776	-		48	1,776	48	1,776	48	1,776
Yard chassis 40'(20' x2)	13	48	624	48	624	-		48	624	-		48	624
(Unit train operation)													
Rail mounted transfer crane	2,381	6	14,286	6	14,286	6	14,286	6	14,286	6	14,286	6	14,286
Road tractor	37	24	888	24	888	24	888	24	888	24	888	24	888
Road chassis 40'(20' x2)	13	24	312	24	312	24	312	24	312	-		24	312
(Container yard operation)													
Rail mounted transfer crane	2,381	36	85,716										
Rubble tired transfer crane	952			36	34,272			24	22,848				
Straddle carrier	405					66	26,730	30	12,150				
Top lifter with telescopic speader	310											66	20,460
Yard chassis													
20 footer	10									9,358	93,580(3,552 for six berth)		
40 footer	10									4,679	46,790(1,776 for six berth)		
(Gate operation)													
Weighing scale	62	6	372	6	372	6	372	6	372	6	372	6	372
Shifter	452									12	5,424		
Yard tractor	37									48	1,776		
(Maintenance)													
Forklift truck													
3.0 tons	17	6	102	6	102	6	102	6	102	6	102	6	102
15.0 tons with telescopic side spreader	126	6	756	6	756	6	756	6	756	6	756	6	756
(CFS operation)													
Forklift truck													
3.0 tons	17	120	2,040	120	2,040	120	2,040	120	2,040	120	2,040	120	2,040
6.0 tons	35	12	420	12	420	12	420	12	420	12	420	12	420
Road tractors	37	24	888	24	888	24	888	24	888	24	888	24	888
Road chassis													
20 footer	10	120	1,200	120	1,200	120	1,200	120	1,200	120	1,200	120	1,200
40 footer	10	60	600	60	600	60	600	60	600	60	600	60	600
Pallets	0.04	13,650	546	13,650	546	13,650	546	13,650	546	13,650	546	13,650	546
(Mulitipurpose)													
35 ton mobile cranes for emergency use	190	3	570	3	570	3	570	3	570	3	570	3	570
Forklift truck													
3.0 tons	17	9	153	9	153	9	153	9	153	9	153	9	153
15.0 tons	105	3	315	3	315	3	315	3	315	3	315	3	315
Top lifter with telescopic spreader (35 tons)	310	3	930	3	930	3	930	3	930	2	930	3	930
(Terminal officd)													
Computer	952	3	2,856	3	2,856	3	2,856	3	2,856	3	2,856	3	2,856
Wireless telephone (VHF)	2	165	330	165	330	147	441	183	366	189	378	195	390
Total			152,820		101,376		91,545		102,138		213,786		87,624

Table III-4-9 Comparison on Storage Capacity of Each Operation System per Berth

Item \ Operation system		Rail-mounted transfer cranes and chassis feed	Rubber-tired transfer cranes and chassis feed	All straddle carriers	Combined system of transfer cranes and straddle carriers	All chassis and shifters	Toplifter and chassis feed
Ground slots (GS)		1,824 TEU	1,824	1,680	1,692	1,184	812 TEU
Capacity in three tiers		5,472 TEU	5,472	5,040	5,076	1,184	2,436 TEU
Operational capacity (Ground slots x stacking tiers)	Export dry CNTR (27%)	386 x 3 = 1,158	386 x 3 = 1,158	428 x 2 = 856	358 x 3 = 1,074	320 x 1 = 320	207 x 2 = 414
	Import dry CNTR (31%)	665 x 2 = 1,330	665 x 2 = 1,330	491 x 2 = 982	617 x 2 = 1,234	367 x 1 = 367	237 x 2 = 474
	Special CNTR (6%)	258 x 1 = 258	258 x 1 = 258	190 x 1 = 190	239 x 1 = 239	71 x 1 = 71	92 x 1 = 92
	Empty CNTR (36%)	515 x 3 = 1,545	515 x 3 = 1,545	571 x 2 = 1,142	478 x 3 = 1,434	426 x 1 = 426	276 x 2 = 552
	Total slots (TS)	4,291 TEU	4,291	3,170	3,981	1,184	1,532 TEU
Average stacking tiers $\frac{TS}{GS}$		2.35	2.35	1.89	2.35	1.00	1.89

Table III-4-10 Container Cargo Handling Equipment Required for the Port Terminal (1987–1988)

(Unit: 1000 US$)

Description of Equipments	Q'ty	Unit Cost	Total Cost
(Ships operation)			
Container cranes	4	3,095	12,380
Yard tractor	16	37	592
Yard chassis 40′ (20′x2)	16	13	208
(Unit train operation)			
Rail mounted transfer cranes	2	2,381	4,762
Road tractors	8	37	296
Road chassis 40′ (20′x2)	8	13	104
(Container yard operation)			
Rubber tired transfer cranes	10	952	9,520
(Gate operation)			
Weighing scale	2	62	124
(Maintenance)			
Fork lift truck			
3.0 tons	2	17	34
15.0 tons with telescopic side spreader	2	126	252
(CFS operation)			
Fork lift trucks			
3.0 tons	36	17	612
6.0 tons	4	35	140
Road tractors	8	37	296
Road chassis			
20 footer	36	10	360
40 footer	18	10	180
Pellets	3,950	0.04	158
(Multipurpose)			
35 ton mobile cranes for emergency use	1	190	190
Fork lift truck			
3.0 tons	3	17	51
15.0 tons	1	105	105
Toplifter with telescopic spreader (35 tons)	1	310	310
(Terminal office)			
Computer	1	952	952
Wereless telephone (VHF)	53	2	106
Total			31,732

Table III-4-11 Length of Container Ship (in 1979)

LOA (m)	No. of Ships	Accumulated No.	%
90–	1	1	0.07
95–	4	5	0.38
100–	5	10	0.77
105–	2	12	0.93
110–	4	16	1.24
115–	25	41	3.17
120–	11	52	4.03
125–	17	69	5.34
130–	17	86	6.66
135–	18	104	8.06
140–	25	129	10.00
145–	55	184	14.26
150–	99	283	21.93
155–	71	354	35.41
160–	122	476	36.89
165–	50	526	40.77
170–	123	649	50.31
175–	31	680	52.71
180–	55	735	56.97
185–	48	783	60.69
190–	18	801	62.09
195–	15	816	63.25
200–	73	889	68.91
205–	86	975	75.58
210–	45	1,020	79.06
215–	45	1,065	82.55
220–	27	1,092	84.65
225–	39	1,131	87.67
230–	11	1,142	88.52
235–	3	1,145	88.75
240–	8	1,153	89.37
245–	20	1,173	90.93
250–	4	1,177	91.24
255–	20	1,197	92.79
260–	23	1,220	94.57
265–	11	1,231	95.42
270–	13	1,244	96.43
275–	4	1,248	96.74
280–			
285–	42	1,290	100
290–			
295–			
300–			
	Total	1,290	100%

Table III-4-12 Full Load Draft of Container Ships (in use in 1979)

Full Load Draft m	No. of Ships	Accumu-lated No. of Ships	%	Full Load Draft m	No. of Ships	Accumu-lated No. of Ships	%
4.8–	1	1	0.08	9.4–	56	503	39.64
5.0–	6	7	0.5	6–	111	614	48.38
2–	2	9	0.71	8–	98	712	56.11
4–	3	12	0.95	10.0–	121	833	65.64
6–	1	13	1.02	2–	35	868	68.40
8–	3	16	1.26	4–	82	950	74.86
6.0–	3	19	1.50	6–	74	1,024	80.89
2–	2	21	1.65	8–	48	1,072	84.48
4–	13	34	2.68	11.0–	20	1,092	86.05
6–	18	52	4.10	2–	15	1,107	87.23
8–	5	57	4.49	4–	36	1,143	90.07
7.0–	11	68	5.36	6–	20	1,163	91.65
2–	18	86	6.78	8–	12	1,175	92.59
4–	17	103	8.12	12.0–	39	1,214	95.67
6–	9	112	8.83	2–	–		
8–	11	123	9.69	4–	5	1,219	96.06
8.0–	23	146	11.51	6–	3	1,222	96.30
2–	36	182	14.34	8–	10	1,232	97.08
4–	24	206	16.23	13.0–	31	1,263	99.53
6–	43	249	19.62	2–	–		
8–	35	284	22.33	4–	–	1,264	99.61
9.0–	64	348	29.42	6–	1	1,265	99.68
2–	99	447	35.22	8–	4	1,269	100.00

Table III-4-13 Actual Draft of Container Ship
(actual record of Japanese container carriers)

Ship No.	1	2	3	4	5	6	7	8	9	10
Full Load Draft m	d=9.525	d=10.5	d=10.526	d=10.526	d=11.50	d=11.529	d=11.54	d=11.70	d=12.029	d=12.031
Navigated in the actual draft of written % of d.	81%	56%	74%	82%	87%	64%	95%	88%	93%	82%
	77	69	73	81	85	64	93	84	85	85
	77	67	73	80	85	68	93	84	84	85
	79	83	74	73	82		93	84	83	91
	79	84	74	73	82		92	83	83	91
	79	92	75	71	79		90	84	85	90
	80	93	74	72	79		91	83	83	89
	86	99	76	72	79		84	89	82	91
	86	95	76	72	79		84	87	82	85
	92	91	77	79	77		81	84	82	85
	92	91	76	77	76		81	76	81	
	99		81	82	75		92	77	81	
	93		79	82	74		97	74	79	
	90		75	93	77		98	73	76	
	90		75	93	77		97		76	
			74	78			80			
			74	78			79			
			70				75			
			70				75			
							59			
Average	85.33	83.64	74.74	78.71	79.53	65.33	86.45	82.14	82.33	87.40

Average: 81.55%

Table III-4-14 Navigable Hours in High Tide

Karachi

High Tide D.L. + ft.	Dry Season					
			0.8 x Full Draft		Full Draft	
	(1)	(2)	(3)	(4)	(3)	(4)
0.0	24.0	9.5	0.94	22.6	0.44	10.6
2.0	24.0	10.1	0.02	0.5	0.23	5.5
4.0	19.6	10.7	0.03	0.6	0.17	3.3
6.0	13.7	11.3	0.01	0.1	0.06	0.8
8.0	0.0	11.9				
10.0						
12.0						
Total				23.8		20.2

High Tide D.L. + ft.	Monsoon Season					
			0.8 x Full Draft		Full Draft	
	(1)	(2)	(3)	(4)	(3)	(4)
0.0	24.0	8.7	0.85	20.4	0.21	5.0
2.0	20.8	9.3	0.06	1.2	0.16	3.3
4.0	16.4	9.9	0.04	0.7	0.23	3.8
6.0	13.4	10.5	0.03	0.4	0.17	2.3
8.0	10.2	11.1	0.02	0.2	0.09	0.9
10.0	2.0	11.7			0.05	0.1
12.0	0.0					
Total				22.9		15.4

Average Navigable Hours (23.8 x 2 + 22.9)/3 = 23.5 (ship of 0.8 x Full Draft)
Average Navigable Hours (20.2 x 2 + 15.4)/3 = 18.6 (ship of Full Draft)

Note: (1) Tide Duration Hrs (2) Navigable Draft m
(3) Percentage of Ship Navigable (4) Navigable Hours

Fig. III-4-1 Traffic Forecast

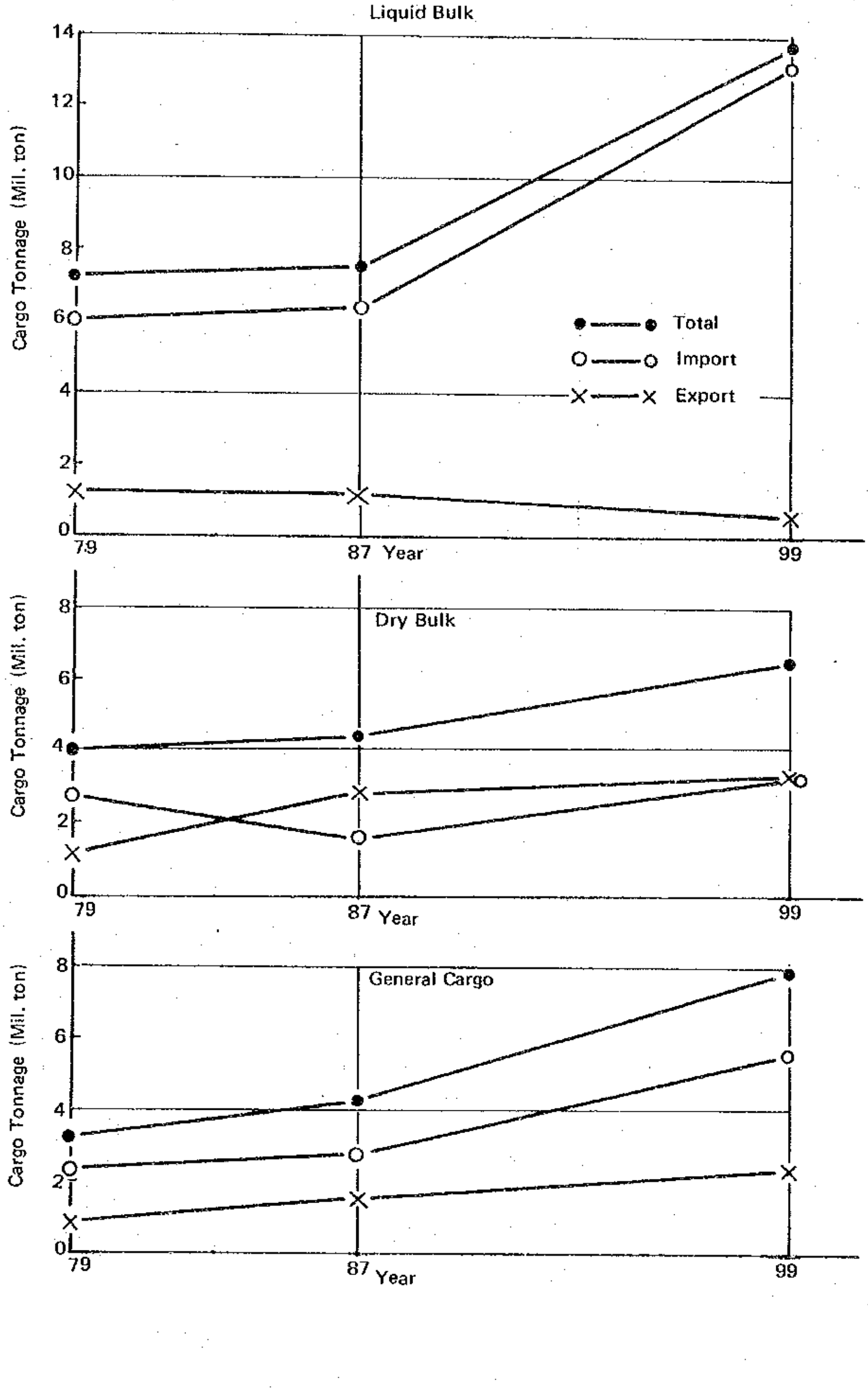
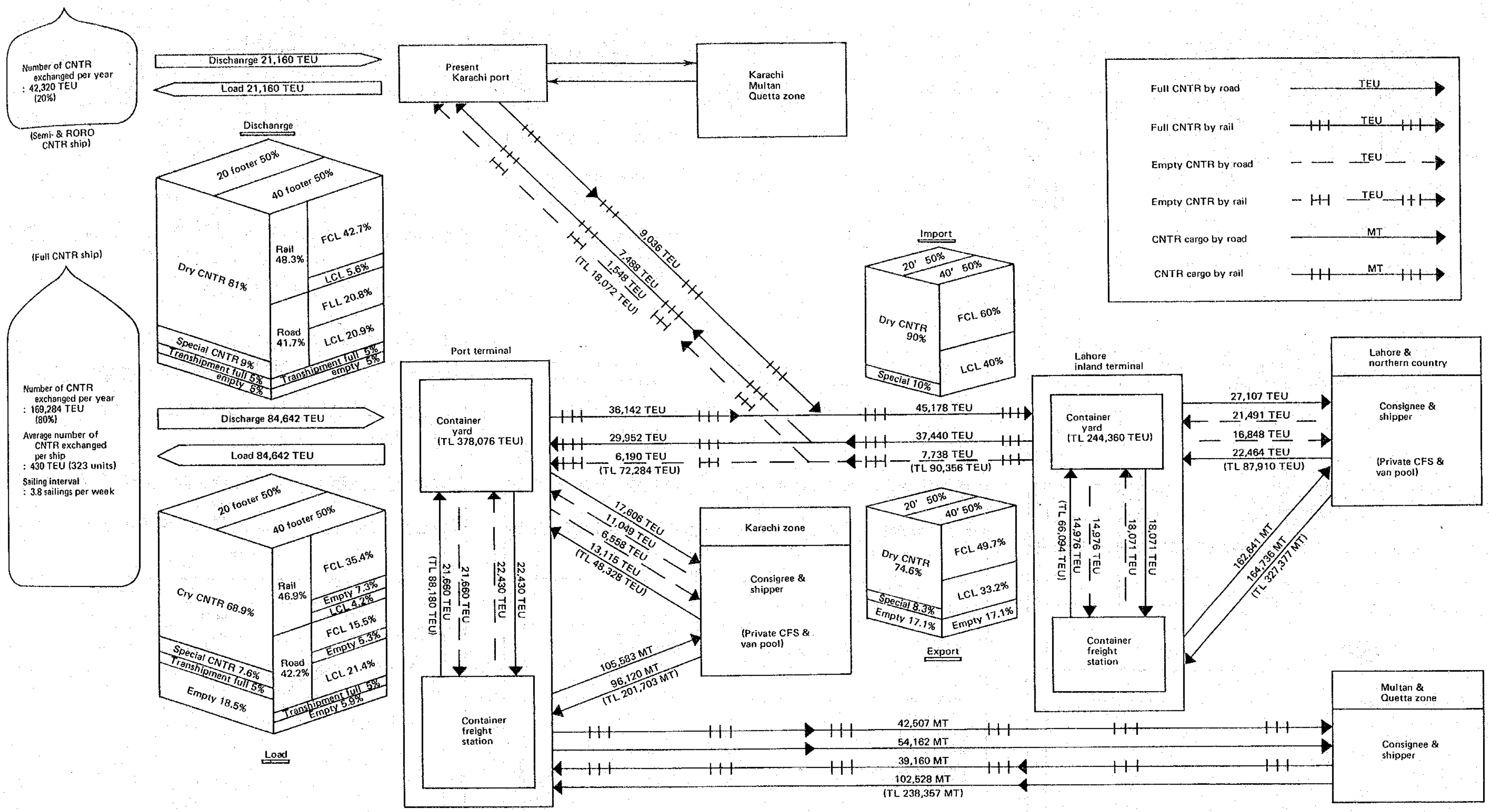


Fig. III-4-2 Forecast of Container & Cargo Movement (1987~1988)



- Share of CNTR stacked on CNTR yard of Port terminal
  - Import dry 31%
  - Export dry 27%
  - Special 6% { Over dimension 30%, Dangerous 40%, Refrigerated 30% }
  - Empty 36%
- Share of CNTR stacked on CNTR yard of Inland terminal
  - Import dry 28%
  - Export dry 20%
  - Special 5% { Over dimension 30%, Dangerous 40%, Refrigerated 30% }
  - Empty 47%
- Percentage of empty CNTR stored at CNTR yard of port terminal
  : 100% of export LCL CNTR
  : 50% of export FCL CNTR
- Percentage of empty CNTR stored at CNTR yard of inland Terminal
  : 100% of export LCL CNTR
  : 75% of export FCL CNTR

