4. Port Development

4.1. Port Planning

4.1.1. Basic Principle

Basic principles for formulating the long term development plan of the new port in the Thrace region, based on the future cargo demand are as follows;

(1)The new port will be developed as the largest commercial port in the Thrace region for public infrastructure and distribution center in the region and nation and as a complementary port to Haydarpasa Port.

(2)Target year of long term development plan is 2015.

(3)Cargo handling volume in the target year would be 24mil. tons including 688,000TEU container cargo in Thrace region and 11mil. tons including 638,000TEU for the new port.

(4)The new port will not deal with passenger.

(5)Maximum size among all types of vessel calling at the new port will be 50,000DWT class container vessel with capacity of 3,000TEU and its berth depth will be 14m.

(6)Container terminal, general cargo terminal and bulk terminal will be developed.

(7)Major port facilities are reclaimed land, wharves, waterways, basins, breakwater and roads.

(8)Land reclamation amounting to approximately 1,000,000m^2 would be implemented.

(9)The layout of port facilities would include sufficient room for future expansion.

4.1.2 Demand for New Port

According the cargo handling volume which is microscopically forecast in 2.3, future cargo handling volume in the new port is estimated as shown in Table 4.1.1. When cargo handling volume in Thrace is distributed to three existing ports, existing cargo handling facilities, commodities of cargo handled at present and factories behind the ports are taken into consideration. In order to make the existing ports' facilities use fully, cargoes are distributed nearly up to capacities of existing ports. The result is shown in Table 4.1.1 and detailed cargo throughput in 2015 is shown in Table 4.1.2.

The cargo throughput in 2015 is 638,000TEU of container and 5,880,000 tons of bulk and general cargo. Out of 638,000TEU, 108,000TEU is transshipment container cargo.

TABLE 4.1.1 Cargo Handling Volume in 2015 by port in Thrace

(Unit: 000ton)

Commodity	Thrace total	Tekirdag	Ambarli	Martas	New port
Sand	8,172		5,254		2,918
Cement	3,010		2,380		630
Clinker	655		389		266
Coal	190		190		0
Soda Ash	240			240	0
Grains	2,096	1,155			941
Sunflower's seed	372			372	0
Cotton seed	72			72	0
Scraps	953		453	500	0
Timber	187				187
Sub total	15,947	1155	8,666	1184	4,942
Pulp	197				197
Ceramics	47	47			0
Fertilizer(bag)	90	90			0
Wheat(bag)	50	50			0
Flour(bag)	265	265			0
Stone	47	47			0
Steel	258	0	97	161	0
Iron	634	69	225	188	152
Metal products	250				250
Machinery	284				284
Sub total	2,122	568	322	349	883
Container['000TEU]	688	0	50	0	638

Note: Number of container includes empity container.

TABLE 4.1.2 Cargo Throughput in New port (unit: 000ton)

Handling type	Export	Import	Domestic In	Domestic Out	Total
Dry Bulk	902 Grain, 636 Clinker, 266	305 Grain, 305	3,548 Sand, 2918 Cement, 630		4,755
Break Bulk		187 Timber, 187			187
General	151 Metal, 26 Machinery, 125	594 Pulp, 197 Iron, 152 Metal, 169 Machinery, 76	55 Metal, 55	83 Machinery, 83	883
(Sub total)	*1,053*	*1,086*	*3,607*	*83*	*5,825*
Container (000TEU)					638 Thrace, 530 Transit, 108

4.1.3 Determination of size of calling vessels

Objective size of ship used in this port planning is summarized as shown in Table 4.1.3.

TABLE 4.1.3 Objective Size of Ships

Vessel type	Maximum ship size (DWT)	Length Over All (m)	Molded Breadth (m)	Full load draft (m)
Container(Main) (3,000TEU)	50,000	290	32.2	13.0
Container(Feeder) (1,500TEU)	27,000	230	32.2	11.0
Ro Ro	19,700GRT	168.8	23.53	8.81
Conventional(Foreign)	15,000	153	22.3	9.3
Conventional(Domestic)	5,000	109	16.4	6.8
Grain(Foreign)	30,000	186	27.1	10.9

(1) Container and Ro Ro Vessels

As examined in 3.5.3, if the port would have a cargo handling throughput of 500 thousand TEU to 1 million TEU per year, there would be some possibility according to its service level for mother container vessel servicing in main line to call at ports in the Sea of Marmara with approximately 500 nautical miles deviation from main container route.

Mother vessel size servicing in main container routes has remarkably become larger and larger, typified by the appearance of the Post Panamax type. However, the Panamax type, with 3,000TEU capacity, which currently the dominant ship size in main routes combined with container ports in the Mediterranean Sea is set up as the objective size of mother container vessel in this port planning.

As for the size of container feeder vessel in this planning, the vessel size with 1,500TEU capacity is set up. The forecast of the maximum size of feeder vessel is made by using annual increasing rate (3.3393%) of full container vessel size in the world from 1980 to 1995 and the present feeder vessel size servicing in the Mediterranean Sea and in Europe, which ranges from 200TEU to 2,000TEU capacity (See Table 4.1.4.).

The relationship between capacities(TEU) of container vessels which are entering service at present and draft and LOA are shown in Figure 4.1.1 and Figure 4.1.2. These relationships are analyzed by OCDI. Based on these relationships, standard size of container ship and standard dimension of berths for container ships is shown in Table 4.1.5. Objective size of container vessel in Table 4.1.3 is determined according to the relationship in Table 4.1.5.

TABLE 4.1.4 Projected Future Size of Feeder Vessel

Servicing Area of feeder vessels	Vessel Size at present	Forecast Vessel Size in 2015
East Mediterranean Sea (Average)	100～200TEU	195～385TEU
East Mediterranean Sea (Maximun)	1050TEU	2025TEU
All European Area(Average)	350～500TEU	675～965TEU

Note: Future vessel size in 2015 is predicted by using annual increase rate of 3.3393% per year which is calculated by use of annual data of average capacity of full container vessel in the world in the table in 3.5.3..

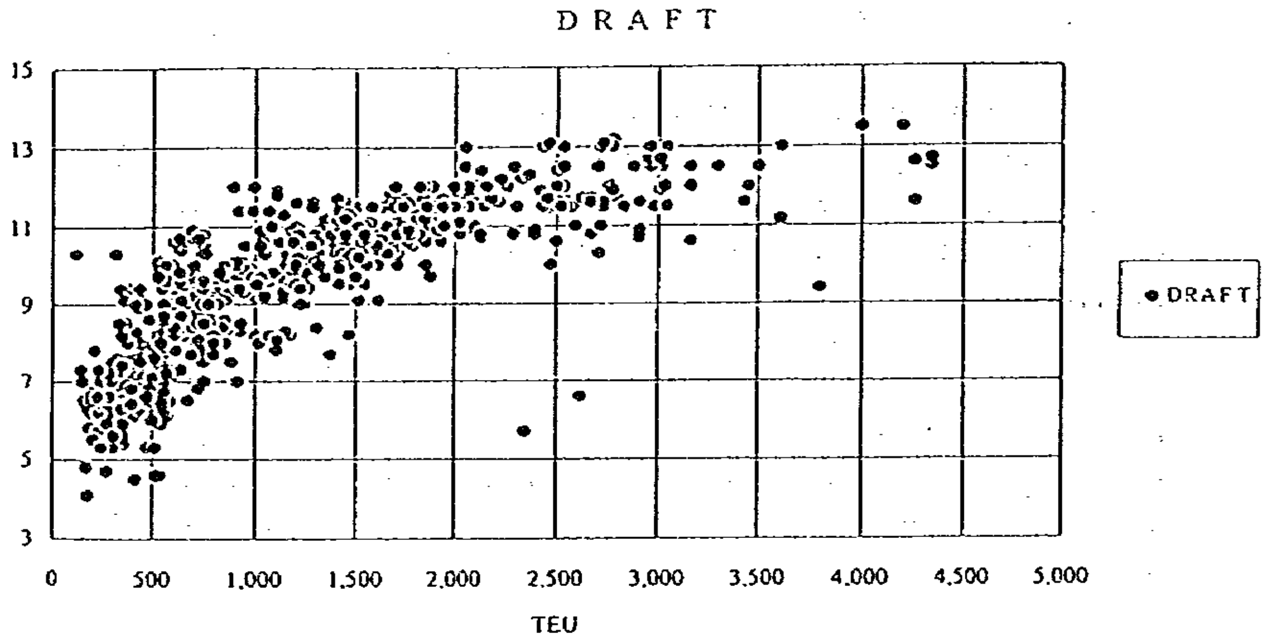


FIGURE 4.1.1 Relationship between Capacity & Draft of Container Vessels

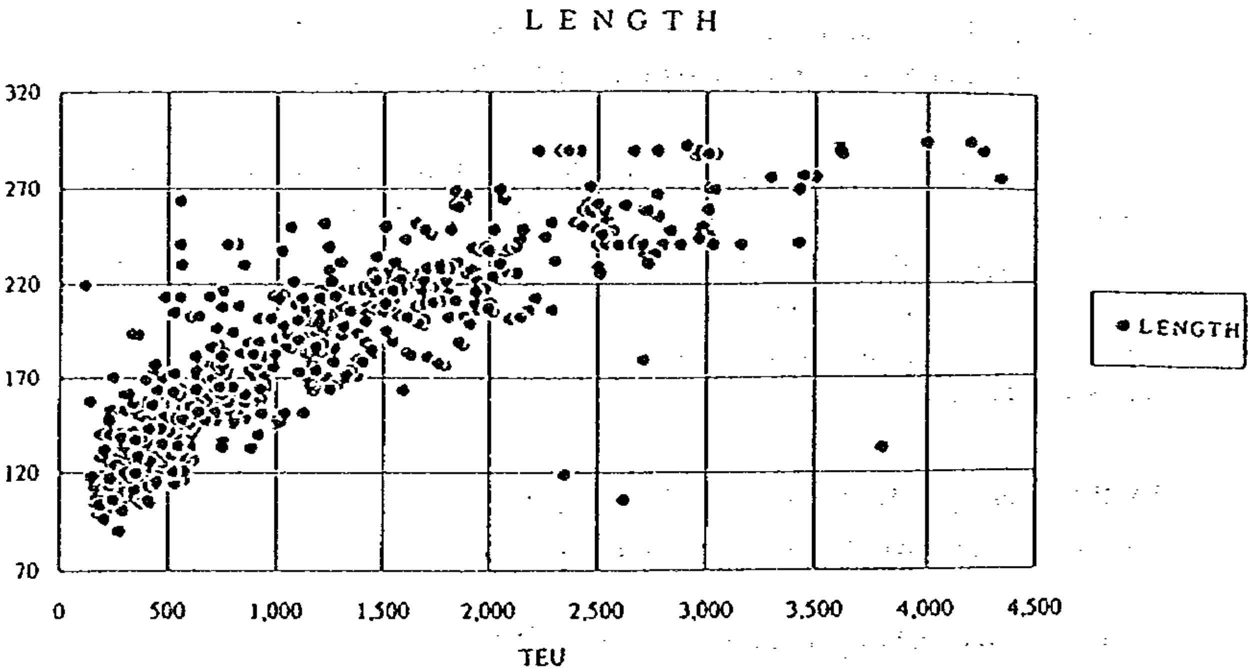


FIGURE 4.1.2 Relationship between Capacity & LOA of Container Vessels

TABLE 4.1.5 Dimension of Container Vessel and Container Berth

Size & Dimension of Container Vessels					Dimensions of Quay		Remarks
Capacity (TEU)	DWT	Full load Draft (m)	Overall Length (m)	Breadth (m)	Berth Depth (m)	Berth Length (m)	
300	6,500	6.7	120	19.0	7.5	150	
500	12,000	8.0	140	21.0	9.0	170	
800	16,000	9.0	170	23.0	10.0	200	
1,200	22,000	10.0	210	31.0	11.0	250	
1,500	27,000	11.0	230	32.2	12.0	280	
2,000	35,000	12.0	260	32.2	13.0	300	
3,000	50,000	13.0	290	32.2	14.0	350	P'max
4,400	60,000	13.5	290	39.4	15.0	350	Over P'max

As shown in Table 4.1.6, RoRo vessels are servicing in Haydarpasa port and Derince port in the Sea of Marmara. Considering the present situation of Ro Ro vessel lines and port development in countries around the Black Sea and the Mediterranean Sea, transportation by Ro Ro vessel will be expected to continue after this. Therefore, a service line by Ro Ro vessel is planned in the New Port as well as in the above two ports.

The average size of Ro Ro vessel calling at Haydarpasa port and Derince port are 18,859GRT(March 1996) and 5,635GRT(August and September 1996). Maximum size among Ro Ro vessels calling at the two ports in terms of dimension is the two vessels calling at Haydarpasa port shown in Table 4.1.7. This size is selected as the objective maximum vessel for the New Port.

(2) Bulk Cargo Vessels

The present distribution figures on the size of bulk cargo vessels calling at Bandirma port in August and September 1996 are shown in Figure 4.1.3. There are three predominant sizes, 301~500GRT, 2,001~3,000GRT and 10,001~15,000GRT. The group distributed around 500GRT are domestic vessels. The other groups around 3,00GRT and 20,000GRT are oceangoing vessels.

TABLE 4.1.6 International Ro Ro lines in Turkey

Ship operator	Line	No. of ship operated	Ship's capacity	Total ship capacity	Trips/yr
D.B.Deniz Nakliyati T. Lnc.	Haydarpasa ~ Trieste	2	120	16,668	85
	Derince ~ Kostence	2	29/55	6155	167
UND Dem & RoRo Islt Inc.	Haydarpasa ~ Trieste	6	120	37,748	63
Marti Gemi Acen Co. Ltd.	Samsun ~ Novorossisk	7	42~62	17,630	186
Cenk Den. Ve Tie Co. Ltd.	Samsun ~ Novorossisk	5	—	20,090	—

Source: Deniz Sektörü Raporu '95, Deniz Ticaret Odasi
Note: TIR is long vehicle which serve in Trans. International Route.

TABLE 4.1.7 Size of Ro Ro Vessels

Vessel's name	UND PRENSES	UND SAFFET BEY
Built year	1987	1987
Length of all(m)	168.8	163.8
Molded width(m)	23.53	23.5
Draft(m)	8.81	8.81
Gross tonnage(ton)	19,689	19,689
Net tonnage(ton)	9257	9257
Total length of trailer line(m)	2,760	2,760
Trailer capacity	150	150

Source: UND RO-RO Carrying Co., November '96

On the other hand, main bulk cargoes in the new port are domestic cargoes, such as sand and cement. In 2015, vessel size navigating the Sea of Marmara and the two Straits is expected to increase by 2.5 times, which is mentioned in Appendix. Therefore, domestic bulk cargo vessels in 2015 will be 1,250GRT. According to the relationship between GRT and DWT by correlation analysis ($logGRT = -0.347 + 1.049logDWT$, $DWT < 6,000$), future vessel size 1,250GRT is equal to 1,918DWT.

In this port planning, maximum vessel size for domestic bulk cargo has been

FIGURE 4.1.3 Size of Calling Vessels at Bandirma Port

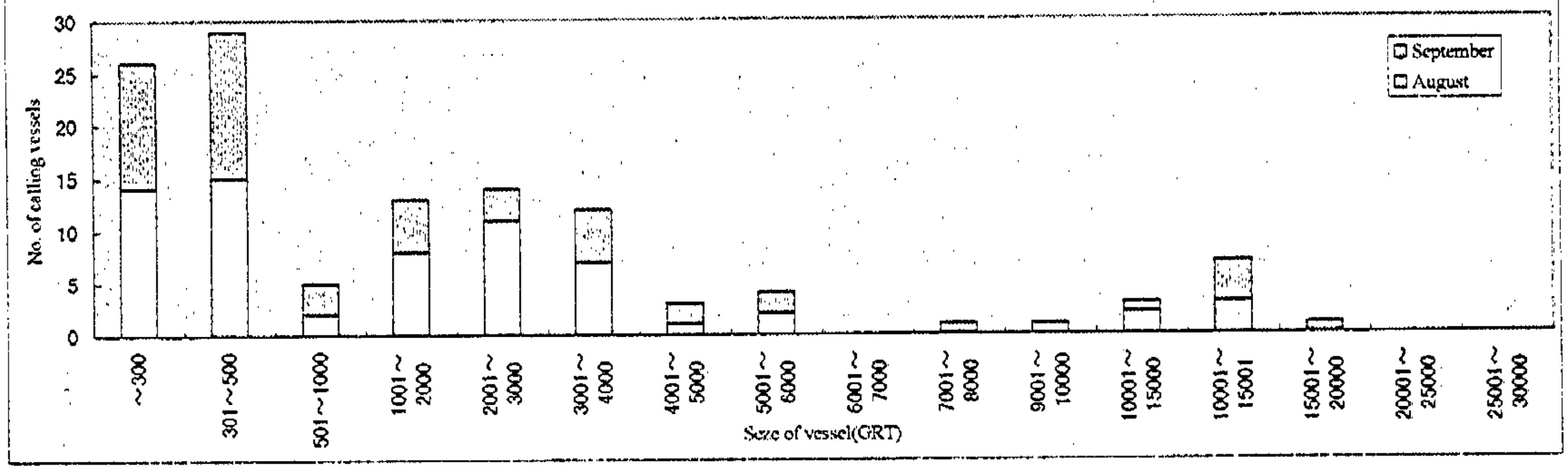
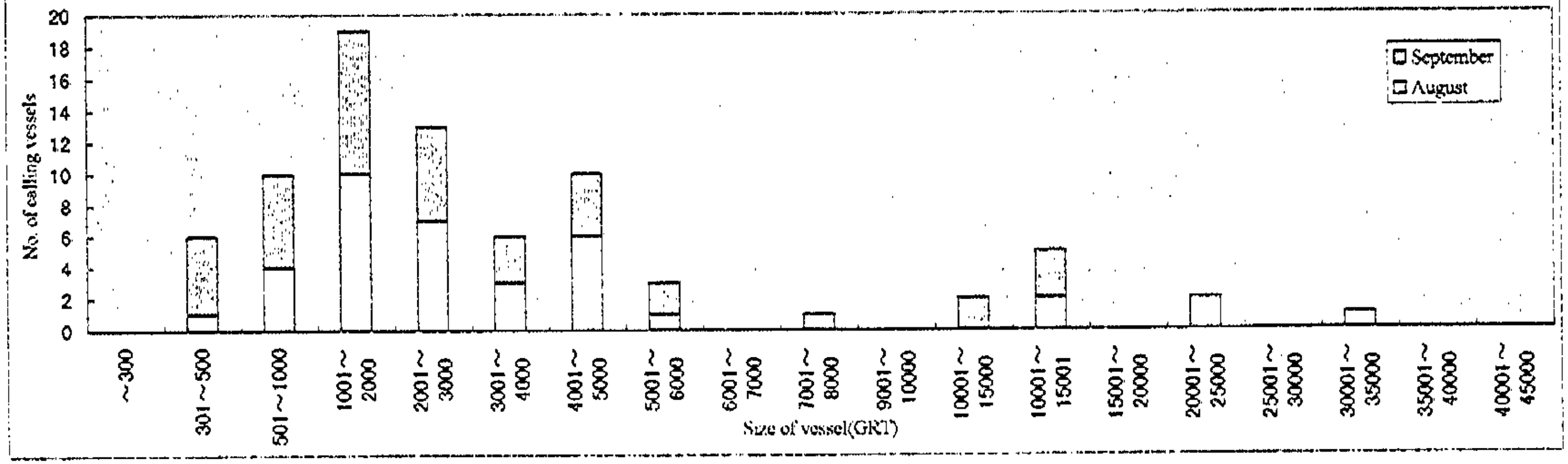


FIGURE 4.1.4 Size of Calling Vessels at Derince Port



determined as 5,000DWT, which is the minimum size among large vessels.
The maximum vessel size for export and import of grain is predicted as 30,000DWT, which is the maximum vessel size in the Sea of Marmara.

TABLE 4.1.8 Standard Size of Ship

(units in m)

Type	Tonnage	Overall length	Moulded breadth	Moulded depth	Full load draft
Passenger ship	G.T				
	2,000	88	13.2	6.4	4.0
	3,000	99	14.7	7.6	4.5
	5,000	120	16.9	9.5	5.2
	8,000	142	19.2	11.6	5.8
	10,000	154	20.4	12.9	6.2
	15,000	179	22.8	14.7	6.8
	20,000	198	24.7	16.1	7.5
	30,000	230	27.5	18.3	8.5
Ferryboat	G.T				
	1,000	73	14.3	9.4	3.7
	2,000	69	17.1	10.7	4.4
	3,000	113	18.9	11.5	4.9
	4,000	127	20.2	12.2	5.3
	6,000	138	22.4	13.2	5.9
	10,000	170	25.4	14.5	6.5
	13,000	188	27.1	15.3	6.7
	15,000	200	28.1	15.7	6.9
Cargo ship	D.W				
	700	58	9.7	5.5	3.7
	1,000	64	10.4	5.8	4.2
	2,000	81	12.7	6.8	4.9
	3,000	92	14.2	7.7	5.7
	5,000	109	16.4	9.0	6.8
	8,000	126	18.7	10.3	8.0
	10,000	137	19.9	11.1	8.5
	15,000	153	22.3	12.5	9.3
	30,000	186	27.1	15.2	10.9
	40,000	201	29.4	16.5	11.7
	50,000	216	31.5	17.5	12.4
	70,000	235	33.8	19.2	13.4
	90,000	252	37.2	20.6	14.2
	100,000	259	38.7	21.2	15.8
	150,000	290	45.0	23.7	17.5
Container ship	D.W				
	20,000	201	27.1	15.6	10.6
	30,000	237	30.7	18.4	11.6
Container ship	D.W				
	40,000	263	33.5	20.7	12.4
	50,000	280	35.8	22.6	13.0
Oil tanker	D.W				
	1,000	61	9.8	4.4	4.0
	2,000	77	12.2	5.6	5.0
	3,000	88	13.8	6.5	5.6
	5,000	104	16.2	7.8	6.5
	10,000	130	20.1	10.1	8.0
	15,000	148	22.8	11.7	9.0
	20,000	162	24.9	13.0	9.8
	30,000	185	28.3	15.2	10.9
	40,000	204	30.9	16.6	11.8
	50,000	219	33.1	17.5	12.7
	60,000	232	35.0	18.4	13.6
	70,000	244	36.7	19.2	14.3
	80,000	255	38.3	19.9	14.9
Pure car carrier	G.T				
	700	77	12.8	6.9	4.3
	1,000	86	14.1	8.0	4.7
	2,000	105	17.1	10.7	5.5
	3,000	117	19.1	12.7	6.0
	5,000	136	22.0	15.8	6.8
	6,000	144	23.1	17.1	7.1
	10,000	166	26.6	21.2	8.0
	15,000	187	29.8	25.1	8.8
	20,000	203	32.2	28.4	9.5
Gas tanker	G.T				
	1,000	70	11.7	5.7	5.0
	2,000	87	14.3	7.3	5.9
	3,000	99	16.1	8.5	6.6
	5,000	117	18.6	10.2	7.5
	10,000	145	22.7	13.1	9.0
	15,000	165	25.5	15.2	10.2
	20,000	181	27.7	16.9	11.0
	30,000	206	31.2	19.6	12.0
	50,000	242	36.1	23.6	13.5

G.T : gross Tonnage
D.W : Dead Weight Tonnage

(3) General Cargo Vessels

The present distribution figures on the size of general cargo vessels calling at Derince Port in August and September 1996 are shown in Figure 4.1.4. There are three predominant sizes, 1,001~2,000GRT, 4,001~5,000GRT and 10,001~15,000GRT, and all groups seem to be related to oceangoing vessels. Ranging from 4,000GRT~5,000GRT account for 70% of all vessels calling the port.

If future vessel size is forecast in the same manner as in above (2), it would be 15,000DWT~20,000DWT ($logGRT = 0.162 + 0.915logDWT,\ DWT \geqq 6{,}000$). Since the major part of general cargo will be containerized, it seems that the size of general cargo vessel would not be greatly enlarged. Therefore, in this planning, the minimum forecast vessel size range, 15,000DWT, was selected as future vessel size for foreign trade general cargo.

Based on above determined DWT, the objective maximum size of conventional vessels is determined referring to Table 4.1.8.of Technical Standards for Port and Harbour Facilities in Japan

4.1.4 Berth Dimension

(1) Berth Depth

The standard berth length and water depth used in Japan are shown in Table 4.1.9. As for the water depth, the figures in Table 4.1.9 are a little greater than 110% of the full draft of a relevant ship.

As for the container berth, to accommodate a mother vessel with 3,000TEU capacity servicing in main line, berth depth should be -14m. Almost main container ports in Europe and Asia have container berths with 14m depth. All major ports in Asia have deep water berths with 14m and over in depth, in particular, Singapore port has container berths with 15m in depth and is considering a further increase in the depth of these berths. Container berths with 15m water depth are being planned in Busan and Kaohsiung port, however, Hong Kong port intends to construct container berths with 14.5m water depth.

Europe has the deepest container berths, that is, Hamburg port has container berths of 16m depth and other ports also have berths with depth of 14m and over. Los Angeles, Long Beach and Seattle on the West coast of North America have container berths with 15m in depth. Oakland does not have a 15m berth, because of the huge volume of dredging and the high cost that would entail. Although New York & New Jersey port on the east cost of North America is examining to increase the depth of berth to 14m, its plan has not been realized because of consideration for environmental impacts by dredging and development cost.

TABLE 4.1.9 Standard Dimensions of Berths for Large Ships

Kind of Ships	Length of Berth	Water Depth of Berth	Size of Ships
Passenger Ship	(m)	(m)	Gross Tons
	100	4.5	2,000
	120	5.0	3,000
	150	6.0	5,000
	170	6.5	8,000
	190	7.0	10,000
	220	7.5	15,000
	240	9.0	20,000
	280	10.0	30,000
Cargo Ship			Dead Weight Tons
	70	4.5	700
	80	5.0	1,000
	100	5.5	2,000
	110	6.5	3,000
	130	7.5	5,000
	160	9.0	8,000
	170	10.0	10,000
	190	11.0	15,000
	240	12.0	30,000
	260	13.0	40,000
	280	14.0	50,000
	300	15.0	70,000
	320	16.0	90,000
	330	18.0	100,000
	370	20.0	150,000
Tanker			Dead Weight Tons
	80	4.5	1,000
	100	5.5	2,000
	110	6.5	3,000
	130	7.5	5,000

Kind of Ships	Length of Berth	Water Depth of Berth	Size of Ships
Tanker	(m)	(m)	Dead Weight Tons
	170	9.0	10,000
	190	10.0	15,000
	210	11.0	20,000
	240	12.0	30,000
	260	13.0	40,000
	280	14.0	50,000
	300	15.0	60,000
	310	16.0	70,000
	320	17.0	80,000
Car Carrier			Gross Tons
	100	5.0	700
	110	5.5	1,000
	130	6.5	2,000
	150	7.0	3,000
	170	7.5	5,000
	180	8.0	6,000
	210	9.0	10,000
	240	10.0	15,000
	260	11.0	20,000
Gas Carrier			Gross Tons
	90	5.5	1,000
	110	6.5	2,000
	130	7.5	3,000
	150	8.5	5,000
	190	10.0	10,000
	210	12.0	15,000
	230	13.0	20,000
	260	14.0	30,000
	310	15.0	50,000

(2) Berth length

The required berth length is determined considering the overall length of vessels and mooring method.

In considering a single berth, the angle of a mooring rope and faceline of quay is between 30 and 45 degrees, thus the required berth length is obtained by the following formula.

$$L = LOA + B \times 1.73$$

L : required berth length (m)

LOA : overall length of the maximum vessels (m)

B : breadth of the maximum vessels (m)

(1.73 = tan 60 degree)

In considering continuous berths for general public use, in case where the terminal facilities are leased to stevedoring companies or are directly managed by the port authorities themselves, the terminals are usually used for the general public. In this case, it is difficult to estimate the combinations of the vessels berthing simultaneously. Therefore, the objective vessel size for deciding one berth length of continuous berth is usually estimated as 70% of the vessel size distribution at the target year, that is, 30% of the vessels exceed the objective vessel size.

(3) Dimension of berth for objective ship

Dimension of berths for objective ships in 4.1.3 are shown in Table 4.1.10.

TABLE 4.1.10 Dimensions of Objective Berths

Vessel Type	Ship size (DWT)	Berth depth (m)	Berth length (m)
Container(Main)	50,000	14.0	350
Container(Feeder)	27,000	12.0	280
Ro Ro	19,700GRT	10.0	210
Conventional(Foreign)	15,000	11.0	190
Conventional(Domestic)	5,000	7.5	130
Grain(Foreign)	30,000	12.0	240

The apron is the quay surface between the front line of the berth and the transit shed or open storage area where cargoes and vehicles used for cargo handling are placed temporarily. The width of the apron must be adequate to ensure safe and smooth cargo handling. It is determined considering the way the berth is utilized, the type of transit sheds and warehouses, the cargo handling equipment and the type of connecting land transportation. Apron located in front of sheds and on which forklifts are used should not be less than 15-20 meters wide. Apron adjacent to open storage area where trucks are used for direct loading/unloading should be 10-15 meters wide. In Japan, the apron widths in Table 4.1.11 are adopted as standards.

The apron width of bulk cargo berth and general cargo berths is 20 meters.

TABLE 4.1.11 Standard Values of Apron Width

Water depth of berth	Apron width(m)
4.5m or less	10
4.5m~7.5m	15
7.5m and over	20

The required apron width of container berth depends on the loading and unloading system, type of container crane and cargo handling system in the container yard. The apron width consists of;

a) Clearance from the face line to the crane rail on the sea side
b) Span of crane rail
c) Back reach for hatch cover space

Generally speaking, a. is 3m, b. is decided by the number of lanes of tractor/trailer per berth and c. is decided by the length of hatch cover and the traffic lane of straddle carriers or transfer cranes. The apron width will be between 40 and 60m
In this port planning, the apron width is 50 meters, which is explained in 4.2.

