CHAPTER VII ALTERNATIVE MASTER PLANS

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VII-1 Premises of the Investigation

(1) Ship Size and Average Handling Volume

In planning to build port facilities such as wharves, it is indispensable to accurately determine the size and number of berths required. Since the size of the berths depends on the size of the ships which will call, the first thing that is necessary is to determine the size of the ships which will utilize the port in the future.

The future size of ships is usually predicted by considering present ship size, future cargo predictions, and the trend that ships are getting bigger and bigger. A detailed analysis is made for planning each individual wharf.

The average loading and unloading volumes for different types of vessels calling at the ports between 1981 and1985, very important data for predicting future ship size, are given in Table VII-1-1 and VII-1-2.

(2) Cargo Handling Capacity in the Futrure (2010)

The future cargo handling capacity of the ports is estimated by analyzing the present situation and the possibility of future improvements such as the introduction of high capacity cargo handling equipment and operation systems for general cargoes and container cargoes.

The actual values and the estimates of cargo handling capacity in the year 2010 are shown in Table VII-1-3.

Table VII-1-1 Average Unloading/Loading Volume at Valparaiso Port

(Unit: tons)

Type of Ship	1981			1982			1983			1984			1985		
	Number of Ships	Average Loading Volume	Average Unloading Volume	Number of Ships	Average Loading Volume	Average Unloading Volume	Number of Ships	Average Loading Volume	Average Unloading Volume	Number of Ships	Average Loading Volume	Average Unloading Volume	Number of Ships	Average Loading Volume	Average Unloading Volume
Conventional Liner	686	650	1,492	546	696	1,202	353	736	1,311	411	770	1,432	299	1,424	1,131
Full Container	30	1,773	237	36	1,627	264	49	1,175	488	30	1,116	1,557	56	3,037	4,024
Semi Container	91	776	1,706	95	601	1,414	72	1,023	1,450	68	1,372	1,827	63	1,071	1,624
Bulk Carrier	54	852	1,528	21	6,742	2,277	12	5,070	1,652	19	1,053	1,738	10	1,412	1,476
Refer	137	1,702	1,123	137	2,203	915	202	2,425	570	143	2,299	907	170	2,691	1,036
Fishing Vessel	34	848	1,425	39	267	265	44	743	-	36	681	135	28	186	-
Ro-Ro	22	199	720	22	1,414	414	22	357	1,397	14	423	1,282	24	1,287	737
Others	26	2	137	61			51	295	107	43	86	-	0	116	-
Total	1,080			957			805			764			650		

Source: EMPORCHI, Valparaiso

Note: (1) 1985 figure is only for ten months (from Jan. to Dec.)

(2) Full container ships carried copper.

Table VII-1-2 Average Unloading/Loading Volume at San Antonio Port

(Unit: tons)

Type of Ship	1980		1981		1982		1983		1984	
	Number of Ships	Average Unloading/ Loading Volume	Number of Ships	Average Unloading/ Loading Volume	Number of Ships	Average Unloading/ Loading Volume	Number of Ships	Average Unloading/ Loading Volume	Number of Ships	Average Unloading/ Loading Volume
Conventional Liner	272	3,180	266	2,827	248	3,419	231	3,304	255	361
Full Container	-	-	5	3,094	14	6,033	13	3,321	16	5,684
Semi Container	17	2,575	31	2,467	33	3,686	29	2,435	38	1,545
Bulk Carrier	55	18,214	74	15,533	77	16,621	72	14,258	48	17,300
Liquid Carrier	21	3,186	28	2,512	20	2,768	26	4,686	28	1,230
Refer	8	3,619	20	2,451	19	5,434	20	2,024	21	4,093
Fishing Vessel	1	339	2	1,876	-	662	-	50	87	25
Ro-Ro		-	16	1,181	24	965	12	1,229	11	2,657
Others	1	-	2	-	-	-	16	-	11	-
Total	372		444		435		419		423	

Table VII-1-3 Cargo Handling Capacity of the Ports

Type of Cargo	Item	Future (2010)
General Cargo (Break Bulk Cargo)	° Average handling performance ° Working efficiency ° Working conditions	° 100 t/hour/ship ° 0.8 ° 3 gangs/ship ° Mobile crane, Ship gear
Container	° Average handling performance ° Working efficiency ° Working conditions	° 50 boxes/hour/ship ° 0.8 ° 2 container gantry cranes
Agricultural Bulk (wheat)	° Average handling performance ° Working efficiency ° Working conditions	° 400 t/hour, ship ° 0.8 ° Pneumatic unloaders, Ship gear
Fruit	° Average handling performance ° Working efficiency ° Working conditions	° 100 t/hour/ship ° 0.8 ° 3 gangs/ship ° Mobile crane, Ship gear
Copper	° Average handling performance ° Working efficiency ° Working conditions	° 180 t/hour, ship ° 0.8 ° 2 gangs/ship ° Mobile crane, Ship gear

(3) Ratio of 40 Foot Containers

The historical ratio of 40 foot containers at the port of Valparaiso is shown in Table VII-1-4. The ratio increased from 7% in 1980 to 17% in 1985.

Table VII-1-4 Ratio of 40 Foot Containers in Valparaiso Port

	1980	1981	1982	1983	1984	1985
Ratio of 40' Containers	7	9	9	13	-	16.6*

Source: * EMPORCHI
Containerization International Yearbook

On the other hand, at major container terminals in Japan, the ratio of 40 foot containers was 41.3% in 1982 and 45.2% in 1983 as shown in Table VII-1-5.

As mentioned above, the ratio is assumed to reach 40% in the year 2010.

Table VII-1-5 The Ratio of 40 Foot Containers at Container Terminals in Japan

	1982				1983			
	Number of Containers			Ratio of 40' Containers	Number of Containers			Ratio of 40' Containers
	20'	40'	TEU	(%)	20'	40'	TEU	(%)
Tokyo (8 berths)	268	181	630	(40.3)	275	187	650	(40.5)
Yokohama (6 berths)	199	111	420	(35.8)	142	176	494	(55.3)
Nagoya	86	35	156	(28.9)	101	45	191	(30.8)
Osaka (5 berths)	120	59	239	(33.0)	118	76	271	(39.2)
Kobe (12 berths)	430	391	1,213	(47.6)	464	430	1,324	(48.1)
Total	1,103	777	2,658	(41.3)	1,110	914	2,930	(45.2)

Source: Statistics of Each Port Terminal Development Corporation

(4) Methods to Determine the Number of Berths

For planning purposes, various methods are used to determine the required number of berths. In this study, the following two methods are used to determine the number of berths for the subject ports.

① Method considering the frequency of ship entry and cargo handling capacity.

② Method of simulation by queuing theory.

These methods are explained below.

1) Method using frequency of ship entry and handling capacity

$$\text{Number of berths} = \frac{\text{Total number of mooring days}}{\text{Annual number of workable days} \times \text{Berth occupancy ratio}}$$

Total number of mooring days:

(Number of calling ships) x (Per ship average days of mooring)

$$\text{Number of calling ships: } \frac{\text{Annual cargo volume handled}}{\text{Average loaded cargo volume per ship}}$$

Per-ship average days of mooring:

$$\frac{\text{Loaded cargo volume per ship}}{\text{Average cargo handling capacity per day}} + \text{Number of days necessary for purposes other than cargo handling}$$

Berth occupancy ratio: 0.4 - 0.7

According to the UNCTAD report, the berth occupancy ratio for *conventional general cargo operations* should be set so as not to exceed the figures given in the table below, which are based on a ratio of ship cost to berth cost of 4 to 1:

Table VII-1-6 Berth Occupancy Ratio

Number of berths in the group	Recommended maximum berth occupancy (%)
1	40
2	50
3	55
4	60
5	65
6-10	70

2) Method of Simulation by Queuing Theory

(i) Application of Queuing Theory to Port Planning

Ships calling at a port expect to be moored at a designated berth immediately, in the order of arrival, and carry out cargo handling. If a ship is already berthed at the quay and there is no room for the present ship to be berthed, the latter ship has to wait until after the first ship completes its cargo handling and leaves. (The ship expects to be berthed as soon as it enters a port. However, the port management body wants to minimize the number of quays in order to increase the efficiency of the use of quays. How to balance these conflicting desires, namely, what service level should be set, is an important factor in port planning.)

This phenomenon of ships arriving and leaving a port can be analyzed by queuing theory, as in the analysis of the situation at a bank, where variables include the number of windows and the time each customer takes at the windows. For a port, the variables include the arrival of ships, the number of berths and the berthing time. A queuing theory unique to ports must be developed. To this end, the pattern of ship entries and the pattern of the berthing time must be found out. Great efforts are being exerted to clarify these patterns at ports. As to the pattern of ship entries, normally it is a random Poisson distribution.

In the pattern of the berthing time by ships as expressed by a histogram, normally there is Phase 2 or Phase 3 Erlung Distribution (See Fig. VII-1-1).

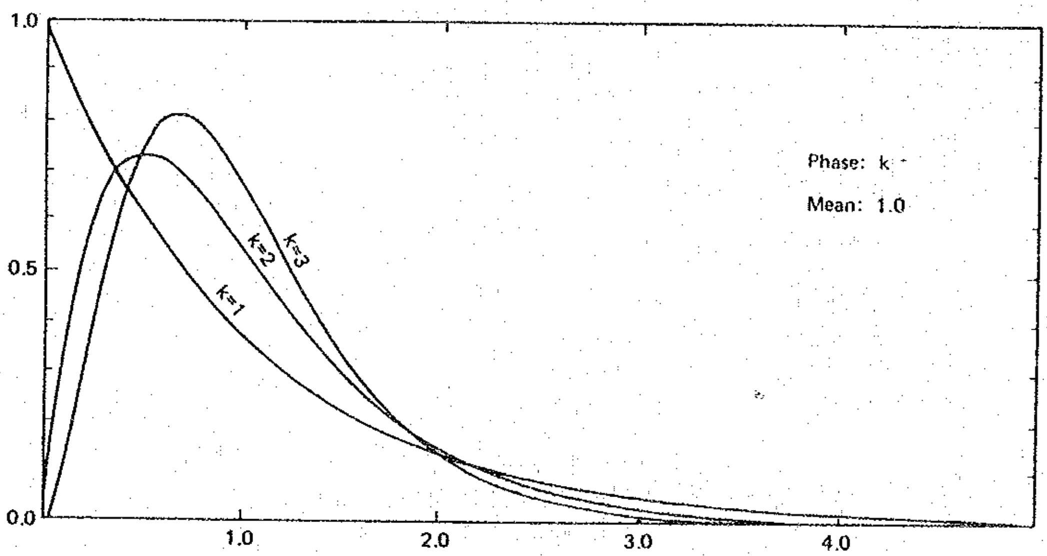

Fig. VII-1-1 Erlung Distribution

As is known already, the following four factors are indispensable to the determination of the queuing phenomenon:

① Distribution of arrivals of ships to be berthed
② Distribution of berthing time
③ Number of berths
④ Methods of service

Factor ④ concerns such matters as service in the order of arrival or preferential service. Normally, service in the order of arrival predominates but, in the case of a container port, preferential service is sometimes given to full-container ships.

(ii) Methodology of the Simulation Test

Ships entering the port take a berth according to their orderoofarrival and then start loading/unloading work. If the berths are occupied, the ships wait until the preceding ships leave. Queuing theory is used to make projection concerning the situation of ships calling at or leaving the port. However, theoretical analysis alone cannot cope with the complicated reality of port activities.
For this reason, a computer is used to follow the movement of ships i.e. entering - berthing - loading/unloading and leaving.
A simulation is used for the analysis of port congestion at the target year of the master plan of the ports of Valparaiso and San Antonio. The flow of the simulation model used on this occasion is shown in Fig. VII-1-2.
Input data comprise ship types, number of berths, frequency distribution of calling ships, and frequency distribution of mooring time. Output data are comprised of the waiting time and berth occupancy.

(iii) Basic conditions of simulation cost

① Pre-ship cargo volume and the number of ships are assumed from actual results.

② As indicated in Fig. VII-1-3, an Erlung distribution of Phase 2 applies well to the berthing time of general cargo ships. This distribution is used for other ship types, too, because the distribution of their berthing time is also nearly in accordance with the Phase 2 distribution.

③ Simulation tests are conducted for the Master Plan.

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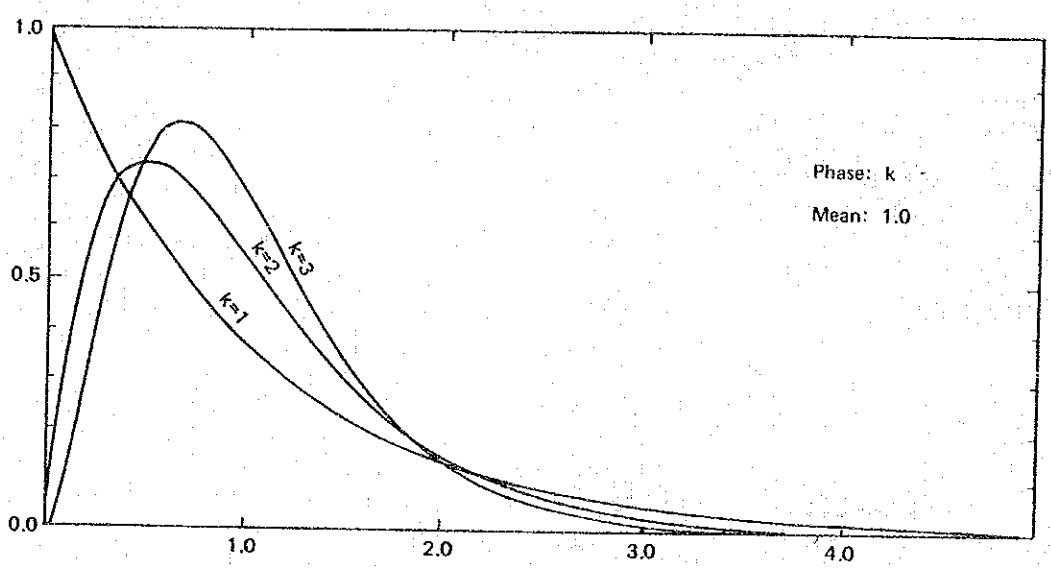

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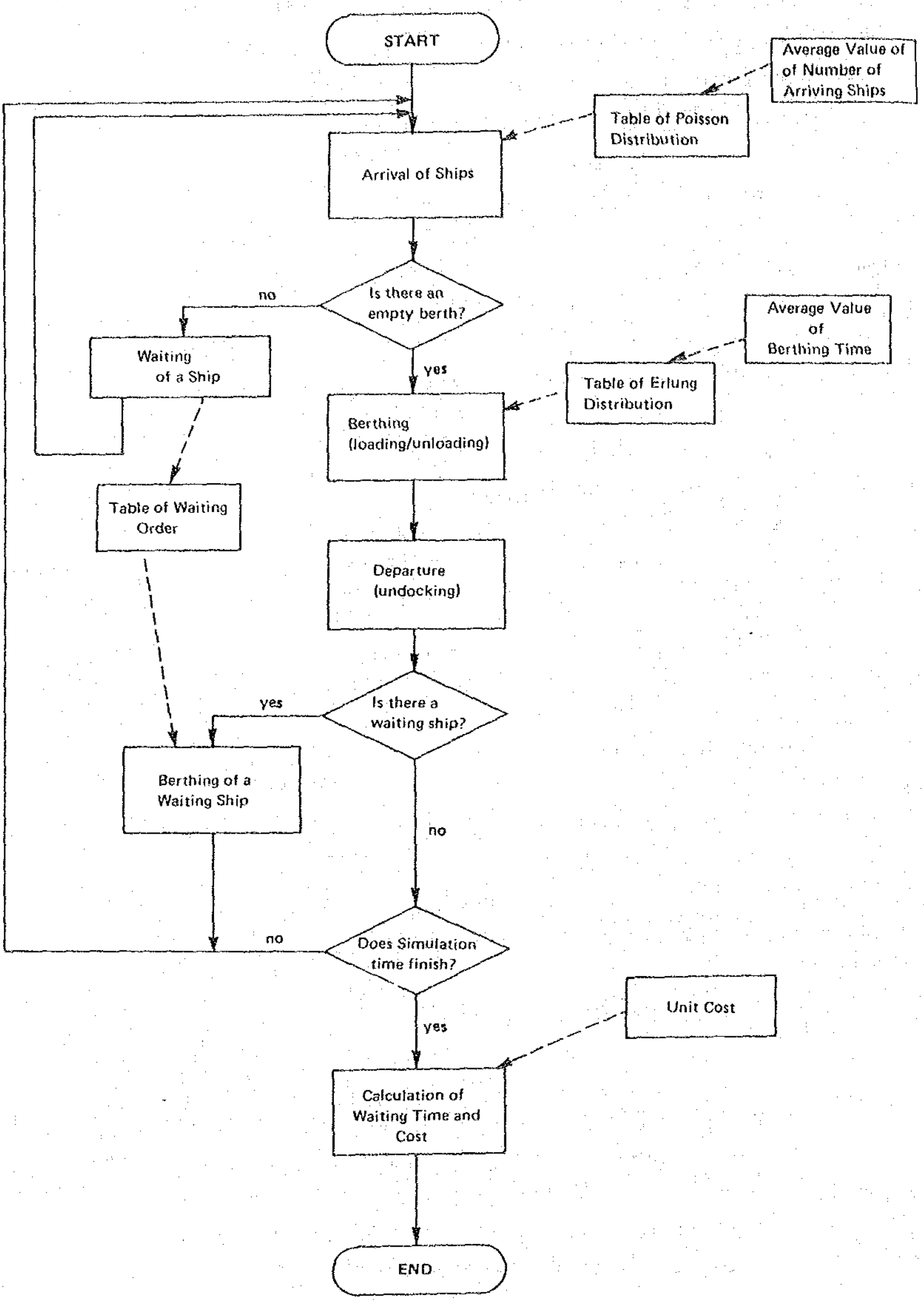


Fig. VII-1-2 Flow Chart of the Simulation Model

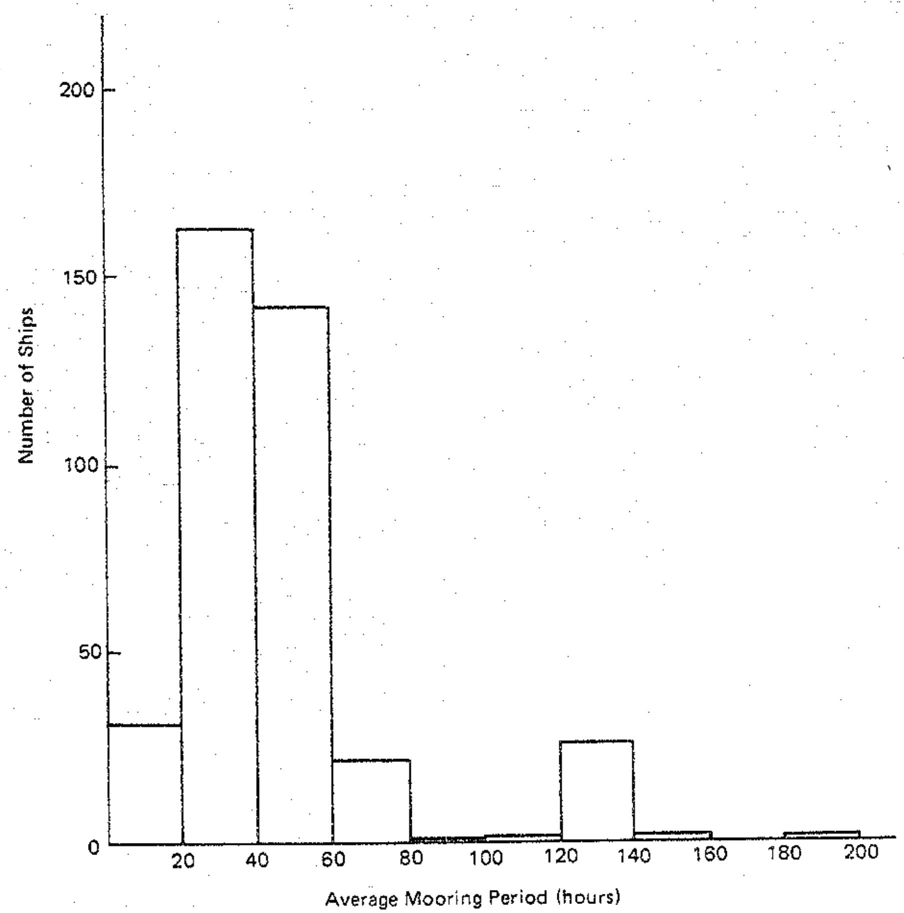


Fig. VII-1-3 (a) Relation between Mooring Period and Number of Ships (Port of San Antonio, 1984)

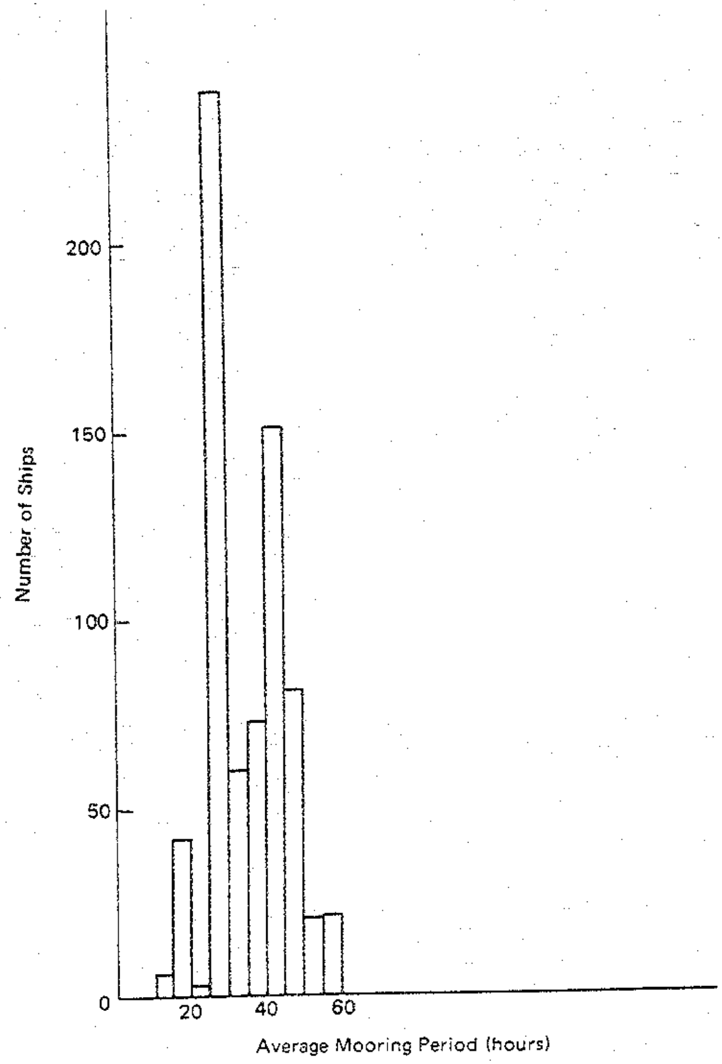


Fig. VII-1-3 (b) Relation between Mooring Period and Number of Ships (Port of Valparaiso, 1984)

(5) Procedure of Determining the Number of Berths

Fig. VII-1-4 shows the procedure of determining the number of berths using the two methods employed in this study.

First, the number of berths required for the target year is estimated by type of cargo by the method using the frequency of ship entry and handling capacity.

Next, the simulation test is conducted for the overall plan.

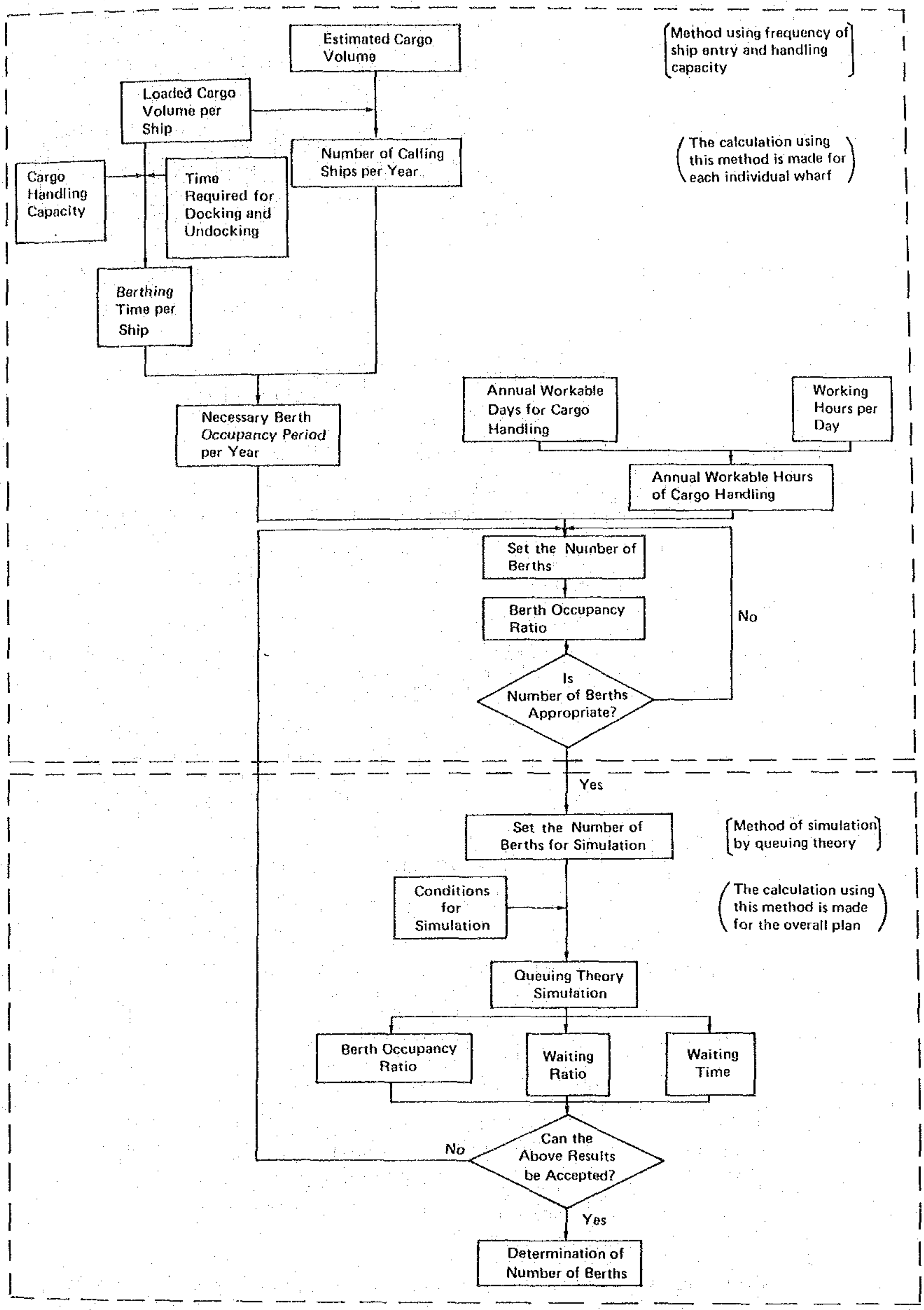


Fig. VII-1-4 Flow Chart for Determining the Number of Berths

(6) Classification of Areas for the Layout Plan

In formulating layout plans, the overall port area is usually classified into several zones in terms of the type of port activity: wharf zone, production zone, recreation zone, buffer zones, port administration and port service-related office zone, reserved zone, and inter-zone connection areas.

The wharf zone is the space for cargo handling activities within the port area. This zone includes aprons, cargo handling areas and warehouse areas.

The production zone is composed of the land area for the port-related industries which will locate there, and of wharves for the exclusive use of these industries.

The recreation zone includes not only the water areas for beaches, sailing zones and yacht harbors, but also land areas for parks which will be used by the workers at the port as well as the general public.

The buffer zones are composed of green belts, open space and waterways which will separate various zones which might adversely affect each other.

The port administration zone is the space for port administration offices and for other port related offices that will provide services for port operation.

The reserved zone is the space set aside for future port development. This is of the utmost importance to ensure continued smooth expansion of the port in the future.

Inter-zone connection areas are generally the spaces alloted for the construction of roads and railways connecting the various zones with each other and with the city located behind the port.

The locations of all these zones must be determined so that all the facilities belonging to the same category are put together, and can thereby function efficiently.

(7) Criteria for Evaluation

The alternative plans are evaluated based on the following criteria:

① Convenience

Maneuverability - Vessels calling at the port should be able to maneuver easily and safely when entering and leaving the port and when berthing and deberthing at the quaywall.

Layout - The facilities should be designed so that cargo can flow through the port efficiently. The location of cargo handling facilities and access roads affects the movement of cargo.

Utilization of Facilities - Port facilities, such as transit sheds, open storage yards, wharves, and access roads; and cargo handling equipment, such as forklifts, trucks, and mobile cranes, must be utilized efficiently.

② Safety

Calmness - The water should be as calm as possible.

Emergency Measures - Facilities must be arranged so that personnel can effectively respond to any accidents which may occur in the port.

③ Construction Cost

Total Construction Cost - The total cost should be minimized.

One way to reduce costs is to design the facilities in such a way that the volume of earth to be dredged and the volume of earth necessary for land reclamation are equal.

④ Flexibility

Adaptability - The plan should be adaptable to unanticipated changes in the future circumstances of the port and the region.