Fig. III-4-3 Comparison of Port Terminal Layout

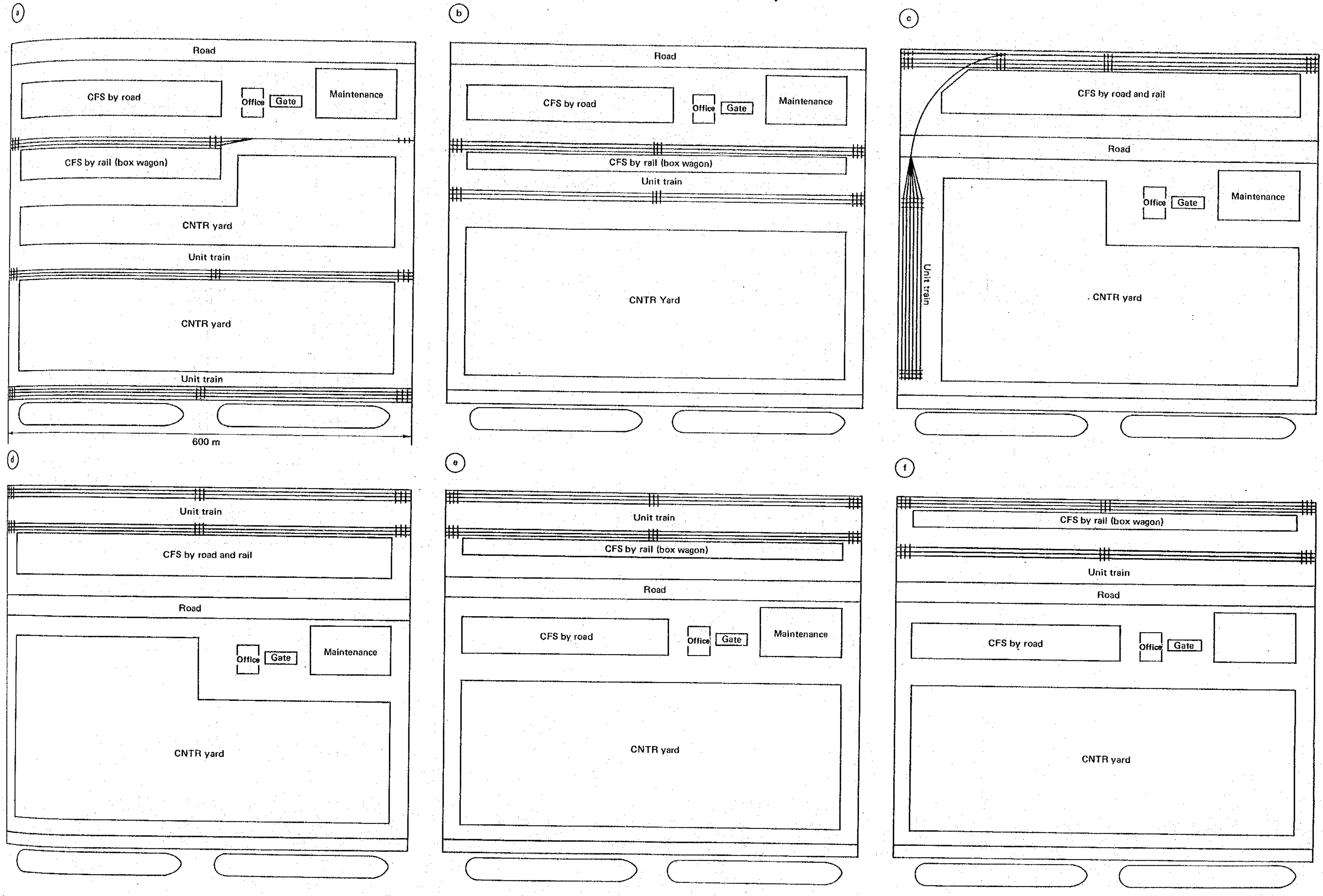


Fig. III-4-4 Basic Layout of Port Terminal (Master plan)

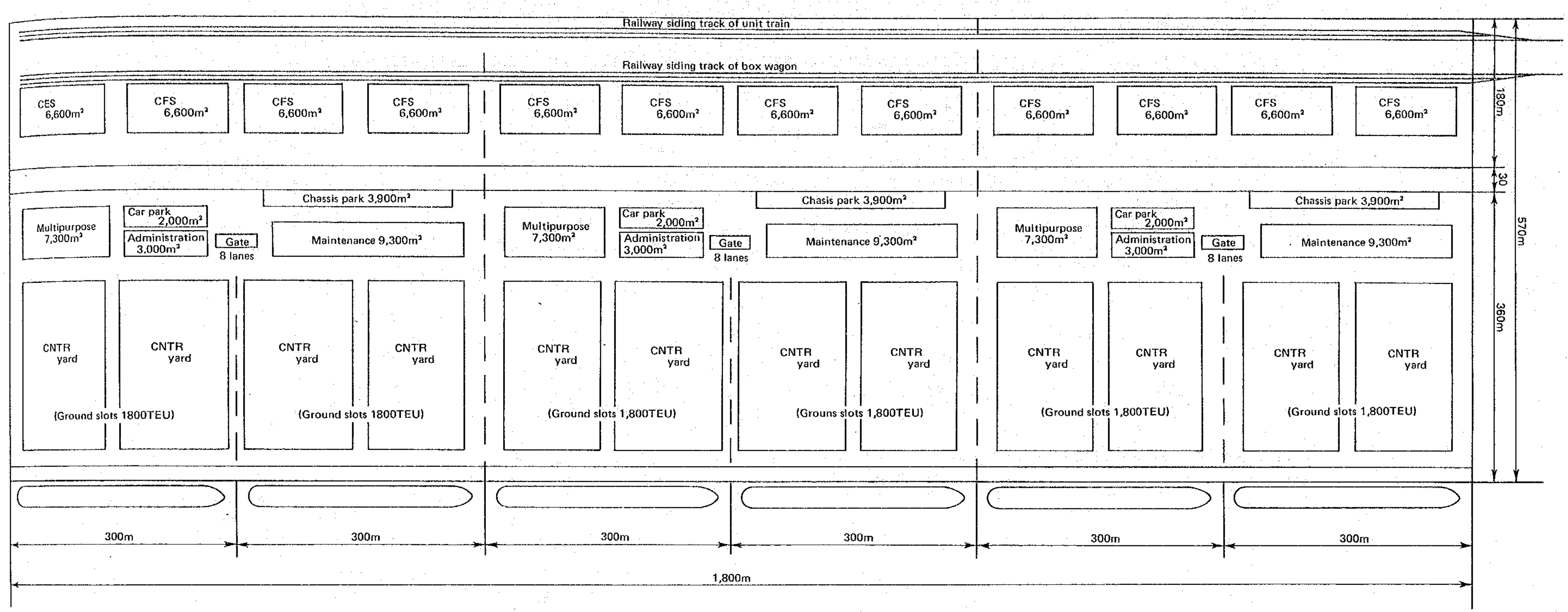


Fig. III-4-5 Layout of Port Terminal (Urgent Plan)

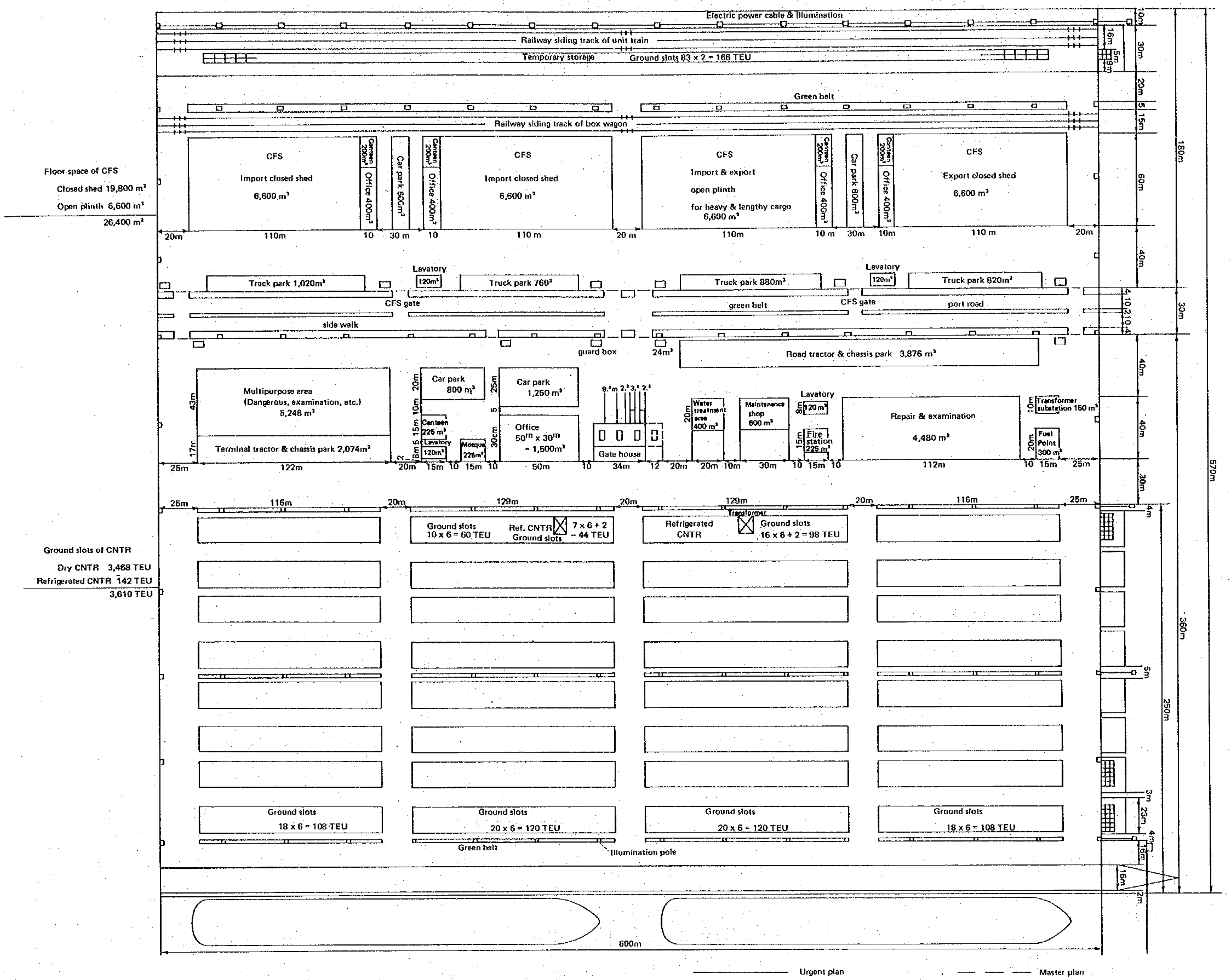
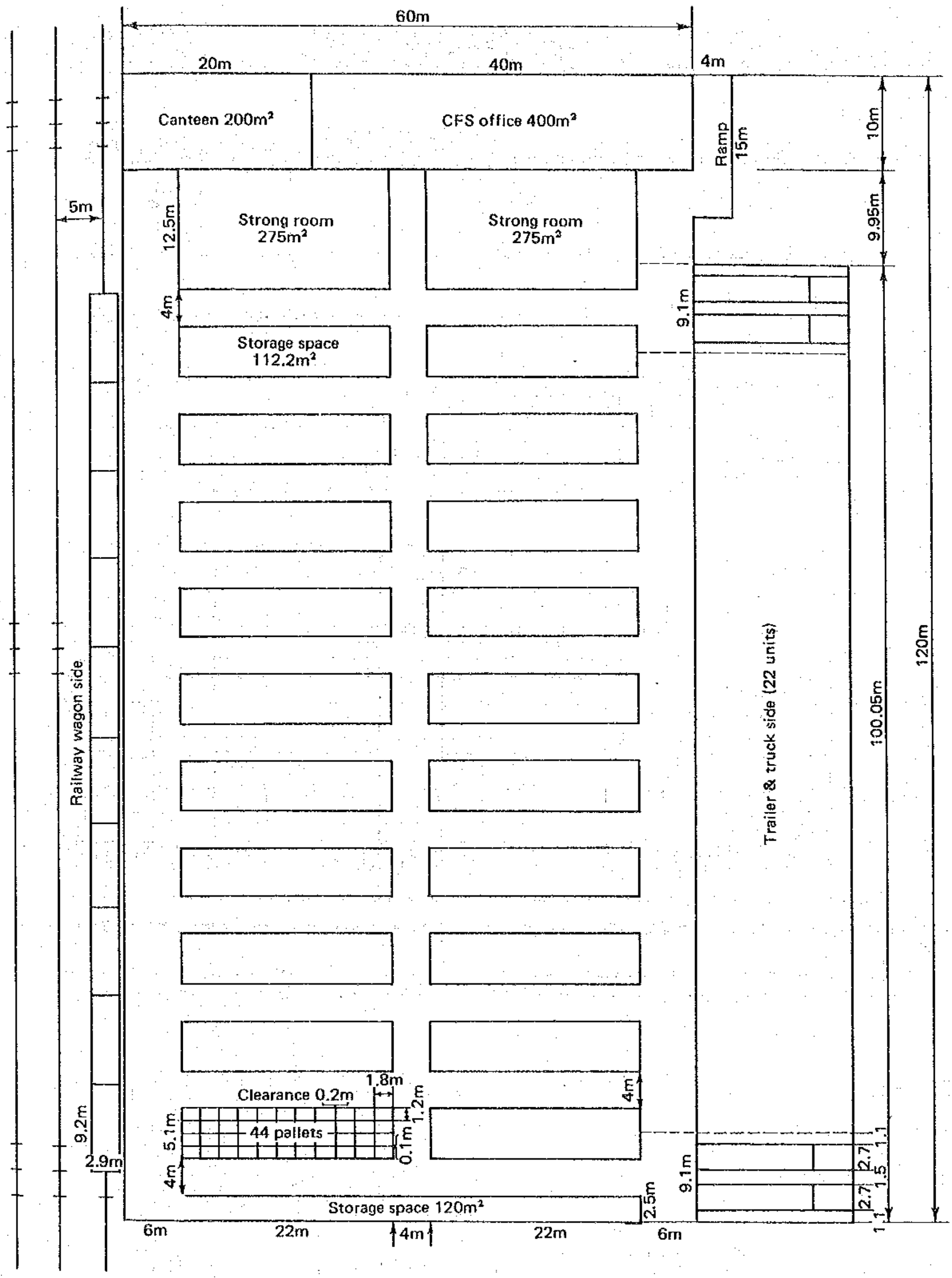


Fig. III-4-6 Layout of Closed Shed



Cargo storage space	: 275m² x2 + 112.2m² x20 + 120m²	= 2,914m²	(44.2%)
Passage space	: 60m x 110m − 2,914m²	= 3,686m²	(55.8%)
		6,600m²	