4.1.5 Required Number of Berths for New Port

The required number of berths is calculated by dividing the estimated future cargo throughput per year by the estimated future cargo handling efficiency expressed in terms of ton or TEU per berth as follows;

N = Ct / Uf

N : required number of berths
Ct: future cargo throughput per year (ton or TEU)
Uf: cargo handling efficiency per year and berth (ton or TEU)

The cargo handling efficiency per year and berth varies from terminal to terminal because the cargo handling efficiency changes in accordance with the cargo handling system including working hours at the terminals and the berth occupancy rate at the terminals. Hence, the cargo handling efficiency is estimated through a productivity analysis of cargo handling equipment in 4.2. The cargo handling efficiency for various vessel types is shown in Table 4.1.12.

TABLE 4.1.12 Ship Type and Cargo Handling Efficiency

	Maximum ship size (DWT)	Loading ratio	Cargo Volume per ship (ton)	Average Cargo Handling Volume /day/ship (ton)
Container(Main)	3,000TEU	0.5	1,500TEU	1,080TEU/day/ship
Container(Feeder)	1,500TEU	0.5	750TEU	1,080TEU/day/ship
Dry Bulk	5,000	0.8	4,000	5,200
(Grain)	30,000	0.8	24,000	6,000
Break Bulk	15,000	0.6	9,000	3,100
(Timber)	15,000	0.8	12,000	2,000
General	15,000	0.6	9,000	1,500

Future cargo throughput of the new port is explained in 4.1.2. Required number of berths is calculated as follows;

1)Container Handling Berth

n = (Total Cargo Volume)

/ (Berth occupancy × Working day × Handling volume/day/ship)

= 638,000TEU/(0.6 × 330days × 1,080TEU/day/ship) = 3.0

2)Dry Bulk Berth

Sand, Clinker, etc.

n = 3,184,000ton/(0.70 × 330days × 5,200ton/day/ship) = 2.7

Cement, etc.

n = 630,000ton/(0.50 × 330days × 8,100ton/day/ship) = 0.5

Grain, etc.

n = 941,000/(0.50 × 330days × 6,000ton/day/ship) = 1.0

3)Break Bulk Berth

Timber, etc.

n = 187,000/(0.60 × 330days × 2,200ton/day/ship) = 0.5

4)General Cargo Berth

Iron, Metal products, Pulp, etc.

n = 599,000ton/(0.60 × 330days × 3,100ton/day/ship) = 1.0

Machinery, etc.

n = 284,000ton/(0.60 × 330days × 1,500ton/day/ship) = 1.0

The results of calculation are shown in Table 4.1.13. Total required berths are ten(10) and total length of berths is 2,064 meters including Ro Ro ramp. The container berth for main vessel is included in three container berths for feeder vessels. However, the berth length with 350m for main vessels has a depth of 14m.

TABLE 4.1.13 Required Berth

Berth	Required number of berth	Berth depth	Total length of berths
Container berth	3	-12.0m (-14.0m)	840m (350m)
Dry bulk berth(D)	3 1	-7.5m -11.0m	390m 190m
Grain berth(F)	1	-12.0m	240m
General cargo berth	2	-11.0m	380m
Ro Ro ramp	1	-10.0m	24m
Total			2,064m

Note: D; Domestic trade, F; Foreign trade

4.1.6 General Port Development Plan

(1) Container Terminal

Three container berths are necessary to handle container cargo throughput in 2015. These berths are arranged continuously in a straight line for flexible use of gantry cranes. The container yard will be located just behind the container berth and its depth will be 400m. The necessary area, detailed layout and dimension of container terminal are examined in 4.2.

The direction of container berth should be selected so that vessels will not encounter strong winds when berthing or detaching. According to the wind rose shown in 3.2, the direction had better to be selected approximately in the N-S direction.

(2) Conventional Cargo Terminal

In general, most bulky cargo wharves have become exclusive wharves due to rationalization of transportation compared with general cargo wharves. Since forecasted main bulk cargoes in the new port will be sand, cement and grains, cargo handling system in the terminal will be selected properly and layout of the terminal will be considered for smooth movement of bulky cargoes. The terminal for bulk cargoes such as grains and cement are examined in 4.2.

Facilities with the same use such as bulk cargo wharves, general cargo wharves, foreign trade wharves, domestic wharves and specialized terminals should be consolidated, respectively, in order to facilitate the rationalized operations of port functions. Hence, grain wharf, general cargo wharves, timber wharf and bulk domestic wharves are consolidated respectively.

In this section, area for cargo handling and storage, such as general cargo shed and warehouse and open storage-yard for bulk cargoes are examined. The scale of transit sheds is determined using the following formula;

$$W = N/(n \times R) = k \times w \times a \times b$$

W: Cargo storage capacity per shed (t)
N: Required annual handling volume (t/year)
R: Cargo turnover (time/year)
w: Stored cargo volume per unit area (t/m^2)
a: Frontage (m)
b: Depth (m)
n: Number of sheds
k: Occupancy rate (k=0.5)

The gross land area required for transit sheds is determined as follows;

Gross Area = (Net Area of transit sheds)/(0.6~0.7)

Warehouse scale is planned in the same manner as transit sheds. The area for an open storage is determined using the following formula;

$W = N/R = k \times w \times A$

W: Cargo storage capacity (t)
N: required cargo handling volume per year (t/year)
R: Cargo rotation (times/year)
A: Required area for the open storage (m^2)
w: Stored cargo volume per unit area (t/m^2)
k: Occupancy rate (usually, about 0.7)

The necessary storage area for bulk and general cargo handling is shown in Table 4.1.14.

TABLE 4.1.14 Necessary Area for Open Storageyard, Transit Shed, Warehouse

	Required annual handling volume	Cargo Rotation (turnover)	Occupancy rate	Stored cargo volume per unit area (t/m^2)	Required Area (m^2)	Gross Area (m^2)	Area Size (m*m)
(Open Storageyard)							
Sand	2,918,000	12	0.7	5	69,476	99,252	
Clinker	266,000	12	0.7	5	6,333	9,048	
Timber	187,000	25	0.8	0.25	93,500	133,571	
Timber	187,000	12	0.8	1.2	40,582	57,974	
						299,844	200*1500
(Transit Shed)							
Pulp	197000	25	0.5	3	5,253	7,505	
Iron	152000	25	0.5	3	4,053	5,790	
Metal Products	250,000	25	0.5	2	10,000	14,286	
Machinery	284,000	25	0.5	1.5	15,147	21,638	
						49,219	70*710
(Warehouse)							
Pulp	197000	12	0.7	3	7,817	13,029	
Iron	152000	12	0.7	3	6,032	10,053	
Metal Products	250,000	12	0.7	2	14,881	24,802	
Machinery	284,000	12	0.7	1.5	22,540	37,566	
						85,450	100*860

(3) Access Channels and Basins

Water area facilities should be as calm as possible, so they are sheltered from natural forces such as wind and wave by protective facilities.

According to technical standards in Japan, the direction of the channel should deviate 30° to 60° from the prevailing wave direction and the maximum wind direction so that calmness and maneuverability are secured.

Channel bends should be avoided as much as possible. When bends are inevitable, the channel can be arranged so that the angle of intersection of the centerline of the channel approaching the bend does not exceed 30°.

The channel distance from the end of the sheltering facilities to the mooring facilities should be designed as 5L (L = ship length) or more, which is the stopping distance of 4L plus a clearance of 1L.

The width of a channel with two way traffic in this plan will be 1.5L, because the length of the channel is not long and traffic by object vessel will be frequent. Hence, the width of main channel is 450m($\fallingdotseq 1.5 \times 290$), because the length of maximum object vessel is 290m.

The water depth of channel is obtained according to the formula;

$d > 1.1D$

d: Water depth of channel

D: Full draft of object ship

In many cases, berth depth of object ship is used as water depth of a channel. Hence, the water depth of the channel is 14m.

Turning basin of a circle with diameter of 2L or longer for turning by tug is adopted as the standard in Japan.

(4) Breakwaters

The layout of breakwater is determined after examining following items;

- Calmness in the harbour
- Ease of vessel operation
- Maintenance of water quality in the harbour
- Construction and maintenance cost
- Influence of breakwater installation on the surrounding area
- Future port development.

As for the calmness of basins, it is preferable that the harbour area always be tranquil. However, maintenance of sufficient calmness even in stormy weather is quite difficult in practice. Cargo handling is possible if the wave height in front of mooring facilities is within the heights listed in Table 4.1.15. Therefore, the layout of the water area facilities should maintain wave calmness within these heights even in strong wind (10～15m/sec). In Japan, port plans are made so that the heights in Table 4.1.15 are obtained 95~97.5% of the time.

The above standard for calmness in water area facilities is used in the planning of new port layout so that the wave heights in Table 4.1.15 are obtained 95～97.5% of the time.

TABLE 4.1.15 Critical Wave Height for Cargo Handling

Ships size(DWT)	Critical wave height ($H_{1/3}$)
1,000t or less	0.3m
1,000t ～ 5,000t	0.5m
5,000t or over	0.7m
container ships	0.5m

(5) Port Traffic Facilities

Port traffic facilities are necessary to ensure smooth linkage between wharves and the hinterland. The dock transportation facilities are comprised of roads, railways, and canals, when necessary tunnels and bridges are prepared.

The port traffic facilities to be planned differ according to the nature and status of the port and the kind, volume and shape of cargoes handled there. Good traffic facilities promote quick and economic transportation and the smooth flow within the port.

The new port will be one of the largest commercial ports in the Sea of Marmara, handling 530 thousand TEU of container and 5.9 mil. ton of dry bulk and general cargoes generated from/to the Thrace region in 2015.

Although dock railways are advantageous in mass transportation over relatively long distances, the use of railways is declining in Japan because they require a considerable area of marshaling yards among other reasons.

1) Roads

The planned traffic volume is obtained from the port cargo handling volume as given below.

Planned traffic volume (cars/hr)
= Annual cargo handling volume (tons/year)
$\times \alpha / W \times \beta / 12 \times \gamma / 30 \times (1+\delta) / \varepsilon \times \sigma$

Where:

α : Share by vehicles	= Car transportation / all transportation(1.0 or less)
β : Monthly variation	= Cargo volume in the peak month/average monthly cargo volume (about 1.2)
γ : Daily variation	= Cargo volume on the peak day / average daily cargo volume (about 1.5)
W: Loading ratio of trucks (t/truck)	= Cargo transportation volume per loaded truck (4t truck: general cargo, 8t truck: bulk cargo)
ε : Loaded truck ratio	= Number of loaded trucks / total number of trucks (about 0.5)
δ : Rate of related vehicles	= Number of related vehicles / number of total trucks (about 0.5)
σ : Hourly variation	= Traffic generation per peak hour / daily traffic generation volume (about 0.12)

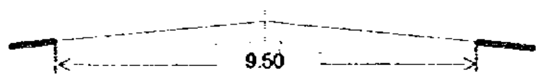
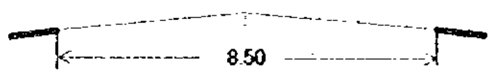
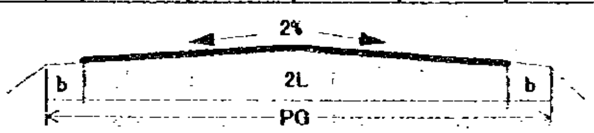
The final number of traffic lanes is decided by comparing the rate of the planned traffic volume of the road with the standard design volume per lane which is given in Table 4.1.16. At the same time, Turkish highway standard is referred to.(See Table 4.1.17)

The planned traffic volumes based on annual cargo throughput handled in the new port are shown in Table 4.1.18. .According to the total traffic volume and standard design traffic volume per lane in Table 4.1.16, six(6) lanes will be necessary in 2015. Since Turkish highway standard per lane is 1,200 in flat topografic model or 650 in rolling model, four (4) or six(6) lanes is necessary. Therefore, six(6) lanes is decided as the final number of traffic lanes.

TABLE 4.1.16 Standard Design Traffic Volume per Lane

Type of road	Standard design traffic volume (cars/hr)
Connection roads between ports and a truck highways	600
Other roads	350

TABLE 4.1.17 Highway Geometric Standards Out of town: 2-Lane Roads

Project Elements			First Class					
Service Level			D		D		D	
Traffic*	Annual Average Daily Traffic		12000		6500		4000	
	Project hourly traffic		1200		650		400	
Topographic Model		TM	Flat		Rolling		Mountainious	
Project Velocity		Vp(km/hr)	100	80	80	70	70	60
Minimum Proximity Radius		R(m)	400	250	250	200	200	150
Minimum Clothode Parameter		A	160	130	130	120	120	100
Maximum longitudinal slope		m (%)	4	4	6	6	7	7
Vertical proximity constant	closed proximity	Kk	107-56	44-26	44-26	29-20	29-20	17-15
	open proximity	Ka	51-35	30-23	30-23	22-19	22-19	16-15
Maximum superelevation		n (%)	8	8	8	8	8	8
Safety stopping distance		Ld (m)	155	110	110	90	90	70
Safety passing distance		Lg (m)	670	550	550	480	480	420
Lane width		L (m)	3.5	3.5	3.5	3.5	3.5	3.5
Berm width		b(m)	2..50	2.5	2	2	2	2
Platform width		PG (m)	12	12	11	11	11	11
Bridge width	Short bridge (0-45 m)	Wk(m)						
Bridge project load H: 20 - S: 16	Long bridge (>45 m)	Wu(m)						
Underpass (min. h:5)		h(m)	5	5	5	5	5	5
Template								
Expropriate width	Total width	KG(m)	Normal 60.00± project requirements					
	Length	Le(m)						

* The traffic value estimated to be reached 20 years after project is finished

** Can be increased up to 10% in areas where no ice and snow

***In mountainous terrain, on mixed sections, berm widths are 50 cm. more on the fill side and 50 cm. less on the split side

TABLE 4.1.18 Planned new port oriented traffic volume in 2015

Cargo	Annual cargo handling volume (ton/year)	Share of vehicles (α)	Loading truck ratio (W)	Monthly variation (β)	Daily variation (γ)	Rate of related vehicles (δ)	Loaded truck ratio (ε)	Hourly variation (σ)	Traffic volume (cars/hr)	Number of traffic lanes
Sand	2,918,000	1	8	1.2	1.5	0.2	0.5	0.12	525	
Cement	630000	1	8	1.2	1.5	0.2	0.5	0.12	113	
Clinker	266000	1	8	1.2	1.5	0.2	0.5	0.12	48	
Timber	187,000	1	8	1.2	1.5	0.5	0.5	0.12	42	
Grain	941,000	1	8	1.2	1.5	0.5	0.5	0.12	212	
Pulp	197,000	1	8	1.2	1.5	0.5	0.5	0.12	44	
Iron	152,000	1	8	1.2	1.5	0.5	0.5	0.12	34	
Metal products	250,000	1	8	1.2	1.5	0.5	0.5	0.12	56	
Machinery	284,000	1	4	1.2	1.5	0.5	0.5	0.12	128	
Container(FCL)	255,643	1	20,40	1.2	1.5	0	0.5	0.12	307	
Container(LCL)	532,591	1	8	1.2	1.5	0	0.5	0.12	80	
Total									1,590	6

Note: Unit of Container(FCL) in column "Annual cargo volume " is box.

Since main cargoes are originated to/from Istanbul, six-lane access road to Trans-European North-South Motorway is necessary. There are two alternative routes to the moteorway, one is to Çorlu interchange through Çorlu which is 30km from the site and another is Kinali 2 interchange through seaside state highway, E84 which is 45km from the site. The E84 is always congested in summer and at weekend. In order to avoid spurring on congestion of E84 and to separate port oriented traffic from ordinary traffic, the route to Çorlu interchange is recommendable. However, since the existing road to Çorlu interchange is two-lane road, widening from two lanes to six lanes is necessary. Moreover, to separate the port oriented traffic from ordinary traffic of E84, cross of access road and E84 is planned as grade separation. The access road is underpass. 3~4 km approach access road which directly connect with the new port and the existing road to Çorlu is newly constructed.

For examination of existing highway capacity, road planning, EIA of traffic noise and vibration and air pollution, planned traffic volume oriented to/from the new port in Thrace is distributed to each direction in the hinterland.

Cargoes are distributed in accordance with the microscopic cargo forecast, namely, cargoes which are estimated by correlation analysis with value added of industrial products are distributed into four districts by the value added in the districts in Thrace. Cargoes related to factories for which locations are identified are divided according to the scale of factory. To give actual examples, clinker and coal are distributed by location of cement factory and sunflower seeds and cotton seeds are done by oils and fats factories. Others are divided according to value added of industrial products. Distribution results are compiled into three direction radiating from the new port to the east, west and north.

According to the above cargo volume distributed to the various directions, traffic volume in the year 2015 is calculated by means of above mentioned method. Results are shown in Table 4.1.19.

TABLE 4.1.19 Distribution of port oriented traffic volume

Direction from Port		East		North		West	
Cargo	Loading truck ratio (W)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)
Sand	8	505000	91	1,906,000	343	507,000	91
Cement	8	186000	33	257,000	46	187,000	34
Clinker	8	0	0	266,000	48	0	0
Timber	8	12,000	3	164,000	37	11,000	2
Grain	8	82,000	18	778,000	175	81,000	18
Pulp	8	2,000	0	193,000	43	2,000	0
Iron	8	15,000	3	122,000	27	15,000	3
Metal products	8	6,000	1	238,000	54	6,000	1
Machinery	4	16,000	7	252,000	113	16,000	7
Container(FCL)	20,40	15,816	19	224,013	269	15,816	19
Container(LCL)	8	32,949	5	466,693	70	32,949	5
Total			182		1,226		182

2) Parking Lots

A parking lot for mooring facilities used by Ro Ro vessels should be large enough so as not to aggravate the nearby traffic condition by considering the number of vehicles carried by the Ro Ro vessels, rate of utilization and convergence. The area for a parking lot is determined using the following formula;

$A = a \times n \times \alpha \times \beta$

A: Area for a parking lot (m^2)

a: converted necessary area for 8t truck (82~93m^2 per truck)

n: capacity of Ro Ro vessel

α : rate of usage(usually 0.8 in planning)

β : rate of concentration(daily average 1.0)

In this port planning, a parking lot is arranged for vehicles using Ro Ro vessel. Since capacity of objective Ro Ro vessel is 150, required area for parking lot is calculated as follows;

$$A = 90 \times 150 \times 0.8 \times 1.0 = 10{,}800\text{m}^2$$

3) Railway connection

The railway connection to hinterland will not be arranged in this long term plan, because land transportation in the hinterland will not much depend on railways due to relatively short distance from the new port to Istanbul where is 150km far from the port and major origin and destination of container.

Few container terminals in Asia has railways connection except Kaoshiung port. On the other hand, most ports in Europe have railways connection to wharves or terminals, because considerable volume of containers have been carried by railways. Many terminal operators in Europe have emphasized on the significance of railway transportation, since the availability of railway transportation has a large effect on the competitiveness of terminals. However, dock railways on aprons of container berths are not much used at present and happen to be seen as obstruction of terminal operation. Many large-scale terminals newly constructed have not dock-railways on aprons. Container terminal in Rotterdam port has not dock railway on apron.

Dock railways have been installed in most of terminals in North Western Coast of USA, but container terminals installed with dock railways are few in Los Angeles and Oakland, because they have large scale container transit terminals near container yards. Terminals in the East Coast excluding the Wand terminal in Charleston are connected with dock railways which are installed behind container yard, not installed on apron.

(6) Mooring Facilities for Smaller Vessels and Port Service Vessels

The objective vessel for the mooring facilities for smaller vessels and port service vessels is tugboat, as only container vessels call at the new port in the year

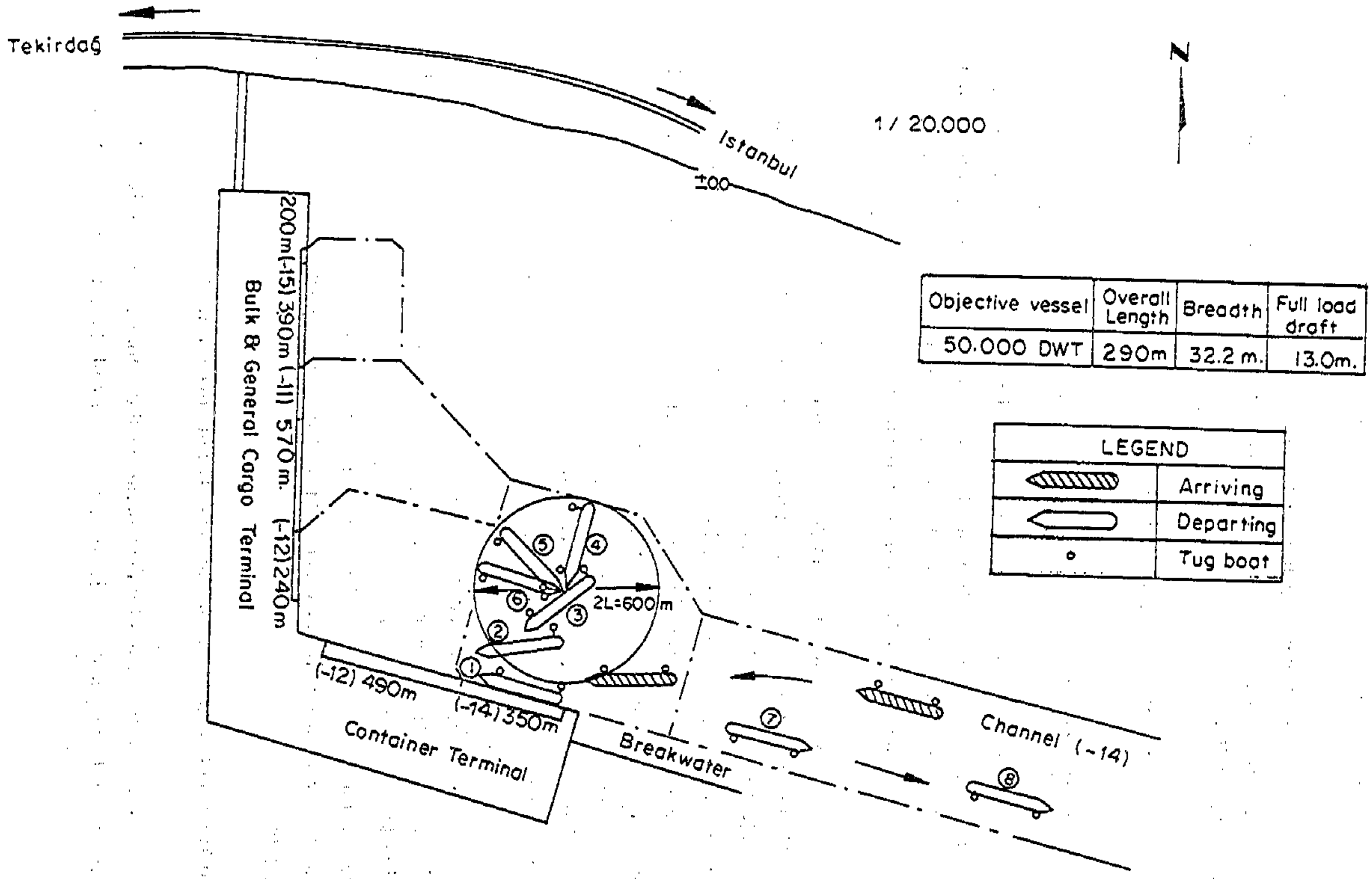


FIGURE 4.1.5 Maneuvering Chart

2005. Refueling of calling vessels is directly done by oil tanker. Port activities and services in the year 2015 which is the target year of the master plan are taken into consideration in determining the necessary scale of facilities.

Two tugboats with 4,000 PS are necessary to assist berthing of a container vessel, according to maneuvering chart. (See Figure 4.1.5) The dimensions of service tugboat are shown in Table 4.1.20.

Table 4.1.20 Dimensions of Tugboat

Class	Gross tonnage	Length	Draft	Berth depth	Berth length
2,000PS	300	29.6m	3.8m	4.0m	50m

Consequently, mooring facility of 4.0 meters in depth and 100 meters in length is necessary for two tugboats in the year 2005, however, the facility of 200 meters in length is planned in consideration of the master plan.

Since the new port is located in the inland sea and relatively near to the oil refinery to the north of Izmit Bay, it is able to be steadily and directly supplied with oil for container vessels berthing at the new port. Therefore, refueling facilities, such as oil tanker berth and oil storage tanks, are not planned.

Approximately 270 large container vessels with capacity of more than 1,000 TEU will call annually at the port in the year 2005. Necessary volume of oil (2,500 kl.) for a vessel can be transported by 2,000 DWT tanker.

The length of mooring facility is 200 meters and its basin is 4.0 meters in depth. To secure the calmness of the basin for tugboat, breakwater of 100 meters in length is necessary. The layout of mooring facilities for smaller vessels and port service vessels is as follows;

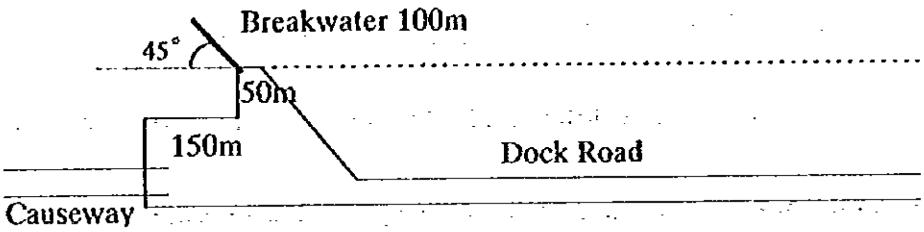


Figure 4.1.6 Mooring Facilities for Smaller Vessels and Port Service Vessels

(7) Alternative Layout Plans

The decisive factor for the port planning at the military owned coastal area is the depth of the sound layer whose N-value exceeds 50. Because of this, the container berths with 12m and 14m water depth must be constructed more than 1,000m off shore, in order to avoid dredging the sound layer. Consequently if the entire area between berths and the shore line would be reclaimed, it would result in too much reclamation works.

Moreover, DLH has proposed a basic idea shown in Appendix as one of the alternative layout plans. The idea is that main berths such as container berths should be in a straight line and placed at offshore side, and its berths should be sheltered by breakwater.

Among many proposed layouts, six alternative layout plans are examined. These general layouts are classified into three basic configurations, such as Plan 1 group, Plan 2 group and Plan 3 as shown in Figure 4.1.7. Six alternative layouts are Plan 1 (Figure 4.1.8), Plan 1-3 (Figure 4.1.9), Plan 1-4 (Figure 4.1.10), Plan 2 (Figure 4.1.11), Plan 2-4 (Figure 4.1.12) and Plan 3 (Figure 4.1.13).

Though it depends on which way will be more economical, another revetment must be constructed along the shore side of the artificial land in Plan 1, as shown in Figure 4.1.8. Looking at Figure 4.1.8, we feel that the fact the plan is not using the shore side of the artificial land is not reasonable or economical, and we feel we want to use the water front and water area of the shore side. The series of Plan 1-2 and Plan 1-3 (Figure 4.1.9) show plans to do so.

Observing these plans, we find that we have to construct three lines of structures, namely, one breakwater, a quay wall for berths and revetment along shore side of the artificial land. If we can use the breakwater as the revetment for reclamation, it would be economical. Plan 2-4 (Figure 4.1.12) shows the idea.

Plan 3 offers a completely different idea but is a typical port configuration.

The results of total evaluation of alternative general layouts are shown in Table

4.1.21. All alternative plans don't have definite weak-points. As mentioned in 4.1.1, sufficient room for future extension and flexibility and unity in operation for future extension in a layout plan are also important as a selection criterion. However, the pattern of Plan 1-2 and Plan 2 after 2015 requires relatively long revetment and breakwater to secure calmness in berths.

TABLE 4.1.21 Evaluation of Alternative General Layouts

Layout Case	P1	P1-3	P1-4	P2	P2-4	P3
Calmness at berths	○	○	○	○	○	○
Berthing, Detaching	○	△	△	○	○	◎
Consolidation in cargo handling & storage	○	△	△	○	○	◎
Room for future extension	○	○	○	△	○	○
Flexibility and unity in operation for future extension	○	○	○	△	○	○
Total construction cost(civil works)	△	○	○	◎	◎	△
Total Evaluation	○	○	○	△	◎	○

Note: ◎; Excellent, ○; Better, △; Little inferior
"Calmness at berths" had better to be examined quantitatively.
"Berthing, Detaching" had better to be asked comments of navigation experts.

Two reclaimed lands will be separated into two artificial islands. Unity in operation of Plan 1-2 and Plan 2 will be spoiled. Consequently, we have to give up on Plan 1-2 and Plan 2.

According to the total construction cost which is the only piece of conclusive evidence, Plan 2-4 is the best. The study team recommends Plan 2-4 as a general layout of the long term development plan for the new port in Thrace.

The estimations of harbour calmness in Plan 3 by computer are shown in Figure 4.1.14 ~ Figure 4.1.18. The coefficients of diffraction in Plan 2-4 are taken from diffraction diagram. The wave height distribution by directions which is taken into consideration of wave refraction and shoaling, is shown in Table 4.1.22.

The calmness at -14m container berth in Plan 2-4 and Plan 3 are 95% and 95% of the time respectively.