Room for Future Development - It is important to reserve space for future port development adjacent to the planned facilities.

⑤ Environmental Protection

Impact on the Social Environment - Deleterious effects of port development on the lives of the local inhabitants should be minimized.

Impact on the Natural Environment - Water pollution and beach erosion due to port development should also be minimized.

VII-2 Allotment of Container Berths Between the Two Ports

As the two subject ports basically share the same hinterland, all of the cargoes which will pass through the area will be divided between the two ports. Based on the present trade patterns and the cargo predictions, it seems that the non-container cargoes will continue to follow the same trading routes in the future as at present.

(1) Alternative Plans

Thus, the alternatives considered herein are alternative locations for the necessary container berths. Essentially, the different alternatives are evaluated based on the following criteria:

① Least cost analysis from the economic viewpoint
② Natural conditions
③ Port-related infrastructures and established port functions
④ The preferences of shipping companies.

The future cargo volumes and the growth ratios at both ports based on the demand forecast are presented in Table VII-2-1.

Table VII-2-1 Future Cargo Volume and Growth Ratio at Each Port

	Cargo Volume (Thousand Tons)				Anual Growth Ratio (%)			
	1984	1990	2000	2010	84/90	90/2000	2000/2010	1984/2010
Container Cargo	638	1,527	2,867	3,635	15.7	6.5	2.4	6.9
Non-Container Cargo	3,252	3,547	3,708	4,515	1.5	0.4	2.0	1.3
Total	3,890	5,074	6,575	8,150	4.5	2.6	2.2	2.9

Three alternative plans are considered. The alternatives are presented in Table VII-2-2.

Table VII-2-2 The Alternatives for Assessment

(Number of Berths)

	Valparaiso Port		San Antonio Port	
	Container	Non-Container	Container	Non-Container
Alternative 1	3	5	1	6
" 2	2	5	2	6
" 3	1	5	3	6

The layout plans of the alternatives are presented in Figures VII-2-1 through VII-2-3, respectively.

(2) Necessity of Breakwater in Alternatives 2 and 3

Planning of the container wharf at San Antonio Port was done with the idea that the service levels of container cargo handling at both ports (San Antonio Port and Valparaiso Port) should be the same. New breakwaters are therefore needed for the following reasons.

① Vessel entrance and exit at San Antonio Port are limited when there are strong winds and high seas because the topographical nature of the port makes for southwesterly winds, the prevailing wind direction.

② It is difficult to ensure a stopping distance for vessels (5L...about 1 Km) because the water areas in the port are narrow. Even under calm conditions, therefore, the vessels are stopped near the port entrance and have to be taken in two until the quay wall by tugboat.

③ However stopping vessels in rough water areas when there are strong winds and high seas makes vessel control virtually impossible and is dangerous. Thus, San Antonio Port is faced with particular problems where it is narrow and winds come in from the side.

In tugboat use in Japan, the limitations are a wind velocity of elow 15 - 20 m/s and/or a wave height of below 1.0 - 1.5m.

These undesirable weather and sea conditions are estimated to account for about 30 - 40% of the year by the method described in Chapter VIII.

④ Container vessel companies hoping to provide efficient, reliable service, however, are not happy with the idea of being confronted with these limitations.

⑤ Accordingly, new breakwaters are needed to ensure the continued existence of wide water areas and calm water areas.

It will also be necessary to remove part of the old breakwater.

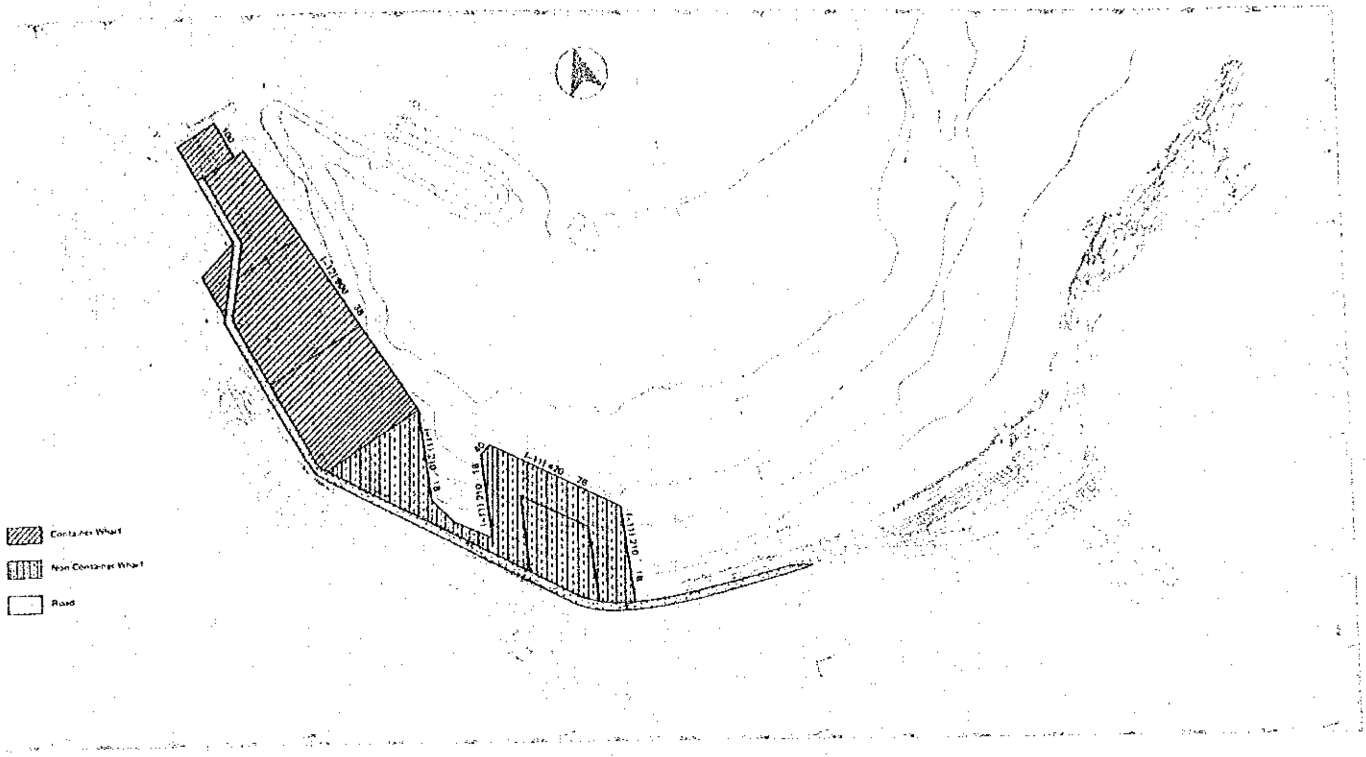
A comparison of the construction costs of Alternatives 2, 3 and excavation plans for the port of San Antonio is shown in Table VII-2-3.

Table VII-2-3 Construction Costs

(Unit: Billion Pesos)

	Alternatives 2,3		Excavation Plans	
	2 Container Berths (Fig.VII-2-2)	3 Container Berths (Fig.VII-2-3)	2 Container Berth	3 Container Berth
With Breakwater	44.3	53.4	48.9	60.7
Without Breakwater	-	-	42.0	53.9

There is no significant difference between the alternatives and the excavation plans. In the case of having 3 container berths, the construction costs of the excavation plans are even more than that of Alternative 3. As Alternatives 2 and 3 have an excellent service level (described above), we will adopt Alternatives 2 and 3 as an alternative plans.



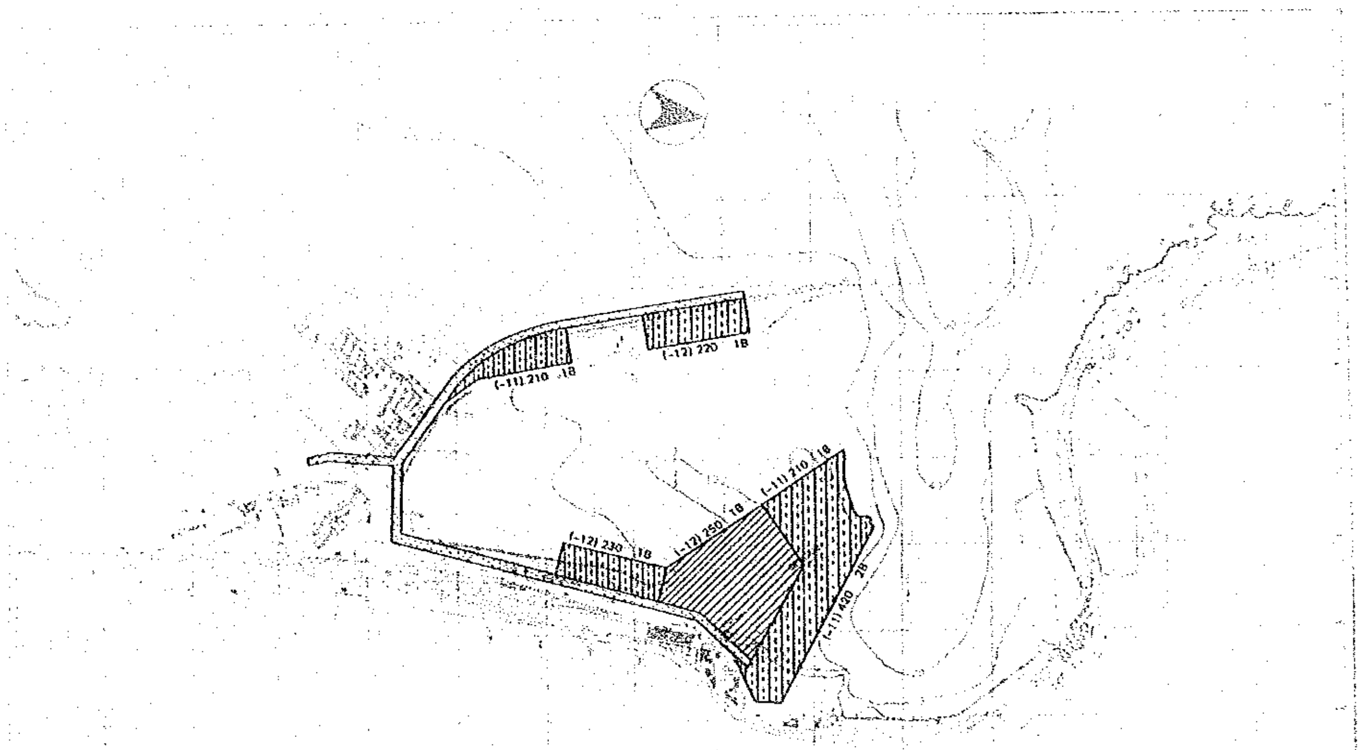
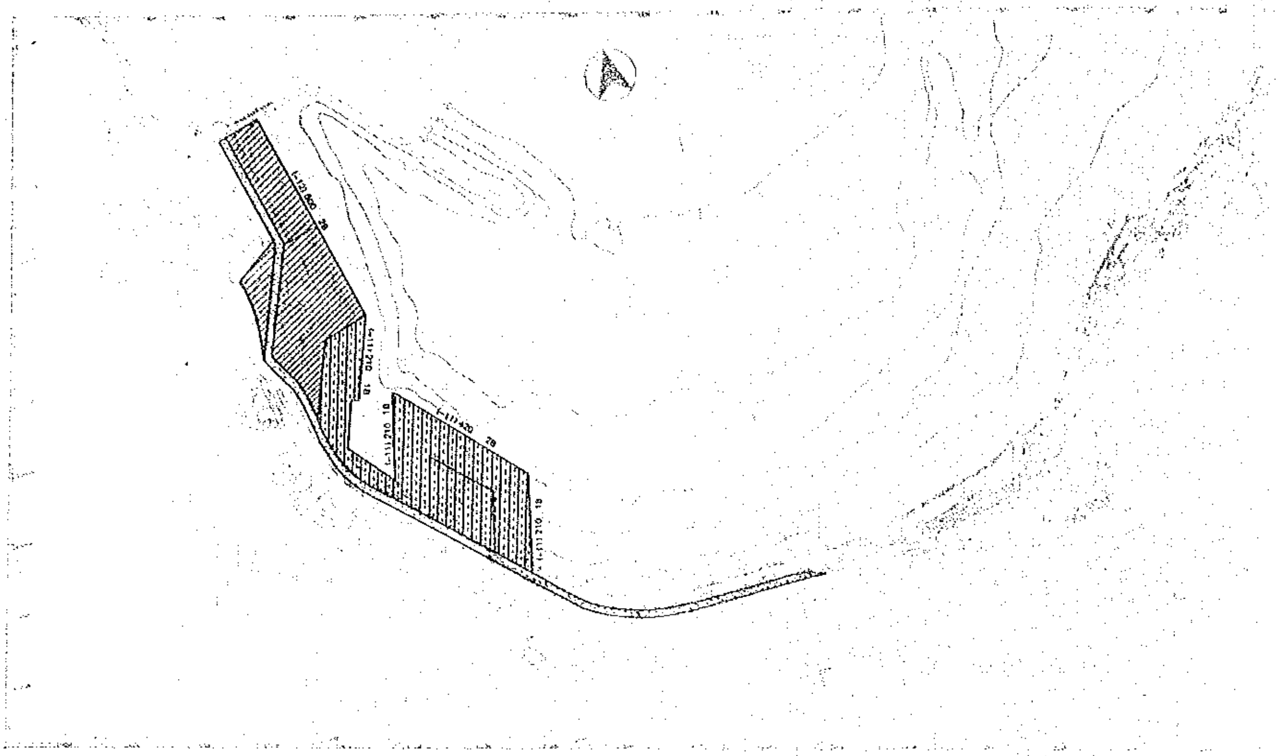


Fig. VII-2-1 Alternative 1



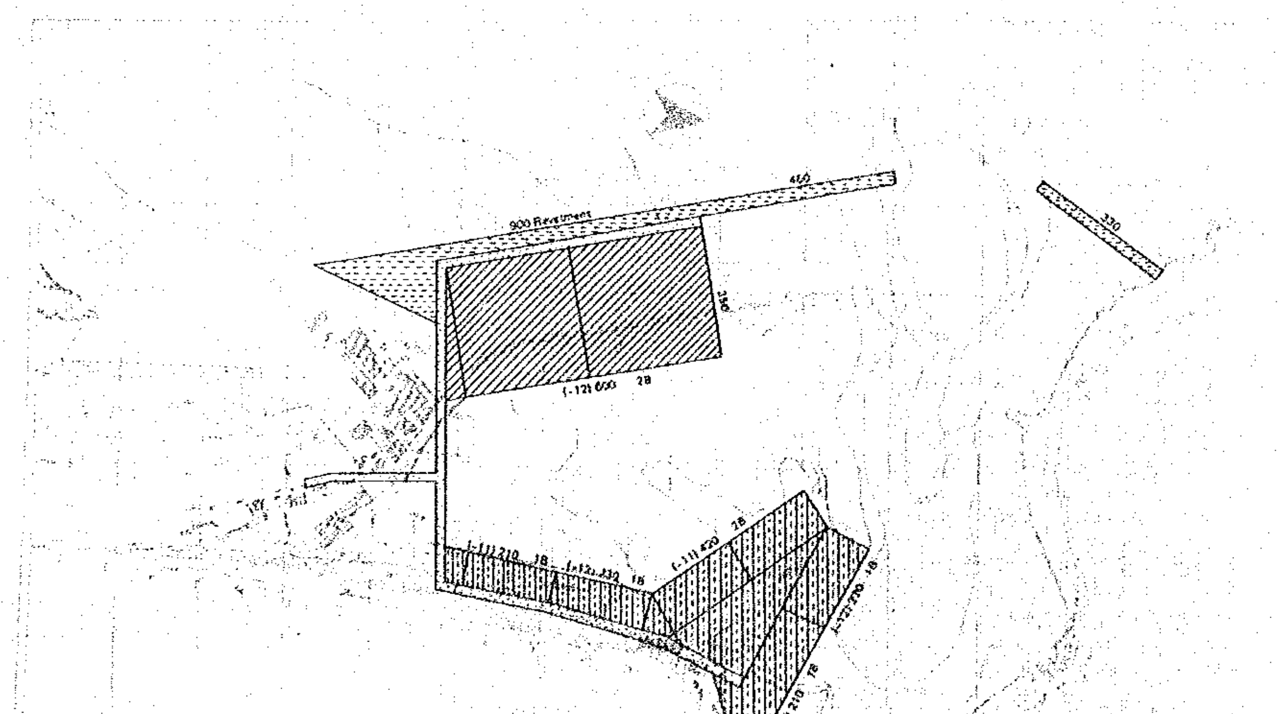


Fig. VII-2-2 Alternative 2

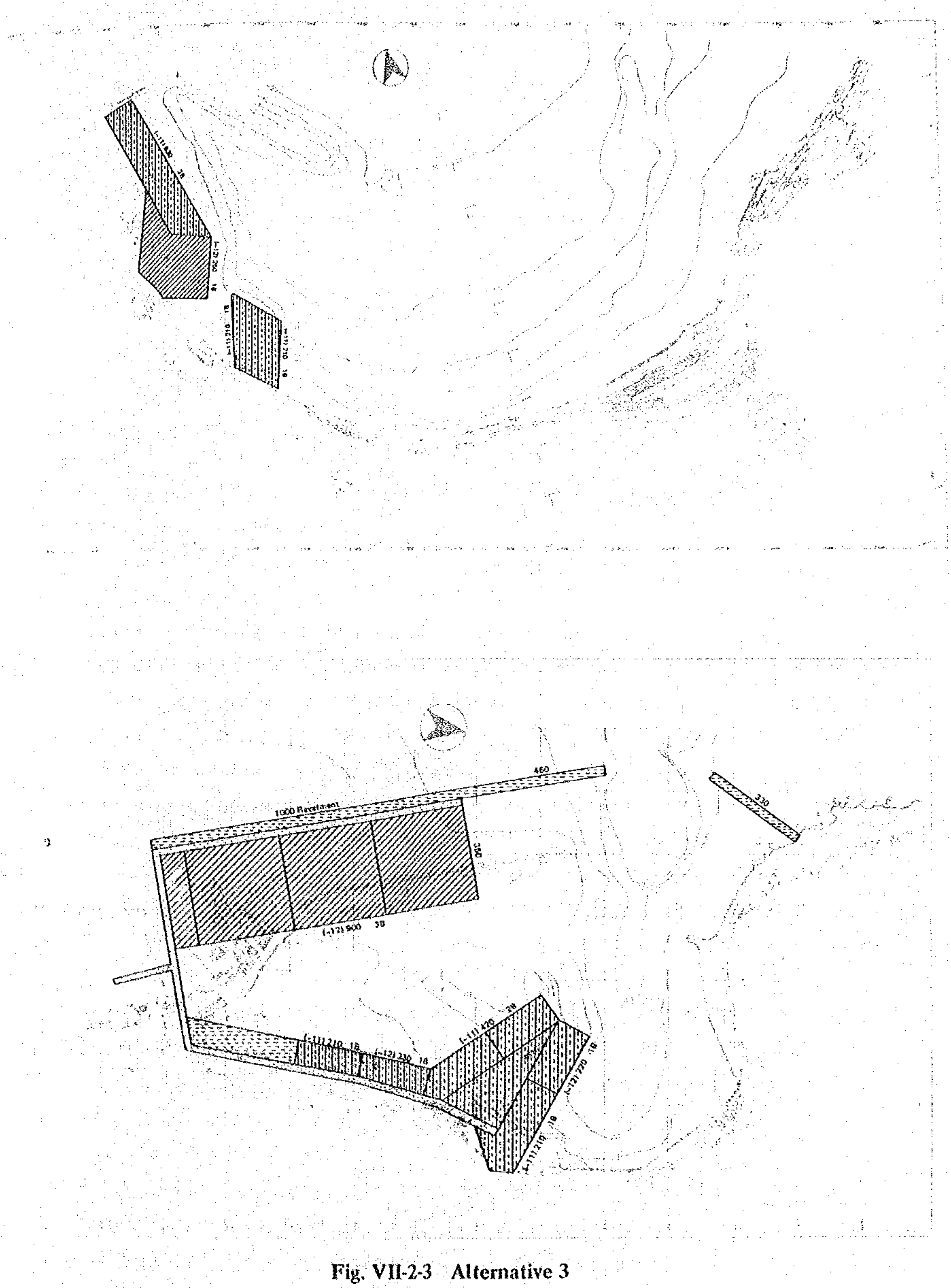


Fig. VII-2-3 Alternative 3

(3) Evaluation of the Alternative Plans

1) Least Cost Analysis

The results of the Least Cost Analysis which compares the total cost of the alternatives including harbour cost and inland transportation cost shows that Alternative 1 is the least expensive as shown in Table VII-2-3.

Table VII-2-4 Total Cost of the Alternatives

	Total Cost (million pesos)
Alternative-1	207,713
Alternative-2	229,053
Alternative-3	231,389

2) Natural Conditions

At San Antonio Port, it is difficult to shelter the harbour entrance from the southwesterly winds which are the prevailing winds because the port faces the Pacific Ocean directly and the existing navigation channel is located along a deep trench. On the other hand, the natural conditions at Valparaiso are superior: Valparaiso Port is located on the north side of Angeles cape, and so it is sheltered somewhat from the southwesterly waves which tend to be weak due to the diffraction effect.

It may be said that it would basically be impossible to provide the same service level at both of the ports. Due to the natural conditions, the calmness in the harbor area of San Antonio cannot be guaranteed.

3) Port Related Infrastructures and Established Port Functions

Container transport is mainly used for the transportation of general cargo, and thus it is of a purely commercial nature. Essentially, there is a strong need for well-established functions and facilities to support the transport of container cargoes.

To date, the port-related infrastructures and the port functions at San Antonio have not been developed to any considerable extent. Therefore, realistically, if a container terminal is constructed in San Antonio it will require a significant investment in port-related infrastructures to support the movement of container cargo.

Overall, there is already a well-established agglomeration of related commercial establishments around the port of Valparaiso, and thus the necessary investment to support a container terminal at Valparaiso would be relatively small.

4) The Preferences of Shipping Companies

One factor which is beyond the control of the port planners and the port authority is the preferences of regular shipping companies. Although shipping companies' main concern is the level of port charges, there are various other factors involved including maneuverability, time limitations, established shipping and distribution networks and a general intertia whereby shipping firms tend not to change their port of call without very strong motivating factors.

It can be said that at present, under the free competition system, San Antonio probably does not offer sufficient attraction for regular liner operators to use the port as a regular port of call.

Even if the facilities at Valparaiso Port were to remain just as they are at present and a full-fledged container terminal were built at San Antonio, it is more than likely that the majority of containers which are transported by regular liners would still concentrate at Valparaiso. Not providing sufficient facilities at Valparaiso might result in a reduced growth rate for container cargoes.

It must be remembered that this analysis primarily concerns regular liner vessels which must follow a schedule by calling at a limited number of ports on a regular basis.

(4) Conclusion

The results of the above analysis suggest that the container facilities should be concentrated at Valparaiso. In other words, Valparaiso should be considered as the base port for container cargoes for the region, and San Antonio should be considered as a secondary container port to supplement the activities of the base port. Based on this analysis, it seems that alternative 1 may be the best alternative.

However, the above analysis is carried out only from the viewpoint of port development planning. Other factors should be considered before determining the preferable plan. For example, overall, long-term regional economic plans must also be considered. To some extent, and given sufficient time and investment capital, cargo flow can be determined by governmental policy. Related development plans for urban development and overland transportation may all effect the final choice. Furthermore, the future plans and preferences of the private sector must also be considered. All of these factors should be considered synthetically before selecting the best alternative which, essentially, is a policy decision of the central Government.

VII-3 Alternativo Master Plans of the Port of Valparaiso

(1) Capacity of Present Facilities

In order to determine the required scale of the plan for future cargo traffic, it is necessary to figure the present capacity of the port. Port capacity is generally calculated in terms of the volume of cargo which can be handled.

Since port capacity varies according to the type of the cargo, size of the lot, size of the berth, method of loading and unloading, etc., it is often represented simply as the volume of cargo which can be handled at the entire port.

The present capacity of the port of Valparaiso was estimated by analyzing the relationship between the volume of cargo handled at each berth and the size of the berth, in terms of general cargoes and container cargoes. The values used for the analysis are 1984 data.

1) General Cargoes

(i) Cargo handling capacity of wharves

Some of the data related to the handling of general cargoes is shown below.

① Average loading/unloading capacity per ship
61 tons/hour (average number of gangs 3 gangs)

② Average actual hours worked per day 22.5 hours

③ Working days per year 347 days
From the rough analysis of calmness (degree of sheltering) drescribed in Chapter III, the rate of available working days is over 98% and it is assumed that rainy, foggy or another bad weather days account for another 10 days (about 3%). As cargo cannot be handled under these conditions, the number of days available for using berths is:

365 days x 0.95 = 347 days

④ Number of berths 6 berths

As noted in Chapter III, the berthing facilities in the port of Valparaiso comprise 10 berths. However, it is assumed that Baron Pier is not available under the present conditions. So, the number of berths are 6 berths for general cargo. Using these data, the present annual port capacity for general cargo is estimated as follows:

$$61 \times 22.5 \times 347 \times 6 = 2,850 \text{ thousand tons}$$

Assuming that the berth occupancy ratio is 100%, the port capacity is estimated as 2,850 thousand tons.

2) Containers

Some of the data related to the handling of containers is shown below.

①	Average loading/unloading capacity per ship	20 containers/hour (13 tons per container)
②	Ratio of empty containers	30%
③	Average actual hours worked per ship	22.5 hours
④	Working days per year	347 days
⑤	Number of berths	1.5 berths

Berths No.4 and No.5 are prepared as container berths. However, the total length of these two berths is 365 m, and this length is not sufficient for two full size container vessels.

Then, it is assumed that the present number of container berths is 1.5 berths.

Using these data, the present capacity for container cargo is estimated as below:

$$(20 \times 13) \times 0.7 \times 22.5 \times 347 \times 1.5 = 2,130 \text{ thousand tons}$$

3) Summary

As mentioned above, the port capacity is estimated assuming a berth occupancy ratio of 100%. However, this is not a realistic value. Table VII-3-1 shows the capacity based on the appropriate berth occupancy ratio and on a ratio near the upper limit. Assuming an appropriate berth occupancy ratio, the present port capacity is estimated as about 2,840 thousand tons.

Table VII-3-1 The Present Port Capacity by Berth Occupancy

('000 tons)

Type of Berth	Number of Berths	Capacity		
		Full	Appropriate	Near the Limit
General Cargo	6	2,850	(0.7) 1,990	(0.75) 2,140
Container	1.5	2,130	(0.4) 850	(0.5) 1,060
Total	7.5	4,980	2,840	3,200

Note: The figures in parentheses are the berth occupancy ratios.

(2) The Scale of the Master Plan

1) Container Wharf

(i) Determination of ship and berth size

The servicing conditions of container vessels in Chile are shown in Table VII-3-2. This table shows that the present size of holding ships for containers in Chile is not so large. According to shipping data at Valparaiso Port, 25,000 DWT class full container ships called at the port in 1985. (Refer to Table III-2-8).

Table VII-3-2 Characteristics of Container Ships in Chile

Name of Ships	Gross Tonnage	Dead Weight Tonnage	Length (m)	Maximum Draft (m)	TEU	Construction Year
Antofagasta	13,020	20,350	160.3	13.7	274	1970
CCNI Andino	4,999	7,954	126.3	6.5	580	1980
CCNI Atlantico	5,311	6,583	119.0	7.7	352	1977
Aconcagua	14,704	10,470	174.4	9.1	440	1972
Copiapo	16,911	15,098	174.4	9.4	440	1971
Imperial	16,911	14,499	174.4	9.4	440	1971

With the development of container transport, the worldwide trend is towards larger and faster container vessels. Container vessels of the 50,000 DWT and 3,000 TEU class are beginning service one after another.

The servicing condition of container vessels in Japan is shown in Table VII-3-3.

Table VII-3-3 Characteristics of Full-container Ships in Japan

Name of Ships	Gross Tonnage	Dead Weight Tonnage	Length	Maximum Draft	TEU	Construction Year
	tons	tons	m	m		
Hakusan Maru	23,602	22,935	209	10.52	1,198	1973
Hiei Maru	23,766	24,075	212.5	10.53	1,183	1972
Haruna Maru	16,214	19,620	187	10.52	851	1968
Hira Maru	24,794	24,344	214.6	10.52	1,072	1978
America Maru	31,854	32,207	222.5	11.61	1,676	1982
Shin Kashu Maru	31,012	28,615	222.5	11.0	1,450	1981
Beishu Maru	23,668	24,191	212.5	10.52	1,183	1970
Hikawa Maru	24,770	23,514	214.6	10.52	1,277	1974
Hotaka Maru	21,057	20,400	196	10.52	977	1970
Kiso Maru	38,540	31,771	261.2	11.73	1,836	1972
Yashima Maru	35,480	31,310	245.9	11.03	1,730	1976
Australia Maru	24,044	23,304	213	10.52	1,166	1969

Considering the worldwide trend, we assume a design standard of 30,000 DWT class ships for the container berth. The dimensions of a berth capable of accommodating such vessels are given below.

Table VII-3-4 Dimensions of Proposed Container Berth

Kind of Berth	Ship Size	Size of Berth	
		Length	Water Depth
	D.W.T.	m	m
Container Berth	30,000	300	12.0

(ii) Number of berths

i) For the planning method considering frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of container cargoes handled in 2010 is 3,084 thousand tons.

