(2) Japanese Expert Mission の報告書

Santiago, Chile

April 2, 1985

Mr. Hugo de la Fuente R.
Ingeniero - Director
Dirección de Obras Portuarías
Ministerio de Obras Públicas

Dear Mr. De la Fuente,

Please find attached here with our report on the investigation of damage to facilities in the port of Valparaíso caused by the March 3, 1985 earthquake. I hope you to put full effort for restoring and expanding the port of Valparaíso along with the guidelines shown in this report.

This report was compiled based on the result of investigation carried out during one week of stay. Without a substantial and efficient support of Chilean engineers, it would not be possible to compile this report. On behalf of the Mission, I would like to express my gratitude to you and Chilean engineers.

Sincerely yours,

Akio Nakase, Dr. Eng.,
Leader, Japanese Expert Mission

c.c. to: Sr. Ministro de Obras Públicas
: Sr. Ministro de Transportes y Telecomunicaciones
: Sr. Director General de la Política Exterior
: Embajada del Japón
: Agencia de Cooperación Internacional del Japón

REPORT ON DAMAGE TO PORT FACILITIES
IN THE PORT OF VALPARAISO
BY THE EARTHQUAKE ON MARCH, 3 1985

APRIL 2, 1985

JAPANESE EXPERT MISSION

C O N T E N T

1 Introduction 167

2 Outline of the Port of Valparaiso 169

2-1 Role of the Port of Valparaiso 169

2-2 Port Facilities 169

2-3 Port Activities 170

3 Description of Earthquake on March 3, 1985 180

3-1 Earthquake Event 180

3-2 Ground Motions in the Port of Valparaiso 180

3-3 Liquefaction and Landslide 181

4 Earthquake Damage 185

4-1 Types of Structures in the Port of Valparaiso 185

4-2 Ground Conditions 186

4-3 Descriptions of Damage to Facilities 188

4-4 Cause of Damage 189

4-5 Restriction to the Immediate Use of Facilities 212

5 Basic Concepts for Restoration 215

5-1 Restoration and Development Plan 215

5-2 Earthquake Resistant Design of Facilities 219

5-3 Methods for Restoration 223

5-4 Remarks on Restoration Works 226

6 Suggestions 228

7 Concluding Remarks 230

Appendix

A Design Seismic Coefficient 231

B On the Damage to the Port of San Antonio 238

I.- Introduction

The six man expert mission of the Japanese Govermment was sent to Chile at request of the Chilean Govermment for the purpose of investigating the damage to port and harbour facilities, mainly in the Port of Valparaiso, caused by the March 3, 1985 earthquake.

The mission's task includes an evaluation of the possibilities of immediate use of the damaged facilities and making recommendations for the future plan of restoration and development of the port and harbour facilities from engineeringpoint of view.

Member's List of Japanese Expert Mission

Leader:

Prof. Akio NAKASE : Professor, Civil Engineering, Tokyo Institute of Technology

Seismic Analysis:

Dr. Hajime TSUCHIDA : Director, Structures Division, Port and Harbour Research Institute, Ministry of Transport

Construction:

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Design:

Mr. Hisao OUCHI : Deputy Director, Engineering Division, Ports and Harbours Bureau, Ministry of Transport

Cargo Handling:

Mr. Hiroshi NAMIKI : Head, Technology Division, Japan Cargo Handling Mechanization Association

Itinerary and Activities of the Mission

Mar. 23 (Sat.)	Arrival at Santiago, except for the Leader.
Mar. 24 (Sun.)	Collection of information in Santiago.
Mar. 25 (Mon.)	Meeting with engineers of the Ports Bureau, Ministry of Public Works in Santiago.
Mar. 26 (Tue.)	The Leader arrived at Santiago. Official visit to Ministries of Public Works, Transport and Communication, Foreing Affairs. Moved to Valparaiso.
Mar.27 (Wed.)	Investigation of facilities in the Port of Valparaiso.
Mar. 28 (Thu.)	Ditto.
Mar. 29 (Fri.)	Ditto. Moved to Santiago
Mar. 30 (Sat.)	Investigation of facilities in the Port of San Antonio (day return).
Mar. 31 (Sun.)	Preparation of report.
Apr. 1 (Mon.)	Ditto.

2.- Outline of the Port of Valparaíso

2.1.- Role of the Port of Valparaíso in Republic of Chile

The port of Valparaíso is the nation's largest foreign trade port for Santiago region, where about 40% of the nation's population and manufacturing production are concentrated. The socio - economic activities of Santiago region require close industrial and economic ties with foreign countries through import of industrial products, chemical products and comestible products and the export of fruits, copper and comestible products. The port of Valparaiso has supported the development of the Santiago region and is expected to perform the vital role for the development of the region in future, as a gateway to the sea, linking the region with foreign countries.

2.2.- Port Facilities

2.2.1.- The port of Valparaiso is the nation's largest port with a deep sea breakwater, 10 wharves, 31 cranes, 12 hectare of warehouses and 5 ha of container storage area. (Fig. 2-1) (Table 2-1)

2.2.2.- Wharves were constructed between 1915 and 1930; (Nos. 9, 10 : 1915 - 1920, Nos. 1 to 8 : 1922 - 1930). At that time, the ships were small and cargo volumes were also small and the port had sufficient capacity.

Today the ships have grown larger and cargo work at the wharf has been mechanized. The width of the aprons and the areas of port site, etc. no longer meet the modern standard. For intance, apron widths are less than 20 m., which is modern standard, and containers are stacked every open space in the port due to shortage of container storage area.

In addition, deterioration of reinforced concrete members is obvious at wharves Nos. 4, 9 and 10.

Therefore, redevelopment of port facilities should be carried out to modernize and strengthen the port facilities.

2.2.3.- The Mission concluded by visual inspection that the Barron Pier (Nos. 9, 10) is in danger of collapse due to deterioration of reinforced concrete members.

The Mission recommends to stop using the Baron Pier and to carry out detailed structural inspection and examination of the necessity of the Baron Pier from the view point of cargo handling, before reinforcement and restrictive usage of the Pier.

2.2.4.- Layout of cranes

Layout and the main specification of cranes are shown on the Figure 2 - 2 and Table 2 - 2.

No.26 crane not shown on the Berth No.7 have fallen down by the earthquake.

2.3.- Port Activities

2.3.1.- Table 2-3 shows trend of cargo volumes handled at 11 ports managed by the EMPORCHI and that at the port of Valparaiso.

Chilean economy recorded about 8 % of high economic growth rate during 1976 - 1981. Chile economic activity, however, has been stagnated due to world recessions since 1981. At today the economic activity is getting better slowly.

According to these changes of Chilean economy, cargo volumes handled at 11 ports managed by the EMPORCHI reached about 8.895 thounsand tons in 1980, then decreased to about 8.364 thousand tons and restored 1980's level in 1984.

On the other hand, cargo volumes handled at the port of Valparaiso reached about 2.316 thousand tons in 1981, dro pped drastically to about 1.529 thousand tons in 1982 and remains at 1.664 thousand tons in 1984.

In future, cargo volumes handled at the port of Valparaiso is considered to be increased steadily according to the growth of Gross Domestic Products of Chile, growth of populations of Santiago region and growth of the production of fruits and others.

2.3.2.- The cargo volume handled at the port of Valparaiso in 1984 amounted 1.664.730 tons, foreign trade being 1.402.728 tons and domestic trade 173.018 tons.

In 1984, the leading export commodity was fruits (55% of export cargoes), followed by copper. As for imports, industrial products was the leading import commodity, followed by chemical products and comestible products. (Table 2-4).

2.3.3.- In general, a quay with water depth of 10 m is capable of handling a total of 200.000 tons of general cargoes per year.

A comparison of this standard capacity with the operation results from each quay shows that the standard is exceeded at wharves No. 1, No. 2, No. 3 and No. 8. Conversely, wharves No.4, No. 5, No. 7, No. 9 and No. 10 handle cargo volumes smaller than their standard capacities. This is due presumably to insufficient quay length (No.5, No.7), deterioration of facilities (No.9, No.10) and construction works for a crane (No.4). (Table 2-1)

2.3.4.- The number of containers handled at the port of Valparaíso in 1984 was 42 thousands (41% of the national, 102 thousands), and the container cargoes was about 310 thousands tons.

The volume of container cargoes represents about 22% of the foreign trade cargoes.

Containerization on the west coast of South America has passed its introductory phase and entered into a period of sustained growth. Full-container ships are in service, containerization of general cargoes is making rapid progress and the ports of these pacific coast countries have a large number of containers stacked and waiting for movilization.

Though the history of containerization is merely 20 years, old ports that lack facilities to receive container ships have become internationally less competitive with diminished prospects for further development.

At the port of Valparaiso a container handling crane was provided at No.4 wharf in 1984 to meet containerization and container storage area of 12 hectars were provided behind the No.4 wharf.

At this stage, container handling facilities should be improved not to get far behind the increase of the containers.

But there is still a limit to the berthing at large full-container ships at the No.4 berth and containers are stacked at every open space.

Therefore development of container terminal should be carried out to facilitate the berthing of large container ships and handling containers.

Fig. 2-1

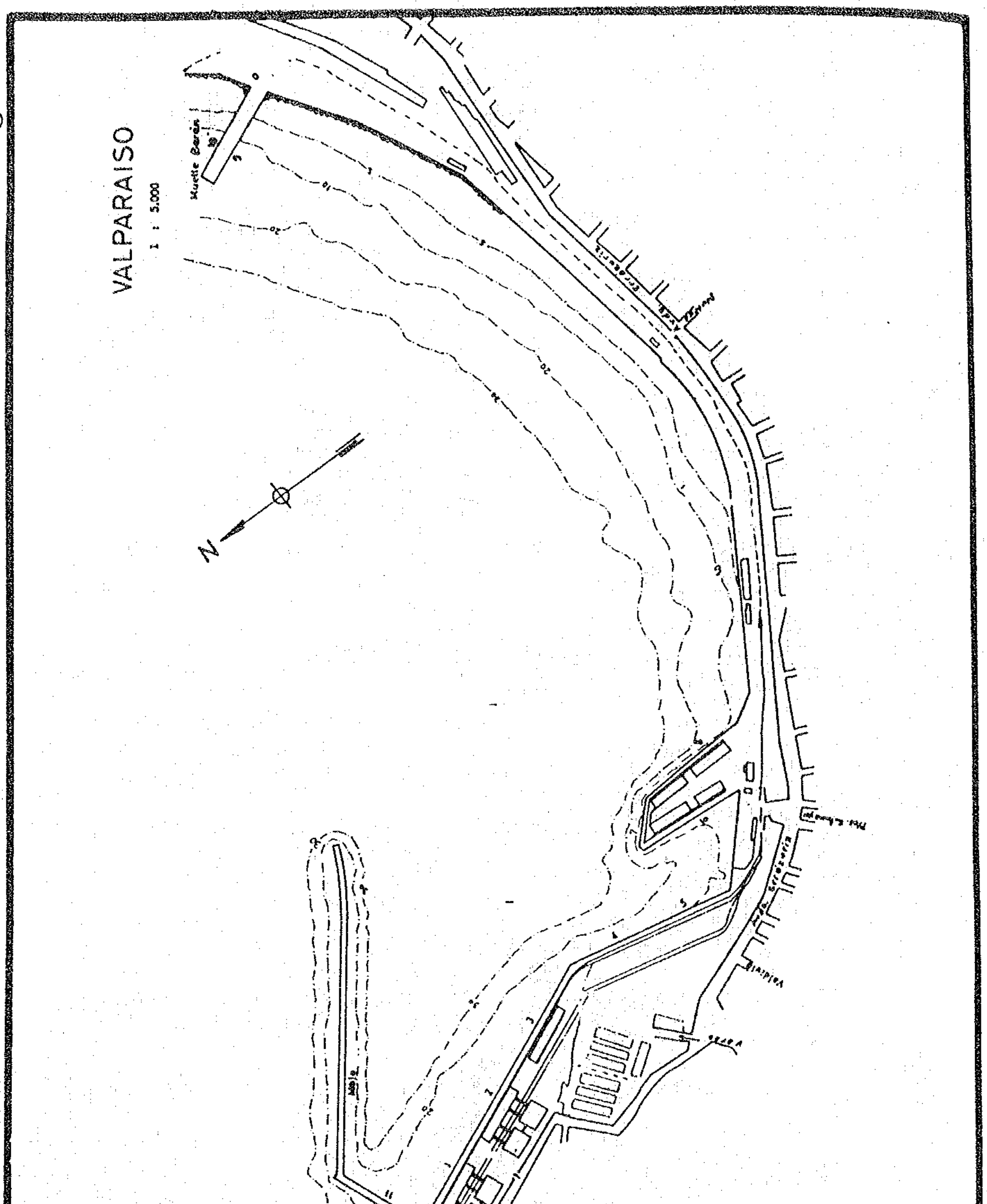


Fig 2-2

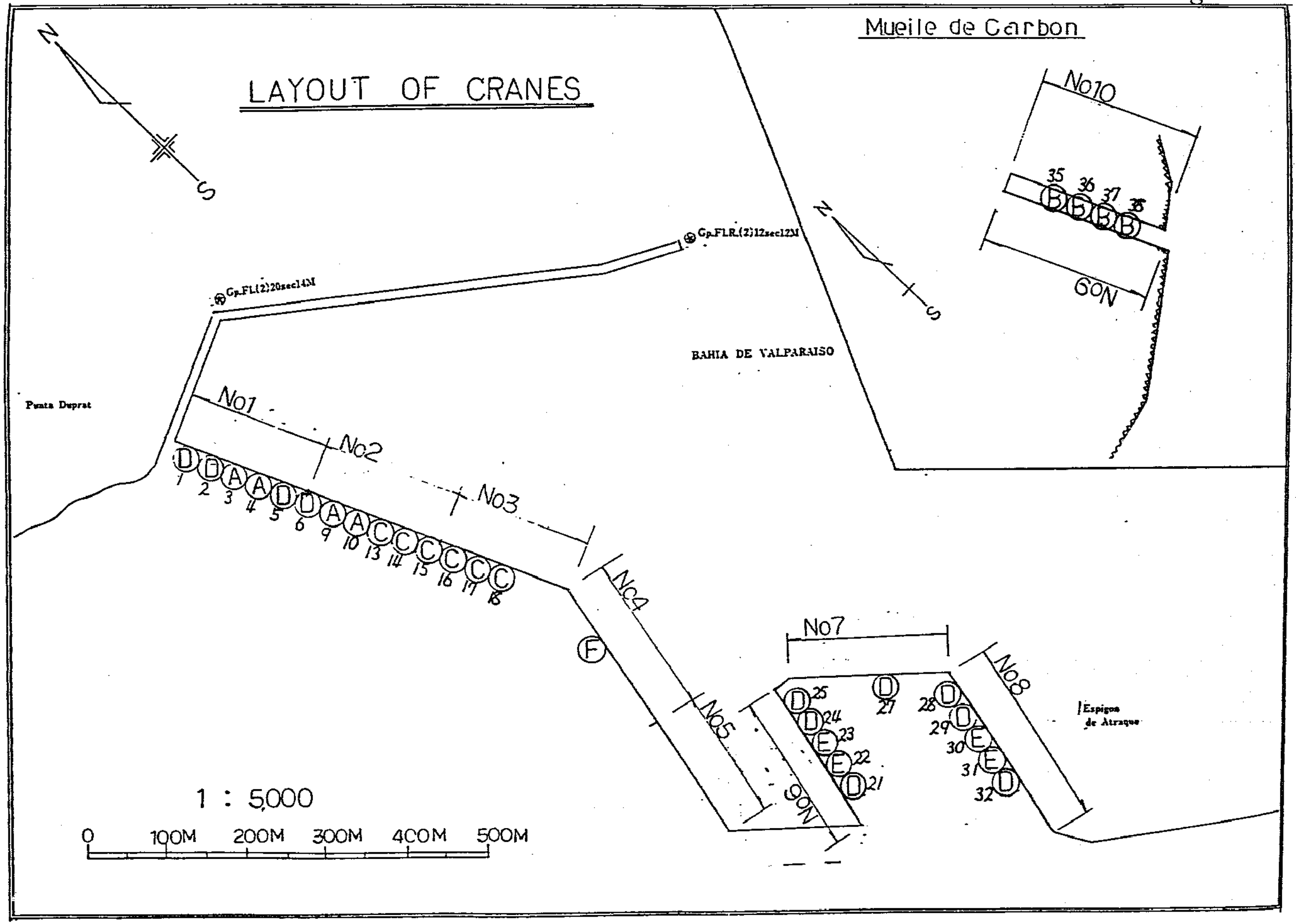

LAYOUT OF CRANES
Mueile de Carbon
N
S
Gp.FL(2)20sec14M
Gp.FLR.(2)12sec12M
BAHIA DE VALPARAISO
Punta Deprat
Espigon de Atraque
No1
No2
No3
No4
No5
No6
No7
No8
No10
60N
90N
1 : 5,000
0
100M
200M
300M
400M
500M

Table 2-1

Facilities and Activities of Valparaiso Port

(Before Earthquake)