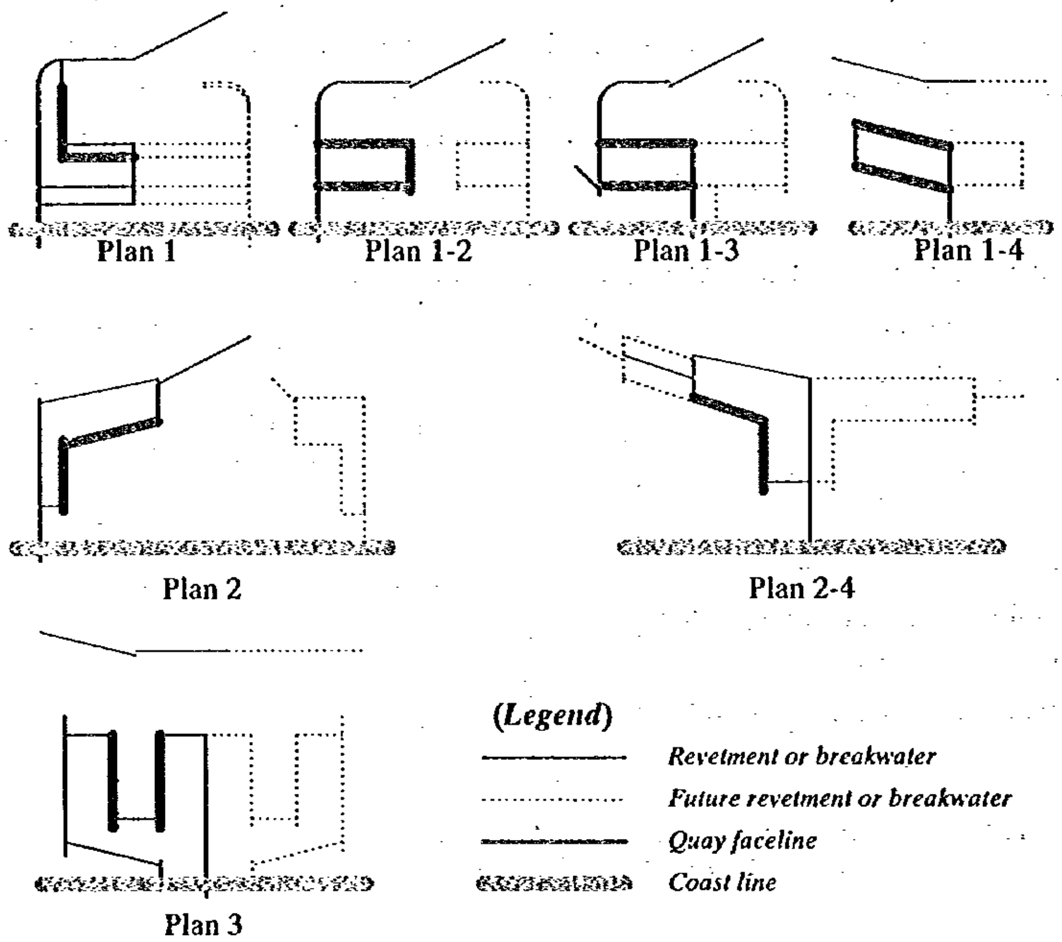


FIGURE 4.1.7 Basic Patterns of Alternative General Layouts

The layout of land use in Plan 2-4 are shown in Figure 4.1.19 and 4.1.20

The general layout of the new port long term development plan is shown in Figure 4.1.21.