Fig. III-4-7(1) Rail-Mounted Transfer Cranes and Chassis Feed

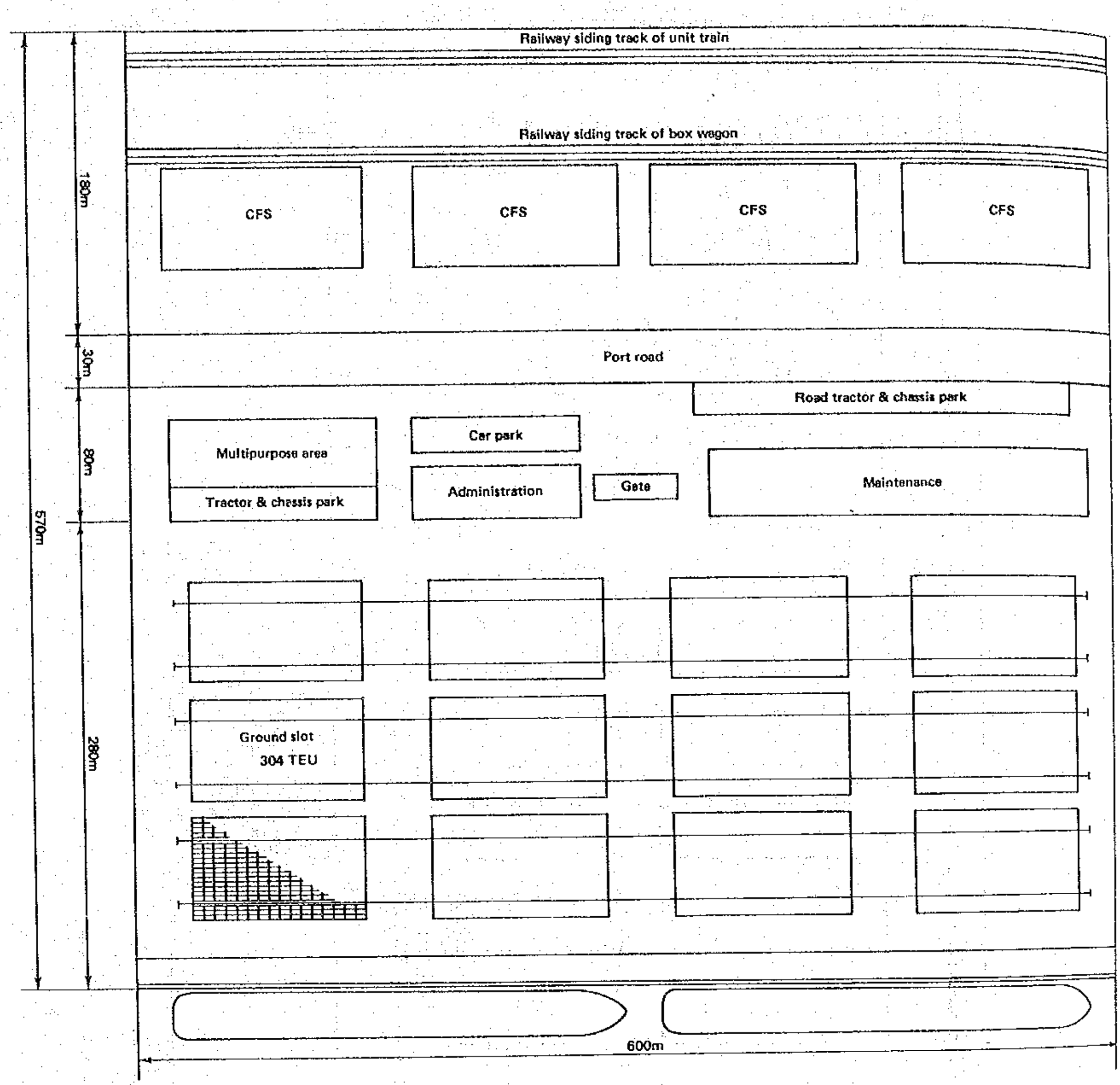


Fig. III-4-7 (2) Rubber-Tired Transfer Cranes and Chassis Feed

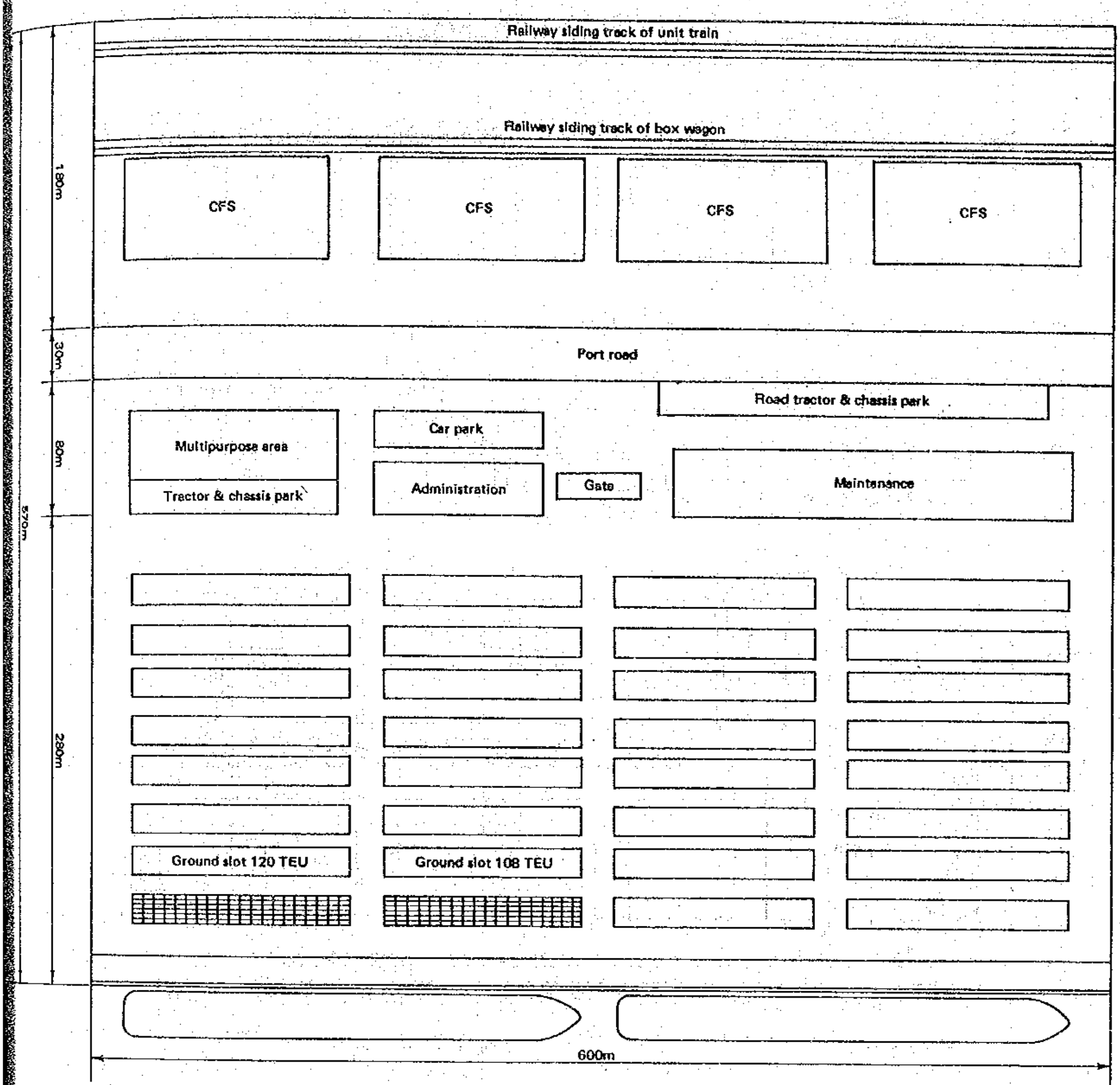


Fig. III-4-7 (3) All Straddle Carriers

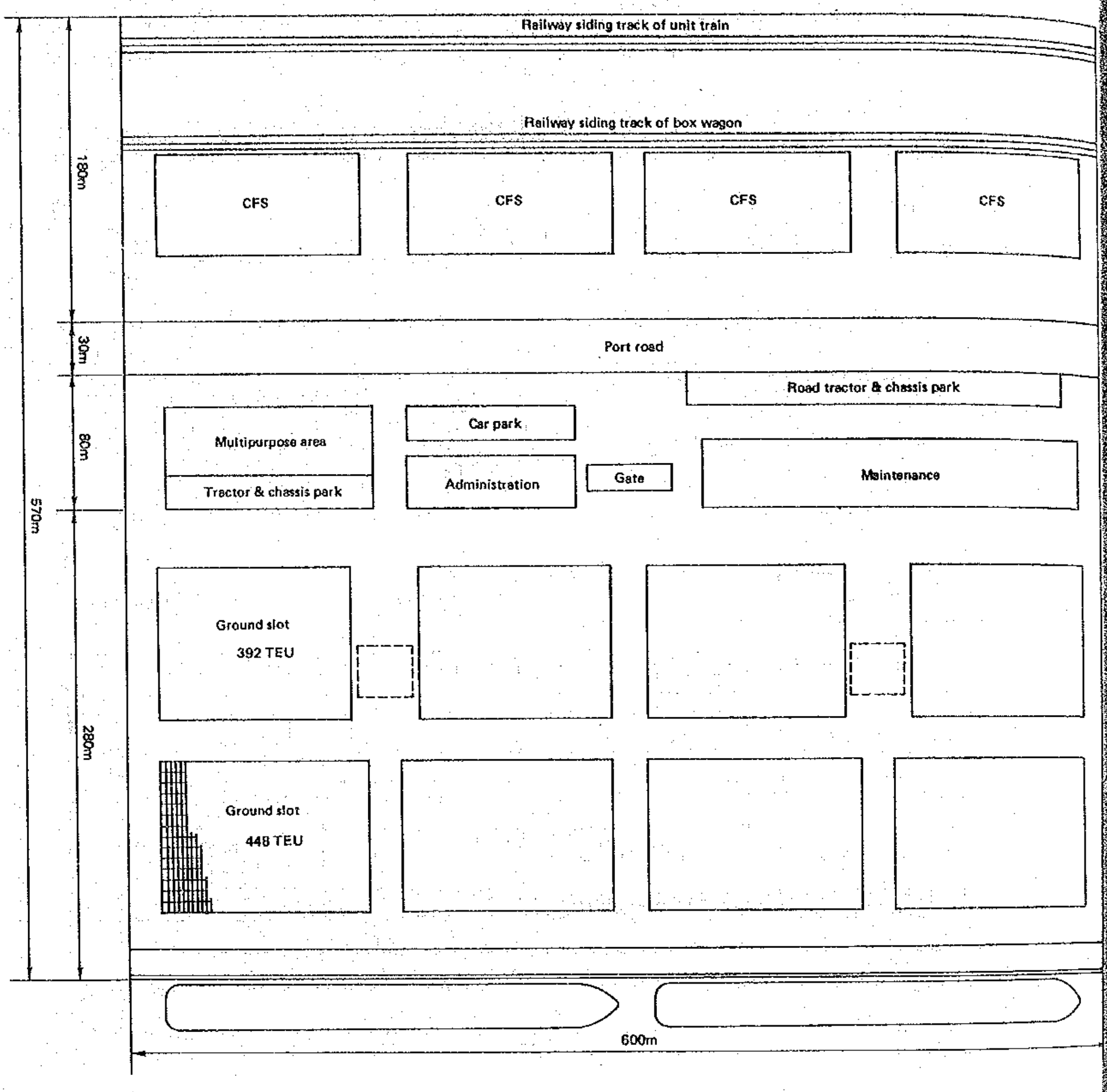


Fig. III-4-7 (4) Combined System of Transfer Cranes and Straddle Carriers

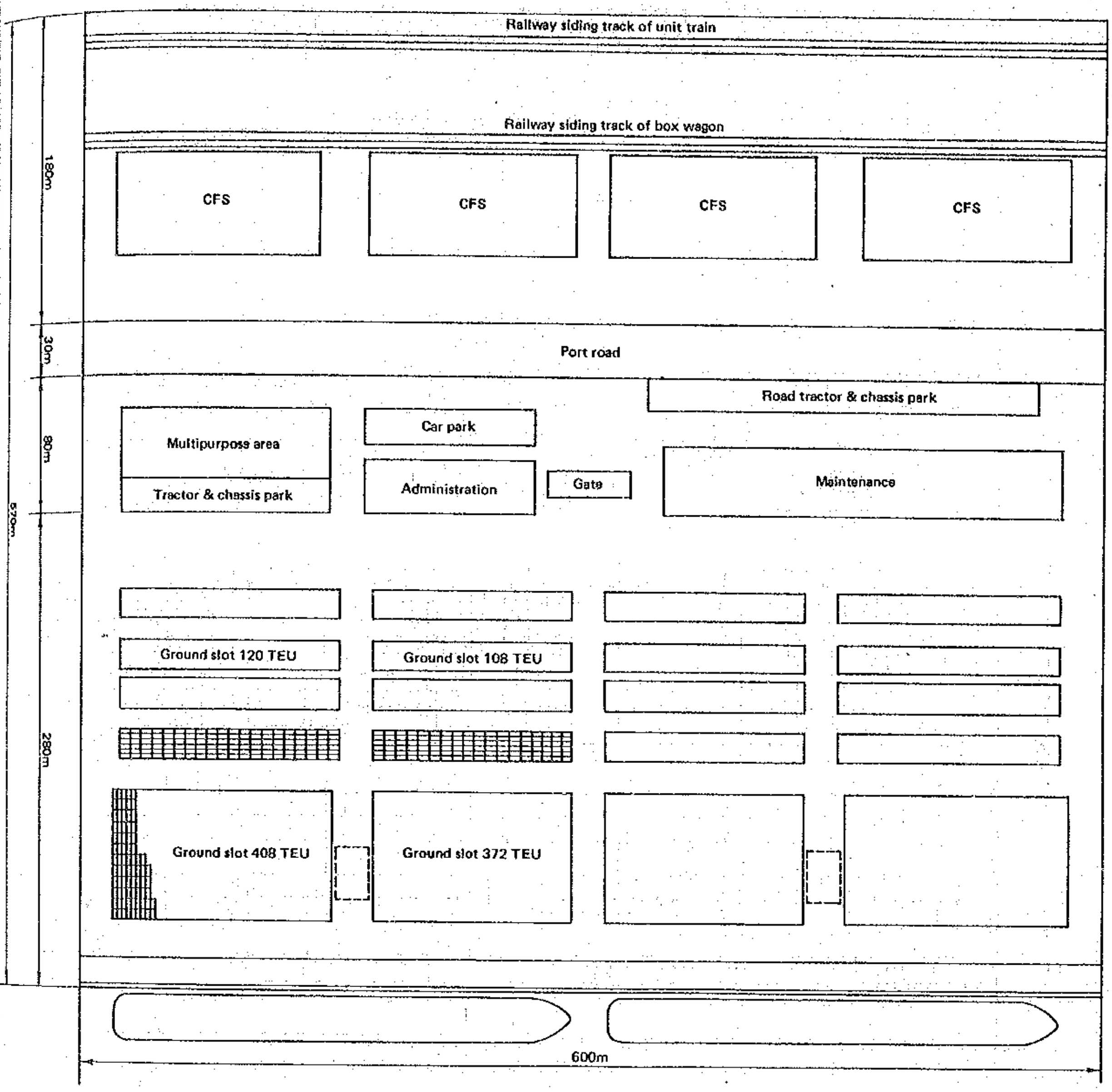


Fig. III-4-7 (5) All Chassis and Shifters

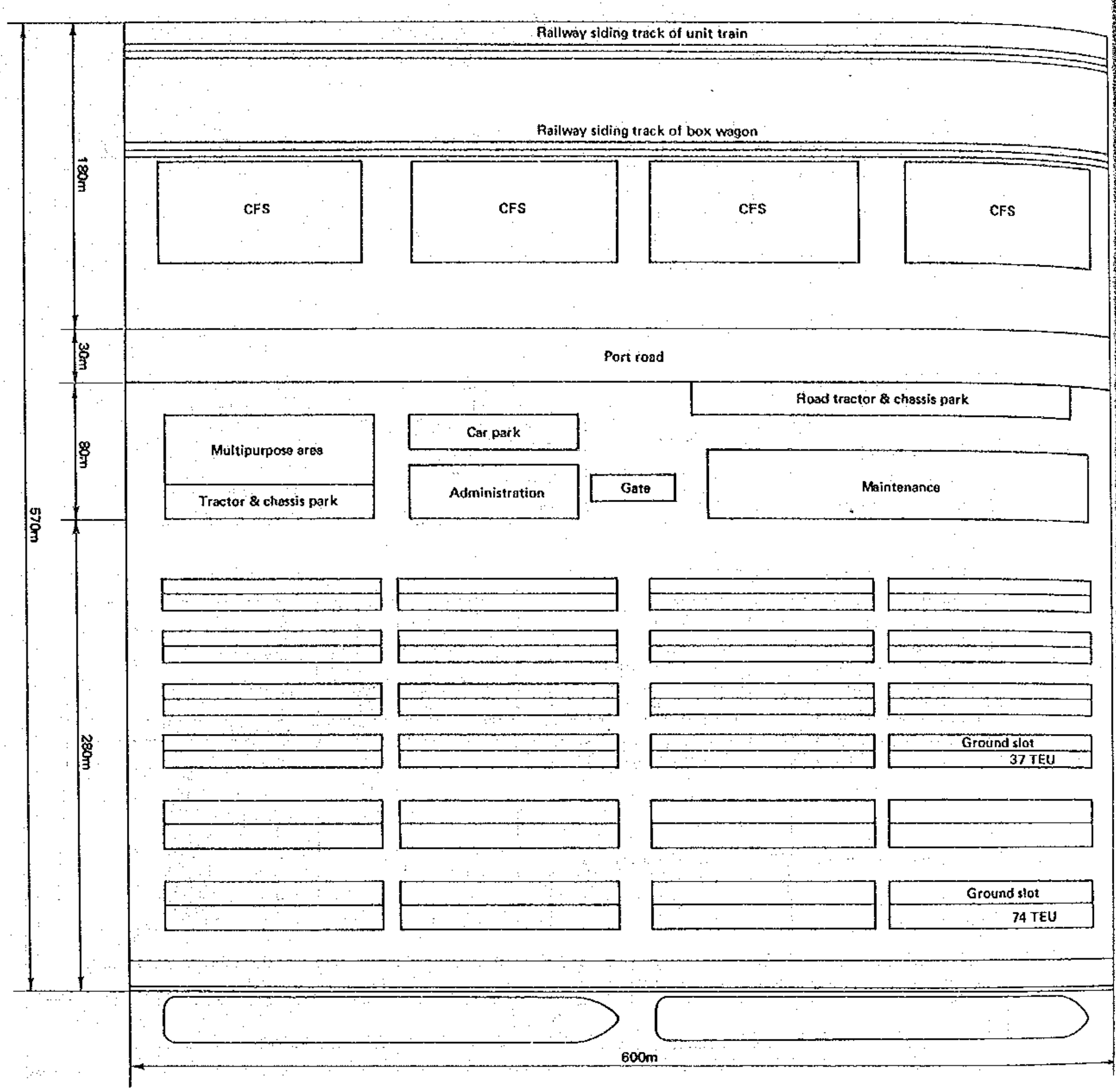


Fig. III-4-7 (6) Toplifters and Chassis Feed

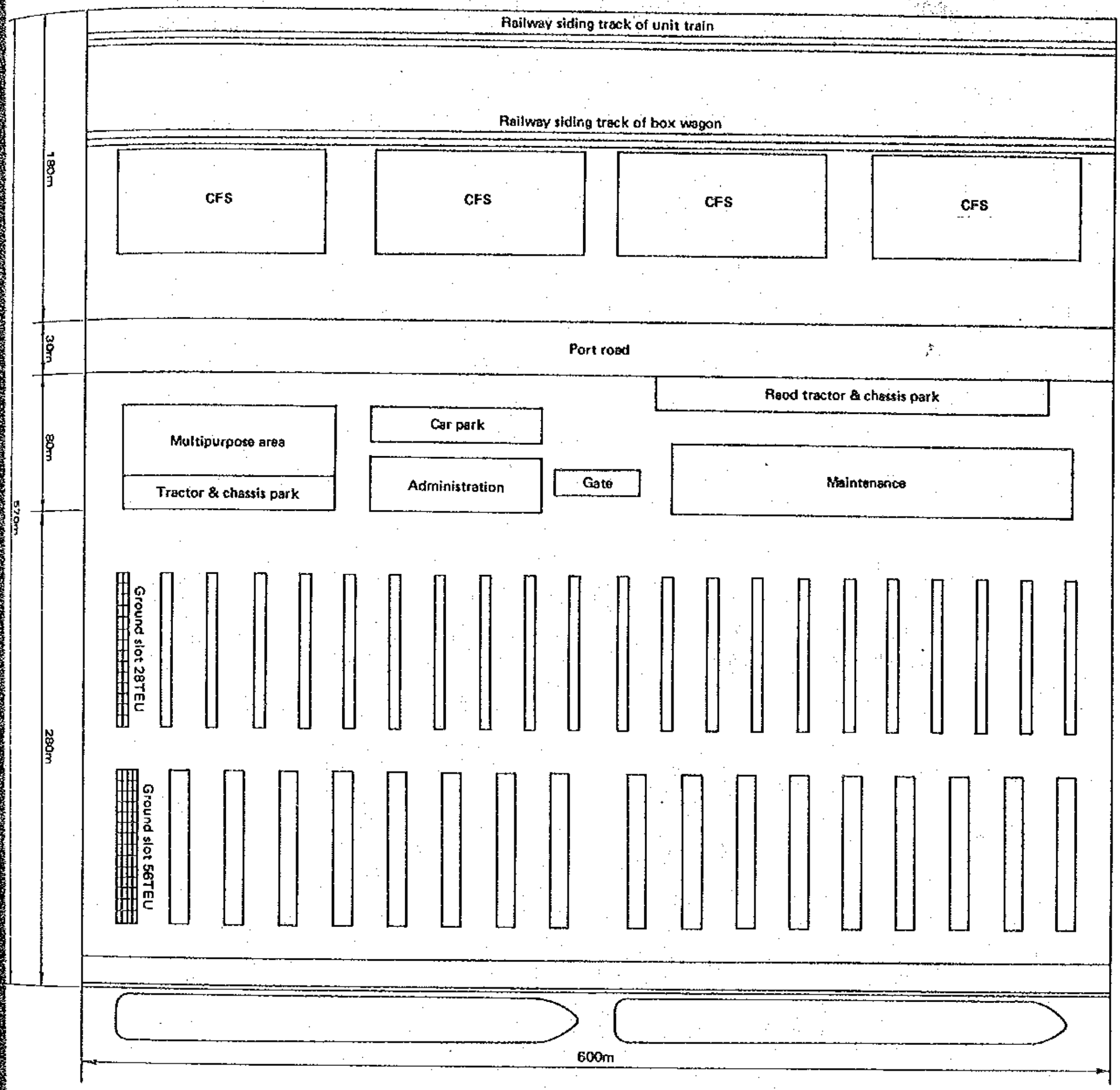


Fig. III-4-8 Comparison of Operation System for Transfering CNTR from and to Unit Train

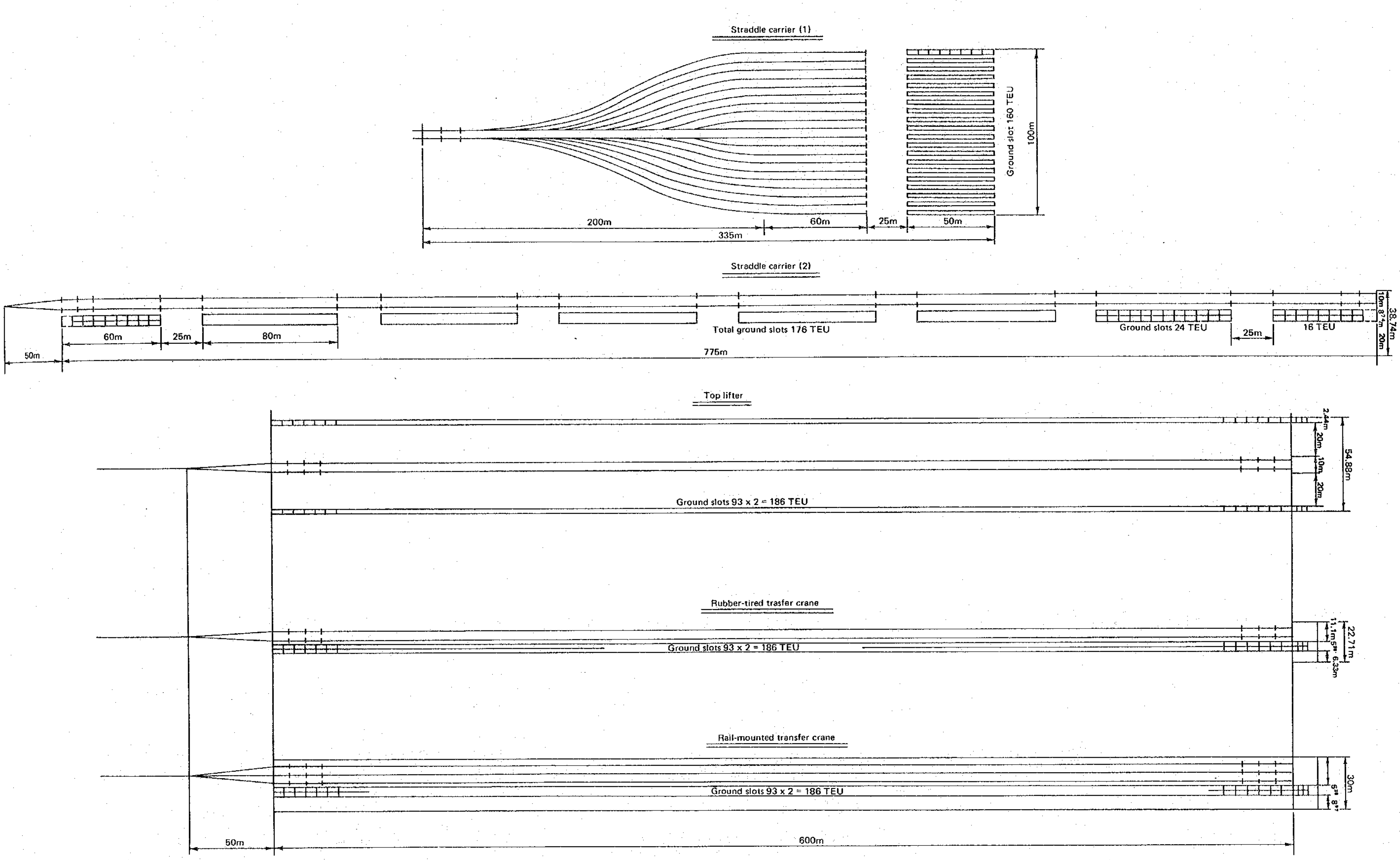


Fig. III-4-9 Organization Chart of Port Terminal (1987—1988)