Berth's No.	Mooring facility (quay)				Ships Calling in 1984	Cargoes Handled in 1984					Cargo Handling Equipment (Crane etc.)			
	Management Body	Lenght (m)	Depth (m)	Year of Completion	Number	Total (t)	Main Commodities				Manage-ment Body	Number	Nominal Capacity (t/h) Rated Load (t)	Used from
							Kind	Volume (t)	Kind	Volume (t)				
1	EMPORCHI	185	9.5	1922-1932	115	226.174 (1.223)*	P.I	56.832	P.Q	27.408	EMPORCHI	4	2.555t/h	3/1973
2	EMPORCHI	185	10.0	1922-1932	134	315,845 (1.707)	C	78.019	P.I	69.767	EMPORCHI	4	6.1 t	4/1953
3	EMPORCHI	260	11.0	1922-1932	129	320.761 (1.233)	C	65.500	P.I	49.361	EMPORCHI	5		6/1966
4	EMPORCHI	220	10.0	1922-1932	45	88.055 (400)	F	29.207	P.C	8.239	SAAM	1	600 t/h 30.5 t	1985
5	EMPORCHI	155	10.0	1922-1932	54	108,256 (698)	F	20.228	P.I	14.640	SAAM	-	-	-
6	EMPORCHI	245	9.0	1922-1932	108	229,828 (938)	F	151.987	P.I	18.397	EMPORCHI	5	2.115 t/h	1973
7	EMPORCHI	120	9.0	1922-1932	42	34,203 (285)	F	20.156	P.I	4.727	EMPORCHI	2	3.6 t	1973
8	EMPORCHI	240	9.0	1922-1932	134	279.127 (1.163)	F	156.812	P.C	29.876	EMPORCHI	6		1973
9	EMPORCHI	220	10.0	1915-1920	18	62.466 (284)	C	16.482	P.C	41.046	EMPORCHI	4	265 t/h 8 t	1961

Berth's No.	Mooring facility (quay)				.ps Calling in 1984	Cargoes Handled in 1984					Cargo Handling Equipment (Crane etc.)			
	Management Body	Lenght (m)	Depth (m)	Year of Completion	Number	Total (t)	Main Commodities				Manage-ment Body	Number	Nominal Capacity (t/h) Rated Load (t)	Used from
							Kind	Volume (t)	Kind	Volume (t)				
10	EMPORCHI	205	8.0	1915-1920	1	15 (0)	P.M	15	-	-	EMPORCHI	-	-	-
Total		2.035				1.664730 (818)								

NOTA : P.I = PRODUCTOS INDUSTRIALES

P.Q = PRODUCTOS QUIMICOS

P.C = PRODUCTOS COMESTIBLES

P.M = PRODUCTOS MINEROS

C = COBRE

F = FRUTA

* Cargo volume/quay length, t/h

TABLE 2-2 SPECIFICATIONS OF CRANES

Cranes	A	B	C	D	E	F
Type of Crane	Semi-Portal Double-Link	Portal Double-Link	Semi-Portal Rope Balance	Semi-Portal Rope Balance	Semi-Portal Rope Balance	Portal Double-Link
Number	No.1BX2 No.2BX2	No.9BX4	No.1BX2,No.2BX2 No.3BX9	No.1BX2,No.2BX2 No.6BX3,No.7BX1	No.6BX2 No.8BX2	No.4Bx1
Manufacturer	ARDELT (Germany)	ANSALDO (Italy)	MAN (Germany)	No.8BX3 MAN	MAN	HITACHI (Japan)
Year of Construction	1953	1961	1966	1970	1970	1984
Design Condition for Earthquake						0,2
Rated Load (t)	10	5,5	5	3	5	30,5/36
Outreach (m)	14,5	13,85		19,375	19,375	34,4
Radius (Max./Min.) (m)	18/7	21,5/7	18/7	22/7	22/7	41/11,2
Span (Height Difference) (m)	12,25 (5.933)	10,15 -	12,25 (5.933)	12,25 (6.125)	12,25 (6.125)	17 -
Lift						
Above Rail (m)	23	23	23	23	23	24
Below Rail (m)	15	15	15	15	15	15,5
Wheel Load (Rail Size)	(A-65)	(A-65)	(A-65)	(A-65)	(A-65)	(DIN KS56)
Sea Side (t/wheel)	21 (8,3m X 4 wheels)	18 (7m X 4 wheels)	22,5	25,7 (6m X 4 Ws)		30 (12m X8 Ws)
Land Side (t/wheel)	21 (6m X 4Ws)	25,5 (7m X4 Ws)	16,3	20,3 (4,5m X 2 Ws)		30 (12m X 6 Ws)
Weight (t) + Balance Weight (t)	110	131	76	76	80	550

TABLE 2 - 3 Trend of Cargo Volumes

(thousand tons)

	11 ports managed by EMPORCHI	Valparaíso Port
1975	4.110	1.187
1976	4.965	1.226
1977	5.535	1.657
1978	6.932	1.710
1979	7.561	1.982
1980	8.895	2.171
1981	8.364	2.316
1982	8.505	1.529
1983	8.302	1.538
1984	9.181	1.664

EMPRESA PORTUARIA DE CHILE
DEPARTAMENTO OPERACIONES

Table 2–4

TONELAJE TRANSFERIDO

SEGUN TIPO DE MERCANCIA 1984

PUERTO : VALPARAISO

Cód.	Tipo de Mercancía	COMERCIO EXTERIOR		CABOTAJE		TRANSITO INTERN.		OTROS	TOTAL TRANSFERENCIA
		Importac.	Exportac.	Desemb.	Embarque	Desemb.	Embarque		
01	Frutas	48.810	419.725	7	458	-	-	-	469.000
02	Trigo	-	-	-	1	-	-	-	1
03	Maíz	2	-	-	-	-	-	-	2
04	Harinas	1.856	-	1.341	229	-	-	-	3.426
05	Celulosa y Pulpa	849	105	-	-	-	-	-	954
06	Madera	279	9.103	239	315	-	-	-	9.936
07	Cobre	16	193.383	16.482	-	-	-	-	209.881
08	Vehículos Rod.	12.392	145	1.258	705	-	-	-	14.500
09	Productos comestibles	91.373	57.295	43.975	16.535	-	-	-	209.178
10	Producción agropecuaria	4.437	11.390	-	25	-	-	-	15.852
11	Productos Mineros y af.	53.773	9.359	308	1.870	-	-	-	65.310
12	Productos Industriales	223.474	11.814	1.481	28.216	-	-	-	264.985
13	Productos Químicos	92.997	19.003	-	12.189	-	-	-	124.189
14	Otros	115.476	25.622	6.022	41.362	-	-	89.034	2[illegible].516
	T O T A L	645.734	756.944	71.115	101.905	-	-	89.034	1.664.730

RUM/evg.-

3.- Description of Earthquake of March 3, 1985

3.1.- Earthquake event

Origin date and time		March 3, 1985, 19:46'54" (local time)
Epicenter	Latitude	33°14'24" S
	Longitude	72°02'24" W
	Depth	15 km
Magnitude (Richter)		7.7

The isoseismal map is presented in Fig. 3-1. The seismic intensities at several cities are shown in Fig. 3-2. The intensity scale used here is the Modified Mercalli Scale. The location of epicenter is shown in both figures. The seismic intensities in Valparaiso City were 7 to 8, and those in San Antonio City were 8.

3.2.- Ground motions in the port of Valparaiso

The locations of accelerographs around Valparaiso and the peak component accelerations are shown in Fig. 3-3. The locations of two accelerographs near Valparaiso Port are shown in Fg. 3-4. H_1 & H2 denote two horizontal peak component accelerations, H denotes one of the two horizontal peak component accelerations. The azimuth of each component was under confirmation, and the information on it has not been available. V denotes a vertical peak component acceleration.

The accelerometers at the two sites in Fig. 3-4 are the SMA-1 accelerographs.

The distances between the accelerograph sites and the sites of the port facilities are relatively small in comparison with the distance from Valparaiso port to the epicenter. Therefore, the accelerations observed at the two sites in Valparaiso may be considered as the accelerations in the port of Valparaiso after some modification on the following points.

As it is seen on the observed peak accelerations, generally, the seismic motions are amplified in the process of propagation through the deposit or the fill overlying the base rock. The degree of the amplification depends on the thickness and the velocity of shear wave propagation of the deposit or the fill. In many cases of practice, however, the larger the thickness is, the larger the amplification is. Unfortunately, no information on the thickness of the fill and the deposit in the port is available at present. According to the observation of the topography around the port, it may be reasonable to consider that the thickness of deposit is larger in the area of the berths Nos. 6 to 8 than in the area of the berths Nos. 1 to 5.
The berths Nos. 6, 7 and 8 are creating a kind of earth structure extending into the sea. This earth structure has larger freedom. This may help the amplification of the ground motions in the area of the berths Nos. 6 to 8.
Taking above mentioned points into consideration, peak horizontal accelerations of ground motions of the earthquake of March 3, 1985 in the port of Valparaiso are estimated as follows:

	on base rock	on ground surface
Area of the berths Nos. 1 to 5	0.20 g	0.25 g
Area of the berths Nos. 6 to 9	0.20 g	0.30 g

g: acceleration of gravity, usually 980 gals (=cm/sec^2)

3.3.- Liquefaction and land slide

No evidence of liquefaction and land slide was reported in the port area. It was not found through the site observation by the team, too.

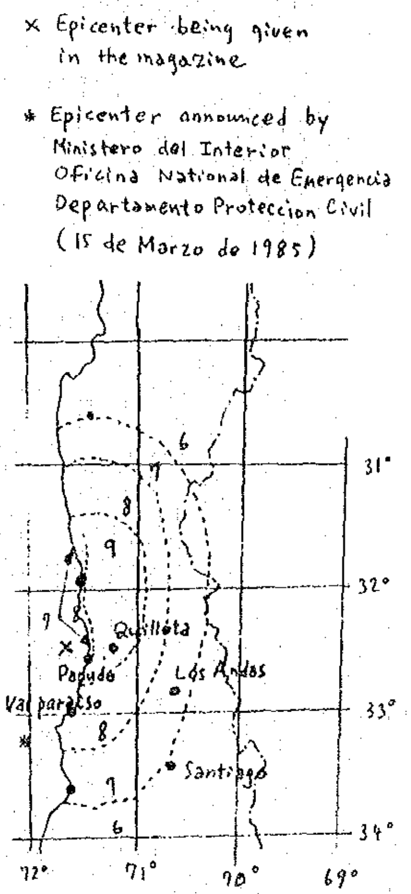


Fig. 3-1 Isoseismal map of the earthquake of March 3, 1985 (After ERCILLA, 13 marzo 1985)

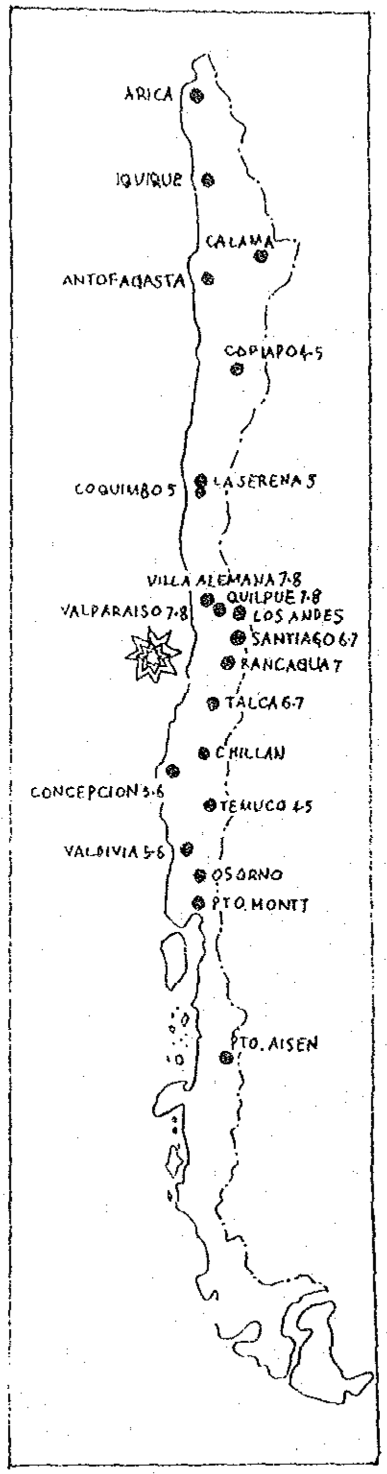
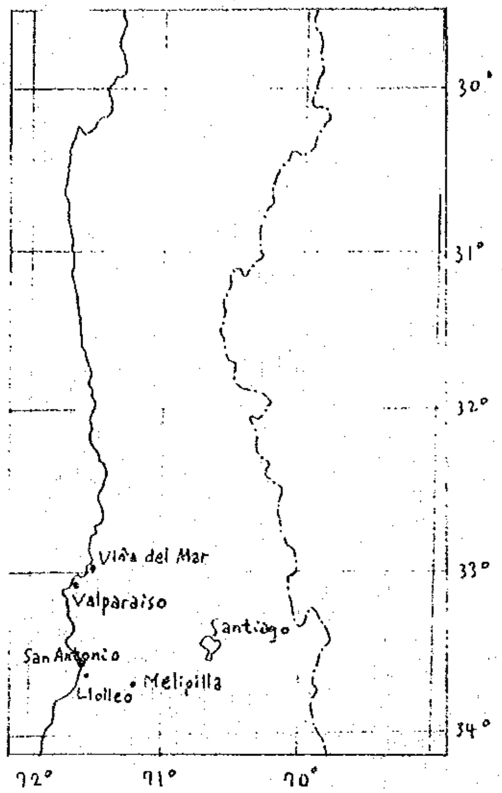


Fig. 3-2 Seismic Intensities (After ERCILLA, 6 marzo 1985)



Valparaiso, on rock, $H_1 = 0.197$ G
$H_2 = 0.16$ G

Valparaiso, on fill, $H_1 = 0.27$ G
$H_2 = 0.19$ G

Llolleo, on sand, $H_1 = 0.75$ G
$H_2 = 0.41$ G
$V = 0.82$ G

Quintay, $H_1 = 0.18$ G
$H_2 = 0.203$ G

Melipilla, $H = 0.50$ G

Fig. 3-3 Accelerograph locations in and around Valparaiso and peak component acceleration

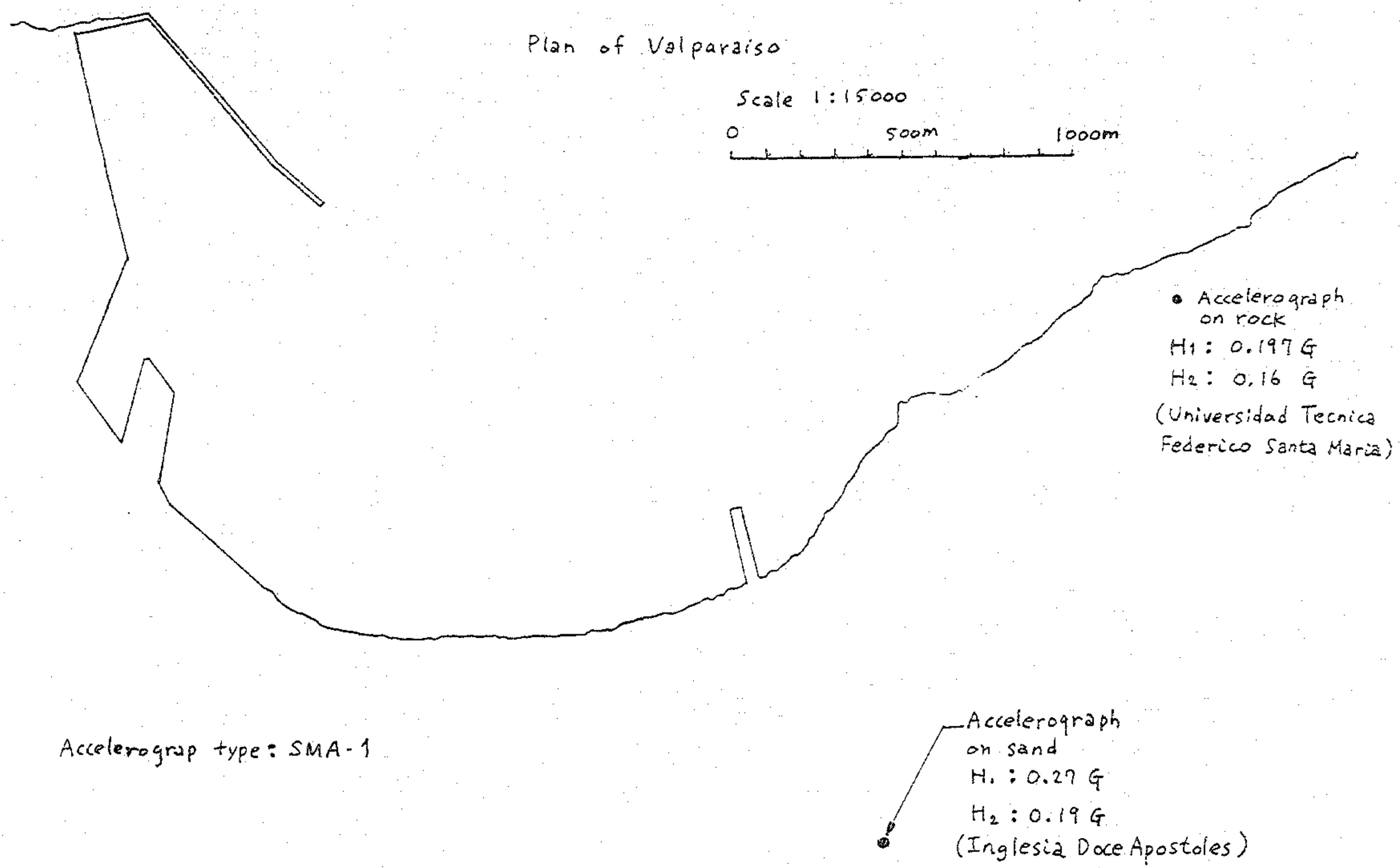


Fig.3-4 Accelerograph locations in Valparaiso and peak component accelerations of the earthquake of March 3, 1985

4.- Earthquake Damage

4.1.- Types of structures in the port of Valparaíso

(1) Mooring facilities

The mooring facilities in the port of Valparaíso are gravity type structures except for the berth Nos. 9 and 10, Barón Pier.