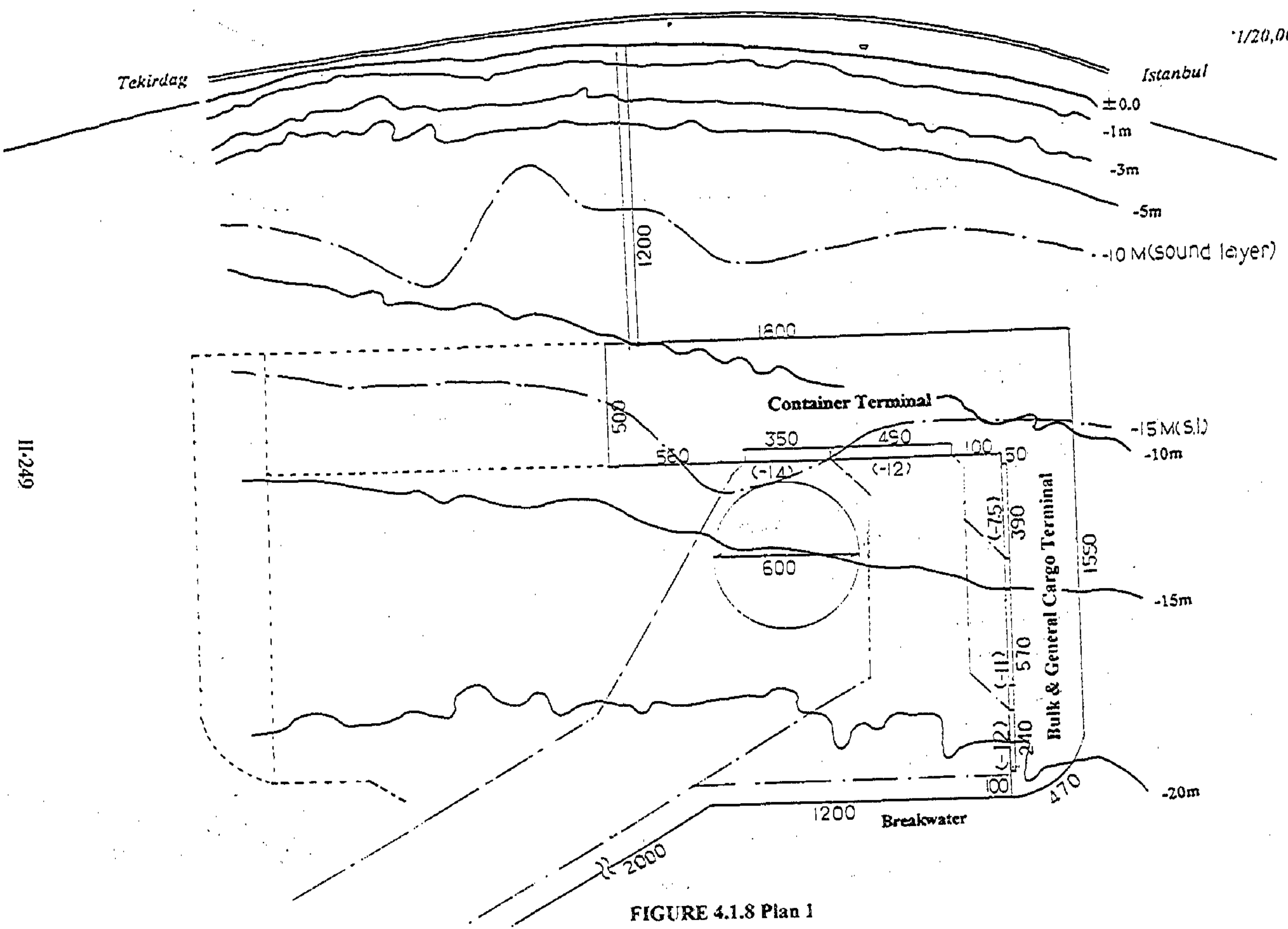


FIGURE 4.1.8 Plan 1

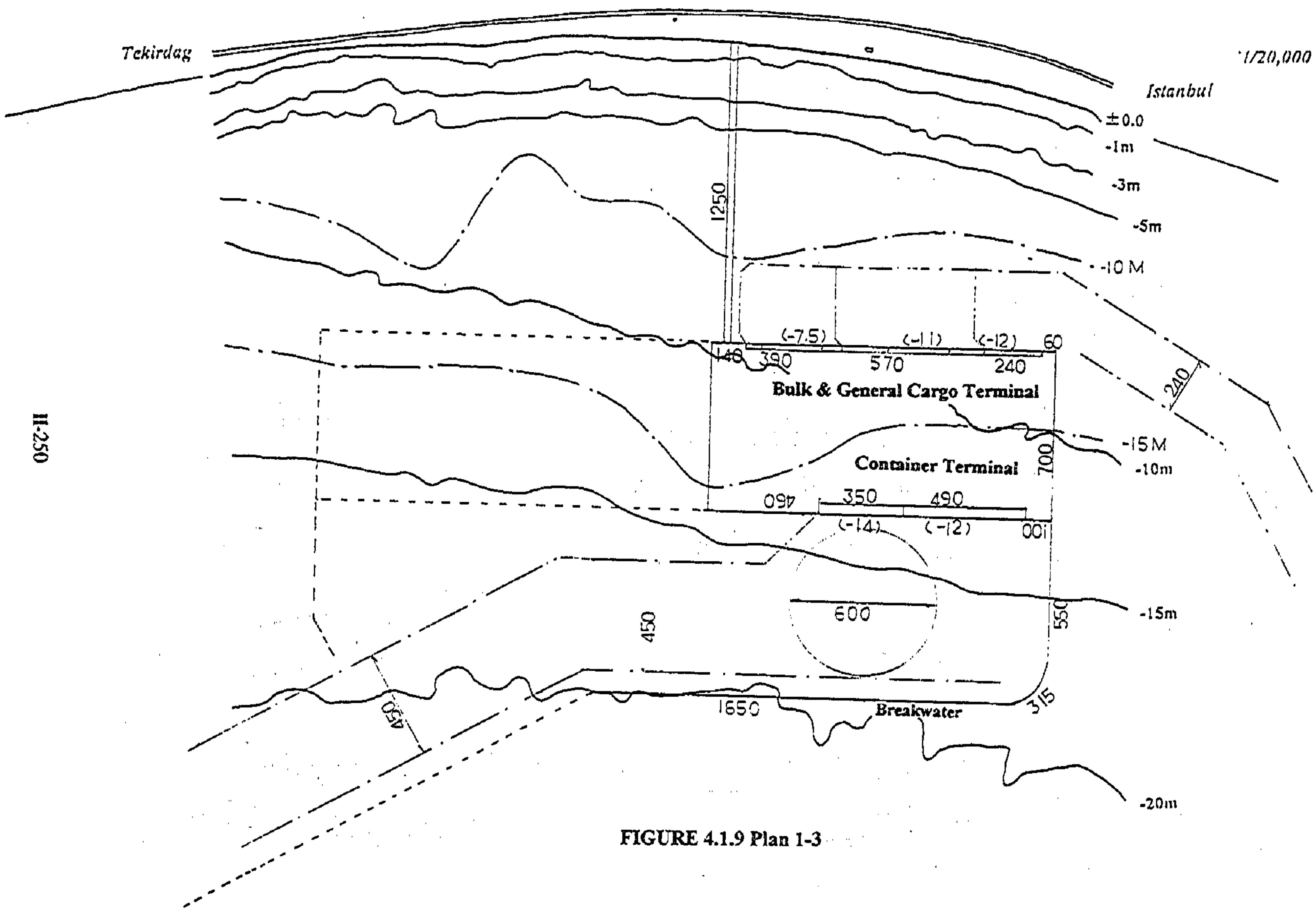


FIGURE 4.1.9 Plan 1-3

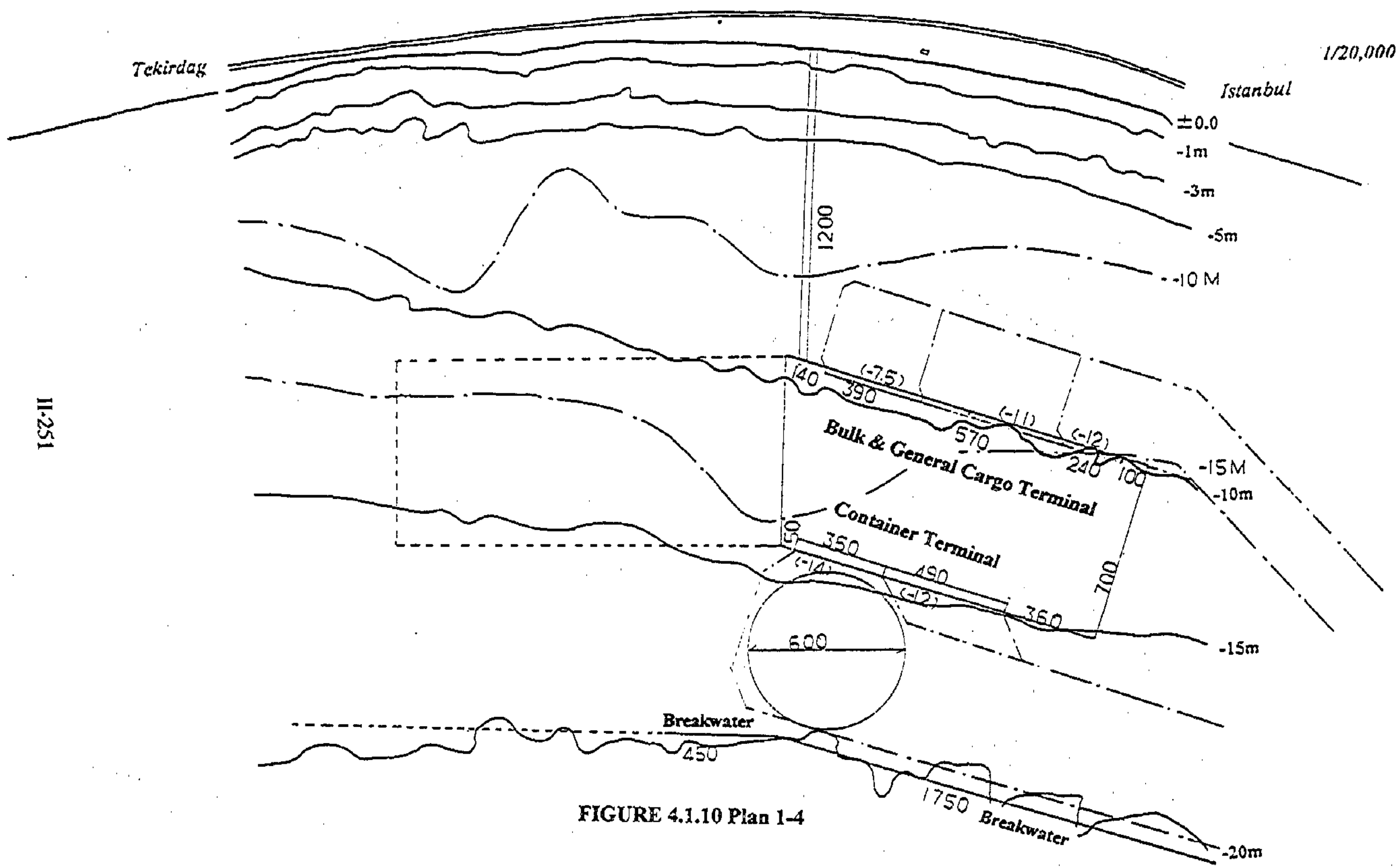


FIGURE 4.1.10 Plan 1-4

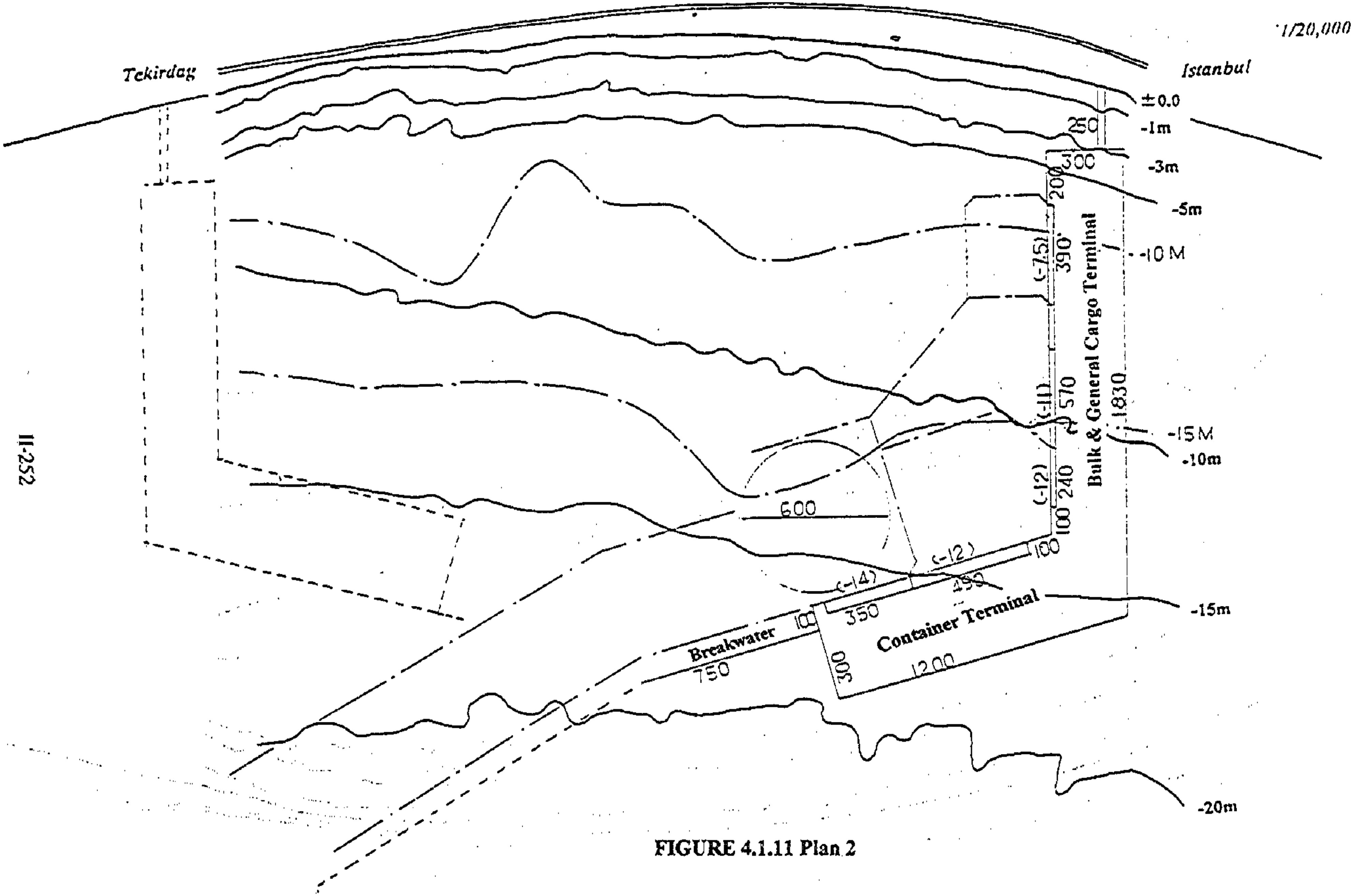


FIGURE 4.1.11 Plan 2

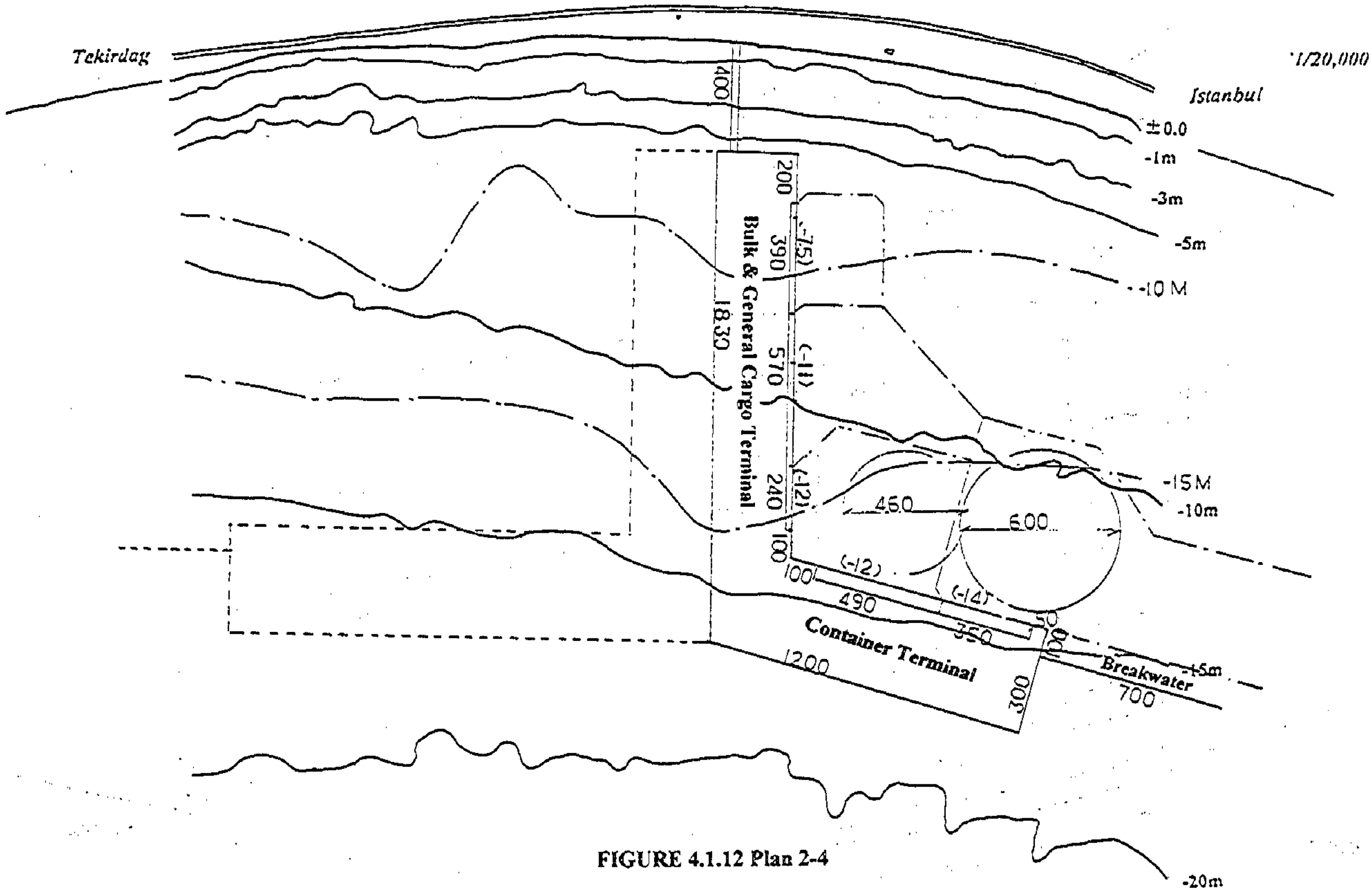


FIGURE 4.1.12 Plan 2-4

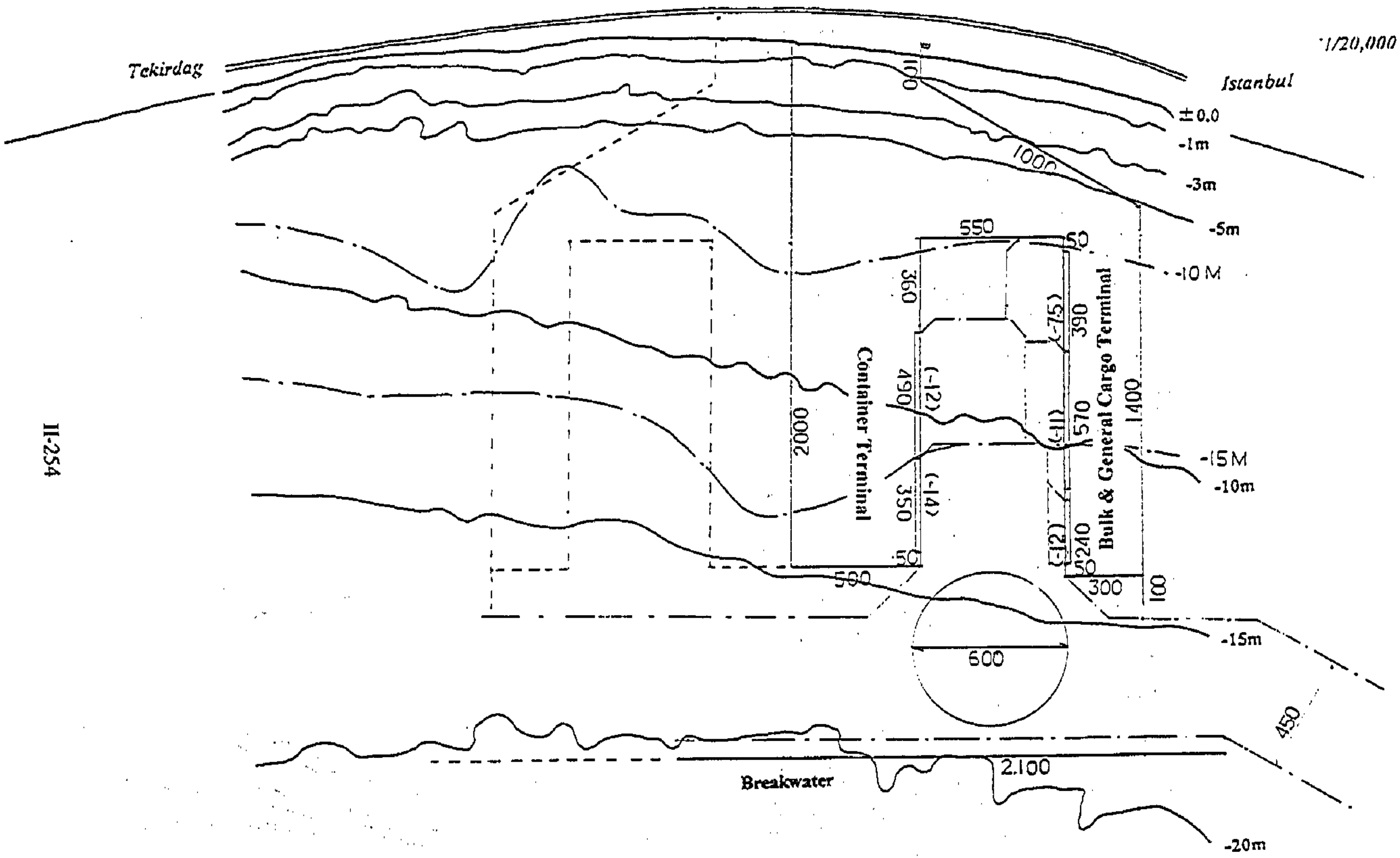


FIGURE 4.1.13 Plan 3

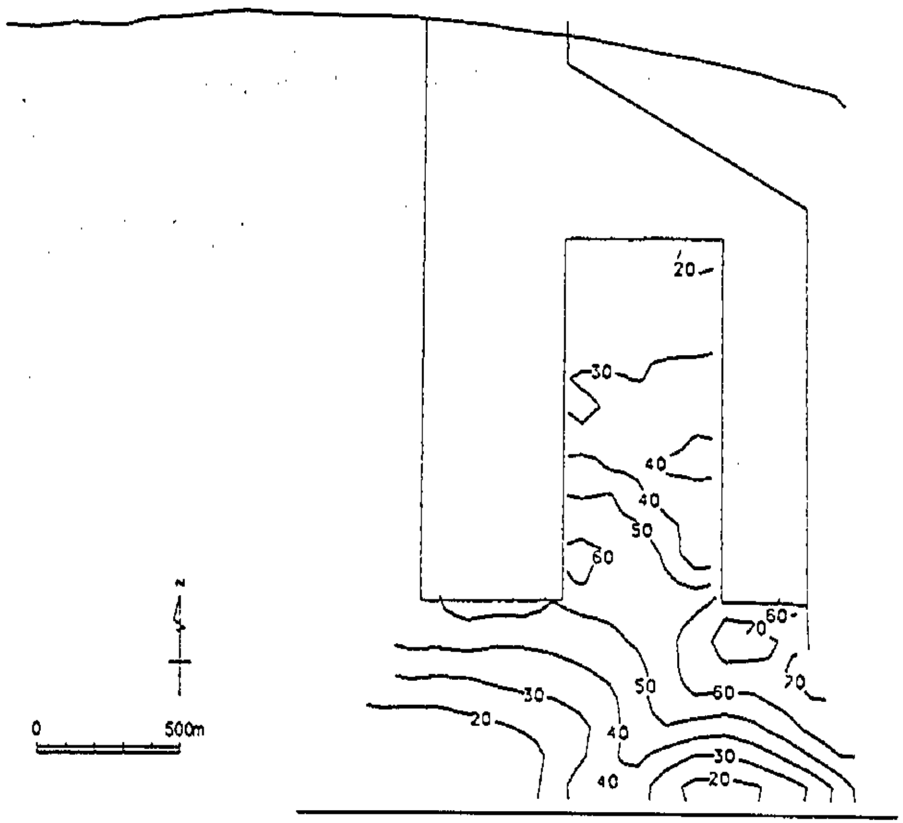


FIGURE 4.1.14 Diffraction Diagram of SE Wave

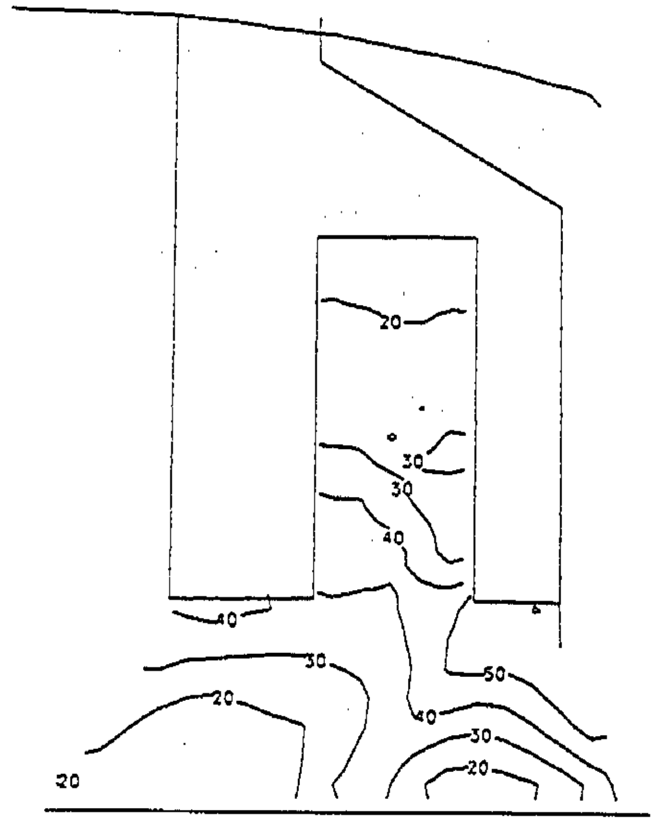


FIGURE 4.1.15 Diffraction Diagram of SSE Wave

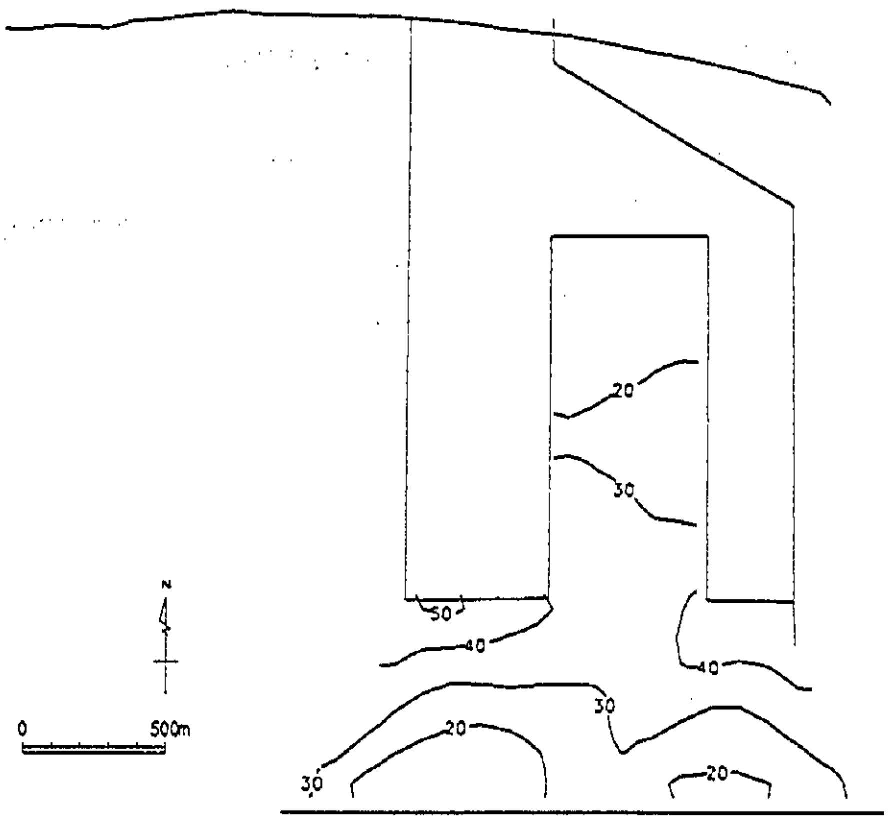


FIGURE 4.1.16 Diffraction Diagram of S Wave

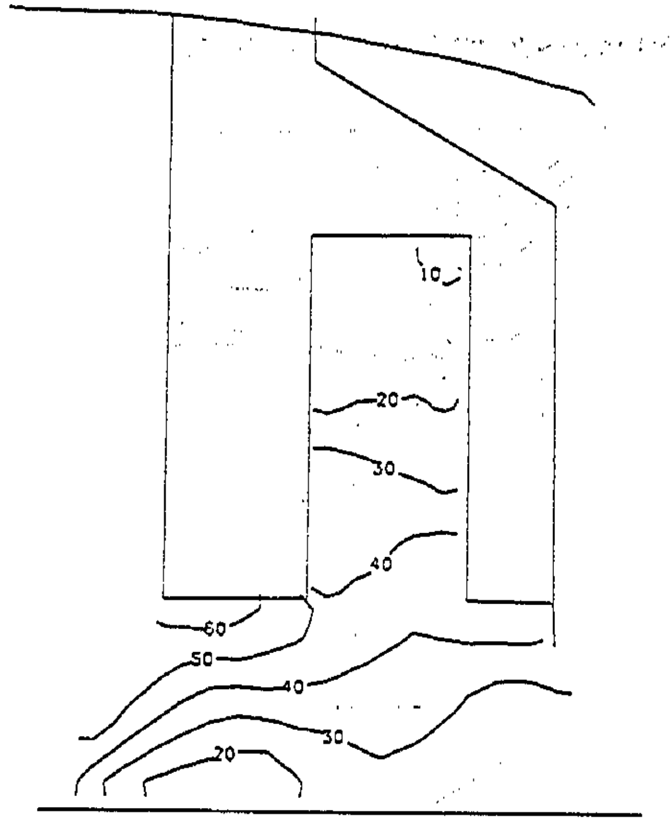


FIGURE 4.1.17 Diffraction Diagram of SSW Wave

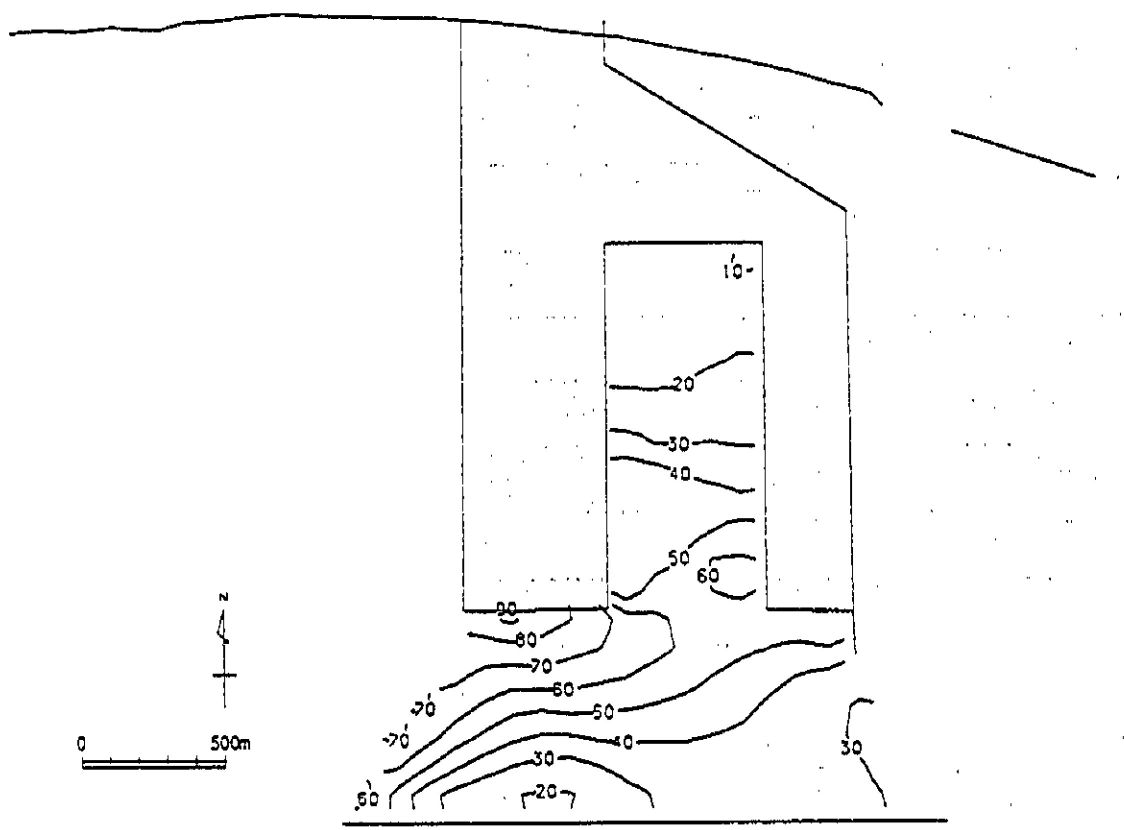


FIGURE 4.1.18 Diffraction Diagram of SW Wave

TABLE 4.1.22 Wave Height Distribution by Directions at the site

Wave Height Class	SW	SSW	S	SSE	SE	ESE	Total	(%)
0m～0.3m			71067 81.762				71067	81.762
0.3m～0.6m	206 0.237	283 0.326	434 0.499	1055 1.214	432 0.497	386 0.444	2796	3.217
0.6m～0.9m	295 0.339	736 0.846	1339 1.540	1993 2.293	1077 1.239	705 0.811	6144	7.069
0.9m～1.2m	278 0.320	654 0.752	1111 1.278	1426 1.641	526 0.605	351 0.404	4347	5.001
1.2m～1.5m	143 0.164	358 0.412	582 0.670	522 0.601	88 0.101	72 0.083	1765	2.031
1.5m～1.8m	63 0.072	117 0.135	201 0.231	165 0.190	22 0.026	25 0.029	594	0.683
1.8m～2.1m	5.8 0.007	22 0.025	56 0.065	46 0.053	12 0.014	12 0.014	153	0.177
2.1m～2.4m	1.4 0.002	6.4 0.007	12 0.014	11 0.013	1.9 0.002	2.3 0.003	36	0.041
2.4m～2.7m		1.7 0.002	1.7 0.002	4.8 0.006	1 0.001	0.5 0.001	10	0.011
2.7m～3.0m			0.7 0.001	5.7 0.007			6	0.007
3.0m～3.3m			0 0.000	0.1 0.000			0	0.000
3.3m～			0.2 0.000	1.6 0.002			2	0.002
Ratio of direciòn(%)	1.141	2.505	4.300	6.019	2.484	1.789	(86920)	100

Note: Upper figure are frequency, lower are %.

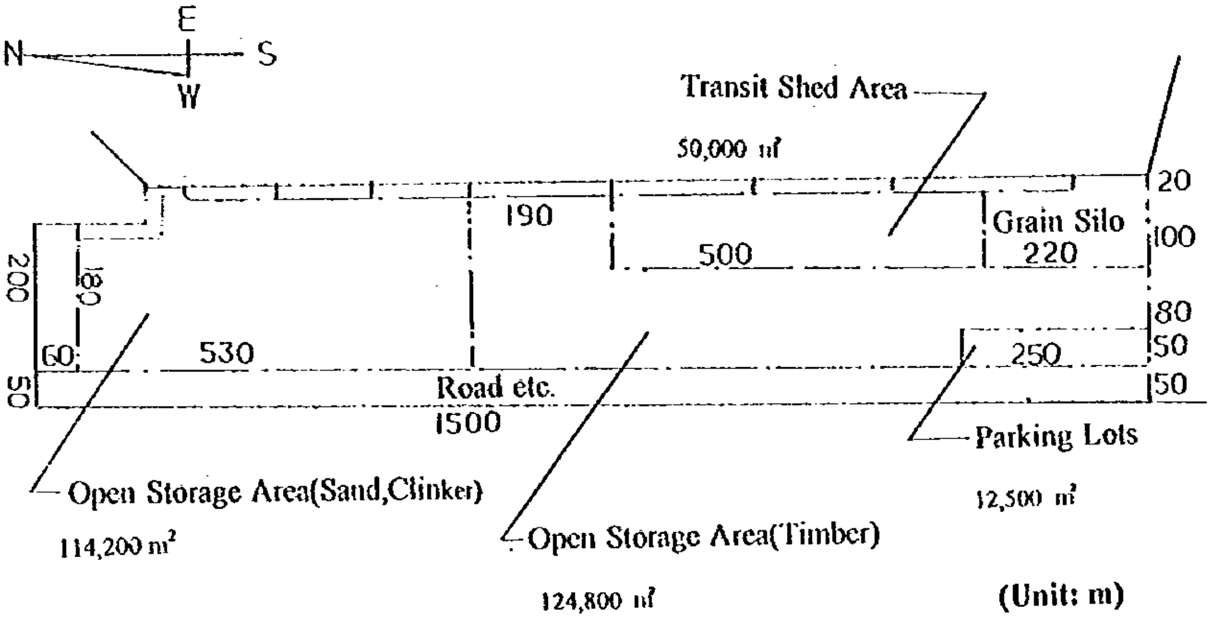


FIGURE 4.1.19 Layout of Land Use in Plan 2-4 (Bulk & General cargo Terminal)

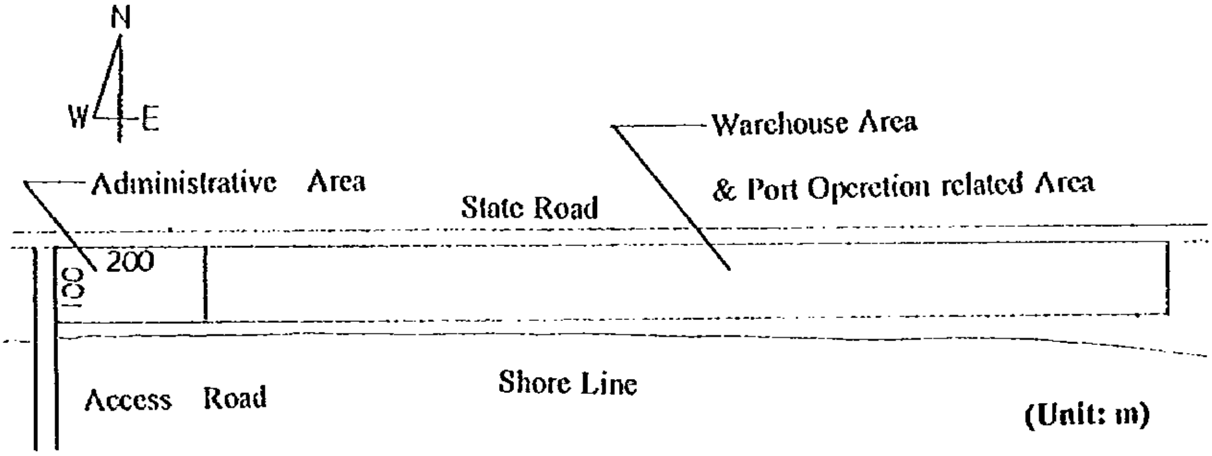


FIGURE 4.1.20 Layout of Land Use in Plan 2-4 (Existing Land)

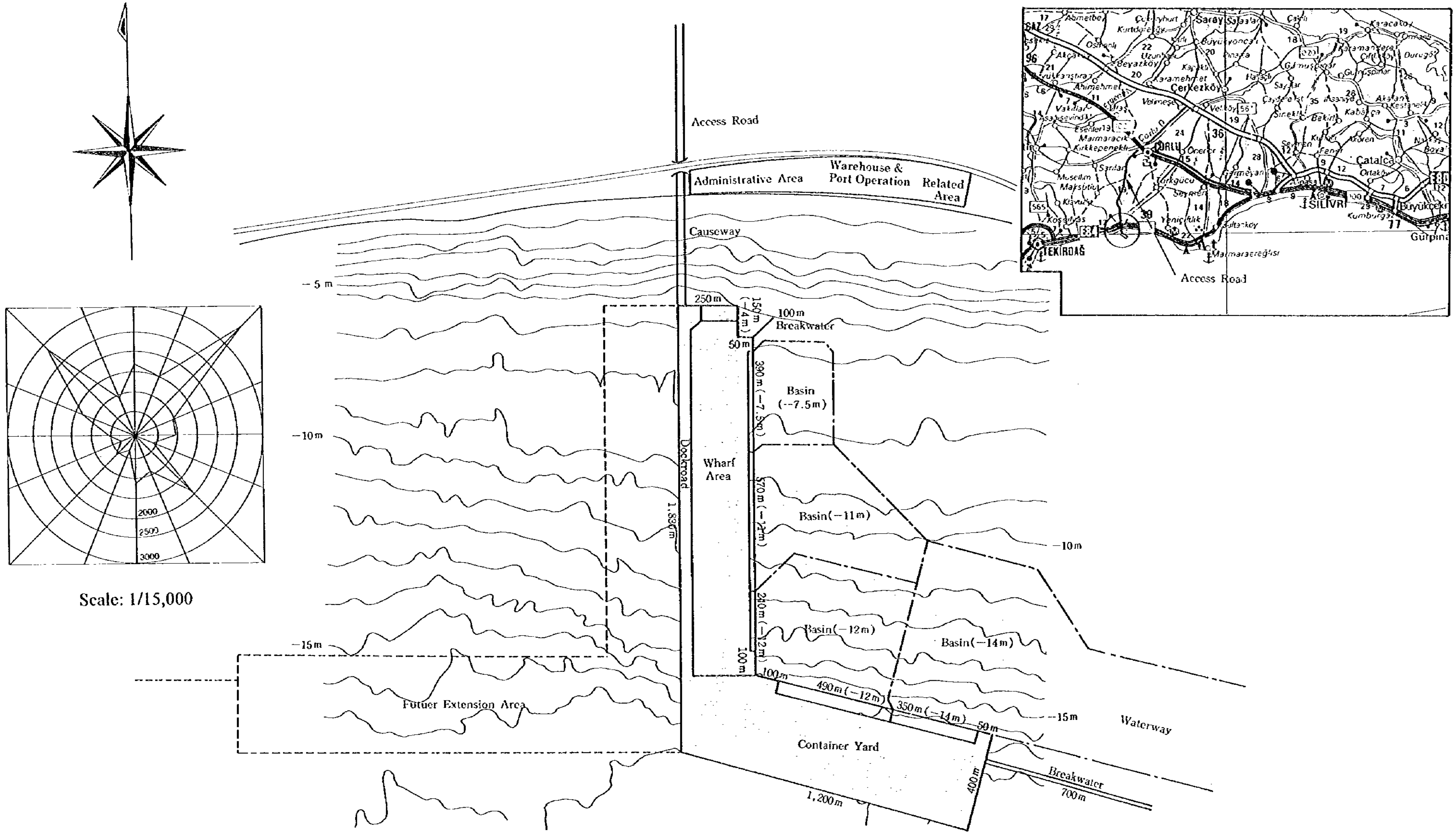


FIGURE 4.1.21 General Layout of New Port Long Term Development Plan

4.1.7 Short Term Development Plan

(1) Demand and Required Number of Berths

Comparing with the cargo handling capacity as of 2005 and cargo demand in 2005, which is mentioned in chapter 2, 270,000TEU extra cargo handling capacity for container is necessary in Thrace region by 2005.

TABLE 4.1.23 Comparison of Existing Capacity & Cargo Demand

Commodity	Cargo Demand in 2005	Existing Capacity as of 2005	Extra Needed Capacity by 2005
Dry bulk cargo(000ton)	9,921	10,191	0
General cargo(000ton)	897	1,578	0
Container(000TEU)	320	50	270

To handle 270,000TEU per year (Out of 270,000 TEU, 46,000 TEU is transshipment containers), two(2) container berths should be constructed. Calculation to require the number of container berths is as follows;

The number of container handling berth(n)
= (Total Cargo Volume)
/ (Berth occupancy × Working day × Handling volume/day/ship)
= 270,000TEU/(0.6 × 330days × 1,080TEU/day/ship) = 1.3

Consequently, two(2) berths is planned in the short-term development plan. Maximum feeder container vessel's size calling at the new port in the year 2005 is predicted that of 1,100 TEU capacity and a berth length for the vessel is 240 meters. 480 meters length for two berths is necessary. Considering that the length for berth with 12 meters in water depth is planned 490 meters, berth dimensions in short-term development plan are decided to be 490 meters in length and 12 meters in depth.

(2) Roads

Planned traffic volume generated to/from the new port in 2005 is shown in Table 4.1.24 and distribution of the traffic volume is shown in Table 4.1.25. According to the result calculated, two(2) lanes will be necessary in 2005.

TABLE 4.1.24 Planned new port oriented traffic volume in 2005

Cargo	Annual cargo handling volume (ton/year)	Share of vehicles (α)	Loading truck ratio (W)	Monthly variation (β)	Daily variation (γ)	Rate of related vehicles (δ)	Loaded truck ratio (ε)	Hourly variation (σ)	Traffic volume (cars/hr)	Number of traffic lanes
Container(FCL)	100,809	1	20,40	1.2	1.5	0	0.5	0.12	121	
Container(LCL)	210021	1	4	1.2	1.5	0	0.5	0.12	63	
Total									184	2

Note: Unit of Container(FCL) in column "Annual cargo volume" is box.

TABLE 4.1.25 Distribution of port oriented traffic volume in 2005

Direction from Port		East		North		West	
Cargo	Loading truck ratio (W)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)	Annual cargo handling volume (ton/year)	Traffic volume (cars/hr)
Container(FCL)	20,40	3,850	5	93,126	112	3,840	5
Container(LCL)	4	8,010	2	194,001	58	8,010	2
Total			7		170		7

In order to minimize construction cost and improve feasibility of the project in the short-term development plan, connecting treatment to existing road along the coast was examined.

The volume of port oriented traffic in 2005 is 184 vehicles per hour. According to the traffic survey in 1994, average daily traffic volume on the coastal road near the site was 5,568 vehicles per day, of which large vehicles such as bus, truck and trailer comprised 29.5%. Traffic volume of existing coastal road in 2005 will increase up to 10,599 vehicle/day, assuming increase rate of traffic corresponds to GDP growth rate in Turkey. Hourly traffic volume of the road is 1,272, in case hourly traffic rate(peak hourly traffic volume / average daily traffic volume) is 0.12. One-way traffic volume is 636 vehicle/hour.

There are three types of connecting treatment as follows;

1)Connection with inland existing road and grade separation from existing coastal road, the same as in the master plan
Grade separation of access road with two lanes (or six lanes) and existing coastal road and approximately 2 km access road with 2 lanes to existing inland road to Corlu will be necessary.

2)Connection with existing coastal road by grade separation

Grade separation of access road with two lanes (or six lanes) and existing coastal road and two run-off roads from existing coastal road will be necessary.

3)Connection with existing coast road by level crossing

Level crossing and run-off will be necessary. Grade separation work during operation will be necessary after the year 2005.

The cost of No. 3 treatment is the lowest among the three alternatives, following by No. 2. Treatment capacity of alternative No. 3 is examined.

This examination is based on the "Planning and Design of Level Crossing - Basic -" (The Association of Traffic Technology Research Institute).
Actual saturated flow rate can be calculated as follows;

$S_A = S_B \times \alpha_W \times \alpha_G \times \alpha_T \times \alpha_{RT} \times \alpha_{LT}$

where; S_A :Actual saturated flow rate
S_B :Basic saturated flow rate
α_W :Compensation rate for road width
α_G :Compensation rate for road gradient
α_T :Compensation rate for Large sized vehicles
α_{RT} :Compensation rate for right turn vehicles
α_{LT} :Compensation rate for left turn vehicles

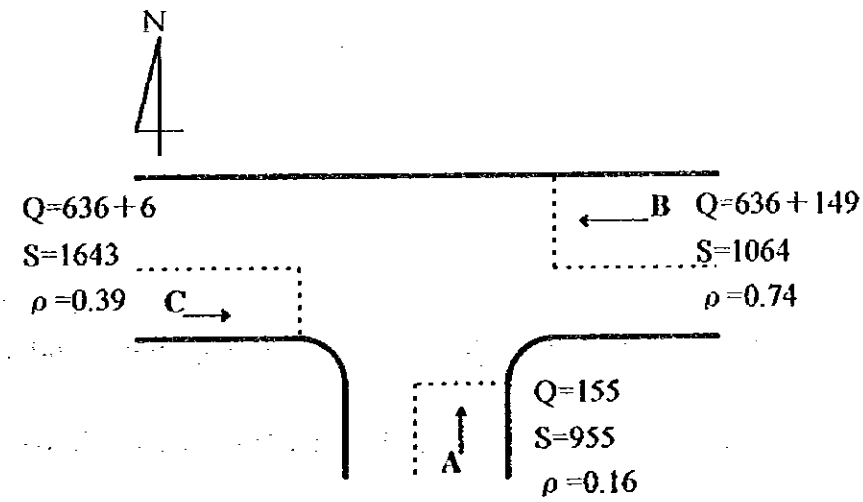


FIGURE 4.1.22 Calculation Conditions for Saturated Flow Rate

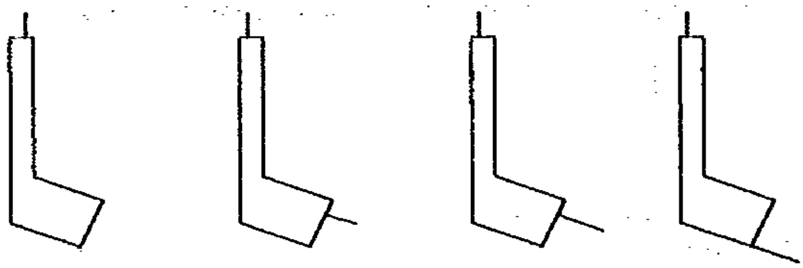
Regulated traffic flow at each entrance of intersection (ρ)(ratio of saturated traffic flow and designed traffic flow) are ρ_A=0.16, ρ_B=0.74, ρ_C=0.39 respectively. Saturation flow rate for same signal (Maximum saturation flow rate which can simultaneously flow at same direction signal) are 0.74 for E-W direction and 0.16 for N-S direction, therefore, saturation flow rate for the crossing(Amount of saturation flow rates) is 0.9 (0.74+0.16). Saturation flow rate for the crossing should be 0.8~0.9 (which is taken signal loss from 1.0) as a target in cross planning.

This case is the same as the maximum, 0.9. Moreover, traffic volume of this existing coastal road on weekends and in summer time is considerably increased. Especially in summer when traffic becomes seriously congested, therefore, this level crossing treatment is absolutely impossible.

In the short-term development plan, grade separation of access road with two lanes and existing coast road and two run-off roads from existing coast road was recommended as a crossing treatment.

(3) Breakwater

To determine the length of breakwater in the short-term development plan, harbor tranquillity simulation was conducted for below four general layout.



(a) *l = 0 m* (b) *l = 200 m* (c) *l = 400 m* (d) *l = 400 m*

FIGURE 4.1.23 Objective Layouts for Tranquillity Simulation

Calculation conditions for tranquillity simulation are as follows;

1)Mean water depth in harbor: −15m(constant depth)

2)Spreading parameter: Smax=25 (Swell which has short decay distance)

3)Wave height of incident waves at gap of outlying facilities: 1.0 m

4)Reflection coefficient of sides of port facilities

Breakwater(Slope of rubble stone)	Kr=0.4
Quay-wall (Vertical wall type)	Kr=0.9
Revetment(Vertical wall type)	Kr=0.9
Revetment(Slope of rubble stone)	Kr=0.4
Natural beach	Kr=0.1

5)Incident waves

TABLE 4.1.26 Incident Waves

Principal direction of incident waves	Significant wave period(sec)
ESE	4.5
SE	4.5
SSE	5.5
S	5.0
SSW	5.0
SW	4.5

6) Maximum number of reflection: 2

The diffraction diagrams of SSE, S, SSW and SW waves are shown in Figure 4.1.24~4.1.27. The results of tranquillity simulation are as follows;

TABLE 4.1 27 Result of Tranquillity Simulation

Layout	(a)	(b)	(c)	(d)
Calmness of the time	92.05%	95.42%	98.39%	92.28%

Layout (b) was adopted as the length of breakwater in the short-term development plan which can maintain the wave calmness in front of container berth more than 95% of the time and is economical.

(4) General Layout for the Short-term Development Plan

Requirements to be constructed by 2005 are two container berths, container yard, road including causeway to container yard and basin. The general layout of short term development plan is shown in Figure 4.1.28. The reclaimed area is approximately 45,000m^2.

