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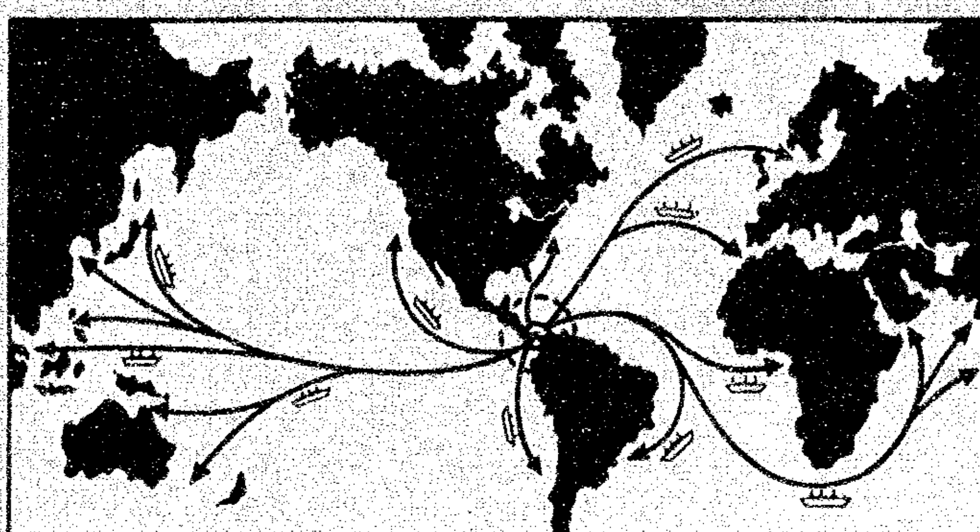
NATIONAL PORT AUTHORITY
THE REPUBLIC OF PANAMA

THE STUDY ON THE REHABILITATION PLAN AND THE CONTAINER TERMINAL OPERATION PLAN AT THE PORT OF CRISTOBAL IN PANAMA

FINAL REPORT

PART III SHORT TERM PLAN



November 1993

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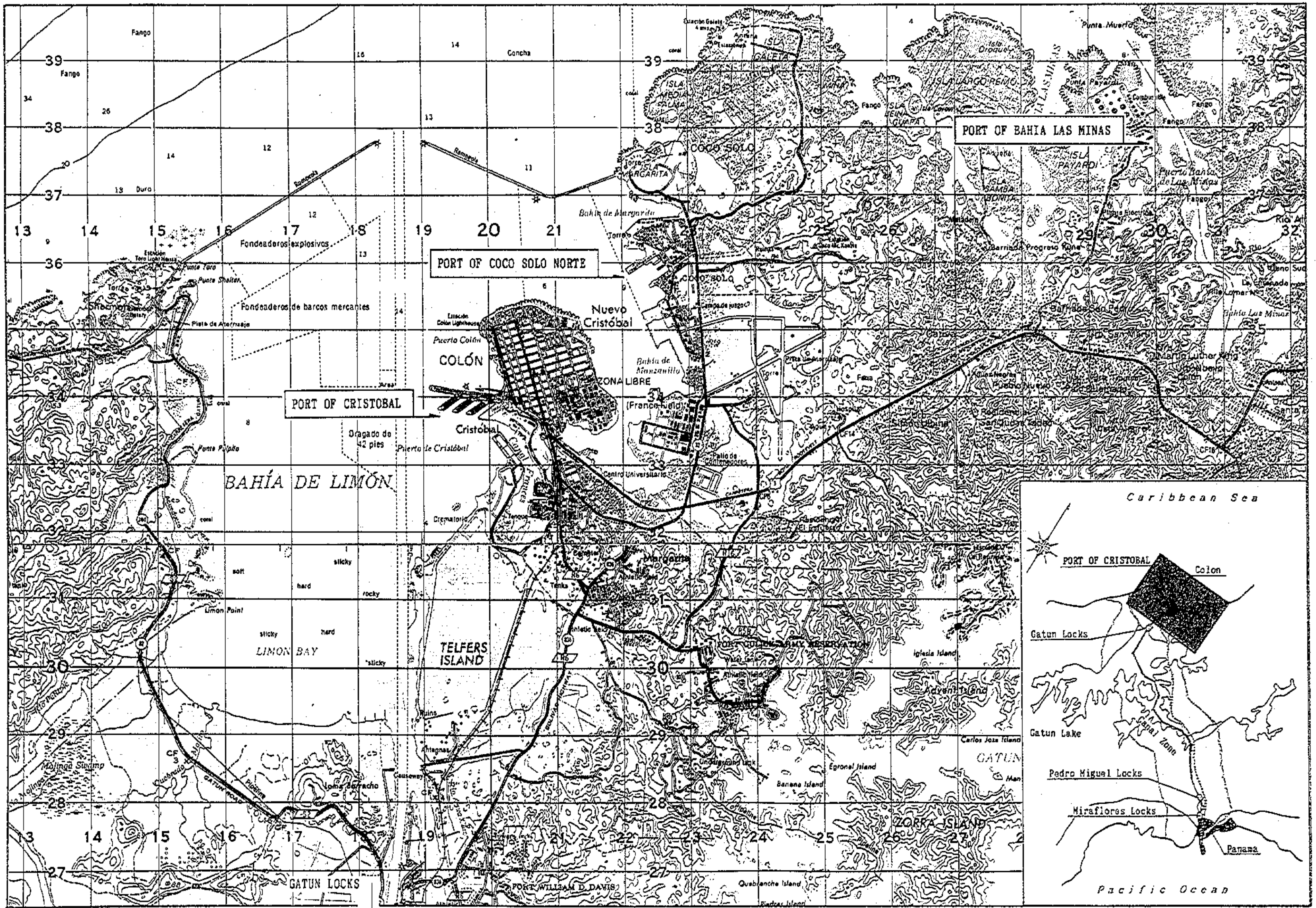

LOCATION MAP

ABBREVIATION LIST

A	APN	Notional Port Authority
	APSA	Atlantic-Pacific, S.A.
	ARI	Interoceanic Regional Authority
B	B/L	Bill of Laden
	BOD	Biochemical Oxygen Demand
	BOT	Build, Operate and Transfer
C	CFS	Container Freight Station
	CIF	Cost, Insurance and Freight
	COD	Chemical Oxygen Demand
	COFRISA	Consortium for the Development of Folk River, S.A.
	CPC	Centerport Concept
D	DO	Dissolved Oxygen
	DWT	Dead Weight Tonnage
E	EIA	Environmental Impact Assessment
	EIRR	Economic Internal Rate of Return
	EPZ	Export Processing Zone
F	FCL	Full Container Load
	FEU	Forty-foot Equivalent Unit
	FIRR	Financial Internal Rate of Return
	FOB	Free on Board
G	GDP	Gross Domestic Products
	GT	Gross Tonnage
H	HHW	Highest High Water
I	IEE	Initial Environmental Examination
	IMO	International Maritime Organization
L	LAQ	Lease a Quay
	LCL	Less than Container Load
	LLW	Lowest Low Water
	LUP	License to Use a Port
M	M/O or O/M	Maintenance and Operation, or Operation and Maintenance
	MHW	Mean High Water
	MIPPE	Ministry of Planning and Economic Policy
	MLB	Mini Land Bridge

	MLW	Mean Low Water
	MLWS	Mean Low Water Spring
	MSL	Mean Sea Level
N	NPV	Net Present Value
O	ODA	Official Development Assistance
P	PCC	Panama Canal Commission
	PLD	Precise Level Datum
R	Ro-Ro	Roll-on Roll-off
S	SS	Suspended Solid
T	TEU	Twenty-foot Equivalent Unit
U	UNCTAD	United Nations Conference on Trade and Development

Exchange Rate

1 US Dollar = 1 Balboa = ¥ 107.5
(as of July 1993)

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CHAPTER 1 BASIC POLICY FOR SHORT TERM PLAN

In this Chapter, we illustrate the basic policy for short term development of the port proposed on the basis of general concept of the function of public port and basic policy for the development of the Ports of Cristobal described in Introduction and Chapter 1 of PART II (Master Plan Study) of the Report.

In respect to the government commercialization policy, recommendations and proposals for short term plan are made on the basis that at least all infrastructures for project facilities including a new container terminal shall be owned and controlled under jurisdiction of APN.

1.1 Short-Medium Term Prospect of Socio-economical Conditions of Panama

In connection with short term planning for development of the Ports of Cristobal, the future prospect of relevant factors on socio-economical conditions of Panama needs to be clear as a base of planning works. The following represent are our basic understanding on this point.

(1) Steady growth of Panamanian economy can be expected at least over the next ten years, provided that the world economy and political/military balance with the United Sates and other neighboring countries will be stable.

(2) Under the same conditions as the above, Panamanian social/political regime will become more stable, attracting foreign investment to Panama.

(3) Scale of the trade between Panama and Central/South American countries will be steadily expanded as the economic activities in those regions will be activated in the probable absence of hazardous intra or international conflicts.

(4) Management and operation of the Panama Canal will be handed over successfully to Panamanian side by the year 2000, and on going expansion scheme will be in the final stage reserving more potential capacity to accept increasing number of vessels passing the Canal.

(5) On going and/or under planning expansion scheme for free trade zones in Panama will be mostly realized, providing the country with substantial increase in job opportunities and sea born cargo traffic followed by net income increase of the nation.

(6) The Government's efforts in upgrading overall socio-economic position of Colon city area will create more attractive business environment for both domestic and international economic circles stimulating their investment incentives.

1.2 Objectives of the Short Term Plan

Taking into consideration various requirements for the current situation of the port and overall demand of future port traffic, the core objectives of the plan are identified as follows:

(1) Improvement of total capability of the port in handling cargo flow including container traffic demand in particular which is already beyond the present capacity.

(2) Establishment of appropriate port management and operation system fit to run the public port under the current situation surrounding APN and other port related entities.

(3) Strengthening of sound financial position of APN for steady provision of high quality port service through a self-standing and sustainable manner of management.

(4) Identification of scale and substance of the physical development project and level of the other managerial and operational improvement schemes appropriate, as an intermediate step of development, in achieving the proposed goal of Master Plan.

1.3 Selection of Target Year

The year of 2000 is selected as target year for the short term plan of the project. The decision is made in consideration of the following factors:

(1) The target year of planning for such infrastructure as port needs to be within a practical time span so that the feasibility of the project can reasonably be confirmed based on reliable forecasts on various future conditions. For the purpose of the feasibility study, less than 10 years span is normally selected as a target year of planning.

(2) The second factor to be considered is the actual lead time required for preparatory or construction works for the project which differ depending on the size of a respective project. At least 5 years should be reserved for such purpose in this project which includes a new container terminal and minor improvement works on existing facilities.

(3) According to the agreement between the governments of Panama and the United States, an alternative site for a new container terminal currently under control of PCC is supposed to be returned to Panama by the year 2000.

(4) Considering the current level of GDP in Panama as well as the recent trend of its rapid growth, it may be fair to say that the Panamanian economy will soon be taking off, at latest around year 2000, and thus needs to be supported by well prepared infrastructure to accommodate appropriately such a scale of economic activity.

(5) In order to educe the maximum effect of the project, it is essential to synchronize the

timing of service commencement with other relevant infrastructures such as road, rail way, power supply system and utility mains, some of which are likely to be upgraded in and around year 2000.

1.4 Overall Policy for Reasonable Selection of Short Term Scheme

In selecting an appropriate scheme for short term development out of the number of development schemes proposed in the Master Plan, the following factors are considered as evaluation index:

(1) Flexibility for future expansion
(2) Immediate effect on current problems
(3) Profitability for further investment
(4) Practicability for smooth implementation
(5) Scale of positive impact on Panamanian economy
(6) Scale of environmental impact on the surrounding area

1.5 Basic Strategy for Short Term Planning

While the management improvement and physical planning for short term plan shall generally be in accordance with the overall concept and scenario of the long term development and layout plan proposed in the Master Plan, the following strategies are adopted for particular consideration in the short term plan:

(1) Short term planning should be conducted on the basis that the present legal or juridical system for port administration will generally be maintained at least for the proposed planning term.

(2) In order to secure the successful introduction of more efficient port management and operation system, a phased improvement scheme should be proposed.

(3) The total target scale of cargo handling capacity of the port after completion of the proposed schemes should be determined somewhat higher than the forecasted cargo traffic demand, considering possible inefficiency of port operation at the initial stage of service commencement.

(4) In determining the development site of a new container terminal, the maximum flexibility in selecting the sites for further development should be preserved so that we can easily cope with possible future contingency.

(5) The structural type of infrastructure of the wharf should be selected on the basis not only of cost and engineering applicability but also of local material availability and easy maintenance of the structure.

(6) With a view to minimize the initial investment cost of the project, only vital supporting facilities including access facility should be included.

(7) In evaluating the project feasibility, higher side estimation should be adopted for project cost and expenditure, while lower side estimation for economic benefit and revenue, so that we can keep allowance for the negative effect of possible contingency.

(8) To cope with immediate improvement requirement both for port facility and operation, urgent counter measures should be included in short term plan regardless of its target year.

(9) Alternative sites for the short term development should be carefully selected considering the future availability of PCC area in particular, with a view to avoiding possible failure in securing the space for key facilities of the project.

(10) All project facilities should be planned under careful consideration of environmental impact to minimize the marginal effect of the project.

(11) With a view to supporting or stimulating the activities of the Colon Free Zone, project site and function should be planned to fit the particular nature of traffic demand of Free Zone.

(12) Considering the significant role of the Canal to the Panamanian economy, layout plan of the project facilities should be drawn not to cause the Canal operation any harmful effects.

CHAPTER 2 DEMAND FORECAST FOR SHORT TERM PLAN

Demand forecast of port traffic has been already carried out for the target years of both 2000 (Short Term Plan) and 2010 (Master Plan) in Chapter 2 of Part II. Therefore, the results of the demand forecast for the year 2000 are summarized in this chapter.

Further, container cargo distribution to/from domestic origins and destinations is estimated in section 2.3 in order to appraise the project's feasibility.

2.1 Total Cargo Volume

The total cargo volume handled at the ports of Cristobal in 2000 is summarized in the following table.

Table 2-1-1 Total Cargo Volume at Ports of Cristobal in 2000
(Thousand metric tons)

Cargo Type	Import	Export	Total
Break Bulk	278	157	435
Containerized	1,265	426	1,691
Solid Bulk	120	-	120
Liquid Bulk	-	5	5
Tranship.: Break	54	54	108
-Ditto-: Container	72	72	144
Total	1,789	714	2,503

2.2 Container Cargo Throughput

Among the estimated total cargo in 2000, the container cargo expressed in metric tons and TEUs is shown in Table 2-2-1.

Table 2-2-1 Container Cargo Throughput in 2000
(Cargo volume in thousand metric tons, number of containers in thousand TEUs)

	Import	Export	Total
a. Laden			
Cargo Volume	1,265	426	1,691
Numbers in TEUs	173	65	238
b. Empty			
Numbers in TEUs	12	126	138
Total (a+b)			
Numbers in TEUs	185	191	376
c. Transhipment			
Cargo Volume	72	72	144
Numbers in TEUs	8	8	16
Grand Total	1,337	498	1,835
(TEUs)--	193	199	392

2.3 Container Cargo Distribution by Domestic Origins and Destinations

In the demand forecast carried out in Chapter 2 of Part II, total container cargo based on TEUs was estimated. In this chapter, volume of container cargo to/from each origin and destination is estimated in order to appraise the project's feasibility.

According to the trend of past records, it can be said that the average volume per TEU by each origin and destination has remained unchanged and the tendency will continue until 2000 at least.

The container cargo distribution by domestic origins and destinations is shown in the following table.

Table 2-3-1 Cargo Flow by Domestic Origins/Destinations

Total Cargo: (thousand metric tons)

	Import	Export	Total
Free Zone	780	416	1,196
Panama General -----	763	167	930
Solid Bulk --	120	-	120
Liquid Bulk -	-	5	5
Total	1,663	588	2,251
Transhipment	126	126	252
Grand Total	1,789	714	2,503

Container Cargo:

	Metric Tons	TEUs
Free Zone	1,055,000	263,000
Panama	636,000	113,000
Transhipment	144,000	16,000
Total	1,835,000	392,000

2.4 Number of Ship Calls

Result of estimate for number of ship calls in 2000 is shown in Table 2-4-1 (refer to 2.6 of Part II).

Table 2-4-1 Number of Ship Calls in 2000

Ship Type	Cargo Volume	Ship Calls
Container & Ro/Ro Ship	392,000 TEUs	560
Mix Type Ship	543,000 m.t.	453
Solid Bulk Carrier	120,000 m.t.	12
Liqd. Bulk	5,000 m.t.	2
TOTAL		1,027

2.5 Passenger Traffic

Around 20,000 passengers arrived at the port of Cristobal in 1991, but few passengers actually disembarked because of poor facilities, insufficient security measures and lack of attractions around the port.

Therefore, assuming that the present number of passenger ships will continue calling until 2000, the current number of passengers, that is 20,000 persons, will disembark and stay in Panama.

CHAPTER 3 PHYSICAL PLAN OF PORT FACILITIES

Physical plan of recommended project in short term stage is described in this chapter.

3.1 Development of New Container Terminal

A new container terminal is planned to be developed at Telfers Island. Transfer crane system is adopted as cargo handling system. Annual throughput of container cargo of this terminal in the year 2000 is estimated as follows;

	(thousand TEUs)	
Laden	103	
(Import)		(69)
(Export)		(25)
(Tranship)		(9)
Empty	59	
Total	162	

3.1.1 Construction of Terminal Facilities

Layout plan of major facilities is shown in Figure 3-1-1.

(1) Wharf

One container berth for Panamax type container vessels will be constructed. Major specifications are as follows:

Length	300 m
Depth	-13 m (possible to be deepened up to -14 m in future)

(2) Terminal Area

Terminal has area of 1,050 m^2 (300 m X 350 m). Area use is shown as below.

	(m^2)	
Apron	15,900	(300 X 20)
Marshaling Yard	54,900	(1,495 ground slots)
Back Yard	34,200	(CFS, Office etc.)
Total	105,000	

Base allocation of slots in the marshalling yard to containers is roughly indicated in the Figure. Reefer containers will be assigned at the most inner row, which will be equipped with reefer plugs for 100 TEU containers. This allocation should be flexibly revised upon actual situation of yard operation.

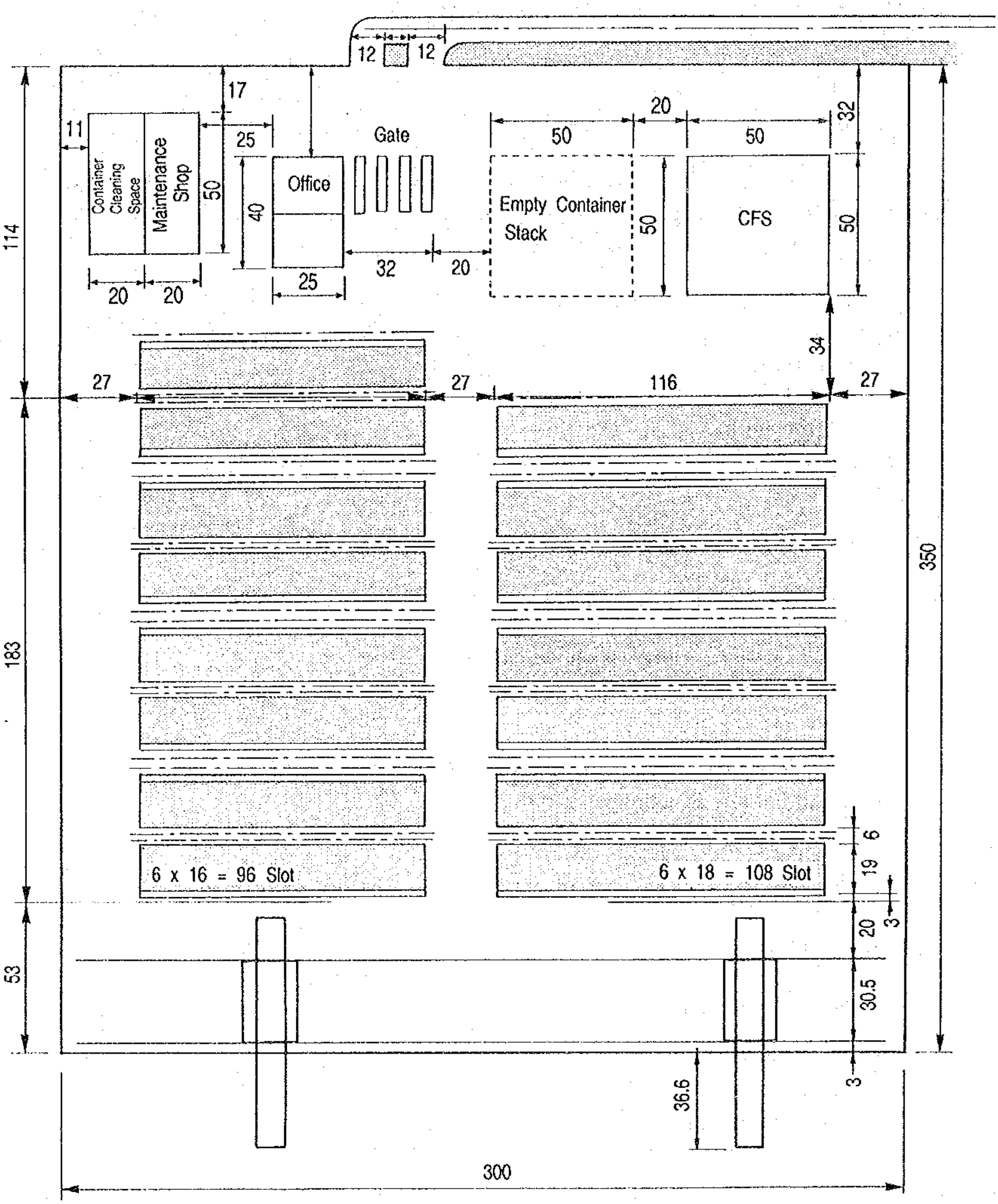


Figure 3-1-1 Layout Plan of New Container Terminal

(3) Buildings

In the terminal area, a CFS, a terminal office and a maintenance shop will be provided. Areas required for these buildings are as follows;

	(sq.m)
CFS	2,500
Terminal Office	1,000
Maintenance Shop	1,000
Total	4,500

In long term stage, this maintenance shop will be relocated to the other new terminal and will be expanded in order to serve for all terminals in Telfers Island. CFS will be expanded in long term stage.

Next to the maintenance shop, a 1000 sq.m of container cleaning space will be provided.

(4) Waterways and Basins

Access navigation routes to the container berth should be provided from both the northward and the southward directions. Turning basin should be secured for Panamax size vessels in front of the terminal as shown in Figure 3-1-2. This area is also used by other vessels which call at existing wharves at the port of Cristobal. Total area of waterways and basins will be approx. 100 ha in total.

3.1.2 Cargo Handling Equipment

Container cargo handling equipment required for operation of the new terminal is illustrated in this section.

(1) Container Crane

Two container cranes for Panamax type container vessels will be provided at quay side. Basic specification of these cranes, which is almost the same as existing ones at Pier No.9, is shown as follows.

Rated capacity (under the spreader)	:	41 metric ton
Out Reach	:	36.6 m
Rail Span	:	30.5 m

A wide rail span in the same level with super gantry cranes for over Panamax type vessels will be appropriate considering future possible replacement by super gantry cranes.