② The per-container cargo volume is 14 tons.

③ The handling capacity of container cranes is 25 boxes per hour. The working efficiency is assumed to be 0.8 considering possible time waste in using the container cranes and cargo handling by outside vessels.

④ The per-berth number of container cranes is 2.

⑤ The operating hours of the container cranes are 22.5 hours a day.

⑥ It is assumed that the per-ship number of loaded containers that are loaded or unloaded is 300. The 300 per ship figure is forecast based on the current handling patterns of containers at the port. It is said that the average number of loaded containers per ship is presently 183 to 300. The ratio of empty containers to loaded containers is 30%.

So, the per-ship number of containers to be handled is forecast as 390.

⑦ The number of days available for using berths is 347 days per year. The cargo handling hours per day are assumed to be 22.5 hours.

⑧ Days necessary for purposes other than cargo handling are presumed to be 0.2 days per ship.

Based on the above assumptions, the necessary number of container berth in 2010 is calculated as follows:

$$\text{Total number of containers in 2010} = \frac{3,084,000}{14} \times 1.3$$

$$= 286,400 \text{ boxes}$$

$$\text{Number of calling ships} = \frac{286,400}{390}$$

$$= 735 \text{ ships}$$

$$\text{Per-ship average days of mooring} = \frac{390}{22.5 \times 25 \times 2 \times 0.8} + 0.2$$

$$= 0.63 \text{ days}$$

$$\text{Total number of mooring days} = 735 \text{ ships} \times 0.63 \text{ days}$$

$$= 463 \text{ ship·days}$$

The berth utilizing ratio is calculated by substituting suitable numbers as the number of berths. Table VII-3-5 shows the results.

Table VII-3-5 Berth Utilizing Ratio by Number of Berths

Number of Berths	Berth Utilizing Ratio	Estimate
2	0.68	△
3	0.44	○
4	0.33	×

Thus, by the method considering frequency of ship entry and handling capacity, the number of berths required as container berths is 2 or 3.
For reference, the number of containers per unit quay length in Europe and Japan and an outline of major container berths in Japan are presented in Fig. VII-3-1 and Table VII-3-6.

(iii) Size of the container terminal

The container terminal consists of the following facilities other than the quaywall.

① Container Yard
② Container freight station
③ Maintenance shop
④ Administration office
⑤ Cargo handling equipment

The size of these facilities varies according to the cargo handling system. There are three major cargo handling systems, that is the chasis system, the straddle carrier system and the transfer crane system. In addition to these systems, some container cargoes are handled by forklift.
Each system has its own pros and cons. In deciding on one system or another, it is necessary to make a full study of the land requirements and handling volume at the port.
In calculating the area of the container terminal, it is assumed that the transfer crane system which is recommended in Chapter XI is adopted.

The required ground slots of containers can be calculated using the following formula:

$$GS = \frac{NC \times CS}{t \times n \times WD}$$

Where, GS : Number of ground slots of containers (TEU)
NC : Number of containers handled per year (TEU)

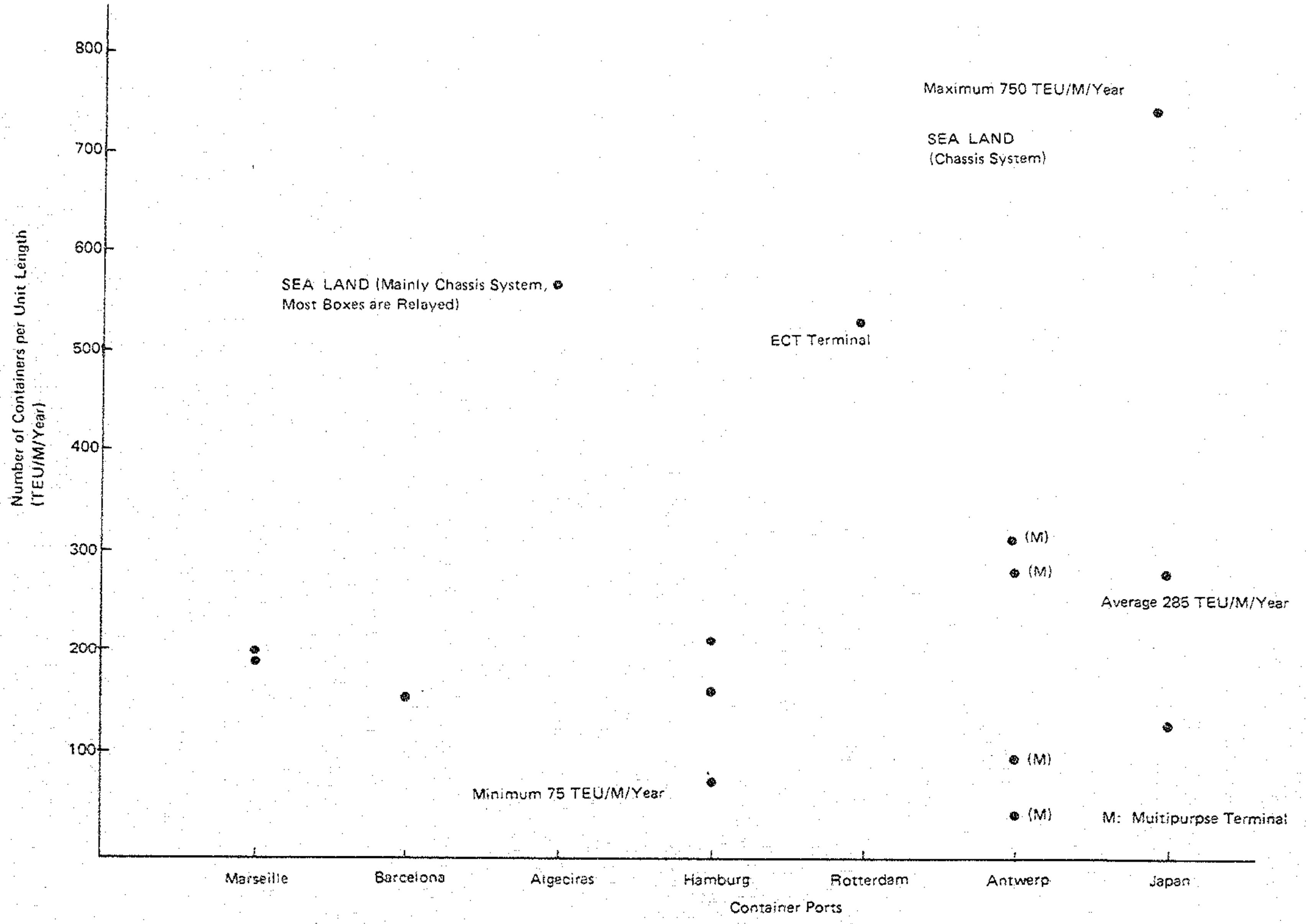


Fig. VII-3-1 Number of Containers (TEU) per Unit Quay Length
Handled by Container Terminals in the Principal Container Ports in Europe and Japan in 1983

Table VII-3-6 Outline of Major Container Berths in Japan

Port	Name of Terminal	No. of Berths	Management Body	Lessee(s)	Size of Container Terminal: Total length of Berths	Water Depth of Berths	Total Area of Teminals	No. of Gantry Cranes	Container Cargo Volume Handled in 1983	Remarks
Tokyo	Ohi 1,2	2	Tokyo Port Development Corporation	K line	530 m	12 m	21.5 ha	4	900 (thousand F/T)	
	" 3,4,5	3	"	Mitsui-OSK Lines	850	12	31.5	6	3,660	
	" 6,7	2	"	N Y K	600	12	22.2	4	3,700	
	" 8	1	"	Japan Line YS Line	300	12	11.1	2	1,410	
Yokohama	Honmoku A-5,6	2	Yokohama Port Development Corporation	Sea-Land Service	600	12	22.1	2	3,660	
	" A - 7	1	"	N Y K	250	12	8.1	2	1,440	
	" A - 8	1	"	K Line	250	12	8.3	2	580	
	Daikoku - 1	1	"	YS Line	300	12	10.5	2	830	
	" 2	1	"	N Y K	300	12	10.5	2	660	
	Honmoku Jetty D - 4	1	"	A P L	300	13	10.5	2	-	Opened on Nov. 27 1984
Nagoya	Kinjo	3	Nagoya Container Berth Co., Ltd.	Japan's Big Six Shipping Firms	850	12	26.6	5	3,100	
Osaka	South Port - 1	1	Osaka Port Development Corporation	K Line	250	12	7.7	2	350	
	" 2	1	"	Mitsui-OSK Lines	250	12	7.5	2	550	
	" 3, 4	2	"	K Line	550	12	16.5	4	1,660	
	" 5	2	"	N O L	300	12	10.5	2	2,170	
Kobe	Port Island - 1	1	Kobe Port Development Corporation	Sea-Land Service	300	12	10.4	2	4,070	
	" 2	1	"	YS Line Japan Line	300	12	10.5	2	1,410	
	" 3, 4	2	"	N Y K	600	12	21.0	4	3,020	
	" 5	1	"	A P L	250	12	8.4	2	1,530	
	" 6	1	"	U S L	300	12	9.0	2	660	
	" 7	1	"	Mitsui-OSK Lines	300	12	9.8	2	1,860	
	" 8, 9	2	"	Mitsui-OSK Lines	600	12	20.3	4	2,830	
	" 10	1	"	YS Line	300	12	7.9	2	1,220	
	" 11	1	"	N Y K	350	12	8.5	2	800	
	" 12	1	"	K Line	350	12	8.1	2	930	

CS : Days of containers' stay in terminal (storage period)

t : Number of stacking tiers (stacking height) for rubber tired transfer crane

n : Net stacking container ratio exclusive of operational allowance for slot availability due to reservation, shifting or congestion

WD : Annual working days, 330 days.

Table VII-3-7 Values of CS, t and n

	Handling mode of Containers	CS	t	n
a.	Import FCL (by rail and road)	4	3	0.9
b.	Import LCL (")	4	3	0.9
c.	Export FCL (")	7	2.5	0.9
d.	Export LCL (")	7	2.5	0.9
e.	Empty containers	4	3	0.9

As for days container stay in the terminal (the storage period), the ratio of cargo with a storage period less than or equal to 7 days is 80 - 90% in Japan. It is assumed that storage period is 7 days for export containers and 4 days for import containers, considering the actual flow of container cargo in Chile.
In the case of the transfer crane system, in general the number of stacking tiers is 3 tiers for import containers and 2.5 tiers for export containers.

Table VII-3-8 shows the number of containers in 2010.

Table VII-3-8 Number of Containers in 2010

	Import	Export
Container Cargo Volume	1,997,000 tons	1,087,000 tons
Per-Container Cargo Volume	14 tons	
Number of Containers	143,000(200,000 TEU)	77,700(109,000 TEU)
Number of Empty Containers	66,200 (92,700 TEU)	

From the above conditions, the number of container ground slots is calculated as follows:

① Import containers

$$GSa = \frac{200,000 \times 4}{3 \times 0.9 \times 330} = 898 \text{ TEU}$$

② Export containers

$$GSb = \frac{109,000 \times 7}{2.5 \times 0.9 \times 330} = 1,028 \text{ TEU}$$

③ Empty containers

$$GSc = \frac{92,700 \times 4}{3 \times 0.9 \times 330} = 416 \text{ TEU}$$

Total ground slots: GSt = GSa + GSb + GSc
= 2,342 TEU

It is assumed that the required ground area per slot is 35 m^2, and the required ground area for containers is 82 thousand m^2 (2,342 TEU x 35 m^2).

Considering the peak ratio of 1.3, the required area will be about 107 thousand m^2. As the berth length is 300 m, the width of the container yard will be about 119 m.

The container terminal will require various facilities and the necessary width of each facility is as follows:

Width of Apron: 40 m

C.F.S., control office, etc.: 70 m

Separate Road: 20 m

Area for Transhipment by Unit Train: 40 m

Fig. VII-3-2 shows a layout of a standard terminal based on the above assumptions.

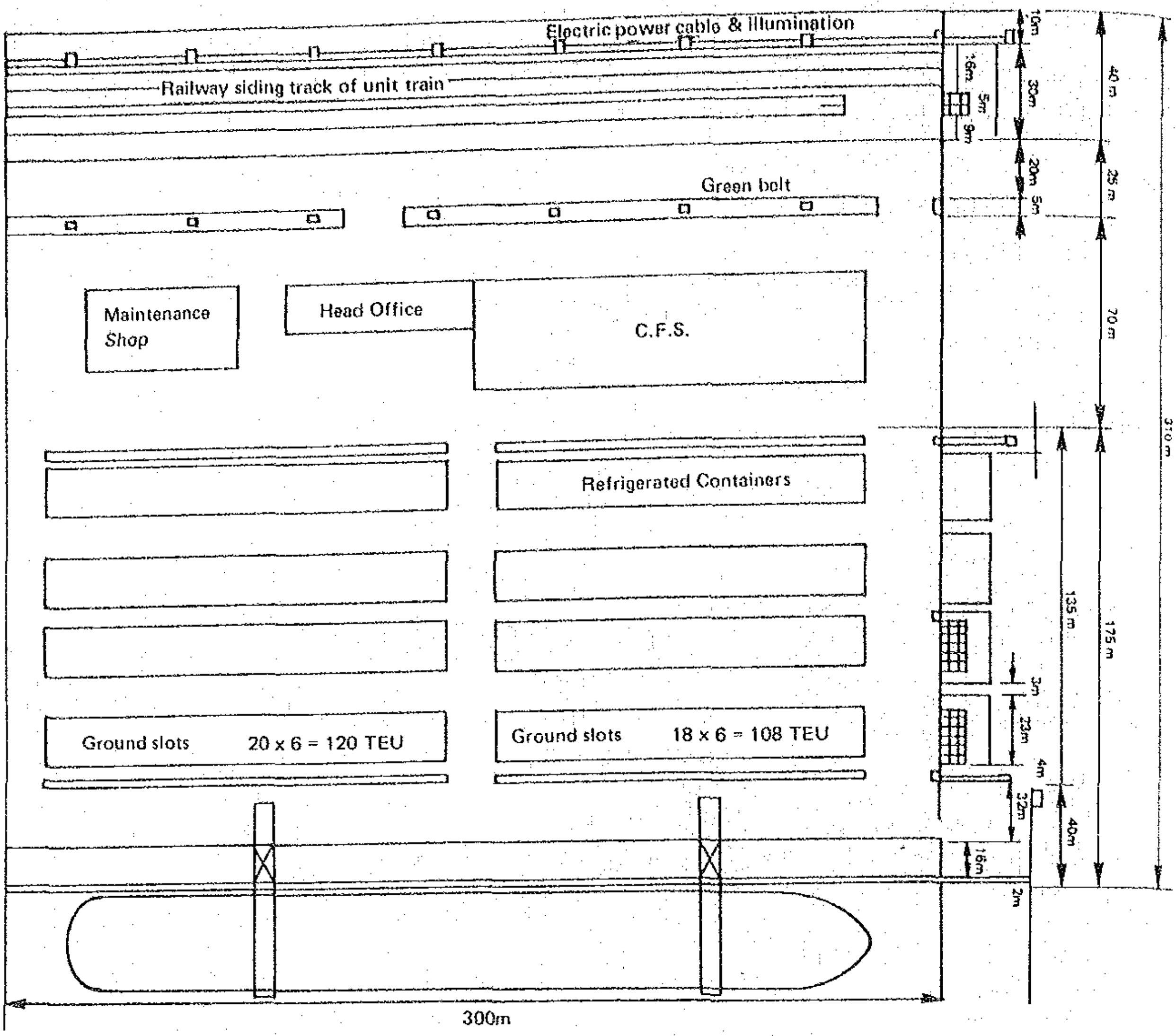


Fig. VII-3-2 Layout of Container Terminal

(2) General Cargo Wharf

1) Determination of ship and berth size

At Valparaiso Port, from 1981 to 1985, more than 95 percent of conventional cargo ships were smaller than 20,000 DWT. Of this figure, about 75 percent were from 10,000 to 20,000 DWT. (Including refer ships, this figure is about 56 percent). (Refer to Table III-2-8).

The majority of ships transporting general cargo in the world are of the 15,000 to 20,000 DWT class. The nature of transport cargo being what it is, the rapid emergence of inordinately large ships is unthinkable.

Under these circumstances, 20,000 DWT class conventional ships, mainly regular liners, will be the ships which the general cargo wharf at Valparaiso Port will accommodate.

The dimensions of the proposed general cargo berths are shown in Table VII-3-9.

Table VII-3-9 Dimensions of Proposed General Cargo Berths

Type of Berth	Ship Size (DWT)	Size of Berth	
		Length (m)	Water Depth (m)
General Cargo Berths	20,000	210	11.0

2) Required Number of Berths

For calculating by the method considering the frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of general cargoes handled in 2010 excluding containerized cargoes is 1,753 thousand tons.

② The average cargo handling capacity per ship to 100 tons/hour·crew. A working efficiency of 0.8 is presumed considering unavoidable waste of time.
The 100 tons/hour figure is assumed based on the actual handling volume of 85 tons/hour in 1985.

③ For general cargo, the average per ship loading/unloading volume is 3,000 tons.
The 3,000 tons per ship loading/unloading volume is forecast based on the actual five year average of loading/unloading volume per ship.

④ The number of days available for using berths is 347 days per year.
The number of hours that cargo is handled per day is assumed to be

22.5 hours per day.

⑤ Days necessary for purposes other than cargo handling are presumed to be 0.2 days per ship.

Based on the above assumptions, the necessary number of general cargo berths (for foreign trade) in 2010 is determined as follows:

$$\text{Number of calling ships} = \frac{1,753,000}{3,000}$$

$$= 584 \text{ ships}$$

Per ship average days of mooring

$$= \frac{3,000}{22.5 \times 100 \times 0.8} + 0.2$$

$$= 1.9 \text{ days}$$

Total number of mooring days

= 584 ships x 1.9 days

= 1,110 ship·days

The berth occupancy ratio is calculated by substituting suitable numbers as the number of berths. Table VII-3-10 shows the results.

Table VII-3-10 Berth Occupancy Ratio by Number of Berths

Number of Berths	Berth Occupancy Ratio	Estimate
4	0.80	△
5	0.64	○
6	0.53	×

Thus by the method considering the frequency of ship entry and handling capacity, the number of berths required as general cargo berths is 4 or 5.

3) Cargo handling and storage facilities

The size of cargo handling and storage facilities including storeyards, transit sheds and warehouses must be determined according to the types, volume, and handling conditions of cargoes.

Table VII-3-11 shows the movement of general cargo at the port of Valparaiso in 1985.

Table VII-3-11 Movement of General Cargo

(Unit: %)

	Direct	Indirect	
		Storage Facility	Storage Yard
Fruit and Other General Cargo	69.5	27.5*	3.0*
		30.5	

* Assumption based on the available data

Source: EMPORCHI

For the port of Valparaiso, facilities are planned assuming that 30% of the general cargo (except fruits cargo) passes through transit sheds and 10% of fruits cargo passes through open storage yards, and the remaining 60% of general cargo and 90% of fruits cargo are handled directly.

In 2010 the volume of cargoes passing through transit sheds is about 350 thousand tons and the volume of cargoes passing through open storage yards is about 160 thousand tons.

(i) General cargo transit sheds

The necessary area of transit sheds is determined by the following formula:

$$A = \frac{N}{R\alpha W}$$

A: Necessary area of transit sheds (m^2)

N: Annual volume of cargoes handled: 350 thousand tons

α: Utilization rate: 0.6

R: Turnover of transit sheds: 24 times a year

W: Volume of cargoes per unit area: 1 t/m^2

Table VII-3-12 Required Area of Transit Sheds

Volume of cargo handled N (thousand tons)	Annual storage volume RαW (tons/m^2)	Required area N/RαW (m^2)
350	14.4	24,000

(ii) Open Storage Yards

The necessary area of the open storage yards is determined by the following formula:

$$A = \frac{N}{R\alpha W}$$

A: Necessary area of open storage yards (m^2)

N: Annual volume of cargoes handled: 160 thousand tons

α: Utilization rate: 0.7

R: Turnover of the open storage yards: 24 times a year

W: Volume of cargoes stacked per unit area: 1 t/m^2

Table VII-3-13 shows the necessary size of the open storage yards.

Table VII-3-13 Required Area of Open Storage Yards

Volume of cargo handled N (thousand tons)	Annual storage volume RαW (tons/m^2)	Required area N/RαW (m^2)
160	16.8	10,000

4) Estimate of the Number of Berths Using the Method of Simulation by Queuing Theory

The main aims of using the simulation tests are to evaluate port operation efficiency in terms of (A) port congestion and ship waiting time, and (B) the influence of ship arrival irregularity and berthing time irregularity. The results of such simulations are more appropriate than the estimates based only on the berth allotment method making use of the simple berth occupancy ratio.

As shown in Table VII-3-14, two cases of simulation tests based on different numbers of berths in the year 2010 have to be carried out.

Table VII-3-14 Two Simulation Test Cases

(Unit: berths)

Type of Cargo	Case-1	Case-2
General Cargo	5	4
Container	3	2
Total	8	6

(i) Simulation cases

In order to determine the appropriate number of berths required in 2010, the following matters have to be examined by the simulation tests.

① Is the number of berths required as general cargo berths 5 or 6 ?

② Is the number of required as container berths 2 or 3 ?

(ii) Premises for the simulations

The simulation tests for these cases are carried out under the following assumptions:

① Ships can enter and leave at any time.

② Service time is estimated by the type of cargo and a per-ship cargo volume based on the cargo handling capacity in 2010 shown in Table VII-1-3.

③ General cargo ships use general cargo berths and container ships use container berths in principle.

(iii) Input data

The following Table VII-3-15 shows the simulation test input data by each case and type of berth.

Table VII-3-15 Simulation Input Data

Type of Berth	Number of Berths	Rank of Ship Size ('000 DWT)	Number of Ships	Service Time (hours)
General Cargo	5 (4)	∿ 5	27	24.0
		5 ∿ 10	38	34.0
		10 ∿ 20	285	42.1
		20 ∿ 30	31	47.8
Refer		∿ 10	136	41.5
		10 ∿ 20	58	49.0
Container Cargo	3 (2)	∿ 10	183	7.3
		10 ∿ 20	257	13.0
		20 ∿ 30	295	18.5

(iv) Simulation test results

The results of the simulation tests are shown in Table VII-3-16.

Table VII-3-16 Results of Simulation Tests

	Case-1				Case-2			
	Average Berth Occupancy Ratio	Ship Waiting Ratio (%)		Per Ship Waiting Time (hours)	Average Berth Occupancy Ratio	Ship Waiting Ratio (%)		Per Ship Waiting Time (hours)
		Waiting ships to ship entry	Waiting time to mooring time			Waiting ships to ship entry	Waiting time to mooring time	
General Cargo	0.64	21.3	7.9	3.2	0.79	45.6	34.1	[illegible]
Container	0.47	15.4	7.6	1.0	0.53	48.0	50.1	[illegible]
Total				2.3				[illegible]

The output data of the simulation tests include the berth occupancy ratio, the ratio of the number of waiting ships to ship entry, the ratio of waiting time to mooring time and the waiting time per ship.

In order to propose the optimum plan as the Master Plan, the following criteria are considered.

① The berth occupancy ratio should be 0.4 - 0.7.

② The desirable ratio of waiting time to mooring time is 10% or less.

③ The desirable waiting time per ship is less than half a day, with a maximum of one day.

Judging from these criteria, Case-1 selected as the most appropriate plan.

(3) Port Traffic Facilities

1) Port Roads

(i) Modal Split

Table VII-3-17 indicates the planned annual cargo handling tonnage in the year 2010 for the port and industrial complex and also indicates the cargo shares handled by road and rail transport estimated in Chapter VI.

Table VII-3-17 Forecast Traffic Volume by Transport Mode

('000 type)

	Inward			Outward			Total		
	Road	Rail-way	Total	Road	Rail-way	Total	Road	Rail-way	Total
Conventional Cargo	932	215	1,147	493	91	584	1,425	306	1,731
Container	797	287	1,084	1,790	178	1,968	2,587	465	3,052
Total	1,729	502	2,231	2,283	269	2,552	4,012	771	4,783

(ii) Method

Planned traffic volume has been estimated using the equation presented below. This equation is an empirical formula that is used in drawing up master plans for Japanese port projects.

This formula permits a simple forecast of the traffic volumes generated by a port and industrial complex from a macroscopic viewpoint, so it is especially useful for long-term port plans.

$$\text{Planned traffic volume (vehicles/hr)} = N \times \frac{1}{W} \times \frac{\alpha}{12} \times \frac{\beta}{30} \times \frac{1 \times \delta}{\varepsilon} \times \gamma$$

(Equation VII-1)

where, N: Annual cargo volume (t)

w: Average tonnage/truck

α: Monthly variation (peak month/ordinary month)

β: Daily variation (peak day/ordinary day)

δ: Rate of related vehicles (Related vehicles/all trucks)

ε: Loading rate (loaded trucks/all trucks)

γ: Hourly variation (generated traffic volume of peak hour/generated traffic volume of peak day)

It is assumed that by the year 2010, values for α, β, δ, ε, will be close to the values found in Japan, and values for w and γ are adopted based on the actual data. Therefore, the following values are employed.

$w = 20.5$ (In case of containers: $w = 13.9$)
$\alpha = 1.2$, $\beta = 1.4$, $\delta = 0.5$, $\varepsilon = 0.5$, $\gamma = 0.17$

The equivalent passenger car units are assumed to be 3.78. This figure is from the actual data from the Multi-modal Corridor study.

(iii) Estimated Traffic Volume

The total traffic volume generated by conventional cargo is 625 trucks and that generated by container cargo is 1,674 trucks in 2010 as shown in Table VII-3-18.

Table VII-3-18 Estimated Traffic Volume and Required Number of Lanes

	Transported Cargo Volume ('000 tons)	Total Transported Traffic (Veh/hr)	Required Number of Lanes
Conventional Cargo	1,425	625	2
Container	2,587	1,674	4
Total	4,012	2,299	4

Note: The required number of lanes is calculated on a capacity of 650 trucks per hour per 2 lanes.

(iv) Design of the Road Sections

The port roads will accommodate a large number of heavy trucks. To accommodate these heavy trucks, the width of each lane is 3.5m and the shoulders are 2.5 m wide so they can be used for parking when necessary.

Workers and visitors travelling to and from the port area will primarily travel by bicycle or on foot. Thus, an appropriate sidewalk or bicycle path should also be prepared with a width of 2.5 m. The designs of the proposed road sections are presented in Fig. VII-3-3 for 2 lanes and Fig. VII-3-4 for 4 lanes. The total width of the 2-lane road is 17 m.

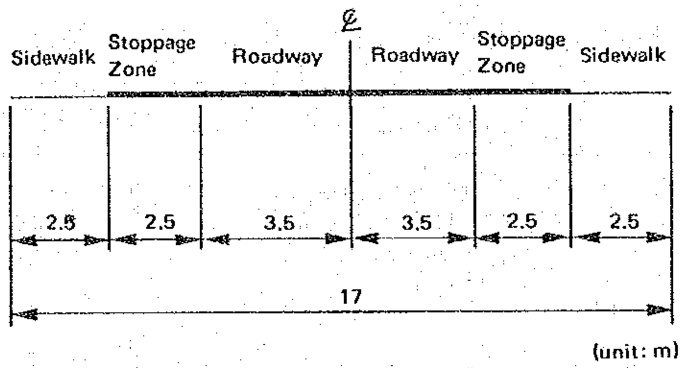


Fig. VII-3-3 Cross Section of Port Roads (2 Lanes)

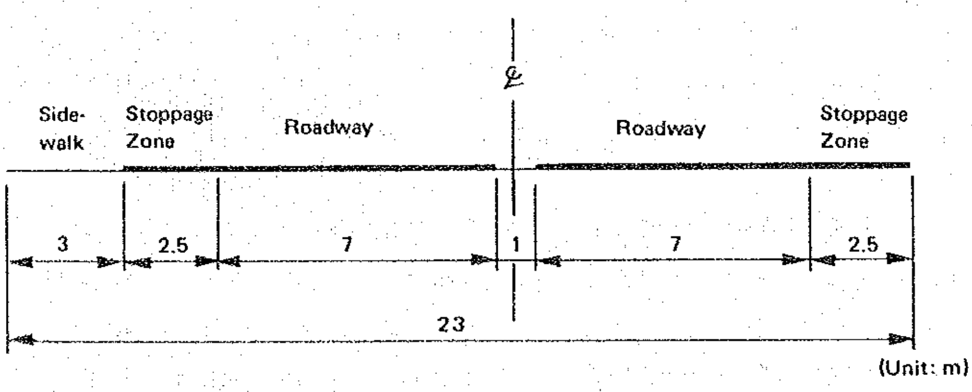


Fig. VII-3-4 Cross Section of Port Roads (4 Lanes)

2) Port Railway

The primary cargoes for railway transportation are containers and general cargo, and the total estimated traffic volume by railway is about 770 thousand tons in 2010 as shown in Table VII-3-19. Then, it may be necessary to arrange a railway siding behind the container berth and in the yard behind the transit sheds at some general cargo berths.

Table VII-3-19 Forecast Traffic Volume by Railway at the Port of Valparaiso

('000 tons)

Commodity	Forecast Traffic Volume
Container	466 (15%)
General Cargo	258 (19%)
Copper	42 (20%)
Total	766

Note: Figures in parentheses are the share of the total volume for each type of cargo

(4) Alternative Layout Plans

1) Concept for Preparing Alternative Plans

In order to prepare master plans, it is necessary to consider the following items in addition to the basic concept for the master plan discussed in Chapter IV.