The structures of Barón Pier is a kind of open type wharf with reinforced concrete piles.

As for the gravity type structures, caissons are employed for the berth No. 7, and concrete blocks are employed for other berths. (The sizes of concrete blocks are relatively small).

The following is the types of structures and their principal dimensions of each berth.

Fig 4-1

Berth Nº	Type of structure	Design water depth	Design rown height of structure	Note
1	concrete block	- 10.96 m	+ 0.54	
2	ditto	ditto	ditto	
3	ditto	ditto	ditto	
4	open type wharf with concrete piers	ditto	ditto	diameters of concrete pier is 3 meters concrete piers support crane rails
5	concrete block	ditto	ditto	
6	ditto	- 8.96	ditto	mound is partly high
7	caissons	ditto	ditto	
8	concrete block	ditto	ditto	
9	open wharf of reinforced	max. - 13.96 m	+ 6,04	Berths Nos.9 and 10 are on both side of the some structure
10	concrete	ditto	ditto	

(2) Breakwater

The breakwater consists of two parts of different types. The structures of the breakwater consist of concrete blocks in the part of 163 meter length from the origin, and the caissons and mound in the remaining part of 123 meter length.

The waterdepth near the sea side end of the breakwater is so large as 40 meters.

The top level of the mound of stones and/or sand is -14 m and the caissons are being placed on it. The slope of upper part of the mound is rather steep, (5:4).

(3) Seawalls. There are seawalls in the part, between the berth Nos. 5 and 6 and the part between berths Nos. 8 and 9.

Concrete blocks and caissons are used like the mooring facilities.

In some part, the sloping seawalls with stones are also employed.

4.2.- Ground conditions

As the soil conditions, soil profiles of only some points around the berths Nos.6,7 and 8 are available, because the facilities in the port were constructed in 1920 s'. According to those soil profiles, the original sea bottom exists at about - 10 meters near the sea shore and it exists at more deeper depth of about - 35 meters with steep slope at the place of the berth No. 7.

Soft clay or silt exists in the surface layer. The thickness of this layer is about 5 m in average, and nearly 10 m at the berth No.7

Hard clay with stone and sand lies under the soft clay layer. Then, it is supposed that the settlement of the structures and the backfill become greater with the increase of tickness of the soft layer.

The crownheight of structure is getting lower with increase of distance from the seashore. But it is considered that settlement due to consolidation of the soft clay has been almost completed.

As for the berths Nos. 1, 2 and 3, the foundation layer is considered to lie at relatively shallow level, accordind to the topographical conditions behind the Port of Valparaíso.

4.3.- Descriptions of damage to facilities

4.3.1.- Main structures

Main facilities of the port of Valparaíso consist of a breakwater and ten berths of guaywalls, berths Nos. 9 and 10 are pier type in Barón area.

All these facilities were more or less damaged except for the berths Nos. 9 and 10. In some berths, the face line of the guaywall was observed to move or bulge towards the sea.

In addition to the main facilities, cracks and settlements were seen in the roads, railroads, marshalling yards and cargo handling facilities. Among these, cargo handling cranes and apron pavements were badly damaged. Some cranes derailed and rails were either deformed, moved or broken.

All these damage appeared exclusively in the filled area as shown in Fig. 4-2.

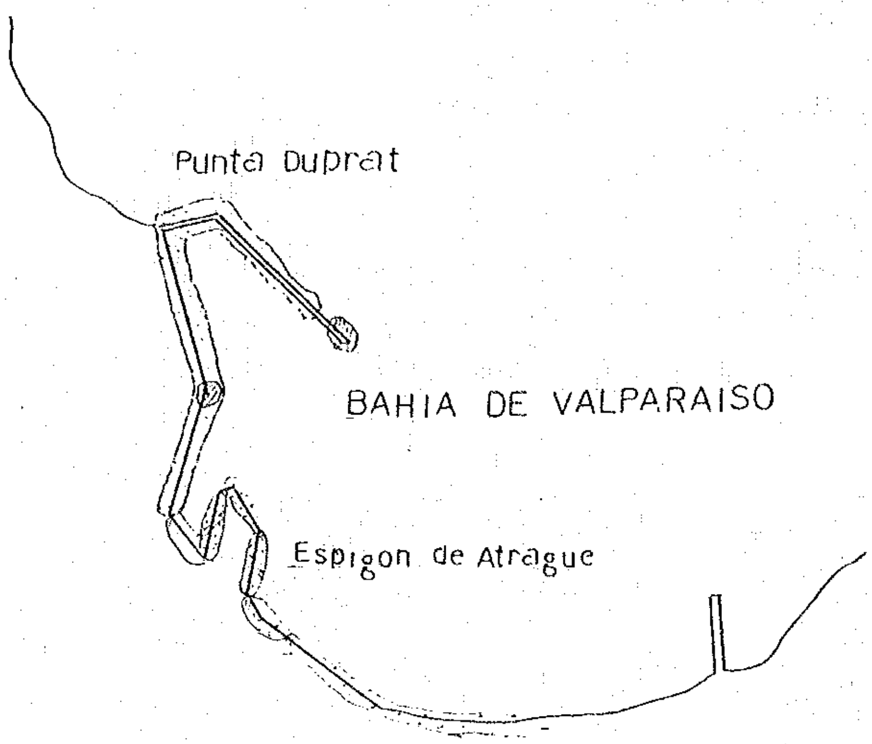
4.3.2.- Cranes

Typical damaged condition of the cranes are shown on the Table 4-2.

Since the inspection time was limited and the inspection was carried out mainly visually from the ground level, the detailed inspection should be carried out according to the each crane's operation manual and maintenance manual.

Fig4-2

Distribution of damage



Legends

Settlements
Cracks and partial movements

Table 4-1-a

Berths Nos. 1 ~ 3 (Blocks)

Main part of wall	1. No marked damage was observed except for settlement of about 5 cm 2. Investigation was not made for bottom part.
Apron pavements	1. Cracks of 2 3 cm wide, parallel to the wall face line, were observed at the breakwater side.
Foundation for cranes	1. Crane rails slightly deformed
Top part of wall	1. Meandering, with amplitude of 30 cm at maximum, was seen as a whole, but absolute displacement was not know due to absence of information of original position.
Others	1. Cracks, parallel to the wall face line, were seen in warehouses and storage yards.
Relative evaluation of damage	Small

Table 4-1-b

Berths Nos. 4 (Open type wharf with vertical concrete piles)

Main part of wall	1. There was no observable damage except for slight settlement. 2. Indentations of blocks, 65 cm at maximum were observed, and most of the concrete piles filted to some extent towards the sea. In the Nª 5 berth phenomenon of sand flow was seen. These observations indicated that blocks of the Nª 4 berth tended to more towards the sea as in the Nª 5 berth, however, its movement was restricted at the top and bottom ends by the concrete piles.
Apron pavements	1. Local settlements were seen at the Nª 3 berth side. 2. Vertical gap of about 20 cm appeared at center of pavement, parallel to the wall face line (Fig.4-3-a)
Foundation for cranes	1. There was no appreciable change in elevation. 2. Rail gange increased towards the Nª 5 berth side, 14,05 m at obe Nª 3 berth side and 17,17 m at the other end.
Top part of wall	1. Settlement, relative to the elevation at the Nª3 berth side, was 4～5 cm.
Others	1. A warehouse collapsed partly. 2. Pavements at storage yard moved and settled by about 3 cm.
Relative evaluation of damage	Not clear

Table 4-1-c

Berth Nº5 (Open type wharf with vertical concrete piles)

Main part of wall	1. Indentations between blocks were small and the wall face seemed flat. The wall face tilted towards the sea, being maximum at the centre of the berth, which indicated that the structure was in a dangerous state.

Table 4-1-d

Berth Nª 6 (Blocks)

Main part of wall	1. The wall likely moved as a whole towards the sea. 2. Vertical openings between blocks were small, however, the wall face seemed to tilt towards the sea to some extent. Apart from the earthquake damage, width of mound top at the Nª7 berth side was found to decrease largely, which might lead to serious problem in stability of the structure.
Apron pavements	1. All through the berth, appreciable cracks parallel to the wall face line were seen at warehouse columns, centre of apron and behind the wall top. 2. Settlements were seen in the vicinity of the Nª7 berth (Fig. 4-3-C)
Foundation for cranes	1. Elevation of the foundation descended towards the Nª7 berth by 23 cm. 2. There were derailing due to meandering of the rail.
Top part of wall	1. The wall top bulged by about 17 cm as a whole towards the sea. 2. Elevation of the Nª7 berth side wa lower than the other end by about 50 cm.
Others	1. Warehouse floor seemed to remain flat.
Relative evaluation of damage	Medium

Table 4-1-e

Berth Nº7 (Caissons)

Main part of wall	1. Settlement increased towards the Nº6 berth 2. Difference between elevations of the berth ends was 48 cm.
Apron pavements	1. Vertical gap of 30 40 cm appeared at behind the caissons throughout the berth. 2. Pavement slabs were totally broken (Fig.4-3-d)
Foundation fro cranes	1. Settlement was of similar pattern to and less than that in the main part of wall. 2. Elevation difference of the wall was about 8 cm.
Top part of wall	1. Throughout the berth, settlement was likely about 40 cm. 2. Deep cracks developed, and at some parts the wall top extended towards the sea.
Others	1. Cracks developed in the warehouse columns.
Relative evaluation of damage	Great

Table 4-1-f

Berth Nº8 (Blocks)

Main part of wall	1. Settlement appeared at the Nº7 berth side. 2. Wall face line bulged towards the sea by about 20～30 cm. 3. Indentations of the wall concrete blocks were seen, which was pronounced at the land side end. The wall itself was found to tilt towards the sea.
Apron pavements	1. Pavements slabs in the vicinity of the Nº7 berth settled and broken. (Fig. 4-3-e) 2. Fill material underneath the pavement slab spilled out. 3. Appreciable cracks developed at boundaries of the wall top, crane foundation and foundation for warehouse column, throughout the berth.
Foundation for cranes	1. Foundations heaved or settled partly. 2. Elevation difference of the rails was 30—40 cm.
Top part of wall	1. Wall face line bulged towards the sea. 2. Settlements and cracks were seen. 3. Vertical gap between the wall top and pavement slab was 20～30 cm.
Others	1. Cracks developed in warehouse columns.
Relative evaluation of damage	Great

Table 4-1-g

Berth Nos. 9 and 10 (Concrete trestle pies)

Main part of wall	No damage seemed to be caused by the earthquake, however, degree deterioration of concrete and stell members was serious.

REMARKS

1. Distances shown in the tables and figures were those actually measured by the use of vyñil tape, no correction being made for temperature and tension.

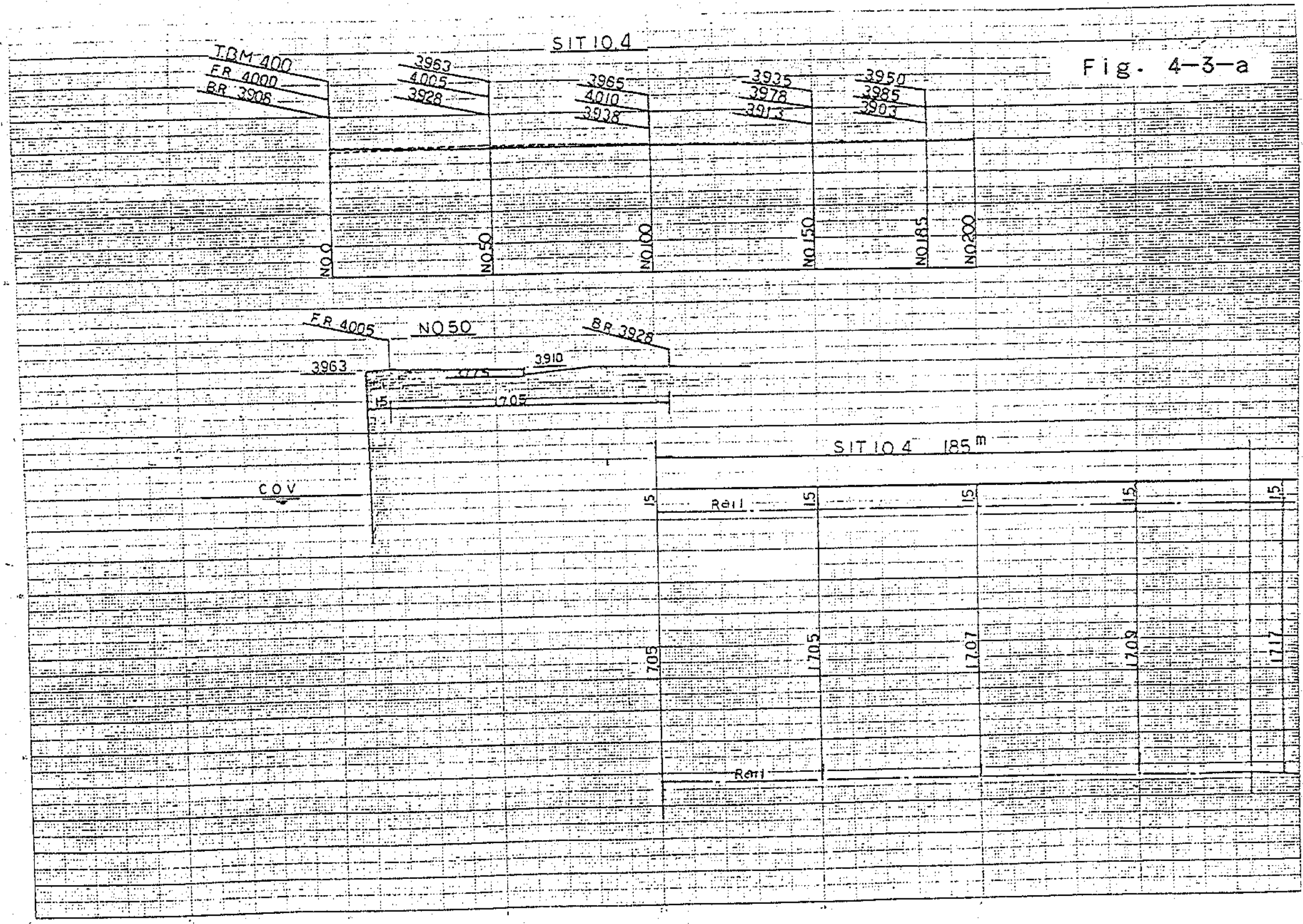
2. Distances in the figures are in meter (m).

3. Levelling was made with respect to temporary bench marks (B.M.)

   (1) Berth Nos. 6 - 8 : B.M. was set at land side end of shed, elevation of which was assumed to be +4,00 m.