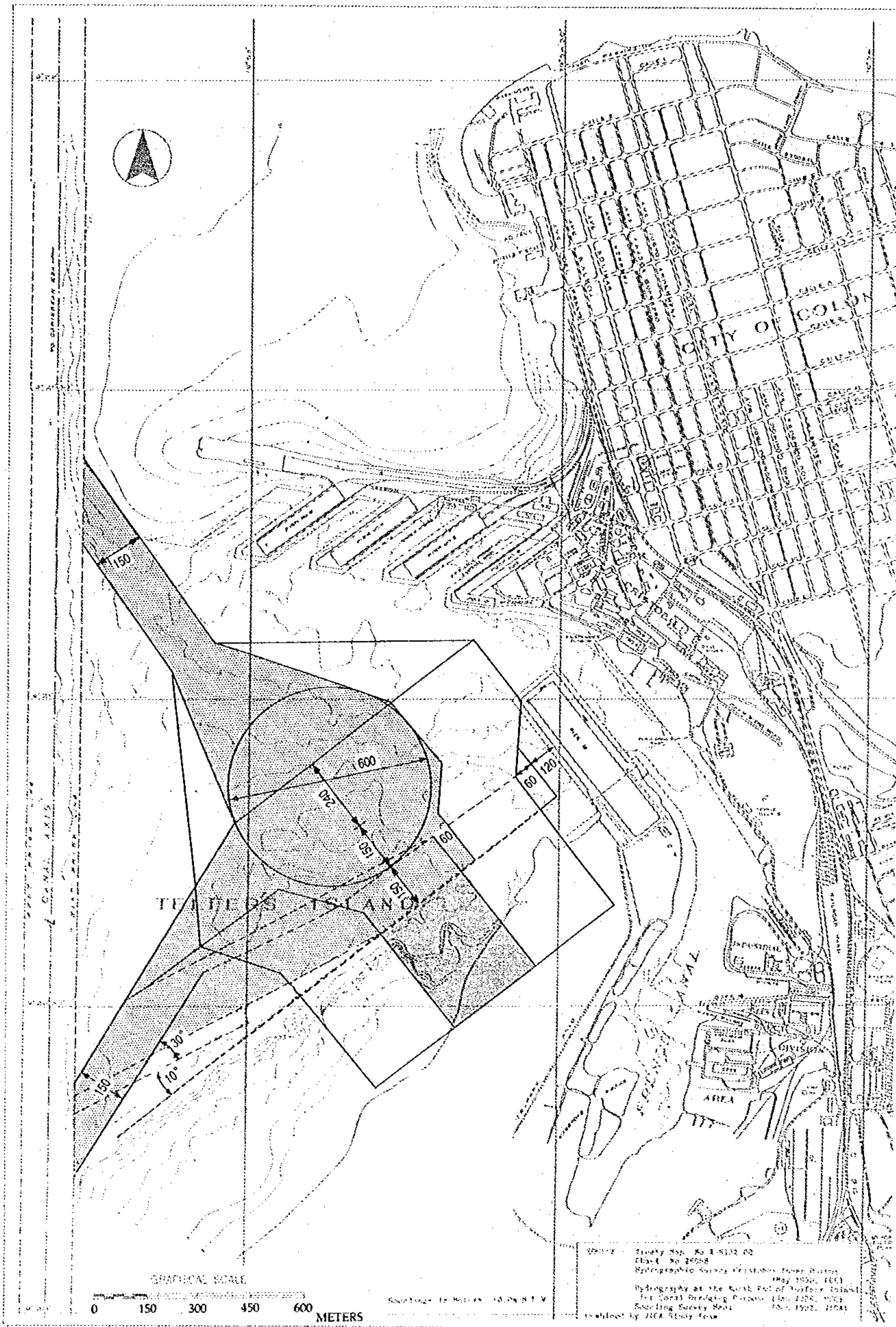


Figure 3-1-2 Waterways and Basins for New Container Terminal (Short Term)

(2) Transfer Cranes

Four tire mount type transfer cranes will be deployed in the marshalling yard. Basic specification is shown below.

Span	:	23 m (6+1 row)
Height	:	4 layers clearance

(3) Top-loaders and Forklifts

Top-loaders are mainly used for empty container handling in container yard. Forklifts are mainly used in CFS. Required equipment by number and type is as follows.

Top-loader	:	2
Forklift	:	4

(4) Chassis and Tractor

Required number of chassises and tractors are estimated as follows.

Chassis	:	17
Tractor	:	10

3.2 Modernization of Existing Container Terminal

3.2.1 Expansion and Improvement of Major facilities

In order to cope with the future requirement for upgrading the service level, expansion and re-arrangement of container yard is planned in short term stage.

(1) Expansion of Container Yard

Container yard will be expanded northward by 1.87 ha in total as shown in Figure 3-2-1. The expanded area will be used for container marshaling area and inner access space.

(2) Re-pavement of Container Yard

Based on the visual inspection, 1,848 sq.m of existing container yard should be improved in short term stage in order to secure smooth operation.

(3) Development and Rehabilitation of Supply Mains

Necessary supply system is already equipped in the existing container yard. New installment of a supply system is not needed, however, regular maintenance is required.

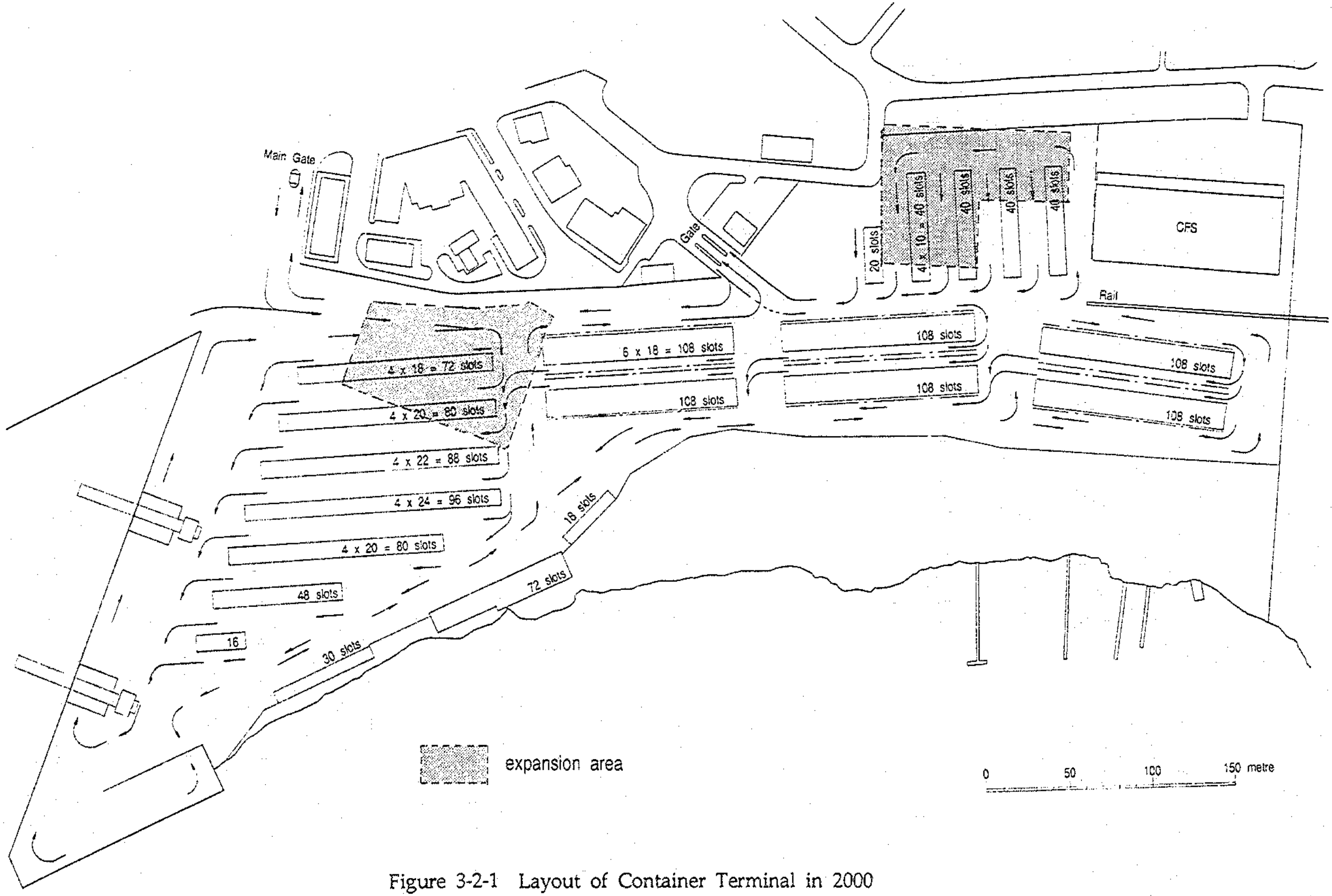


Figure 3-2-1 Layout of Container Terminal in 2000

(4) Others

3.2.2 Improvement and Replacement of Container Cargo Handling Equipment

(1) Container Crane

Existing container cranes were installed from 1984 to 1986. Considering the normal life of container cranes, these cranes should be replaced around the year 2000.

(2) Transfer Crane

Three transfer cranes should be deployed at container terminal in short term stage. Since existing two transfer cranes are old (produced in 1968) and one of them is out of order and under repair at present, they should be replaced during short term stage.

(3) Top-loader, Forklift

Due to the partial introduction of transfer crane system, required number of Top-loader (or Reach Stacker) and Forklift will be reduced. However, many of them are rather old and gradual replacement is needed.

(4) Chassis, Tractor

The number of chassis is definitely short of the required number. Almost all of them are old and needed to be replaced as soon as possible. Twenty five chassises will be needed in the year 2000.

3.3 Modernization of Existing Piers

3.3.1 Improvement of Major Facilities

(1) Pier No.6

No special reconstruction or improvement is not planned. Ordinary maintenance work will be conducted.

(2) Pier No.7

In order to cope with increasing container cargo handling, the quay shed on Pier No.7 should be totally demolished. The remaining area will be paved and used as a tentative container stacking area.

(3) Pier No.8

No special reconstruction or improvement is planned. Ordinary maintenance work will be conducted.

(4) Mole and Surrounding Area

Northern part of mole area will be exclusively used for access road to PCC's navigation control center. Only southern part can be used for port operation.

In order to tentatively stock automobiles to be imported or exported and empty containers, 4,860 sq.m of mole area presently used for railroad branch line will be leveled and paved.

3.3.2 Improvement and Replacement of Cargo Handling Equipment.

There is no wharf crane on these piers. Vessels berthing at these piers are expected to use their own ship gears for cargo handling. However, a mobile crane is preferable to be deployed mainly in order to support efficient container cargo handling at Pier No.7.

3.4 Improvement of Related Facilities Surrounding the Port

3.4.1 Access Road and Parking Area

Access road from Boliver Highway to Telfers new container terminal should be constructed along Telfers Road and Limon Road.

Two lane road will be enough during short term stage, however, space for possible future expansion to four lanes should be reserved along the road. Between terminal and access road, the space for possible future introduction of access railroad should be reserved. It is not necessary to pave this area. This area can be tentatively used as a parking area for truck and trailers.

A short cut way via south side of the base ball park will be mainly used to access Randolph Road.

Since access from the port of Cristobal to the Colon Free Zone is poor condition at present, new access routes will be provided in line with expansion of the Free Zone presently undergoing.

3.4.2 Container Stacking Yard Outside of the Port

A wide space of approx. 27 ha for stacking empty containers and vehicles will be provided at south side of existing container terminal by concession to the private sector.

3.4.3 Removal of Anchorage Area "F"

Anchorage area "F" is a space for small vessels which transit the Panama canal. An area with similar conditions to this anchorage can be found at the south side of Margarita Island. Since there is a plan of large scale development for marina and residence, it is an appropriate area to relocate the anchorage.

CHAPTER 4 CARGO HANDLING SYSTEM PLAN

4.1 Improvement of Layout Plan for Existing Container Terminal

4.1.1 Allocation of Container Stacks

The annual volume estimated to be handled in 2000 is 165 thousand TEU. The number of ground slots to be allocated for each container traffic mode is worked out taking into consideration such factors as dwelling time, stacking height, stacking efficiency, annual working days and peak factors. These have been minutely investigated. The proposed allocation for each traffic mode is shown in Table 4-1-1.

Table 4-1-1 Allocation of Container Stacks

No.of Stack	Application	Ground Slots	Dwell. Days	Stack. Height	Effici- ency	Peak Ratio	Opera. Days	Through- put(TEUs)
1	Export(empty)	72	6.5	4.0	0.85	1.3	310	8,981
2	Export(empty)	80	6.5	4.0	0.85	1.3	310	9,979
3	Export(empty)	88	6.5	4.0	0.85	1.3	310	10,977
4	Export(empty)	96	6.5	4.0	0.85	1.3	310	11,974
5	Export(loaded)	80	2.8	3.0	0.85	1.3	310	17,374
	Export(loaded)	40	2.8	3.0	0.85	1.3	310	8,687
6	Export(empty)	8	6.5	4.0	0.85	1.3	310	998
	Export(empty)	8	6.5	4.0	0.85	1.3	310	998
7	Tranship	8	3.5	3.0	0.85	1.3	310	1,390
8	Tranship	30	3.5	3.0	0.85	1.3	310	5,212
	Export(empty)	42	6.5	4.0	0.85	1.3	310	5,239
9	Import(empty)	30	10.4	4.0	0.85	1.3	310	2,339
10	Import(loaded)	18	6.0	3.0	0.85	1.3	310	1,824
11	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
12	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
13	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
14	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
15	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
16	Import(loaded)	108	6.0	3.0	0.85	1.3	310	10,945
17	Import(loaded)	20	6.0	3.0	0.85	1.3	310	2,027
18	Import(loaded)	40	6.0	3.0	0.85	1.3	310	4,054
19	Import(empty)	40	10.4	4.0	0.85	1.3	310	3,118
	Import(empty)	24	10.4	4.0	0.85	1.3	310	1,871
20	Reefer	16	5.0	2.0	0.85	1.3	310	1,297
21	Reefer	40	5.0	2.0	0.85	1.3	310	3,243
Total		1,428						167,253

4.1.2 Layout of Container Terminal

Figure 4-1-1 shows the proposed layout of the container terminal behind Pier No.9, which will have seven stacks with a total of 480 slots immediately behind Pier No.9, three stacks with 120 slots along the boundary of PCC's area, six stacks with 648 slots in the middle of the terminal and five stacks with a total of 180 slots between terminal gate and CFS including a total of 56 slots for reefer stacks. Three units of transfer cranes are to be provided for six stacks and five units of top-loaders are for remaining stacks.

Systematic storage of container should be established by using appropriate computer system.

4.1.3 Marshaling of Containers

The container handling flows in the terminal are shown in Figure 4-1-2(1)-(4).