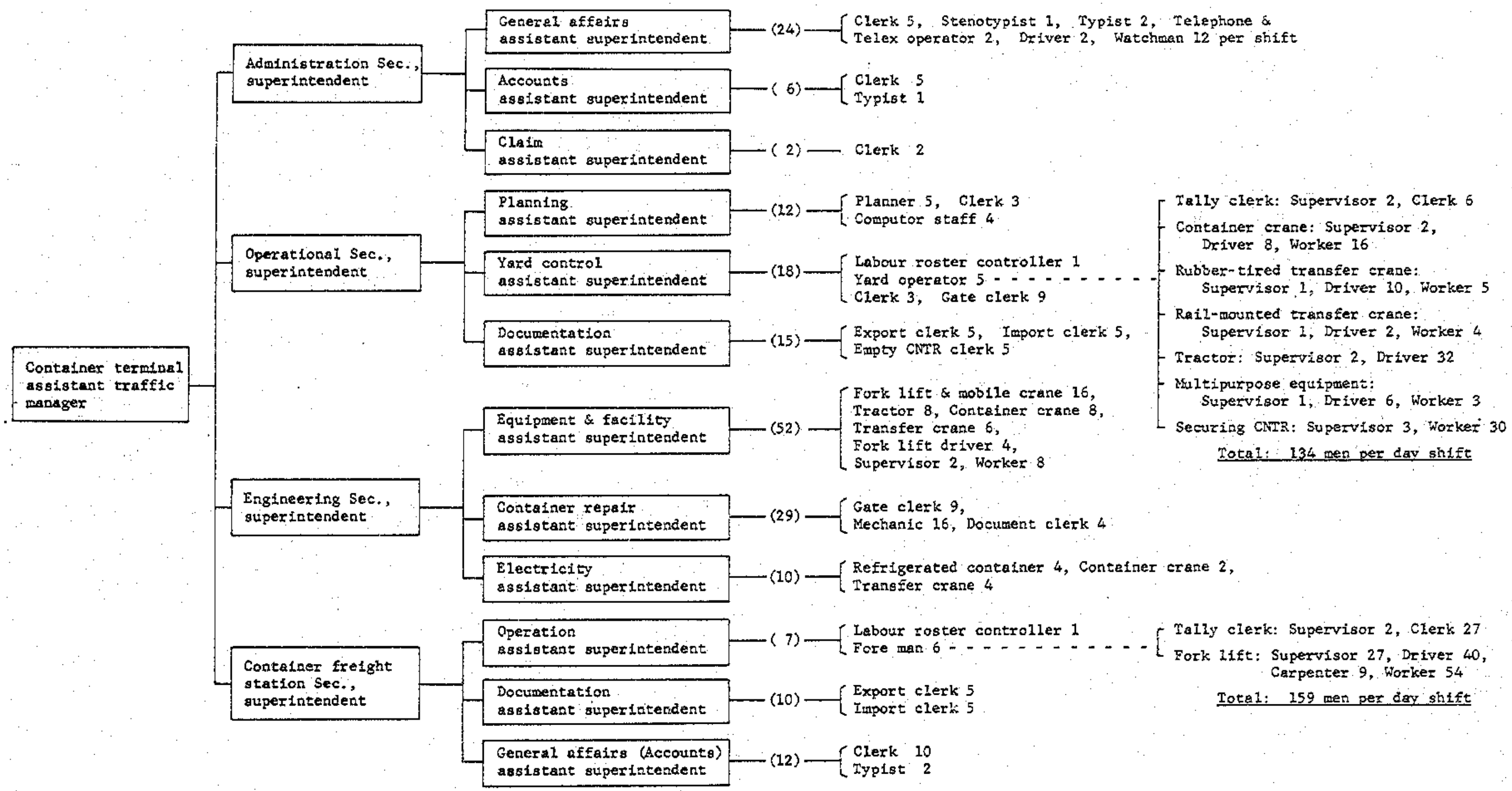


Fig. III-4-10 Container Berth Layout, Karachi (Master Plan)

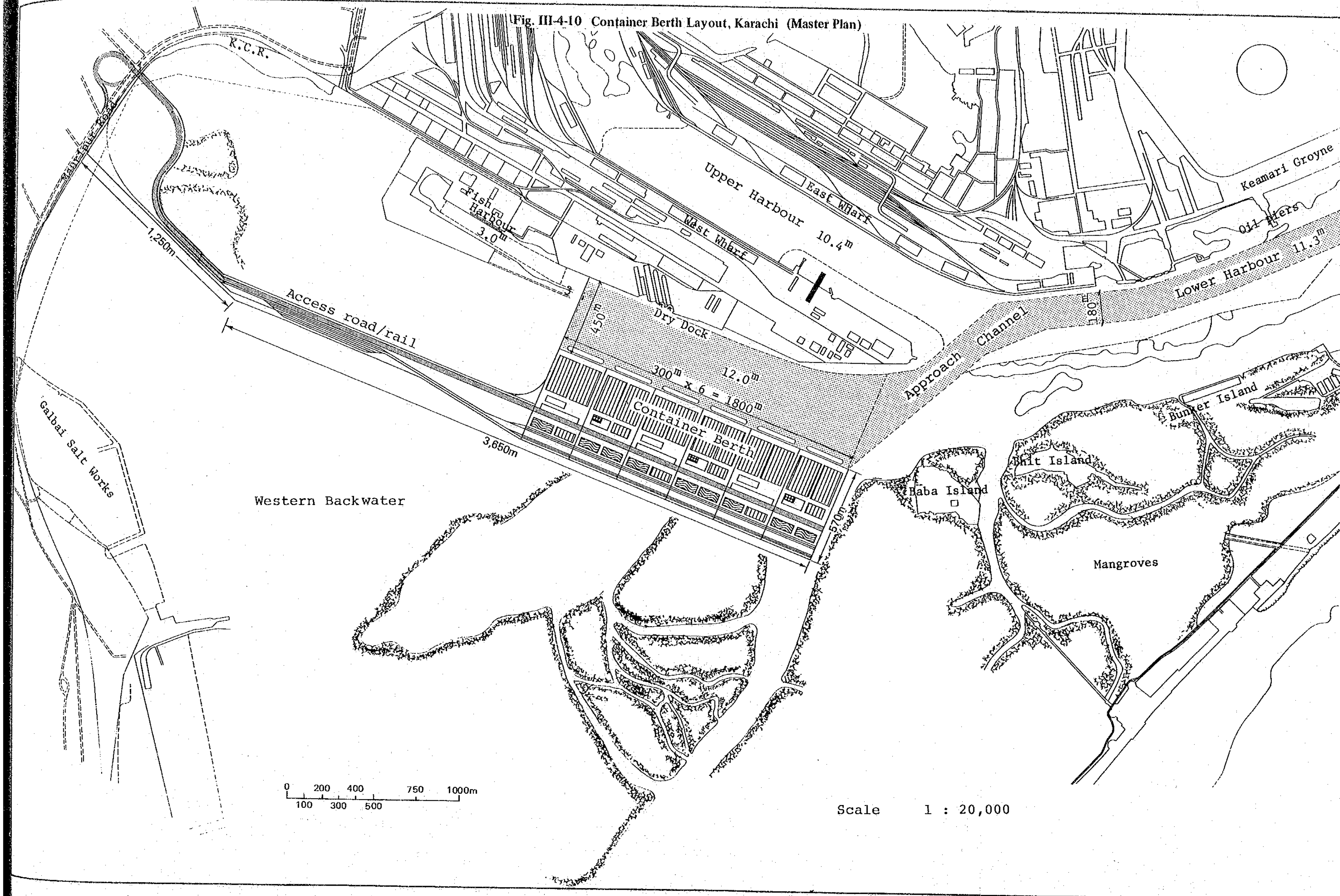


Fig. III-4-11 Container Berth Layout, Karachi (Urgent Plan)

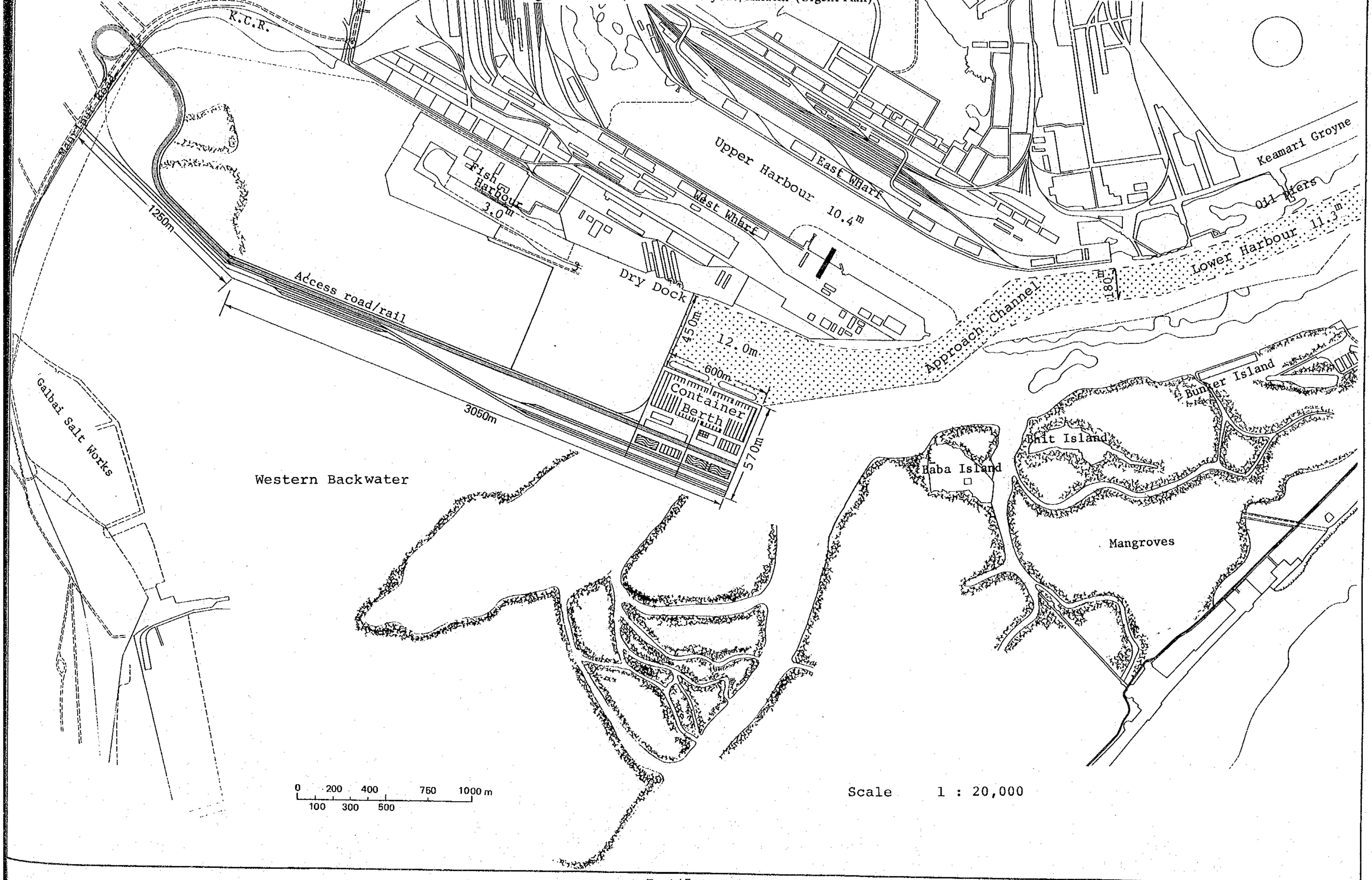


Fig. III-4-12 Western Backwater Scheme

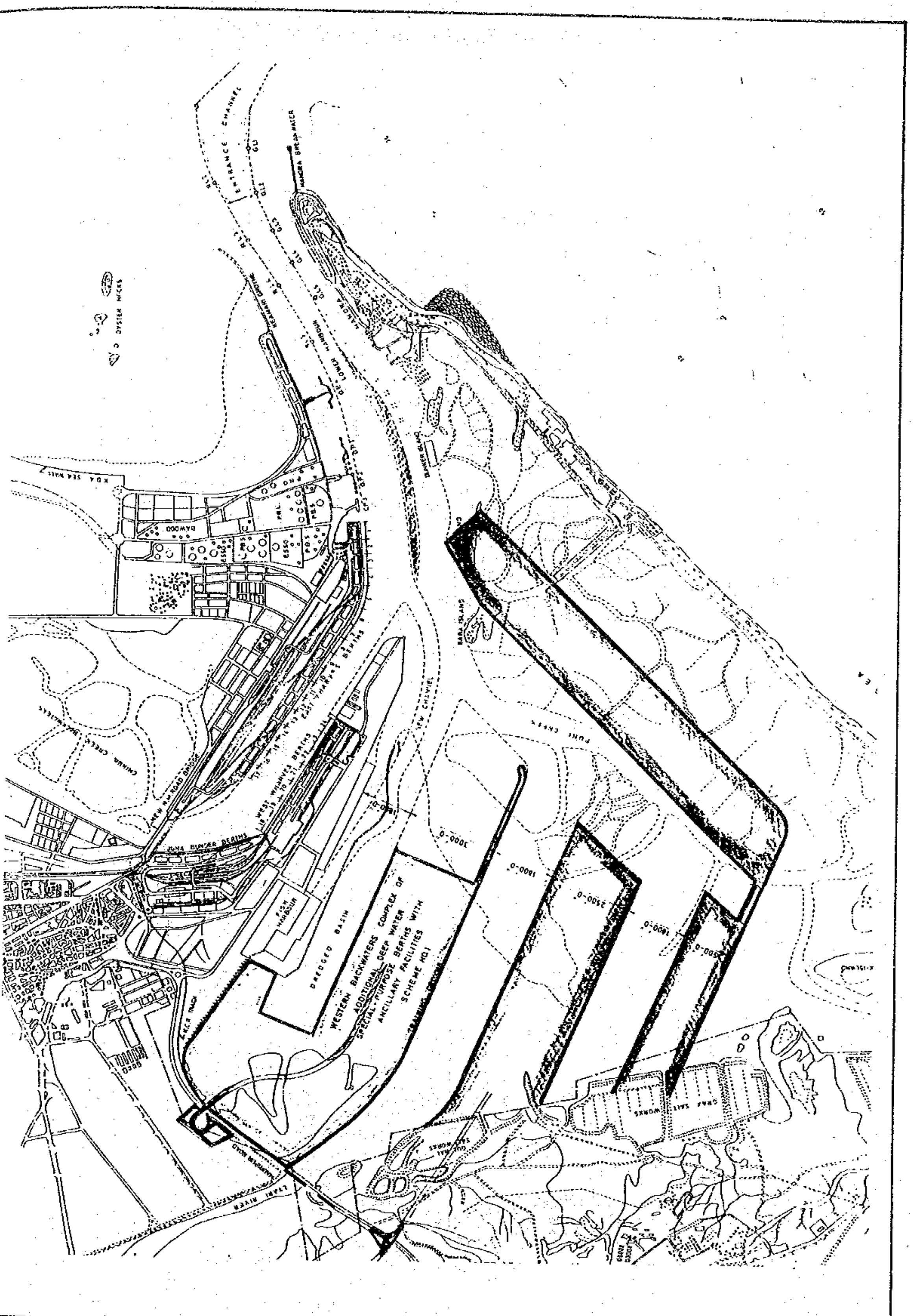


Fig. III-4-13 Existing & Planned Channel Depth

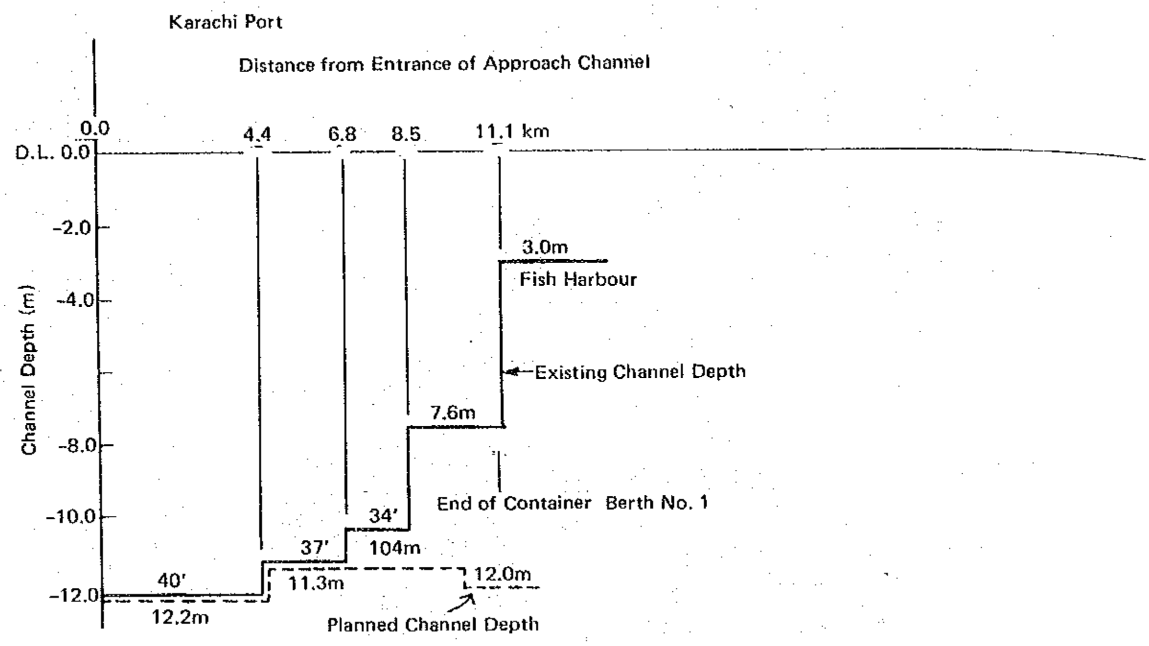


Fig. III-4-14 Channel Depth & Ship's Draft

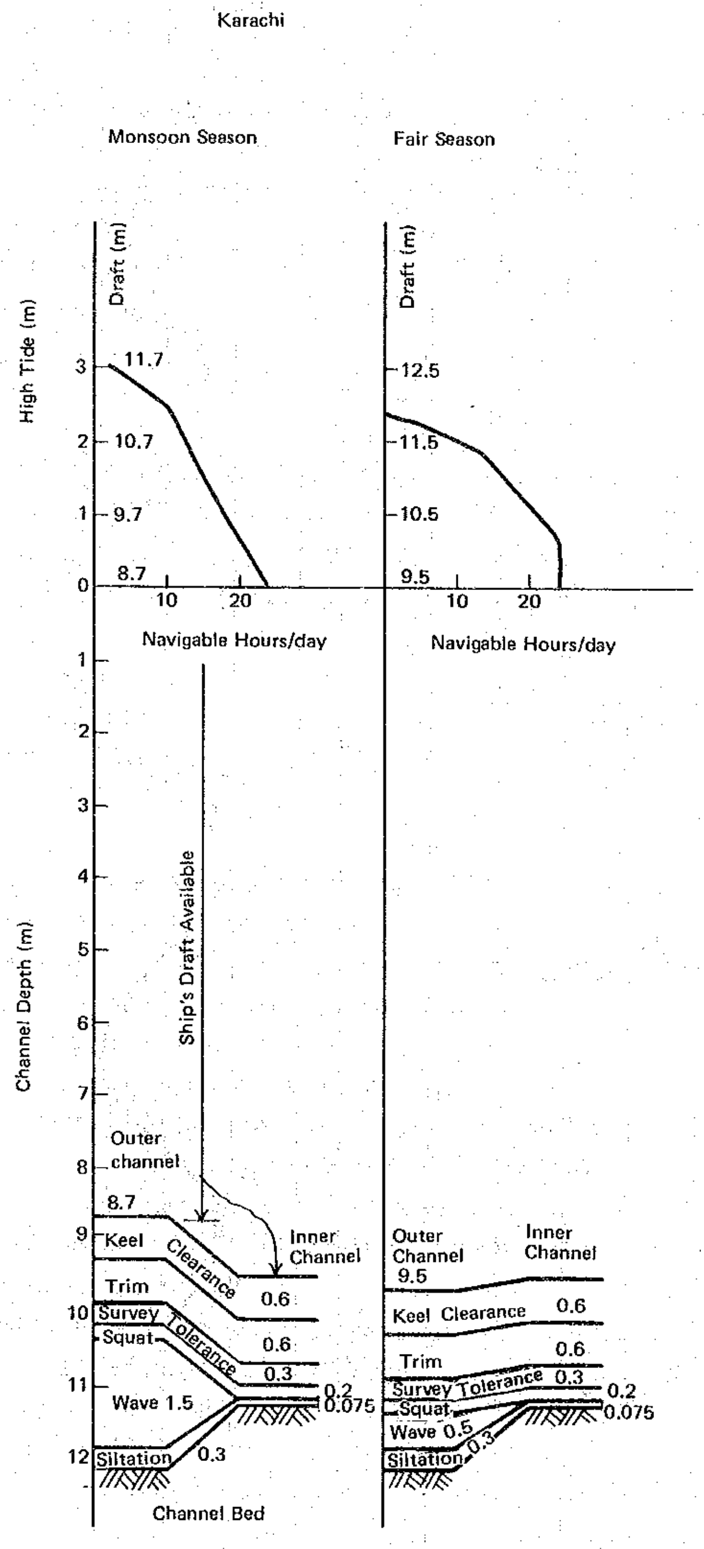
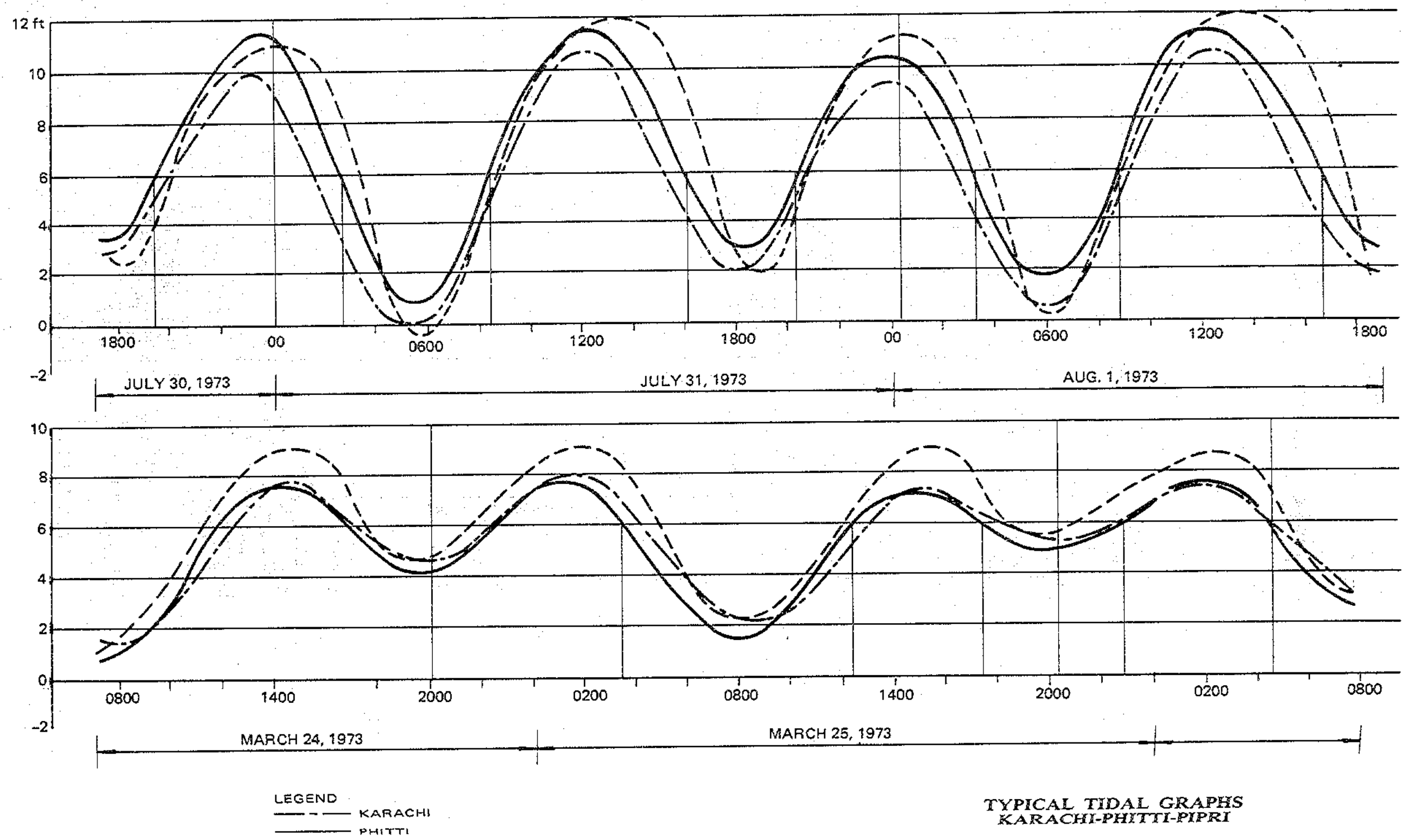