   (2) Berth Nº4: B.M. was set on the wall top at the Nº3 berth side end, elevation of which was assumed to be + 4,00 m

4. Closing error in the levelling, for a distance of 614 m, was 1 mm.


SITIO 4
TBM 400
FR 4000
BR 3906
3963
4005
3928
3965
4010
3938
3935
3978
3913
3950
3985
3903
NO 0
NO 50
NO 100
NO 150
NO 185
NO 200
FR 4005
NO 50
BR 3928
3963
3910
15
7.05
SITIO 4 185m
COV
15
Rail
7.05
17.05
17.07
17.09
17.17
Fig. 4-3-a

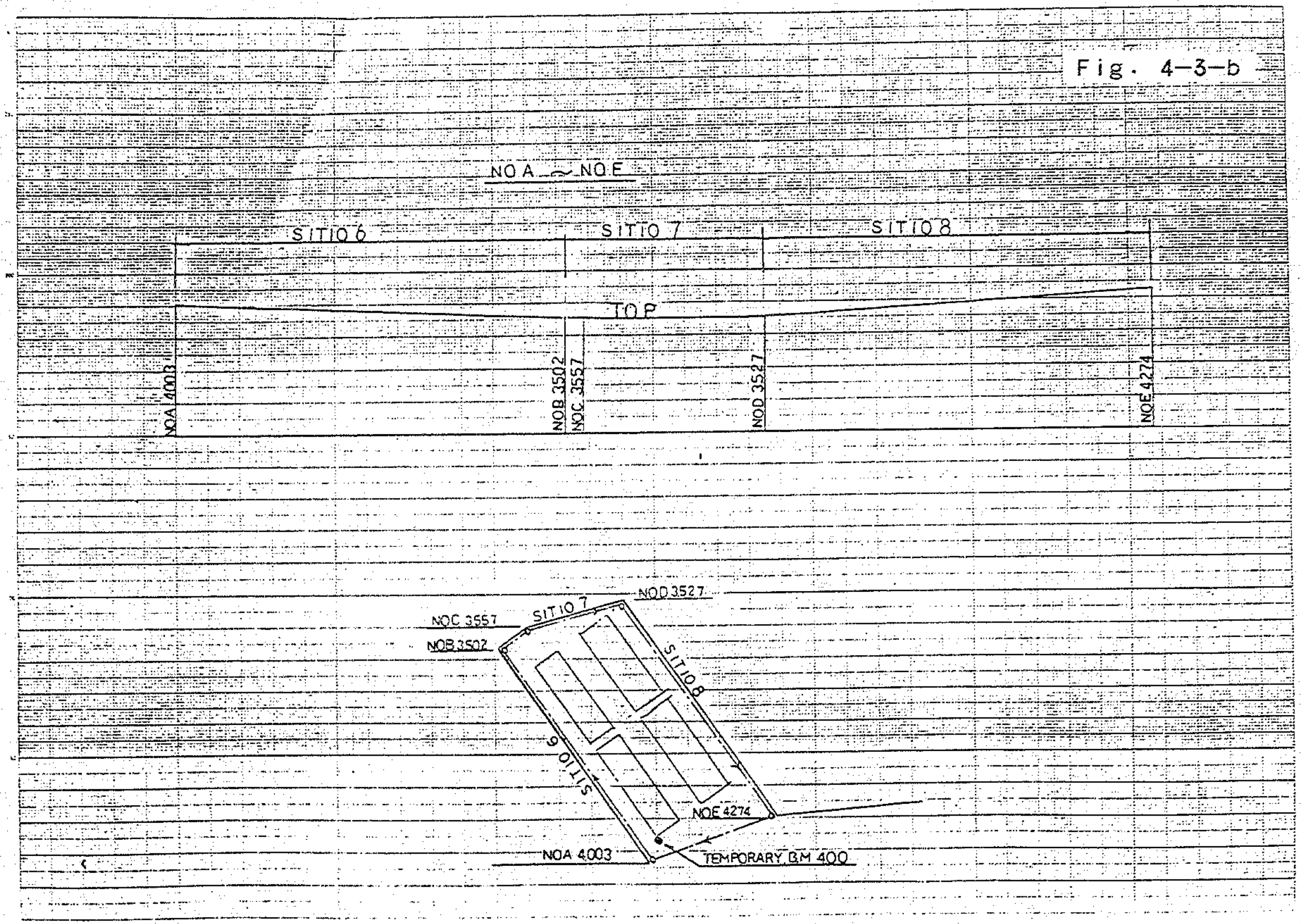
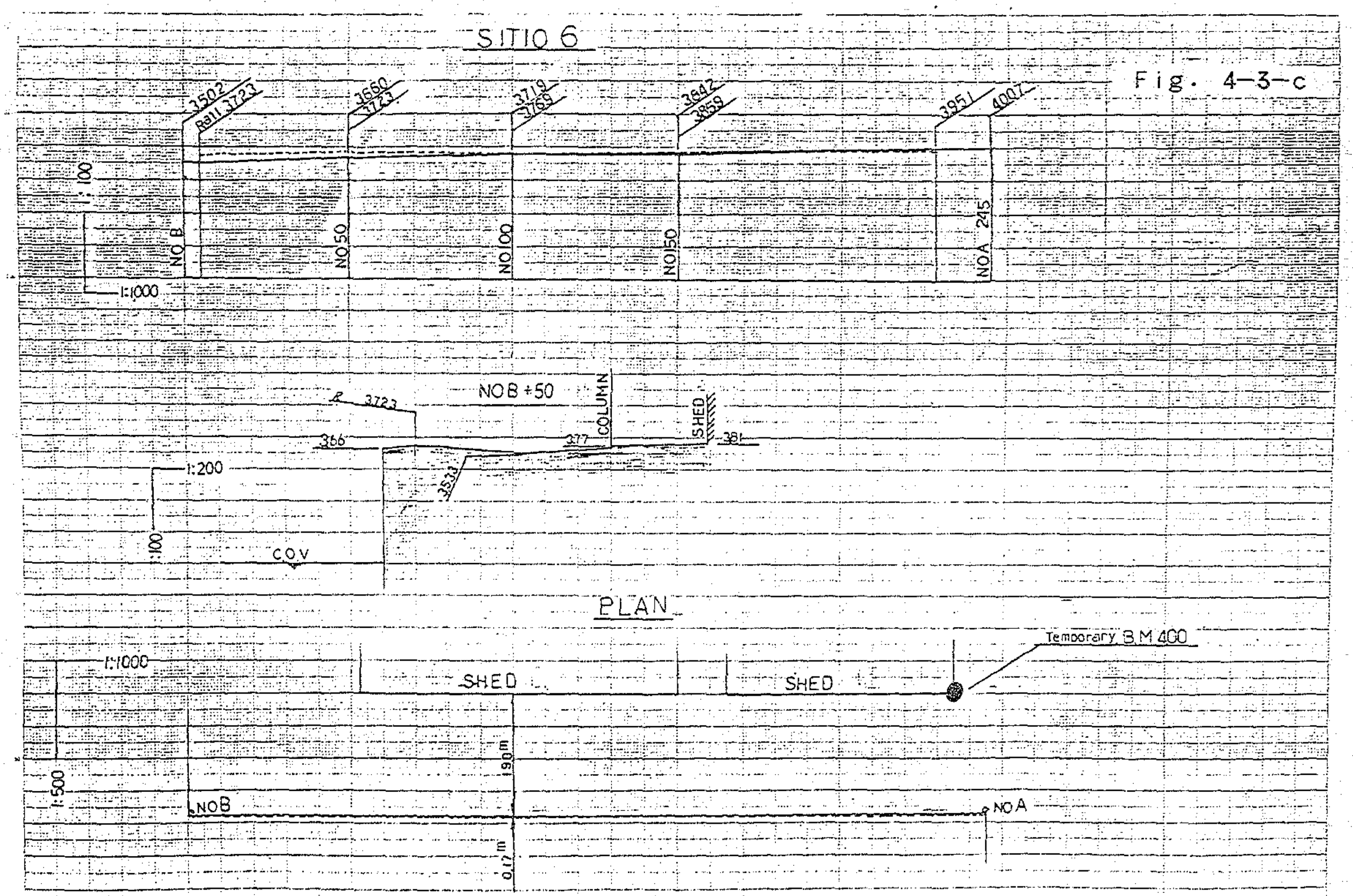

NO A ~ NO E
SITIO 6
SITIO 7
SITIO 8
TOP
NOA 4003
NOB 3502
NOC 3557
NOD 3527
NOE 4274
NOC 3557
NOB 3502
SITIO 7
NOD 3527
SITIO 8
SITIO 6
NOE 4274
NOA 4003
TEMPORARY B.M 400

Fig. 4-3-b

Fig. 4-3-c


SITIO 6
3502
Rail 3723
3660
3723
3719
3769
3842
3859
3951
4007
1:100
1:1000
NO B
NO 50
NO 100
NO 150
NO A 245
NO B +50
3723
366
377
381
COLUMN
SHED
3533
1:200
1:100
COV
PLAN
Temporary B.M 400
1:1000
SHED
SHED
1:500
NO B
190m
0.17m
NO A

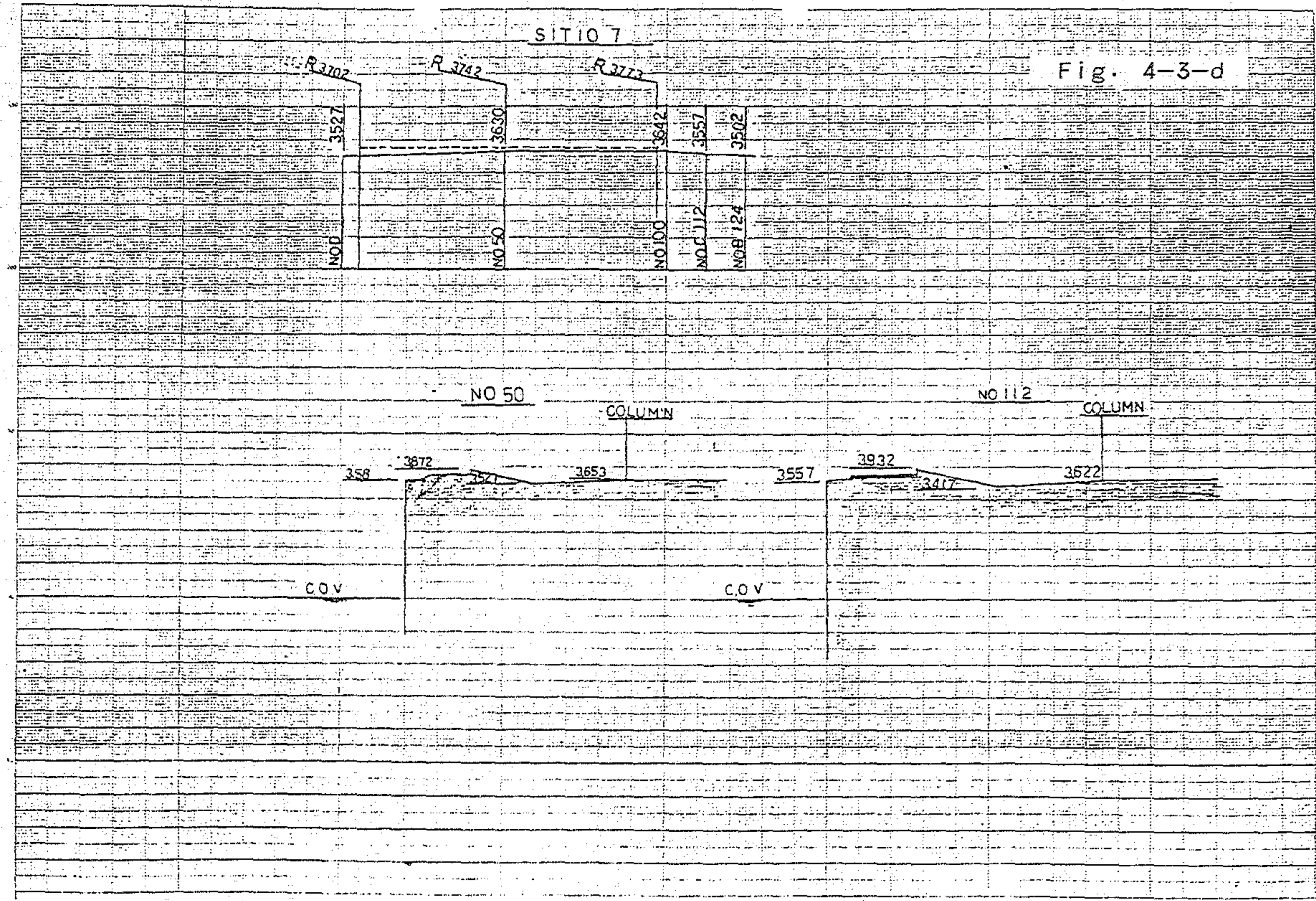
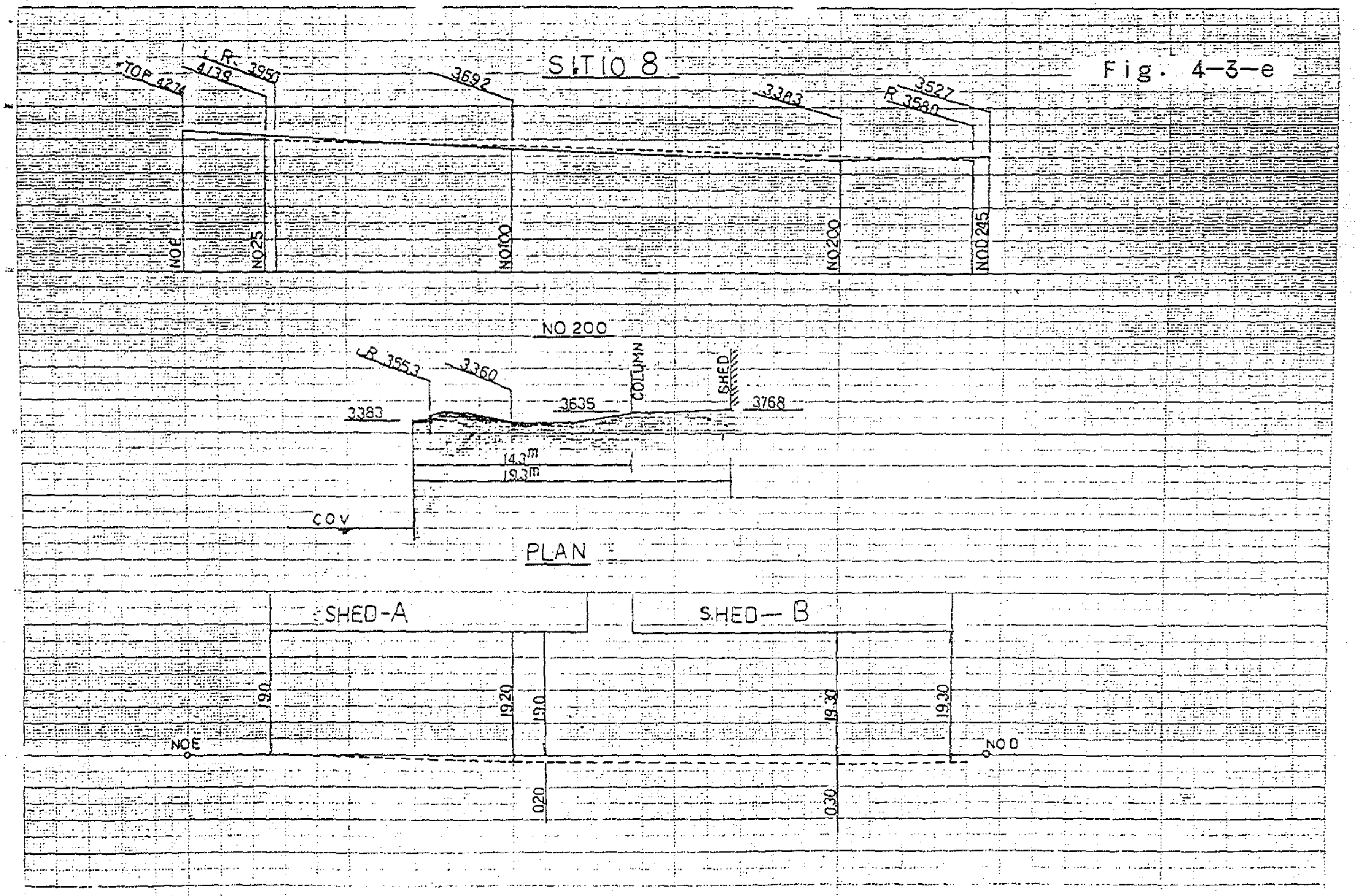

SITIO 7
R 3702
R 3742
R 3773
3527
3630
3642
3557
3502
NOD
NO 50
NO 100
NO C 112
NO B 124
NO 50
COLUMN
358
3872
3521
3653
3557
NO 112
COLUMN
3932
3417
3622
COV
COV

Fig. 4-3-d

Fig. 4-3-e


SITIO 8
TOP 4274
4139
L.R. 3950
3692
3383
3527
R 3580
NOE
NO25
NO100
NO200
NOD245
NO 200
R 3553
3360
3383
3635
COLUMN
SHED
3768
14.3m
19.3m
COV
PLAN
SHED-A
SHED— B
190
1920
190
1930
1930
NOE
NO D
020
030