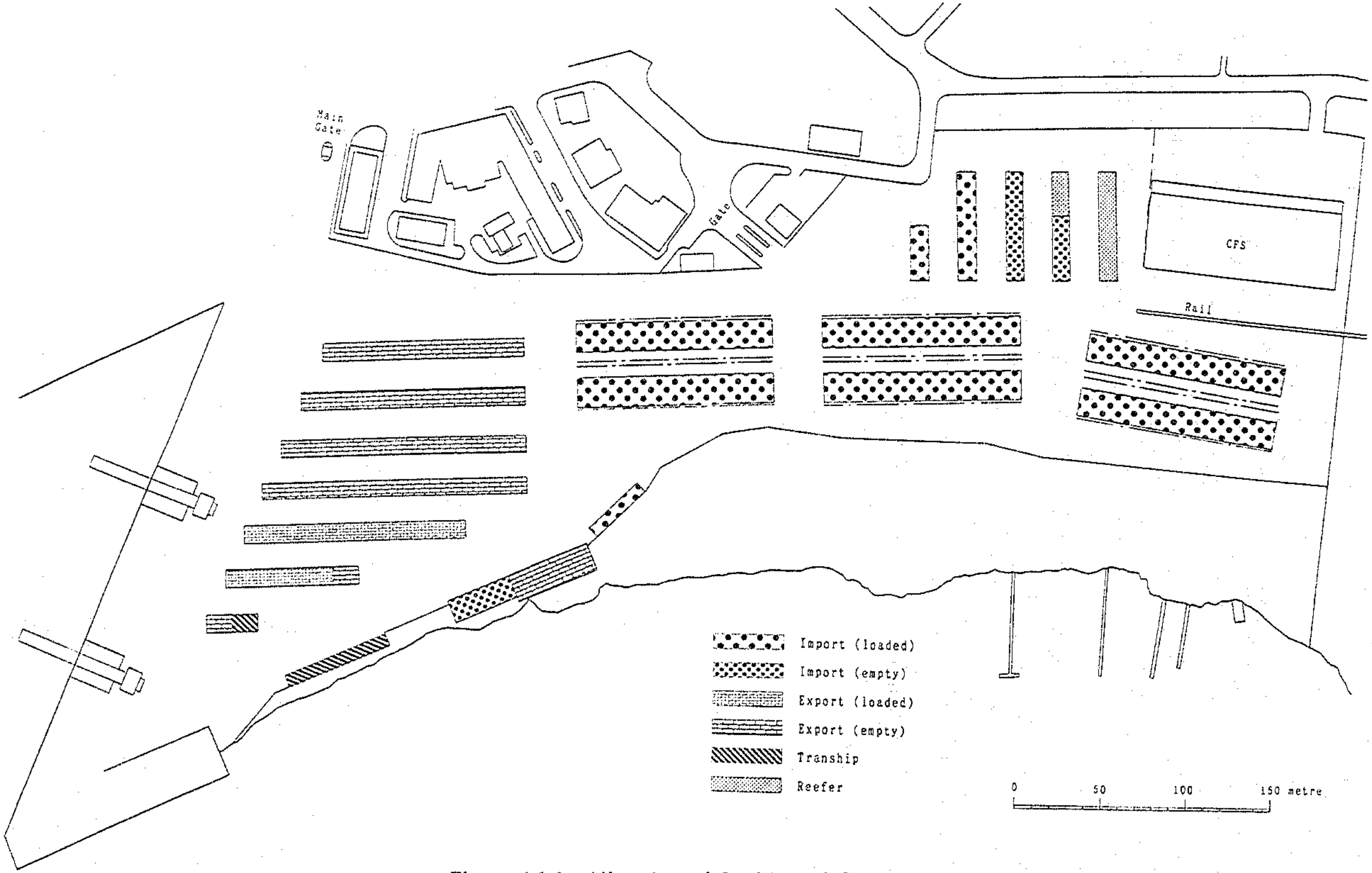


Figure 4-1-1 Allocation of Stacking of Container

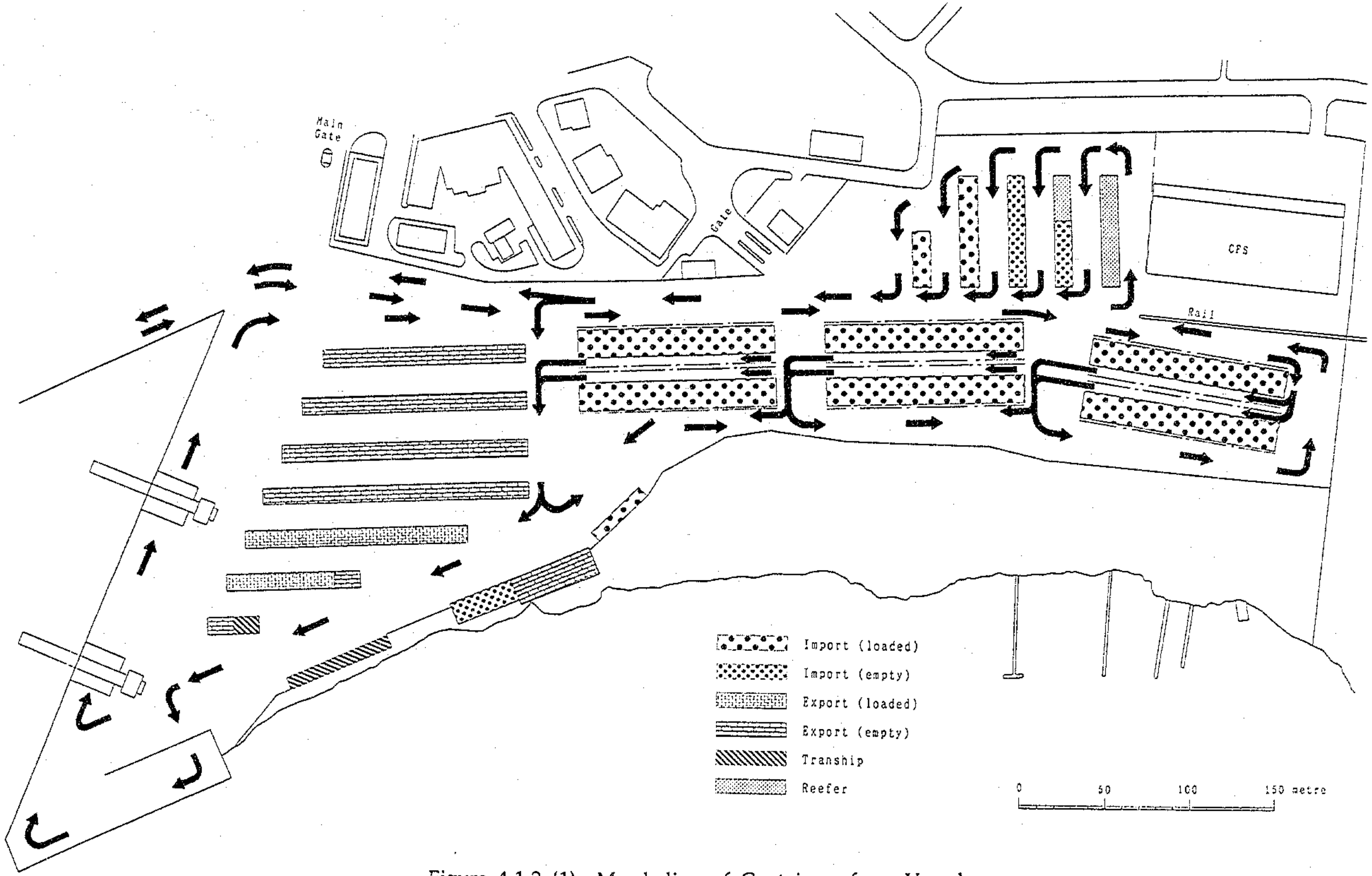


Figure 4-1-2 (1) Marshaling of Containers from Vessels

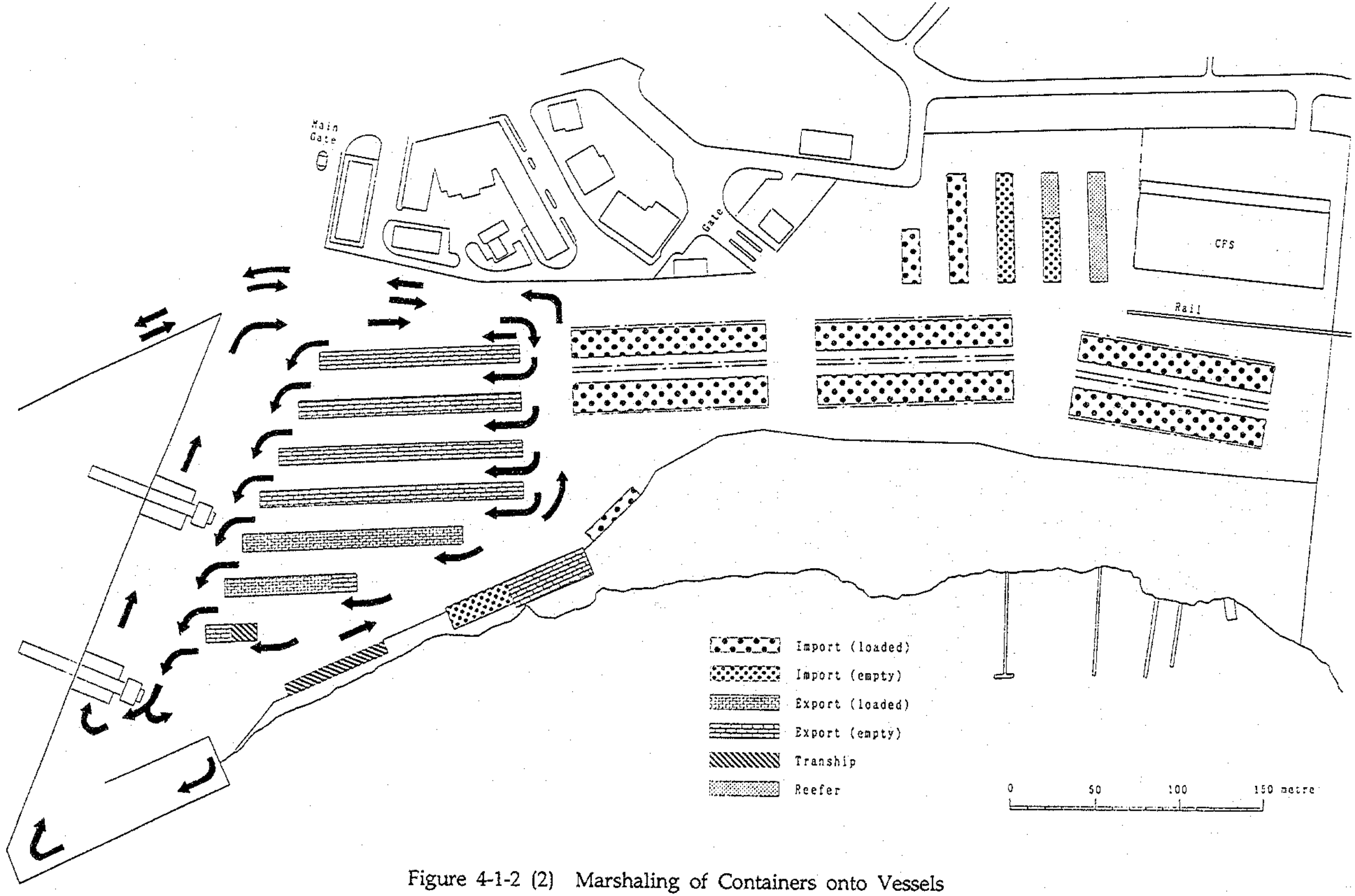


Figure 4-1-2 (2) Marshaling of Containers onto Vessels

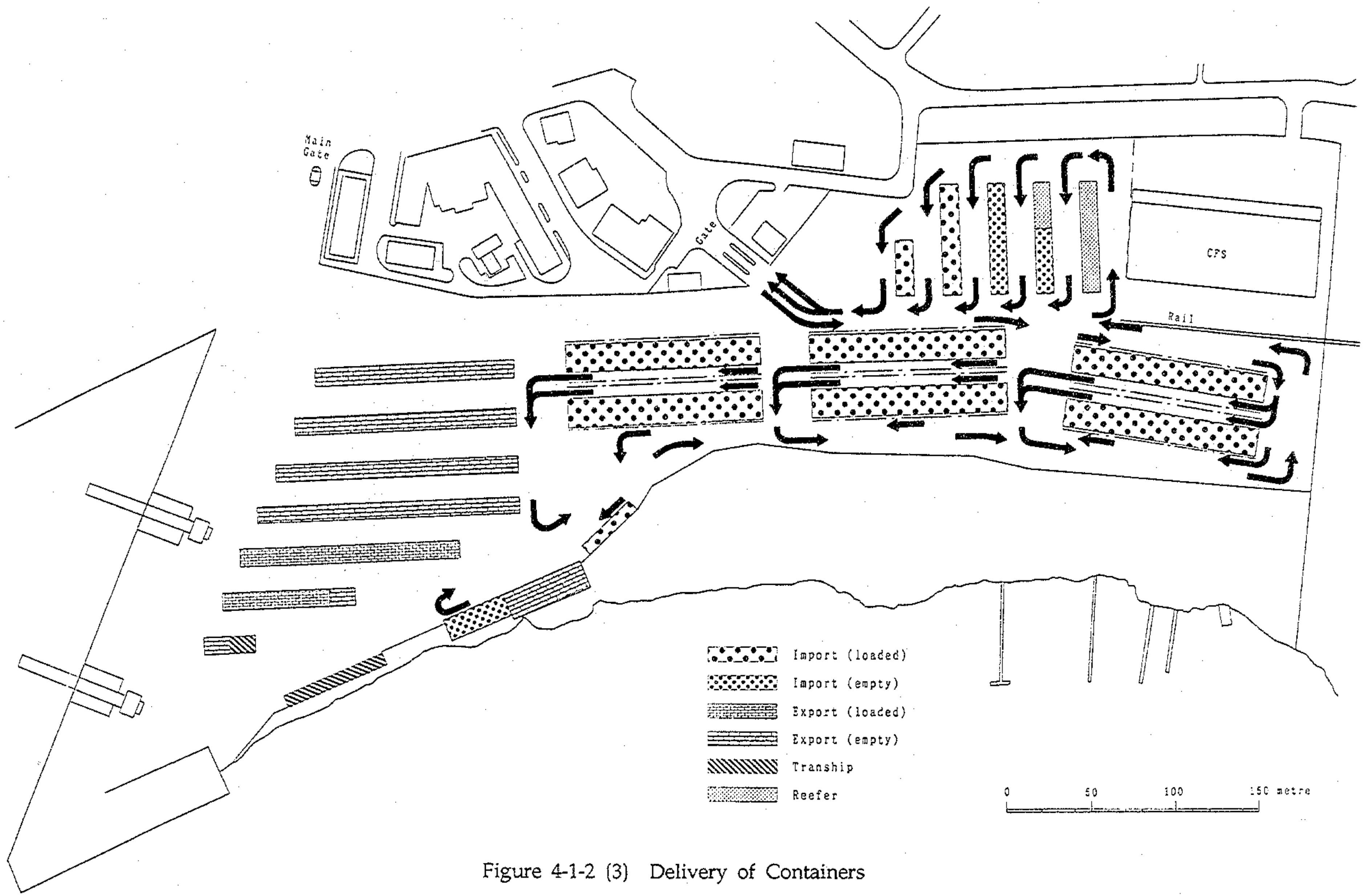


Figure 4-1-2 (3) Delivery of Containers

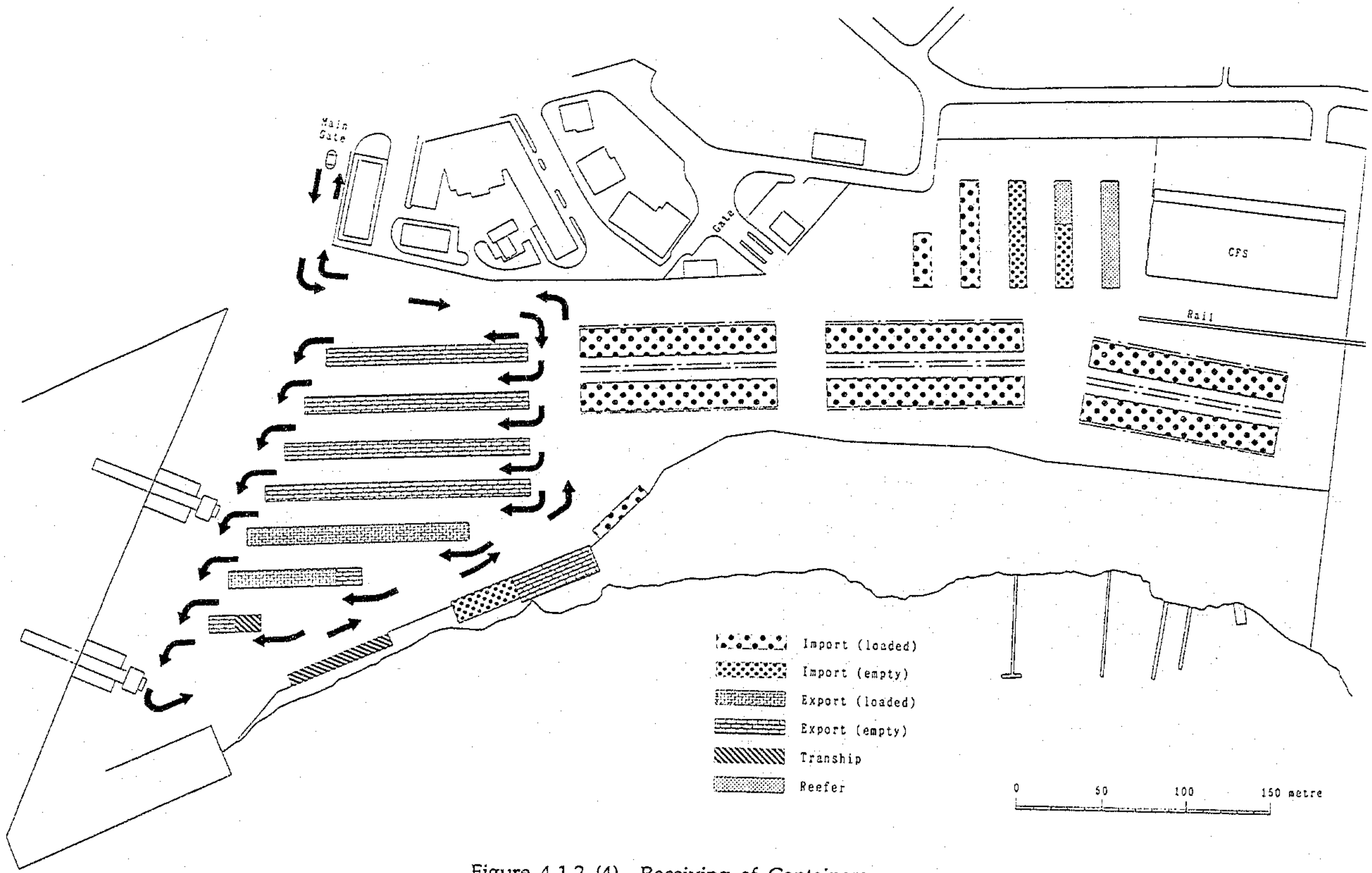


Figure 4-1-2 (4) Receiving of Containers

4.2 Improvement Plan for Container Handling System

Based on the analysis of the existing container handling system, it is recommended by the study team that a full-scaled container terminal should be established in order to conduct more effective operation for future container traffic.

The following points would be advisable from the viewpoint of the container handling system so as to realize this recommendation;

(1) strengthening communications between container control department and other departments.

(2) strengthening the terminal operation

(3) improving the maintenance and repair system

(4) establishing a training system.

4.2.1 Strengthening Communications

Regarding the general concept of the container terminal, it is basically designed on the assumption that various functions of the terminal such as the gate, the yard operation and the loading/unloading operations would function systematically as a whole.

In order to implement the functions above, it is necessary to stress the importance of the smooth information-exchange among the functions concerned. Reliable communications will enable confirmation of the fulfillment of each department's responsibility during container handling operation and to compensate for each other's weak point.

4.2.2 Strengthening the Terminal Operation

Strengthening the terminal operation would be advisable in order to realize the following points;

1) employing experienced staff and youthful terminal operators, and
2) introducing container terminal computer systems.

At present, part of the container handling plans are prepared by shipping agents, and all are taken care of manually. So it is difficult to prepare consistent plans rapidly. In order to establish efficient and safe container operations, APN should prepare all container handling plans by itself. Therefore, experienced staff and youthful terminal operators should be employed to establish the unification and flexibility of planning.

In spite of the fact that the annual container handling volume at the port of Cristobal has reached about 150 thousand TEUs, computerized container terminal operation has not been introduced. Therefore, a container terminal computer system should be introduced, however, the development of computer system should take into consideration the possibility of further extending the system.

4.2.3 Improving Maintenance and Repair System

Improving maintenance and repair system should take the following points into consideration;

1) carrying out preventive maintenance,
2) planning of replacement scheme or disposal scheme,
3) employing qualified mechanical and electrical engineers,
4) employing youthful maintenance and repair workers,
5) reinforcing workshop capability, and
6) introducing a computerized maintenance and repair system.

All maintenance and repair works are carried out directly by APN staff, however, preventive maintenance such as monthly and annual checks are not performed due to increased productivity and lack of budgets and allocation of maintenance. Preventive maintenance is not only beneficial in terms of effective container handling operation but will help lengthen the equipment's lifespan, and should be conducted according to the regulation and planning.

There is a plethora of old and useless equipment. APN does have procurement plans for cargo handling equipment but does not have any replacement plan or any disposal plan. Replacement and/or disposal may be less important than the procurement plan from budgetary requirement point of view. However, replacement plan or disposal plan are more important than procurement plan in terms of having the appropriate amount of cargo handling equipment and also in terms of maintaining cargo handling equipment in an economical fashion.

The execution of corrective maintenance and repair for heavy handling equipment is a complicated task that requires experience; experienced mechanical and electrical engineers should be employed, and youthful workers should also be employed as they are able to learn new maintenance and repair techniques more easily than aged workers.

Since the port of Cristobal was returned thirteen years ago, most of the machines and tools at the workshop are becoming superannuated. Therefore, APN should replace the old and useless machines and tools and get one four-ton truck equipped with necessary repairing instrument to be used a movable shop truck.

APN keeps many kinds of records of maintenance and repair works. However, there are no proper records for analysis of all the actual records and data. Records related to maintenance and repair can neither be analyzed nor utilized sufficiently. Thus a computerized maintenance and repair system should be introduced at the level of personal computer, which is able to analysis the actual records and data easily and obtain the necessary information sufficiently.

4.2.4 Establishment of Training System

APN has no training programs. In order for the port of Cristobal to realized an excellent level of service and to remain competitive with neighboring ports, it is crucial to increase cargo handling efficiency through the systematic training. Therefore, it is necessary to establish a training system for staff members and workers in charge of management, operations, maintenance and repairs of the port facilities/equipment. To establish such a training system, it is necessary to raise the budget. On-the-job training as well as training at specialized training facilities are quite effective in developing trainee's faculties. The following measures are also recommended;

1) Invite special experts who have extensive experience and can teach workers to operate and maintain equipment. Experts should be assigned to several departments to assist in on-the-job training.

2) Select several suitable candidates and send them overseas to take training courses. This method is most effective for the staff of each department, ship planners, maintenance engineers and computer operators, who will all require a comparatively high level of technical knowledge in their respective fields.

Figure 4-2-1 shows examples of training curriculum.

Training Cource			Month: First	Second	Third	Fourth	Fifth	Sixth
Planning of Container Handling Operation	Theory	Port management Container handling system Shipping transport Container transport Structure of vessel Customs system Trading system CFS Special container handling operations Others						
	Practice	Vessel's entry/departure Discharging/loading Delivery/receipt Stowage plan Stacking plan Others						
Operation of Container Handling Equipment	Theory	Outline of mechanical and electrical engineering Specification of equipment Structure and installation Functions of equipment Management of fuel oil and lubricanting oil Outline of cargo handling system Outline of basic of dynamics Others						
	Practice	Gantry crane						
		Transfer crane						
		Top-loader						
		Folklift						
		Tactor/chassis						
Maintenance and Repair	Theory	Outline of maintenance & repair Maintenance and repair guidance Management of fuel oil and lubricanting oil Management of spare parts Outline of mechanical and electrical engineering Reports others						
	Practice	Gantry crane						
		Transfer crane						
		Top-loader						
		Folklift						
		Tactor/chassis						
Container Handling Operation	Theory	Container handling system Sling and tools Weight and measurement Names of containers' parts Kinds and names of containers Kinds of handling equipment Kinds of goods Weight and measurement Outline of vessels Others	Group-A		Group-B		Group-C	
	Practice	Container handling operation						

Note: Lecture / Practical training / On-the-job training

Figure 4-2-1 Examples of Training Curriculum

CHAPTER 5 PRELIMINARY DESIGN AND TECHNICAL FEASIBILITY

This chapter deals with the preliminary design of major port facilities. Design criteria to be applied in the project preparation are also one of the important aspects.

5.1 Design Basis

5.1.1 Lines and Levels

Location and level of each facility should be based on the official figure. Especially the levels showing on plans and drawings should conform to the authorized datum which is widely utilized by the government authority, port users and APN. It is also important that the datum should be harmonized with the charts and tide tables.

The proposed project datum is MLW, Mean Low Water, the same one utilized currently by APN. The UTM system has to be adopted for the horizontal control since it is also presently applied by APN and internationally accepted.

Note : The datum generally used in the topographic maps in Panama is MSL, Mean Sea Level or PLD, Precise Level Datum.

5.1.2 Design Codes and Standards

There are three useful codes for structural design, namely;

- Panama Structural Design Regulation (Rep 84)
- The codes of ACI : American Concrete Institute
- The codes of AISC : American Institute of Steel Construction

These codes or similar should be applied to the project. In addition to these, it is concluded to apply the Technical Standards for Port and Harbor Facilities in Japan to design marine structures and facilities. During the detailed design and construction stage, various standards should be applied. During the construction supervision period, the technical specification of ASTM, American Standard of Testing Materials will be widely utilized.

5.1.3 Service Life

When APN prepares a repair work design, the most important basic concept is the "long life structure" unless it is just a minor repair work. The design life for permanent structures currently considered by APN is 50 years. The Study Team supports the same concept for the project planning and design. This length of life can be applied mainly to waterfront structures like wharf and seawall since they cannot easily be reinstalled.

It is recommended that the following figures by applied to the project.

Table 5-1-1 Service Life of Structures

Structures		Life in Year
Waterfront Structure	: Quay and Pier	50
-ditto-	: Seawall	35
Pavement		10 - 25 (depends on materials)
Utilities		25
Building and Offices		25
Equipment *		5 - 15

The entire project service life for evaluation will be 25 years.
As discussed in Chapter 4 of Part III, the service life of cargo handling equipment is as follows.

- Gantry crane 15 years
- Transfer crane 15 "
- Top-loader 8 "
- Forklift 8 "
- Tractor 8 "
- Chassis 5 "

5.2 Natural Conditions

5.2.1 Climatic Condition and Oceanographic Condition

(1) General Climate in Panama

Panama is in a tropical climatic zone. The temperature here is relatively flat and the normal temperature is about 29 deg.C through the year. The monthly lowest temperature is recorded during the transition time, while the highest one is recorded during the rainy season, however the difference is minor. The most typical climate is the two-phased season; the rainy season starts generally in mid-April and turns to the dry season in mid-December.

(2) Tide

Tidal range at the site is very minor comparing to those along the Pacific coast. The authorized tides at the port of Cristobal is as follows:

H.H.W.	+ 0.67 m
M.H.W.	-
M.S.L.	+ 0.16 m or PLD + 0.04 m
M.L.W.	0.00 m or PLD - 0.12 m
L.L.W.	- 0.26 m

Note : PLD = Precise Level Datum
MLW is the project datum.

(3) Wind

Winds in Cristobal are mostly governed by the Northeast trades, the land-sea breezes and thunderstorms. Heavy winds in the rainy season are mainly generated by the thunderstorms. The Northeast trades and "Northers" prevail during the dry season and frequently generate heavy winds.

The instantaneous recorded maximum wind speed is 27 m/sec. However it is recommended to adopt a larger wind intensity than this record as the design wind speed. The proposed design wind speed for the structural design is 35 m/sec.

(4) Wave

The proposed design waves in the project site are as follows:

Site-C	H 1/3 = 1.8 m
Site-T	H 1/3 = 1.1 m
Site-F	H 1/3 = 0.8 m
Site-CS	H 1/3 = 0.8 m

(5) Current

The observed current velocity by the Study Team in Limon Bay is 20 cm/sec (0.4 knot) or less. It is proposed to adopt the design current of 50 cm/sec.

(6) Rainfall Intensity

Rainfall intensity is large. According to the data for 94 years observation, the annual average rainfall intensity is 3,294 mm. Rainfall intensity is one of the governing factors to perform a design of storm water drainage. The maximum rainfall intensity for five years recurrence will be used by such design. The proposed design rainfall intensity is 131 mm/hour.

(7) Visibility

The visibility in Cristobal is rather good.

(8) Seismic Coefficient

According to the data prepared by Panama University, the project site is in the seismic zone No.2, where the intensity is 0.16 g.

Note: "g" is the acceleration of gravity.

It is proposed to adopt the seismic intensity of 0.20 g for structural design, which will also be used as the design seismic coefficient for the landward wharf crane foundation at the existing pier No.9 by APN.

5.2.2 Seabed Features and Geotechnical Condition

Submarine features in Cristobal and its vicinity can be subdivided into two categories:

Category : Natural Shape

This area has few artificial impact such as dredging and reclamation. Both Site-C and Site-CS belong to this. A slope between the coastline and -6m line is 5% and relatively sharp. Then the seabed slope becomes minor until the flat area of MLW -8m to -10m.

Category : Artificial Shape

The seabed feature at Site-T belongs to this. The existing flat area is maintained MLW -12.0m or deeper for the PCC's vessel anchorage area and the approach channel to the port of Cristobal managed by APN. While the near-shore slope is different from the natural shape and there is a flat lagoon of -0.5m to -3.0m. Between the edge of this shallow flat and the deep flat, there is a steep slope of 30% or more. Figures 5-2-1 and

5-2-2 show the existing water depth of the sites. Figures 8-2-3, 8-2-4 and 8-2-5 show the existing cross sections of the sites.

Littoral drift, the sand movement by current force, is not a significant factor in the site. It is assumed that the natural soil deposit on the seabed is about 2 cm/year. In this aspect, Limon Bay can provide the project site with a preferable condition. This situation may make maintenance dredging cost reasonably low. In case that 50 ha of dredged seabed are used for vessel anchorage and maneuvering, an expected siltation will be about 50,000 m3 and the cost of this dredging amounts to $250,000 only for every five years.

The subsoil condition of the project site is the most important natural condition. According to the previous soil investigation data and the seven soil borings conducted by the Study Team in November 1992, the typical geotechnical condition can be shown in Figure 5-2-3.

There are basically three layers, namely the upper extremely soft clay layer, the second soft clayey or sandy layer and the lower layer consisting of the Gatun formation and its weathered one. The most significant layer is the Gatun formation. This layer forms a good bearing stratum both for pile foundation and gravity wall foundation. While, when this rock layer exists at MLW -30m or deeper, the required pile length will be long, then the piling cost will increase. Also if this layer exists above the design wharf depth, the required dredging cost will be very high and such a work will not be justified from the view point of construction economy.