(i) Relation with existing port facilities
Since the present port activities should not be interrupted during the construction of new port facilities, the negative effects on the present port facilities must be minimized. For this reason, the new plan should ideally take place in an area which is, by and large, separate from existing port facilities and activities. However, it is not feasible to develop new facilities in an entirely separate area considering natural and economic

conditions. Therefore, it is necessary to carefully consider the utilization of existing port facilities and substitute facilities during the development work.

(ii) Relation with neighboring city districts

In Valparaiso port, the port district is located adjacent to urban areas. Usually, it is necessary to establish a buffer zone between port facilities and the existing city district in order to maintain or improve the overall environment of the city. However, it is difficult to establish such a buffer zone at this port, and, for the same reason, the reclamation area will be minimized.

Another way to prepare space for port related facilities such as warehouses, businesses and industry is through redevelopment of the existing city districts near the port.

2) Alternative Master Plans and Rationales for Each Plan

The alternative master plans are termed A, B, C and D as shown in Fig. VIII-3-5 - 8.

Special considerations have been made in preparing each alternative plan, as outlined below.

i) Plan A

This plan is consistent with "Zoning Plan B" presented in the progress report. The container berths are located west of Baron pier and the general cargo berths are located at existing berths number 1 - 8.

As for the general cargo berths, a slip between berths number 4, 5 and 6 is reclaimed to obtain the area for the stockyard. For the container yard, it is necessary to utilize the area for FF.CC.

In order that the construction of the container terminal and the actual services begin as soon as possible, and so that the initial work and the initial investments be kept as small as possible, existing berth number 8 and the adjacent new berth are utilized as container berths.

The prominent feature of the plan is the location of the container wharves, narrowing the water area inside the port which would become difficult to control the traffic from the port via the access road.

ii) Plan B

Plan B is similar to Plan A. In order to obtain a sufficient stockyard for containers, the container berths are located east of Baron Pier.

This plan resolves the future traffic problem by linking the port with the new access road which is planned east of Valparaiso city. This plan would permit future development of the port after the year 2010.

iii) Plan C

This plan is consistent with "Zoning Plan A" presented in the progress report. The container berths are located at existing berths number 1 - 7 and the general cargo berths at existing berth number 8 and in the adjacent water area. Recreation areas such as a marina and parks, and the urban area are located around Baron Pier in accordance with the removal of the "PUERTO" station.

For the container berths, the city district behind existing berth number 1 - 3 is redeveloped to obtain the area for the container stockyards.

The prominent feature of this plan is the overall location of the entire port facilities, congesting both ship and road traffic.

Under this plan, it would be difficult to navigate vessels and to control road traffic in the future.

iv) Plan D

This plan is basically the same as plan C. The main difference is that the hill behind existing berth No.1 would not be cut.

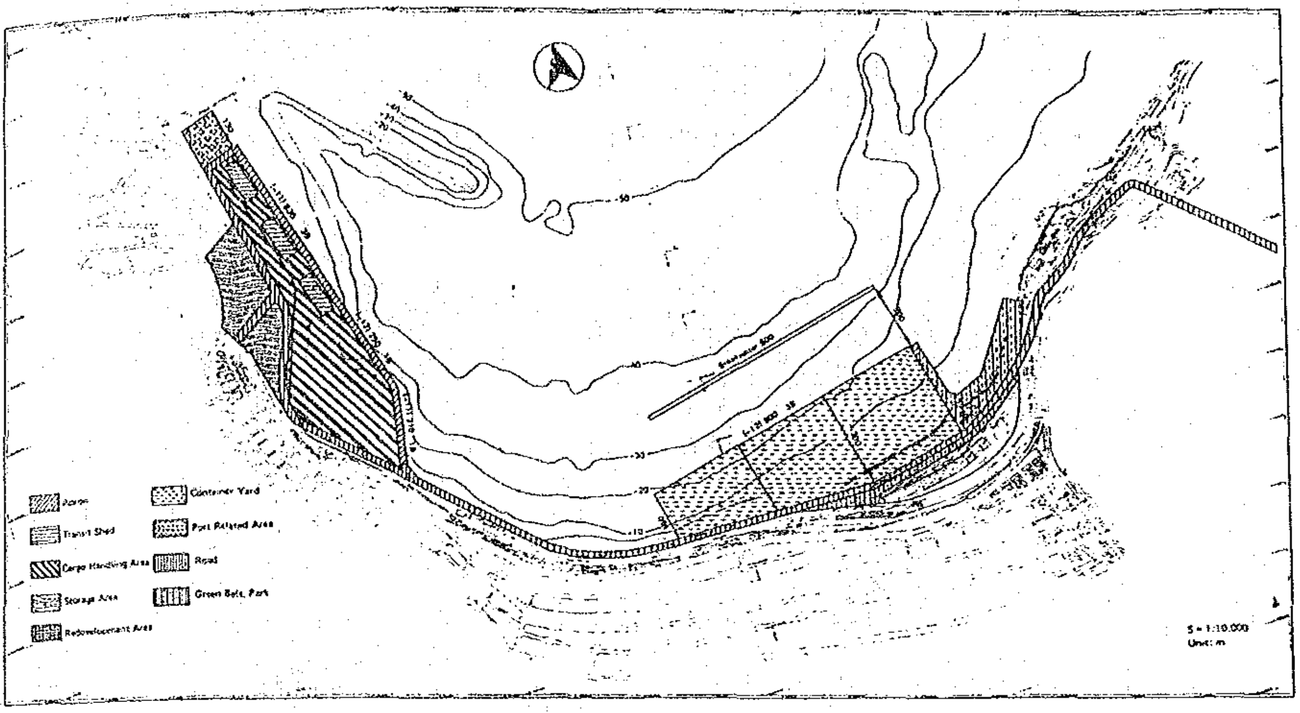


Fig. VII-3-5 Master Plan of Valparaiso Port (2010) Plan A

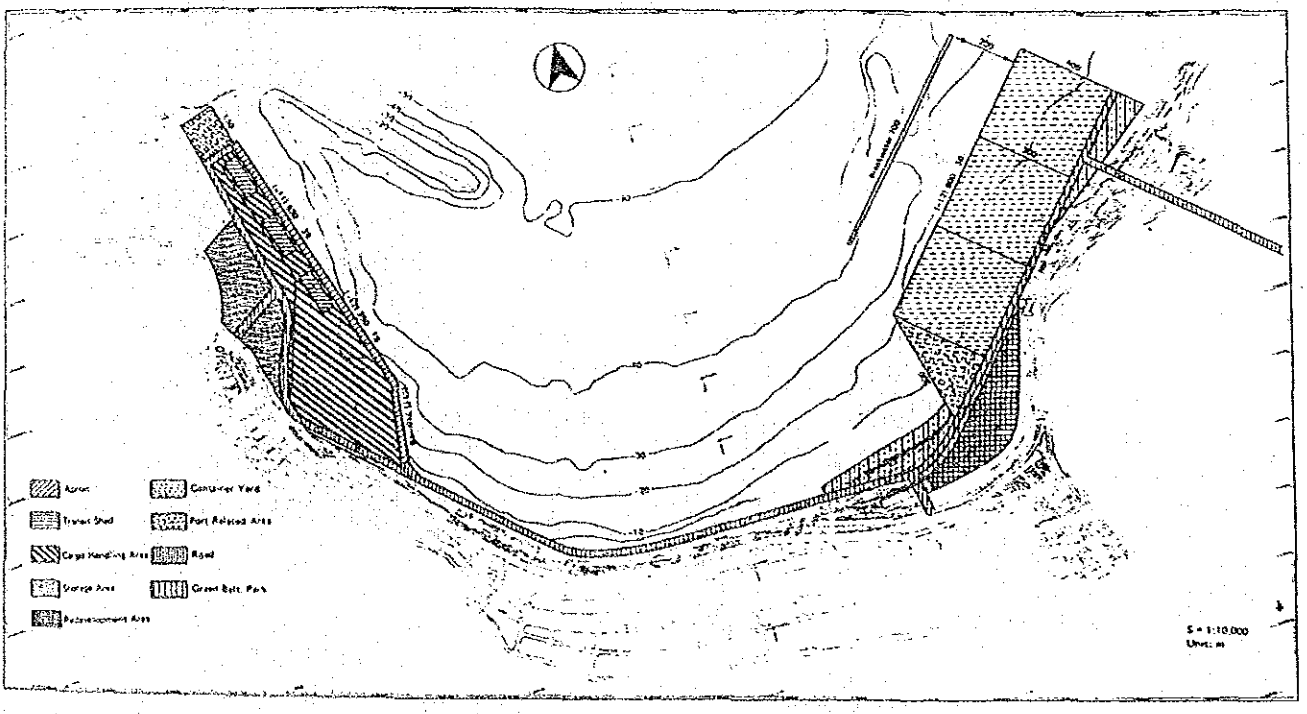


Fig. VII-3-6 Master Plan of Valparaiso Port (2010) Plan B

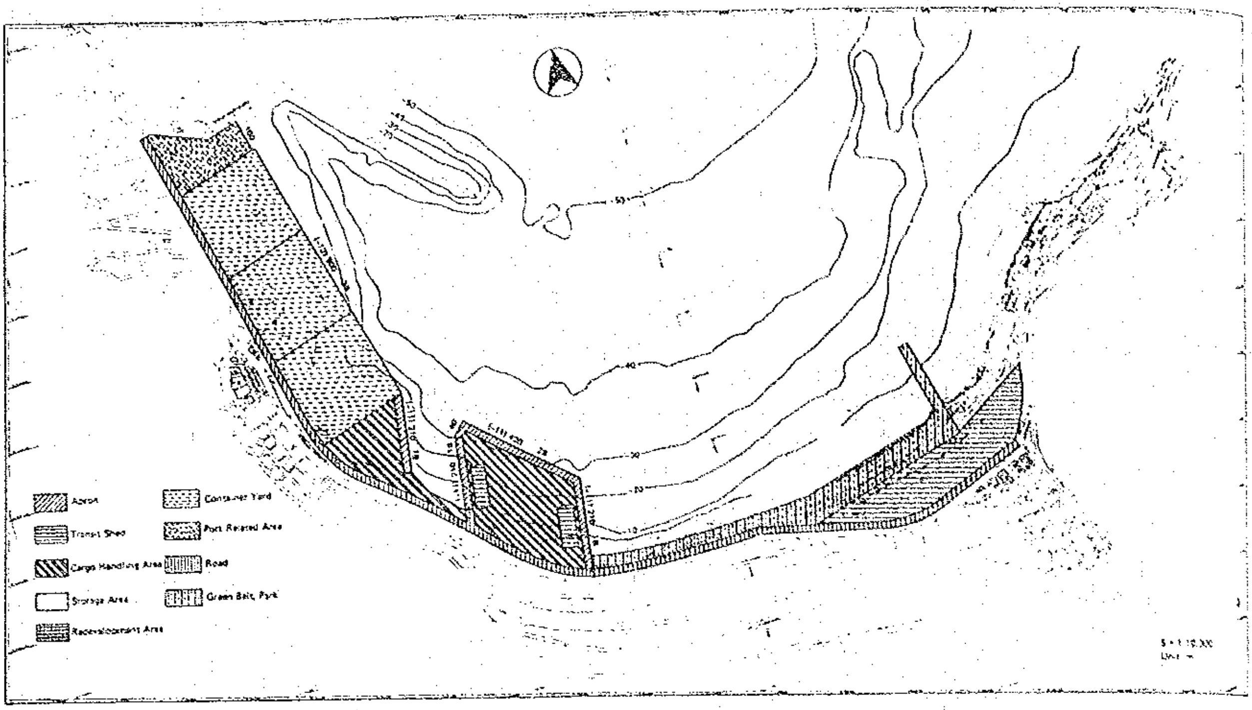


Fig. VII-3-7 Master Plan of Valparaiso Port (2010) Plan C

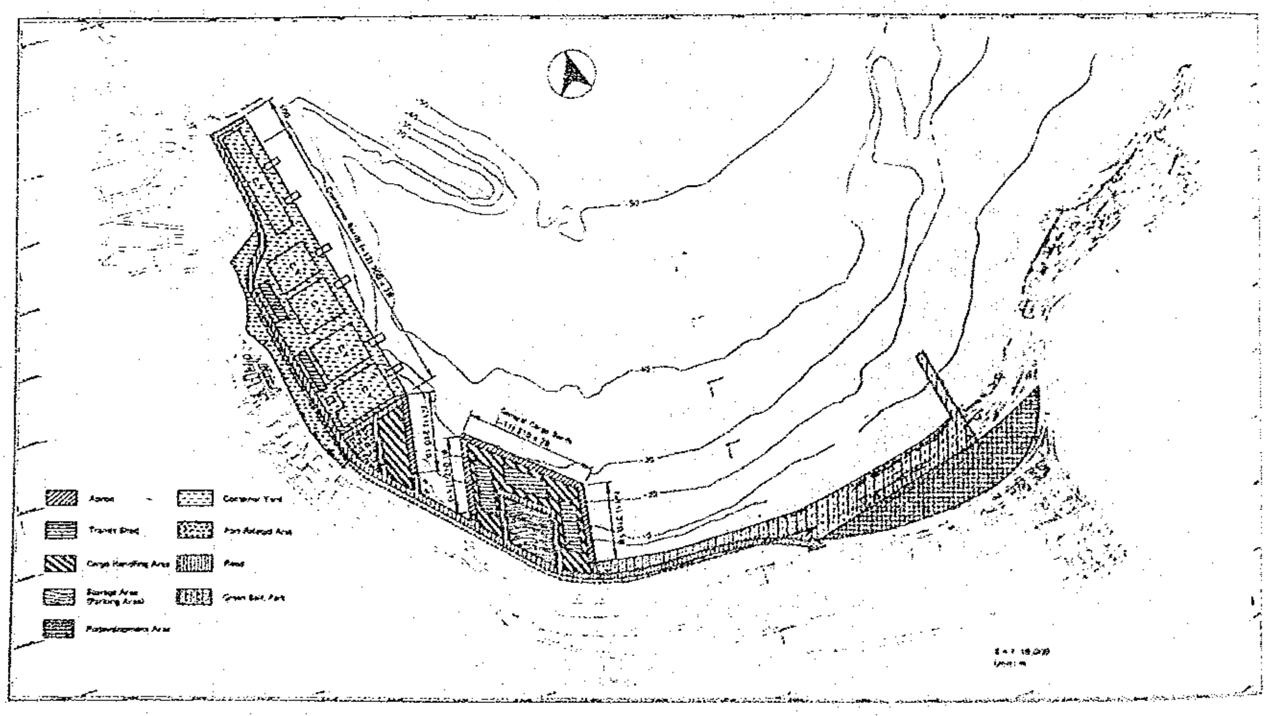


Fig. VII-3-8 Master Plan of Valparaiso Port (2010) Plan D

(5) Rough Evaluation of the Alternative Plans

The alternative plans are evaluated based on the criteria for evaluation explained in VII-1(7). The four alternative plans are evaluated as summarized in Table VII-3-20. As a result of this comprehensive evaluation, Plan B and Plan D are evaluated nearly equally. However, Plan B costs much more money than Plan D. So, Plan D is recommended as the Master Plan for Valparaiso Port, as shown in Figure VII-3-9.

Table VII-3-20 Evaluation of the Alternative Plans

Criteria		Evaluation			
		Plan A	Plan B	Plan C	Plan D
Convenience	Maneuverability	○	◎	△	△
	Layout	○	◎	○	○
	Utilization of Facilities	○	○	◎	◎
Safety	Calmness	◎	○	◎	◎
	Emergency Measures	○	○	○	○
Economy	Total Construction Cost	△	△	○	◎
Flexibility	Adaptability	△	◎	△	△
	Room for Future Development	○	○	○	○
Environment	Impact on Social Environment	△	○	△	△
	Impact on Natural Environment	○	△	○	○

Note: ◎ Excellent ○ Good △ Some Problem

The overall construction costs of alternative plans for the port of Valparaiso are estimated as indicated in Table VII-3-21. The construction costs include all the port civil works at the planned berths and procurement of container cranes excluding on-land cargo handling equipment. A sum of 30% of the direct cost to cover indirect costs for construction works, 15% for physical contingencies and 5% for engineering studies is also included in the construction costs.

Table VII-3-21 Construction Costs of Alternative Plans at Valparaiso

Alternative	Construction Cost (billion Chile pesos)
A	81.1
B	80.8
C	51.3
D	46.9

(billion = 1,000,000,000)

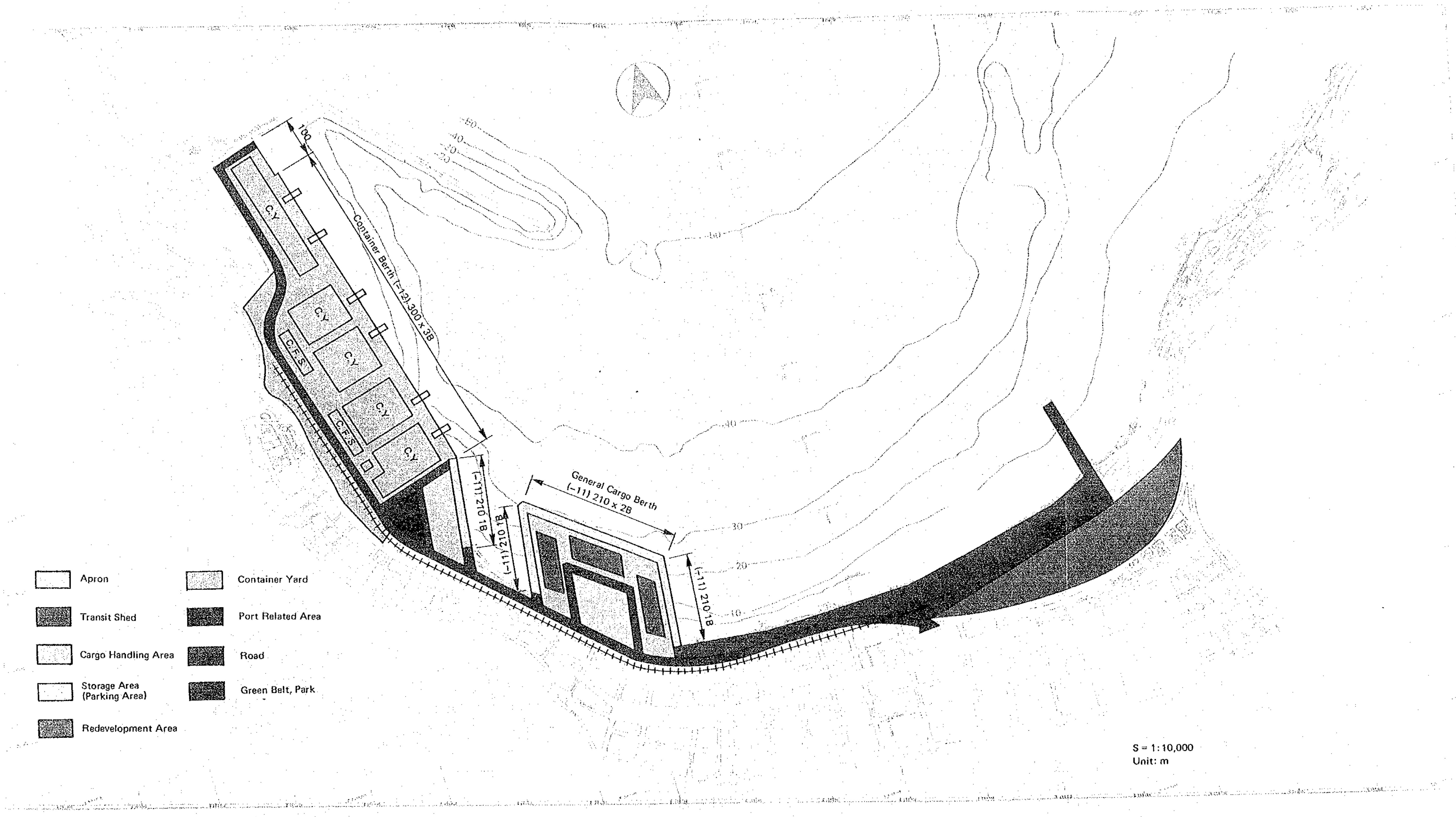


Fig. VII-3-9 Master Plan of Valparaiso Port (2010)

VII-4 Alternativo Master Plans of the Port of San Antonio

(1) Capacity of Present Facilities

The present capacity of the port of San Antonio was estimated by analyzing the relationship between the volume of cargo handled at each berth and the size of the berth in terms of general, container and grain cargoes. The values used for the analysis are from 1984.

1) General Cargoes

Some of the data related to the handling of general cargoes (including copper) at the port of San Antonio are shown below.

① Average loading/unloading capacity per ship:
79 tons/hour (average number of gangs 3 gangs)

② Average actual hours worked per ship 22.5 hours

③ Working days per year 330 days

From the rough analysis of calmness (degree of sheltering) presented in Chapter III, the rate of available working days is 92%. It is assumed that rainy or other bad weather days account for another 2%. As cargo cannot be handled under these conditions, the number of days available for using berths is approximately.

365 day x 0.9 ≒ 330 days

④ Number of general cargo berths 3 berths

As noted in Chapter III, we judge that the berthing facilities in this port presently comprise only the 4 berths located at the jetty and the grain berth. It is assumed that berths No.5, No.6 and No.7 are used for the general cargo, so the number of general cargo berths is three. Berths No.6 and No.7 were seriously damaged by the earthquake, but these berths can still be used with a limited load for a short period of time.

Using these data, the present annual port capacity for general cargo is estimated as follows:

79 x 22.5 x 330 x 3 ≒ 1,760 thousand tons

Assuming that the berth occupancy ratio is 100%, the port capacity is estimated as 1,760 thousand tons.

2) Containers

Some of the data related to the handling of containers are shown below.

① Average loading/unloading capacity per ship	25 boxes/hour
② Average actual hours worked per ship	22.5 hours
③ Working days per year	330 days
④ Number of berths	1 berth
⑤ Number of empty containers	30%

Berth No. 4 is used for the container cargoes.
Using these data, the present annual capacity for containers is estimated as follows:

25 x 0.7 x 22.5 x 330 x 1 = 130 thousand containers

3) Grains

Cargo handling equipment, working hours and other items concerning grain cargo handling are as follows:

① Average loading/unloading capacity per ship	400 tons/hour
② Average actual hours worked per day	22.5 hours
③ Working efficiency (assumed)	0.7
④ Working days per year (assumed)	260 days
⑤ Number of berths	1 berth

These data are used to estimate the annual grain handling capacity as follows.

400 x 0.7 x 22.5 x 260 x 1 = 1,640 thousand tons

The wheat berth is located at the north part of the port (PANUL).
The appropriate berth occupancy rate is assumed as 40%, and the present berth capacity is 650 thousand tons.

4) Summary

The port capacity estimated in the above sections assumes a berth occupancy of 100%. However, this is not a realistic appraisal. Table

VII-4-1 shows the port capacity considering appropriate berth occupancy. At the appropriate berth occupancy level, the present port capacity is estimated as about 2,460 thousand tons.

Table VII-4-1 The Present Port Capacity by Berth Occupancy

(Unit: '000 tons)

Type of Berth	Number of Berths	Capacity	
		Full	Appropriate
General Cargo	3	1,760	(0.55) 940
Agricultural Bulk (Wheat)	1	1,640	(0.40) 650
Container Cargo	1	1,690	(0.40) 670
Total	5		2,460

Note: Figures in parentheseses are the berth occupancy ratios

As for the general cargo berths, the appropriate berth occupancy ratio is 55% and the capacity is 940 thousand tons as noted in the table. However, if the occupancy rate was 75%, near the upper limit which could possibly be handled at these berths, the capacity would be 1,280 thousand tons.

(2) The Scale of the Master Plan

1) Multipurpose Wharf

(i) Determination of ship and berth size

This berth will handle containers, bulky cargoes and so on. In choosing the berth size, semi-container ships which carry containers along with other cargoes at the same time are considered. Table VII-4-2 shows the semi-container ships of Chilean shipping companies.

The average size of ships belonging to CCNI is about 26,000 DWT.

On the other hand, the size of newly built ships are from about 10,000 DWT to 27,000 DWT according to the data of Nihon Yusen Company.

In addition, as a matter of course full-container ships will also call at the port of San Antonio.

Table VII-4-2 Semi-Container Ships in Chile

Firms	Number of Ships	Gross Tonnage	Dead Weight Tonnage	TEU
CCNI	4	63,814	102,236	1,636
CSAU	2	24,048	34,232	524
Empremar	3	28,463	47,347	882
Total	9	116,325	183,815	3,042

Source: Nihon Yusen Company

Under these circumstances, 30,000 DWT class vessels are the ships which the multipurpose wharf at the port of San Antonio will accommodate.

The dimensions of the multipurpose berth are shown in Table VII-4-3.

Table VII-4-3 Dimensions of Proposed Multipurpose Berth

Kind of Berth	Ship Size	Size of Berth	
		Length	Water Depth
Multipurpose	30,000 DWT	250 m	12.0 m

(ii) Number of berths

For the planning method considering the frequency of ship entry and handling capacity, the following conditions are assumeed:

① This berth is a multipurpose berth, but the cargo considered herein is the container cargo.

The volume of container cargoes handled in 2010 is 551 thousand tons.

② The per container cargo volume is 14 tons.

③ The working efficiency is assumed to be 0.8 considering possible time waste in using the container cranes and cargo handling by outside vessels.

④ It is assumed that the per ship number of loaded containers that are loaded or unloaded is 300. The 300 per ship figure is forecast based on the current handling patterns of loaded containers at the ports.
The ratio of empty containers to loaded containers is 30% from the actual data. So, the per ship number of containers to be handled is forecast as 390.

⑤ The number of days available for using berths is 330 days per year. The cargo handling hours per day are assumed to be 22.5 hours.

⑥ Days necessary for purposes other than cargo handling are presumed to be 0.2 days per ship.

Based on the above assumption, the necessary number of container berths in 2010 is calculated as follows:

Total number of containers is 2010 $= \dfrac{551{,}000}{14} \times 1.3$

$= 51{,}160$ boxes

Number of calling ships $= \dfrac{51{,}160}{390}$

$= 131$ ships

Per-ship average days of mooring $= \dfrac{390}{22.5 \times 25 \times 1 \times 0.8} + 0.2$

$= 1.1$ days

Total number of mooring days = 131 ships x 1.1 days

= 144 ship·days

The berth utilizing ratio is calculated by substituting appropriate numbers as the number of berths. Table VII-4-4 shows the results. The necessary number of berths is one.

Table VII-4-4 Berth Utilizing Ratio by Number of Berths

Number of Berths	Berth Utilizing Ratio	Estimate
1	0.44	○
2	0.22	×

2) General Cargo Wharf

(i) Determining of ship and berth size

i) Present ship size

According to the data of EMPORCHI on the general cargo ships calling at the port of San Antonio in 1984, the maximum ship size was about 30,000 DWT. But as shown in Fig. III-2-3, the main ship size was 10,000 - 20,000 DWT representing 71% of all general cargo ships.

ii) Determination of ship and berth size for plan

On the other hand, the majority of ships transporting general cargo in the world are of the 15,000 - 20,000 DWT class. The nature of cargo transport being what it is, rapid emergence of inordinately large ships in unthinkable.

Table VII-4-5 Dimensions of Proposed General Cargo Berths

Kind of Berth	Ship Size	Size of Berth	
		Length	Water Depth
General Cargo	20,000 DWT	210 m	11.0 m

(ii) Number of berths

For the method considering frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of foreign trade general cargoes handled in 2010 excluding containerized cargoes is 1,712 thousand tons.

② The average cargo handling capacity per ship is 120 tons/hour. A working efficiency of 0.8 is presumed considering unavoidable waste of time.
The 120 tons/hour figure is assumed based on the actual handling rate of 98 tons/hour in 1984 for general cargo and on the actual handling rate of 180 tons/hour for copper in 1984.

③ For General cargo, the average per ship loading/unloading volume is 3,000 tons.
The 3,000 tons per ship loading/unloading volume is forecast based on the actual five year average of loading/unloading volume per ship.

④ The number of days available for using berths is 330 days per year. The number of hours that cargo is handled per day is assumed to be 22.5 hours per day.

⑤ Days necessary for purpose other than cargo handling are presumed to be 0.2 days per ship.

Based on the above assumptions, the necessary number of general cargo berths in 2010 is determined as follows:

$$\text{Number of calling ships} = \frac{1,712,000}{3,000} = 571 \text{ ships}$$

Per ship average days of mooring

$$= \frac{3,000}{(120 \times 22.5 \times 0.8)} + 0.2$$

$$= 1.4 \text{ days}$$

Total number of mooring days = 571 ships x 1.4 days
= 1,799 ship·days

The berth utilizing ratio is calculated by substituting suitable numbers as the number of berths. Table VII-4-6 shows the results.

Table VII-4-6 Berth Utilizing Ratio by Number of Berths

Number of Berths	Berth Utilizing Ratio	Estimate
3	0.81	△
4	0.61	○
5	0.48	×

Thus by the method considering frequency of ship entry and handling capacity, the number of berths required as general cargo berths is 3 or 4.

(iii) Planning of cargo handling areas

The scale of transit sheds and open storage yards has to be decided in consideration of the types and quantities of cargoes and the conditions of handling. Cargoes can be divided into three groups depending on how they are handled after unloading.

