b. Dredging Limit Lines

Figure 7-1-4 shows the "Dredging Limit Lines" around the existing APN port facilities.

(3) Changes of Jurisdictions

It is reported that the existing pier No. 16 is under the APN's management. It is also expected that some PCC areas may reverted to Panama during the life of the Treaty. Gradual reversion of some areas and facilities may be carried out, however the location and schedule are not known yet.

Figure 7-1-1 The Port of Cristobal and Its Vicinities

Source: "Treaty Map"

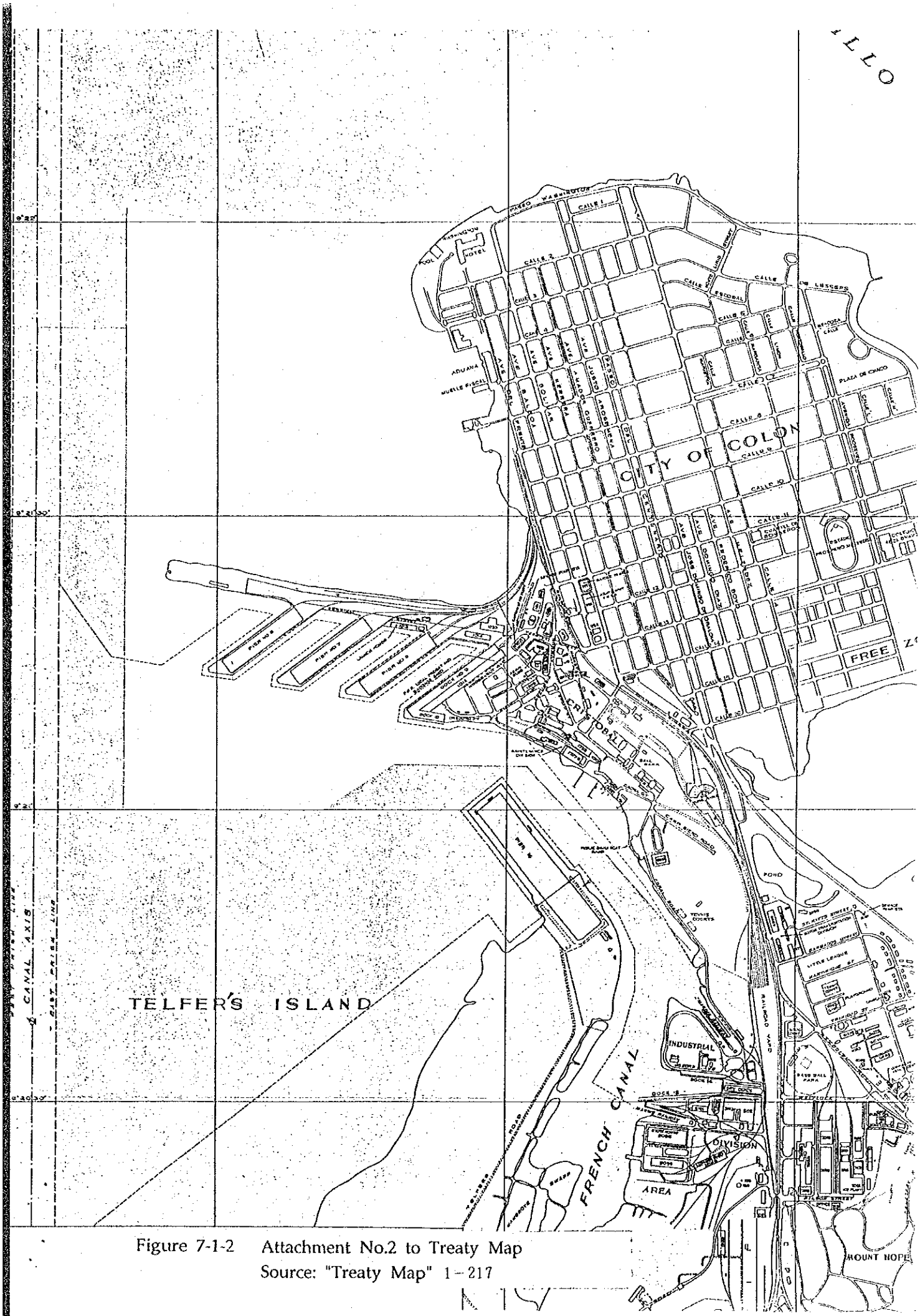


Figure 7-1-2 Attachment No.2 to Treaty Map
Source: "Treaty Map" 1－217

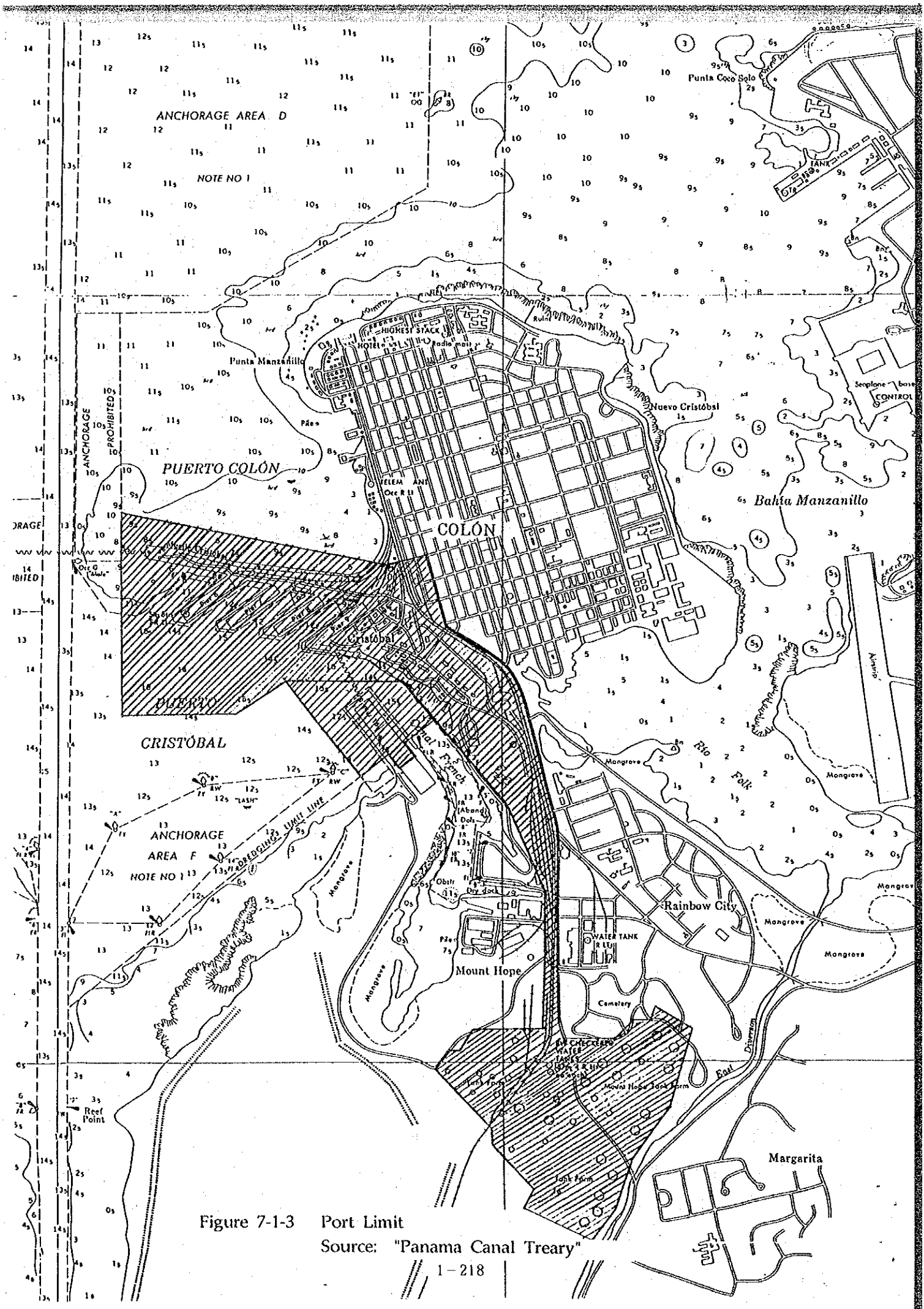


Figure 7-1-3 Port Limit

Source: "Panama Canal Treary"

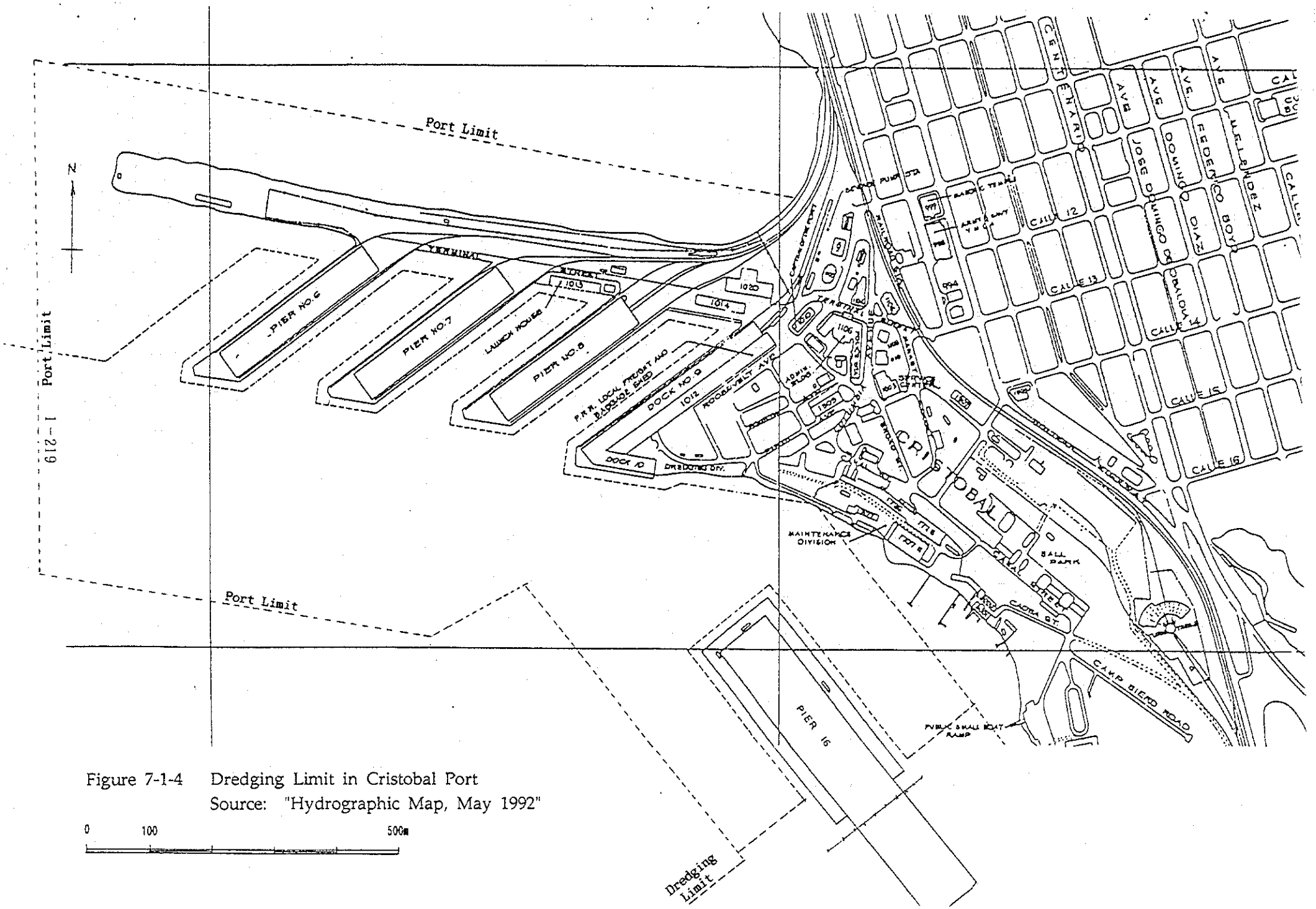


Figure 7-1-4 Dredging Limit in Cristobal Port
Source: "Hydrographic Map, May 1992"

7.1.3 Land Use

(1) Present Use

Land area specified in the "Port Limit", except the narrow access with the port area and the tank yard, is a direct port operation area where cargo handling work takes place. This area can be divided into six categories:

Area I. Piers No. 6, No. 7 and No. 8
Area II. Mole, mother pier to Area I
Area III. Piers No. 9 and No. 10 and the container yard with CFS
Area IV. Pier No.16
Area V. Administration and storage facility
Area VI. Access to the external road

Present land use in these areas can be summarized as shown in Figure 7-1-5.

Area I. Pier No. 6

Pier No. 6 is located at the west end of the finger piers. Major cargoes handled here are conventional cargoes, containers and vehicles. Trailers run inside the transit shed where empty containers are also stored. No container crane is provided.

Area I. Pier No. 7

Recently, rehabilitation work was given; to widen and pave apron by demolishing the bay shed. With this improvement, the main cargoes here will change from conventional cargoes to containers by degrees.

Installation of water supply system is being done. No container crane is provided.

Area I. Pier No. 8

Recently, rehabilitation work was given; installation of new rubber fender system along the north face. The south face is rarely used because the pier No. 9 is always occupied by a large vessel, and enough basin cannot be given to the south face of Pier No. 8. However rail facility is utilized mainly for conveying cargoes out of shed. No container crane is provided.

(Note: According to the APN berthing regulations, a total beam of two vessels berthing between fingers should not exceed 50 meters.)

Area II. Mole

Mole provides not only access to the finger piers but also space for stocking empty containers. Function of the mole is not only for port operating purpose but also for protecting the finger piers from the north-east waves during the dry season.

Area III. Piers No. 9 and No. 10

These piers are the busiest areas in the port. Pier No.9 is a fully containerized marginal wharf with two container cranes. Open storage area behind this pier is being paved at present for better handling conditions.

Pier No. 10 is also marginal but has a limited wharf length. Ro-Ro vessels also use this wharf.
Currently these piers are operated by privates companies.

Area III. Container Yard with CFS

The hinterland behind Piers No. 9 and No. 10 is the only container yard in the port of Cristobal. The total area is about 7.5 ha. Transference of containers are operated by several types of conventional forklifts. CFS is also provided.

Area IV. Pier No.16

Pier No.16 is an exclusive pier for bunker supply to vessels. This pier handles three types of oils that are; fuel oil, light diesel and heavy diesel. The pipeline connects between the pier and the Mount Hope Tank Farm.

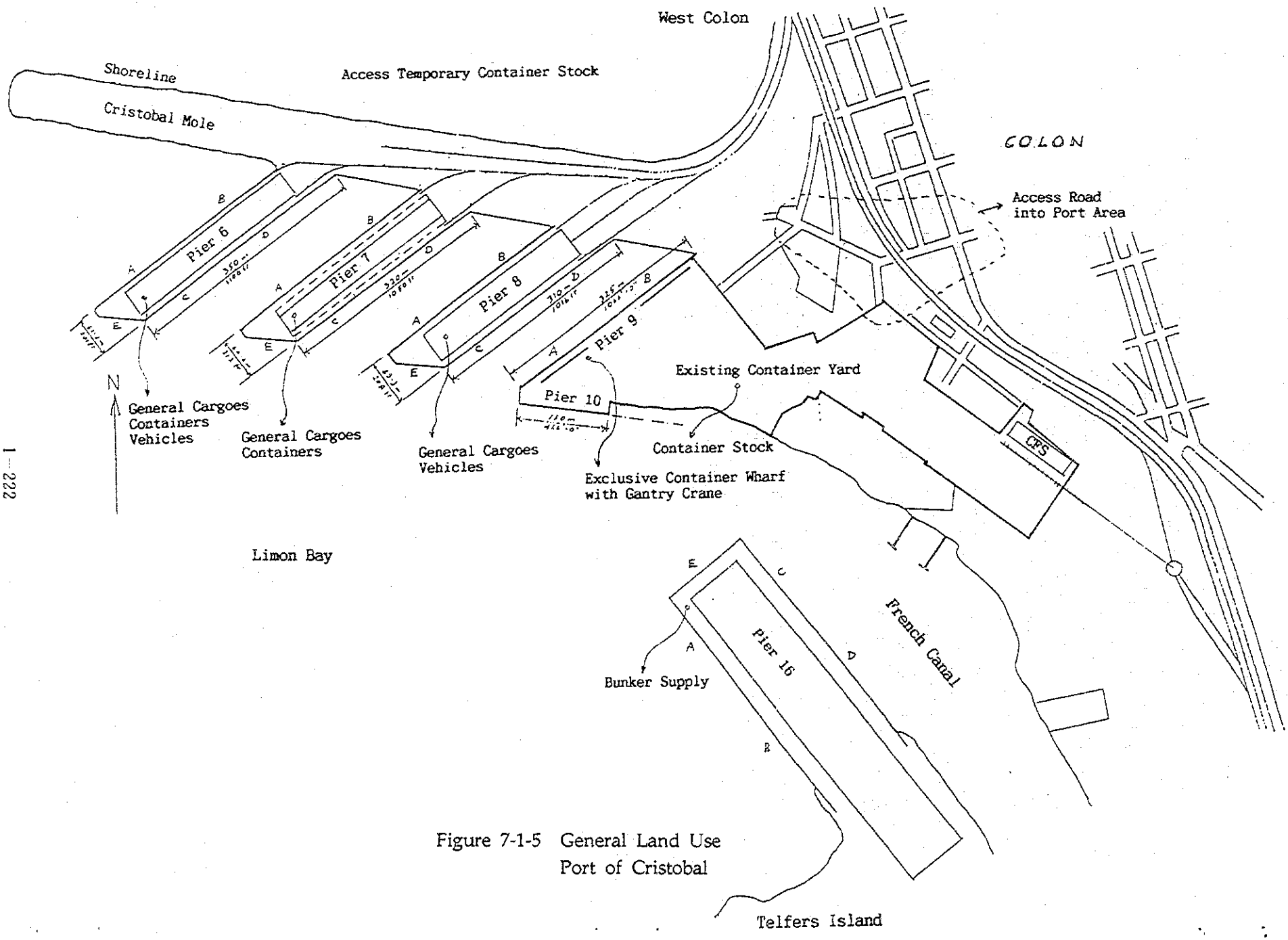


Figure 7-1-5 General Land Use
Port of Cristobal

7.1.4 General History of Pier Construction and Their Improvement

(1) History

The port of Cristobal was initially constructed by U.S.A. as a conventional cargo handling port during the period from 1912 to 1918. Each pier required more than two years to be built and all the piers were ready to operate in 1919. Completion time recorded is as follows.

Table 7-1-1 History of Original Pier Construction

Year of Completion	Pier
1914	No. 9 Marginal Wharf
1915	No.10 Marginal Wharf
1916	No. 8 Finger Pier
1917	No. 7 Finger Pier
Not Known	No. 6 Finger Pier
	No.16 U-Shaped open deck structure

Source: APN

All these facilities were reverted to Panama in accordance with the Panama Canal Treaty in 1979 from the previous occupation by U.S.A. The government of Panama appointed APN to manage them.

Since 1985, to meet a rapid growth of container cargo demands, the Second Port Project financed by the World Bank was introduced by APN. Major project components are summarized below:

a. Removal of transit shed at Pier No. 9
b. Rehabilitation and up-grading of Pier No. 9 as a container wharf
c. Installation of two container cranes at Pier No. 9
d. Improvement of container handling equipment

In addition to these, the following improvement works were performed by APN with their own budget.

a. Installation of new rubber fenders at Pier No. 7
b. Apron widening by demolishing the existing bay shed at Pier No.7
c. Repairing works to the lower deck surface at Pier No. 7
d. Installation of new rubber fenders at Pier No. 8

(2) Design and Construction Records in 1910's

A part of the drawings were being filed in APN and PCC as well however, design sheets of the piers were not available.
Detailed construction record is not available so far. However, major items such as

pile driving method and concrete specifications were found in the PCC library.

(3) Design and Construction Records for the Recent Works

Among the works made by APN, design record of two container cranes and their foundations on Pier No.9 and design of new rubber fenders are kept in file.

7.2 Piers No. 6, No. 7 and No. 8

This section deals with the existing conditions of the series of finger piers. Piers No. 6, No. 7 and No. 8 are the major berthing facilities of the Port. The existing conditions and their dimensions will be discussed. Finally, the structural conditions will be evaluated based on the visual inspection.

7.2.1 Basic Layout and Typical Section

The piers are of finger type and were built in parallel, next to each other. Vessels can berth at both facelines of the piers. The distance between the two neighboring piers is only 90 m not wide enough to accommodate two vessels at the same time.

Each pier is a typical open structure consisting of concrete deck on pile foundations. Width of the deck is about 64 meters and the length is between 310 meters and 350 meters.

All the piers are well protected by the mole against north-east winds and waves that prevail.

Refer to Figures 7-2-1, 7-2-2, 7-2-3 and 7-2-4 for the basic layout and typical sections of the piers.