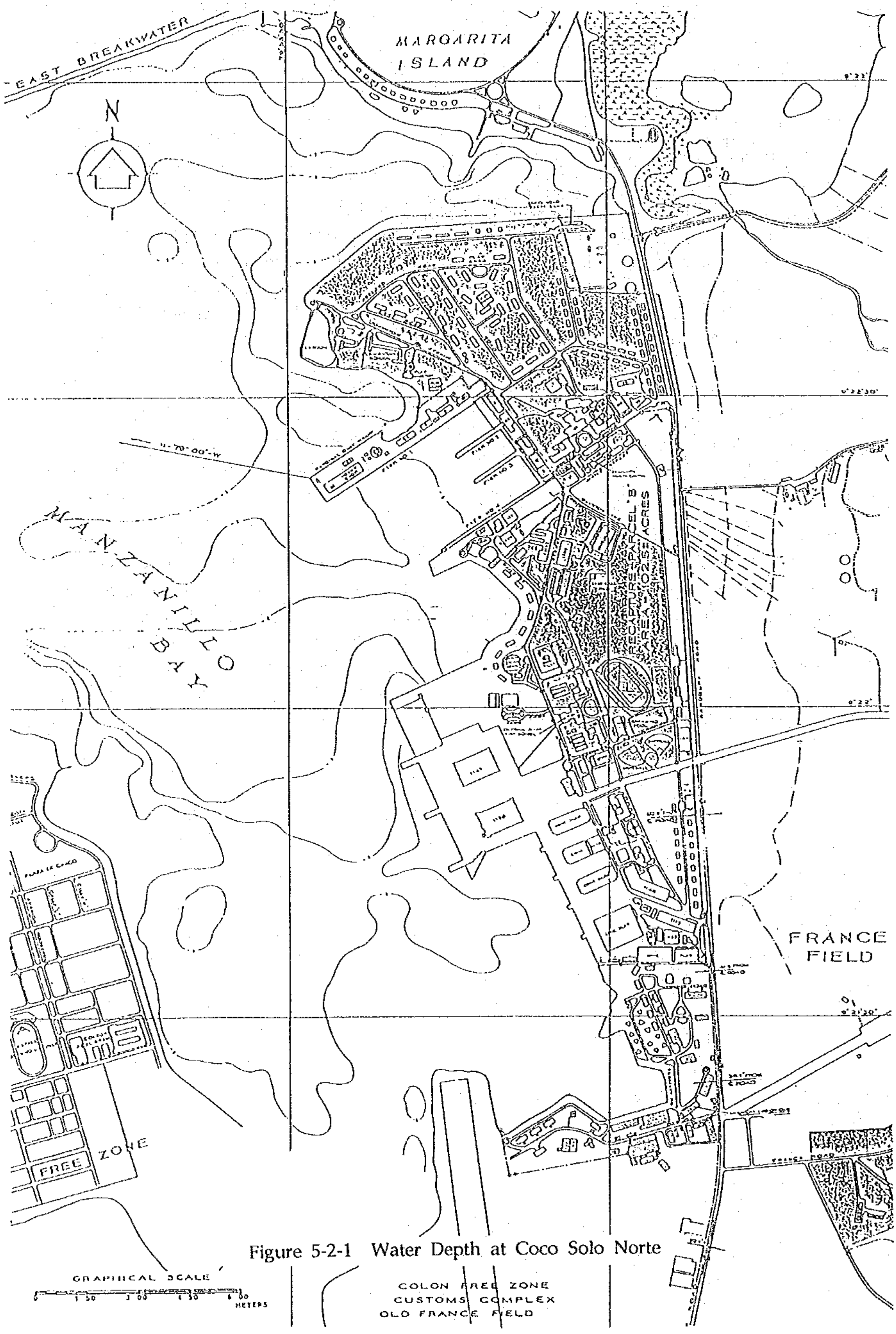


Figure 5-2-1 Water Depth at Coco Solo Norte

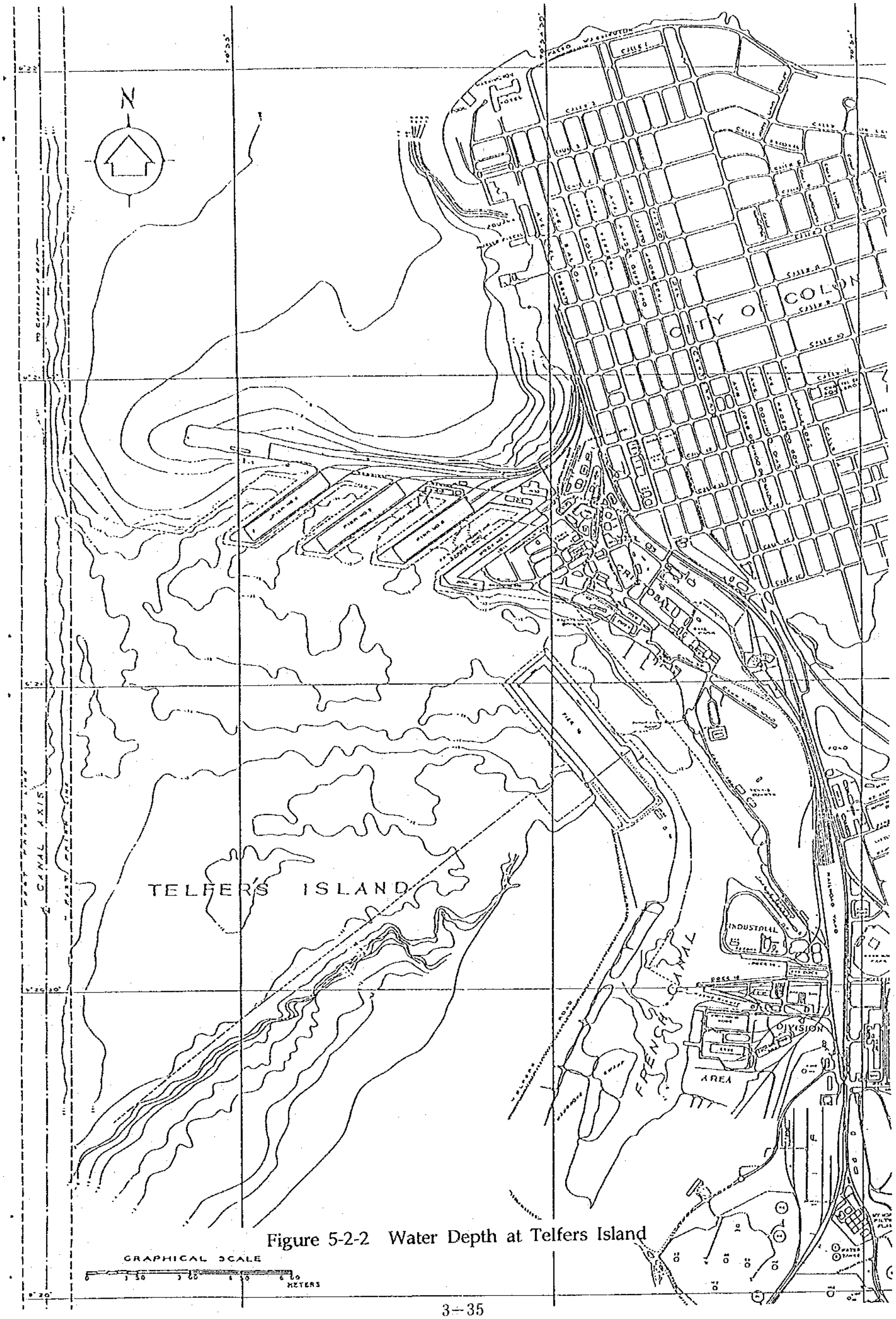


Figure 5-2-2 Water Depth at Telfers Island

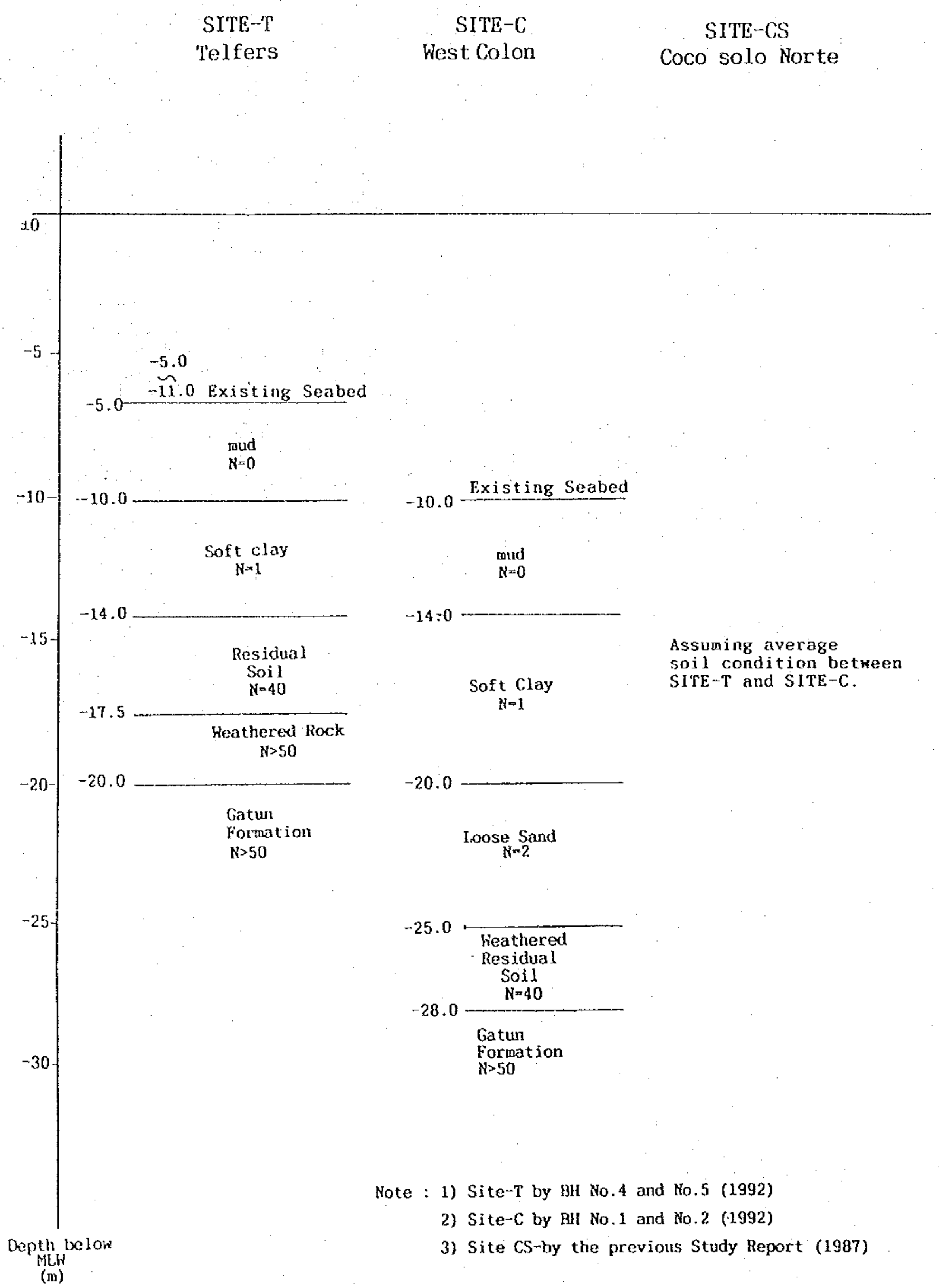


Figure 5-2-3 Typical Soil Section

5.3 Material Conditions

This section deals with the design criteria relating to the quality of materials which will be commonly utilized in the project.

5.3.1 Concrete

Concrete is the most commonly used material. Depending on the usage, five grades of concrete specification will be applied.

Table 5-3-1 Concrete Classification

Specifications	Grade				
	A	B1	B2	C	D
Specified Compressive Strength of Concrete (fc')MPa	34.5	30.0	24.0	21.0	17.0
Allowable Flexural Compressive Stress (fc)MPa fc = 0.45f'c	15.5	13.5	10.8	9.45	7.65
Modules of Elasticity (Ec)	3.0E4	2.6E4	2.5E4	2.3E4	2.1E4

Notes: 1. Each grade of concrete is intended to be used for:

Grade A : Precise prestressed members
Grade B1 : Marine structures
Grade B2 : Civil works and building works
Grade C : Reinforced concrete on utility works
Grade D : Concrete block or plain concrete on revetment

2. Requirements for fc' shall be based on the tests of cylinders made and tested in accordance with "Method of Sampling Freshly Mixed Concrete" (ASTM: C172)

5.3.2 Reinforcement

The tensile stress (fs) of deformed reinforcement, which will be used in this project, shall not exceed the values shown in the following table.

Table 5-3-2 Reinforcement Specification

Specifications	Grade	
	40	60
Yield Strength (fy) MPa	275	414
Allowable Tensile Stress (fta) MPa	138	166
	(except building works)	

5.3.3 Protective Concrete Cover to Reinforcement

Reinforcing steel will be installed with a minimum concrete cover as follows:

(1) For common structures other than marine purpose

Table 5-3-3 Concrete Cover for Common Works

Specification	Cover
- Concrete cast permanently Exposed to earth	75mm
- Concrete exposed to earth or weather:	40 - 50mm
- Concrete deck slabs:	35 - 50mm
- Concrete not exposed to weather nor in contact with ground:	25 - 40mm

(2) For marine structures

Table 5-3-4 Concrete Cover for Marine Works

Environmental Conditions	Slabs (mm)	Beams (mm)	Columns (mm)
Severely Corrosive Conditions	75	75	75

Note: "Severely corrosive condition" is a condition in which concrete is in air occasionally effected by sea water splash.

5.3.4 Structural Steel

Structural steel in this project will be specified as follows.

Table 5-3-5 Structural Steel Specification

Specification	Specified Numbers
Yield strength (fy)	245 MPa
Young's modulus	200,000 MPa
Shearing modulus	80,000 MPa
Poisson's ratio	0.3
Coefficient of thermal expansion	11E-6/degree C
Allowable axial tensile stress	137 MPa
Allowable bending stress	137 MPa

5.3.5 Corrosion Rates of Steel

The assumed corrosion rates of steel surface in sea water will be as follows. The values in the list below indicate the rate for one side only.

Table 5-3-6 Corrosion Rates of Steel Exposed Surface

Corrosion Environment		Corrosion Rate (mm/year)
Sea side	: Above H.W.L.	0.39
	: Between H.W.L. and the seabed	0.13
	: Below the seabed	0.04
Land side	: In marine atmosphere	0.13
	: In soil (1)	0.04
	: In soil (2)	0.03

Notes: 1) Above the residual water level
2) Below the residual water level
3) Corrosion rates based on the Technical Standards for Port and Harbor Facilities in Japan, have been increased by 30% as a tropical zone effect.

Total corrosion thickness should be calculated using the following formula.

Tc = Cr x (Lo - Lp)

where, Tc : Corrosion thickness (mm)

Cr : Corrosion rate (mm/year)
Lo : Project life or facility life, assuming 50 years
Lp : Project life reduction by an initial protection such as cathodic protection and anti-corrosion paint. (year)

5.3.6 Unit Weight of Materials

Unit weight of general use materials will be as shown in list below.

Table 5-3-7 Unit Weight of Common Materials

Materials	Unit Weight in kg/m3
Reinforced Concrete	2,400
Plain Concrete	2,400
Structural Steel	7,850
Sand (in air)	1,800
Rock/Stone (in air)	1,800
Asphalt	2,300

5.4 Structure Design Methods

5.4.1 Design Method of Structural Analysis

All structures will be designed at the worst combination of loads which may act on the structure at the same time.

(1) Working stress Design Method

All marine structures shall be designed and calculated by the working stress design (WSD) method. All steel structures shall be designed using the working stress design method (WSD) based on American Institute of Steel Construction (AISC). The WSD method has been based on the allowable stresses indicated in the appropriate codes, namely:

Reinforced Concrete	:	ACI 318-77
Steel Structure	:	AISC

(2) Ultimate Strength Design Method

All concrete buildings will be designed using the ultimate strength design (USD) method based on ACI-318.

5.4.2 Design Method of Pile Foundations

(1) Bearing Capacity of Pile Foundations

<u>Ultimate Bearing Capacity</u>

The ultimate bearing capacity of a pile can be calculated in accordance with the following formulas;

$Ru = 40NAp$ ---------- in sandy soil

$Ru = 8CpAp + \bar{C}aAs$ ---------- in cohesive soil

Where,
- Ru : Ultimate bearing capacity of a pile (tf)
- Ap : Tip area of the pile (m2)
- As : Total circumferential surface area of the pile (m2)
- N : N value of the subsoil at the tip of the pile

When the subsoil is fine sand or silty sand saturated with water and having N value of 15 or more, the N value for calculation shall be modified by the following formula;

$$N = 15 + 1/2\ (N' - 15)$$

Where, N : Measured N value
Cp : Cohesion at the tip of the pile (tf/m2)

$\bar{Ca}$: Mean adhesion for the total embedded length of the pile (tf/m2)

In this case, the adhesion can be obtained from the table shown below.

<u>Allowable Bearing Capacity</u>

The allowable bearing capacity of pile foundation can be obtained by reducing the ultimate bearing capacity of a single pile by a specified safety factor.

Ra = Ru/Fs

Where, Ra : Allowable Bearing Capacity (tf)
Ru : Ultimate Bearing Capacity (tf)
Fs : Safety Factor

Table 5-4-1 Safety Factor for Bearing Piles

Normal Condition		2.5 or more
Seismic Conditions	Bearing pile	1.5 or more
	Friction pile	1.5 or more

(2) Pulling Resistance of Pile Foundation

<u>Maximum Pulling Resistance</u>

The maximum pulling resistance can be calculated by the following formulas;

Rut = $\bar{N}$As/5 --------- in sandy soil

Rut = $\bar{Ca}$As --------- in cohesive soil

Where, Rut : Maximum pulling resistance of a pile (tf)

$\bar{N}$: Mean N value for the total embedded length of the pile in sandy soil

As : Total circumferential surface area of the pile (m2)

$\bar{Ca}$: Mean adhesion for the total embedded length of the pile (tf/m2)

<u>Allowable Pulling Resistance</u>

The allowable pulling resistance can be obtained by reducing the maximum pulling force of a single pile by a safety factor.

Rta = Rut/Fs

Where, Rta : Allowable pulling resistance of a pile (tf)
Rut : Maximum pulling resistance (tf)
Rs : Safety Factor

Table 5-4-2 Safety Factor for Pulling Resistance

Normal Condition	3.0 or more
Seismic Conditions	2.5 or more

(3) Combined Stress of Pile

The piles shall be designed taking into account both cases, the combinations of stresses and separate stress cases which occur due to axial loads and lateral loads.

Prestress Concrete Piles

The allowable compressive stress on the pile concrete by external forces, including bending, shall not exceed the following.

$$fc' = 0.33\ fc'' - 0.27\ fpe$$

Where, fc" : The characteristic strength of the concrete (Minimum 280 days cylinder strength)
fpe : The effective prestress on the gross cross section

The combined stresses to be considered in the working condition will be those due to axial load eccentricity by slenderness of pile and prestress on the section.

The combined stresses to be considered during lifting will be those due to bending and prestress on the section.

Steel Pile

See Table 5-4-3 for steel piles.

Table 5-4-3 Allowable Stress of Steel Piles

(kgf/cm²)

Kind of stress \ Kind of steel	SS41, SM41, SMA41, STK41	SM50, STK50	SM50Y, SMA50
Axial tensile stress (per net sectional area)	1,400	1,900	2,100
Axial tensile stress (per gross sectional area)	$\frac{l}{r} \leqq 20$ 1,400 $20 < \frac{l}{r} < 93$ $1,400 - 8.4\left(\frac{l}{r} - 20\right)$ $\frac{l}{r} \geqq 93$ $\frac{12,000,000}{6,700 + (l/r)^2}$	$\frac{l}{r} \leqq 15$ 1,900 $15 < \frac{l}{r} < 80$ $1,900 - 13\left(\frac{l}{r} - 15\right)$ $\frac{l}{r} \geqq 80$ $\frac{12,000,000}{5,000 + (l/r)^2}$	$\frac{l}{r} \leqq 14$ 2,100 $14 < \frac{l}{r} < 76$ $2,100 - 15\left(\frac{l}{r} - 14\right)$ $\frac{l}{r} \geqq 76$ $\frac{12,000,000}{4,500 + (l/r)^2}$
Bending tensile stress (per net sectional area)	1,400	1,900	2,100
Bending compressive stress (per gross sectional area)	1,400	1,900	2,100
Member which receives combined axial and bending stresses	(1) In case of the axial tensile stress $\sigma_t + \sigma_{bt} \leqq \sigma_{ta}$ and $-\sigma_t + \sigma_{bc} \leqq \sigma_{ba}$ (2) In case of the axial compressive stress $\frac{\sigma_c}{\sigma_{ca}} + \frac{\sigma_{bc}}{\sigma_{ba}} \leqq 1.0$		
Shearing stress (per gross sectional area)	800	1,100	1,200

Symbols in Table indicate the following:

l: Effective buckling length of the member (cm)

γ: Radius of gyration of area for the cross sectional area of the member (cm)

σ_t, σ_c: Tensile stress by axial tensile force and compressive stress by axial compressive force acting on the section (kgf/cm²)

σ_{bt}, σ_{bc}: Maximum tensile stress and maximum compressive stress by bending moment acting on the section (kgf/cm²)

σ_{ta}, σ_{ca}: Allowable tensile stress and allowable axial compressive stress on the axis with smallest moment of inertia (kgf/cm²)

σ_{ba}: Allowable bending compressive stress (kgf/cm²)

5.4.3 Safety Factor on Structural Stability

(1) Sliding and Overturning of Structure

Table 5-4-4 Safety Factors on Structure Analysis

Gravity Type				Sheet Pile Wall Type			
Sliding		Overturning		Overturning			
				In Sandy Layer		In Clayey Layer	
Normal	Seismic	Normal	Seismic	Normal	Seismic	Normal	Seismic
1.2	1.0	1.2	1.1	1.5	1.2	1.2	1.2

(2) Slope Stability

Table 5-4-5 Safety Factor on Circular Failure

Type of Analysis	Safety Factor
New Structures	1.3
Existing Structures	1.2
Dredging Slope (permanent)	1.2
Dredging Slope (temporary)	1.0

5.5 Particular Design Criteria : Marine Facilities

This subsection deals with the proposed design criteria for major waterfront facilities.

5.5.1 Wharf

(1) Objective Vessel

Table 5-5-1 Dimension of Objective Vessels

Tonnage	Overall Length	Molded Breath	Molded Depth	Full-load Draft	Note
20,000 DWT	201	27.1	15.6	10.6	Container
40,000 DWT	263	33.5	20.7	12.4	"
53,000 DWT	320	39.0	23.0	13.5	"
15,000 GT	179	22.8	14.7	6.8	Passenger
30,000 GT	230	27.5	18.3	8.5	"
5,000 DWT	109	16.4	9.0	6.8	General Cargo
10,000 DWT	137	19.9	11.1	8.5	"
15,000 DWT	153	22.3	12.5	9.3	"
10,000 DWT	130	20.1	10.1	8.0	Oil Tanker
30,000 DWT	185	28.3	15.2	10.9	"
40,000 DWT	204	30.9	16.6	11.8	"

(2) Berthing Conditions

Berthing velocity : V = 0.10 m/sec, over 20,000 DWT
V = 0.12 m/sec, 10,000 - 20,000 DWT
V = 0.15 m/sec, less than 10,000 DWT

Angle of fender contact : 10 degrees to the faceline

(3) Wharf Dimensions

- For Container vessels : 40,000 DWT
  Design Water Depth = Maximum draft + Clearance
  = 11.0 + 1.0
  = 12.0 m below MLW

  Berth length : 300m

- For Container vessels : 53,000 DWT
  Design Water Depth = 13.0 + 1.0
  = 14.0 m below MLW
  Berth length : 350m

- For Passenger boat : 30,000 GT
  Design Water Depth = 10.0 m below MLW
  Berth Length = 280 m

- For General Cargo vessel : 15,000 DWT
  Design Water Depth = 11.0 m below MLW
  Berth Length = 190 m

- For Oil Tanker : 40,000 DWT
  Design Water Depth = 13.0 m
  Berth Length = 260 m

(4) Basic Load Conditions for Container Wharf

Dead loads shall be determined considering the features of structure and appropriate unit weights of materials.

- Surcharge
  Surcharge for normal condition : W=3.0 t/m2 (29.4 KN/m2)
  Surcharge for seismic condition : W=1.5 t/m2 (14.7 KN/m2)

- Wheel Loads
  Mobile crane truck : 40 ton capacity
  Forklift truck : 25 ton capacity
  Truck : M18, MS18
  Tractor trailer : 40 foot container

- Container wharf crane
  Gauge : 30.5 m
  Overall weight : approx. 750 tons
  Nominal capacity : 41 ton under spreader
  Number of wheels : 8 No. per corner

  Max. wheel load at seaside wheel at a working condition is 45.5 tons.

Surcharge intensity by wharf crane loads can be reduced according to the operation system under the crane.

The largest load to be supported by the container wharf structure is the wharf crane, so called a gantry type crane, running on the rail. The related factors of this crane to the wharf design are rail span and wheel loads. These two figures normally depend on the vessel size. The wider vessel body requires the longer crane outreach, thus the weight of the crane becomes larger.

Panamax type container vessel;

Span	15m - 20m
Weight of crane	650 - 850 tons

Post-panamax type container vessel;

Span	20m - 30m
Weight of crane	1,100 - 1,300 tons

In this study, the following numbers are used.

Span	30.5 m
Weight of crane	750 tons

This means that the design span is for a large crane however the weight of crane is for the typical Panamax vessel. Figure 5-5-1 shows the typical arrangement of equipment and other space required for crane operation at the wharf apron.
The recommended wharf crane size is shown in Chapter 4 of Part III.

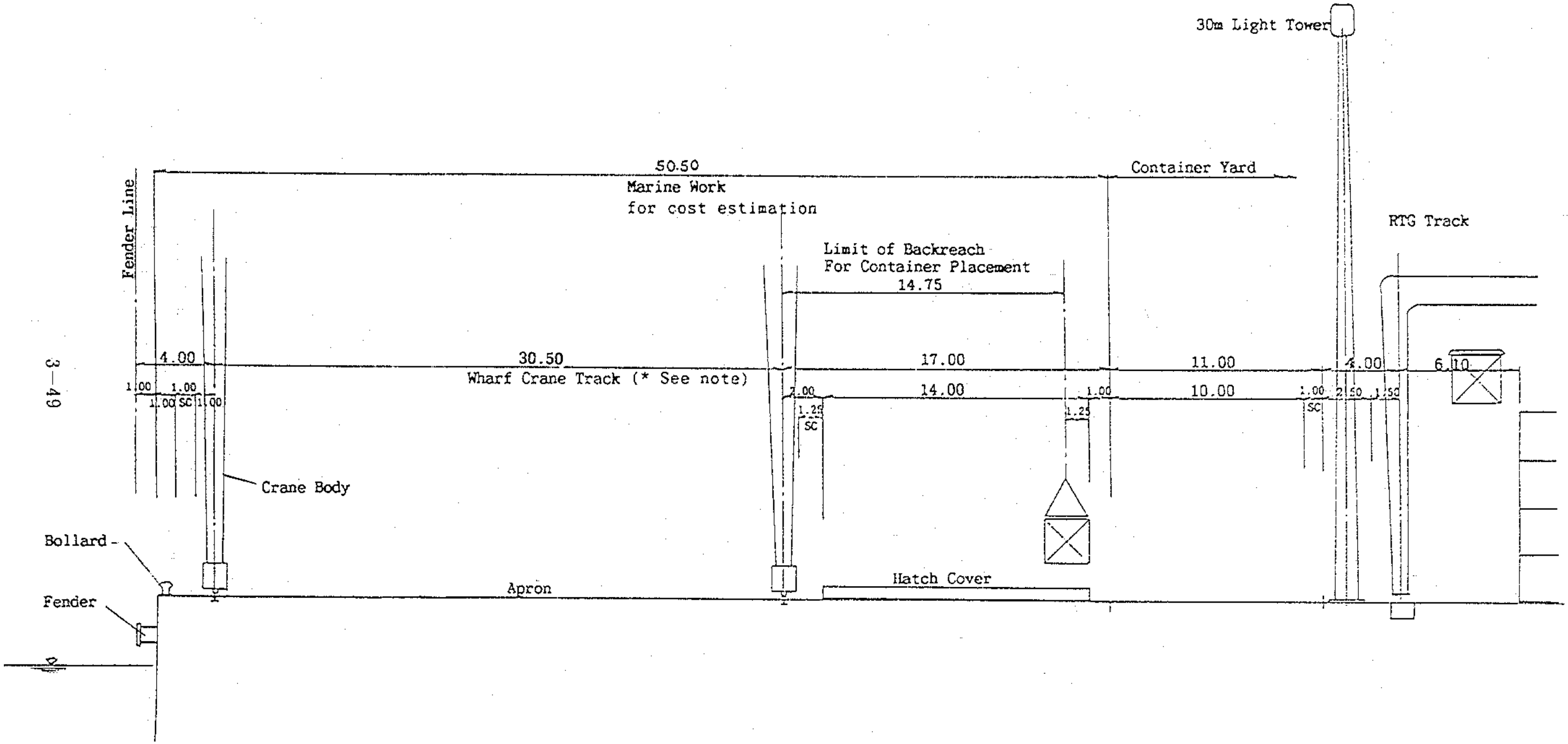


Figure 5-5-1 Wharf Crane and Apron Use Arrangement (Typical)

The existing gantry cranes will be replaced in the years 2000 and 2002, respectively. The main specifications of new gantry cranes will be almost the same as the existing gantry cranes.

