FEDERATIVE REPUBLIC OF BRAZIL

FEASIBILITY REPORT
ON
THE PRAIA MOLE PORT CONSTRUCTION PROJECT

VOL. I

NOVEMBER, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 14.3.5 Allocation of the interest payable

(Unit: in Cr$ 1,000)

Facilities	1st stage			Master plan		
	Slab	Coal	Oil	Slab	Coal	Oil
Breakwaters	16,570	19,630	14,630	20,580	17,850	12,400
Dredging	14,400	10,510	2,000	15,020	10,230	1,670
Reclamation	5,170	6,110	110	5,170	6,110	110
Subtotal	36,140	36,250	16,740	40,770	34,190	14,180
Mooring facilities	11,380	4,180	1,160	14,840	7,850	1,110
Revetment	2,410	2,410	500	2,560	2,360	400
Other facilities	8,970	6,270	1,770	11,290	7,160	1,900
Cargo handling facilities	13,020	18,810	—	21,670	29,950	—
Subtotal	35,780	31,670	3,430	50,360	47,320	3,410
Total	71,920	67,920	20,170	91,130	81,510	17,590

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ERRATA

Feasibility Report on the Praia Mole Port Construction Project

(Note: * Shows the line from below)

Page	Line	For	Read
(Conclusions and recommendations)			
i	15	Atalantic	Atlantic
v	6	whereever	wherever
	1*	ateel	steel
vi	7*	spec	spect
viii	Note	means	meant
xii	2*	sucy	such
(Summary)			
3	1	and schedule	and construction schedule
(2)	7*	state	State
(5)	10*	coal for	coal and petroleum products for
	10∿9*	and petroleum products for	(to be deleted)
(8)	Table 2	DET	DWT
(10)	5	isset	is set
(14)	4*	crowan	crown
(18)	8*	brabbing	grabbing
(19)	2	onth	on the
(22)	1	method	methods
	11	It	If
	11	is started	work is started
	8*	at (10 -----)	at 20 (10 -----)
(25)	5	wmount	amount
(26)	15	methods	methods,
	13*	Port, and	Port and
(27)	9*	lenger	longer
(29)	3	harbour	harbours
(30)	9*	Found	Fund
		found	fund
	3*	task	tasks
(31)	8	beause	because
(33)	12*	renumeration	remuneration
(33)	11*	renumeration	remuneration
(35)	4*	returns	return
(36)	11*	Clab	Slab
(38)	5	In	If
(39)	6*	income	income and
(40)	Table 8	w/o dividend of 100% -----)	w/o dividend, 10% of the total investment excluding subsidy is taken as an annual cost
	10*	an	and
	5*	divided	dividend
	1*	as shown	are as shown

Page	Line	For	Read
(41)	Table 9, b-②	77.2	67.2
(43)	11	onoy	only
	11*	rately	rarely
	3*	abut	about
(44)	1*	to to	to do
(Contents)			
iii	10~5	Conclusion	Conclusion -
(Chapter 1)			
1	9	SIDERUGICA	SIDERURGICA
	10	pushed,	pushed
	17*	National	Nacional
3	5	USIMINAS,	USIMINAS'
5	9	Counsellar	Counsellor
6	2	jointed	joined
7	12*	Paid a transport	Paid a
15	9*	Derecto	Director
	8*	Minister	Ministry
(Chapter 2)			
20	10	reet	reef
	12	Portocellying	Portocel lying
21	Fig. 2.3.1	Baixo de	Baixo do
23	13	called are	called canga are
	14	canga	(to be deleted)
	15	it self	itself
25	Fig 2.3.2	Baixo de	Baixo do
48	Table 2.3.6,5*	79.3	73.9
62	2*	waves	wave
63	9*	Directions	direction of
83	3	higher	highest
	4	164	159
84	5	live-stock	livestock
86	Table 2.4.1		(to be replaced with the one attached herewith)
87	8*	live-stock	livestock
92	Title	Manufactured	manufactured
95	10	Gross	Grosso
97		Noua	Nova
		VFCO	VFCB
98	Table 2.4.7	RFFA	RFFSA
107	Table 2.5.1		
	Facilities, 2	yard,	yard
	4	unloader yard,	unloader, yard
	5 and 6	shiploader storage,	shiploader, storage
	9	yard,	yard
	10	Silo,	Silo
	1*	2,500 T/H	16,000 T/H
109	3*	~10,000	~100,000
110	4	enterance	entrance
112	1*	Ground	Grand
(Chapter 3)			
114	7	mills	mills are
	Table 3.1.3		
	Crude steel, 6	0.04	0.03
	7	0.05	0.04
(Chapter 4)			
161	3	habour	harbour
(Chapter 5)			
196	3	coal	ore

Page	Line	For	Read
	5*	coal	ore
197	6	domestic	domestic trade
199	10	domestic	domestic trade
202	5*	dischange	discharge
204	Table 5.4.1	Piper	Pier
		Car	Wagon
205	Table 5.4.2 Remarks	per a berth	per berth
		two berth	two berths
206	11	Table 5.4.6 (1st stage)	Table 5.4.5 (1st stage)
208	Table 5.4.5,1*	1,841	1.841
		1,744	1.744
		1,711	1.711
209	Table 5.4.6,1*	1,764	1.764
		1,740	1.740
		1,738	1.738
		1,738	1.739
226	Table 5.5.5,1	Rainforced	Reinforced
(Chapter 6)			
227	11	Fig. 2.3.18	Fig. 2.3.19
235	16*	lending	bending
237	4*	2-3-2	2-3
260	5	6.2.23	6.2.14
	6	6.2.24	6.2.17
	8	6.2.14	6.2.15
		6.2.16	6.2.18
	9	6.2.15	6.2.16
287	13	large concrete	(to be deleted)
303	1	meibod	method
	8~9	for the travelling direction and at least 2.5 times as wide as the bucket width	(to be deleted)
331	1	a	an
	12*	and	any
340	7	Car	Wagon
344	16*	hweel	wheel
	12*	water	(to be deleted)
	7*	is	are
350	2	6.3.20	6.3.23
362	13	Graffing	Grabbing
365	8*	transformers	transformer
366	4 and 10	Apart	A part
367	Fig. 6.4.1	plase	phase
		car	wagon
		sile	silo
368	Fig. 6.4.2	plase	phase
		Reelaimer	Reclaimer
		car	wagon
		sile	silo
		barth & gard	berth and yard
		athers	others
369	Fig. 6.4.2 Columns: 2,3,4 and 6	Feed system	Cable reel
(Chapter 7)			
388	9	2,320.764	2,320,764
389	5*	seems	seem

Page	Line	For	Read
(Chapter 8)			
397	13*	may applied	may be applied
400	5∿4*	reclamated	reclaimed
(Chapter 9)			
411, 413 and 415	3	First stage Second stage	Local currency Foreign currencv
	8*	Car	Wagon
413	RECLAMATION	(9,626)	(9,686)
415	12*	(9.626)	(9,626)
419	3*	cargo	cargo handling
421	3.	(8.599)	(8,599)
421	3.1 and 4.	sheets piles	sheet piles
	3.1	fendors	fenders
	6.4.1	stocker	stacker
421 and 423	6.4.3	car sile	wagon silo
423	6.2	1,432	(1,432)
(Chapter 10)			
425	13	list	lost
427	5	10.1.1	10.2.1
431	2	20 N 30	20 < N < 30
432	Table 10.2.3		
	Turnning basin	2,300	2,330
	2*	realaiming	reclaiming
434	3	shorten	shortened
435	Table 10.3.1	revetment	revetment (1)
		Revetment (2nd stage slab)	Revetment (2nd stage slab) (2)
439	4*	largs	lanes
	3*	stocker	stacker
441		car	wagon
443		car	wagon
		sile	silo
445		car	wagon
	7.1	9.492	(9,492)
447	TOTAL and GRAND TOTAL	6.5	65.0
	TOTAL of coal yard in '82		27.2
451	4.	sheets piles	sheet piles
	6.3	record discussions	record of discussions
	6.4.3	car	wagon
455	1	Conclusion	Conclusion -
(Chapter 11)			
461	Fig. 11.1.1	Inpormation	Information
464	7	Improvement	improvement
	15	carris	carries
		imporovement	improvement
	17	relative	(to be deleted)
466	Table 11.1.1	Other	Others
	Column: Foreign	501.1	501.4
	Total	501.1	501.4
467	8	harbour	harbour dues
468	9*	been that	been said that
	1*	1975	1976
469	13*	relatinely	relatively

Page	Line	For	Read
(Chapter 12)			
473	8*	longshoring	longshore
476	13	port	port.
	14	given	Given
(Chapter 13)			
485	Table 13.3.1		
	Dredging	4.58^{4m^3}	$4,580 \times^{1000m^3}$
		52	5.2
485	Physical	Pysical	Physical
	Physical	Pysical	Physical
487	Table 13.3.2,1	Anual	Annual
489	13	the cost	the operating cost
	12*	expences	expenses
490	Table 13.4.1 (1)		
	82	115.1	15.1
493	19	Cr$	US$
497	3	TOMELADA	TONELADA
498	1*	efficient	coefficient
499	7	studies	studied
501	Table 13-1		
	Columns: 3 and 6	Construcution	Construction
	4 and 7	thousand	million
	2*	5,610	5.610
502	Note 2)	(to be corrected entirely)	The management expenses in Tables 13.4.1 (1) and (2) are estimated to be twice as much as the total of this table.
504	1	13-5	Table 13-5
	Table 13-5 (1)	2,384.2	107.6
	17	2,572.3	107.6
		1,751.4	70.0
		1,751.8	70.0
505	1	13-5	Table 13-5
	Table 13-5,3	ULS.A.	USA
	Column: Remarks	120	60
		60	120
506	Table 13-6		
	Column: Remarks	120	60
		60	120
507	3*	5	25
509	Table 13-8,1	39.	39.7
509	3	979	1979
	Column: ⑤	64.0	(to be deleted)
(Chapter 14)			
513	Columns: Petralum	Petralum	Petroleum
		1st stage	1st stage | 2nd stage
518	1*		(to be deleted)
518	Table 14.3.1, 2	9.14	91.4
520	Table 14.3.4,2*	47,232	8,448
		19,584	153.6
521	Table 14.3.5		(to be replaced with the one attached herewith)
522	Table 14.3.6	Oils	Oil
524	11* and 4*	Administration	Management
	8*	machine	equipment
525	Table 14.3.8	8.610	8,610
526	12	speially	specially
527	Table 14.3.9,⑩	4.87	4.97

Page	Line	For	Read
530	7	Return)	Return).
531	14*	entends	extends
	7*	difficule	difficult
537	Table 14.5.2, 2	Portbrás	Portobrás
	Column:		
	Financing terms	Owned capital	Owned capital
			- do -
	(two places)	deferment	grace period
539	6	cannot	Praia Mole Port cannot
	15*	became	becomes
541	Column: b-②	77.2	67.2
543	8*	subsidized	subsidize
547	1980	155140010	1551400.0
		-151400.0	-1551400.0
549	2	W/O	W/
		SUBSIDIEX	SUBSIDIES
551	(Three places)	deferment	grace period
553		Cr$2,738.4m	Cr$2,738.4
561	5*	DIVIDENT	DIVIDEND
563	5*	DIVIDENT	DIVIDEND
567	7*	018.4	-18.4
571	5	20	2012
	Columns: 38 and 39	6.0	0.0
582	9	Vetória	Vitória
	16	mills	mill
589	8	dort	chart
	12*	waves	wave
	8*	of waves	by direction
	7*	ocean	Ocean
	1*	Recurrence	recurrence
590	6*	of	the
(Appendix)			
608	2	M	S
612		REGNED	LEGEND
623, 627 and 629		ARHOR	ARMOR

Table 2.4.1 Population distribution by regions

	1960		1970		1977		Population density		Average growth rate during the ten-years period from 1960 to 1970 (%)
	Actual, thousand persons	Ratio (%)	Actual, thousand persons	Ratio (%)	Actual, thousand persons	Ratio (%)	Area (km^2)	Population density (persons/km^2)	
North	2,601.5	3.67	3,650.8	3.86	3,863	3.86	3,578	1.08	3.9
Northeast	22,428.9	31.59	28,675.0	30.34	30,362	30.34	1,546	19.64	2.7
Southeast	31,063.0	43.76	40,332.0	42.68	42,710	42.63	925	46.17	2.9
Minas Gerais & Espirito Santo	(10,987)		(13,097)		(13,329) (1,711)		(587) (46)	(21.00) (37.20)	
Rio de Janeiro & Guanabara	(7,101)		(9,274)		(5,084) (4,573)		(43) (1)	219.43	
São Paulo	(12,975)		(17,959)		(19,013)		(248)	(76.09)	
South	11,892.1	16.75	16,683.6	17.65	17,662	17.65	578	30.56	3.9
Center-West	3,006.9	4.23	5,167.2	5.47	5,473	5.47	1,879	2.91	6.2
Total	70,992.4	100.0	94,508.7	100.0	100,070	100.0	8,506	11.76	3.3

North : Rondonia, Acre, Amazonas, Roraima, Pará, Amapá

Northeast: Maranhão, Piãui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco Alagoas, Fernando de Noronha, Sergipe, Bahia

Southeast: Minas Gerais, Espirito Santo, Rio de Janeiro, Guanabara, São Paulo

South : Parana, Santa Catarina, Rio Grande do Sul

Center-west : Mato Grosso, Goias, Distrito Federal

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PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to make a survey of the Brazilian plan to build the Praia Mole Port, survey being conducted by the Japan International Cooperation Agency.

The Agency dispatched a survey team consisting of 9 members led by Mr. Susumu Maeda, Planning Manager of the Overseas Coastal Area Development Institute of Japan. The survey was conducted during the period from February 4, 1977 to March 15, 1977 with the cooperation of the Brazilian Government and all related organizations.

After completion of the field survey, the survey team analysed and evaluated their findings, and the data supplied by the Brazilian Government, on the vasis of the basic matters and the Scope of Work agreed upon by the Brazilian and Japanese Governments. After further readjustments having been made in Brazil regarding construction cost, the present report has been complied.

We strongly hope that the Praia Mole Port Construction Project will be implemented soon in order to promote Brazil's economic development and further enhance the friendship between Brazil and Japan.

In conclusion, we would like to express our gratefulness to the Government and the people of Brazil for their close cooperation and assistance extended throughout the survey.

Shinsaku Hogen
President,
Japan International
Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir:

It is my great pleasure to submit herewith a report on the Feasibility Study for the Construction Project of Praia Mole Port of the Federative Republic of Brazil.

In order to examine the feasibility of the construction project, the Japanese survey team headed by myself conducted a preliminary survey last autumn, a principal survey for 40 days from Feb. 4 this year and another survey in August also this year, at the request of the Japan International Cooperation Agency. The findings of these surveys were discussed to study the viability of the Praia Mole Port construction project, and this is the report.

For the principal survey started in February this year, the Japanese survey team made various preparatory studies before its departure for Brazil and submitted the result to the Brazilian Government for suggestions and improvements.

In the final stage of the survey, the Japanese survey team joined efforts with the Brazilian counterpart to make a thorough end-to-end settlement of all major problems. As a result, the Japanese survey team and the Brazilian Authority in charge reached an agreement on many points.

On behalf of the Japanese survey team and myself I would like to express my deepest appreciation to the government of the Federative Republic of Brazil, the Empresa de Portos do Brazil S.A., and various Brazilian companies for their unlimited cooperation and assistance and warm hospitality extended to the team during its stay in Brazil.

My indebtness is also great to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs, the

Japanese Consulate Generals in Rio de Janeiro and São Paulo, the Japanese Embassy in Brasilia, Kawasaki Steel Corporation and many other Japanese companies having their branches in Brazil, that have given us valuable suggestions and assistance in the three field surveys and in preparation of this report.

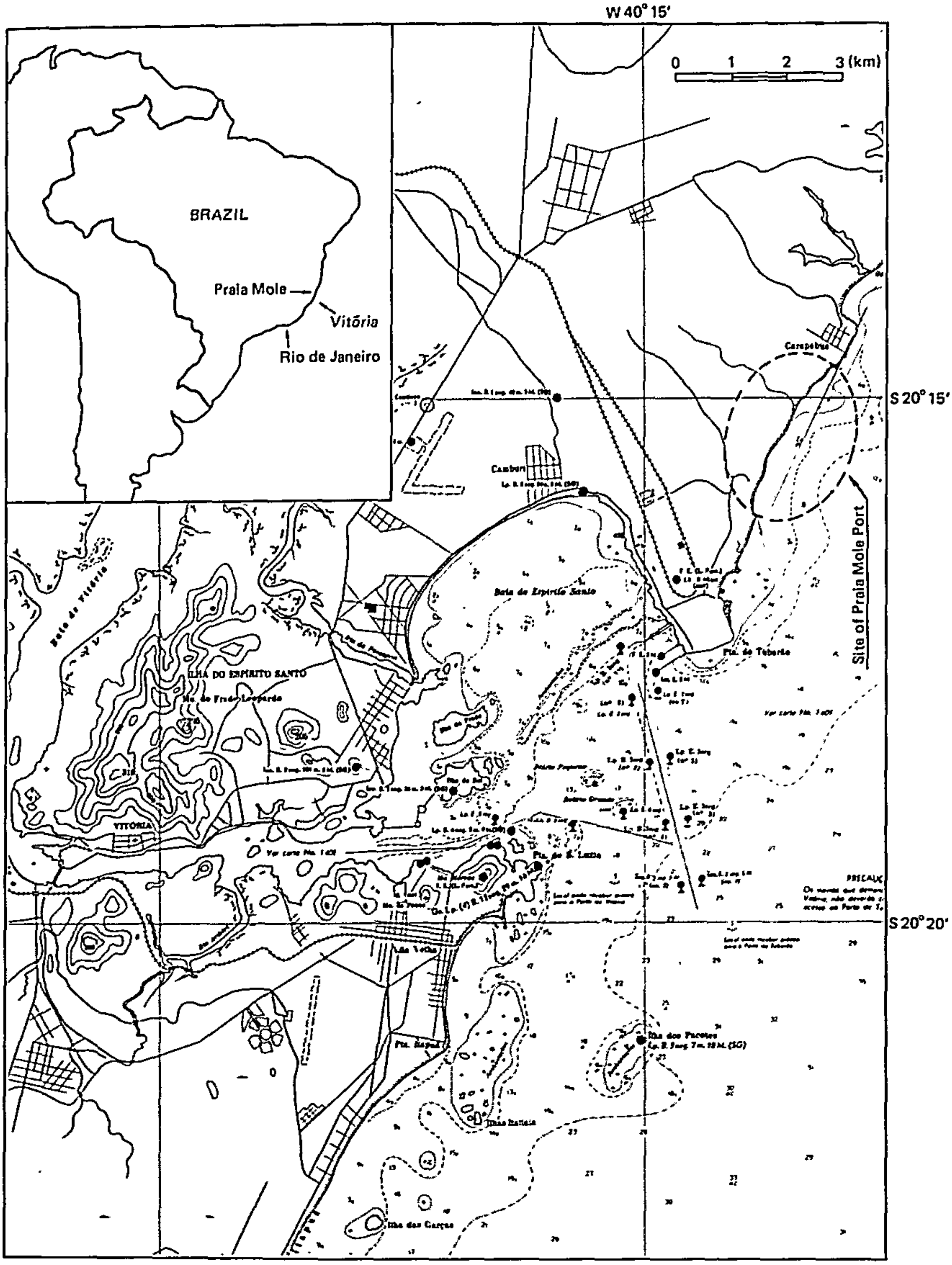
In the February survey, the Port and Harbour Research Institute of the Ministry of Transport and the Overseas Economic Cooperation Fund dispatched an official each, and the Overseas Coastal Area Development Institute of Japan has had taken it upon themselves to prepare this report.

Sincerely yours,

August 31, 1977

Susumu Maeda

Susumu Maeda, Head,
Japanese Survey Team for the
Construction Project of
Praia Mole Port
(General Manager, the Overseas
Coastal Area Development
Institute of Japan)



W 40° 15'
0 1 2 3 (km)
BRAZIL
Praia Mole
Vitória
Rio de Janeiro
S 20° 15'
S 20° 20'
Site of Praia Mole Port
Camburi
Carapebus
Baia de Espirito Santo
Pta. de Tubarão
ILHA DO ESPIRITO SANTO
VITORIA
Ilha dos Pacotes
Ilha das Garças

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

Contents

CONCLUSIONS AND RECOMMENDATIONS

I. Feaibility of Praia Mole Port construction project

1. Praia Mole Port as a public port

Vitória Port, which has long played an important role as a window of Espito Santo State and its hinterland, will amass its weight more and more with the development of the region. Vitória Port leaves little room for its expansion, and is not suitable for large-sized bulk carriers because of topographical limitations. It is quite wise and logical of the Brazilian Government to plan to gradually transform Vitória Port into a port specializing in commercial functions and to assign Praia Mole Port to handle cargoes for which large-sized bulk carriers are indispensable. Namely, the construction of Praia Mole Port, not as one exclusive to CST, but as one for the public in general, is a most opportune scheme.

2. Technical feasibility

The beach of Praia Mole is exposed direct to the Atalantic Ocean, and is not completely up to the grade as a site for port construction. But, with the technologies of today, the construction of port will be none too difficult.

When we must hasten the construction of the port to be in time for the commissioning of CST, it will alter the case. Namely, we may possibly have to promote the dredging, reclamation and construction of mooring facilities in parallel with the construction of breakwaters. The works in such a process will often be endangered by waves. Fatal accidents may not be an impossibility; while the cost will soar and the construction will go behind the schedule. We should not go out on a limb for thinking only of the present; rather should we start modestly with the construction for the purpose of safety, leaving the delay in the mill construction as the second importance.

We should not start the dredging and construction of mooring facilities until the harbour will have been protected practically.

3. Economic feasibility

The steel mill construction was decided upon prior to the present project, and it is less meaningful to discuss the present project from the national economic viewpoint. The Praia Mole Port construction project is far better than expanding Vitória Port to answer the needs of CST, and is justifiable economically in this respect.

4. Financial feasibility

4-1 If the port construction includes the 2nd stage in order to meet the 6 million ton production of CST and if the Port has come to handle the cargo volume as planned originally, it will be able to stand its own feet.

4-2 No matter what the preconditions may be, it is necessary for the government to shoulder, in some way or other, all the costs for the construction of breakwaters, channels and basins, which do not yield revenues directly, so that the Project can prove itself feasible financially.

Even in the advanced countries, it is a common practice that the government defrays out of the treasury all the expenditures for such facilities stated in the above. By the nature of the capital goods Praia Mole Port will have, it is hard to equalize the incidence among the users as against the temporal order. In addition, Praia Mole Port is intended for the development of a basic industry in Brazil and for the expansion of export trades. Considering these and other various factors, it will be quite logical for the government to support financially the project.

4-3 Let us assume that the breakwaters, channels and basins are entirely financed by the government. But this still is not enough for the port to sustain its financial health unless the port's tariff is set at least 20% higher than Vitória's.

Although this tariff difference may act to the disadvantage of the port, the highly efficient facilities and high vessel accommodation capacity will more than offset the disadvantage, and will never fail to attract the users.

II. Master plan of the port

1. The port should have the dimensions large enough to satisfy the 12 million tons-a-year production system of CST and a room permitting the construction of public wharves of a sizable scale.

2. It is assumed that the 6 million tons a year production system will be set up in 3 years after establishment of the 3 million tons-a-year production system, and this third year is set as a target year for the detailed layout of facilities.

3. At present, it is left uncertain whether CVRD will construct a pellet loading facility at Praia Mole Port. Participation of CVRD in the Praia Mole Port construction project will be beneficial not only to CVRD itself but to PORTOBRÁS. For this reason, the master plan for the port is made on presupposition that CVRD will take its share in the project.

III. Design and execution of structures

1. In selecting the types of structures and construction methods for the port facilities, consideration will be given so as to make the most of the materials, equipments and supplies available in Brazil.

   Where foreign alternatives have proved helpful in reducing the construction cost, they will be employed whereever justified so to do, provided that the Brazilian Government's autarky policy must be respected anyway.

2. The Japanese survey team and the prominent engineers representing the Hydraulics Research Institute of PORTOBRÁS discussed over the design wave heights and the types of structures to be employed in designing the breakwaters. As a result, it was finally agreed that the design maximum significant wave height be set at 5.0 m and that the type of breakwater structure be of the rubble mound type.

3. In regard to the type of structure for the mooring facilities, the Brazilian part is considering a cast-in-situ reinforced concrete pile structure with steel pipes as casing elements. From the viewpoints of workability and economics, the steel pipe pile type pier structure using imported ateel materials should be employed.

IV. Dredging works

1. The dredging work ranks with the breakwater work in its gravity on the Praia Mole Port construction project. If we keep pace with the construction of CST, we are forced to start the dredging works under nearly total defenselessness. Whether the work can progress on time hangs on changeable wave conditions, and the readiness of the port for use will also be governed by the progress of the dredging works, accordingly.

2. Where it is required to dredge the harbour without guards by the breakwaters, large seaworthy cutter suction dredgers will be called for. There are possibilities that we shall have to confront comparatively hard soils dispersed within the dredging area, and it is desirable to employ such dredgers that can manage them. The fleet of cutter suction dredgers available in Brazil is considered insufficient in this respec, and it is recommended to charter one powerful cutter suction dredger from abroad in order to help the fleet to be assigned to Praia Mole Port.

3. There are at least two most advanced hopper suction dredgers in Brazil. At the moment, however, they are scheduled to be commissioned in other ports, and we have been told that PORTOBRÁS has its intention to purchase or charter a hopper suction dredger for Praia Mole Port.

V. Time of completion of the port, and construction cost

1. Completion of the port

1-1 In discussing the overall construction schedule, it was assumed that the preparatory work would start in August, 1977.

1-2 Discussion was first made about a case where the dredging, reclamation and the construction of mooring facilities are carried out in parallel with the construction of breakwaters for the purpose of completing the port in time for the comissioning of CST (this case being termed "original plan" in this report). Then, the construction schedule was studied as to another case where the port construction work is pushed forward in the best, orthodox way (termed "alternative plan" in this report) irrespective of the start of CST's operation.

Assuming that the time of completion of the coal pier which is given precedence over any others is the time of commissioning of the port, Praia Mole Port will be available for operation as follows.

Original plan	Feb. 1, 1981
Alternative plan	Sep. 1, 1982

In the original plan, the north breakwater will be still in process leaving some 600 m yet to be worked out when Praia Mole Port is due for service.

2. Construction cost

2-1 Construction cost

The estimate of the construction cost was made based on the commodity prices as of Feb., 1977.

Also, the exchange rates were set as follows.

Cr$12.8 = US$1, ¥300 = US$1

The construction cost was estimated as follows.

Table 1. Construction cost of Praia Mole Port

(in US$1,000)

	Original plan	Alternative plan	Modified alternative plan
Construction cost, total	374,296	340,945	315,938
(Foreign currency component)	69,296	46,196	68,126
1st stage construction cost, total	309,884	277,763	262,292
(Foreign currency component)	54,365	31,265	44,933

Note: By the modified alternative plan is means the case where the import ratio of cargo handling equipment is increased up to approx. 55% as against some 23% employed for the original and alternative plans.

2-2 Concept of foreign currency component

The construction materials, machines, parts, dredgers and others which should preferably be procured from abroad for the purpose of the Praia Mole Port construction project are as listed in the Record of Discussions.

The principle on which these articles were selected has been explained in III-1.

The higher the import ratio of the parts for the cargo handling facilities, the lower the construction cost for the cargo handling facilities. It is, therefore, desirable to increase their import ratio as much as possible with the approval of Brazilian part.

VI. Administration system of Praia Mole Port

The administration systems of the ports in Brazil are being consolidated into the semi-governmental system (mixed economy company system). It is recommended that Praia Mole Port be put under the Espirito Santo State Port and Dock Company (tentatively called Companhia de Docas de Espirito Santo) to be established shortly for unitary control according to the said system.

VII. Necessity of technical cooperation to PORTOBRÁS

PLANAVE, the consultants to PORTOBRÁS, is undertaking planning, design and estimate of cost for the project, and is considered qualifiable and worthy of being assigned to the project. However, PORTOBRÁS is suffering from a dearth of engineers. For this reason, it is desirable to despatch specialists from Japan to assist PORTOBRÁS in the project.

The specialist team which will be composed of a dredging and a cargo handling equipment specialit respectively should be able to promote not only the dredging work, but the project as a whole. Namely, the team members should be engineers of high caliber able to give pan advice about the project.

VIII. Organization for the execution of the project

It is required to strengthen the engineering staff at the head office of PORTOBRÁS and at the same time establish a fully staffed site office at Vitória. PORTOBRÁS should give the representative of the site office a wide scope of authority concerning primarily engineering affairs.

IX. Conservation of environment

In implementing the project, full consideration should be given to its effect on the surroundings, and pertinent measures should be taken to prevent evil effects whenever so required.

Since huge breakwaters are to be stretched out from the beach, continued efforts should be made to investigate the changes in the nearby coastal qualities for the purpose of identifying the problems arising out of the breakwater construction, sucy as coastal erosion, and the measures against them without losing time.

SUMMARY

Summary of survey findings and study results

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SUMMARY OF THE SURVEY FINDINGS AND STUDY RESULTS

I. Purpose of the survey

Although the construction of Praia Mole Port has been planned by the Brazilian Government as a link of the construction of Companhia Siderurgica de Tubarão (CST), it is destined to handle not only the raw materials and products of CST, but coal for USIMINAS, petroleum products and various cargoes which are expected to increase in amount consequent upon the development of the hinterland. Namely, it has been planned as a public port.

This study was conducted for the purpose of making sure of the technological, economic and financial feasibility of the Praia Mole Port construction project.

II. Location

1. Geographic and socio-economic conditions

CST is constructed in a suburb of Vitória some 500 km north of Rio de Janeiro. Praia Mole Port is planned to be built in the coastal frontage of CST.

The port site is only 15 km off the central part of Vitória, and is well harnessed with infrastructural facilities such as roads, railways, port (Vitória Port), airport, and various urban facilities. This infrastructural position may have served a major reason for choosing the site for CST.

Judging from the relative position of Praia Mole Port to Rio de Janeiro Port and Santos Port and other various factors, it is considered that the hinterland of Praia Mole Port is over the entire Espirito Santo State and a part of Minas Gerais State.

These states turn out export agricultural produce such as coffee beans, maize and sugar which are also the key export items of Brazil.

At present, Capuaba Wharf, which is intended for handling agricultural produce for export, is being constructed at Vitória Port based on the Export Corridor Programme.

The manufacturing industry in the two states is still in its infancy, except for iron and steel making and cement production, but is expected to grow when CST is put into operation.

As regards mining, it has been said that Brazil has a quarter share of the world's total reserve of iron ores, and Minas Gerais state has the majority of it. Lying south of Praia Mole Port is the iron ore export terminal owned by Companhia Vale do Rio Doce (CVRD), which is part of Vitória Port and is sometimes called Tubarão Terminal.

It is able to accommodate ore carriers of 250,000 DWT class, and is exporting more than 50 million tons of iron ore a year. CVRD observes that iron ore exports will increase if the world business turns for the better, and seems likely to use the Tubarão Terminal only for large-sized vessels with Praia Mole Port assigned for comparatively small carriers if such favourable turn appears.

Topographically, Vitória Port has no room to spare for expansion, and is unable to accommodate larger vessels than those of 50,000 DWT class.

Praia Mole Port, if completed, will go a long way toward promotion of the commercial functions of Vitória Port as it can shoulder such cargoes as coal and oil which require large carriers for their transportation.

Judging from the future development of the hinterland area and the present condition of Vitória Port, the construction of Praia Mole Port as a public port capable of accommodating large vessels is justifiable.

2. Environmental conditions

Praia Mole is a sandy beach facing the open sea (the Atlantic Ocean). As a consequence, we must first attach paramount importance to wave conditions in planning the port.

To our regret, the data about the waves in the coastal waters of Brazil are very meagre. So far as Praia Mole Port is concerned, however, the wave data observed in the nearby waters are available, not to say enough in terms of the period of observation.

The wave conditions were set based on chiefly these data while taking into account meteorological conditions, the design wave heights for the nearby ports, scale and significance of breakwaters. The Japanese survey team and the Brazilian counterpart agreed each other that the design wave height for the breakwaters be 5.0 m of significant wave whose recurrence period is 50 years.

There is nothing particular to speak of about the tides, currents and coastal sand drift to be caused thereby.

The annual rainfalls are about 1,239 mm, far less compared with 2,238 mm at Santos Port, and will be no matter.

The daily wave conditions were investigated, and it was found that the probability of waves exceeding 1.5 m in height is about 50% on a day-to-day basis. Since the basic data used for the analysis is the daily maximum significant wave heights, the 1.5 m height may be discounted a little. Such a result should, however, be kept in mind in the case of the harbour works in the open sea.

The geology in and around Praia Mole is an alternation of quartzfamily sandy soil and clayey soil (mainly composed of kaolinite). Under it is granite. Reddish brown rocks called canga which contains a great amount of iron are seen at places. The bottom quality in the entire area of Praia Mole Port will not pose any particular problem as a structural foundation. However, canga should be warned against in planning the port and harbour facilities and in planning the dredging work.

III. Master plan of the port

1. Basic principles

Praia Mole Port was originally planned for handling raw materials to, and semi-finished products from CST, and the various surveys were made for it. The policy veered before materialization, and it was finally decided to construct Praia Mole Port as a public port by the Brazilian Government. The master plan for the Praia Mole Port construction on which the survey team and PORTOBRÁS reached an agreement has been formulated based on the following principles.

1-1 A public port to handle the cargoes not only for CST, but to share the functions of Vitória Port by shouldering part of cargoes which are expected to increase with the development of the hinterland. CST will, however, be the largest user of Praia Mole Port for the time being, and therefore the port facilities should be planned and laid out with full account taken of the CST's plans.

1-2 The ultimate annual production of CST is said to become 12,000 thousand tons, as against the annual output of 6,000 thousand tons agreed upon among Japan, Brazil and Italy. In the present project, therefore, Praia Mole Port is planned to handle the cargoes of CST, coal for Usinas Siderurgicas de Minas Gerais S/A (USIMINAS) and petroleum products for with the target year set at the time when CST is ready to turn out 6,000 thousand tons of slabs a year. For further cargo handling requirements, an allowance for expansion of Praia Mole Port has been secured to meet 12,000 thousand tons a year of CST's production in addition to increases in public cargoes.

1-3 Use by CVRD of Praia Mole Port for shipping iron ore or pellets is considered favorable for both CVRD and PORTOBRÁS from the economic viewpoint, and Praia Mole Port is planned on condition that CVRD will participate in the project.

2. Targets

2-1 Target year

The master plan for the Praia Mole Port project will be made according to a long-term forecast with the future expansion plan taken into consideration, but the feasibility of the project will be assessed with reference to the target year set in compliance with the immediate operation plan of CST.

In the master plan, the time by which the 3,000 thousand tons a year production system will be completed is termed the 1st stage, and the period from the end of the 1st stage to the time by which the 6,000 thousand tons a year production system will be completed is termed the 2nd stage. The target year for the 1st stage has been set at 1981 as CST is scheduled to start operation in May, 1981. Although the start of the 2nd stage is not yet to be determined, the port facilities will be planned on condition that it will come three years after the completion of the 1st stage, that is, in 1984.

2-2 Volume of cargo to be handled

The cargo traffic of Praia Mole Port has already been forecast by PLANAVE, the consultants to PORTOBRÁS, and is judged agreeable on the whole. The Japanese survey team modified it to a degree. What is most important in projecting the cargo volume is to make clear the division of functions with the adjacent Vitória Port. It is judged reasonable that Praia Mole Port should bear the following functions for the time being.

2-2-1 Import of coal to, and export of semi-finished products from CST.

2-2-2 Overall takeover of the oil unloading facilities now dispersed within Vitória Port.

2-2-3 Import of coal to USIMINAS.

2-2-4 Export of iron ore or pellets from CVRD

The volume of cargoes to be handled at Praia Mole Port is as shown in Table 1.

Table 1. A comprehensive list of cargoes to be handled at Praia Mole Port

(in thousand tons)

		1st stage			2nd stage		
		Foreign trade	Domestic trade	Total	Foreign trade	Domestic trade	Total
General cargoes							
	Outbound	1,500	1,000	2,500	3,000	2,000	5,000
Slab	Inbound	-	-	-	-	-	-
	Total	1,500	1,000	2,500	3,000	2,000	5,000
Bulk cargo (solid)							
	Outbound	-	-	-	-	-	-
Coal	Inbound	3,499	885	4,384	6,437	1,565	8,002
	Total	3,499	885	4,384	6,437	1,565	8,002
Bulk cargo (liquid)							
	Outbound	-	-	-	-	-	-
Oil	Inbound	-	3,241	3,241	-	3,942	3,942
	Total	-	3,241	3,241	-	3,942	3,942
	Outbound	1,500	1,000	2,500	3,000	2,000	5,000
Total	Inbound	3,499	4,126	7,625	6,437	5,507	11,944
	Total	4,999	5,126	10,125	9,437	7,507	16,944

Note: Not including iron ore and pellets from CVRD.

2-3 Types and sizes of vessels for which the port is planned

The types and sizes of vessels are planned as classified by type of cargo and type of trade (foreign, domestic). The slabs for Italy are planned to be transported by slab carriers of 80,000 DWT class. On the other hand, Kawasaki Steel Corporation, Japanese recipient of slabs from CST, is studying the use of ore carriers of 120,000 DWT class for slab transportation, and it has been said that these vessels will use the port within 15 m of water depth.

The types of the largest ships planned for Praia Mole Port by type of cargo are as listed in Table 2.

Table 2. Types of the largest ships planned by type of cargo

	Hull particulars				Remarks
	DET, tons	Length, m	Width, m	Draught, m	
Slab carrier	120,000	270	42	16	Ore carrier (Draught to be limited)
Coal carrier (Ocean-going)	120,000	260	41	16	
(Coastal)	80,000	240	33	13	
Oil tanker	60,000	240	34	12.8	
Pellet carrier	120,000	-	-	-	

3. Layout of port facilities

3-1 Layout of breakwaters, channels and anchorage basins

According to wave observation data, southerly waves are present a little more than easterly ones, but there is not so significant difference between the two. According to wind observation data available at site, the north-east wind is prevailing all the year. The layout of breakwaters and channels are planned taking into account the layout of the adjacent Tubarão Terminal facilities.

The basins and waters protected with the north and south breakwaters are given an ample space to permit a future expansion while maintaining an enough turning basin for ships entering and leaving the port.

3-2 Mooring facilities, cargo handling facilities and storage facilities

The mooring facilities will be arranged clear of canga and other hard soils so that the pile structures suitable for deep water may be constructed economically.

Since the 1st stage work of CST is to be started from the southern part of its premises adjacent to CVRD's, relevant mooring facilities will be constructed in the south of the harbour. Namely, the northern half of the harbour basin is left for the future expansion.

In consideration of the geography of CST's premises, their frontal waters will be reclaimed to install slab berths, handling and storage facilities for slabs and coal.

4. Facilities planning

4-1 Breakwaters

South breakwater : 3,400 m

North breakwater : 3,700 m

4-2 Channels and turning basin

The channels and turning basin will be planned for coal carriers of 120,000 DWT class which are the largest to enter the port.

4-2-1 Channels

The width of a channel isset at 270 m which is equal to the overall length of the largest ship to visit the port.

The depth of the channel is set at -19 m which is the load line plus an allowance for wave-caused pitching.

4-2-2 Turning basin

A turning basin with a diameter of 540 m (twice as much as the maximum hull length) and a depth of -17 m will be prepared within the harbour on condition that the turning is made by tugboat.

4-3 Mooring facilities and reclaimed land

The numbers and lengths of the mooring facilities by type of cargo are given in Table 3.

Table 3. Planned scale of mooring facilities

Type of cargo	Ship size, DWT	Number of berths	Depth of berth, m	Aggregate length of berths, m
Slab	120,000	3 (1)	-15.0	960
Coal	120,000	1	-17.0	310
Coal	80,000	1 (1)	-15.0	280
Oils	60,000	1	-14.0	-

Note: The values in parentheses show the numbers planned for the 2nd stage which are included in respective totals.

It remains uncertain when the facilities for exporting iron ore or pellets are constructed, but it is sure that the Tubarão Terminal will gradually specialize for large ships. For Praia Mole Port, the ships of 120,000 DWT class will be considered, accordingly.

As a land lot for handling and storing slabs and coal, an area of 1,115,000 m^2 will be reclaimed at the back of the slab berth.

The crown height of the mooring facilities and reclaimed land will be +4.00 m taking account of the tide.

4-4 Cargo handling facilities

The capacity and quantity of principal cargo handling facilities will be planned to raise the highest economy in consideration of the cost caused by waiting ships.

A coal yard for CST is planned on the reclaimed land in the port, and CST will take up all the responsibilities for the installations of the yard equipment.

The cargo unloading and transporting facilities and tank yards other than oil berths are also outside the scope of responsibilities to be borne by PORTOBRÁS. The tank yards will be installed outside the compounds of the port.

The major cargo handling facilities are listed in Table 4.

Table 4. Major cargo handling facilities and their capacity

Location	Name of equipment	Capacity	Quantity		
			1st stage	2nd stage	Total
Coal pier	Unloader	2,000 T/H	2	0	2
	Unloader	1,000 T/H	0	2	2
	Conveyor	2,500 T/H	2	0	2
	Conveyor	1,200 T/H	0	2	2
Coal yard	Stacker	2,500 T/H	2	1	3
	Reclaimer	2,000 T/H	1	1	2
	Conveyor	2,500 T/H	2	1	3
	Conveyor	2,000 T/H	1	1	2
between berth and yard	Conveyor	2,500 T/H	2	0	2
	Conveyor	1,200 T/H	0	2	2
CVRD's premises	Wagon loading facility	2,000 T/H	1	0	1
	Conveyor	2,000 T/H	1	0	1
Slab berth	Slab loader	35 T	5	3	8
Slab yard	Slab crane	35 T	10	8	18
	Tractor	320 HP	6	4	10
	Trailer	110 T	14	10	24

4-5 Roads and railways

Praia Mole Port will be served with an artery of about 5.5 km in aggregate length diverted from National Route 101.

A railway will also be shunted from the Vitória-Minas Railway of CVRD, but will not be constructed until the 2nd stage. A space for the railway extension will be left in the port compounds, however.

4-6 Tugboats

Five tugboats of 3,200 HP class will be provided.

IV. Basic designs of facilities

1. Breakwaters

1-1 Design criteria

1-1-1 Tide level

H.H.W.L.: +1.80 m (annual max. water level which is almost the same as the highest level ever recorded)

M.H.W.S.: +1.34 m to 1.66 m (according to observations for 17 years)

L.W.L. : ±0.00 m

1-1-2 Wave height and period

As already stated, the maximum design significant wave height is set at 5.0 m. However, it may be reduced to 4.0 m depending on the water depth of the breakwater.

The period of the design waves is set at 12 sec.

1-2 Type of structure and cross section

As regards the type of structure, various structures were discussed in comparison with the concrete caisson type breakwater, and it was finally agreed to employ the rubble mound breakwater as originally proposed by the Brazilian counterpart.

The cross section of the breakwaters was determined unanimously by the Japanese and Brazilian parties concerned according to the results of hydraulic model tests conducted at the Hydraulics Research Institute of PORTOBRÁS during the stay of the Japanese survey team in Brazil.

The crowan height of the south breakwater is set at +9.5 m max. on condition that the overtopping should in principle be avoided. On the other hand, the crown height of the north breakwater is set at +7.3 m max. to permit the overtopping to some degree.

2. Mooring facilities

2-1 Selection of type

The gravity type quaywall, steel sheet pile quaywall, steel sheet pile quaywall with relieving platform and piled pier (including open-type wharf) were subjected to comparison study in regard to structural characteristics and construction cost, and the piled pier (including open-type wharf) was judged best.

Hence, it was determined to employ the piled pier, and the foundation structures of steel pipe pile type, PC pile type and cast-in-situ pile type were studied. As a result, the steel pipe pile type was considered most excellent. For the slab berths and coal piers, the steel pipe pile type is used, accordingly.

As regards the oil berths, the steel pipe pile type dolphin is considered preferable in view of their service conditions.

2-2 Length of piles

According to the soil boring test data presented by PORTOBRÁS, the mean penetration length of the piles was studied. As a result, sandy ground with an N-value of more than 30 was selected as a pile bearing stratum, and the penetration depth was set at -32.5 m or so for the slab berths. As regards the coal piers and oil berths, boring data are insufficient, and the penetrating depth is set at about -30 m tentatively.

3. Cargo handling facilities

3-1 Design criteria

The design conditions for the cargo handling equipment are shown in Table 5.

Table 5 Principal design conditions for cargo handling facilities

	Coal	Slab
Applicable ship	East berth: Max. 120,000 DWT Min. 20,000 DWT West berth: Max. 80,000 DWT Min. 20,000 DWT	Max. 120,000 DWT Min. 20,000 DWT
Cargo to be handled	Bulk density: 0.8 t/m^3 Lump size: ϕ1 ∿ 63.5 mm (Mean size ϕ 10∿15 mm) Moisture content: 8∿9% Angle of repose: 37° (On belt conveyor)	Weight: Max. 35t Width: 800 ∿ 2,000 mm Length: 5,000∿12,500 mm Thickness: 120∿305 mm
Wind velocity	During work: Max. 16 m/sec. During suspension: Max. 35 m/sec.	
Weather	Ambient temperature: Max. 40°C Min. 5°C Rainfall: Max. 200 mm/day	
Applied standards	JIS (Japanese Industrial Standard) JEC (Japanese Electro-technical Committee) JEM (Japan Electrical Machine Industry Association)	

3-2 Coal unloader

In view of the economics and service requirements, a rope-trolley type bridge unloader is selected.

Since a 120,000-ton berth with 2,000 T/H unloaders will be constructed first, large and small grab buckets will be used to meet respective purposes during the first stage period.

The grab bucket will be of the union purchase type which ensures high working stability.

The principal particulars of the coal unloader are as follows.

	2,000 T/H	1,000 T/H
Lowering and hoisting speed	130 m/min.	120 m/min.
Trolley traversing speed	210 m/min.	160 m/min.
Grab capacity	30 m^3	15 m^3
Gauge	20 m	18 m

3-3 Stacker

The stacker will be of the hydraulic cylinder derricking type of light weight. The travelling device will be of the four-wheeled type whose running is less susceptible to deformation of the rails due to non-uniform settling if it is not so serious.

The main particulars of 2,500 T/H stacker are as follows.

Boom slewing radius	:	27 m
Boom derricking height	:	up to 13 m (in terms of stackable height)
Slewing speed	:	0.2 rpm
Running speed	:	30 m/min.
Gauge	:	7 m

3-4 Reclaimer

The reclaimer will be of the revolving bucket wheel type. The travelling device will be just the same as that for the stacker.

The main particulars of 2,000 T/H reclaimer are as follows.

Boom slewing radius	: 38 m
Boom derricking height	: up to 13 m (in terms of reclaimable height)
Slewing speed	: 0.2 rpm
Gauge	: 7 m
Running speed	: 5/30 m/min. (two-step speed change-over)
Bucket wheel revolving speed	: 7 rpm

3-5 Belt conveyor for coal transportation

The extension from the coal piers to the coal yard and that from the coal yard to the wagon loading facility for USIMINAS coal will be composed of various sizes of belt conveyors in combination. The largest will be 2,500 T/H in capacity, 1,800 mm in belt width and 160 m/min. in belt speed.

The belt will be a steel cord one.

3-6 Slab loader

The semi-rope-trolley bridge type crane will be employed in view of economics and service requirements.

The slinging gear will be of the lifting magnet type with a special brabbing means.

Its main particulars are as follows.

Rated load	: 35 tons
Lowering and hoisting speeds	: 35 m/min. (lowering slabs)
	80 m/min. (no-load speed)
Trolley traversing speed	: 100 m/min.
Gauge	: 15 m

3-7 Slab crane

The slab crane which unloads the slabs onthe slab yard and loads them again on a trailer will be of the gantry type.

The crane will have a straddle of 35 m, the width of the slab yard. One leg will be of the pinned type in order to be adaptable to a slight dislocation of the rails.

The trolley will be of the self-propelling type, and the cabin will be of the fixed type.

The main particulars are as follows.

Rated load	:	35 tons
Lowering and hoisting speeds	:	15 m/min.
Traversing speed	:	40 m/min.
Travelling speed	:	50 m/min.

V. Dredging and reclamation

1. Plan of dredging and reclamation

The dredging work is counted among the most important tasks in the Praia Mole Port construction project, and weighs as heavy as the breakwater work.

The dredging of channels, turning basin and anchorage basins will amount to 2,400 thousand m^2 in area and to 10,260 thousand m^3 in net volume excluding extra dredging and slope work.

The gross volume of reclamation soil will amount to about 6,750 thousand m^3. All the dredging work is completed in the first stage period.

The dredging thickness will be 2 to 6 m, and the dredging volume will be 2,470 thousand m^3 for clayey soil and 7,790 thousand m^3 for sandy soil.

2. Selection of types of dredgers

The dredging will be carried out by hopper suction dredgers and cutter suction dredgers.

The assignment of dredging sites to the dredgers and the location of clayey soil dump sites were discussed as to several plans for merits and demerits. It was preferred as best that the clayey soil is dumped at the site scheduled for future reclamation and that the hopper dredgers cover the tract from the channels to the turning basin.

A fleet of dredgers will include one hopper dredger of 4,000 to 5,000 m^3 class which has a high seaworthiness, one cutter suction dredger of 8,000 HP class, and three cutter suction dredgers of 3,000 HP class. The 3,000 HP class cutter suction dredgers will deliver soil dredged by the hopper dredgers to the sites now designated as reclamation land or planned as future reclamation land.

3. Work period and procurement of dredgers

The dredging work will be carried out without protection by the breakwaters because the breakwater work will also be carried out concurrently. For this reason, the mean monthly working days are set at 25 for the hopper dredger and 20 for the cutter suction dredgers.

The period of dredging work, including extra dredging, slope finish and maintenance and repair of dredgers, is as follows.

Dredgers	Number	Wrok period (in months)
4,000 m^3 class hopper suction dredger	1	22
8,000 HP class cutter suction dredger	1	30
3,000 HP class cutter suction dredger	3	16

The fleet of dredgers owned by Brazil includes the most advanced hopper suction dredgers of 5,000 m^3 class, which, however, are scheduled to serve at other ports, while, the cutter suction dredgers are poor on the whole. For this reason, a 4,000 m^3 class hopper suction dredger and an 8,000 HP class cutter suction dredger may be chartered from Japan, and the cost estimate will be made as such. However, it seems Brazil has the intention of purchasing a 4,000 m^3 class hopper suction dredger.

VI. Execution method and construction schedule

1. Breakwaters

The transportation of stones for rubble mound breakwaters will be undertaken by 22-ton dump trucks, and the stones will be laid direct from the shore off to construct a breakwater. The leading edge of the breakwater in process will be provided with a tractor shovel to sink the stones.

The armoring will be carried out from above the breakwater so far as it is within the reach of a large-sized crane. The bottom of the slopes and other parts which do not permit access of the crane arm will be worked out from the sea.

It the breakwater is started in February, 1978, the completion of the south breakwater will be at the end of April, 1981 when the north breakwater will leave some 600 m yet to construct. The north breakwater will be completed at the end of March, 1982.

Each breakwater will have its core first built up to a height of +3.3 m, and it will be not until the end of January, 1981 that the harbour is nearly protected.

The construction schedule is studied on condition that the number of monthly working days is 20 with the number of working hours per day set at (10 for offshore work).

2. Mooring facilities

The pile driving will be carried out by making use of a pile driver or a temporary scaffolding while shifting it with the progress of work.

The steel pipe piles to be used will be the ones into which imported steel sheets are formed at a Brazilian factory.

The steel sheet piles and raking piles for the revetment of the slab berths will be driven by a floating pile driver.

The steel pipe piles for the oil berths will be driven by a floating pile driver. It should be noted by way of precaution that the piles falling on the slope of the breakwater must be driven in before the rubble mound work of the breakwater.

3. Completion of the port

As of August, 1977, the procedures for expropriation were being pushed forward for the procurement of the rights-of-way for a temporary work road leading to Praia Mole Port.

In order to complete the port by the beginning of December, 1980 when the coal pier must be put into commission as required by CST, the preparatory work for the port construction will have to be started in August this year, and the construction work of breakwaters, dredging, reclamation and installation of mooring facilities may have to be carried out in parallel. Even with this, the commissioning of the coal pier will be from February, 1981 at the earliest. At this time, however, the north breakwater will be still in the process of construction, leaving some 600 m; namely, the breakwaters will be just about enough to protect the harbour.

The slab berths will be put into use at the beginning of May, 1981, and the substructure of an oil berth in July same year.

VII. Estimate of construction cost

1. Criteria for estimate

The estimate of the construction cost is made on the following conditions.

1-1 Estimate based on the prices as of February, 1977.

1-2 Exchange rates: Cr$12.8 = US$1, ¥300 = US$1

1-3 Exemption from import duties (customs duties, IPI), carrying-in duties on imports (ICM) and service dues (ISS).

1-4 Those coming out of the scope of estimate: cargo handling facilities at the coal yard for CST, and oil handling facilities (loading arm, oil delivery pipeline, storage tanks, etc.).

1-5 The foreign currency will be allocated to those which cannot be procured in Brazil or those which can be procured in Brazil but at a high price. The ratio of imports will be studied by making much of the Brazilian Government's policy for promotion of autarky. A list of commodities agreed upon between Japan and Brazil according to the above considerations is given in the Record of Discussions.

1-6 The physical contingency for the civil work (including tugboats and electrical installation work) is set at 10% of the construction cost. As regards the cargo handling facilities, on the other hand, it will be reasonable from the current state of Brazil to put aside as physical contingency some 35% of foreign currency as required when the import ratio is reduced to a minimum. In this case, if the import ratio is increased, the total construction cost will decrease; thus, no contingency is considered for the total construction cost.

2. Construction cost of Praia Mole Port

The total construction cost of Praia Mole Port, including contingencies, as calculated according to the above conditions, will amount to US$374 million (US$112 million for cargo handling facilities and US$262 million for civil works). The foreign currency component will wmount to US$69 million (US$43 million for civil works and US$26 million for cargo handling facilties).

The construction cost of the 1st stage, the completion of which is most pressed to meet the 3 million tons a year production of CST, will amount to US$310 million and US$54 million will be accounted for by a foreign currency component.

If the import ratio of cargo handling facilities can be increased up to about 55% (as against the original 23%) without regard to the Brazilian Government's policy of autarky, the total construction cost will be US$349 million (of which US$91 million will be made up with a foreign currency component). The construction cost of the 1st stage will amount to US$294 million (including US$68 million of foreign currency component).

VIII. Alternatives of execution methods and construction schedule

1. Necessity of the study on the alternatives

Even if we will make our best to make the port ready for the commissioning schedule of CST, we will have to go on with the dredging work and the construction of mooring facilities when the harbour is not protected by breakwaters at all. (Let us call this the original plan.) But this scheme is not preferable in Praia Mole Port where the works are often endangered by the battering waves. Chances are that sudden changes in weather may sink the dredgers or damage the works in process, or that the construction work may have to be made over at the cost of more time and money than are originally expected and also to the detriment of CST's operation schedule.

For this reason, it is felt desirable that the breakwater work should precede any other works, and the dredging and construction of mooring facilities should be started only when the harbour protection has been completed or nearly completed. The execution methods overall schedule and construction cost are, therefore, worth studying from the viewpoint of this orthodox way of work. The results of studies of this alternative method are summarized as follows.