1) cargoes stored in the transit shed to prevent damage due to rainfall and theft, 2) cargoes which may be kept safely at the open storage yards, and 3) cargoes for immediate delivery without using these facilities.

Table VII-4-7 shows the movement of general cargo at the port of San Antonio in 1985.

Table VII-4-7 Movement of General Cargo

(Unit: %)

	Direct	Indirect	
		Storage Facility	Storeyard
General Cargo (Including Copper)	73	7	20
Bulk Cargo	88	5	7

Source: EMPORCHI

As for the port of San Antonio, the volume of general cargo will increase as shown in the demand forecast, so the ratio of cargo passing through transit sheds will become higher. In the case of ports in Japan (Tokyo and Yokohama Ports), the ratio of general cargo passing through transit sheds is about 30%.

Facilities are planned based on the assumption that 30% of the general cargo will pass through transit sheds, 10% will pass through open storage yards and the remaining 60% will be handled directly.

Other major cargoes are assumed to be handled as follows.

Wheat is delivered immediately. 90% of copper and bulky cargo will be kept at the open storage yard and the other 10% will be handled directly. As explained above, the remaining general cargoes are assumed 30% through the transit sheds, 10% through the open storage yards and 60% by immediate delivery.

Based on the above assumptions, in 2010 the volume of cargoes passing through transit sheds is 288 thousand tons and the volume of cargoes passing through open storage yards is 756 thousand tons.

1) General cargo transit shed

The necessary area of transit sheds and warehouses is determined by the following formula:

$$A = \frac{N}{R \alpha W}$$

A: Necessary area of transit sheds (m^2)

N: Annual volume of cargoes handled: 288 thousand tons

α: Utilization rate: 0.6

R: Turnover of transit sheds: 24 times a year

W: Volume of cargoes per unit area: 1.5 t/m^2

$$A = \frac{288,000}{24 \times 0.6 \times 1.5} = 13,000 \ m^2$$

Accordingly, an area of at least 13,000 m^2 is required for the storage facilities, that is the combined area of the transit sheds and the warehouse.

2) Open storage yards

The necessary area of open storage yards is determined by the following formula:

$$A = \frac{N}{R \alpha W}$$

A: Necessary area of open storage yards (m^2)

N: Annual volume of cargoes handled: 756 thousand tons

α: Utilization rate: 0.7

R: Turnover of the open storage yards: 24 times a year

W: Volume of cargoes stacked per unit area: 1.5 t/m^2

$$A = \frac{756,000}{24 \times 0.7 \times 1.5} = 30,000 \ m^2$$

Accordingly, an area of at least 30,000 m^2 is required for the open storage yards.

These figures are calculated based on various assumptions, so the scale of transit sheds and open storage yards should be reconfirmed based on further analyses of the present and estimated future cargo flows.

3) Grain wharf

(i) Determination of ship and berth size

As shown in Table VII-1-2, for ships calling at the port of San Antonio the average loading and unloading volume of agricultural bulk cargo is about 17,000 tons per ship.

On the other hand, the ship size of grain bulk carriers which call at the port of San Antonio is mainly from 25,000 DWT to over 30,000 DWT (refer to Fig. III-2-3), and the average tonnage is about 30,000 DWT.

So far as general bulk cargo is concerned, it is necessary to increase cargo handling efficiency. Table VII-4-8 shows the size of grain carriers in the world from 1970 to 1980. Though vessels less than 40,000 DWT still account for more than 50% of all vessels, the share of these smaller vessels is gradually decreasing, a situation which shows that the trend is going toward larger and larger ships as part of the rationalization of transport.

Table VII-4-8 World Grain Carriers

Year / DWT (thousand tons)	1970	1975	1980
Less than 40	89	69	52
40/60	10	15	20
60/80	1	7	17
80/100	-	2	2
More than 100	-	7	9

Source: Cargo Systems Research/Consultancy Division

But considering that the volume of cargo will not increase but rather decrease based on the demand forecast, and considering the ship size at present, it will be sufficient to prepare berths which can accommodate the 40,000 DWT vessels which continue to handle much of the world grain traffic.

The dimensions of the proposed grain berth are shown in Table VII-4-9.

Table VII-4-9 Proposed Grain Berth

Kind of Berth	Ship Size	Size of Berth	
		Length	Water Depth
Grain Berth	40,000 DWT	230 m	12.0 m

(ii) Number of berths

i) Method considering frequency of ship entry and handling capacity

In planning, the following conditions are assumed:

① The volume of grain cargoes in 2010 is 724 thousand tons.

② As for grain cargo handling, high cargo handling efficiency is usually the main goal. However, the volume of grain cargoes in 2010 is only 724 thousand tons, and this volume is less than the volume in 1984. Then it seems to be sufficient if the handling capacity in 2010 is equal to the existing handling capacity. Assuming simultaneous use of three sets of handling equipment including ship gear, the grain handling rate in the year 2010 is forecast as 400 tons/hour/ship. For this calculation, working efficiency is presumed to be 0.8.

③ The average per ship loading/unloading volume is 17,000 tons. The 17,000 tons/ship figurte is based on the actual five year per ship average of 16,385 tons.

④ The berths are available for use 330 days per year. The cargo handling hours per day are assumed to be 22.5 hours.

⑤ Days necessary for purposes other than cargo handling are presumed to be one day per ship.

$$\text{Number of calling ships} = \frac{724{,}000}{17{,}000}$$

$$= 43 \text{ ships}$$

$$\text{Per-ship average days of mooring} = \frac{17{,}000}{22.5 \times 400 \times 0.8} + 0.2$$

$$= 2.6 \text{ days}$$

$$\text{Total number of mooring days} = 43 \text{ ships} \times 2.6 \text{ days}$$

$$= 112 \text{ ship·days}$$

The berth utilizing ratio by the number of berths is shown in Table VII-4-10.

Table VII-4-10 Berth Utilizing Ratio by Number of Berths

Number of Berths	Berth Utilizing Ratio	Estimate
1	0.34	○
2	0.77	×

So considering the frequency of ship entry and handling capacity, the number of berths required as grain berths is one.

4) Chemical Wharf

(i) Determination of ship and berth size

As shown in Table VII-1-2, for ships calling at the port of San Antonio, the average loading and unloading volume of chemical liquid cargo is about 1,200 to 4,700 tons per ship. The major ship size is from 20,000 DWT to 25,000 DWT.
Taking into account the worldwide trend toward larger ships, the chemical liquid wharf at the port of San Antonio should be able to accommodate 30,000 DWT vessels.
According to Figs. VII-4-1 and VII-4-2, 30,000 DWT ships measure about 190 m in length and about 11 m in full-load draft. The length of a quay for a 30,000 DWT ship normally is equal to the ships length plus a margin for the low line and the stern line. Water depth alongside the quay is 12m, which represents the full load draft plus an appropriate keel clearance.

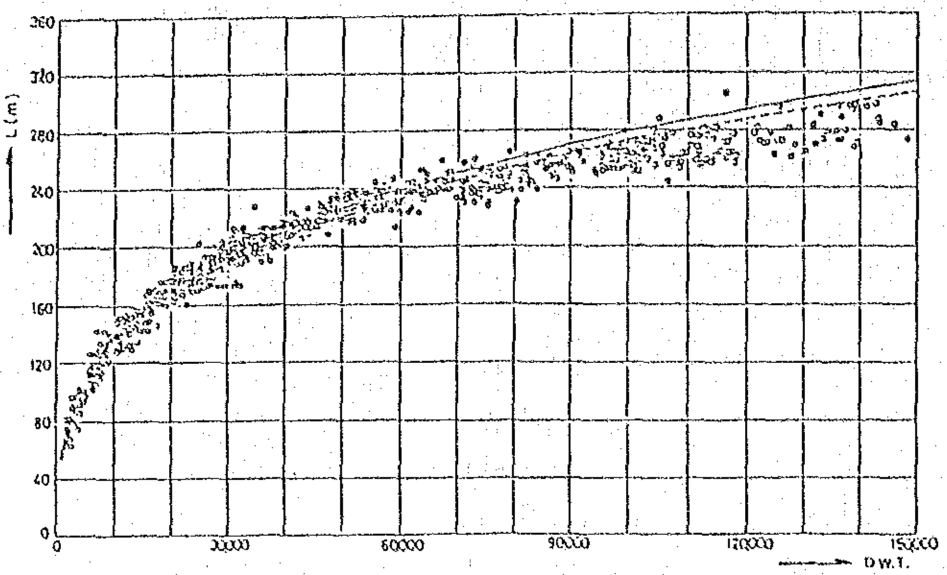


Fig. VII-4-1 Relation between Ship Size (DWT) and Length (L)

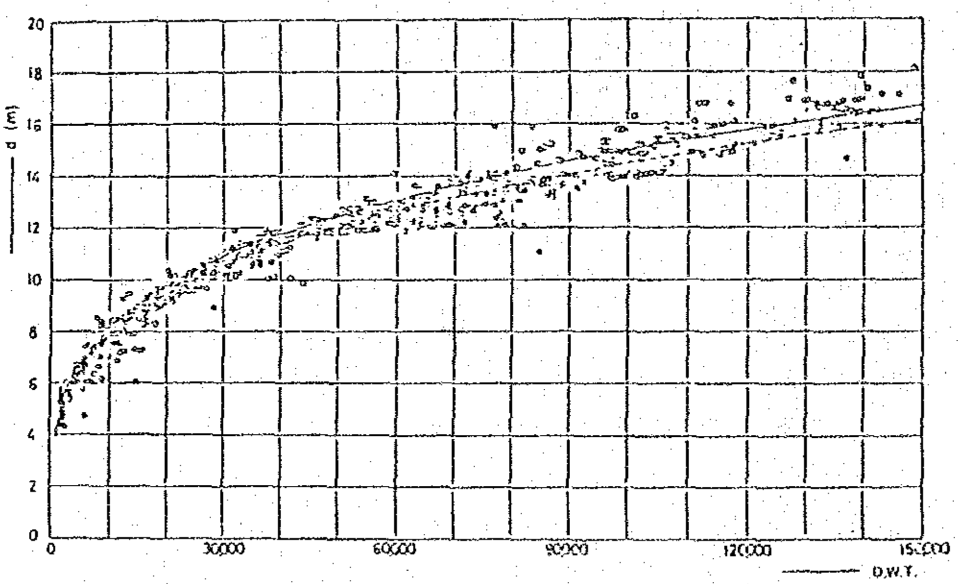


Fig. VII-4-2 Relation between Ship Size (DWT) and Full-Load Draft (D)

The dimensions of the proposed chemical berth are shown in Table VII-4-11.

Table VII-4-11 Proposed Chemical Berth

Kind of Berth	Ship Size	Size of Berth	
		Length	Water Depth
Chemical	30,000 DWT	220 m	12.0 m

(ii) Number of berths

In planning, the following conditions are assumed:

① The volume of chemical liquid cargo in 2010 is 354 thousand tons.

② The average cargo handling capacity per ship is 200 tons/hour. A working efficiency of 0.8 is presumed considering unavoidable waste of time. The 200 tons/hour figure is assumed based on the actual handling volume.

③ The average per ship loading/unloading volume is 5,000 tons. The 5,000 tons per ship loading/unloading volume is forecast based on the actual highest loading/unloading volume per ship.

④ The number of days available for using the berth is 330 days per year. The number of hours that cargo is handled is assumed to be 22.5 hours per day.

⑤ Days necessary for purposes other than cargo handling are presumed to be 0.2 days per ship.
Based on the above assumptions, the necessary number of berths in 2010 is determined as follows:

$$\text{Number of calling ships} = \frac{354{,}000}{5{,}000}$$

$$= 71 \text{ ships}$$

Per ship average days of mooring

$$= \frac{5{,}000}{(200 \times 22.5 \times 0.8)} + 0.2$$

$$= 1.6 \text{ days}$$

$$\text{Total number of mooring days} = 71 \text{ ships} \times 1.6 \text{ days}$$

$$= 114 \text{ ship·days}$$

The berth utilizing ratio is calculated by substituting suitable numbers as the number of berths. Table VII-4-12 shows the results.

Table VII-4-12 Berth Utilizing Ratio by Number of Berths

Number of Berths	Berth Utilizing Ratio	Estimate
1	0.35	○
2	0.17	×

Thus by the method considering frequency of ship entry and handling capacity, the number of berths required as chemical berths is 1.

4) *Estimate of the total number of Berths Using the Method of Simulation by Queuing Theory*

As shown in Table VII-4-13, two simulation tests based on different numbers of berths in the year 2010 have to be carried out.

Table VII-4-13 Simulation Test Cases

Type of Cargo	Case-1	Case-2
General Cargo	4	3
Agricultural Bulk (Wheat)	1	1
Chemical Liquid	1	1
Container	1	1
Total	7	6

(i) Simulation cases

Specifically, in order to determine the appropriate number of berths required in 2010, the number of general cargo berths has to be examined by the simulation tests.

(ii) Premises for the simulation

The simulation tests for these cases are carried out under the following assumptions.

① Ships can enter and leave at any time.

② Service time is estimated by the type of cargo and per-ship cargo volume based on the cargo handling capacity in 2010 shown in Table VII-1-3.

③ General cargo ships use general cargo berths, in principle. However, general cargo ships can also use the multi-purpose berth.

④ Ships loading cargoes other than general cargo have to use the berths designed for their specific type of cargo.

(iii) Input Data

The following Table VII-4-14 shows the simulation test input data by case and type of berth.

Table VII-4-14 Simulation Input Data

Type of Berth	Number of Berths	Rank of Ship Size ('000 DWT)	Number of Ships	Service Time (hours)
General Cargo	4 (3)	∿ 5	26	17.3
		5 ∿ 10	54	34.3
		10 ∿ 20	402	37.4
		20 ∿ 30	58	56.6
Refer		∿ 10	24	38.6
		10 ∿ 20	11	56.6
Agricultural Bulk Cargo (Wheat)	1 (1)	10 ∿ 20	8	27.4
		20 ∿ 30	9	39.3
		30 ∿ 40	26	74.3
Chemical Liquid Cargo	1 (1)	∿ 10	8	32.1
		10 ∿ 20	10	34.3
		20 ∿ 30	46	41.5
		30 ∿ 40	7	60.3
Multi-purpose	1 (1)	∿ 10	33	10.5
		10 ∿ 20	46	22.0
		20 ∿ 30	52	33.0

(iv) Simulation Test Results

The results of the simulation tests are shown in Table VII-4-15.

Table VII-4-15 Results of Simulation Tests

	Case-1				Case-2			
	Average Berth Occupancy Ratio	Ship Waiting Ratio (%)		Per Ship Waiting Time (hours)	Average Berth Occupancy Ratio	Ship Waiting Ratio (%)		Per Ship Waiting Time (hours)
		Waiting ships to ship entry	Waiting time to mooring time			Waiting ships to ship entry	Waiting time to mooring time	
General Cargo	0.66	28.6	17.2	6.9	0.88	60.9	99.6	39.8
Agricultural Bulk	0.33	25.0	2.5	14.3	0.33	25.0	2.5	14.3
Liquid Bulk	0.33	29.5	3.7	15.3	0.33	29.5	3.7	15.3
Multi-purpose	0.42	39.7	4.6	10.4	0.42	39.7	4.6	10.4
Total				8.6				30.8

The output data of the simulation tests include the berth occupancy ratio, the ratio of the number of waiting ships to ship entry, the ratio of waiting time to mooring time and the waiting time per ship.

In order to propose the optimum plan as the Master Plan, the following criteria are considered.

① The berth occupancy ratio should be 0.4 - 0.7.

② The desirable ratio of waiting time to mooring time is 10% or less.

③ Desirable waiting time per ship is less than half a day, with a maximum of one day.

Judging from these criteria, Case-1 is selected as the most appropriate plan.

(3) Port Traffic Facilities

1) Port Roads

Using the same method described in Chapter VII-3 (3), the appropriate number of lanes is determined below.

Table VII-4-16 shows the modal split at the port of San Antonio, and Table VII-4-17 shows the estimated traffic volume and required number of lanes.

Table VII-4-16 Forecast Traffic Volume by Transport Mode

('000 tons)

	Inward			Outward			Total		
	Road	Railway	Total	Road	Railway	Total	Road	Railway	Total
Conventional Cargo	503	588	1,091	861	805	1,666	1,364	1,393	2,757
Containers	184	15	199	214	138	352	398	153	551
Total	687	603	1,290	1,075	943	2,018	1,762	1,546	3,308

Table VII-4-17 Estimated Traffic Volume and Required Number of Lanes

	Transported Cargo Volume ('000 tons)	Total Transported Traffic (Veh/hr)	Required Number of Lanes
Conventional Cargo	1,364	387	2
Containers	398	167	2
Total	1,762	554	2

$\gamma = 0.11$

The total traffic volume generated by conventional cargo is about 390 trucks per hour and traffic from containers is about 170 trucks per hour in 2010. The total traffic in the port is about 550 trucks per hour, so the required number of lanes is 2 and the width of the port roads is 17m, the same as the width of the port roads in the port of Valparaiso.

2) Port Railway

The primary cargoes for railway transportation are copper and wheat, and the total estimated traffic volume by railway is about 1,550 thousand tons in 2010 as shown in the following Table.

Table VII-4-18 Forecast Traffic Volume by Railway at the Port of San Antonio

('000 tons)

Commodity	Forecast Traffic Volume
Copper	386 (80%)
Wheat	680 (94%)
Containers	153 (28%)
Other Cargoes	327 (21%)
Total	1,546

Note: Figures in parentheses are the share of the total volume for each type of cargo

Table VII-4-18 shows that a significant volume of cargo will be carried by railway, so it is necessary to arrange a railway siding on the apron or in the yard behind the transit shed.

(4) Alternative Layout Plans

1) Preparation of Alternative Plans

In order to prepare a master plan, several conditions must be considered. For example, the potential range of port development, the scale of the port facilities to be developed, and the relations with the existing port facilities and with the city district must be considered. At this time, the southern land outside the breakwater should be reserved for future development after 2010. As the port has very narrow sea areas, the reclamation should be limited as much as possible. In addition, the quay-walls of the port are not resistant to earthquakes and are superannuated, especially berths 6 and 7. Thus, it is best to suspend the utilization of these berths.

Under these conditions, there are five possible areas for constructing new berths, from A to E as shown in Fig. VII-4-3.

As for each site, site A has good calmness but it would be necessary to reconstruct the facilities (berths 1 and 2) which were destroyed by the earthquake, which would cost more than building a new quaywall. Site B is located at the side of the harbour, and the water depth of the site is shallow. Site C is affected, more or less, by waves such as reflected waves, so it is necessary to examine measures to break the waves and otherwise protect the area. Site D has no distinct problems. Finally, site E is exposed to southwest winds, which are the prevailing winds at the port, and thus the calmness is not so good.

Alternative plans are made using these sites considering the scale of facilities required in 2010.

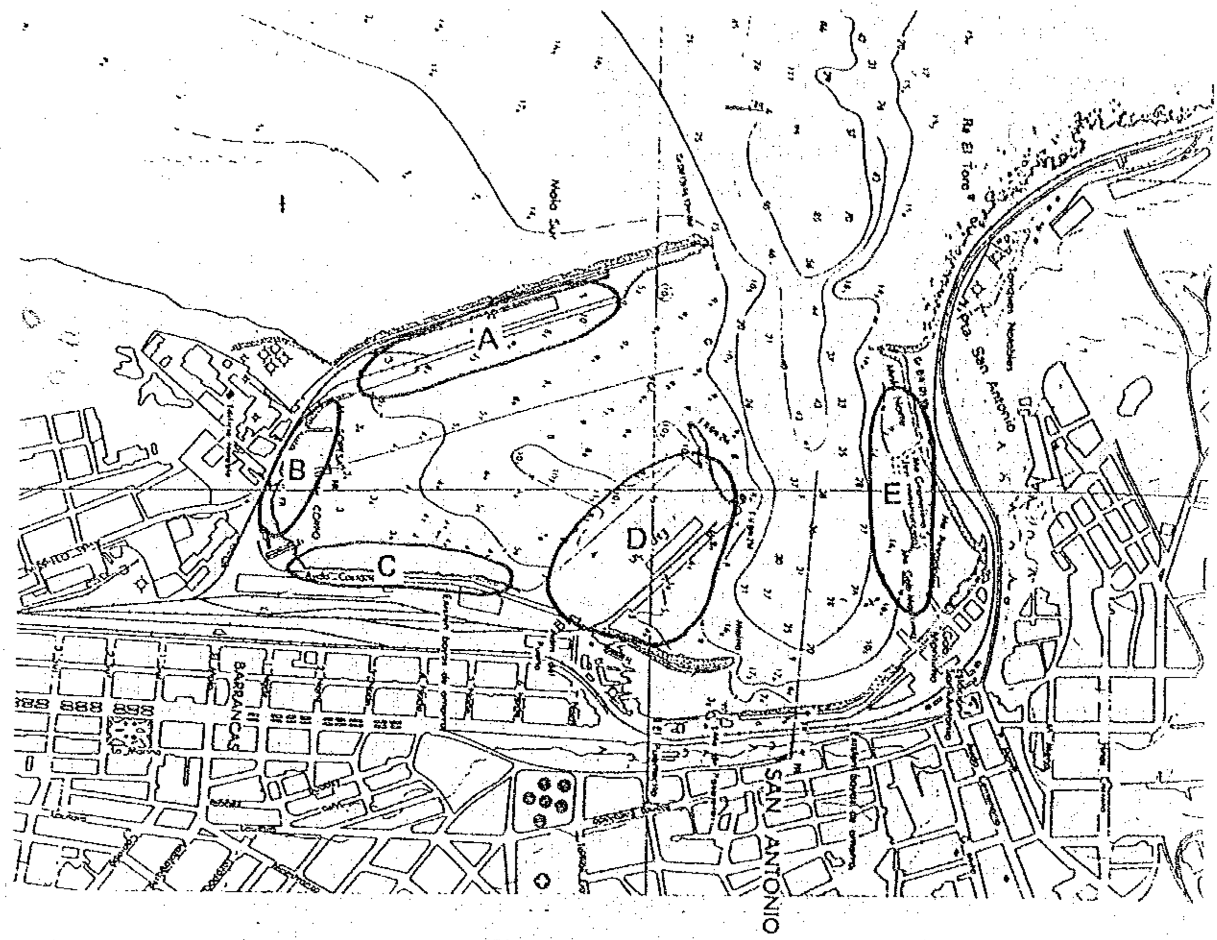


Fig. VII-4-3

(i) Alternative Plan A

In this plan, the jetty is expanded by reclamation and the port facilities are concentrated around this jetty for handling general cargoes and container cargoes. The wharf at the bottom of the breakwater will have two functions. On the one hand it is used as a substitute facility during construction works, and on the other hand it is used for handling dirty cargoes such as copper powder, and dangerous cargoes because it is located away from the other wharves. In the future, chemical cargo is forecast to take the place of the dirty cargoes. As to the handling of the dirty cargoes, it is necessary to consider clean handling methods using appropriate handling machines.
As for the grain berth, it is necessary to equip this berth with modern facilities in place of the present handling methods, to

increase handling efficiency.
The waiting area for fishing ships will be located near the present dolphin berth for wheat and the sea area will be protected by a new small breakwater built of stone. The pier should possibly be adjusted for the fishing vessels. Then, the small fishing vessels can be gathered in one area.

(ii) Alternative Plan B

In this plan, the multipurpose berth is adjusted with a small scale reclamation in front of the fish meal factory using the land from in front of the superannuated berths 6 and 7. The general cargo wharves will be reconstructed on the same face line at the southern side of the jetty. The other required berths will be provided at the sites of Berths No.1 and No.2 which collapsed from the earthquake, in line with the face line of Berth No.3.
This plan provides good access because the bypass road under construction will approach the southern part of the port where the main port facilities will be concentrated. Besides, this plan retains areas for future port expansion.
Moreover, under the plan it is possible that large vessels and small vessels can navigate separately.
On the other hand, the wharf yards do not have sufficient width. In addition, it seems that the cost of reconstructing these berths will be more expensive than the cost of constructing new berths. Because of the concentration of quaywalls in this narrow sea area, ship meneuvers will become difficult. There is also the problem of relocating the factory.

(iii) Alternative Plan C

In this plan, the new grain berth and general cargo wharf will be located at the northern part of the port where the dolphin berth for grain has been constracted. Other parts of the plan are basically the same as alternative plan A.
This plan presents difficulties for ship maneuvering and the harbor would be subject to waves which enter directly at the

northern port area. Besides, the quaywalls will be situated in three different areas. This would present problems for port management.

(iv) Alternative Plan D

Under this plan, the chemical wharf would be located at the existing berth No.1.
This would be good for the security of the port, because berth No.1 is located away from the other wharves. Other facilities are the same as under plan A except for the berth located at the tip of the jetty where the calmness is not so good.

(3) Rough Evaluation of the Alternative Plans

Based on the criteria described before, the three alternative plans are evaluated as summarized in Table VII-4-19. As a result of this comprehensive evaluation, Plans A and D are evaluated equally.

Table VII-4-19 Evaluation of Alternative Plans

Criterion		Evaluation			
		Plan A	Plan B	Plan C	Plan D
Convenience	Maneuverability	○	△	△	○
	Layout	◎	○	△	◎
	Utilization of Facilities	◎	○	○	○
Safety	Calmness	◎	△	△	◎
	Emergency Measures	○	○	○	○
Economy	Total Construction Cost	○	○	△	◎
Flexibility	Adaptability	○	○	○	○
	Room for Future Development	○	◎	○	○
Environment	Impact on Social Environment	○	○	△	○
	Impact on Natural Environment	○	○	○	○

Note: ◎ Excellent ○ Ordinary △ Some Problem

However, Plan D costs slightly less than the other plans and has more calmness than Plan B. Thus Plan D is recommended as the Master Plan, as shown in Fig. VII-4-8.

The overall construction costs of the alternative plans for the port of San Antonio are estimated as indicated in Table VII-4-20 on the same basis for the cost estimation as that adopted to the port of Valparaiso.