1) Gantry Crane

a) Hoisting capacity: 41 tons under spreader
b) Outreach: 37 m
c) Span: 22.555 m
d) Backreach: 12.2 m
e) Total lifting height: 45 m
f) Lifting height above rail: 30 m
g) Lifting height under rail: 15 m
h) Power source: Supplied from outside
i) Approximate working speed:
   - Hoisting speed with 41 tons load: 50 m/min.
   - Hoisting speed with no load: 120 m/min.
   - Trolley traversing speed: 150 m/min.
   - Travel speed: 46 m/min.

2) Transfer Crane (Tire Mounted)

a) Hoisting capacity: 30.5 tons under spreader
b) Span: 23.47 m
c) Lift (9'6" containers 4 high): 14.94 m
d) Approximate working speeds
   - Hoisting speed with 30.5 tons load: 17 m/min.
   - Trolley traversing speed: 35 m/min.
   - Travel speed: 90 m/min.

(5) Load Conditions for General Cargo Wharf

- Surcharge

Surcharge at normal condition	:	W=3.0 t/m2
Surcharge at seismic condition	:	W=1.5 t/m2

- Wheel Loads

Mobile crane truck	:	40 ton capacity
Forklift truck	:	25 ton capacity
Truck	:	M18, MS18
Tractor trailer	:	40 foot container

(6) Load Conditions for Other Wharf

The required loads for passenger wharf and oil tanker wharf shall be decided based on the loading system to be adopted. When the wharf is utilized by multi-purpose use, the largest loads among them shall be taken into account.

(7) Bollards and Corner Mooring Posts

Bollards and mooring posts shall be provided to suit the hawser pulls from the design ships. Mooring post means a post which is normally located each end of a berth to accept larger tractive forces exerted by stern line and bow line. Bollards shall be a sufficient mooring fitting which is generally located along the faceline of wharf and maintains the vessel position through breasting lines and spring lines.

Large corner mooring posts shall be placed at the ends of the berths capable of taking the mooring forces from ships during storms. The tractive force on a corner mooring post or bollard shall be a value showing in the table corresponding to the gross tonnage of maximum objective vessels, and the spacing and minimum number of installation of them per berth are also shown.

Table 5-5-2 Tractive Forces of Ships

Gross Tonnage of Vessels	DWT	Tractive Force of Corner Mooring Post (tf)	Tractive Forces on Bollard(tf)
200 - 500		15	10
501 - 1,000		25	15
1,001 - 2,000	3,550	35	15
2,001 - 3,000	3,750	35	25
3,001 - 5,000	6,250	50	25
5,001 - 10,000	12,500	70	35 (25)
10,001 - 15,000	18,800	100	50 (25)
15,001 - 20,000	25,000	100	50 (35)
20,001 - 50,000	65,550	150	70 (35)
50,001 -100,000	125,000	200	100 (50)

Note: The parenthesize values are for the force on a mid bollard having no more than 2 spring lines.

Table 5-5-3 Arrangement of Bollard

Gross Tonnage of of Vessels	Maximum Spacing of Bollard (M)	Minimum Number on Bollard per Berth
- 2,000	10 - 15	4
2,001 - 5,000	20	6
5,001 - 20,000	25	6
20,001 - 50,000	35	8
50,001 - 100,000	45	8

5.5.2 Seawall and Armor Rock Protection

For the design of rock-armored type structures exposed to wave action, the required size of armor rock shall be determined by the design wave height using the Hudson Formula (refer to US Army Coastal Engineering Research Center, CERC, Shore Protection Manual, Section 7.37).

Hudson's Formula is as follows:

$$W = \frac{Wr\ H^3}{Kd\ (Sr - 1)^3 \times \cot\theta}$$

Where,
- W : Weight of an individual armor unit in the primary cover layer (tf) When the cover layer is two quarry stones in thickness, the stones comprising the primary cover layer can range from about 0.75 W to 1.25 W with about 75 percent of the individual stones weighing more than W.
- Wr : Unit weight (saturated surface dry) of armor unit (tf/m3)
- H : Design wave height at the structure site in meter
- Sr : Specific gravity of armor unit, relative to the water at the structure (Sr=Wr/Ww)
- θ : Angle of structure slope measuring from horizontal in degree
- Kd : Stability coefficient

For the design of the submerged rock protection layers and rock rubble toe protection, the size of rock shall be determined by considering the stability of the rock against disturbance due to propeller scour or wave action.
The method set out in the CERC will be applied in the case of wave action.

$$W = \frac{Wr\ H^3}{Ns\ (Sr - 1)^3}$$

Where, W : Mean weight of individual armor unit (tf)

Wr : Unit weight of rock (saturated surface dry) tf/m3

H : Design wave height (the incident wave height causing no damage to the structure) in meters

Sr : Specific gravity of rubble or armor stone relative to the water on which the structure is situated, Sr = Wr/Ww

Ww : Unit weight of water, Sea water = 1.03 tf/m3

Ns : Design stability number for rubble foundations and toe protection.

5.6 Particular Design Criteria : Civil Works

5.6.1 Road and Yard Pavement

(1) Pavement in General

The design load should be decided based on the loading conditions and the use of facilityies. Type of pavement should be based on the various conditions including trafficability, maintenance, subsoil condition and construction economy.

It is proposed that the basic pavement type for each area use be as follows:

Wharf apron	Concrete pavement
Inner access	Concrete pavement or Asphalt pavement
Container stacking area .... (Marshalling yard)	Asphalt pavement or Interlocking Concrete Block pavement or Concrete pavement
Container load support	Concrete heavy pavement
Yard crane foundation	Concrete heavy pavement
Transfer point	Concrete pavement
Maintenance shop	-ditto-
Fuel supply station	-ditto-

The design of pavement structure shall be based on the following conditions:

i) Reclaimed soil would be expected to be "silty sand" or "sand clay" at least. Corresponding C.B.R. of these soils could be expected between the range of 5 to 7. Thus, C.B.R. of 5 is used in this design.
ii) C.B.R. of the existing grade could be expected 10 or more.

(2) Road Arrangement

The lane arrangement shall depend upon the daily maximum traffic at the project target year. Addition to this requirement, an appropriate allowance at road sections shall be considered.

i) Minimum unit lane width
   Service road = 3.5 m
   Entrance = 3.5 and 4 m

ii) Minimum number of lanes
   Major service road = 2 lanes x 2 ways = 4 lanes
   Minor service road = 1 lane x 2 ways = 2 lanes

iii) Pedestrian
   Entrance = 4 m
   Other = 1.5 m and 2 m

5.6.2 Storm Water Drainage

Drainage shall basically be the separate system between storm-water line and sewerage line. Effluent after the required treatment can be discharged into storm-water drainage main, if so required. Drainage system shall primarily consist of network of reinforced concrete pipe with outfalls sloping seaward depending upon the shape and level of the area. Rainfall intensity shall be of five (5) year return period with corresponding storm duration. The proposed design rainfall intensity is 131 mm/hour.
The volume of storm water runoff shall be estimated by the following rational formula.

$$Q = CIA / 360$$

Where, Q = run-off flow (m3/sec)
C = Coefficient of runoff
I = rainfall intensity (mm/hour)
A = area served (hectare)

The average coefficient of runoff or the impervious factor for various types of surface shall be as given by Kuichling or similar.

The hydrant design criteria of pipes, side gutters, and sewer computation shall be performed using the Manning's Formula.

$$V = \frac{1}{n} R^{2/3} i^{1/2}$$

Where, V : velocity of flow (m/sec)
n : roughness coefficient
R : hydraulic radius (m)
i : hydraulic gradient (m/m)

The minimum and maximum velocity shall be 0.75 m/sec and 2.4 m/sec respectively. For structural and practical purposes, the pipe shall have a minimum crown cover of 0.75 m.

Sides of paved access roads and paved open storage area shall be provided with inlets on laterals connected to reinforced concrete pipes to manholes spaced at approximately every 20 to 40 m to the main drainage sloped to the outfall.

5.7 Particular Design Criteria : Building

5.7.1 Main Gate (Terminal Gate) and Control House (Terminal Office Building)

(1) Main Gate (Terminal Gate)

The required number of truck lanes shall be calculated by the following formula:

$$N = Mc \times p / (Dy \times H) \times (S / 60)$$

where,
- N : Required number of truck lanes
- Mc : Annual handling volume of containers (TEUs)
- p : Peak ratio
- Dy : Annual operating days (days)
- H : Operating hours per day (hours)
- S : Necessary procedure time per truck (about 3 min.)

The main gate should be located near the outer access roads and at the center of the container yard. This should be provided with the required number of lanes for entrance and exit. At least two 40 ton weigh-bridges should be provided at the main gate.

(2) Control House (Terminal Office)

The control house shall be provided with enough space for various office activities. One office shall generally be provided per unit container terminal. The required area for the office shall be decided based on the method of office operation and the number of persons working in the terminal.
The required office floor area shall be calculated by the following formula:

$$Ac = Np \times ap$$

Where,
- Ac : Required office floor area (m2)
- Np : Number of persons working in the terminal, Assuming 150 persons
- ap : Required unit floor area per person, Assuming 10 m2/p

It is recommended to locate the Control House near the Main Gate.

5.7.2 Maintenance Shop

(1) Maintenance Shop at New Terminal

Required building shall be derived from the following requirements:

The building shall provide a sheltering area for equipment repair and maintenance and at the same time.

The following functions shall be provided.

- Forklift garage
- Support and service facilities
- Repair and maintenance facilities for containers
- Control office
- Structure for three tons travelling crane
- Training of personnels

Supporting and service facilities shall include:

- Tire repair bay with air compressor
- Welding bay with welding machine
- Spare parts and tool storage room
- Locker room and toilet facilities

The size of the maintenance shop depends on such factors as the rates of container damage, the type and number of cargo-handling vehicles and machines to be used in the terminal. The basic requirements to maintenance shop are as follows:

Area : 1,000 sq.m (40 m x 25 m)/berth
Height : 10 m
Width of the space in front of the maintenance shop: more than 10 m

(2) Maintenance Shop Improvement in Existing Container Terminal

The following machines and tools should be replaced:

(a) All types of dissolving and assembling tools
(b) Measuring tools
(c) Rust removers, painting tools
(d) Handling machines
(e) Machinery

Including the above instruments, the necessary maintenance instruments are shown in Chapter 5 of Part II.

5.7.3 Container Freight Station : CFS

(1) CFS at New Terminal

CFS shall include the following space:

- Storage area
- Offices
- Locker and toilet facilities
- Lock-up area

On the landward side, a loading platform of 4 meters wide shall be provided for smooth cargo loading and unloading by mechanical works.

Required area of CFS is calculated as below:

S = (W x D x p) / (w x r x T)

Where,
W : Cargo volume treated in CFS (ton)
D : Average dwelling time (days)
p : Peak ratio
w : Average stacking weight on unit area in CFS (ton/sq.m)
r : Effective use ratio of floor area in CFS
T : Annual operating days (days/year)

(2) CFS at Existing Container Terminal

There is no necessity to provide an additional CFS to the existing one, since its space is enough for cargo demands in 2010.

5.7.4 Weigh Bridges

Design parameters required for weigh bridge shall be as follows:

Type: Motor Truck Scale, pit type
Capacity 40 tons, smallest division 10 kg
Platform size 15.0 m x 3.0 m
Automatic display and recorder should be provided.

5.7.5 Upgrading and Modernization of Existing Piers

(1) Required Parking Area for Imported Cars

The required parking area shall be calculated by following formula:

Ac = ac x Nc

Where,
AC : Required parking area for imported vehicles (m2)
ac : Unit slot per average vehicles
Assuming 20 m2/vehicle
Nc : Number of imported cars (vehicles/year)

This area shall be provided near the finger piers.

(2) Transit Shed for Conventional Cargo

The required shed area shall be calculated by the following formula:

As = Ms/n/as

Where,	As	:	Required shed area	(m2)
	Ms	:	Cargo volume	(t/year)
	n	:	Annual cycle of shed use	(cycles/year)
	as	:	Unit loading	(t/m2)

Note: It is proposed to demolish the existing shed on Pier No.7 at an early stage. Thus the existing shed on Pier No.6 will be used for conventional cargo handling.

(3) Passenger Terminal

A part of the existing shed on Pier No.8 shall be modified into a Passenger Terminal Building. The building shall provide enough services to annual passengers of 75,000 persons in 2010.

Required space for this terminal shall be determined based on the following standard planning parameter per person.

Table 5-7-1 Standard Planning Norm for Passenger Terminal

Area	Parameter
Waiting space by passenger	1.00 sq.m/person
Cafeteria/Kitchen	0.30 " "
Ticketing Office	0.15 " "
Luggage Room	0.15 " "
Toilets	0.15 " "
Total	1.75 sq.m/person

This modified terminal shall have functions of immigration and custom office, as well as an information center of tourism around Colon City and shopping center which serves for passengers and crews. Required area for passenger terminal is estimated as follows:

Table 5-7-2 Required Area for Passenger Terminal

Function	Area (sq.m)
Terminal Facilities	900
Custom and Immigration	200
Information and Tourist Office	300
Shop (10 tenants)	750
Restaurants and Coffee Shops (3 tenants)	450
Total	2,600

5.8 Particular Design Criteria : Utilities

5.8.1 Water Supply and Fire Fighting System

The water supply system for the project shall consist of water reservoir, pump house, elevated tank and distribution system for domestic use separated from the distribution lines for ships hydrants and fire fighting system. Pump for each distribution system shall be provided to meet the design requirements of each system. The layout shall start from the interconnection to the existing supply main. From the interconnection point, an extension pipe shall be installed to connect to the proposed ground reservoir. From the water reservoir, water for domestic use shall be provided with adequate pressure. While the water for ships and fire fighting system shall be pumped directly from the water reservoir to the ships and fire fighting system distribution line.

Water lines in the terminal shall basically be a loop in order to keep constant water pressure and ease of repair works when so required. All pipes and fittings shall be centrifugal cast iron pipes and cast iron fittings. Cast iron pipes shall be centrifugal cast in metal or sandline mold.
The following basic water demand shall be considered:

i) Ship Supply System
100 tons per hour to provide two (2) foreign cargo vessels with 10 tons of water each.

ii) Fire Fighting System
Minimum 100 tons/hour for one hour service through the fire hydrant before arrival of the fire brigade to continue attacking the fire

iii) Domestic Use
The water consumption rate shall not be less than 10-50 liters day/capita, for passengers and employees respectively.

Minimum pressure at the farthest service point during operation shall not be less than 1.0 kg/cm2.

5.8.2 Sewerage System

Sanitary waste water shall be collected and treated by the septic tank with leaching chamber. The treated waste water from the leaching chamber of septic tank will permeate into the ground and excess water, if any, will be discharged to adjacent storm drainage line through cast iron soil pipes. The required volume of septic tank shall not be less than 0.05 m3 per person.

5.8.3 Power Supply and Lighting System

(1) Lighting

Standard intensity of illumination to be designed in this project by respective building and facility shall be as follows:

Table 5-8-1 Interior Illumination Requirement

Type of Building	Illumination Level (lux)
Control House (Terminal Office)	
Offices	400
Staff Area	300
Corridors	150
Storage	100
CFS	
Storage Area	200
Offices	400
Maintenance Shop and Gate House	300
Pump House and Power House	200

Table 5-8-2 Exterior Lighting Requirement

Area Classification	Illumination Level (lux)
a) Service Roads	15
b) Container Marshalling Yard	25
c) Apron	15
d) Parking Area	15

(2) Power Supply

Power supply in the normal condition should be made by the existing city main. Power demands should be estimated to ensure the terminal in operation.
A conjunction point where power will be supplied to the new terminal area should be the nearest point to Telfers Island. The existing overhead primary line may be required to be upgraded. A transformer pole with transformers, wiring for secondary service drops to the terminal should be arranged.

Emergency Power Supply:
Loads shall be divided into the essential and non-essential load and the former shall be maintained by a stand-by generator during the blackout.

i) Characteristics of Generator

Type	....	Diesel engine driven electric generator
Capacity	....	Essential load estimated

ii) Emergency Power Demands
The following loads shall basically be considered as the essential load to be provided with emergency supply during utility power outage.

- Exterior Lighting: Flood lights for open storage areas, vehicle parking area, apron, gates and perimeter lighting
- Interior Lighting: Thirty to fifty percent of the lighting fittings are on emergency circuit.
- Water Pumps: One set of pumps is provided with emergency power.
- Refrigerated Container (Reefer): Power receptacles for connecting refrigerated containers will be provided with emergency power.
- Container wharf Crane: Enough power to two wharf gantry cranes per unit wharf should be ensured.

(3) Telecommunications

A main telephone terminal cabinet (MTTC) shall be installed for receiving the required number of direct lines from the city telephone system. Direct lines and pay phones brought to each facilities shall be planned accordingly.

- Control House (Terminal Office) : The system shall have a private automatic branch exchange (PABX) with a maximum of 10 direct lines and maximum of 40 exchange lines.
- Other Buildings : The container freight station, Maintenance Shop, Weigh-bridge and Gate Houses will have a single line served by the PABX of the Control House.

5.9 Preliminary Design of Wharf Structure

This section deals with the study results of preliminary wharf structure design for a new container terminal. The required construction cost varies by its structural type and soil condition. Thus the purpose of this alternative study is not only to estimate the required cost to be added to the project costs but also the selection of the most suitable structural type for each soil condition.

5.9.1 Structural Alternatives

For the wharf alternative study, two types of soil conditions were selected, namely Soil-C and Soil-T. The former is a typical soil condition at Site-C, West Colon offshore and the latter is that at Site-T, Telfers Island north coast. These two soil conditions are shown in Figure 5-2-3. Regarding to the design wharf depth, two possible figures, MLW -12 m and MLW -14 m, were selected.

Four alternative structural types were chosen as follows:

- Open Structure with vertical piles	OSV	Figures 5-9-1, 5, 9 & 13
- Concrete Caisson Box	CC	Figures 5-9-2, 6, 10 & 14
- Steel Sheetpile Wall	SP	Figures 5-9-3, 7, 11 & 15
- Concrete Block	CB	Figures 5-9-4, 8, 12 & 16

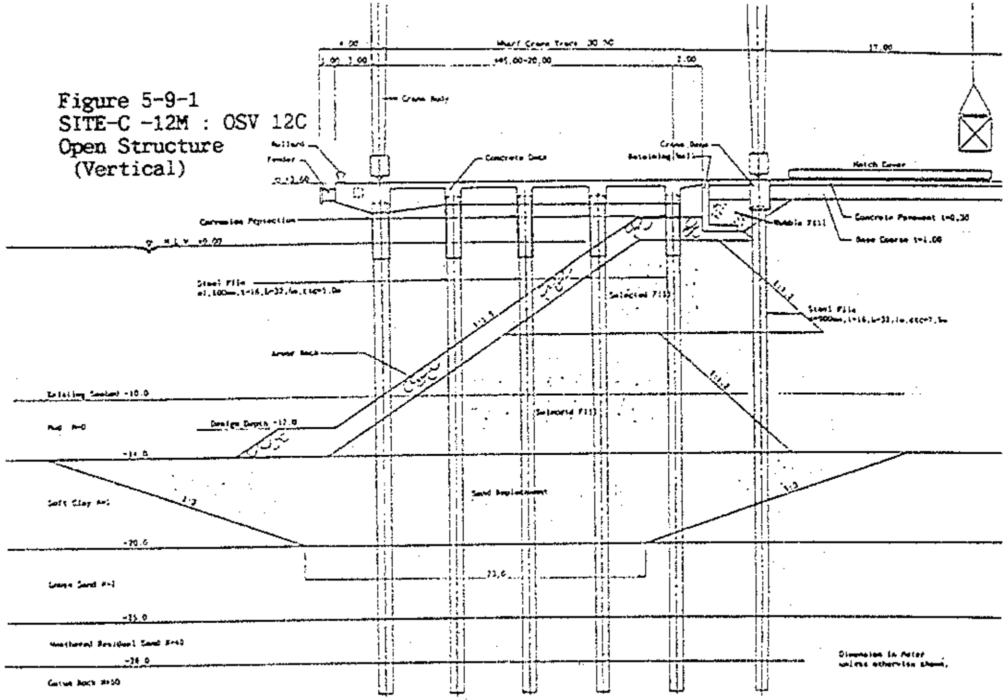


Figure 5-9-1
SITE-C -12M : OSV 12C
Open Structure
(Vertical)