BERTH No. 4

Fig. 4-4-a

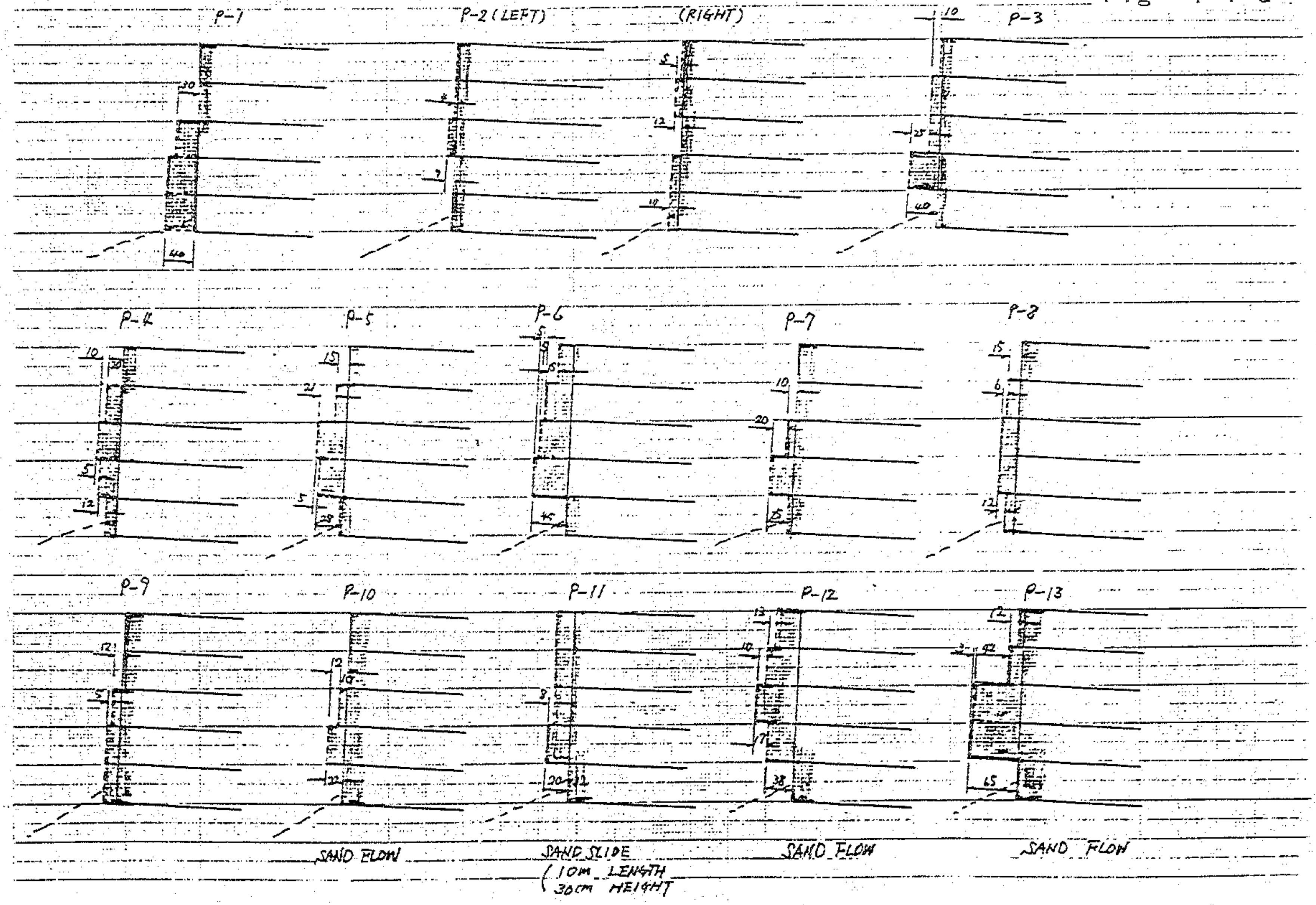
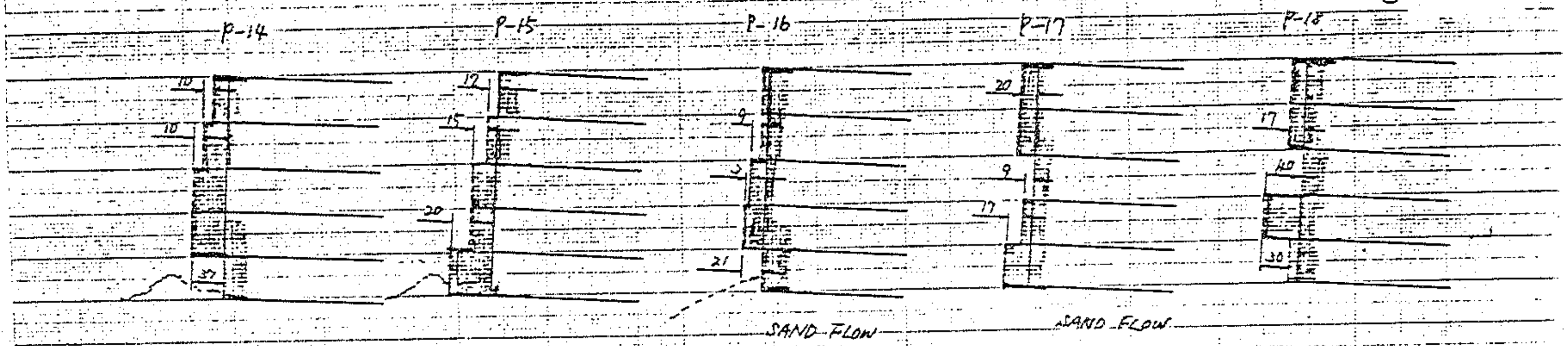
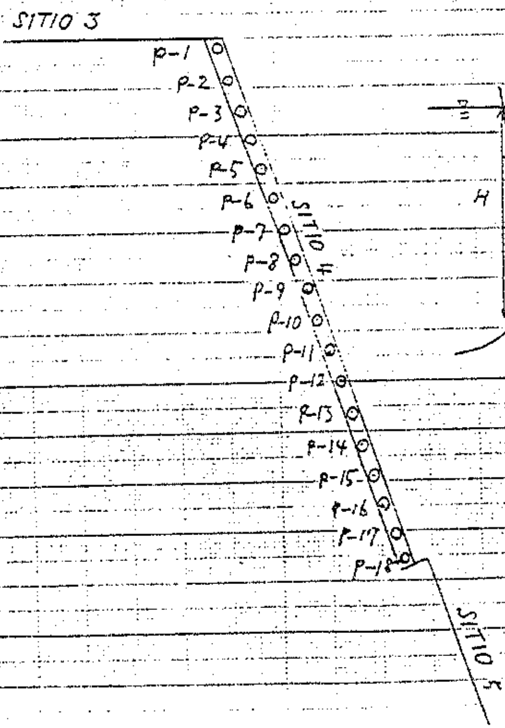
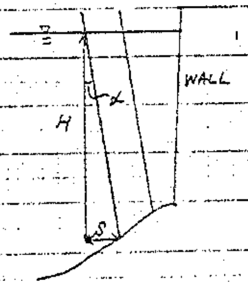


Fig. 4-4-b





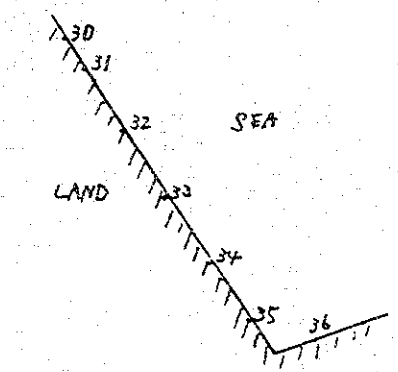


PILE	DEPTH (H)	WIDTH (S)	α°
P-1	10.7 m	28 cm	1.5 DEG
P-2	10.1	10	0.6
P-3	9.4	12	0.7
P-4	9.4	3	0.2
P-5	11.0	15	0.8
P-6	10.7	20	1.1
P-7	11.6	11	0.5
P-8	9.8	16	0.2
P-9	11.0	13	0.9
P-10	10.7	15	0.8
P-11	10.4	0	—
P-12	10.4	17	0.9
P-13	9.8	13	0.8
P-14	10.1	43	2.4
P-15	9.8	32	1.9
P-16	10.7	40	2.1
P-17	9.1	23	1.4
P-18	9.4	28	1.7

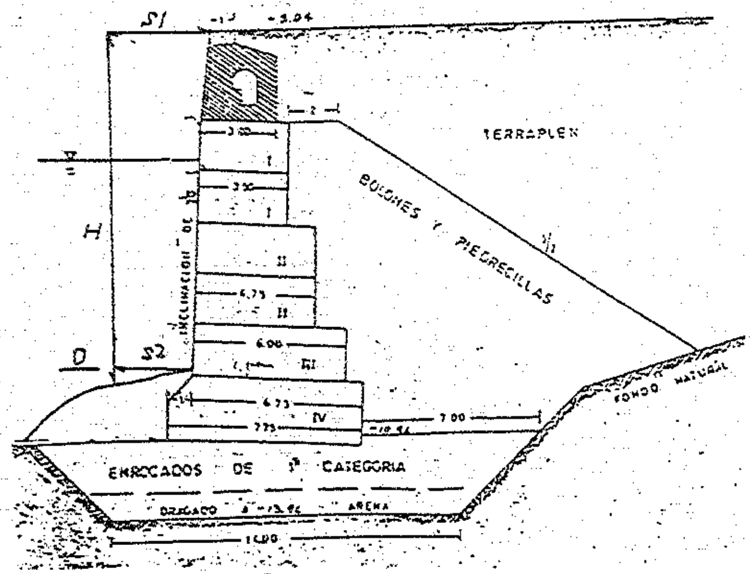
THE SUPERSTRUCTUR OF WALLS DECLINES TOWARDS SEA SIDE.

Fig. 4-4-c

BERTH No.5



INVESTIGATION POINT	H	S1	S2	D	NOTE
31	14.65 m	50cm	15cm	Bottom	SEE FIG1
32	14.40	70cm	120cm	9.8m	" SEE FIG2
33	14.00	"	70cm	"	SMOOTH SURFACE
34	13.85	"	64cm	Bottom	"
35	6.00	"	30cm	"	"



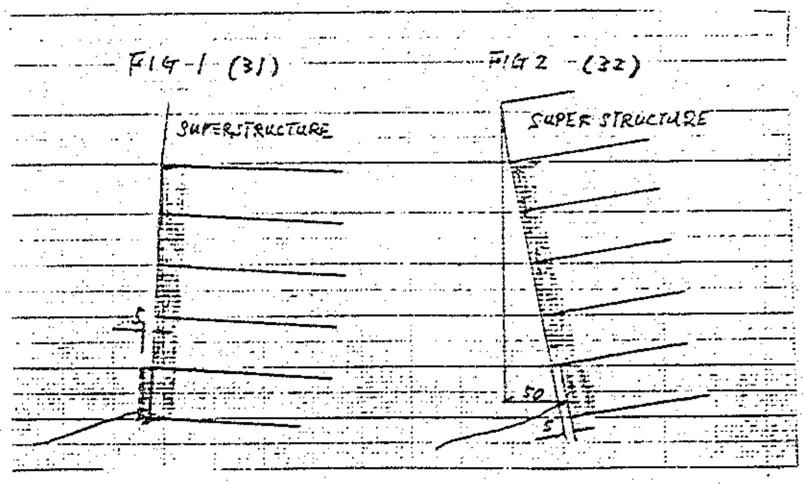
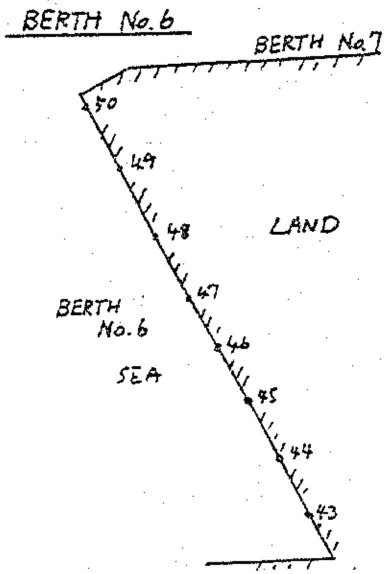
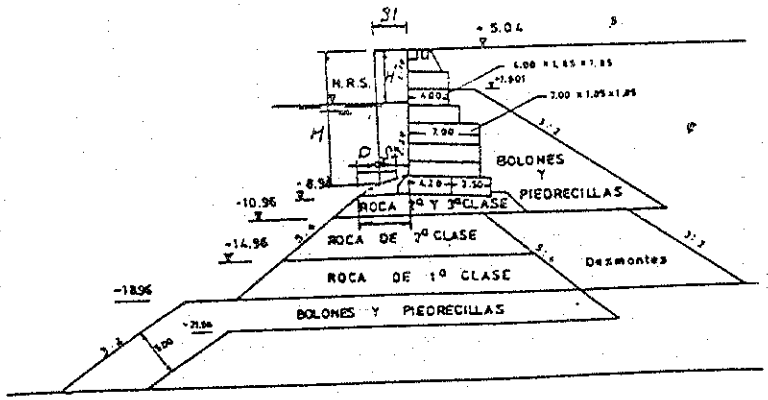


Fig. 4-4-d

BERTH No.6



INVESTIGATION POINT	H	H'	B	S1	S2	D	NOTE
50	13.45m	2.90m	3.0m	70cm	20cm	9.1m	
49	13.40m	3.20m	5.0m	〃	35cm	9.1m	
47	12.70m	3.20m	over 5.0m	〃	25cm	9.1m	
45	13.40m	3.30m	over 5.0m	〃	28cm	9.1m	
43	6.95m	3.50m	over 5.0m	〃	50cm	3.7m	



SITIO 6

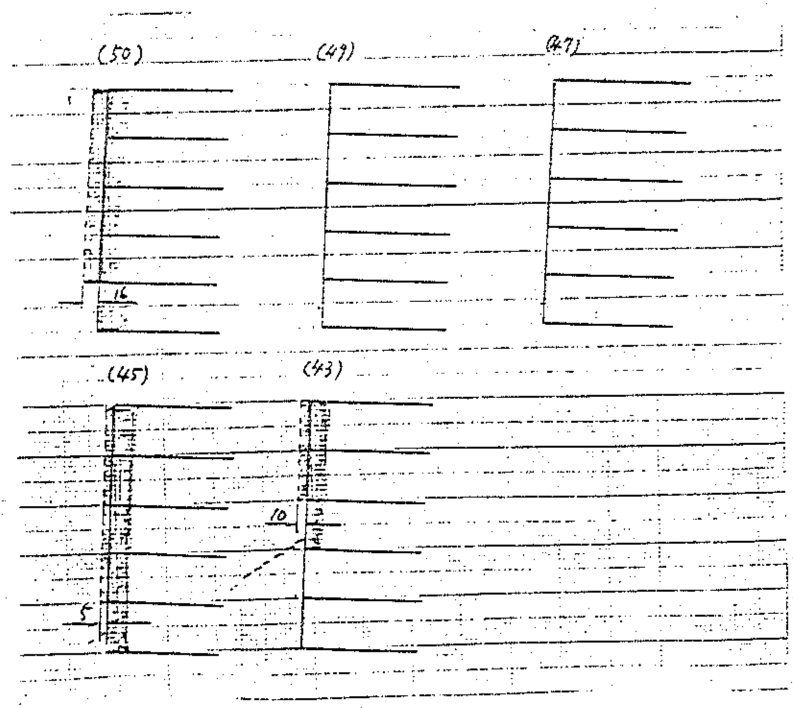
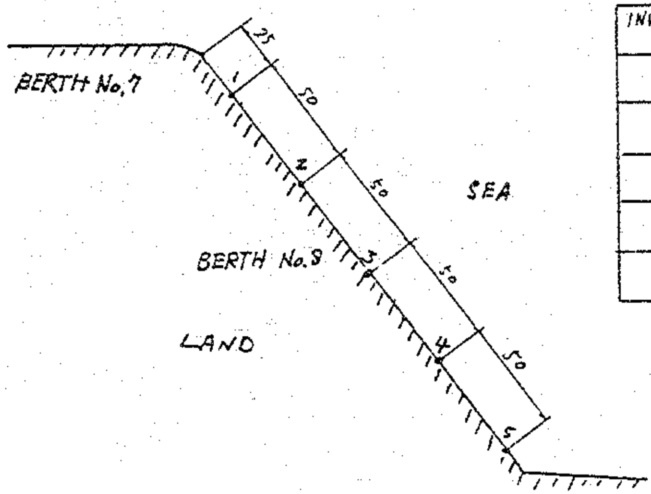
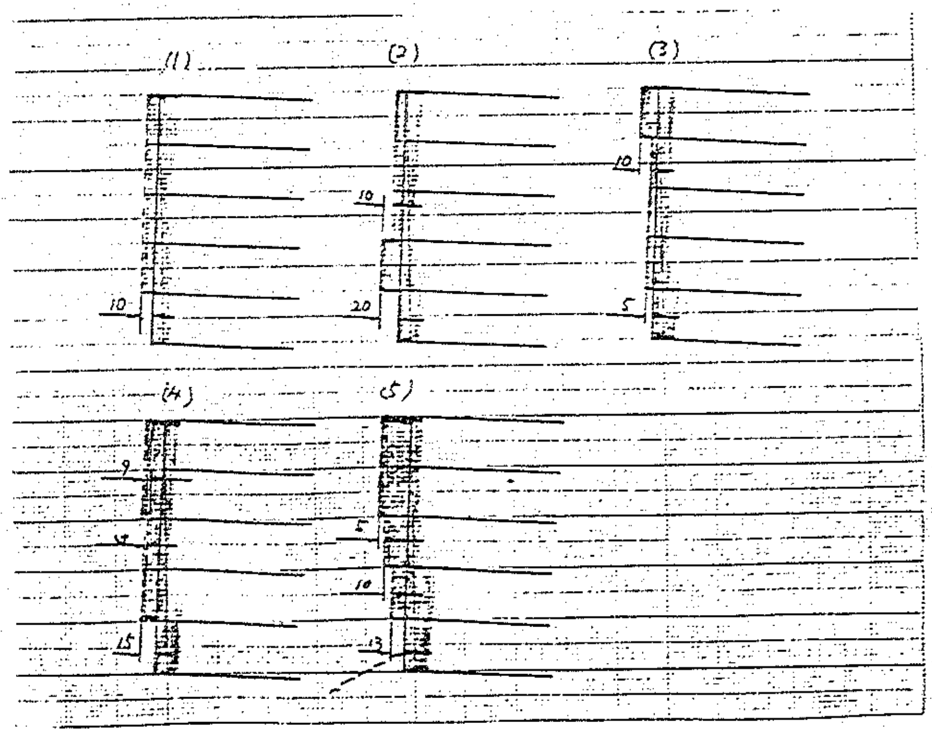


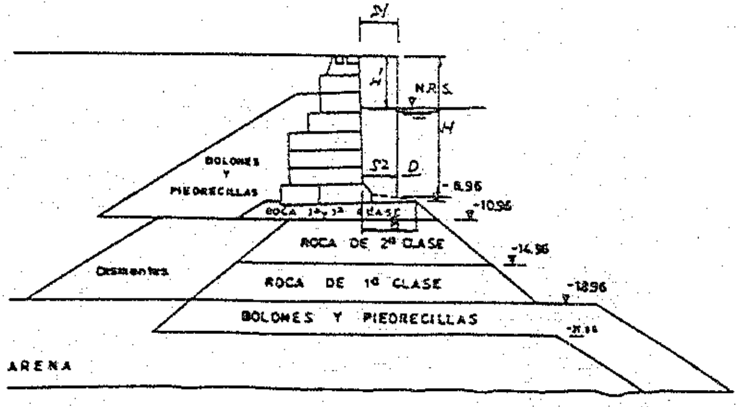
Fig. 4-4-e

BERTH No. 8



INVESTIGATION POINT	H	H'	B	S1	S2	D
1	13.5m	3.0m	—	50cm	30cm	9.8m
2	13.05m	3.2m	2.0m	〃	40cm	9.8m
3	12.55m	3.3m	2.0m	〃	35cm	9.8m
4	12.7m	3.5m	5.0m	〃	45cm	9.1m
5	12.5m	3.8m	5.0m	〃	15cm	9.1m





SITIO 8

TABLE 4 - 2. Damaged Condition and Necessity of Restoration

No.	Item	Cranes																													
1.	Berth No.	1						2		3						4	6					7	8					9		10	
2.	Crane No.	1	2	3	4	5	6	9	10	13	14	15	16	17	18	Hitachi	21	22	23	24	25	27	28	29	30	31	32	35	36	37	38
3.	Type of Crane	D	D	A	A	D	D	A	A	C	C	C	C	C	C	F	D	E	E	D	D	D	D	D	E	E	D	B	B	B	B
4.	Damaged Condition																														
	Case I Portal leg								O	O	O		O	O					O	O	O	O		O	O	O					
	Portal ring												O		O																
	Case II																		O	O	O		O	O	O						
	Case III																		O	O	O		O	O	O						
5.	Restoration																														
	Case IV								O	O	O		O	O	O				O	O	O		O	O	O	O					
	Case V			O	O			O	O																			O	O	O	O
	Case VI			O				O								O															

CASE I : Buckling due to over compression stress by the earthquake, or deformation due to hitting by handling cargo.