2. Time of completion of Praia Mole Port, and construction cost

If the start of dredging is put off by a large margin from the original plan to February, 1981 and if the construction of mooring facilities is started at the same time, the completion of the coal pier which is in urgent need will be at the end of August, 1982, or 19 months behind the schedule as compared with the original plan.

The total construction cost will be US$341 million, or US$33 million less than that in the original plan. The foreign currency component will be US$46 million.

If the import ratio of the cargo handling facilities is increased up to about 55% just as in the calculation of the construction cost of the original plan, the total construction cost will become US$316 million of which US$68 million will be accounted for by a foreign currency component.

In this case, the construction cost of the 1st stage will be US$262 million (including a foreign currency component of US$45 million). In case the total construction cost is US$341 million, the construction cost of the 1st stage will amount to US$278 million.

3. Advantages of the alternative plan

3-1 The best thing the alternative can offer is that the almost complete protection of harbour by breakwaters makes it possible to carry out dredging, reclamation and construction of mooring facilities safely and reliably. If the breakwater work can be pushed forward on time, the date of completion committed to CST will be sure to be observed. The alternative plan gives the following advantages in addition to the above.

3-2 Dredging

3-2-1 The working area of the cutter suction dredgers will be expanded, and the dredging and reclamation will be accomplished more reasonably.

3-2-2 The working efficiency of the cutter suction dredgers will be improved, and the work period will be shortened.

3-2-3 The construction cost will also be saved, accordingly.

3-2-4 Since the seaworthiness will become less important to the cutter suction dredgers, the large dredger of 8,000 HP class is no lenger required.

3-2-5 Since more than three years can be gained till the start of dredging works, it will afford an ample time for review of the deployment program of dredgers in Brazil, and the project may possibly be undertaken by Brazilian dredgers alone if the circumstances favor. (In the cost estimate for this alternative plan, the entire dredging works are assumed to be undertaken by Brazilian dredgers alone.)

3-3 Others

3-3-1 The floating pile driver is applicable to the pile driving work for the mooring facilities.

3-3-2 The total construction cost will be reduced by some US$33 million.

3-3-3 The fact that the construction period for the 1st stage is put over by one year will moderate the yearly investments considerably as compared with the original plan, letting PORTOBRÁS ease up on the fund management.

3-3-4 Since an ample lead time is provided before the start of dredging works, it becomes possible to carry out wave observations to obtain more clear patterns of waves Praia Mole Port is expected to experience.

IX. Administration and operation system of Praia Mole Port

1. Port and harbour administration system in Brazil

The ports and harbour in Brazil are under the control of the Ministry of Transport through the hands of PORTOBRÁS (Empresa de Portos do Brazil S.A.) wholly owned by the Central Government.

PORTOBRÁS is engaged in the following tasks.

1-1 Planning and execution of national policy of ports and harbours.

1-2 Performance, promotion and approval of the surveys and plans for the construction, improvement and operation of ports and harbours, and technical assistance to meet the purposes thereof.

1-3 Execution and promotion of the construction and improvement business concerning ports and harbours.

1-4 Management and operation of ports and harbours.

1-5 Control and auditing of the port and dock companies in regard to their administration and operating activities to which PORTOBRÁS has assigned undertakings by contract or which are accredited by PORTOBRÁS.

1-6 Promotion of use of inland waterways, and execution of inland waterways construction projects.

Unless in case of special circumstances, PORTOBRÁS does not lay direct hands on the administration and operation of each specific port.

The President of PORTOBRÁS is appointed by the President of Brazil on the recommendation of the Minister of Transport.

PORTOBRÁS is staffed with about 720 as against a scheduled capacity of 3,000.

2. Systems employed by individual ports

The systems of port and harbour administration in Brazil are rather complicated. There is one called "Mixed Economy Company Port." This is a semi-governmental incorporated system most widely practised in Brazil.

PORTOBRÁS has a policy of setting up this type of port and dock company in each state in order to operate and control the ports in each specific state collectively. At present, all other types of organizations are being phased out into this type.

For those ports which are under the unitary control of this type of company, almost all of construction projects are financed by PORTOBRÁS, and the outlays for administration, operation and maintenance are made up by dues and charges for use of ports and harbours.

3. Systems of development and improvement of ports and harbours

In case of a large scale port construction project or when it is feared that the port authority is nowhere near up to a project technically, PORTOBRÁS directly undertakes the project. It was told that, PORTOBRÁS would undertake the construction of Praia Mole Port.

The completed facilities are handed over to the port and dock company as an investment in kind. If the project is made on loans, the repayment is made by PORTOBRÁS, and not by the company.

The largest source of port improvement funds is an object tax called the Port Improvement Found (NPF). This found is a 2% tax on the CIF price of each import as payable by the consignor.

The funds raised this way are allocated to the investment in ports and harbours, for repayment of loans and interests.

4. Organization for the execution of the project

Although PORTOBRÁS is the owner of the Praia Mole Port construction project, all the technical taska including planning, design and cost estimate are borne by PLANAVE, a Brazilian consulting firm. PLANAVE is considered trustworthy as consultants for the project.

On the other hand, PORTOBRÁS is rather weak in its engineering staff, although we were told that PORTOBRÁS had an intention to employ more engineers to strengthen its staff for the Praia Mole Port construction project. For this reason, it is considered that Japan should extend technical cooperations to PORTOBRÁS.

4-1 Scope of technical cooperation

The technical cooperation to PORTOBRÁS should preferably be extended on a government-to-government basis beause of acceptability on the part of Brazil.

The sectors where technical cooperations are in need are dredging works and cargo handling systems, and each sector will necessitate one specialist advisor each. So far as the things go, it is highly probable that the dredging works for Praia Mole Port will have to be conducted without protection from the open sea and against hard stratum, like canga, present at places. For the purpose of expedient dredging works, it is highly desirable to dispatch the said specialist from Japan. It is hoped that the qualifications of the specialist are the ability and full experience in giving proper suggestions, recommendations and advice not only for the dredging works but also for the promotion of the entire project.

Since the project includes a good number of large-sized cargo handling facilities unfamiliar to Brazilians, a specialist in the cargo handling equipment will also be necessitated.

The President of PORTOBRÁS Mr. Arno Oscar Markus told the head of the third survey team dispatched in early August this year that Brazil would be ready to accept, in addition to the above two specialists, an advisor for the promotion of the entire project according to the technical cooperation plan of the Japanese Government.

4-2 Organization for the execution of the project

PORTOBRÁS has much to solve in setting up the physical strength to face the project. In view of the significance, magnitude, dimensions and limitations on construction period, it is desirable to install an amply staffed site office at Vitória and the headquarters of PORTOBRÁS should empower the representative of the site office to have a fair amount of latitude in handling mainly engineering matters.

5. Management system after completion of Praia Mole Port

There are conceivable two management systems; one in which a mixed economy company as explained in the foregoing is established for unitary management of all the ports and harbours in Espirito Santo State, including Vitória Port and Praia Mole Port, and the other in which an independent management system is established to control and operate Praia Mole Port only.

Praia Mole Port and Vitória Port are within easy reach from each other, and the former system will be a logical choice because of cost economy and interchangeability of staffers and labors.

X. Dues and charges in Brazilian ports and the philosophy of their establishment

1. Tariff system - types of dues and charges

The main sources of revenues to be put into the coffers of the port authority are dues and charges for use of ports and harbours (including entrance dues, berthage and cargo handling charges, etc.) and longshore cargo handling charges. Also, pilotage and towage are levied if such services are extended by the port authority.

2. Concept for establishment of tariffs

The dues and charges for use of ports and harbours generally are set on the cost principle, and the following costs are considered in establishing them.

Costs for administration, operation and maintenance

Costs for depreciation

Costs for capital renumeration

The capital renumeration is like a dividend, and PORTOBRÁS admits port authorities to recover 10% of investments as a cost for capital remuneration.

If the tariff rates underlying the above three cost items yield the earnings in excess of expenditures, the surplus is transferred to the national treasury so far the mixed economy port is concerned.

The balance of payments position is checked every month, and if it is in the red, the tariff rates are increased.

There is no established method in the depreciation; each port authority and PORTOBRÁS determine it. The channels, anchorage basins and breakwaters are not considered as depreciable assets, however.

XI. Economic analysis

1. General development impact

1-1 Vitória Port has little room for expansion, and there is no nearby place suitable for the construction of a port either. Pria Mole Port planned with the construction of CST taken advantage of will serve not only as a port for CST, but play a major role as a public port capable of accommodating large vessels and making a great deal toward the regional development.

1-2 The construction of a deep-water large-scale port like Praia Mole Port that faces the open sea is the first-ever experience in Brazil, and the port construction technologies to be nurtured through the project will go a long way toward the construction of ports and harbours in Brazil in the future.

1-3 Another form of economic impact the project can offer is the employment opportunities - labor force required during the construction of Praia Mole Port and about 1,000 port workers in the employ after completion of the port.

2. Economic evaluation

As the construction of CST is a matter already decided upon, it will be of little significance to evaluate the project from the viewpoint of national economy. For this reason, the degree of contribution toward the improvement in transport conditions by the construction of Praia Mole Port permitting the entry of large vessels is studied in comparison with that expected when there is nothing to be depended upon other than Vitória Port.

2-1 Basic principle of analysis

2-1-1 As an index of evaluation, the internal rate of return is taken up.

2-1-2 Vitória Port has no spare capacity to handle the cargo for CST. For this reason a comparative study is made on the case where facilities for handling cargoes for CST are constructed at Vitória Port. In this case, the maximum vessel considered is of the 40,000 DWT class.

2-2 Cost and benefit

2-2-1 Cost

The cost for construction, maintenance and repair, electric power and fuel, and management and operation are compared between Praia Mole Port and Vitória Port.

2-2-2 Benefit

The benefit is the reduction in the cost for maritime transportation due to the difference in the size of ships and the curtailment of the expenses for secondary transportation from Vitória Port to CST. The cargoes considered for computation of benefit are import coal and oil (by coastal shipping). Although the cost for export of cargoes will also be saved, their degree of contribution to the Brazilian national economy is not certain, and such economy, if ever, has no direct and visible effect on the Brazilian economy as compared with that the foreign consignees are expected to enjoy. For this reason, the export cargoes are excluded in the benefit calculations.

The secondary transportation from Vitória Port is considered to be borne by rail.

2-3 Internal rate of return, and appraisal of the project

The internal rate of return is calculated for a period of 25 years starting in the first year when the operating revenues are earned. The results show that the internal rate of returns is in the range of 16.6% to 18.3%; namely, that the construction of Praia Mole Port has a great bearing on the national economy so far as it presupposes the construction of CST.

XII. Financial analysis

1. Methodology

The financial position of the port authority (mixed economy company) controlling and operating Praia Mole Port is examined in the following methods. The tariff rate per ton of cargo which provides an important footing for earning power is studied with reference to the tariff now enforced in the nearby Vitória Port.

1-1 Investigation of the cost per ton of cargo

1-2 Analysis by DCF (Discounted Cash Flow) method

1-3 Investigation of the cash flow based upon the income and expense estimation

2. Cost share per ton of cargo at Vitória Port

The cost share to be borne by the user per ton of cargo is calculated as follows according to the Vitória Port tariff sanctioned by PORTOBRÁS in February, 1977. (The values in parentheses are mean values.)

Clab	:	Cr$43.18 ∿ 45.76 (44.46)
Coal	:	Cr$32.95 ∿ 38.28 (35.61)
Oil	:	Cr$ 7.68

3. Investigation of the cost per ton of cargo

3-1 Calculation of the cost per ton of cargo

The cost per ton of cargo to be handled at Praia Mole Port is calculated by dividing by the target volume of cargoes to be handled the total of the cost for annual depreciation, interest of the loan, maintenance and repair, electric power and fuel, and management and operation.

The cost per ton of cargo is calculated for the 1st stage and the master plan (up to 2nd stage) with respect to the following four cases each.

Case A : Ordinary case in which the expenses concerning depreciation are regarded as a cost.

Case B : A case in which the breakwaters, dredging works (channels and basins) and reclaimed land are regarded as non-depreciable assets.

Case C : A case in which the breakwater and dredging works are undertaken on a separate accounting system (100% grant or subsidy of the Government).

Case D : A case in which 10% of the total investment (i.e., what is termed "capital remuneration" by PORTOBRÁS) is included in the cost with the interest payable and the depreciation for breakwaters, channels and basins excluded from the cost.

The results of computation for the above four cases are given in Table 6.

Table 6. Costs per ton of cargo

(in Cr$)

	1st stage			2nd stage			Remarks
	Slab	Coal	Oil	Slab	Coal	Oil	
Case A	90.16	50.75	12.19	62.87	36.35	9.60	
Case B	88.99	48.52	11.78	62.22	36.00	9.32	
Case C	71.89	40.60	4.70	52.44	31.60	4.39	
Case D	126.30	70.19	18.23	86.80	50.16	14.07	
(Reference) Target cargo	thousand tons 2,500	thousand tons 4,384	thousand tons 3,241	thousand tons 5,000	thousand tons 8,002	thousand tons 3,942	
Current incidence per ton of cargo in Vitória Port	44.47	35.61	7.68	44.47	35.61	7.68	According to the tariff currently in force at Vitória Port

3-2 Evaluation

If the project ends by completion of the 1st stage only, the tariff rates for Praia Mole Port will become much higher than those for Vitória Port.

In the project covers the 2nd stage, the cost per ton of cargo to be handled at Praia Mole Port will be on an even level in terms of tariff rates with Vitória Port if Case C is applied; namely, Cr$52.40 for slabs, Cr$31.60 for coal and Cr$4.39 for oil. In practice, however, the tariff may have to be set higher with an adequate margin added to the cost.

4. Analysis by DCF method

The purpose of this analysis is to evaluate the profitability of the project according to the discount rate (FRR - financial rate of return) that will make both the income and expenses equal during the life of the project.

4-1 Income and expenses

The expenses include the construction cost so far discussed with respect to the original plan and the expenses for management and operation and others explained in XII-3.

For the income, the tariff currently in force at Vitória Port, and 20% increase and 50% increase therefrom (3 cases in all) are considered for Praia Mole Port.

The Government subsidy is regarded as income of the years when they are invested in respective installations. For the calculation of FRR, the project life is set at 25 years.

4-2 Calculation of FRR, and evaluation

The FRR is calculated as shown in Table 7.

Table 7. Calculation results of FRR

Tariff level	1st stage		2nd stage		Remarks
	w/o subsidy	w/subsidy	w/o subsidy	w/subsidy	
Current tariff	Minus	6.0	3.7	9.4	
up 20%	2.6	9.7	6.5	13.2	
up 50%	5.8	14.5	9.7	18.2	

Note: The "subsidy" means the 100% government subsidy for the breakwater and dredging works.

The interest rate on bank loans in Brazil is found to be within the range of about 10 to 12%, and this value is preferred as a measure to judge FRR.

If the project is limited to the 1st stage only, the Praia Mole tariff will have to be set far and away higher than the Vitória's, or the financial position of Praia Mole Port will go nowhere but down. Of course, the Government should support Praia Mole Port financially.

Even if the 2nd stage is completed, the financial soundness of Praia Mole Port will not be ensured unless the Government subsidy is combined with about 20% higher tariff than Vitoria's.

5. Investigation of the cash flow based on income expenses

5-1 Major premises for discussions

As already stated repeatedly, it is foreseen that Praia Mole Port will not go well financially if the 1st stage alone is counted upon. Naturally, it is necessary to study the master plan.

The subjects put to comparative study are enumerated in Table 8.

Table 8. Study cases

	Tariff level	100% government subsidy for breakwaters and basins	Others
Case a - ①	Current Vitória tariff	nil	w/dividend
②	up 20% from current Vitória tariff		w/dividend
Case b - ①	Current Vitória tariff	esse	w/dividend
②	up 20% from current Vitória tariff		w/dividend
Case c - ①	Current Vitória tariff		w/o dividend of 100% of the total investment excluding subsidy taken as an manual cost)
②	up 20% from current Vitória tariff		

The capital of the port and dock company is set at 50% of the difference between the total investment and the yen loan component if no government subsidy is available, and the remaining 50% is considered to be made up for by long-term loans available in Brazil.

Where the government subsidy is available, the capital is the difference between the total investment an the sum of the yen loan component and the government subsidy.

The corporation tax is payable from the time when the accumulated dificits have been reduced to zero.

The dividend will be payable in such a term when the net profit after tax and legal reserve has exceeded as required level of divided reserve, provided that no dividend will be paid in Case C.

5-2 Computation results and evaluation

The statment of income and the cash flow statement results for each case over a period of 30 years as shown in Table 9.

Table 9 The statement of income and the cash flow statement

Item	w/o subsidy (Case a)		w/subsidy (Case b)		w/subsidy (Case c)	
	a - ①	a - ②	b - ①	b - ②	c - ①	c - ②
Turn of year from deficit	16th year	4th year	4th year	1st year	No black figures in 25 years	8th year
Turn of year from accumulated deficits to profit	Deficit is not cleared off in 25 years	8th year	6th year	4th year	Deficit is not cleared off in 25 years	16th year
First year of dividend to be paid	No divident in 25 years	13th year	13th year	6th year	—	—
Max. amount of accumulated deficits						
Time	15th year	3rd year	3rd year	A year before commissioning	On the rise	7th year
Amount	Cr$1.415.4 million	Cr$348.9 million	Cr$193.3 million	Cr$67.0 million	—	Cr$711.1 million
Max. amount of short-term loans						
Time	15th year	3rd year	A year before commissioning	A year before commissioning	7th year	3rd year
Amount	Cr$1,966.0 million	Cr$264.7 million	Cr$67.2 million	Cr$77.2 million	Cr$444.0 million	Cr$227.0 million
Financial state 25 years after commissioning						
Recurring profit rate	0.33	0.67	0.88	0.97	Deficit	0.62
Retained profits	0	Cr$874.1 million	Cr$1.711.2 million	Cr$2,512.4 million	0	Cr$2,239.4 million
Cash deposit	Cr$-783.8 million	Cr$646.9 million	Cr$3,258.7 million	Cr$4,119.5 million	Cr$10.1 million	Cr$4,952.7 million
Year of recovery of initial investment(depreciable assets)	Unrecoverable	14th year	12th year	13th year	Unrecoverable	18th year

Notes: 1) Years given are as counted from the year commissioned.
2) The recurring profit rate refers to the rate of profit before tax to the revenue.
3) The subsidy means the 100% government subsidy for the breakwater and dredging work.

According to the computation results, Case B - ② where the breakwaters and dredging works are 100% subsidied by the Government while the tariff is set 20% higher than that in Vitória Port shows that Praia Mole Port will become able to pay dividend to its capital subscribers from the sixth year of commissioning, and that the accumulated deficits will be reverted to a surplus from the fourth year. Accordingly, Case B - ② is preferred from the managerial viewpoint.

6. Composite evaluation

Taken the results of the above three analyses altogether, the following conclusions will be reached.

The project will be able to maintain its financial soundness onoy when the project is completed up to the 2nd stage under the government subsidy to the breakwaters and dredgings and when Praia Mole tariff is set about 20% higher than Vitória's.

Even in the advanced countries, it is not rately the case that breakwaters and dredgings are wholly supported by the government financially. By the nature of the capital goods Praia Mole Port will have, it is hard to equalize the incidence among the users as against the temporal order. On the other hand, Praia Mole Port is a public port intended for the development of a basic industry in Brazil and for the expansion of export trades. Taken altogether, it will be quite reasonable for the Brazilian Government to subsidize the project.

A difference of abut 20% in tariff rates from the nearby port will be not too much for the users considering that Praia Mole Port is equipped with highly efficient facilities and is able to accommodate large vessels.

XIII. Conservation of environment

In implementing the project, full consideration should be given to what influence it will have on the surroundings, and relevant measures should be taken to protect the environment from evil effects.

In the beach of Praia Mole, sand drift is not so conspicuous. Since long breakwaters are to be projected from the shore off, a survey on the qualitative change of the nearby coastal stretches should be continued in order to take measures and actions to obviate coastal erosion whenever and wherever required so to to.

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CHAPTER 1. GENERAL

1. General

1-1. Background of the survey

The survey was made to draw up plans necessary for the construction of Praia Mole Port as one of the economic cooperation commitments given by the Japanese Government to President Geisel during his stay in Japan in September 1976. In response to the request of the Japanese Government, the Japan International Cooperation Agency commissioned The Overseas Coastal Area Development Institute of Japan (OCDI) to undertake the survey.

COMPANHIA SIDERŨGICA DE TUBARÃO (Tubarão Steel Mill Co., Ltd.; hereinafter referred to as CST) had pushed, forward on its own a survey for the construction of Praia Mole Port as a private port since around the beginning of 1973 when the Tubarão Steel Mill construction plan was almost boiled down by the joint efforts of Japan, Italy and Brazil. The results of CST's survey were complied in a report titled "Final Report of Port Project for Feasibility Study of Tubarão Steel Mill, September 5, 1974." Later, the Brazilian Government set out a policy to make Praia Mole Port, as a public one rather than the one available to CST alone, in order to handle not only CST cargoes, but also various types of cargo which will rise in volume with the development of the hinterland. Thus, DNPVN (Departmento National de Portos E Vias Navigação, an organization in charge of ports and harbours in the Ministry of Transport, existing before establishment of PORTOBRÁS) took it upon itself to undertake the survey for the planning of the Praia Mole Port construction. DNPVN conducted hydraulic model tests, soil surveys and other technical researches and investigations while leaving the task of exercising general control over the construction planning to PLANAVE. The achievements of DNPVN's survey were compiled into a report titled "Estudos Para Implantação do Porto de Praia Mole - ES. minuta do relatorio final" issued in March 1976.

President Geisel visited Japan in September 1976 and requested Japanese Government to extend economic cooperation to the Praia Mole Port Construction Project, and the Japanese Government gave its consent to his proposal with the proviso that the Japanese economic cooperation presupposes that the Brazilian plan be qualified by a Japanese survey to be feasible. Thus, OCDI was assigned by the Japan International Cooperation Agency to undertake the survey. After a review had been made on the various past reports available in relation to Praia Mole Port OCDI conducted a preliminary field survey for 17 days from October 29 to November 14, 1976 in order to collect basic data and examine whether Brazil would be ready to accept a principal survey team. In February 1977 a 9-member principal survey team was sent to Brazil for 40 days. The team included an official each from the Ministry of Transport and the Overseas Economic Cooperation Fund, in addition to the OCDI members.

The results of the surveys were compiled into "Preliminary Survey Report on the Construction of Praia Mole Port in the Federative Republic of Brazil (December, 1976)" and "Interim Survey Report on the Construction of Praia Mole Port in the Federative Republic of Brazil (March, 1977)" which were duly submitted to the Japan International Cooperation Agency (both reports were written in Japanese).

In July this year, a third survey team was despatched for the purpose of final adjustment of the construction cost estimate.

1-2. Purpose of the survey

The Brazilian Government planned to construct a steel mill in Tubarão, Espirito Santo State, in order to manufacture semifinished iron and steel products for the purpose of meeting the increasing demand for iron and steel in Brazil and at the same time for promoting export trade. At present the preliminary work, including clearance of woods, is on the move with a view to put the steel mill into operation by October 1980. Praia Mole Port has been planned as a public port not only to handle raw materials to and products from CST but also to handle coal to the USIMINAS, steel mill and oil products.

The principal survey was carried out to study the technical, economic and financial feasibility and viability of the Praia Mole Port Construction Project.

1-3. Scope of the survey

When this survey was started the Brazilian Government had made various surveys on the Praia Mole Port Construction Project, and had formulated layout plans for the port facilities.

The results of the survey undertaken by the Japanese team have a direct bearing on the materialization of the economic cooperation.

For these reasons, it was planned to study the following for the purpose of drawing up the plans for Praia Mole Port in detail.

① Study of the Brazilian Government's plans

- ⓐ Layout of port facilities
- ⓑ Design criteria of port facilities
- ⓒ Basic design of port facilities
- ⓓ Dredging and reclamation plan
- ⓔ Plan of cargo handling facilities and other related facilities
- ⓕ Estimate of construction costs and construction methods (including construction schedule)

② Preparation of alternative plans if found necessary according to the results of study in step ① above

③ Economic and financial analyses

④ Study of organization and system for administration, management and operation of Praia Mole Port

⑤ Study of environment impact brought by the port construction

⑥ Identification of problems standing in the way of the Project implementation, and recommendations.

1-4. Formation of the survey team

1-4-1. Preliminary survey team

Head	Susumu Maeda, General Manager, The Overseas Coastal Area Development Institute of Japan (OCDI)
Member	Tomoo Ishiwata, Deputy Director, Planning Department, OCDI
Member	Katsutoshi Tanimoto, Chief, Breakwaters Laboratory, Hydraulic Engineering Division, Port and Harbour Research Institute, Ministry of Transport
Member	Minoru Takase, Counsellar, Social Development Cooperation Dept., Japan International Cooperation Agency (JICA) (also participated in the third survey)

1-4-2. Principal survey team

Head (Port planning)	*Susumu Maeda, General Manager, OCDI
Deputy Head (Transportation economy)	Tomoo Ishiwata, Deputy Director, Planning Department, OCDI
Member (Economic and financial analysis)	Takashi Hashikawa, Deputy Manager, Technical Division Economic research and Technical Appraisal Department, The Overseas Economic Cooperation Fund
Member (Hydraulics)	Katsutoshi Tanimoto, Chief, Breakwaters Laboratory, Hydraulic Engineering Division, Port and Harbour Research Institute, Ministry of Transport
Member (Geotechnique)	Yukio Komori, Civil Engineer, OCDI
Member (Structural design)	Katsutoshi Endo, Civil Engineer, OCDI
Member (Cargo handling equipment)	Nobuyuki Fujii, Mechanical Engineer, OCDI
Member (Working Craft and execution)	Isamu Hirayama, Mechanical Engineer, OCDI

Member (Cost estimate) *Toru Yokota, Civil Engineer, OCDI

(* jointed the third survey)

1-5. Itinerary

1-5-1. Preliminary survey

Date	Day of the week	Activities
Oct. 29	Fri.	Left Tokyo at 20:00 for Brazil.
Oct. 30	Sat.	Arrived at Rio de Janeiro at 15:30 (by way of Papeete and Lima)
Oct. 31	Sun.	Analyzed the data collected by the Consulate General, made arrangements on survey schedule.
Nov. 1	Mon.	First talks with President of PORTOBRÁS Markus, PORTOBRÁS executives, and PLANAVE executives.
Nov. 2	Tue.	National holiday. Head Maeda and Takase moved to Brasilia.
Nov. 3	Wed.	Head Maeda and Takase: Paid a transport courtesy call to Vice Minister of Transport Newton Cyro Braga and Director of Asia and Oceania division of Ministry of Foreign Affairs, and visited Ambassador Yoshida and others at the Japanese Embassy. Later moved to São Paulo. Ishiwata and Tanimoto: Held a meeting with PORTOBRÁS and PLANAVE, and collected data. Later moved to São Paulo.
Nov. 4	Thu.	Visited the Hydraulics Lab., São Paulo Univ.

Date	Day of the week	Activities
Nov. 5	Fri.	Left São Paulo in the morning for Rio de Janeiro. Head Maeda and Tanimoto: Visited the Hydraulics Research Lab., PORTOBRÁS. Head Maeda and Ishiwata: Held meetings separately at PORTOBRÁS.
Nov. 6	Sat.	Inspected Rio de Janeiro Port in the morning. Moved to Vitória in the afternoon.
Nov. 7	Sun.	Reconnoitered CST construction site and Praia Mole Port construction site.
Nov. 8	Mon.	Investigated the breakwater work at Portocel in the morning. In the afternoon, investigated CVRD Tubarão Terminal and quarry for Praia Mole Port breakwaters, and paid a courtesy call to the Governor of Espirito Santo State.
Nov. 9	Tue.	In the morning, visited the Vitória Port Authority and investigated Vitória Port. In the afternoon, moved to Rio de Janeiro. Head Maeda and Ishiwata: Held meetings at PORTOBRÁS concerning planning.
Nov. 10	Wed.	In the morning, visited the head office of CVRD, and asked about CVRD's situation concerning the participation in the Praia Mole Port project. (Tanimoto sorted the collected data.) In the afternoon, held the final, working-level meeting at PORTOBRÁS.

Date	Day of the week	Activities
Nov. 11	Thu.	In the morning, conferred with President Markus and others.
Nov. 12	Fri.	Left Rio de Janeiro at 10:00.
Nov. 14	Sun.	Reached Tokyo at 18:30. (by way of Mexico City)

1-5-2. Principal survey

Date	Day of the week	Activities
Feb. 4	Fri.	Left Tokyo at 18:15.
Feb. 5	Sat.	Reached Rio de Janeiro at 16:20. (via Los Angeles)
Feb. 6	Sun.	Free
Feb. 7	Mon.	In the morning, arranged the survey schedule at the Consulate General. In the afternoon, held the first meeting with President Markus and PORTOBRÁS executives at PORTOBRÁS, ending primarily with courtesy calls and adjustment of survey schedule.
Feb. 8	Tue.	PORTOBRÁS gave a briefing on the progress of work made after the preliminary survey. In the morning: results of hydraulic model tests In the afternoon:- No. 1 crew: Design wave height and type of structure of breakwaters No. 2 crew: Soil survey results, dredging plan, etc.

Date	Day of the week	Activities
		Head Maeda moved to Brasilia, paid a courtesy call to the Director of the Asia and Oceania Division, the Ministry of Foreign Affairs, and then made arrangements with Ambassador Yoshia.
Feb. 9	Wed.	Head Maeda: Visited Vice Minister of transport Braga and President Markus, of PORTOBRÁS.
		No. 1 crew: collected financial data at Rio Office of the Tokyo Bank.
		No. 2 crew: In the morning, visited the Hydraulics Lab. of PORTOBRÁS.
		In the afternoon, visited ISHIBRAS. Tanimoto alone stayed at the Hydraulics Lab. for continued arrangements about the design wave height.
Feb. 10	Thu.	Gave PORTOBRÁS a briefing on the Japanese plan.
		Tanimoto and Komori cooperated with PORTOBRÁS engineers at the Hydraulics Lab. concerning the design wave height.
Feb. 11	Fri.	Detailed explanation and discussion of the Japanese plan by specialty.
		No. 1 crew: Discussion over cargo handling facilities and other related facilities.
		No. 2 crew: Discussion over design and execution method of Breakwaters.

Date	Day of the week	Activities
		No. 3 crew: Discussion over port administration and operation and financial analysis.
Feb. 12	Sat.	Edited the results of discussions.
Feb. 13	Sun.	Moved to Vitória (except for Head Maeda).
Feb. 14	Mon.	Head Maeda: Moved to Salvador and surveyed Salvador breakwaters and Aratu Port.
		Members: Reconnoitered CST construction site, Praia Mole Port construction site, and investigated the quarries for breakwaters.
Feb. 15	Tue.	No. 1 crew: Surveyed the breakwater work at Portocel in the morning and CVRD Tubarão Terminal in the afternoon.
		Tanimono alone collected meteorological data at the meteorological station in the afternoon.
		No. 2 crew: Surveyed Vitória Port tariff in the morning, and in the afternoon joined No. 1 crew to investigate CVRD Tubarão Terminal.
		Head Maeda: Moved from Salvador to Vitória, and paid a courtesy call to the Governor and Vice-Governor of Espirito Santo State.
Feb. 16	Wed.	Head Maeda: Moved from Vitória to Rio de Janeiro, and visited the head office of PLANAVE in the afternoon.

Date	Day of the week	Activities
		No. 1 crew: Visited the Vitória Port Authority and surveyed Vitória Port and Capuaba Terminal construction site for working capacity, material costs, labour costs, etc. and financial conditions.
		No. 2 crew: Investigated the UBU Port construction project.
Feb. 17	Thu.	Head Maeda: In the morning, visited CVRD head office to ask about CVRD's situation concerning participation in the Praia Mole Port construction project. In the afternoon, visited Christian Nielsen to investigate the present conditions of contractors, and submitted an interim report to Consul General Ishii in Rio.
		No. 1 crew: Moved from Vitória to Rio de Janeiro. In the afternoon, visited Christian Nielsen together with Head Maeda.
		No. 2 crew: Moved from Vitória to Brasilia viá Rio. In the afternoon, inquired of GEIPOT about the traffic and transport plans in Brazil and position of Praia Mole Port in the plans.
Feb. 18	Fri.	No. 1 crew (in Rio): Visited CBD to survey dredgers, etc.
		No. 2 crew (in Brasilia): Visited the Economic Research Institute of the Planning Agency to inquire about the present state of the economics in Brasil and the economic position of iron and steel industry.

Date	Day of the week	Activities
Feb. 19	Sat.	No. 1 crew (in Rio): Sorted the survey results and data. No. 2 crew (in Brasilia): Moved from Brasilia to Rio.
Feb. 20	Sun.	Free
Feb. 21	Mon.	Carnival
Feb. 22	Tue.	ditto.
Feb. 23	Wed.	Moved from Rio to São Paulo. In the afternoon, visited Villares to study cargo handling equipment production facilities.
Feb. 24	Thu.	No. 1 crew: In the morning, visited the Hydraulics Lab. of São Paulo Univ. In the afternoon, visited Vardella to study cargo handling equipment production conditions. No. 2 crew: In the morning, visited LPW to study the conveyor equipment production conditions. In the afternoon, joined No. 1 crew to visit Vardella. No. 3 crew: Visited the Tokyo Bank of Brazil to collect financial data and inquire about the present state of autarky rate.

Date	Day of the week	Activities
Feb. 25	Fri.	No. 1 crew: Investigated Santos Port and Cosipa Steel Mill. No. 2 crew: Visited Siemens and Goodyear to study the production conditions of electric machinery and conveyor belts. Head Maeda: Moved to Rio de Janeiro after completion of survey by No. 1 crew.
Feb. 26	Sat.	Free
Feb. 27	Sun.	Members moved from São Paulo to Rio de Janeiro except Head Maeda.
Feb. 28	Mon.	Inspected the Sepetiba Port construction site.
Mar. 1	Tue.	Started discussions with PORTOBRÁS to boil down the Japan-Brazil joint plan. In the morning: Arrangements on basic matters for discussions. In the afternoon:- No. 1 crew: Dredging and temporary road. No. 2 crew: Cargo handling equipment and other facilities. No. 3 crew: Design wave height and the type of structure of the breakwaters.
Mar. 2 Mar. 3 Mar. 4	Wed. Thu. Fri.	Continued discussion by group of specialty to boil down the Japan-Brazil joint plan.
Mar. 5 Mar. 6	Sat. Sun.	Improvement of the plan according to the results of discussion, and preparation of a draft exchange note.

Date	Day of the week	Activities
Mar. 7	Mon.	Presentation to PORTOBRÁS of the results of discussion.
Mar. 8	Tue.	Advance working-level discussions with Director Mario and other executives of PORTOBRÁS over the draft documents for exchange.
Mar. 9	Wed.	Final meeting with President Markus and other executives of PORTOBRÁS. President Markus and Head Maeda signed and exchanged the documents.
Mar. 10	Thu.	Head Maeda and Ishiwata: In the morning, visited PORTOBRÁS to ask about the organization and the present state of the plans for Praia Mole Port construction, administration and operation. Head Maeda: Reported the results of survey to Consul General Ishii in Rio. Members: Sorted the data.
Mar. 11	Fri.	Head Maeda: Made a day's trip to Brasilia to report to Vice Minister of Transport Braga, Derecto of Asia and Oceania Division Minister of Foreign Affairs, and Ambassador Yoshida on the results of survey. Members: In the morning, visited PORTOBRÁS to inquire about the road plan, financial calculations and stochastic method of projecting cargo volume, etc. In the afternoon, prepared for departure, shipped baggages, and settled the accounts.

Date	Day of the week	Activities
Mar. 12	Sat.	Called at PORTOBRÃS' counterpart Mr. Da Rin's.
Mar. 13	Sun.	Left Rio de Janeiro at 10:00
Mar. 14	Mon.	Left Mexico City at 10:15.
Mar. 15	Tue.	Arrived at Tokyo at 18:35 (via Los Angeles)

CHAPTER 2. LOCATIONAL CONDITIONS

2. Locational Conditions

2-1 Outline

The Tubarão Steel Mill is scheduled to be constructed to the east of Tubarão Terminal of CVRD in Tubarão in a suburb of Vitória, the capital of Espirito Santo State. The site was selected by the Central Government and the Espirito Santo State Government. Praia Mole Port is planned to be constructed in the frontal coastal area of the Tubarão steel mill site.

The selected site is near Vitória City and is well equipped with traffic means such as roads, railways and port (Vitória Port) and also with civic facilities. Behind the site are Espirito Santo State and Minas Gerais State which are emerging as a promising land of mining and agriculture. Namely, Praia Mole Port is expected much not only as a port for handling steel mill's raw materials and products, but also as an export port of mining and agricultural produce.

The port site is open to the Atlantic and provides an easy access to large vessels. In order to protect the harbour from waves, however, the construction of large-scale breakwaters is required.

2-2 Geographical conditions

Praia Mole Port is about 15 km northeast of Vitória City, and the nearby Espirito Santo Bay has Vitória Port. Vitória Port is equipped with facilities for handling general cargoes, iron ore, coal and oils; Tubarão Terminal specifically constructed for shipping iron ore is provided with the most advanced facilties capable of mooring ore carriers of 250,000 DWT class.

Praia Mole Port is adjacent to such major public ports as Rio de Janeiro Port 270 sea miles on the south and Salvador port 475 sea miles on the north. Table 2.2.1 shows the distances by sea from Vitória Port to major ports, and Fig. 2.2.1 illustrates the location of major ports.

Table 2.2.1 Distances by sea from Vitória Port to major ports

(in nautical miles)

Ports	Distance by sea	Ports	Distance by sea
BELÉM	2,091	PARANAGUÁ	645
RECIFE	931	IMBITUBA	853
SALVADOR	475	RIO GRANDE	1,160
SANTOS	480	PORTO ALEGRE	1,340
RIO DE JANEIRO	270		

Naturally, Praia Mole Port and Vitória Port will be sure to vie with each other. Accordingly, Praia Mole Port construction plan should take fully into consideration the division of functions between the two ports. But, the other ports will not be in a vying position with Praia Mole Port.

Praia Mole Port is to be constructed by reclaiming a sandy beach streching over some 5 km in the north-south direction from the north side of the neck of Cape Tubarão. The Tubarão Steel Mill construction site behind the reclaimed land is a large hilly districts about 20 m above the sea level. In planning the roads and railways to connect the port area and its hinterland, topographic conditions should also be taken into account.

Fig. 2.2.1 Location of major ports in Brazil

2-3 Environmental conditions

2-3-1 Topography

As illustrated in Fig. 2.3.1, Praia Mole is a sandy beach stretching over a distance of about 5 km from Cape Tubarão to Carapebus. The coastal line is turned about 26° clockwise from the north; namely, it extends nearly NNE to SSW.

Praia Mole is exposed to the open sea. On either end of the beach is an outcrop of rocks called canga. Canga can also be seen at places over the stretch. Also canga is present in the seabed. At an eastern point where the water depth is 20-odd meters, there is a reet of about -6 m deep (Baixo do Carapebus).

The beach stretching from Cape Tubarão to Portocellying some 60 km toward the north has reportedly natural jetties of canga at places. South of Cape Tubarão is a small bay (Baia do Espirito Santo) with many rocks. Vitória Port sits along a channel sewing its way through Vitória Bay on the back of Vitória Island. The coast around Vitória is classed as a submerged one.

There is only a single river of several meters wide that empties itself into Praia Mole. The largest nearby river is Rio Doce about 80 km north of Praia Mole. It forms a large coastal plain on the north. According to Chart No. 70, it has a well-developed sand spit at the estuary extending from north down.

The slope of the sea bottom is from 1/100 to 1/250 with a distance of 1 to 1.5 km off the shoreline to attain a water depth of 10 m and 4 to 5 km to attain a water depth of 20 m. It takes 40 to 45 km to attain a water depth of 100 m. Farther off is a continental shelf having a slope of 1/5 to 1/6, reaching a depth of 2,000 m or more, and again we reach shallows of 30 m to 100 m deep called Banco do Vitória. The continental shelf there is quite irregular in topography. On the north of Rio Doce, the continental shelf stretches about 200 km, and there are shallows called Parcel Dos Abrolhos which leads to the most complicated continental shelf in Brazil. The stretch from Rio Doce to Vitória has the continental shelf constricted

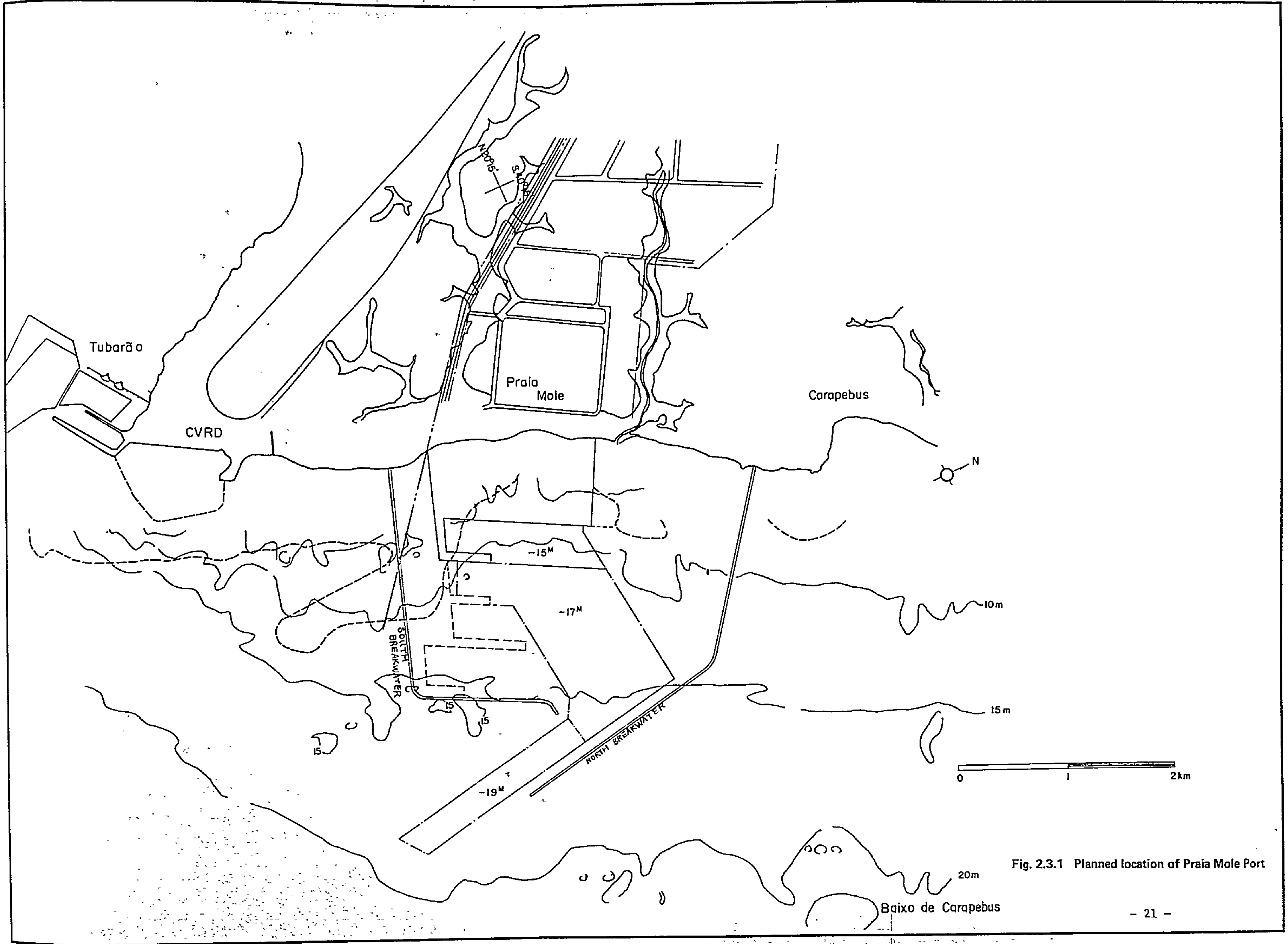


Fig. 2.3.1 Planned location of Praia Mole Port

2-3-2 Geology

The geological survey was being pushed forward by the Brazilian counterpart when we visited Brazil for the principal survey, and the geological data acquired by the end of the principal survey are outlined as follows.

The strata around Praia Mole are composed of an alternation of quartz-family sandy soil and clayey soil (mainly of kaolinite), and below the alternation is granite. According to the offshore boring results, it is found that the granite stratum is deeper than -50 m. According to the land boring results the granite stratum becomes deeper as it goes from south to north, and it again rises far toward north. The depth of the granite stratum is -20 m around Tubarão, -100 to -200 m around the Praia Mole Port construction site and -15 m to -20 m at Carapebus.

Reddish brown iron-rich rocks called are present spottedly around the shoreline. Their canga thickness is said to be about several meters. The canga on the shoreline shows it self porous as pitted by erosion. It is not so strong, but is generally fragile.

It is, therefore, important to take into consideration the distribution of canga in planning the facilities in Praia Mole Port.

The location of canga and typical soil profile are shown in Figs. 2.3.2 and 2.3.3.

2-3-3 Meteorology

(1) Outline

In Brazil, the northern coast falls on the wet tropical zone to the trade wind dry zone, while the eastern coast lies in the trade wind wet zone to the west wind temperate zone. Although the South American Continent fringes the Atlantic, no monsoon is predominant. In the South Atlantic, the Benguela Current chills the waters up to near the equator, and the tropical depression is hardly developed. The major factor that changes weather in Brazil is the northward heading of cold fronts to be developed at around the southern end of the continent.

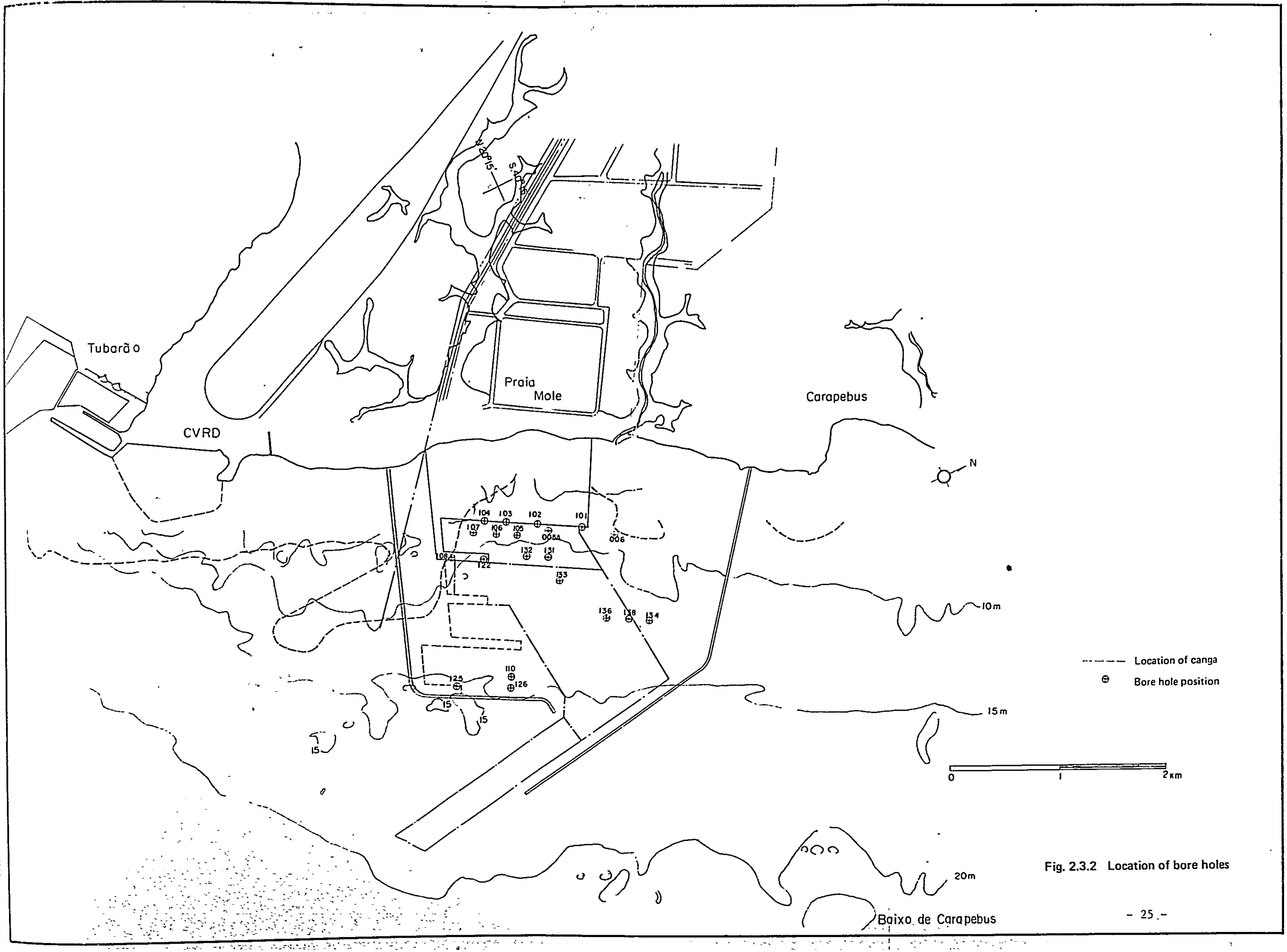


Fig. 2.3.2 Location of bore holes

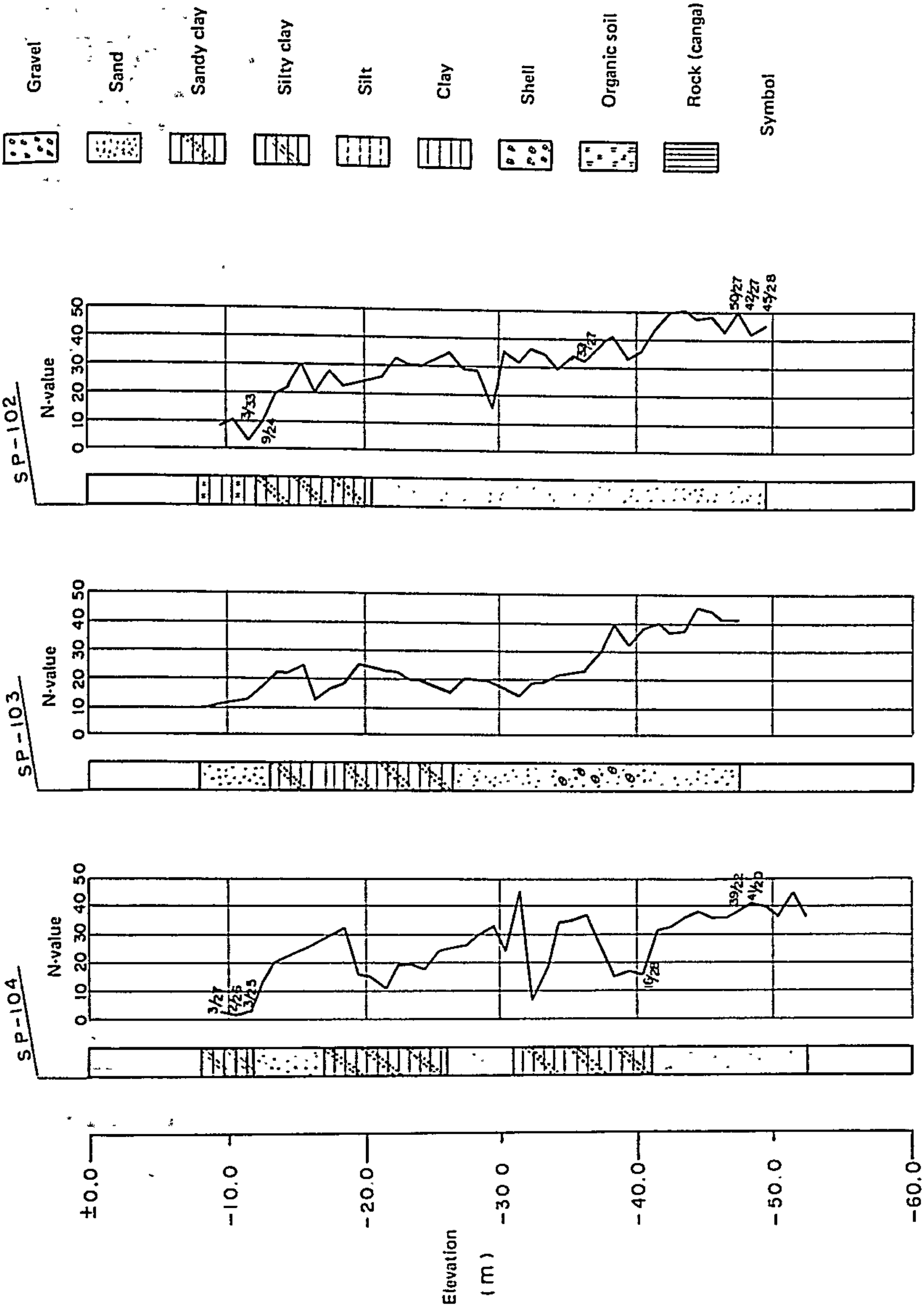


Fig. 2.3.3 Soil profile (1)

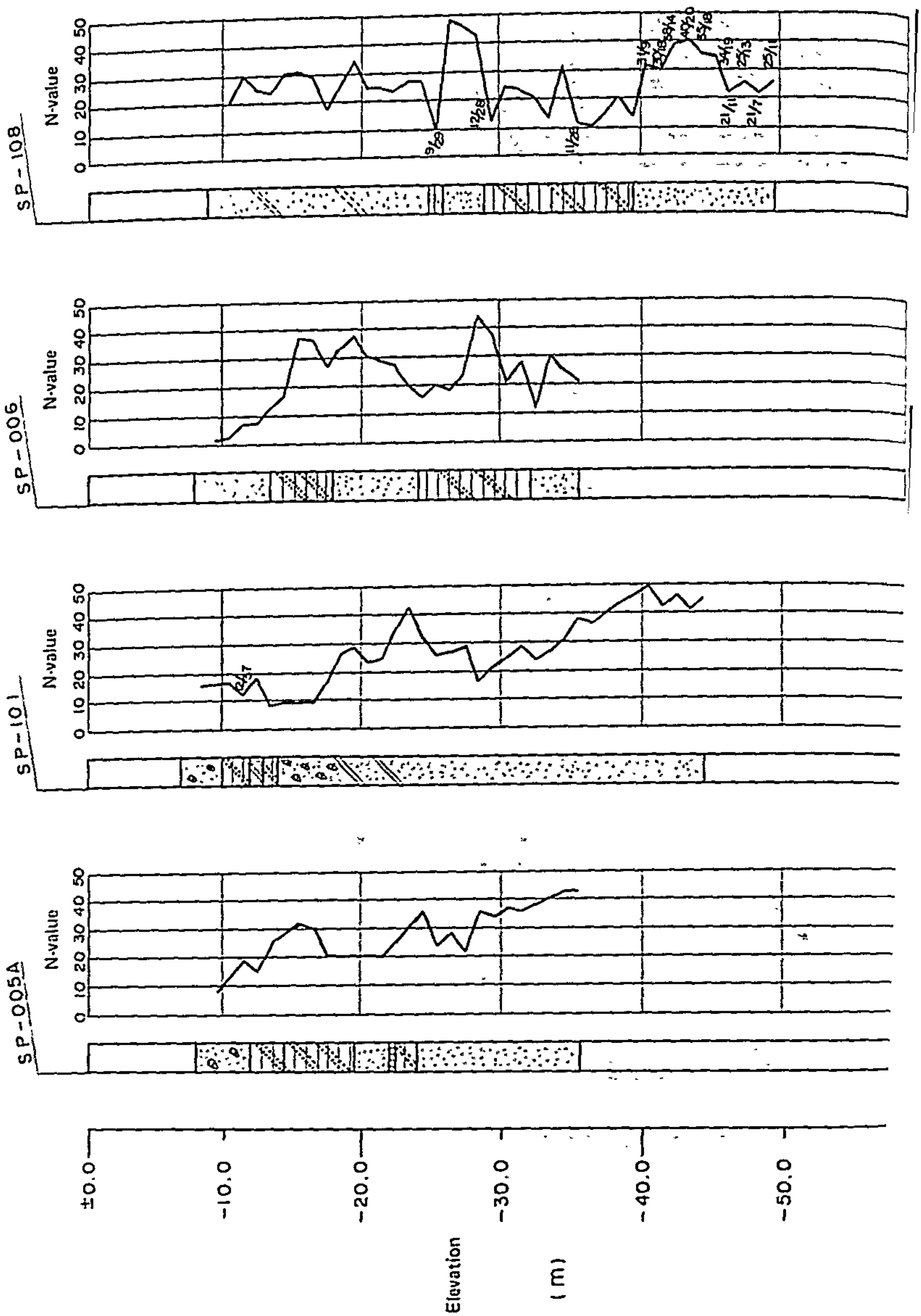


Fig. 2.3.3 Soil profile (2)