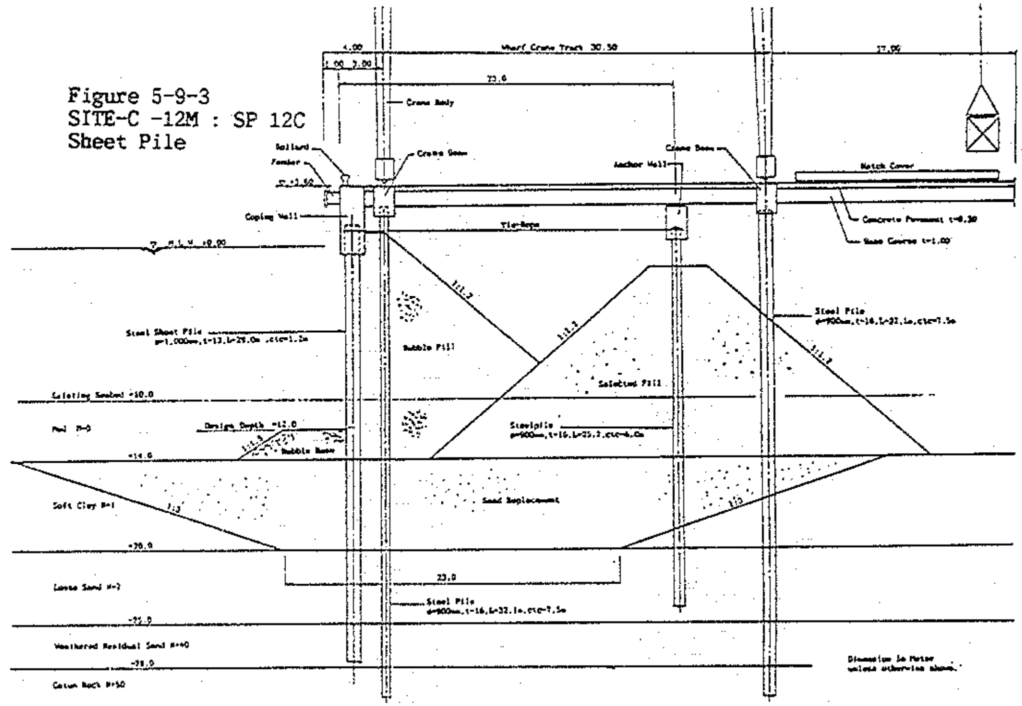


Figure 5-9-3
SITE-C -12M : SP 12C
Sheet Pile

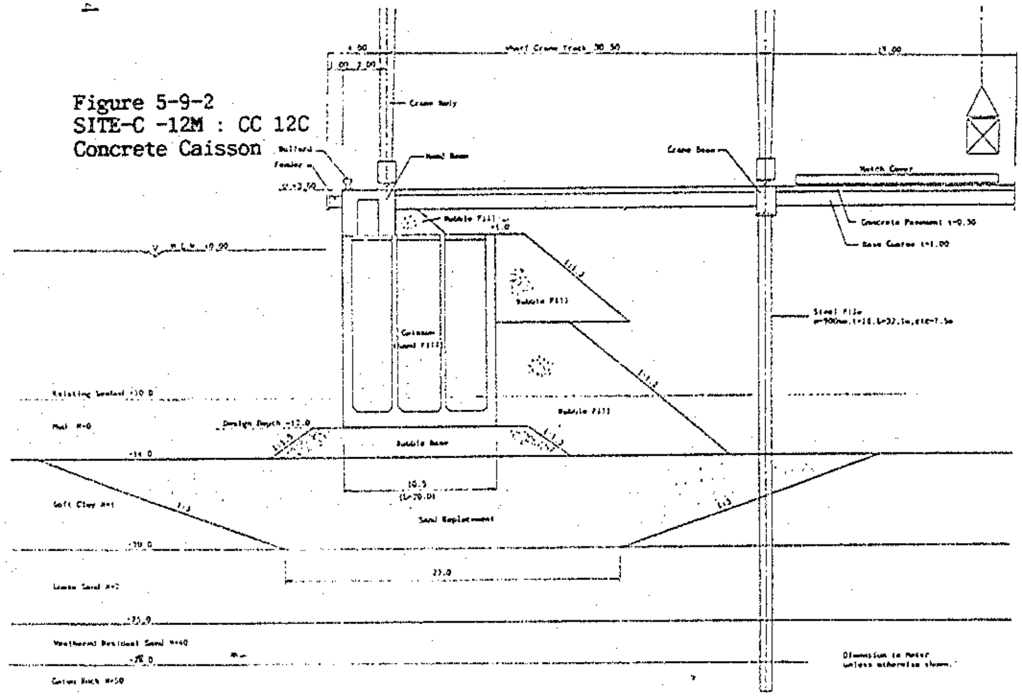


Figure 5-9-2
SITE-C -12M : CC 12C
Concrete Caisson

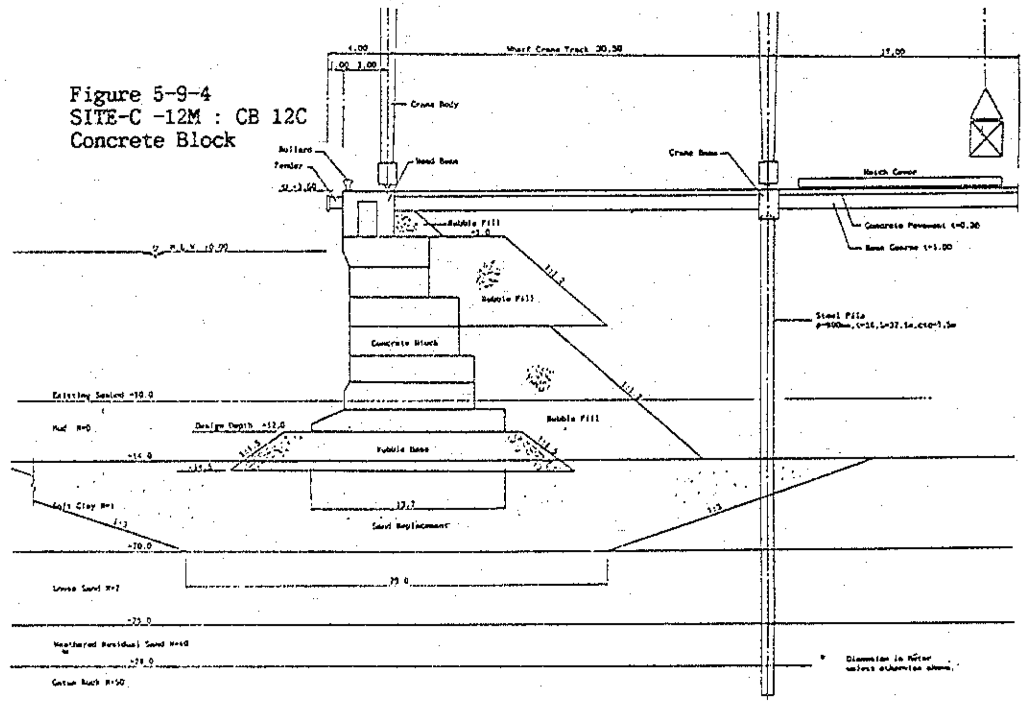


Figure 5-9-4
SITE-C -12M : CB 12C
Concrete Block

Figure 5-9-5
SITE-C -14M : OSV 14C
Open Structure
(Vertical)

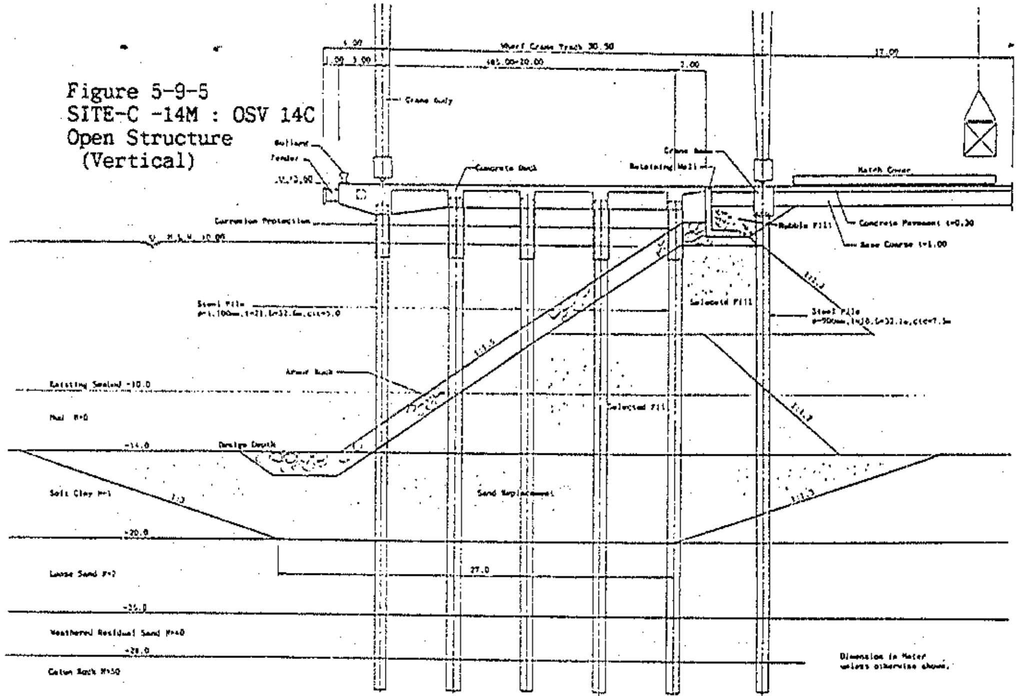


Figure 5-9-7
SITE-C -14M : SP 14C
Sheet Pile

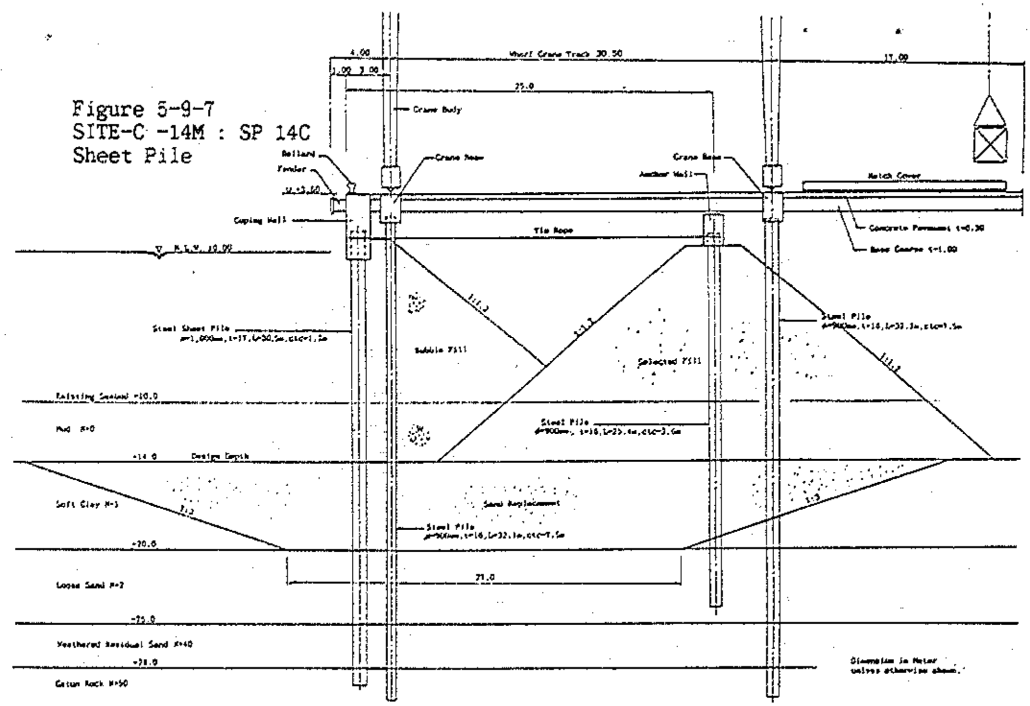


Figure 5-9-6
SITE-C -14M : CC 14C
Concrete Caisson

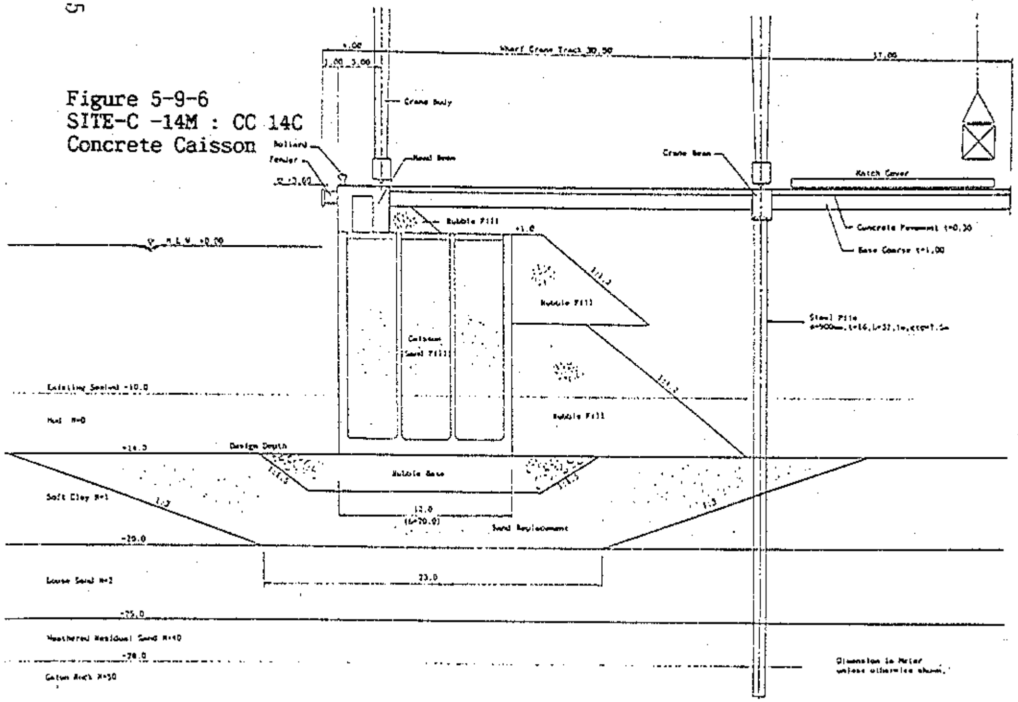
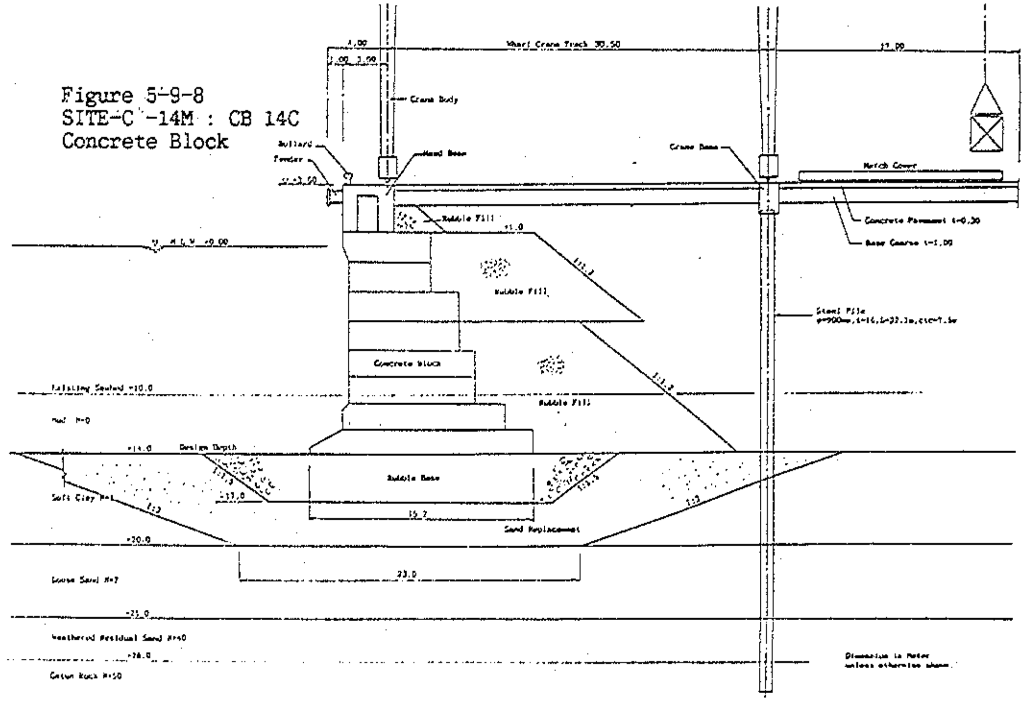


Figure 5-9-8
SITE-C -14M : CB 14C
Concrete Block



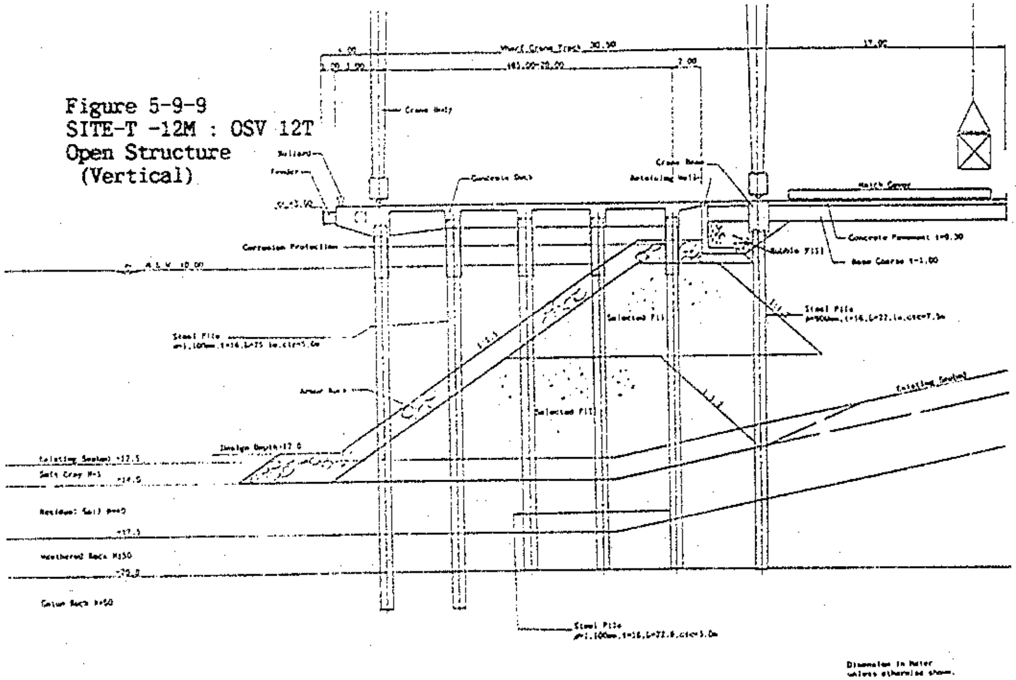


Figure 5-9-9
SITE-T -12M : OSV 12T
Open Structure
(Vertical)

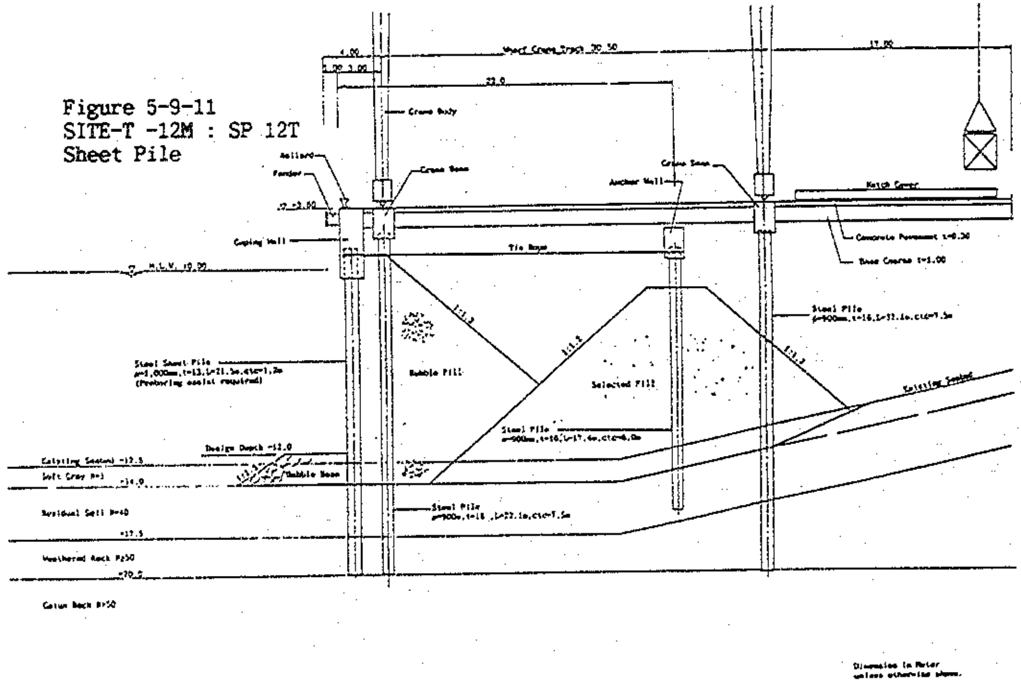


Figure 5-9-11
SITE-T -12M : SP 12T
Sheet Pile

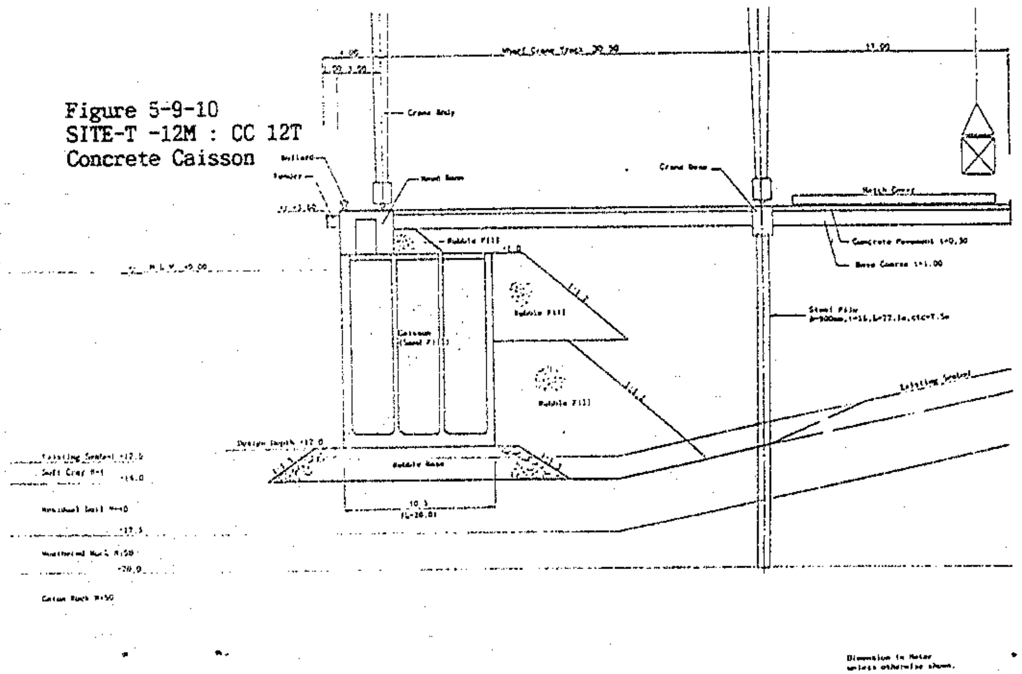


Figure 5-9-10
SITE-T -12M : CC 12T
Concrete Caisson

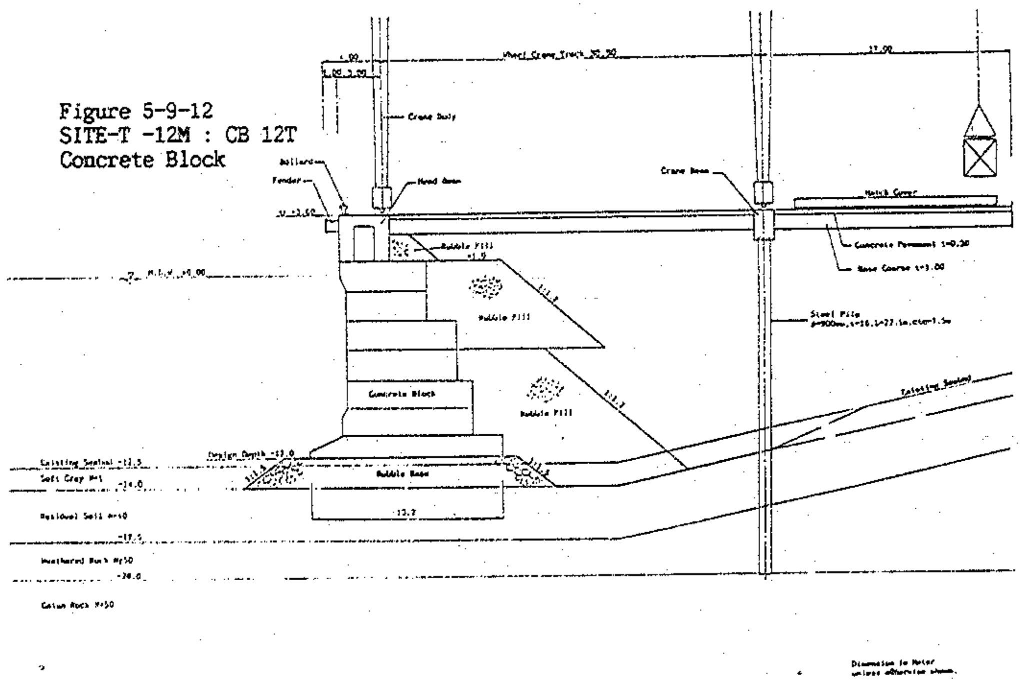


Figure 5-9-12
SITE-T -12M : CB 12T
Concrete Block

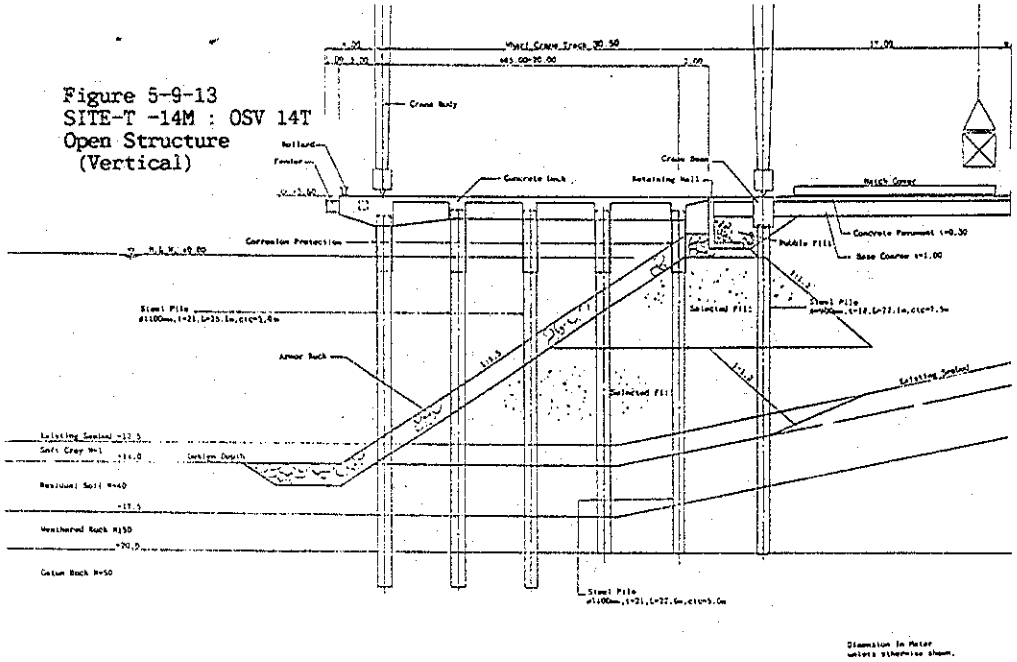


Figure 5-9-13
SITE-T -14M : OSV 14T
Open Structure
(Vertical)