Table VII-4-20 Construction Cost of Alternative Plans at San Antonio

Alternative	Construction Cost (billion Chile pesos)
Plan A	20.8
Plan B	22.8
Plan C	22.6
Plan D	20.3

(billion = 1,000,000,000)

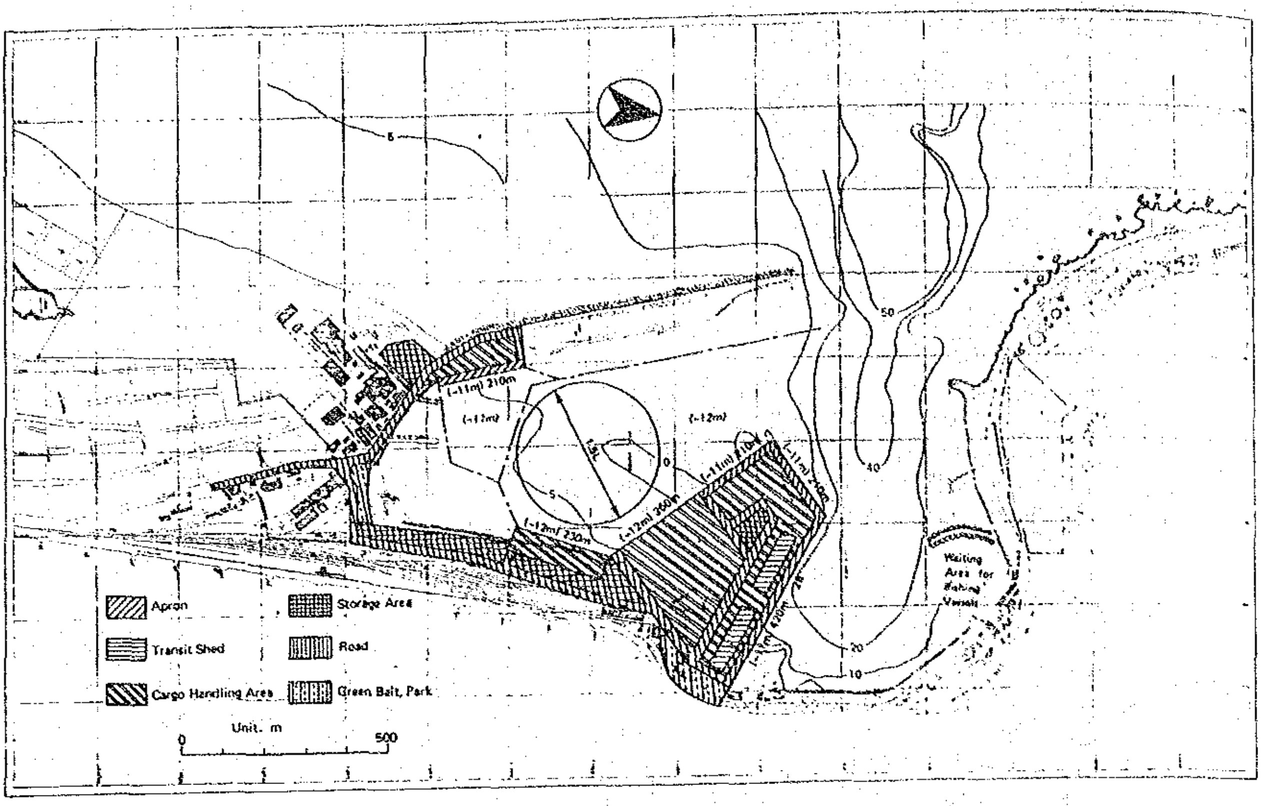


Fig. VII-4-4 Master Plan of San Antonio Port (2010) Plan A

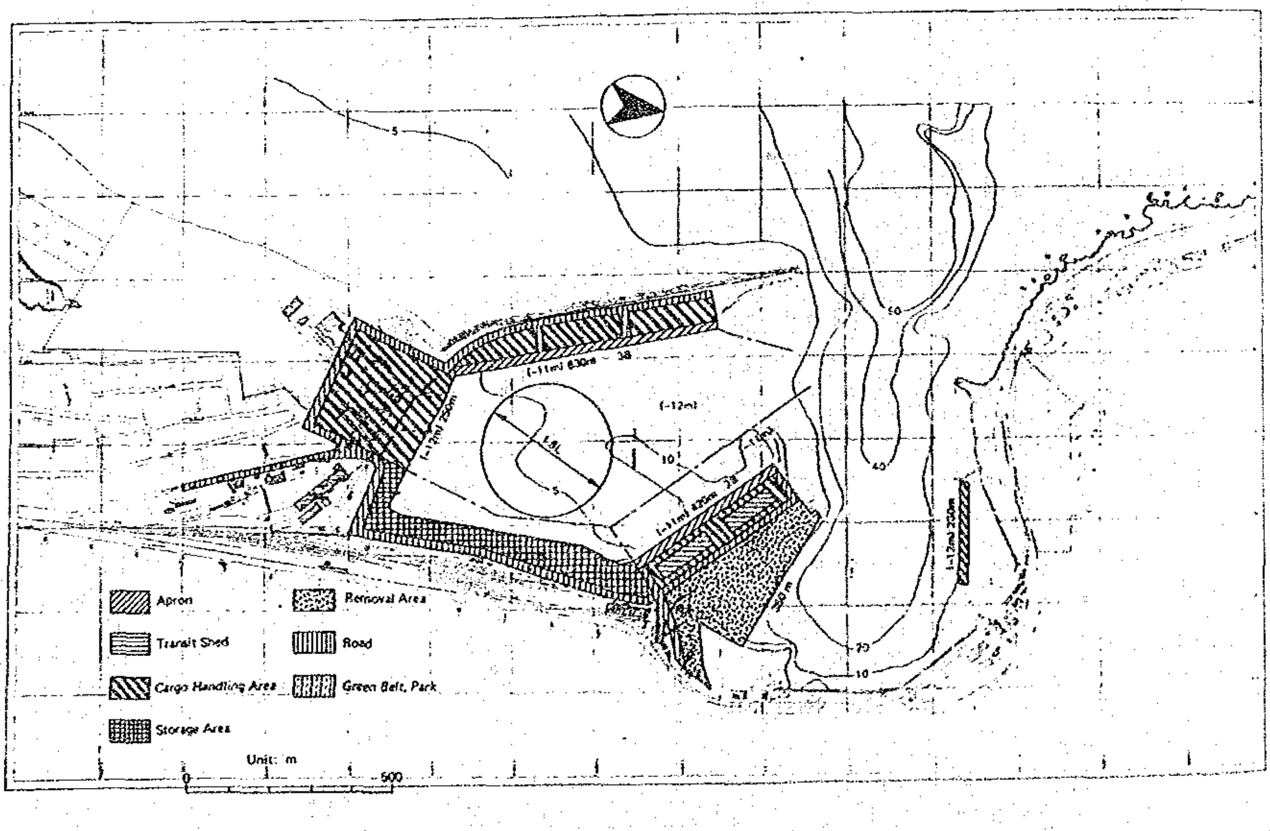


Fig. VII-4-5 Master Plan of San Antonio Port (2010) Plan B

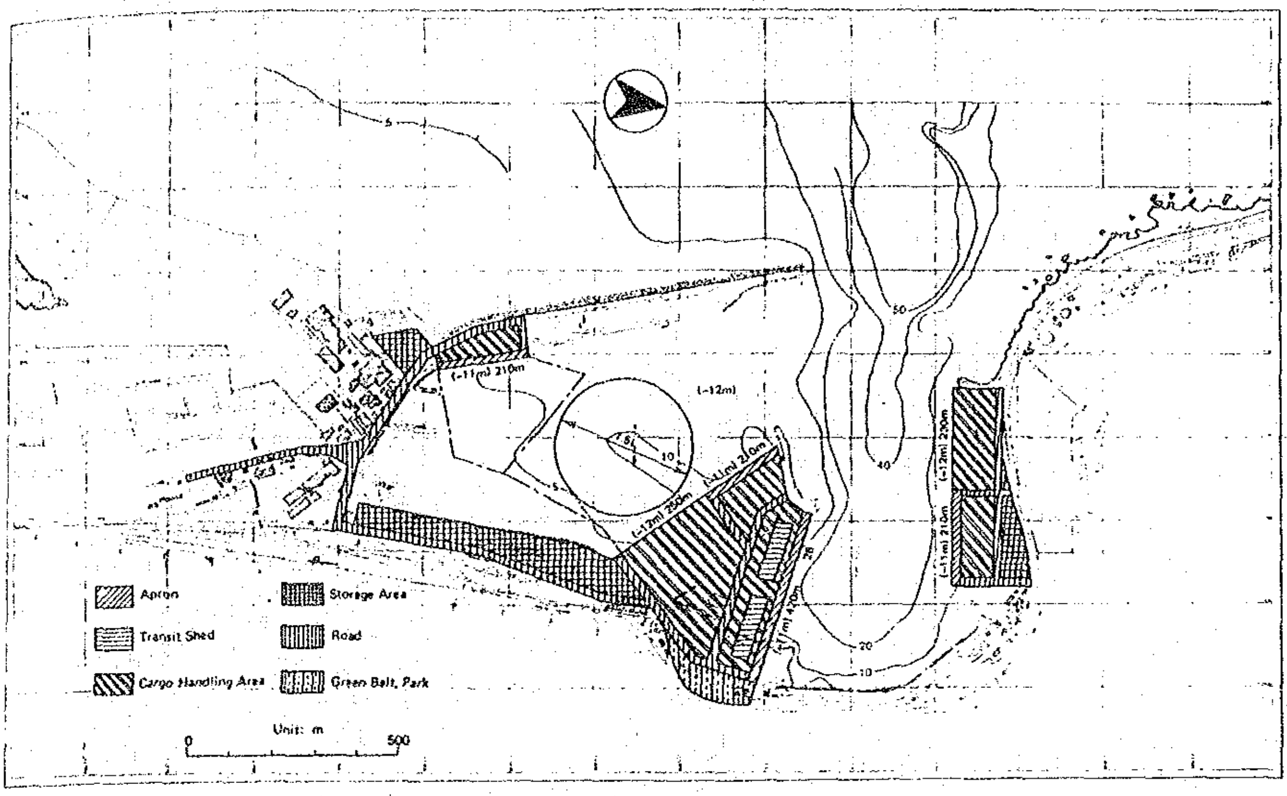


Fig. VII-4-6 Master Plan of San Antonio Port (2010) Plan C

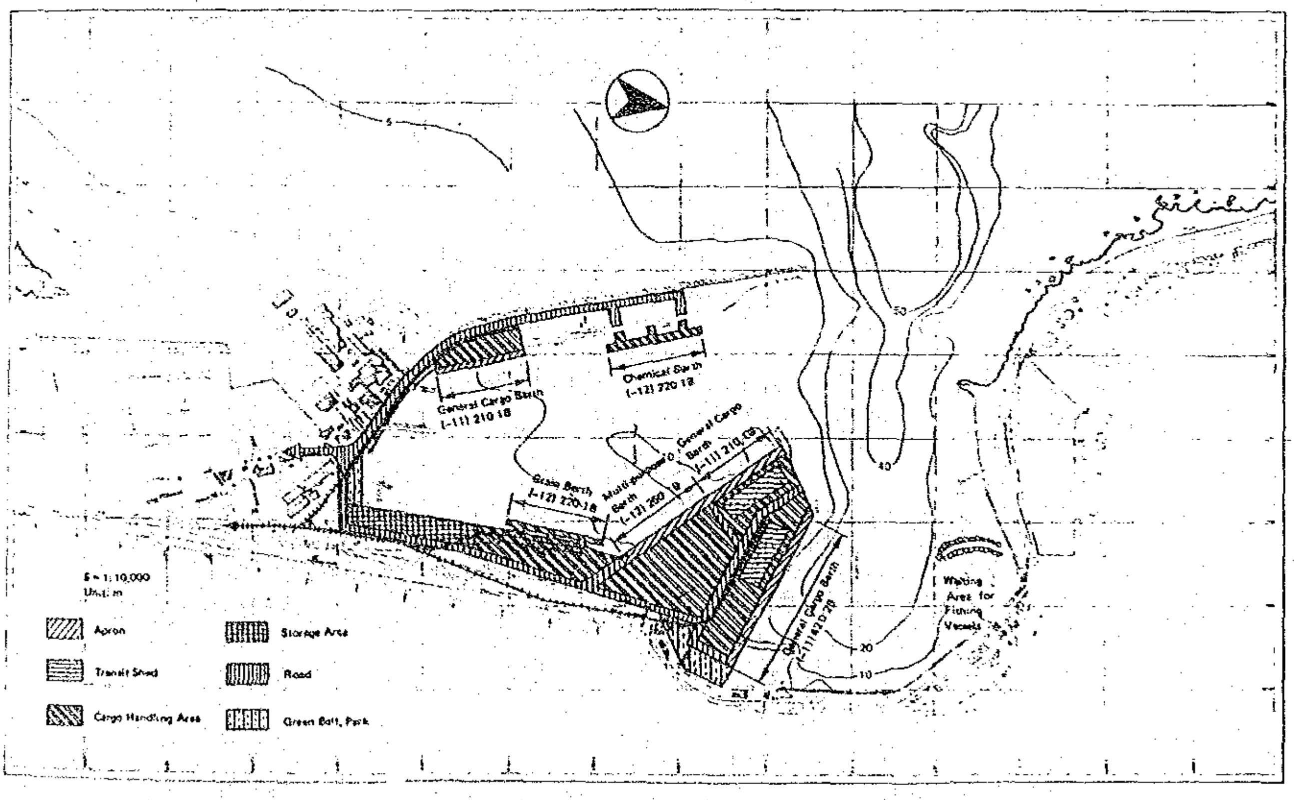


Fig. VII-4-7 Master Plan of San Antonio Port (2010) Plan D

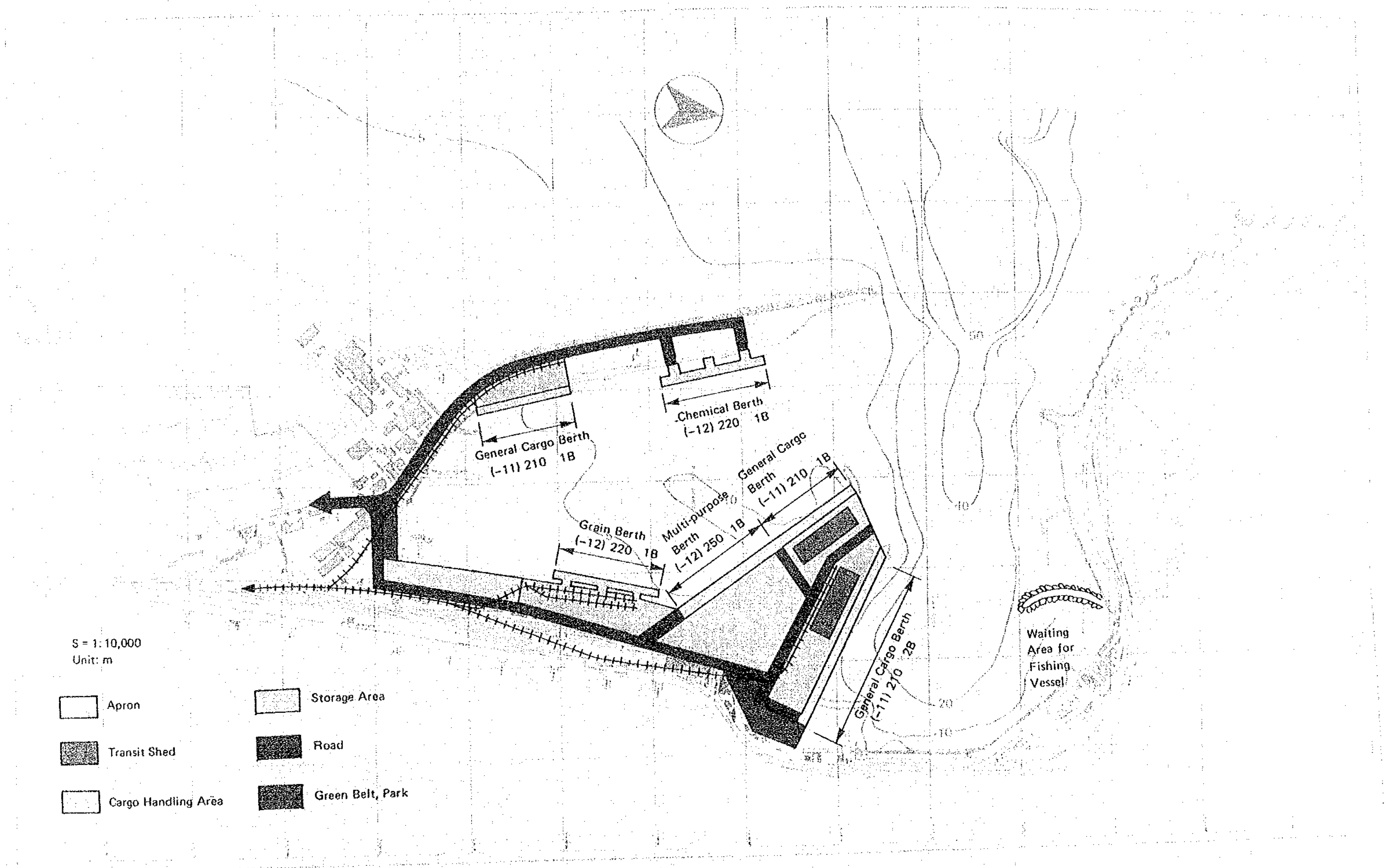


Fig. VII-4-8 Master Plan of San Antonio Port (2010)

VII-5 Aseismic Berths

(1) General

As shown in Chapter III, the aseismicity of the present port facilities is rather low. This is clear from the destruction caused by the earthquake and the evaluation of the aseismicity of the remaining port facilities. As both ports are located in areas of frequent earthquake activity, it is necessary to consider aseismicity as part of the restoration plan.

Ideally, of course, all the port facilities should be designed so that they can withstand the effects of the largest earthquake which is likely to affect the port areas. However, this would be prohibitively expensive. Furthermore, it is difficult to state exactly the highest acceleration from earthquake activity which will strike the ports.

As it is not economical to design all of the port structures to withstand the strongest probable earthquake, the best plan is to prepare a few aseismic berths which have a higher seismicity than the other port structures. This strategy balances the absolute need for emergency facilities in the case of a major earthquake with the need to minimize overall investment.

There are two ways of thinking concerning the purpose of the aseismic berths, as follows.

① To ensure the smooth transportation of emergency port cargoes in the period immediately after a major earthquake to sustain human life.

② To ensure the essential economic activities in the hinterland for a longer period after a major earthquake until other damaged facilities can be restored or replaced.

The former criteria refers mainly to emergency food, clothing, housing materials and medical supplies for the people who suffer the adverse effects of the earthquake. The latter concept is somewhat more subjective. It is based upon an evaluation of which cargoes would be necessary to maintain the general economic flow and the livelihood of the people in the hinterland while damaged facilities are being repaired.

(2) Estimation of the Required Number of Aseismic Berths

Based on the two ways of thinking presented above, the required number of aseismic berths is calculated below.

1) Required Number of Aseismic Berths to Handle Emergency Port Cargoes

The volume of emergency port cargoes which would have to be handled at the ports following a major earthquake is estimated in Chapter V-3. Using the same calculation method used for the Master Plan (the method considering the frequency of ship entry and the handling capacity), the required number of berths to handle this emergency port cargo is calculated below, based on five assumptions.

① The volume of emergency cargos handled in 2010 is 2,450 tons per day

② The average cargo handling capacity per ship is 80 tons/hour·crew.

③ The number of hours that cargo is handled is 24 hours per day.

④ Hours necessary for purposes other than cargo handling are 2 hours per ship.

⑤ The average per ship unloading volume is assumed to be 1,000 tons.

Based on these assumptions, the necessary number of emergency berths in 2010 is determined as follows:

$$\text{Number of calling ships} = \frac{2,450}{1,000} = 2.5 \text{ ships}$$

$$\text{Per ship average hours of mooring} = \frac{1,000}{80} + 2 = 14.5 \text{ hours}$$

$$\text{Total number of mooring hours} = 2.5 \text{ ships} \times 14.5 \text{ hours} = 36.25 \text{ ship·hours}$$

Thus, the number of berth required as emergency berths is 2.

2) Required Number of Aseismic Berths to Ensure the Essential Economic Activities in the Hinterland until the Damaged Facilities coulb be Repaired

It is difficult to state clearly which cargoes are most important, or which cargoes would be crucial to maintain the economic activity in the hinterland of the ports. In Chapter XII-2, an effort is made to determine the volume of these cargoes, that is the ideal number of berths based on an economic analysis. The result of this analysis is that from an economic viewpoint, five aseismic berths should be provided.

However, the cost to provide five aseismic berths is estimated to be about 16 billion pesos, and considering the Chilean national budget, this cost is too high.

3) Conclusion

Based on the two basic ways of thinking, the results of a preliminary analysis suggest that two berths would be necessary to handle the emergency port cargoes and five berths would be necessary to ensure the essential economic activity in the hinterland in the event of a major earthquake. The analysis is based on the available data, and a more detailed analysis may be necessary before making a final decision.

It is difficult to state which of these concepts should be applied for the long-term port plans. This decision would depend on governmental policy. Realistically, for the middle term, the decision will probably be based on engineering factors and national fiscal priorities.

From the engineering viewpoint, based on the present layout of the ports and the proposed port development, it seems that a maximum of 2 aseismic berths at the port of Valparaiso and 2 aseismic berths at the port of San Antonio could be efficiently constructed as part of the overall port development. These berths would be designed to withstand an earthquake with a magnitude of 8 based on the analysis of the probable return period of earthquakes presented in Chapter VIII.

Considering engineering, finance, the required handling volume and the different ways of thinking concerning the aseismic facilities, we recommend that a total of three aseismic berths be provided as soon as possible.

(3) Location of the Aseismic Berths

Ideally, the aseismic berths should be located as far away from each other as possible. They should also be located away from places where dangerous cargoes are handled, and a clear management system concerning the use of these berths in an emergency should be worked out beforehand. Furthermore, the berths should have good access to inland transport routes, so that the emergency cargoes can be distributed as smoothly as possible.

Of course, the basic way of thinking concerning the aseismic berths is that if one of these berths is damaged by a seismic force beyond the design level, the other berths will probably still be functional as they will be located some distance away from each other and thus will be subject to different seismic shocks. Similarly, the different berths should also be connected with different transport networks so that if some roads or railways are significantly damaged by an earthquake, other transportation routes may still be open.

Thus, clearly, all three of the aseismic berths should not be located at the same port. We recommend that two of the aseismic berths be located at San Antonio and that the other aseismic berth be located at Valparaiso based on the following reasoning.

① The hinterland of Valparaiso Port is more developed than the hinterland of San Antonio. In the event of an earthquake, the large number of old buildings located nearby Valparaiso Port would probably suffer serious damage, and the overland flow of cargoes via the port access road network, especially the mountain road to Santiago, would probably be interrupted.

② The test of the vibration characteristics of the ground at the two ports shows that the response value at Valparaiso is higher than at San Abntonio. This means that the Valparaiso Port area may be more easily affected by earthquakes than the area around San Antonio Port. However, there is a higher possibility of liquefaction at San Antonio, and there is a fault located in the water area near the port.

Of course, great care will have to be taken to ensure that the aseismic facilities at both ports are constructed carefully.

As for the locations of the aseismic berths within each port, we note the following criteria.

① A safe waterway: it should be possible to enter and exit safely from the berthing area even after a major earthquake.

② A safe distance from facilities where dangerous cargoes are handled.

③ Good access to overland transport.

④ Sufficient yards for handling cargoes.

⑤ As for the use of these berths during normal times, no permanent specialized cargo handling equipment should installed which would interfere with the ability of these berths to be used to handle general cargo during an emergency.

⑥ Location relative to other non-aseismic berths: the aseismic berths should not be too close to other berths which might collapse during an earthquake.

⑦ The berths should be located on the firmest possible foundation ground layer to minimize the possibility of earthquake damage caused by soft ground, liquefaction and seismic activity near faults.

In conclusion, we recommend that berth G-1 at Valparaiso (existing berth No.8) and berths G-4 and G-5 at San Antonio (existing berths No.6 & No.7) be prepared as aseismic berths as part of the overall restoration project.

VII-6 Phase Plans

(1) Phase Plan of the Port of Valparaiso

The Master Plan for the port of Valparaiso with a target year of 2010 must naturally be executed gradually, in stages. When planning the construction, attention must be paid to the following main points: 1) availability of facilities to meet changing cargo demand, 2) minimization of the disruptive effects of construction on daily port operations, 3) consideration of the aseismic berth, and 4) an even distribution of the construction investment over the entire development. The gradual construction investment will continuously stimulate the regional economy.

As for the ability of the port facilities to meet the projected cargo demand, the main items are the container berths and the general cargo berths. The phase plan for constructing the berths at the port which, of course, is based on the Master Plan, is presented as Table VII-6-1.

First, a review of the present situation. At present, assuming that the container cargo is handled at berths No.4 and 5, the container cargo handling capacity of the port is 1,060 thousand tons. Then, assuming that the general cargo is handled at the remaining 6 functional berths, No.1-3 and 6-8, the present cargo handling capacity of the port for general cargo is approximately 2,140 thousand tons. Thus, at present, there is an excess handling capacity for general cargo.

Basically, the phase plan presented in the table is designed so that the berths which will be available for use in every year of the plan have a sufficient capacity to handle the estimated cargo demand for both container cargo and general cargo. There will be some excess capacity in 1990, but in every other year of the plan the capacity will be commensurate with the projected cargo throughput, and the berth occupancy ratios should be within reasonable levels.

Berth G-1, which is one of the first berths to be constructed, is designed as an aseismic berth. Thus, an aseismic facility will be provided at the earliest possible time.

Furthermore, as new berths will be constructed step by step, the investment will be well distributed throughout the development period.

Now, a brief review of the construction plan for the berths. Table VII-6-2 summarizes the time frame of the construction plan for the berths. Table VII-6-1 shows the locations of the old and new berths as well as an outline of the projected cargo demand relative to the cargo handling capacity under the plan.

First, restoration works will begin at berth 9 at Baron Pier. This berth will accommodate general cargo from 1987 through 1992, and the restoration works will have to be completed before cargo handling at the berth begins to ensure safety.

In 1988, construction works on two new berths, C-1 will begin. C-1 will be located near berths No.1 and 2, and so these berths will have to be retired along with the beginning of the construction work on the new facility. Thus the capacity of the port for general cargo will temporarily be reduced to 1,430 thousand tons. The two new berths will be completed in 1990.

In 1991, construction work on another new berth, C-2, will begin. As C-2 is located near existing berths No.3 and 4, these berths will have to be retired along with the beginning of the construction of C-2.

In 1993, C-2 will be completed as a new container berth. In that year berth No.5 which is presently used for container cargo will begin to be used for general cargo, and the containers cargoes will then all be handled at the container berths C-1 and C-2. The restored berth No.9 at Baron Pier will then finally be retired.

In 1994, construction work will begin on G-2, another new general cargo berth. This construction will be completed in 1996, and the handling capacity for general cargoes will thereby increase along with the increasing demand.

In 1995, construction work will begin on still another new general cargo berth, G-3. This berth will be completed in the year 1998, and will replace berth No.5 which will be retired in that year.

Finally, construction of the last two new general cargo berths, G-4 and G-5, will begin in the year 2000. These berths will be completed in 2003 and will replace berths 6 and 7 which will be retired at that time.

In 2003, construction work will begin on the last new container berth, C-3. This berth will be completed in 2005.

In conclusion, as noted in Table VII-6-1, the development plan through the year 2010 can be divided into 3 phases. In the first phase, container wharves are constructed to meet the increasing container cargo demand, and a new general cargo berth is constructed as an aseismic facility. In the second phase, general cargo wharves will be built on newly reclaimed land to meet the increasing volume of general cargo. In the third phase, along with the construction of another container berth, it becomes necessary to construct new general cargo berths to replace older facilities which will be retired.

Fig. VII-6-2 ~ 4 show plans for the port at each phase.

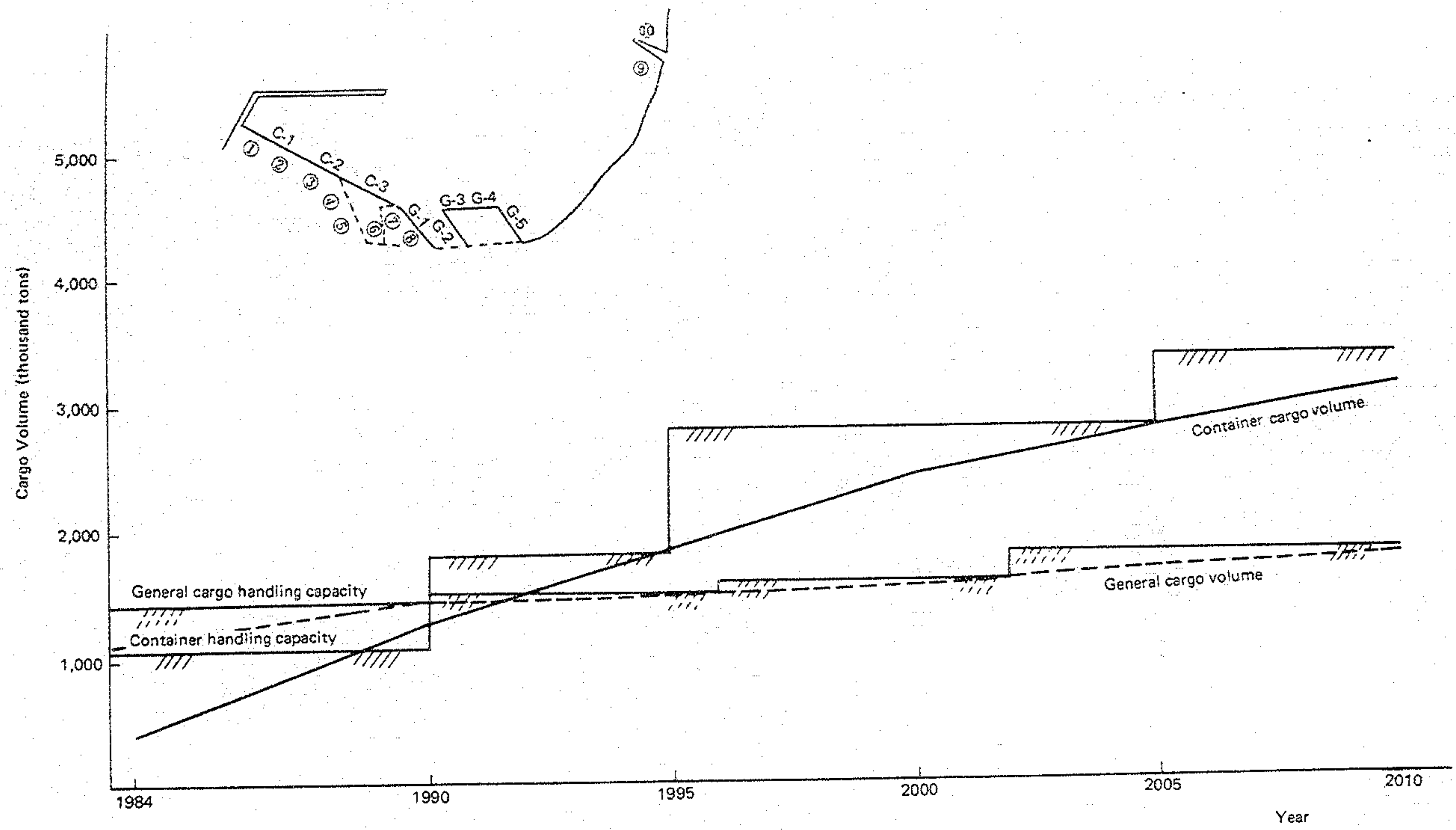
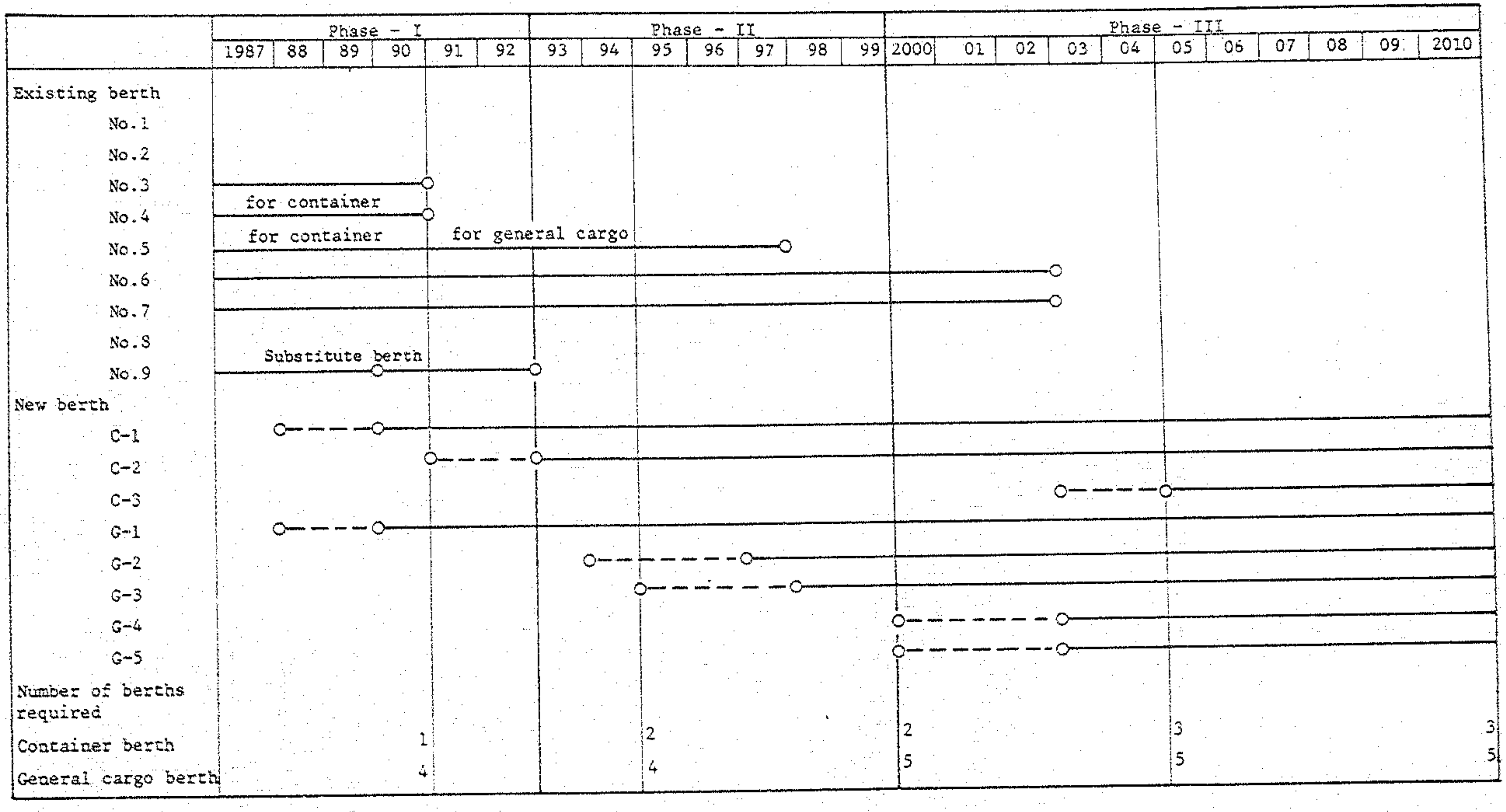