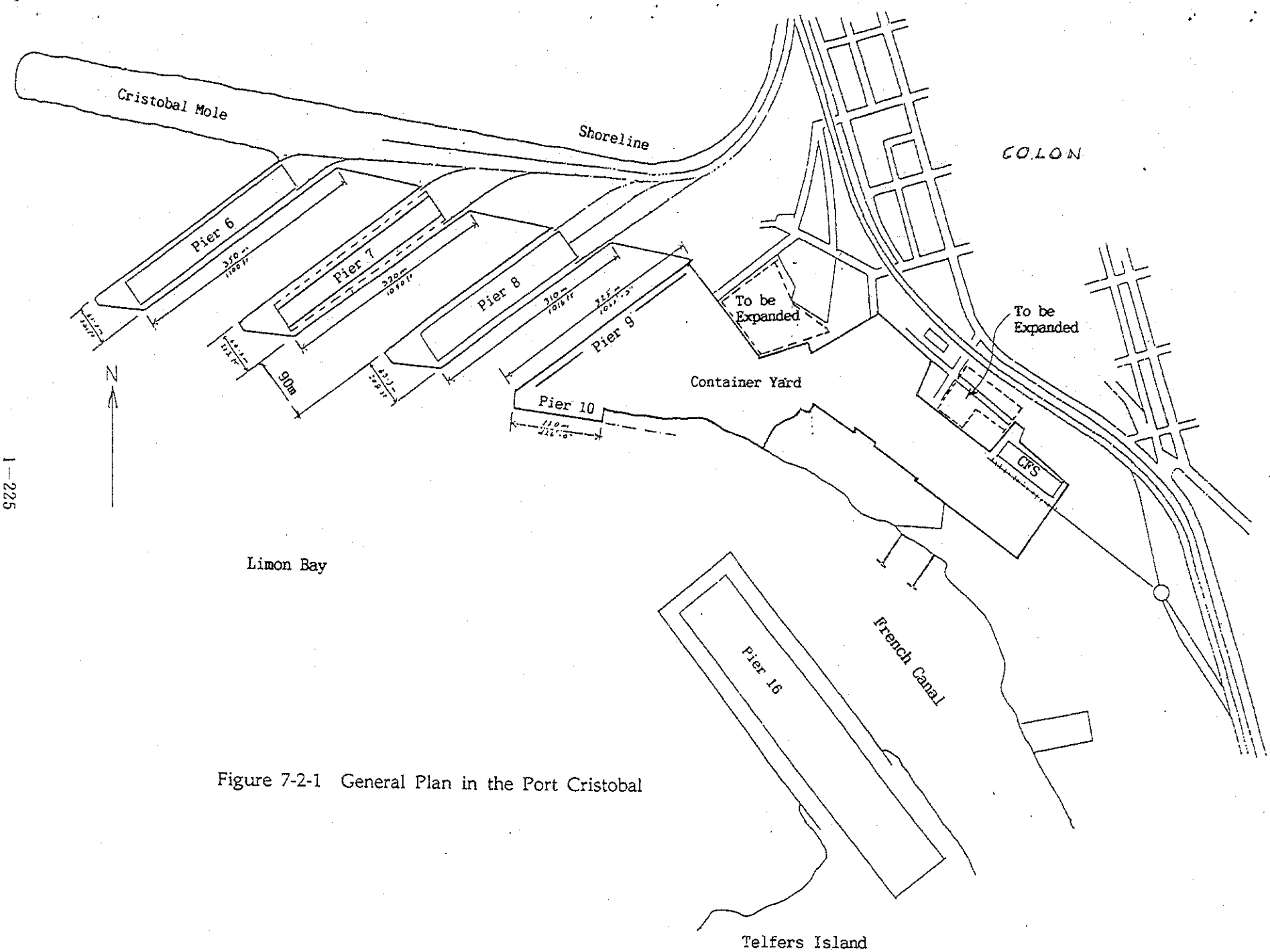


Figure 7-2-1 General Plan in the Port Cristobal

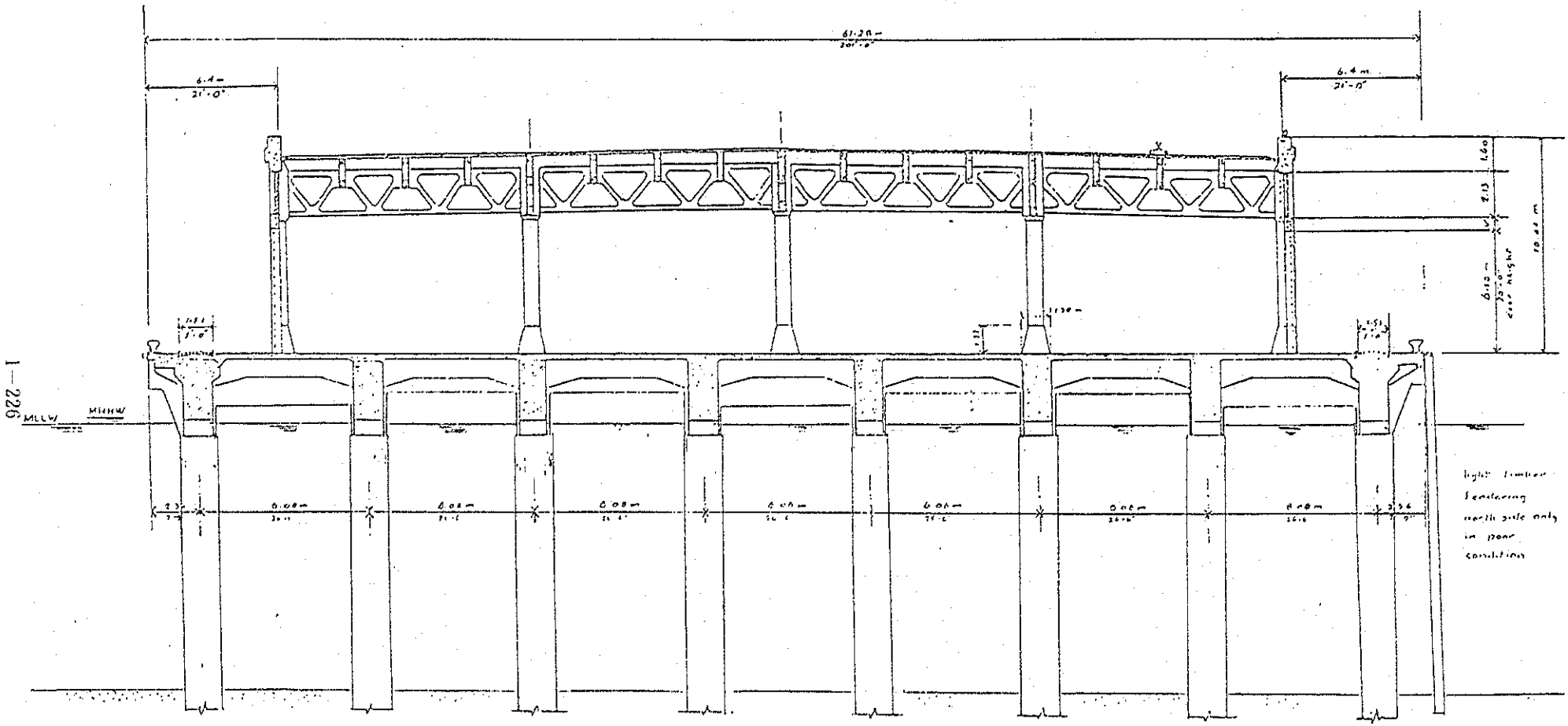


Figure 7-2-2 Typical Section of Pier No. 6

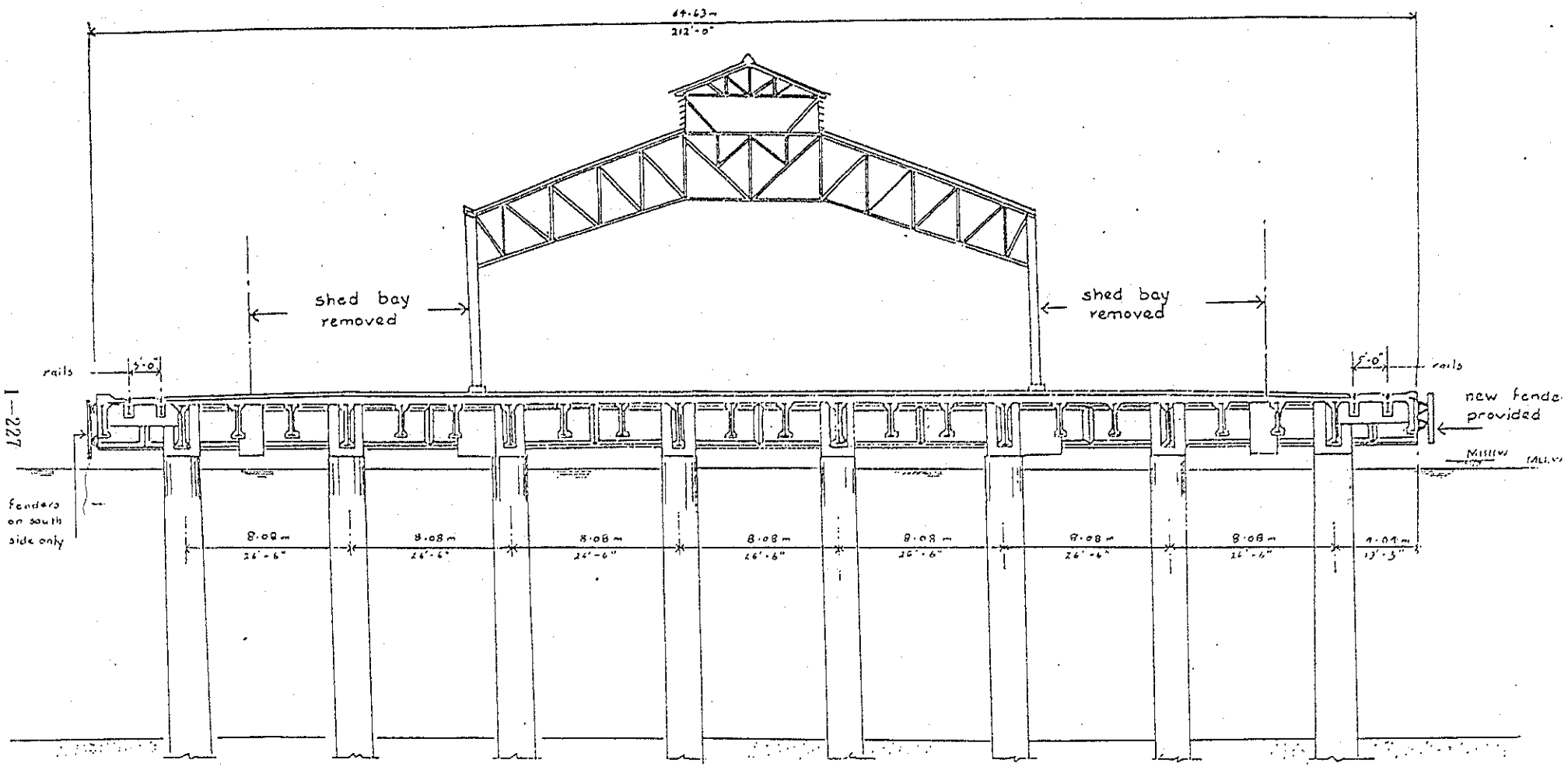


Figure 7-2-3 Typical Section of Pier No. 7

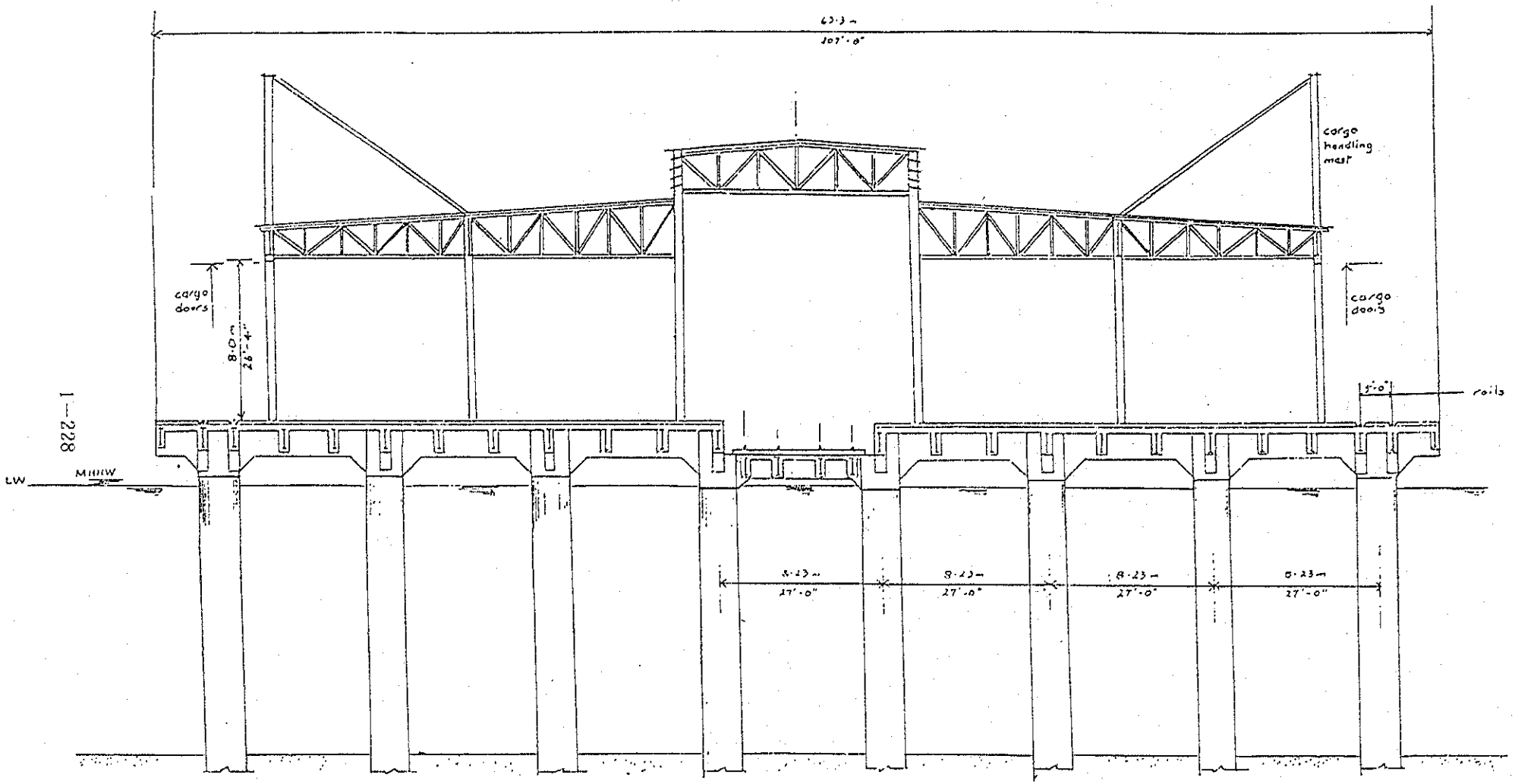


Figure 7-2-4 Typical Section of Pier No. 8

7.2.2 Present Use of Piers

The piers currently handle cargoes mixed with conventional cargo, containers and vehicles. Since they have no wharf crane, cargo handling is being conducted by mobile cranes and/or ship's gears. In 1990, numbers of vessels stopped at these piers are so recorded as 130 vessels, 130 vessels and 110 vessels for Pier No. 6, Pier No. 7 and No. 8 respectively. Since the total numbers of vessels that loaded/unloaded cargoes in Cristobal Port in 1990 was 544, 68% berthed at the piers No. 6, 7, 8.

Classifications of the pier use by vessel type is as follows:

- Pier No. 6: Composite vessel, Ro-Ro vessel and Container vessel
  Note: Composite vessel carries both conventional cargoes and containers.
- Pier No. 7: Composite vessel, Container vessel and Ro-Ro vessel
- Pier No. 8: Composite vessel, Ro-Ro vessel, Fishing boat and others

This indicates that the port is predominantly influenced by the recent increase of container cargoes.

Each pier has a transit shed however, it is not functioning for container handling system but just a shelter. Since the apron is narrow, trailer trucks are forced to run inside the shed. Cargoes in the shed are mostly containers, vehicles and a few breakbulks.

Transportation mode has gradually changed from combined system of road and rail to vehicular system. All the piers have rail system, however only the system at Pier 8 is currently utilized.

Thus, all the piers are facing the changes of transportation mode which can be summarized as follows:

a. Containerization is to be introduced here to meet the rapid increase of container cargo demands. Container handling requires normally a wider space than that for conventional cargoes.

b. Vessel size became larger than before. It has become rather too difficult to accommodate two vessels at one side of the pier face simultaneously. Moreover, accommodating two vessels in parallel in the space between finger piers, has also become difficult.

c. Vehicular traffic became the major transport means instead of railroad.

These changes show that the original design concept does not meet the current requirements.

7.2.3 Inventory of Major Facilities

(1) Piers and Civil Works

The Pier is a typical open structure of reinforced concrete superstructure supported by reinforced concrete piles. Concrete slab is covered with bricks at Piers No.7 and 8, however APN has renovated the pavement at Pier No.7 with reinforced concrete.

Piles consist of a circular mass of concrete reinforced by rails and ordinary steel bars. The size of the piles is 1.8m (6') diameter and the interval is about 8 meters or more. Thus a pile shares various deck loads covering 64 sq. meters or more.

Drawings indicate that the pile tip penetrated about 3 meters into the Gatun Rock by excavating. Therefore the piles have enough bearing capacities against vertical loads.

The pile top is rigidly connected with the reinforced concrete beams to resist against lateral forces, so called "rigid frame structure (Rahmen)".

Table 7-2-1 Structural Dimensions : Finger Piers

Pier	Name	Berth		Structure		
		Length (m)	Depth MLW(m)	Length (m)	Width (m)	Elevation MLW(m)
No. 6	A - B	291	-11.4	350	61.3	+3.6
	C - D	309	-12.0	350	61.3	+3.6
	E	72	-12.0	350	61.3	+3.6
No. 7	A - B	276	-10.8	320	64.6	+3.6
	C - D	300	-12.0	320	64.6	+3.6
	E	72	-12.0	320	64.6	+3.6
No. 8	A - B	283	-11.4	310	63.3	+3.6
	C - D	303	-12.0	310	63.3	+3.6
	E	75	-12.0	310	63.3	+3.6

Source : APN

Table 7-2-2 Apron : Finger Piers

Pier	Width (m)	Pavement	Note
No. 6	6.0	R.C.Pavement	---
No. 7	18.0	R.C.Pavement	Renovated in 1992
No. 8	6.0	Brick Pavement	---

Source : APN
Note : R.C. means reinforced concrete

(2) Transit Shed

Each pier has a transit shed which covers approximately 70% of deck area. The shed at Pier No. 7 has partially been demolished for a wider apron. Major dimensions are shown as below.

Table 7-2-3 Transit Sheds : Finger Piers

Pier	Number Story	Length (m)	Width (m)	Area (m^2)	Clearan. (m)	Strictire		Remarks
						Support	Roof	
No.6	one	292	48	14,000	7.0	R.C.C.	R.C.T	
No.7	one	288 (288)	50 (27)	14,400 (7,900)	6.2	R.C.C.	S.T.	Before renovation (After renovation)
No.8	one	264	52	13,700	8.0	R.C.C.	S.T.	

Source : APN
Note : "Before" means dimension of shed before the partial demolishing.
"After" means dimension of shed after the partial demolishing.
"R.C.C." means R.C.Column
"R.C.T." means R.C.Truss
"S.T." means Steel Truss

(3) Railroad

Rail sidings of 5' gauge (1.50 meter) were laid along both aprons of each pier. In addition to this, two lane rail sidings were provided at the center of Pier No. 8 inside the shed. Rail elevation at Pier No. 8 is 1.5 m lower than the deck floor so that the freight car's floor would be the same level as the shed floor.

Table 7-2-4 Rail Siding : Finger Piers

Pier	Length of Siding	Lane			Remarks
		North	Middle	South	
No.6	310	1	--	1	--
No.7	300	1	--	1	--
No.8	300	1	2	1	Lower Floor for Middle Lane

Only the middle lane at Pier No. 8 is used now.

(4) Utilities and Lighting

Each pier has its bunker supply and water supply, however the latter can not provide sufficient service due to damage. New water supply pits at Pier No. 7 is currently under construction.

Lighting system is provided in the shed, however they are insufficient for safe night works. External flash lighting is provided on the shed wall, however the number is so limited that enough illumination cannot be provided. There is no facility for navigational aid at the head of the piers. Neither telecommunication system nor fire fighting system are provided.

(5) Wharf Fittings

Since the completion of the piers in 1910's, timber fenders have been provided. Due to the current changes of vessel size, a large berthing energy made their life short. Most of them were seriously damaged and vessels often hit the concrete structures. In order to improve this situation, renewal of fender system with new rubber fenders is being undertaken. Present condition and future plan are shown below.

Table 7-2-5 Fender System : Finger Piers

Pier	Wood	Rubber	Size	Interval	Number
No.6 North	Damaged	--	--	--	--
No.6 South	Damaged	--	--	--	--
No.7 North	--	Renewed	F. H-800	13.7m	22
No.7 South	--	Renewed	F. H-800	13.7m	21
No.8 North	--	Renewed	F. H-800	9.2m	26
No.8 South	--	Renewed	F. H-800	9.2m	28

Source : APN
Note : "F" means Fentek. Fender height is 800mm.

APN plans to renew the fender system at Pier No. 6 with rubber fenders. Since deck corner is not protected well, concrete edge may easily be damaged unless proper fender system is given.

The existing bitt installation is as follows:

Table 7-2-6 Bitt Installation : Finger Piers

Pier	Size	Interval	Remarks
No.6	D18" x H27"	9.0 m	--
No.7	D18" x H27"	13.7 m	Renewed when fenders are installed
No.8	D18" x H27"	18.3 m	5 will be new, others to be repaired

Source : APN

7.2.4 Visual Investigation on Finger Piers

This subsection deals with the results of visual inspection of the existing piers. Diver inspection was also conducted over the submerged part of the existing pile foundations.

(1) Purpose of Investigation and Scope

This subsection aims at collecting necessary data regarding present conditions of the existing facilities for planning future roles of the piers. Each pier will be given a certain function in establishing a rehabilitation and/or up-grading plan, which is the primary target of the study.

In order to carry out this task, three evaluation criteria were considered.

a. Whether the existing facilities are durable enough for the present use or not.
b. Will any repair works be necessary in the near future to prolong the facility life. If necessary, what kind of repair work should be conducted.
c. Whether the existing facilities are durable for new loading criteria which may be recommended in the Long Term Plan.

If the present function or utilization of each pier were maintained, only the first two tems will be evaluated. So far, future functions are not allocated, therefore item c will also be studied as required.

In order to meet these requirements, visual observation on the existing finger piers ncluding architectural works, fixed equipment and civil works were conducted. This subsection covers the following structures on the finger piers:

a. Main superstructures including concrete beams and slabs
b. Foundation piles including submerged parts
c. Building works, transit sheds
d. Utilities and wharf fittings
e. Railroads
f. Cargo handling equipment (Refer to Part I. Chapter 9 for details)

(2) Evaluation of Structures

Review criteria for structures are prepared in order to evaluate the surveyed data in a quantitative manner.

All the concrete beams and slabs were technically reviewed by this grade classification. Required cost for repair works to be incorporated in the Long Term Plan and Short Term Plan will be estimated based on this classification.

Table 7-2-7 Damage Grade of Structures by Visual Investigation

D.G.	Present Status and Possible Countermeasures
0 (zero)	- No damage at present. - No problem should occur if present use continues.
I	- No damage at present except minor hair crack and scratching. - No problem should occur if present use continues. No repair work should be required.
II	- There are crack but no structural damage. - No problem should occur if present use continues. Monitoring should be made every year. Maintenance work would be required in future.
III	- There are cracks and a few damages. Structural strength begins to reduce. - Little problem might occur if present use continues but repair works should be required. Monitoring of damaged parts should be conducted every year. Repair records should be filed.
IV	- There are heaving of concrete covers and some are partially fallen. There are R-bar exposures.Structural strength has already reduced, but it is not critical. - Careful use of deck should be introduced on the damaged parts. However present use can be continued after required repair works are conducted. Repair works should be conducted within a year in order to prevent main structure from severe damage. Repair records should be filed. If no repair work is provided, loading condition on deck should be restricted, however this is not a recommendable method. If no repair works is performed, within few years damaged grade will advance to V. Monitoring of damaged parts (or repaired parts) should be made every year.
V	- Advanced damage of Grade IV. There are heavy structural damage that reached deep into the concrete members. R-bar are rusting and partly cut down. Damage will expand rapidly due to heaving of reinforcement. Concrete covers over R-bars will be easily fallen. Urgent repair works of concrete should be made. - Even after rehabilitation, loads on damaged deck may be restricted. If enough repair works to reinforce are made, loading condition can be the same as before. Repair works both for reinforcement and concrete should urgently be performed, in order to prevent failure of main structure. Repair record should be filed.

Source : Study Team
Note : "D.G." means Damage Grade

(3) Results of Visual Investigation

a. Civil Works

Pier No. 6

Although the structure is 75 years old, concrete cracks created by rusting of reinforcing bars are rarely observed. Normally lower surface of concrete deck is the portion easily affected by seawater, however no significant damage was found. The present conditions of the concrete surface seem to be rather good in comparison with similar structures in other tropical countries. This is because of well controlled concrete quality.

Bottom surface of the concrete slabs is about MLW + 3.00 meter and is not affected by wave splashing. Concrete covering the reinforcing bars is thick enough to protect the beams from an influence of chemical action.

Thickness of the apron slab is 30 cm on which a protective concrete pavement was covered. The thickness of the slab seems to be thick enough. The surface of the concrete pavement has very few damages and has no problem for vehicular trafficability.

Since no rubber fender is provided yet, concrete at the apron edges were partly damaged by direct vessel contacts. Exposed reinforcing bars begins to rust, however the damage is not significant and the damage grade is minor.

Pier No. 7

Beam concrete are reinforced by H-shaped steel girder and re-bar. Concrete covering beneath the steel flange member has partly fallen off due to the steel rusting, and the separation of concrete and steel surface has begun.

APN surveyed the damage of this pier in 1990 and repair works were performed in 1991 by a local contractor. These works were carefully conducted and their performance are excellent. Patching works to damaged slabs were also given during the said repair works, although the damage grade was not serious.

The original brick pavement at the apron area has been replaced with a concrete over-lay. Part of the shed, its both sides, has been demolished for the widening of apron.

Replacement of old timber fenders by modern rubber fenders was completed. At the same time, repairs to the upper edge of concrete deck were also given.

Pier No. 8

Beam concrete are reinforced by H-shaped steel girder same as Pier No. 7. Concrete covering beneath the beam has partly fallen off, however magnitude of them is much less than Pier No. 7. Exposed steel flange was cleaned and painted with thick grease to prevent the steel from further rusting. It is expected that this greasing may protect the steel from rusting, just like covering with concrete, if they keep greasing constantly.

Concrete slab seems sound enough like the other piers.

As mentioned before, two rail siding tracks were laid along the pier center. Rail elevation is 1.5 m lower than the deck floor. According to the inspection and the information from the drawings, rails were laid on the lateral beams whose ends are supported by piles. Refer to Figure 7-2-4. This lateral beam is rigidly connected to the piles. It is needless to say that the other beams are all rigidly connected to the piles. No crack or disconnection between the lateral beams and the piles were found.

The original brick pavement lays over the slab concrete. The brick pavement at apron is a little rough due to aging, however the main concrete slab has no damage. At the south faceline, replacement of old timber fenders by new rubber ones was completed. Some damages to the edge concrete still remain, since no repair work was given.

While the installation of new rubber fenders along the north faceline has been performed together with corner protection works.

Piles

According to the drawings obtained, all the piles at finger piers are circular section and have the same size (six feet diameter).

Structural characteristics are summarized as follows:

- Casing by round steel plates, external diameter of which is 6 feet.
- Reinforced by steel rails, eight of them were inserted into the casing. However, the drawings did not show that these rails reach to the pile tip (bottom of the excavation).
- Re-bars around the rails as stirrup
- Concrete filling inside the casing
- Pile end is of trumpet shape by rock excavation.*

Note: Construction method of the piles was outlined by PCC file however, the elevation of the pile end is not known.

Casing steel near the splash zone is seriously corroded, however this will not affect pile strength since the main and permanent component of the pile are the concrete reinforced by rails.

According to the divers' report about the submerged piles, steel casings still remained over the pile surface and are covered by seaweed. Visual observation was also carried out after cleaning them. So far, no significant damage was found except the corrosion of the steel casing pipe. However that has no bad effect to the quality of the pile since the casing had been driven as the contemporary construction measures. Pile near the seabed was invisible due to mud water.

For the time being, there is no evidence to indicate any structural damage on the piles.

Conclusion of Visual Investigation

i) Average damage grade is I to II.

There is only few severe damage of grade III. So far structural problems due to aging can not be observed.

The piers can be utilized as the present level. Only minor repair works will be required to the beams.

ii) An introduction of the recent containerization did not give damages to the structures.

Drawings show that the construction of the original structures was built with care and quality. There is no evidence showing large impact forces (ship collision) to create a severe structural damage.
The pier was designed and constructed as the rigid frame structure having no expansion joints. This makes the pier more durable against horizontal forces because all piles will share such forces.

Table 7-2-8 shows the damage grade for each structure.

Table 7-2-8 Damage Grade : Finger Piers

Location/Pier	Total Number	Damage Grade					
		0	I	II	III	IV	V
1. Pier No.6							
- C Beams (No.)	389	369	11	5	4		
- C Beams (index)		95%	3%	1%	1%		
- C Slabs (No.)	178	93	51	32	2		
- C Slabs (index)		52%	29%	18%	1%		
- C Piles (No.)	212	191	15	6			
- C Piles (index)		90%	7%	3%			
Average (index)		84%	10%	6%	0.1%		
2. Pier No. 7							
- C Beams (No.)	389	379	8	2			
- C Beams (index)		97%	2%	1%			
- C Slabs (No.)	178	146	13	19			
- C Slabs (index)		82%	7%	11%			
- C Piles (No.)	212	199	11	2			
- C Piles (index)		94%	5%	1%			
Average (index)		93%	4%	3%			
3. Pier No. 8							
- C Beams (No.)	551	500	35	16			
- C Beams (index)		91%	6%	3%			
- C Slabs (No.)	257	245	4	7	1		
- C Slabs (index)		95%	2%	3%	0.4%		
- C Piles (No.)	295	282	11	2			
- C Piles (index)		96%	4%	0.1%			
Average (index)		93%	5%	2%			

Source : Study Team
Note : "C" means Concrete

b. Architectural Works : Transit Sheds

The main skeleton of the sheds has no significant damage. Columns and walls near the gate have minor damages due to trailer's contacts. Both protection and maintenance works are required.