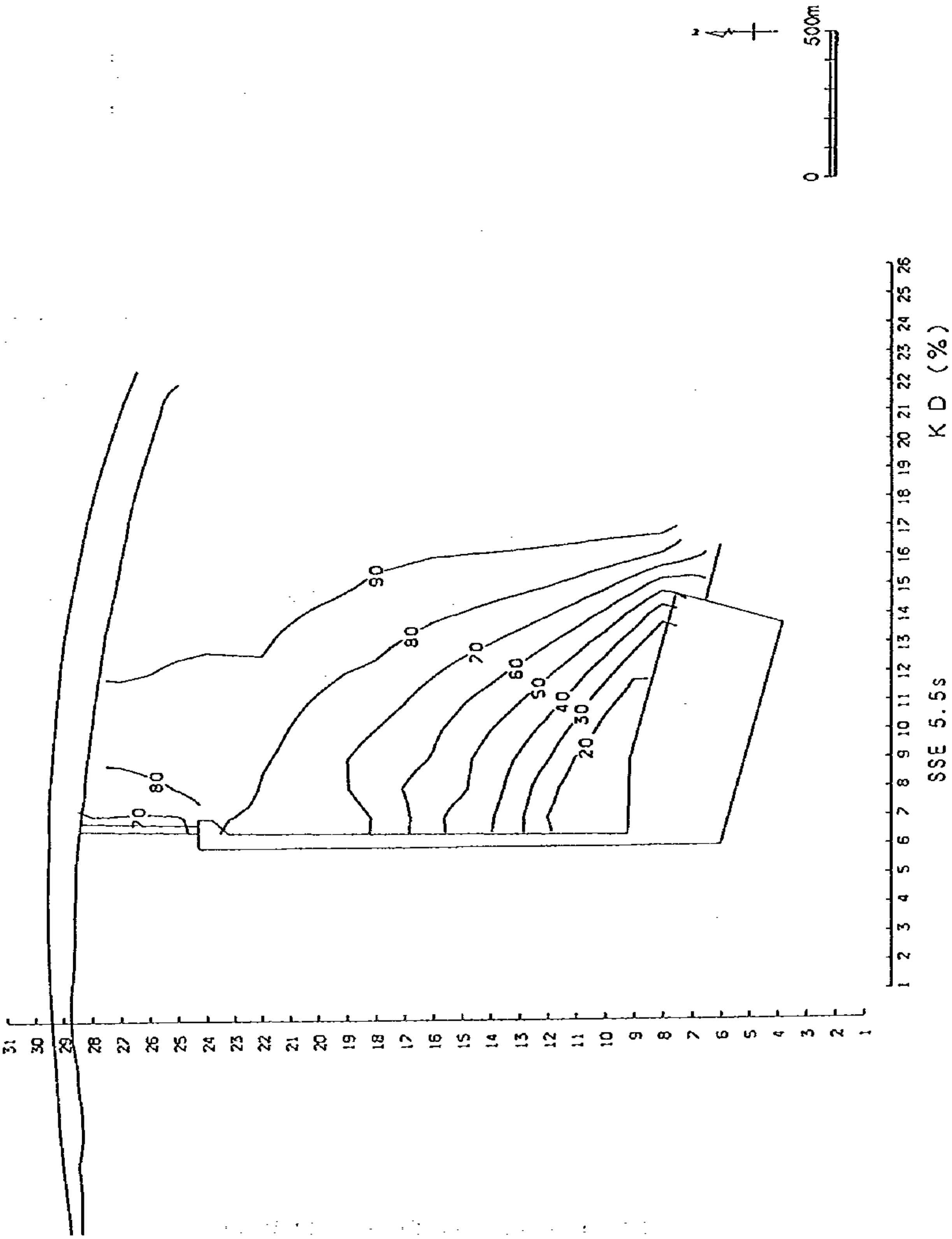


FIGURE 4.1.24 Diffraction Diagram of SSE Wave

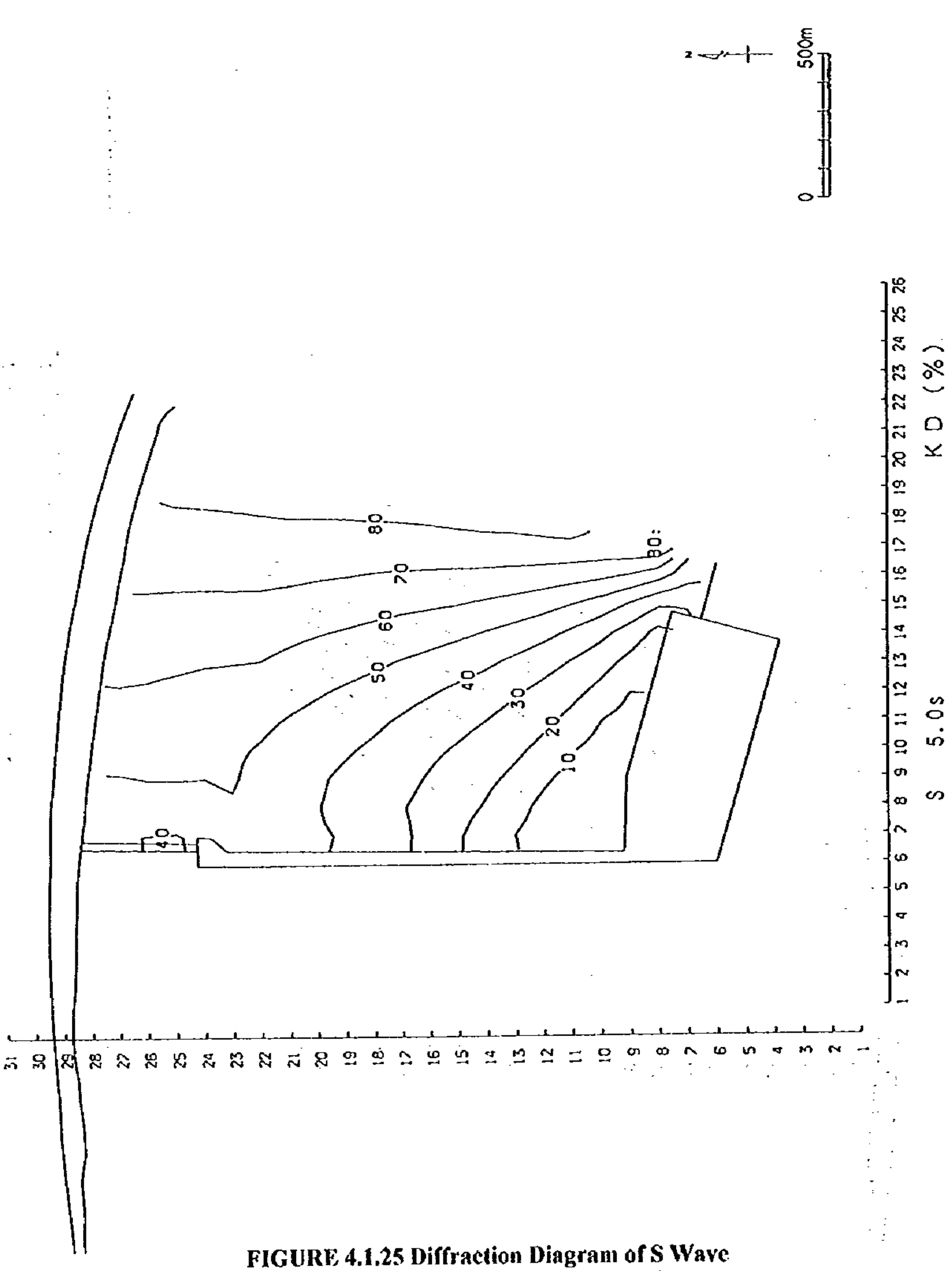


FIGURE 4.1.25 Diffraction Diagram of S Wave

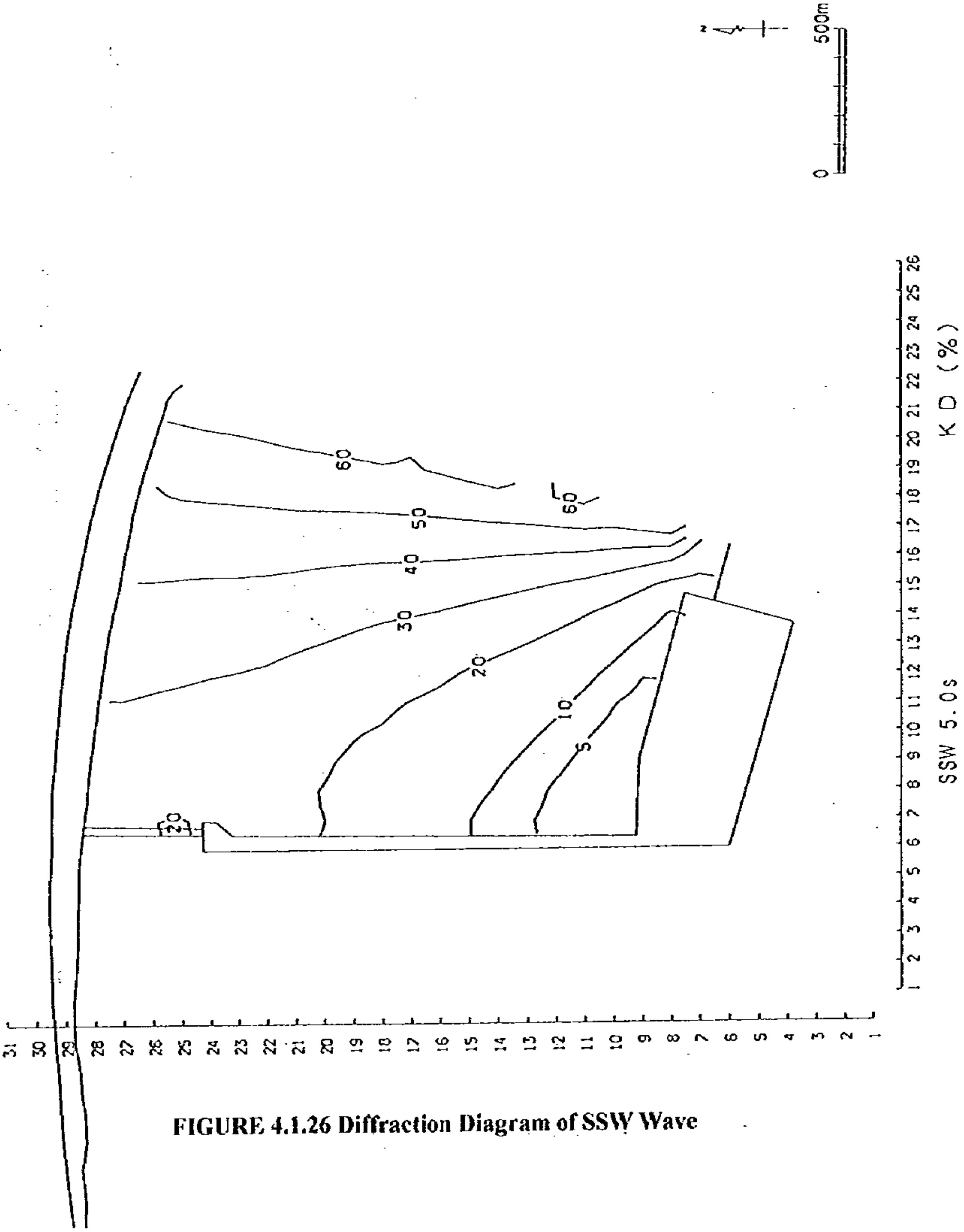


FIGURE 4.1.26 Diffraction Diagram of SSW Wave

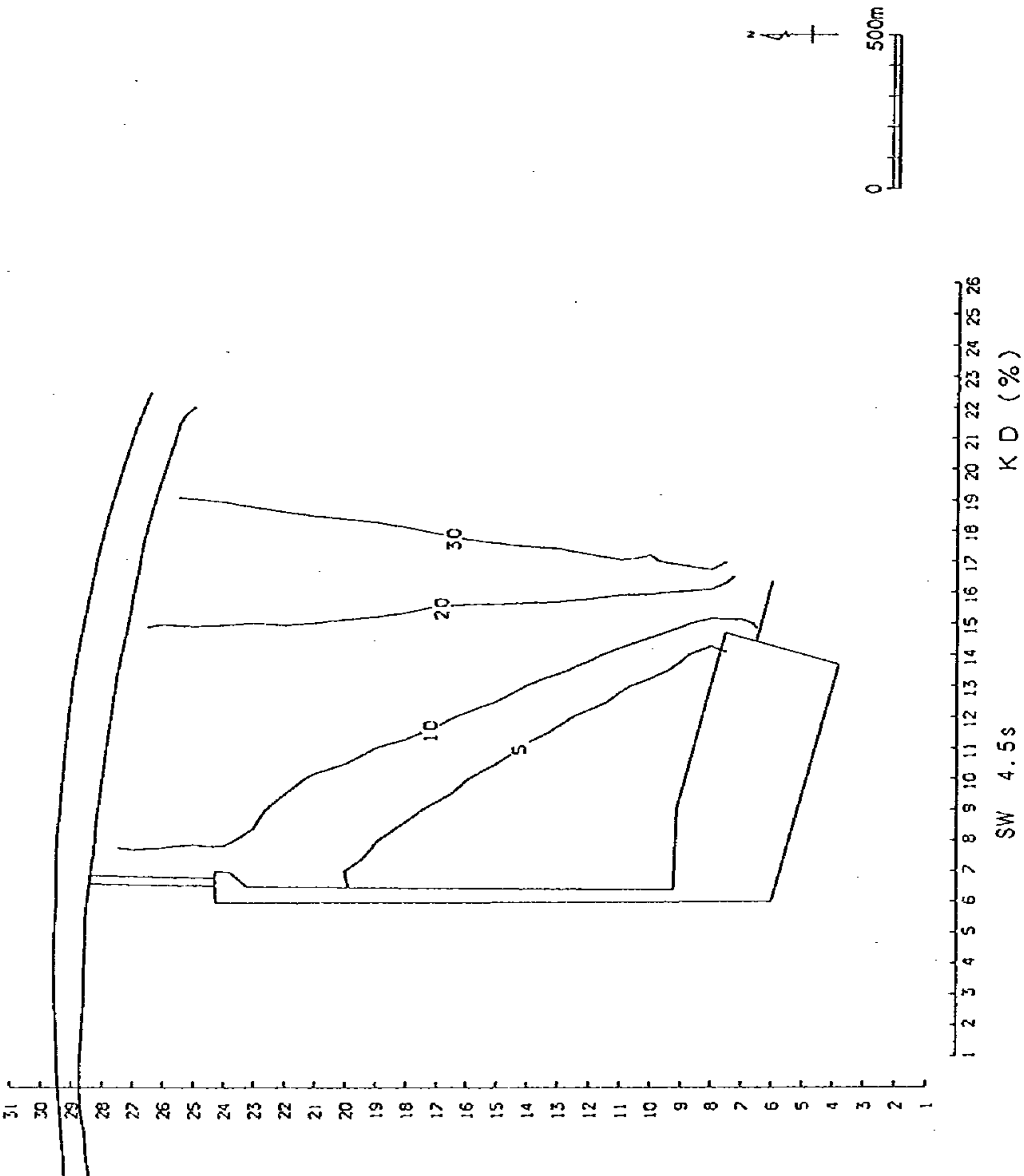
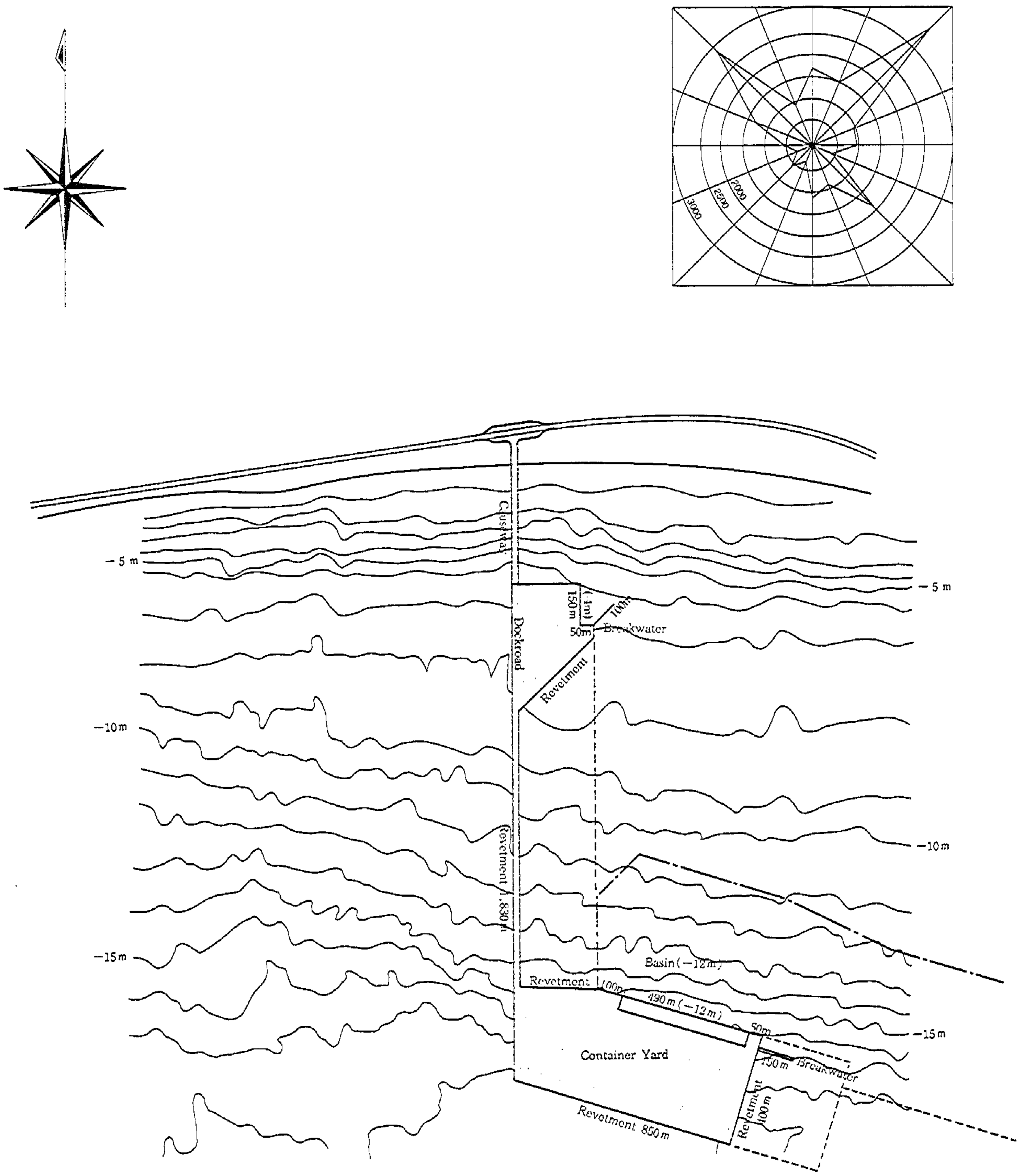


FIGURE 4.1.27 Diffraction Diagram of SW Wave



Scale: 1/15,000

FIGURE 4.1.28 General Layout of Short Term Development Plan for New Port

4.2. Cargo Handling System

4.2.1 Container Handling Facilities

(1) Required Scale of Storage Facilities

1) Container Yard

Container movements within the port are outlined in Figure 4.2.1. The container handling volume of the New port at year 2015 is estimated as follows.

TABLE 4.2.1 Container Handling Volume of the New Port

		Laden Containers				Reefer	Empty	Total
		Import	Export	Domestic	Transit			
Year 2005								
Container Volume	(TEU)	98,147	52,606	12,089	45,880	5,175	55,984	269,880
Year 2015								
Container Volume	(TEU)	235,433	141,797	36,272	108,554	12,570	103,927	638,554

The required storage number of container of each stage is calculated by the following formula.

Ml = (My x Dw) / Dy x P

where, Ml : Required storage number of containers (TEUs)

My : Annual container throughput (TEUs)

Dw : Average dwelling days (days)

Dy : Operating days (330 days)

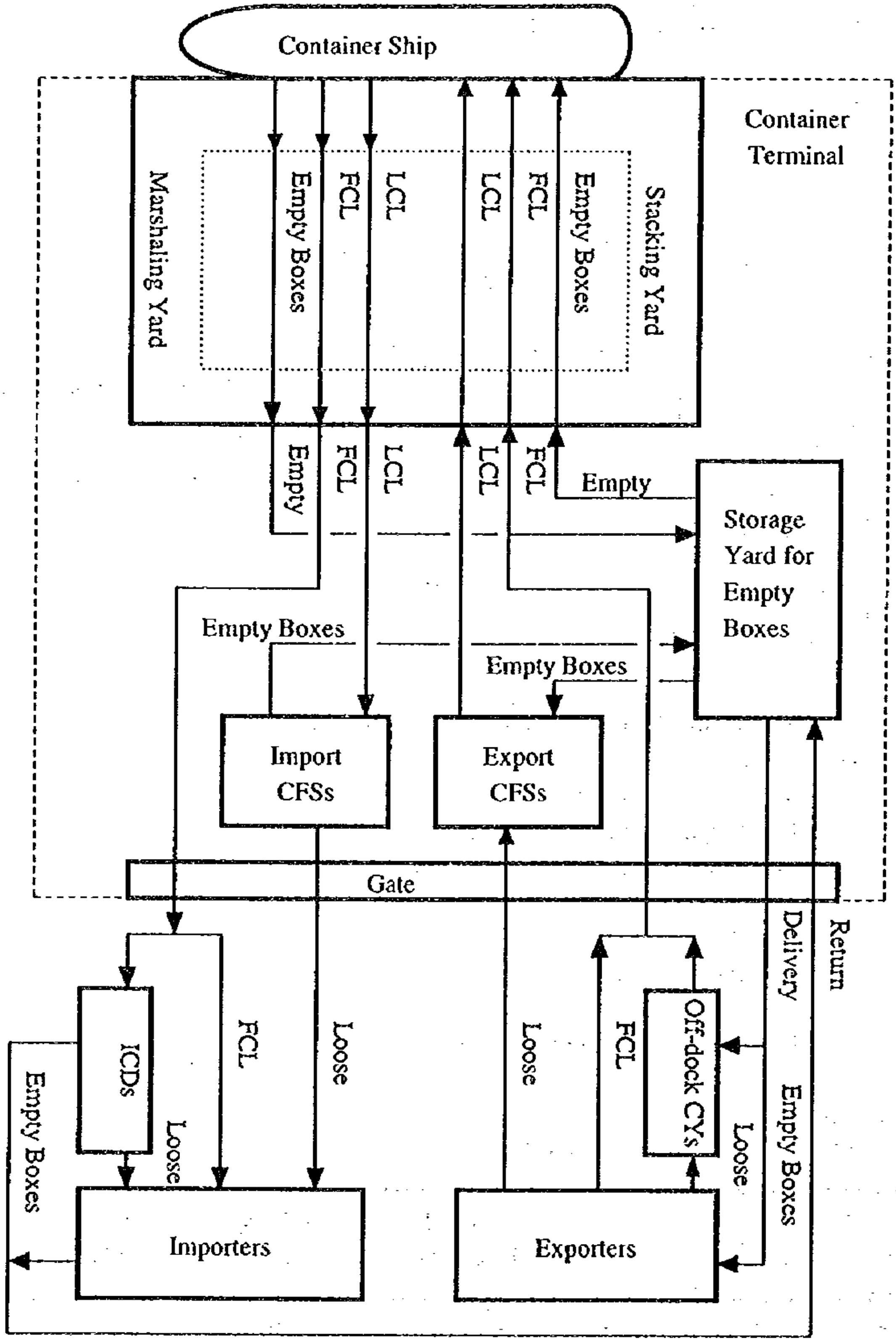
P : Peak ratio (1.3)

Premises for calculation are as follows.

- Dwelling time in container yard and container freight station

The present average dwelling time of import container is about 20 days. This is rather long compared with other ports. However, the current customs law and legislation, which is the main reason for such a long dwelling time, is being changed in accordance with the European Customs regulations. Therefore this figure is assumed to be reduced to about 10 days in the year 2015 as described in the Report. Dwelling time of export containers and domestic containers is assumed as 5 days, 3.5 days for transit containers, and 10 days for empty containers.

FIGURE 4.2.1 Container Cargo Flow Chart



IDCs : Inbound Container Depots

- Stacking height of containers

Import/export containers could be stacked at maximum four layers in the container yard if "1 over 4" type transfer cranes are used. However, operationally, it is desirable to stack 3 high on an average basis for import containers and 3.5 high for export and transit containers. The stacking height of reefer container shall be 2 and empty containers shall be 5.

- Required number of ground slots

Required number of ground slots is calculated by the following formula.

Sl = Ml / L

where, Sl : Required number of ground slots (TEU)

Ml : Required storage number of containers (TEUs)

L : Stacking height of containers (box)

The results of the calculation are shown in Table 4.2.2.

TABLE 4.2.2 Required Storage Capacity in Container Yard

		Laden Containers					Empty	Total
		Import	Export	Domestic	Transit	Reefer		
Year 2005								
Annual Container	TEU	98,147	52,606	12,089	45,880	5,175	55,984	269,880
Dwell days	days	10	5	5	3.5	5	10	
Req. Storage	TEU	3,866	1,036	238	633	102	2,205	8,081
Ave. Stacking height	box	3.0	3.5	3.5	3.5	2.0	5.0	
Req. Ground Slot	TEU	1,289	296	68	181	51	441	2,326
Year 2015								
Annual Container	TEU	235,433	141,797	36,272	108,554	12,570	103,927	638,554
Dwell days	days	10	5	5	3.5	5	10	
Req. Storage	TEU	9,275	2,793	714	1,497	248	4,094	18,620
Ave. Stacking height	box	3.0	3.5	3.5	3.5	2.0	5.0	
Req. Ground Slot	TEU	3,092	798	204	428	124	819	5,464

2) Container Freight Station

The required area for the CFS is calculated by the following formula.

A = (Mc x Dw x P) / (w x r x Dy)

where, A : Required floor area of CFS (m^2)

Mc : Annual handling volume of container cargo through CFS (ton)

Dw : Dwelling time at CFS (3 days)

P : Peak ratio (1.3)
w : Volume of cargo per unit area (1.3 ton / m²)
r : Utilization rate of CFS floor (0.5)
Dy : Operating days of CFS (330 days)

Using the premises mentioned above and assuming CFS service ratio is 10 %, the required area of the CFS is calculated as follows.

For year 2005,
Mc = 162,842TEU x 12.5 ton/TEU x 0.1 = 203,553 (ton)
A = (203,553 x 3 x 1.3) / (1.3 x 0.5 x 330)
= 3,700 m²

For year 2015,
Mc = 413,502TEU x 12.5 ton/TEU x 0.1 = 516,878 (ton)
A = (516,878 x 3 x 1.3) / (1.3 x 0.5 x 330)
= 9,398 m²

The required capacity of CFS is 4,000 m² in the year 2005, and 10,000 m² in the year 2015.

3) Other facilities

a) Gate

The required number of truck lanes is calculated by the following formula.

N = Mc x p / (Dy x H) x (S/ 60)

where,
N : Required number of truck lanes
Mc : Annual handling volume of containers (box)
p : Peak ratio (1.3)
Dy : Annual operating days (330 days)
H : Operating hours per day (18 hrs)
S : Necessary procedure time per truck (3 minutes)

The required number of truck lanes is 3 lanes for the year 2005, 6 lanes for the year 2015. As necessary equipment, two truck scales should be equipped at the gate in the year 2005 and three truck scales in the year 2015.

b) Terminal Office

The required area for the terminal office will depend on the method of operation and other factors. An area of 3,000 m² will be planned in the target year of 2005 for the terminal office.

c) Others

① Repair of Damaged Containers

The container terminal will need space to repair damaged containers in the target year of 2015. A container repair yard of around 1,200 m² is planned in the target year 2005, and around 2,400m² in the year 2015.

② Washing and Cleaning Containers

For washing and cleaning of empty containers at the container terminal, an area of 600 m² is planned.

③ Custom Inspection

For the purpose of custom inspection for the loaded import containers, an area of 600 m² is planned.

Figure 4.2.2 and figure 4.2.3 show the layout image of container yard in the target year 2015 and 2005.

4) Traffic in the Container Terminal

Traffic lines in the container terminal shall be decided considering the effective container handling work. Traffic lines of the terminal trailer and outside trailer shall be considered based on the following points.

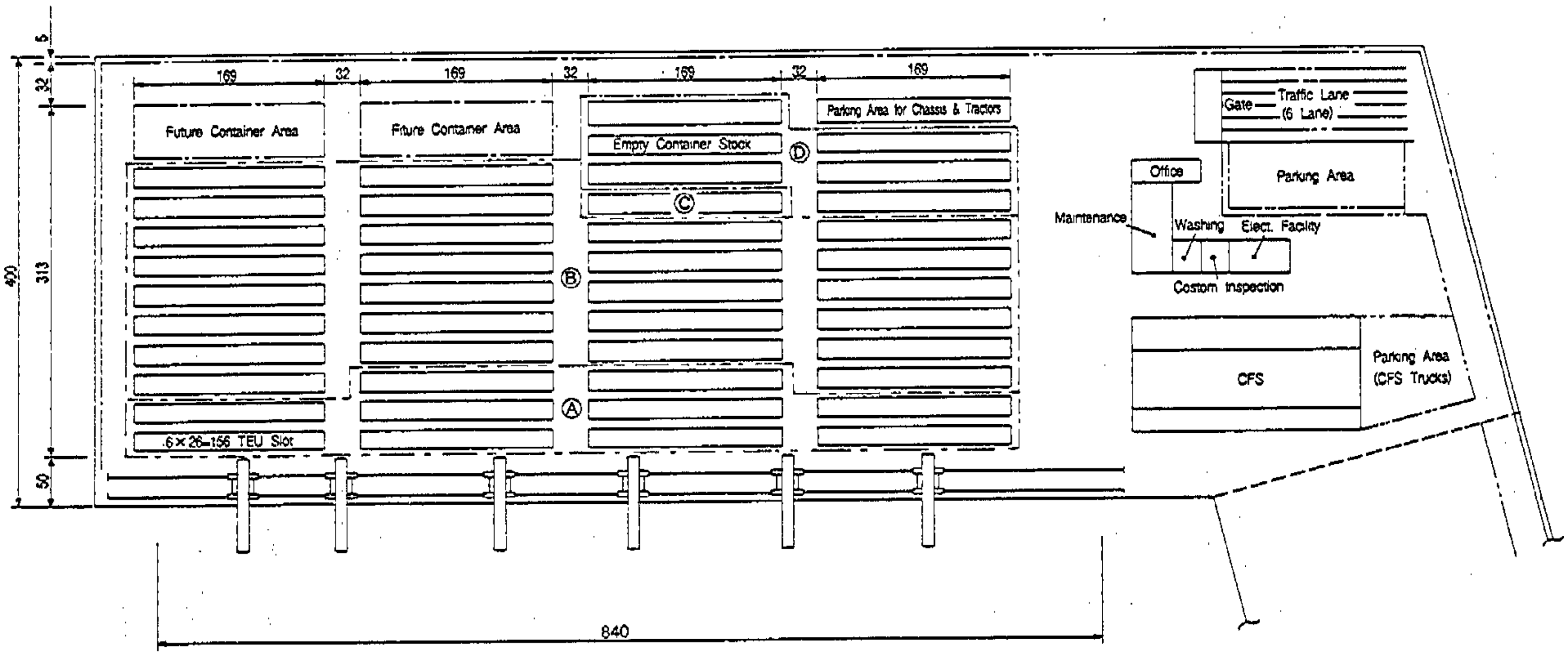
(a) Traffic of terminal trailer at apron for ship side container handling shall be one way from shop's aft side to forward side. Door-side of the container shall be kept towards ship aft side.

(b) Traffic of outside trailer coming to the container terminal for transportation of containers shall also be one way traffic at container stacking area.

(c) In order to prevent cross traffic of inbound and out bound outside trailer around gate and gate side stacking area as much as possible, one traffic lane is provided at back side apron for outbound trailer traffic.

Proposed traffic plan of the container terminal is shown in Figure 4.2.4.