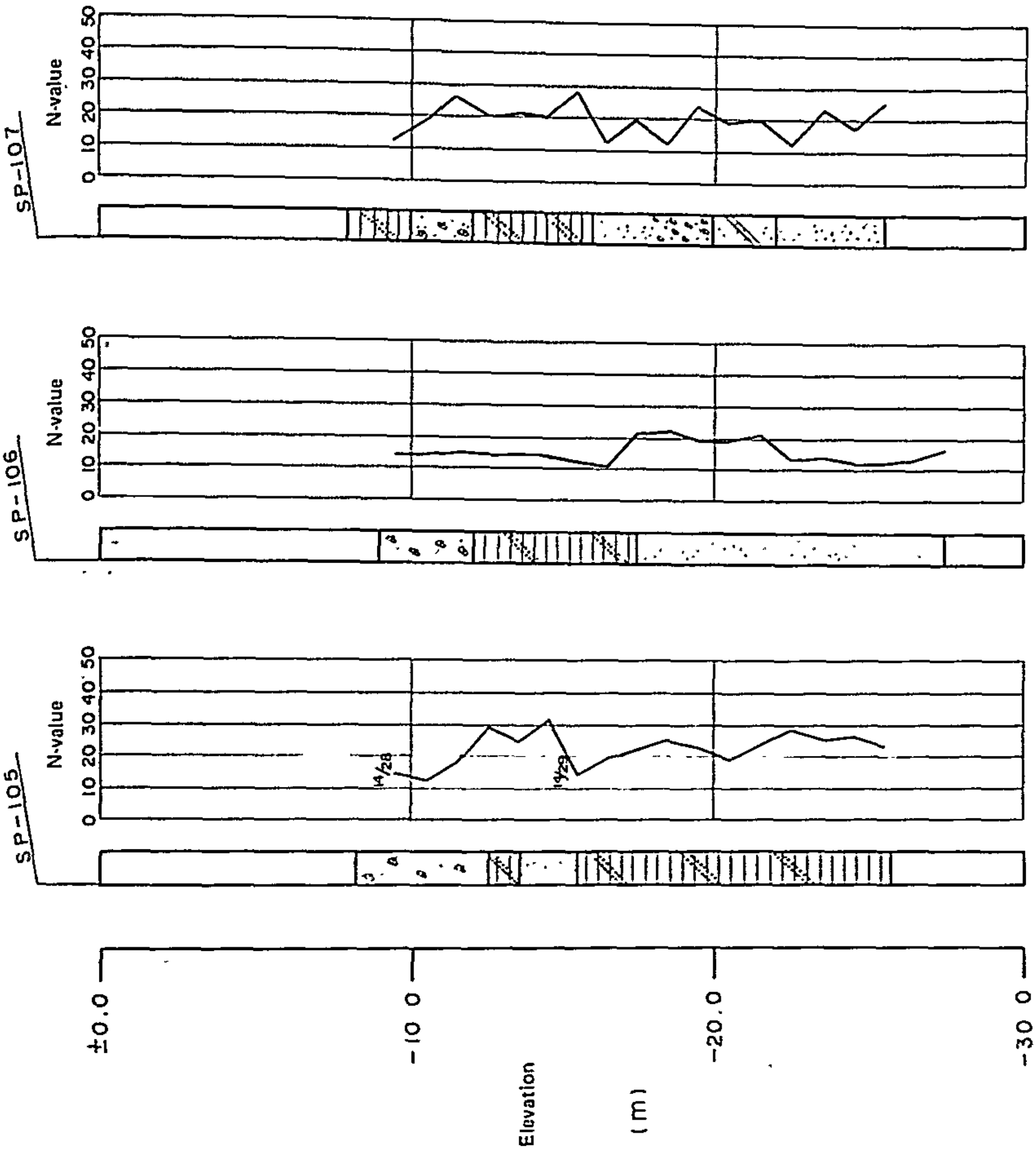


Fig. 2.3.3 Soil profile (3)

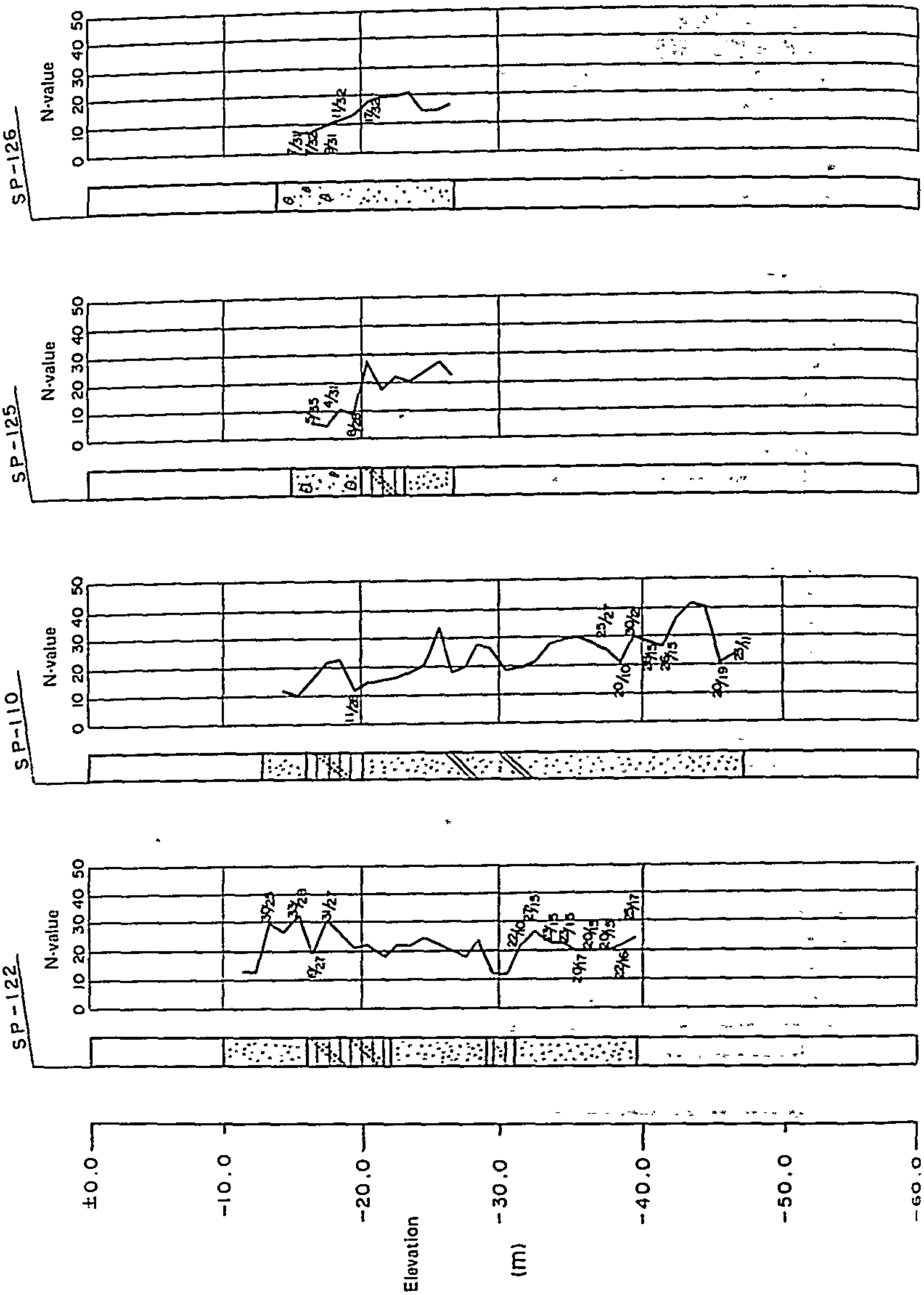


Fig. 2.3.3 Soil profile (4)

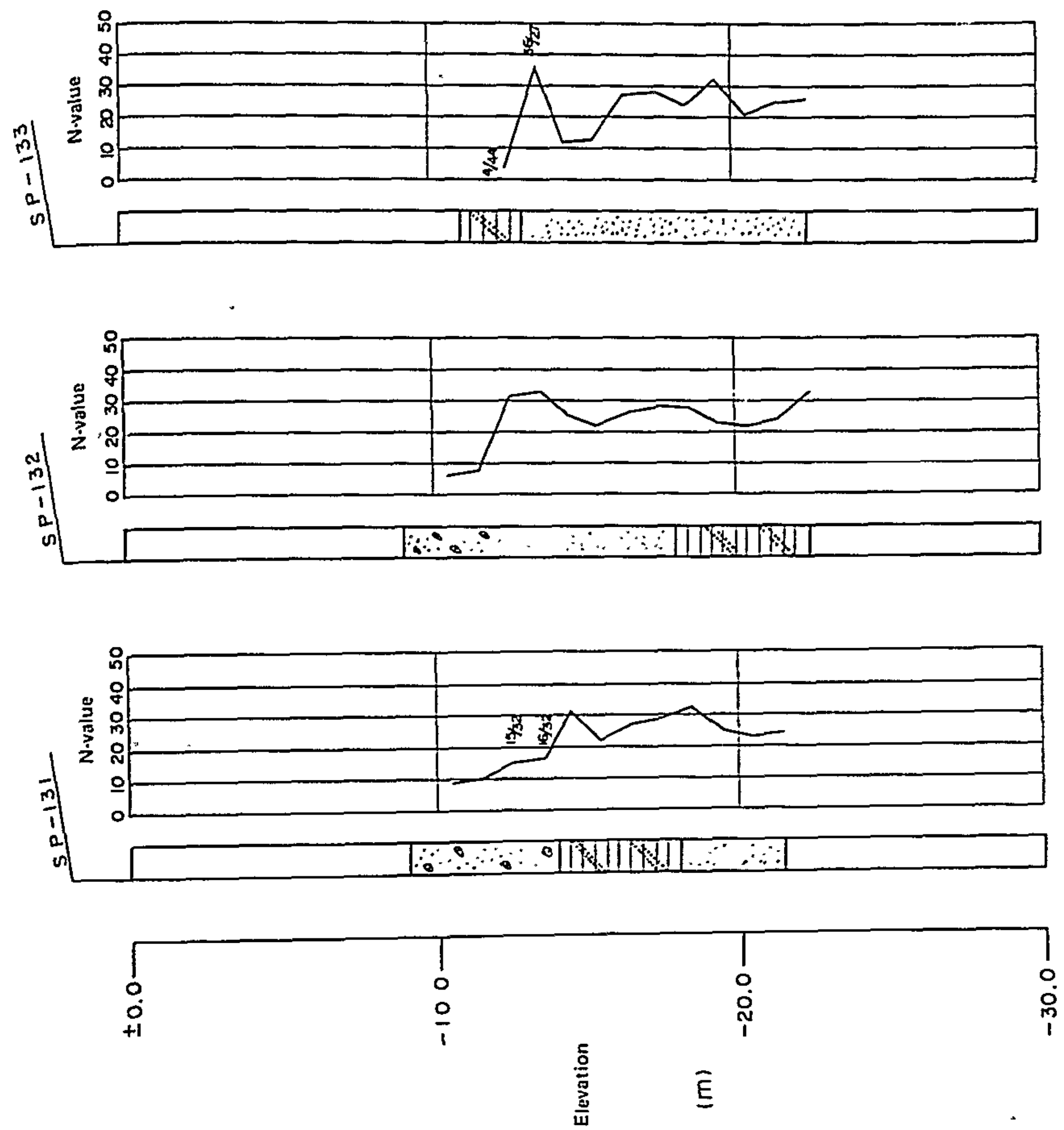


Fig. 2.3.3 Soil profile (5)

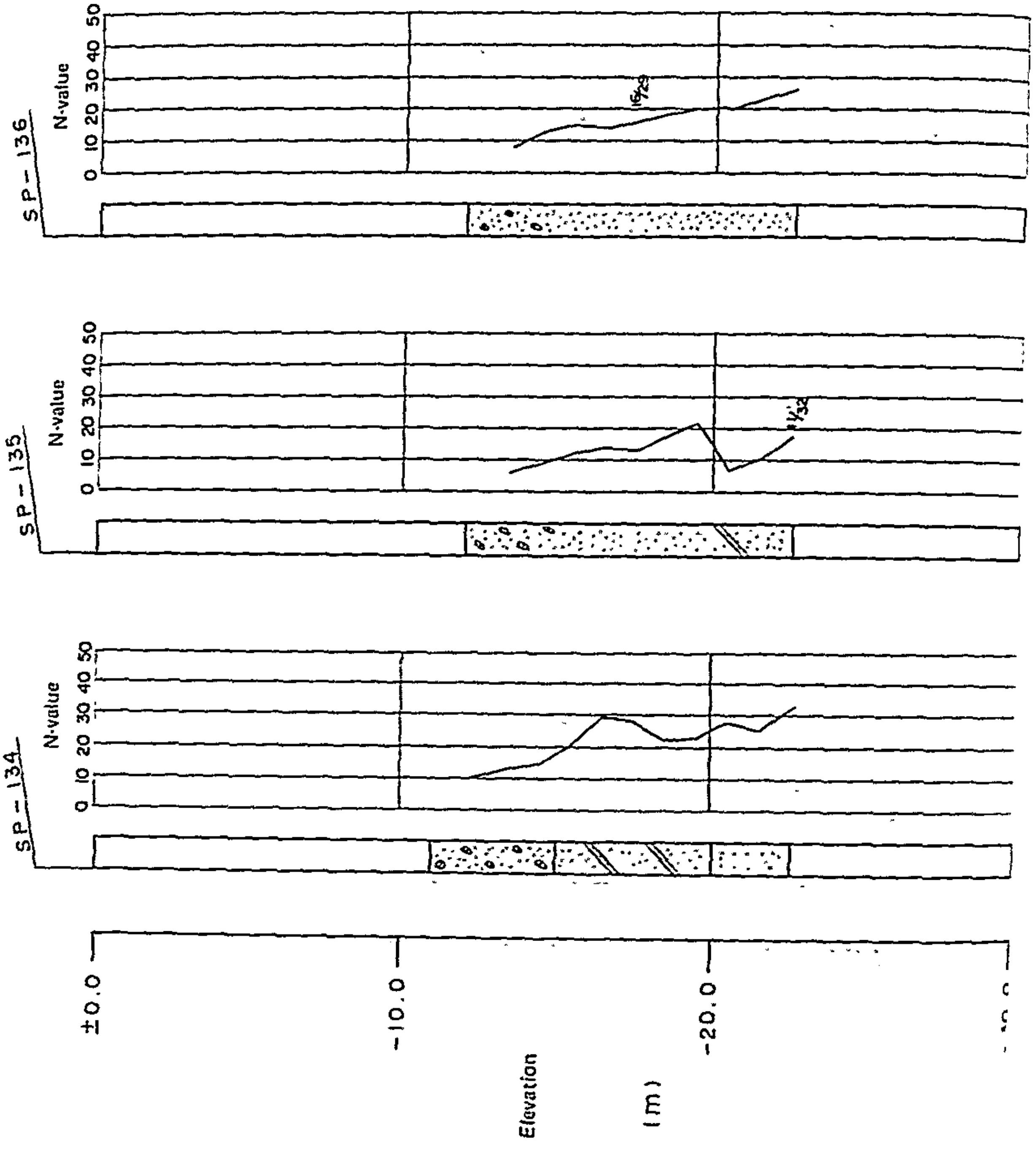


Fig. 2.3.3 Soil profile (6)

In the east coast of Brazil, the normal weather is seen when a warm high pressure air mass overlies the ocean and continent. At this time, sultry air blows the east coast, but the weather is generally fine. On the other hand, a cold front is developed with the cold high pressure air mass near the southern end of the continent and it goes up north periodically to change the weather. When the cold front has reached the frontiers, the atmospheric pressure usually attains the lowest and with the cold front farther up north, the power mostly declines. The coming and going of the cold front entails the following change in the weather.

① The atmospheric pressure drops.

② The north wind will amasses its strength. Just before arrival of the cold front, however, a flat calm state will appear on and off. With the passing of the cold front, the wind will suddenly veer round to southeast or southwest. When the depression is noticeable, gusts will rage.

③ The humidity will then rise, and the sky will be clouded. Sometimes, it will rain suddenly, but it will continue only a day or so.

④ Then, the temperature will plunge down by say ten degrees Centigrade in a day when the cold front clears through a given point.

This change in weather as accompanied by the northing of the cold front in Brazil is subclassified into the following seven patterns depending on the force of cold front in relation to the topographical conditions such as the mountains in Rio Grande do Sul State.

① The cold front will go up north upcountry toward the northern-most region. This type appears when the cold air mass is influential.

② Checked by the mountains in Rio Grande do Sul, the cold front is separated, and the seaside component alone moves up north along the coast. While loosing its energy it may often reach the coast between Bahia and Recife.

③ On the contrary, the landside component alone moves up north, and there are some occasions when it reaches Amazonia in winter.

④ The cold front marks time in the south, developing a depression (cyclone) and it moves south-eastward. This is seen most in winter.

⑤ The cold front stays in the deep north, developing a depression. This phenomenon is limited to winter. By chance, cyclones develop near Rio de Janeiro and cause a strong southwest wind to raise high waves between Santos and Cabo Frio.

⑥ The cold front goes down south.

⑦ The cold front remains on the sea and attacks the east coast. In this case, east or northeast wind blows from the cold high pressure air mass toward the cold front.

The northing of the cold front serving a major influence over the weather change in Brazil and its effects have been outlined above. The weather conditions around Vitória related with the cold front are given in the Report on Agitation in Tubarão. Table 2.3.1 gives excerpts of the report, showing the monthly average frequency of occurrence of cold fronts.

Table 2.3.1 Frequency of cold front traffic passing over Vitória

Month	Number of normal days	Number of days before visit of cold front	Number of days after visit of cold front	Total	Mean frequency
Jan.	5	5	2	12	2.6
Feb.	5	8	2	15	1.9
Mar.	3	3	2	8	3.8
Apr.	3	2	2	7	4.3
May	3	3	2	8	3.9
Jun.	3	3	2	8	3.8
Jul.	3	3	2	8	3.9
Aug.	4	1	2	7	4.4
Sep.	3	2	2	7	4.3
Oct.	3	1	2	6	5.1
Nov.	3	1	2	6	5.0
Dec.	4	3	2	7	3.4

The data were obtained from the synoptic charts prepared over five years by Escritório de Meteorologia do Ministério da Agricultura. The cold front visits most frequently in October and November, but appears least in January and February in summer. As the cold front comes and goes away, the wind changes from east or northeast to north or northwest and then to southwest, south and to southeast to complete an elliptic cycle. Table 2.3.1 suggests that the south wind will continue about two days after the passing of the cold front.

Fig. 2.3.4 shows an example of synoptic chart at 12:00, July 2, 1974 (HMG). The Atlantic ocean off the east coast is covered with a high pressure air mass having a central pressure of 1,035 mb, and a cold front is seen stretching from Argentine to Paraguay.

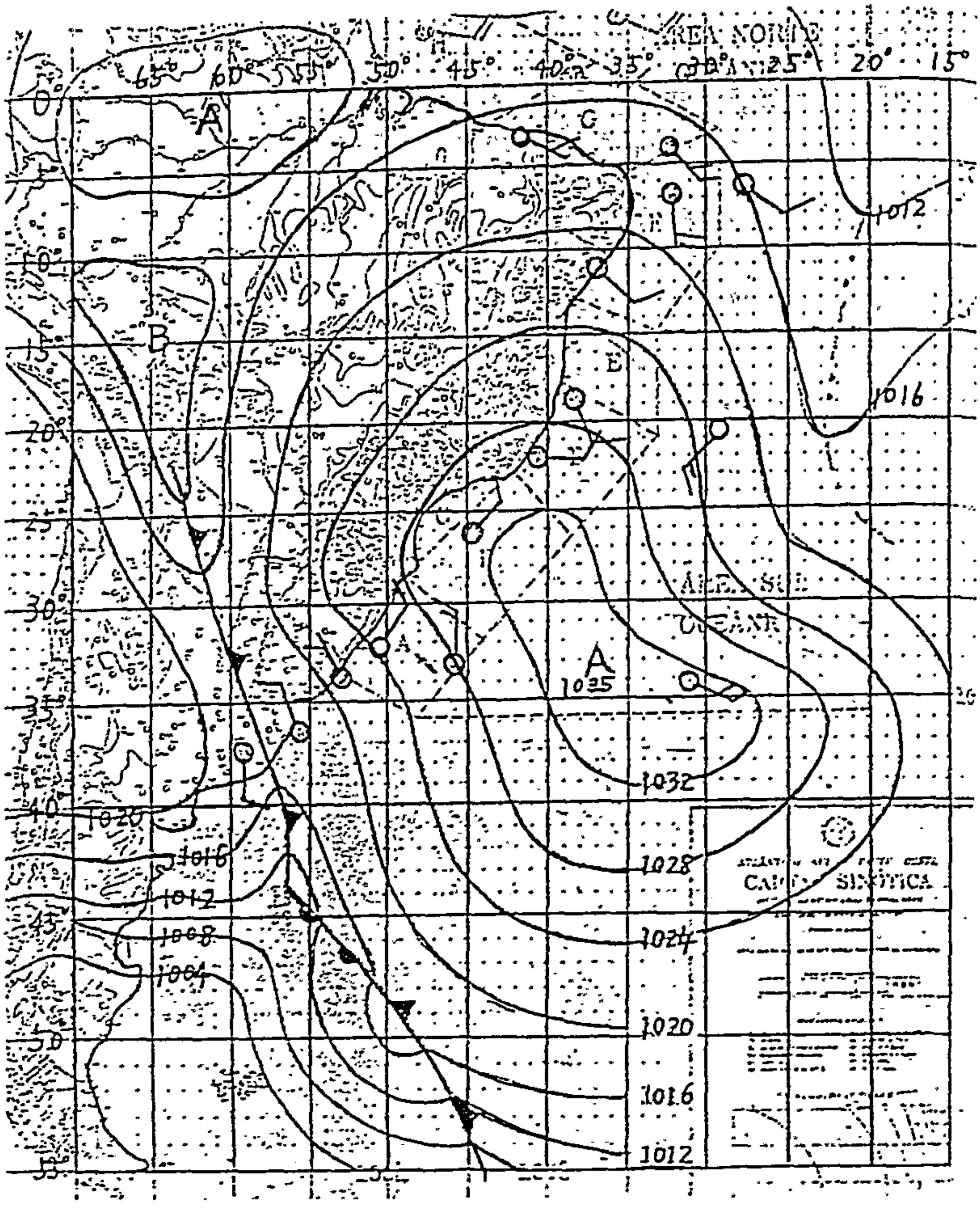


Fig. 2.3.4 Synoptic chart (12:00, July 2, 1974)

(2) Winds

The winds in Vitória have been well clarified statistically as seen in a PLANAVE's report. The available data may be summarized as follows.

1) Wind data by Escritório de Meteorologia do Ministério da Agricultura

A weather station in Santa Maria Island in Vitória has been observing winds, and Prof. Robson Sarmento, Espirito Santo Federal University, analyzed the wind data acquired between 1931 and 1960. From the professor's efforts, the following may be pointed out.

① In the April-August period, the southwest wind prevails at a ratio of 19 to 26% to total. (See Table 2.3.2)

② In the September-March period, the northeast wind prevails at a ratio of 22 to 33% to total. (See Table 2.3.2)

③ Throughout the year, the northeast wind is prevalent with a ratio of 27.4%, followed by the southwest wind of 23.7%. (See Fig. 2.3.5)

④ The wind velocity is not so strong on the whole. In October to December, however, winds of 20 m/sec. or stronger are recorded three times on the average.

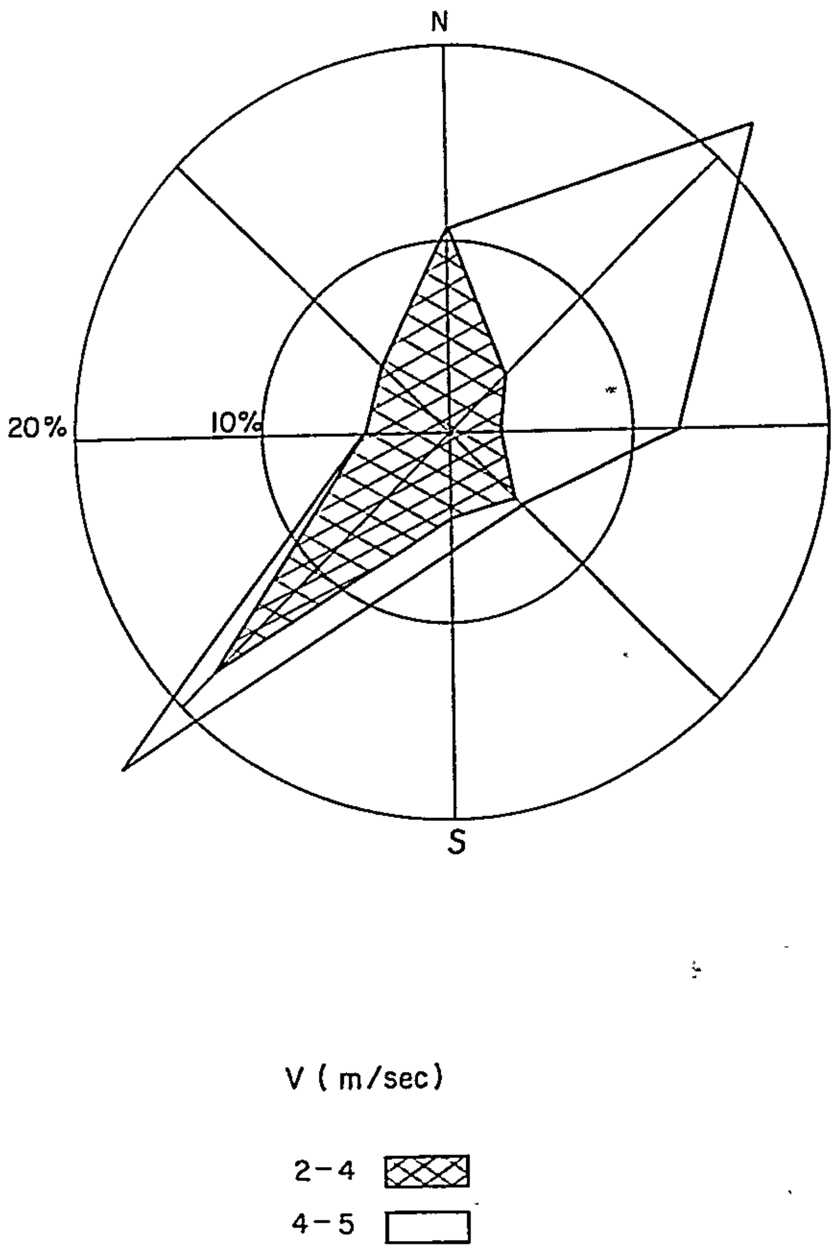


Fig. 2.3.5 Wind rose (Vitória weather station)

Table 2.3.2 Frequency of winds in Vitória by direction (1931-1960)

Month	Frequency							
	N	NE	E	SE	S	SW	W	NW
Jan.	17	33	9	2	2	6	2	5
Feb.	15	27	9	2	2	5	1	5
Mar.	11	20	9	4	4	14	3	4
Apr.	7	9	8	5	6	24	5	3
May	6	8	8	5	5	26	6	3
Jun.	7	9	9	4	5	21	6	3
Jul.	8	12	8	4	5	22	6	4
Aug.	13	18	10	3	4	19	3	5
Sep.	12	23	8	4	3	17	3	4
Oct.	11	26	9	4	5	18	3	2
Nov.	10	22	8	6	6	17	3	3
Dec.	14	28	8	4	4	13	3	3

2) Wind data available at Tubarão Terminal

CVRD observed winds at Tubarão Terminal, and the data for the January, 1967 to February, 1968 period and for the June, 1970 to December, 1971 period are complied in the PLANAVE's report. The data for the former period are derived from the 1969 report prepared by Soros Associates Inc. The data for the latter period are according to a report issued in 1972 by Companhia Internacional de Engenharia (CIE). These data show the following.

① Tubarão Terminal is shielded from violent winds, and there are no wind troubles all the year that may hinder ship's maneuver.

② The frequency of winds by velocity is as follows, with the exception of occasional gusts.

- o less than 3.3 m/sec.: approx. 55%
- o 3.6 to 7.2 m/sec. : approx. 40%

- 7.5 to 9.7 m/sec. : approx. 5%
- Winds of more than 9.7 m/sec. are on record, but rarely. Winds of more than 12.2 m/sec. have not yet been recorded.

③ In the December-May period, the northerly wind, particularly northeast wind prevails. From the beginning of June, the southerly wind starts blowing. It dominates in October and November. In the southerly winds, the southwest ones are seem most.

④ Generally, the southerly winds have a higher velocity than northerly ones.

⑤ The changes in wind are seen with the coming and going of the cold front. Namely, as the cold front comes up, the wind direction will first change from northeast to northwest. When the cold front goes away, the wind direction will change southwest.

A wind rose prepared with 1971 observations is given in Fig. 2.3.6.

3) Wind data available at Vitória Airport

Vitória Airport is also observing winds. As regards the data available from 1969 and thereafter, the yearly maximum wind velocity is as shown in Table 2.3.3. The maximum wind velocity recorded in the last eight years is 19.5 m/sec.

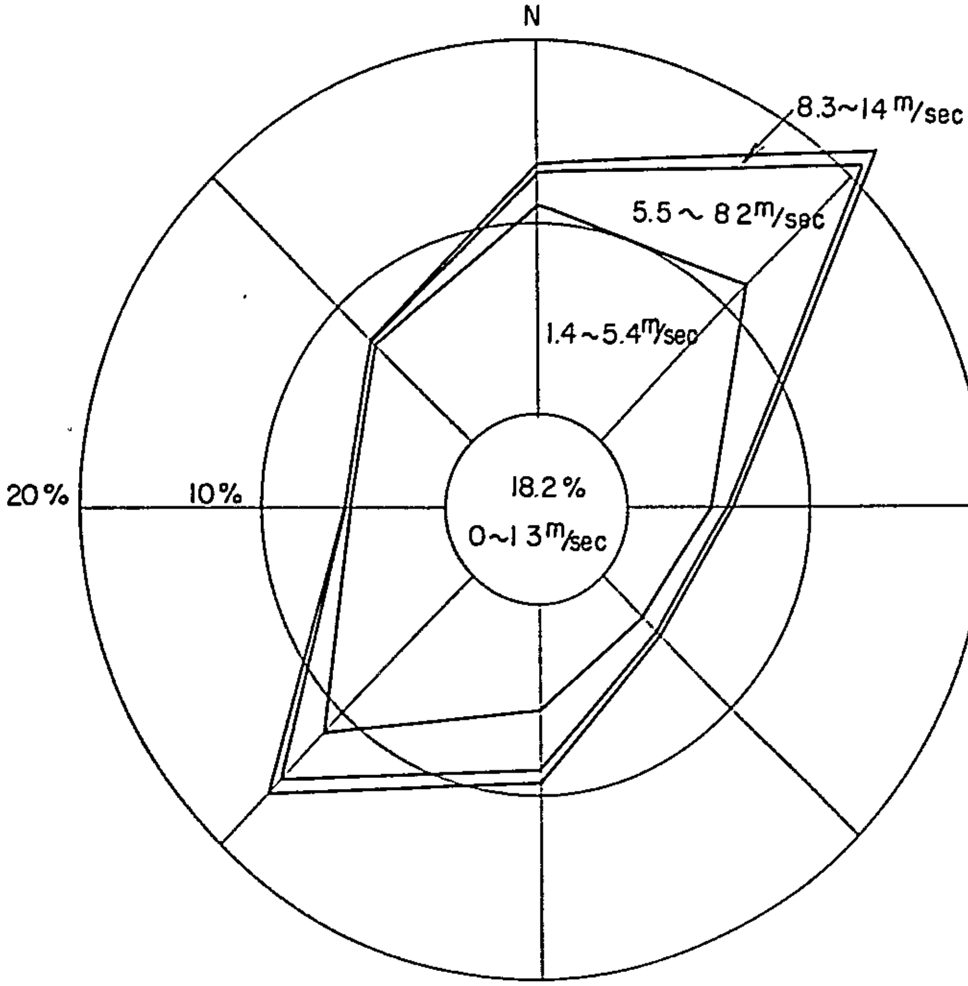


Fig. 2.3.6 Wind rose (Tubarão Terminal, 1971)

Table 2.3.3 Yearly maximum wind velocity at Vitória Airport

Year	Max. wind velocity (m/sec)	Wind direction * (date)		
1969	11.3	Frequent		
1970	13.9	10° (12/1)	40° (12/1)	
1971	19.5	230° (12/5)		
1972	15.4	Frequent		
1973	18.0	260° (11/25)		
1974	18.0	90° (1/8)	80° (1/10)	
1975	12.9	60° (2/23)	80° (10/2)	60° (10/31)
1976	13.4	80° (2/22)		

* Angles measured in the clockwise direction from the north.

4) Offshore winds observed by Marinha do Brasil

Marinha do Brasil prepared monthly weather and oceanological maps for each of 5° by 5° waters according to the observations during the 1951 to 1972 period. The wind directions are given in eight-points bearing, and the appearance rates of winds by direction and the monthly average wind velocity (on Beaufort scale) are given. Table 2.3.4 shows monthly prevailing wind directions and wind velocities on Beaufort scale for three 5° by 5° regions near Vitória. The relationship between the coastline and the 5° by 5° regions is shown in Fig. 2.3.7.

Table 2.3.4 Offshore prevailing wind (Marinha do Brasil)

Month	Region I			Region II			Region III		
	Direction of prevail-ing wind	Frequency (%)	Beaufort wind scale	Direction of prevail-ing wind	Frequency (%)	Beaufort wind scale	Direction of prevail-ing wind	Frequency (%)	Beaufort wind scale
Jan.	NE	36	3	N	33	4	NE	32	4
Feb.	NE	34	3	N	35	4	NE	38	4
Mar.	E	33	3	N, NE	27	3	NE	30	3
Apr.	SE	27	3	E	21	3	NE	23	3
May	SE	30	3	E	24	3	N, NE	20	3
Jun.	SE	29	3	E	29	3	NE	23	3
Jul.	E	33	3	E, SE	20	3	NE	29	4
Aug.	E	39	3	NE	28	3	NE	32	4
Sep.	E	36	3	NE	36	4	NE	36	4
Oct.	NE	34	3	NE	30	4	NE	30	4
Nov.	NE	36	3	NE	27	3	NE	26	4
Dec.	NE	31	3	N	32	4	NE	23	4

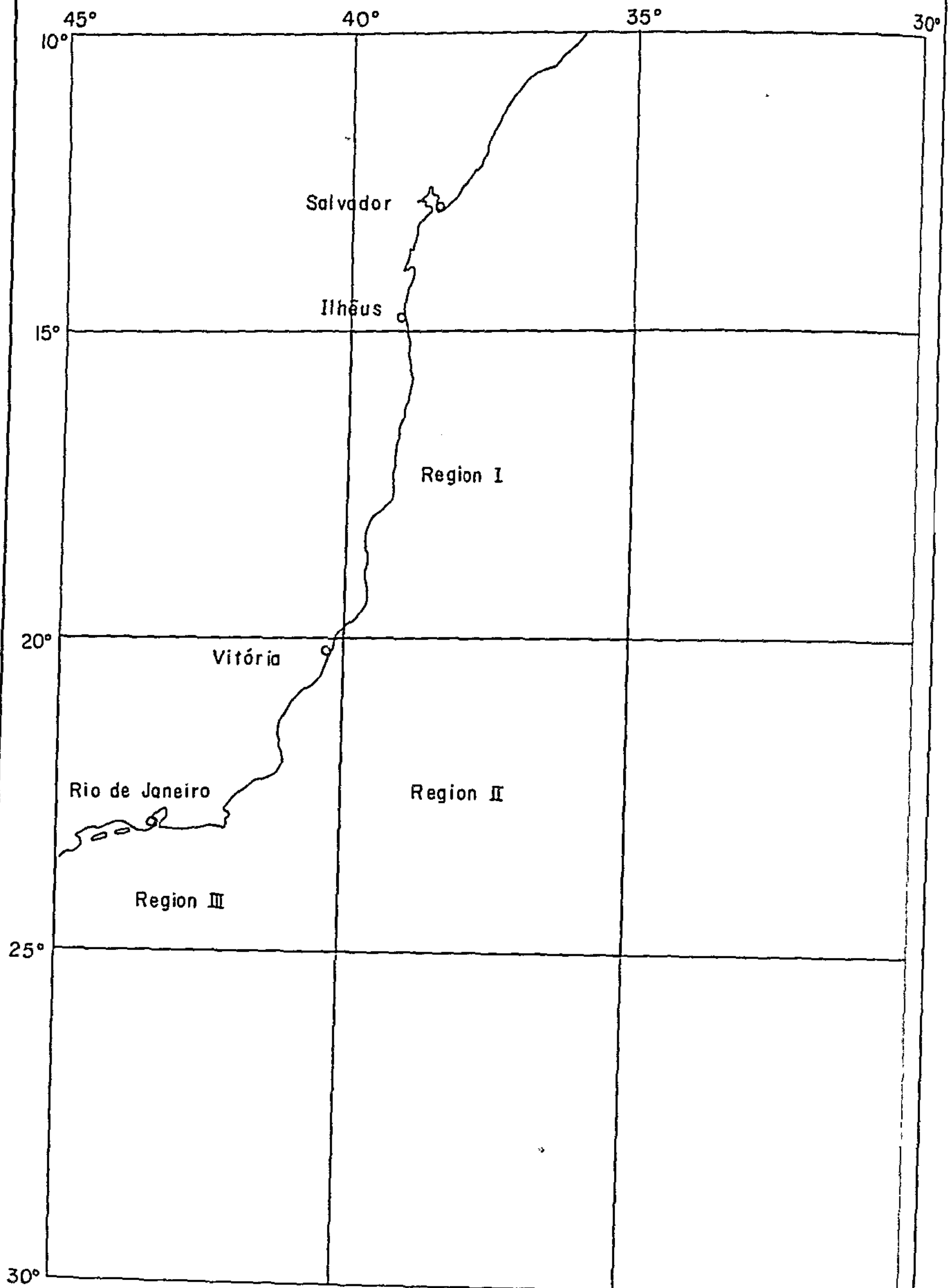


Fig. 2.3.7 5° by 5° regions near Vitória

In the region to the northeast of Vitória northeast winds prevail in October to February while east or southeast winds blow in March to September. In the region lying in the southeast direction north or northeast winds prevail in August to March and east or southeast winds in April to July. In the region to the southwest of Vitória northeast winds prevail throughout the year.

5) Offshore wind data by U.S. Naval Oceanographic Office

In the PLANAVE's report, the offshore wind observations by the U.S. Naval Oceanographic Office have been analyzed. Fig. 2.3.8 shows a wind rose at Marsden Square 376 (40° - 50° W by 20° - 30° S). It is found that the northeast and north winds are dominant.

The shore and offshore observations of winds around Vitória have been statistically analyzed as stated in the above. They may be put together as follows.

① Generally, the winds near Vitória are not so strong. The yearly change is unlikely to be so large. It may be safely said that the yearly maximum wind velocity will be around 20 m/sec.

② On the yearly average, the prevailing wind direction will be northeast. The southwest wind comes next. Seasonally, the northerly winds dominates in summer to autumn and the southerly winds in winter to spring.

③ Usually, the wind changes with the coming and going of a cold front. Namely, the wind veers from northeast to northwest with the approach of cold front. Then, it changes to southwest as the cold front goes away. The southwest wind is generally stronger. The seasonal change in wind referred to in ② corresponds to that in the frequency of appearance of cold fronts.

④ In the coastal waters, the northeast winds are also prevalent. Depending on the season and region, however, east or southeast winds may happen to prevail.

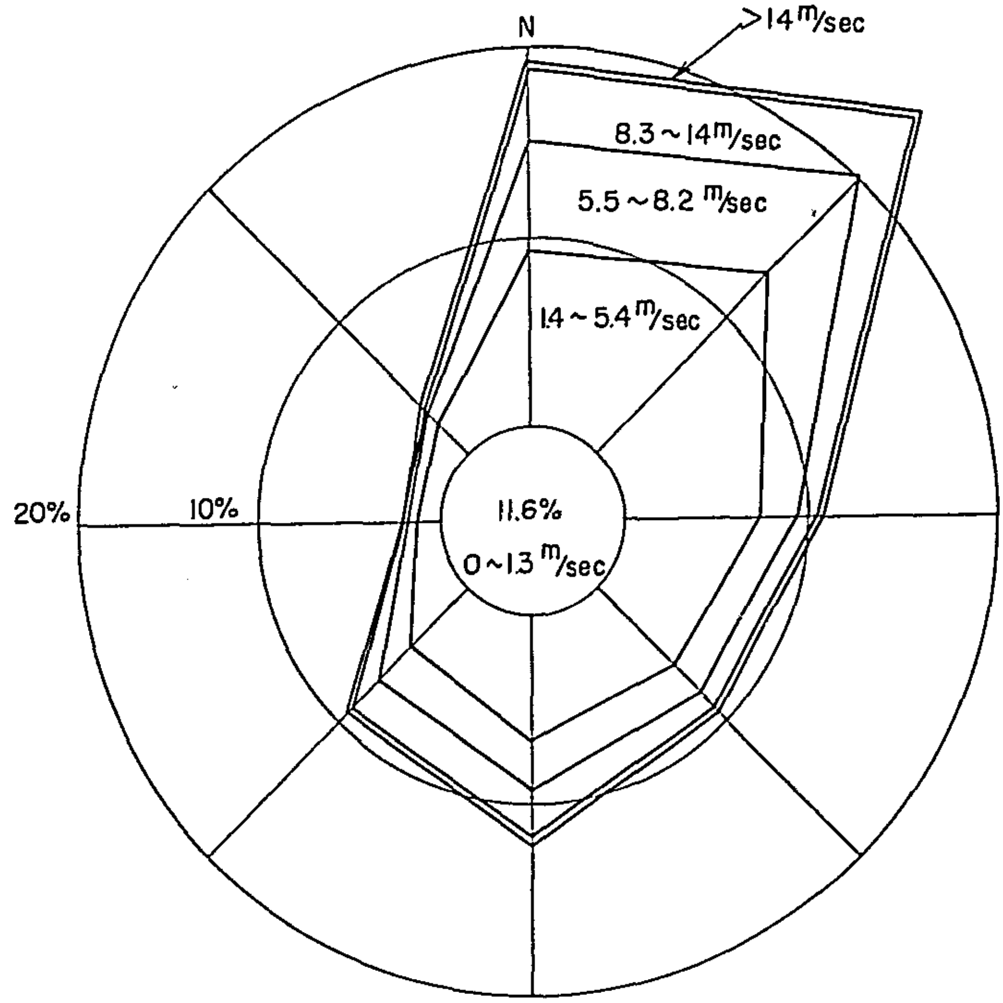


Fig. 2.3.8 Wind rose (at Marsden Square 376)

(3) Temperature and precipitation

According to the results of survey by Prof. Robson Sarmento over a period of 1931 to 1970, the temperatures, precipitation, humidities and atmospheric pressures are as shown in Tables 2.3.5 through 2.3.7.

Table 2.3.5 Temperatures (°C) (1931 - 1970)

MONTH	Mean max.	Mean min.	Max.	Min.	Monthly mean
JANUARY	29.9	22.7	36.4	17.4	25.8
FEBRUARY	30.9	23.1	37.0	19.1	26.1
MARCH	30.4	22.8	36.4	18.1	25.8
APRIL	28.8	21.5	35.6	16.5	24.4
MAY	27.4	20.0	35.0	15.3	23.0
JUNE	26.3	19.0	34.0	14.2	21.9
JULY	25.3	18.2	32.2	13.2	21.0
AUGUST	26.0	18.5	34.9	13.5	21.5
SEPTEMBER	26.5	19.5	33.6	13.9	22.4
OCTOBER	26.9	20.4	34.4	15.4	23.1
NOVEMBER	27.6	21.1	35.0	14.2	23.8
DECEMBER	29.0	22.0	36.8	17.2	24.8

Table 2.3.6 Precipitation and rainy days (1931 - 1970)

MONTH	TOTAL PRECIPITATION (mm)	MAXIMUM PRECIPITATION IN 24 HOURS (mm)	RAINY DAYS
JANUARY	120.3	136.2	12
FEBRUARY	77.1	100.6	9
MARCH	118.6	147.7	12
APRIL	103.6	138.7	13
MAY	87.1	135.5	12
JUNE	71.4	196.9	9
JULY	62.3	47.4	12
AUGUST	44.2	79.3	9
SEPTEMBER	72.3	73.9	9
OCTOBER	118.6	115.2	13
NOVEMBER	173.8	183.8	16
DECEMBER	189.2	129.8	17

Table 2.3.7 Evaporations, humidities and atmospheric pressures (1931 - 1970)

MONTH	MEAN EVAPORATION (mm)	MEAN HUMIDITY (%)	MEAN ATMOSPHERIC PRESSURE (mb)
JANUARY	94.4	80	1008.6
FEBRUARY	91.6	78	1008.9
MARCH	92.6	79	1009.6
APRIL	83.3	79	1011.4
MAY	81.5	79	1013.3
JUNE	73.7	80	1015.6
JULY	60.8	79	1016.9
AUGUST	88.4	78	1015.8
SEPTEMBER	89.1	78	1014.1
OCTOBER	85.3	80	1011.8
NOVEMBER	79.5	80	1009.4
DECEMBER	84.0	80	1008.4

The maximum of the monthly average temperatures is recorded in February with 26.1°C. The minimum is 21.0°C in July. The difference is 5.1°C. The difference between the maximum and minimum in a month is about 20°C, by far larger than the difference in the average temperatures due to seasonal change.

The yearly average rainfalls are 1,238.5 mm. The monthly statistics show the minimum in August and the maximum in December. The maximum 24-hour rainfall ever recorded was 196.9 mm in June. The number of rainy days is 9 to 17 a month throughout the year.

2-3-4 Oceanology

(1) Waves

1) Outline

In mapping out a port development plan, it is important to discuss wave characteristics from the following two different viewpoints.

① Ordinary waves on which to discuss the harbour calmness, the number of days available for cargo handling works and the number of days available for operation of working craft for port and harbour construction.

② Abnormal waves on which to determine the design waves that govern the structure and design of breakwaters.

It is usually required to statistically process wave data obtained by actual measurements or hindcasting and to take into account the wave transformation. Fig. 2.3.9 shows a general routine for determining the particulars of waves to be used for design.

To investigate ordinary waves, wave data of at least several years are required. To investigate the abnormal waves it is preferable to collect wave data for several tens of years. If the wave data observed are insufficient or if there are no meteorological data from which to estimate waves, we must determine a proper design wave in relation to the design waves in the nearby ports and taking account of the existing structures as to their wave worthiness.

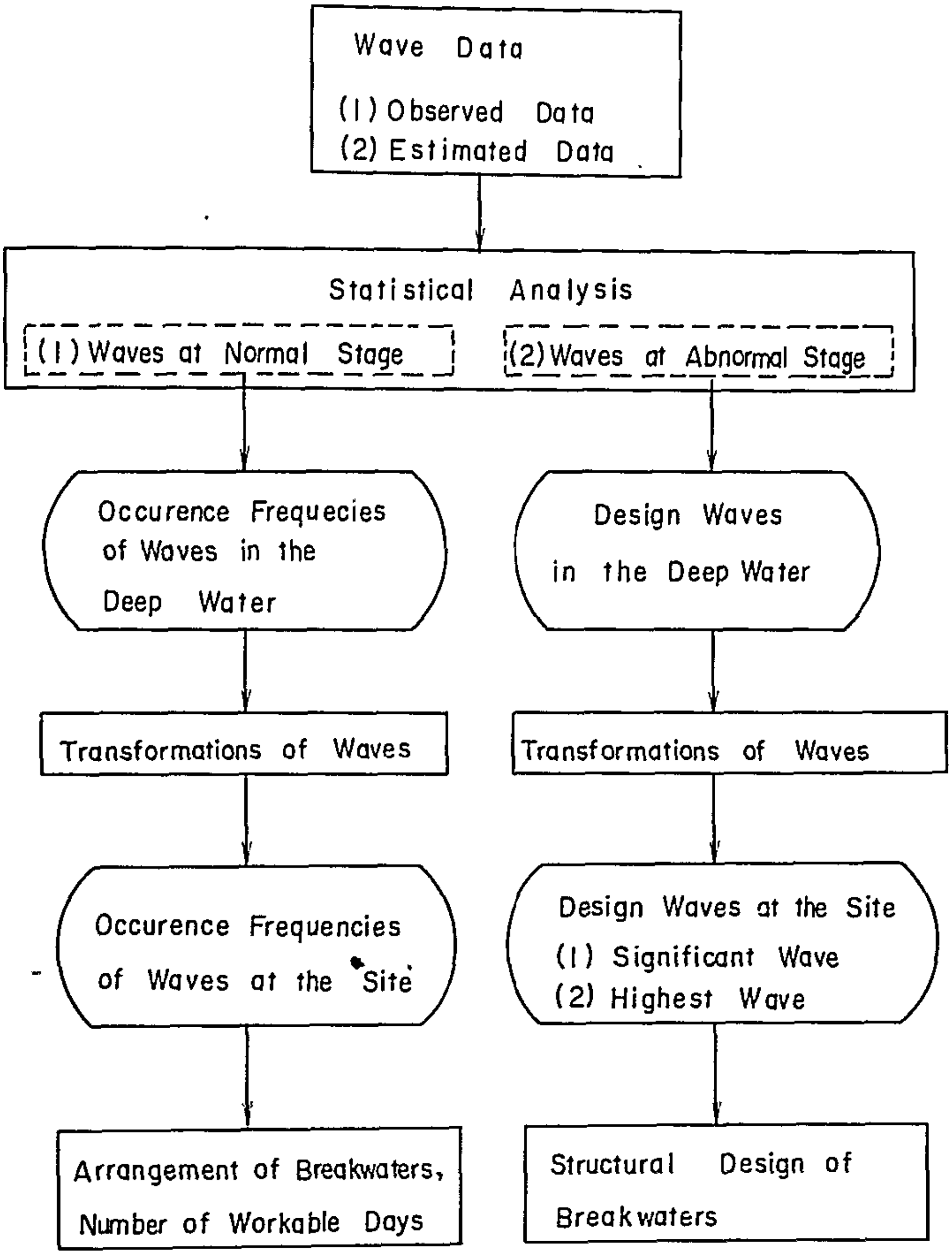


Fig. 2.3.9 General routine for determination of design waves

As for Praia Mole Port, waves have been observed in the nearby waters for a limited period, and the data have been analyzed. The wave conditions are set according to these actually observed data while taking account of the weather conditions and design conditions incorporated into the structures of nearby ports and harbours. In determining the design waves, it is mandatory to make much account of the scale and magnitude of the breakwaters.

Fig. 2.3.10 shows a routine for computation of wave transformation.

2) Wave observations along the Brazilian coasts and the design waves for existing breakwaters

In order to have a general idea about the waves in Brazil, the survey team took a look at the existing conditions of wave observations along the entire Brazilian coasts and the design waves applied to the existing breakwaters. In Brazil, the wave observation was started in 1962. The wave measuring stations, period of observation and water depth are given in Fig. 2.3.11.

In many cases, the observation period is as short as one year per spot. The equipments used include pressure type wave recorder, ultrasonic wave recorder and buoy type wave recorder. $H_{s\ max.}$ and $H_{max.\ max.}$ show respectively the maximum significant wave height and the maximum value of the heighest wave heights recorded during the observation period. The thin lines in the Figure 2.3.11 running toward the stations show the directions of ordinary waves with high frequency of appearance. The thick lines show the directions of waves with large heights. It should be noted that these wave directions have been influenced by topographic conditions.

$H_{s\ max}$ is 2.9 to 3.0 m at Tramandai, Paranaguá and Santos, 2.2 to 4.25 m at Tubarão, Portocel and off Rio Doce, and 2.2 to 2.45 m at Aracaju, Maceió and Recife. At Portocel and Recife, the observation is still in progress, and an $H_{s\ max}$ of 3.6 m was recorded at Portocel.