Most of the gates made of steel are out of order due to steel corrosion. Floor has no damage such as cracks or settlement. Clearance between the floor and roof truss is more than high enough for ordinary transit sheds.

By giving minor repair works, the existing transit sheds will fully be recovered. However further discussions should be made with regard to well-balanced usage of apron and shed as the container cargo handling normally requires a wide open space.

c. Utilities and Wharf Fittings

Both bunker and water supply systems are aged and damaged. Normal service is not being provided to port users. Bunker pits are not made with closed box but open and no sole, thus the fuel oil easily fell off the open sea. This situation should be modified from environment and fire protection point of view.

Most of the water supply pits are aged and out of order, thus new pits are currently being constructed at Pier No. 7.

Existing timber fenders have been replaced by rubber fenders recently. All the fenders at Pier No. 7 and Pier No. 8 were replaced. It is recommended to install the same type of fenders to Pier No. 6, in order to prevent the structure from further damage by direct contact of vessels.

Several mooring bitts fell off. However enough numbers of bitts were provided, thus there is no urgent problem on this matter. It is desirable to moor single rope on one bitt.

Lighting facility for apron is not enough to provide proper illumination for night works.

Telecommunication and fire fighting system are not provided. These should be properly installed to meet the modern port facility requirements.

d. Railroads and Equipment

At present, railroads laid on the apron are not used. Reason for this situation is thought to be the present change of cargo handling system. If rail siding will not provide any more service, it had better give in all the apron space to mobile crane operation and vehicular traffic purposes.

Only the siding in Pier No. 8 shed currently provides rail-track services from time to time. Utilization of rail in the port area should be discussed carefully since the available space is so limited and an extensive effort for the maintenance of rails will be required.

Equipment working on the piers are mostly mobile machines, including cranes, forklifts trucks and trailers.
A fixed crane at the head of Pier No. 8 is not in operation now.

7.2.5 Rehabilitation and Up-Grading Schedule of Finger Piers

(1) Past Performance

APN's past performance to the finger piers can be summarized as follows:

Pier No. 6 No record

Pier No. 7

a. Partial demolishing and renovation of the shed
b. Widening of apron and its concrete pavement
c. Installation of new rubber fenders
d. Re-installation of bitts
e. Repair work to the bottom of the concrete deck

Pier No. 8

a. Installation of new rubber fenders
b. Repair work to the bottom of the concrete deck

(2) Plan at Present

APN has decided to extend further rehabilitation and up-grading of their facilities. The following works will be performed by APN soon.

Pier No. 6

a. Installation of new rubber fenders
b. Rehabilitation of water supply system

Pier No. 7

a. Rehabilitation of water supply system

Pier No. 8

a. Rehabilitation of water supply system

7.3 Mole Behind the Finger Piers

This section deals with the existing mole laid behind the finger piers.
This mole is made of dike and has no berthing facility. However, it has a function as a shelter to prevent the finger piers from northern waves and also an access to the main port premises. The existing conditions of the mole and its dimensions will be discussed. Finally, preliminary structural evaluation will be carried out based on the visual inspection.

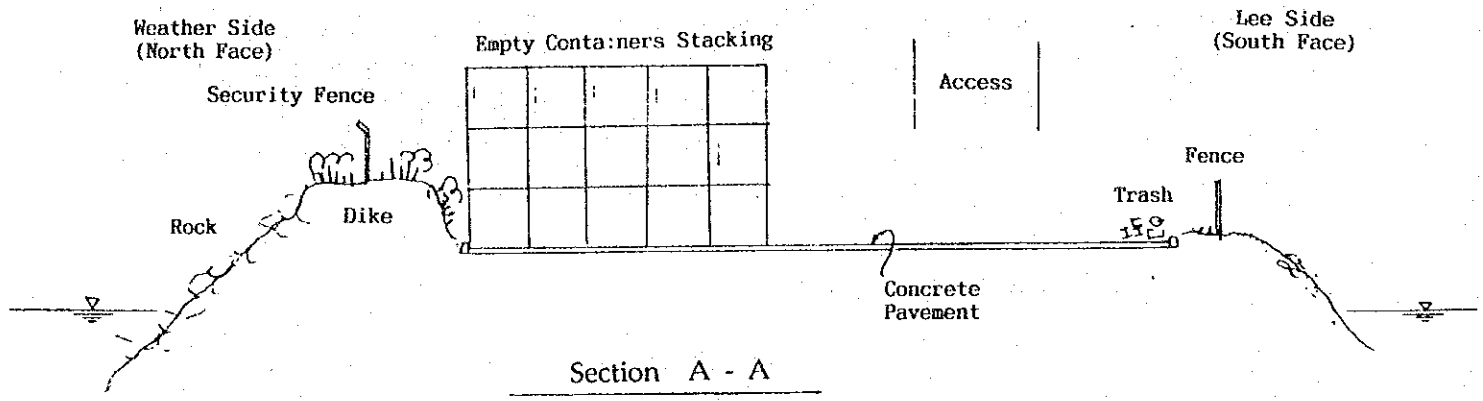
7.3.1 Basic Layout and Typical Section

Fundamental type of this mole is the typical earth dike armored by rock ripraps. The dike is approximately 1,000 meters long extended westward from the southern end of Colon City. Refer to Figure 7-2-1 for its general layout.

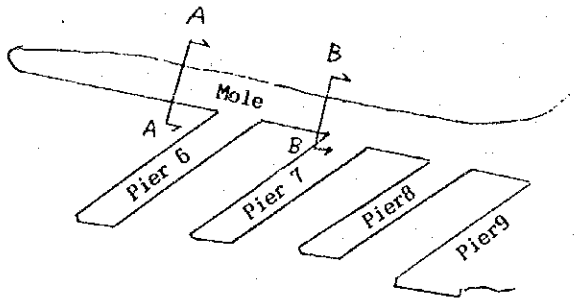
It is assumed, as discussed before, this mole aims at:

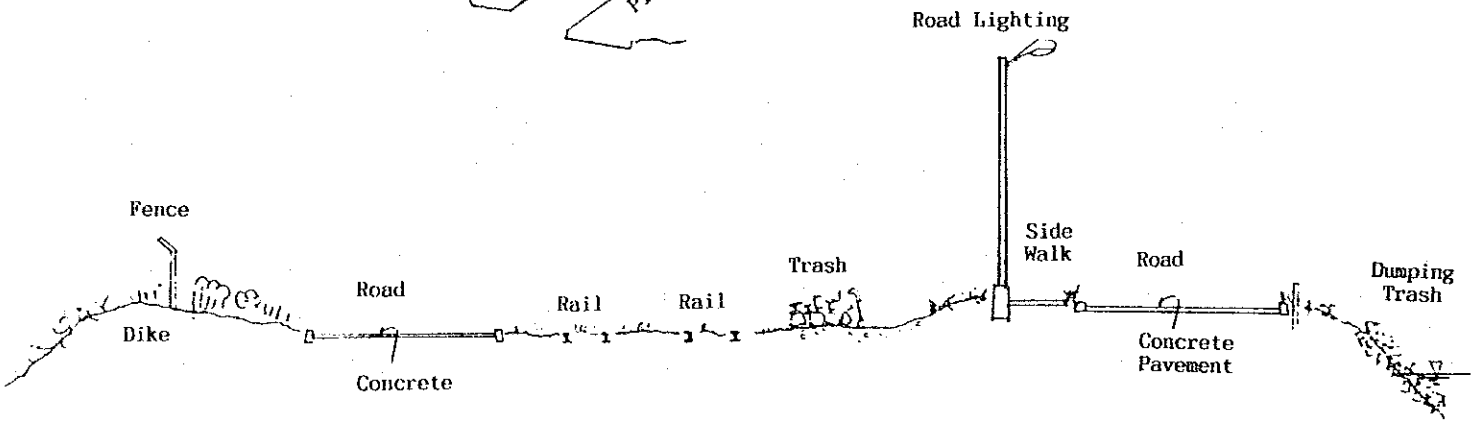
a. Provision of a function as a shelter to protect other port facilities against the prevailing north-east waves
b. Access between the mother land and finger piers
c. Defense purpose in the past

Effective width of the dike is about 40 meters. Typical sections are provided in Figure 7-3-1.



Section A - A





Section B - B

Figure 7-3-1 Typical Section of Mole

7.3.2 Present Use of Mole

With respect to the land use, the major function of this mole is to provide an access between finger piers and the mother land. However, usages other than access can also be seen;

a. Open storage area for various conventional cargoes
b. Open storage area for empty containers
c. Temporary storage area for construction materials
d. Dumping area of construction debris

It is obvious that vehicular transport override railroad transport, and all the rail sidings on the mole were not used anymore, except only the middle tracks on Pier No. 8, which are in service.

7.3.3 Inventory of Major Facilities

(1) Mole Dike

The mole is 1,030m in length. Width varies from 60 to 120 meters and elevations from MLW +3.0m to +3.6m.
Basic structural type is an earth dike. Northern slope of the dike is protected by amour rocks of 10 ≈ 30 kg at the gradient 1:1.5. On the southern slope there is no particular riprapping but ordinary earth.
Core materials of the mole dike is the dredged soil.

(2) Pavement

Access way on the dike is paved with reinforced concrete. Expansion joints are provided at every five meters. There is no storm water drainage.

(3) Railroad

There are two lanes of rail siding remaining on the dike. They branch off to each pier at the root. Rail siding runs up to Pier No. 6.

(4) Utility Mains and Lighting

All distribution mains including bunker system, power supply and water supply are embedded in the dike along the south slope. Distribution lines to office and workshop are also embedded in the earth bed. Lighting poles are installed at the center of the mole and illuminate the access.

(5) Architectural Facilities

At the root of the mole, there are various buildings and offices including APN office,

duty-free shop, etc. While at the head, there are contamination office and carpenter's workshop. Fence is provided from the north edge along the entire dike. Southern fence is provided only along the west of Pier No.6.
At the head of the mole, abandoned small sheds remains.

7.3.4 Visual Inspection on Mole

(1) Scope

A visual inspection was conducted on the major facilities for:

a. Pavement
b. Slope Protection
c. Railroad
d. Utility mains and Lighting
e. Architectural Facilities

(2) Results of Visual Investigation

a. Civil Works

Prevailing wind is the north-east direction during the dry season, from December to April. Thus, waves generated by the wind in the Limon Bay hit the northern face of the dike. While the southern face is rather calm.

The mole dike is protected by rock riprapping along the northern slope. No significant damage to the slope by waves is observed. There is no indication of slope erosion by coastal current either. The present amour rocks seem to be fairly good.
On the contrary, the southern slope is not protected since the sea is calm. The slope covered with solid waste and construction debris which spoils the landscaping.
It is recommended that these materials be disposed of at a specified land fill area.

Access concrete pavement is heavily damaged. This damage is not caused by earth settlements but by frequent large wheel loads created by trailer-tractors loading containers. The most serious damage can be seen at the root of the Pier No. 6 where uneven settlements and water pool are found. Repair works should be conducted promptly.

b. Utilities

The distribution mains could not be investigated visually because they are underground. However, the distribution branches seem to be alright, thus distribution mains do not seem to have a significant problem.

Lighting on the mole has no damage and are maintained well. Lighting poles are sound enough and no mark of scratches by vehicles. These lights can be used if proper maintenance were given.

c. Architectural Works

Major damage on architectural works was not found.

7.3.5 Rehabilitation and Up-Grading Schedule of Mole

(1) Past Performance

There is no record of a rehabilitation work to the mole so far.

(2) Plan at Present

It seems that APN has no plan for the mole improvement within the next two years.

(3) PCC's Plan

PCC plans to construct a control building with navigation tower at the head of the mole. PCC also intends to construct an access road along the northern slope of the mole for their exclusive use.

7.4 Piers No. 9 and No. 10 and Their Back-Up Yard

This section deals with the existing conditions of Piers No. 9 and No. 10 and their hinterland. The existing conditions and their dimensions will be discussed here.

7.4.1 Basic Layout and Typical Section

Pier No. 9 is a typical marginal wharf located next to Pier No. 8. Pier No. 10 is only 130 meters long and connected to Pier No. 9 at a sharp angle of 45 degrees. Their back-up area is a sole container yard (concession area) but has a deformed shape.

Structural type of the piers is a typical open structure supported by piles. Pier No. 9 is exclusively used for container cargo handling, where two container wharf cranes were installed. Refer to Figure 7-4-1 for the typical section of wharf structure.

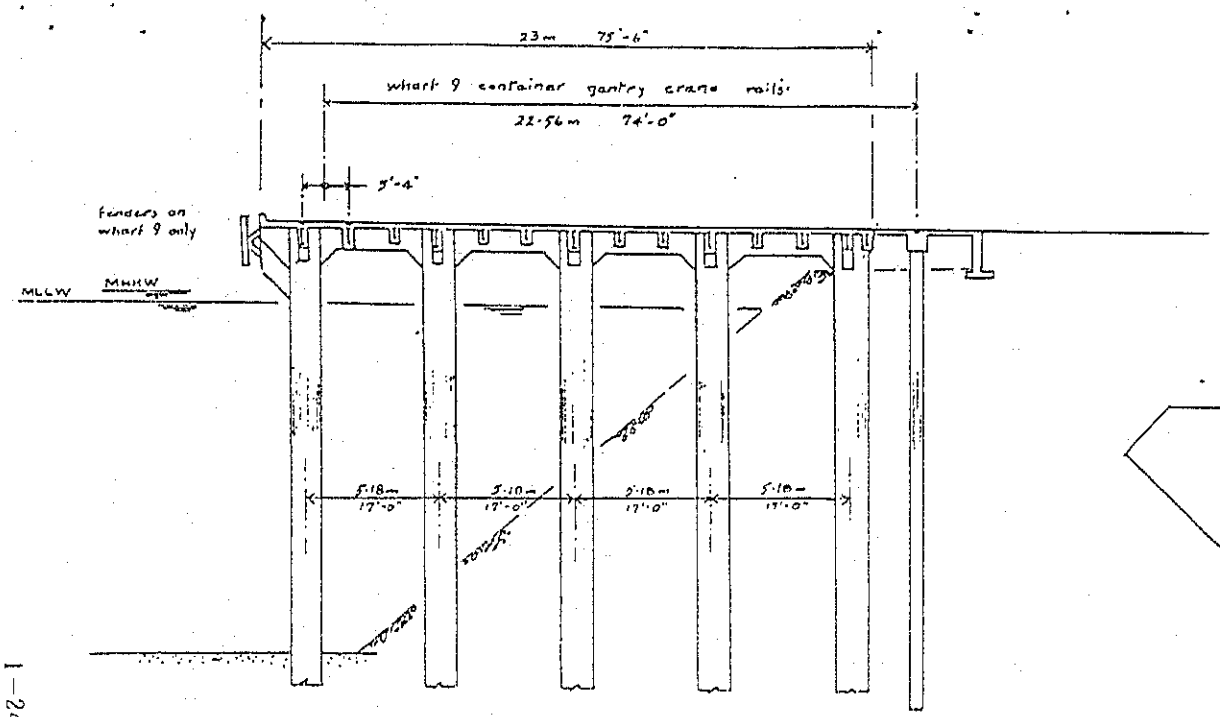
7.4.2 Present Use of Marginal Wharves and Yard

Pier No. 9 was modified to container wharf by the 2nd Port Project financed by the World Bank. Most of the container cargoes are currently being handled here. Pier No. 10 is not modified as a container wharf, yet it provides services to container vessels as well as Ro-Ro vessels. Numbers of vessels that handled cargoes in 1990 at Pier No. 9 and No. 10 were 180 and 90 vessels respectively.

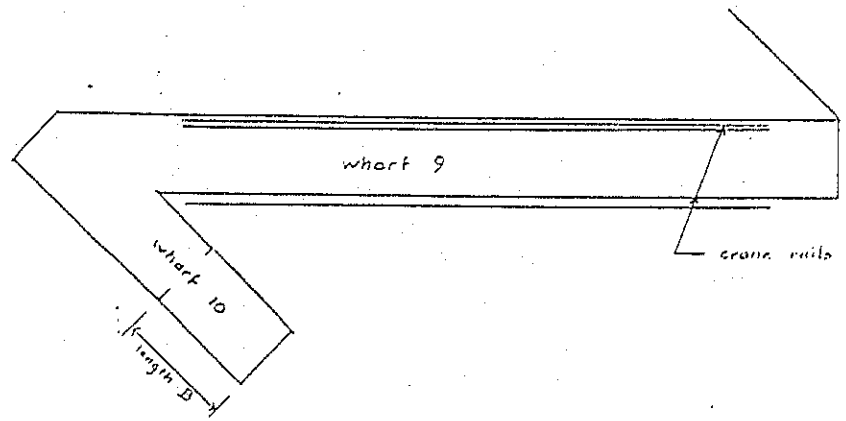
On the wharf apron, two container gantry cranes as well as forklift trucks and trailers are operating.

Previous transit shed behind the pier was demolished for the containerization by the 2nd Port Project and turned to be an open storage yard. The area is approximately 2 ha.

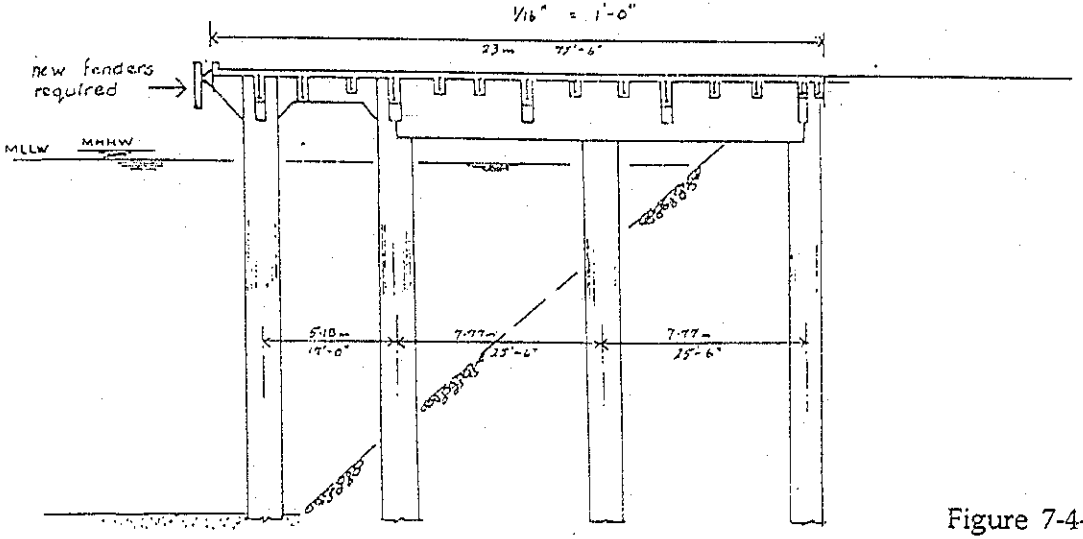
Eastward the open storage area, there is a 7.5 ha container marshalling yard. Yard equipment including trailer trucks, forklift trucks and transfer cranes are providing their services. Container freight station (CFS) of 6,500 m^2 is ordinarily operated.



typical cross section - wharf 9 and part 10
1/16" = 1'-0"



identification plan n.t.s.



typical cross section - wharf 10 length B
1/16" = 1'-0"

Figure 7-4-1 Typical Section of Piers No. 9 and No. 10

7.4.3 Inventory of Major Facilities

(1) Piers and Civil Works

Pier is a typical open structure as same as the finger piers comprising of reinforced concrete deck supported by reinforced concrete piles.
Water depth is MLW-12.0 m at the faceline and the earth fill was made up to the ground height of MLW + 3.6 m. An average gradient of this submerged slope is 1:1 covered with rock riprapping. Earth behind the wharf is retained by wall structures. Piles are of concrete mass reinforced by rails and ordinary steel bars. The size of the piles is 1.35 meters diameter.

Drawings indicate that the pile tip penetrated about 3 meters into the Gatun Rock, thus the piles have enough bearing capacities against vertical loads.
The pile top is rigidly joined with the reinforced concrete beam so that the total structural stability is strong.

Table 7-4-1 Structural Dimensions : Marginal Wharves

Pier	Name	Berth		Structure		
		Length (m)	Depth MLW(m)	Length (m)	Width (m)	Elevation MLW(m)
No. 9	A - B	311	-12.0	325	23	+3.6
No.10	-	127	-12.0	130	23	+3.6

Source : APN

The apron is all paved by reinforced concrete.

(2) Utilities and Lighting

Each pier has bunker supply system and water supply system which are installed in the pits. Among these, the system in Pier No.9 is newly constructed by the 2nd Port Project.

3 lighting poles stand on the open storage area and 12 poles in the container yard. The pole is 30m high.
Neither telecommunication nor fire fighting system were provided.

(3) Wharf Fittings

Aged timber fenders at Pier No. 9 were completely replaced by the following rubber fenders during the 2nd Port Project. However, fenders at Pier No. 10 remain as they were.

- SEIBU H-1,000 x L-700 with protector
- Installed at every 10 meters
- Total number: 27 units

Size of the bitts here are the same as those on the finger piers.

- Size ϕ18" x H27"
- Installed at every 20 meters

(4) Cargo Handling Equipment

There are two container cranes, one made in Korea and the rest in Japan. Forklift trucks and trailer-tractors are operating here. There are two transfer cranes in the yard as well.

(5) Open storage area and Container yard

All these areas are paved with reinforced concrete. Gradient of pavement surface is well designed so as to collect rain water to drainage pits.

Area after demolishing the old transit shed is partly unpaved, however this will be paved soon. Imported vehicles and containers are rested here, but few conventional cargoes.

(6) Architectural Facilities

CFS is the most important facility which provides services to LCL cargoes. Structural specifications of the CFS is given as below:

- Size of CFS: 6,500 m^2
- Structural (frame): Concrete
- Structural (Roof): Asbestos Plate
- Floor: Concrete
- Loading Deck: Concrete
- Gate: Steel Roll Shutter

Other than CFS, there are various offices including:

- Container control office
- Gate house
- Maintenance Shop

(7) Railroad

One rail lane is siding at the south of CFS towards the eastern boundary fence.

(8) Security Fence

Along the yard boundary, steel fence is installed to secure the cargoes and equipment.

7.4.4 Visual Investigation on Marginal Wharves and Yard

(1) Purpose of Investigation and Scope

This investigation aims at collecting necessary data regarding present conditions of the existing facilities for planning future roles of the facilities. It is granted that these facilities will be used as a container terminal so far. In order to evaluate the existing facilities, two criteria were prepared.

a. Whether the existing facilities are durable enough for the present use or not.
b. Will any repair works be necessary in the near future to prolong the facility life?

In order to meet these requirements, visual observation were conducted.
This subsection will cover observation on;

a. Main wharf superstructures
(excluding submerged part of piles)
b. Architectural works
c. Pavement and drainage at open storage yard and container marshalling yard
d. Utilities and wharf fittings
e. Rail track
f. Cargo handling equipment

(2) Evaluation of Pier Structures

The same review criteria used for the finger piers are adopted for the marginal wharves. Refer to subsection 7.2.4 item (2).

(3) Results of Visual Investigation

a. Civil Works

<u>Concrete Beams and Slabs</u>

Although the structure is 75 years old, concrete cracks on beams and slabs created by R-bar corrosion are not observed. The concrete does not seem to be affected by seawater. The main beam seems to have reinforced during the 2nd Port Project to resist the heavy gantry crane loads. Concrete slabs are as good as the finger piers.
Apron pavement is well maintained and no problem was found.

Piles

The piles are of concrete reinforced by steel rails, 4.5′ diameter with steel cylinder casing. The steel casing was corroded and inner concrete are partly exposed, however this will not affect pile strength. The pile top have had some minor abrasions but were repaired.

Seawall

Since the sea is very calm generally, the slope of the seawall beneath the deck is not washed away at all. Therefore no settlement of the ground was observed.

Conclusion of Visual Investigation

i) Average damage grade is I. for Pier No. 9 and I to II for Pier No. 10. There is no serious damage of grade III or more. So far structural problems due to aging can not be observed. The pier can be utilized as the present level.

ii) An introduction of container cargo handling system did not give damages to the structures.

b. Architectural Works

CFS

CFS seems to be functioning well from a structural point of view.

Control House

The building is well maintained for the current use.

Gate House

Trailers' contacts gave some damages to the gate, however this does not affect actual operation.

c. Utilities and Wharf Fittings

Bunker and water supplies on Pier No. 9 are well designed and maintained. However, the bunker pits on Pier No. 10 do not have sole, and a possibility of oil leakage would be an environmental problem.

Rubber fenders on Pier No. 9 are still new and well maintained. However on Pier No. 10, timber fenders still remain and are ruined. New fender system should be installed soon.
There are total 15 lighting towers around the area which seem sufficient for the current use.

Approx. 30 m high lighting towers stand along the boundary fence. The towers are well maintained and have no damage by contacts of mobiles.

d. Open Storage Area and Container Marshalling Yard

A part of the open storage area is unpaved after the demolishing of the old shed, however all of the container yard is paved with reinforced concrete. Some cracks are observed, however no ground settlement was generated so far. Drainage system seems to be alright.

e. Cargo Handling Equipment

Two gantry cranes are now operating well. No significant accident or damage on the gantry cranes were reported so far, however refined maintenance work should be maintained. On the apron and the yard, forklifts and trailers are operating mainly and two transfer cranes work as well. Visual inspection can not tell a serious problem to these equipment.

There are two transfer cranes in the yard. Forklifts and trailer-trucks are operating as well. There seems to be no significant problem from the visual investigation.

f. Railroads

One rail lane is siding at the south of CFS towards the eastern fence. This track is being used for cargo transport. The rails seems to be alright.

g. Fence

The fence surrounds the entire container yard. It is of galvanized steel made. Part of the fence is slanting due to the contacts of mobiles.