Fig. VII-6-1 Phase Plan for Constructing Berths of the Master Plan of the Port of Valparaiso

Table VII-6-1 Time Flow of Phase Plan at the Port of Valparaiso



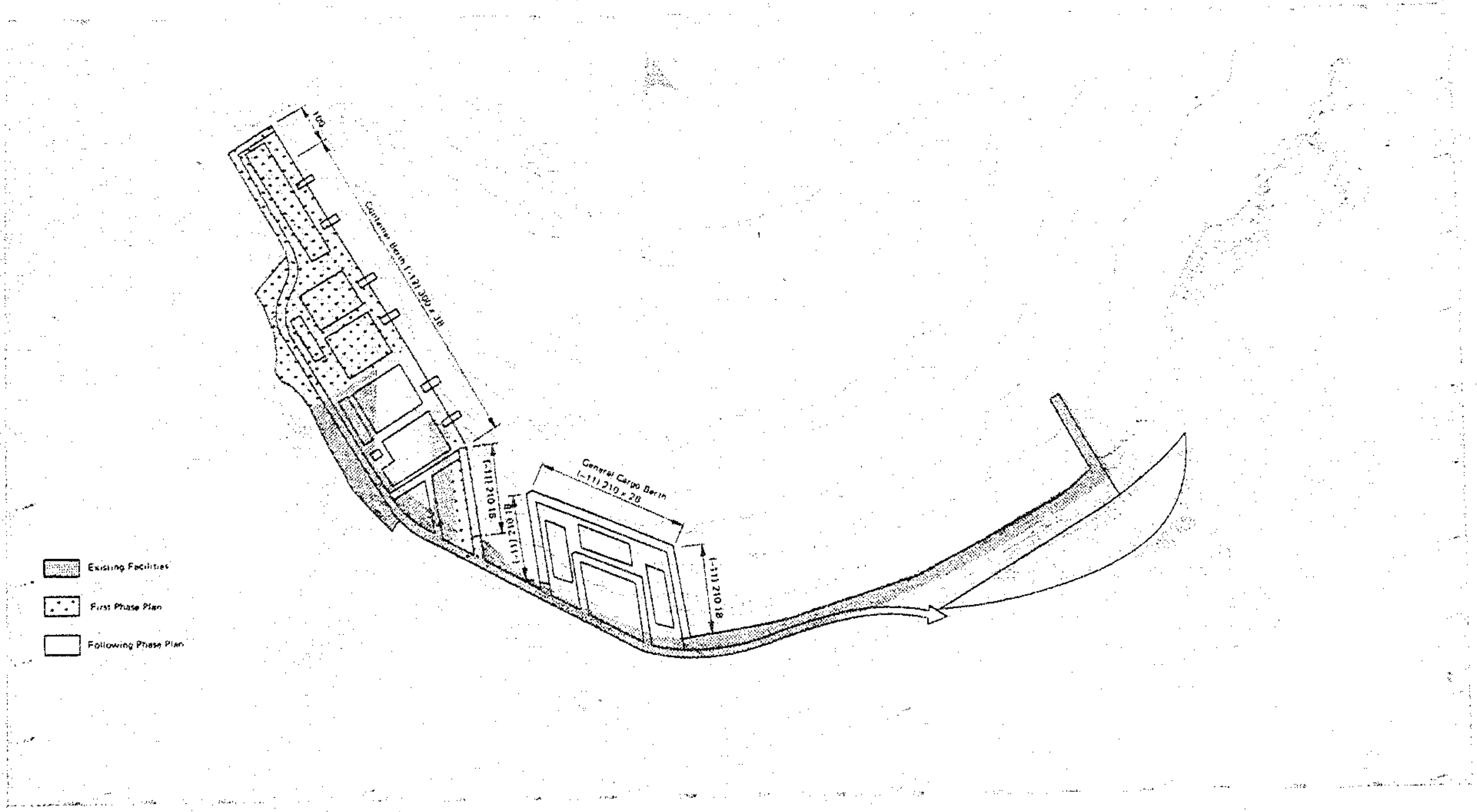


Fig. VII-6-2 Phase Plan (First Phase) 1988 ~ 1992

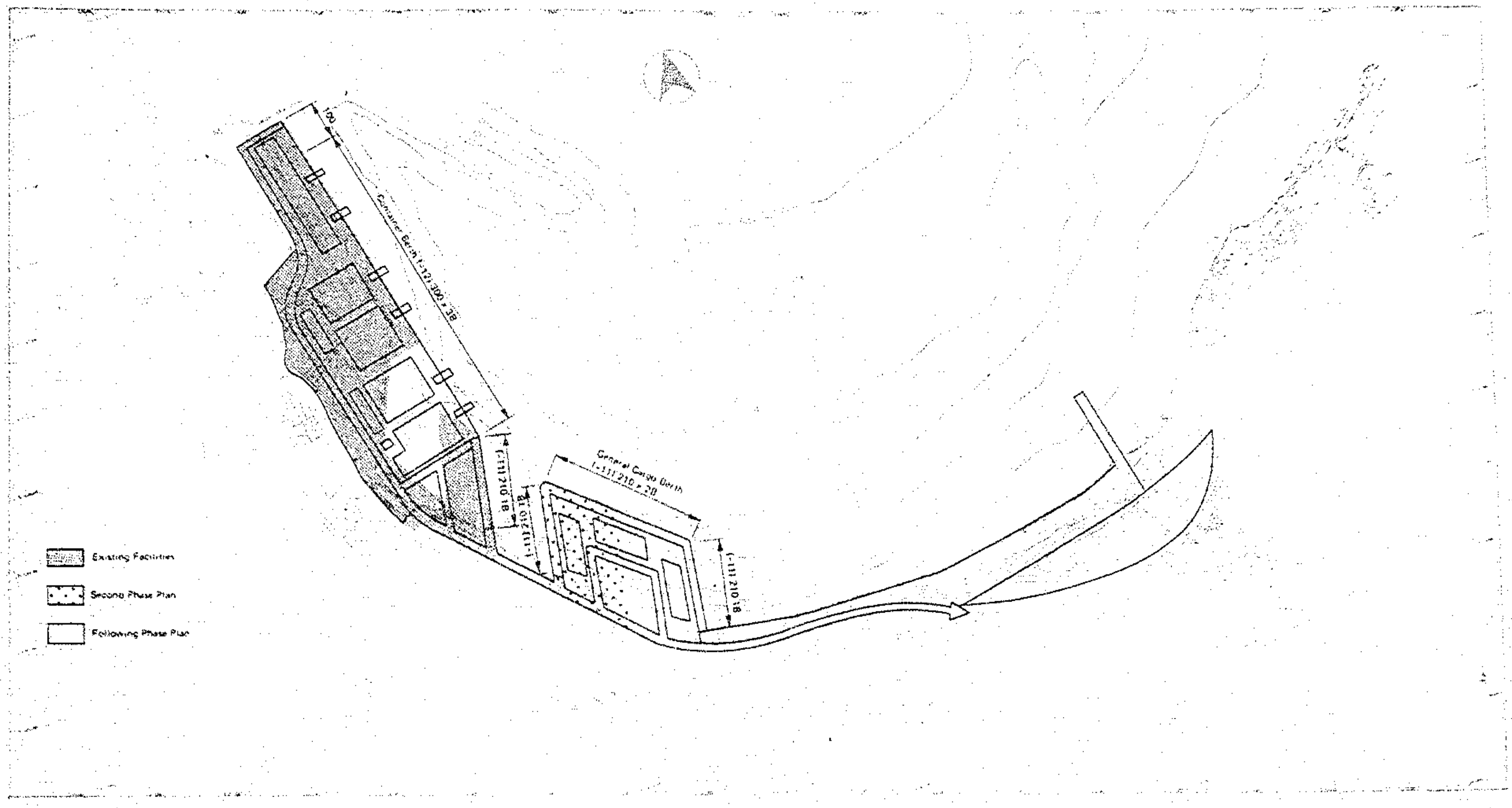


Fig. VII-6-3 Phase Plan (Second Phase) 1993 ~ 1999

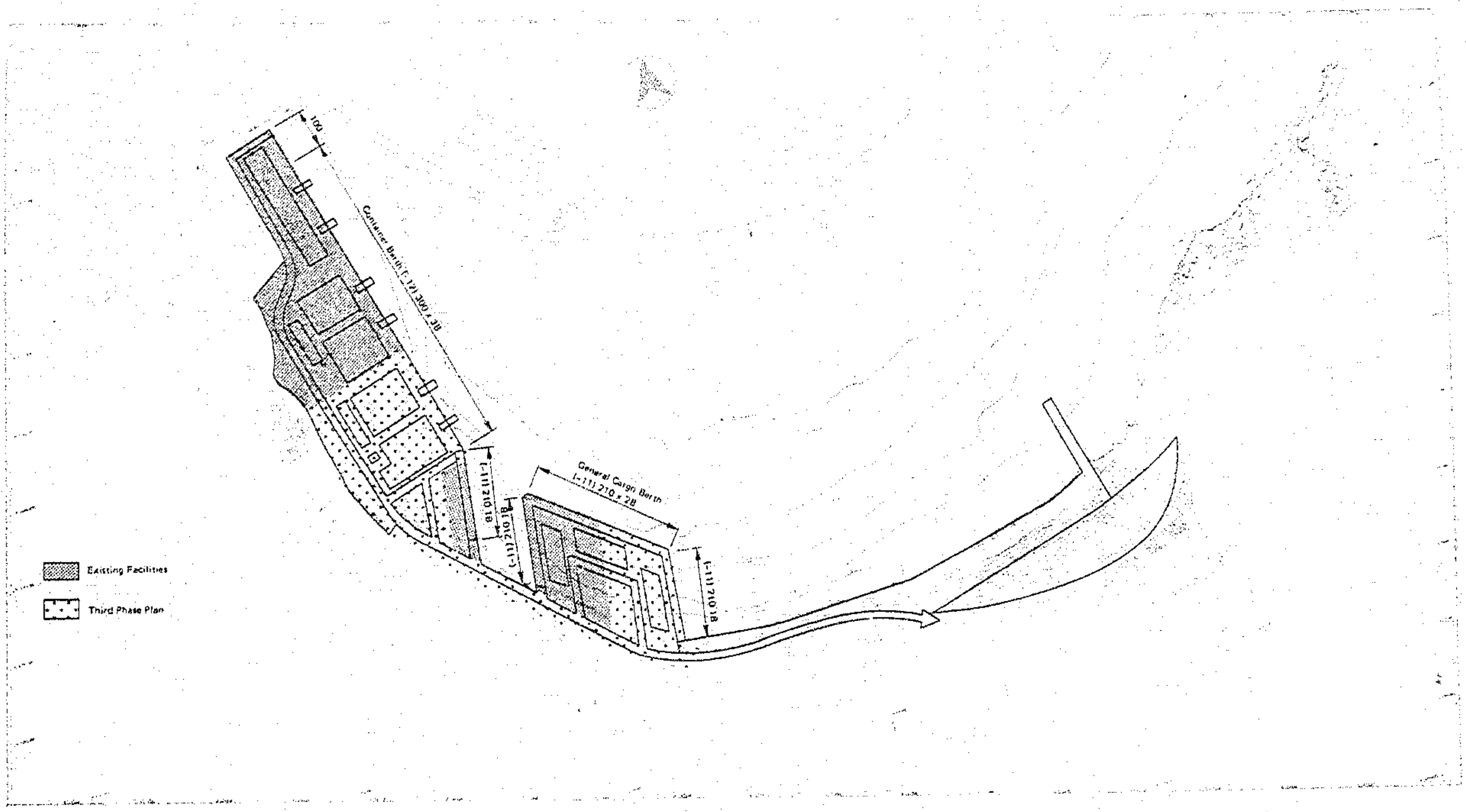


Fig. VII-6-4 Phase Plan (Third Phase) 2000 ~ 2010

(2) Phase Plan of the Port of San Antonio

As for the port of San Antonio, due to the extensive earthquake damage, there are not enough port facilities to accommodate the cargo demand. There are also highly superannuated berths being used at the port, and these berths will have to be restored or replaced.

A general outline of the time flow of the phase plan is presented in Table VII-6-3, and a layout of the port showing the old and new berths as well as a figure showing the relative growth of the cargo demand and the cargo handling capacity are shown in Figure VII-6-5.

Early in the plan, general cargo wharves will be constructed to meet the projected cargo volume, and these will be aseismic berths which can be used in case of emergency. Later on, various berths will be constructed step by step to meet the growing demand for various types of cargoes.

As the cargo capacity is currently not sufficient to accommodate the cargo demand, berth No. 10, which is actually located at the port of Valparaiso, is considered as part of the port of San Antonio for this planning process, and this berth will be used to handle some of general cargo demand until 1991. Some restoration works have to be performed before this berth can be used safely, and so berth No. 10 will be restored along with berth No.9 at Valparaiso Port as soon as possible.

As for the present handling capacity of the port, assuming that three berths are available for handling general cargo, that is berths No.5, 6 and 7, the present cargo handling capacity for general cargo at the port is 1,280 thousand tons.

Now, we consider the construction plan step by step. In 1987, construction work will begin on berth G-1. Prior to the recent earthquake, this berth was known as berth No.3. It was a new berth, under construction, and was almost completed at the time the earthquake occurred. Thus, the initial construction works at this berth will be relatively minor, and should be completed within one year. This berth is classified as a general cargo berth, but it will actually be used to handled both general cargo and chemicals until the construction of a berth exclusively for handling chemical cargo is completed in 1998.

In 1988, construction work will begin on berth G-3, a new aseismic general cargo berth. As this berth will be located near berths 6 and 7, these old berths will be retired when the construction works begin.

In 1990, the construction of berth G-3 will be completed, and the construction of the other aseismic berth, G-4, will begin. Berth G-4 will be completed in 1992 and will replace berth No. 10 (at Valparaiso) which will be retired in that year.

In 1996, construction work will begin on the chemical berth, berth C-1. The berth will begin operations in 1998. From that year, all chemicals will be handled at C-1, and berth G-1, which was used to handled chemicals and general cargo from 1988 through 1996 will be retired. Thereafter, a completely new berth G-1 will be constructed at the site of the old G-1. Thus, the construction works on the new G-1 will begin in 1998, and in the same year construction works will begin on another new berth, W-1.

Berths G-1 and W-1 will both be completed in the year 2000. The new G-1 will be used exclusively for general cargo. W-1, which is actually designed to handle wheat, will also be used as a general cargo berth until 2005.

In 2001, construction will begin on a new multipurpose berth, M-1. M-1 is located beside the existing berth No.4, so berth No.4 will be retired when the construction of M-1 begins.

M-1 will be completed in 2003, and in that same year construction work will begin on another new berth, G-2. As G-2 is located at the site of berth No.5, the old berth will be retired when the construction of the new berth begins.

Finally, in 2005, berth G-2 will be completed. Also in that year berth No.8, which is used to handle grain, will be retired as it will become too old, and berth W-1 will shift from handling general cargo to handling grain.

As with the facilities at Valparaiso, the facilities at San Antonio are designed so that there will always be a sufficient cargo handling capacity to accommodate the projected cargo demand. However, as noted above, berth No. 10 which is actually located at Valparaiso is considered as part of San Antonio Port for planning purposes and will be used to handle part of the general cargo over several years.

Generally, the construction plan can be divided into three phases. In the first phase (1988-1992), aseismic general cargo berths will be constructed to meet the projected cargo demand and to provided necessary facilities in case of an emergency. In the second phase (1993-1999), the chemical wharf will be constructed along with additional general cargo handling facilities.

The multipurpose berth and the grain berth will be provided in the third phase (2000-2010).

Fig. VII-6-6 ~ 8 show plans for the port at each phase.

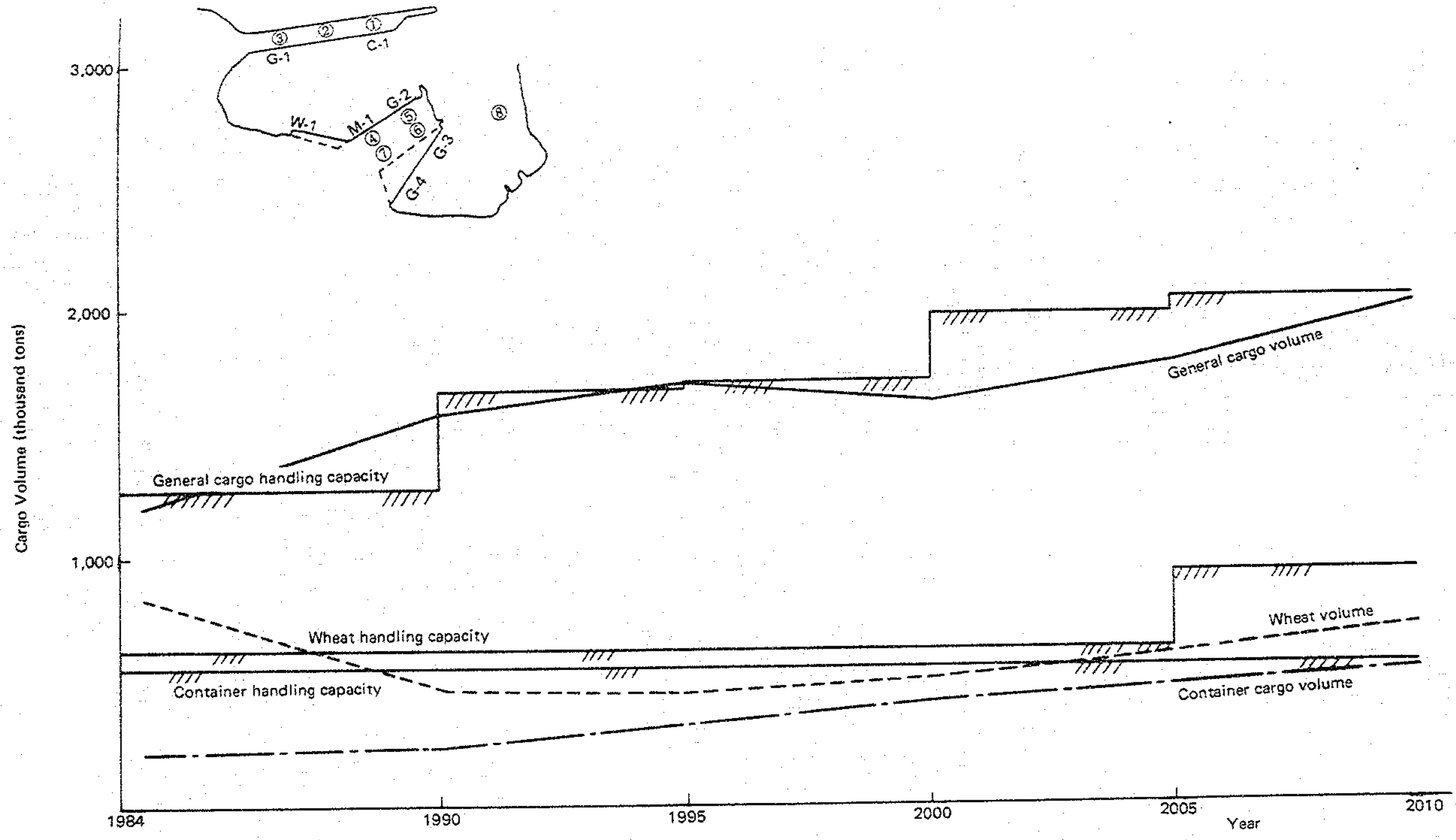
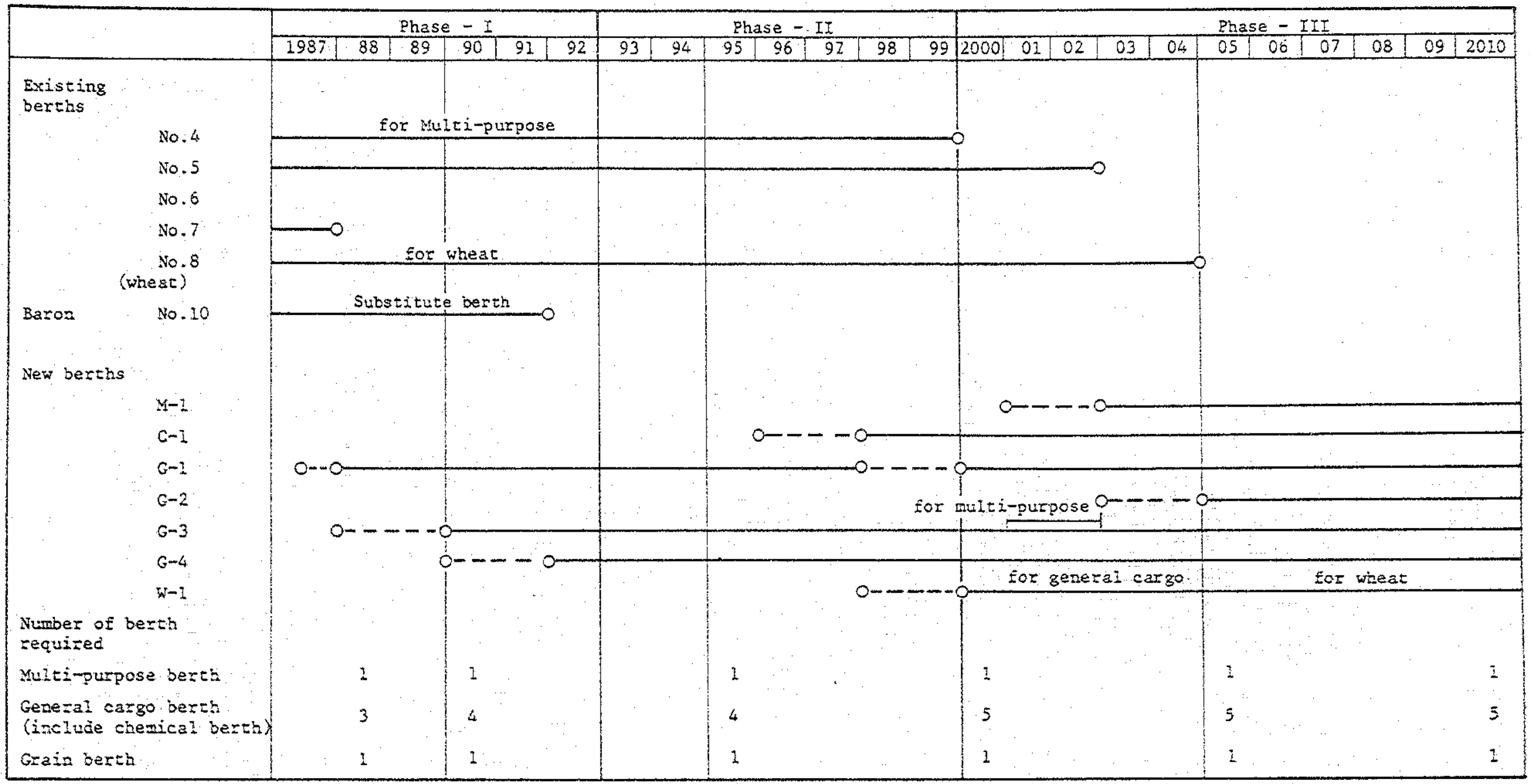


Fig. VII-6-5 Phase Plan for Constructing Berths of the Master Plan of the Port of San Antonio