In Brazil, the breakwaters facing the open sea are present at Tramandai Imbituba, Itajai, Ubu, Tubarão, Ilhéus, Recife and Mucripe, and are being constructed at Portocel and Luis Correia. Most of the breakwaters are single or double moles of the rubble mound type. The detached breakwater

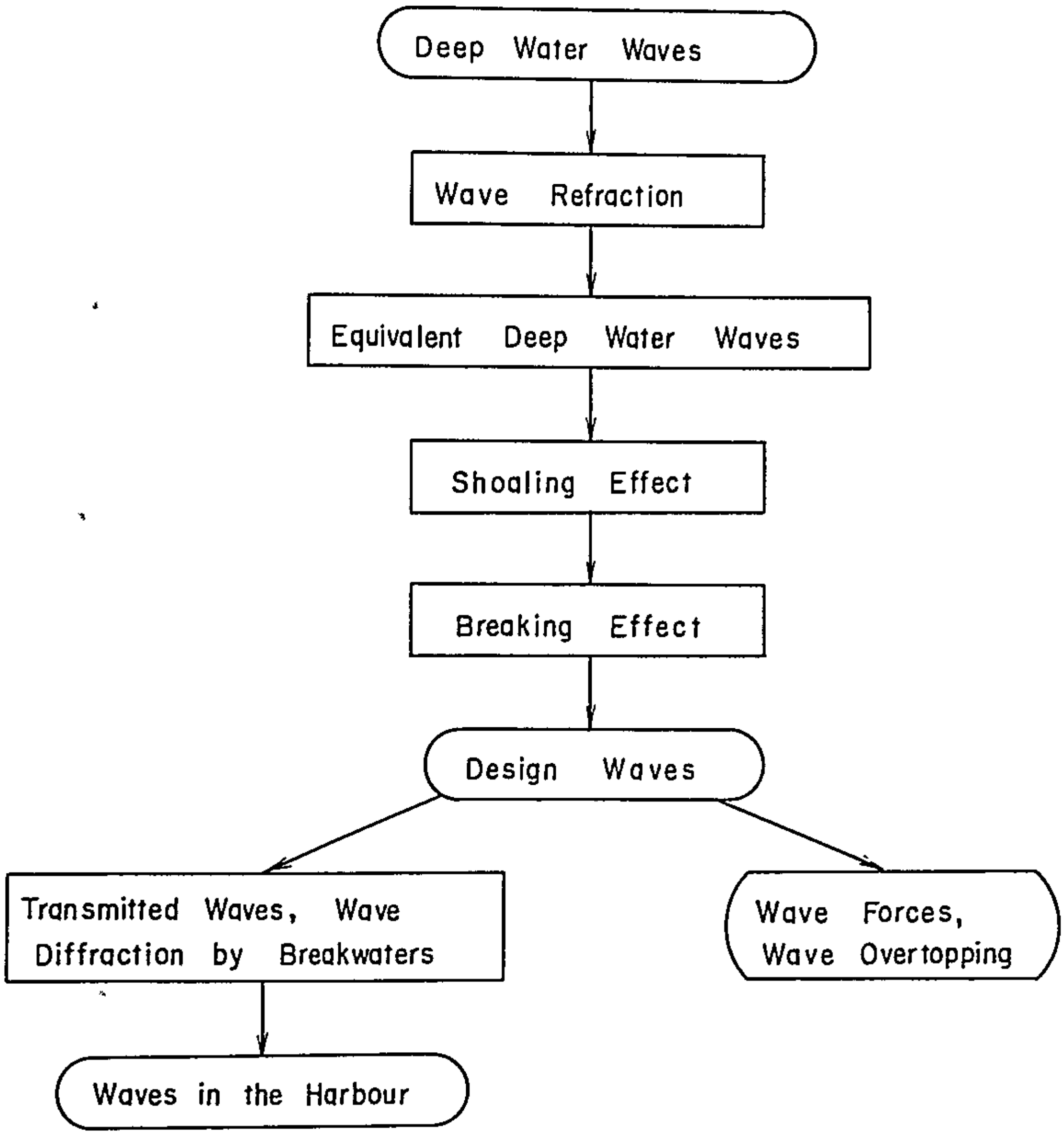


Fig. 2.3.10 Routine for computation of wave transformation

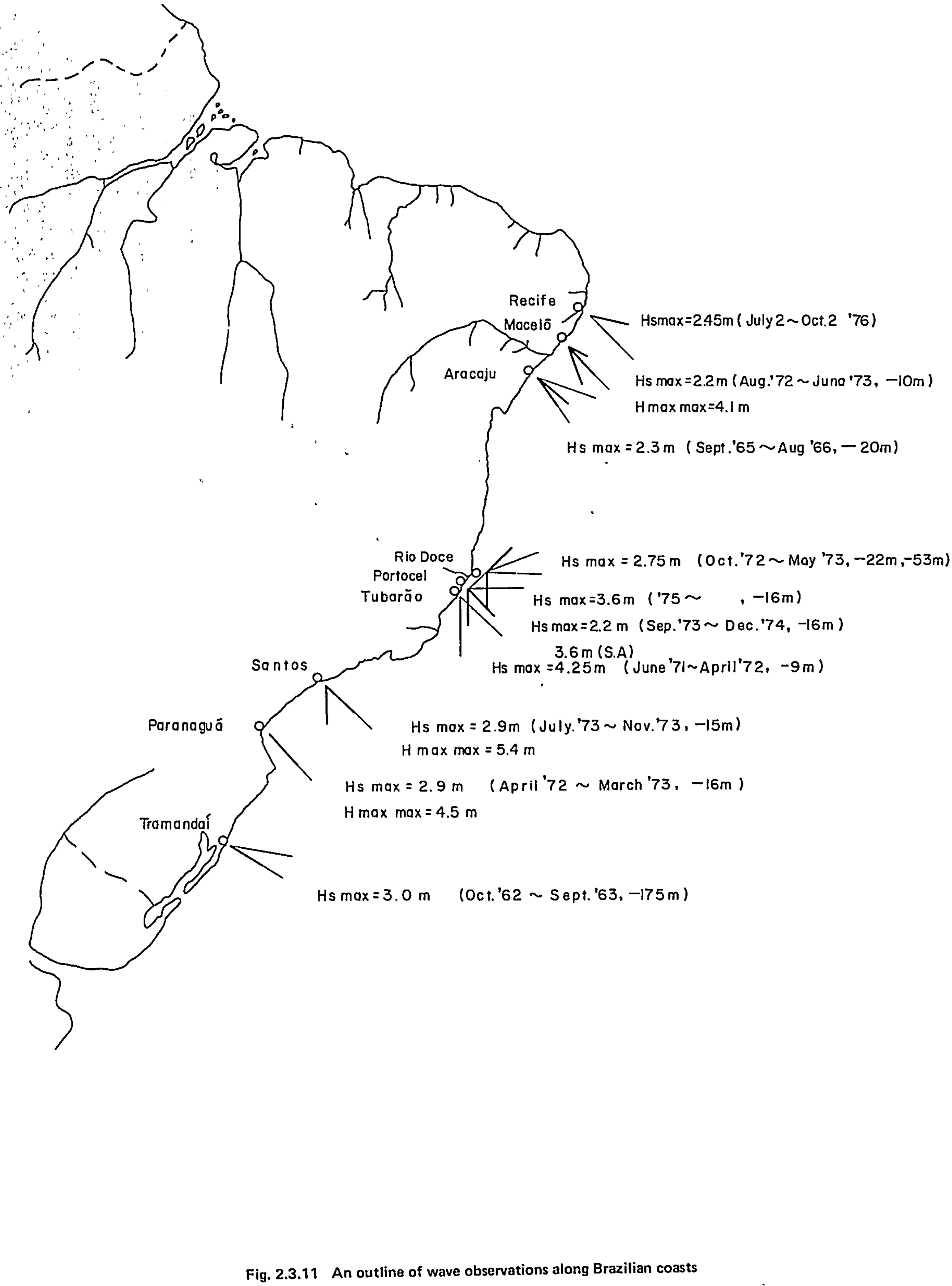


Fig. 2.3.11 An outline of wave observations along Brazilian coasts

existing numbers only one seen in Recife. Fig. 2.3.12 shows the head depths, design high water levels and design wave heights of these breakwaters.

The design significant wave height is 4.8 m in the south, 3.0 to 4.0 m in Espirito Santo State in central Brazil, and about 2.5 m in the northeast. Reflecting the difference in severity of climate, the design wave height is set smaller the more northern the place of breakwater goes from the southern end.

3) Observed wave data

The data available for the determination of wave conditions at Praia Mole Port are as listed below.

① Wave data observed by CVRD at Cape Tubarão.

② Wave data observed at PETROBRÁS' platform off Rio Doce.

③ Wave data observed at Portocel.

④ Sea and swell charts by U.S. Navy Hydrographic Office.

⑤ Ocean wave statistics prepared by the National Physical laboratory of the Ministry of Technology, U.K.

As stated in 2), the data ①, ② and ③ were obtained by making use of wave recorders installed along the coasts while the ④ and ⑤ were a compiled with the data observed offshore aboard ships. All these data have been analyzed in respective reports as outlined below.

(a) Wave data observed by CVRD at Cape Tubarão

CVRD conducted a wave survey around the breakwater between June, 1970 and April, 1972. The observation outside the breakwater was made during the period of June 8, 1971 to April 28, 1972. The measuring instrument used was Hydro Products O.E.C.'s pressure type wave gage, Model WR-421,

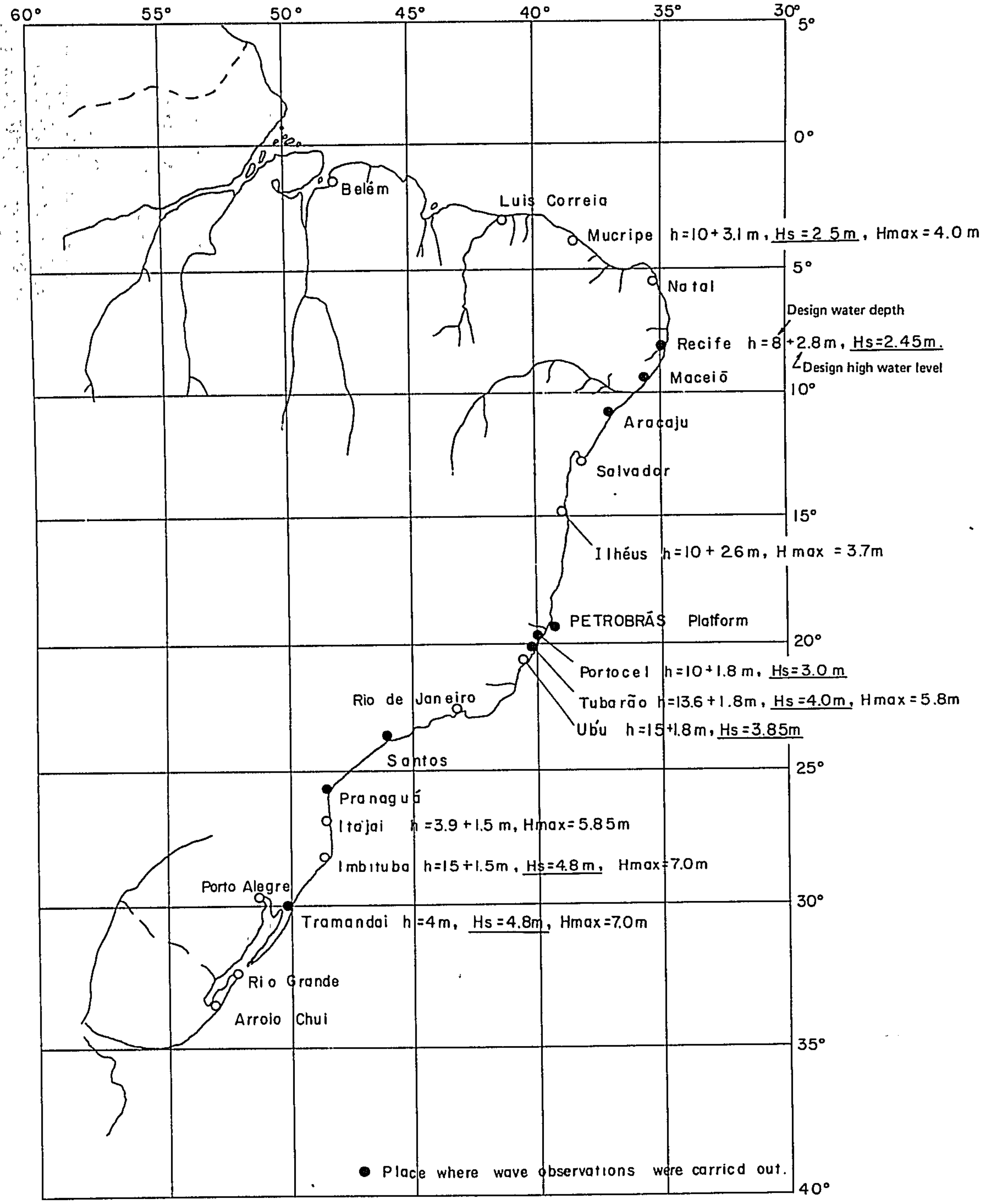


Fig. 2.3.12 Design wave heights of existing breakwaters

which was installed at the water depth of -9 m. The measurement and recording were made for a period of 10 to 20 min. at an interval of about 12 hrs. The ratio of successful measurements to total was about 60%. However, the ratio during the period from January to April, 1972 was as low as 18 to 31%. The observation of wave direction was conducted for 58% of the days when the wave height measurements were carried out, but few measurements were made during the period from June 8, 1971 to April 28, 1972.

The data thus obtained were analyzed by the Centro Technológico de Hidráulica (CTH) of the São Paulo University. The wave height ($H_{1/3}$) with recurrence period of one year is 3.3 to 3.7 m, that with a recurrence period of five years 4.1 to 4.7 m, and that with a recurrence period of ten years 4.5 to 5.1 m, though the values may change depending on the method of analysis applied. The wave directions are mostly southeast and south. Although the data were obtained at the place nearest to Praia Mole of all observation stations, they may have been affected largely by topographic conditions because the observations were made near the Cape Tubarão and because the depth of installation of a wave recorder was as shallow as -9 m.

(b) Wave data observed at PETOROBRÁS' platform off Rio Doce

Waves were observed at PETROBRÁS' platform (S.1 and S.3) off Rio Doce, some 100 km north of Praia Mole, during the period of October 13, 1972 to May 31, 1973. During the period, the platform was moved in the range of 9.6 km (S.1) to 48 km (S.3) off the coastline or in the range of 20 m (S.1) to 50 m (S.3) in terms of water depth. The measuring instrument used was Neyrpic's ultrasonic wave recorder, and the measurement was conducted at an interval of 12 hrs. on the average.

CTH analyzed 189 wave height recordings and 380 wave direction observations. The wave height ($H_{1/3}$) with a recurrence period of ten years is 3.3 to 3.5 m. Fig. 2.3.13 shows a frequency distribution of waves by direction.

As is seen in Fig. 2.3.13, the east-southeast waves and east waves are predominating. Since the data were obtained at a place deep enough to avoid the topographic effects, it is considered that they are very useful in knowing the general characteristics of waves off Espirito Santo State.

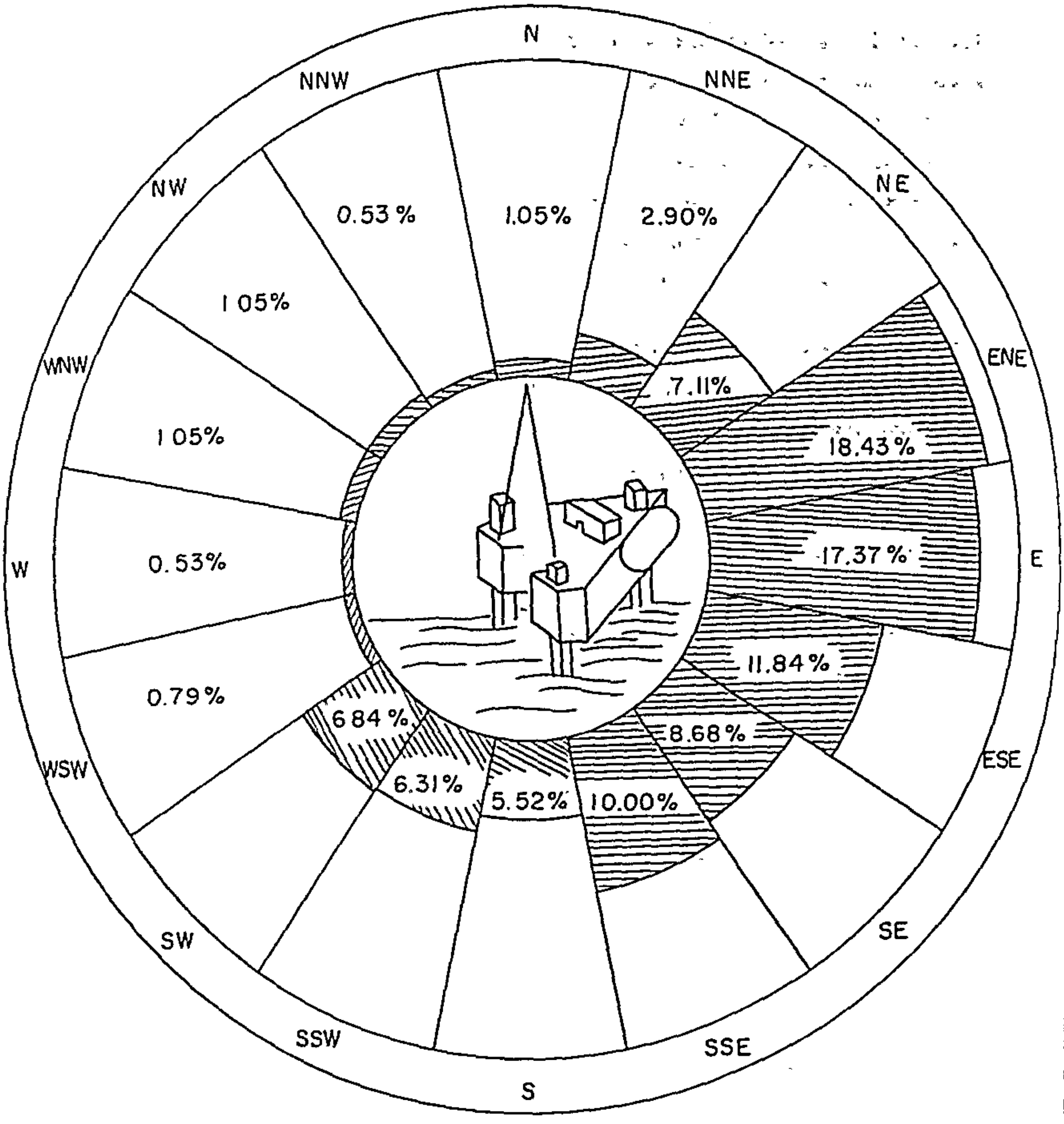


Fig. 2.3.13 Frequency of waves occurrence by direction
(at platform S1 & S3 off Rio Doce)

It should be noted, however, that the observation period was as short as about eight months and that the data failed to cover the winter.

(c) Wave data observed at Portocel

Portocel which lies about 60 km north of Praia Mole is now under construction. At Portocel, wave observations were carried out between September, 1973 and December, 1974 and still have been carried out, but on and off. The measuring instruments used are pressure type wave recorder, OSPOS, and buoy type wave recorder, Wave Rider, both being made in the Netherlands. The measurement is taken for 15 min. at an interval of 3 hrs.

The data obtained during the period of 1973 to 1974 were analyzed by the Danish Hydraulic Institute (DHI). The ratio of successful measurements was 85%. The results are as summarized below.

① The largest waves recorded during the investigation period were 2.2 m in $H_{1/3}$ and 3.4 m in H_{max}. It was only three times that $H_{1/3}$ exceeded 2 m (June 1, July 1 and September 1).

② From January to May, $H_{1/3}$ was smaller than 1.5 m, and from June to October it was generally lower than 1.5 m.

③ The Directions waves with large height were mostly S to SE, but E to NE waves were prevalent in terms of frequency.

④ The waves that may continue for one hour once in thirty years are 3.0 m in $H_{1/3}$.

⑤ The mean wave period was 5 to 15 sec., and the average mean period for all waves was 8 sec. The significant waves of 2 m or more showed a mean period of less than 9 sec.

⑥ It was found that significant waves of 2 m or larger would continue for six hours once every two years.

PORTOBRÁS' observations later found 3.6 m of significant wave height. It is therefore necessary to analyze the data including recent ones. Since Portocel is located on the south of the Rio Doce delta, the northeast waves may be cut off. It should be borne in mind that the data obtained are influenced by topographic conditions.

(d) Sea and swell charts by U.S. Navy Hydrographic Office

The U.S. Navy Hydrographic Office prepared the wave data by visual observation aboard a ship and issued 5° by 5° charts showing monthly statistics of waves. Fig. 2.3.14 shows annual occurrence frequencies of waves by direction (%) derived from these charts.

In the northern region, both wind waves and swells are predominated by southeast ones by a slight margin. In the southern region, the northeast waves and swells prevail. On an arithmetic mean basis, the wind waves are predominated by northeast ones with 30.8%, followed by southeast ones with 20.6%. As regards swells, the southeast ones prevail with 23.6% as against 22.7% and 21.3% of east and northeast waves, making little difference among them. Seasonally, northeast waves and swells prevail in summer, while southeast waves and swells come atop in winter. The chart data are based on the observations of as old as 1932 to 1940. In recent years, however, the U.S. Navy Hydrographic Office seems likely to have been updating and processing the data to cover not only 5° by 5° regions, but specific waters. The data from the Sea and Swell Charts have been analyzed in PLANAVE's report and SOROS's report.

(e) Data by Ocean Wave Statistics

N. Hogben and F.E Lamb, of the National Physical Laboratory, the Ministry of Technology, U.K., collected the results of visual observations of waves made by ocean-going vessels in the world over a period of eight years from 1953 to 1961. The wave data were sorted for each of 10° by 10° areas. Praia Mole falls on the boundary between Area 37 (W30° - 40°, S10° - 20°) and Area 40 (W40° - 50°, S20° - 30°), and the data have been analyzed in PLANAVE's report and CTH's report.

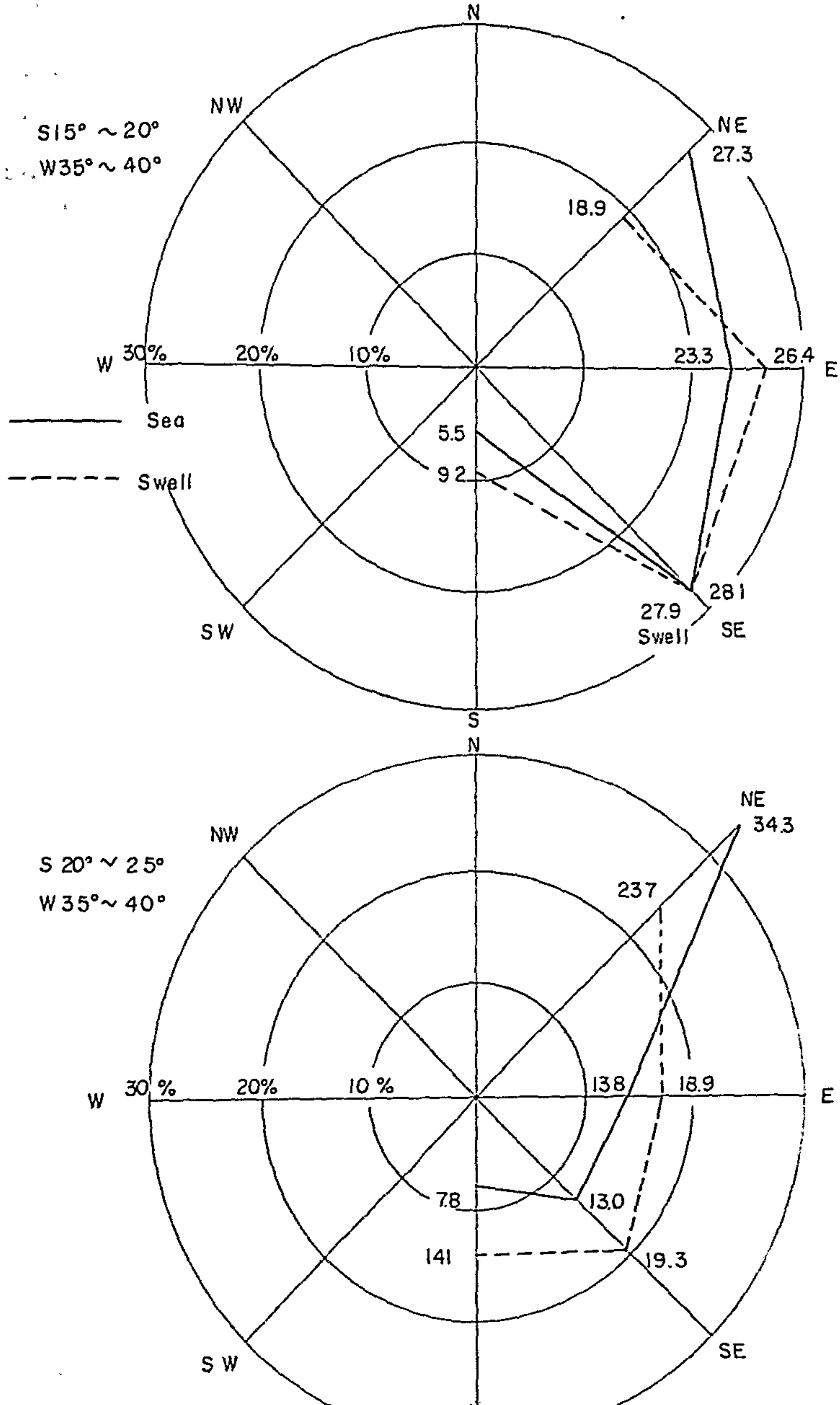


Fig. 2.3.14 **Annual frequency of occurrence of sea and swell by direction (source: Atlas of Sea and Swell Charts)**

According to the Ocean Wave Statistics, NE to ENE waves are predominant, and their maximum wave height is 6.5 m with a period of 8 to 9 sec. S waves are very high. In Area 40, a wave height of 9 m with a period of 10 to 13 sec. was recorded. SE to SSE waves are less frequent, and their height is relatively small. Fig. 2.3.15 shows the frequency of occurrence of waves by direction in the range of 30° to 180° as measured clockwise from north.

It should be noted that the Ocean Wave Statistics were based on visual observations over a very wide range of area.

4) Discussion of wave conditions in Praia Mole

The wave data useful in discussing the wave conditions in Praia Mole have been outlined in the foregoing. But none of them is satisfactory to stand direct use because of limitations in the period and coverage of observations and restrictions by topographic effects. It was therefore decided to use Portocel's data because of the period of observations being the longest of all the coastal observation data and to study them while taking into account the wave transformation due to refraction. The followings are the results of analysis made jointly by the Japanese survey team and the Instituto de Pesquisas Hidroviārias of PORTOBRÁS (INPH) during its stay in Brazil.

Portocel's September, 1973 to December, 1974 data have been explained in the foregoing. Later, the data for the following periods were collected and processed by INPH.

May 17, 1975 to July 24, 1975 : w/wave direction data
April 26, 1976 to May 24, 1976 : w/o wave direction data
July 7, 1976 to October 6, 1976: w/o wave direction data

All told, the data are net worth of about 20 months of survey. The data were processed according to Tucker-Draper's simplified method.

For the data obtained in 1976, the wave direction was estimated on the basis of previous observations. The frequency distribution of daily maximum significant wave heights by direction at the observation station at

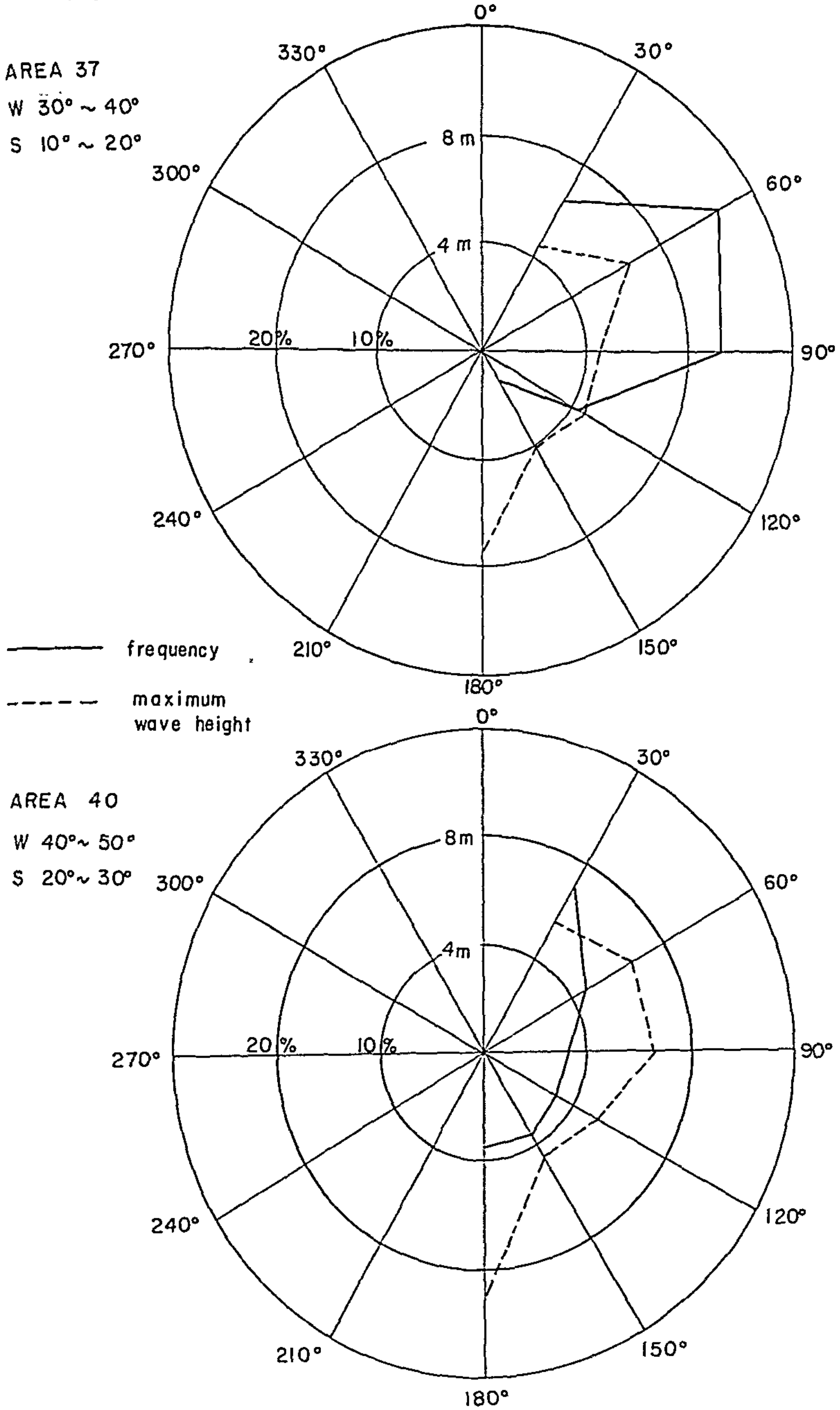


Fig. 2.3.15 Frequency of occurrence by direction and maximum wave height by Ocean Wave Statistics

Portocel was determined stochastically. The effects of wave refraction at Portocel were taken into account for determining principal particulars of offshore waves. The refraction coefficient and refraction angle at the wave observation station were those corresponding to the period of 8 sec. set forth in DHI's report.

Figs. 2.3.16.(1) through (4) show the exceeding probabilities of NE, E, SE and S deep water waves.

The data used were 621 in terms of the number of days of observation, and were extrapolated to determine the wave heights with a recurrence period of one year, five years, ten years, thirty years and fifty years. The results are as shown in Table 2.3.8.

Table 2.3.8 Deep water wave height, $H_{1/3}$ (m) with various return period

Direction in deep water	Recurrence Period (year)				
	1	5	10	30	50
NE	3.85	4.30	4.50	4.80	5.00
E	3.35	3.85	4.15	4.50	4.70
SE	3.80	4.45	4.70	5.15	5.35
S	3.80	4.55	4.85	5.30	5.60

The wave height which is likely to appear once a year is 3.35 to 3.85 m, while the wave height with an appearance probability of once every fifty years is 5.00 to 5.60 m. Anyway, the above probability will be little affected by wave direction.

In determining the wave height expected at the port construction site from these deep water waves, it is required to take into account the effect of shallow water transformation. Figs. 2.3.17 and 2.3.18 show the refraction coefficient (Kr) and refraction angle ($\Delta\theta$) at Praia Mole obtained by numerical solution of the ray equation.

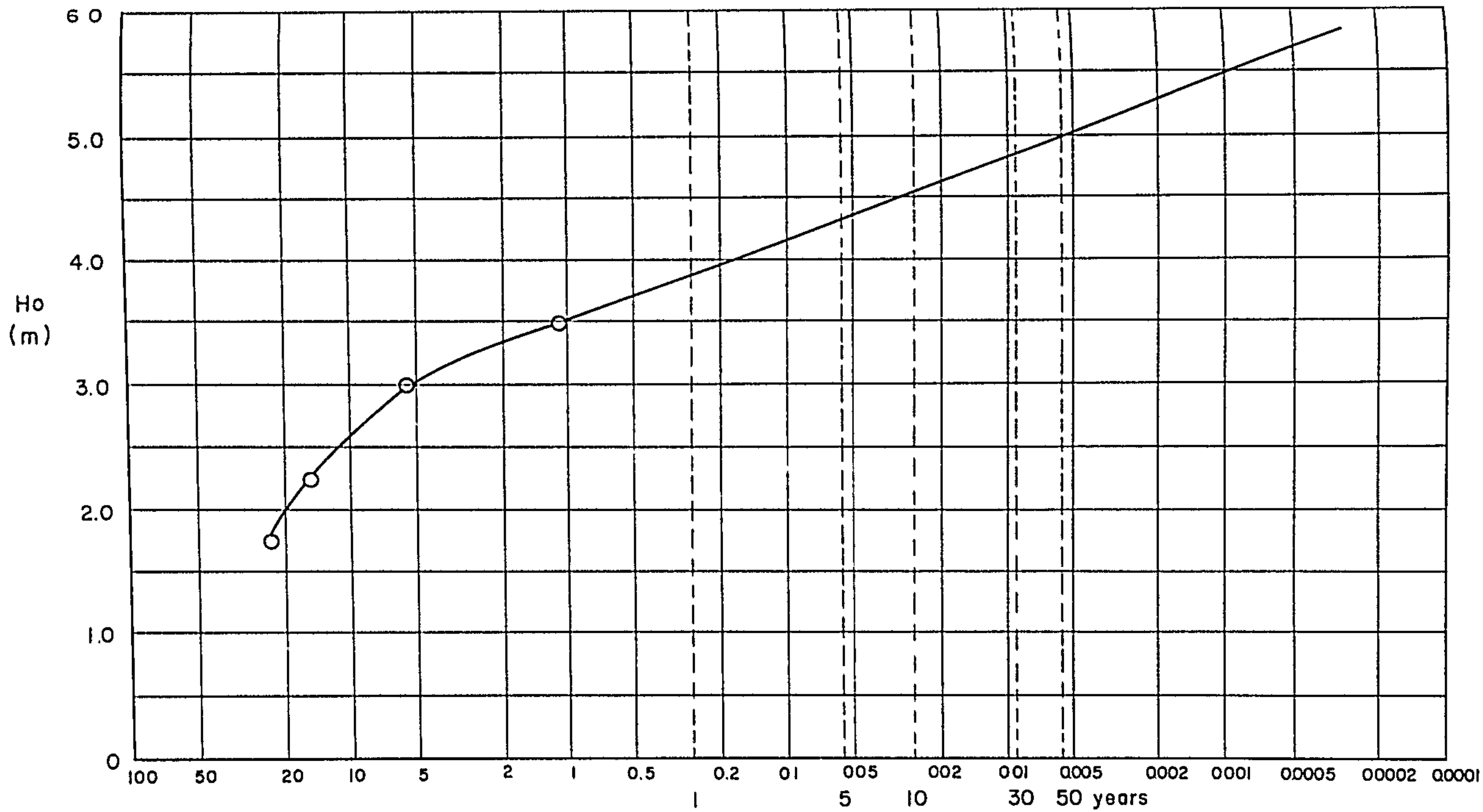


Fig. 2.3.16 Exceeding probability of deep water wave height
(1) NE wave

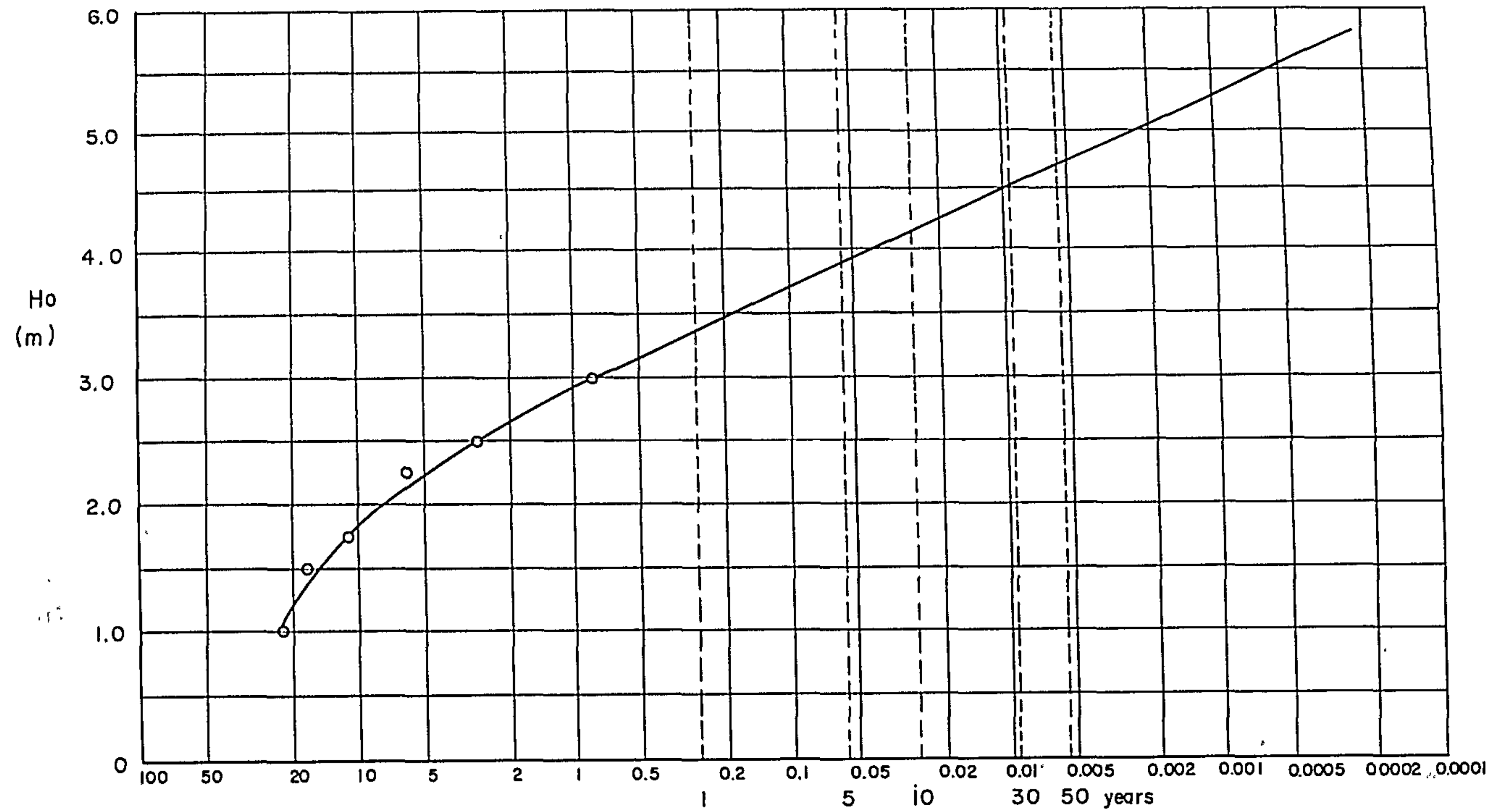


Fig. 2.3.16 Exceeding probability of deep water wave height
(2) E wave

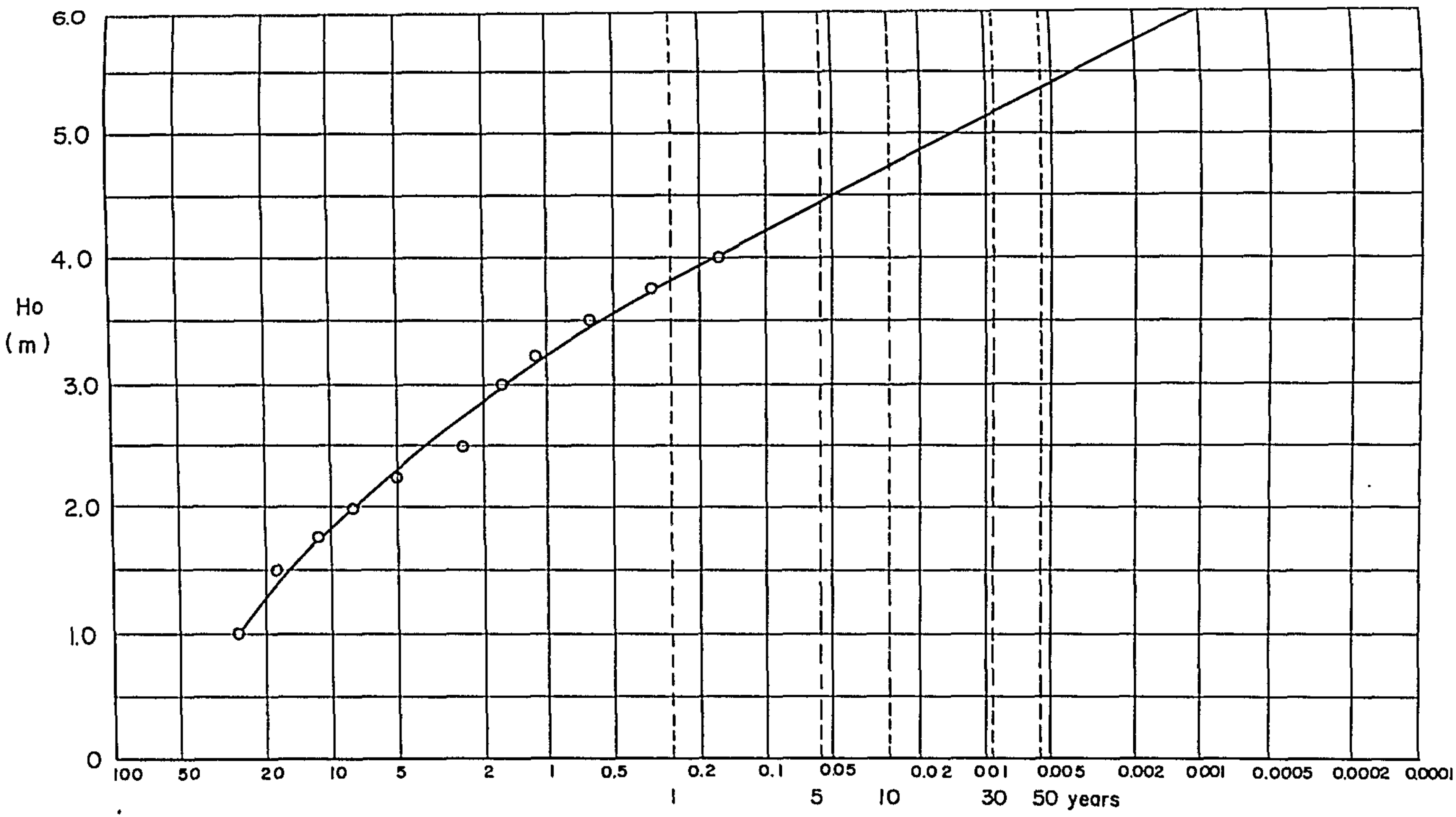


Fig. 2.3.16 Exceeding probability of deep water wave height
(3) SE wave

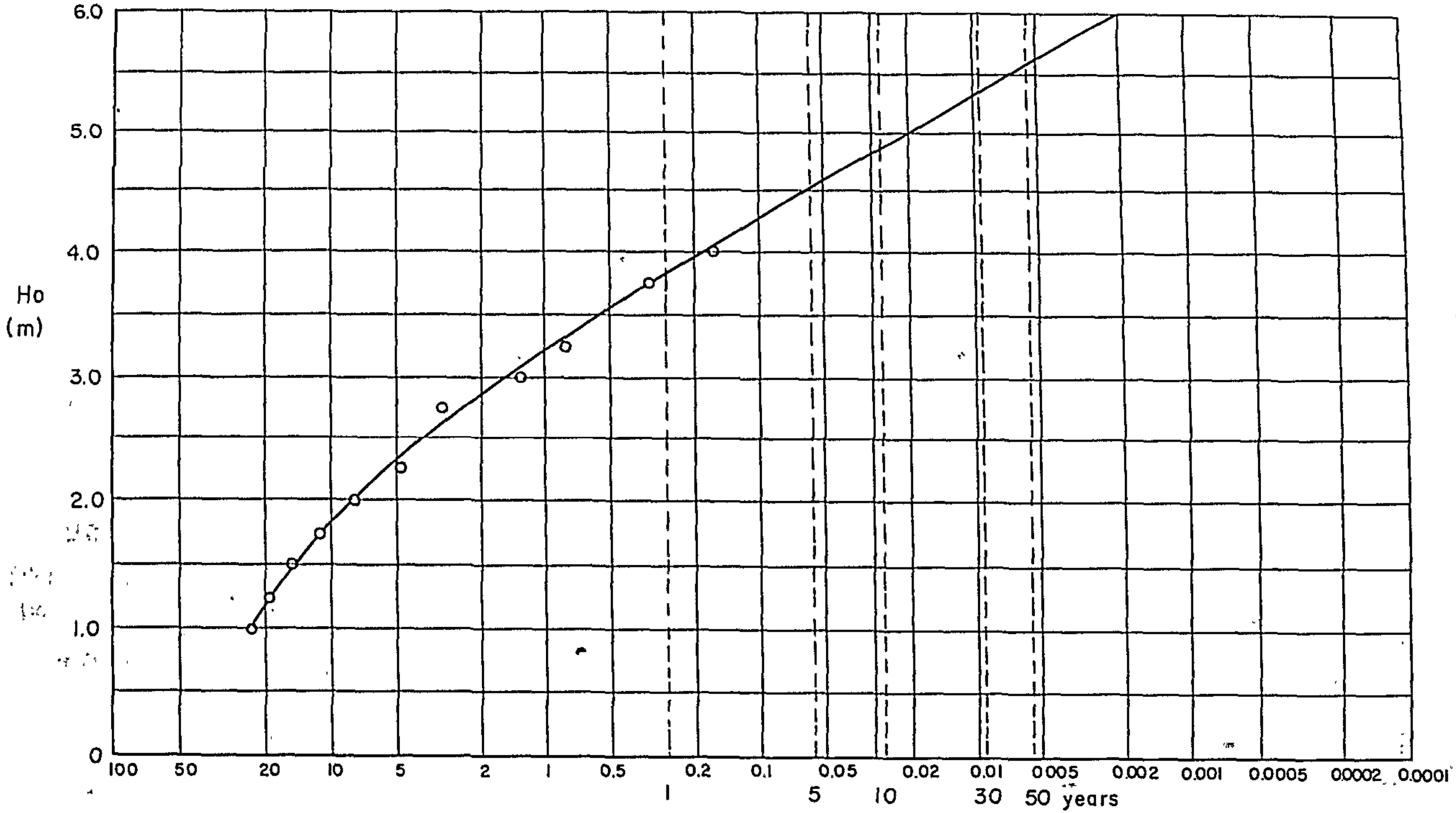


Fig. 2.3.16 Exceeding probability of deep water wave height
(4) S wave

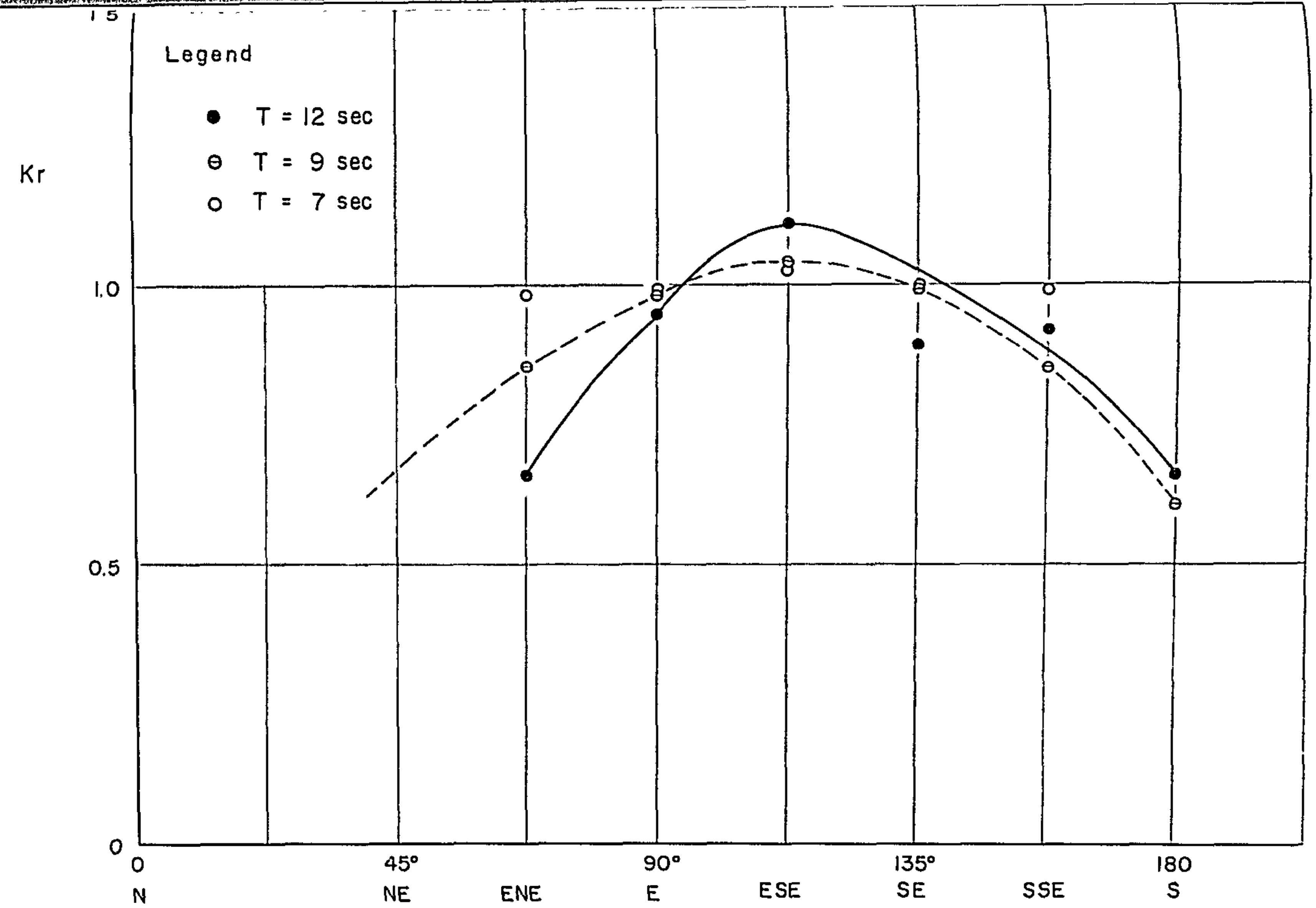


Fig. 2.3.17 Refraction coefficient by wave orthogonal method

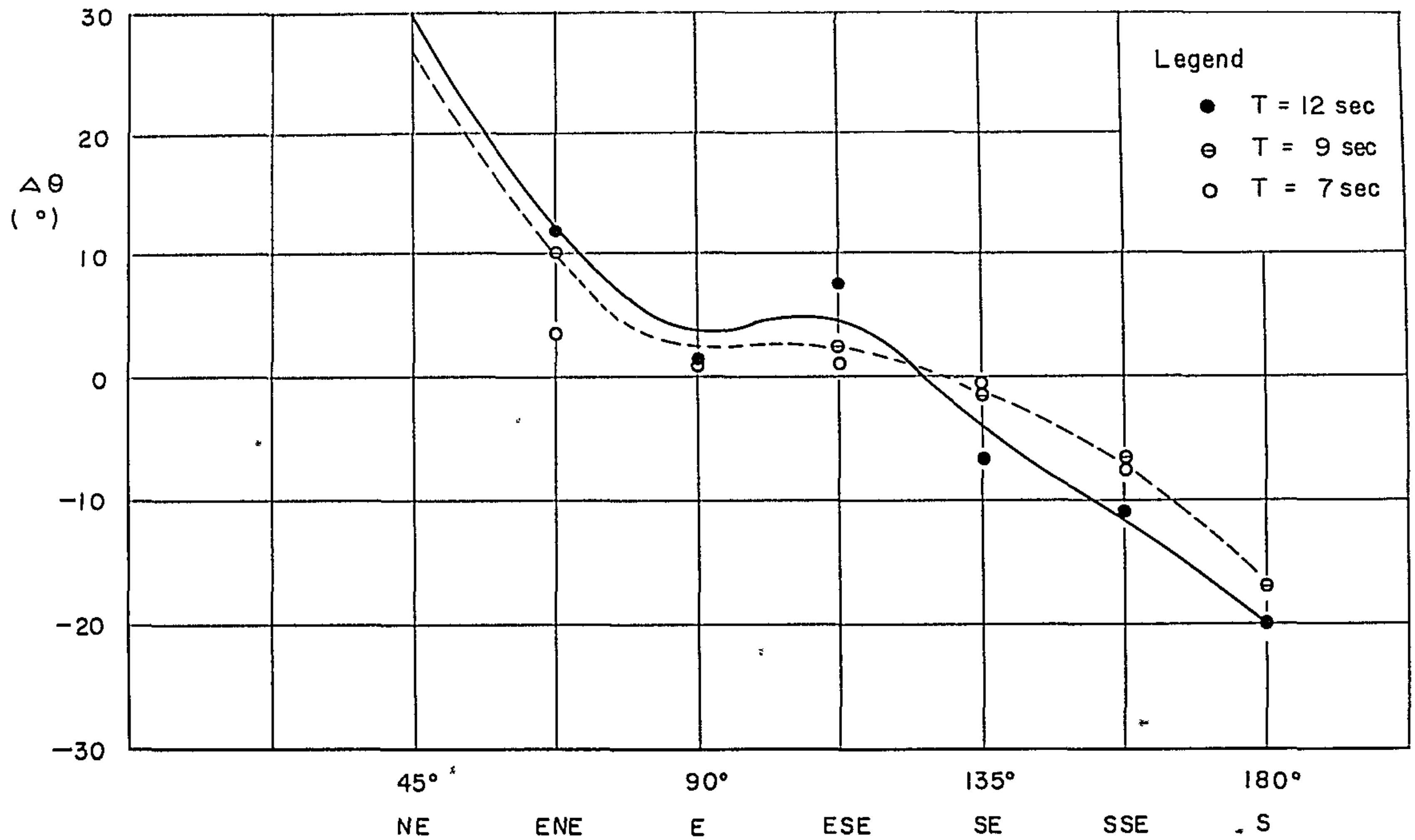


Fig. 2.3.18 Angle of wave direction deviated by refraction

The refraction angle is the angle deviated from the deep water wave direction, and its closkwise direction is taken positive. The topography of the sea bottom is somewhat complicated, and there was experienced such a case that the wave rays intersected each other. Two wave rays were selected to cover Praia Mole almost entirely, and the calculations of the refraction coefficient and angle were made as to a water depth of around 20 m. The results are hence macroscopic. Microscopically, it should be noted that it is not rarely the case that the refraction coefficient changes largely depending on the position along the breakwater. Since actual waves occur irregularly, the results shown in the figures are leveled off to some degree into the values listed in Table 2.3.9 for design purposes. The shoaling coefficient is set at 1.0.

Table 2.3.9 Refraction coefficient (Kr) and refraction angle ($\Delta\theta$)

Wave direction in deep water	Kr	$\Delta\theta$	Wave direction at site
NE (45°)	0.6	25°	70°
E (90°)	1.0	0°	90°
SE (135°)	1.0	0°	135°
S (180°)	0.7	-20°	160°

Fig. 2.3.19 shows a wave height at Praia Mole which has been determined from the once a fifty years deep water wave height by taking into account the wave refraction.

NE wave at deep water is transformed into ENE wave ashore of 3 m in $H_{1/3}$, while S wave at deep water is transformed into SSE wave ashore of 4 m in $H_{1/3}$. It is therefore recommended that the design wave for the breakwater be determined according to the solid lines appearing in the figure. Namely, it is preferable to take 5.0 m of $H_{1/3}$ for E to SE waves for the design of breakwaters. The period may well be set at 8 to 12 sec. considering the observation results.

In discussing the harbour calmness, it will do if the probabilities of wave heights for 16 directions shown in Table 2.3.10 are taken into account.