7.4.5 Rehabilitation and Up-Grading Schedule of Marginal Wharves and Yard

(1) Past Performance

APN's past efforts to the marginal wharf is the pavement work of open storage yard after demolishing the transit shed.

(2) Plan at Present

As seen in Figure 7-2-1, the center part of the container yard is regarded a bottleneck, which is made narrow by APN administration yard on the north and PCC yacht club on the south.

APN announced that an effort to make this neck wider is to be scheduled. It is reported that two areas (see Figure 7-2-1) will be the target of yard expansion and preparation work as cleaning the site has started already. Some buildings will have to be demolished and top soil will be covered over the existing ground up to the same level as the container yard.

7.5 Pier No.16

This section deals with the existing conditions and dimensions of Pier No.16 and its utilities. The structural conditions will be evaluated based on the visual inspection.

7.5.1 Basic Layout and Typical Section

Pier No.16 is an exclusive bunker pier located at the north end of Telfers Island, in front of Pier No.10 across the French Canal. Because of its location, the access to this pier is to take a long way round via Mount Hope Tank Farm up the northward.

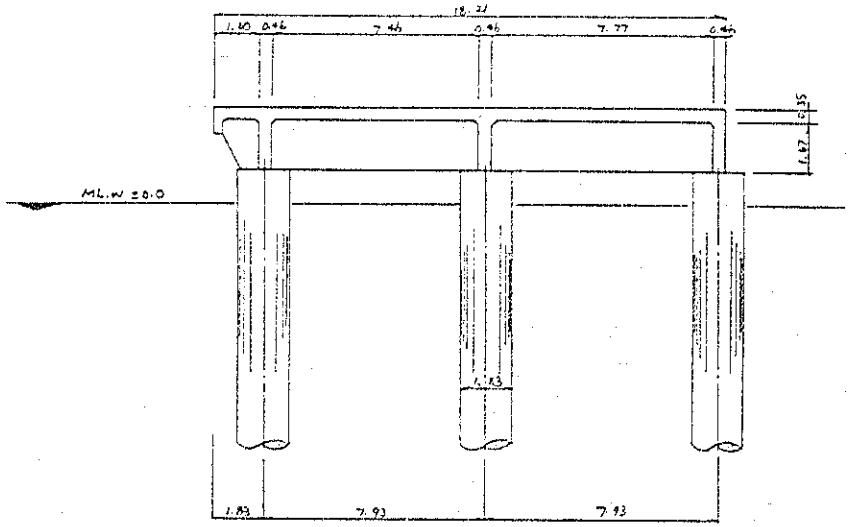
The pier has a U-shaped figure as seen in Figure 7-2-1. The total length is about 700 meters by 20 meters width. The pier is a typical open structure consisting of concrete deck on pile foundation which is same as the finger piers. Refer to Figure 7-5-1 for the typical section of the pier.

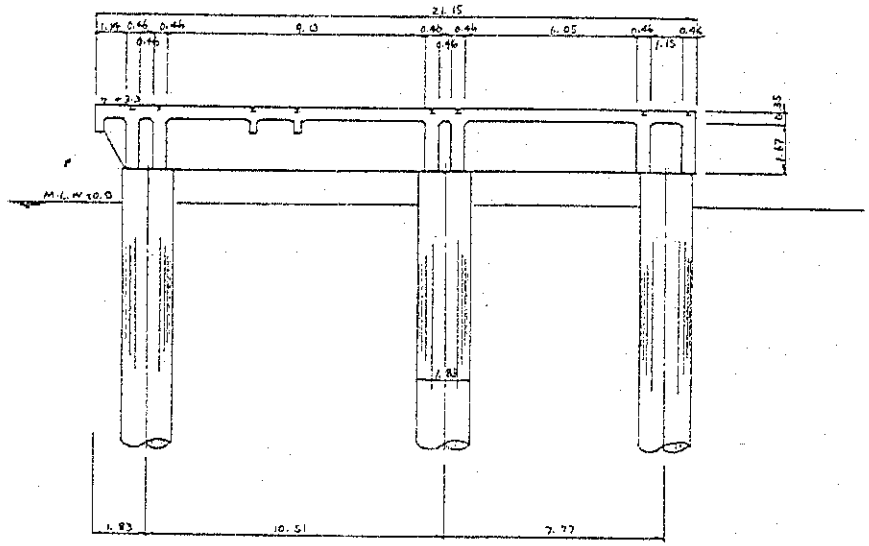
7.5.2 Present Use of Pier

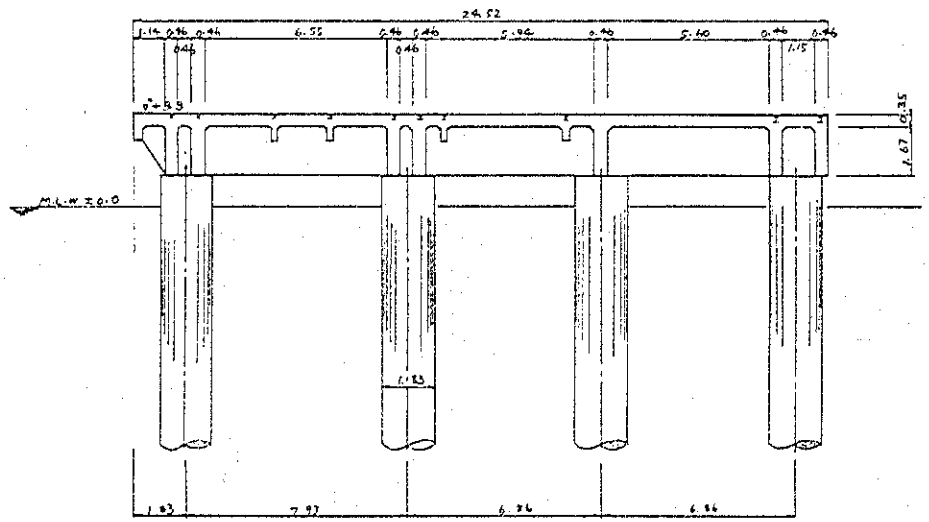
According to the Panama Canal Treaty, the Telfers Island area is controlled by PCC, however only Pier No.16 and its surrounding basin have reverted to Panama and are controlled by APN at present.

Pier No.16 provides bunkering services to the vessels calling to the port of Cristobal which handles three types of oil that are; fuel oil, light diesel and heavy diesel.
The pier sometimes handles vehicles in case that the other finger piers are fully occupied.
Numbers of vessels that berthed at Pier No.16 are 411 in 1990. The vessel type is mainly composite vessel, tanker and fishing boat.

The bunkering service is currently administrated by a private company (A.P.S.A) that has a concession contract with APN. Oil is handled by two fixed loading arms and movable pumps.







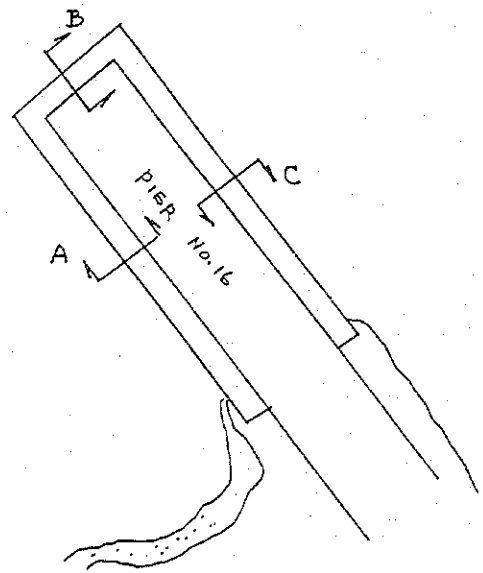


Figure 7-5-1 Typical Section of Pier No. 16

7.5.3 Inventory of Major Facilities

(1) Pier and Civil Works

The pier is a open structure of reinforced concrete superstructure supported by reinforced concrete piles. Piles consist of a circular mass of concrete reinforced by rails and re-bars. The size of the piles is 1.8 meters (6') diameter which is just the same as those in the finger piers.

Original drawing was not available, however the piles seem to have enough bearing capacity against vertical loads judging from the similarity of its dimensions to that of the finger piers.
The pile top is rigidly connected with the reinforced concrete beams to resist against lateral forces.

Table 7-5-1 Structural Dimensions : Pier No. 16

Pier	Name	Berth		Structure		
		Length (m)	Depth MLW(m)	Length (m)	Width (m)	Elevation MLW(m)
No.16	A - B	321	-12.6	351.6	24.5	+3.3
	C - D	321	-12.0	351.6	21.2	+3.3
	E	137	-8.7	139.6	18.2	+3.3

Source : APN

The aron is all paved with reinforced concrete.

(2) Utilities

Pipelines run along the pier's upper deck and also under the deck. The pipelines originally come from the Mount Hope Tank Farm running along the access road to the pier. There are two fixed loading arms on the western side of the pier. Bunker pits covered by steel cover locate at a certain pitch.

Water line also runs along the upper deck which is 6" diameter. The water line come from the Mount Hope running parallel to the oil pipeline with a diameter of 10". Fire fighting system are provided on the pier deck at a certain pitch.

Electric power line comes from the sub-station at Mount Hope along the eastern coast of the French Canal across the said canal underwater. A power house with transformer locates at the eastern root of the U-shaped pier.

(3) Wharf Fittings

Rubber fenders are installed along the faceline of the pier as follows.

Bollards are installed at every 18.30 meters.

Table 7-5-2 Fender System : Pier No. 16

Faceline	Design Base	Nos.	Pitch(m)
Western	45,000 DWT	13	18.30
	7,000 DWT	10	9.15
Eastern	45,000 DWT	10	18.30
	7,000 DWT	18	9.15
Northern	7,000 DWT	14	9.15

Source : APN
Note : R.C. means reinforced concrete

7.5.4 Visual Investigation on Pier No. 16

(1) Purpose of Investigation and Scope

This subsection aims at collecting necessary data regarding present conditions of the existing facilities for planning future roles of the facilities. It is granted that Pier No.16 will be used as a bunker berth exclusively so far.
In order to evaluate the existing facilities, two criteria were prepared.

a. Whether the existing facilities are durable enough for the present use or not.
b. Will any repair works be necessary in the near future to prolong the facility life?

In order to meet with these requirements, visual observation were conducted.
This subsection will cover observation on:

a. Main superstructure including concrete beams and slabs
b. Foundation piles including submerged parts
c. Utilities including pipelines and wharf fittings

(2) Evaluation of Structure

Review criteria for structure are prepared in order to evaluate the surveyed data in a quantitative manner as shown in Table 7-2-7 which are used for the evaluation of finger piers.

(3) Results of Visual Investigation

a. Civil Works

Concrete Beams and Slabs

Beam concrete are reinforced by H-shaped steel girder and re-bar. Since the bottom surface of the beams were affected by seawater for 75 years, some of the beams' bottom have severe damage due to the corrosion of reinforcing steel girder. Such damages can be observed along the outer faceline of the U-shaped pier that faces to the ocean. Concrete covers came off and corrosion of the steel progressed deeply and the original thickness of the steel was lost. However, other beams in the deck center and inner faceline of the pier are fairly good, just like the conditions of finger piers.

While, the bottom surface of the slabs do not have significant damage compared to the beams. Slabs did not seem to be affected by seawater since they are about 3 meters above sea level.

Apron pavement is of reinforced concrete type and is well maintained.

Piles

According to the observation, the piles are of the same type and size which are used for Finger Piers No.6, No.7 and No.8. (Refer to Part I, 7.2.4 (3))

Casing steel near the splash zone is seriously corroded and a part of the concrete cover has come off, however this damage is minor because the piles are made of mass concrete. There is no critical damage on pile top.

According to the diver's inspection on the submerged part of the piles, steel casing still remained over the pile surface and are covered by seaweed. So far, no significant damage was found.

Conclusion of Visual Investigation

Average damage grade is I to II in general, however grade III to IV appears partly (Beams along the outer faceline of the pier).

The pier can be utilized as the present level, however prompt repair works to the damaged beams should be conducted in order not to allow further corrosion.

The pier was designed and constructed as the rigid frame structure having no expansion joints which made the pier more durable against horizontal forces.

Table 7-5-3 shows the damage grade of the concrete structure for Pier No.16.

Table 7-5-3 Damage Grade : Pier No. 16

Location/Pier	Total Number	Damage Grade					
		0	I	II	III	IV	V
- C Beams (No.)	798	224	170	180	150	74	
- C Beams (index)		28%	22%	23%	18%	9%	
- C Slabs (No.)	219	55	39	85	40		
- C Slabs (index)		25%	18%	39%	18%		
- C Piles (No.)	312	197	55	35	25		
- C Piles (index)		63%	18%	11%	8%	5%	
Average (index)		36%	20	23%	16%		

Source : Study Team
Note : "C" means Concrete

b. Utilities

Oil pipelines running along the pier seems to be installed after the completion of the superstructure as the fuel demands arises. The pipelines are hanging by steel angles or steel bars under the deck

No oil leakage has been observed, however a part of the steel surface of the pipe were exposed and some corrosion is being progressed. Such maintenance work as sand blasting and painting/greasing should be given promptly. The hanging steel elements also has some corrosion, thus maintenance of them should also be required.

Regarding utilities on upper deck, two fixed loading arms are well maintained. Bunker pits or fire fighting system are also working in good condition.

c. Wharf Fittings

There are two types of fenders along whole of the pier faceline installed in 1990. All of the fenders are fairly good except one fender that fell off due to a rough vessel contact. In spite of the good condition of the fenders, concrete deck where fenders are fixed looks poor because of the concrete rusting along the faceline.

Bollards are fixed rigidly and no problem was found.

7.5.5 Rehabilitation and Up-Grading Schedule of Pier No16

(1) Past Performance

APN's past performance to Pier No.16 can be summarized as follows:

a. Installation of new rubber fenders

b. Rehabilitation of potable water supply system
c. Installation of new (additional) pipelines which was conducted by the concession company (APSA)

(2) Plan at Present

APN does not have rehabilitation and/or up-grading plan at present.

7.6 Main Access to the Port Area

Access roads between the port and its hinterland should be maintained to provide a smooth vehicular traffic. This section deals with the conditions of the existing main access roads including their traffic capacity and the present traffic volume.

7.6.1 General Layout and Road Section

Figure 7-6-1 and Figure 7-6-2 show the main access roads to the existing port and typical sections respectively. The existing access and the nearby roads are generally "two lane-two way" road.

7.6.2 Visual Inspection on Main Access

(1) Road Access

As shown in Figure 7-6-1, there are two types of pavement, asphalt pavement and concrete pavement. The asphalt pavement has some damages or holes on the surface treatment. They are not critical for the current traffic, however they should be repaired soon for better conditions. As for the concrete pavement, joints are properly provided. Minor cracks caused by the concrete shrinkage are observed, however they are not serious for the current traffic.

The railway crossing is well maintained, thus there is few irregular shakes during the drive.

(2) Railway

Railroad section is five-foot gauge with double tracks. The rail condition is fair as far as freight trains run in a moderate speed as they do now. Unevenness and deformation of the railway were not found. Rail-track is partly grassy, however general conditions of the ballast seems to be alright. When the railroad traffic grows, the railway crossing should be controlled better than now.

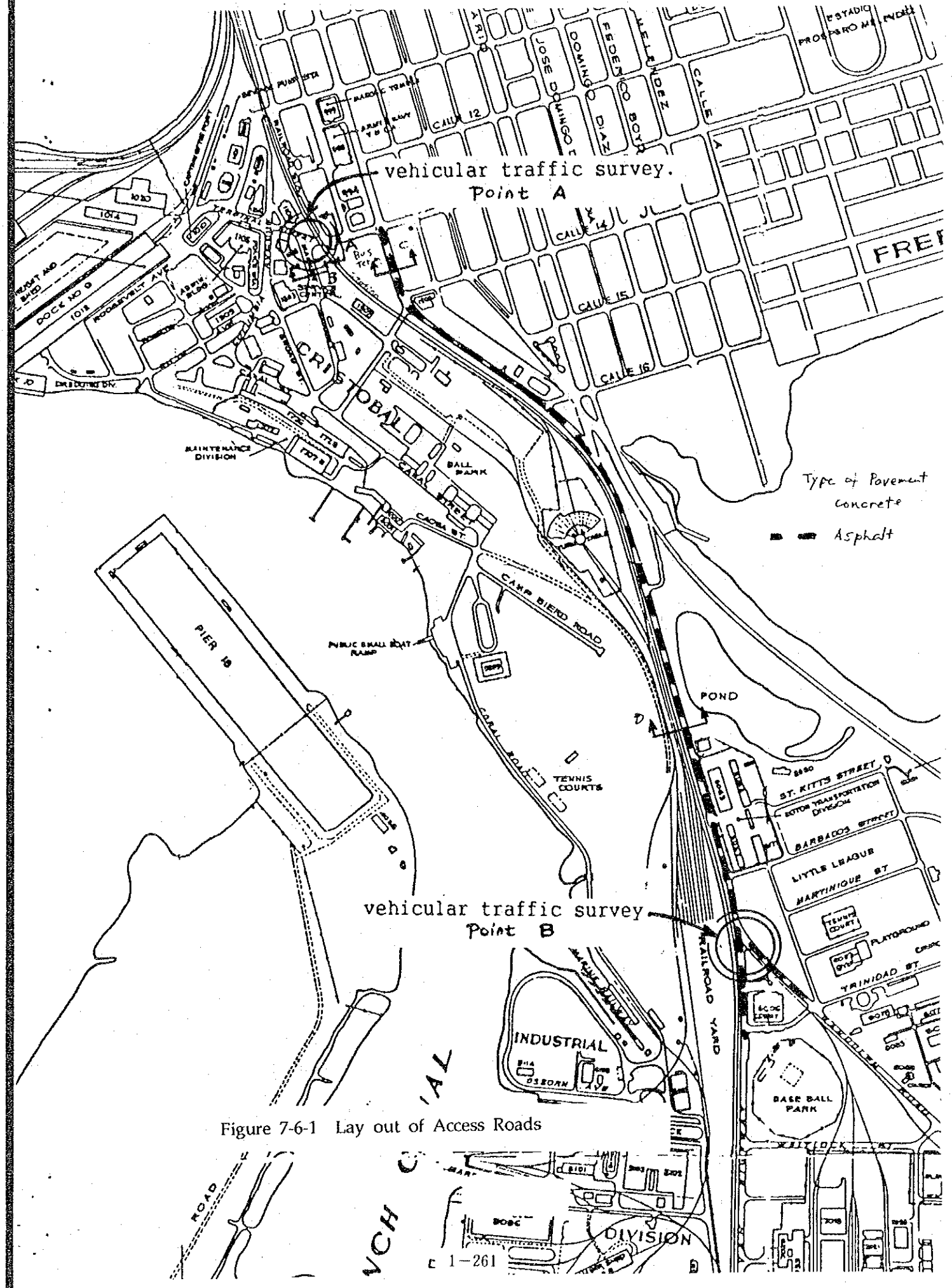


Figure 7-6-1 Lay out of Access Roads

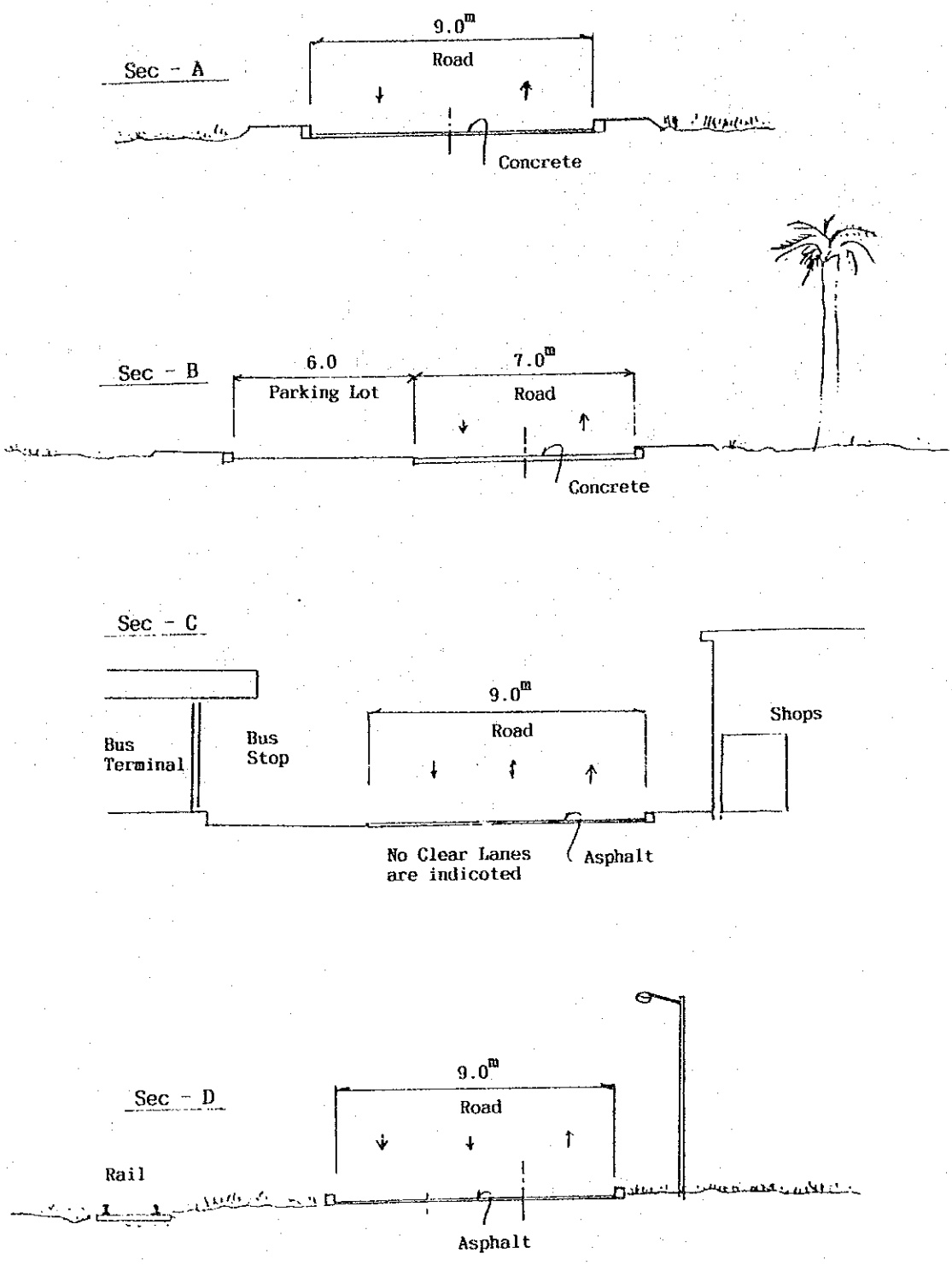


Figure 7-6-2 Typical Section of Access Roads

7.6.3 Existing Vehicular Traffic

(1) Traffic Capacity on Present Road Section

The Table below shows the allowable traffic capacity based on the dimensions of the roads section.

Table 7-6-1 Allowable Traffic Capacity

Section	Width (m)		Volume (cars/day)
	Left Lane	Right Lane	Capacity
A	3.5	3.5	8,000 - 13,000
D	5.5 (2 Lanes)	3.5	11,000 - 19,000

Note : The capacity above shows the numbers of sedans.
One truck is equivalent to 3 sedans

(2) Existing Peak Traffic

Vehicular traffic survey conducted by the Study Team indicates the hourly peak vehicular traffic as follows: (Refer to Part I, Chapter 2, 2-8 for details)

Table 7-6-2 Present Access Traffic Volume

Unit: Vehicle/hour

Capacity Item	Survey Point	
	Point - A	Point - B
Traffic Ca-pacity	700	1,050
Peak Capacity	450	1,150

7.6.4 Preliminary Evaluation

(1) Existing Port Entrance

At present, particular traffic regulations around the survey points are not established. Since these access roads are congested with ordinary cars and trailer-trucks and port operating mobiles, a by-path may be arranged in the future.

The present utilization of the railway is quite low compared to the vehicular traffic. The future utilization of rail-tracks should be discussed depending on the demands.

Such a future arrangement will be discussed during the Long Term Plan stage.

(2) Access to Telfers Island

A traffic from Panama is not allowed to make a left turn to Telfers, but no sign indicates so. As for the intersection here, a further discussion will be made during the Long Term Plan stage.

The present utilization of railway is quite low compared to the vehicular traffic. The future utilization of railroads should be discussed depending on the demands.

Such a discussion will be made during the Long Term Plan stage.

7.7 Existing Facilities and New Terminal Development

This section deals with preliminary concepts for the existing port facilities to last longer. Recommendations through the study and site investigation will be provided for obtaining more sound technical data.

7.7.1 Basic Concept of Existing Facility Use

(1) Advantages on Natural Conditions

The port of Cristobal is located at a wide, deep and calm inner basin. Access channel and anchorage are well protected by the existing breakwaters. The water depth is maintained at the minimum depth of MLW -12.0 m by the APN's maintenance dredging.

(2) Infrastructure and Port

Construction of port requires a large amount of money and a long duration before starting the operation, however construction cost should be minimum in order to reduce tariff and port charges.

(3) Cost Aspect

According to the visual observation on the existing facilities and the review of the design records though they are so limited, the port facilities are sound in terms of structural durability.

The existing piers and wharves can be utilized as longer as possible to meet the requirements if APN provides necessary maintenance and repair works. The earlier repair work, the lesser total repair cost. It is also recommended that APN seek the present maximum utilization rate of the facilities.

(4) Maximum Utilization

It seems that the present cargo traffic demands are exceeding or will exceed the cargo handling capacity in Cristobal. Only Pier No9 can be classified as the container wharf. This wharf and its back-up yard including CFS will be the core of the port between the existing finger piers and a new terminal to be proposed by the Study Team.