Table VII-6-2 Time Flow of Phase Plan at the Port of San Antonio



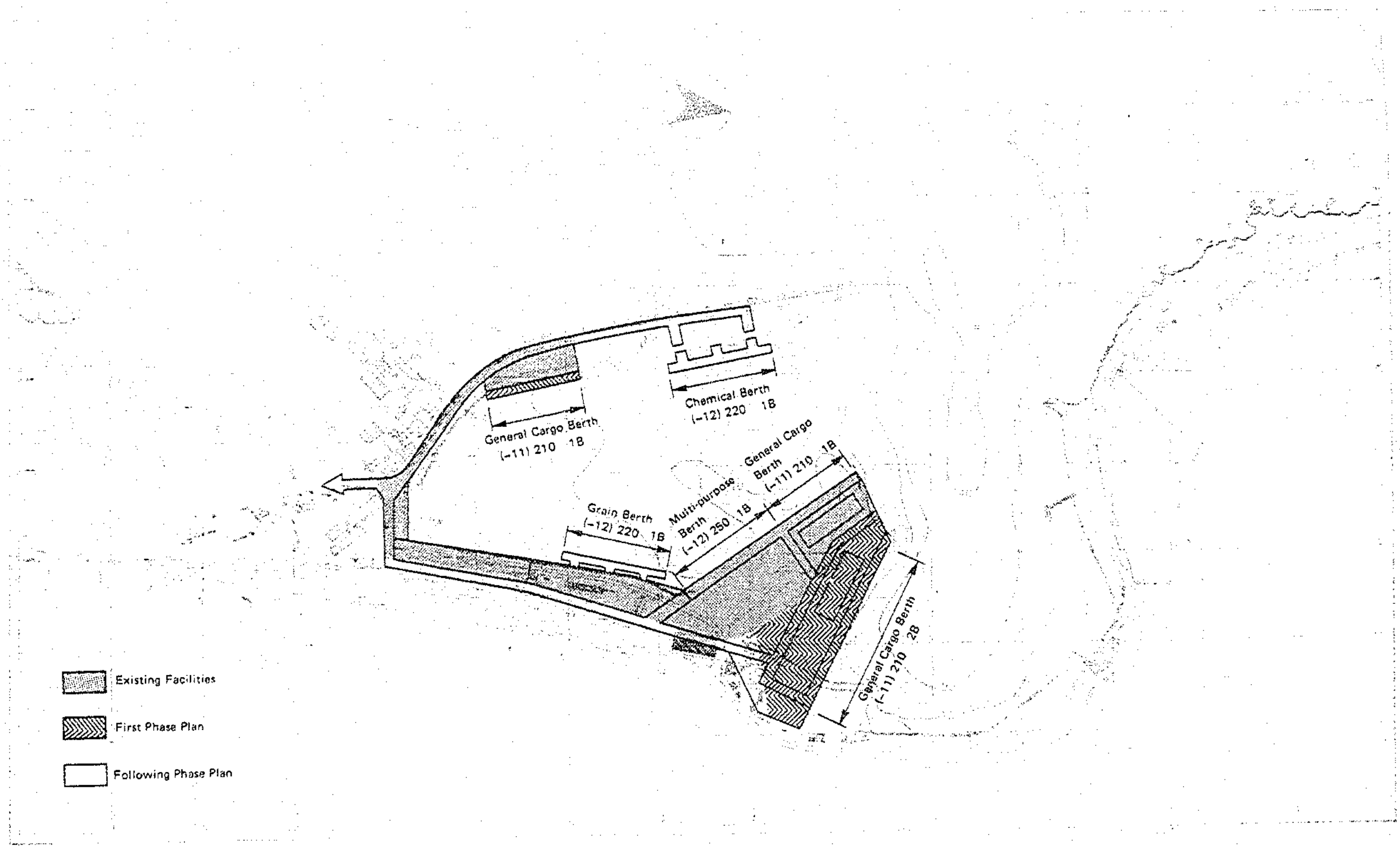


Fig. VII-6-6 Phase Plan (First Phase) 1988 ~ 1992

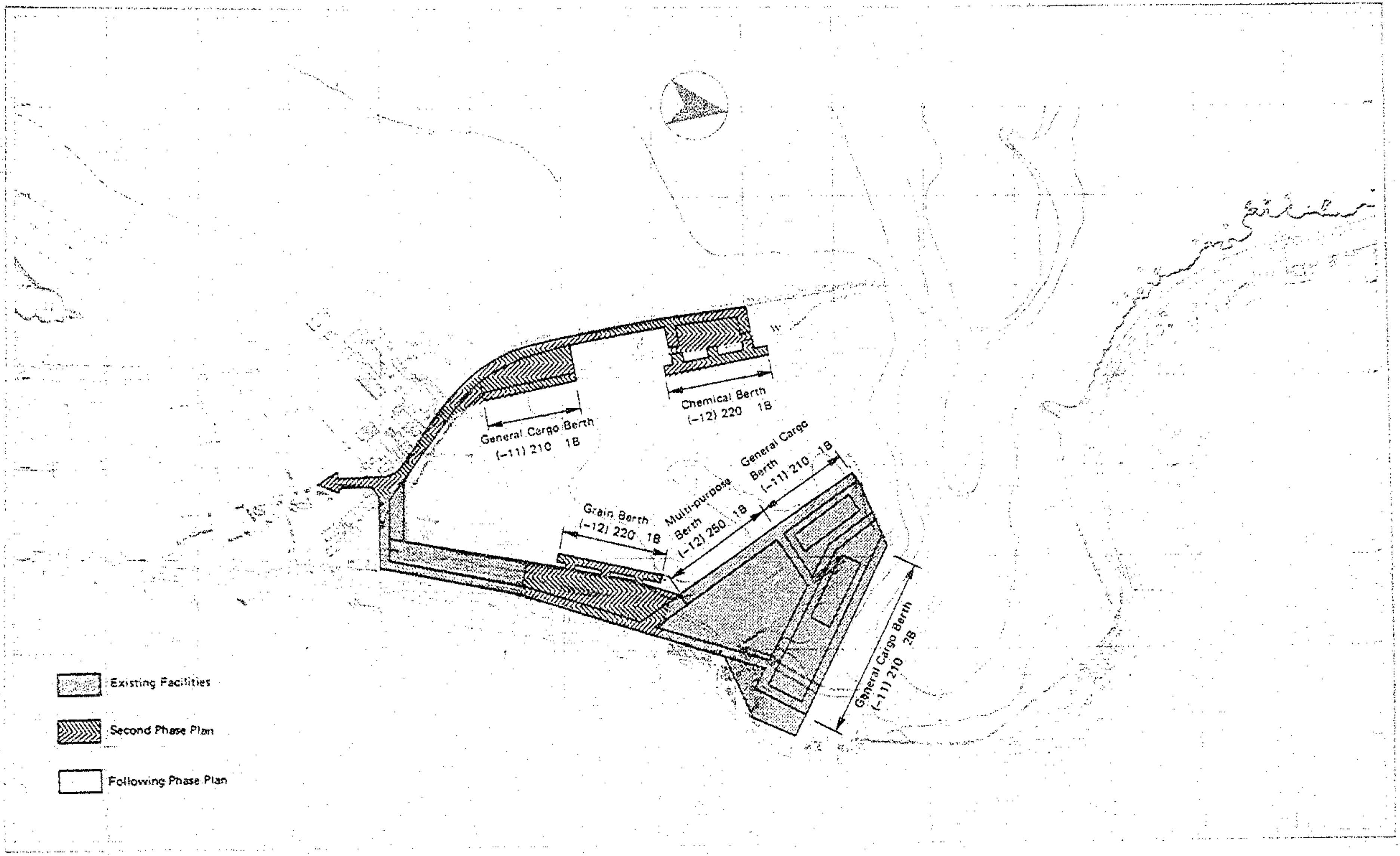


Fig. VII-6-7 Phase Plan (Second Phase) 1993 ~ 1999

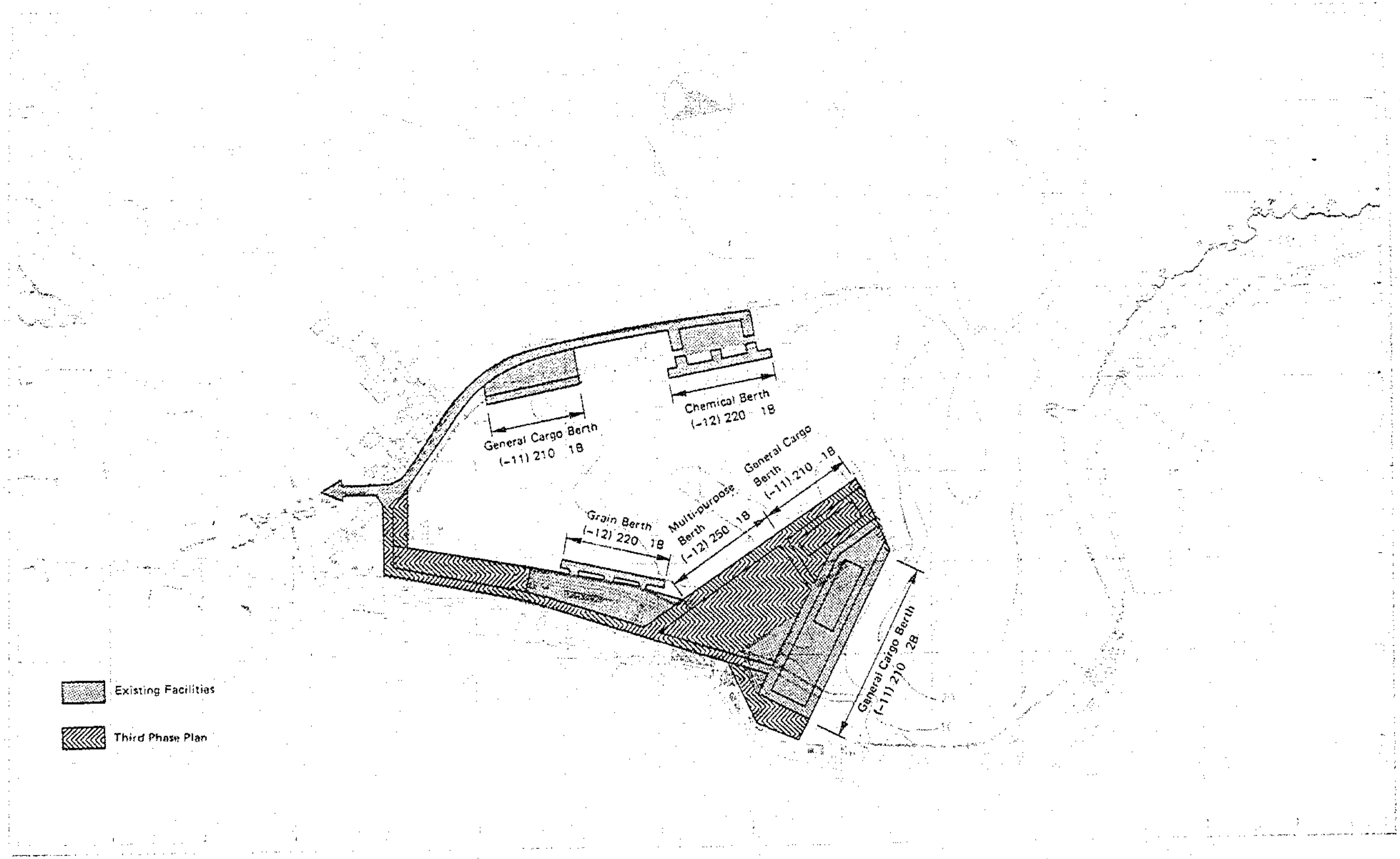


Fig. VII-6-8 Phase Plan (Third Phase) 2000 ~ 2010

VII-7 Analysis of Ship Size in the Future

For purposes of analyzing ship size in the future from the view of the contents of this plan, it is necessary to separate ship types into container and non-container ships.

1. Non-Container Ships

According to the statistics of Lloyd's Register of Shipping, the average gross tonnage (G/T) per ship of those other than oil tankers and ore bulk-carriers decreased from 2,779 G/T in 1960 to 2,161 G/T in 1970. There were no marked fluctuations to 1983, which showed 2,196 G/T (Refer to Table VII-7-1). Statistics on launchings and ships under construction show that cargo vessel, too, have seen no marked fluctuations: remaining about 6,500 G/T - 9,000 G/T and 9,000 G/T - 10,000 G/T, respectively (Refer to Tables VII-7-2, 3).

It is difficult to predict trends for individual shiptypes because these statistics are not broken down in such detail.

The average dead weight tonnage (D/W) of foreign trade liner ships, excluding full container ships, in Japan have been also seen no marked fluctuations: from 11,800 D/W in 1980 to 11,000 D/W in 1982 (Refer to Table VII-7-4).

Table VII-7-1 World Fleet Trends

Year	Total		Oil Tanker		Ore Bulk Carrier		Others (Cargo Vessel etc.)	
	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T
1948	29,340	80,292	...	15,594	...	...	...	64,698
1950	30,852	84,583	2,158	17,174	...	...	28,694	67,409
1955	32,492	100,569	3,575	26,455	...	...	28,917	74,114
1960	36,311	129,770	4,543	41,465	...	...	31,768	88,305
1965	41.865	160,392	5,307	55,046	1,403	18,757	35,155	86,589
1969	50,276	211,661	5,869	77,392	2,378	41,792	42,029	92,477
1970	52.444	227,490	6,103	86,140	2,528	46,651	43,813	94,699
1971	55,047	247,203	6,292	96,141	2,760	53,797	45,989	97,265
1972	57,391	268,340	6,462	105.129	3,048	63,487	47,881	99,724
1973	59,606	289,927	6,607	115,365	3,303	72,648	49,696	101,914
1974	61,194	311,323	6,785	129,491	3,491	79,438	50,918	102,394
1975	63,724	342,162	7,024	150,057	3,711	85,548	52,989	106,557
1976	65,887	372,000	7,020	168,161	3,932	91,738	54,935	112,101
1977	67,945	393,678	6,912	174,124	4,313	100,922	56,720	118,632
1978	69,020	406,002	6,882	175,035	4,557	106,545	57,581	124,422
1979	71,129	413,021	6,950	174,213	4,638	108,323	59,541	130,485
1980	73,832	419,911	7,112	175,004	4,706	109,596	62,014	135,311
1981	73,864	420,835	6,986	171,697	4,736	113,084	62,142	136,054
1982	75,151	424,742	7,021	166,828	4,947	119,298	63,183	138,616
1983	76,106	422,590	6,882	157,279	5.073	124,397	64,151	140,914

Sourse: Lloyd's Register of Shipping [Statistical Tables]

Table VII-7-2 World Ship Launchings

Year	Total		Oil Tanker		Bulk Carrier		Cargo Vessel		Others	
	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T
1977	2,549	24,167	229	7,500	381	8,545	518	4,518	1,421	3,604
1978	2,342	15,407	217	3,964	146	3,380	476	4,108	1,503	3,954
1979	2,236	11,788	222	3,367	96	2,024	380	2,985	1,538	3,412
1980	2,209	13,935	246	4,716	147	3,901	264	1,953	1,552	3,365
1981	2,160	17,066	239	4,413	262	7,951	230	1,564	1,429	3,138
1982	2,238	17,290	187	3,412	320	9,000	254	1,632	1,477	3,245
1981.III	523	4,268	61	1,329	65	1,994	70	467	327	478
IV	598	4,828	66	1,015	83	2,587	64	312	385	713
1982 I	478	3,975	39	745	76	2,171	65	547	298	513
II	555	4,909	57	1,287	77	2,487	85	643	336	492
III	549	4,093	38	659	85	2,245	70	552	356	636
IV	582	4,195	43	707	80	2,137	71	703	388	648
1983 I	493	4,087	33	832	74	1,908	79	704	307	643
II	495	3,332	28	319	60	1,585	69	785	338	642

Source: Lloyd's Register of Shipping [Merchant Shipbuilding] and [Annual Summary of Merchant Ships Launched in the World]

Table VII-7-3 Ships under Construction

Year	Total		Oil Tanker		Bulk Carrier		Cargo Vessel		Others	
	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T	Number	Thousand G/T
1977	2,051	20,937	142	6,869	249	5,873	457	4,674	1,203	3,520
1978	1,889	15,522	131	4,495	130	3,283	470	4,459	1,158	3,285
1979	1,780	12,686	138	3,494	115	2,903	327	3,250	1,200	3,038
1980	1,749	15,397	190	4,822	171	5,330	249	2,207	1,139	3,038
1981	1,874	16,348	185	4,454	220	6,917	241	2,076	1,228	2,900
1982	1,914	16,672	132	3,563	273	7,883	254	2,465	1,255	2,760
1981.III	1,844	15,817	191	4,343	201	6,190	244	2,124	1,208	3,161
IV	1,874	16,348	185	4,454	220	6,917	241	2,076	1,228	2,900
1982. I	1,916	16,312	182	4,570	221	6,720	254	2,010	1,259	3,012
II	1,892	16,686	174	4,616	240	7,223	237	2,008	1,241	2,840
III	1,968	16,678	157	4,151	249	7,290	254	2,340	1,308	2,898
IV	1,914	16,672	132	3,563	273	7,883	254	2,465	1,255	2,760
1983. I	1,838	15,666	120	3,187	258	7,151	256	2,546	1,204	2,782
II	1,759	15,026	111	2,343	261	7,076	268	2,799	1,119	2,808

Table VII-7-4 Trend of Foreign Vessels in Japan

Year	Total			Liner Ship									Trumper			Oil Carrier		
				Sub-Total			Full container		Others									
	Number	'000 G/T	'000 D/W	Number	'000 G/T	'000 D/W	Number	'000 D/W	Number	'000 D/W			Number	'000 G/T	'000 D/W	Number	'000 G/T	'000 D/W
1969	1,171	15,111	24,277	409	2,966	4,074							590	5,185	8,185	172	6,960	12,018
1970	1,337	18,112	29,396	452	3,200	4,390	14	254	438	4,136			712	7,063	11,310	173	7,849	13,696
1971	1,415	21,086	34,255	406	3,123	4,204							807	8,089	12,824	202	9,874	17,227
1972	1,414	23,317	38,719	406	3,115	4,214							798	9,035	14,647	210	11,166	19,859
1973	1,349	25,772	43,449	347	3,141	4,000							797	9,773	15,978	205	12,858	23,471
1974	1,215	27,933	47,665	283	2,836	3,490							721	10,720	17,145	211	14,377	27,030
1975	1,201	27,432	46,795	262	2,720	3,279	44	1,078	218	2,201			726	10,630	17,656	213	14,082	25,860
1976	1,138	28,487	49,183	253	2,667	3,183							664	10,753	17,947	221	15,067	28,063
1977	1,047	27,587	48,627	247	3,790	3,265							604	10,867	18,039	196	13,930	27,323
1978	946	26,502	45,911	217	2,672	3,060							542	9,917	16,613	187	13,913	26,238
1979	830	22,334	37,913	200	2,636	3,010							494	10,262	17,042	136	9,436	17,861
1980	874	23,551	40,208	175	2,512	2,792	60	1,437	115	1,355			536	10,396	17,185	163	10,643	20,231
1981	836	21,089	35,209	168	2,455	2,662	69	1,621	99	1,041			508	10,260	17,019	160	8,374	15,528
1982	928	24,420	40,460	160	2,504	2,699	73	1,739	87	960			579	12,367	20,518	189	9,550	17,243
1983	988	25,074	41,256	155	2,432	2,622							638	12,907	21,036	195	9,735	17,598

Source: Shipping Bureau, Ministry of Transport, Japan
Nippon Yusen Kaisha

2. Container Ships

1) Progress of Containerization

The history of containerization is as follows:

① First Generation (before 1966)

- Inception of the system.
- Size of containers not yet decided.
- Ships for carrying containers generally converted from general cargo ships or oil tankers with the range of 500 to 800 TEU and with self-sustaining gantry cranes on board.
- Use of existing breakbulk cargo berths.

② Second Generation (1966 - 1970)

- The first lift-on/lift-off full container ship pioneered the service between the US East Coast and Europe. (1966.4, Sea-Land)
- International container age begins.
- ISO Standard on freight containers decided. (20', 40' container)
- New containerships with 700 to 1,500 TEU (without cargo gear) are built.
- Container terminals equipped with quay-side container cranes are constructed.

③ Third Generation (since 1971)

- Long-distance international container services are inaugurated. (Europe - Far East, Europe - US West Coast)
- Containerization beginning to penetrate developing countries. (Southeast Asia, the Middle East, South America)
- Tendency to enlarge the size of containerships to the Panama Canal Limit. (over 2000 TEU)
- Appearance in specified trades of LASH and Seabee.
- Introduction of intermodal transport between oceans and interwater-ways.

④ The latest generation

- High-cube containers (9' or 9'-6' in height) introduced.
- Container stacked 3 or 4 high through the use of newly-developed tall straddle carriers or rubber-tired transfer cranes of wide span.
- Hoisting speed and trolley-traversing speed of quay-side container cranes increased.
- Semi-automatic terminal operation
- Land-bridge operations combining railway with sea transport organized.
- Round-the-world services by U.S.L. and Evergreen.

2) Shipbuilding Trends

The trend of newly completed full containerships from 1971 to 1984 is shown in Table VII-7-5.

New full containerships in 1984 show the highest record in TEU, exceeding the old record in 1978. Regarding average ship size, a tendency to enlarge is evident from 1,454 TEU (26,400 D/W) in 1983 to 2,054 TEU (34,665 D/W) in 1984

Table VII-7-5 Yearly Tonnages of Newly Completed Full Containerships in 1971-1984

Year	No.	Up(%)	GT	Up(%)	DW	Up(%)	TEU	Up(%)	TEU/GT	Mean TEU	Mean DW
1971	44		870,774		833,167		40,814		0.047	928	18,935
1972	68	54.5	2,008,996	130.7	1,713,838	105.7	82,727	102.7	0.041	1,217	25,203
1973	49	-27.9	1,453,894	-27.6	1,313,540	-23.4	64,590	-21.9	0.044	1,318	26,807
1974	29	-40.8	500,948	-65.5	463,917	-64.7	22,529	-65.1	0.045	777	15,997
1975	24	-17.2	430,090	-14.1	448,420	-3.3	24,127	7.1	0.056	1,005	18,684
1976	43	79.2	730,632	69.9	752,485	67.8	40,708	68.7	0.056	947	17,550
1977	63	46.5	1,271,120	74.0	1,267,212	68.4	66,550	63.5	0.052	1,056	20,114
1978	107	69.8	1,918,907	51.0	2,201,181	73.7	105,225	58.1	0.055	983	20,572
1979	94	-12.1	1,678,473	-12.5	1,908,894	-13.3	99,228	-5.7	0.059	1,056	20,307
1980	61	-35.1	1,367,024	-18.6	1,438,337	-24.7	84,873	-14.5	0.062	1,391	23,579
1981	49	-19.7	905,216	-33.8	964,291	-33.0	53,776	-36.6	0.059	1,097	19,679
1982	51	4.1	881,426	-2.6	1,038,114	7.7	52,873	-1.7	0.060	1,037	20,355
1983	59	15.7	1,393,390	58.1	1,557,747	50.1	85,801	62.3	0.062	1,454	26,402
1984	55	-6.8	1,642,001	17.8	1,906,573	22.4	112,990	31.7	0.069	2,054	34,665

Source: Nippon Yusen Kaisha (N.Y.K.)

3) Container Services to and from South America

Until 1983, container services to and from Chile were operated by ANDES GROUP (FE/SAM), CPU/EMP/EURAN GROUP (E/SAW), CSAV (USGEC/SAW) and CCNI (USEC/SAW).

In 1984, a new group (the EUROSAL GROUP) began the service between Europe and the South American West Cost with four new full containerships featuring 1,888 - 2,181 TEU and 34,000 - 38,000 DWT, as shown in Table VII-7-6. These are all PANAMAX-size containerships.

4) The Panama Canal Limit

Container operators expect the next generation to revolve around the following three points.

First, the size of containerships will tend to be enlarged to a capacity of over 3,000 TEU. The restrictions on ship size imposed by the Panama Canal may be ignored by some container operators whose services do not include that waterway.

Second, trunk line services by large capacity ships will involve a very limited number of major ports.

Third, the concept of round-the-world services will become a reality.

These three points are inconsistent with each other in certain areas, but overlap in others.

There is little chance that the containerships to and from the South American West Cost will exceed the Panama Canal Limit, shown as follows:

PANAMA CANAL LIMIT

Ship Length	(L)	= 900'
Wide	(W)	= 106'
Draft	(D)	= 40' (W=less than 104')

Table VII-7-6 Containerships of EUROSAL Group

OPERATOR	SHIP's NAME	TYPE	YEAR	GT	DW	TEU	SP'D	L x B x D
JOHNSON	BO JOHNSON	FC	1984	31446	34680	1905	0.0	201.0 x 32.2 x 11.5
CSAV	MAIPO	FC	1984	31248	37933	1888	18.5	203.1 x 32.2 x 12.0
PSNC	ANDES	FC	1984	32150	37042	2145	0.0	202.5 x 32.2 x 12.0
HAPAG	HUMBOLDT EXPRESS	FC	1984	32444	34307	2181	18.5	206.0 x 32.2 x 11.7
FULL CTNR SHIP (4)	TOTAL			127288	143962	8119		
EUROSAL	G.TOTAL			127288	143962	8119		

NAME OF GROUP : EUROSAL

MEMBERS

PSNC (GBI), CSAV (CHL), JOHNSON (SWD), HAPAG (GFR)

START OF SERVICE :

CALLING PORTS :

CALLAO, GUAYAQUIL, LIVERPOOL, AMSTERDAM,
HAMBURG, BREMEN, ANTWERP, SAN ANTONIO,
ANTOFAGASTA, ARICA, BUENAVENTURA, GOTHEMBURG,
BILBAO, VALPARAISO

Source: Nippon Yusen Kaisha (N.Y.K.)

VII-8 Examination of Number of Berths in Light of Seasonal Fluctuations of Fruit Harvest

(1) The monthly volume of cargoes in 2010

1) The monthly volume of fruit cargoes in 2010 is distributed with the ratio of monthly fluctuation at present. For other cargoes (mainly general cargo) excluding container cargoes, the monthly fluctuation of volume at present is almost nothing. Therefore, monthly cargo handling volume in 2010 is represented by yearly cargo handling volume divided into twelve. The result is shown in Fig. VII-8-1.

2) As shown in Fig. VII-8-1 cargo handling volumes in February, March and April are markedly large and are way above appropriate berth occupancy, 65%.

(2) Examination of number of berths

1) The number of berths for monthly cargo volume mentioned above is determined for a comparison of construction costs and berth maintenance and administration costs with ship waiting costs, in considering whether to apply peak cargo volume (for three months) or average cargo volume throughout the year.

2) The berth occupancy ratio for cargo volume in March is 93% for 5 berths, upsetting capacity control.

As a countermeasure, the two following proposals might be considered:

- make an increase of 1 bulk cargo berth.
- make use of 3 container berths for one month only.

3) Ship waiting time in these cases is shown in Table VII-8-1. According to the table, ship waiting time where there are 6 bulk cargo berths is 49.3 days, with container berths 92.4 days, and with 5 bulk cargo berths 175.4 days.

4) Ship waiting costs and construction costs in these cases are shown in Table VII-8-2. From this table, it is clear that the use of container

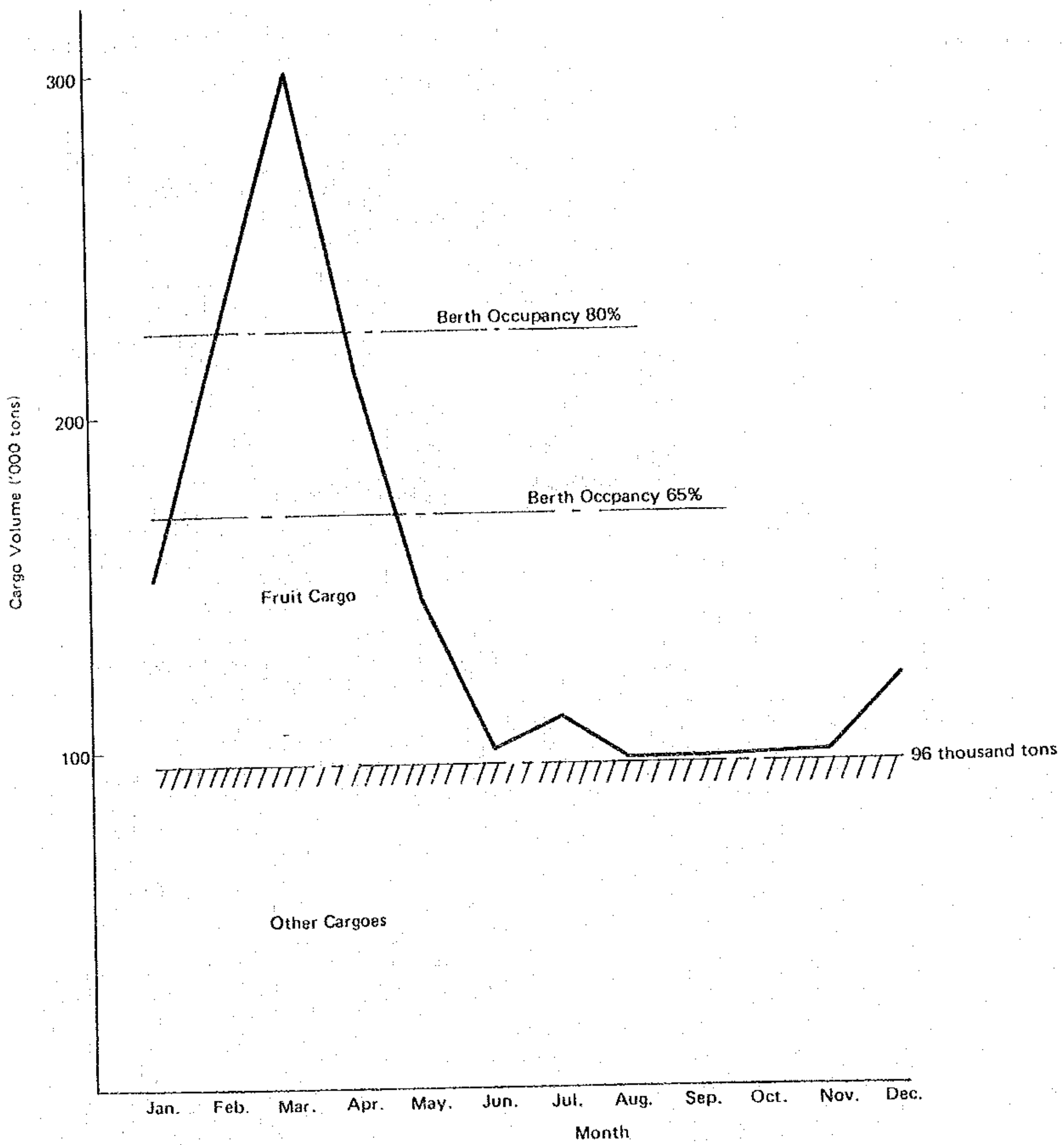


Fig. VII-8-1 Cargo Volume per Month at the Port of Valparaiso (2010) berths is the most economical.

5) Care must be taken in operating the berths when shipping fruit cargoes at the container wharf to avoid limiting entrance and exit of container vessels.

Table VII-8-1 Ship Waiting Time (Days)

Case-1 General Cargo Berths

Cargo Volume ('000 tons)		Feb.	Mar.	Apr.	Total
		223	299	213	
5 Berths	Berth Occupancy (%)	75	93	72	
	Total Waiting Time (days)	22.4	135.1	17.9	175.4
6 Berths	Berth Occupancy	62	80	60	
	Total Waiting Time (days)	6.5	37.5	5.3	49.3
					126.1

Case-2 General Cargo Berths and Container Berths (March only)

Cargo Volume ('000 tons)			Feb.	Mar.	Apr.	Total
			223	299	213	
5 G.C Berths	Berth Occupancy (%)	G.C. Berths	75	80	72	
		Container Berths	-	70	-	
3 Container Berths	Total Waiting Time (days)	G.C. Berths	22.4	37.5	17.9	
		Container Berths	-	14.6	-	92.4
6 Berths	Berth Occupancy (%)		62	80	60	
	Total Waiting Time (days)		6.5	37.5	5.3	49.3
						43.1

Table VII-8-2 Cost Comparison

Unit: million pesos

Item		Waiting Time	Waiting Cost	Construction Cost
1 General Cargo Berth	°New Berth	126.1 days	1,050	2,000
	°Use of Baron pier	126.1 days	1,050	760
Container Berth		43.1 days	360	0

Note: Costs are calculated by N.P.V. (Net Present Value) with a discount ratio of 12%.
Construction costs do not include maintenance and administration costs.