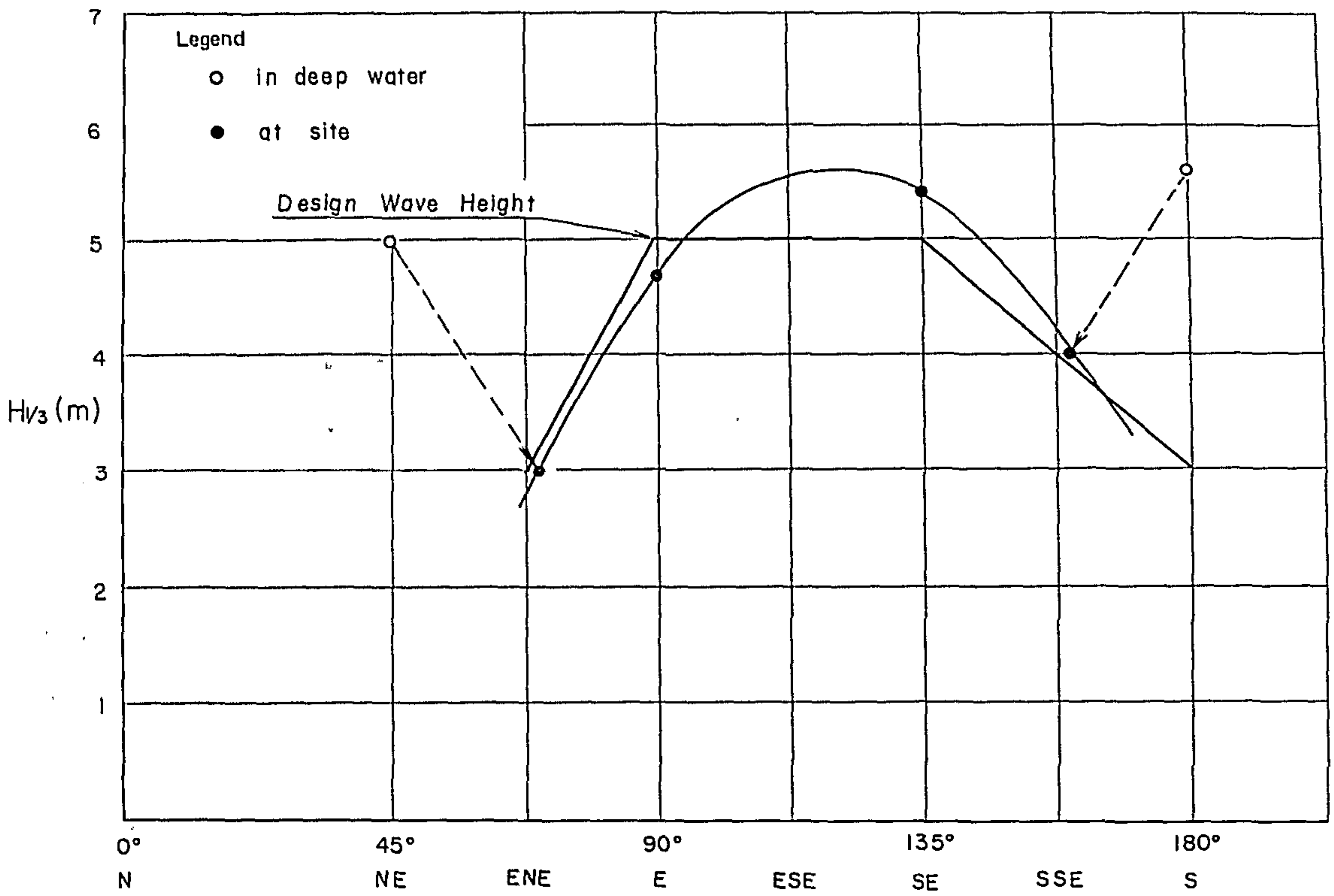


Fig. 2.3.19 Design significant wave heights by direction
(recurrence period: 50 years)

Table 2.3.10 Exceeding probability of wave height by wave direction

ENE		E		ESE		SE		SSE	
$H_{1/3}$ (m)	Pex (%)	$H_{1/3}$ (m)	Pex (%)	$H_{1/3}$ (m)	Pex (%)	$H_{1/3}$ (m)	Pex (%)	$H_{1/3}$ (m)	Pex (%)
0.60	24.2	0.75	14.3	0.75	17.3	0.75	20.4	0.35	23.8
1.05	22.9	1.00	14.2	1.00	16.0	1.00	17.9	0.70	21.9
1.35	15.3	1.25	11.4	1.25	11.7	1.25	12.0	1.05	14.5
1.80	5.3	1.50	11.4	1.50	11.7	1.50	12.0	1.40	7.7
2.10	1.3	1.75	7.2	1.75	7.4	1.75	7.5	1.75	3.1
		2.00	4.0	2.00	4.6	2.00	5.3	2.10	1.3
		2.25	4.0	2.25	3.7	2.25	3.3	2.45	0.32
		2.50	1.9	2.50	1.8	2.50	1.7	2.80	0.16
		2.75	0.54	2.75	0.81	2.75	1.1		
		3.00	0.54	3.00	0.81	3.00	1.1		
				3.25	0.38	3.25	0.73		
				3.50	0.22	3.50	0.43		
				3.75	0.11	3.75	0.21		
				4.00	0.054	4.00	0.11		

Pex. : Exceeding probability

To prepare Table 2.3.10, NE and S deep water waves are transformed into Praia Mole ENE and SSE waves with the same frequency the deep water waves have, and one third the frequency of E waves and SE waves respectively is assigned to ESE waves. Namely, E and SE waves ashore appear at a frequency two thirds as much as at the deep water. The table is based on many hypotheses. The total frequency of SSE and SE waves is 44.2% in conflict with a total 38.5% of ENE and E waves. This is a bit different from the general acceptation, but such a difference is inevitable due to insufficient information on waves. Fig. 2.3.20 shows the exceeding probability of waves at Praia Mole by directions.

The probability at which the waves exceed 1.5 m in height is about 50%, and that at which the waves exceed 2.0 m is about 20%. It should be noted, however, that the data refer to the daily maximum significant wave heights.

(2) Tides and currents

The tide observation is made at Vitória Port Tide Station (20° 19'2" S by 40°19'1" W) in Urubu Island. In addition, CVRD seemed to have conducted observations at Cape Tubarão.

Fig. 2.3.21 shows the datum level at Vitória Tide Station.

The tide observation datum level (O.D.L) is 413.6 cm below the bench mark, and the mean sea level (M.S.L) is 105.5 cm above O.D.L. The chart datum level (C.D.L.) or tide datum level is 79.5 cm below M.S.L.; namely, there is a difference of 26.0 cm between O.D.L. and C.D.L.

As regards the harmonic constants, the Liverpool Tidal Institute carried out a harmonic analysis of tidal data obtained during the period of March 1, 1961 to February 21, 1962. Table 2.3.11 shows 15 major tidal constituents.

Table 2.3.12 shows yearly observation during the 1956 ∿ 72 period.

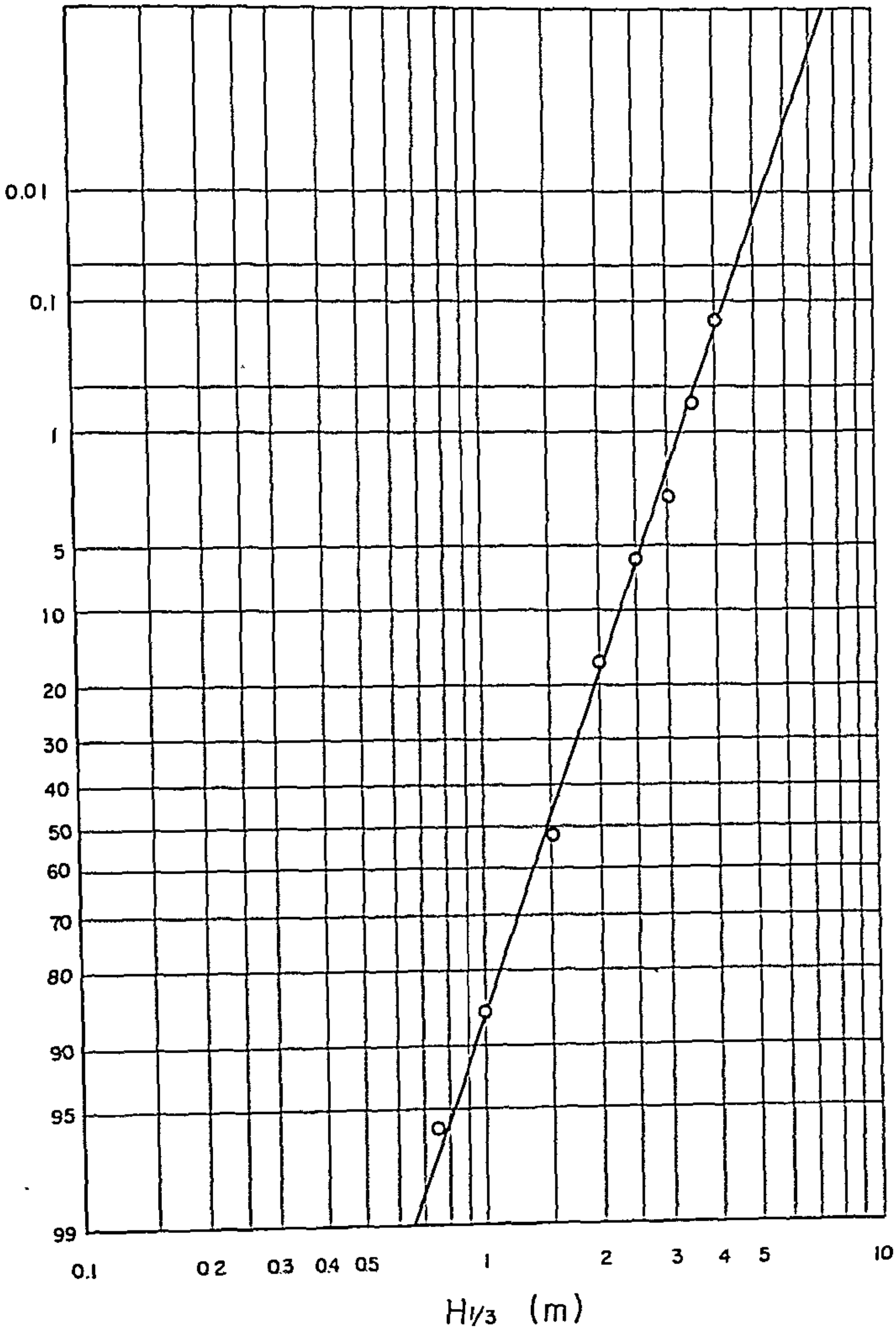


Fig. 2.3.20 Exceeding probability of daily maximum significant wave heights (Praia Mole)

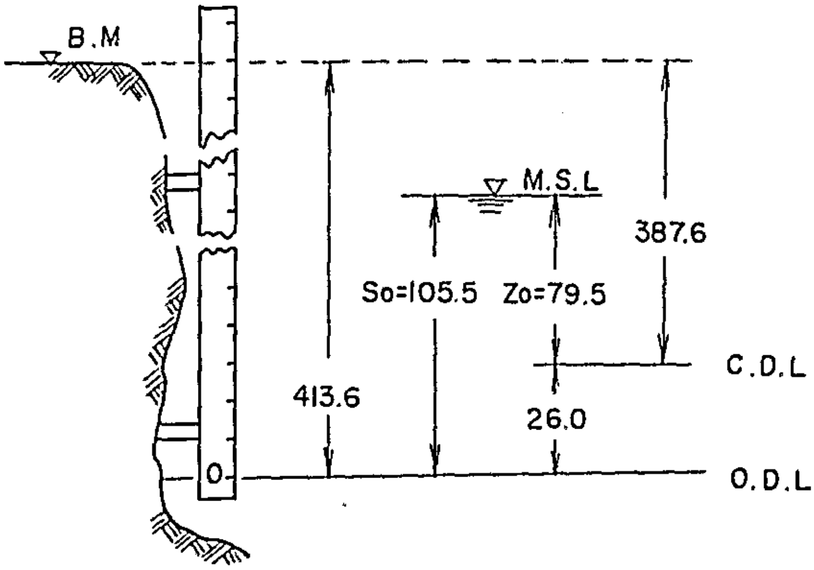


Fig. 2.3.21 Datum level at Vitória Port Tide Station

Table 2.3.11 Harmonic constants of tide (Vitória Port Tide Station)

	H (cm)	G (°)
Sa	5.5	1.0
S_{sa}	0.7	73.8
MS_f	1.1	213.8
K_1	5.2	158.1
O_1	6.8	97.6
P_1	1.8	149.5
Q_1	2.6	66.8
M_2	46.2	88.2
S_2	20.4	99.2
N_2	6.8	97.3
K_2	6.1	96.7
U_2	1.3	103.4
P_2	2.1	106.6
L_2	1.4	88.3
M_4	0.3	340.6

Table 2.3.12 Yearly water levels (with reference to C.D.L.)

Year	M.H.W.S. (cm)	M.L.W.S. (cm)	H.H.W.S. (cm)	H.L.W.S. (cm)	M.W.L. (cm)
1956	156	-19	159	-5	70
1957	134	-26	164	-17	66
1958	143	-13	169	-2	62
1959	161	-14	177	-1	72
1960	163	-8	182	3	71
1961	162	-14	174	2	66
1962	164	-12	177	8	78
1963	158	-12	168	5	74
1964	149	-12	164	1	68
1965	154	-7	164	5	63
1966	157	-16	179	0	76
1967	159	-14	175	-1	76
1968	166	-9	182	18	79
1969	156	-14	171	-6	74
1970	156	-13	181	-2	73
1971	161	-15	181	9	74
1972	160	-11	173	-3	73

M.H.W.S. : Mean High Water Spring

M.L.W.S. : Mean Low Water Spring

H.H.W.S. : Highest High Water Spring

H.L.W.S. : Highest Low Water Spring

M.W.L. : Mean Water Level

The original data were given with reference to O.D.L., but are superimposed on C.D.L. with 26 cm deducted from them. The spring high water (mean high water spring, M.H.W.S.) is 134 to 166 cm, and the higher high water spring (H.H.W.S.) is 164 to 182 cm. The design high water level taken for the design of structures along the coast in Espirito Santo State is 180 cm, almost the same as the yearly highest water level.

The tidal conditions stated in the chart No. 1410 (1973 edition) for Vitória are as follows.

Mean high water spring (M.H.W.S.)	:	146 cm
Mean high water neap (M.H.W.N.)	:	105 cm
Mean water level (M.W.L.)	:	80 cm
Mean high water lunitidal interval (M.H.W.I.)	:	3 hrs. 42 min.

The Brazil Current is running down southward near Vitória at the velocity that changes in the range of 0.5 to 1.0 kt with month.

2-4 Socio-economic conditions

2-4-1 Hinterland

The point which is projecting from the west of Minas Gerais State toward São Paulo State is called the "Minas Triangle", where advanced agriculture and live-stock farming have been operated. Geographically, the area is near Santos Port. The south of Minas Gerais State is near Rio de Janeiro Port. Therefore, the area Praia Mole Port is likely to cover, that is, the hinterland of Praia Mole Port, will at least include Espirito Santo State and part of Minas Gerais State.

Fig. 2.4.1 shows the relative position of the said two states to come under the influence of Praia Mole Port, along with those parts for which Praia Mole Port is sure to vie with Santos Port.

2-4-2 Population in the hinterland

In 1972, the total population in Brazil exceeded 100 million, and the population density was 11.8 persons per km^2. The annual average population growth rate during the 1960 ∿ 72 period was about 3%. The regional population distribution is shown in Table 2.4.1. From the table, it is found that the southwestern states which account for about 10% of the total land area are inhabited with 40% of the total population.

Fig. 2.4.1 Hinterland of Praia Mole Port

Table 2.4.1 Population distribution by regions

	1960		1970		1977		Population density		Average growth rate during the ten-years period from 1960 to 1970
	Actual, thousand persons	Ratio	Actual, thousand persons	Ratio	Actual, thousand persons	Ratio	Area (km^2)	Population density (persons/km^2)	
North	2,601.5	3.67	3,650.8	3.86	3,863		3,578	1.08	
Northeast	22,428.9	31.59	28.675.0	30.34	30,362		1,546	19.64	
Southeast	31,063.0	43.76	40.332.0	42.68	42,710		925	46.17	
Minas Gerais & Espirito Santo	(10,987)		(13,097)		(13,329) (1,711)		(587) (46)	(21.00) (37.20)	
Rio de Janeiro & Guanabara	(7,101)		(9,274)		(5,084) (4,573)		(43) (1)	219.43	
São Paulo	(12,975)		(17,959)		(19,013)		(248)	(76.09)	
South	11,892.1	16.75	16,683.6	17.65	17,662		578	30.56	
Center-West	3,006.9	4.23	5,167.2	5.47	5,473		1,879	2.91	
Total	70,992.4	100	94,508.7	100	100,070		8,506	11.76	

North : Rondonia, Acre, Amazonas, Roraima, Purá, Amapá

Northeast : Maranhão, Piáui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco Alagoas, Feruando de Norouha, Sergipe, Bahia

Southeast : Minas Gerais, Espirito Santo, Rio de Janeiro, Granabara, São Paulo

South : Parana, Santa Catarina, Rio Grande do Sul

Among others, the population densities in Guanabara, Rio de Janeiro and São Paulo States are extremely high.

Espirito Santo and Minas Gerais States coming under the influence of Praia Mole Port have a population of about 14,000 thousand or 22.2 persons/km^2 - twice as large density as the national average.

2-4-3 Industry

(1) Outline

In spite of the Oil Shock as late as 1973, Brazil showed a real growth rate of 9.6% in GDP in 1974. Entering 1975, the rate plunged down to 4.2% or half the rate achieved a year before. This was due first to the great damage inflicted by frost upon the granary in the south of Brazil. The growth rate of the agricultural sector of this year went greatly down to -2.0% compared with a real growth rate of 9.0% in a year before. Secondly, it was due to the influence of the Oil Shock which had taken since the latter half of 1974 to quench the manufacturing activities. Its real growth rate was only 4.2%.

By type of industry, GDP was supported most by the tertiary industry with 53.6%, followed by the manufacturing with 34.0% and agriculture and live-stock farm with 12.4%. On the other hand, the population working in agriculture, forestry and fishery account for 44.3% of the total (as of 1974), for all their productivity is very low.

Table 2.4.2 shows the transition of real growth rate of GDP by industrial sector.

As regards the foreign trade, the bulk of exports from Brazil is accounted for by the primary products.

Table 2.4.3 shows the change in the component ratios of exports.

2.4.2 Transition of real growth rate of GDP by industrial sector

	Composition ratio, 1970	Actual growth rate						Composition ratio, 1975
		1970	1971	1972	1973	1974	1975	
GDP	100.0	9.5	11.3	10.4	11.7	9.6	4.2	100.0
Agriculture and Livestock	14.6	5.6	11.4	4.1	3.5	8.5	3.4	12.4
Agriculture	9.9	6.3	14.8	4.0	3.2	12.4	-2.0	8.5
Livestock	4.7	4.2	4.3	4.3	4.3	-	14.9	3.9
Industry	32.7	11.1	11.2	13.8	15.5	8.2	4.2	34.0
Mining	0.8	8.3	----	----	----	----	----	1.0
Manufacturing	23.8	11.0	11.3	14.1	15.8	7.6	3.7	24.5
Construction	6.0	14.8	8.4	13.0	15.4	10.0	3.8	6.2
Electric	2.1	10.1	11.4	11.1	12.5	12.0	10.2	2.3
Services	52.7	9.9	11.3	10.0	11.6	10.8	4.4	53.6
Commercial	17.4	8.9	12.8	11.9	12.8	11.0	3.2	17.9
Transport and communication	5.4	15.0	8.4	8.1	14.0	16.5	9.3	5.8
Others	29.9	9.4	11.3	9.2	10.5	9.6	4.2	29.9

Source : Vulgas Economic Research Institute

Table 2.4.3 Transition of component ratios of exports by industrial sector

(%)

	1970	1971	1972	1973	1974	1975
Primary products	74.8	68.5	68.3	66.1	61.1	60.3
Iron ore	7.7	8.2	5.8	5.9	7.2	10.5
Manganese	1.1	1.3	0.7	0.3	0.6	0.9
Semi-finished products	9.1	8.3	7.8	7.7	8.0	7.4
Manufactured goods	15.2	20.0	22.9	23.6	28.5	29.9
Others	0.9	3.2	1.1	2.6	2.4	2.4
Total	100	100	100	100	100	100

The primary products which registered 75% in 1970 were dropped to 60% in 1975, while the manufactured products rose from 15% in 1970 to 30% in 1975. The export market of primary products is very changeable while the crops are also changeable and contingent on weather conditions. All these combine to make it hard to maintain the gradual increase of exports. After a slump of 92.9% decline in 1971, the annual average growth marked a fair value of 27% till 1974.

(2) Agriculture

In 1975, the agriculture in Brazil employed about 44% of the total working population, took a 12% share in GDP, and shouldered more than 70% of the total export value, earning itself the highest position in the country's industries.

Those out of the main agricultural products in Brazil which are contributed largely by the activities in Espirito Santo and Minas Gerais States are listed in Table 2.4.4 below.

Table 2.4.4 Agricultural products in Espirito Santo and Minas Gerais States

in thousand tons

Classification	Year	Products for domestic consumption				Products for export						
		Manioc	Potatos	Beans (Feijao)	Meat (bovine and swine carcases)	Maize	Soy beans	Unulled rice	Coffee beans	Cotton	Cocoa	Sugar
Espirito Santo	73	416	6	44	* 44	234	-	93	98	1	7	41
	74	596	-	45	* 43	246	-	69	164	-	7	37
Minas Gerais	73	1,814	199	282	* 340	1,994	36	828	244	106	-	328
	74	2,120	373	419	* 347	2,313	58	479	588	61	-	300
Subtotal	73	2,230	208	326	* 384	2,228	36	921	342	107	7	369
	74	2,716	373	464	* 390	2,559	58	548	752	61	7	337
All-Brazil total	73	26,528 (8.4)	1,337 (15.6)	2,231 (14.6)	* 2,612 (14.7)	14,186 (15.7)	5,012 (0.7)	7,160 (12.9)	1,746 (19.6)	2,273 (4.7)	196 (3.6)	6,680 (5.5)
	74	24,715 (11.0)	1,673 (22.3)	2,238 (20.7)	* 2,640 (14.8)	16,285 (15.7)	7,876 (0.7)	6,483 (8.6)	3,220 (23.4)	1,959 (3.1)	165 (4.2)	6,673 (5.1)

Notes : 1. Meat refers to the products of '70 and '71.

2. Source : IBGE

3. The values in parentheses are percentages to national total.

Major exports from Brazil include coffee beans, sugar and soybeans as well as mineral products.

As regards cassava, potatoes, lima beans and meat for domestic consumption, Espirito Santo and Minas Gerais States take a 10% to 20% share of the national total. As regards the export products, the two States account for 23% of coffee beans, 15% of maize and 5% of sugar; namely, all major export agricultural products but soybeans are produced much in the two states.

For the purpose of promoting the export of upcountry agricultural produce, an agricultural produce wharf is being constructed at the industrial wharf area in Vitória Port according to the Export Corridor Plan.

(3) Manufacturing

Brazil is the most industrialized country in Latin America. Its economy has made rapid progress on the strength of mainly the manufacturing industry. Although the real growth rate of the manufacturing industry was as low as 4.4% in 1975, it had been more than 10% every year theretofore.

The manufacturing industry in Brazil is composed of mainly foods, beverages, tobacco, plastics, textile and clothing, metals, transport machinery and electrical appliances. As shown in Table 2.4.5, Espirito Santo and Minas Gerais States have a comparatively large share in the production of metal products and cement.

Table 2.4.5 Major Manufactured goods in Espirito Santo and Minas Gerais States

(in thousand tons)

		Iron	Steel ingots	Steel plates	Shapes	Wire	Semi-finished steel product	Cement	Paper and cardboard	Primary petroleum products (1,000 m^3)	Secondary petroleum products (1,000 m^3)
Espirito Santo State	73	-	73	-	114	-	-	361	-	-	-
	74	-	96	-	114	-	-	361	-	-	-
Minas Gerais State	73	3,493	2,905	1,064	944	307	200	3,591	63	3,474	118
	74	3,776	2,956	990	1,090	356	200	4,079	82	3,581	111
Subtotal	73	3,493 (63.1)	2,978 (41.7)	1,064 (39.0)	1,058 (37.5)	307 (62.3)	200 (47.0)	3,952 (29.5)	63 (4.0)	3,474 (8.7)	118 (3.4)
	74	3,776 (64.6)	2,692 (35.9)	990 (38.0)	1,204 (38.3)	356 (69.8)	200 (62.9)	4,440 (29.8)	82 (4.4)	3,581 (8.6)	111 (3.2)
All-Brazil total	73	5,532	7,149	2,728	2,821	493	425	13,398	1,587	39,735	3,133
	74	5,846	7,502	2,608	3,142	510	318	14,920	1,854	41,756	3,482

Values parenthesized are percentages to national total.

Of the metal products, pig iron, wires and semi-finished steel products are mainly produced in Espirito Santo and Minas Gerais States with a share of more than 60%. The two States' share in the production of rolled steel products is a little shorter than 40%. The two States turned out 4,400 thousand tons of cement in 1974, or about 30% of the national total, indicating that the cement industry carries some weight in the two states. All in all, however, the manufacturing industry in the two states is yet to be developed, except for iron and steel and cement. In fact, the two states have a great potential of future growth.

(4) Mining

At present, the percentage contribution of the mining industry to GDP is only 1%. However, Brazil ranks among the world's top producers of iron ore. In addition, it produces lime stones, manganese and coal. Iron ore accounts for more than 90% of the total output of mineral products.

The reserves of iron ore in Brazil have been said to be a quarter of the world reserves. Besides, almost all of the iron ore output in Brazil now comes from Minas Gerais State. About three quarters of the total iron ore output are exported. The exports of iron ore in 1975 were up 20.7% from the previous year's level of 59.4 million tons, amounting to 71.7 million tons. Manganese is also one of the most important export items, and Minas Gerais State is producing 18% of the total output. The exports of manganese in 1975 were up only 4.5% as against a sharp growth of 89% in the preceding year. But because of price increase, the export value increased as much as 60%. Minas Gerais State's share in the production of lime stone is 34%. It is totally consumed in the country as a cement raw material and for iron and steel making.

Coal is produced in three southern states - Rio Grande do Sul, Santa Catarina and Parana -, but Minas Gerais and Espirito Santo States have no coal reserve. Coal produced is of low quality, and almost totally is used for thermal power stations, though part goes to iron and steel making.

Table 2.4.6 shows those mineral products in which production Espirito Santo and Minas Gerais States have a comparatively large share in Brazil.

Table 2.4.6 Mineral products in Espirito Santo and Minas Gerais States

(in thousand tons)

		Crude oil (1,000 m^3)	Natural gas (1,000 m^3)	Iron ore	Lime stone	Mangan-ese	Dolomite	Bauxite	Chromium ore	Nickel ore	Zinc ore
Espirito Santo State	73	36	3	-	488	-	-	2	-	-	-
	74	222	14	-	475	8	-	1	-	-	-
Minas Gerais State	73	-	-	54,928	7,218	353	394	843	-	276	132
	74	-	-	91,427	8,437	511	283	816	45	272	161
Subtotal	73	36 (-)	3 (-)	54,928 (99.9)	7,706 (29.6)	353 (13.6)	394 (29.4)	845 (99.5)	- (-)	276 (98.2)	132 (100)
	74	222 (2.1)	14 (0.9)	91,427 (99.9)	8,912 (34.5)	519 (18.5)	283 (22.9)	817 (95.2)	45 (10.6)	272 (100)	161 (100)
All-Brazil total	73	10,102	1,180	55,019	26,169	2,594	1,339	849	327	281	132
	74	10,565	1,488	91,482	25,806	2,800	1,237	858	424	272	161

Values parenthesized are percentages to national total.

2-4-4 Transportation network within the hinterland

(1) Roads

Vitória City and principal cities in Brazil have been connected together with national roads, Route 101 and Route 262. Route 101 is a trunk road extending north-south along the coast from Osrio, Rio Grande do Sul State, to Touros, Rio Grande do Norte State. At present, the Rio to Salvador section has been fully paved, while the remainder from Rio down south has some parts under construction. The route joins the national road Route 116 which runs from Rio to São Paulo. Route 262 runs east to west from Vitória to Corumbá, Mato Gross State, bordering on Bolivia, by way of Belo Horizonte and Uberlandia, Minas Gerais State from which national roads Route 040 and Route 050 are running to Brasilia. The Vitoria-Uberlandia section has been fully paved, and the remainder on the west has some sections under construction and some others for which construction is planned.

The Praia Mole Port construction site is well served with a road network as it is just about 7 km short of the national road Route 101.

Fig. 2.4.2 shows main roads and railways running in and around the Vitória region.

(2) Railways

As of 1974, Brazil had a trackage of 30,480 km of which 80% was owned and operated by the Federative Railway Public Corporation (RFFSA). 92% of the locomotives were diesel-powered ones, and there were few sections that ran on electricity. The track gauges are diversified, impeding railway transit. As a result, the weight of railway transportation is only 20% of the national total traffic.

Terminating Vitória City are the Leopoldina Railway of RFFSA (Estrada de Ferro Leopoldina, EFL) and the Vitória-Minas Railway of CVRD (Estrada de Ferro Vitória a Minas, EFVM). EFL is connected at Rio to the Brasil Central Railway (Estrada de Ferro Central do Brasil, EFCB) which leads to Belo Horizonte and São Paulo. As illustrated in Fig. 2.4.3, the gauges

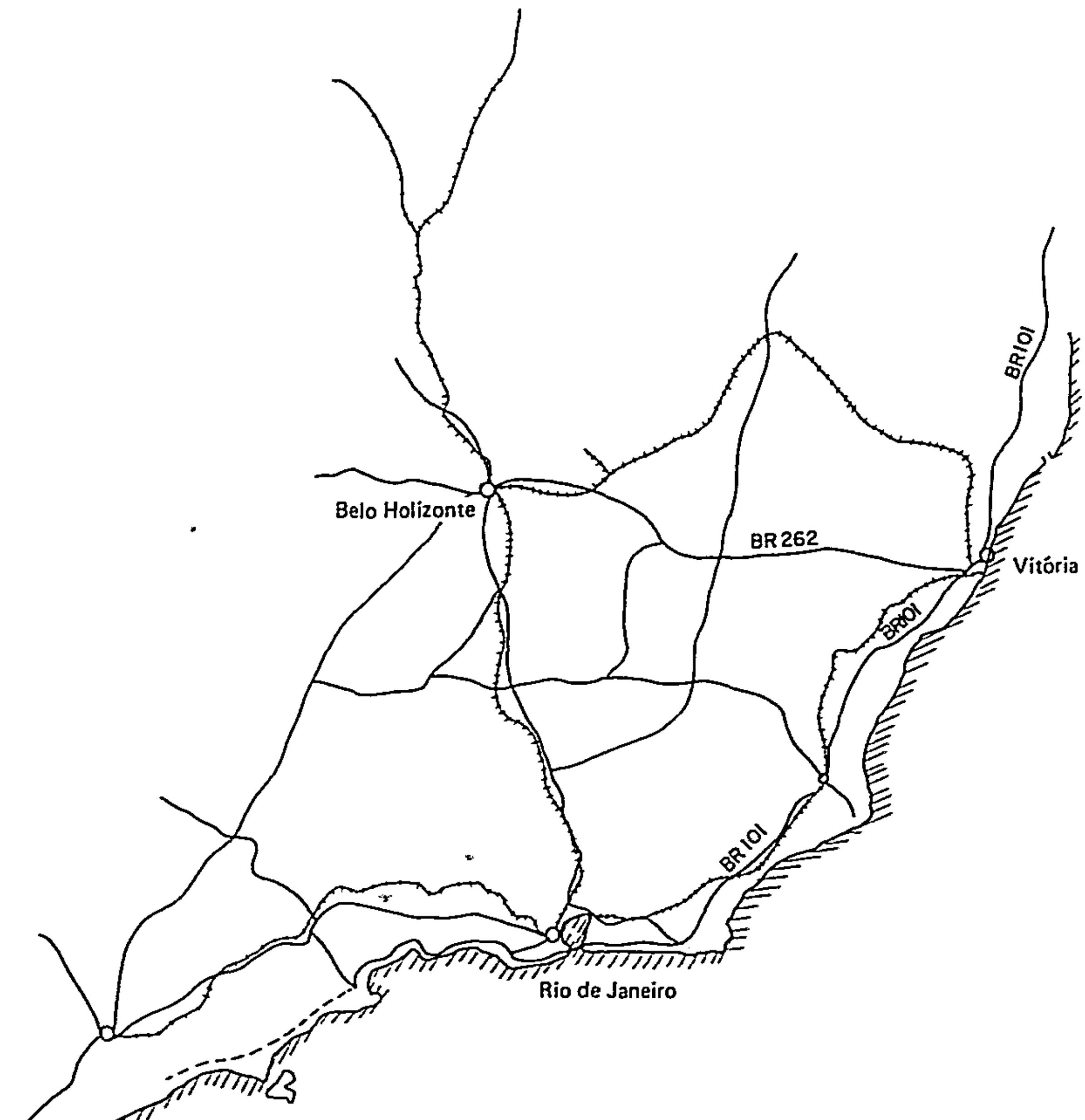


Fig. 2.4.2 Main roads and railways serving Vitória

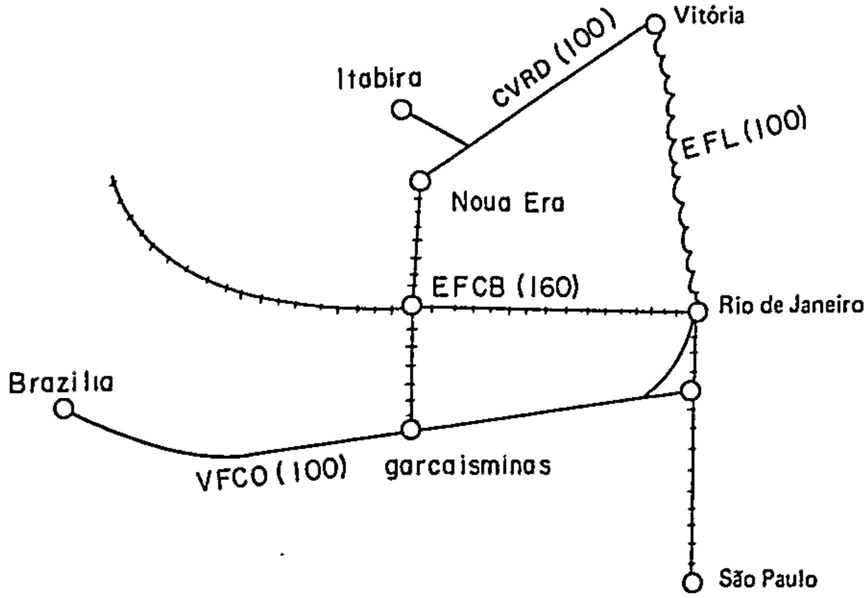


Fig. 2.4.3 Gauges of railways connecting Vitória and its hinterland

are different (EFL: 1.00 m; EFCB: 1.60 m), and troublesome transshipping is required.

EFVM is a line used only for the transportation of ore from Itabira Mine, and is connected to EFCB at Nova Era from which one can go everywhere in Brazil. However, the gauges are also different there. EFVM is run down to Tubarão Terminal of CVRD, located near Praia Mole Port. It also is directly connected to the steel mill of USIMINAS, and will provide an important overland transportation means in conveying coal and others which are to be handled at Praia Mole Port for USIMINAS steel mill.

Namely, the freighters can return loaded with the cargoes bound for inland after unloading iron ore at Tubarão Terminal, bringing about large payoff without hampering the principal duty of iron ore transportation. Table 2.4.7 shows the existing state of railways in Brazil.

Table 2.4.7 Railways in Brazil (as of 1974)

	Aggregate length	Electrified length	Breakdown by gauge			
			0.76 m	1.00 m	1.435 m	1.60 m
RFFA	24,119	1,053	202	22,190	-	1,727
FEPASA	5,296	1,196	-	3,469	-	1,647
6 private railways companies	1,065	69	20	851	194	-
Total	30,480	2,318	222	26,690	194	3,374

Although Vitória is favored with a railway network, the railways cannot be counted upon much as a hinterland transportation means except for specific cargoes.

2-5 Present state of Vitória Port

2-5-1 Outline

As shown in Fig. 2.5.1, Vitória Port is divided into commercial wharf, industrial wharf and Tubarão Terminal. The former two stand within the Bay of Espírito Santo as protected from the open sea by Cape Tubarão and Cape Santa Luzia.

The commercial wharf is located on Vitória City in Espirito Santo Island east of Santa Maria Inlet, and is composed of an aggregate 720 m of quaywalls and related facilities, while the industrial wharf is situated at the opposite of the commercial wharf, and is handling coal, oils and other bulk cargoes. Tubarão Terminal is located within the Bay on Cape Tubarão, and is owned and operated by CVRD for loading iron ore.

In 1976, the number of vessels entering Vitória Port reached 1,330, and the cargoes handled amounted to about 45,000 thousand tons, the largest of the volumes handled at the Brazilian ports. About 90% of the cargo handled at Vitória Port is accounted for by export ore from Tubarão Terminal.

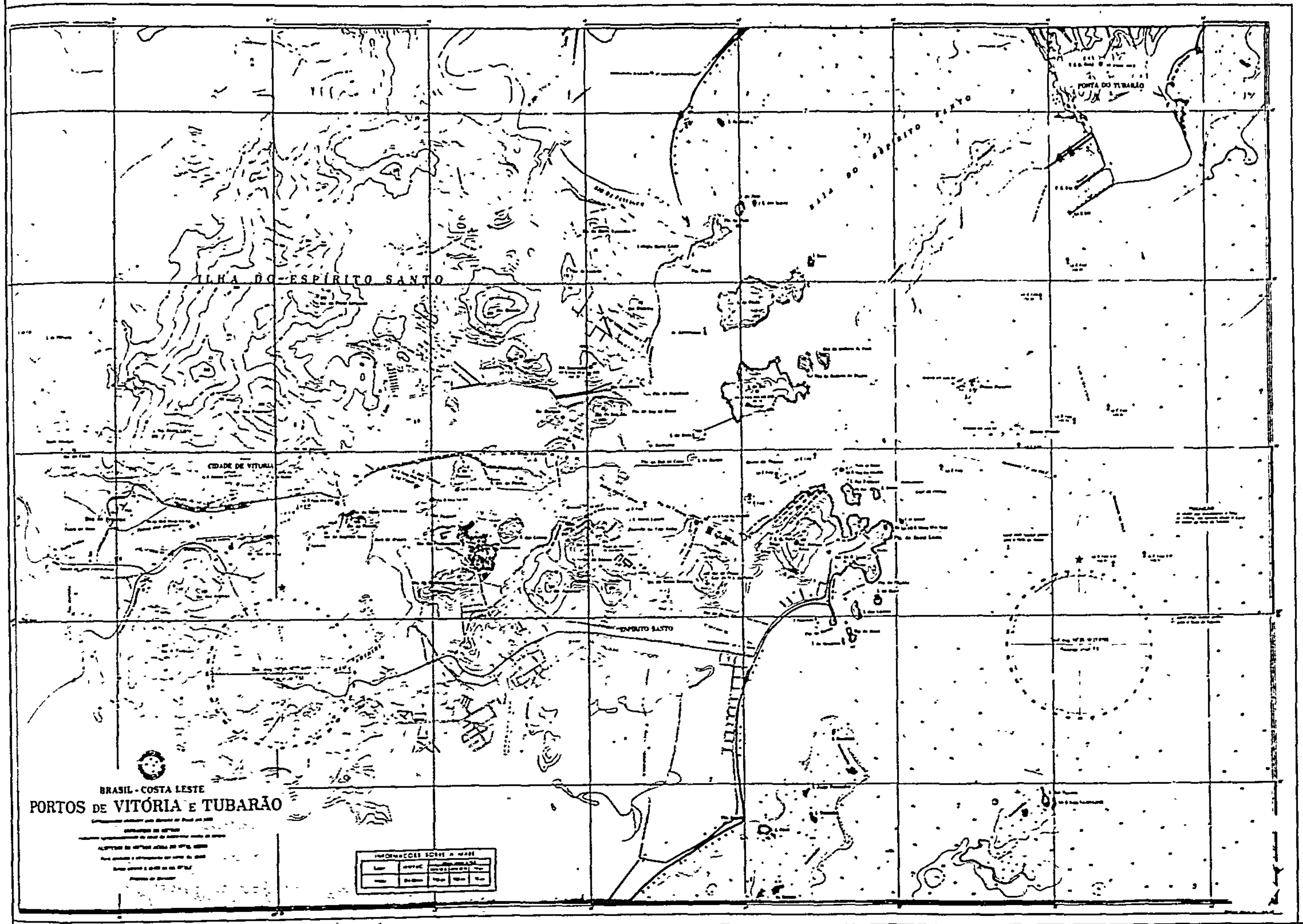
At Vitória Port, the construction of Capuaba Wharf is under way as a link of the Export Corridor Plan for the purpose of exporting iron and steel products and frozen products. In addition, it is planned to improve Atalia Wharf, adjacent to Capuaba Wharf, into a cereal wharf for the purpose of relieving the already overloaded commercial wharf.

2-5-2 Present state of port facilities

(1) Channels and turning basins

The enterance channel and turning basin have been separated from those for Tubarão Terminal, with the exception that the enterance channel cross each other at some part outside the bay.

The enterance channel to the commercial and industrial wharves is running nearly east to west along Santa Maria Inlet, and has a depth of -13 m, a width of 120 m and an aggregate length of about 3.5 km. The basin included between the commercial and industrial wharves have a width of about



REFERÊNCIA:
CARTA NAÚTICA Nº 1401

QUILOMETROS

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Fig. 2.5.1 Location of Vitória Port

CONSÓRCIO PLANAVE - RENDEL, PALMER & TRITTON
AV GRAÇA ARANHA 182 - 8º AND GUANABARA

PLANO DIRETOR PORTUÁRIO DO BRASIL
V I T Ó R I A
C A R T O G R A F I A
C A R T A N A Ú T I C A
SITUAÇÃO DO PORTO

Nº PROJETO: 30.633-E
Nº DESENHO: 54/101101
ESCALA:
CALC:
PROJ:
DES: Adilson
VERIF:
APROV:
DATA: 17/01/74

530 m, and the maximum turning basin available within the inlet is 330 m in diameter. At present, the vessels of up to 182 m are permitted free entry. The larger vessels are also permitted to enter with the help of tugboats during a specific zone of hours. The largest vessel that can enter the Port is 240 m. It seems that such a large vessel is let to come in and go out only in the daytime by making use of three tugboats. This enterance channel is planned to be widened to 220 m in future, but this is the maximum limit topographically.

The enterance channel serving Tubarão Terminal is running nearly north to south over an aggregate length of 8 km. It is -23 m in depth, 550 m in width. There is a 270 m diameter turning basin in front of the pier, and the ore carriers of up to 250,000 DWT are navigable.

(2) Mooring facilities

The commercial wharf is located on Espirito Santo Island, and has an aggregate quaywall length of 720 m. The port area is a narrow strip running along Vitória City, and has an aggregate area of 120,000 m^2. With the growth of Vitória City, the port area has grown into the hub of the city, and now there is no room to spare for further expansion. Since the port area at the back of the quaywall is narrow, the commercial wharf will not be able to grow any more.

On the other hand, the industrial wharf is pieced out with a special cargo terminal on the continental side. In addition, there are Paul Wharf (coal and ore) and Atalia Wharf (ore) which are used only for handling CVRD's iron ore and USIMINAS' coal. Since 1976, Atalia Wharf has hardly ever been used. The industrial wharf area is also equipped with ESSO Terminal and SHELL and TEXACO Terminal, unloading oils and alcohol. The SHELL and TEXACO Terminal has no mooring facilities to speak of, and the unloading is made from vessels anchoraged in front of Capuaba Wharf. Once Capuaba Wharf is put into operation, the berth will not be available to SHELL and TEXACO Terminal any longer.

Tubarão Terminal has two iron ore loading piers for CVRD use only and PETROBRÁS' quay for domestic import of oils. No. 2 ore loading pier is capable of accommodating 250,000 DWT carriers.

Fig. 2.5.2 and Table 2.5.1 show the layout and list of port facilities in Vitória Port.

2-5-3 Operational conditions of facilities

(1) Vessels coming in and leaving the Port

Vitória Port is called at by about 2,000 vessels a year, or about 3.5% of the national total. It should be borne in mind, however, that the proportion of ocean-going vessels is large. The ratio of the ocean-going vessels to the national total is about 10%, and most of them call at Tubarão Terminal for loading iron ore.

A great part of the vessels are large-sized vessels; ships of 10,000 DWT and larger account for 58.5% and those of 100,000 DWT or larger account for 15.8%. Type-wise, ore carriers lead the list with 37% of the total, followed by general cargo ships with 34%, oil carriers and coal carriers in turn.

Table 2.5.2 shows the transition of the ships entering the port during the past three years, and Table 2.5.3 the tonnage classification of the ships which visited in 1976.

(2) Cargo traffic

In 1975, the cargo handled at Vitória Port amounted to about 58,000 thousand tons, or about 30% of the national total. It should be added that some 40% of foreign trade cargoes in Brazil was handled at Vitória Port. This was due mainly to the iron ore exported from Tubarão Terminal.

According to the achievements in 1975, the bulk cargoes opened up a lead over general cargoes which amounted to about 300 thousand tons handled mainly at the commercial wharf. Of the bulk cargoes, about 3,316 thousand tons was handled at the industrial wharf, and the remainder which amounted to about 54 million tons was loaded at Tubarão Terminal.

By type of cargoes, iron ore for domestic and foreign export amounted to 54 million tons, or an overwhelming 94% of all, followed by the domestic and foreign import of coal, coke and oils and export of iron and steel

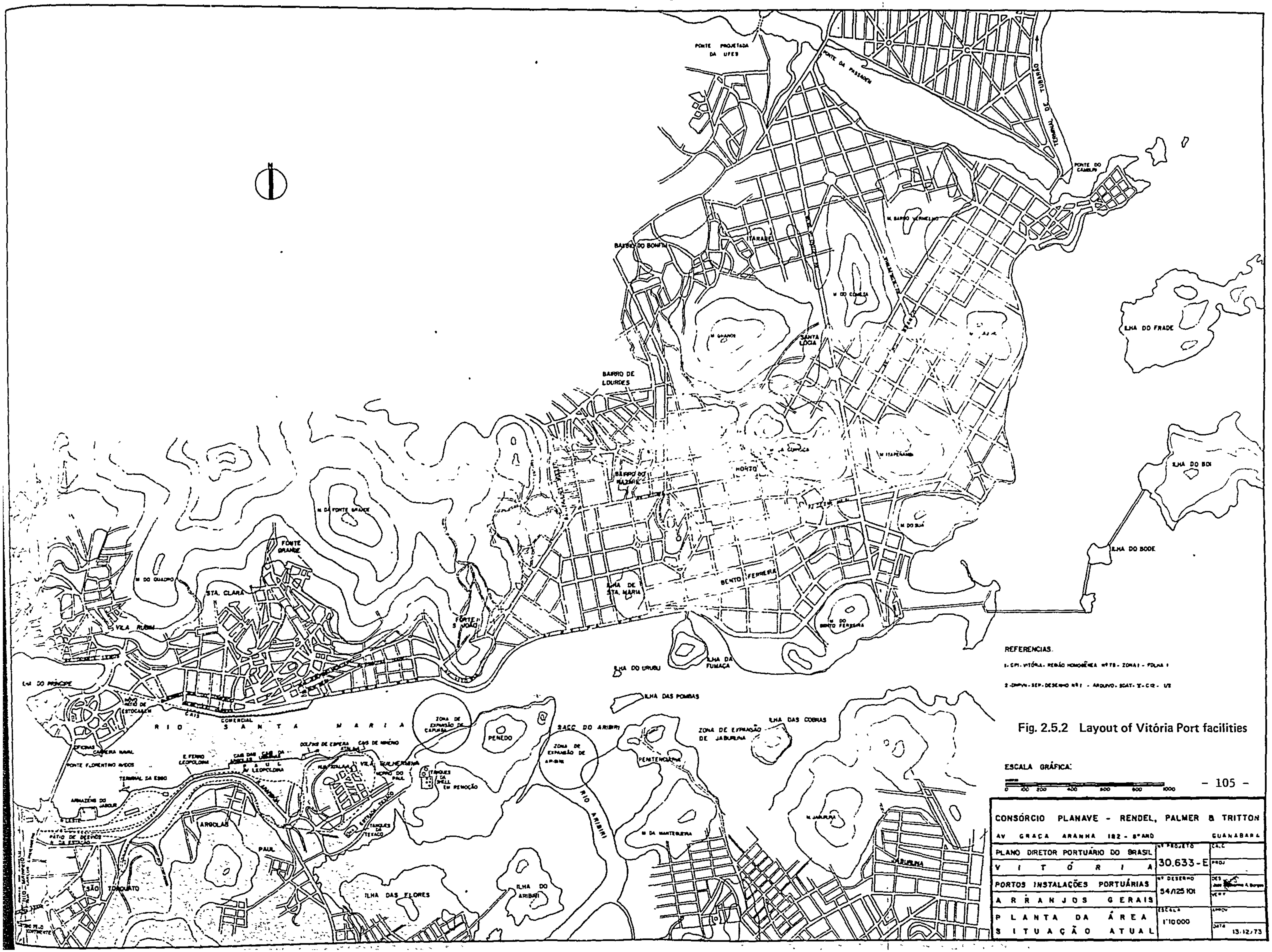


Fig. 2.5.2 Layout of Vitória Port facilities

Table 2.5.1 A comprehensive list of mooring facilities in Vitória Port (as of April, 1977)

Site	Name	Length	Water depth	Main	Facilities
Commercial wharf	No.1 Wharf	150 m	-3.0m ~ -10m	General cargoes	Warehouse, 9,600 m ; open storage yard, 93,200 m^2; cranes (1.5 t ~ 12.59 t) × 13 units
	No.2 "	215 m	-8.5m ~ -10m	"	
	No.3 "	355 m		"	
Industrial wharf	Paul wharf A	260 m	-11 m	Coal for Usiminas	240T/H unloader yard, 60,000 m^2
	" B	160 m	-11 m	Iron ore	700T/H shiploader storage, 25,000 t
	Atalaia wharf	110 m	-11 m	Iron ore	1,700T/H shiploader storage,135,000t
	Esso Terminal	Dolphin × 1 unit	-7.6 m	Oils	28,700 m^3 tank
	Shell & Texaco Terminal	Buoys	-	Oils	
(Facilities under construction)	Capauba Terminal	541 m	-13 m	Iron products, etc.	Refrigerated warehouse, warehouse, 11,500 m^2; open storage yard, 150,000m^2
	Cereal Terminal	220 m	-13 m	Cereals	Silo, 90,000 t
	(Modification of Atalaia Wharf)				
Tubarão Terminal	Tubarão No.1 Pier	680 m	-18 m	Iron ore	8,000 T/H unloader × 2 units
	Tubarão No.2 Pier	350 m	-21 m	"	2,500 T/H unloader × 2 units
	Petrobras Wharf	140 m	-16 m	oils	

Table 2.5.2 Transition of vessels calling at Vitória Port

(in thousand tons)

Year	National total			Vitória Port			Remarks
	Ocean-going	Coastal	Total	Ocean-going	Coastal	Total	
1973	11,778	20,445	32,223	1,204 (10.2)	649 (3.2)	1,853 (5.6)	
1974	10,905	20,249	31,154	1,203 (11.0)	725 (3.6)	1,928 (6.2)	
1975	11,184	39,129	50,313	1,079 (9.6)	732 (1.9)	1,811 (3.6)	

Notes : 1. Vitória Port includes Tubarão Terminal.

2. The values in parentheses are percentages to national total.

Table 2.5.3 Tonnage classification of vessels calling at Vitória Port (1976)

Unit : Number of ships

Classification (D.W.T.)	Ocean-going	Coastal	Total	%	Remarks
∿ 5,000	41	405	446	33.5	
5,000 ∿ 10,000	75	31	106	8.0	
10,000 ∿ 20,000	152	98	250	18.8	
20,000 ∿ 40,000	102	10	112	8.4	
40,000 ∿ 60,000	104	-	104	7.8	
60,000 ∿ 80,000	64	-	64	4.8	
80,000 ∿ 10,000	38	-	38	2.8	
100,000 ∿	210	-	210	15.8	
Total	786	544	1,330	100	

products.

Tables 2.5.4, 2.5.5 and 2.5.6 show the cargo traffic.

2-5-4 Problems of Vitória Port

① The enterance channel to the commercial and industrial wharves has a width of 120 m and a depth of -13 m, and is planned to be widened to 220 m in future. Even after widening, the largest vessel that can enter is 50,000 DWT. Worse, no further expansion is possible because of topographical limitations.

Considering the fact that the carriers of coal, iron ore and oil have been growing in size, Vitória Port will soon become unable to handle these types of cargoes.

② The space at the back of the commercial wharf is only about 45 m in width. This is too narrow to rationalize the cargo handling operations. Since the commercial wharf is at the center of Vitoria City, there is no room for its improvement. The streets leading to the main roads have been congested to the great detriment of overland transportation.

③ Ore loading capacity of Tubarão Terminal is about 100 million tons a year even when No. 2 pier is added with belt conveyors. Tubarão Terminal leaves no room for expansion.

Table 2.5.4 Transition of cargo traffic through Vitória Port

(in thousand tons)

Year	National total			Vitória Port			Remarks
	Foreign trade	Domestic trade	Total	Foreign trade	Domestic trade	Total	
1973	113,418	32,471	145,889	43,379 (38.12)	1,361 (4.2)	44,740 (30.7)	
1974	136,663	39,777	155,330	53,112 (38.9)	1,924 (4.8)	55,036 (35.4)	
1975	146,815	43,722	190,537	55,823 (38.0)	1,898 (4.3)	57,721 (30.3)	

Note : Vitoria Port includes Tubarão Terminal.
The values in parentheses are percentages to national total.

Table 2.5.5 Volume of cargo handled at Vitória Port as classified by packing style (1975)

(in thousand tons)

Classification	Inbound				Outbound				Total
	Bulk		General cargoes	Subtotal	Bulk		General cargoes	Subtotal	
	Solid	Liquid			Solid	Liquid			
Vitória Port	1,697	381	176	2,254	1,238	-	117	1,355	3,609
Tubarão Terminal	-	513	-	513	53,358	240	-	53,598	54,111
Total	1,697	894	176	2,767	54,596	240	117	54,953	57,720

Note : Vitória Port refers to the commercial and industrial wharfages.

Table 2.5.6 Commodity breakdowns of cargo traffic (1975)

in thousand tons

Article	Foreign trade			Domestic trade			Subtotal		
	Export	Import	Total	Export	Import	Total	Export	Import	Total
Iron ore	53,792	-	53,792	336	-	336	54,128	-	54,128
Coal and coke	-	1,247	1,247	30	327	357	30	1,574	1,604
Oils	-	26	26	240	894	1,134	240	920	1,160
Iron products	483	87	570	2	1	3	485	88	573
Others	68	121	189	2	64	66	70	185	255
Ground total	54,343	1,481	55,824	610	1,286	1,896	54,953	2,767	57,720

CHAPTER 3. TUBARÃO STEEL MILL CONSTRUCTION PLAN

3. Tubarão Steel Mill construction plan

3-1 Outline

The iron and steel industry in Brazil is a comparatively new business. But Brazil now is ranked the 15th largest iron and steel making country following Australia. As shown in Table 3.1.1, Brazil is the largest producer of all the Latin American countries, holding more than 40% of Latin America's total output.