In this sense, APN should fully use the existing port facilities, not to abandon them.

(5) Port Expansion and Reversion of PCC Areas

Sooner or later, an extension of existing container yard and/or construction of a new container terminal will be required. If PCC brings their facilities together

systematically and remove them out of the port operation area, APN would easily prepare its future plan for an effective port operation.

(6) Environmental Aspect

Container port facility is basically environmental free. So a limited pollutant will be discharged from the container terminal. However it is recommended to construct a port at an open space facing to a wide basin for a rapid dilution of water. The present Cristobal Port is confronting the criteria now.

7.7.2 Capacity of Existing Facilities

As discussed before, cargo handling capacity of the existing facilities depends on the following factors.

a. Physical space
b. Structural durability and its life span
c. Access to the hinterland

One of the key issue is both the structural strength and durability of the existing piers and wharves, since they are 75 years old. A general answer to this issue is that the existing piers and wharves are basically so sound that they have enough structural strength and durability as far as they operate as they do now.

7.7.3 Existing Facilities and Maintenance Work

This subsection deals with a preliminary total evaluation on the existing port structures and maintenance and repair efforts to be made.

(1) Pier Structures

Preliminary Evaluation

Finger piers and marginal wharves are structurally sound. No significant damage or quality loss due to aging were found so far. With minor repair works as APN does at present, the life span of these structures can last longer.

Required Repair Works

The same type of repair works, which had done to Pier No7, should be given to the damaged concrete beneath the deck of Pier No6, No8 and No16

Other Considerations

Apron should better be wider for modern cargo handling. To widen the apron,

demolishing of shed is required. The most preferable balance of them should be studied based on the allocated function to each finger pier.

(2) Mole

Preliminary Evaluation

The mole is structurally sound. This earth dike have few settlement on the pavement which is not serious. Erosion of amour rocks are not found either.

Required Repair Works

Strengthening of amour rocks over the existing riprapping along the north coast.
Repair works to damaged concrete pavement, particularly at the vicinity of Pier No.6.

Other Considerations

Along the southern slope of the mole, waste solid and construction debris are being dumped. It is recommended that APN monitor and control such dumping.

(3) Pavement

Preliminary Evaluation

Road pavement including the existing main access to the port entrance and container yard has some damages on its surface treatment. However, they are not critical.

Required Repair Works

Repair works by patching the surface damages.

Other Consideration

Wider road section or a by-path might be required at the main access to avoid congestions.
Rain water drainage pits should be maintained for smooth discharging.

(4) Architectural Works

Preliminary Evaluation

Significant problems on the existing transit shed, control office and CFS could not be observed from a structural point of view.

Required Repair Works and Renovation

Gates of transit sheds should be renovated.

A minimum repair work might be required at the roof where there is a leak. Supporting columns and entrance wall of the sheds should be protected from mobile contacts. Installation of edge protection steel would be preferable.

Other Considerations

Function allocation to each shed should be the basic criteria for shed renovation. Required size of shed and CFS should carefully be studied.

(5) Utilities

Preliminary Evaluation

With a minor repair work and renovation, both the water supply and bunker systems will work good.

Required Repair Works

Repair works of water supply facility at Piers No6, No7, No8 and No10 will be given.
Supply pits should be provided with closed-box type pits so that no oil leaks.

Other Consideration

To be a real modern port, telecommunication at the berth front and fire fighting system in sheds and CFS should be introduced.

CHAPTER 8 STRUCTURAL REVIEW ON EXISTING PIERS

This chapter deals with the structural review on the existing piers of the port of Cristobal. The results of visual investigation and concrete core sampling and design records and drawings collected will be the basis of analysis which will be conducted by computer.

8.1 Necessity of Structural Review and Scope

8.1.1 Necessity of Structural Review

In the near future, more exact functions will be allocated to the existing piers. Function allocation, modernization of these piers and required design for structural upgrading to meet new functions will be studied in Part II, Long Term Plan.

In order to cope with above aspects, there are three questions.

i) Are the existing piers structurally durable enough for the present utilization?

ii) What kind of routine repair works should be given to the existing piers regardless of use?

iii) What kind of structural strengthening should be made to upgrade the existing piers for new functions?

The latter two questions will be answered in Part III, Short Term Plan. Thus this chapter concentrates on the first question.

The figure below indicates the meaning of "Routine Repair Works" and "Upgrading".

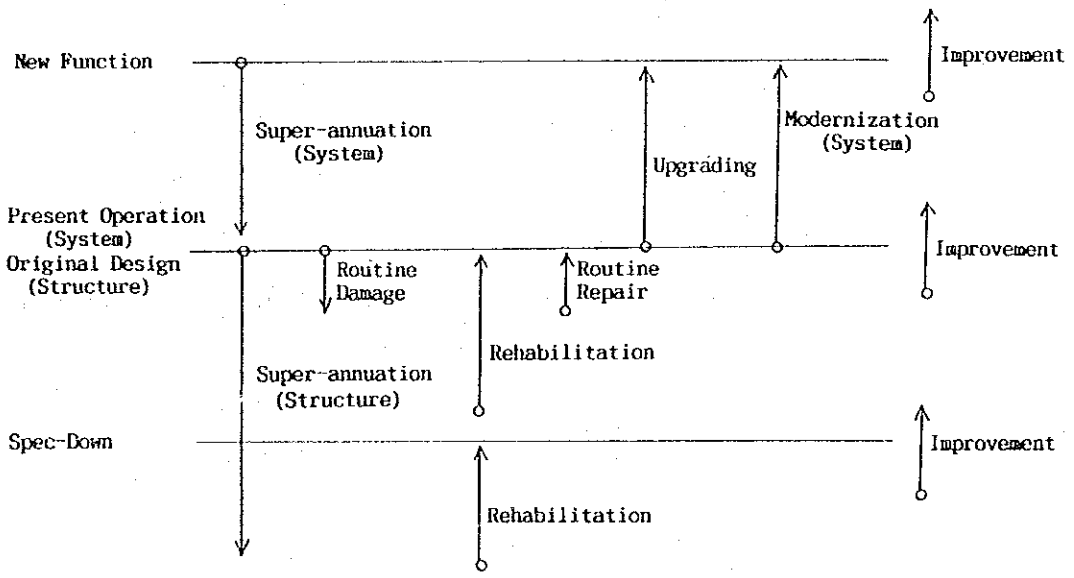


Figure 8-1-1 Identification of Routine Repair and Upgrading

8.1.2 Evaluation Based on the Visual Investigation Results

The results of the visual investigation show the following findings:

- A few minor damages to deck corner or beam bottom in Piers No. 6, No. 7 and No. 8.
- Severe concrete rusting on the bottom surface of the beams in Pier No. 16. But such damages are limited to outer faceline of the pier.
- Foundation piles made of cylinder mass of concrete have very few rusting on their top. No damage on the submerged part.

Above damages are regarded to be minor in terms of structural durability as a whole. And they can be repaired as a routine repair work, the life time of the structure will be lengthened to some extent.

However, in order to evaluate the structural durability of the piers more carefully and quantitatively, a structural analysis should be required to know how stable the piers are against such external loads as enlarging vessel berthing forces or seismic forces.

8.1.3 Scope of Structural Review

The scope of structural review consists of the following:

i) Calculation of allowable forces and working forces on each main structural members by computer analysis to check the safety of the piers

ii) Evaluation of the result of concrete core sampling

An object of structural analysis will be the existing Piers No. 6, No. 7, No. 8 and No. 16.

A special attention should be paid to the durability of pile end (connection point between piles and Gatun formation), where no reinforcement was provided.

8.2 Structural Section of Piers

Based on the drawings/data collected, structural frames to be analyzed are established as shown in Figures 8-2-1, 8-2-2, 8-2-3 and 8-2-4.

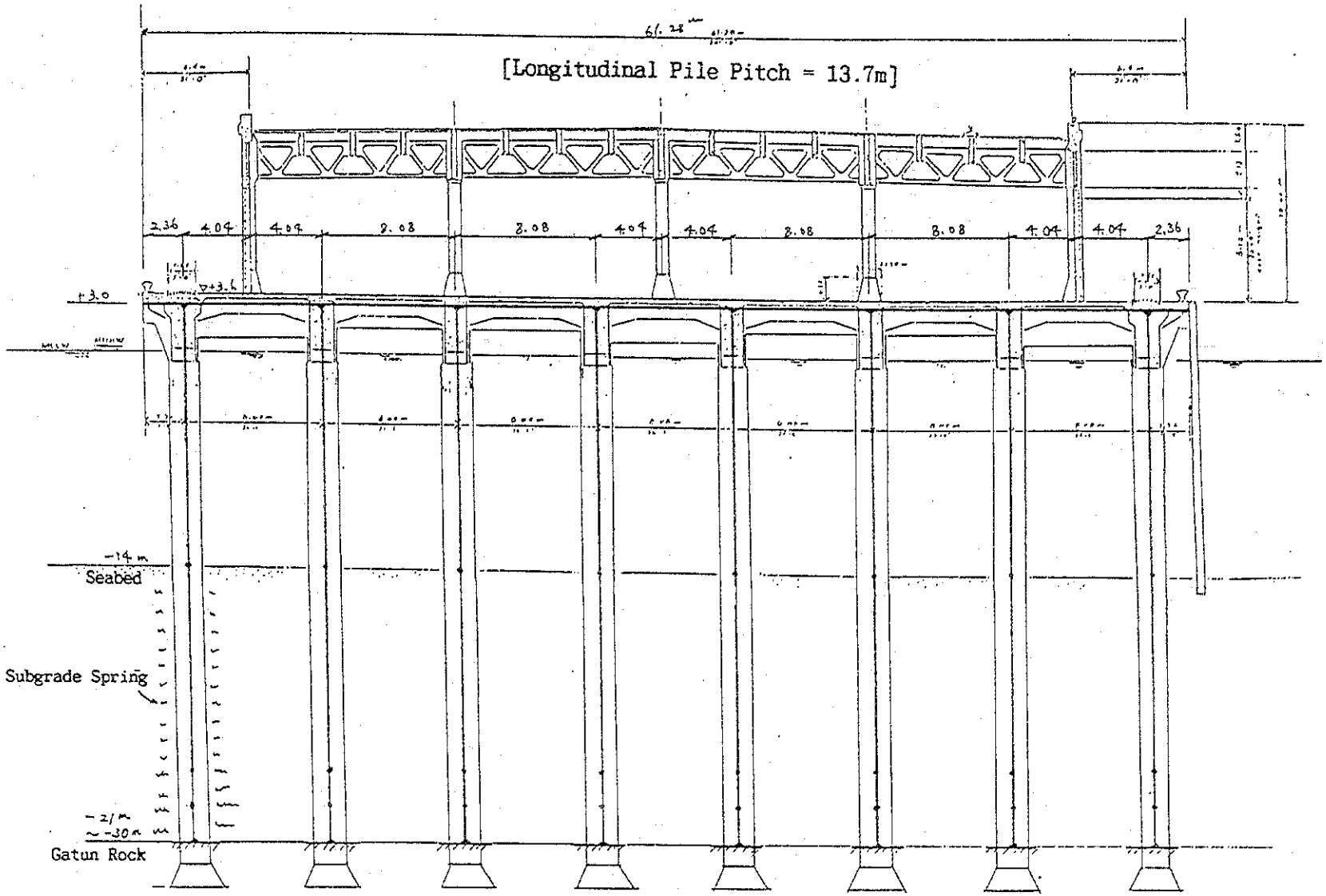


Figure 8-2-1 Typical Section and Frame : Pier No. 6

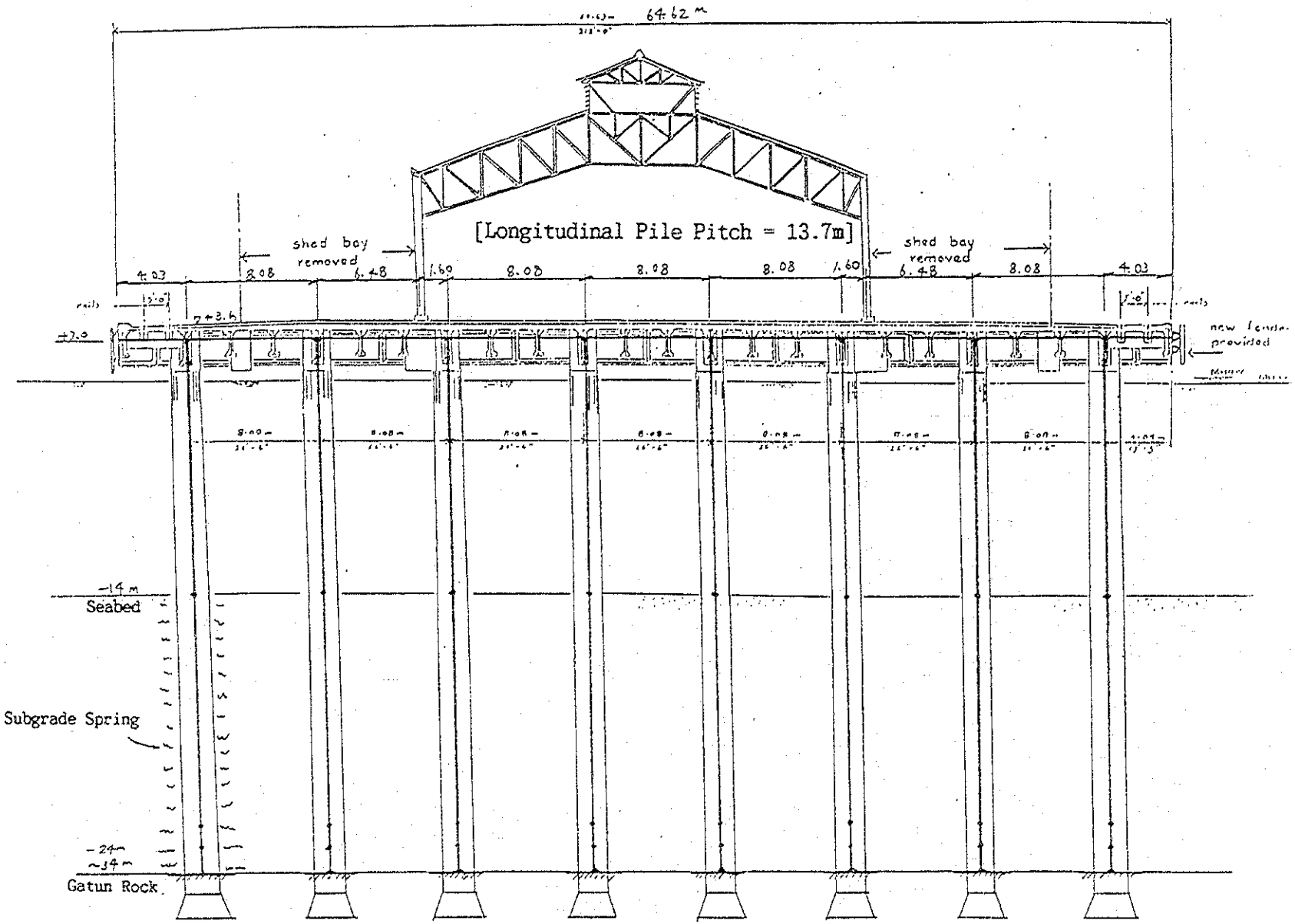


Figure 8-2-2 Typical Section and Frame : Pier No. 7

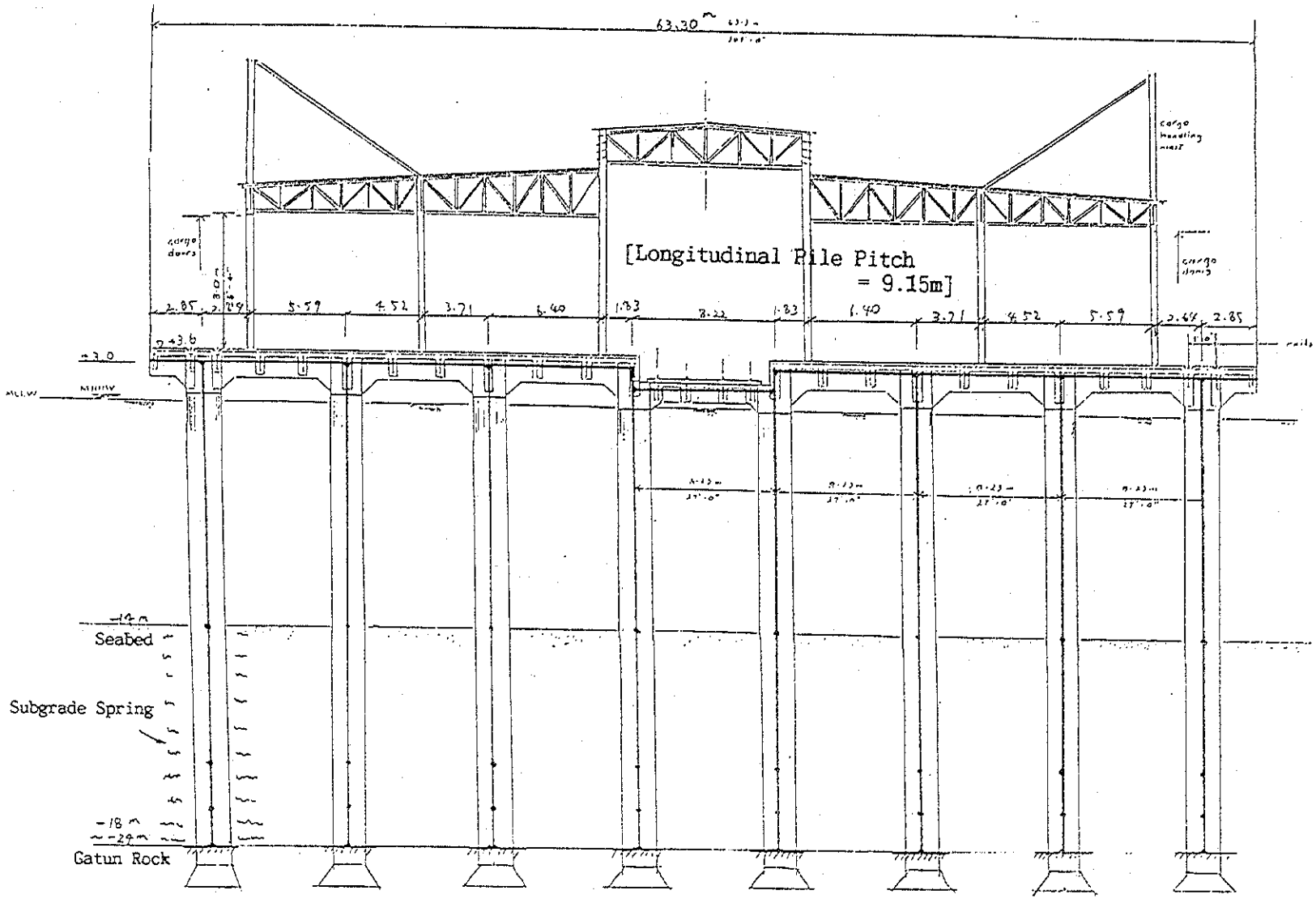
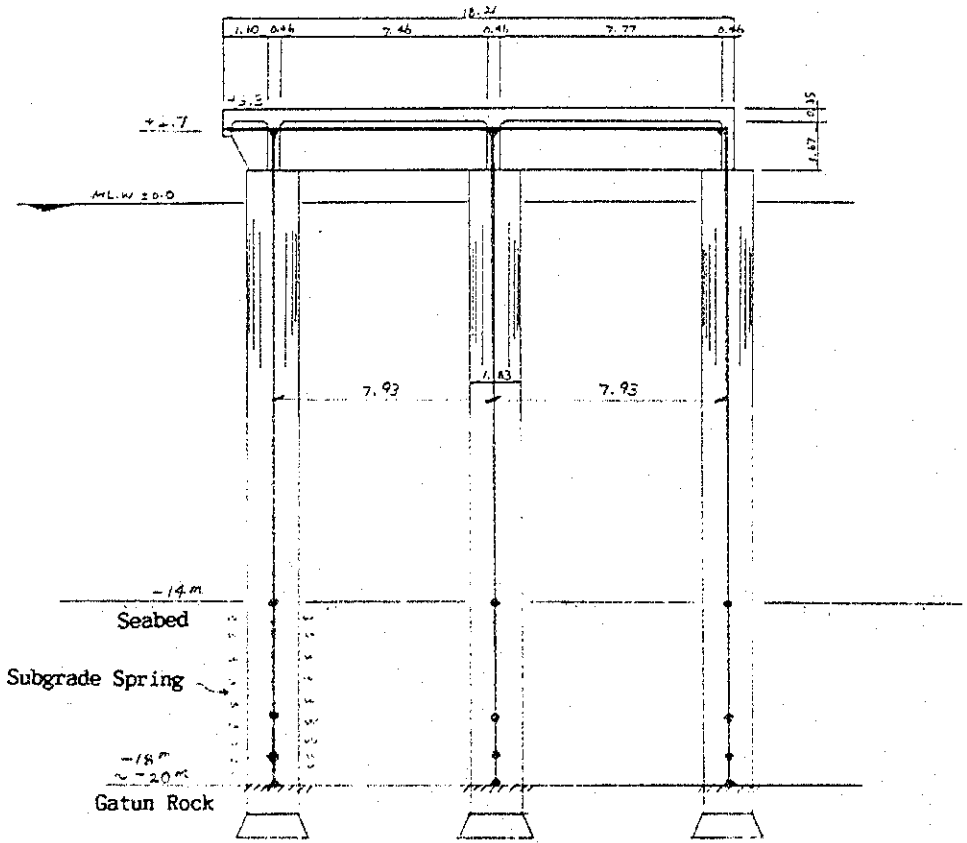


Figure 8-2-3 Typical Section and Frame : Pier No. 8

[Longitudinal Pile Pitch = 9.15m]



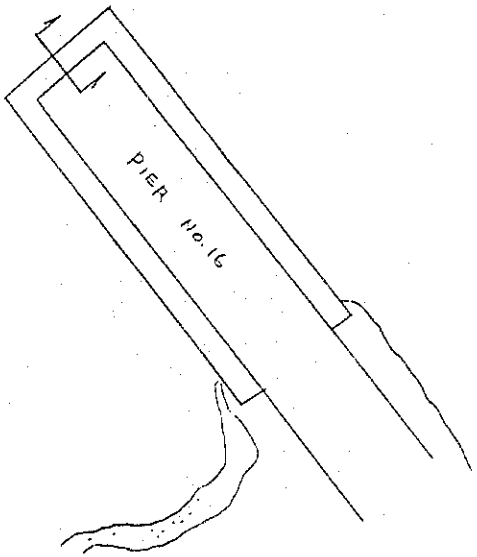


Figure 8-2-4 Typical Section and Frame : Pier No. 16

8.3 Result of Concrete Core Sampling

8.3.1 Purpose and Scope

In order to establish the quality and condition of the pier structure investigated because of their age and the surrounding environment, concrete cores were taken from the pier slabs. Total 8 cores were taken from Piers No.6, No.7, No.8, No.10 and No.16, the locations of which are shown in Figure 8-3-1.

The concrete cores were tested in laboratory to conduct an axial compression test to determine their present compressive strength.

8.3.2 Result of Core Sampling and Compression Test

The cores were drilled with a gasoline engine powered portable drilling machine equipped with a four-inch diamond bit. Locations of the cores were selected carefully not to cut the existing reinforcing bars in the slabs. The size of the cores is 4" diameter and the length varied but minimum 4".

Table 8-3-1 shows the result of axial compression test.

Table 8-3-1 Result of Compression Test

No.	Pier	Core Size		Compressive Strength	
		Diameter (inch)	Length (inch)	Direct (kg/cm2)	Corrected (kg/cm2)
1	No.16	4	4.75	238	217
2	No.16	4	8.0	452	452
3	No. 6	4	6.5	301	292
4	No. 6	4	5.75	272	260
5	No. 7	4	4.5	415	373
6	No. 8	4	5.0	655	609
7	No. 8	4	7.0	386	378
8	No.10	4	8.0	458	458
Average		4	6.2	397	380
Average among the lowest 4 samples		4	5.0	299	287

8.3.3 Evaluation

According to the visual inspection on the core samples taken, it is obvious that the concrete was casted and cured with a excellent quality control in 1910's. The quality of concrete generally decreases year by year due to chemical action from sea water, however, the result of compression test shows that very few chemical action affected the concrete quality of the Cristobal piers which sustained the concrete strength.

Regarding the concrete strength, although the figures varied by cores, it is assumed that the standard concrete strength of fc'= 350 - 400 kg/cm2 was used in the original construction of the piers. In the structural analysis, it is recommended to apply a standard concrete strength of fc'= 240 kg/cm2 to be on the safe side.