CASE II : Derail of the landside whee ls.

CASE III : Buckling of land side truck frames.

CASE IV : To be reinforced/restored/repaired.

CASE V : Recommended to disuse after detailed investigation

CASE VI : Recommended to add, based on a plan formulated through feasibility study.

4.4.- Cause of damage

4.4.1.- Quaywalls

The main cause of the damage to the quaywalls in the port of Valparaíso is considered that the ground motions during the earthquake of March 3, 1985 exceeded the ground motions against which the quaywalls can maintain stability, according to the following consideration.

Although the quaywall of concrete block type have some displacement caused by the earthquakes in the past, the seismic stability of the original quaywalls in the berths Nos.1, 2, 3 and 5 was analyzed.

In the analysis, the angle of internal friction of the backfill was assumed to be 40 degress. The procedure of the analysis was that being used in Japan. According to the analysis, the stability of the quaywall is almost critical against the design seismic coefficient of 0.1.

On the other hand, as it is described in the related section of this report, the peak acceleration on the ground was 0,25 g - 0,3 g. The relation-ship between the peak acceleration of earthquake ground motions and the design seismic coefficient is not simple. However, it is easily understood that the earthquake ground motions of 0.25 g ~ 0.3 g was quite severe to the quaywall which can resist against the earthquake ground motions equivalent with the design seismic coefficient of 0.1. Some information on the relation ship between the design seismic coefficient and the peak acceleration is included in the appendix of this report.

There remains somethings still unexplained. That is the reason the quaywalls of the berths Nos.1, 2, 3, and 7 did not suffer evident damage.

It has not been made clear, but it might be possible that the thicknesses of soil layer and fill material are thinner in the area of the berths Nos.1, 2, and 3, and the acceleration there was not so large as that in other area. This may be one of the possible explanations on the performance of the quaywalls of the berths Nos.1, 2, and 3.

The quaywall of the berth No.7 consists of concrete caissons and has larger stability in comparison with the quaywalls of the berths Nos.1, 2 and 3. This may explained the performance of the quaywall of the berth No.7.

It should be noted that for the quaywalls of the berths Nos.6 and 8, the concrete blocks of a little larger widths were used in comparison with the blocks for the berths Nos.1, 2 and 3. Therefore, the quaywalls of the berths Nos.6 and 8 have larger stability against the earthquake ground motions. However, they are not as stable as the quaywall of the berth No.7.

It might be wondered why the quaywalls of the north - south directions suffered damage and the quaywalls of the east-west direction did not. It is not clear whether the quaywalls of the east-west direction were not damaged because of their direction or not. If the damage depends on the direction, the possible explanation is that the earthquake ground motions in both directions differed markedly or that the quaywalls of the east-west direction had sufficient stability against the earthquake ground motions.

Anyway, it may be concluded that the damage was caused by the severe earthquake ground motions.

4.4.2.- Settlement of apron

No evidence of liquefaction was observed in the port area. Therefore, it is not certain, but te possible explanation is that some amount of the reclaimed soils had been sucked out gradually during the long time after the construction completion.

4.4.3.- Cranes

The damage to the cranes is considered mainly due to abnormal deformation of foundations and runways at the time of earthquake.

After a rough inspection of all cranes, it seems that in a similar earthquake in future all berths would not have suffered crane damage, if all foundations and runways ar constructed firm-ly. In connection with this problem, concerned engineers should clarify the design conditions of each crane whether it has been designed by enough seismic condition or not. It is noted that cranes existing in Japan have been designed to take account the horizontal load of 20% of the self weight.

4-5 - Restriction to the immediate use of facilities

4-5-1 - Quaywalls

Berth No.	Restriction to immediate use of facilities
1 2 3	The wharves may be used as before the earthquake No restriction on loading is needed
4	Before starting utilization of a large scale crane, detailed inspections of each pier and concrete block wall (especially piers No. 10-No. 18) should be made. It is desirable not to stack containers and cargoes and not to park trucks within 20 m from the face line of the wharf.
5	The wall of the wharf was measured to have inclined to sea side and the wharf is considered to have very little margin in its stability. It is possible that the wharf would be damaged more severely if an earthquake which is equivalent to or stronger than the last one, takes place. Detailed inspetions should be carried out and restrictions should be decided, as soon as possible. It is desirable not to stack contarners and cargoes and not to park trucks within 20 m from the face line of the wharf.
6 7	The wharves may be used as before the earthquake, after repair of the damaged pavement of the apron. Restoration of rubble mound is urgently needed at parts where necessary mound width is not secured. (Necessary mound width be calculated from the view point of stability of the wharves.)
8	The wall of the wharf was measured to have inclined to sea side and the wharf is considered to have little margin in its stability. It is possible that the wharf would be damaged more severely if an earthquake which is equivalent to or stronger than the last one, takes place.

	· And it is also possible that the wharf would be damaged if cranes with heavy weight are placed on the wharf. Before starting utilization of cranes, detailed inspections should be carried out and restrictions of loading should be decided.
9 10	Deterioration of concrete and steal is obvious. It is desirable to stop using the wharves. Detailed inspections and large scale restoration are necessary if the wharf has to be used.

4.5.2.- Cranes

(a).- Without the realignment of the crane travelling rails, all cranes should not be used basically. The dimensional tolerances of the travelling rail's installation for each crane must have been given in each crane's manual.

In case of Hitachi crane on the No.4 berth, followings are given in the operating manual.

Span........................	Less than 17 m	± 10 mm
Height difference between left and right side rails....	Less than	20 mm
Gradient difference between left an right side rail......	Less than	1/1000
Rails Longitudinal gradient..	Less than	1/1000
Meandering..................	Less than	± 2.5 mm

(b).- After realignment of the crane travelling rails, the detailed inspection according to the operating and/or maintenance manual should be carried out completely. Some damaged parts may be found in the period of above inspection.

These parts should be replaced or repaired before ordinary operation.

(c).- The cranes damaged especially by the earthquake and before the earthquake are shown on the Table 4-2. These parts should be reinforced and repaired before ordinary operation.

5.- Basic Concepts for Restoration

5.1.- Restoration and Development Plan

5.1.1.- The following measures should be ex-ecuted for the port of Valparaíso to perform the vital role for the development of the Santiago region as a gate way to the sea, linking the area with foreign countries.

(1).- Restoration of port facilities damaged by an earth quake on Mar. 3rd. 1985.

(2).- Strengthning of port facilities against earth-quake.

(3).- Redevelopment of port facilities.

(4).- Development of container terminal.

5.1.2.- Restoration of damaged port facilities should be executed urgently to recover port cargo handling efficiency.

5.1.3.- Redevelopment of port facilities and development of container terminal should be executed based on a plan formulated through feasibility study.
EMPORCHI is carring out the study on forecast of future volume of cargoes to be handled at the port of Valparaiso. In succesion of the study, study on basic plan to improve the port of Valparaiso for the target year of 2,000 and decide a short term improvement plan with 1990 as the target year for facilities requiring immediate improvement and make a feasibility study concerning this plan should be carried out.
Strengthening of port facilities against earthquake resistance should be carried out together with redevelopment of port facilities and development of container terminal because the improvement will need fundamental changes of structures and large investment. In this context.
(a).- Restoration of port facilities damaged by the earthquake, and
(b).- Feasibility study on improvement of port facilities against earthquake, redevelopment of port facilities and development of container terminal should be carried out urgently.
Subsequently redevelopment of port facilities and development of container terminal should be executed. Double investment could be avoidable because the restoration works needed are repavement of apron, reconstruction of crane rails, and replacement of rubble mound.

5.1.4.- Schedule of restoration works should be decided based on the following principles.

(1).- Not to disturb port activities during reconstruction works.

..... to restore each one berth of three groups (No. 1 to 3, No. 4 ~ 5, No. 6 to 8) by turns.

..... to complete restoration before next January (because, cargo volumes handled at the port of Valparaíso in February, March and April are larger than other months).

(2).- To give priority to important berth and berth without alternative berth.

..... to give priority to No. 4, which is only container handling berth.

(3).- To consider natural conditions

.... to restore No. 7 in autumn and winter, which is affected by high waves in summer.

Tentative restoration schedule is shown in Fig. 5 - 1.

This schedule was planned based on short term survey by the Mission.

Before execution of restoration, the schedule should be examined and decide by the Chile side.

FIG. 5-1　Restoration Schedule

Berths No.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1										o priority is given to No.3, the most damaged wharf amoung No. 1 – No.3. o wharf No.1, cranes are able to used, is restored after No.1 and No.2 are restored.
2										
3										
4	inspection restoration works									o priority is given to the only container handling berth. o detailed inspection is needed
5	inspection restoration works									
6										o priority is given to No.7 and No.8, use of which is high. o No.7, which is not highly used and affected by high waves in summer, is restored after No. 6 and No.8 are restored in autumn and winter.
7	inspection									
8										
9	prohibited berthing									
10										

5.2 - Earthquake resistant design of facilities

The design procedure for port and harbour facilities considered in this report is that being used currently in Japan, which is described in the references 1, 2). This procedure is a result of continuo s improvements based on the seismic experiences and the researches. The concept of the procedure is applicable to the facilities in the port of Valparaíso.

In the design procedure, the design seismic coefficient is a very important factor and it has to be determined for each specific site. In the following paragraphs, considerations on the design seismic coefficient for the facilities in the port of Valparaíso will be described.

5.2.1- Designs seismic coefficient of restoration

As it has been stated in the related paragraph, the quaywalls of original design satisfy the stability requirement against the earthquake ground motions equivalent to the design seismic coefficient of about 0.10. The relationship between the ground motions and the design seismic coefficient will be described in Appendix A. According to the analysis by Prof. Lastrico and Prof. Monge, the quaywalls may maintain stability against a little larger design seismic coefficient. It is considered that the difference between the present analysis ant the Prof. Lastrico's analysis is caused by the differences in the assumed design conditions.

As it has been mentioned in the related paragraph also, the demaged quaywalls should be restored to recover their functions as soon as possible. However, the restoration does not increase the seismic stability of the quaywalls. Moreover, the quaywalls have the accumulated displacements caused by the last and previous earthquakes, and the seismic stability of the quaywalls has decreased in comparison with the seismic stability of the quaywalls of the original deseign. This means that when the quaywalls are subjected to the earthquake ground motions similar to those of the earthquake of

March 3, 1985, the restored quaywalls will probably suffer similar or more severe damage.

5.2.2 - Design seismic coefficient for the port of Valparaíso

As has been stated, the existing quaywalls have stability against the seismic coefficient, about 0.10, although the accumulated displacements due to the last and previous earthquakes are ignored. When the expected earthquake ground motions in the Port of Valparaíso and their return period are taken into consideration, it is considered that the seismic stability of the existing quaywalls is insufficient and it should be increased in their earliest opportunities, such as reconstruction.
The mooring facilities to be constructed in the future port development should have higher seismic stability.

In principle the followings can be Said. From view point of minimizing the possibility for the facilities to be damaged by the earthquake, higher design seismic coefficient is preferable. On the other hand, however, the construction cost of the facility increases as the design seismic coefficient becomes higher. Therefore, the design seismic coefficient for the public facilities should be determined after the intense consideration on balance among the following factors;
Possibility of damage to the port facilities.(This is evaluated from such factors as the expectancy of the earthquake ground motions and the adopted design seismic coefficient)
Disturbance to the social activity, people's life, and the port operation, caused by the damage to the port facilities.
Increase of construction cost.

Therefore, the design seismic coefficient can not be determined only from physical point of view. In reality, however, the methodology to determine the optimum design seismic coefficient has not been established, and not all the necessary data for the consideration are avaible. At present, determination of the design seismic coefficient largely depends on the judgements by the engineers and the administrative peoples in concern.

As far as the data and the information obtained during the activity of the team within the limited time length are concern, it is judged that the design seismic coeficient for the facilities in the port of Valparaiso should be at least in the range of 0.15 to 0.20. The reason is described in Appendix A.

The earthquake ground motions depends largely on the ground conditions at the site, such as stratification and stiffness of soils. It may be ideal to specify different design seismic coefficient to each facility, depending on the ground condition;however, the limited amount of data and the time which the team has , do not allow such detailed determination.

5.2.3- High aseismicity berth

As it has been described, the facility designed with the large design seismic coefficient is expensive. Therefore, the following may be one of the appropriate considerations. If all the mooring facilities in a port are designed considering the very large earthquake ground motions which scarcely appear there, the facilities will be very safe. But the investment is inefficient, as many of the facilities last their structural lives without meeting such earthquake ground motions considered in their design. The port, however,needs some minimun quantity of the mooring facility even after the very large earthquake ground motions which scarcely appear. Therefore, some facilities have to be designed taking such very large ground motions into consideration and the rest are designed against the earthquake ground motions which are not extremely large, to save the construction cost.

From above mentioned point of view, in Japan in recent years, the high aseismicity berths were constructed in some ports. A structure of the high aseismicity berth is intended to survive the extreamly large earthquake ground motions which may damage seriously the structures of the other berths of ordinary aseismicity. After Such a destructive earthquake, materials for rescue and reconstruction will be transported throngh the high aseismicity berths. If the high aseismicity berths has some extra capacity, then, a part ot the ordinary port operation can be maintained with the high aseismicity berths

Decision should be made by the Chilean authority in concern whether the concept of the high aseismicity berth will be adopted for the port of Valparaíso or not. The team, however, feels that it is adequate that one or two heigh aseismicity berth(s) will be constructed in the Port of Valparaíso. In this case, it is considered appropriate that the design seismic coefficient for the high aseismicity berth is 0.25.

5.2.4 - Further study on the design seismic coefficient

It is hoped that the adequateness of the seismic coefficient and the number of the high aseismicity berth will be confirmed or if necessary, will be modified by the more precise study in future.

5.3.- Methods for restoration

Berth No.	Type of structure	Methods for restoration
1 2 3	concrete block	1. Uneven surface of apron pavement should be repaired by overlay on present pavement. 2. Rails for cranes and foundation for rails should be repaired. 3. Existing mooring posts and bollards may be used.
4	Open-type wharf with concrete piers	1. Restoration works should be decided through detailed inspections on concrete blocks and concrete piers. When it is confirmed that the concrete block wall has not inclined to seaside and concrete piers are not damaged through detailed inspections, this wharf can be used as before. 2. Seaside rail should be located within the middle third of piers and it is necessary to decide restoration method considering that the foundation of land side rail bears whole horizontal force of the crane. 3. Uneveness of face line and crown height of the guaywall should be repaired by replacement of the crown concrete. 4. Uneven surface of apron pavement should be repaired by overlay on present pavement. 5. Steengthen beams of the open wharf, if necessary. Rails for cranes and foundation for rails should be repaired. Existing mooring posts and bollards may be used.

Berth No.	Type of structure	Methods for restoration
5	Concrete block	1. Final conclusion should be reached through detailed inspections. 2. It is probable that sesimic resistance would be insufficient. When the resistance is insufficient, reconstruction of the wharf as a caissson type gravity wall, or re clamation of water area between wharf No.5 and No.6 should be chosen based on the future plan of the port.
6 7	Concrete block Caisson	1. Uneveness of face line and crown height of the guaywall should be repaired by replacement of the crown concrete. 2. Existing pavement slab and poor quality materials for base and subbase course should be removed thoroughly. Materials of good quality should be filled, and compacted fully. - Base and subbase course of necessary thickness should be placed and pavemen slub should be placed. 3. Rails for cranes and foundation of rails should be repaired. 4. Existing mooring posts and bollards may be used. 5. Widths of rubble mound in front of the concrete block wall in the original design should be maintained. 6. Underwater concrete should be filled into large gaps between concrete block to prevent the sucking out of backfills.