Table 3.1.1 Crude steel output in Latin American countries

(in thousand tons)

	1974	1973	1972	1971	1970
Latin America					
Argentina	2,366	2,205	2,141	1,915	1,823
Brazil	7,572	7,150	6,518	5,997	5,390
Central America	15	10	6	9	8
Chile	654	549	631	654	592
Colombia	325	362	373	325	310
Cuba		220			140
Mexico	5,103	4,760	4,431	3,821	3,811
Peru	485	356	181	179	94
Uruguay	14	12	13	15	16
Venezuela	1,043	1,063	1,128	924	927
Total Latin America	17,844	16,687	15,617	13,999	13,101

Table 3.1.2 Production of pig iron and crude steel

(in thousand tons)

Classification	1974	1975	1976	Remarks
Pig iron	5,846	7,053	8,048	
Crude steel	7,507	8,309	9,174	

In 1976, the output of crude steel was 9,174 thousand tons of which about 48% was accounted for by steel plates and 52% by non-steel plates. (See Table 3.1.2)

The steel mills are located near São Paulo, Rio de Janeiro and Belo Horizonte which are the largest iron and steel consuming market in Brazil. Transportation of iron ore to the mills is very easy. Ranked among three biggest steel mills CSN, COSIPA and USIMINAS which are all national companies. They turn out about half the national total production. (See Table 3.1.3)

Table 3.1.3 Production by steel mill (Jan. to Nov., 1976)

(in thousand tons)

	Pig iron		Crude steel		Steel plate & oth steel products	
	Q'ty	Ratio	Q'ty	Ratio	Q'ty	Ratio
CSN	1,091	0.12	1,237	0.15	994	0.15
COSIPA	685	0.09	700	0.08	752	0.11
USIMINAS	1,539	0.24	2,124	0.26	1,526	0.23
Subtotal	3,315	0.45	4,061	0.49	3,272	0.49
ACESITA	179	0.03	267	0.04	155	0.04
COSIGUA	-		306	0.05	239	0.05
MANNESMAN	321	0.04	516	0.06	370	0.06
Others	3,474	0.48	3,194	0.38	2,682	0.36
Subtotal	3,974	0.55	4,283	0.51	3,449	0.51
Total	7,289		8,344		6,721	

Table 3.1.4 Production and consumption of steels in Brazil

	1974			1975			
	Steel plate	Other steel products	Total	Steel plate	Other steel products	Total	Remarks
Domestic product	2,618.5	3,141.9	5,760.4	3,112.0	3,532.0	6,644.0	
Imports	2,762.7	875.8	3,638.5	1,476.0	604.7	2,080.7	
Exports	35.0	108.6	143.6	58.2	67.7	125.9	
Domestic consumption	5,346.2	3,909.1	9,255.3	4,529.8	4,069.0	8,598.8	

In addition, there are some 40 mills in Brazil. They are operated on a small scale except for some. Tables 3.1.2 and 3.1.3 show the production records of pig iron and crude steel in Brazil.

The consumption of steels is shown in Table 3.1.4. In 1975, the domestic consumption amounted to about 8,600 thousand tons, far above the domestic production. Namely, about 2 million tons or about 24% of the total consumption was imported from abroad. Compared with the year-before level, the consumption growth in 1975 was 7.6% as against the ten-year average annual growth rate of 9% (1960 - 1970), which was higher than any other country in the world.

Realizing the domestic demand for steels and with the hope of making Brazil a supplier of iron and steel to the Latin American countries, the Brazilian Government is making every effort to bring up the iron and steel industry in the country. The Brazilian Government is expanding the big three national steel mills - CSN, COSIPA and USIMINAS, and is now planning the construction of Itaqui Steel Mill, AÇOMINAS Steel Mill, Mendes Junior Steel Mill and Tubarão Steel Mill as large-scale through steel mills. AÇOMINAS and Tubarão Steel Mills are under construction with a view to putting them into partial operation in around 1981.

3-2 Tubarão Steel Mill construction plan

3-2-1 Background of the plan

Marked progress in Brazilian industry in recent years has caused a shortage of iron and steel supply against demand, pressing the Brazilian Government to make up and implement a self-sufficiency plan for iron and steel. Furthermore, the Brazilian Government is endeavoring to promote export for the purpose of improving its trade balance, to export semi-finished products rather than primary products such as iron ore, and at the same time to bring up the iron and steel industry as the mainstay of the Brazilian industry.

For these reasons the construction of Tubarão Steel Mill has become one of the most important national projects mapped out and pushed forward by the Brazilian Government. It is also expected that the construction of Tubarão Steel Mill serves a great spur to the promotion of the regional development in Espirito Santo State.

The plan to build a modern through steel mill in Tubarão, Espirito Santo State was prepared by the Brazilian Government in the beginning of 1973. Later, Japan and Italy decided to participate in the plan as a link of their economic cooperation programs, and in March, 1974, Tubarão Steel Mill (CST) was established as a pilot company by joint efforts of Japan, Italy and Brazil. Since then, the feasibility study of the steel mill construction project has been pushed forward under the lead of CST. In june, 1976, CST changed its articles of incorporation in order to launch upon the construction of steel mills in addition to the production of iron and steel.

CST is 51% owned by SIDERBRÁS, a Brazilian iron and steel public corporation, and 24.5% each of the rest by the Japanese business group led by Kawasaki Steel Corp., and Finsider International of Italy. CST is expected to turn out 3 million tons a year of slabs after completion of the first stage (May, 1981) and 6 million tons a year of slabs and blooms after completion of the second stage. Yet, there is a room for the expansion of another 6 million tons. The three partners are determined to take charge of the products in proportion to their subscription rate in principle. (SIDERBRÁS: 51%; Finsider: 24.5%; Kawasaki: 24.5%)

At present, CST has its head office in Vitória City, and is engaged in the preparation of construction implementation plan and development of construction site.

3-2-2 Tooling-up plan

The activities of CST center on the production of pig iron by blast furnaces and steel by converters. In the first stage, one blast furnace and two converters will be built, and in the second stage, they will be strengthened to two and three, respectively. In the first stage, blooming mill will be installed, and in the second stage two continuous casting mills will be installed.

The principal equipments to be installed in the first stage are as follows.

① Coal yard and coke oven furnace

Coal yard	:	Storage capacity, 60 days' worth
Stacker/reclaimer	:	3 units, each having a capacity of 4,000/750 tons/hr.
Coke oven furnace	:	3 batteries, each having 47 gates and a height of 6,500 mm

② Beneficiator, sintering furnace and blast furnace

Car dumper	:	1 set, 3,600 tons/hr.
Iron ore yard	:	2 yards, with 20 days' worth of storage capacity
Stacker/reclaimer	:	2 units, 3,600/2,500 tons/hr.
Ore bed	:	2 beds
Stacker/reclaimer	:	1 unit each, 2,500 tons/hr.
Sintering facilities	:	1 set
Blast furnace	:	1 unit, with a planned melting capacity of 3,285,000 tons/year and an inner capacity of 4,415 m^3

③ Converter facilities

Converter	:	2 units, with a planned steel-making capacity of 3,371,000 tons/year, charging capacity of 280 tons and an inner volume capacity of 490 m^3

④ Blooming mill facilities

Blooming mill	:	1 unit, with a planned output capacity of 3,000,000 tons/year
Soaking pit	:	30 pits, 140 tons each

3-2-3 Mill layout plan

Fig. 3.2.1 shows a layout of Tubarão Steel Mill.

3-2-4 Construction schedule of Tubarão Steel Mill

Fig. 3.2.2 shows the construction schedule of Tubarão Steel Mill.

3-2-5 Equipment investment plan

The equipment investment plan is as shown in Table 3.2.1.

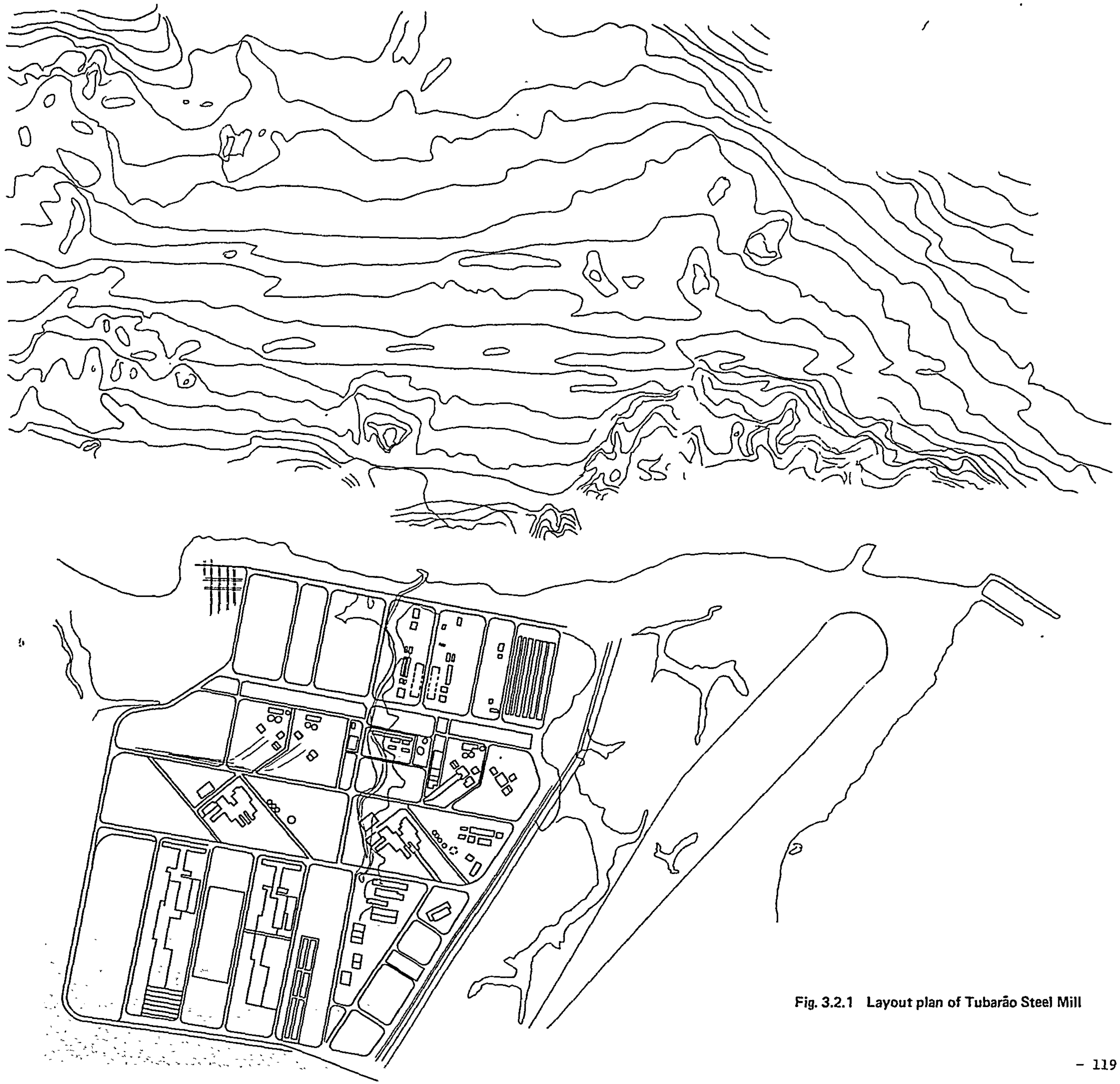


Fig. 3.2.1 Layout plan of Tubarão Steel Mill

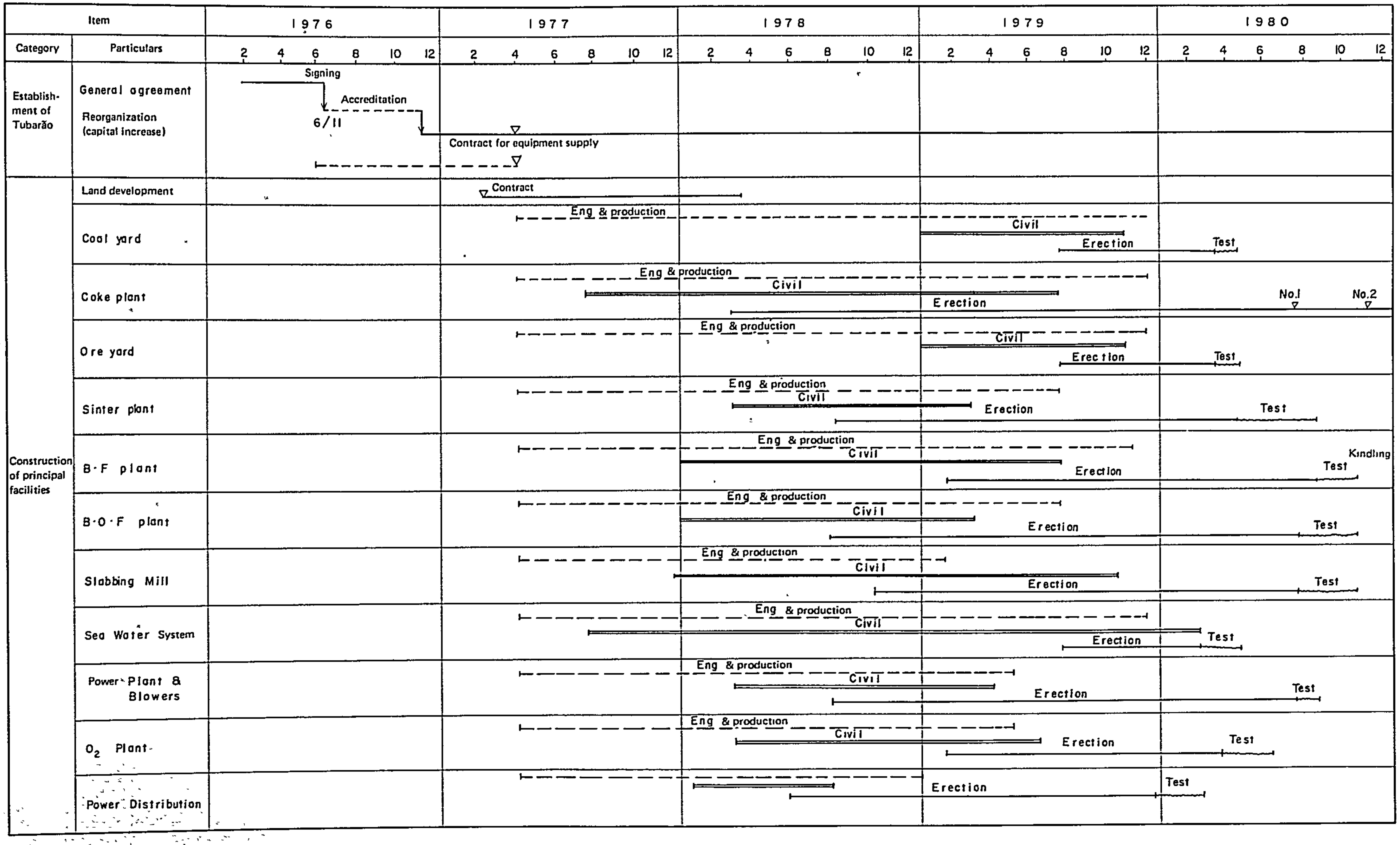


Fig. 3.2.2 Construction schedule of Tubarão Steel Mill

Table 3.2.1 Equipment investment plan

in US$ million

Item		Amount
Equipment funds	Japan	514
	Italy	495
	Brazil	394
Land acquisition	Brazil	6
Civil works	Brazil	294
Installation work	Brazil	338
Supervision		19
Engineering		34
Subtotal		(2,094)
Expenditures before commissioning		154
Interest on construction investments		212
Taxes, IPI, ICM, etc.		17
IPI (credit)		-
Financial transaction tax		8
Working funds		78
(Total investments)		(2,563)
Borrowings during operation		0
Total required funds		(2,563)

CHAPTER 4. MASTER PLAN FOR PRAIA MOLE PORT

4. Master plan for Praia Mole Port

4-1 Surveys so far made in relation to the master plan

4-1-1 Surveys by CST

CST studied candidate port sites along with a survey for the planning the mill facilities, and compiled its achievements into a report titled "Final Report of Port Project for Feasibility Study of Tubarão Steel Mill, Sept. 5, 1974."

In the report, the port selected for Tubarão Steel Mill is planned to meet the first-stage output of 3 million tons to begin with, and a space allowance is provided for the future expansion of the port in consideration of future growth in the iron and steel output. For the first stage, a berthage having an aggregate length of 800 m and a depth of -17 m is planned in order to handle semi-finished iron and steel products of CST and coal for CST and USIMINAS.

CST discussed three port plans as shown in Figs. 4.1.1 and 4.1.2; Tubarão within the Bay of Espirito Santo, Camburi at the head of Cape Tubarão, and Praia Mole on the east beach adjacent to the mill construction site. In CST's opinion, Tubarão plan involves a technical problem in dredging the channel, and the remaining two plans are technically feasible. Particularly, CST recommended the Camburi plan. However, the Camburi plan interferes with the shoreline owned by CVRD, and cannot be realized unless CVRD's consent is obtained. For this reason, the Praia Mole plan was finally proposed.

CST's plan was made for Tubarão Steel Mill and USIMINAS only, and no allowance was taken for the future development of the port as a public one.

Later, the Brazilian Government decided to shape the port of Praia Mole into a public port, and CST's study report served as a basic data upon which the Brazilian Government could plan Praia Mole Port.

4-1-2 Surveys by PLANAVE

At the request of PORTOBRÁS, PLANAVE started a survey in September, 1974 in order to map out a plan for developing Praia Mole as a public port.

Plan PRAIA MOLE (final), Plan TUBARÃO, and Plan CAMBURI

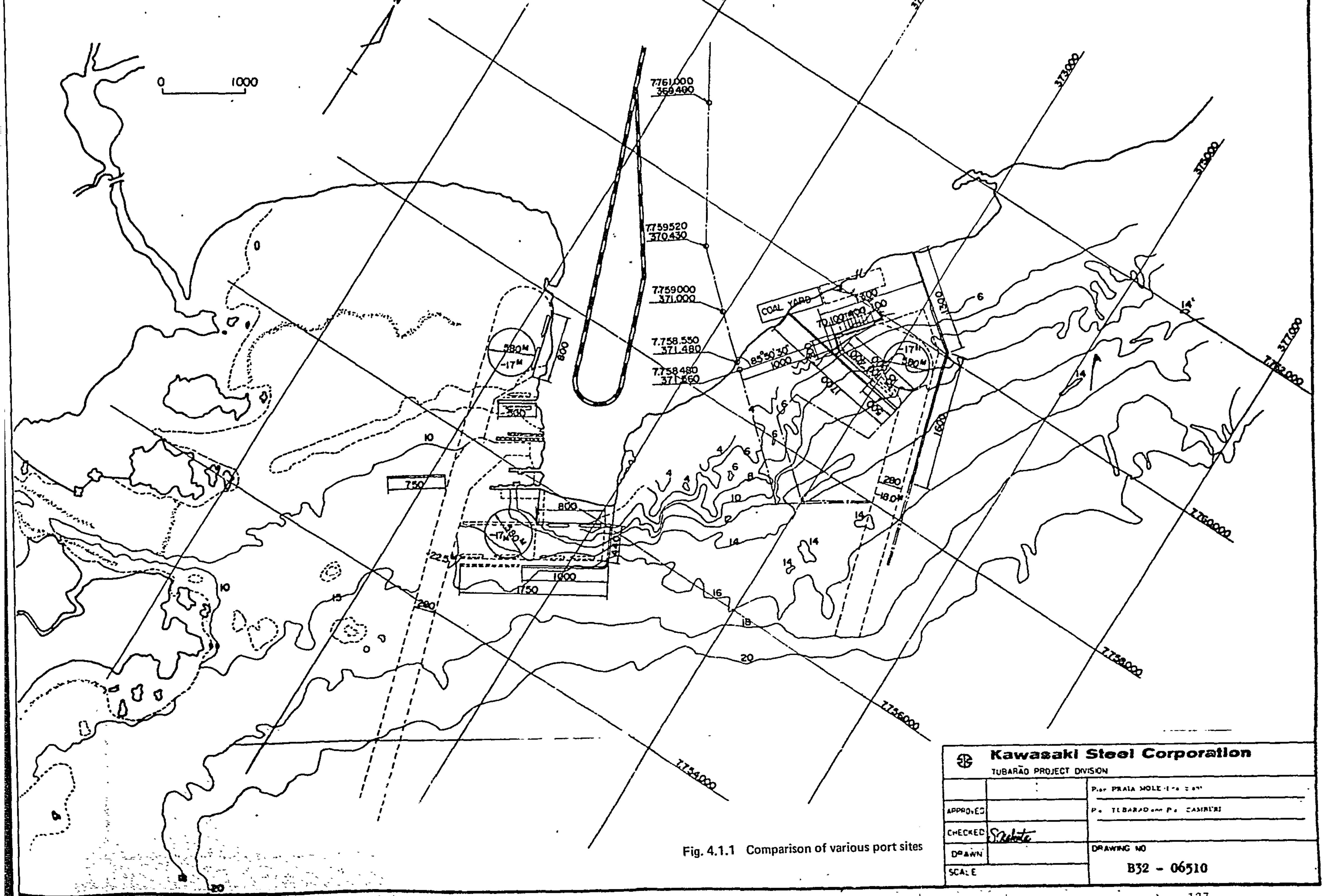


Fig. 4.1.1 Comparison of various port sites

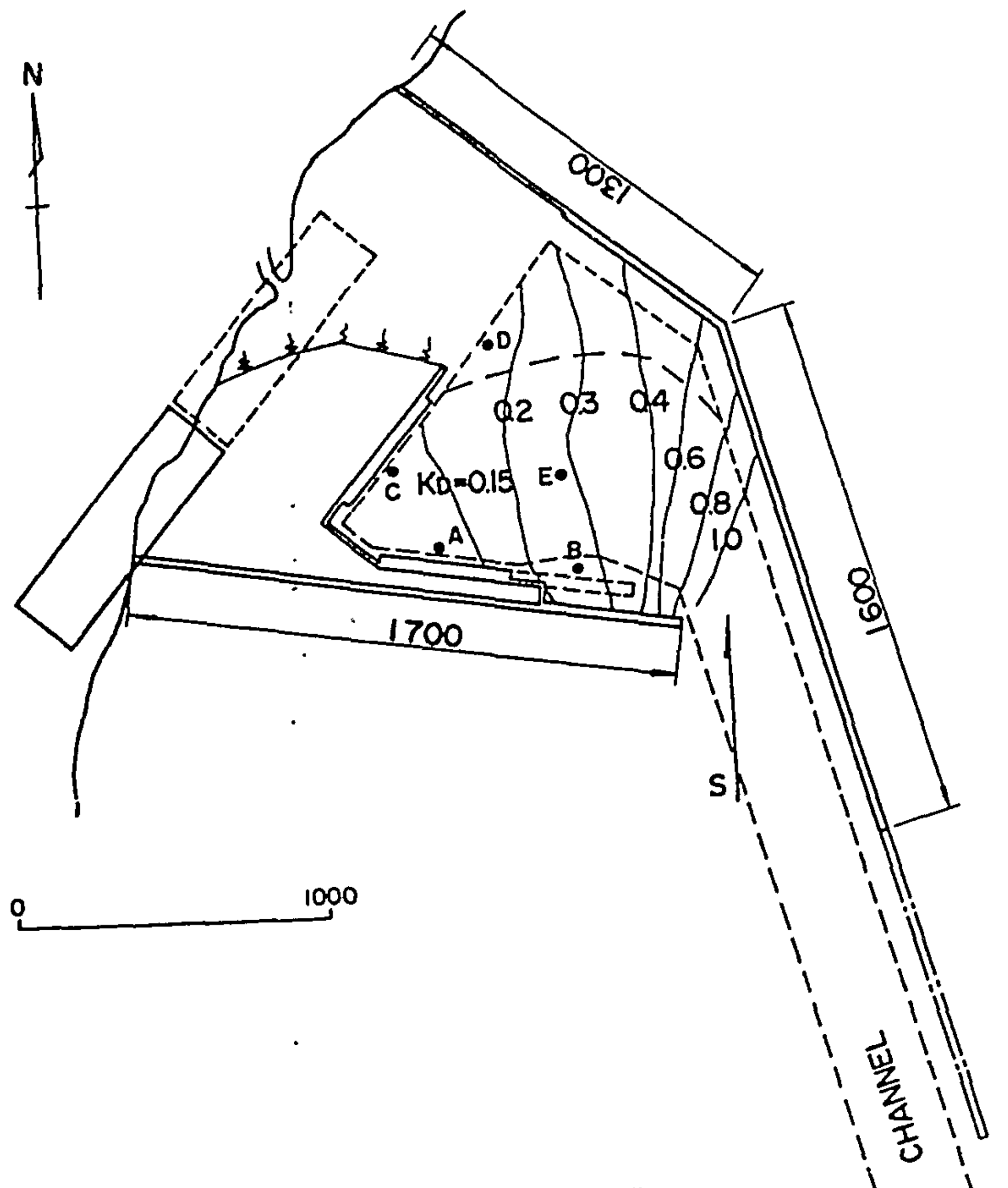


Fig. 4.1.2 Plan of the port of Praia Mole (by CST)

WAVE PELIOD T = 12"

WAVE LENGTH L = 150m

HARBOR ENTRANCE DEPTH H = 19m

REFLECTION COEFFICIENT

RUBBLE	0.4
WHARF	0.8

$A = \sqrt{0.11^2 + (1.0 \times 0.4)^2} = 0.41$

$B = \sqrt{0.2^2 + (1.0 \times 0.4)^2} = 0.45$

$C = \sqrt{0.11^2 + (0.8 \times 0.4)^2} = 0.34$

$D = \sqrt{0.14^2 + (0.4 \times 0.4)^2} = 0.21$

$E = \sqrt{0.3^2 \times (1.0 \times 0.4)^2} = 0.50$

AVAILABILITY

CHANNEL (LOWER THAN 1.5m)	99.2%
TURNING BASIN (" 1.0m)	100.0%
WHARF	
(" 0.7m)	99.5% AT A POINT
(" 0.5m)	99.1% " C "

Kawasaki Steel Corporation

TUBARÃO PROJECT DIVISION

d			Plan PRAIA MOLE (Reflection Analysis)
c	APPROVED		
b	CHECKED	S. Nakata	
a	DRAWN		DRAWING NO. B32 – 06511
	SCALE		

RE . . DATE NAME

The results were compiled into a report titled "Estudos Para Implantação do Porto de Praia Mole - ES, minuta do relatório final (1976)."

In the report, discussions were made on a long-term basis over the ultimate production scale of Tubarão Steel Mill (12 million tons), handling of public cargoes such as oils and cereals and also of bulk cargoes by large-sized carriers while presenting a detailed plan of handling semi-finished iron and steel product and coal for the CST's second stage production (6 million tons), and coal and oil for USIMINAS. Fig. 4.1.3 shows the plans proposed by PLANAVE.

The planned mooring facilities include two coal berths for 80,000 DWT ships, three slab berths for 120,000 DWT ships and one oil berth of 60,000 DWT ships, and the total berthage, including the future expansion space is protected by north and south breakwaters with an aggregate length of 6,280 m. In this plan, it is possible to construct the port step by step from south to north in keeping with the construction stage of Tubarão Steel Mill. Namely, the plan places an emphasis on minimizing the initial investments.

The Praia Mole Port Construction Project for which President Geisel requested the Japanese Government to extend economic cooperation to Brazil was based on this PLANAVE's survey report.

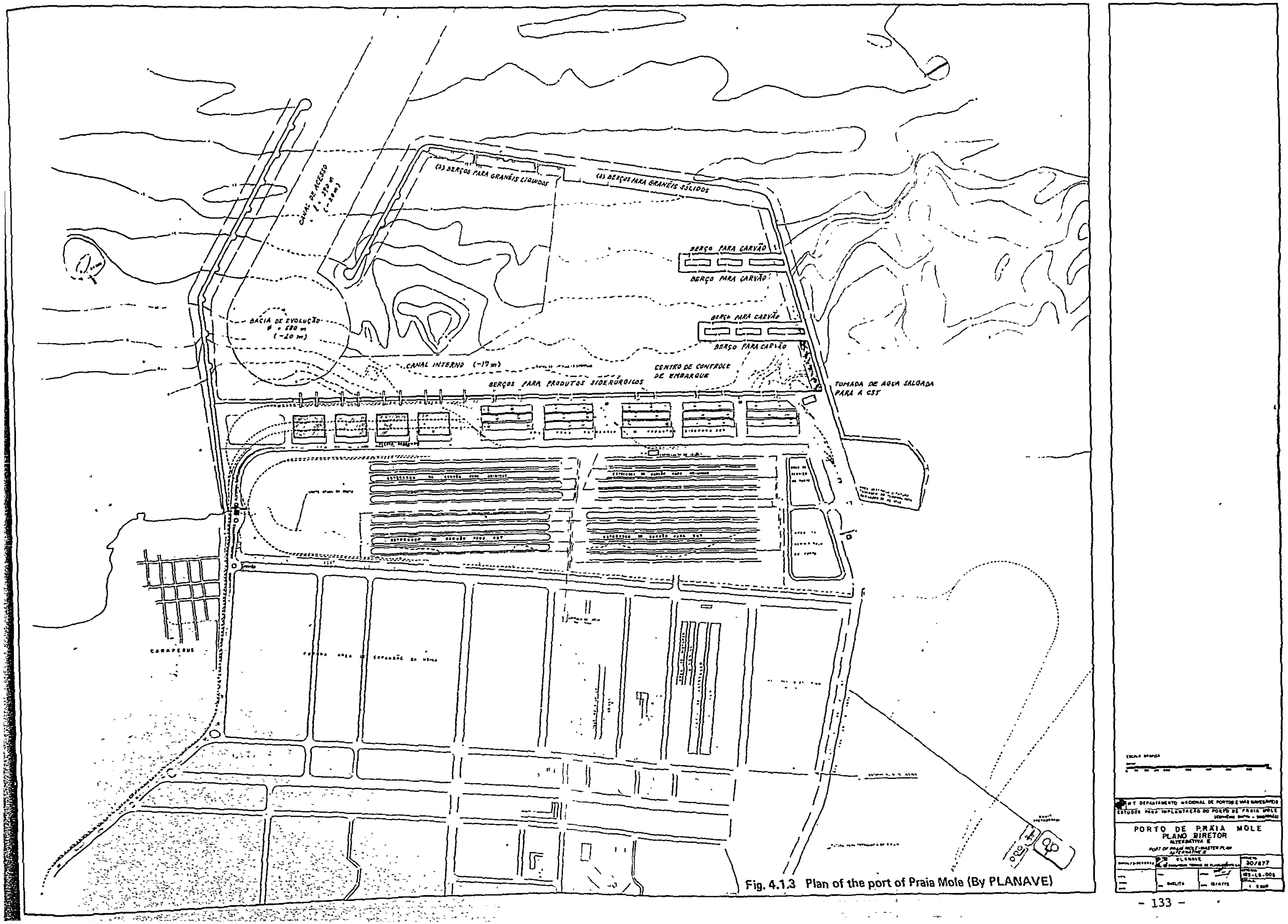


Fig. 4.1.3 Plan of the port of Praia Mole (By PLANAVE)

4-2 Basic principles for the port planning

① We are of the opinion that the port of Praia Mole must handle not only raw materials and semi-finished products of Tubarão Steel Mill, and coal and oils for USIMINAS, but also, taking a part of Vitória Port's functions, serve as a public port to handle the cargoes which will rise with the growth of the hinterland. What has been identified as cargoes to be handled by Praia Mole Port, for the time being, includes the raw materials and semi-finished iron and steel products for Tubarão Steel Mill and coal for USIMINAS. Tubarão Steel Mill is the largest single user for the moment. It is, therefore, necessary to take fully into account the various Tubarão Steel Mill's plans in planning Praia Mole Port.

② It has been said that Tubarão Steel Mill will produce 12 million tons of slabs a year in the ultimate stage. The plan set out in the concrete is still within the pale of 6 million tons a year in terms of mill production scale, and no further plan has been decided upon yet. For this reason, the time when the production of 6 million tons a year will be ready is taken as a target year for the project.
An ample space for expansion is, however, secured for what will be required thenceforth as a result of the production increase, the increased mill-related cargoes and to handle various cargoes which will also rise in volume. The detailed layout of the facilities indispensable for such expansion must be left to future studies.

Tubarão Steel Mill is scheduled to be put into commission in May, 1981, and all possible measures should be taken to complete the port in time for the commissioning of the Mill.

③ Up until now, none of the problems surrounding the participation of CVRD in the project has been solved. It is ovserved, however, that the participation of CVRD will be of great benefit not only to CVRD itself, but to PORTOBRÁS. We are of the opinion, therefore, that the planning must be made on presupposition that CVRD will take part in the project. In this case, the ore yard will be procured within the premises of CVRD's Tubarão Terminal, and hence no ore yard will be considered within the port area.

④ The yard for storing coal for USIMINAS should preferably be operated in conjunction with other related facilities from the viewpoint of economy. For this reason, it will be installed within the port area.

4-3 Targets of the plan

4-3-1 Target year

The master plan for the Port will be studied on a long-term basis in order to provide for the future expansion. In immediate confirmation of the feasibility, however, it is required to set a target year in tune with the operating schedule of Tubarão Steel Mill. Whereas Tubarão Steel Mill will see 12 million tons a year of slabs in the ultimate stage, the planned maximum production scale mutually agreed upon among Japan, Brazil and Italy is 6 million tons, and no definite plan has been set forth beyond that scale. What has been officially determined, however, is up to 3 million tons.

In this planning, studies were made with Tubarão Steel Mill operation divided into two stages - the 1st stage when the production at a rate of 3 million tons a year is ready and the 2nd stage when the production at a rate of 6 million tons a year is ready. Since Tubarão Steel Mill is scheduled to start 3 million tons a year production in May, 1981, the target year for the first stage was set at 1981. Although it is unknown when the second stage operation will start, it is assumed to be 1984, 3 years after the completion of the first stage, for the purpose of planning Praia Mole Port.

4-3-2 Cargo traffic at the Port

(1) Outline

The volume of cargoes to be handled at Praia Mole Port has already been projected and reported in detail by PLANAVE. It is judged that PLANAVE's estimate is moderate, and it will be enough to touch upon the cargo volume according to PLANAVE's report. Here some corrections are made because some parts of the expansion programs for the Brazilian steel mills have been put over recently.

In projecting the cargo volume to be handled at Praia Mole Port, it is most important to identify the functions to be divided between Praia Mole Port and the adjacent Vitória Port. Considering the existing state of

Vitória Port, particularly with respect to facilities, room for expansion and channel leading to commercial and industrial wharves, Praia Mole Port should be assigned the distribution function requiring large-sized vessels. We are of the opinion that, for the moment, Praia Mole Port should preferably undertake the functions as enumerated below.

① Acceptance of coal for CST and export of semi-finished products such as slabs.

② Acceptance of oils by taking over from Vitória Port and putting together for efficient operation the oil terminals which now are dispersed within Vitória Port.

③ Domestic and foreign import of coal for USIMINAS.

④ Export of iron ore or pellets produced in excess of the capacity of CVRD Tubarão Terminal.

The measures to be taken when the capacity of Tubarão Terminal is exceeded are being sought for by CVRD. It has been said that the maximum railway capacity to transport iron ore is 130 million tons. This capacity should be fully used for maximum economy. Partly because Tubarão Terminal is hard to be expanded beyond the existing plan and partly because Praia Mole Port is to be constructed by the side of it, it will be a good strategy for CVRD to use Praia Mole Port. Also, the participation of CVRD in the Praia Mole Port construction project will be of help to PORTOBRÁS business through taking a share in the costs for breakwater construction and dredging work.

The cargoes relating to the aforesaid functions are taken as the cargoes to be handled for the moment at Praia Mole Port.

(2) Slabs

The first stage operation of Tubarão Steel Mill is scheduled to begin with the inaugural firing of No. 1 blast furnace (inner volume: 4,410 m^3)

in May, 1981. But the second stage operation is left uncertain. For the purpose of planning, however, it is assumed that it will start in the beginning of 1984 with No. 2 blast furnace (with the same inner volume as No. 1 blast furnace) completed within 1983.

In PLANAVE's report, it is stated that the first stage operation will start in 1979 and that the second stage operation will come to reality in three years later, that is, in 1982. Judging from CST's recent plan and current progress of plant construction, the commissioning of Tubarão Steel Mill in 1979 will scarcely be realized. Table 4.3.1 shows CST's production plan of pig iron and slabs.

Table 4.3.1 Production plan of pig iron and slabs

(in thousand tons)

	Pig iron	Slab
1981	3,285	3,000
1984	6,570	6,000

It has been decided that Japan, Italy and Brazil are responsible for taking respective parts of slabs by prorogation of share-holdings. With reference to the first stage operation, for example, 1.5 million tons of slabs, or the half of the total output, will go to Japan and Italy, while the remaining half will be used for consumption in Brazil. One third of the domestic part will be sent to USIMINAS, and two thirds to CSN and COSIPA. The slabs thus distributed will be processed at respective places. The transportation of slabs to USIMINAS will be by CVRD's Vitória-Minas Railway, while the transportation to CSN and COSIPA will be by sea because the railway denies economic and technical feasibility so far as the existing circumstances stand.

Table 4.3.2 shows the volume of slabs to be handled at Praia Mole Port.

Table 4.3.2 Slabs to be transported by way of Praia Mole Port

(in thousand ton)

	Foreign export	Domestic export	Total
1981	1,500	1,000	2,500
1982	1,500	1,000	2,500
1983	1,500	1,000	2,500
1984	3,000	2,000	5,000
1985	3,000	2,000	5,000
1986	3,000	2,000	5,000
1987 *	3,000	2,000	5,000
1988 *	3,000	2,000	5,000

* : not including 3rd stage operation

It has been planned that the export of USIMINAS' products will be from Paul Wharf (to be specialized by changing the coal yard) of Vitória Port as ever and from Capuaba Wharf now under construction, and use of Praia Mole Port has not been considered.

(3) Coal

As already stated, Tubarão Steel Mill will start No. 1 blast furnace in May, 1981 and No.2 blast furnace in three years thereafter to turn out pig iron 3,285 thousand tons and 6,570 thousand tons, respectively.

On the other hand, the steel mill of USIMINAS has a pig iron production capacity of 3.5 million tons (No. 1 blast furnace with an inner capacity of 829 m^3; No. 2 blast furnace with an inner capacity of 829 m^3; No. 3 blast furnace with an inner capacity of 2,650 m^3), and is planning to build additionally a through steel production plant having a pig iron production capacity of 6 million tons. However, it is not clarified when the plan is implemented, but the through production plant is expected to be put into operation in around 1984. Coal necessary for these plants will be furnished 30% from domestic sources and 70% from overseas sources for USIMINAS and 10% from domestic sources and 90% from overseas sources for Tubarão. All the coal will be transported by sea and handled at Praia Mole Port.

The coal ratio is 638 kg/ton on the average (coke ratio: 400 to 420 kg/ton), and the volume of coal to be handled at Praia Mole Port will be as specified in Table 4.3.3.

(4) Others

For the moment, nothing definite is known about iron ore and pellets of CVRD. But, if the world's economy takes a turn for the better to step up the demand for iron ore or pellets, Tubarão Terminal will be overloaded in a few years. In such an event, approximately 40 million tons of iron ore or pellets will be handled at Praia Mole Port for efficient use of the facilities.

(5) Oil

As regards oil consumption in Vitória region, PETROBRÁS has made a forecast by the year 1980 as shown in Table 4.3.4.

The demand for oil from 1980 forth has been projected by PLANAVE by type of article based on the past records as follows.

<u>Yearly growth rates of oil demand</u>

Gasoline	9.0%
Diesel oil	8.0%
Combustion oil	6.0%

If the oil estimated to grow at these rates is all handled at Praia Mole Port, the volume of oil to be handled at Praia Mole Port will increase as calculated in Table 4.3.5.

Table 4.3.3 Coal by way of Praia Mole Port

(in thousand tons)

Classification	1981			1984		
	Foreign import	Domestic import	Total	Foreign import	Domestic import	Total
Usiminas Steel Mill	1,563	670	2,233	2,680	1,148	3,828
Tubarão Steel Mill	1,936	215	2,151	3,757	417	4,174
Total	3,499	885	4,384	6,437	1,565	8,002

Note : To start No.1 blast furnace of Tubarão Steel Mill in May, 1981 presupposes the import of coal at Praia Mole from Dec., 1980.

Table 4.3.4 Demand forecast of oil in Vitória Region (by PETROBRÁS)

(in thousand tons)

Product	1975	1976	1977	1978	1979	1980
Gasoline	225	247	272	299	329	361
Kerosine	15	15	15	15	15	15
Diesel oil	341	377	417	462	513	568
Cumbustion oil	494	730	1,247	1,795	1,939	2,094
Total	1,075	1,369	1,951	2,571	2,796	3,038

Table 4.3.5 Forecast of oil demand

(in thousand tons)

Product	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Gasoline	329	361	393	429	468	510	555	605	660	719
Kerosene	15	15	15	15	15	15	15	15	15	15
Diesel Oil	513	568	613	663	716	773	835	901	973	1,051
Combustion Oil	1,939	2,094	2,220	2,353	2,494	2,644	2,802	2,970	3,149	3,338
Total :	2,796	3,038	3,241	3,460	3,693	3,942	4,207	4,491	4,797	5,123

(6) Summary

To sum up the above discussions, the cargo volume to be handled at Praia Mole Port at the first and the second stage will be as shown in Table 4.3.6.

4-3-3 Planned vessels

The vessels should be planned by type of cargo in consideration of transport economy as well as the accommodation capacity of the counterpart ports.

(1) Slabs

It has been planned that the slabs for Italy are transported by 80,000 DWT slab carrier, while a study is being made on the transportion of slabs for Japan together with iron ore by ore carrier which calls at Tubarão Terminal. According to Kawasaki Steel Corp., the recipient of slabs for Japan, it is planning to assign for slab transportation 120,000 DWT class ore carriers plying now between Tubarão Terminal and Japan. It has been said that the draught will be within -15 m for the purpose of slab loading. The largest ocean-going vessel is, therefore, 120,000 DWT ore carrier, and will be operated at an applicable draught within the water depth of -15 m required of the slab carrier for Italy.

As regards the domestic slab carriers, there is no definite plan because the facilities for the unloading ports have not yet been determined, but vessels of 30,000 to 50,000 DWT class are expected to be used.

Table 4.3.6 A comprehensive list of cargoes to be handled at Praia Mole Port

(in thousand tons)

		1st stage			Master plan		
		Foreign trade	Domestic trade	Total	Foreign trade	Domestic trade	Total
Semi-finished steel products Slab	Outbound	1,500	1,000	2,500	3,000	2,000	5,000
	Inbound	-	-	-	-	-	-
	Total	1,500	1,000	2,500	3,000	2,000	5,000
Bulk (solid)							
Coal	Outbound	-	-	-	-	-	-
	Inbound	3,499	885	4,384	6,437	1,565	8,002
	Total	3,499	885	4,384	6,437	1,565	8,002
Bulk (liquid)							
Oil	Outbound	-	-	-	-	-	-
	Inbound	-	3,241	3,241	-	3,942	3,942
	Total	-	3,241	3,241	-	3,942	3,942
Total	Outbound	1,500	1,000	2,500	3,000	2,000	5,000
	Inbound	3,499	4,126	7,625	6,437	5,507	11,944
	Total	4,999	5,126	10,125	9,437	7,507	16,944

Note: Not including iron ore or pellets by Rio Doce.

For the first and the second stages no special berth is planned for the domestic slab transportation, but the same berth will be used for both domestic and foreign transportation.

(2) Coal

Coal is imported mainly from U.S.A., Canada, Poland and Australia by making use of 80,000 DWT class coal carriers as standard. With increase in the volume of coal imports and in the haul, the transportation will be made economically by the larger rather than the smaller vessels. For this reason, the 120,000 DWT coal carriers are planned for coal import.

Although 20,000 to 30,000 DWT class coal carriers are now operated for transportation of domestic coal, they will be superseded by larger carriers with the improvement of the facilities at the loading ports.

For this reason, carriers of 80,000 DWT class max. is planned for domestic coal transportation so that the ocean-going vessels may also be employed in the domestic coal transportation.

(3) Oil

For the oil transportation, Amazonas type carriers of 26,400 DWT and a draught of 10 m are running to serve Vitória Port. With increase in oil demand, the oil carrier will have to be increased in size. For this reason, 60,000 DWT tanker is planned for the Port.

(4) Ore

As regards the export of iron ore or pellets from Praia Mole Port, there is no definite plan yet. Since No. 2 pier of Tubarão Terminal with a giant capacity is available for ready service, it will be sufficient to plan for ore carriers of suitable sizes in a manner not to affect the channel plan in Praia Mole Port. For this reason, 120,000 DWT ore carriers are planned, just as in the case of coal carriers.

Table 4.3.7 shows the largest ships by type of cargo to be considered in planning Praia Mole Port.

Table 4.3.7 Maximum planned ships by type of cargo

	Deadweight tonnage (tons)	Length (m)	Width (m)	Full-load draught (m)	Remarks
Slab carrier	120,000	270	42	16	Ore carrier with limited draught
Coal carrier (ocean-going)	120,000	260	41	16	
Coal carrier (coastal)	80,000	240	33	13	
Oil carrier	60,000	240	34	12.8	
Pellet carrier	120,000	-	-	-	

4-4 Study on the layout of port facilities

4-4-1 Concept of the layout

So far, many plans have been studied about the layout of port facilities. They are boiled down to two plans - Plan A (Fig. 4.4.1) and Plan B (Fig. 4.4.2) for comparison study. Plan A was proposed by PORTOBRÁS, while Plan B was studied by the Japanese survey team before being despatched to Brazil. As shown below, both plans have much in common so far as the basic concept is concerned.

① According to the observation data at Portocel, SSE and SE waves are predominating a little over ENE and E waves. But, on a yearly average basis, it seems to be no significant difference in frequency between them. It is, therefore, determined to install a south breakwater to provide against SSE and SE waves and a north breakwater against ENE and E waves.

② According to anemometric site data, NE winds are prevailing throughout the year, but the wind is calm on the whole. Since the vessels calling at Praia Mole Port are generally large, the winds will be no matter to the layout of the port facilities. In support of this, it has been reported that the entrance channel for Tubarão Terminal adjacent to Praia Mole Port has had no wind-caused troubles ever. For these reasons, just as with the channel for Tubarão Terminal, the entrance channel for Praia Mole Port is aligned from SSE to NNW.

A required space of a turning basin is provided within the waters connected to the channel as protected by north and south breakwaters.

③ The basins protected by the north and south breakwaters are given a space large enough for future expansion. As dredging works are required to obtain a depth for large vessels, the basins should be prepared at such an area free of canga or similar hard soils.

④ The mooring facilities require a large water depth, and pile structures are applied to them economically. The alignment should, therefore, be determined to avoid canga and other similar hard soils as far as possible.

⑤ Since the first stage construction of Tubarão Steel Mill is to be started from the northern end of the CVRD's premises, the mooring facilities and others relating to Tubarão Steel Mill are arranged in the south of the port area.

⑥ The slab berth is a facility having a direct bearing on the operation of Tubarão Steel Mill, and requires a large slab yard space behind the quaywall for economic slab handling operations. It is, therefore, located paralled to the coastline, and a land reclamation is planned behind the quaywall to secure a space for slab yards and other various cargo handling facilities.

⑦ For the bulk cargoes such as coal and oil, the cargo handling operation within the port is carried out by making use of belt conveyors and pipelines. Thus, no space will be required behind the quaywall except for the space for belt conveyors and pipelines. For this reason, bulk cargo piers are arranged along the south breakwater. In this case, those facilities which will handle hazardous cargoes such as oil are arranged as far apart from other facilities as possible.

⑧ The slab yard is located parallel to the quaywall just behind the slab berth, and the coal yard is installed by the land side of the slab yard. The oil tank yards will be prepared by the users outside the port area.

⑨ The facilities which may have to be required with the expansion of Tubarão Steel Mill after having attained the 6 million ton production system or with the development of the hinterland in future will be located in the northern half of the port area.

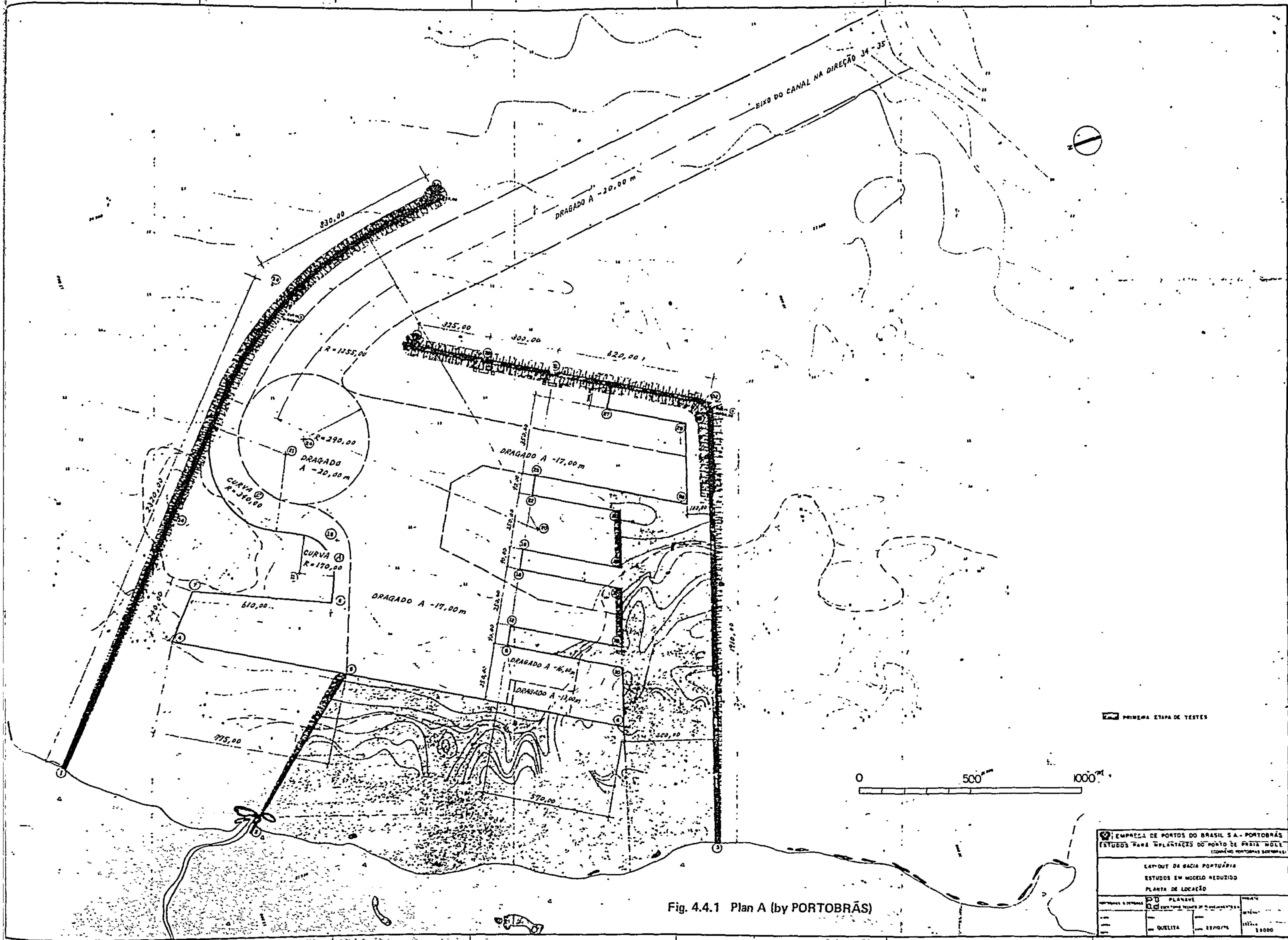


Fig. 4.4.1 Plan A (by PORTOBRÃS)

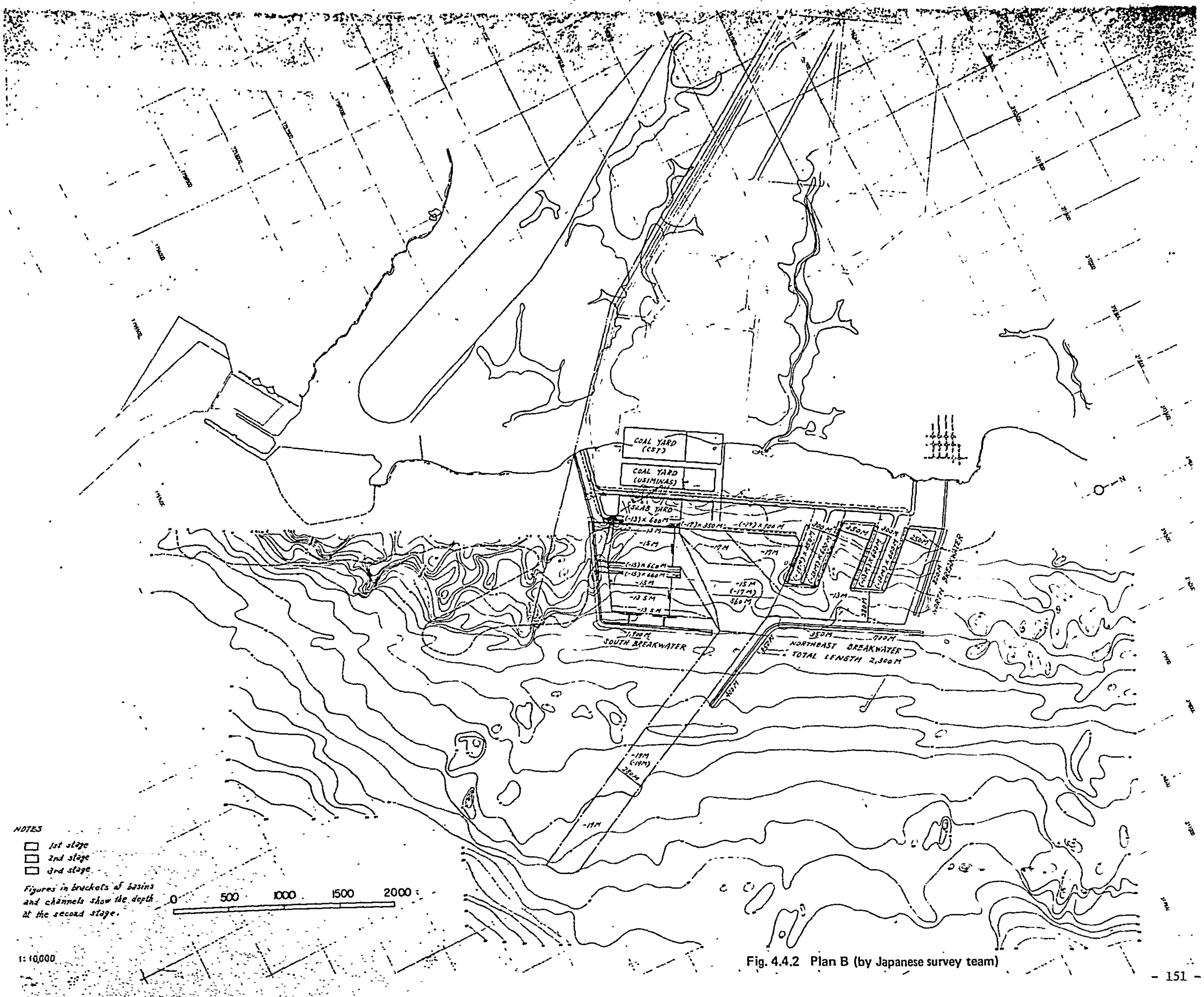


Fig. 4.4.2 Plan B (by Japanese survey team)

4-4-2 Comparison study of Plans A and B

(1) Breakwaters

What marks the difference between the two plans is the layout of the north breakwater.

In Plan A, the north breakwater is extending from ashore to the NW-SE direction to totally block ENE waves. This scheme will be very effective in ensuring the tranquility of the harbour, but will lack pliability for the future expansion. The waterfront reserved for the future expansion will not be enough in case the shipment from CST will be switched from semi-finished products to final products when Tubarão Steel Mill is ready to operate at 12 million tons a year. In addition, considering the large-scale export of agricultural produce expected in a long-term perspective, the space for expansion will be even more scarce for it.