Fig. III-4-15 Tidal Variation



CHAPTER 5. CONSTRUCTION PLAN

5-1 Design of facilities

5-1-1. Selection of quaywall type

Following structure types can be listed as the container berth quaywall.

i) Steel sheet pile cellular cofferdam type quaywall

ii) Concrete block type or concrete cellular block type quaywall

iii) Concrete caisson type quaywall

iv) Pile supported platform

  a) Precast concrete supported platform

  b) Steel pipe pile supported platform

  c) Cast in situ concrete pile supported platform

Site conditions considered for selection of quaywall type are as follows.

i) As indicated in layer differentiation profile in Fig. III-2-13 to Fig. III-2-24 soil conditions below the proposed depth (−12 m K.P.D.) for the container berth are hard clay or sand with congromerate of which standard penetration test shows more than 60 blows/foot to refusal.

ii) Seismicity is moderate, seismic factor is 1/15.

iii) Principal steel material for construction such as steel pipe pile will be imported.

iv) Other construction materials such as cement, aggregate, reinforcing bar will be procured in Pakistan.

Character of each type of quaywall and their adaptability are as follows:

i) Steel sheet pile cellular cofferdom type quaywall

Construction work is comparatively simple, construction period is short and construction cost is comparatively low. However, soil condition as described in site conditions is not suitable for driving sheet piles.

ii) Concrete block type or concrete cellular block type quaywall

Construction work is comparatively simple. Big facilities are not necessary for construction. Supervision is comparatively easy. However, as these types are not monolithic structures, they are not so reliable for deep water berth structures. Therefore, these are not recommendable for the container berth quaywall.

iii) Concrete caisson type quaywall

The site conditions which the bearing strata is very stiff and seismicity is moderate are of great advantages to the gravity type structures.

Most of construction materials of this type structure can be procured in Pakistan.

Its production is reliable because of precast concrete structure.

The work at construction site is comparatively simple and this structure is monolithic structure.

Considering features mentioned above, concrete caisson type quaywall is recommended for this project.

iv) Pile supported type platform

This type structure can be applied for comparatively soft ground and can be easily designed to cope with increasing the depth of berth in future.

In addition, it can be designed as earthquake proof structure. Water flow is not so much affected by this type structure and wave reflection is not much caused.

On the other hand, as two kinds of structure such as pier and revetment have to comparatively fragile for the impaction force of vessels.

a) Precast concrete pile supported type platform

Large diameter precast concrete pile is difficult to produce and drive, therefore the structure have to be designed to resist against large external force by adopting large numbers of pile or butter piles.

In this project site where the ground is very stiff and the pile driving by ordinary method is impossible, the piles must be driven by other method that the pile hole must be drilled in advance and piles are set in the hole.

In this case, construction work will be complicated and construction period will also be longer.

b) Steel pipe pile supported type platform

As large size piles can be adopted, this type structure is suitable for deep water berth. However, problem will be maintenance such as corrosion protection of steel materials and it will be difficult to penetrate the piles up to necessary depth in this hard ground.

c) Cast in situ reinforced concrete pile supported type platform

Supervision of concreting will be difficult because of using underwater concrete.

On the other hand, the erection of big size pile is possible, accordingly the pile numbers can be decreased and maintenance such as corrosion protection of steel materials can be deleted. This type will be possible by adopting the construction method which was executed in Iron Ore and Coal berth at Port Qasim.

The method is as follows. At first, large size steel pipe piles will be driven into hard ground up to 2 to 3 m below the proposed seabed, then hard material inside the piles will be drilled by drilling machine up to necessary depth for the piles and then reinforced concrete piles will be erected in the steel pipe piles.

Considering features of each type structures mentioned above, concrete caisson type quaywall and cast in situ reinforced concrete pile supported type platform are selected and comparative study are performed in the next section.

5-1-2 Comparative design of quaywall structure

(1) Design condition

Design depth	:	−12 m (K.P.D.)		
Crown height of quaywall	:	+ 4.5 m		
Tide level	:	HAT	=	+3.20 m (+10.5 feet)
		MHHW	=	+2.68 m (+8.8 feet)

	MLLW	=	+0.43 m (+1.4 feet)
	LAT	=	-0.43 m (-1.4 feet)

Seismic coefficient	: 1/15	
Berthing speed of vessel	: 0.1 m/sec	
Design load	: Uniform load	
	Container yard	3.0 t/m²
	Under the crane	
	Ordinary	1.0 t/m²
	During earthquake	0.5 t/m²
Container crane load	: Rail span	16 m
	Wheel number	8 wheel/1 corner
	Crane self weight	660 tons
	Wheel load as follows.	

		Vertical	Horizontal
In operation	shore side	36.8 t/wheel	10% of vertical load
(16 m/sec.)	land side	28.5 t/wheel	
In storm	shore side	30.4 t/wheel	Total wind load
(50 m/sec.)	land side	40.6 t/wheel	(153.8 tons)
In earthquake	shore side	20.0 t/wheel	Total seismic force
	land side	30.2 t/wheel	(46.2 tons)

As a reference, specifications of container crane used in Japan are indicated in Table III-5-1.

(2) **Conclusion**

Concrete caisson type quaywall and cast in situ reinforced concrete pile supported platform are indicated in Fig. III-5-1 to Fig. III-5-4. Result of comparative study is indicated in the following table.

Comparative Table

Type of Quaywall	Reliability & Simplicity of Work	Construction Materials	Construction Cost (Million US$/m)
Concrete caisson type	Easy	Major construction materials are available in Pakistan	26
Cast in situ reinforced concrete pile supported platform	Difficult	Steel pipe piles to be imported	31

As indicated in above table, concrete caisson type quaywall is recommended.

5-1-3 Revetment for reclamation (Urgent plan)

Revetment for reclamation will be constructed at south side, north side and west side of container terminal.

Existing ground levels are approximately −1.5 m to +0.3 m at south side, ±0 m at north side and over +0.3 m at west side. These revetments face to calm water in the harbour and are not parmanent structures except west side revetment. In consideration of above conditions, stone pithing type revetment is recommended as shown in Fig. III-5-5.

Outline of soil condition is supposed from the soil data nearby that the surface is covered with 1 to 3 m thick soft soil but comparatively good compacted soil layer underlies this soft soil and the hard clay layer (S.P.T. is more than 50) is encountered elevation approx. −10 m.

However, existing soil data are not sufficient for design because the soil conditions are different by places. Therefore, in execution of this project, the soil investigation at the proposed line of revetment should be performed.

5-1-4 Pavement

(1) Pavement for container yard

Asphalt concrete pavement is recommended for the container yard in consideration of differential settlement, maintenance and rapairment.

However, for the track of rubber tyre transfer crane or straddle carrier, concrete pavement or prestressed concrete pavement is necessary in order to prevent from rutting.

Pavement composition should be designed after estimation of traffic volume at each section such as gate section, passage section, transit section, container storage yard. However, on account of many uncertain factor at present, estimation of traffic volume is difficult, therefore this design is based on the data of Ohi container berth at TOkyo, Japan. Design CBR is assumed 2.5% and design wheel load is 13 t. Pavement composition is shown in Fig. III-5-6. Prestressed concrete pavement composition for rubber tyre transfer crane is shown in Fig. III-5-7.

(2) Pavement for access road

Generated traffic volume per day from container terminal is estimated from annual cargo handling volume by the method described in Chapter 4, Paragraph 4-7-1.

Year	Cargo handling volume by road	Traffic volume per day
1987	661,303 MT	Approx. 1990 (heavy vehicle 670)
2000	2,364,886 MT	Approx. 7090 (heavy vehicle 2363)

Supposing that increasing rate of heavy traffic volume is constant and subgrade CBR is 3%, the standard pavement composition will be as shown in Fig. III-5-8.

5-1-5 Container freight station

Container freight station and office will be reinforced concrete structures and supported by R.C. piles because the structures will be very heavy and constructed on the reclamation ground.

5-2 Methods of Construction

5-2-1 Methods of construction of main facilities

(1) Container berth

The caisson type will be used for the container berth because it will be constructed on a hard ground. Western Back Water, the construction site, is calm waters and there will be few days when work will stop due to inclement weather.

A caisson yard is necessary to manufacture caissons but, because of the difficulty to secure a waterline necessary to caisson yard, caissons will be produced, using a floating dock.

The method to construct the caisson type container berth is shown in Fig. III-5-9.

a. Excavation:
   Dredged by a large heavy type cutter suction dredger. Dredging material will be discharged in the area to be reclaimed.

b. Caisson bed:
   Rubble stone will be brought to the temporary jetty by dump trucks from the quarries sporadically located in the vicinity of Manghopir, and transported to the construction site by self-propelled barges with grab. Leveling of rubble stone surface will be performed by divers. The surface on which the caisson is to be installed must be leveled with special care.

c. Caissons will be manufactured in a floating dock fastened by anchors in an area at Western Back Water where it will not interfere with the navigation of ships and a suitable water depth is available. Concrete forms and reinforcing bars will be transported by pontoons from the temporary jetty. Concrete will be placed, using a concrete mixer barge. If an existing wharf can be used, concrete will be pumped by bringing it from the concrete plant by agitator trucks. After making lower part of caisson in a floating dock, caissons will be installed on the temporary mound provided at a suitable water depth, and concrete will be again done by pumping to reduce the caisson occupancy of the floating dock and speed up the construction work.

d. and e.
   When a caisson is completed, it will be floated from the undersea mound by discharging water from its interior. It will then be towed to its installing position by tugboats and put in place by pouring water into it.

f. Filling sand in the caissons will be collected by self-propelled barges with grab from the offshore, and poured into the caissons immediately after its installation. Also backfilling sand will be placed in position by self-propelled barges with grab.

g. Precast concrete will be used for cover concrete and put in place immediately after the throw-in of filling sand. Coping concrete will be placed after the completion of reclamation when the sinking of caisson stops.
h. Dredged material at channel and basin will be used for reclamation.
i. The sea-side rails for crane foundations will be installed on the caissons. The rail foundations on the land side will be of reinforced concrete beam structure resting on steel-pipe piles driven to a sufficient depth to assure required bearing capacity.
j. Pavement:
Asphalt concrete pavement will be used so as to be able to cope with the future settlement of the reclaimed ground.

(2) Dredging and Reclamation

As the material to be dredged contains hard material slightly, dredging works will be carried out mainly by a large size heavy type cutter suction dredger. Dredging material will be used for reclamation fill. And dredging works for deeping the channel will be carried out by a training suction hopper dredger not to higher the navigation of the ships and other small boats.

5-2-2 Work Base

Generally, the layout of work base for caisson type berth must reflect consideration for mainly the caisson yard, the concrete plant and the stone yard. At Port Karachi, basically a floating dock will be used because of the difficulty to provide a caisson yard on the waterline and concrete will be placed, using concrete mixer barge, but it is desirable to be able to use the existing wharf and manufacture caissons in the floating dock moored along the wharf.

It is desirable for the stone yard, the material yard and the yard for preparing reinforcement bars to be located as closely to the loading jetty as possible. A temporary loading jetty will be constructed at a suitable place if no existing facility can be used.

5-2-3 Materials for Work

The quantities of major construction materials are shown in Table III-5-2. Ordinary portland cement or sulphate resisting cement is used. This cement is produced in Pakistan. Reinforcing bars can also be procured domestically.

Concrete coarse aggregates will be collected and brought from Hub River while concrete fine aggregates and gravel for pavement will be collected and brought from Malir River.

Steel pipes and rails will be imported because they are not produced in Pakistan.

5-2-4 Construction Machines and Working Crafts

(1) Construction Machines

Construction works in Pakistan have greatly intensified in recent years as many roads, bridges and buildings are constructed. And construction machines including bulldozers, power shovels, trucks, concrete plants and cranes are used for these works.

However, the quantity of these construction machines is not sufficient for this project, and most of them are imported and are very expensive. Thus, it appears to be very difficult to procure within Pakistan a large number of construction equipment for the long period required for this project, so that it is appropriate to consider bringing most of the machines from Japan or other foreign country.

At the stage of actual work performance, it will be necessary to study more about the possibility of procuring in Pakistan itself and the neighboring countries.

(2) Working Crafts

Port Karachi possesses some working craft including tugboats, floating cranes and dredgers and uses them for the operation and cargo handling of ships in port. However, practically no working craft other than these exist in Pakistan and it is impossible to procure domestically working craft for this project and there is no choice but to bring them from Singapore or some other country.

5-2-5 Labor Force

The Pakistani construction related labor force is fairly abundant; thus, ordinary workers can be easily procured and it is possible to secure skilled workers for civil engineering machines, road construction and building works from domestic sources.

As for marine construction, since working crafts will be procured from abroad, we conceived the following about the securing of labor necessary for this project:

Pakistan:	Ordinary workers and general skilled workers (masons, reinforcement workers, operators, mechanics, etc.)
Foreign:	Skilled labourers (divers, crew, scaffolding men)

5-2-6 Construction Schedule

Table III-5-3 shows the construction schedule under the urgent plan. The total period is five years: 1-1/2 years for engineering study, bidding, etc. and 3-1/2 years for construction.

5-3 Construction Cost

5-3-1 Conditions of cost estimates

Construction cost is estimated based on the following conditions:

a) Exchange rates between Pakistan Rupee, Japanese Yen and US Dollar are assumed to be as follows:

US$ 1.00 = Rs 9.9 = ¥210

b) Estimates are based on unit prices in the year 1980.

c) Unit prices of construction materials and labour wages are based on the NESPAK PRICE INDEX and the data obtained through the site survey.

d) Construction vessels are assumed to be brought from and returned to Singapore and its vicinity after completion.
Thus, round-trip transportation expenses and insurances are included in the estimate.
Equipment and construction materials domestically unavailable will be transported from Japan and are expressed in CIF prices.

e) Taxes such as import duties and sales tax on both domestic and imported goods are excluded because of transfer cost.

5-3-2 Construction cost

The construction cost for Master Plan and Urgent Plan are shown in Table III-5-4 and Table III-5-5, respectively.

Also yearly investment plan for Urgent Plan are shown in Table III-5-6.

Table III-5-1 Specifications of Container Crane Used in Japan

Berth	No. 1	No. 3	No. 4	No. 6	No. 8	No. 8	No. 5	No. 6	No. 7
Crane No.	OC11	OC31	OC41	OC61	OC81	OC82	HC51	HC61	HC71
Crane Type	High speed, rope trolley	High speed, rope trolley	Semi-rope trolley	Flexible boom, high speed, semi-rope trolley	Flexible boom, rope trolley	Flexible boom, high speed, semi-rope trolley	High speed, rope trolley	Semi-rope trolley	Semi-rope trolley
Completion date	Jun. 1975	Apr. 1975	Feb. 1974	Mar. 1973	Mar. 1972	Oct. 1972	May 1974	Jan. 1971	May 1970
Lift load (t)	45.0	50.0	45.0	50.0	44.0	49.6	43.5	39.5	39.5
Lift load (t)	30.5 35.0 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5 35.5 (Hatch cover)	30.5 35.6 (Hatch cover)	30.5	30.5	30.5
Crane gauge (m)	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Rail span (m)	16.0	16.0	16.0	16.0	16.0	16.-	16.0	16.0	16.0
Traversing (m) — Trolley overall traversing distance	62.5	67.0	67.0	67.0	67.0	67.0	61.0	57.0	57.0
Traversing (m) — Out reach (from rail on sea side)	35.5	35.0	35.0	35.0	35.0	35.0	35.0	33.5	33.5
Traversing (m) — Back reach (from rail on land side)	11.0	16.0	16.0	16.0	16.0	16.0	10.0	7.5	7.5
Lift (m) — Overall lift	37.0	37.0	37.0	37.0	37.0	37.0	38.6	33.5	33.5
Lift (m) — Overall surface	25.0	25.0	25.0	25.0	25.0	25.0	25.0	21.7	21.7
Lift (m) — Below rail surface	12.0	12.0	12.0	12.0	12.0	12.0	13.6	11.8	11.8
Effective interval within legs	16.0	16.0	16.0	16.0	16.0	16.0	16.0	14.5	14.5
Effective height beneath bridge beam (m)	9.0	9.0	9.0	9.5	9.0	9.5	10.7	9.0	9.0
Power (cable winding)	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 3000V 50Hz	A.C 550V 50Hz	A.C 550V 50Hz	A.C 550V 50Hz
Generator drive motor output (KW)	A.C 500	3φ Transformer 750 KVA	3φ Transformer 500 KVA	3φ Transformer 750 KVA	A.C.350 (75% ED)	A.C 500 (60% ED)	3φ Transformer 800 KVA	A.C 400 (Continuous)	A.C 400 Continuous)
Generator combination	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation	Winding and traveling / Travers-ing and elevation
Generator output (KW.A)	405 / 100	SCR500A / SCR300A	— / SCR150A	— / SCR300A	250 / 100	400 / 110	—	290 / 110	290 / 110
Motor output — Winding (Rated)	D.C 370 (Continous)	D.C. 370 Continuous)	D.C 220 (Continuous)	D.C 370 (Continuous)	D.C 220 (Continuous)	D.C 185 x 2 (Continuous)	D.C 185 x 2 (Continuous)	D.C 125 x 2 (Continuous)	D.C 125 x 2 (Continuous)
Motor output — Traversing (Rated)	D.C. 80 (Continuous)	D.C 45 x 2 (Continuous)	D.C 25 x 2 (Continuous)	D.C 45 x 2 (Continuous)	D.C 50 (60% ED)	D.C 100 (40% ED)	D.C 75 (Continuous)	D.C 25 x 2 (Continuous)	D.C 25 x 2) (Continuous)
Motor output — Traversing (Rated)	D.C 12.5 x 8 (30 mins)	D.C 15 x8 (30 mins)	D.C 15 x 8 (30 mins)	D.C 15 x 8 (30 mins)	D.C 12.5 x 8 (30 mins)	D.C 12.5 x 8 (30 mins)	D.C 30 x 4 (60 mins)	D.C 20 x 4 (30 mins)	D.C 20 x 4 (30 mins)
Motor output — Elevation (Rated)	D.C 75 (60 mins)	D.C 75 (30 mins)	D.C 7.5 (30 mins)	D.C 95 (30 mins)	D.C 90 (30 mins)	D.C 90 (30 mins)	D.C 75 (30 mins)	D.C 67 (30 mins)	D.C 67 (30 mins)
Speed (m/min) — Winding Total load/No load	50/120	50/120	35.5/90	50/120	35.5/90	50/120	50/120	35.5/71	35.5/71
Speed (m/min) — Traversing	150	150	125	150	125	150	150	125	125
Speed (m/min) — Traveling	45	45	45	45	45	45	45	45	45
Speed (m/min) — Elevation (min/cycle)	8	8	8	8	8	8	8	8	8
Number of wheels — Quay side	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	6 x 2	6 x2
Number of wheels — Shore side	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	8 x 2	6 x 2	6 x 2
Maximum wheel load (t/wheel) — In operation — Quay side	29.6	37.7	30.1	38.2	33.7	38.1	30.3	37.1	37.4
Maximum wheel load (t/wheel) — In operation — Shore side	27.0	29.6	28.2	28.5	21.8	27.6	32.4	28.9	26.4
Maximum wheel load (t/wheel) — In storm — Quay side	31.6	30.8	26.4	35.9	33.3	30.4	32.9	30.2	30.5
Maximum wheel load (t/wheel) — In storm — Shore side	41.0	46.0	45.3	43.6	35.7	43.7	45.2	43.8	42.5
Traveling range (m)	270	400	400	450	300	300	150	200	200
Crane weight (t)	550	615	575	660	583	635	631	521	510
Traveling rail height Quay side/Shore side (m)	4.0 / 4.0	4.02 / 4.18	4.02 / 4.18	4.02 / 4.18	4.02 / 4.18	4.02 / 41.8	3.82 / 3.98	3.82 / 3.98	3.82 / 3.98
Operating room mounting system	Trolley suspension	Trolley suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly suspension	Trolly Suspension	Trolly suspension
Remarks	With steady rest Telescopic spreader, 2 Spreader truck, 2	With steady rest Telescopic spreader, 1 Spreader truck, 1	20ft Spreader, 1 40ft Spreader, 1	With steady rest 20ft Spreader, 1 40ft Spreader, 1	20ft Spreader 2 40ft Spreader, 2 Spreader truck, 3	With steady Suspension fixture, 1	With steady rest Sea side rocking leg Stacking frame	Spreader 20' x 1 35' x 1 Stacking frame With receptacle	Spreader 20' x 2 40' x 2