Berth No.	Type of structure	Methods for restoration
8	Concrete block	1. Final conclusion should be reached through detailed inspections. When it is confirmed that the concrete block wall has not inclined to sea side or stablity of the wall against sliding and falling down is secured, this wharf can be used as before. 2. Items 1 to 6 of Berths Nos. 6 and 7 should be applied to this berth.

5.4 - Remarks on Restoration Works

5.4.1 - Top Part of Walls

1) Based on the previous record of weather conditions, the best time period for construction should be chosen.

Full caution should be taken for backfill materials not to be washed out by waves. If necessary, special counter-measure for preventing the washing out may be used at time of removing and reconstructing.

2) It is considered effective to insert the connecting bars between existing blocks and newly constructed top part.

3) During the construction, forms for concreting extrude towards the sea out of the wall face line, so the forms should be protected against wave action.

5.4.2 - Apron Pavements and Crane Foundations.

1) Existing pavement slabs and rubbles, or soft soils at the crane foundation should be removed throughly.

2) Material underneath the pavement should be of satisfactory quality.

3) In the course of compaction of subgrade material, full caution should be taken for the wall itself not to be badly influenced.

5.4.3 - Main Structures and Rubble Mounds

1) It should be fully considered that the seismic resistance of each facility has been weakened due to unevenness of blocks, tilting towards the sea, increase in earth pressure etc.,even after restored partially.

2) Detailed inspection of the shape of mound should be made for securing necessary mound width by placing necessary amount of rubbles.

3) Openings between blocks or caissons should be carefully filled for reclaimed soils not to be sucked out.

5.4.4 - Others

1) For the works of repairing the crown height or overlaying of damaged pavements, carefull stability analysis is necessary, because these works will give rise to decrease in stability of the whole structures.

Stability analysis should be carried out with condition of $\phi = 35°$, because strength parameter of backfill soil might be decreased by possible sliding in it.

2) It should be tried to reduce the cost by the reuse of bollards, bitts, etc.

3) Full consideration should be taken for items such as quality control, management of construction schedule, safaty control and so on.

4) Some kinds of shelter may be necessary for protecting working crafts against rough weather.

6.- Suggestions

6.1.- Study on Development Project of the Port of Valparaiso.

6.1.1.- Objective of the study

The objective of the study is to decide a basic plan to improve the port of Valparaiso for the target year of 2.000 and decide a short - term development plan with 1990 as the target year for facilities requiring immediate improvement and make feasibility study concerning this plan.

6.1.2.- Scope of the study

(1).- Present conditions of the port of Valparaiso.

a).- Port Facilities

b).- Port Activities

c).- Port Operation

(2).- Natural Conditions

a).- Climate

b).- Sea conditions

c).- Soil conditions

d).- Earthquakes

(3).- Basic Priorities for Development of the Port of Valparaiso.

a).- Socio-economic Activities in the Area Centered Around Santiago Region.

b).- Port Functions Required in Santiago Region

c).- Basic Priorities for Developing the Port of Valparaiso

(4).- Forecast of future volume of cargoes to be handled at the Port of Valparaiso.

a).- Present situation and trend of cargoes handled at the Port of Valparaiso.

b).- Socio-Economic Frame Prerequisite to Cargo Volume Forecasting.

c).- Future Forecast on Volume of Cargoes at the Port of Valparaiso.

(5).- Master Plan for The port of Valparaiso Development Project.

a).- Strategy or the Master Plan

b).- Estimate of the Scale of the Plan

c).- Master Plan and Evaluation

d).- Construction Plan of the Master Plan

(6).- Short-Term Development Plan for the Port of Valparaiso

a).- Target for Short-Term Plan

b).- Site Selection

c).- Required Berths

d).- Alternative Options for the Short-Term Development Plan.

e).- Container Terminal Plan

(7).- Design, Construction and Cost Estimation

a).- Design of Port Facilities

b).- Method of Construction

c).- Estimation of Construction Plan

(8).- Economic Analysis

a).- Benefit

b).- Cost

c).- Shadow Pricing

d).- Economic Profitability

(9).- Financial Analysis

a).- Analysis of Financial Statement

b).- Discount Cash Flow Analysis

c).- Sensitivity Analysis

7.- Concluding Remarks

This report has been compiled based on the results of investigation at site and collection of information. It should be noted that a limitation of time and an absence of some important data have made some parts to be described qualitatively rather than quantitatively. It is hoped that the Chilean side pays an effort for restoring and developing facilities of the Port of Valparaiso along with the guidelines shown in this report.

Assistance and cooperation given to the mission, throughout the course of investigation, by the Ministry of Public Works and the Empresa Portuaria de Chile are gratefully acknowledged.

References

1) Bureau of Ports and Harbours, Ministry of Transport (Supervision): Technical Standars for Port and Harbour Facilities in Japan, 1980, published by the Japan Association for Ports and Harbours.

2) M. Morihira, H. Tsuchida, S. Noda, and T. Inatomi: Earthquake Resistant Design for Quaywalls and Piers in Japan, published by Japan Society of Civil Engineers, 1984.

APPENDIX A Design Seismic Coefficient

A1. Introduction.

The design seismic coefficient in this report corresponds that in the design procedure for port and harbourfacilities currentty being used in Japan. 1.2) The design seismic coefficient should be determined for each port or site, based on the factors described in the text. Analysis on the efficiency of the invest-ment was not possible, because of the limited time and data as well as the insufficient establishment of the methodology. Therefore, hereafter in this appendix, the consideration of physical aspect to derive the design seismic coefficient for the port of Valparaíso will be described.

A2. Seismic activity around the port of Valparaíso.

Geophysical condition

The seismicity of subduction zone is very active. The Chilean cost is located along the subduction zone of the Nazca plate, therefore it is clear that the port of Valparaíso is located in the zone of high seismic activity.

Large earthquakes

The followings are the large earthquakes which took place around the port of Valparaíso and were presented in the reference. 3)

Year	Epincentral area	Magnitude	Damage to Valparaíso
1575		7 - 7.5	-
1641		8.5	-
1730		8 3/4	-
1822		8 1/2	-
1906		8.4	-
1928	Talca		-
1965	La Ligua		No
1971	Papudo		Yes
1985	Algarrobo	7.7	Yes

The damage to the facilities in the port of Valparaîso by the 1971 earthquake is presentd in the reference 4). The 1965 earthquake did not cause any reported demage in the port of Valparaîso, however, its location of epicenter and magnitude are not much different from those of the 1971 earthquake. Therefore, the 1965 earthquake is considered as one of the earthquake which should not be ignored in the seismic considerations on the port facilities in the port of Valparaîso. The 1906 earthquake had potenciality to demage the facilities in the port of Valparaîso, although the port facilities did not exist at the time of the earthquake.

Within 85 years after 1900, at least 4 earthquakes influenced significantly the area of the port of Valparaîso.
From this fact, it is understood that the port of Valparaîso is located in the zone of high seismic activity.

Expectancy of peak acceleration at Valparaîso

According to the statistical studies, the peak accelerations at Valparaîso was estimated for the different return periods as below 5,6):

Return period	Peak acceleration on ground
50 years	250 gals
100 years	400 gals

For reference, the similar expectancy and the design seismic coefficient at 5 Japanese port are given in table A-1.

Design earthquake acceleration

From the information and data described in the text and the preceding paragraphs in this Appendix, the following peak accelerations are considered appropriate values for the earthquake resistand design of the ordinary port facilities in the port of Valparaîso.

At base rock surface	200 gals
At ground surface	250-300 gals

Design seismic coefficient

The relationship between the peak acceleration and the design seismic coefficient is not simple. According to the research based on the analysis of seismic damage to the gravity type quaywalls, the following empirical formula has been derived 7):

$$e_k = \frac{\alpha_{max}}{g} \qquad \text{for } \alpha_{max.} < 200 \text{ gals}$$

$$e_k = \frac{1}{3}\left(\frac{\alpha_{max}}{g}\right)^{\frac{1}{3}} \qquad \text{for } \alpha_{max.} \geqq 200 \text{ gals}$$

where, e_k: design seismic coefficient

α_{max}: maximun acceleration of ground motions in gals

g : acceleration of gravity in gals

This formula represent the upper bound of the relations between the maximun accelerations and the design seismic coefficient; in other words, the formula gives conservative relationship between them. It should be noted that the acceleration in this formula corresponds to that recorded by the SMAC-B2 accelerograph. The SMAC-B2 accelerograph has a narrower frequenay range than that of the SMA-1 accelerograph, and the SMAC-B2 accelerograph has tendency to give a smaller peak accelaration tham that the SMA-1 accelorograph does. According to the experiences, it is assumed here that the differences are approximately 15% for the record on the rock site and 7 % for the record on the fill or the deposit. So, the peak accelerations in the preceding paragraph are modified as follows:

	Accelerations by SMA-1	Accelerations by SMAC-B2
On fill or deposit	250-300	230-280
On rock	200	170

By the formula, above accelerations can be converted into the design seismic coefficient; namely 0.17 on rock and 0.21 ~ 0.22 on ground.

Taking the fact that the formula gives conservative values and the experiences in Japan into consideration, it is concluded that the design seismic coefficient for the facilities in the port of Valparaíso is in the range of 0.15 to 0.20.

In the similar way, the design seismic coefficient for 400 gals is calculated as 0.24. Taking this and the practice in Japan into consideration, the design seismic coefficient for the high seismicity berth is determined as 0.25

Some experiences in Japan

During the 1978 Miyagiken Oki earthquake, the facilities in the port of Shiogama and the Sendai were subjected to the similar earthquake ground motions 8). The recorded peak accelerations in that area were about 200 gals on the baserock and 280 gals on the ground. Most of the mooring facilities in both ports were designed with the design seismic coefficient 0.15. The performances of those structures were satisfactory. This fact is supporting the determination of the design seismic coefficients in this report.

References

1) Bureau of Ports and Harbours, Ministry of Transport (Supervisión): Technical Standars for port and Harbour Facilities in Japan, 1980, published by the Japan Association for Ports and Harbours.

2) M. Morihira, H. Tsuchida, S. Noda, and T. Inatomi: Earthquake Resistant Design for Quaywalls and Piers in Japan, published by Japan Society of Civil Engineers, 1984.

3) Juan Carlos Labbe R. and Rodolfo Saragoni H.: Seismicidad en Chile, Publication Ses I 7/76 (124), Universidad de Chile, Facultdad de Ciencias Físicas y Matemáticas, Departamento de Obras Civiles, Sección Ingeniería Estructural, Octubre 1976.

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9) H. Kawasumi: Measures of Earthquake Danger and Expentancy of Maximum Intensity throughout Japan as Inferred from the Seismic Activity in Historical Times, Bull. Earthg. Res. Ins., Vol.29, 1951.

10) H. Goto and H. Kameda: Probabilistic Study on Maximum Ground Motions during Earthquakes, Journal of the Japan Society of Civil Engineers, N° 159, 1965.

11) S. Hattori: Regional Distribution of Presumable Maximum Earthquake Motions at the Base Rock in the Whole Vicinity at Japan, Bull. of International Institute of Seismology and Earthquake Engineering, Vol. 14, 1976.

12) S. Kitazawa, et al.: Expected Values of Maximum Base Rock Accelerations along Coasts of Japan, Technical Note of the Port and Harbour Research Institute, N° 486, 1984.

Table A-1 Examples of approximate expectancy of acceleration and design seismic coefficient.

Researcher(s)	Return period (year)	Port				
		Tokyo	Osaka	Akita	Hosojima	Hachinohe
Kawasumi[9] (on ground)	75	300	200	100	50	100
ditto	100	600	300	100 – 150	100	150
Goto and Kameda[10] (on ground)	75	300	250	200	150	150
Hattori[11] (on rock)	100	200	50 – 100	150	100	150
Uwabe and Kitazawa[12] (on rock)	75	250	220	250	200	200
	100	270	250	280	220	220
Design seismic coefficient*		0.18	0.18	0.12	0.12	0.12

* Factor for subsoil condition 1.0 and importance factor 1.2 are used. Details can been found in the references 1,2).

Appendix B. On the Damage to the Port of San Antonio

The expert mission visited the port of San Antonio as day return. Major purpose of the visit is to learn about the damage took place in the port of San Antonio and to reflect what the mission learned there to the consideration on the aseismicity of the facilities in the port of Valparaíso. The followings are brief records of the mission's impression.

Liquefaction

It was evident that the liquefaction occured in the sand fill behined the mooring facilities. The cracks in the ground and the extreamly severe damage to the structure are explaining occurences of the liquefaction.

The sand found there was very fine and uniform. If the sand there is relatively loose, it liquefys very easily under not very large ground motions. The maximum acceleration recorded at Llo - Lleo, about 6 km distant from San Antonio was 0.25 g. The acceleration in San Antonio may not be same to that at Llo-Lleo, but it must be large enough to liquefy the sand in the port. The design criterion for assessing liquefaction potential can also explain the liquefaction there. The criterion is explained in the reference (1).

Cause of Damage

The liquefaction causes increase of pressure to the structure and decrease of bearing capacity. The lateral resistance of pile is also decreased by the liquefaction of sand layer in which the pile is driven. It is clear that those phenomenon as well as large acceleration caused the damage.

Inspection

The expert mission felt that the structures of the berths Nos. 3 through 7 should be inspected very carefully. The deformation should be measured and the stresses in the deformed member should be analyzed to examine the reliability of the structures. If necessary, the restriction of loading should be made. The concrete piles of the structure of the berth No.5 should be inspected whether cracks exist in the piles or not. If there are cracks of width exceeding certain limit, the durability of the piles might decrease considerably.

Improvement of Ground

The sand fill behined the structures needs to be densified to increase resistance to the liquefaction. If necessary, the liquefaction potential should be assessed by means of the design criterion. Attension should be given to the effect to the structure caused by the densification works.

Reference

1) Bureau of Ports and Harbours, Ministry of Transport (Supervision): Technical Standards for Port and Harbour Facilities in Japan, 1980. Published by the Japan Association for Ports and Harbours.

(3) IMO専門家の報告書

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Abril 11 de 1985

Estimado señor Valenzuela,

Me es grato dirigirme a Ud. en relación a la visita del señor John Sullivan, experto de la Organización Marítima Internacional (OMI) a fin de colaborar con las autoridades nacionales competentes sobre la manera más efectiva de utilización de los puertos de San Antonio y Valparaíso después de los considerables daños sufridos por ambos, a raíz del sismo que asoló el país el día 3 de Marzo.

Sobre este particular, y como resultado de dicha misión, me es grato hacerle llegar una copia del informe preliminar en idioma Inglés preparado por el consultor luego de sus visitas a los puertos de San Antonio y Valparaíso. La traducción en Español y el informe detallado serán proporcionados a la mayor brevedad.

Hago propicia la ocasión para saludarle muy atentamente.

Pierre den Baas
Representante Residente

Señor
don Miguel Valenzuela
Jefe, Departamento de
Estudios, Dirección de Obras Portuarias
Ministerio de Obras Públicas
Presente

PRELIMINARY REPORT

CONCLUSIONS/RECOMMENDATIONS FOR THE PORTS OF VALPARAISO AND SAN ANTONIO, CHILE
MADE BY IMO CONSULTANT JOHN SULLIVAN AT THE COMPLETION OF HIS MISSION
MONDAY MARCH 25 THROUGH MONDAY APRIL 1, 1985

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1. GENERAL COMMENTS

1.1 The preliminary conclusions/recommendations made in this report are reached within the framework of terms of reference for the consultant:

" 1. Operational methods to improve good productivity and berth occupancy considering drastic reduction of berth-capacity due to damage caused by earthquake,

2. Replacement of cargo handling equipment, particularly port cranage and container feeder services,

3. Day-to-day operations including allocation of space/area for container stacking, warehouses and information systems".

1.2 A more detailed mission report will be prepared and delivered by the consultant to IMO, London upon the termination of the mission.

1.3 Considering the fact that some emergency measures have already been implemented since March 3, the recommendations or advice in this paper deals only with the actual situation prevailing at both ports at the time of mission.

1.4 The objectives and the aims for the recommendations/advice are governed by the consultant's efforts to devise methods for optimizing the operations with effective, comprehensive and cohesive utilisation of existing resources, manpower and facilities, in order to achieve the greatest possible contribution, at least cost in real terms, to the growth of the national economy and to avoid further economic strain on some US$1800 million burden created by the earthquake.

1.5 The consultant believes sincerely that the contents of this preliminary report will be interpreted in the light of the above expressed views and not to be regarded upon as controversial. Experience shows that the pursuit of increased performance in ports, particularly when this involves changes in

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operational methods and customs, may easily become subject to resistance. The benefits resulting from well founded changes, however, may accrue in the form of a faster ship turn-round, improved cargo flow with streamlined cargo operations. The incentive to achieve this in the two ports in caption should be the optimal utilisation of their combined capacities and facilities, for the benefit of EMPORCHI and for the port users.

1.6 Finally it must be borne in mind that the contents of this paper is formulated by the consultant who, aided by his findings, favors and advises that Valparaiso and San Antonio, with only 40 sailing miles apart, should be treated as "twin ports", in terms of capacity utilisation and as such planning and execution of their joint operations be coordinated as one port.