In Plan B, on the other hand, the north breakwater is a detached one arranged to protect the harbour from ENE and E waves, and the north end of the breakwater is left open for future expansion. A temporary breakwater to provide against the waves invading the harbour through the open end is installed in a manner that may not hamper the future expansion work. Also, the detached breakwater makes it easy to change the intra-harbour water and thus prevent intra-harbour pollution.

From the viewpoint of construction work, Plan A is feasible as shore work while Plan B involves offshore work. Thus, the construction cost is quite different between the two.

When choosing between Plans A and B, it is required to carefully study the performance of the works, execution capacity on the Brazilian part and construction cost, etc.

(2) Layout of coal piers

In Plan A, two piers are run from the south breakwater. They are set 250 m apart from each other and the slab berth, and the length of each pier is equal to one berth. At the pier approach, a space with 400 m of width is prepared along the south breakwater. Although this space is not used for the time being, it is planned because of the difficulties in obtaining a space for future use within the port area topographically and because the area at the neck of the south breakwater is not suitable for structures (mooring facilities) since canga is present.

In Plan B, on the other hand, one coal pier having 2 berths' worth of length is run 300 m off, and parallel to, the slab berth, and a space necessary for installation of belt conveyor is located along the south breakwater. No other reclaimed land is planned. The coal pier with 2 berths at one side is favorable in view of the flexibility of cargo handling equipment, belt conveyor arrangement and effective use of basins. As, in Plan A, one jetty is planned on the north, the layout of two piers must be a reasonable arrangement.

Choosing between the two plans should be made in a long perspective as it is sure to have much to do with the dimensions of the basins and future use plan of the northern area inside the harbour.

(3) Measures for the pier to handle pellets and other bulk cargoes

For the moment, there is no plan about handling bulk cargoes like pellets. It is, however, expected to export such cargoes from Praia Mole Port

In Plan A, a pier running parallel to the coal piers is arranged, in addition to quaywalls along the south breakwater and near its bend.

In Plan B, one pier having a 2 berths' worth of length is arranged 300 m apart from, and parallel to, the coal pier. As a consequence, Plan B makes both the aggregate length and water depth of the south breakwater smaller compared with Plan A.

Choosing between the two plans should be made after due consideration of the construction cost and period for north breakwater, and export prospects of pellets and other bulk cargoes.

(4) Use plan of the northern part of the port

What poses problems on the use plan of the northern part of the port left for future expansion is the canga snag lying on the extension line of the entrance channel and the waves invading the harbour through the harbour entrance.

In Plan A, the jetty surrounding the canga snag is extended from the north breakwater to be parallel to the slab berths with the slab berth side used as a quaywall and the channel side as a wave-breaking revetment. This scheme is very effective in view of the tranquility of the harbour. However, the aggregate length of waterfront is short, the basins made small, and the maneuver of ships within the harbour made difficult.

In Plan B, some of the slab berths are extended toward the south-east to surround the canga snag. In this scheme, there is no trouble in ship's maneuver and future expansion of the port. But, the usableness of the quaywall facing the harbour entrance, and measures against reflecting waves should be studied carefully.

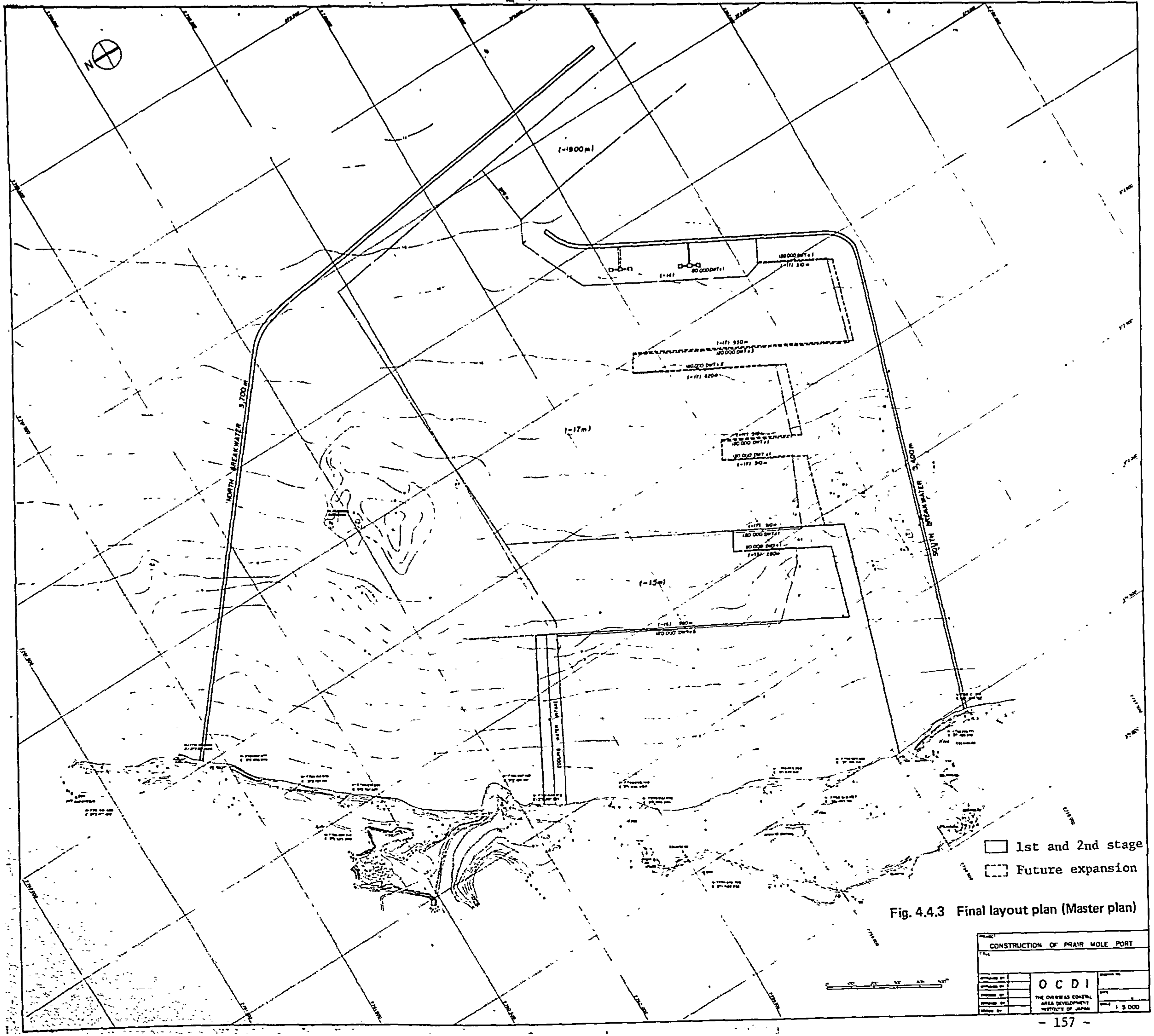
We are of the opinion that the layout plan for the northern part has a close relation with the future use plan and, therefore, it should not be decided at this time when no clear visions are set out on a long-term basis.

4-4-3 Determination of the layout plan for the port facilities

(1) Outline

According to the comparison study of Plans A and B, the layout as illustrated in Fig. 4.4.3 has finally been determined.

In deciding upon this layout, special consideration has been given to the following as well as to such layout engineering problems as ship's maneuverability and function of facilities.



1st and 2nd stage

Future expansion

Fig. 4.4.3 Final layout plan (Master plan)

① It is not a good strategy to fix the plan when the long-term visions have not yet been formulated, though it is necessary to provide as much space for future expansion as possible.

② The layout of port facilities should be so made that the execution methods and equipment now available in Brazil can manage as much work as possible.

In planning the layout of each facility, the following have been studied.

(2) *Layout of the north breakwater*

The construction of detached breakwater is difficult so far as the present engineering setup of Brazil stands. There is no manufacturing facilities when concrete caisson type breakwater is to be used for the purpose of reducing the construction period. Also, Brazilian divers have no experience in leveling a rubble bed for installation of the caissons. The construction cost of the detached breakwater of concrete caisson type is much more than the rubble mound breakwater planned in Plan A.

On the other hand, the spreading of rubbles by dump trucks has been practised with confidence in various ports and harbours in Brazil. Since the Vitória region has quarries with rich reserves the rubble mound breakwater can be built with less cost. In addition, the construction period does not pose serious problems.

For these reasons, the north breakwater is decided to have nearly the same type as in Plan A, but the starting point of the north breakwater will be shifted farther up north in order to have more space for future expansion.

(3) Coal piers and pellet piers

If a coal pier equivalent to two berth length is installed, its head will be projected to almost the center of the harbour, which will affect the planning of the port facilities in the northern part of the harbour.

Although no definite plan is made for the northern part, the layout should be made so as to leave a space with a high degree of freedom when the north breakwater is extended from shore.

The two berth long pellet pier is not sited to stand in the way of the planning of northern part. It is, therefore, decided to install a pellet pier equivalent to 2 berth length in order to increase the number of berths.

Namely, three piers are run along the south breakwater. The pier interval is set at 300 m with reference to the ship's length and in consideration of the relative position to the turning basin.

The pier layout explained above entirely shifts more offshore that part of the south breakwater which runs parallel to the coastline as compared with Plans A and B. Thus, the aggregate length and water depth increase a little, and the construction cost increases as much. But the cost increase will be none too much if the overall development of the Port is seen in a long perspective.

(4) Future plan of the northern part

It is not proper to fix up the plan for the northern half of the port hastily at present. As regards the slab berths, the plan should be limited to the extent that will be enough to meet the export of semi-finished products expected when Tubarão Steel Mill is operating at an annual output of 6 million tons. Tubarão Steel Mill may change the export items in the more distant future, and the layout of port facilities in the nrothern part is not planned, accordingly. It should be studied when the production schedule of Tubarão Steel Mill has took a clear picture.

4-5 Calmness of harbour

4-5-1 Calculation method of wave heights in the harbour

The wave heights within the habour can be determined in the following methods.

① Hydraulic model test

② Numerical test by mathematical model

③ Use of diffraction diagrams or diffraction calculation

For the various layouts of Praia Mole Port, Centro Tecnologico de Hidrãulica, São Paulo University, has been conducting three-dimensional hydraulic model tests. However, the harbour shape is comparatively simple, and the waves reflecting from the boundaries within the harbour are not so serious. Accordingly, the diffraction calculation method is employed in the present analysis. In this method, the waves passing through or over-topping the rubble mound are neglected.

In the calculation, the north and south breakwaters are considered respectively semi-infinite ones as shown in Fig. 4.5.1.

By approximating Sommerfeld's solution, the secondary diffraction calculation is made with account taken of the reflection of waves from the breakwaters. It is possible to calculate irregular waves having directional spectra due to linear superimposition. The conditions for calculation are as follows.

① Shape of harbour : 2 cases - one in which all the breakwaters have been completed, and the other in which the north breakwater alone leaves 600 m yet to be completed when the coal carrier service is started.

② Water depth : h = 18.5 m const.

③ Reflection coefficient of breakwaters : 0.3

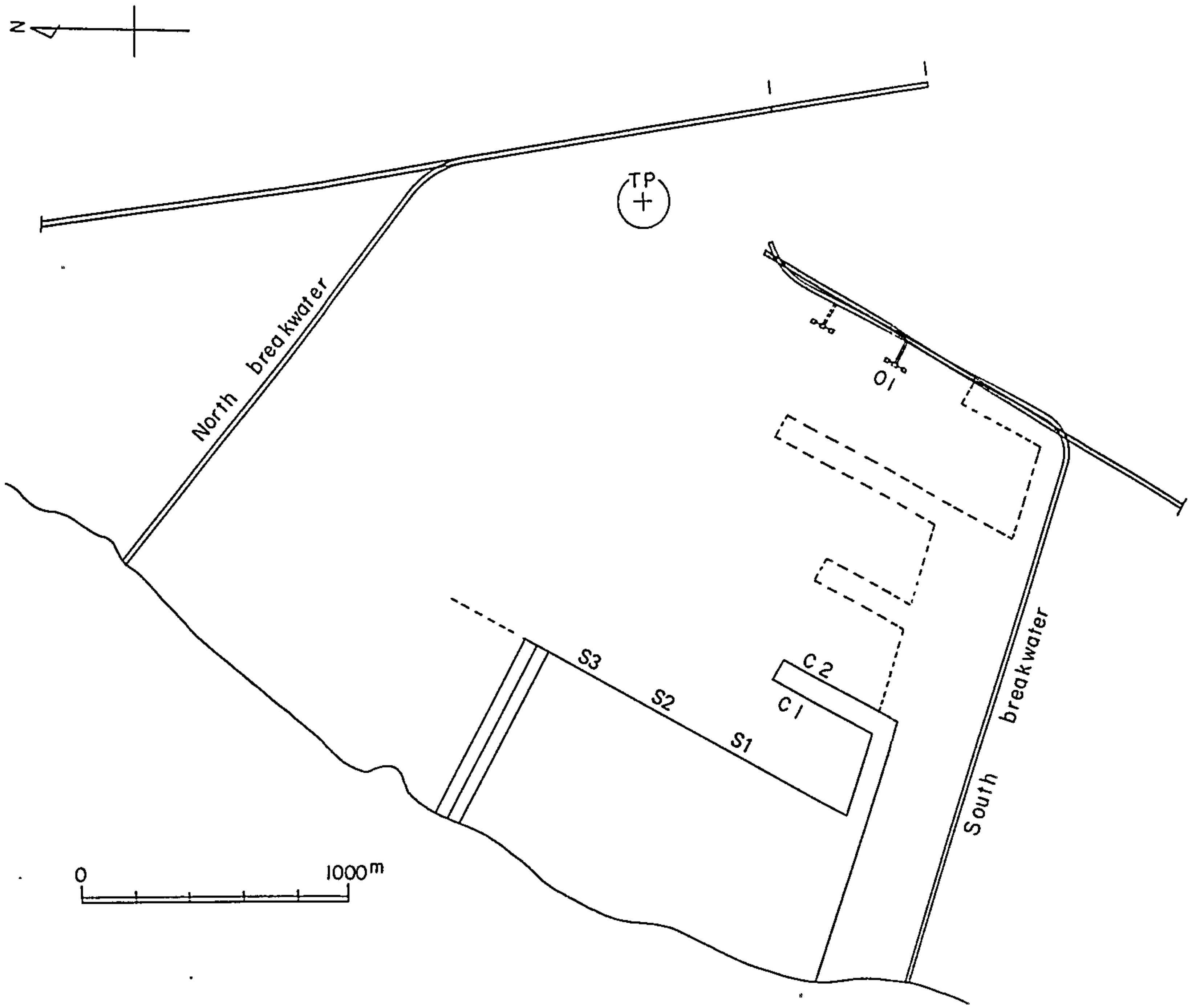


Fig. 4.5.1 Layout of breakwaters and berths

④ Waves outside the harbour: Irregular waves having directional spectra, $T_{1/3}$ = 12 sec.

⑤ Wave direction : ENE, E, ESE, SE and SSE, provided that ENE waves are omitted when all the breakwaters have been completed.

4-5-2 Diffraction coefficients in the harbour

Figs. 4.5.2(1) through 4.5.2(9) show contour maps of diffraction coefficients of irregular waves. The diffraction coefficients at berths and turning point of the channel (T.P.) as shown in Fig. 4.5.1 are as listed in Table 4.5.1.

Table 4.5.1 Diffraction coefficient at berths and turning point of channel

(1) Under construction

	ENE	E	ESE	SE	SSE
S1	0.11	0.12	0.13	0.09	0.06
S2	0.08	0.13	0.15	0.14	0.08
S3	0.11	0.18	0.24	0.20	0.14
C1	0.09	0.17	0.11	0.08	0.05
C2	0.10	0.18	0.11	0.08	0.05
O1	0.05	0.08	0.08	0.07	0.06
TP	0.10	0.17	0.30	0.54	0.80

(2) Final

	ENE	E	ESE	SE	SSE
S1	-	0.01	0.02	0.03	0.04
S2	-	0.01	0.03	0.04	0.05
S3	-	0.02	0.05	0.06	0.07
C1	-	0.01	0.02	0.03	0.04
C2	-	0.01	0.03	0.03	0.04
O1	-	0.01	0.03	0.04	0.05
TP	-	0.10	0.19	0.38	0.64

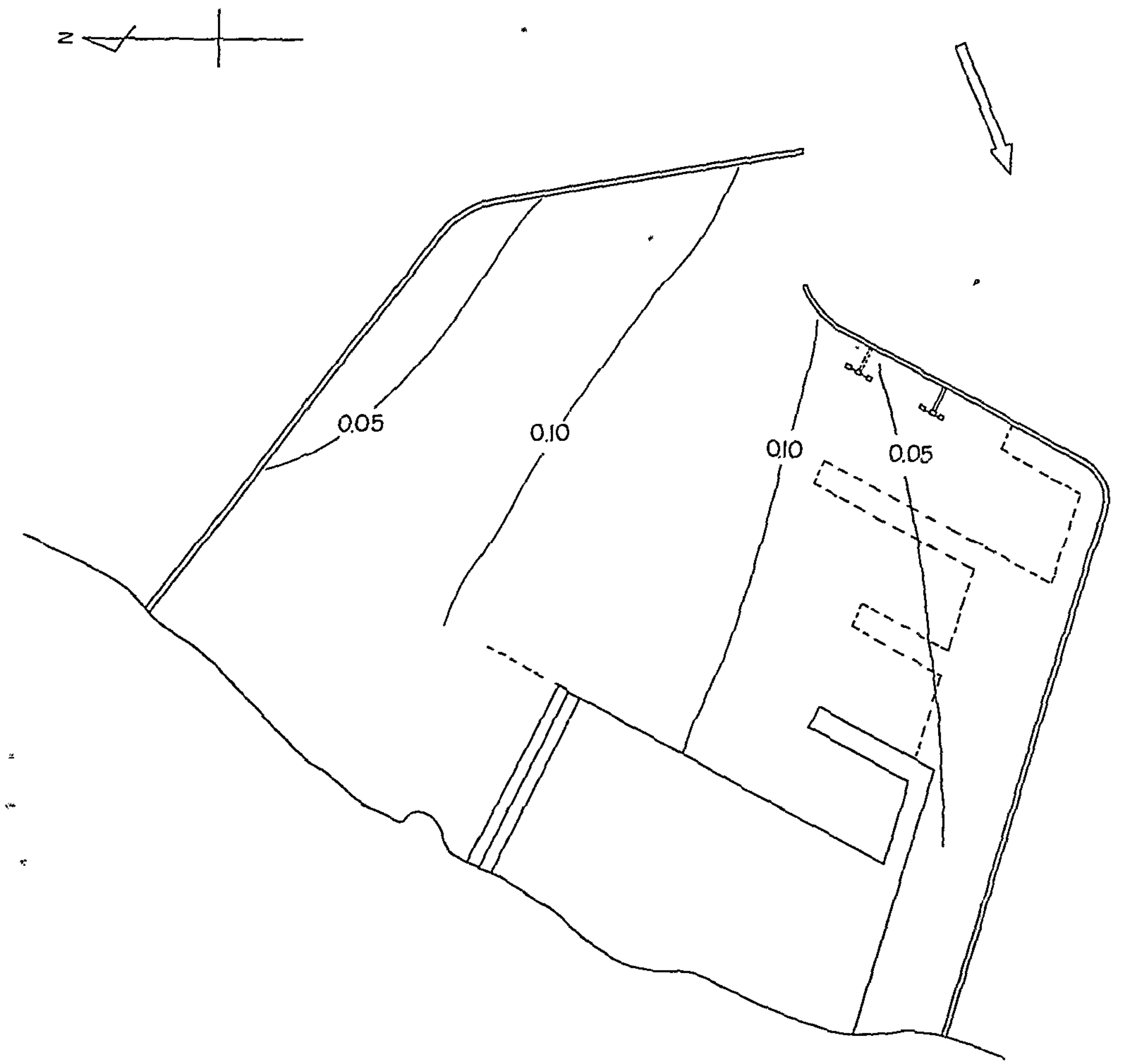


Fig. 4.5.2 Diffraction coefficients in the harbour (1)
(Under construction: ENE)

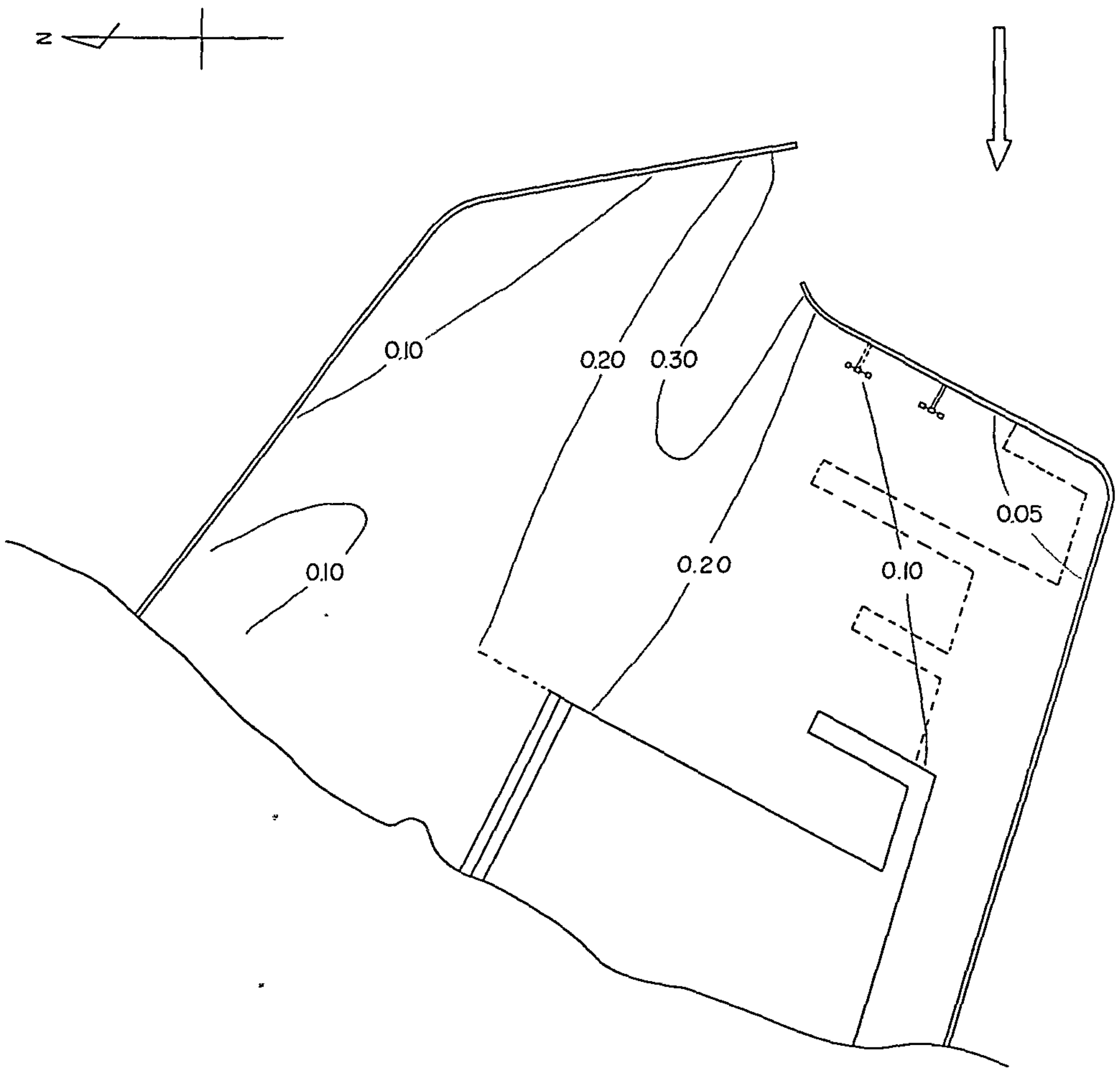


Fig. 4.5.2 Diffraction coefficients in the harbour (2)
(Under construction: E)

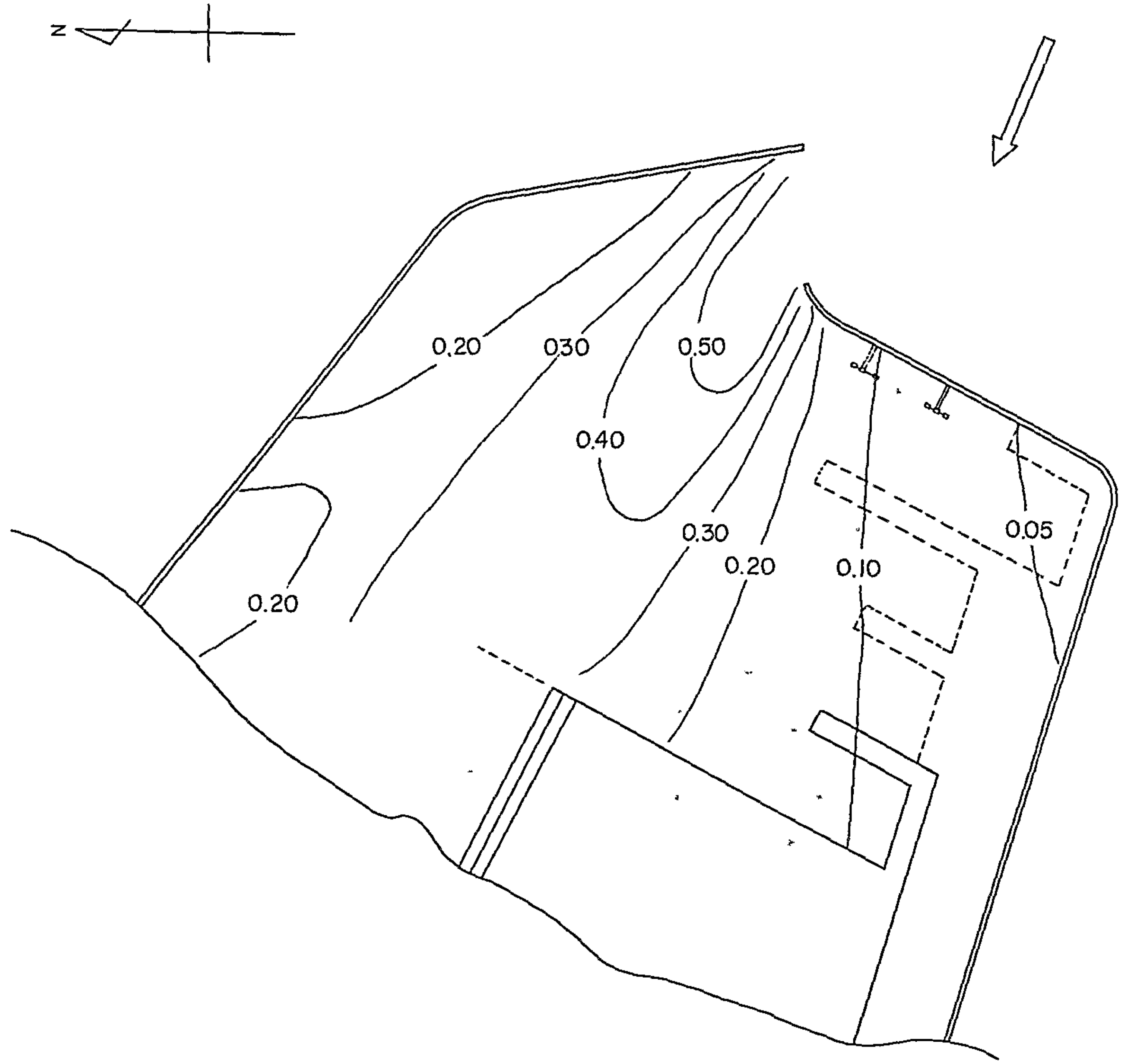


Fig. 4.5.2 Diffraction coefficients in the harbour (3)
(Under construction: ESE)

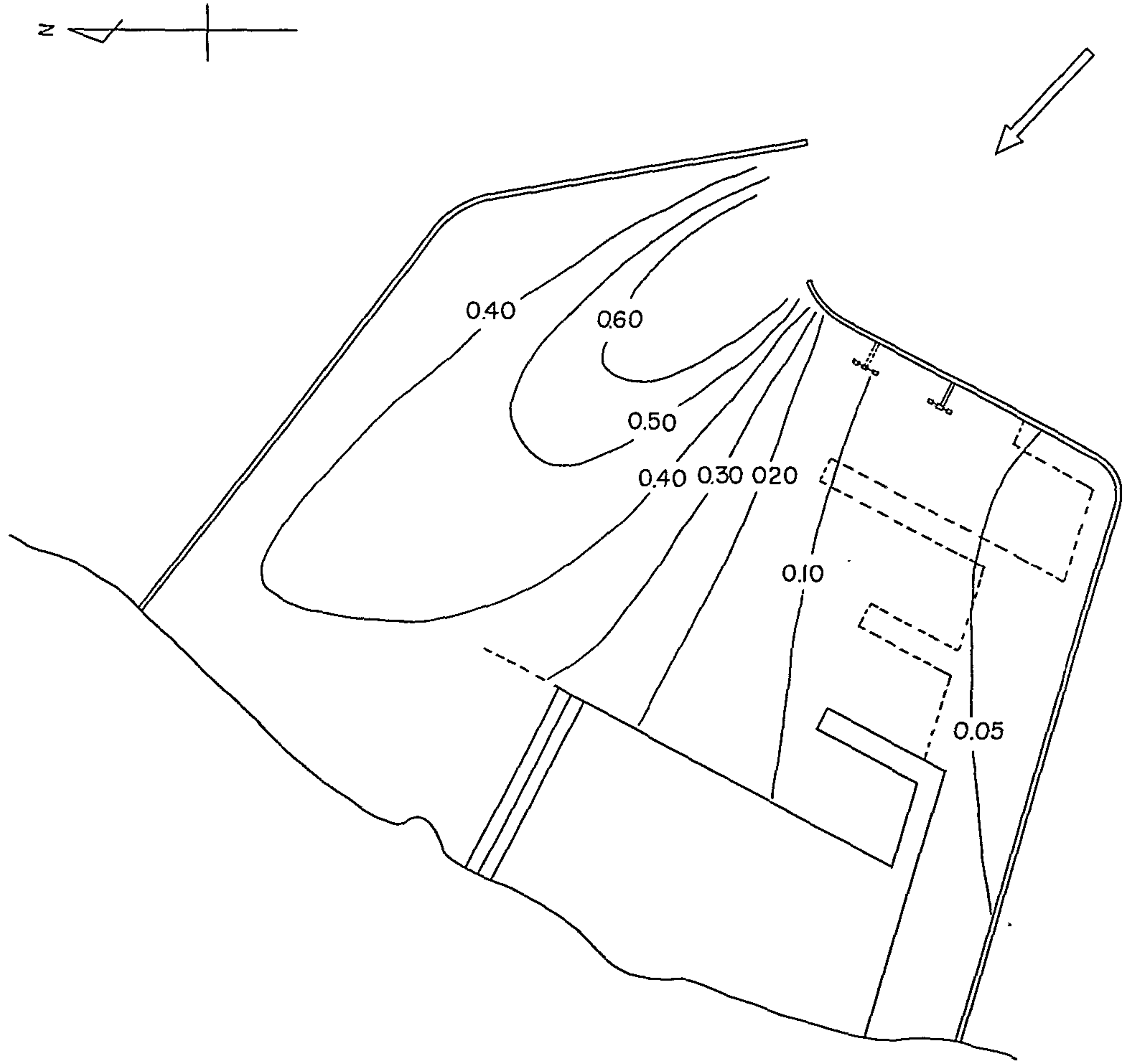


Fig. 4.5.2 Diffraction coefficients in the harbour (4)

(Under construction: SE)

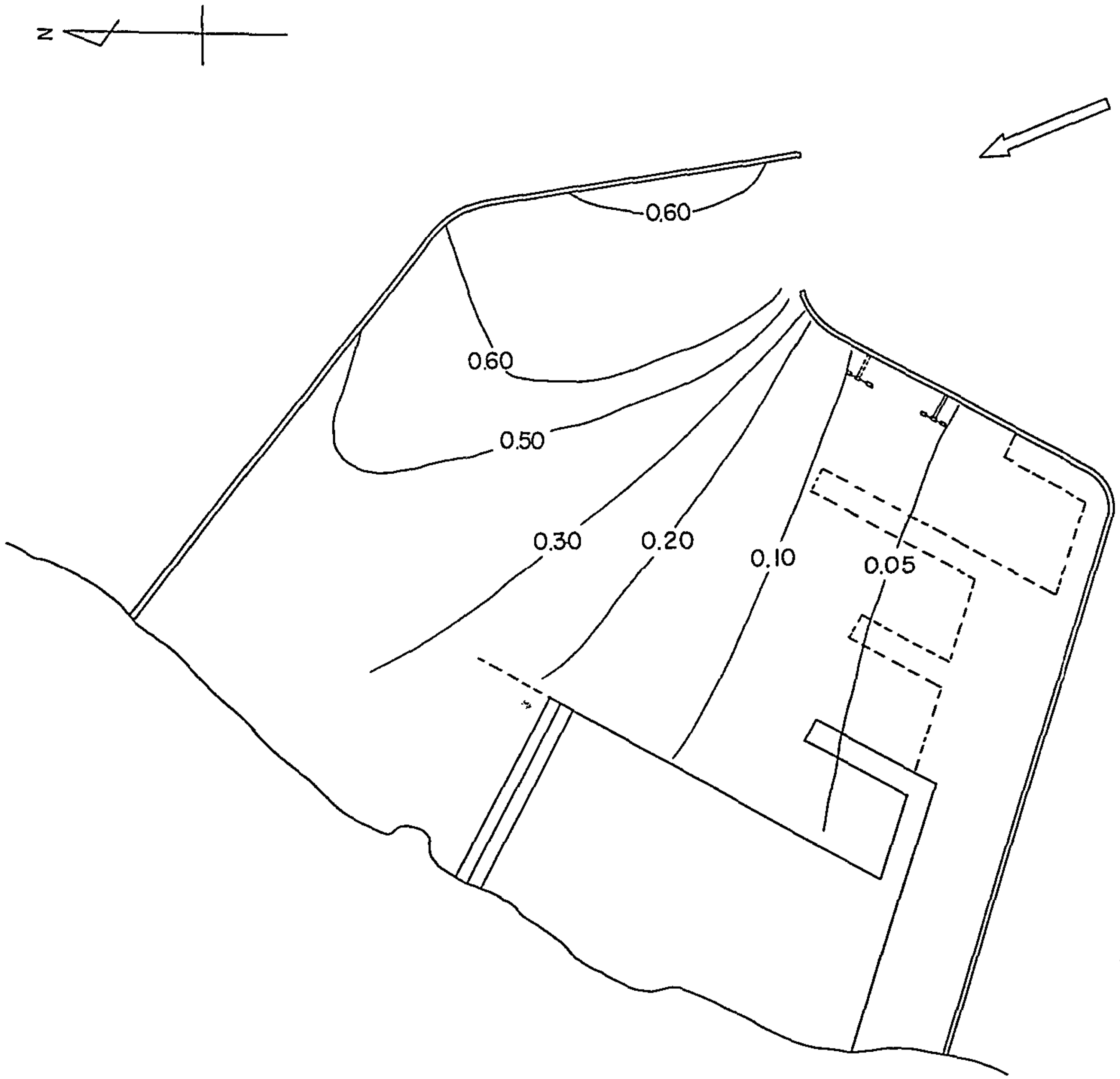


Fig. 4.5.2 Diffraction coefficients in the harbour (5)
(Under construction: SSE)

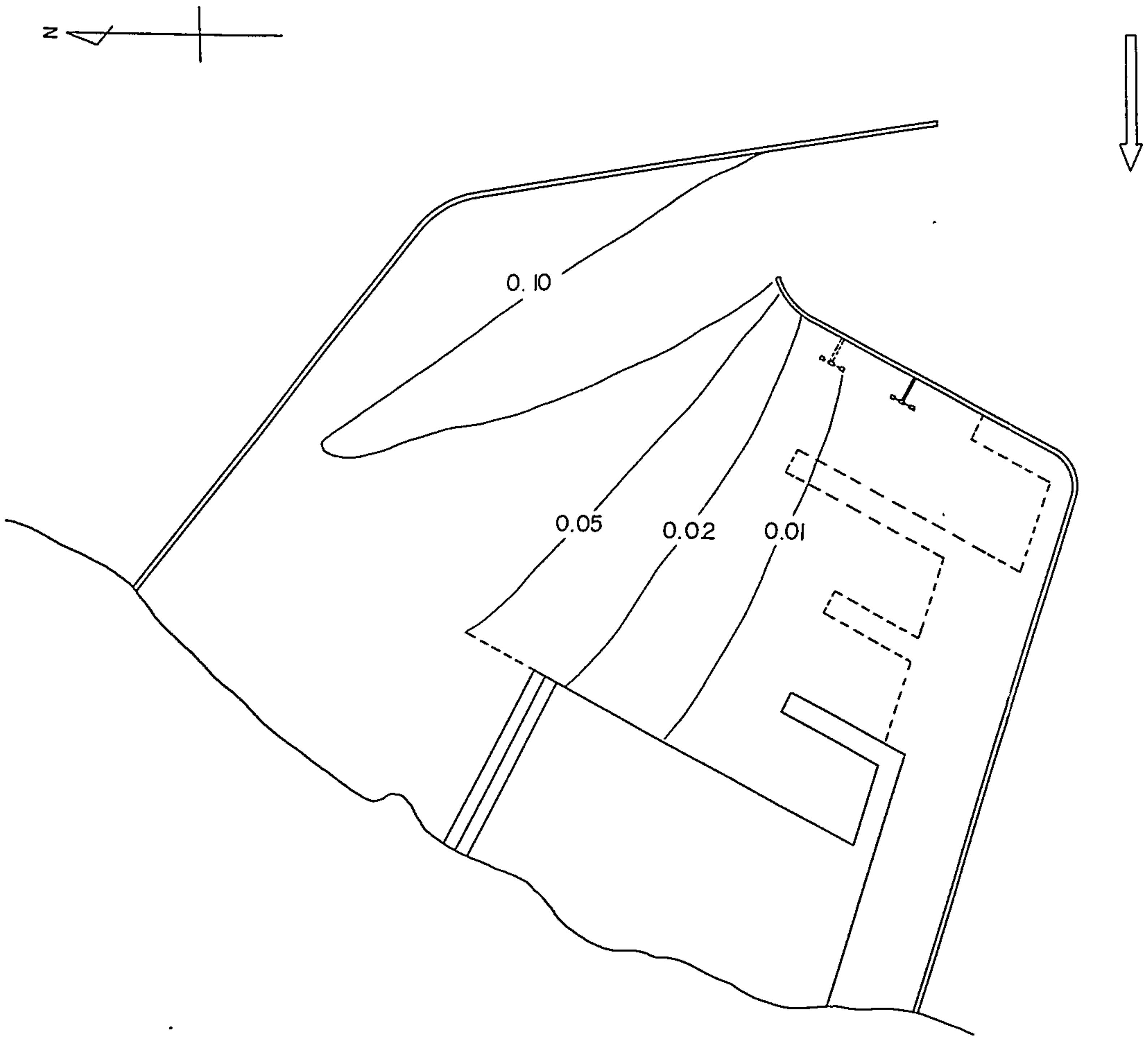


Fig. 4.5.2 Diffraction coefficients in the harbour (6)

(Final: E)

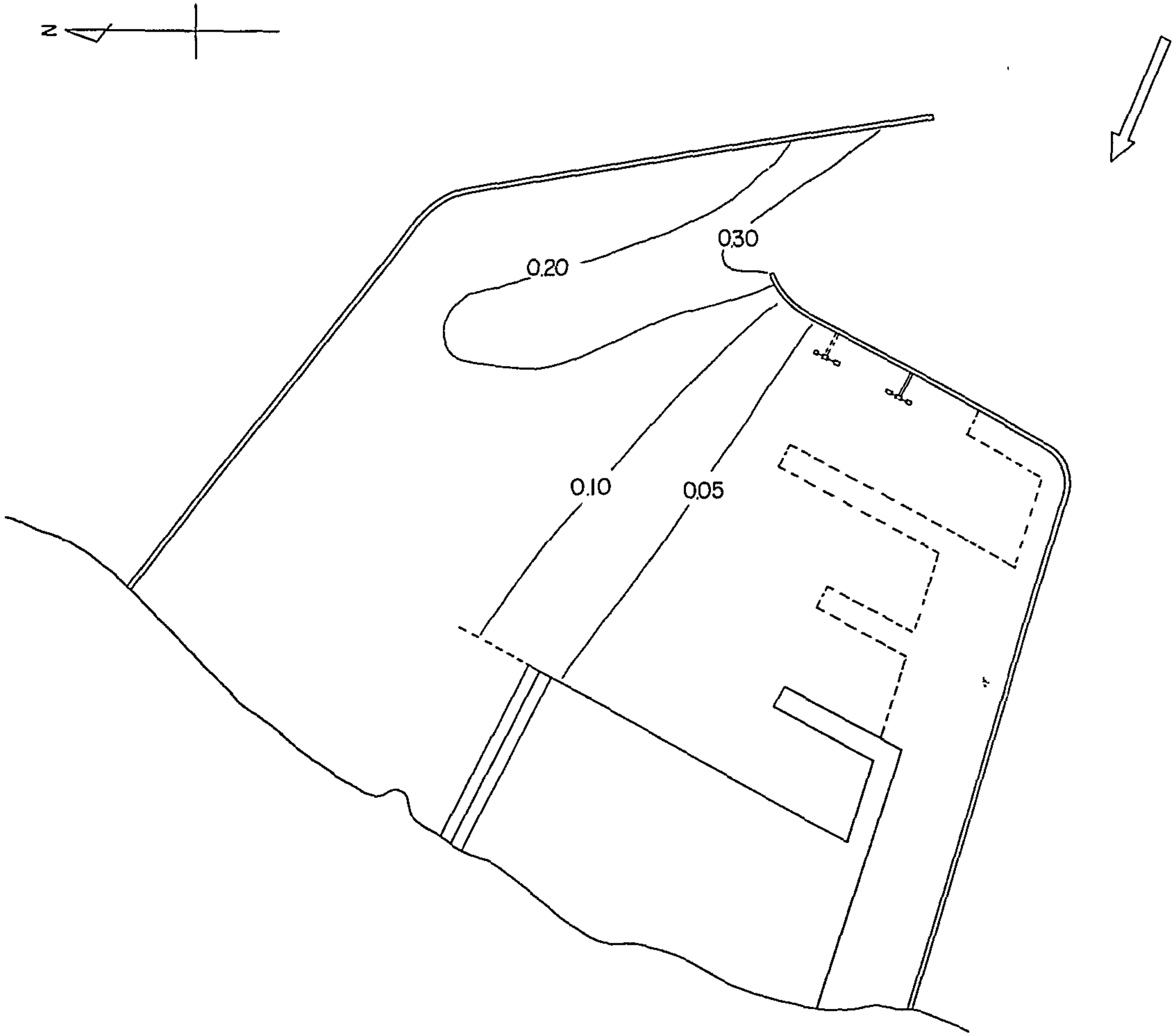


Fig. 4.5.2 Diffraction coefficients in the harbour (7)
(Final: ESE)

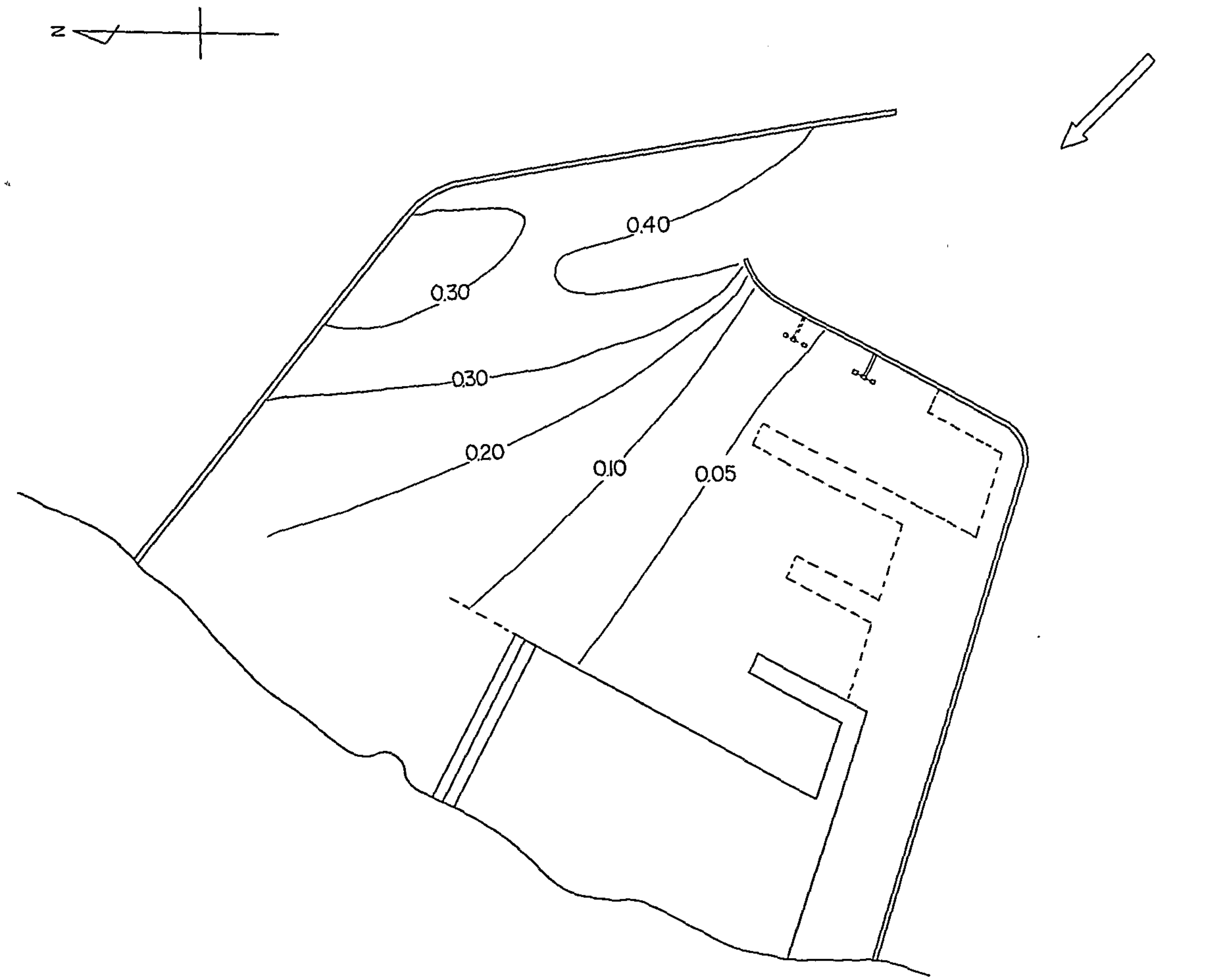


Fig. 4.5.2 Diffraction coefficients in the harbour (8)
(Final: SE)

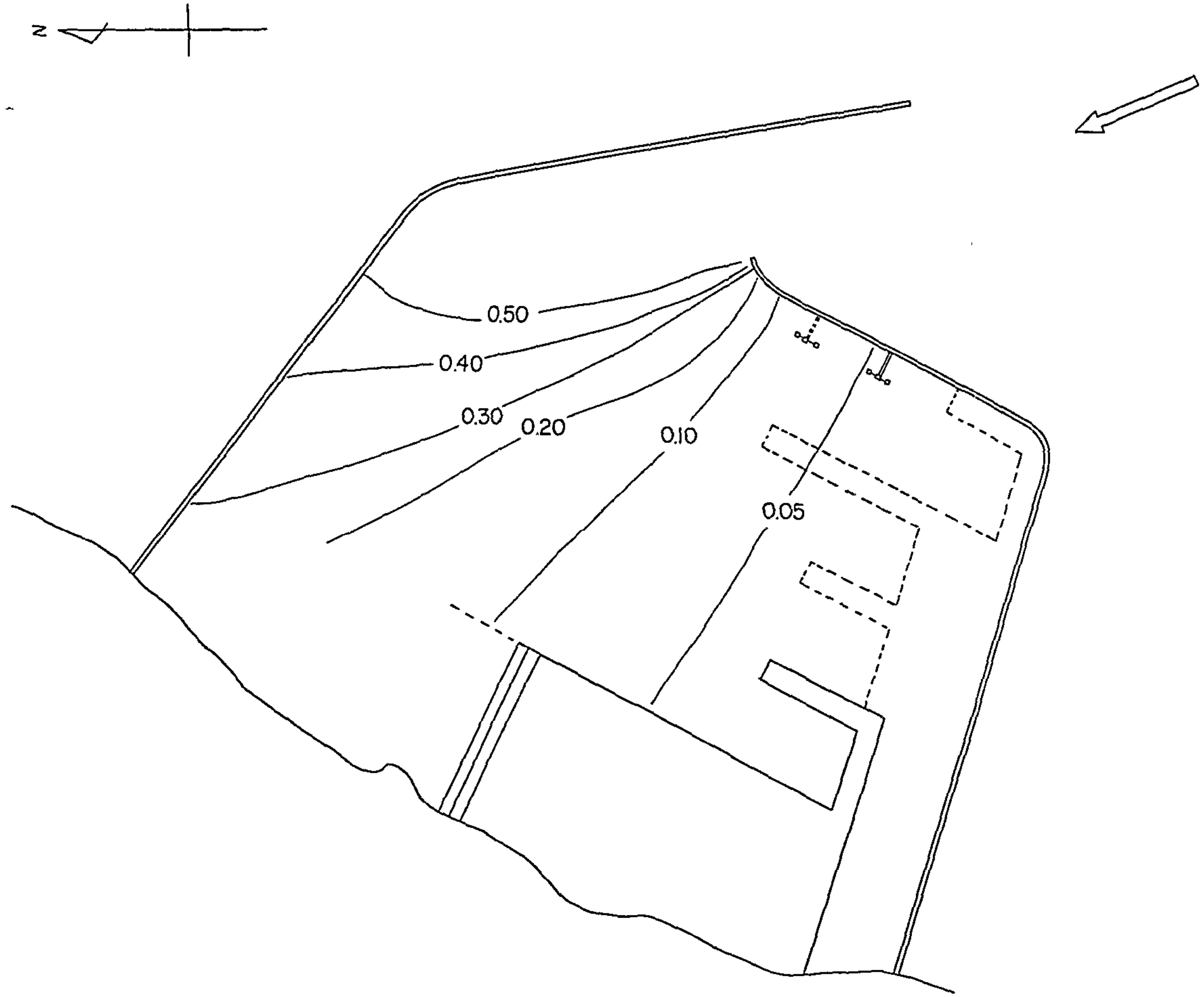


Fig. 4.5.2 Diffraction coefficients in the harbour (9)
(Final: SSE)

As regards the berths, S3 shows the largest diffraction coefficient in any cases. In the construction stage, the diffraction coefficient is 0.24 as against ESE waves. In the completed stage, the diffraction coefficient is smaller than 0.07, and the incident wave height corresponding to the wave height of 0.5 m in the harbour is more than 7.14 m. Accordingly, there will be no trouble so far as the calmness of the harbour is concerned. The diffraction coefficient tends to become a little smaller the smaller will the period becomes than 12 sec.

At the turning point of the channel, on the other hand, it is evident that the diffraction coefficient becomes larger the more southerly the waves will become. In the construction stage, the diffraction coefficient becomes as high as 0.8 with respect to SSE waves. Table 4.5.2 shows the incident wave heights outside the harbour when the wave height is 0.5 m at berth S3 and 1.5 m at the turning point of the channel.

Table 4.5.2 Incident wave heights corresponding to wave heights of 0.5 m at S3 and 1.5 m at T.P.

(1) Under construction

	ENE	E	ESE	SE	SSE
0.5 m at S3	4.5 m	2.8 m	2.1 m	2.5 m	3.6 m
1.5 m at TP	15.0 m	8.8 m	5.0 m	2.8 m	1.9 m

(2) Final

	ENE	E	ESE	SE	SSE
0.5 m at S3	-	25.0 m	10.0 m	8.3 m	7.1 m
1.5 m at TP	-	15.0 m	7.9 m	3.9 m	2.3 m

4-5-3 Appearance frequencies of wave heights in the harbour

Given the appearance frequencies of wave heights outside the harbour by wave direction and the diffraction coefficients, the appearance frequencies of wave heights in the harbour can be determined. Figs. 4.5.3(1) through 4.5.3(5) show the appearance rates at which the incident wave heights shown by wave direction in Table 2.3.10 are exceeded and the appearance rates at which the wave heights at berth S3 as determined by the diffraction coefficients in Table 4.5.1 are exceeded.

The above figures show both construction stage and completed stage; it is found that the wave height at the berth is much smaller than the corresponding one outside the harbour.

Fig. 4.5.4 shows the appearance rate for all directions which is the sum of the directional appearance rates.

The daily maximum significant wave height corresponding to the once in a year is 3.8 m outside the harbour, 0.87 m and 0.22 m at berth S_3 in the construction stage and completed stage, respectively. It is inferred that when all the breakwaters have been completed, 0.5 m will never be exceeded at berth S_3. In the construction stage, the ratio at which the daily maximum significant wave height exceeds 0.5 m is 7.5%, or some 27 days a year. At other berths, the values are much smaller.

Fig. 4.5.5 shows the wave height appearance rate at the turning point of the channel obtained just the same way as above. The ratio at which the daily maximum significant wave height exceeds 1.5 m is 3.8% in the construction stage and 0.76% in the completed stage, or 14 days and 3 days a year respectively.