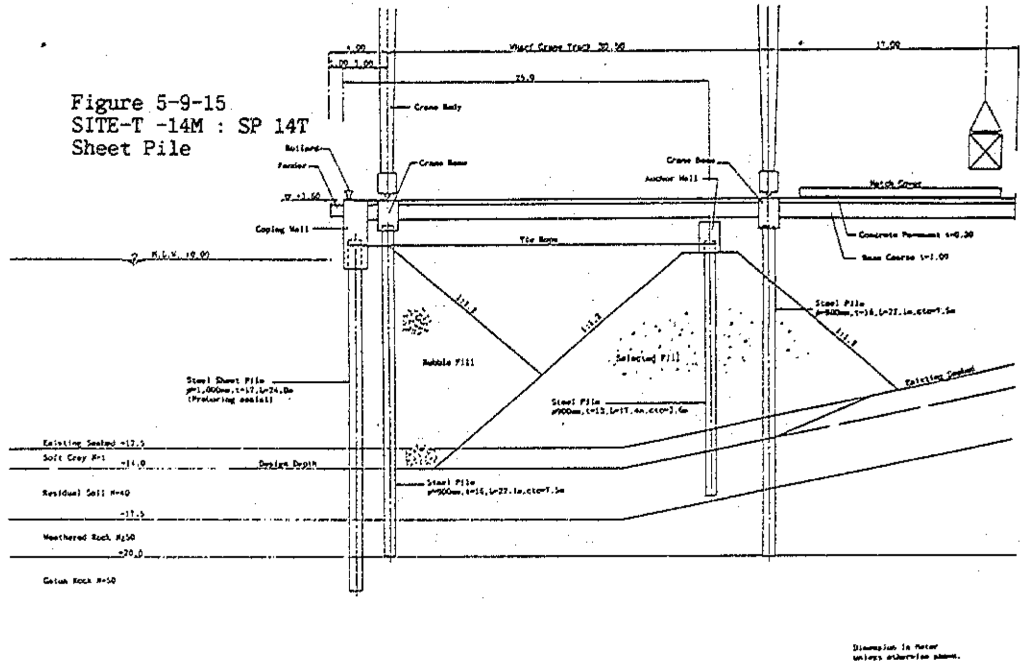


Figure 5-9-15
SITE-T -14M : SP 14T
Sheet Pile

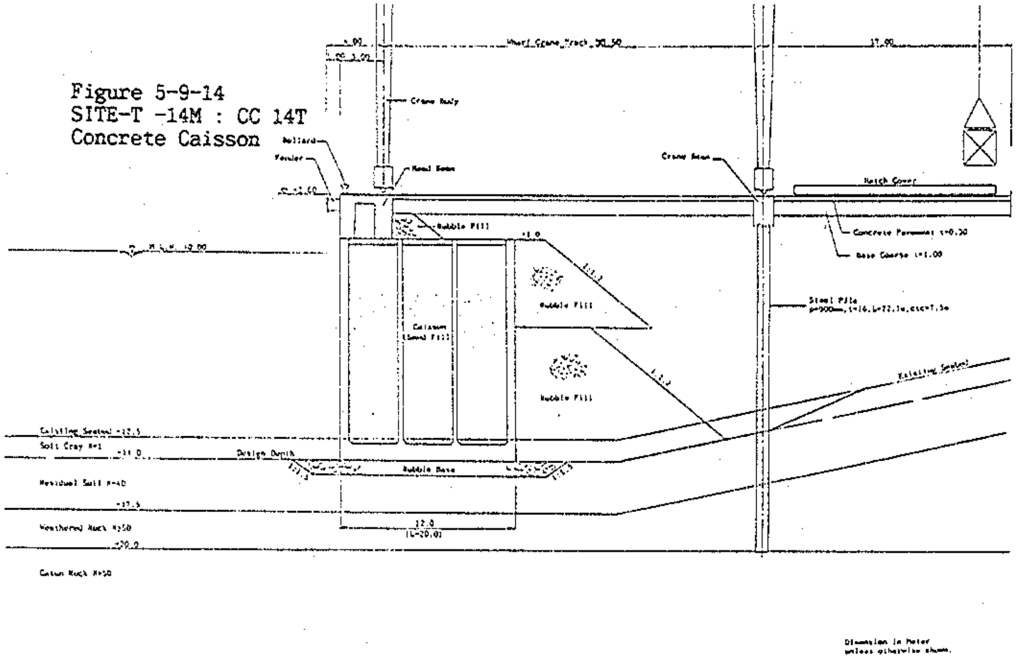


Figure 5-9-14
SITE-T -14M : CC 14T
Concrete Caisson

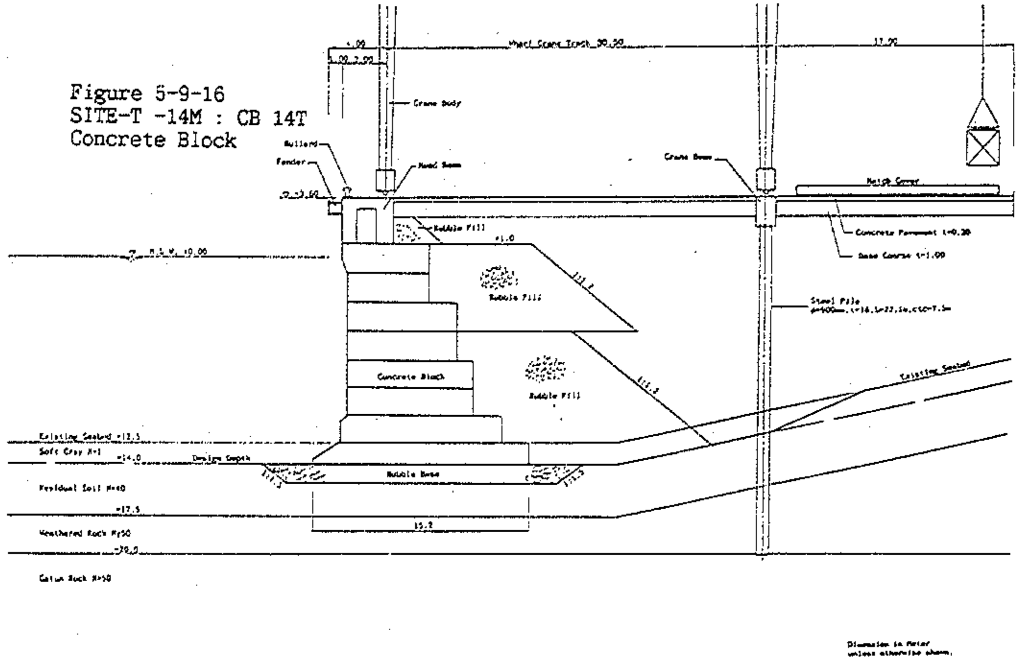


Figure 5-9-16
SITE-T -14M : CB 14T
Concrete Block

5.9.2 Evaluation of Structural Alternatives

All the alternatives are evaluated by five respective viewpoints.

- Structural stability and durability
- Easy construction: Easy and simple construction method will gain high marks.
- Local material use: The more local material requirements, the higher marks
- Maintenance costs
- Construction costs

These viewpoints on the alternative were quantitatively evaluated by a pointing method.

Best (BT) 20 points,	Better (B) 16 points
Good (G) 12 points,	Fair (F) 8 points

If any alternative gains a full mark, the total point is 100. Figure 5-9-17 shows the evaluation results.

SITE-C: Soil-C

The highest mark was gained by CC followed by OSV. However, both SP and CB were marked by lower point.

SITE-T: Soil-T

Similar to Site-C, the highest mark was given to CC. OSV gained the second place however lower marks than those at Site-C. Similar to Site-C, both SP and CB were not appreciated.
By these reasons, type CC concrete caisson box should be given the most stabilized status with the highest points. Thus, this alternative study suggests to choose two structural types for further detailed evaluation.

CC : Concrete Caisson Box and
OSV : Open structure with vertical piles

Tables 5-9-1 and 5-9-2 show the wharf structural comparison for Site-C and Site-T.
During the second visit of the Team to Panama, it is concluded that the new container terminal be built at Site-T with a wharf structure of concrete caisson box type.

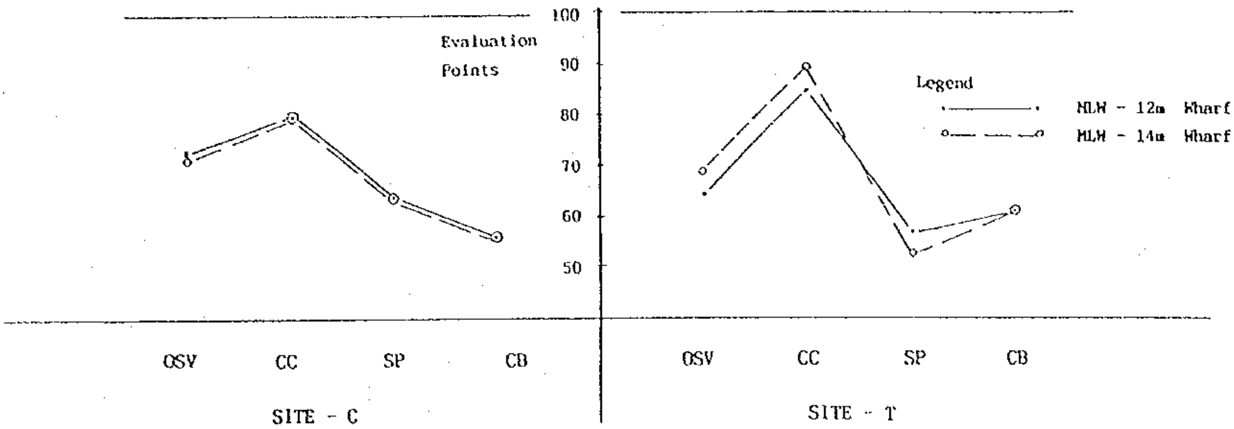


Figure 5-9-17 Wharf Structural Evaluation

Table 5-9-1 Summary of Wharf Structural Comparison at SITE-C : West Colon

Evaluation Items	Wharf Design Depth MLW -12.0m				MLW -14.0m			
	OSV	CC	SP	CB	OSV	CC	SP	CB
Structural Stability	B	B	G	F	B	B	G	F
Easy Construction	BT	G	B	G	BT	G	B	G
Local Material Use	F	B	F	B	F	B	F	B
Maintenance Costs	G	B	G	G	G	B	G	G
Construction Costs	B	B	B	F	B	B	B	F
Total Evaluation (Total Points)	B 72	BT 76	B 64	G 56	B 72	BT 76	B 64	G 56

Table 5-9-2 Summary of Wharf Structural Comparison at SITE-T : Telfers

Evaluation Items	Wharf Design Depth MLW -12.0m				MLW -14.0m			
	OSV	CC	SP	CB	OSV	CC	SP	CB
Structural Stability	B	BT	G	F	B	BT	G	F
Easy Construction	G	G	G	G	G	G	G	G
Local Material Use	G	B	F	B	G	B	F	B
Maintenance Costs	F	BT	F	B	F	BT	F	B
Construction Costs	B	BT	B	F	BT	BT	G	F
Total Evaluation (Total Points)	B 64	BT 80	F 56	B 60	B 68	BT 88	F 52	B 60

5.9.3 Detailed discussion on Wharf Structure Alternatives

Generally the wharf construction cost shares about 30% of the whole terminal construction cost. Another large variable cost item is dredging and reclamation which shares about 15% of the terminal cost in this project. Thus, these two items share about 45% of the total cost. (Note: Terminal construction cost includes all the civil, building and utilities except the cargo handling equipment.)

Other costs than these big two are rather constant, since the on-land civil works as pavement and building works like CFS are all common items to the terminal. The dredging and reclamation cost is largely depending on the drawn faceline of wharf. Thus the required cost can be obtained when the faceline is fixed.

The purpose of this subsection is, thus, to undertake the preliminary construction cost estimation based on the rough structural design of wharf. This subsection aims also compare and evaluate various structure types applied to the project condition. The purpose of construction cost estimation is two holds, namely;

- How much initial investment should be made for each alternative?
- How the design water depth and wharf depth influence the initial construction cost?

Addition to these questions, this section aims at confirming the possibility of wharf construction at site and undertaking a study of construction economy. In order to analyze these aspects, two wharf depths namely MLW -12m and MLW -14m were chosen.

(1) Summary of Alternative Study

a. Unit wharf construction cost at Site-C is about 8% higher than those of Site-T, averaging the type OSV and CC.
(Note : An unit wharf construction cost is the cost per wharf meter except the equipment cost.)
b. Unit wharf construction cost for the -14m wharf is about 15% higher than those of the -12m wharf, averaging type OSV and CC.
c. The concrete block (CB) is not suitable since it is the highest or higher cost plans than any others.
d. Required wharf construction period for all the alternatives is about 14 months a berth. There is no large difference.
e. Construction material locality selects type CC since all the materials except steel bar reinforcement are available in Panama. Type CC has advantageous in terms of less maintenance cost since there is no exposed steel face to seawater.
f. Type OSV is also a possible alternative if the new terminal site is selected at Site-C or similar soil condition.
g. Type CC is the best alternative for the time being, if the new terminal is constructed at the existing northern coastline of Telfers Island, Site-T.

(2) Preliminary Wharf Construction Cost Estimates

Table 5-9-3 shows each unit cost of 16 structural alternatives.
Figure 5-9-18 shows this in graphic display.

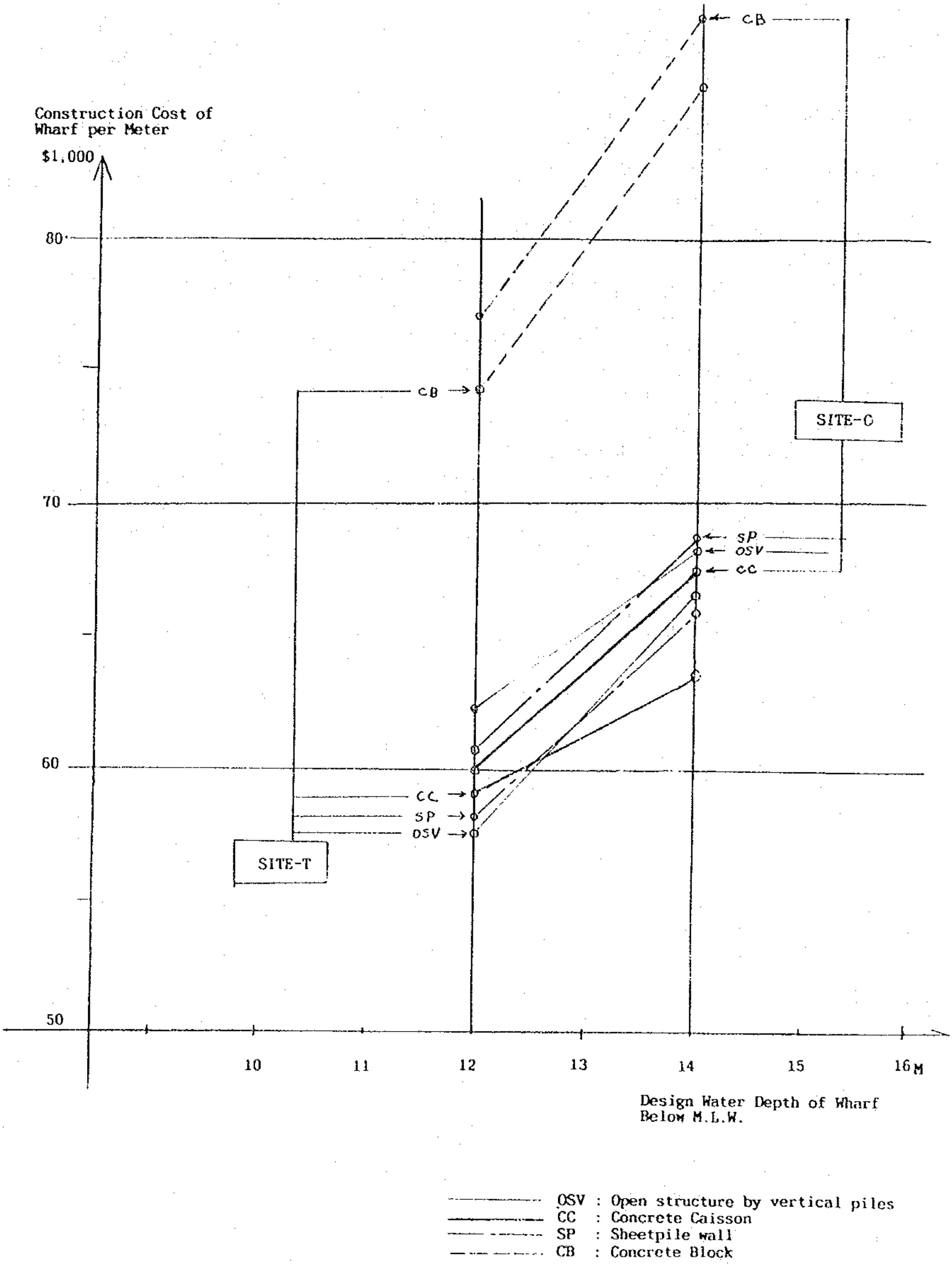


Figure 5-9-18 Cost Comparison Study by Wharf Structure

Table 5-9-3 Cost Summary of Wharf Alternatives

unit: 1,000 $/wharf meter

Wharf Depth (m)	Type	SITE-C cost	SITE-C index	SITE-T cost	SITE-T index
MLW -12.0	OSV	61.7	105%	57.4	98%
	CC	60.3	103%	58.7	100%
	SP	60.6	103%	57.6	98%
	CB	76.5	130%	74.4	127%
MLW -14.0	OSV	67.9	116%	65.4	114%
	CC	67.5	115%	63.0	107%
	SP	68.1	116%	66.6	113%
	CB	90.5	154%	85.8	146%

Note: Index in the table shows a cost fluctuation against the unit cost of 53.1 $/m of concrete caisson type of -12m wharf at Site-T.

The lowest cost structure at Site-C is the concrete caisson type regardless of wharf depth. The 12m CC wharf cost will increase by 11% for the 14m wharf case. The lowest one at Site-T for -12m depth is the open structure type, however, this is very similar to those of the steel sheet pile wall and the caisson type. While the 14m wharf cost shows that the caisson type is the lowest and overriding the others. This indicates that the soil condition here is very suitable to CC structure.

In case that the new container terminal is constructed at Site-T, it can be recommended to construct -14m wharf for more flexible wharf use to meet the unexpected large container vessels calling.

(3) Open Structure Alternatives

An open structure consists of a superstructure of deck supported by a group of piles as a substructure. All the existing piers in the port of Cristobal belong to this type. This is the most popular selection under the medium soil condition and a deeper water. In order to estimate a possible cost in the project, two types of pile foundation systems were examined.

As described before, there are three types of geotechnical conditions, namely Soil-T, Soil-C and Soil-CS. The first one is representing a shallow Gatun formation covered by a medium solid layer which can be seen at Telfers Island. While, the Gatun formation in the second type is embedded deeper than MLW -25m which is overlaid by several medium solid layers and a muddy surface layer of 15m thick. This soil concept typically is seen at the West Colon site. The last one is a composite type between two types discussed above, as seen in Coco Sole.

The pile foundation concepts can be divided into two categories, namely a vertically driven pile system and a batteredly driven pile system. Piles in the former are driven or installed perpendicularly as seen at the existing piers at the port of Cristobal. The latter piles should be driven not vertically but angled, batter piles. The practical batter angle is normally between 10 degrees and 20 degrees. A comparison study between these two piling concepts was examined for the project. Soil-C was selected for this alteration since the soil condition of other two sites do not seem to be suitable for the batter pile use. Another important condition is the pile material. Steel materials were selected for an easy construction operation and to ensure to drive the piles into the expected hard bearing stratum, the Gatun formation.

General condition of this structural alternative study is as follows:

a. Vertical piles vs. Batter Piles
b. Pile material, steel pipe piles
c. Soil condition at Site-C, Soil-C
d. Wharf design depth, MLW -12.0m and -14.0m
e. Decisive loading condition: Seismic condition
   (Seismic coefficient Kh=0.20)
f. Superstructure, concrete decks and beams

(3) Study Results

Preliminary design together with rough cost estimation were conducted. The cost changes for these alternatives are demonstrated in Figure 5-9-19. The typical structural sections are shown in Figures 5-9-20 to 5-9-23.

As seen in the figure, the required cost of the two is very similar. All the construction unit cost per wharf meter are between 62,000 $/m and 68,000 $/m. The cost for vertical pile wharf, OSV, is rather sensitive to the wharf depth, while the cost for batter pile one, OSB, is flat against the wharf depth. Interesting matter is that the lowest costs at -12m wharf and -14m wharf are OSV and OSB respectively. This shows that OSV is better for -12m wharf and OSB is better for -14m wharf in SITE-C.