2. VALPARAISO - OPERATIONS

2.1 Berth occupancy

The average berth occupancy in 1984 was 39% with over 55% slack on the port's intrinsic capacity.

The present berth occupancy can be optimized by combining the capacity available here and in San Antonio in a more coordinated manner than implemented prior to March 3. There is a situation, perhaps permanent, whereby the reparation/reconditioning of some of the berths and their back-ups may not be warranted from an economic point of view.

2.1.1 A contingency plan for berth occupancy/utilisation should be prepared for the twin ports. No such plan has been drawn in the past, however, the earthquake warrants this plan which has to be up-dated and revised at monthly intervals.

2.1.2 During the intermediate period while seismographic and strength tests are carried out to estimate the extent of the repairs required for berths Nº 4, 5, 6, 7 and 8, ships to load perishables be given priority at berths Nº 1, 2, 3 and 4.

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2.2 Berth throughput (perishables)

The berth throughput for 1983 and 1984 was 40% - 42%, on 8.3 berths basis. The following observations are made at berths Nº 1, 2 and 3 during 5 consecutive days while 5 reefer ships were loaded and 2 multi-purpose vessels loaded perishables and discharged break bulk cargo.

a) There is an extended degree of unnecessary and overlaping transfer and loading operations particularly on the apron. Over utilisation of FLTs is excessive. This results in bottlenecks and mini congestions on the quay side where too many FLTs are lined up idle.

b) Four different lifting gears are used to load the pallets:

1) Pallet cages
2) Pallet wires slings with top spreader and steel side bars
3) Nylon straps
4) Pallet forks (singles and twins)

c) Not all cargo is palletized (onions) and palletisation is done behind the shed resulting in longer queueing time and space occupancy.

Berth throughput, hook cycle, berth occupancy can be improved with approx. 20% over the present utilisation/productivity when and if:

aa) all cargo is palletized or palletisation is done at the shed back-up area yard.
bb) only one type of lifting gear is used: twin pallet forks.
cc) pallets are lifted for loading into ship's hold directly from the truck's deck and not off-loaded on the quay first and then hooked after.

The above recommendations are easy to implement and they go also for similar operations of same nature at all other berths where perishables are exported. The exception is at the berths Nº 5, 6, 7 and 8 during the transition period.

/...

2.3 Berth throughput - other palletized cargo

The same overutilisation of FLT's also exists here. Direct delivery cargo should be lifted for loading into ship's hold directly on truck's/rail cars' decks and vice versa, without being put on the quay first.

2.4 Container operations

Due to time factor the consultant did not have time to analyse container operations. Having in mind that the port users are presently exercising their right to take over container delivery/receipt, thus become responsible for all container operations in this port, the consultant recommends that to streamline further the EMPORCHI's portion of quay side container paper work is computer - ized by integrating this to the existing facilities of the port users. When berths Nº 4 and 5 are made fully operational, a detailed study of the container operations should be considered.

3. VALPARAISO - CARGO HANDLING EQUIPMENTS

3.1 Forklift trucks

The extended unnecessary use of transfer and quay side equipments should be reduced. This calls for a closer cooperation between EMPORCHI and the port users. The berth system and the custom of this port with 50% direct delivery which is close to 90% during the shipment period of the perishables warrants that a sensible reduction in overutilisation of FLTs must be eliminated. The present FLT park can handle twice as much, perhaps more traffic/cargo flow than 1,1 million tons of 1984.

3.2 Container handling equipment

The existing container transfer equipment is slow. If EMPORCHI is to invest in new equipment the consultant recommends that 2 side loaders instead of 2 sophisticated shifters (combined straddle carrier and transtainer) should be purchased. With situation as described under item 2.4 whether the port users should undertake the investment in new equipment should also be considered.

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3.3 Quay side cranes

The nature of berth system with close to 100% direct delivery for perishables and 50% to 60% for general cargo entails that transfer and discharge/loading operations warrants that there should be as few obstructions as possible, preferably none, on the apron and at shed seaward fronts. Fixed quay cranes are prime sources for quay side congestions and help create bottle necks with ensuing impact on hook cycle, berth throughput and berth occupancy.

The consultant recommends that increased use of ship's gear be implemented and encouraged. The quay cranes be dismantled and reduced to nails. To absorb the peaks and to compensate slow ship hook cycle, money from the nails be invested in mobile cranes of 3 tons capacity each.

4. VALPARAISO - SPACE/AREA FOR CONTAINERS AND WAREHOUSES

The consultant recommends that once the fixed cranes are phased out (the emblem of EMPORCHI can remain unchanged), all the verandahs at the sheds be torn down including the bridges connecting berths Nº 1, 2 and 3 to each other. By doing so the apron and marshalling areas between and behind the sheds will be considerably increased.

4.1 As soon as the seismatic and strength tests are obtained and the future of berths Nº 6, 7 and 8 decided upon this pier is recommended for conversion to multi-purpose pier by tearing down three sheds leaving only the south-east shed behind.

4.2 There seems to be no need to consider improvements nor eventual extension of the Baron pier (berths Nº 9 and 10).

4.3 Yards (open storage area)

The existing yard facilities are under utilized and there seems to be no need to consider additional space allocation beyond the existing limits.

4.4 Container marshalling, stacking and back-up areas

If seismatic and strength tests warrant that containers can be stacked in three high within the existing areas there appears to be no need for addition

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al space allocation in this respect as the existing facilities are ample for a traffic volume upto 65.000 TEUs.

Any decision regarding container traffic in this port is recommended for careful consideration to avoid patch-work solutions. There will also be container area on the pier if the proposed conversion described 4.1 above is implemented.

4.5 The existing infrastructure and the geography of Chile seems not to warrant the need for an inland container depot in Santiago.

5. SAN ANTONIO - OPERATIONS

5.1 Berth occupancy

In 1984 this was approx. 49% and the berth throughput about 85%. The question is whether this port can achieve the same results with berth capacity reduced to 5.

5.1.1 The consultant sees no immediate problems to this effect as:

a) The container traffic is expected to decrease for about 50% from 1984 level of 20.966 TEUs to about 8 - 9.000 TEUs in 1985. This drop will take place from around July/August 1985 in connection with a major Lines plans to divert the calls to Valparaíso.

b) The traffic peaks can be eased by combining and coordinating the capacity use of the twin ports.

5.2 Bulk cargoes

The volume of bulk cargo traffic for 1985 is estimated to stand at:

- grain 800.000 t
- c. concen. 115.000 t
- others 405.000 t = 1.320.000 t or approx. the same volume as for

1984. The cargo flow volume, all told, is estimated to remain at 2 million level for some years.

Berths Nº 5 and 6 should be given priority for bulk shipments while Nº 3 should be allocated to copper concentrate shipments.

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5.2.1 The draft at berths 5 and 6 is 30 ft at low and 34 ft at high tide. There is no safety margin to allow dredging for the pier and consequently no way of chartering larger vessels to obtain economy of scales for grain imports. However, the consultant recommends that the cases of dead freight payments to grain tonnages should be surveyed to determine the causes and eventually reduce or eliminate these.

5.2.2 The consultant strongly recommends that the proposals to convert the oil jetty facing north of the pier to a full scale grain terminal where larger shipments can be handled (the depth is about 40 m.), should be definitely abandoned. Not only the investments in new facilities will be exorbitant but same will require the increase of storage capacity (ies) to room large lots one at a time.

5.3 The consultant did not have the opportunity to observe cargo/berth operations in this port. Arrangements to shuffle his time to be in San Antonio did not help as the first ship since March 25 arrived on March 31 to load copper concentrate and the next three ships were expected to call on Monday April 1.

5.3.1 The consultant is therefore, not in a position to comment on this issue but believes is safe to assume that the situation in Valparaiso related to berth/cargo operations goes, to certain extent, also to this port and same recommendations can be considered for remedy.

6. SAN ANTONIO - CARGO HANDLING EQUIPMENT

6.1 Mobile equipment

There is adequate number of equipment, owned by EMPORCHI and by private port users to handle general cargo and containers. The planned use of one of the 50 t mobile cranes ton grain discharge is correct and should be implemented.

6.2 Quay side cranes

The consultant recommends that the use of quay cranes should be phased out for good and the plans to install three new ones on shed Nº 3 be abandoned. Use of ship's gear alone should be implemented. To speed ship's hook cycle,

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whenever this occurs, use of approx. 3 t cap. mobile cranes should be adopted.

6.3 Replacement of aged and slow locos

The consultant supports the plans to replace the two aged locos with two new ones which will help increase the efficiency of operations and help improve better utilisation of resources. His views on this issue have already been relayed to the representative of The World Bank.

7. SAN ANTONIO - SPACE/AREA FOR CONTAINERS AND WAREHOUSES

7.1 Containers yard

With the reference to item 5.1.1 the consultant sees no need to extend the existing container yard and back-up facilities beyond the present limits. The space on the pier alone is sufficient for a traffic of up to approx. 25.000 TEUs.

7.2 Warehouses

Considering the berth system and the infrastructure the consultant sees no need in increasing shed capacity beyond the one on the pier which can cover transit storage demand of about 1 to 1.2 million tons.

7.3 Yards (open storage)

There exists ample quay/apron space to handle grain traffic for up to 2 million tons a year and storage for 1 million tons of general cargo a year. The consultant sees no need to extend the existing facilities beyond their present limits.

7.4 Any investment for repairs/reconditioning of berths 1 and 2 would be waste of money. These two berths and the facilities are recommended for consideration as lost.

7.4.1 Berth Nº 3 deserves to be reconditioned as it appears that this can be achieved with a reasonable investment.

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7.4.2 The consultant recommends that all investments should be concentrated to the pier and to berth Nº 3.-

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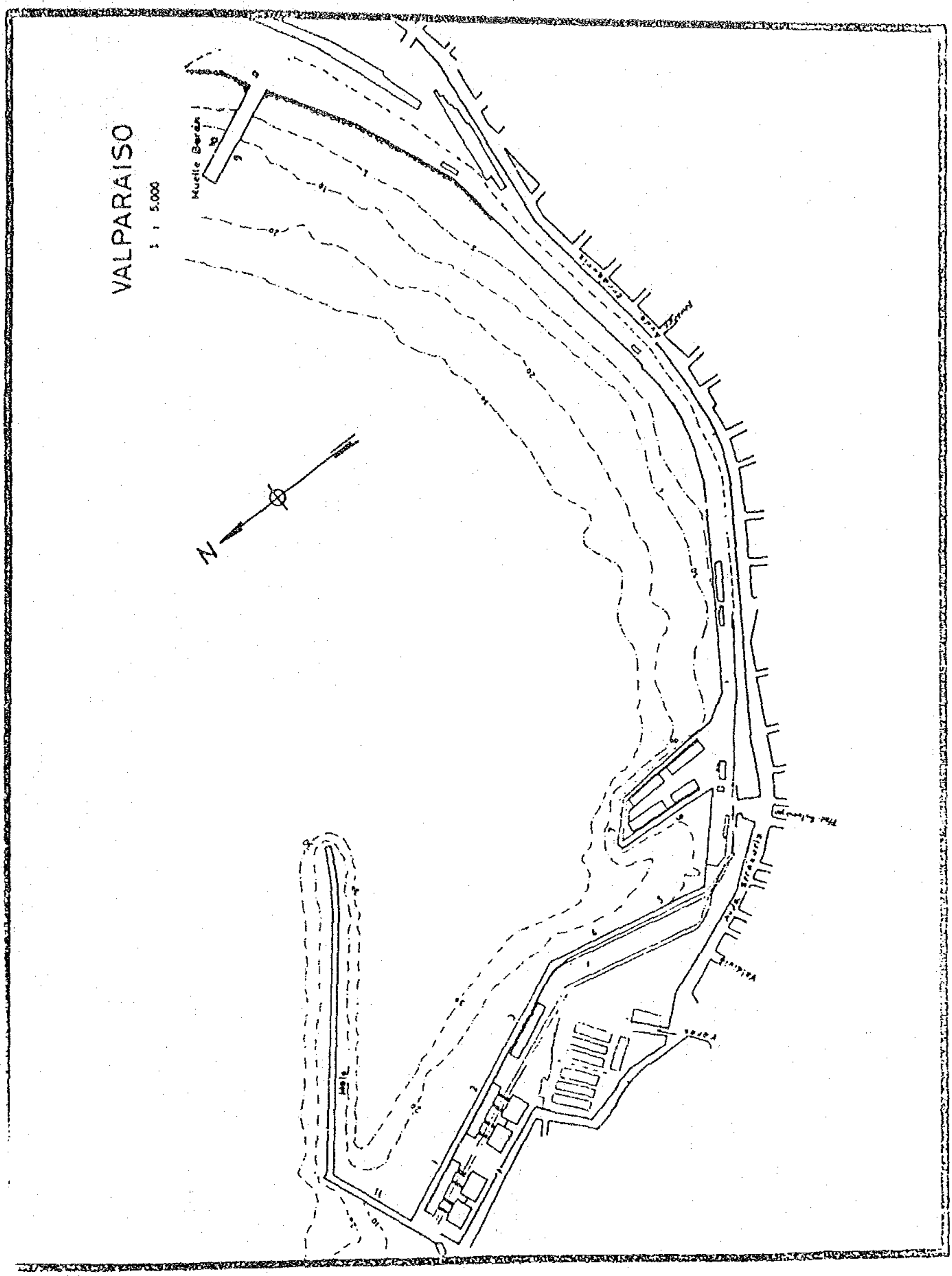
Santiago, April 2, 1985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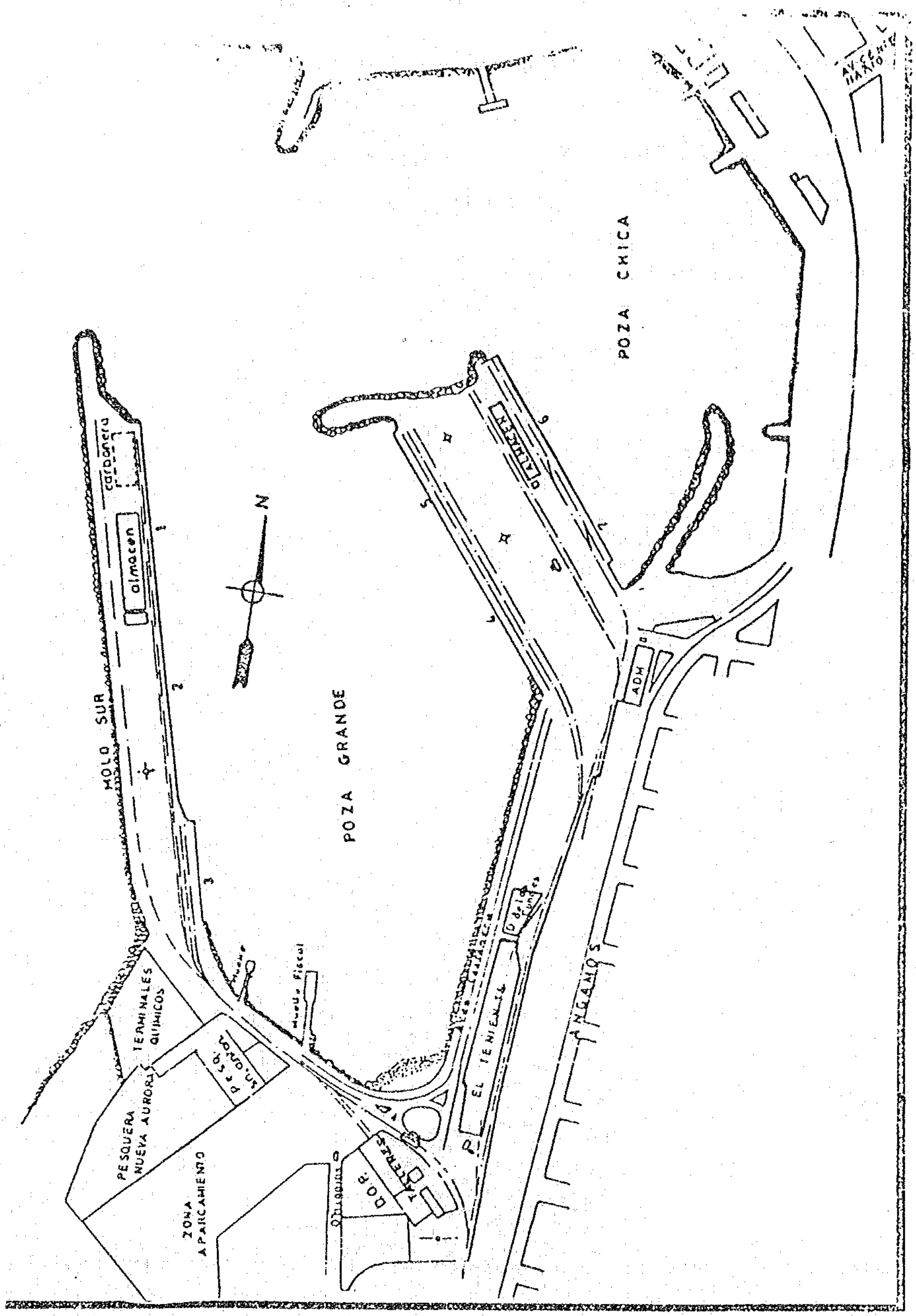
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