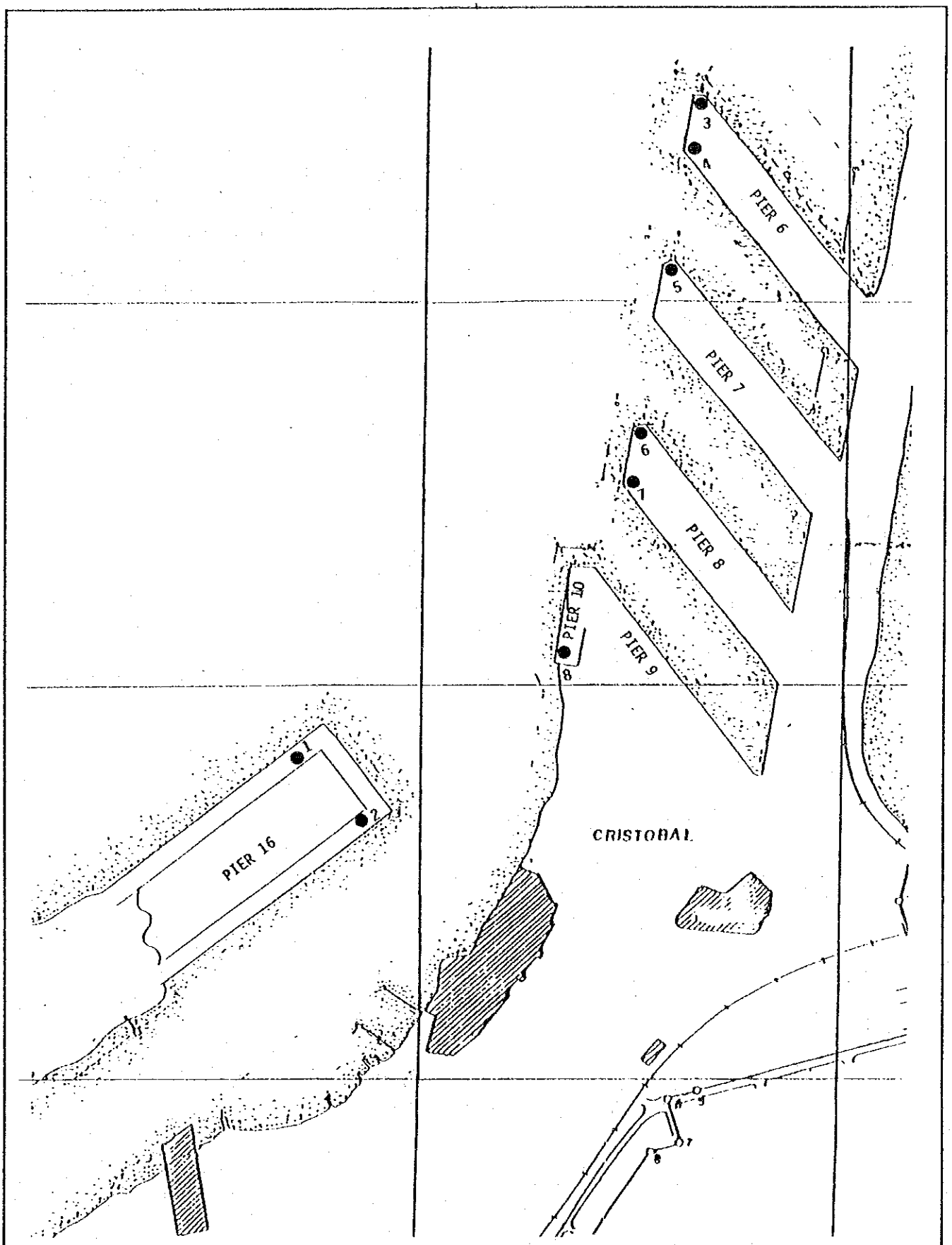


Figure 8-3-1 Location of Concrete Core Sampling

8.4 Basic Condition of Structural Analysis

8.4.1 Method of Structural Analysis

The structural analysis was conducted by a two-dimensional (2-d) frame model "UC-Frame" which is a refined program of displacement method. This program calculates any frame structures regardless of their shapes or type of members or materials. Three-dimensional (3-d) method shall not be applied because the piers (more than 300 m long) were constructed in one united block having more than 200 piles; too many to apply 3-d method. Fortunately the piers have systematical pile arrangement, thus 2-d method will be enough for analyzing this type of structures.

8.4.2 Assumptions

Such technical assumptions as structural features or type of external loads were established as follows:

(1) Gatun Rock Formation

The depth of Gatun Rock formation varies from place to place in the port of Cristobal including the areas where Piers No.6, No.7, No.8 and No.16 locate. The depth of Gatun formation by each pier is as follows:

Table 8-4-1 Depth of Gatun Rock Formation by Pier

Pier	Seabed	Gatun Rock
Pier No. 6	-14 m	-21 to -30 m
Pier No. 7	-14 m	-24 to -34 m
Pier No. 8	-14 m	-18 to -24 m
Pier No.16	-14 m	-18 to -20 m
		(Elevations below MLW)

The structural analysis are conducted at both the deepest and shallowest Gatun elevations.

(2) Longitudinal Pile Pitch

Frame skeletons were set up by each pier as shown in Figures 8-2-1, 8-2-2, 8-2-3 and 8-2-4. The longitudinal pile pitch is as follows:

Pier No. 6	13.7 m
Pier No. 7	13.7 m
Pier No. 8	9.15 m
Pier No.16	9.15 m

(3) Dead Loads

Dead loads include the self weight of super-structures (concrete beams and slabs) and sheds. In addition, the weight of foundation piles shall be considered since they are heavy (6.1 t/m) which cannot be ignored.

(4) Surcharge Load

A surcharge load of 3.7 t/m2 (750lb/sq.ft) is considered during the normal operation. This surcharge is equivalent to what had been considered in the original design.

(5) Berthing Force

The following fender reactions are considered in the analysis.

Table 8-4-2 Berthing Force

Vessel Size	Fender Reaction	Piers			
		No.6	No.7	No.8	No.16
50,000 DWT	60 t	o	o	o	
30,000 DWT	40 t	o	o	o	
20,000 DWT	30 t	o	o	o	
7,000 DWT	15 t				o

Note: "o" shows "applied".

The said reaction is assumed to be shared by several numbers of pile rows which is shown below.

Pier No.6	2 rows
Pier No.7	2 rows
Pier No.8	3 rows
Pier No.16	3 rows

(6) Seismic Force

Seismic force created by an earthquake is the horizontal inertia force acting on dead loads. The seismic force (H) is calculated by multiplying seismic coefficient (Kh) by dead weight (W).

$$H = W \times Kh$$

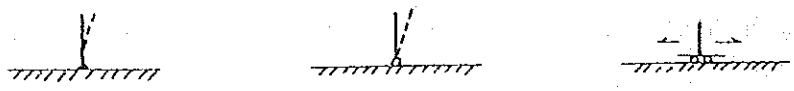
The proposed coefficient in this study is 0.20, however a series of Kh is assumed as 0.05, 0.10, 0.15 and 0.20 in the analysis.

(7) Beam and Pile Connections

The condition of connection between beams and piles is the rigidly fixed connection.

(8) Pile End Condition

The lowest end of piles were driven into Gatun Rock by rock excavation. Figure 8-4-1 shows the features of foundation piles.
The condition of the connection between piles and Gatun Rock is hard to define; it could be one of the following three types.



Fix Pin Roller

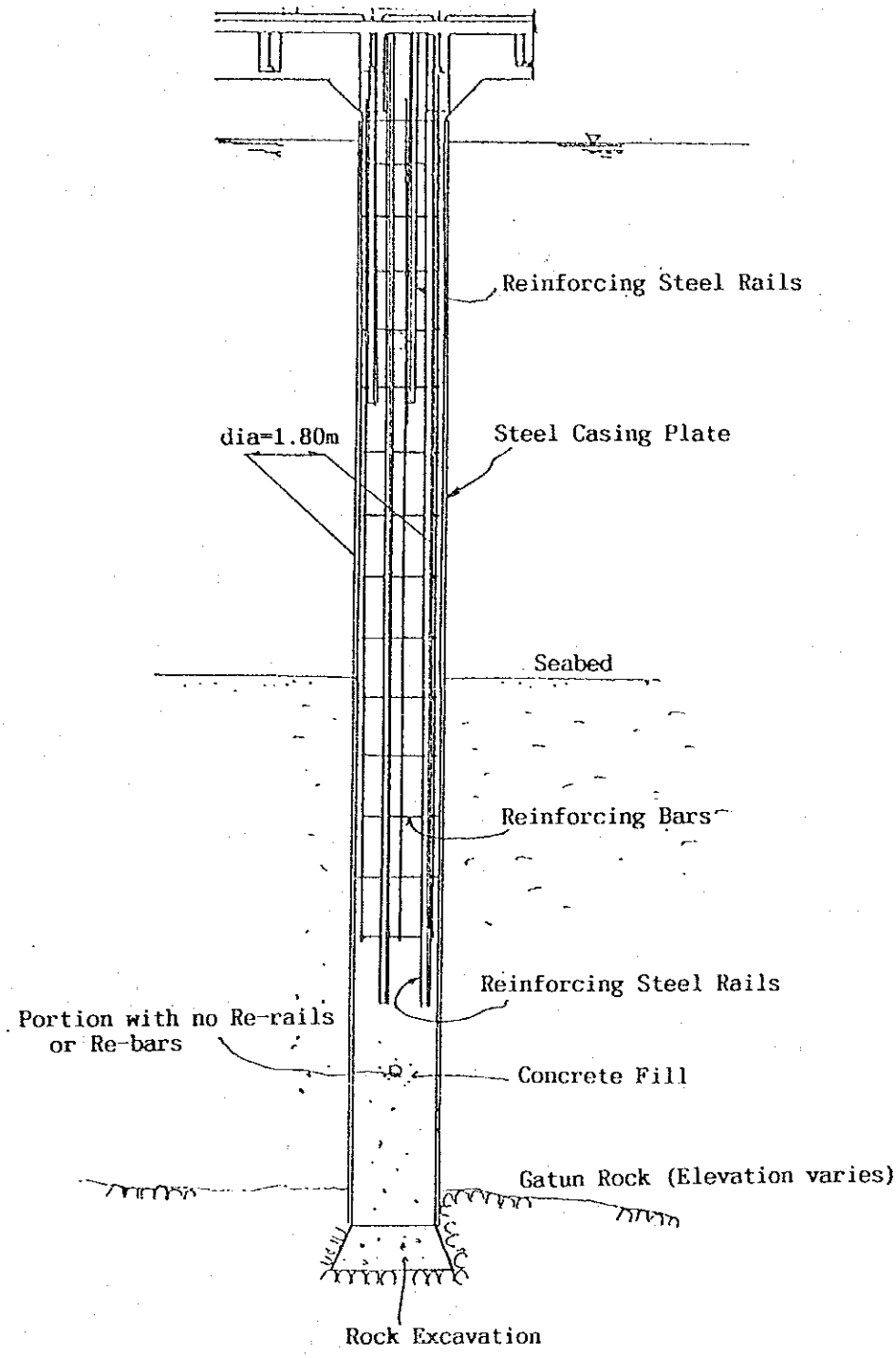


Figure 8-4-1 Features of Foundation Piles

If the rock excavation and concrete filling were done properly, the connection may be regarded as fix. If not, it may be pin. If the pile section is damaged (cracks or disconnection) and sub-soil is disturbed, it may be roller too.

From the above view points, the analysis has been conducted first of all at the fix-case followed by pin-case and roller-case. So that the analysis would show various results regardless of the connection status.

(9) Safety Factor

In this study, the safety factor is defined as follows:

$$\text{Safety Factor} = \frac{\text{Working Stress}}{\text{Allowable Stress}}$$

Thus, if the factor is 1.0 or more, the structure is evaluated as structurally durable.

(10) Sub-soil Condition

According to the soil investigation and the related data, the sub-soil condition between seabed and Gatun formation is mud or soft clay which does not seem to have lateral resistance to piles. However a proper subgrade spring (equivalent to N value = 1) will be given to the piles since the diameter of piles is wide (1.8m).

(11) Concrete Strength

Concrete strength can be defined from the result of the concrete core sampling and their compression test as mention in 8.3 of this chapter. The result indicates that the standard concrete quality of the piers' superstructures is assumed as Fc' = 240 Kg/cm2.

Therefore the following criteria shall be applied in the analysis.

Table 8-4-3 Concrete Strength

	Long-term	Short-term
Sc (Axial compressive stress	72 kg/cm2	108 kg/cm2
Sb (Bending compressive stress)	90 kg/cm2	135 kg/cm2
St (Tensional stress)	-3 kg/cm2	-4.5 kg/cm2

Figures 8-4-2 (a)(b)(c)(d) show the basic loading case by each pier.

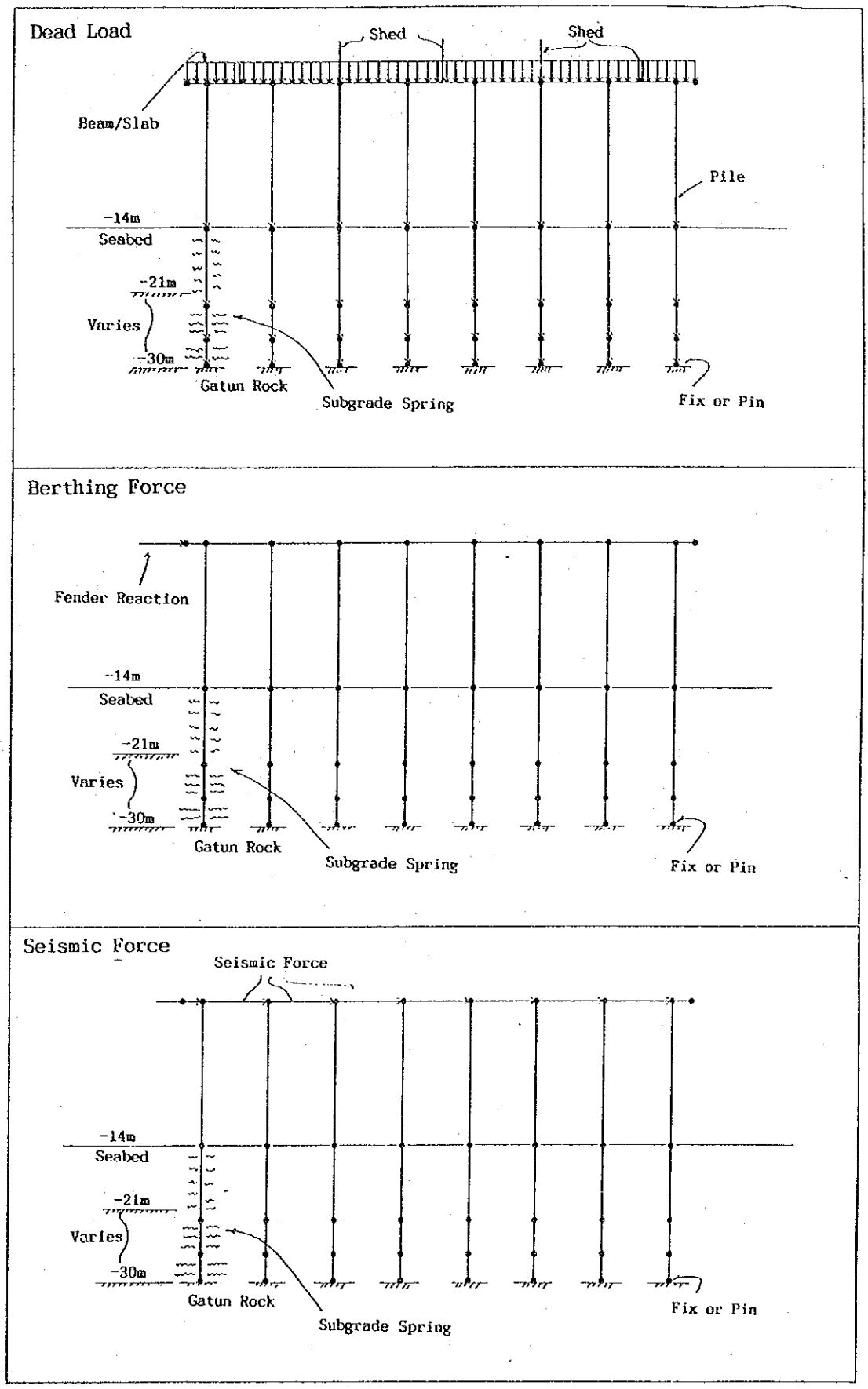


Figure 8-4-2 (a) Basic Loading Case : Pier No. 6

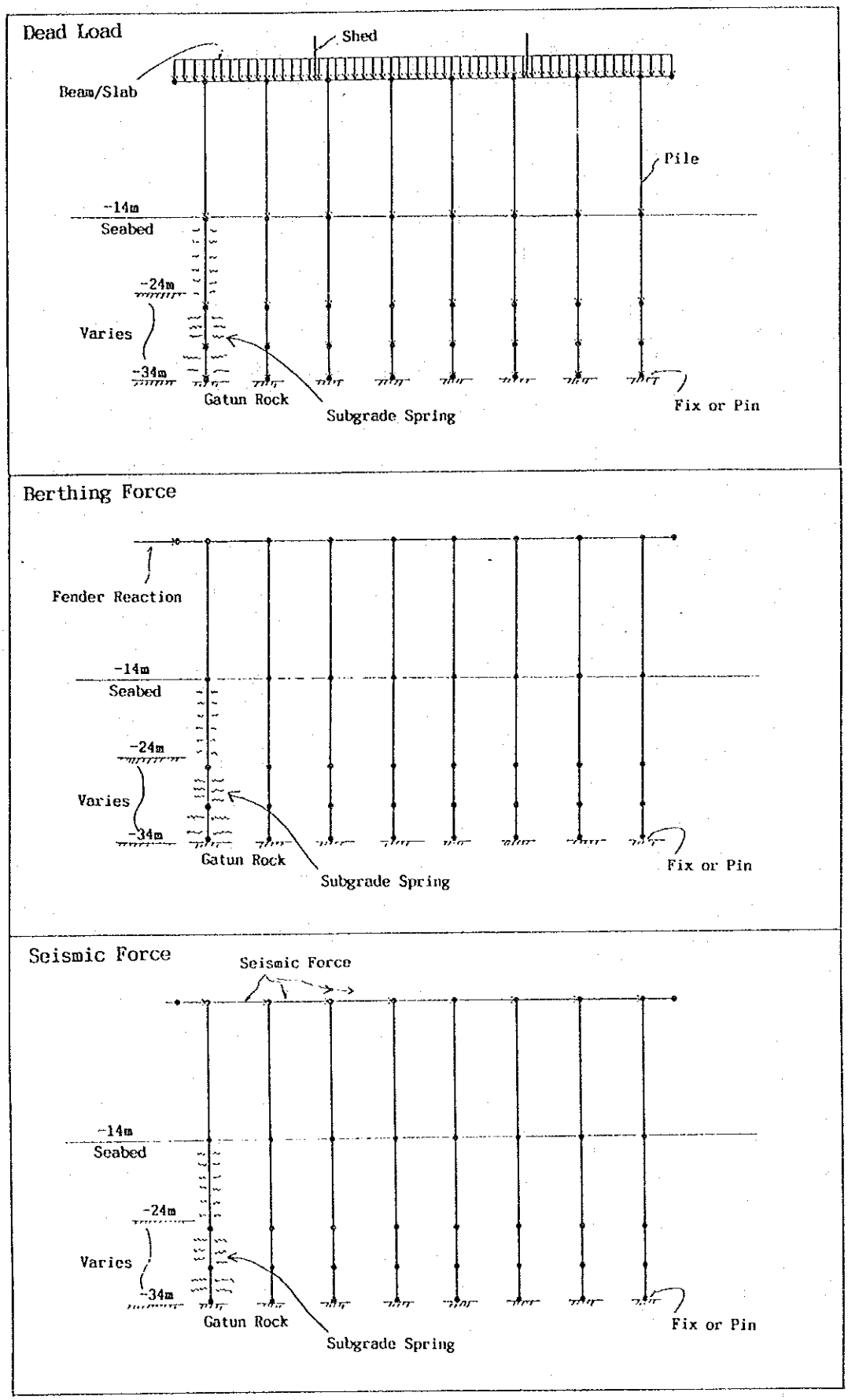


Figure 8-4-2 (b) Basic Loading Case : Pier No. 7

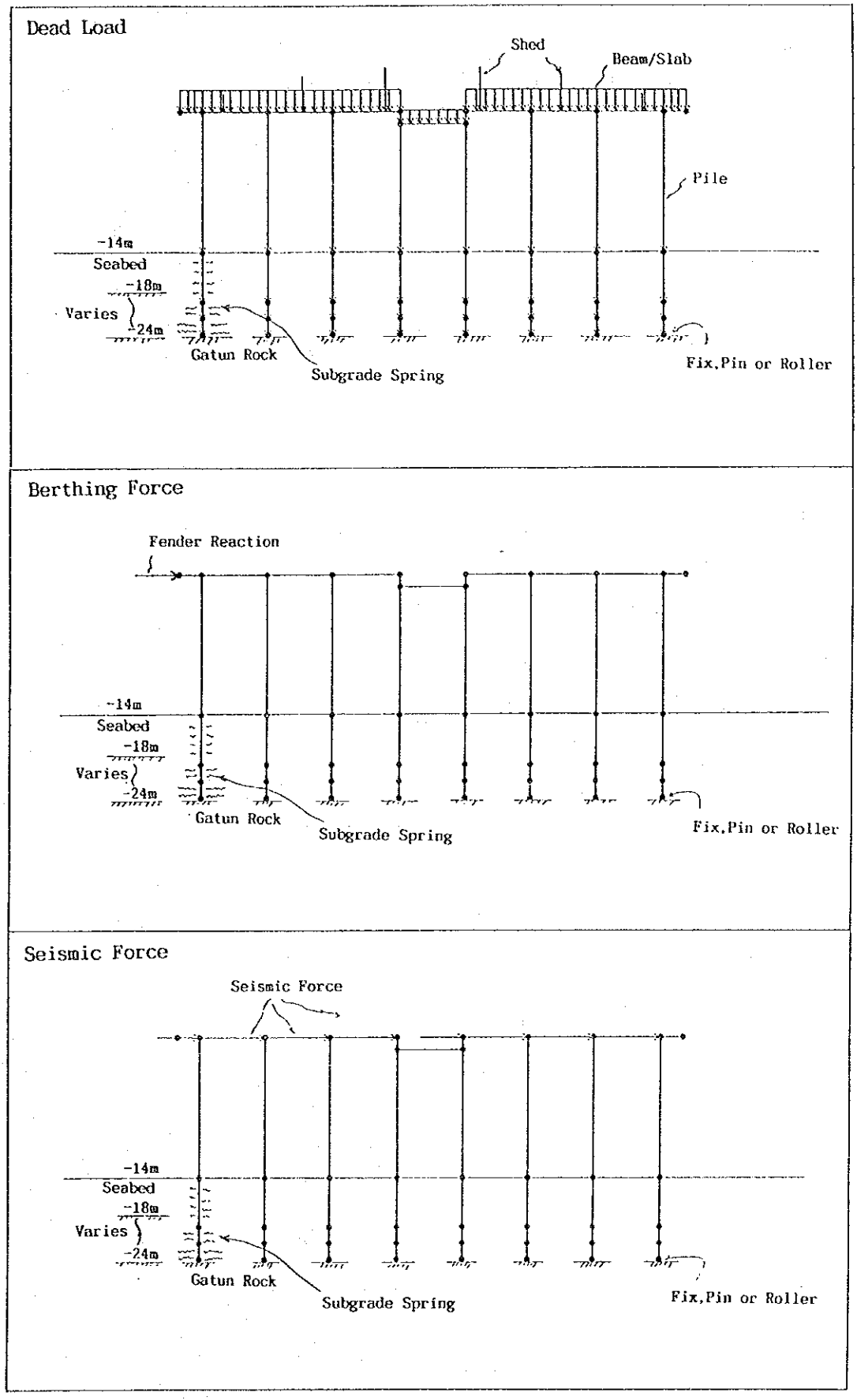


Figure 8-4-2 (c) Basic Loading Case : Pier No. 8

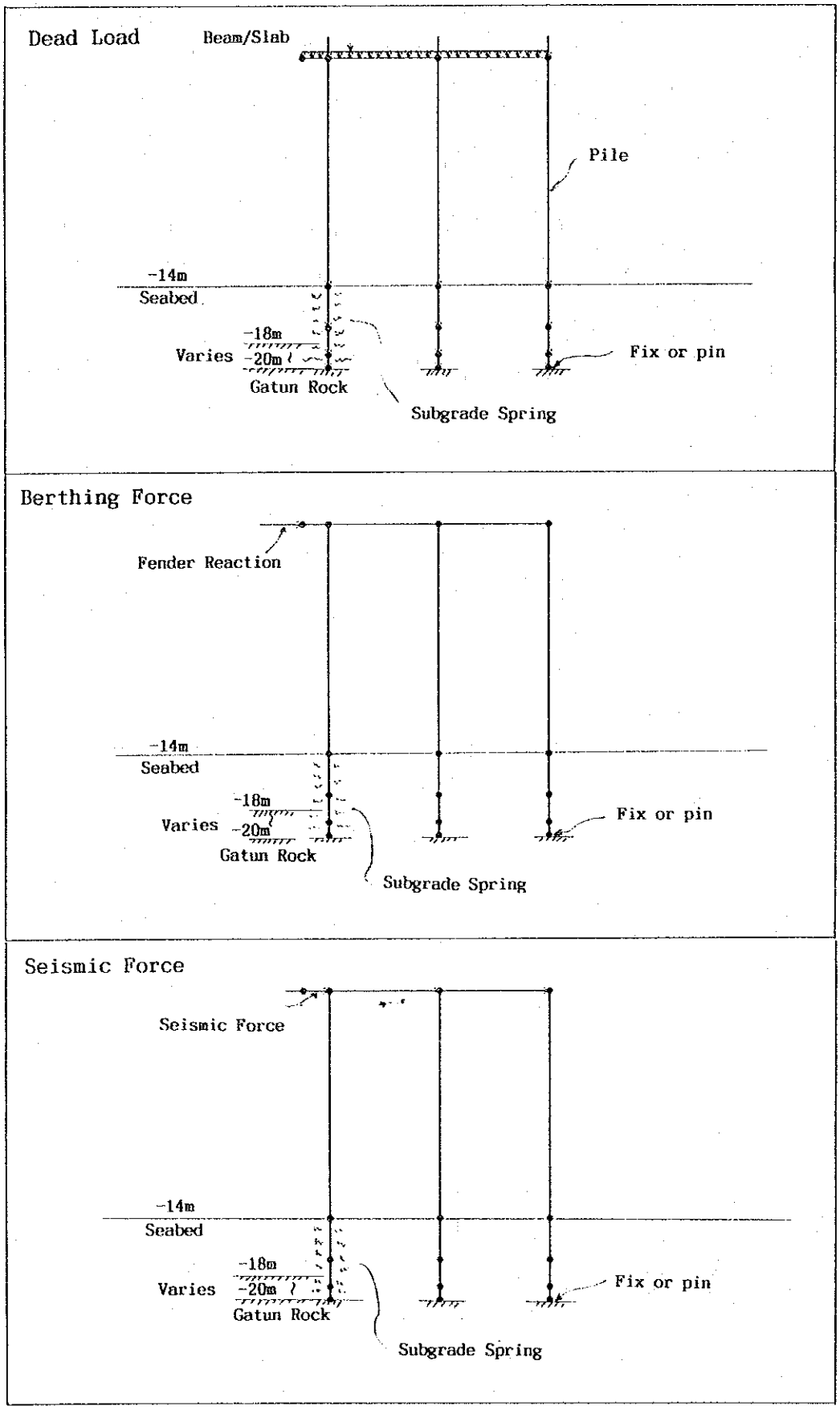


Figure 8-4-2 (d) Basic Loading Case : Pier No. 16

8.4.3 Points to be Highlighted

(1) The stability of the piers is thought to be very much influenced by the depth of Gatun formation. It may generally be thought the pier is less stable if the Gatun is deep. However, by taking into account the peculiarities of the structures (connection between piles and Gatun as well as soft sub-soil), a necessary attention should also be paid to the case that the Gatun is shallow.