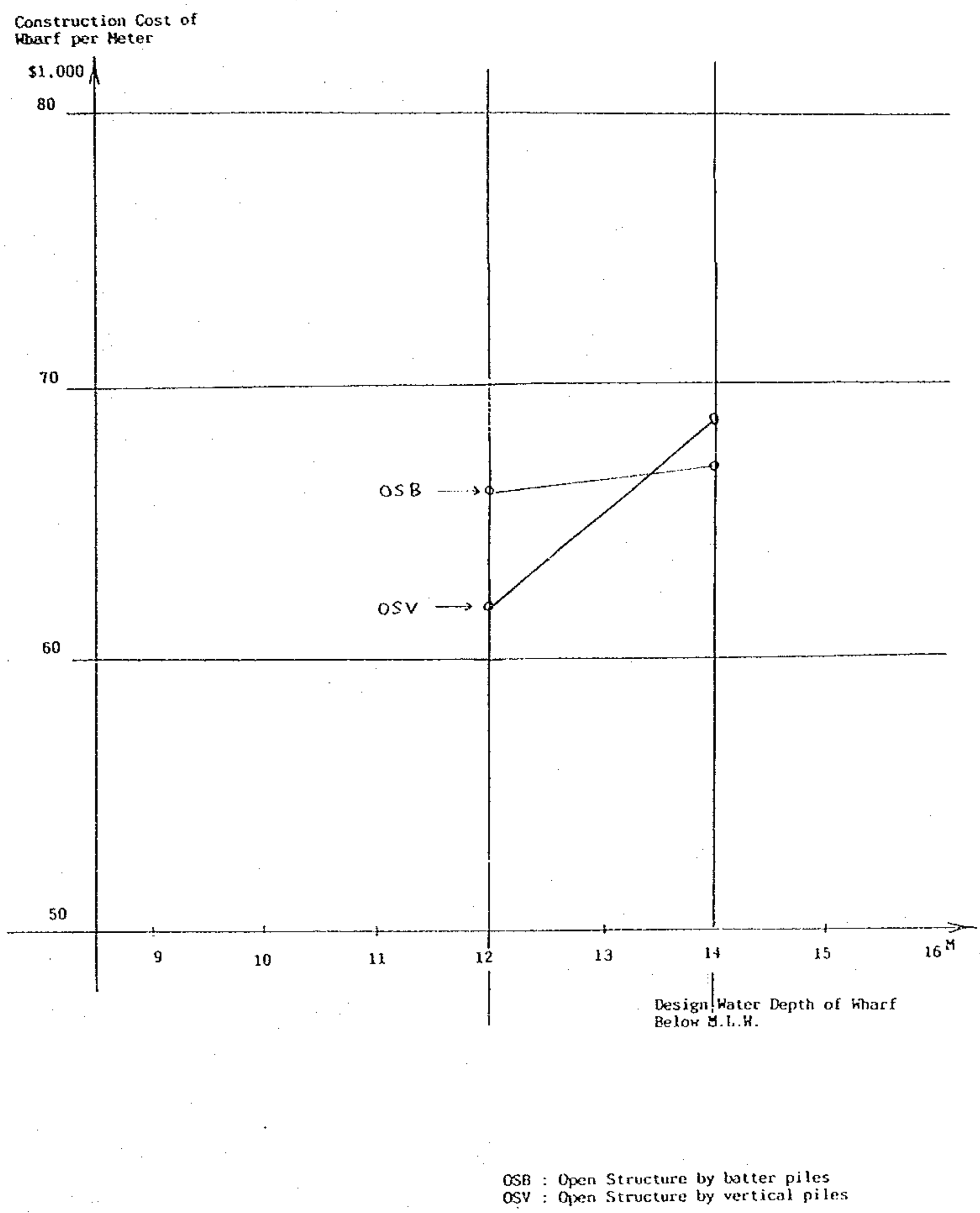


Figure 5-9-19 Open Structure Alternatives : Site-C

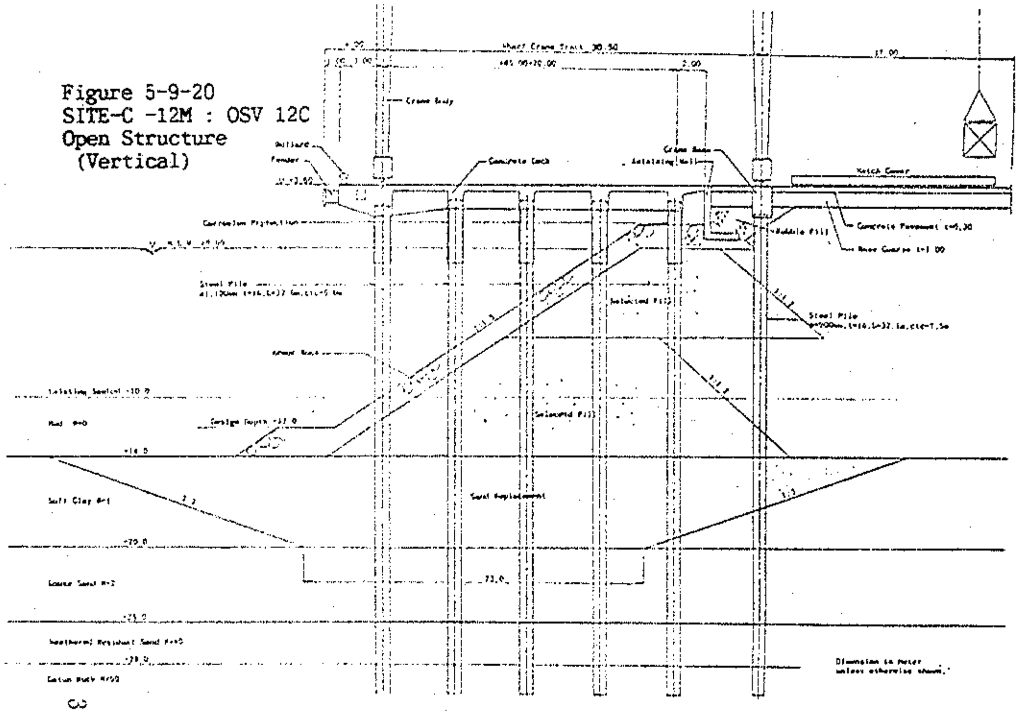


Figure 5-9-20
SITE-C -12M : OSV 12C
Open Structure
(Vertical)

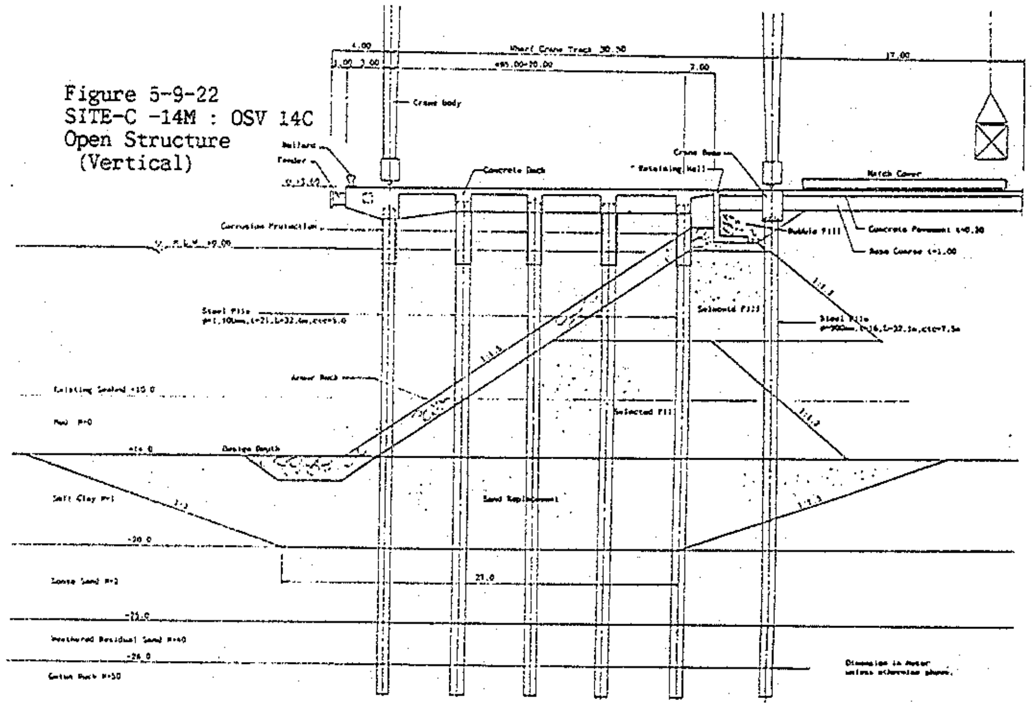


Figure 5-9-22
SITE-C -14M : OSV 14C
Open Structure
(Vertical)

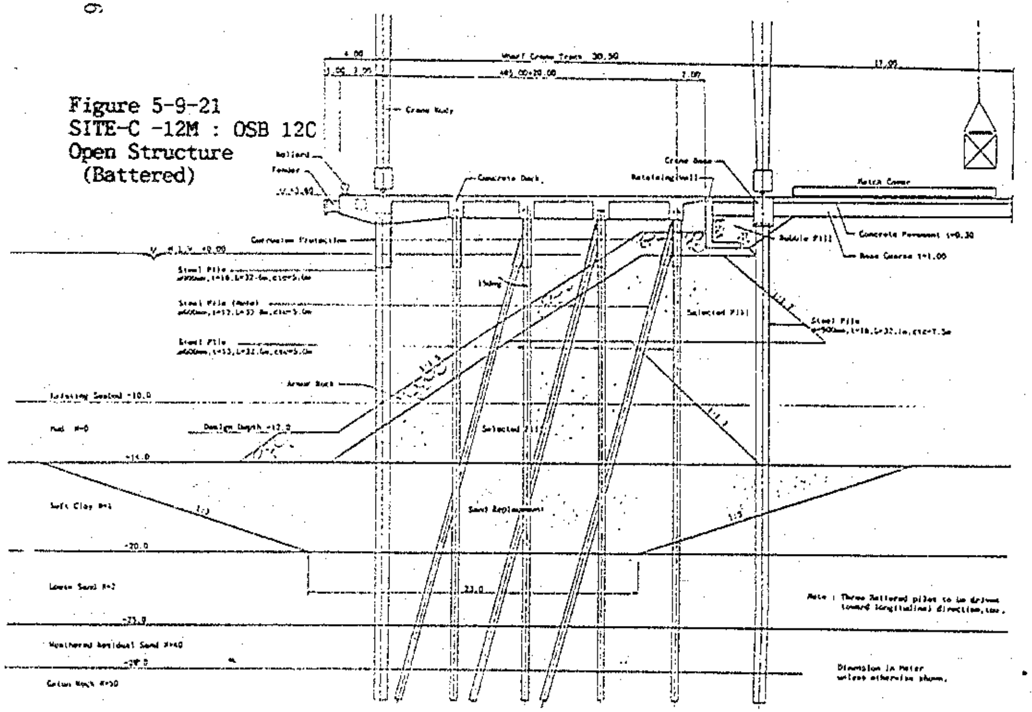


Figure 5-9-21
SITE-C -12M : OSB 12C
Open Structure
(Battered)

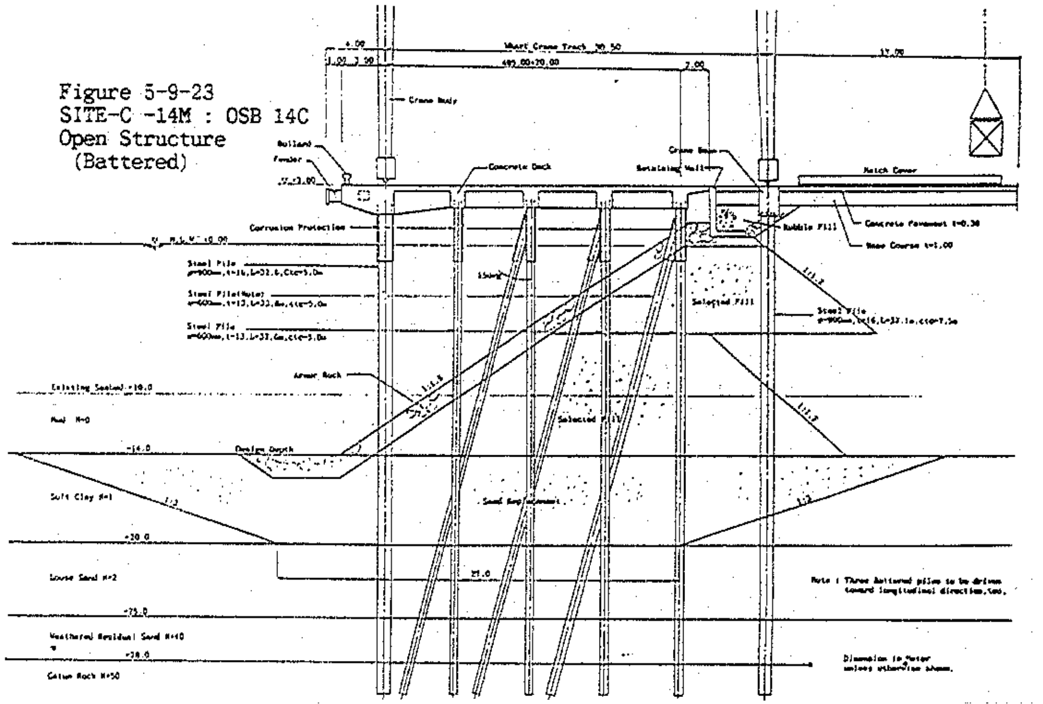


Figure 5-9-23
SITE-C -14M : OSB 14C
Open Structure
(Battered)

5.10 Preliminary Design of Seawall and Armor Rock Protection

5.10.1 Design Wave

Recorded largest hurricane wind velocity in Cristobal is about 27.5 m/sec (54 mile/hour). A preliminary estimation of hurricane wave to be generating in the Limon Bay was carried out as shown in Table below 5-10-1.

Table 5-10-1 Wave Intensity by Hurricane Wind (Limon Bay)

Wind Force U (m/s)	Wave Height H 1/3 (m)	Wave Period T 1/3 (sec)	Note
17.5	0.8	2.8	
20.0	0.9	2.9	
22.5	1.0	3.0	
25.0	1.1	3.2	
27.5	1.3	3.4	Maximum
30.0	1.5	3.6	

The possible wave at the mouth of the existing breakwaters was estimated by the weight of the remaining concrete armor block at the existing breakwater. This is based on the assumption that the maximum wave in past might be similar to the wave by which the existing block weight was calculated. The existing breakwater is a typical sloping breakwater which consists of core rubble and armor rock and concrete block. Basic dimensions are known.

A possible design wave is estimated for this breakwater using Hudson's Formula. The weight of rubble or concrete blocks covering the slope surface of a structure receiving the wave action may be calculated by the following formula.

$$W = \frac{Wr\ H^3}{Kd\ (Sr - 1)^3 \cot \theta}$$

Where,
- W : Minimum weight of rubble or concrete blocks (ton)
- Wr : Unit weight or rubble or block in air (ton)
- Sr : Specific gravity of rubble or block to sea water
- θ : Angle of the slope to horizontal plane (degree)
- H : Wave height (m)
- Kd : Stability coefficient determined by the armoring material and damage rate

Wave height shall be the significant wave height H 1/3 after refraction at the water depth at which the breakwater is constructed.

Thus,

$$H^3 = W\ KD\ (Sr - 1)^3 \cot \theta / Rt$$

The following figures are known:

W	=	1.5 m x 1.5 m x 1.5 m x 2.3 = 7.8 ton/ea.
Wt	=	2.3 t/m3
Sr	=	2.3/1.03 = 2.2
cot θ	=	1.5
Kd	=	5 - 8 takes 6.0

Thus,

$$H^3 = 7.8 \times 6.0\ (2.2 - 1)^3 \times 1.5/2.3$$
$$= 56.8$$
$$H = 3.8\ m$$

It is assumed that the existing breakwater was constructed against the design wave of 4 meter high. The breakwater is partially damaged. This might be caused by the following reasons.

- Settlement of breakwater foundation
- Damage by larger waves than the design wave

It is recommended to adopt a wave of 4.0 meter high for the project (or equivalent offshore wave).

(Note: This wave is a shoal water wave in front of the breakwater, MLW-10m. This wave is refracted by the seabed configuration during the propagating to shoal water. The deepwater wave not affected by refraction is named the offshore wave. Wave after refraction is named the equivalent offshore wave, Ho'. Hudson formula should be applied to this Ho'.)

It is assumed that the offshore wave height is between 4 m and 5 m.

The waves in front of the wharf were estimated combining the local wave generating in Limon Bay and the external wave intruding through the breakwater entrance. Mixed waves can be obtained by the square rule.

$$Hc = (H1^2 + H2^2)^{0.5}$$

Where,
- Hc : Combined wave (m)
- H1 : Local wave (m)
- H2 : Penetrating wave through the breakwater entrance (m)

The design waves in front of the wharf front are estimated as follows:

Condition 1. External wave at the entrance : 4.5 m

2. Diffraction coefficient and diffracted wave.
   - Site-C Kd=0.3 , H2=0.3x4.5=1.4m
   - Site-T Kd=0.2 , H1=0.9m
   - Site-F Kd=0.15, H1=0.7m
   - Site-CS Kd=0.15, Hs1=0.7m

3. Local wave by 25.0m/sec wind velocity, U = 25m/sec
   Wave height = 1.1 m
   Diffraction coefficient and diffracted wave.
   - Site-C Kd=1.0 , H2=1.0x1.1=1.1m
   - Site-T Kd=0.5 , H2=0.5x1.1=0.6m
   - Site-F Kd=0.3 , H2=1.1x0.4=0.2m
   - Site-CS Kd=0.3 , H2=1.1x0.4=0.4m

Combined Waves
- Site-C Hc = (H1^2 + H2^2)^0.5
  = (1.4^2 + 1.1^2)^0.5 = 1.8 m
- Site-T Hc = (0.9^2 + 0.6^2)^0.5 = 1.1 m
- Site-F Hc = (0.7^2 + 0.4^2)^0.5 = 0.8 m
- Site-CS Hc = (0.7^2 + 0.4^2)^0.5 = 0.8 m

Similar to the wharf front waves, design waves for seawall are estimated. The secondary diffraction coefficient is assumed at 0.5 since the seawall will be located at the side of the new terminal.

Combined Waves
- Site-C Hc = 0.5 x 1.8 = 0.9 m
- Site-T Hc = 0.5 x 1.1 = 0.6 m
- Site-F Hc = 0.5 x 0.8 = 0.4 m
- Site-CS Hc = 0.5 x 0.8 = 0.4 m

5.10.2 Armor Rock Rip-rapping at Wharf Slope

The armor rock rip-rapping type is recommended in case of open structure.
The minimum weight of armor rock can be calculated by the Hudson's Formula.
The slope of the rip-rapping is 1:1.5.

$$W = \frac{Wr\ H^3}{Kd\ (Sr - 1)^3 \cot\theta}$$

$$= \frac{2.65 \times Hc^3}{6\ (2.65/1.03-1)^3 \times 1.5}$$

$$= 0.076\ Hc^3$$

Site-C	W = 0.076 x 1.8^3 = 0.44 ton/ea.	say 600 kg/ea.
Site-T	W = 0.076 x 1.1^3 = 0.10 ton/ea.	say 100 kg/ea.
Site-F	W = 0.076 x 0.8^3 = 0.04 ton/ea.	say 60 kg/ea.
Site-CS	W = 0.076 x 0.8^3 = 0.04 ton/ea.	say 60 kg/ea.

5.10.3 Armor Rock Rip-rappig at Seawall

The Armor rock rip-rapping type is recommended in case of seawall.
The minimum weight of armor rock can be calculated by the Hudson's Formula.
The slope of the rip-rapping is 1:2.0. Refer to Figures 5-10-1 to 5-10-4.

Site-C	W = 0.057 x 0.9^3 = 0.042 ton/ea.	say 60 kg/ea.
Site-T	W = 0.057 x 0.6^3 = 0.012 ton/ea.	say 30 kg/ea.
Site-F	W = 0.057 x 0.4^3 = 0.004 ton/ea.	say 30 kg/ea.
Site-CS	W = 0.057 x 0.4^3 = 0.004 ton/ea.	say 30 kg/ea.

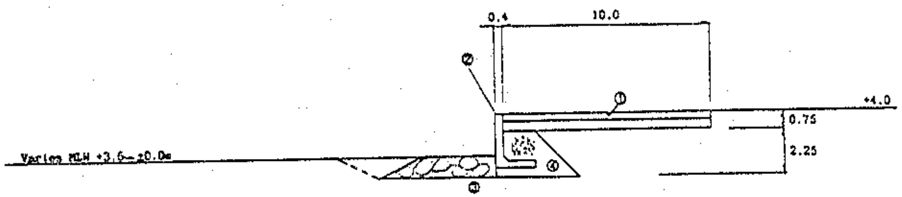


Figure 5-10-1 Seawall : MLW +3.6 - +0.0m

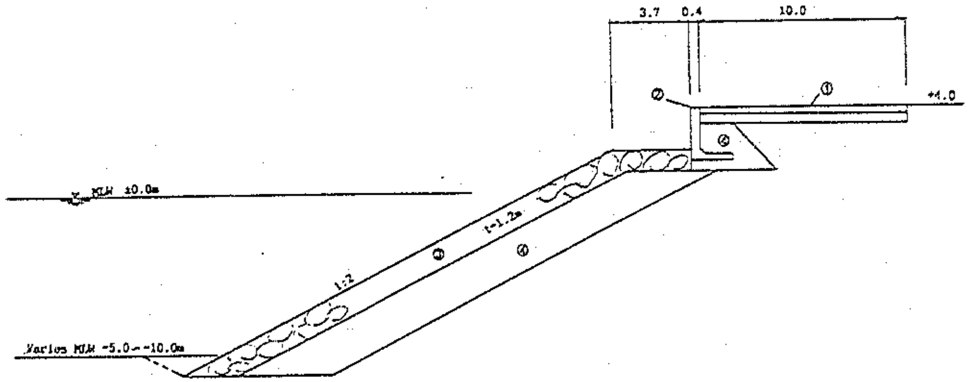


Figure 5-10-3 Seawall : MLW -5.0 - -10.0m

Legend
① Apron Concrete t=0.30m
② L-shaped Retaining Wall
③ Armor Rock
④ Rubble Backfill

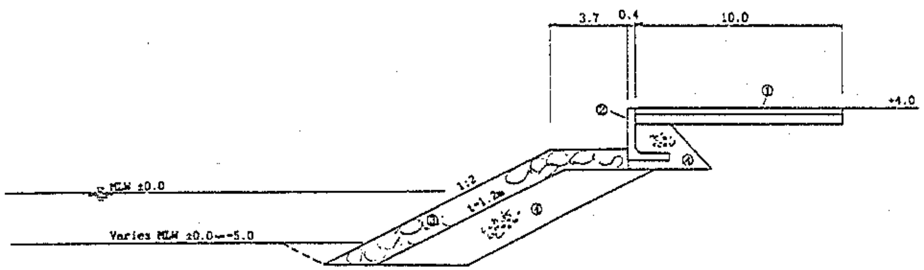


Figure 5-10-2 Seawall : MLW +0.0 - -5.0m

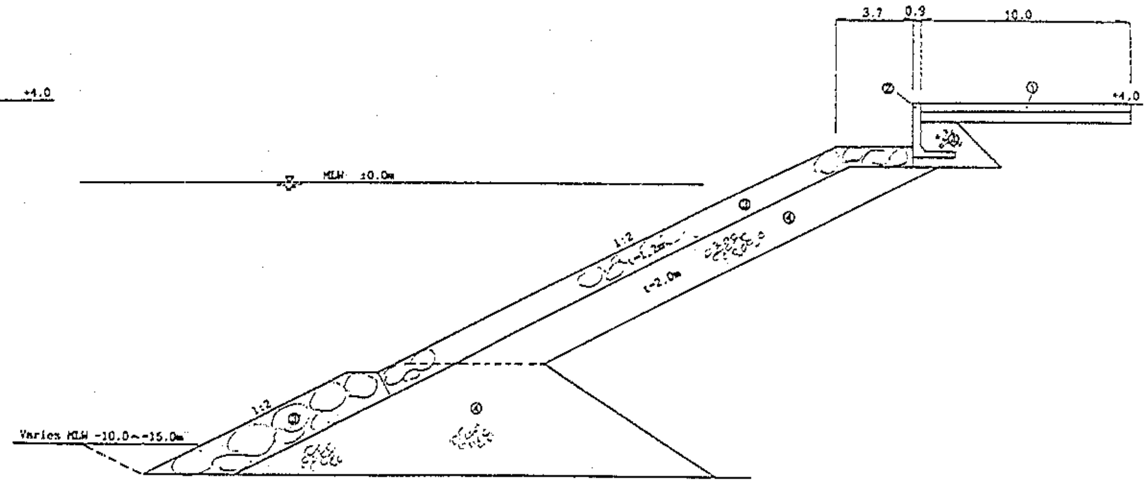


Figure 5-10-4 Seawall : MLW -10.0m - -15.0m

CHAPTER 6 MAINTENANCE AND REHABILITATION PLAN OF THE EXISTING FACILITIES

The existing port facilities consist of finger piers, mole, container operation yard with marginal wharves at the main port area and U-shaped pier at the northern end of Telfers Island. All these facilities should play their roles on the provision of required services for port users, as they conduct at present and will meet new functions for the future. This should continue even after the commencement of the new container terminal operation at Telfers Island.

The required works for these existing facilities can be divided into two basic categories regarding their effect on the port capacity.

Rehabilitation of the Existing Facilities and Renewal of the Existing Cargo Handling Equipment: (Prospective-1)

- This investment aims at maintaining the present service level of the existing port facilities.
- Equipment renewal of the existing container terminal will be categorized in this component.

Upgrading of the Existing Facilities and Replacement of the Existing Cargo Handling Equipment (Modernization): (Prospective-2)

- This investment aims at upgrading the existing port facilities.
- Modification cost of the existing finger piers, mole and container terminal will belong to this component.
- Equipment replacement to advanced ones at the existing container terminal will also belong to this.

This chapter deals with the former, while Chapter 5 has provided necessary discussion regarding the latter.

The required maintenance and rehabilitation of the existing structures will be carried out based on the grade of existing damage. The objective structure shall carefully be observed not only superstructure but also substructure including a submerged foundation piles. The basic sequence of design procedure on this matter will be as follows:

i) Hearing and Collection of Records
ii) Visual Inspection
iii) Physical Inspection, if necessary
iv) Classification of Damage in Grades
v) Recognition of Urgency
vi) Design of Repairing Works
vii) Repairing
viii) Records

In step (v), a decision on each damage shall be made with respect to its urgency. If the damage is few, it will be repaired by the routine maintenance work which shall be performed periodically. However, if the damage is significant to the life of structure and its utilization, an urgent repair work shall be conducted.

6.1 Required Routine Maintenance Work for Existing Container Terminal

This section deals with the required routine maintenance work for the existing container terminal together with its marginal wharves.

Note: According to the visual inspection, this facility does not require any large scale rehabilitation work but routine maintenance work which is an ordinary repair work being carried out by APN at present.

6.1.1 Required Repair Works for Marginal Wharves : Piers No.9 and No.10

The marginal wharf is currently the busiest one for container cargo handling. The existing wharf cranes are installed on this wharf. It is expected that only this wharf can provide port users with enough services with respect to container handling until the completion of the new terminal. Even after, the wharf will provide continuously the required services.

APN is taking care of the wharf by giving not only the periodical structural maintenance but also a functional upgrading such as widening the concrete apron for smooth traffic circulation. For the time being, APN's efforts on the structural maintenance is going well.

It is expected that APN continues these efforts in order that the wharf's life lasts long. For this purpose, the following actions should be conducted.

a. Periodical visual inspection
b. Systematic filing system on the inspection records
c. Planning of routine maintenance works and its budgeting
d. Planning of required works for improvement
e. Supervision of maintenance works
f. Review and appraisal of works conducted

Major objectives of maintenance efforts are as follows:

a. Concrete slabs and beams
b. Concrete pile foundation including submerged piles
c. Utilities for wharf operation

Addition to these elements, the rock armor riprapping at the wharf slope should be