FIGURE 4.2.2 Layout of Container Terminal in the Target Year 2015



Ⓐ : Export and Transshipment
Ⓑ : Import (and Domestic)
Ⓒ : Reefer
Ⓓ : Empty

FIGURE 4.2.3 Layout of Container Terminal in the Target Year 2005

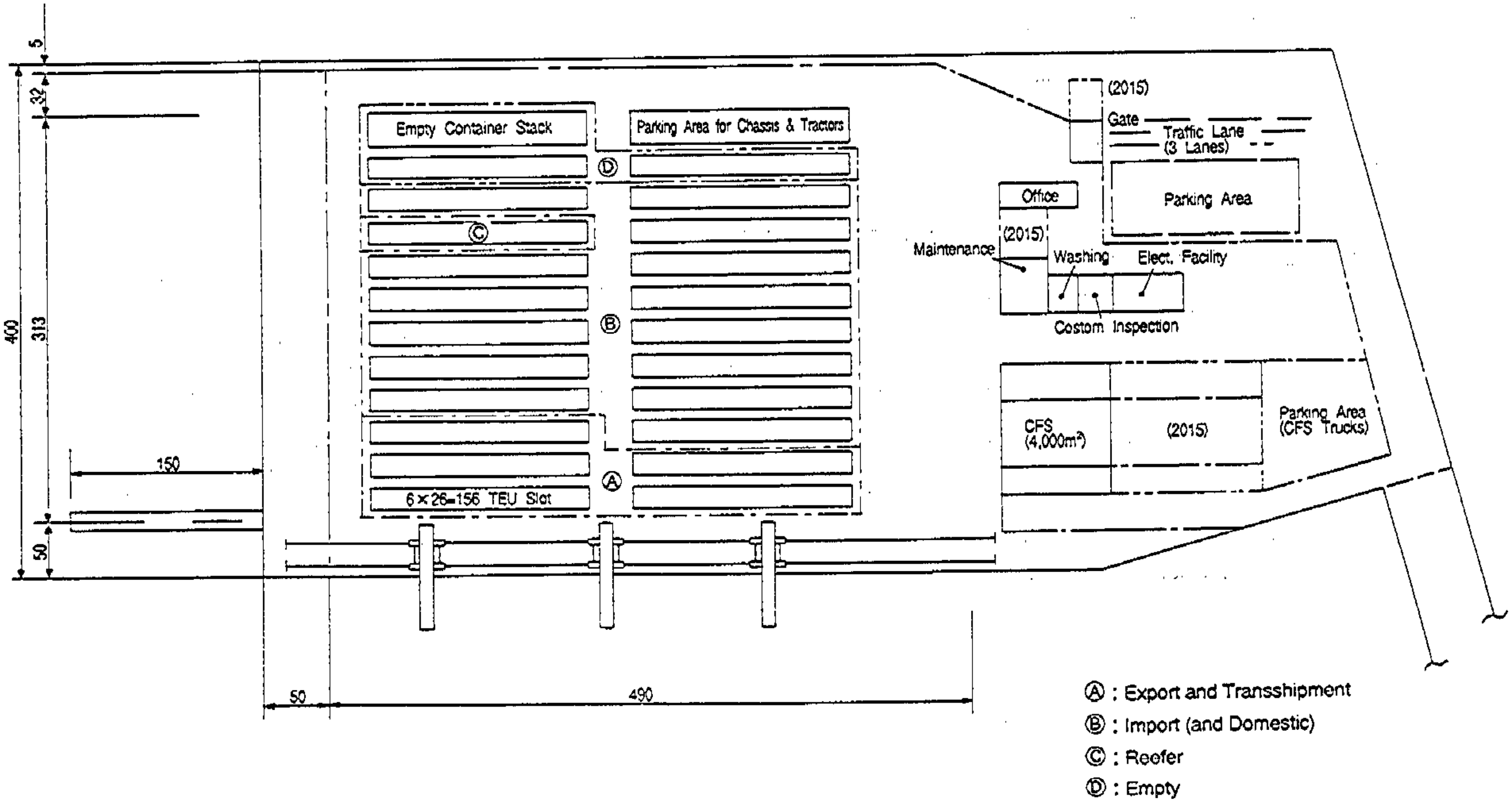
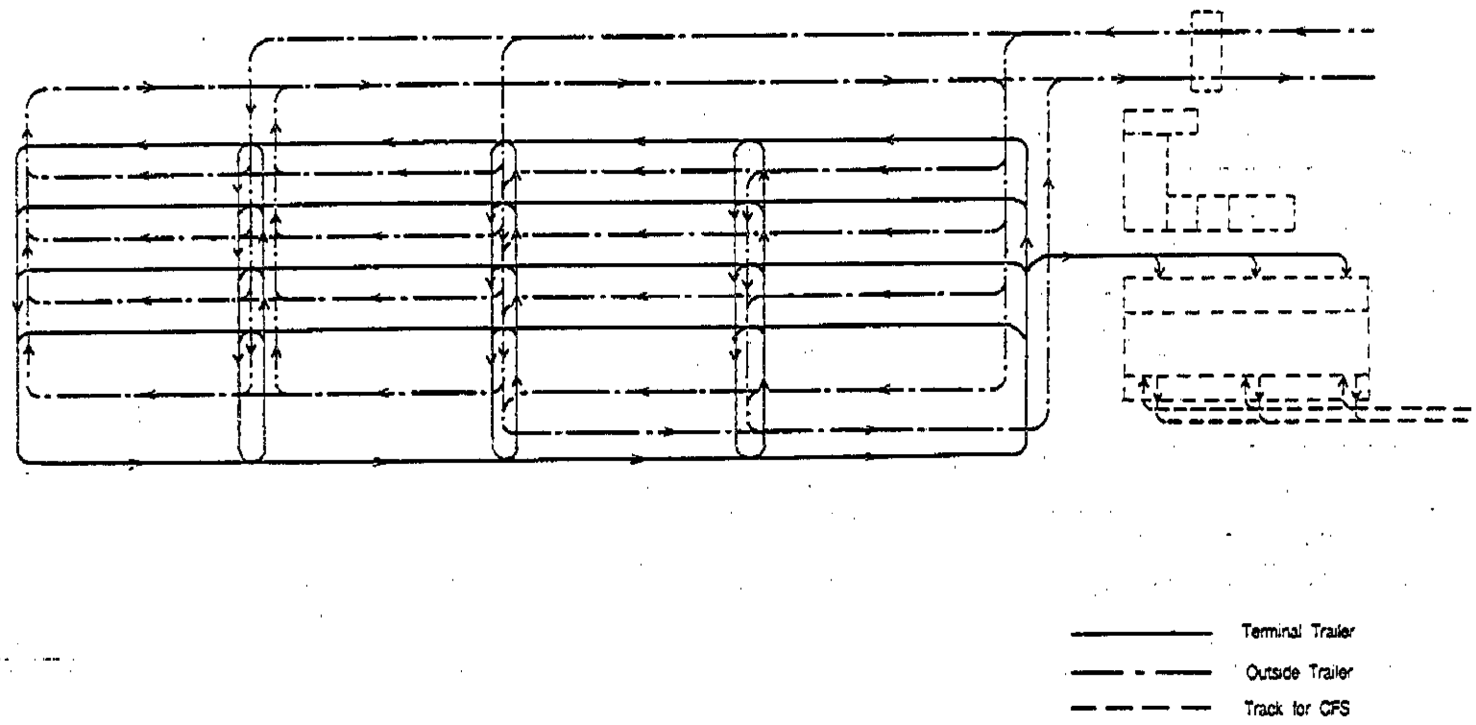


FIGURE 4.2.4 Traffic Flow of the New Container Terminal



5) Dimension of Berth Apron

Width of berth apron is calculated using the following formula.

$$L = A + Sp + B$$

where, L : Width of Berth Apron

A : Distance from Face Line of the Pier to the Seaside Rail (2.5 m)

Sp : Gantry Crane Rail Span

B : Width of Backside Traffic Area

Gantry Crane Rail Span is decided by the following formula.

$$Sp = T1 \times n$$

where, T1 : Necessary Width of Traffic Lane (5m)

n : Number of Lane (5 = Simultaneous operated crane number(3) + Spare lane (2))

Therefore, Sp = 25 m

Width of backside traffic lane is decided considering the width of hatch cover and one traffic lane using the following formula.

$$B = Hc + T2$$

where, Hc : Width of hatch cover of the container vessel (13.5 m)

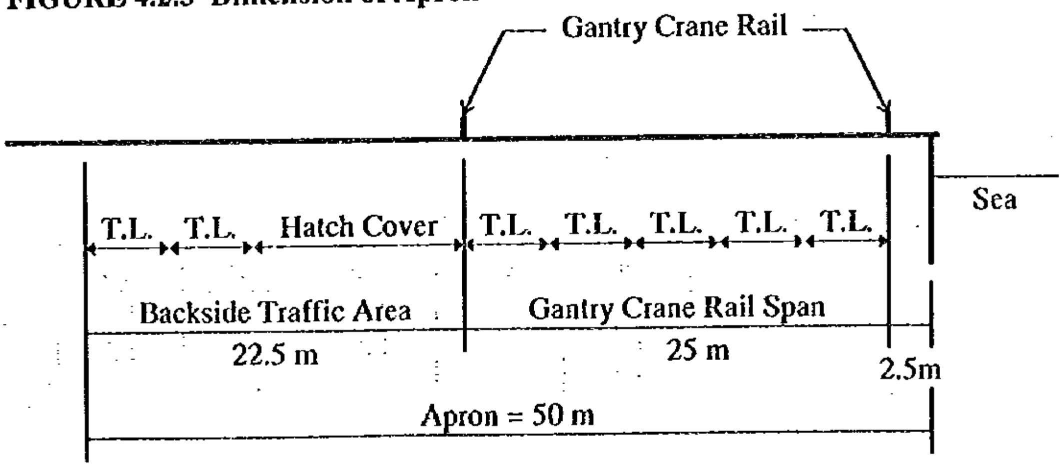
T2 : Width of Traffic Lane (4.5 m x 2 = 9 m)

Therefore, B = 22.5 m

Width of apron shall be as follows.

L = 2.5 + 25 + 22.5 = 50 m.

FIGURE 4.2.5 Dimension of Apron



T.L. : Traffic Lane

(2) Evaluation of Container Handling Facilities

In order to reveal container movements and evaluate the proposed facilities in the New port, a computer simulation was conducted. The container handling capacity per year is determined according to the demand in 2015. The conditions for the simulation and results are as follows.

- Arrival times of container ship : estimated as average distributed arrival of ships in a week. Container throughput is estimated as 638,000 TEU per year. Details are shown in Table 4.2.4.
- The number of containers discharged/loaded per ship : Five ship types are considered, namely main vessel and four types of feeder vessels. Details are shown in Table 4.2.3.
- Net container handling productivity at dock side : 25 boxes per hour for gantry crane.
- Percentage of 20 ft. boxes : 50 %
- Percentage of empty export containers : 50 %
- Percentage of empty import containers : 5%
- Percentage of import CFS cargo : 10 % of laden containers
- Annual working days : 330 days
- Daily working hours : 18 hours by three shifts
- Dwelling time of FCL container in the terminal : average 8, 10, 12 days (3 cases)
- Dwelling time of FCL container in the CFS : average 3days

TABLE 4.2.3 Type of Arrival Ships

	Ship Size	Number of Containers Handled		Number of Arrival (Ship/Week)	Remarks
		Import (TEU)	Export (TEU)		
Main Vessel	3000 TEU	1500	1500	2	M
Feeder Vessel 1	300 TEU	150	150	9	F1
Feeder Vessel 2	500 TEU	250	250	4	F2
Feeder Vessel 3	700 TEU	350	350	3	F3
Feeder Vessel 3	900 TEU	450	450	1	F4

TABLE 4.2.4 Assumed Schedule of Container Ship Arrival

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Arrival Ship	M	F1	F1	F1	M	F1	F1
	F1	F2	F3	F2	F1	F2	F3
	F1	F4			F3		

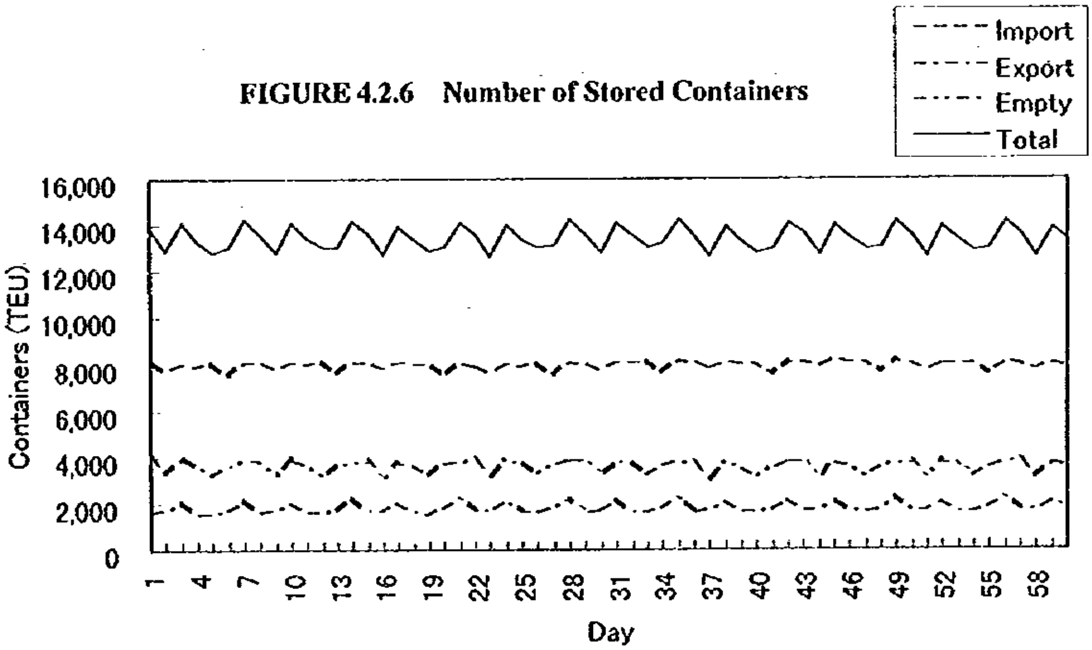
1) Container Storage Capacity

In the simulation, the number of containers passing through the New port per annum is a given condition, and the scheduling of the container ship arrival is considered as distributed equally in a week. All ships are considered as weekly service. Transit containers are counted as import containers just for the sake of convenience. According to the result of the simulation, the number of containers dwelling in the marshaling yard and empty box storage place is about 14,500 TEUs during peak conditions as shown in Figure 4.2.6. Variation of the number of containers due to the dwelling time is shown in Table 4.2.5.

TABLE 4.2.5 Dwelling Time and Number of Containers in the Terminal

Dwelling Time (days)	Number of containers (TEU)
8	13,000
10	14,500
12	16,200

FIGURE 4.2.6 Number of Stored Containers

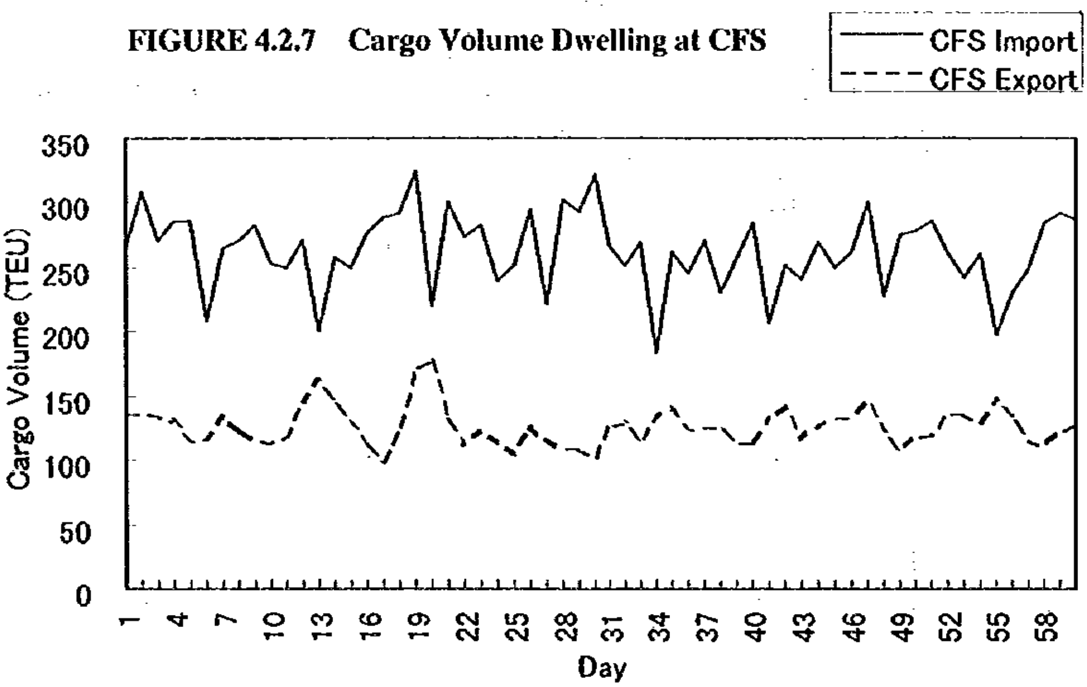


Thus the minimum required storage capacity of the container yard is 14,500 TEUs. Comparing the above minimum required storage capacity with the planned stacking capacity of 18,534 TEUs of the container terminal mentioned in the section 4.2.1.1, the container handling capacity is sufficient to handle the demand in the year 2015.

2) Container Freight Station (CFS)

According to the result of simulation, the volume of container cargo dwelling at import and export CFS is estimated as 325 TEUs and 177 TEUs respectively during peak conditions. Variation of cargo volume in the CFS is shown in Figure 4.2.7. Thus, the planned area of CFS (10,000m^2) is sufficient for the demand in the year 2015.

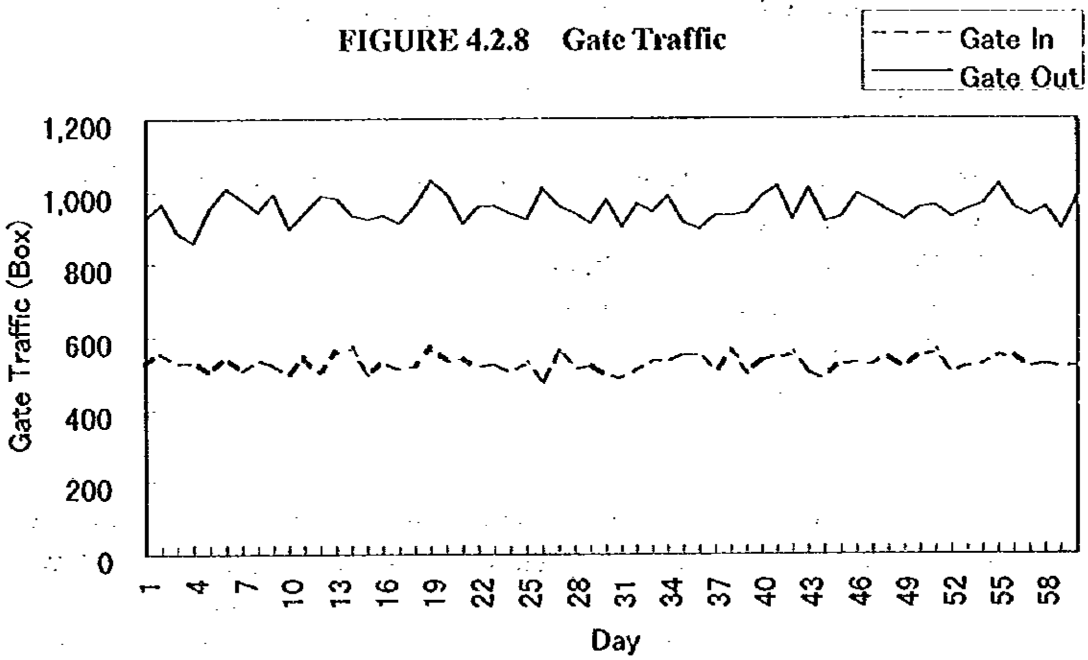
FIGURE 4.2.7 Cargo Volume Dwelling at CFS



3) Required Number of Lanes of the Terminal Gate

According to the result of simulation, daily traffic volume through the terminal gate is as shown in Figure 4.2.8. Maximum traffic of containers is 1,029 units for gate out traffic and 567 units for gate in traffic.

FIGURE 4.2.8 Gate Traffic



4.2.2 Bulk Cargo Handling Facilities

(1) Grain Terminal

The grain cargo handling volume of the New port in the year 2015 is estimated as follows.

Export Grain Cargo:	636,000 ton per year
Import Grain Cargo :	305,000 ton per year

1) Storage Facilities

Required storage capacity of silo is calculated using the following formula.

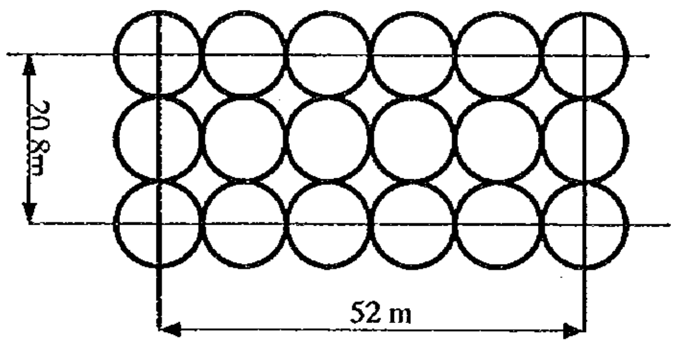
$V = (N \times C) / (R \times a)$

where,
V : Required storage capacity (ton)
N : Annual handling volume of cargo
C : Peak ratio (1.3)
R : Turnover ratio
a : Utilization ratio (0.7)

Turnover ratio of the silo is determined as 40, which is a normal level of productivity at a general grain terminal. Objective main vessel size is 30,000DWT and loading volume is 24,000 tons. Accordingly, capacity of the silo shall be more than 24,000 tons. Considering utilization ratio of 0.7, minimum required capacity will be 34,300 tons.

Based on these premises, required storage capacity is calculated as 45,000 tons.(2,500 ton x 18 bins)

FIGURE 4.2.9 Layout of Silo



2) Loading and Unloading Facilities

Capacities and number of loading/unloading facilities are determined using the following formula.

$$Qm = N / (Dy \times O \times H \times me \times n)$$

where, Qm : Minimum capacity of loader/unloader

N : Annual handling volume of cargo

Dy : Annual operating days (330 days)

O : Berth occupancy ratio (0.5)

H : Operating hours per day (18 hrs)

me : mechanical efficiency (0.6)

n : Number of units

As for the number of units, operable number of hatches and provision for mechanical breakdown shall be considered, then two units of loaders/unloaders will be a practical choice. Also, operating days for one vessel shall be less than 4 days considering the ship operation schedule. In this condition, minimum capacity of loader/unloader shall be 6,000 ton/day.

Based on these premises, required minimum capacity of loader/unloader is calculated as follows.

Loader	300 ton / hour, 2 sets
Unloader	300 ton / hour, 2 sets

3) Other equipment for the Grain Terminal

Equipment and facilities required other than silo and loader/unloader are as follows.

a) Belt conveyors of 300 ton / hour capacity, two lines
b) Conveyors and elevators in the machinery tower
c) Removable devices of foreign materials
d) Weighing devices
e) Fumigation facilities
f) Sampling devices
g) Dust controller
h) Machinery tower
i) Battery operated bulldozers

4.2.3 Cargo Handling Equipment

(1) General Cargo Handling Equipment

According to the proposed future cargo handling system above, it is necessary to ensure the cargo handling productivity. Therefore, the introduction of cargo handling equipment shall be carried out based on the economic viewpoint to increase the loading/unloading efficiency, thereby enhancing the overall functions of the port.

1) Forklift

The required number of forklifts for general cargo is calculated by the following formula.

$$N = Mc \times 2 \times 1.3 / (Dy \times h \times p)$$

where, N : Required number of forklift
Mc : Annual handling volume of general cargo.
Dy : Annual operating days of general cargo
h : Operating hours per day (18 hours)
p : Handling productivity (tons/hour)

The required number of forklift is 13 units of 5 ton type for normal duty cargo and 13 units of 10 ton type for heavy duty cargo.

2) Mobile Crane

Cargo handling of general cargo and bulk cargo is planned to be carried out by the rail mounted shore crane. Capacity of the shore crane shall be 10 tons and two sets for each berth shall be provided.

Required general cargo handling equipment is proposed as shown in Table 4.2.6.

TABLE 4.2.6 Required General Cargo Handling Equipment

Equipment	Capacity	Unit	Quantity
Forklift	10 ton	No.	13
	5 ton		13
Shore Crane General Cargo	10 ton		4
Shore Crane Bulk Cargo	10 ton		8
Pneumatic Unloader for Cement handling	200 ton /hr		1
Belt Conveyor for Cement handling	200 ton/hr		1

(2) Container Handling Equipment

1) Gantry Crane

The required number of gantry crane is calculated by the following formula.

$Nc = My / Ec \times e \times O \times H \times Dy \times (1 + r)$

where,
- Nc : Number of crane
- My : Annual container throughput (TEUs)
- Ec : Handling productivity of crane per hour (25 boxes)
- e : Efficiency of container crane operation (0.8)
- O : Berth occupancy ratio (0.6)
- H : Working hours per day (18 hours)
- Dy : Working days per year (330 days)
- r : Ratio of 40 footer container (0.5)

The result of calculation of required number of crane is as follows.

for year 2005

$Nc = 269{,}880 / 25 \times 0.8 \times 0.6 \times 18 \times 330 \times (1 + 0.5) = 3$ cranes

for year 2015

$Nc = 638{,}554 / 25 \times 0.8 \times 0.6 \times 18 \times 330 \times (1 + 0.5) = 6$ cranes

2) Transfer Crane

The required number of transfer cranes and top loaders is calculated from the total handling volume of containers such as,

- Handling volume at berth
- Handling volume at yard, which is calculated by the following formula.

  $Hv = Mc / (1+r) / (Dy \times h) \times P$

  where,
  - Hv : Handling volume at yard (box/hour)
  - Mc : Annual handling volume of containers (TEU)
  - r : Ratio of 40 footer container (0.5)
  - Dy : Annual operating days (330 days)
  - H : Working hours per day (18 hours)
  - P : Peak ratio (1.3)
- Average handling capacity of transfer crane is assumed 12 box per hour

The results of the calculation are shown in Table 4.2.7.

TABLE 4.2.7 Required Number of Transfer Crane

		unit	Quantity
Year 2005			
Handling Volume at Berth	Gantry Crane	Box / Hr	75
Handling Volume at Yard	Transfer Crane	Box / Hr	34
Total Handling Volume	Transfer Crane	Box / Hr	109
Required Number	Transfer Crane	Units	10
Year 2015			
Handling Volume at Berth	Gantry Crane	Box / Hr	150
Handling Volume at Yard	Transfer Crane	Box / Hr	80
Total Handling Volume	Transfer Crane	Box / Hr	230
Required Number	Transfer Crane	Units	20

Yard container handling system worth investigating for the new Terminal of the Sea of Marmara can be classed into the following two types considering the existing world advanced systems.

The first is the rubber-tired gantry crane system (RTG). This system has the greatest usage and most container terminals in the world adopted this system. All container terminal in Turkey operated by TCDD has adopted this handling system. RTG system is proven container handling system from the technical view point and the safest operation system. Also, RTG can change the working lane easily, and move to the most busy stacking area. This nrovavility gives more flexibility to the container handling operation.

The second is the rail-mounted gantry crane system (RMG). In Southeast Asia and Japan, three new RMG container terminals are planned and/or constructed recently, namely Singapore Pasir Panjang Terminal (8 tiers), Hong Kong International Terminal (6 tiers) and the New Terminal of Kawasaki Port of Japan (4 tiers). The storage capacity per unit area of the RMG terminals is expected to be 1.3 to 1.9 times higher than the RTG system, if higher stacking system is adopted. Also, these three RMG terminals are planned to incorporate automatic stacking and extracting operations, there by liberating crane operators from the complex container manipulation, such as shuffling and shifting, which is inevitable for high-tier stacking storage.

Comparing these two system, there remains a question whether a high-tiering system based on RMG can be applied to the New port. Because the New Port handles less transshipment containers and majority of the cargo is import containers, which require quick extracting operation for its consignee. The application of RMG system with higher stacking tier increase shuffling and shifting manipulation and complicate container handling. This is the biggest problem to be solved for the RMG system. In this point, the effectiveness of the RMG system has not yet been verified. Also, it has not yet been proved whether automatic operation system can actually attain intended high accuracy, speed and reliability of container handling operation. An operation system which matches the high container stacking is also still under development.

In this reason, we propose to adopt RTG system for the New port as the most suitable system from the technical and economical view point.

3) Top Loader

Required number of top loaders for the container yard is calculated by the same formula mentioned above for transfer crane. Annual handling volume of container is estimated as about 38,000 TEU and 90,000 TEU for year 2005 and 2015 respectively. Required number of top loader is 1 unit for the year 2005, 2 units for the year 2015.

4) Chassis

Required number of chassis for shipping is calculated by the following formula.

$N = Tc \times n / Tm / Ef$

where, N : Required number of chassis
Tm : Minimum cycle time of the crane
n : Number of crane
Ef : Operation Efficiency (0.7)
Tc : Cycle time, which is calculated by the following formula.

$Tc = Tl + Tu + 3600 \times S / V$

where, Tl : Average loading time (Sec.)
Tu : Average unloading time (Sec.)
S : Around trip distance (Km)
V : Running speed (Km/hour)

Required number of chassis for CFS is calculated by the following formula.

$N = Mc / (Dy \times h \times 60 \times 0.75 / t) \times P$

where, N : Required number of chassis
Mc : Annual handling volume of containers through CFS (TEU)
Dy : Annual operating days of CFS (330 days)
h : Operating hours per day
t : Cycle time (90 minutes)
P : Peak ratio (1.3)

The results of the calculation are shown in Table 4.2.8.

TABLE 4.2.8 Required Number of Chassis

	Ti	Tu	S	V	Tc	Tm	n	N (unit)
Year 2005								
Berth CFS Sub-total Total (include 15% spare)	120	120	1	15	480	144	3	15 6 21 25
Year 2005								
Berth CFS Sub-total Total (include 15% spare)	120	120	1	15	480	144	6	30 14 44 51

5) Tractors

Required number of tractors is the same as the number of chassis (excluding spare chassis), thus 21 units are required for year 2005 and 44 units for year 2015.

6) Forklift for CFS

Required number of forklifts for CFS is calculated by the following formula.

N = (Mc x 2 x 1.3) / (Dy x h x p)

where, N : Required number of forklift

Mc : Annual handling volume of containers through CFS (ton)

Dy : Annual operating days (330 days)

h : Working hours per day (18 hours)

p : Handling productivity (10 ton/hour)

Required number of forklifts for CFS is calculated as 11 units for year 2005, and 24 units for 2015.