Source; Keihin (Tokyo Bay) Port Development Authority

Table III-5-2 Major Construction Materials (Karachi Port)

Material	Item	Unit	Quantity		Supply		Remarks
			Urgent Plan	Master Plan	Local	Foreign	
Sand, Stone & Cement	Stone	m^3	110,000	159,000	○		Rubblestone, Revetment
	Filling sand	m^3	190,000	570,000	○		Caisson filling, backfilling
	Reclamation fill	m^3	3,900,000	6,800,000	○		
	Cement	t	13,200	38,500	○		
	Fine aggregate	m^3	18,000	52,000	○		
	Coarse aggregate	m^3	32,000	91,000	○		
	Crusher run	m^3	195,000	560,000	○		Container Terminal and Road Pavement
Steel	Steel pipe pile	No	135	405		○	ϕ711.2, t=12, ℓ=17m
		No	400	1,200		○	ϕ609.6, t=12, ℓ=17m
	Reinforcement Bar	t	4,400	13,200	○		
	Rail	m	30,600	49,600		○	
Others	Steel forms					○	
	Scaffolds					○	
	Fuel oil				○		
	Rubber fender					○	
	Sleeper					○	

Note: Construction materials for CFS and other buildings are not included in figures.

Table III-5-3 Construction Schedule for Karachi Port

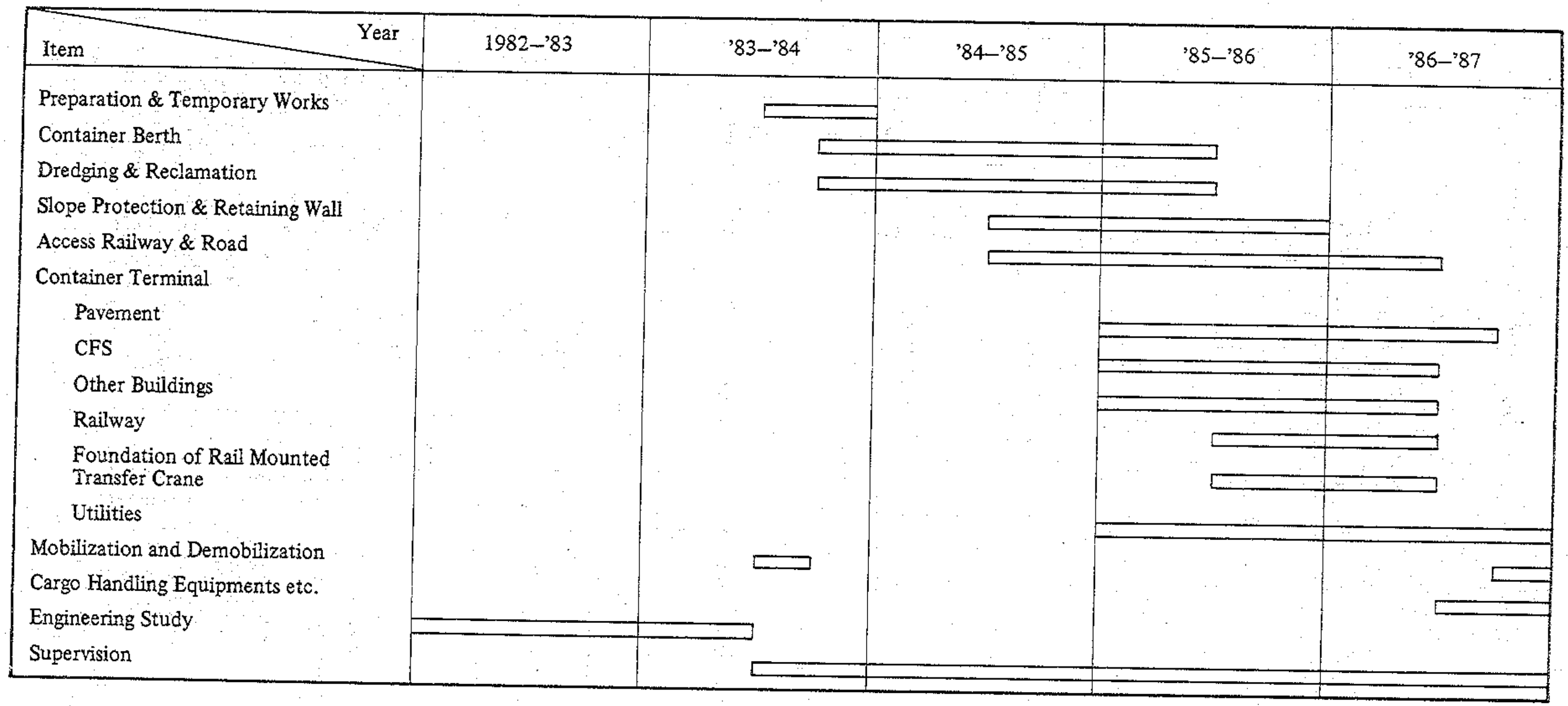


Table III-5-4 Construction Cost for Karachi Port (Master Plan)

Unit: 1000 US$

ITEM	PARTICULARS	UNIT	QUANTITY	AMOUNT LOCAL	FOREIGN	TOTAL
1	Preparation & Temporary Works	L.S		1,104	395	1,499
2	Container Berth	m	1,800	22,911	23,523	46,434
3	Dredging & Reclamation	m^3	8,950,000	8,052	20,710	28,762
4	Slope Protection & Retaining Wall					
	Slope Protection	m	9,300	1,860	797	2,657
	Retaining Wall	m	144	206	1,165	1,371
5	Access Railway and Road					
	Railway	m	14,000	365	2,064	2,429
	Road	m	4,100	2,312	578	2,890
	Interchange	Nos	1	2,286	571	2,857
6	Container Terminal					
	Pavement	m^2	846,750	29,030	7,259	36,289
	CFS	m^2	59,400	12,067	3,017	15,084
	Office & Other Buildings	m^2	30,147	5,610	1,403	7,013
	Railway	m	10,800	231	1,312	1,543
	Foundation of Rail Mounted Transfer Crane	m	1,800	3,810	3,810	7,620
	Utilities	L.S		6,002	2,572	8,574
7	Mobilization & Demobilization	L.S		-	2,857	2,857
8	Equipments					
	Cargo Handling Equipments	L.S		-	101,376	101,376
	Navigational Aids	L.S		-	143	143
	Sub Total			95,846	173,552	269,398
9	Engineering Study & Supervision	L.S		2,694	8,082	10,776
10	Physical Contingency		15% of Item 1-7 + 5% of Item 8	14,377	18,881	33,258
	Total			112,917	200,515	313,432

Table III-5-5 Construction Cost for Karachi Port (Urgent Plan)

Unit: 1000 US$

ITEM	PARTICULARS	UNIT	QUANTITY	AMOUNT LOCAL	FOREIGN	TOTAL
1	Preparation & Temporary Works	L.S		638	255	893
2	Container Berth	m	600	7,637	7,841	15,478
3	Dredging & Reclamation	m^3	4,700,000	4,321	11,113	15,434
4	Slope Protection & Retaining Wall					
	Slope Protection	m	9,300	1,860	797	2,657
	Retaining Wall	m	72	447	239	686
5	Acess Railway and Road					
	Railway	m	11,700	315	1,785	2,100
	Road	m	4,100	1,327	332	1,659
	Interchange	Nos	1	1,334	333	1,667
6	Container Terminal					
	Pavement	m^2	282,400	9,682	2,421	12,103
	CFS	m^2	19,800	4,024	1,006	5,030
	Office & Other Buildings	m^2	9,881	1,851	463	2,314
	Railway	m	3,600	77	437	514
	Foundation of Rail Mounted Transfer Crane	m	600	1,270	1,270	2,540
	Utilities	L.S		2,001	857	2,858
7	Mobilization & Demobilization	L.S		-	1,905	1,905
8	Equipments					
	Cargo Handling Equipments	L.S		-	31,732	31,732
	Navigational Aids	L.S		-	143	143
	Sub Total			36,784	62,929	99,713
9	Engineering Study & Supervision	L.S		997	2,992	3,989
10	Physical Contingency		15% of Item 1-7 +5% of Item 8	5,518	6,252	11,770
	Total			43,299	72,173	115,472

Table III-5-6 Yearly Investment Plan (Karachi Port)

Unit: 1,000 US$

Item	Particulars	1982 - '83			'83 - '84			'84 - '85			'85 - '86			'86 - '87			Total		
		L/C	F/C	Sub Total	L/C	F/C	Sub Total	L/C	F/C	Sub Total	L/C	F/C	Sub Total	L/C	F/C	Sub Total	L/C	F/C	Total
1	Preparation & Temporary Work				638	255	893										638	255	893
2	Container Berth				1,091	1,120	2,211	4,364	4,481	8,845	2,182	2,240	4,422				7,637	7,841	15,478
3	Dredging & Reclamation																		
	Dredging				309	794	1,103	1,235	3,175	4,410	618	1,587	2,205				2,162	5,556	7,718
	Reclamation				308	794	1,102	1,234	3,175	4,409	617	1,588	2,205				2,159	5,557	7,716
4	Slope Protection & Retaining Wall							769	345	1,114	1,538	691	2,229				2,307	1,036	3,343
5	Access Railway & Road							744	612	1,356	1,488	1,225	2,713	744	613	1,357	2,976	2,450	5,426
6	Container Terminal																		
	Pavement										5,533	1,383	6,916	4,149	1,038	5,187	9,682	2,421	12,103
	CFS										2,683	671	3,354	1,341	335	1,676	4,024	1,006	5,030
	Other Buildings										1,234	309	1,543	617	154	771	1,851	463	2,314
	Railway										39	218	257	38	219	257	77	437	514
	Foundation of Rail Mounted Transfer Crane										635	635	1,270	635	635	1,270	1,270	1,270	2,540
	Utilities										1,001	428	1,429	1,000	429	1,429	2,001	857	2,858
7	Mobilization & Demobilization				-	953	953							-	952	952	-	1,905	1,905
8	Equipments													-	31,875	31,875	-	31,875	31,875
	Sub Total				2,346	3,916	6,262	8,346	11,788	20,134	17,568	10,975	28,543	8,524	36,250	44,774	36,784	62,929	99,713
9	Engineering Study & Supervision	305	922	1,227	230	690	920	154	460	614	154	460	614	154	460	614	997	2,992	3,989
10	Physical Contingency				352	587	939	1,252	1,768	3,020	2,635	1,647	4,282	1,279	2,250	3,529	5,518	6,252	11,770
	Total	305	922	1,227	2,928	5,193	8,121	9,752	14,016	23,768	20,357	13,082	33,439	9,957	38,960	48,917	43,299	72,173	115,472

Fig. III-5-1 Karachi Port Container Berth (Caisson Type Quaywall)
Cross Section

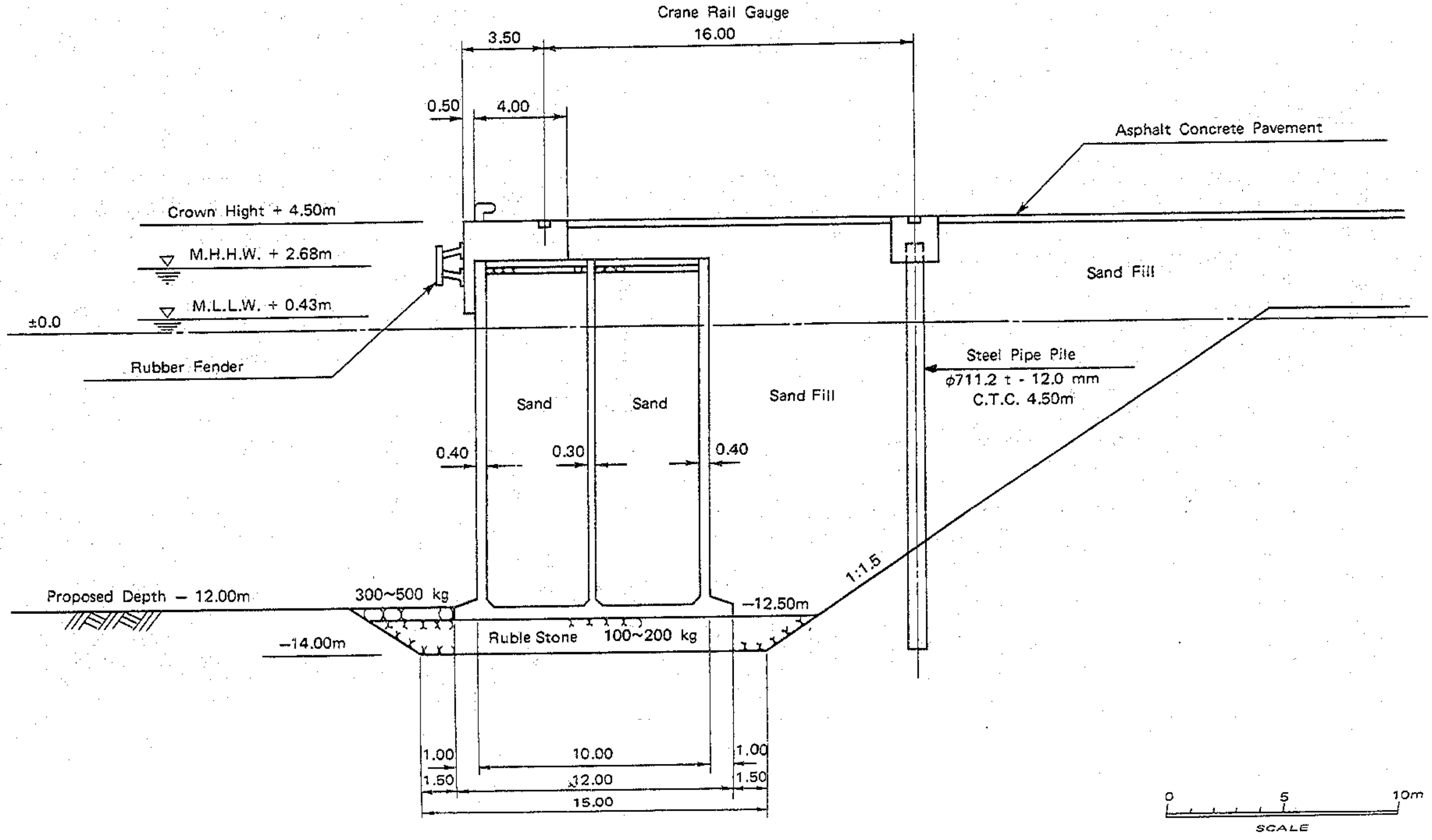


Fig. III-5-2 Karachi Port Container Berth Caisson Detail

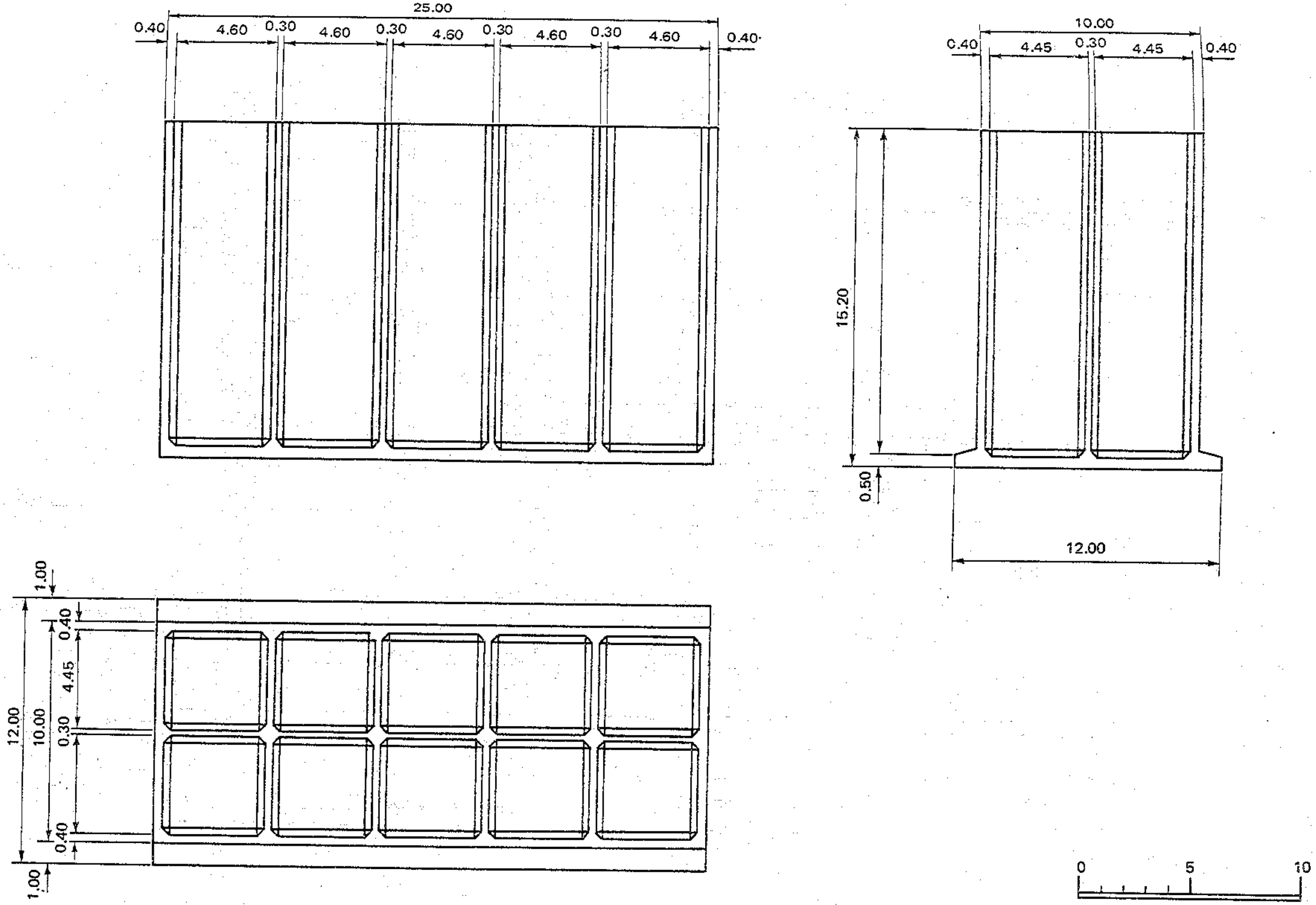


Fig. III-5-3 Karachi Port Container Berth Cast in situ RC Pile Supported Type Platform Cross Section