(2) Sectional forces and stress of piles and beams would depend on the condition of pile/Gatun connection (fix, pin or roller). Generally if the said connection is fix, bending moment at the lowest pile end is large. If it is pin, then the bending moment at the same turns zero, but larger bending moment on the pile top and beam should occur.

In such a sense, a careful attention should be paid to evaluate which case (fix, pin or roller) is stable or unstable for the piers.

(3) According to the original drawings obtained, the foundation piles do not seem to be reinforced by steel rails or re-bars at their bottom end which surely is the weak point against tensional force. Therefore in the fixed-pile/Gatun-case, the tensional stress of non-reinforced concrete may exceed the allowable stress causing cracks. Then the connection turns to be pin or roller.

(4) Self weight of the piles is heavy (6.1t/m) which may decrease the tensional stress of the piles. Therefore the length of the piles (depends on the depth of Gatun) may affect the safety.

(5) Various types of external loads were taken into consideration, thus the result of analysis would clarify the durability of each pier quantitatively.

8.5 Result of Structural Analysis

8.5.1 Summary

(1) It has become clear that the depth of Gatun Rock surely have influence on the sectional forces of piles in the fix-case, that is;

M (pile top)(shallow) < M (pile top)(deep)
M (pile bottom)(shallow) > M (pile bottom)(deep)

where M : Bending moment
(bottom) : Lowest end of pile
(top) : Top of pile
(shallow) : Shallow Gatun Rock
(deep) : Deep Gatun Rock

When Gatun Rock is deep, M(bottom) becomes small because the moment extends over longer piles than the ones when Gatun Rock is shallow. Therefore the result shows M(bottom) at Pier No.8 is larger than Pier No.6, No.7 in the fix-case.

(2) An influence due to the pile/Gatun connection (fix, pin or roller) can be described as follows:

M (pile top)(fix)	< M (pile top)(pin/roller)
M (pile bottom)(fix)	> M (pile bottom)(pin/roller) = zero
M (beam)(fix)	< M (beam)(pin/roller)

When the pile/Gatun connection is fix, M(bottom) shares a part of M(top). But when it is pin or roller, M(bottom) becomes zero which causes a larger M(top). The result shows that M(pile top)(fix) of Pier No.8 is larger by 10 to 15% than that of Pier No.6, No.7, owing to the depth of Gatun Rock. However M(pile top)(pin) and M(pile top)(roller) are nearly the same figure for all the piers.

(3) Not only the heavy self weight of the super-structures but also the weight of piles, the piles do not have an tensional axial force in any loading case. A tensional stress on pile generates due to a bending moment, however all or most of the tensional stress vanishes by a compressive axial force by the self weight.

Therefore, a tensional stress on pile in the fix-case is regarded to be nil for Piers No.6, No.7 in the deepest case because their piles are long.

However, a tensional stress on pile concrete in the fix-case is exceeding an allowable stress in all piers in the shallowest case and Pier No.8 and No.16 in the deepest case. Figure 8-5-1 shows the critical depth of pile bottom at Pier No.6 in seismic cases Kh=0.20. Safety factor with respect to concrete tensile stress is rapidly increase after MLW -25 m. This figure indicates that safety factor on concrete tensile stress normally exceeds one if the pile bottom elevation is MLW -30m or deeper.

(4) Because of the pier's heavy self weight, seismic force is by far larger than berthing force. Therefore, the seismic case will be the point to be discussed in the evaluation work.

8.5.2 Result of Stress Calculation

(1) Safety of the members by pier against various loading cases are summarized in Table 8-5-1(a) and (b).

(2) Safety factors of stress against berthing forces are more than 3.0 for all the piers regardless of the condition of pile/Gatun connection or the depth Gatun. Therefore the piers are stable enough against the existing fender reactions which have been designed and installed for 50,000 DWT vessel (for Pier No.6, No.7 and No.8) and

7,000 DWT (for Pier No.16).

(3) If the pile/Gatun connection is fix and the Gatun formation is shallow, bending moment at the piles' bottom appears to be so large that tensional stress might be generated and that might create cracks at the pile/Gatun connections. However, no pull-out force acts on any piles.

(4) When cracks occurred at the pile bottom, the pile/Gatun connection turns to be pin connection from fix. And in the worse case, it becomes roller connection. In such cases, the bending moment at the pile top becomes larger than the fix-case, however the top of piles and beams have enough sectional areas and strength to resist against any possible forces.

(5) From the above results, it has proved that the piers are stable against such external loads as berthing forces and seismic force (Kh=0.20) although the condition of pile/Gatun connection turns to be pin or roller from the fix condition.

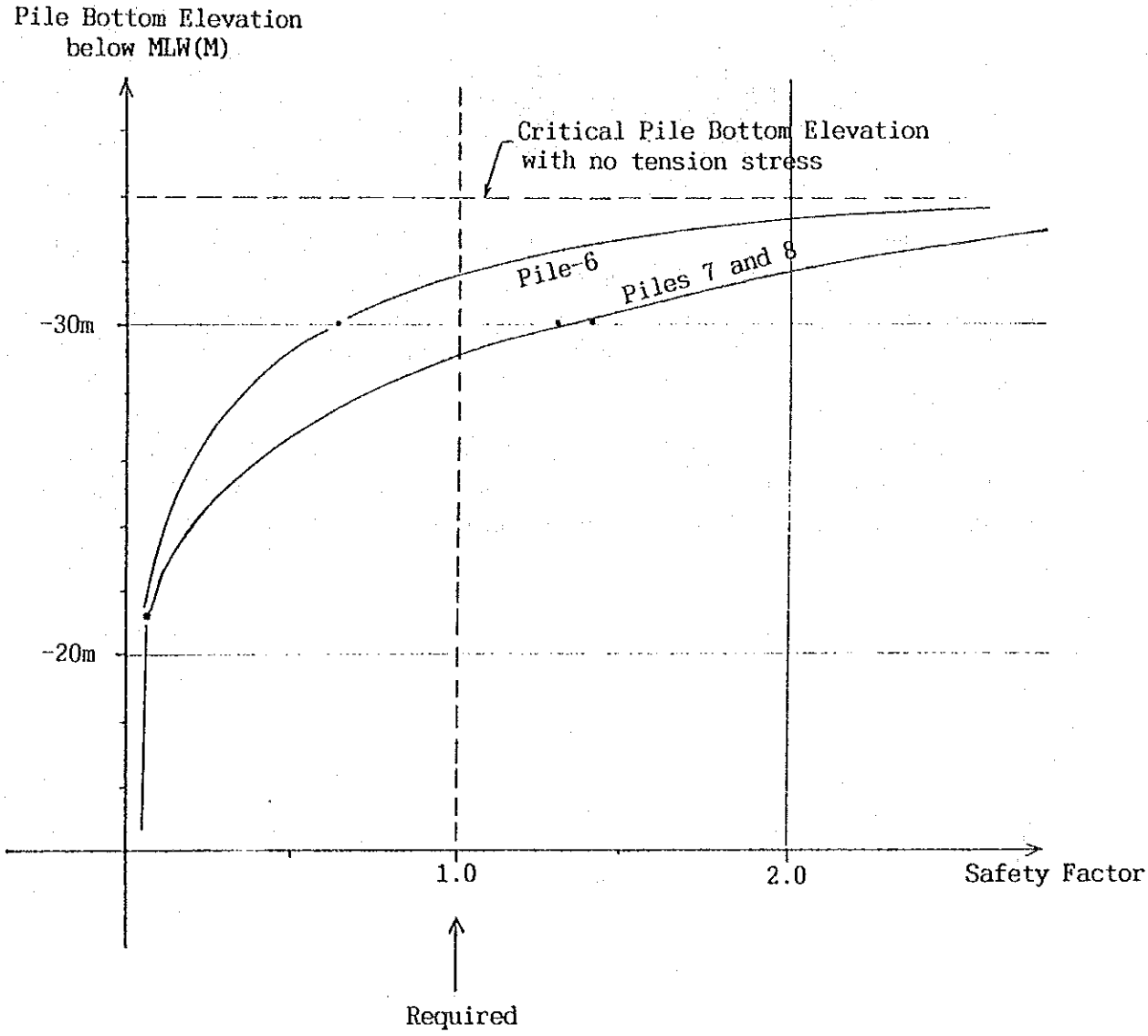
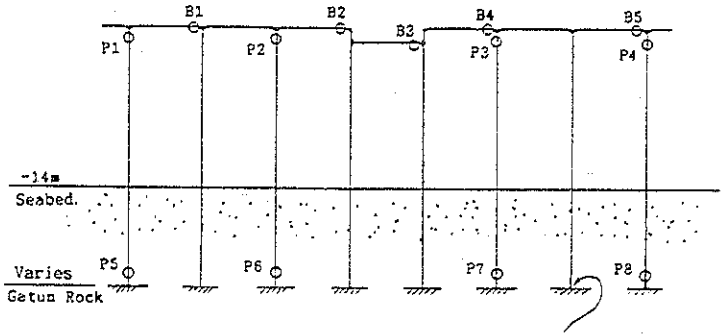


Figure 8-5-1 Critical Depth of Pile Bottom : Pier No.6
(at Seismic Condition of Kh = 0.20)

Piers	Case	Pile End : Fix													Pile End : Pin													Pile End : Roller											
		B1	B2	B3	B4	B5	P1	P2	P3	P4	P5	P6	P7	P8	B1	B2	B3	B4	B5	P1	P2	P3	P4	P5	P6	P7	P8	B1	B2	B3	B4	B5	P1	P2	P3	P4	P5	P6	P7	P8
No.8 Gatun -18m	Fender 20,000DWT																																							
	30,000DWT																																							
	50,000DWT																																							
	Seisimo Kh=0.05																																							
	Kh=0.10										x	x	x	x																										
	Kh=0.15										x	x	x	x																										
	Kh=0.20										x	x	x	x																										
No.7 Gatun -24m	Fender 20,000DWT																																							
	30,000DWT																																							
	50,000DWT																																							
	Seisimo Kh=0.05										x	x																												
	Kh=0.10										x	x	x	x																										
	Kh=0.15										x	x	x	x																										
	Kh=0.20										x	x	x	x						△		△	△																	
No.6 Gatun -21m	Fender 20,000DWT																																							
	30,000DWT																																							
	50,000DWT																																							
	Seisimo Kh=0.05										x	x	x	x																										
	Kh=0.10										x	x	x	x																										
	Kh=0.15										x	x	x	x																										
	Kh=0.20										x	x	x	x								△	△																	

Piers	Case	Pile End : Fix													Pile End : Pin												
		B1	B2	B3	B4	B5	P1	P2	P3	P4	P5	P6	P7	P8	B1	B2	B3	B4	B5	P1	P2	P3	P4	P5	P6	P7	P8
No.8 Gatun -24m	Fender 20,000DWT																										
	30,000DWT																										
	50,000DWT																										
	Seisimo Kh=0.05																										
	Kh=0.10										x	x	x	x													
	Kh=0.15										x	x	x	x													
	Kh=0.20										x	x	x	x													
No.7 Gatun -34m	Fender 20,000DWT																										
	30,000DWT																										
	50,000DWT																										
	Seisimo Kh=0.05																										
	Kh=0.10																										
	Kh=0.15																										
	Kh=0.20					△		△	△											△		△					
No.6 Gatun -30m	Fender 20,000DWT																										
	30,000DWT																										
	50,000DWT																										
	Seisimo Kh=0.05																										
	Kh=0.10																										
	Kh=0.15																										
	Kh=0.20										x																



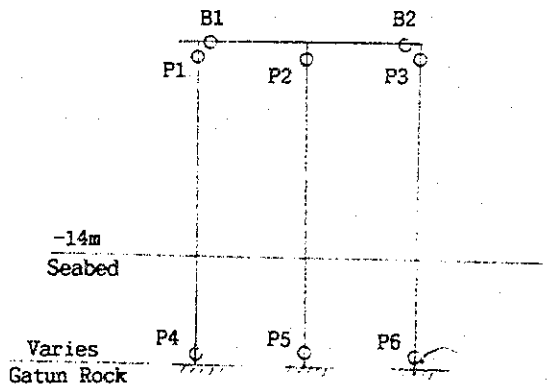
Gatun/Pile Connection : Fix, Pin or Roller

x : Tension stress exceeds the allowable thereby crack may occur.
△ : Stress exceeds the allowable but not critical.

Table 8-5-1 (a) Safety of Pier Members against External Forces
Piers No.6, No.7 and No.8

Pier	Case	Pile End : Fix								Pile End : Pin							
		B1	B2	P1	P2	P3	P4	P5	P6	B1	B2	P1	P2	P3	P4	P5	P6
No.16 Gatun -18m	Fender 7,000DWT																
	Seismic Kh=0.05																
	Kh=0.10						x	x	x								
	Kh=0.15						x	x	x								
	Kh=0.20						x	x	x								
No.16 Gatun -20m	Fender 7,000DWT																
	Seismic Kh=0.05																
	Kh=0.10																
	Kh=0.15						x	x	x								
	Kh=0.20						x	x	x								

x : Tension stress exceeds the allowable thereby crack may occur.
: Stress exceeds the allowable but not critical.



Gatun Rock Connection : Fix or Pin

Table 8-5-1 (b) Safety of Pier Members against External Forces
Pier No.16

8.5.3 Final Evaluation

(1) According to the design drawings that belong to APN, the finger piers as well as Pier No.16 were designed for a surcharge load of 3.7 t/m2 (750lb/sq.ft) as the operational condition.

This surcharge load is relatively big in comparison with the recent port design criteria. Therefore the piers can be utilized for such various purposes as general cargoes, passenger or even container handling purposes.

However, the existing concrete traverse beams will be required to be strengthened against the wharf crane load. Preliminary discussion regarding this upgrading work will be discussed in Part II. Chapter 6.

(2) The piers are stable against the possible maximum berthing forces. Therefore it will not be necessary to restrict vessel size for future utilization.

However, it should be studied carefully the necessity of two vessel berthing in one slip.

(3) Earthquake records in the past around the Cristobal area has not been obtained, however the result of visual investigation and structural analysis shows that the piers did not seem to have experienced big earthquakes since their completion in 1910's. Anyhow the piers are stable against the seismic force of Kh=0.20 which is the proposed figure and thought to be fairly enough for structures in this area.

(4) In order to lengthen the life time of the piers, a regular check-up should be made and necessary repairs should also be given to the piers' deck. The foundation piles should basically be alright, however bottom of the beams or slabs are to be required to be maintained well by anti-corrosion measures and/or patching works.

As for Pier No.16, a part of the concrete beams are damaged due to steel corrosion which is a little serious than that of the finger piers, therefore a necessary repair work should be given promptly as a routine maintenance work.

CHAPTER 9 CARGO HANDLING SYSTEM

9.1 Cargo Handling Equipment

9.1.1 Present Condition of Cargo Handling Equipment

The cargo handling equipment of the port of Cristobal is mainly used for container handling and general cargo handling.

Present condition of cargo handling equipment owned by APN is as follows:

(1) Container Crane

Two container cranes are installed on Pier No.9 which were constructed in 1984 (HITACHI) and 1986 (SAMSUNG) respectively. The main specification of each crane is almost the same as shown in Table 9-1-1.

Table 9-1-1 Specification of Container Crane

Item		Specification
Type of crane		Rope trolley, hinged boom type gantry crane
Rated load		40.6 tons under the spreader
Span		22.555 m
Trolley travel		
1) Outreach		36.576 m
2) Backreach		12.192 m
3) Total length of trolley travel		71.323 m
Lift		
1) Total lift		41.6 m
2) Lift above rail		26.6 m
3) Lift under rail		15.0 m
Power source		
1) Supply voltage		D.C 500 V
		A.C 480 v, 60 Hz, 3 Phase
Operating Rated Speeds		
Motion		Speed
Main hoist	Rated load	49 m/min.
	Spreader only	110 m/min.
	Intermediated load	Proportionally
Trolley travel		152 m/min.
Gantry travel		45.7 m/min.
Boom hoist(excluding latching time		5 min./one way

Source: APN
Notes: above specification is SAMSUNG

Table 9-1-2 shows the performance of container cranes during the year of 1992. HITACHI shows the highest working ratio of 388 hours/month. However, SAMSUNG shows only 93 hours/month as it was out of service due to broken Trolley Travel Gear from 31st Oct.1991 to 10th July 1992; the same trouble occurred from Dec. 1989 to May 1990.

Table 9-1-2 Performance of Container Cranes

Year: 1992

Month	No. of Ship	Operation Hours (hours)			
		HITACHI	SAMSUNG	Total	hrs/ship
January	15	415		415	27.7
Febuary	13	360		360	27.7
March	14	502		502	35.9
April	15	366		366	24.4
May	12	462		462	38.5
June	17	374		374	22.0
July	18	340	144	484	26.9
August	21	347	383	730	34.8
September	18	327	309	636	35.3
Total	143	3,493	836	4,329	30
hrs/month		388	93	481	

Source: APN

(2) Transtainer

There are two transtainers with a capacity of 40 tons at the container yard which were purchased in 1990 to increase the container handling efficiency. However, both transtainers were manufactured in 1968 and have greatly exceeded their regular working lifetime; not surprisingly, one was out of operation for 2 weeks to overhaul the engine and change electric cables.

(3) Top-Loader

There are seven top-loaders with a capacity of over 30 tons, however, at present, only one is kept in good working condition while the remaining six are in normal condition as shown in Table 9-1-3. Three of them have been in use for 10 years and are beyond their regular working lifetime.

(4) Reach-Stacker

The port has only one reach-stacker which is in good working condition as it was purchased in 1991.

(5) Tractor and Chassis

There are twenty-four tractors, of which sixteen are kept in good working condition, one is in normal condition and the remaining seven are in bad condition. The port has fourteen chassis, six are kept in good condition, four are in normal condition but waiting for spare tires etc. and the remaining four are in bad condition as shown in Table 9-1-3.

(6) Forklift

There are forty-four forklifts; thirty-two are in good condition most of which were

purchased in 1985-1990, eleven are in normal condition, however, three of them were purchased in 1980 and one is bad condition as shown in Table 9-1-4.

Table 9-1-3 Classification of Cargo Handling Equipment

As of November 1992

Kind of Equipment	Purchase Year	Capacity (ton)	Manufacture	No. of Unit	Working Condition		
					Good	Norm	Bad
Transtainer	1990	30	PACECO	1	●		
	1990	30	PACECO	1		●	
	Total			2	1	1	0
Top-Loader	1984	30	LANSING	1		●	
	1981	30	CATERPILLAR	1		●	
	1981	35	RAYGOWAGNER	1		●	
	1981	40	PETTIBONE	1		●	
	1987	30	KOBELCO	1		●	
	1988	35	KENWOOD DART	1		●	
	1991	40	CATERPILLAR	1	●		
	Total			7	1	6	0
Reach-Stacker	1991	42	KALMAR	1	●		
	Total			1	1	0	0
Tractor	1981	-	OTAWA	1	●		
	1981	-	OTAWA	1	●		
	1981	-	OTAWA	1			●
	1983	-	OTAWA	1	●		
	1984	-	CAPACITY	1			●
	1984	-	CAPACITY	1	●		
	1984	-	CAPACITY	1	●		
	1984	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1985	-	CAPACITY	1	●		
	1989	-	CAPACITY	1	●		
	1989	-	CAPACITY	1	●		
	1989	-	CAPACITY	1	●		
	1989	-	CAPACITY	1	●		
	1989	-	CAPACITY	1			●
	1989	-	CAPACITY	1			●
	1989	-	CAPACITY	1			●
	1989	-	CAPACITY	1			●
	1989	-	CAPACITY	1			●
	1989	-	CAPACITY	1		●	
	Total			24	16	1	7
Chassis							
	Total			14	6	4	4

Source: APN

Note: Good: in good operating condition
Norm: requires some miner repaired
Bad: almost unrepairable

Table 9-1-4 Classification of Forklifts

As of November 1992

No.	No. of Reg.	Purch-ase Year	Capa-city (ton)	Manufacture	No. of Unit	Working Condition			
						Good	Norm	Bad	
1	125	1989	2	KOMATSU	1	●			electric
2	126	1989	2	KOMATSU	1	●			electric
3	127	1989	2	KOMATSU	1	●			electric
4	128	1989	2	KOMATSU	1	●			
5	129	1989	2	KOMATSU	1	●			
6	130	1989	2	KOMATSU	1	●			Coco Solo
7	8	1980	4	YALE	1			●	
8	23	1980	4	CATERPILLAR	1		●		
9	24	1980	4	CATERPILLAR	1		●		
10	34	1980	4	CATERPILLAR	1		●		
11	4-15	1980	4	CATERPILLAR	1	●			
12	102	1984	4	KOMATSU	1		●		
13	103	1984	4	KOMATSU	1		●		
14	104	1984	4	KOMATSU	1	●			
15	105	1984	4	KOMATSU	1		●		
16	109	1985	4	KOMATSU	1		●		
17	110	1985	4	KOMATSU	1	●			
18	111	1985	4	KOMATSU	1	●			
19	112	1985	4	KOMATSU	1	●			
20	100	1985	4	TOYOTA	1		●		
21	4-42	1989	4	KOMATSU	1	●			
22	113	1989	4	KOMATSU	1		●		
23	114	1989	4	KOMATSU	1		●		
24	115	1989	4	KOMATSU	1	●			
25	116	1989	4	KOMATSU	1	●			
26	117	1989	4	KOMATSU	1	●			
27	118	1989	4	KOMATSU	1	●			
28	119	1989	4	KOMATSU	1	●			
29	120	1989	4	KOMATSU	1	●			
30	121	1989	4	KOMATSU	1	●			
31	122	1989	4	KOMATSU	1	●			
32	123	1989	4	KOMATSU	1	●			
33	124	1989	4	KOMATSU	1	●			
34	131	1990	4	CATERPILLAR	1	●			
35	132	1990	4	CATERPILLAR	1	●			
36	133	1990	4	CATERPILLAR	1	●			
37	134	1990	4	CATERPILLAR	1	●			
38	135	1990	4	CATERPILLAR	1		●		
39	136	1990	4	CATERPILLAR	1	●			
40	137	1990	4	CATERPILLAR	1	●			
41	138	1990	4	CATERPILLAR	1	●			
42	139	1990	4	CATERPILLAR	1	●			
43	-	1985	8	KOMATSU	1	●			
44	4745	1985	10	CLARK	1	●			
Total					44	32	11	1	

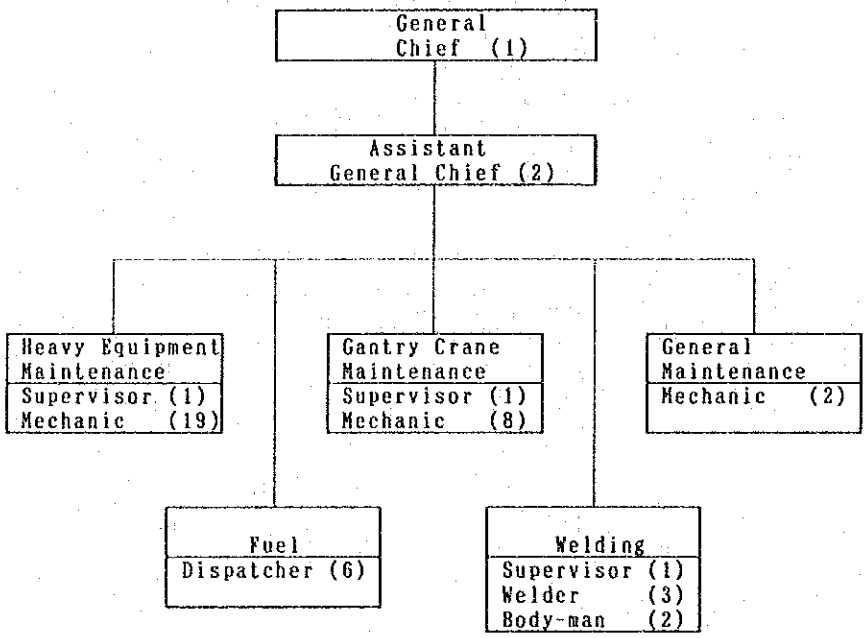
Source: APN

Note Good: in good operating condition
Norm: requires some miner repaired
Bad: almost unrepairable

9.1.2 Present Condition of Maintenance of Equipment

(1) Organization and Number of Employees

The maintenance and repair of equipment are carried out by the Mechanic Department which consists of forty-five employees as shown in Figure 9-1-1.