7) Specification of gantry crane and transfer crane

Main specifications of gantry crane and transfer crane are as follows.

a) Gantry Crane

- Hoisting capacity	40.0 ton (Under spreader)
- Outreach	35.1m

- Span	25 m
- Backreach	11 m
- Total lifting height	38.0 m
- Lifting height above rail	25.0 m
- Lifting height below rail	13.0 m
- Power source	Supplied from outside
- Approximate working speed	
Main hoist with full load	50 m/min
Main hoist with no load	120 m/min
Trolley travel	150 m/min
Gantry travel	45 m/min
Boom hoist	4 min/half cycle

Outline of gantry crane is shown in Figure 4.2.10.

b) Transfer Crane

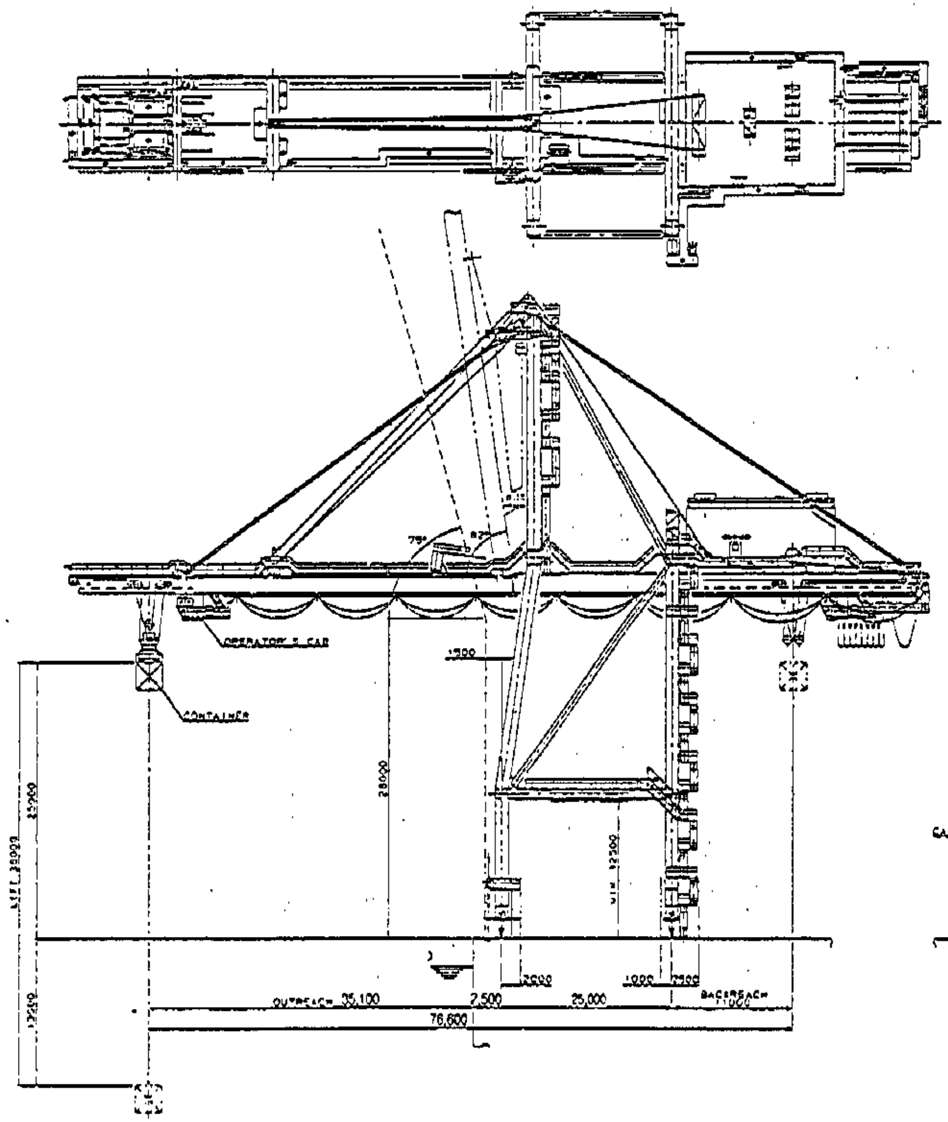
- Type	Eight (8) Rubber Tired Diesel Electric Powered Gantry Type Traveling Crane, 2 wheel drive
- Hoisting capacity	40.0 ton (Under spreader)
- Span	23.47 m
- Lifting height under spreader	15.24 m (9'6" containers 1 over 4)
- Approximate working speed	
Hoist with full load	20 m/min
Hoist with no load	45 m/min
Trolley travel	70 m/min
Gantry travel	135 m/min

Outline of transfer crane is shown in Figure 4.2.11.

8) Required number of container handling equipment

Required number of container handling equipment is shown in Table 4.2.9.

FIGURE 4.2.10 Outline of Gantry Crane



PARTICULARS				
HOISTING LOAD		52.5 ton (CONTAINER)		
RATED LOAD		40.0 ton (UNDER SPREADER)		
CONTAINER		ISO 20' & 40'		
DEVICE	SPEED(m/min)	MOTOR		CONTROL
		kW	Q'ty	
HOIST(FULL/SMP)	50/120	410	1	THYRISTOR LEONARD
TROLLEY TRAVEL	150	90	1	THYRISTOR LEONARD
GANTRY TRAVEL	45	15	8	THYRISTOR LEONARD
BOOM HOIST	4 min/Raise or Lower	110	1	THYRISTOR LEONARD
POWER SOURCE		AC 5.8 kV 50Hz 3φ		

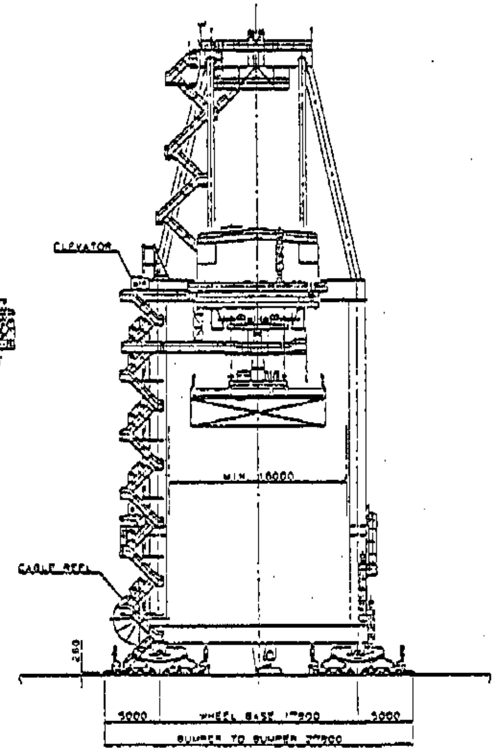
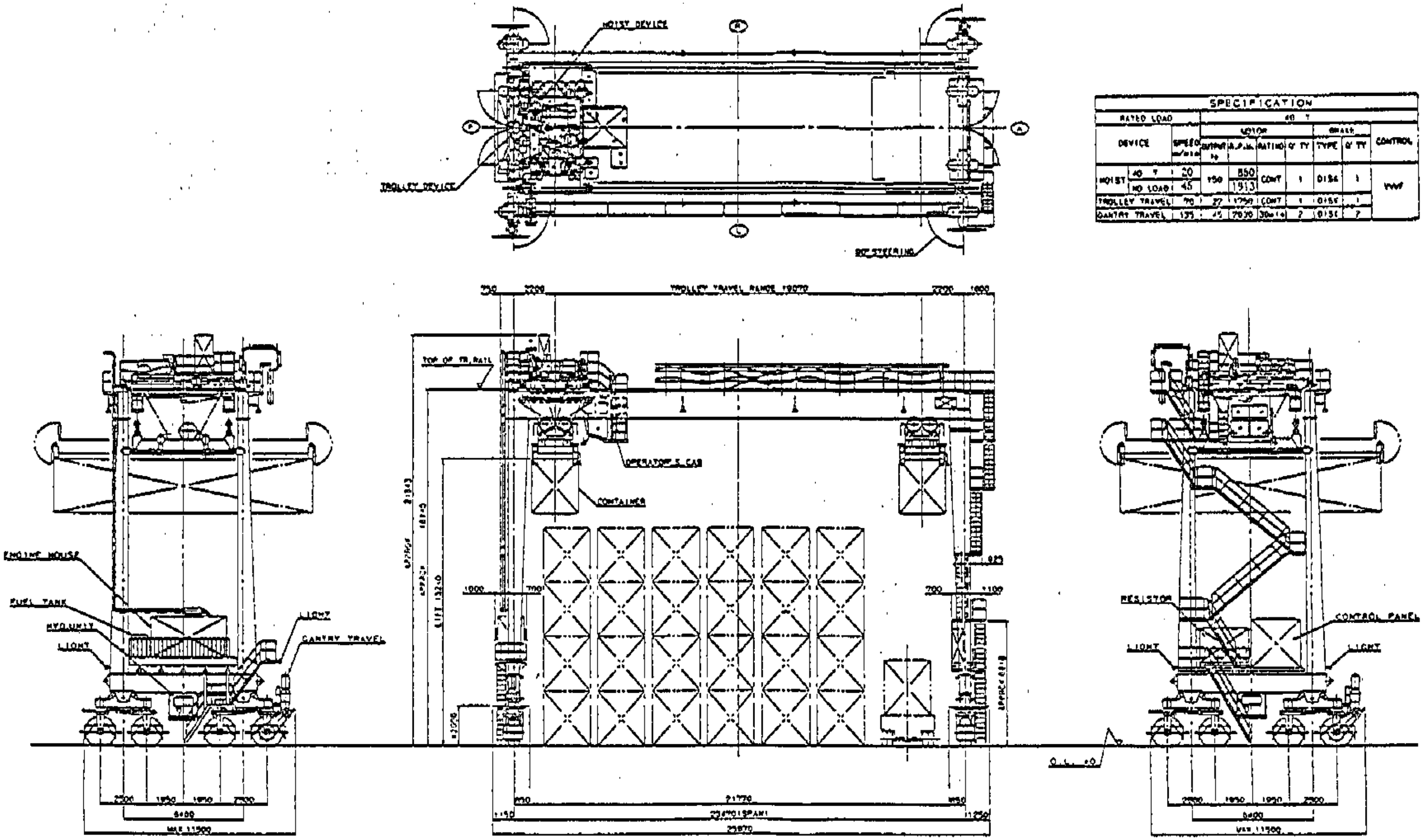


FIGURE 4.2.11 Outline of Transfer Crane



SPECIFICATION									
RATED LOAD		40 T							
DEVICE	SPEED m/min	MOTOR				BRAKE		CONTROL
		OUTPUT kw	R.P.M.	RATING	Q'TY	TYPE	Q'TY	
HOIST 40 T	20	150	850	CONT	1	DISC	1	VVVF
HOIST NO LOAD	45		1913					
TROLLEY TRAVEL	70	27	1750	CONT	1	DISC	1	
GANTRY TRAVEL	135	45	7030	30min	2	DISC	2	

TABLE 4.2.9 Required Number of Container Handling Equipment

Equipment	Capacity	Unit	Quantity	
			Year 2005	Year 2015
Gantry Crane	40 ton	No.	3	6
Transfer Crane	Tire mount type,40 ton Lift 1 over 4, Span 6+1		10	20
Top loader	40 ton		1	2
Tractor	for yard		21	44
Chassis	20'-40'		25	51
Forklift	2-4 ton		11	24

4.2.4 Labor Formation

Required number of labor formation per gang by each commodity is proposed considering the grade of handling efficiency as shown in Table 4.2.10.

TABLE 4.2.10 Required Number of Workers per Gang by Commodities

					Container		
Field	Role	General Cargo	Bagged Cargo	Bulk Cargo	Field	Role	
On board	Supervisor	0.5	0.5	0.5	Control Office	Planner	0.5
	Foreman	1.0	1.0	1.0		Supervisor	0.5
	Deck Man	1.0	1.0	1.0	On board	Lasher	6.0
	Crane Driver	1.0	1.0	1.0		Signal man	1.0
	Machine Driver	1.0	1.0	1.0	On dock	Crane Driver	1.0
	Hold Man	10.0	14.0	2.0		Cranker	2.0
	Sling Man	2.0	2.0	2.0	Container Yard	Transfer Crane Driver	3.0
On dock	Foreman	0.5	0.5	0.5		Signal man	3.0
	Worker	6.0	8.0	1.0		Tallying	1.0
	Machine Driver	2.0	2.0	2.0		Tractor driver	5.0
	Crane Driver	(1)	(1)	(1)	Total		23
Warehousing	Foreman	0.5	0.5	0.5	CFS	Worker	2.0
	Worker	4.0	6.0			Forklift driver	1.0
	Machine Driver	1.0	1.0	2.0		Measuring staff	1.0
Tallying	Tally man	1.0	1.0	1.0		Tractor driver	0.2
Total		32	40	15		Tally man	1.0
					Total		5

4.2.5 Computer System

(1) Outline of Computer System

At the port of Haydarpasa, container handling operation is managed by both inventory card and computer controlled location planning system.

Computerized yard location planning and stowage planning are both popular in many container terminals in different ports of the world. From a historical viewpoint, degree and extent of computerization in the world is categorized into three levels as shown in Table 4.2.11.

TABLE 4.2.11 Degree and Extent of Computerization

	Annual Throughput of container	Terminal Office	Yard Operation
Level 1	< 60,000 TEU	Manual	Manual
Level 2	60,000 - 150,000 TEU	Computerized	Manual
Level 3	> 150,000 TEU	Computerized	Computerized

Almost all of the container terminals in the world have reached Level 2. Some terminals in Europe, USA and Japan are proceeding to Level 3. The annual container throughput at the New port will reach Level 3.

(2) Introduction of Computerized Container Operation System

As mentioned above, the New port should introduce a computerized operation system. Since it is difficult to introduce the total computer system mentioned below at once, it will be necessary to start with a small scale computer system during the port development period. Initial computer system shall have the following functions.

- Promoting the stacking plan
- Determining container storage positions
- Determining re-handling when unloading containers
- Promoting the shift plan in the yard
- Promoting the sequence plan of ship loading/discharging
- Controlling the yard map

However, the development of a small scale computer system should be made under the consideration of the possibility of extending components of the system for further development. The total computer system is introduced in the target year of 2015, and the basic component of this system is divided into the following three systems.

1) Terminal Control System

This system includes the following two major programs.

- Marshaling yard control program

  Function : Determination of export container locations

  Determination of import container location

  Determination of change of locations, instruction and revision

  Storage container list including container location and status

- Gate Control Program

  Function : In-bound container control

  Out-bound container control

2) Terminal Planning System

This system includes the following three major programs

- Loading schedule program

Function: Inputting and filing the number of loading containers and their status from a specific vessel

preparing preliminary plans, a bay plan, a storage plan, a schematic plan, a sequence check list, etc..

Final/revision of preliminary plans.

Calculation of weight, height of center of gravity of the ship, cargo combinations, monitoring and others.

Monitoring of operation

- Discharging schedule program

Function : Inputting and filing the number of containers discharged and their status from a specific vessel.

Preparing preliminary plans, a schematic plan, a sequence check list and re-handling list.

Monitoring of operation

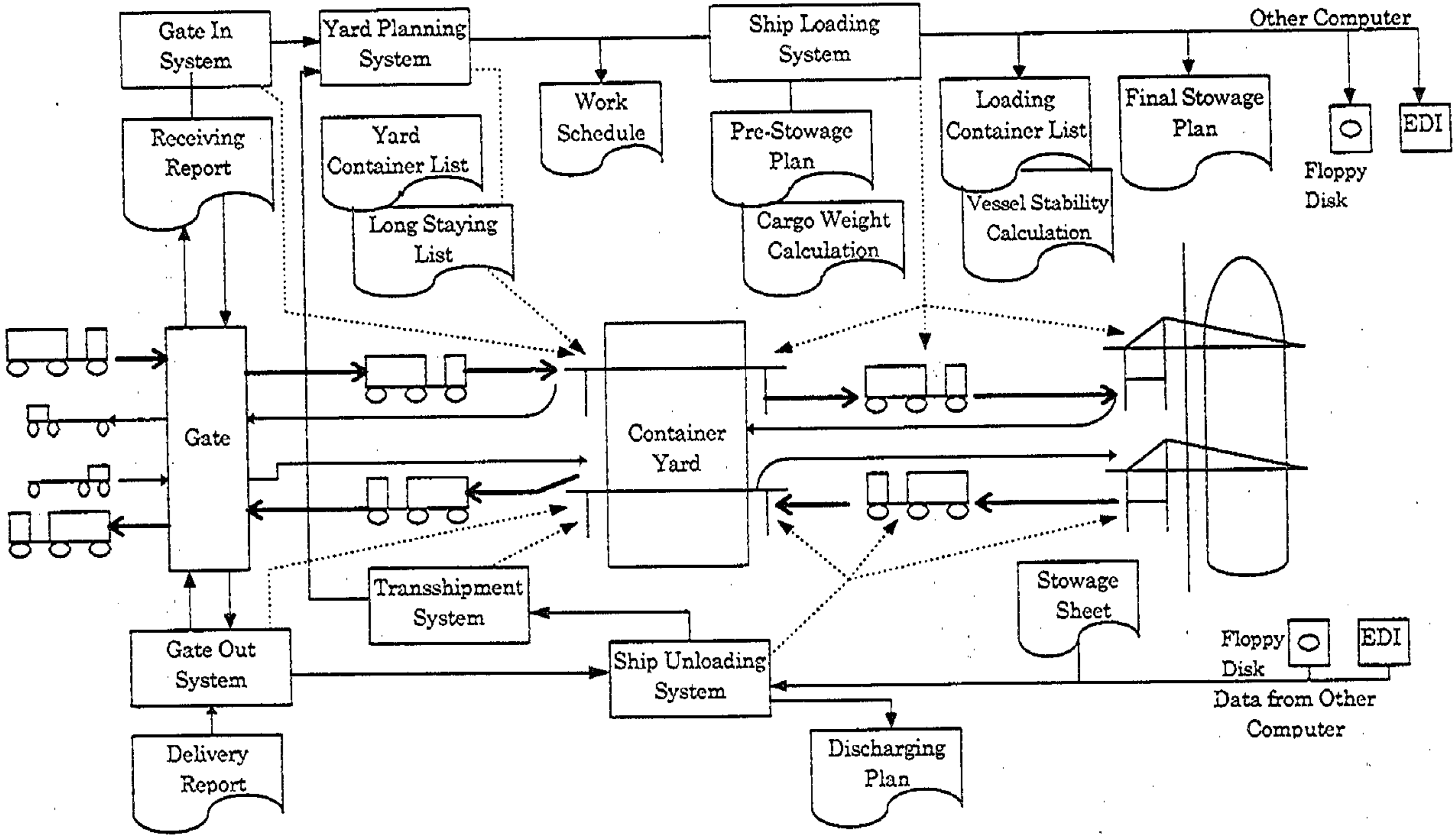
- Program for optimal handling equipment procedure

3) Documentation system

This system finalizes all the information processed and/or developed in systems described previously. Preparing documentation to submit to the parties concerned and filing the necessary information for port statistics can be carried out with this system.

Outline of total computer system is given in Fig 4.2.12.

FIGURE 4.2.12 Outline of Total Computer System at Terminal



4.3 Preliminary Design

4.3.1 Conditions and Typical Cross Sections of Existing Facilities

(1) Conditions of Existing Facilities

The present conditions of the existing port facilities around the Sea of Marmara are as follows:

1) Haydarpasa port

a) Breakwater

The crown height and the center line of the concrete block on the breakwater (1) which is 600 m in length and the breakwater (2) which is 1,750 m in length are kept at their present values. No disarrangement of rubble stones on the off-shore side of the breakwater were found. The breakwater is Haydarpasa Port are in good conditions.

b) Berth

The overall condition of each berth is inspected, and the following observations were made as follows:

i) Headlines of all berth are not disturbed.

ii) Settlement of the surface and puddle are found on some aprons.

iii) Pavements of the berths are cracked in some places.

iv) The fenders are not in good condition.

v) The coping stone of the berths are partially destroyed.

vi) The railroads constructed on the aprons are not useful.

Even though some parts of the berths and apron are not in conditions, no fundamental defects are not found on the whole.

2) Bandirma port

a) Breakwater

The breakwater which is (1) 1,000 m in length, and breakwater (2) which is 500 m in length are in good condition as they were constructed.

b) Berth

Even though some flaws were found related to the coping stone of the berth at several places, the berth and the apron in Bandima Port are generally in good conditions.

Tekirdag, Canakkale, Mudanya, Gemlik (Gem Port), and Derince Ports in general, these port facilities are kept in good condition.

(2) Design Conditions and Typical Cross Sections

Design conditions and the corresponding structure of the main port facilities around the Sea of Marmara are summarized in Table 4.3.1.

TABLE 4.3.1 Design Condition and Structural Type

Port	Main Facility	Length (m)	Water Depth (m)	Crown Height(m)	Structural Type	Cargo Commodities	Surcharge (t/m2)	Crane Capacity	Seismic Coeff	Soil Condition
Haydarpasa	Berth No.11	350	-10.00	+3.00	Concrete Block	General	2.0t/m2	35t Luffing	0.08	
	(Improve of No.11)				Steel Pipe Pile	Container		40t Container		
	Berth No.12	300	-12.00	+3.00	Concrete Block	Container	2.5t/m2	40t Container	0.08	
	Berth 13/14	295	-10.00	+3.00	Concrete Block	General	2.0t/m2	35t Luffing	0.08	
	Berth water (2)	1,750	-12.50	+4.00	Rubble-Mound					
Tekirdag	Jetty	343	-10.00	+2.40	Concrete Pile	General		None		
Canakkale	Jetty (Front)	90	-10.00	+2.30	Concrete Pile	General		None		
Kepez	Jetty(under construction)	214.6	-25.00	+2.50	Steel Pipe Pile	General	2.5t/m2	25t Mobile	0.08	
Bandirma	Berth No.7	190	-12.00	+2.00	Concrete Block	Dry Bulk	2.0t/m2	25t Luffing	0.10	
	Break water (1)	1,000	-19.50	+4.00	Rubble-Mound					
Mudanya	Jetty (Front)	92	-12.00	+2.00	Concrete Pile	General		None		
Gemport	Berth No.1/2/3	435.5	-7~12.0	+2.00	Sheet Pile	Container		None		
Derice	Berth No.3/4	410	-9~15.0	+2.50	Steel Pile	Grain(TMO)	2.5t/m2	600t/1,200t/Hr	0.06	
	Berth No.6	200	-12.0	+2.50	Concrete Block	General	3.0t/m2	35t Luffing	0.06	
	Berth No.7	160	-10.0	+2.50	Concrete Block	General	3.0t/m2	35t Luffing	0.06	

1) Breakwater

Among the ports around the Sea of Marmara, rubble mound type breakwaters filled with various types of stones were constructed in the Port of Haydarpasa and in the Port of Bandirma. The crown heights of the breakwaters are between 3.5 and 4.0 m above the mean sea level, and the off shore mounds are covered with 2-6 ton of stones with a grade of one-third or two-thirds.

2) Berth

As concerns deep water berths more than 10.0 m in water depth of berth, four structural types (concrete block, steel pipe pile, concrete pile, and steel sheet pile) were constructed at the ports around the Sea of Marmara as shown in Table 4.3.2, the concrete block type is the most popular in this area. On the other hand, steel pipe pile or concrete pile types are adopted for jetty of deep water berths. Although steel sheet pile berths are the most popular in Japan, it is found only in Gemlik Port (Gemport) in around the Sea of Marmara.

TABLE 4.3.2 Total Length of Each Structural type (more than 10.0 m in depth) (Unit: m)

	Haydarpasa	Tekirdag	Canakkale	Kepez	Bandirma	Mudanya	Gemlik (Gemport)	Derinee	Total
Concrete Block	2,155	--	--	--	1,873	--	--	380	4,408
Steel Pipe Pile	--	--	--	215	--	--	--	440	655
Concrete Pile	--	343	90	--	--	92	--	--	525
Steel Sheet Pile	--	--	--	--	--	--	436	--	436

Focusing on the wall height and the base length of the concrete block type berths of the existing mooring facilities, Figure 4.3.1 shows the ratio of base length to the wall height. From the figure, the base length is assumed to be equal to (4 m + 20% of wall height) for the deep sea berths in the Sea of Marmara, in where the wall height means the height from the top of the crown tot he bottom of the block, that is, the sum total of crown height, berth depth and 0.5 m of embedment of the bottom block.

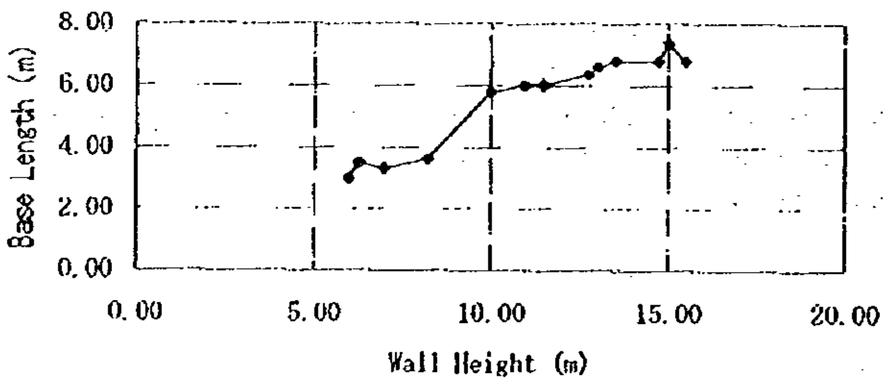


FIGURE 4.3.1 Wall Height and Base Length

4.3.2 Methodology and Standard of Design

Basically, the design procedure carried out in this study is based on the Japanese standard "Technical Standard for Port and Harbor Facilities in Japan". Further, the relevant Turkish Standards related to local conditions are also needed when necessary.

4.3.3 Scale of Port Facilities in Long Term Plan

The layout of the new port in the Long Term Development Plan for the new port in the Sea of Marmara is shown in Chapter , and the main port facilities are as follows:

(1) Breakwater (L = 700 m)

(2) Revetment

(3) -14 m Container Berth (L = 350 m)

(4) -12 m Container Berth (L = 490 m)

(5) -12 m Grain Cargo Berth (L = 240 m)

(6) -11 m General Cargo Berth (L = 570 m)

(7) -7.5 m Bulk Cargo Berth (L = 200 m)

4.3.4 Design Condition and Criteria

(1) Datum Level

The datum level for construction work of port and harbor facilities should be the same level as the Chart Datum, which is approximately equal to the low sea level. Since the tidal range is less than 0.30 m, and the mean sea level is usually adopted as the datum in the ports around the Sea of Marmara, the mean sea level is used as the datum in the study.

(2) Crown Heights

1) Breakwater

The crown height of a breakwater should be not less than about 0.6 times the design significant wave height above the mean spring high water level, and the crown heights are mostly determined as follows:

a) In case of the water area behind the breakwater is so wide that overtopping waves are allowed to some extent, the crown height may be 0.6 $H_{1/3}$ above the mean spring high water level.

b) In case of the basin behind the breakwater is small in water area and is used for small ships and considerable overtopping waves should be perfectly prevented, the crown height of the breakwaters may be 1.25 $H_{1/3}$ above the mean spring high water level.

In this port, $H_{1/3}$ is determined approximately as 4 m in Chapter 6.3.2, 0.6 $H_{1/3}$ and 1.25 $H_{1/3}$ are 2.4 m and 5 m, respectively.

In the Port of Hydarpasa, the crown height of the main breakwater is 3.0 m, and in the Port of Bandiruma, it is 4.0 m. In this study, the crown height of the breakwater is determined as 3.0 m, above the mean sea level

2) Revetment

Since the area behind the revetment is road, container yard, etc. in where the port activities may be limited by the influence of overtopping waves, the crown height should be determined as 4.5 m above the sea level.

3) Berth

In case when the tidal range is less than 3.0 m, the crown height of the berth should be 1~2 meters above the H.W.L.

The crown height of the berths are between 2.5 m and 3.0 m about the main existing facilities around the Sea of Marmara (refer to Table 4.3.1).

In case when the tidal range is less than 3.0 m, the crown height of the berth should be 1~2 meters above the H.W.L., and 2.0 m is suitable for a berth of large ships.

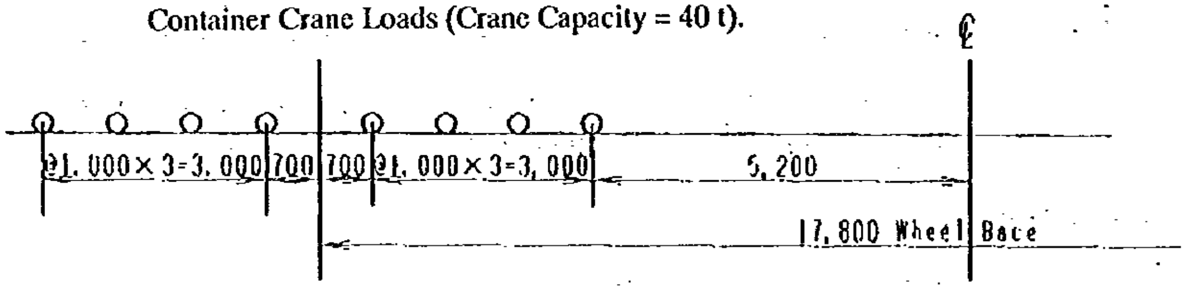
(3) Surcharge on Apron

Surcharge on apron is usually estimated as 2.0 t/m^2 to 2.5 t/m^2 for a general cargo berth in Turkish (refer to Table 4.3.1), and this value seems to be reasonable in this study. However, for a container berth with a container crane, the surcharge should be different between apron under a crane gauge and apron out of track gauge of the crane. In Japan, the value of surcharge is 1 t/m^2 under the crane and 3 t/m^2 out of the crane.

In case of an earthquake, the surcharge is reduced to the half of the ordinary loads.

(4) Crane Load

Container Crane Loads (Crane Capacity = 40 t).



Wheel Load/wheel (unit: t)

	Sea Side	Land Side
Operation Condition (16 m/s Wind)	35.5	32.5
Stormed Condition (55 m/s Wind)	38.5	57.5

(5) Coefficient of Friction

For the coefficient of static friction used in stability calculation against sliding, the values generally used in Japan and Turkey are shown in Table 4.3.3.

TABLE 4.3.3 Coefficient of Friction

Concrete against Concrete	0.5	(0.52)
Concrete against Bed Rock	0.5	(0.52)
Concrete against Rubble	0.6	(0.60)

( ) indicate the values in Turkish

(6) Seismic Coefficient

The design value of the seismic coefficient should be determined in accordance with the following formula with special consideration given to (1) the classification of the region where the structure is located, (2) the subsoil conditions, and (3) the degree of importance of the structure.

Design seismic coefficient (c)

= Regional seismic coefficient (C_o)*Factor for subsoil condition (K)*
Coefficient of importance (S)

The value of the regional seismic coefficient, the factor for subsoil condition, and the coefficient of importance are decided according to the criteria used in Turkey.

The design value of the seismic coefficient was generally taken as 0.08 above sea level during the design of the existing facilities (refer to Table 4.3.1).

(7) Soil Conditions

Soil index of the sea bed is followed that in Chapter 6.1.3.