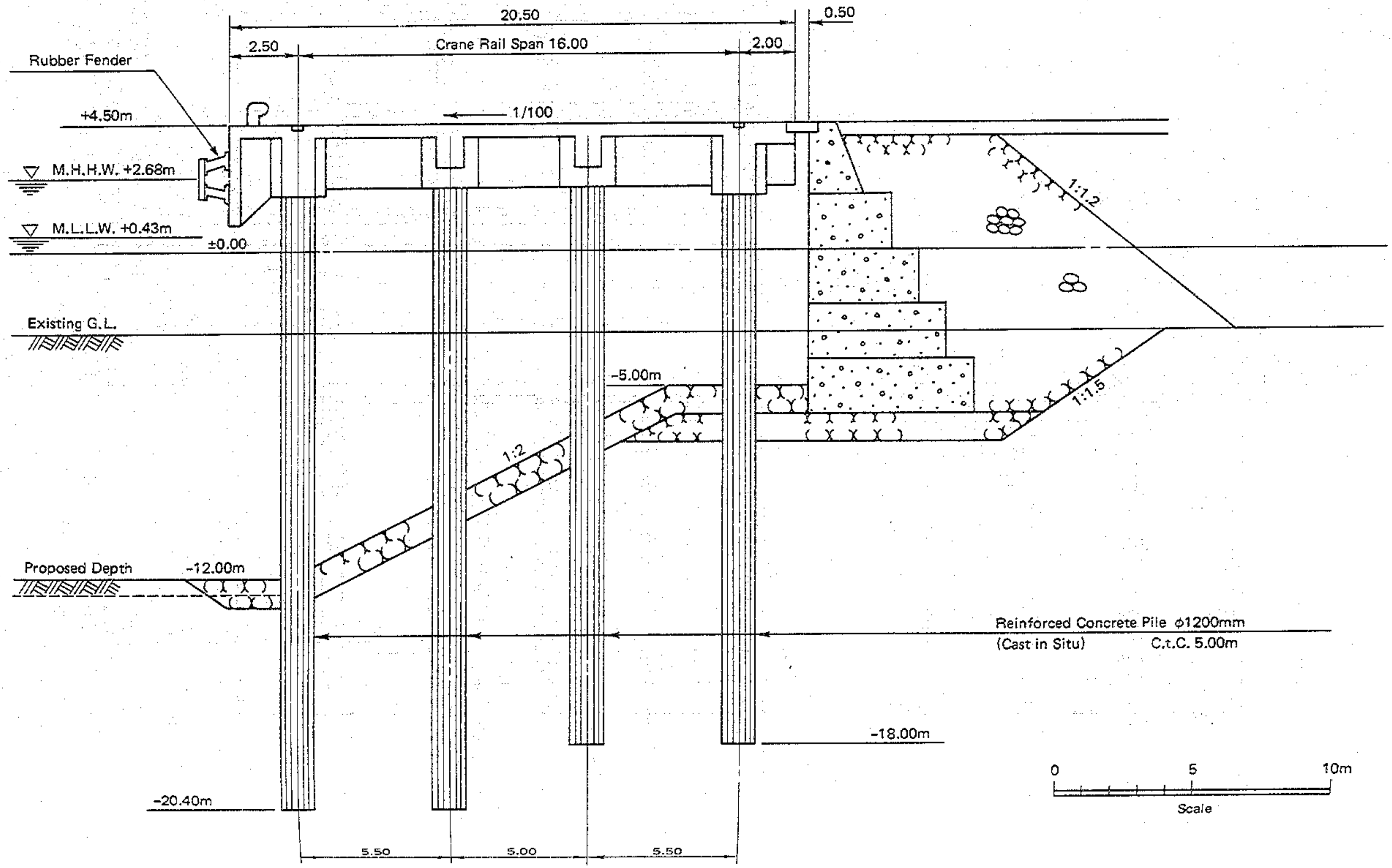


Fig. III-5-4 **Karachi Port Container Berth Cast in situ RC Pile Supported Type Platform Plan**

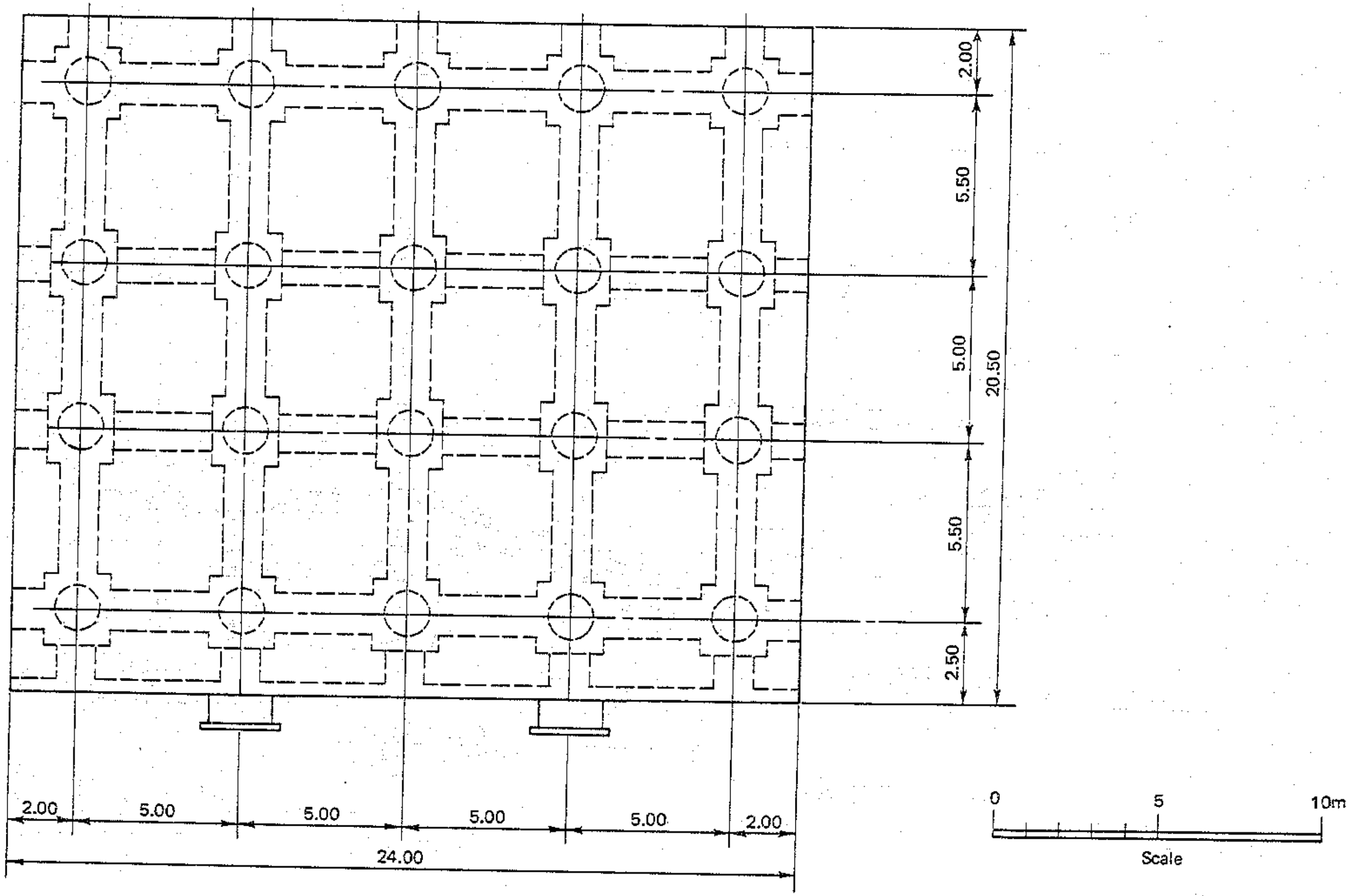


Fig. III-5-5 Slope Protection for the Reclamation of Container Terminal (Karachi Port)

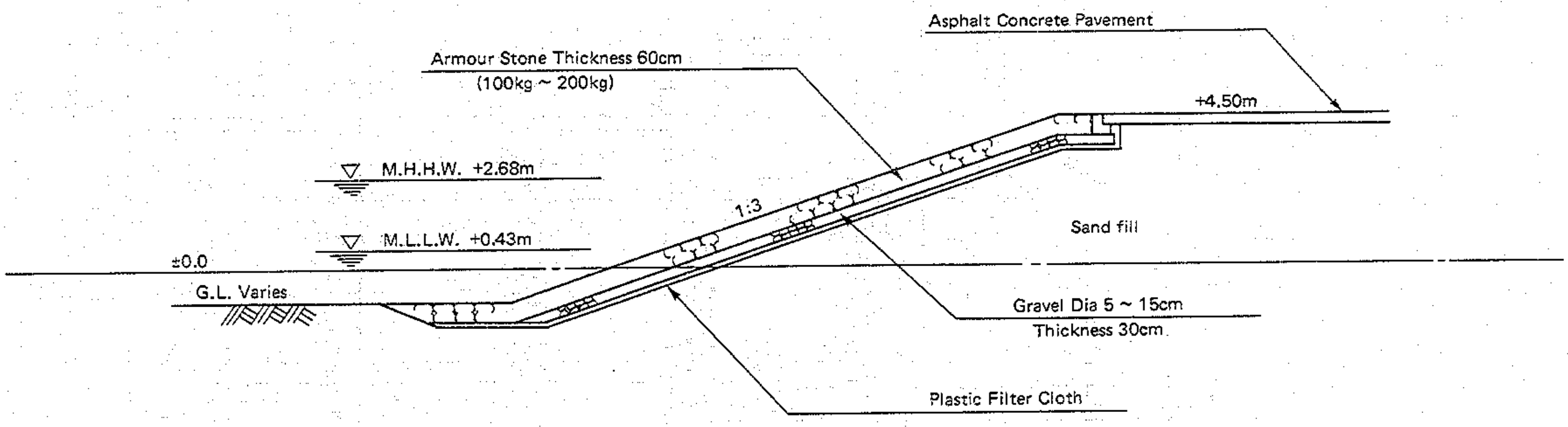


Fig. III-5-6 Asphalt Concrete Pavement for Container Yard

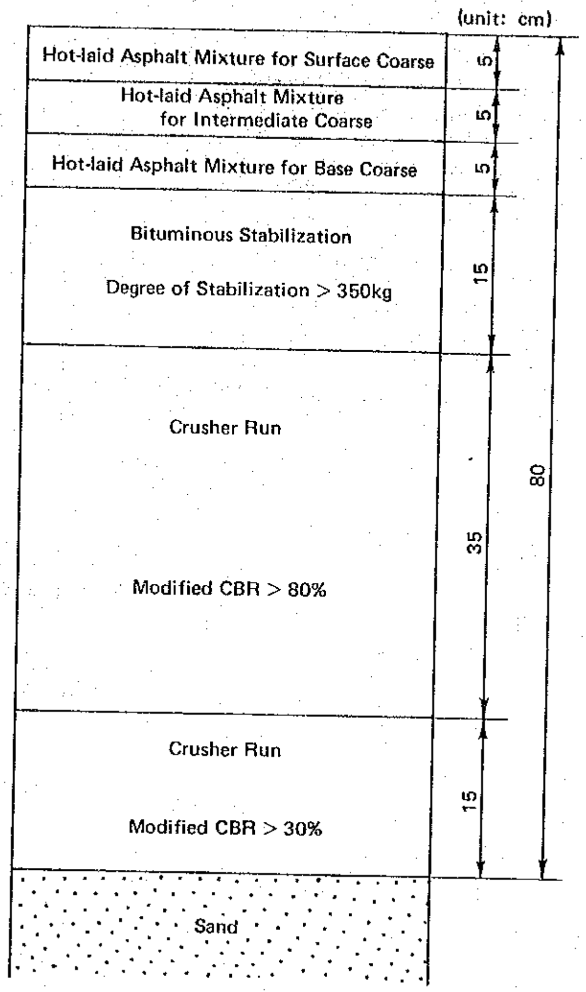


Fig. III-5-7 Pavement for the Track of Rubber Tyre Transfer Crane

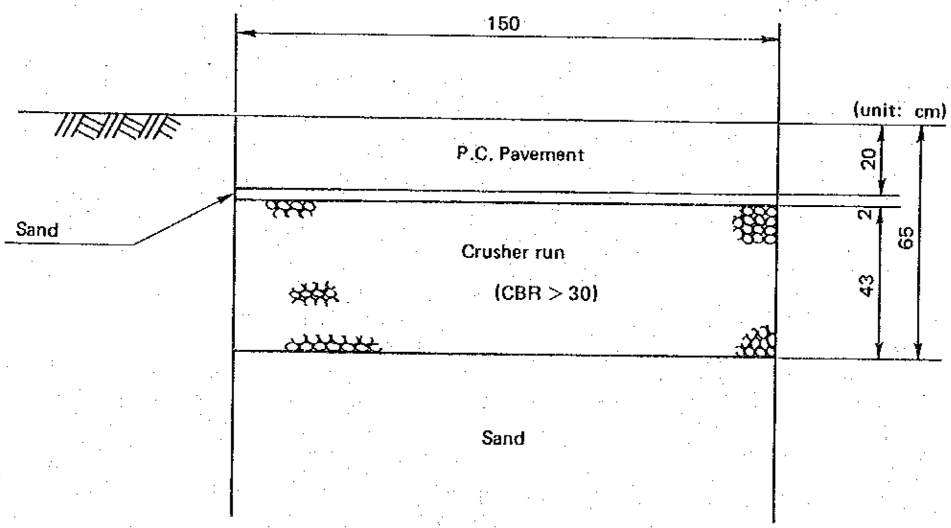


Fig. III-5-8 Asphalt Concrete Pavement for Access Road

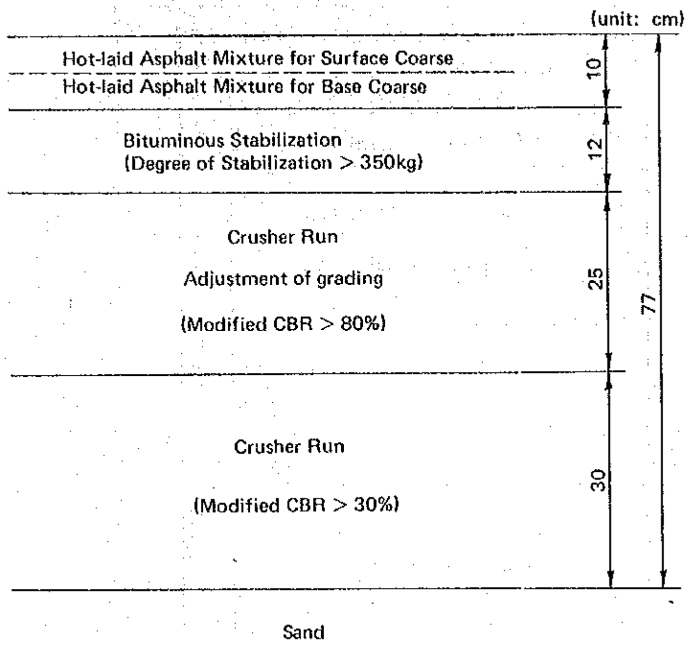
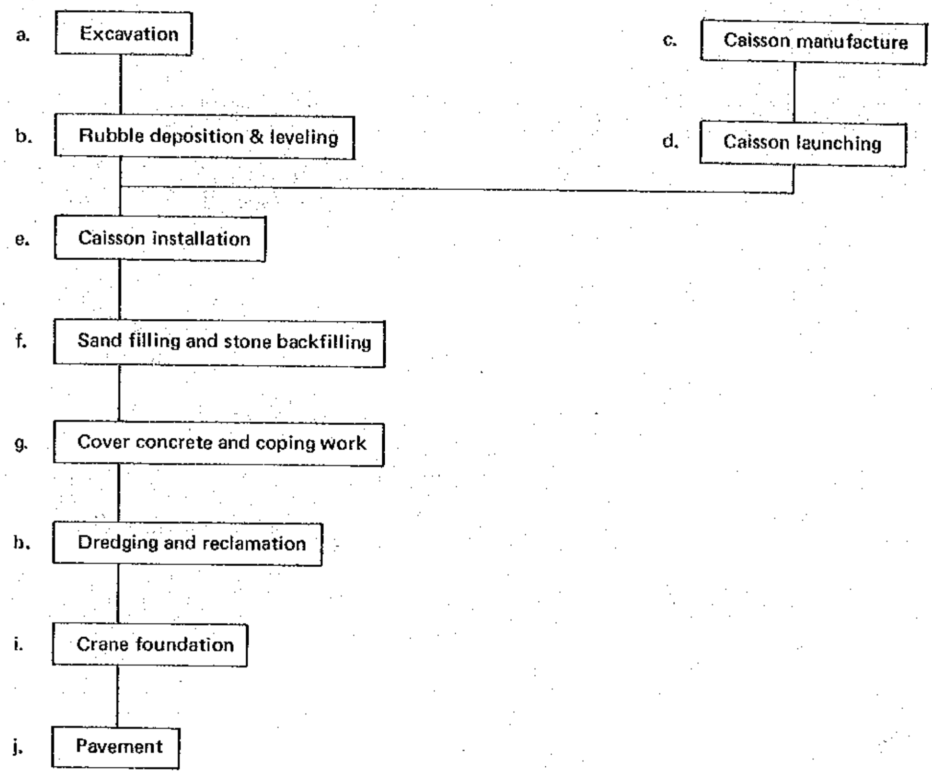
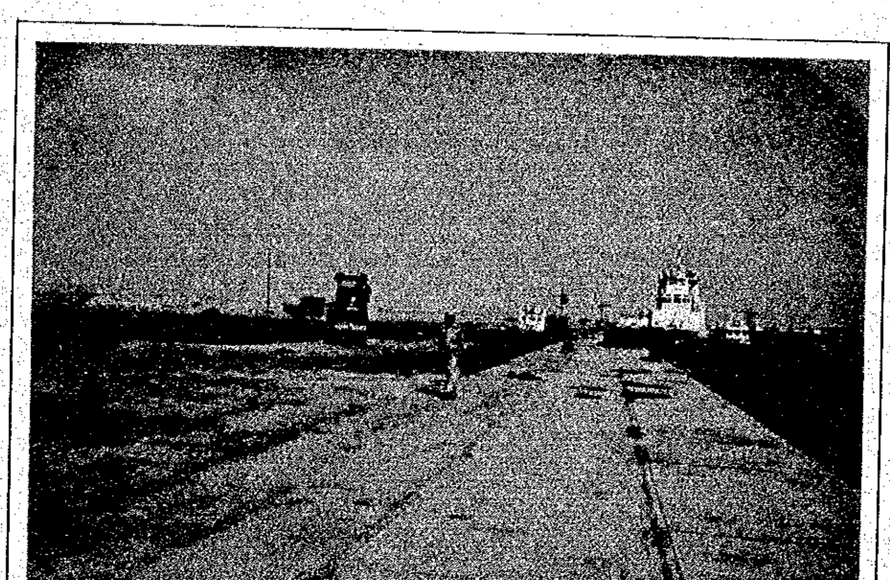


Fig. III-5-9 Construction of Caisson Type Container Berth



PART IV. QASIM PORT



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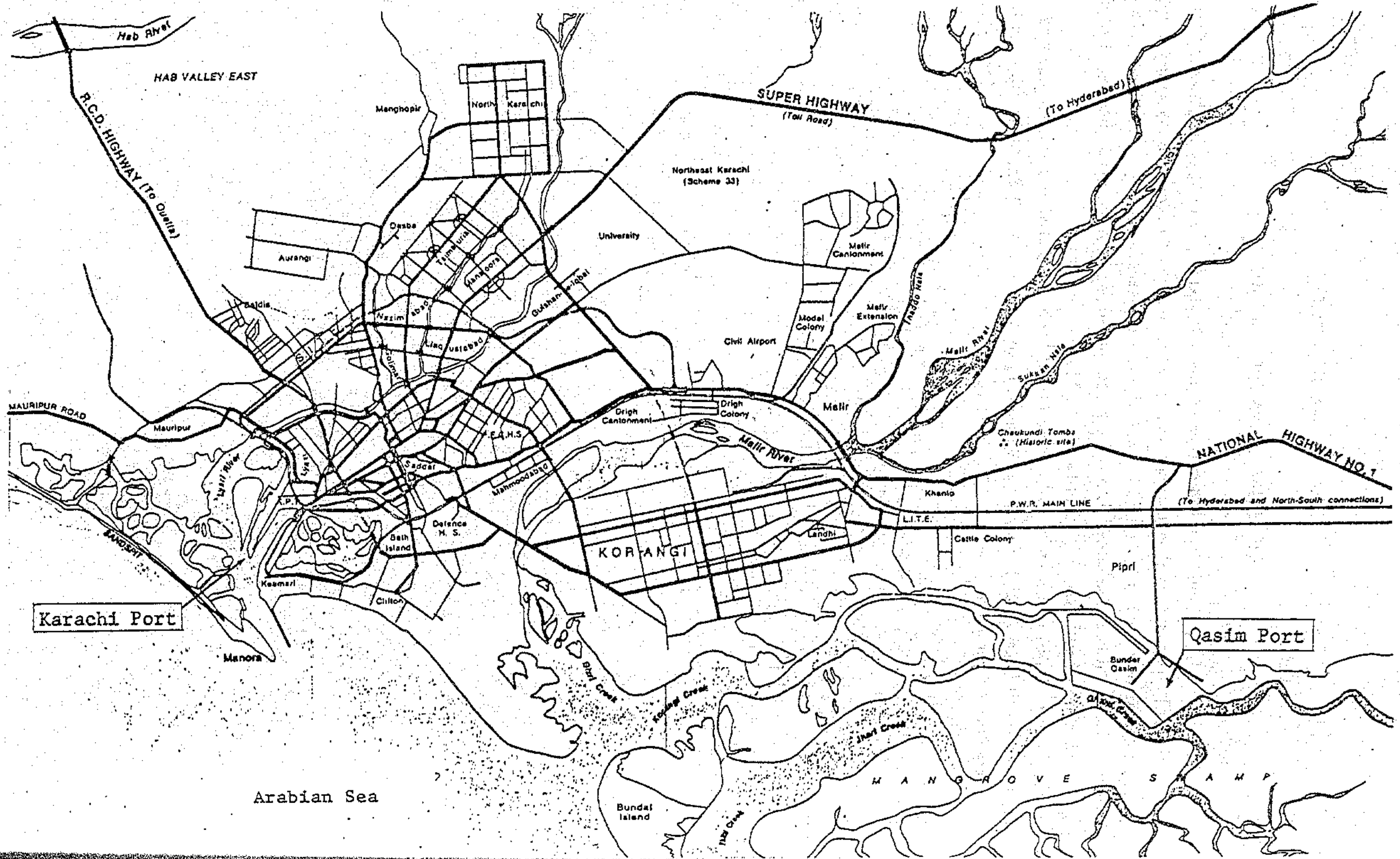
PART IV. QASIM PORT

CHAPTER 1. INTRODUCTION

Qasim Port is the second deep-water seaport located about 30Km east to Karachi Port as shown in Fig. IV-1-1 and its development was decided in order to relieve heavy congestion at Karachi Port. After a series of detailed investigations, the present site was selected out of seven possible sites. Qasim Port is planned to be a bulk and semi-bulk cargo handling port especially for feeding raw material to Pakistan Steel Mill.