Source: APN
Notes: The figure in ( ) is number of persons

Figure 9-1-1 Organization Chart of Mechanic Department

(2) Working Hours

Maintenance work is carried out in three shifts with the following time table:

1st shift	:	from 07:00 to 15:00
2nd shift	:	from 15:00 to 23:00
3rd shift	:	from 23:00 to 07:00

(3) Maintenance and Repair

Generally, small scale maintenance and repair work are carried out by this dept. while large scale repair is referred to a private company. However, in practice, all repair works are performed by this dept.

At present, the maintenance of small forklifts with a capacities of 2 to 4 tons is performed every three months while maintenance of heavy handling equipment is conducted every two months.

(4) Spare Parts

When new equipment is received, the section makes up a spare parts list and keeps it in stock; the spare parts are supplied according to the annual budget. The spare parts inventory is controlled by card system.

(5) Workshop

Small scale maintenance and repair work are mainly performed in the workshop.

Type of equipment currently installed in the workshop is shown in Table 9-1-5.

Table 9-1-5 Present Condition of Workshop

As of November 1992

Kind of Equipment	Capacity	Unit	Condition	
			Good	Bad
Lathe		1	1	
Air Compressure		2	2	
Tire Changer		2	1	1
Hydraulic Pressure	200t	1	1	
	30t	1	1	
Drill Press		1	1	
Grinding Wheel		1	1	
Valve Refacing Unit		1	1	
Bench Vice		6	6	
hydraulic Hose Maker		1	1	
Grease rock	4t	1	1	
Electric Hoist	1t	3	1	2

Source: APN

Note: Good: in good operating codition
Bad: almost unrepairable

9.2 Cargo Handling System

9.2.1 Present Condition of Cargo Handling Operation

(1) Related Organization for Cargo Handling Operation

Main functions of the related department for cargo handling operation at the port of Cristobal are summarized as in Table 9-2-1.

Table 9-2-1 Main Functions of the Related Department for Cargo Handling Operation at the Port

Functin	Verification Dept.	Cargo Handling Dept.	Container Cotrol Dept.	Freight House Dept.
Information on vessels (PCC)		●		
Assignment of pier		●		
Arrangemet of gang		●		
Arrangement of handling equipmnt.		●		
Arrangement of operators		●		
Operation of cargo handling at pier		●		
Document control of imp. cont.(empty)	●			
Document control of imp. cont.(full)	●			●
Document control of exp. cont.(empty)	●			
Document control of exp. cont.(full)	●			
Receiving/delivering cargo at shed				●
Receiving/delivering cargo at CFS				●
Receiving/delivering cont. at CY			●	
Checking cont.(imp./exp.) at pier	●			
Checking cont.(imp./exp.) at main gate	●		●	
Checking cont.(imp./exp.) at terminal gate	●		●	
Checking cont.(imp./exp.) at CY			●	
Inventry of containers at CY			●	
Storage control at CY			●	
Storage control of empty cont. at port area			●	
Storage control of imp. cont.(full) at CY				●

Notes: This table was made based on APN'materials and field survey by the study team

(2) Classification of the Cargo Handling Operations at Pier

At present, the cargo handling operations at each pier are managed by APN and are classified into two categories; a) by vessel type, b) by combination of handling equipment as shown in Table 9-2-2.

(3) Formation of Gang

Formation of gang and total number of workers belonging to the Cargo Handling Department are shown in Table 9-2-3.

However, at present stevedores and operators of forklift and tractor are hired from private companies to cover the insufficient number of available personnel. One private company has eight gangs and is given about 25 % or sometimes more of total cargoes per month from APN.

(4) Performance of Container Handling

As mentioned above, container handling at the port is carried out by combination of handling equipment; container handling volume at each pier in 1991 is shown in Table 9-2-4.

Table 9-2-2 Cargo Handling Operation at Each Pier by Vessel Type by Combination of Handling Equipment

Year: 1991

	Kind of Handling Equipment	Number of Vessel								
		Type of Vessel								Total
		V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	
Pier No.6										
	E-1									
	E-2	14	2		1				2	19
	E-3	14	16		23	2	1	9	4	69
	E-4			8	1		2			11
	E-5	1			1	3				5
	Total	29	18	8	26	5	3	9	6	104
Pier No.7										
	E-1									0
	E-2	30		1	7			4		42
	E-3	45	4	1	22	3	3	7	7	92
	E-4			7		1	1		1	10
	E-5	8			4			1		13
	Total	83	4	9	33	4	4	12	8	157
Pier No.8										
	E-1									0
	E-2									0
	E-3	3	3		3			2		11
	E-4	1			4			1		6
	E-5				1					1
	Total	4	3	0	8	0	0	3	0	18
Pier No.9										
	E-1	58			5	1		1	1	66
	E-2								1	1
	E-3								1	1
	E-4			2						2
	E-5	65			7	7		6	1	86
	Total	123	0	2	12	8	0	7	4	156
Pier No.10										
	E-1									0
	E-2	23			2	1				26
	E-3	39	1	1	11	4		5	5	66
	E-4			1						1
	E-5	14	1		2	1		2		20
	Total	76	2	2	15	6	0	7	5	113
Pier No.16										
	E-1									0
	E-2									0
	E-3	1	1							2
	E-4			5			1			6
	E-5									0
	Total	1	1	5	0	0	1	0	0	8

Source: APN

Notes:
V-1: vessel carries only containers
V-2: vessel carries only general cargoes
V-3: vessel carries only vehicles
V-4: vessel carries mixed cargoes(containers and gen. cargoes)
V-5: vessel carries mixed cargoes(containers and vehicles)
V-6: vessel carries mixed cargoes(gen. cargoes and vehicles)
V-7: vessel carries mixed cargoes(cont., g.cargoes and vehi.)
V-8: vessel carries only empty containers
E-1: gantery crane on the pier
E-2: mobile crane on the pier
E-3: winch on the ship
E-4: ramp
E-5: mixed crane(gantry, mobile, winch and ramp)

Table 9-2-3 Formation of Gang and Total Number of Workers

(1) Formation of gang

Type of Vessel	Formation	By Ship Gear No. of Workers		By Gantry Crane No. of Workers	
		Land-side	Ship-side	Land-side	Ship-side
Container	First Foreman	1or2	1	1or2	1
	Tally Clerk	1		1	
	Gantry Crane Operator			3	
	Crane Operator		3		
	Fofklift Operator	1		1	
	Tractor Driver	4		5	
	Worker	2	8	2	8
	Total	9or10	12	13or14	9
Conventional	First Foreman	1or2	1		
	Tally Clerk	1			
	Crane Operator		3		
	Fofklift Operator	1			
	Tractor Driver	4			
	Worker	2	8		
	Total	9or10	12		
Ro-Ro	First Foreman	1			
	Tally Clerk	1			
	Tractor Driver	5			
	Worker	6			
	Total	13			

(2) Total number of workers

	Number of Workers
First Foreman	12
Tally Clerk	-
Gantry Crane Operator	8
Crane Operator	39
Fofklift Operator	48
Tractor Driver	19
Mobil Crane Ope.	3
Heavy Lift Operator	12
Worker	130
Total	271

Source: APN

Table 9-2-4 Container Handling Volume at Each Pier

Year: 1991

Pier No.	Container	Month												Total
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
6	Import													
	ful 20"	495	8	70	115	170	145	119	86	521	51	140	347	2,267
	ful 40"	190	64	43	44	32	17	71	18	235	15	142	193	1,064
	emp 20"			30	107	30	132		21	20	106	20		466
	emp 40"		4	27				34	33	43	173	8		322
	Export													
	ful 20"	15	68	112	90	252	82	114	133	156	118	158	33	1,331
	ful 40"	11	74	45	67	68	70	42	38	108	78	98	44	743
	emp 20"	1,007	64	36	6	98	182		76	392	404	4	559	2,828
	emp 40"	346	20	10	25		24	18	2	130	128		240	943
	Total(TEU)	2,611	464	498	590	750	763	563	498	2,121	1,467	818	1,893	13,036
7	Import													
	ful 20"	142	182	315	590	84	231	613	295	442	1,417	487	466	5,264
	ful 40"	119	126	137	232	44	92	258	165	202	551	345	130	2,401
	emp 20"	36	98	312	187	41	16	299	172	255	117	126	219	1,878
	emp 40"		26	65	103	0	23	126	107	63	126	105	99	843
	Export													
	ful 20"	116	330	336	480	211	251	459	360	432	904	384	501	4,764
	ful 40"	34	95	138	170	48	151	119	237	354	418	220	180	2,164
	emp 20"	47	288	61	627	9	237	254	37	80	666	493	275	3,074
	emp 40"	9	187	28	31		140	67	12	11	321	313	53	1,172
	Total(TEU)	665	1,766	1,760	2,956	529	1,547	2,765	1,906	2,469	5,936	3,456	2,385	28,140
8	Import													
	ful 20"	80	27	82		120	53	33	3	156	9	94		652
	ful 40"		1	52		34	11	10		15	10			133
	emp 20"					24	30							54
	emp 40"			7				6			14			27
	Export													
	ful 20"	45	20	68		127	53	23	6	40	7	25	5	419
	ful 40"		2	3		44	4	4	1	17	4	4		83
	emp 20"	38		32		50	37	100		72				329
	emp 40"	9	8	7		42	5			10				81
	Total(TEU)	181	69	320	0	561	213	196	11	352	67	127	5	2,102
9	Import													
	ful 20"	1,061	1,536	1,289	1,265	1,713	1,629	2,334	2,006	1,715	1,873	2,020	764	19,205
	ful 40"	646	818	649	760	890	683	1,136	1,128	792	1,004	907	795	10,208
	emp 20"			17	20						1			38
	emp 40"		26		2	1		12	3		25	6	11	86
	Export													0
	ful 20"	116	207	141	185	195	51	87	79	66	254	99	82	1,562
	ful 40"	61	185	1,219	127	169	52	97	47	53	169	73	64	2,316
	emp 20"	989	1,700	1,115	1,201	1,139	1,155	1,464	1,225	1,254	1,706	507	1,050	14,505
	emp 40"	584	541	412	810	1,013	814	713	364	364	807	505	745	7,672
	Total(TEU)	4,748	6,583	7,122	6,069	7,193	5,933	7,801	6,394	5,453	7,844	5,688	5,126	75,874
10	Import													
	ful 20"	361	583	142	262	658	578	251	474	222	432	647	410	5,020
	ful 40"	207	418	208	437	432	371	237	453	385	800	575	300	4,823
	emp 20"	69		1	36		31		5		24	10	22	198
	emp 40"	62	120	52	168	12	111	30	45	16	29	31	115	791
	Export													
	ful 20"	146	144	61	111	187	353	51	224	113	329	141	167	2,027
	ful 40"	157	156	139	189	210	237	25	179	144	204	115	199	1,954
	emp 20"	183	227	43	224	577	154	73	515	78	249	132	9	2,464
	emp 40"	34	132	200	222	243	88	66	373	189	491	327	98	2,455
	Total(TEU)	1,679	2,606	1,445	2,665	3,216	2,730	1,091	3,318	1,881	4,082	3,026	2,016	29,755
Total	Import													
	ful 20"	2,139	2,336	1,898	2,232	2,745	2,636	3,350	2,864	3,056	3,777	3,388	1,987	32,408
	ful 40"	1,162	1,427	1,089	1,473	1,432	1,174	1,712	1,764	1,629	2,380	1,969	1,418	18,629
	emp 20"	105	98	360	350	95	209	299	198	275	248	156	241	2,634
	emp 40"	62	176	151	273	13	134	208	188	122	367	150	225	2,069
	Sub total	3,468	4,037	3,498	4,328	4,285	4,153	5,569	5,014	5,082	6,772	5,663	3,871	55,740
	(TEU)	4,692	5,640	4,738	6,074	5,730	5,461	7,489	6,966	6,833	9,519	7,782	5,514	76,438
	Export													
	ful 20"	438	769	718	866	972	790	734	802	807	1,612	807	788	10,103
	ful 40"	263	512	1,544	553	539	514	287	502	676	873	510	487	7,260
	emp 20"	2,264	2,279	1,287	2,058	1,873	1,765	1,891	1,853	1,876	3,025	1,136	1,893	23,200
	emp 40"	982	888	657	1,088	1,298	1,071	864	751	704	1,747	1,145	1,128	12,323
	Sub total	3,947	4,448	4,206	4,565	4,682	4,140	3,776	3,908	4,063	7,257	3,598	4,296	52,886
	(TEU)	5,192	5,848	6,407	6,206	6,519	5,725	4,927	5,161	5,443	9,877	5,253	5,911	72,469
Grand total		7,415	8,485	7,704	8,893	8,967	8,293	9,345	8,922	9,145	14,029	9,261	8,167	108,626
	(TEU)	9,884	11,488	11,145	12,280	12,249	11,186	12,416	12,127	12,276	19,396	13,035	11,425	148,907
	(%)	6.6	7.7	7.5	8.2	8.2	7.5	8.3	8.1	8.2	13.0	8.8	7.7	100.0

Source: APN

9.2.2 Present Condition of Container Terminal

(1) Organization and Number of Workers

Container terminal at the port of Cristobal is managed by Container Control Department which consists of forty-three employees as shown in Figure 9-2-1.

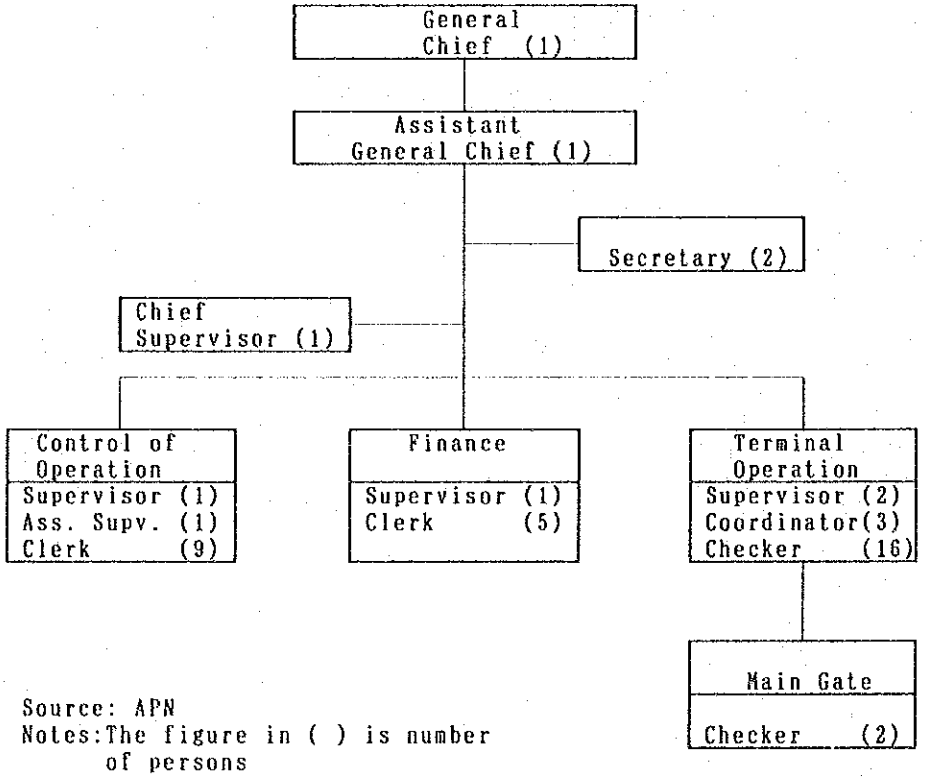


Figure 9-2-1 Organization Chart of Container Control Department

(2) Management of Terminal

1) The delivery/receiving of containers is carried out from 08:00 to 16:00 (Monday - Friday). For Saturday, Sunday, holidays and port holiday (1st, Oct.), all delivery/receiving is made on an overtime basis. However, on Dec.24th and Dec.31st, the port has special working hours such as from 07:00 to 21:00.

2) The starting time for receiving containers is five days before a vessel's ETA (Estimated Time of Arrival), and the closing time for receiving container is twenty-four hrs. or forty eight hrs. prior to the vessel's ETA according to the amount of containers.

3) Free storage periods for various types of container are set in the following manner;

Loaded export : seven normal days (exclusive of Sat., Sun. and holidays)

Loaded import : five normal days (exclusive of Sat., Sun. and holidays)
Transhipment : thirty normal days (exclusive of Sat., Sun and holidays)

(3) Control of Container Terminal Operation

Container terminal operation is mainly controlled by the two sections mentioned above under the general chief. Main functions of these sections are as follows:

1) Inventory Control of Containers

The inventory of containers is managed by container control section; the allocation of containers is controlled using cards which are placed in a board divided in the same way as the yard. There is one card for each container and one color for each shipping agency. Each card has specific container data such as date of delivery, name of the vessel, shipping agency and etc.

2) Container Delivering/Receiving at Yard

Container delivering/receiving at yard is managed by terminal operation section. The received container is allocated by checker according to order of section's supervisor. The movement of containers at yard is controlled by checker and all records are sent to container control section.

3) Terminal Gate

This dept. has the main responsibility for the terminal gate which is controlled by two personnel of this dept. together with the following personnel:

a) Security officer
b) Customs officer
c) Quarantine officers

4) Handling Equipment

As mentioned above, container handling equipment is assigned by cargo handling dept. according to the request from container control dept.

Daily assigned handling equipment owned by APN at the container terminal is as follows:

a) one reach-stacker
b) three top-loaders
c) seven or eight tractors
d) three or four chassis

At present APN does not own enough equipment to meet its daily

requirements, thus the following equipment is obtained from a private company:

a) eight top-loaders
b) one 30 tons forklift
c) three 10 tons forklifts
d) ten tractors

The assignment of above equipment is mainly divided into two categories as follows:

a) APN's equipment is used for delivery of container to the outside of port.
b) Private company's equipment is used for delivering/receiving container from/to vessel and is hired by shipping agent. Shipping agent is given special tariff of USD 90/TEU instead of USD 130/TEU.

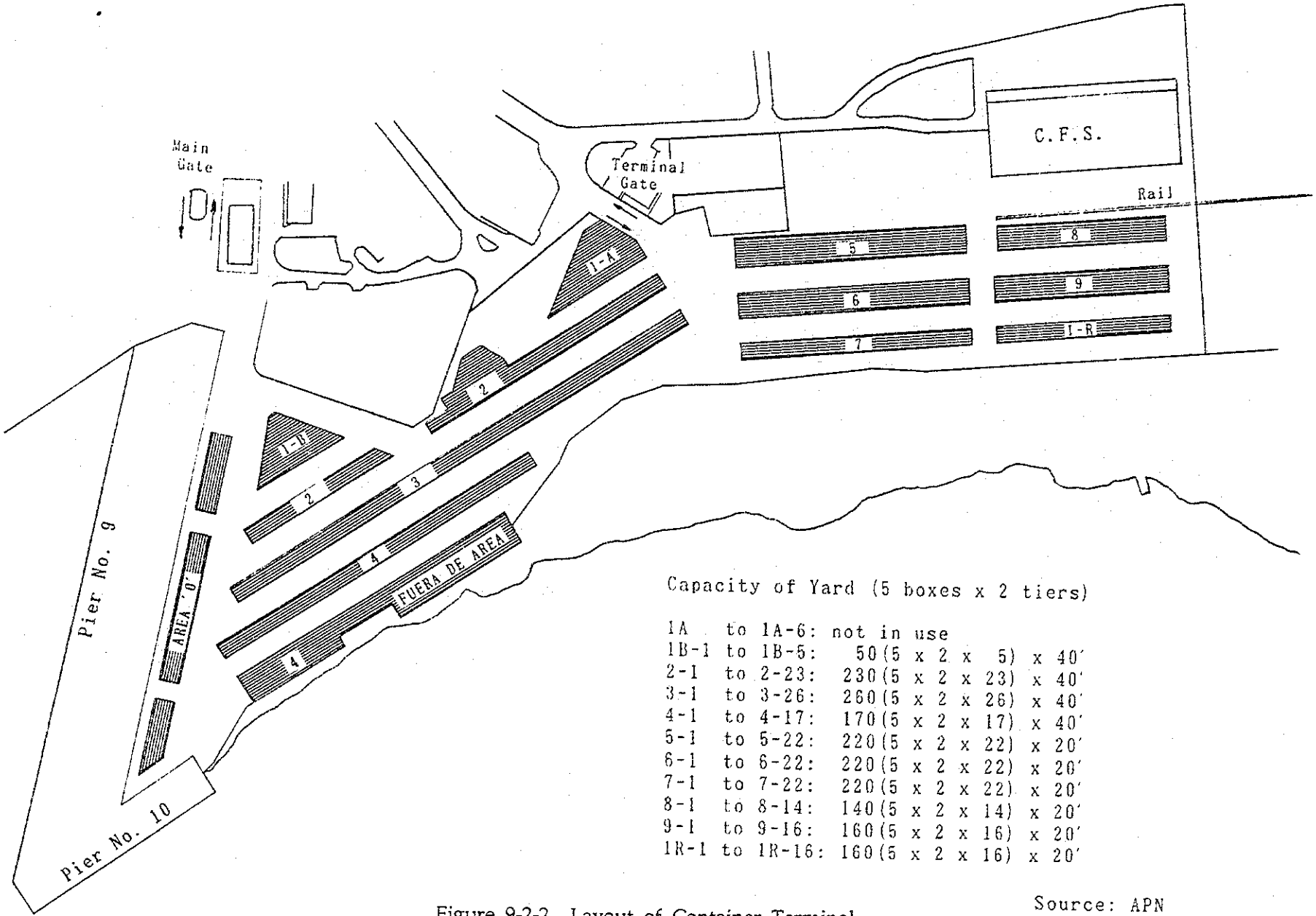
(4) Layout of Container Terminal

Container terminal with a total storage area of 7.5 ha is allocated behind pier Nos.9 and 10, and CFS with a total floor area of around 6,300 sq.m is situated within container yard.

Storage area is divided into one area and eleven sections as shown in Figure 9-2-2, and utilization of these sections is as follows:

Area "0"	:	only export containers
Section 1-A	:	not in use
Section 1-B	:	40' import containers
Section 2,3	:	same as 1-B
Section 4	:	not in use
Section 4 (FUERA DE AREA)	:	empty containers
Section 5,6,7,8,9,1-R	:	20" import containers

* Section 8 is area for CFS'containers
* Section 1-R is area for refrigerated containers



Capacity of Yard (5 boxes x 2 tiers)

1A	to 1A-6:	not in use	
1B-1	to 1B-5:	50(5 x 2 x 5)	x 40'
2-1	to 2-23:	230(5 x 2 x 23)	x 40'
3-1	to 3-26:	260(5 x 2 x 26)	x 40'
4-1	to 4-17:	170(5 x 2 x 17)	x 40'
5-1	to 5-22:	220(5 x 2 x 22)	x 20'
6-1	to 6-22:	220(5 x 2 x 22)	x 20'
7-1	to 7-22:	220(5 x 2 x 22)	x 20'
8-1	to 8-14:	140(5 x 2 x 14)	x 20'
9-1	to 9-16:	160(5 x 2 x 16)	x 20'
1R-1	to 1R-16:	160(5 x 2 x 16)	x 20'

Source: APN

Figure 9-2-2 Layout of Container Terminal

(5) Performance of Container Terminal

1) Container Movement at Container Terminal

Table 9-2-5 shows the number of containers through the gate in Oct.1992.

Table 9-2-5 Container Movement Through the Gate

Year: 1992 Month: October

Day	Gate In				Gate Out				Total				
	Full		Empty		Full		Empty		Full		Empty		
	20'	40'	20'	40'	20'	40'	20'	40'	20'	40'	20'	40'	TEU
1	35	35	263	153	117	49	11	10	152	84	274	163	920
2	89	70	141	136	104	72	19	23	193	142	160	159	955
3	46	34	2	82	20	12	14	48	66	46	16	130	434
4									0	0	0	0	0
5	8	2	68	52	76	73	49	32	84	75	117	84	519
6	19	2	31	261	130	93	17	7	149	95	48	268	923
7	22	9	40	96	140	83	3	3	162	92	43	99	587
8	60	11	111	130	150	129	7	3	210	140	118	133	874
9	74	19	15	41	162	98	14	11	236	117	29	52	603
10	54	5	37	12	122	62	57	5	176	67	94	17	438
11									0	0	0	0	0
12	15	14		70	75	39	6	46	90	53	6	116	434
13	44	31	41	89	141	95	7	3	185	126	48	92	669
14	28	11	40	26	127	60	102	5	155	71	142	31	501
15	91	81	18	33	119	46	37	4	210	127	55	37	593
16	15	22	156	6	91	52	18	6	106	74	174	12	452
17	15	18	79	149	34	9	1	7	49	27	80	156	495
18						4			0	4	0	0	8
19	24	11	81	118	70	29	8	17	94	40	89	135	533
20	31	10	154	152	105	94	43	2	136	104	197	154	849
21	103	103	33	29	86	44	56	15	189	147	89	44	660
22	40	34	67	11	134	113	3	4	174	147	70	15	568
23	88	52	97	14	151	70	5		239	122	102	14	613
24	44	29	13	1	142	92	21	29	186	121	34	30	522
25	5	9		127	6	11			11	20	0	127	305
26	36	16	21	128	123	76	38	14	159	92	59	142	686
27	18	25	31	51	177	111	32	8	195	136	63	59	648
28	34	36	117	10	177	89	26	10	211	125	143	20	644
29	40	20	103		58	20			98	40	103	0	281
30	104	36	186	236	141	96	55	4	245	132	241	240	1,230
31	37	20	186	98	60	51	45	2	97	71	231	100	670
Total	1,219	765	2,131	2,311	3,038	1,872	694	318	4,257	2,637	2,825	2,629	17,614

Source: APN

2) Dwelling Time at the Port

Table 9-2-6 shows the dwelling time of containers at the port. The average dwelling time of containers at present is as follows:

Import container (full)	:	8.9 days
Import container (empty)	:	10.4 days
Export container (full)	:	2.8 days
Export container (empty)	:	6.5 days
Transship container	:	10.3 days