(8) Safety Factor

The safety factors of the facilities are empirically determined based on field investigations, tests, importance of the facility, and design formulas. Comparison of the safety factors for various berths constructed in Japan and in Turkey are shown in Table 4.3.4.

TABLE 4.3.4 Safety Factor

Item		Normal Condition	Special Condition
Gravity Type	Sliding	1.2 (1.2~1.5)	1.1 (1.12)
	Overturn	1.2 (1.5)	1.1 (1.12)
	Bearing	2.5 (2.8)	--
Pile Capacity	Compressive Stress	2.5 (3.5)	1.5 (--)
	Pulling Stress	3.5 (--)	2.5 (--)
Sheet Pile	Embedded Length		
	Sandy Soil	1.5	1.2
	Cohesive Soil	1.2	1.2
Circle Failure		1.3	--

( ) indicate the values in Turkish

4.3.5 Structural Type

(1) Breakwater

Structural type of breakwater are

1) Rubble mound type

2) Concrete block type

3) Concrete cassion type

Around the Sea of Marmara, existing breakwaters were constructed in rubble mound type in the Port of Hydarpasa and Port of Bandirma, and the rubble mound type is recommendable for the new port.

(2) Berth

For berths, typical structural type are

1) Concrete block type

2) Concrete cassion type

3) Sheet pile type

4) Open deck on concrete piles or steel piles

As concerns deep water berths, the concrete block type were selected in the Port of Haydarpasa, Port of Bandirma, and Port of Derince, and open deck type on steel piles was selected in Port of Derince. In Japan, cassion type and steel pile type are very common for deep water berths. In case if the new port, the sea bed is comprised of a soil layer less than 10 m in thickness laying on the bed rock with N-value of more than 50. Since the required embeded length of piles is assumed to be 15 m or more, the pile type is not recommendable for the deep water berth, and the concrete block type is chosen as the structural type.

4.3.6 Preliminary Design and Typical Cross Section

(1) Breakwater

The weight and the slope of rubble covering the slope surface of the breakwater maybe calculated by the following formula.

$W = r*H^3/K_d*(Sr-1)^3*\cot a$

where W: Minimum weight of rubble stones(t)
r: Unit weight of rubble in air (t/cu.m)
Sr: Specific gravity of rubble to sea water
a: Angle of the slope to horizontal plane (degree)
H: Wave height ($H_{1/3}$)
K_d: Stability coefficient determined by the amoring materials and damage rate.

If a is one-seconds or two-thirds, W is calculated relating to the damage rate and Table 4.3.5 shows W value related to the damage rate.

If a will be two-thirds, and damage rate will be more or less 5%, W, minimum weight of rubble stone, will be approximately 6~8 t in case of $H_{1/3}$ is 4 m.

TABLE 4.3.5 Weight of Rubble Stone and Damage Rate

	Damage Rate (%)	0~1	1~5	5~15
	$H_{1/3}$			
a = 2:3	3.0	4.13	2.59	1.84
	3.5	6.56	4.11	2.91
	4.0	9.79	6.14	4.35
	5.0	9.12	12.00	8.50
a = 1:2	3.0	3.10	1.94	1.38
	3.5	4.92	3.09	2.19
	4.0	7.34	4.61	3.26
	5.0	14.34	9.00	6.37

Typical cross section of Breakwater is shown in Fig. 4.3.2.

(2) Revetment

The behind land of the revetment is used for the area at where the port activities, traffic road and container yard etc., may be often limited by the influence of overtopping waves of the revetment. As overtopping waves should be prevented, the crown height of the revetment should be 1.25 $H_{1/3}$ which is equal to 4.5 m above the sea level. The others are almost the same with the cross section of the breakwater. Typical cross section is shown in Fig. 4.3.3.

(3) (-)14 m Container Berth / (-)12 m Container Berth

The structural type of the berth is gravity type, and the following matters should be examined in the stability calculation.

a) Examination of sliding of block

b) Examination of overturning of the block

c) Examination of bearing capacity of foundation at the top of the foundation stone as well as the existing sea bed.

d) Examination of circular slip.

Assuming the typical cross section of -14 m container berth and -12 m container berth which are shown in Fig. 4.3.4, and Fig. 4.3.5, the result of examinations of each matters are shown in Table 4.3.6.

TABLE 4.3.6 Examination of Stability Value

	-14 m Container berth		-12 m Container Berth	
Condition	Normal	Special	Normal	Special
1) Sliding	4.18	2.10	4.4	2.2
2) Overturn	4.48	2.69	4.9	2.8
3) Bearing	40.0 t/m^2	50.0	40.0	50.0
	30.9 t/m^2	37.8	32.4	37.0
4) Circular slip	2.0		1.5	

(4) Other Facilities

a) Container Fright Station ------- Fig. 4.3.6

b) Pavement ----------------------- Fig. 4.3.7

c) Dry Bulk Berth ----------------- Fig. 4.3.8

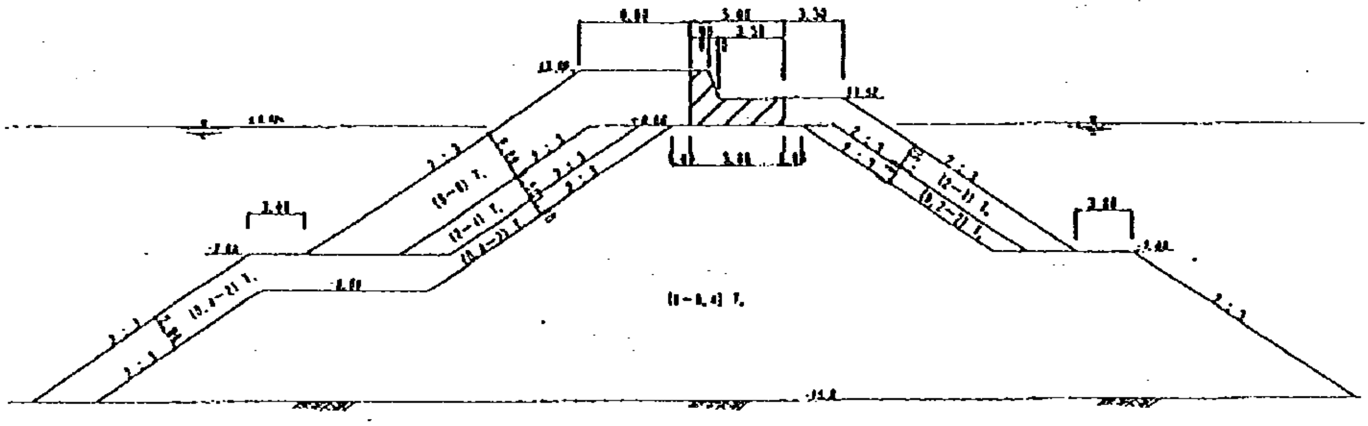


FIGURE 4.3.2 Typical Cross Section of Breakwater

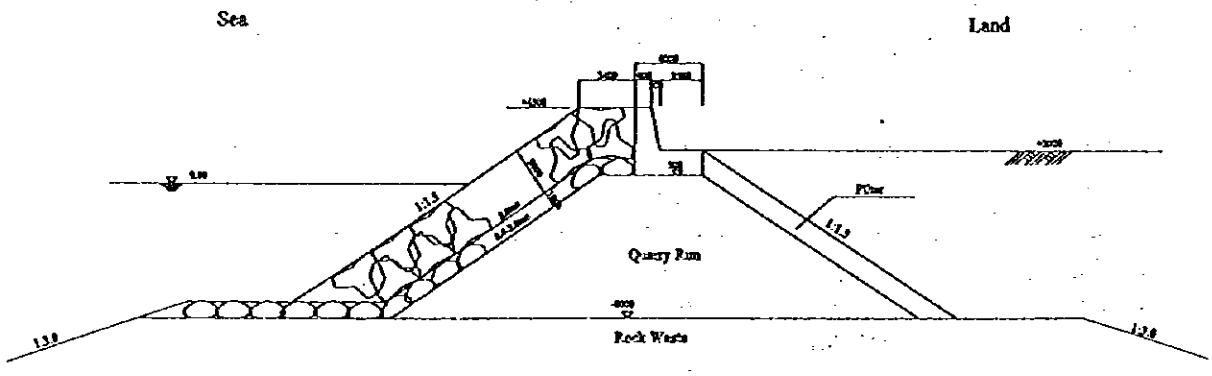


FIGURE 4.3.3 Typical Cross Section of Revetment

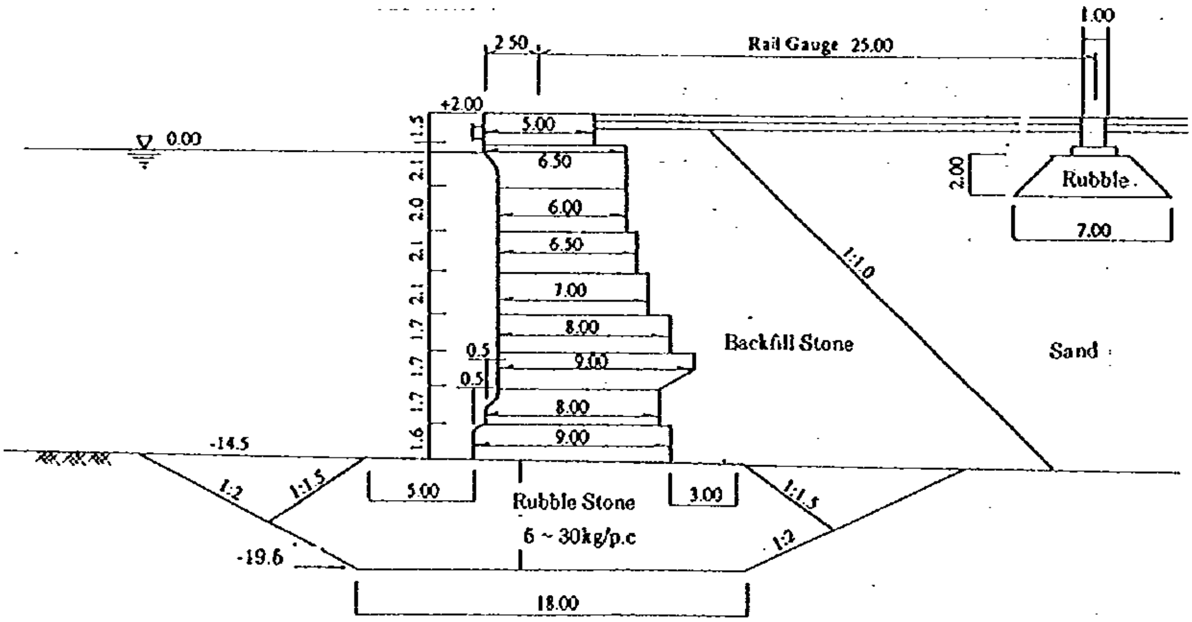


FIGURE 4.3.4 Typical Cross Section of (-)14 m Container Berth

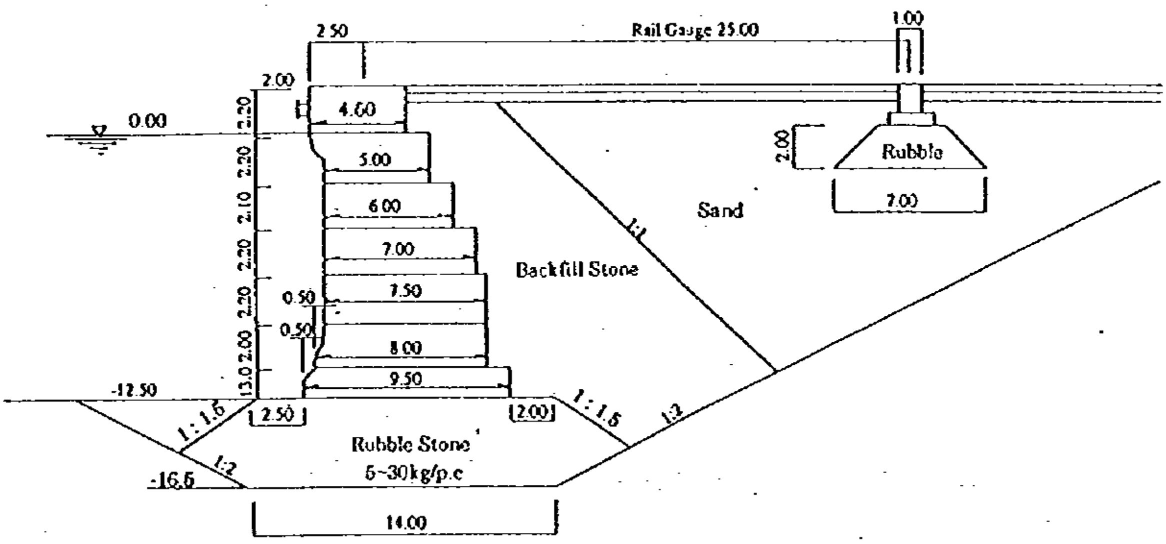


FIGURE 4.3.5 Typical Cross Section of (-)12 m Container Berth

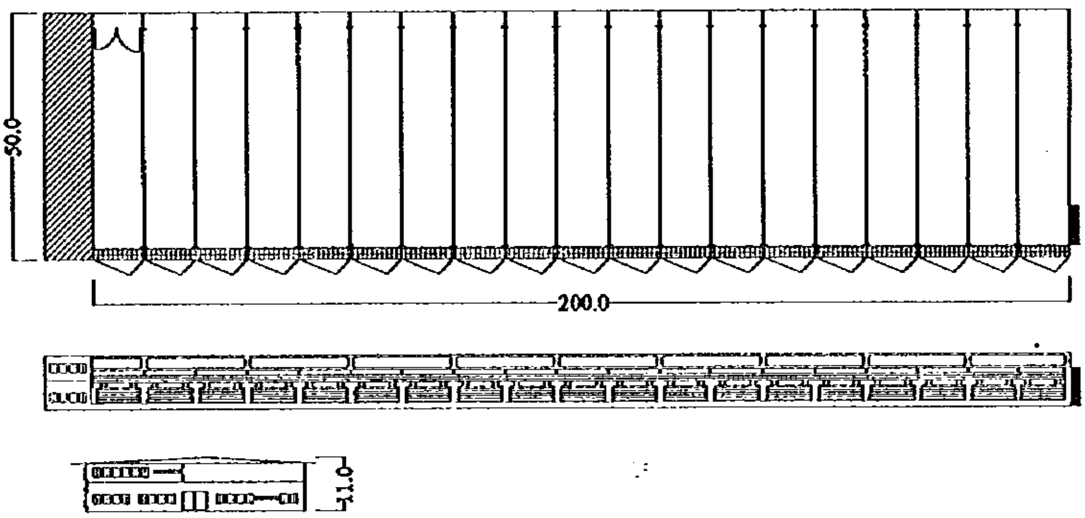
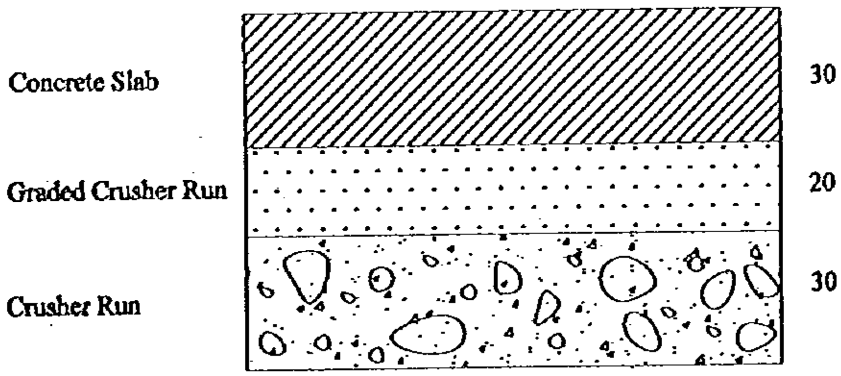


FIGURE 4.3.6 Container Freight Station



Design Coefficient of
Bearing Capacity of Subgrade
K_{30}(kg/cm3)=6(assumed)

FIGURE 4.3.7 Standard Cross Section of Container Yard Pavement

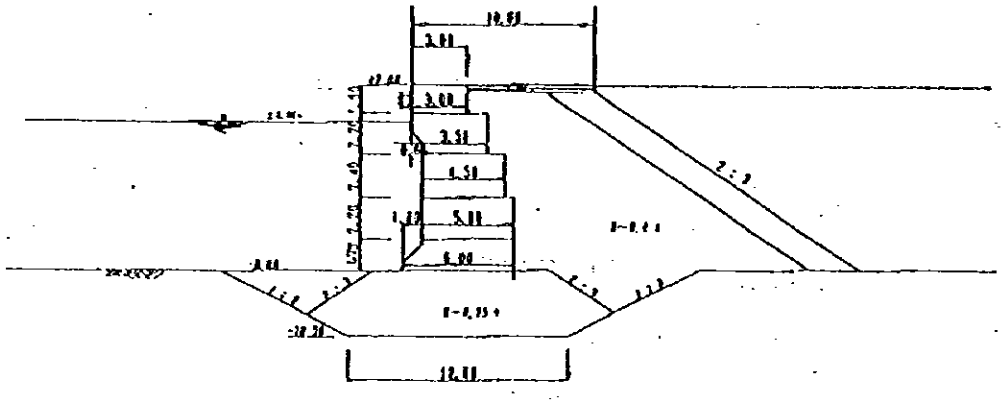


FIGURE 4.3.8 Typical Cross Section of Dry Bulk Berth

4.3.7 Main Port Facilities in Short Term Plan

Main Port Facilities of the Short Term Plan of the new port is shown in Fig. 4.3.9, and port facilities is as follows:

1) (-)14 m Container Berth (L = 50 m)

2) (-)12 m Container Berth (Length = 490 m)

3) Temporary Breakwater (Length = 150 m)

4) Revetment

5) Container Freight Station (C.F.S.)

6) (-)7.5 m Berth for Small Boats (L = 200 m)

7) Container Yard

4.3.8 Typical Cross Section of Main Port Facilities

The design and their typical cross sections are mentioned in Chapter 3.1.5 except the temporary breakwater which is 150 m in length. Since the temporary breakwater will be filled after the next stage will begin, the standard cross section should be designed as a tentative section, and the crown height is determined as 0.6 $H_{1/3}$ above the sea level.

The typical cross section of the temporary breakwater, temporary east revetment and temporary inner revetment are shown in Fig. 4.3.10, Fig. 4.3.11 and Fig. 4.3.12 respectively.

4.3.9 Causeway and Other Facilities

Typical Cross Section of the Causeway, Dockway, West Revetment are shown in Fig. 4.3.13, Fig. 4.3.14 and Fig. 4.3.15.

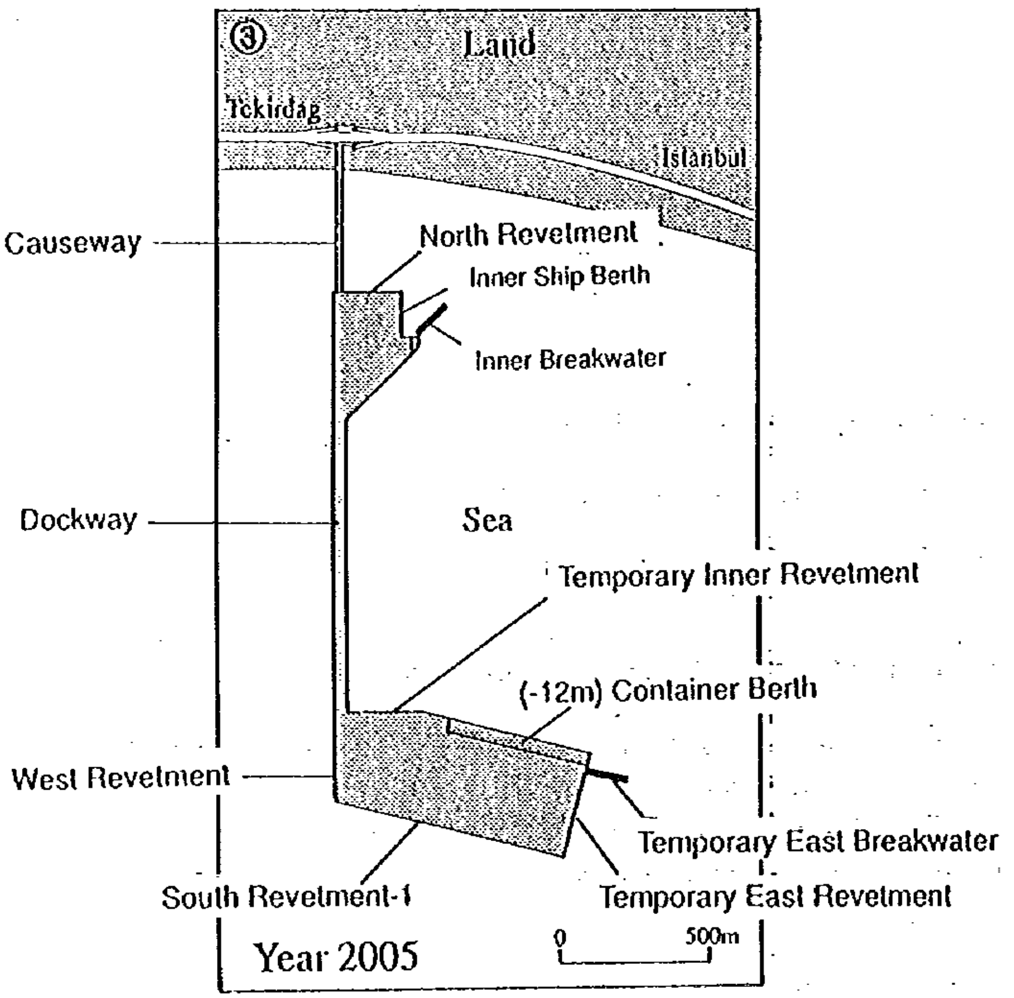


FIGURE 4.3.9 Location of Main Port Facilities

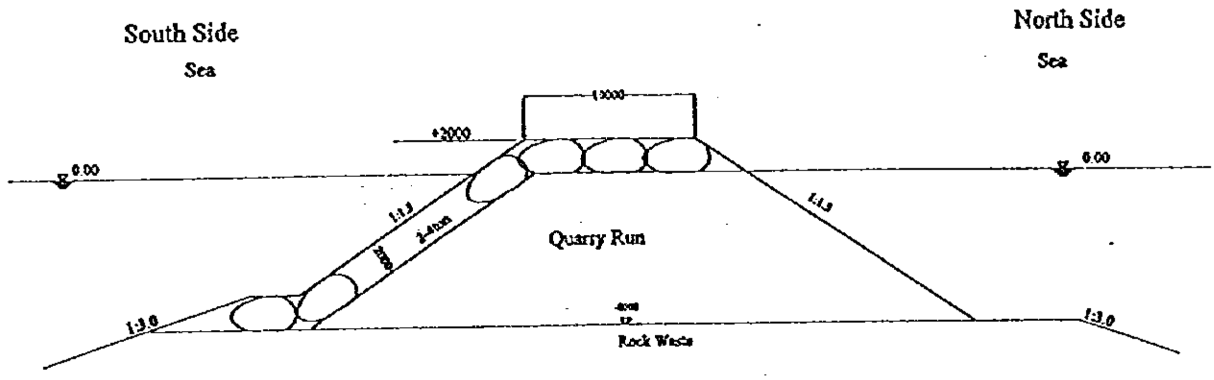


FIGURE 4.3.10 Typical Cross Section of Temporary Breakwater

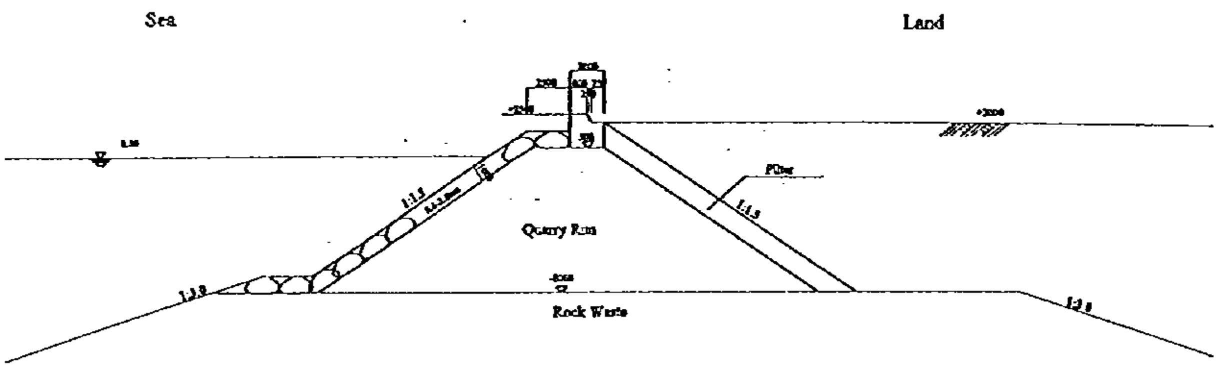


FIGURE 4.3.11 Typical Cross Section of Temporary East Revetment

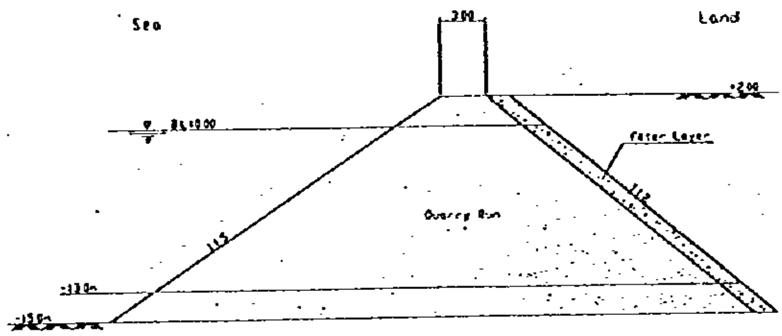


FIGURE 4.3.12 Typical Cross Section of Temporary Inner Revetment

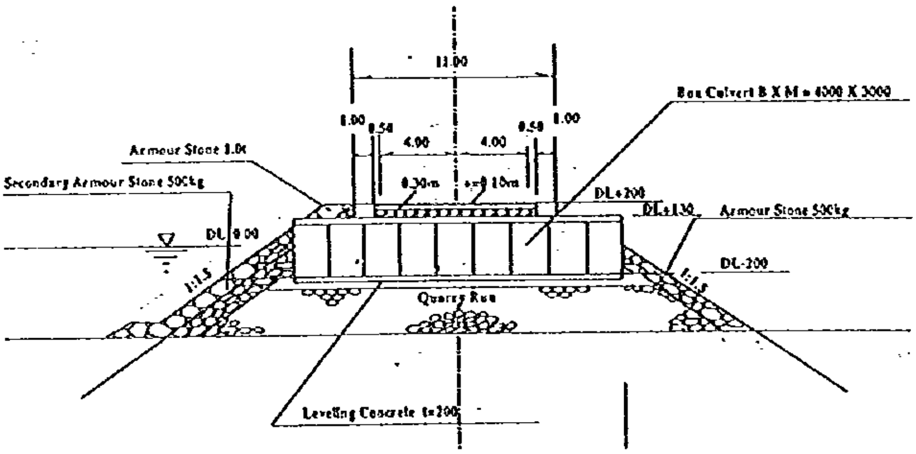


FIGURE 4.3.13 Typical Cross Section of Causeway

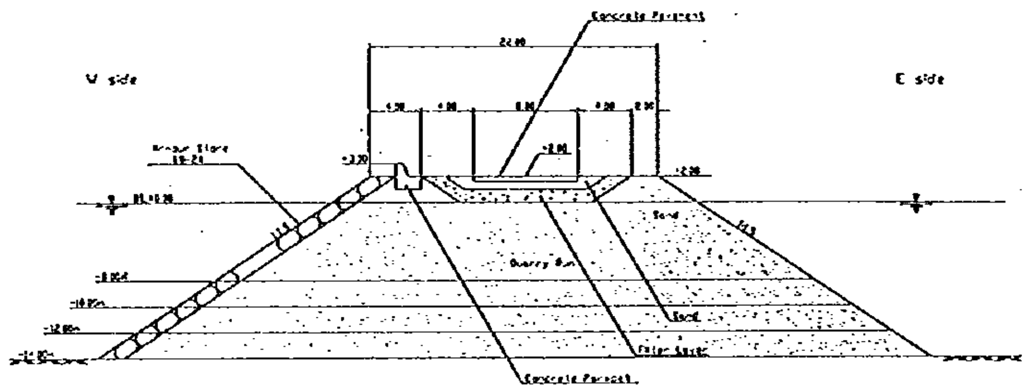


FIGURE 4.3.14 Typical Cross Section of Dockway

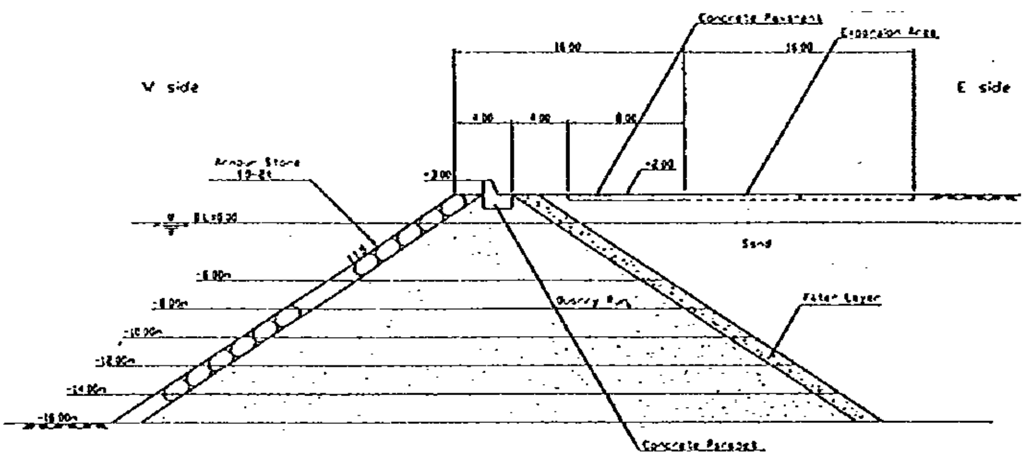


FIGURE 4.3.15 Typical Cross Section of West Revetment