The special purpose Iron Ore and Coal Berth has been completed and started receiving ore carriers. In addition to it, at the Marginal Wharf, out of seven berths (200m long each) first four berths have been completed.

Fig. IV-1-1 Location of Qasim Port



CHAPTER 2. NATURAL CONDITIONS

2-1 General Description of the Approach Channel

Fig. IV-2-1 shows layout of the approach channels of Qasim Port. Qasim Port is situated in the remains of the Indus River (Phitti, Kadiro, and Gharo Creeks).

The whole channel is divided into outer and inner channels. The one is open to the waves approaching from South West during monsoon season whilst the other is in the protected creek. Lengths of the outer and inner channels are 14.1 Km and 29.5 Km, respectively. Therefore, length of the whole channel is 43.6 Km. Width of the outer channel is 185 – 280m at the bottom. Design gradient of the slope is 1:20 and design water depth is 12.4 m. Width of the inner channel is 180 m and design gradient of the slope is 1:6. Design water depth is 11.3 m between C-1 and N points of Fig. IV-2-1 and 10.0 m between N and R. To the east and west sides of the outer channel are areas shallower than 5.5 m. Especially, sand bar at the north west is close to the channel (between A and B points of Fig. IV-2-1).

2-2 Tides

Table IV-2-1 shows tide levels at Phitti (Bundal Island) Pipri points. M.S.L., M.H.H.W., and M.L.L.W. of Pipri are 0.30 m, 0.52 m, and 0.43 m higher than those of Phitti, respectively. Difference between M.H.H.W. and M.L.L.W. is 2.38 m at Phitti and 2.40 m at Pipri.

2-3 Currents

Fig. IV-2-2 shows the maximum velocity and direction of the currents during spring tide at the outer channel. The main features are:

1) Direction of the ebb current is almost parallel to that of the channel whilst the flood current is obliquely crossing the channel. The angle between the direction of the flood current and that of the channel is 20 – 40°.

The velocity of the ebb current is higher than that of the flood current.

2) Current velocity at the location "2" is 0.65 – 1.05 m/s and higher than the velocity at the location "1" where the velocity is 0.1 – 0.55 m/s.

Direction of the current inside Phitti creek is determined by the tides. Discharges of the rivers flowing into the creek are small, so their constributions are negligible. According to the Pakistani charg (PAK-20), the maximum current velocity in the channel (near Buddo Island) during spring tide is 1.5 m/s for flood current and 2.5 m/s for ebb current. Velocities in Phitti creek are 1.25 m/s for flood current and 1.5 m/s for ebb current, respectively.

2-4 Waves

Wave observation was done near the Fair Way Buoy (water depth 18 m) in 1979 and 1980 using a wave rider buoy and OSPOS (Offshore Pressure Operated Suspended). Waves during the period between November and February are small whilst large swell coming from South West is predominant during the time between April and September.

Fig. IV-2-3 shows exceedance curve of significant wave heights ($H_{1/3}$, records of the wave rider buoy) and wave periods. Median significant wave heights during South West monsoon is approximately 2.2 m and median wave period is 9.5 seconds.

Wave direction has been studied by the Hydraulics Research Station. They have calculated refraction pattern of the waves and shown that predominant wave direction at the approach channel is 240° (measured from the true north, clockwise) and the angle between the direction of the wave rays and the approach channel is about 20°.

2-5 Wind

Wind has been observed every 3 hours at Bundal and Khuddi Islands. Fig. IV-2-4 shows wind rose in 1979. Predominant directions are South West and West. Directions of strong wind, higher than 10 m/sec, during monsoon season are also SW and W. Winds, ranging at 15 – 20 m/sec, have been recorded 14 times during the period between January and October of 1980 (11 times between June and October) at Khuddi Island. Strong wind higher than 20 m/sec was not recorded. At Bundal Island, wind higher than 15 m/sec was not recorded during the period between June and October of 1980.

2-6 Bottom Sediments

Fig. IV-2-5 (1) – (3) show the distributions of median diameter d_{50}, sieve analysis coefficient So ($\sqrt{d_{75}/d_{25}}$), and percentage of silt (smaller than 0.075 mm). The followings can be pointed out:

1) Median diameter of bottom sediments outside the channel is about 0.1 mm whilst d_{50} in the channel is approximately 0.05 mm.
2) Sediments have a little bit bigger SO in the channel than outside the channel.
3) Percentage of silt is 10 – 30% outside the channel whilst it is more than 50% in the channel.

Bottom Sediments which were taken on November 13th, 1980 have the same properties mentioned in the above.

According to the Institute of Marine Biology, Karachi University, bottom sediments sampled during monsoon season are fine sand at both outside and inside of the channel. Therefore, hydraulic mechanism will be as follows:

During monsoon season fine sand ($d_{50} \fallingdotseq$ 0.1 mm) is deposited at the channel bottom, but after monsoon season suspended silt is transported to the relatively calm channel areas having bigger water depth and is deposited there.

Few records have been obtained for the sediments at the inner channel. According to the chart, PAK-20, bottom sediments at Phitti Creek are C.S.Sh and M.f.S. Surface soil at the western part of Quidwai Point (inside the creek) is expressed as SG in the boring log record. Therefore, sediments in the creek will be mostly sand.

2-7 Sedimentation at the outer channel

Sedimentation problem at the outer channel, exposed to high waves and currents, has been studies by the Hydraulics Research Station (HRS) since the initial state of Qasim Port construction. At first, infill rate was estimated using the equation about volume of transported sediments. Then, trial dredging was executed in 1973 and expected infill rate into the planned channel was calculated using the record of the volume of the infill into the test pit. The first stage dredging of the present channel started in October 1978 and was completed in April 1980. Total dredged volume during the first stage was about 18 million cubic meters. The second stage dredging was initiated in October 1980 and is being carried on at present. Total volume of the second stage dredging will be approximately 8 million cubic meters.

(1) The previous studies

HRS Report Ex575 [1] is the first report about the estimation of the infill rate of the outer channel. The following equation about sediment transport rate was used:

$$Q_W = \frac{516\,H^6}{h^2\ T^5}\left(\frac{1}{\sinh kh}\right)^6 \quad \cdots\cdots\cdots\cdots \quad (2\text{-}1)$$

where,

Q_W is sediment transport rate by waves (Kg/m/s),
H is wave height (m),
h is water depth (m),
T is wave period (sec),
k is $2\pi/L$,
L is wave length (m).

Wave heights and period at the channel should be determined to estimate infill volumes using equation (2–1). Offshore wave dimensions were assumed to be equal to the values observed at Mardsen Square 66 (10 – 20°N, 60 – 70°E of Arabian Sea).

Taking the effects of wave refraction, breaking, and bottom friction, wave dimensions at the channel was determined.

Estimated volume of maintenance dredging was 0.49 million t/year (in case sediment density is 2.65 t/m^3 and porosity is 0.47, 0.49 million tons is equal to 0.35 million cubic meters) for the channel water depth of 7.2 m and 0.96 million t/year (0.68 million cubic meters). It was mentioned that this maintenance dredging volumes might well be out by a factor of two or three and execution of trial dredging was recommended to estimtate infill volume more exactly.

1) Phitti Creek, Estimate of Siltation in Approach Channels, Report EX575, 1971 October

Trial test pit was dredged during the period between November 1973 and March 1974 on the sand bar area (Fig. IV-2-6)[2].

Width and water depth of the test pit were 183 m and 7.3 m respectively. Central part of this pit was further dredged. Scale of this deeper channel was 1220 m long, 122 m wide, and 10.4 – 11.0 m deep. This means that water depth in the channel is about 4.9 m larger than the natural water depth on the bar.

A relation was established between wind velocity measured at Manora Point in Karachi and wave heights record of OSPOS measured off Manora. Then, wave heights were estimated using the previous records of wind velocity and severity index of waves during monsoon season was calculated in terms of sediment transport. After evaluation of the severity of wave activities during the monsoon season in 1974, infill volume expected at an average year was estimated to be 1.57 million cubic meters for 7.3 m channel water depth, 1.69 million cubic meters for 9.1 m water depth, and 1.70 million cubic meters for 11.0 m water depth.

For the monsoon in 1975, infill volume estimated using the above method was compared with the infill volume actually happened in 1975[3]. In the calculation, they have taken the effect of decrease of trapping efficiency due to shoaling of the channel and evaluated the severity of monsoon waves in 1974 and 1975. The agreement of both infill volumes was good and the above method was considered to be appropriate to estimate siltation volume. Then, expected infill volume for the average monsoon conditions was revised to be 0.99 million cubic meters for 7.3 m water depth, 1.63 million cubic meters for 9.1 m water depth, and 1.82 million cubic meters for 11.0 m water depth.

(2) Sedimentation in 1979 and 1980

The first stage dredging of the outer channel started in October 1978 and was completed in April 1980. Since the commencement of this dredging, monsoons were experienced in 1979 and 1980 and sedimentation volume during these monsoon seasons were calculated.

Fig. IV-2-7 shows examples of cross sections of the channel before and after 1979 monsoon. Inside the channel shoaled by 2 m and to the west of the channel deepened by 1m.

Fig. IV-2-8[4] shows the distribution of the differences of the cross section areas between before and after the 1979 monsoon (+ means accretion and – means scour). The values on the bascissa are landward length measured from point A (See Fig. IV-2-1) along the channel. In this figure the line shown as "central portion (HRS)" means differences of the cross section areas within 160 m of the channel center line. The area under this line is differences of the volume within the central portion and it was +1.01 million cubic meters. Dredging operation continued during the monsoon season in 1979, so it is not possible to know spatial distribution of the infill volumes. Dredged volume by this operation is 5.31 million cubic meters in case of dredging coefficient (ratio between dredged quantities and hopper volumes) of 1.2255 and 4.35 million cubic meters in case of the coefficient of 1.0. The line shown as "North Western Bank (HRS)" means differences of the cross section areas on the North Western zone from 160 m to 1,360 m

2) Port Qasim, Pakistan, Trial Dredging of Phitti Creek Entrance, HRS Report EX698, 1975 May
3) Port Muhammad Bin Qasim, Pakistan, Trial Dredging on Phitti Creek Entrance: Infill during 1974 and 1975 monsoons, HRS Report EX791, 1977 September
4) Port Muhammad Bin Qasim, Pakistan, Infill of Phitti Creek Entrance Channel during the 1979 Monsoon, HRS Report EX949, 1980 October

west of the center line. An area between point A and 1.4 Km accreted and an area between 1.4 – 7 Km was scoured. Differences of the cross section areas in the scoured area are approximately 500 – 800 m^2. Total difference of the volume on the North Western zone is 3.82 million cubic meters scour. The line shown as "North Western Bank (PCI)" means differences of the cross section areas on the North Western zone from 240 m to 1,590 m west of the center line and it was obtained by the Pacific Consultants International (PCI). The area difference calculated by PCI shows about 350 m^2 larger soucr than that of HRS. Total volume difference calculated by PCI is 6.58 million cubic meters scour. The line shown as "South Eastern Bank (HRS)" means area differences on the South Eastern zone from 160 m to 1,360 m east of the center line. The area between point A and 3.8 Km is scoured and the area between 3.8 Km and 8 Km accretes a little bit. Quantity of the accretion at the latter area is 0.33 million cubic meters. The line shown as "Shouth Eastern Bank (PCI)" shows differences of the cross section areas on the zone from 240 m to 1,590 m east of the center line. This line shows almost same tendency as the line shown as "South Eastern Bank (HRS)" According to the line shown as "South Eastern Bank (HRS)", total quantity of the volume difference on the South Eastern zone is 0.70 million cubic meters scour.

Fig. IV-2-9 shows wave refraction pattern on the topography aftr channel dredging. This figure was made by HRS rays incident from South West reflect at the channel and this produces increased wave activity at the North Western Bank. There is also some convergence of wave rays at the seaward end of the dredged channel (near Point A of the South Eastern Bank) which will cause greater wave heights. The places suffering large wave action well agree with the scoured places. The landward portion of the South Eastern Bank (near Point B) has very few wave rays which will produce small wave heights there. This area agrees with the area showing accretion in Fig. IV-2-8.

Two different causes contributing to the sedimentation have to be seperated in order to estimate the future infill volumes. Those are slumping, which will carry on only for short periods after a capital dredging (short term effect), and sediment transport by waves and currents, which will continue for long periods (long term effect). HRS[4)] has proposed a method to calculate sediment budget on a reasonable assumption that bottom sediments are transported from North West to South East. The North Western zone is on the upstream side in terms of sediment transport and will not suffer scour due to spatial non-uniformity of the sediment transport rate. Therefore, scour on the North Western zone is due to slumping of the slope only. The area near Point B on the South Eastern zone is a relatively calm area, so sediment transport rate there is negligible. It was assumed that ten percent of the bottom sediments transported by waves and currents from the North Western zone to the South Eastern zone near Point A can cross the channel. Fig. IV-2-10 shows sediment budget on the above assumptions. Sediment transport volume due to long term effect will be 3.13 million cubic meters from NW to SE. Then, the severity of monsoon waves in 1979 has been compared with the severity of the average monsoon waves in terms of sediment transport using the same method as in the case of trial dredging. According to the calculation, monsoon waves in 1979 was 1.76 times more sever than the average monsoon waves. Therefore, sediment transport rate will be 1.78 million cubic meters after the short term effect of slumping ceases and infill rate will be 1.60 million cubic meters in case of trapping efficiency of 0.90.

HRS[5] has recently proposed a method to evaluate monsoon severity using wave heights records observed at Karachi and Qasim without wind data observed at Monora. Infill volumes in the worst, average, and best conditions in 10 years were estimated when sediment transport rate by waves was proportional to 4, 5, and 6 power of wave height (it is proportional to 6 power of wave height in the case of equation (2-1)). Table IV-2-2 shows expected infill volumes due to long term effects in case of dredging coefficient of 1.2255. Table IV-2-3 shows adjusted infill volumes due to long term effects in case of dredging coefficient of 1.0. Means of the infill volumes (average) are 1.70 million cubic meters in the former case and 1.10 million cubic meters in the latter case.

Fig. IV-2-11 shows differences of water depths between pre-monsoon (April 1980) and post-monsoon (October 1980). Any dredging operation was not done during monsoon season in 1980. Generally speaking, the North Western zone was scoured and both the shipping channel and the South Eastern zone accreted. Remarkable sedimentation occured at the locations near A + 2000, A + 4000, and A + 7000. Especially, near A + 4000 inside the channel accreted by 5 meters.

Fig. IV-2-12 shows differences of the cross section areas between pre- and post-monsoons. Central portion is an area within 240 m of the channel center line and accreted by 4.05 million cubic meters. North Western Bank is an area from 240 m to 1,590 m west of the center line and the area between A + 3000 and A + 8000 is scoured. Total volume of scour is 1.72 million cubic meters. The Bank was scoured almost uniformly in 1979 (See Fig. IV-2-8) whilst an area near Point B was scoured very severely in 1980. South Eastern Bank is an area from 240 m to 1,590 m east of the center line and shows nearly uniform accretion, although the Bank was scoured near Point A in 1979 (See Fig. IV-2-8). Especially, the area between A + 5000 and A + 8000 shows about 400 square meters accretion. Total volume difference (accretion) on the South Eastern Bank is 1.88 million cubic meters.

Fig. IV-2-13 shows sediment budget in 1980 on the following assumptions:

Firstly, sediments are transported from North West to South East,

Secondly, slumping produces scour on the North Western zone, and

Thirdly, trapping efficiency of the channel is 90 percent. Calculated sediment transport volume due to the long term effect is 2.59 million cubic meters from NW to SE. According to HRS Report EX957[5], monsoon severity in 1980 is 1.30 times of that in the average year in terms of sediment transport. Therefore, sediment transport volume of the average year due to the long term effect is 1.99 million cubic meters and average expected infill volume is 1.79 million cubic meters in case of trapping efficiency of 90 percent. This expected infill volume well agrees with the mean of the infill volumes (average) shown in Table IV-2-2 (in case of dredging coefficient of 1.2255) and it is 1.4 – 1.8 times of the mean of the infill volumes (average) shown in Table IV-2-3 (dredging coefficent is 1.0).

Volume of the accretion on the South Eastern zone is 1.88 million cubic meters. Volume of the sediments transported across the channel is 0.26 million cubic meters. Therefore, sediments of 1.62 million cubic meters should have been transported from either the offshore or inshore side of the South Eastern zone. Inshore part of the South Eastern zone is relatively calm area, so

5) Port Muhammad Bin Qasim, Pakistan, An assessment of monsoon severity in 1979 and 1980 using wave data, HRS Report EX957, 1980 November

suspended sediments would have been transported from the surrounding areas and deposited there. An accreting area of the South Eastern Bank (See Fig. IV-2-12) well agrees with the area where few wave rays can be found in Fig. IV-2-9.

(3) Future expected infill volumes

Infill volumes due to both long term and short term effects have to be estimated in order to determine total expected infill volumes.

Since, infill volumes due to short term effect will decrease gradually, they may be calculated by the following equation:

$$Q = Q_0 \cdot 10^{-kt} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2-2)$$

where,

Q is an average infill volume due to short term effect after t years (Unit 10,000 cubic meters),

Q_0 is an infill volume at the first year of the average monsoon severity (Unit 10,000 cubic meters),

t is lapse years,
k is a constant.

As infill volumes in 1979 ($t = 0$) and 1980 ($t = 1$) are 3.82 and 1.72 million cubic meters respectively, the following equation can be obtained:

$$Q = 382 \cdot 10^{-0.346t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2-3)$$

Table IV-2-4 and Fig. IV-2-14 show the expected infill volumes due to short term effect only calculated in equation (2 – 3).

Since expected long term infill volume for the average monsoon severity calculated using infill data in 1980 well agreed with the mean of the infill volumes (average) shown in Table IV-2-2, the latter quantity should be reasonable amount. It is also shown in Table IV-2-4 and Fig. IV-2-14.

(4) Infill volume in the inner channel

It is almost impossible to estimate infill volume expected in the inner channel along Phitti Creek. Sedimentation in the inner channel takes place in such a way that a fine soil material suspended in the water is deposited when transported into relatively calm area and it is very difficult to quantity the phenomenon of this kind of mechanism by the present level of hydrodyanmics. By considering that the infill volume of 50,000 m^3/year is measured along Lower Harbour in Karachi Port through a similar mechanism, an annual infill rate of 80,000 m^3 is estimated for siltation in the inner channel.