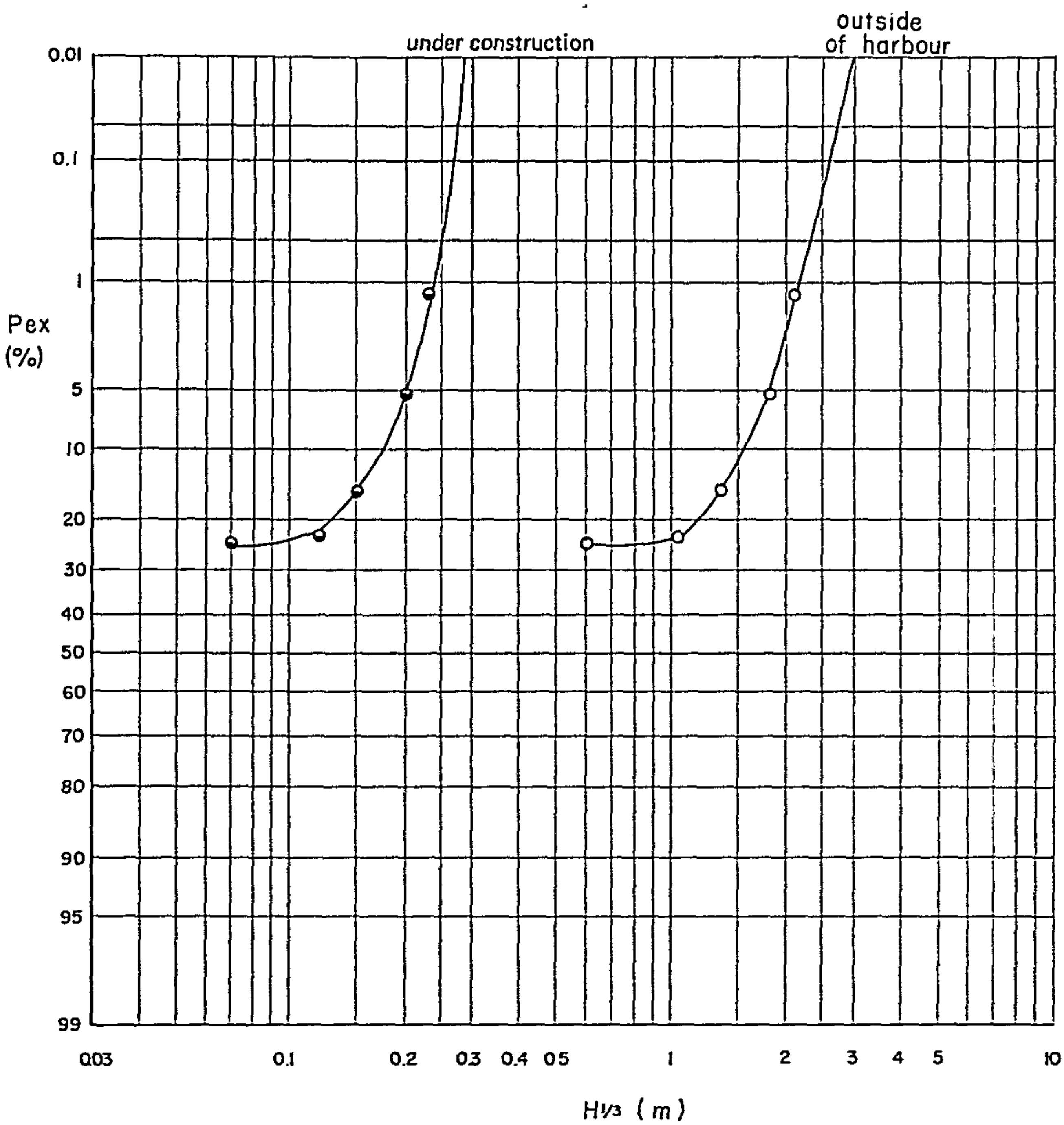


Fig. 4.5.3 (1) Exceeding probability of wave heights outside and inside the harbour (S_3); (ENE)

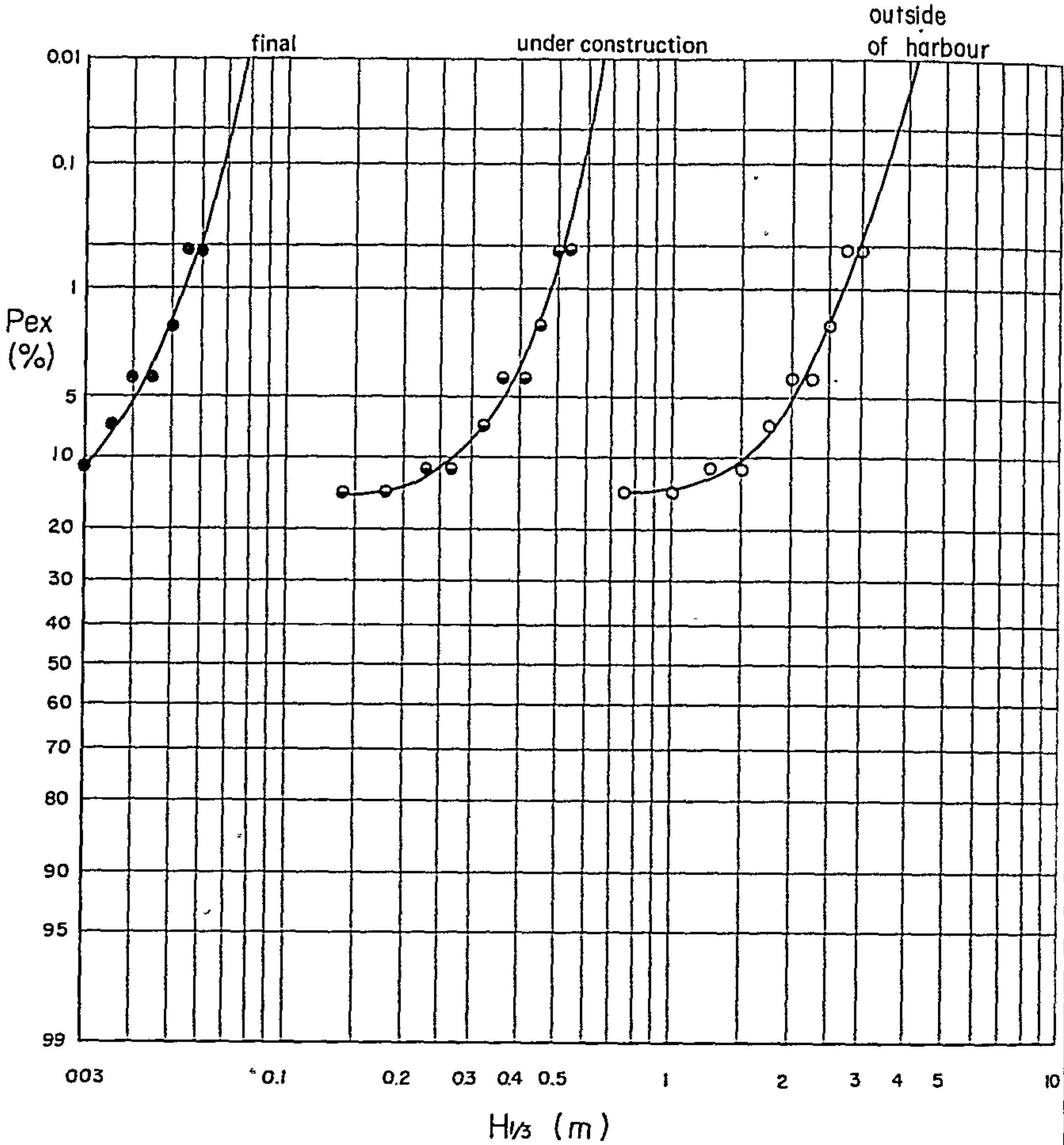


Fig. 4.5.3 (2) Exceeding probability of wave heights outside and inside the harbour (S_3); (E)

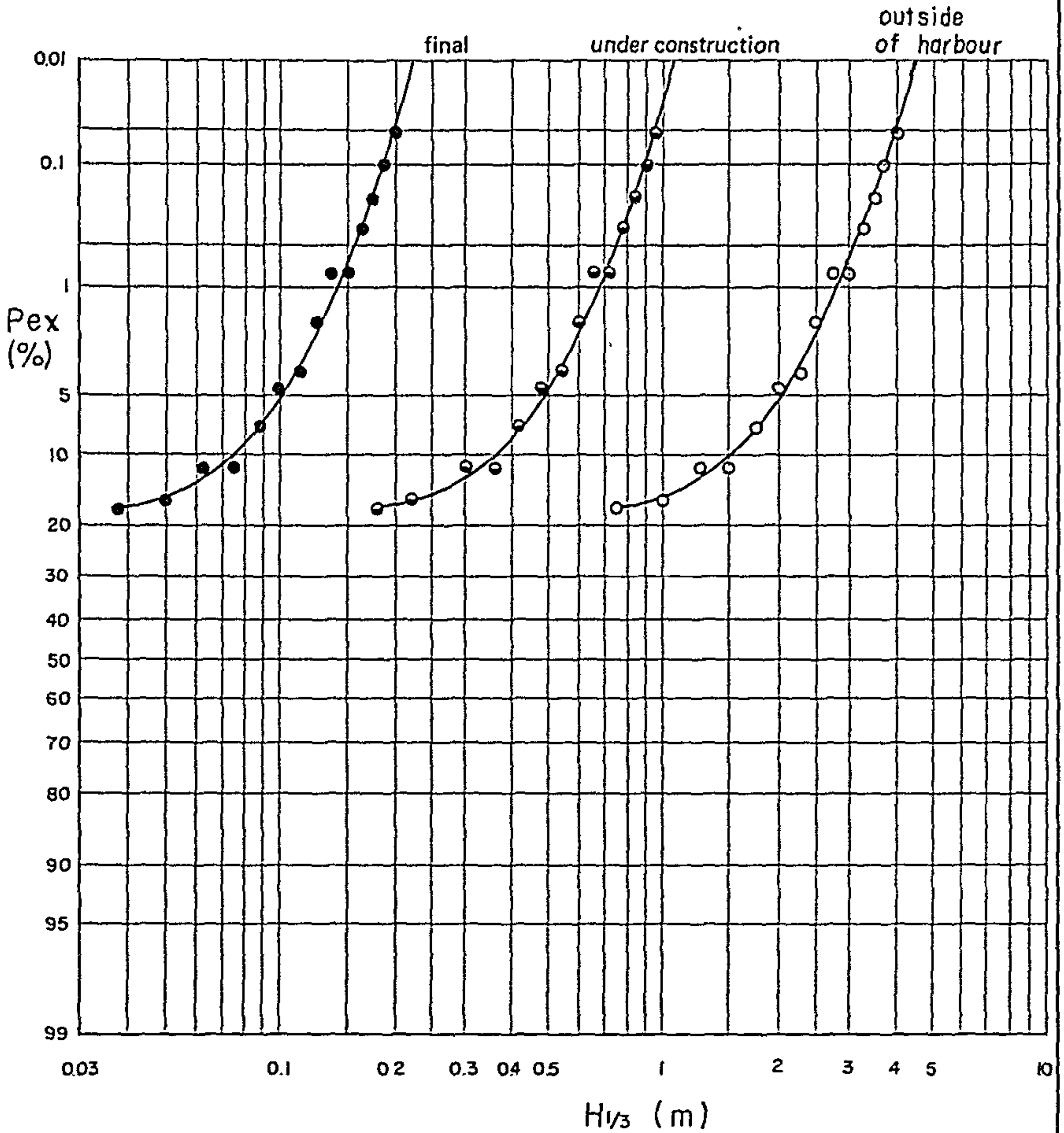


Fig. 4.5.3 (3) Exceeding probability of wave heights outside and inside the harbour (S_3); (ESE)

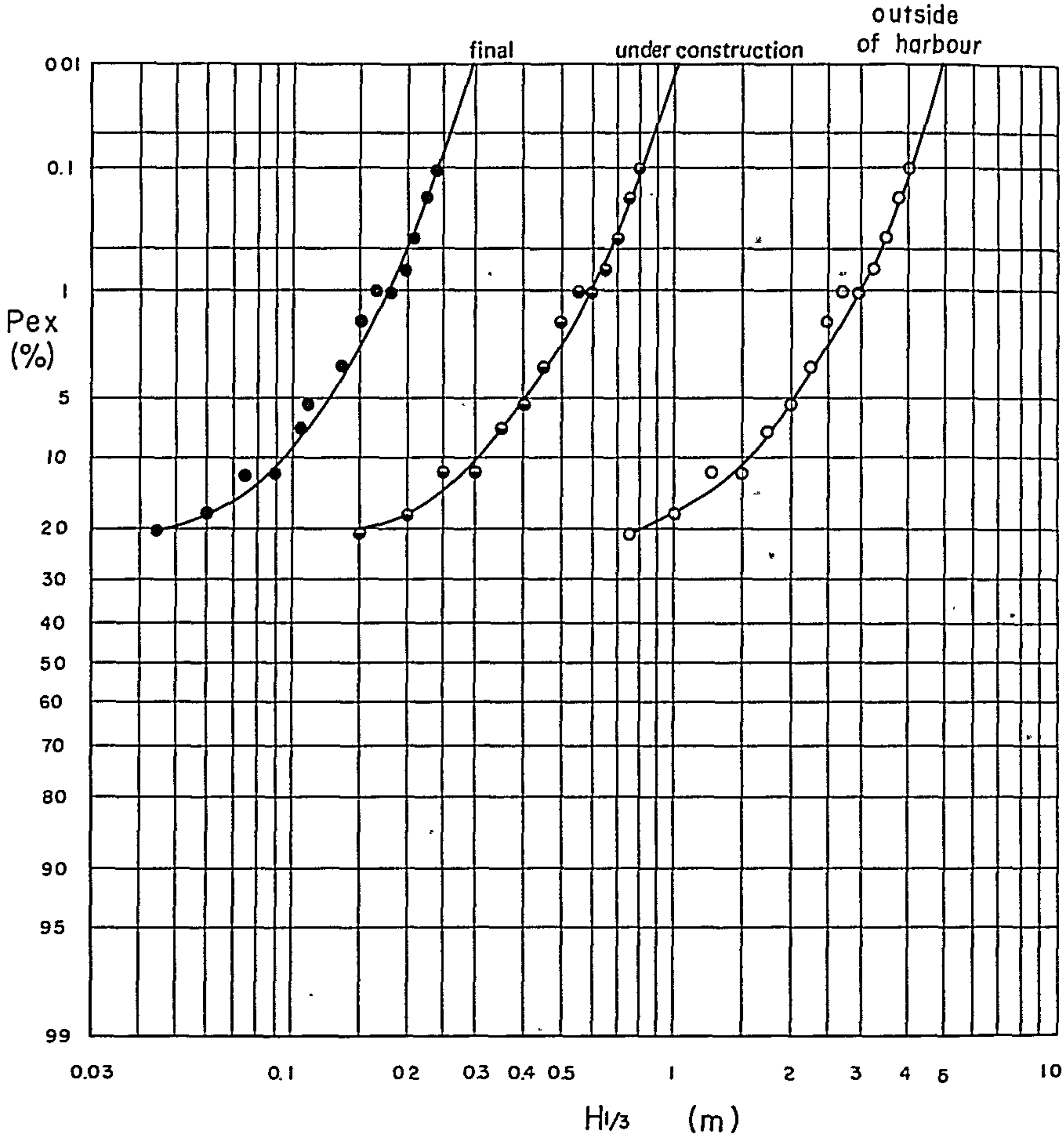


Fig. 4.5.3 (4) Exceeding probability of wave heights outside and inside the harbour (S_3); (SE)

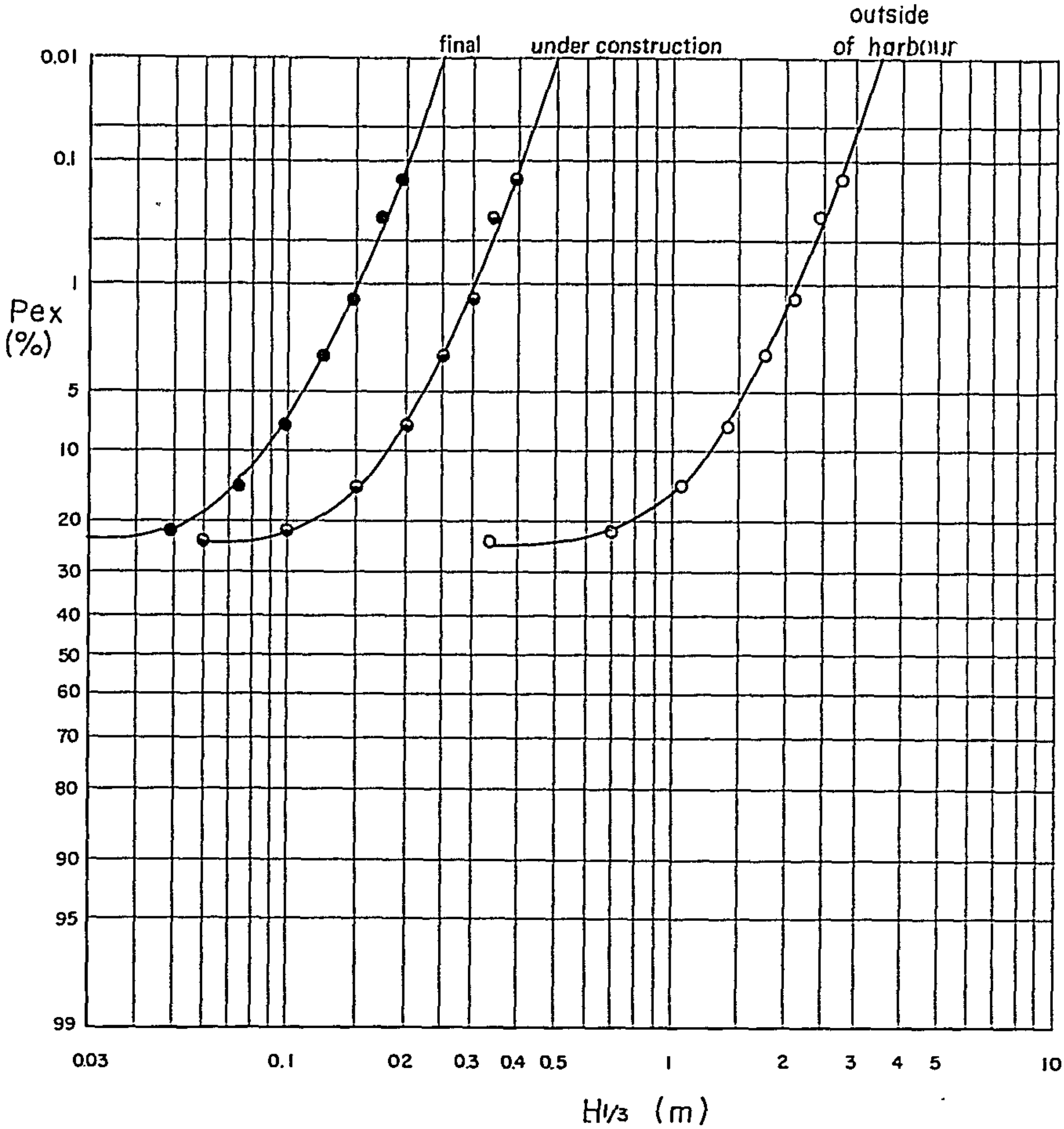


Fig. 4.5.3 (5) Exceeding probability of wave heights outside and inside the harbour (S_3); (SSE)

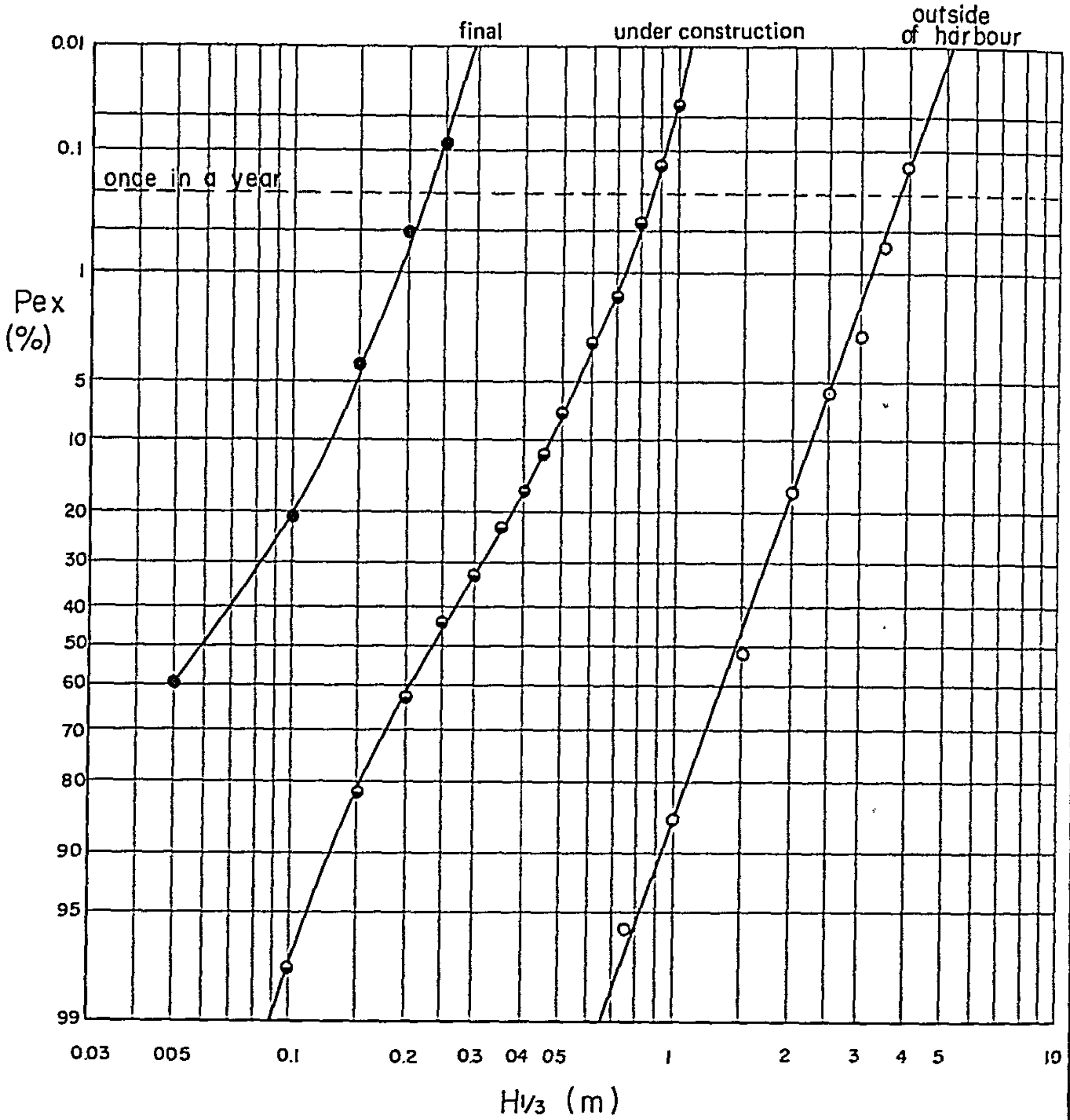


Fig. 4.5.4 Exceeding probability of wave heights outside and inside the harbour (S_3) (All directions)

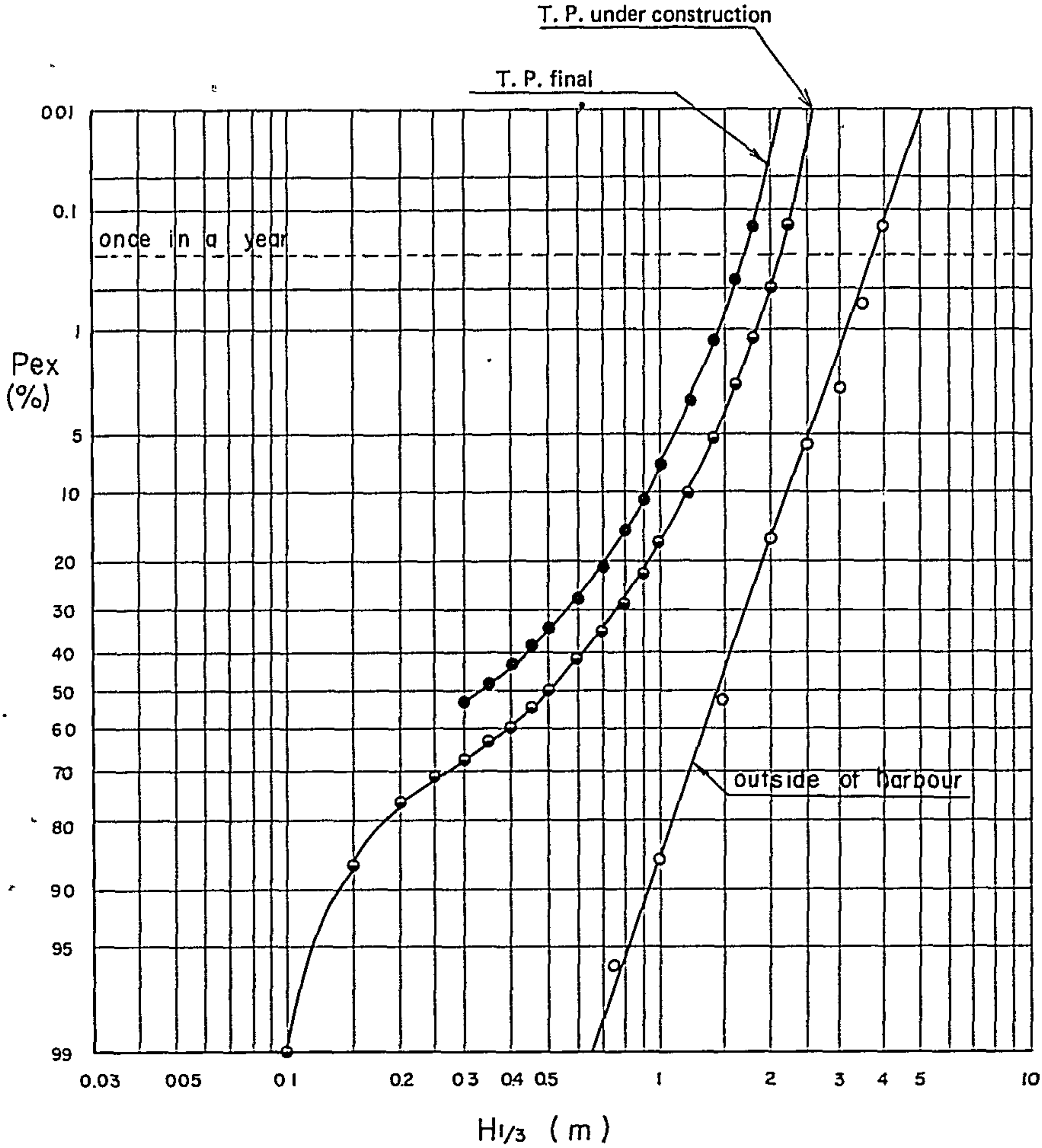


Fig. 4.5.5 Exceeding probability of wave heights outside and inside the harbour (T.P.)

CHAPTER 5. PORT FACILITY PLAN

5. Facility plan

5-1 Breakwaters

A 3,700 m north breakwater and a 3,400 m south breakwater are planned to ensure the harbour calmness.

The north breakwater is streteched about 1,400 m on the extension line of the south breakwater (parallel to the channel) in order to facilitate the entry of vessels and protect the channel from northeast to east waves.

The south breakwater has many facilities just behind, and its crown height should not permit overtopping of waves. Also the crown width of the south breakwater is required to have width in order to accommodate a road leading to the oil berth and install the oil pipelines.

5-2 Channels and turning basin

The channels and turning basin are designed to accommodate 120,000 DWT coal carrier, the largest vessel to enter the port.

5-2-1 Channel width

The channel width is set equal to 270 m which is the length of the largest vessel to enter the Port. In this case, two-way traffic of large vessels is permitted, but in the area protected by the north breakwater the large vessels may be forced to go one way because of the relative position of the turning basin.

5-2-2 Channel depth

The channel depth is determined in the following method in consideration of the sinkage of ship due to pitching motions and squat.

Channel depth = Full-load draught + Maximum wave height x 1/2 + Allowance for sinkage = 16.0 m + 1.8 m + 1 m = 18.8 m $\fallingdotseq$ 19 m

The value 1.8 m is taken with reference to the maximum wave height of an 80% frequency.

5-2-3 Area and water depth of the turning basin

A circular water surface having a diameter three times as large as the length of the largest vessel is required if the vessel is to turn by herself. If the turning is made with the aid of tugboats, however, the turning space requires a diameter twice as large as the length of the largest as standard.

In the plan, a circular water surface having a diameter of 540 m, that is, twice as large as the length of 120,000 DWT coal carrier is taken as a turning basin.

The water depth is set at 17 m (full-load draught, 16 m + 1 m, allowance) because there is no need of considering the sinkage due to wave actions and squat.

5-3 Mooring facilities

5-3-1 Slab berth

The slab berths had better be planned for the combined use by foreign vessels and domestic vessels. This will make it possible to operate the slab berths flexibly and effectively. No particular berths intended for domestic vessels only are planned, accordingly.

120,000 DWT ore carriers are considered for the slab berth, but the water depth is not for the fully loaded condition.

(1) Number of berths required

A berth with two slab loaders, each having a capacity of 200 tons/hr. can handle the following volume of cargo a year as standard.

Berth occupation rate: 50% in case of single berth

60% in case of two berths

70% in case of three berths

Cargo handling efficiency: 8,000 tons a day

10 slabs/hr. x 20 tons/slab x 2 holds x 20 hrs. = 8,000 tons
(Quantity handled per hour x average slab weight x number of cargo holds x number of working hours per day)

Annual cargo handling capacity per berth: -

One berth : 8,000 x 365 days x 0.5 = 1,460 thousand tons

Two berths in common : 8,000 x 365 days x 0.6 = 1,752 thousand tons

Three berths in common: 8,000 x 365 days x 0.7 = 2,044 thousand tons

Number of berths for the 1st stage: -

2,500 thousand tons ÷ 1,752 thousand tons/berth = 1.4 berth ≑ 2 berths

Number of berths for 2nd stage: -

5,000 thousand tons ÷ 2,044 thousand tons/berth = 2.4 berths ≑ 3 berths

It should be noted, however, that the berthing ratio changes depending on the type and performance of the cargo handling equipment selected.

(2) Aggregate length of berths

The length of a berth is determined as the sum of the length of a 120,000 DWT ore carrier and an allowance for mooring ropes, etc.

Length of a berth = Length of ship + Allowance

= 270 m + 50 m = 320 m

Accordingly, the aggregate length of berths is given as follows.

Aggregate length for the 1st stage: 320 m x 2 berths = 640 m

Aggregate length for the 2nd stage: 320 m x 3 berths = 960 m

It will be enough if the ship's width or more is taken as an allowance.

(3) Water depth of berth

It has been said that the slabs for Italy are transported by an 80,000 DWT slab carrier. Although the type of ship to be used is not certain, a water depth of -15 m appears to be enough for the fully loaded 80,000 DWT carrier.

The slabs for Japan will be transported, together with ore, by an ore carrier which calls at Tubarão Terminal. The largest ship planned for this purpose is 120,000 DWT. It has been made clear that the berthing of ships to the slab berths is managed within the water depth of -15 m.

Thus, the water depth of the berths set at -15 m according to the use plan of the users.

(4) Crown height and apron, etc.

The cargo to be handled is semi-finished iron and steel products, and the crown height of the berth should be so designed as to prevent them from the splash of sea water. The apron should also be designed in harmony with the cargo handling system in order not to hamper the cargo handling work. +4.00 m will suffice for the crown height of the quaywall.

5-3-2 Coal pier

Two coal piers are arranged at an interval of 300 m and parallel to the slab berths. The western side of that pier which is nearer to the slab berths is intended for the domestic vessels. Since the basin for the slab berth on the western side of the coal pier is designed to have a depth of -15 m, coal carriers of up to 80,000 DWT are considered for the domestic trade. The foreign coal berth is designed to accommodate coal carriers of 120,000 DWT.

(1) Number of berths required

Berth occupation rate: 50%

cargo handling efficiency:

1 2 unloaders: nominal capacity of 2,000 tons/hr. each

Daily cargo handling volume = Hourly cargo handling volume x working efficiency x Number of working hours per day = 2,000t/hr. x 2 units x 0.5 x 20 hrs = 40,000 tons/day

2 In case of 2 unloaders x 1,000 tons: 20,000 tons/day

Annual cargo handling capacity per berth: -

a = 40,000 tons/day x 365 day x 0.5 = 7,300 thousand tons

b = 20,000 tons/day x 365 day x 0.5 = 3,650 thousand tons

In the first stage, therefore, one foreign trade berth will be enough for the domestic and foreign import of 4,384 thousand tons. In the second stage when 8 million tons of coal are to be handled, it will be sufficient if one berth for domestic trade is added.

(2) Length of berth

The length of domestic trade berth will be the sum of the length of an 80,000 DWT coal carrier and an allowance, and that of foreign trade berth the sum of the length of a 120,000 DWT coal carrier and an allowance.

Length of domestic trade berth = 240 m + 40 m (allowance) = 280 m

Length of foreign trade berth = 260 m + 50 m (allowance) = 310 m

(3) Water depth of berth

The water depth of berth will be the sum of the draught of a planned vessel and an allowance.

Water depth of domestic trade berth = 13 m + 2 m (allowance) = 15 m

Water depth of foreign trade berth = 16 m + 1 m (allowance) = 17 m

It should be noted that the water depth of domestic trade berth is made a little larger because it is set the same as that of the slab berths the opposite.

(4) Crown height and pier width

The crown height is set the same as the slab berth's. The pier width should be so set so as not to hamper the installation of cargo handling equipment and belt conveyors and the replacement work of buckets and at the same time not to interfere with the back side of the cargo handling equipment to be installed on the berth at the back.

5-3-3 Oil berth

The oil berth will be sufficient if the pier is provided with an ample space for accommodating pipelines, loading arms and machine room, etc. The planned vessel is a 60,000 DWT tanker.

(1) Number of berths

Berth occupation rate: 50%

Cargo handling efficiency: -

Loading arm; 2 units x 1,000 tons/hr.

Daily cargo handling capacity = 1,000 tons/hr. x 0.6 x 2 units x 20 hrs. = 24,000 tons/day

Annual cargo handling capacity = 24,000 tons/day x 0.5 x 365 days = 4,380 thousand tons

Accordingly, it will be sufficient if one berth is constructed to provide for 3,942 thousand tons of oil to be imported in the second stage.

(2) Water depth of berth

The water depth of berth is the sum of the draught of the planned tanker and an allowance.

Water depth of the berth = 13 m + 1 m = 14 m

(3) Type

A berthing dolphin is provided at the center of the berth to accommodate pipelines, loading arms, machine room and control room, and mooring dolphins are placed on either side of the berthing dolphin for mooring vessels.

5-4 Cargo handling facilities

5-4-1 Basic concept

The cargo handling facilities include coal unloading, storage and reclaiming facilities for CST and USIMINAS, storage and loading facilities for CST's semi-finished products, and oil unloading facilities.

Coal shipped to Praia Mole Port from domestic and foreign sources is unloaded by the unloaders on the quay, transported by means of pier and ground conveyors to the coal storage yards (for CST and USIMINAS) located at the reclaimed land within the port where the coal is stored by the yard stackers. The coal for USIMINAS is reclaimed by the yard reclaimers onto the reclaiming conveyors and conveyed to the wagon loading silo within CVRD's premises by way of wagon loading conveyors. The railway wagons thus loaded with coal are run to the destination. The coal for CST is directly conveyed to CST's premises by means of reclaimers and conveyors from CST coal yard. The facilities for CST coal yard are not included in the plan. Transfer, storage and reclaiming of coal by brand are all accomplished by remote control from the central control room.

The slabs are transported by tractor-trailer system to the slab yard in the Port from CST, stored temporarily as classified by destination (Japan, Italy and local consuming sites in Brazil) and weight, hauled by trailers to the pier, and loaded aboard ships by means of slab loaders.
The slab yard has slab cranes for loading and unloading work. As the maximum slab measures 12.5 m in length and weighs 35 tons, utmost care is needed in handling the slabs. Stowing of slabs into the ship's holds should be so made as not to hinder the efficient operations of the slab loaders at the ports of loading and dischange.

Oil is unloaded at the oil pier by making use of loading arms and transported to the oil storage facilities through pipelines laid on the breakwater. The oil handling facilities are to be prepared by PETROBRÁS and are not included in the present plan.

5-4-2 Coal handling facilities

The setup of the coal handling facilities is as shown in Table 5.4.1. The tooling-up was determined upon discussions with Brazilian experts on the occasion of the principal survey.

The equipment listed in Table 5.4.1 is determined in the following way.

(1) Unloaders, belt conveyors and stackers

The capacity of unloaders is determined so that the total costs for the construction, maintenance and operation of unloaders including the related facilities such as conveyors and stackers and the ship costs in port (including costs for berth-waiting) are minimized.

In discussing the optimum scale of port and harbour facilities, it is required to consider not only the capacity of unloaders, but the dimensions of berths (number and length). The discussions are, however, made, in this planning, based on the number of berths and their lengths already mentioned.

In determination of the unloader capacity, the construction costs, maintenance costs, operating costs and ship costs in port are put to comparison studies with respect to the cases shown in Table 5.4.2.

In the second stage, domestic coal to be carried by comparatively small vessels (less than 40,000DWT) will amount to no less than 1.6 million tons. Accordingly, it will be favorable to install unloaders specializing in the handling of domestic coal. If the unloaders for large vessels are used for small vessels, their grab buckets must be changed at the cost of much time.

For the combination of unloaders in the second stage, the capacity of unloaders to be installed on the small-vessel berth is studied with the unloader capacity (2,000 tons/hr. x 2 units) set as optimal for the first stage left intact.

The depreciation costs, interest, maintenance costs and operation costs of the facilities (coal pier, unloaders, belt conveyors and stackers) are calculated on the basis of the conditions given in Table 5.4.3.

Table 5.4.1 Contents of coal handling facilities

Equipment	Capacity	Quantity			Remarks
		1st stage	2nd stage	Master plan	
Unloader	2,000(t/h)	2	-	2	Rope trolley type (Fig. 6.3.1)
"	1,000(")	-	2	2	" (Fig. 6.3.2)
Stacker	2,500(")	2	1	3	Hydraulic elevation type (Fig. 6.3.13)
Reclaimer	2,000(")	1	1	2	Bucket wheel type (Fig. 6.3.15)
Piper conveyor	2,500(")	2	-	2	Width, 1.8m; speed, 160 m/min. (Fig. 6.3.17)
"	1,200(")	-	2	2	Width, 1.4m; speed, 130 m/min. (Fig. 6.3.17)
Ground conveyor	2,500(")	2	-	2	Width, 1.8m; speed, 160 m/min. (Fig. 6.3.17)
"	1,200(")	-	2	2	Width, 1.4m; speed, 130 m/min. (Fig. 6.3.17)
Stacking conveyor	2,500(")	2	1	3	Width, 1.8m; speed, 160 m/min. (Fig. 6.3.17)
Reclaiming conveyor	2,000(")	1	1	2	Width, 1.8m; speed, 130 m/min. (Fig. 6.3.17)
Car loading silo relaying conveyor	2,000(")	1	-	1	Width, 1.8m; speed, 130 m/min. (Fig. 6.3.17)
Car loading silo	1,500(")	1	-	1	Batch loading type (Fig. 6.3.20)

Table 5.4.2 Combinations of unloaders

	1st stage				Remarks
Case	A 1,250 t/h x 2 units	B 1,500 t/h x 2 units	C 1,800 t/h x 2 units	D 2,000 t/h x 2 units	Each value shows the coal unloading capacity per a berth

	Master plan				Remarks
Case	A' 2,000 t/h x 2 units 600 t/h x 2 units	B' 2,000 t/h x 2 units 800 t/h x 2 units	C' 2,000 t/h x 2 units 1,000 t/h x 2 units	D' 2,000 t/h x 2 units 1,250 t/h x 2 units	Each combination shows the coal unloading capacity per two berth

Table 5.4.3 Conditions for calculating the depreciation costs and interest, etc.

Item	Coal pier	Unloader	Belt conveyor	Stacker	Remarks
Service life, years	50	15	15	15	
Interest rate, %	10	10	10	10	per annum
Maintenance and operation costs, %	1	5	5	5	Ratio to initial investment

Note: Depreciation cost calculated according to straight-line method.

For the calculation of the berth-waiting cost for ships, the queuing theory is applied on conditions of poisson arrival and constant service time in order to determine the waiting time. The waiting time is corrected for the variation of ship's size. The cost for the berth-waiting time is calculated according to the conditions specified in Table 5.4.4.

With reference to Table 5.4.4, the cargo volume per berth for the second stage corresponds to the case that both the small and large vessel berths are occupied at a rate of nearly 50%.

The capital costs, maintenance costs, operating costs and ship costs calculated for various combinations of unloaders according to the conditions given above are shown in Table 5.4.6 (1st stage) and Table 5.4.6 (2nd stage).

From Table 5.4.5, it is found that Case D (2 units x 2,000 tons/hr.) minimizes the costs, and Case D is selected for the first stage.

From Table 5.4.6, it is found that Case C (2 units x 2,000 tons/hr. unloader + 2 units x 1,000 tons/hr. unloader) minimizes the costs, and thus Case C is selected for the second stage.

The capacity of the belt conveyors is set 20 to 25% more than that of the unloaders. Since the coal to be handled is in a plural number of brands, and in consideration of the maintenance service of the conveyors, etc. the number of lanes is set as follows.

1st stage: 2,500 tons/hr. x 2 lanes

2nd stage: 1,200 tons/hr. x 2 lanes (to be added to the 1st stage)

The capacity of the stackers is planned to meet the conveying capacity of the largest belt conveyors. Namely, the following three units are planned.

1st stage: 2 units x 2,500 tons/hr.

2nd stage: 1 unit x 2,500 tons/hr. (to be added to the 1st stage)

Table 5.4.4 Conditions for calculation of costs for berth-waiting time

Item	1st stage	Master plan	Remarks
Number of berths	1	2	1st stage: berth common to small and large vessels Master plan: 1 berth for large vessels, 1 berth for small vessels
Annual cargo volume, tons	4,400,000	8,000,000	
Annual working days	300	300	
Daily working hours	20	20	
Unloader efficiency	0.5	0.5	Overall efficiency of unloader obtained by multiplying the grab bucket grabbing efficiency by unloading time efficiency
Average-size ship (D.W.T.)	55,000	Coastal ship 30,000 Ocean-going ship 70,000	
Berthage and demurrage US$/t.d.	0.21	Coastal ship 0.24 Ocean-going ship 0.18	Charges per ton per day

Table 5.4.5 Costs per ton of coal (1st stage)

(in US$)

Item \ Unloader capacity x number of units	A 1,250 t/h x 2 units	B 1,500 t/h x 2 units	C 1,800 t/h x 2 units	D 2,000 t/h x 2 units
Construction costs				
I. Cargo handling equipment	$23,600 \times 10^3$	$25,500 \times 10^3$	$27,660 \times 10^3$	$29,119 \times 10^3$
II. Coal pier	$6,785 \times 10^3$			
Capital cost (depreciation cost plus interest)				
I. Cargo handling equipment	$2,738 \times 10^3$	$2,958 \times 10^3$	$3,202 \times 10^3$	$3,378 \times 10^3$
II. Coal pier	475×10^3			
Maintenance and operation costs				
I. Cargo handling equipment	$1,180 \times 10^3$	$1,275 \times 10^3$	$1,380 \times 10^3$	$1,456 \times 10^3$
II. Coal pier	68×10^3			
Berthage and demurrage	$4,703 \times 10^3$	$3,326 \times 10^3$	$2,550 \times 10^3$	$2,153 \times 10^3$
Costs, total	$9,159 \times 10^3$	$8,102 \times 10^3$	$7,675 \times 10^3$	$7,530 \times 10^3$
Costs per ton of cargo	2.08	1,841	1,744	1,711

Note: Cargo handling equipment include unloaders, belt conveyors and stackers.

Table 5.4.6 Costs per ton of coal (1st and 2nd stages)

(in US$)

Item \ Unloader capacity x number of units	A' 2,000 t/h x 2 units 600 t/h x 2 units	B' 2,000 t/h x 2 units 800 t/h x 2 units	C' 2,000 t/h x 2 units 1,000 t/h x 2 units	D' 2,000 t/h x 2 units 1,250 t/h x 2 units
Construction costs				
I. Cargo handling equipment	$45,100 \times 10^3$	$47,000 \times 10^3$	$48,762 \times 10^3$	$50,600 \times 10^3$
II. Coal pier	$13,571 \times 10^3$			
Capital cost (depreciation cost plus interest)				
I. Cargo handling equipment	$5,232 \times 10^3$	$5,452 \times 10^3$	$5,656 \times 10^3$	$5,870 \times 10^3$
II. Coal pier	950×10^3			
Maintenance and operation costs				
I. Cargo handling equipment	$2,255 \times 10^3$	$2,350 \times 10^3$	$2,438 \times 10^3$	$2,530 \times 10^3$
II. Coal pier	136×10^3			
Berthage and demurrage	$5,539 \times 10^3$	$5,034 \times 10^3$	$4,722 \times 10^3$	$4,430 \times 10^3$
Costs, total	$14,112 \times 10^3$	$13,922 \times 10^3$	$13,902 \times 10^3$	$13,916 \times 10^3$
Costs per ton of cargo	1,764	1,740	1,738	1,739

Note: Cargo handling equipment include unloaders, belt conveyors and stackers.

(2) Reclaimers, wagon loading conveyors and wagon loading silo

These facilities are determined to have a little more capacity in reserve than is actually needed in consideration of the unloader capacity, reduction in staying time of the wagons in CVRD yard and the future increase in cargo volume.

Assuming that the wagon loading hopper operates at a daily average working efficiency (η) of 0.7 for 20 hours a day (H) for 250 days a year (D), and that the annual volume of coal to be handled in the second stage (Qt) is 3,828,000 tons, the required wagon loading capacity (Q) is calculated as follows.

$$Q = Qt/D.H.\eta = 3,828,000/250 \times 20 \times 0.7 = 1,093 \text{ tons/hr.}$$

However, the unloading of coal from ships to the coal yards is undertaken by equipment with a considerably larger capacity. For this reason, the maximum capacity of wagon loading silo (Qm) is set at 1,500 tons/hr.

The maximum capacity of the reclaimer (Q_R) to feed coal to the wagon loading silo is calculated as follows with its average working efficiency set at 0.75.

$$Q_R = Qm/0.75 = 1,500/0.75 = 2,000 \text{ tons/hr.}$$

Thus, the number of reclaimers are required in view of the coal yard layout.

1st stage: 1 unit x 2,000 tons/hr.

2nd stage: 1 unit x 2,000 tons/hr. (to be added to the 1st stage)

In the second stage, two reclaimers are required in view of the coal yard layout.

A lane of loading conveyor with a capacity of 2,000 tons/hr. is planned to meet the unit capacity of the reclaimer. The loading time of coal on to the wagons now used by CVRD is calculated as follows based on the above reclaiming facility.

Volume per wagon	:	34.0 m^3
Number of wagons per train	:	160
Bulk density of coal	:	0.8 ton/m^3
Shift time	:	2 min./5 wagons/operation (5 wagons to be loaded at a time)

Since the wagon loading capacity is 1,500 tons/hr., the loading time (T) is calculated as follows.

$$T = (160 \times 34 \times 0.8/1,500) + (160 \times 2/5 \div 60) \doteqdot 4.0 \text{ hrs.}$$

It is not known what effects the value, 4 hrs., has on the iron ore transportation by the Vitoria-Minas Railway. If the delay of 4 hrs. causes the increase of the number of trains due to slower turnaround of wagons the coal load per train may as well be reduced to a half from the practical viewpoint. It should be added by the way that, judging from several tens of millions of iron ore to be handled a year at present by CVRD, the volume of coal to be handled at Praia Mole is less than 10% as much, and will not affect the wagon operations on the whole.

(3) Coal weighing and control facilities

A central control room (C.C.R.) will be installed in order to collectively handle the coal weighing, switching of coal by brand, class and destination, coal loading and unloading, monitoring of transportation machinery in service and various liaison services. The central control room will be furnished with the following equipment and appliances.

① Operation desk: Transmission of instructions to operators of various handling equipments.

② Graphic panel: Display of operating conditions and troubles of various cargo handling equipment.

③ Coal weighing indicator: Instantaneous weighing and display of coal being transported by belt conveyor.

④ Conveyor switching device: Switching of conveyor lines for distribution of coal by brand, quality and destination.

⑤ Telephone and speaker system: In the event of troubles with machinery, telephone and speaker are used for party liaison and general announcement, respectively. The telephone circuit will have 30 channels, of which 10 will be assigned to the speaker system.

5-4-3 Slab handling facilities

The setup of the slab handling facilities is as specified in Table 5.4.7, as agreed upon between the Japanese survey team and the Brazilian side after close discussions on the occasion of the principal survey.

The particulars of the slab handling facilities listed in Table 5.4.7 are determined according to the following.

(1) Slab loaders

The nominal lifting capacity, 35 tons, of a slab loader is determined from the maximum weight per unit of slab of 35 tons. The nominal hourly capacity of a slab loader is set at 400 tons/hr. from the average lifting weight and cycle time, etc. The number of slab loaders required is determined just the same manner as with the coal handling facilities.
Namely, the scale of the slab loaders (capacity x number of units) is so determined as to minimize the total of the construction costs, maintenance costs, operating costs and ship costs in port.

For the purpose of deciding upon the number of slab loaders, the construction costs, maintenance costs, operating costs and ship costs in port are subjected to comparison study as to the cases listed in Table 5.4.8.

The depreciation costs, interest, maintenance costs and operating costs for slab loaders and slab berths are calculated according to the conditions set forth in Table 5.4.9. For the calculation of depreciation costs, the constant amortization method is applied.

The ship's waiting time in port and resultant expenses are calaulated according to the conditions specified in Table 5.4.10.

Table 5.4.7 Scale of slab handling facilities

Equipment	Capacity	Quantity			Remarks
		1st stage	2nd stage	Master plan	
Slab loader	35 (t)	5	3	8	Semi rope trolley type
Slab crane	35 (t)	10	8	18	Gantry type
Tractor	-	6	4	10	
Trailer	110 (t)	14	10	24	

Table 5.4.8 Combinations of slab loaders

1st stage					Remarks
	A	B	C	D	
Case	400 t/h x 4 units	400 t/h x 5 units	400 t/h x 6 units	400 t/h x 7 units	per 2 berths
Master plan					
	A'	B'	C'	D'	
Case	400 t/h x 6 units	400 t/h x 7 units	400 t/h x 8 units	400 t/h x 9 units	per 3 berths

Table 5.4.9 Conditions for calculation of depreciation costs and interest, etc.

Item	Slab berth	Slab loader	Remarks
Service life, years	50	15	
Interest rate, %	10	10	per annum
Maintenance and operation costs, %	1	5	Ratio to initial investment

Table 5.4.10 Conditions for calculation of ship's waiting time and resultant costs

	1st stage	Master plan	Remarks
Number of berths	2	3	
Annual cargo volume, tons	2,500,000	5,000,000	
Annual working days	300	300	
Daily working hours	20	20	
Slab loader efficiency	0.5	0.5	Overall efficiency
Average-size ship, D.W.T.	40,000	40,000	
Berthage and demurrage US$ t/d	0.23	0.23	Charges per ton per day

The capital costs, maintenance costs, operating costs of slab loaders and berths, and ship costs as calculated according to the conditions stated above are listed in Table 5.4.11 (1st stage) and Table 5.4.12 (2nd stage).

From Table 5.4.11, five units of slab loader with a capacity of 400 tons/hr. should be installed for the first stage. From Table 5.4.12, nine units of slab loader with a capacity of 400 tons/hr. (Case D') will be the most economical for the second stage. However, its difference from Case C' (400 tons/hr. x 8 units) is slight. From the viewpoint of initial investment and cargo handling efficiency, C' is considered advantageous and selected accordingly.

(2) Slab cranes

The slab crane to be used for loading and unloading slabs at the slab yard is a gantry crane, and its lifting capacity (35 tons) is determined from the maximum unit weight (35 tons) of slab. The slab crane is to unload the slabs transported from the steel mill and at the same time disburse the slabs toward the pier. Accordingly, it is planned to install two slab cranes at each slab yard.
As a result, ten units of slab crane are required for the first stage, and eight additional units for the second stage (18 units in all).

(3) Tractors and trailers

The trailer is planned to be able to carry three units of 35-ton slab at a time, that is, to have a capacity of 110 tons. One tractor and two trailers are assigned to one slab loader. An allowance is made for machine troubles, and six tractors and fourteen trailers are assigned to five slab loaders for the first stage, and four tractors and ten trailers to three slab loaders to be added in the second stage.

(4) Handling of slabs within the hold

The slabs loaded into the hold by means of the slab loaders are stowed by means of forklifts or other equipment within the hold.

Table 5.4.11 Costs per ton of slab (1st stage)

(in US$)

Item \ Loader capacity x number of units	A 400 t/h x 4 units	B 400 t/h x 5 units	C 400 t/h x 6 units	D 400 t/h x 7 units
Construction costs				
I. Cargo handling equipment	$11,936 \times 10^3$	$14,920 \times 10^3$	$17,904 \times 10^3$	$20,888 \times 10^3$
II. Slab berth	$12,270 \times 10^3$ *			
Capital costs				
I. Cargo handling equipment	$1,385 \times 10^3$	$1,731 \times 10^3$	$2,077 \times 10^3$	$2,423 \times 10^3$
II. Slab berth	859×10^3			
Maintenance and operation costs				
I. Cargo handling equipment	597×10^3	746×10^3	895×10^3	$1,044 \times 10^3$
II. Slab berth	123×10^3			
Berthage and demurrage	$3,110 \times 10^3$	$2,288 \times 10^3$	$1,823 \times 10^3$	$1,564 \times 10^3$
Costs, total	$6,074 \times 10^3$	$5,747 \times 10^3$	$5,777 \times 10^3$	$6,013 \times 10^3$
Costs per ton of cargo	2.43	2.29	2.31	2.41

* <u>For pier alone</u> (applicable to Master plan, too)

Table 5.4.12 Costs per ton of slabs (1st and 2nd stages)

(in US$)

Item \ Loader capacity x number of units	A' 400 t/h x 6 units	B' 400 t/h x 7 units	C' 400 t/h x 8 units	D' 400 t/h x 9 units
Construction costs				
I. Cargo handling equipment	$17,904 \times 10^3$	$20,888 \times 10^3$	$23,872 \times 10^3$	$26,856 \times 10^3$
II. Slab berth	$18,405 \times 10^3$			
Capital costs				
I. *Cargo handling equipment*	$2,077 \times 10^3$	$2,423 \times 10^3$	$2,769 \times 10^3$	$8,115 \times 10^3$
II. Slab berth	$1,288 \times 10^3$			
Maintenance and operation costs				
I. Cargo handling equipment	895×10^3	$1,044 \times 10^3$	$1,194 \times 10^3$	$1,343 \times 10^3$
II. Slab berth	184×10^3			
Berthage and demurrage	$6,808 \times 10^3$	$5,187 \times 10^3$	$4,301 \times 10^3$	$3,749 \times 10^3$
Costs, total	$11,252 \times 10^3$	$10,126 \times 10^3$	$9,736 \times 10^3$	$9,679 \times 10^3$
Costs per ton *of* cargo	2.25	2.03	1.95	1.94

5-4-4 Storage yard

(1) Coal yard

The coal yard for USIMINAS is planned to have the following spaces.

1st stage: 120,000 m^2 (coal storage capacity: 278,000 tons)

2nd stage: 200,000 m^2 (coal storage capacity: 479,000 tons)

In determining the above space, the following factors are taken into account.

① About 1.5 month's worth of coal is taken as a target volume to be stored following the practice of Japanese steel makers.

② The coal storage space of the coal yard is determined as follows on assumption that the storage density is 5.0 tons/m^2 and that the space utilization factor is 50%.

1st stage: 278,000/ (5 x 0.5) = 111,200 m^2
Rounded up to 120,000 m^2

2nd stage: 479,000/ (5 x 0.5) = 191,600 m^2
Rounded up to 200,000 m^2

③ The coal stacking height is set at 13.0 m on condition that the bulk density of coal is 0.8 ton/m^3 and that the angle of repose is 37° and taking into consideration the bearing capacity of reclaimed land and also natural ignition.

④ The number of stacks per yard is set at 4, and the spacing between stacks is set at 30 to 40 m.

(2) Slab yard

The space for the slab yard is planned as follows.

1st stage: 35 m wide x 300 m long x 5 yards = 52,500 m^2
(storage capacity: 208,000 tons)

2nd stage: 35 m wide x 300 m long x 9 yards = 94,500 m^2
(storage capacity: 416,000 tons)

In determination of the yard space, the following points are taken into account.

① One month's worth of storage capacity is taken as a standard following the typical examples practised at the loading ports in Japan.

② The space of slab yard is calculated as follows on condition that the mean storage density is 7.9 tons/m^2 (mean stacking height: approx. 1 m), and that the space utilization factor is 50 to 60%.

1st stage: 208,000/ (7.9 x 0.5) = 52,658 m^2

2nd stage: 416,000/ (7.9 x 0.6) = 87,764 m^2

5-5 Other facilities

5-5-1 Roads and railways

(1) Roads

In the surveys made up until now, the data concerning planned traffic volume, topography and geology are not enough. But, the following roads are planned.

① 36 m wide approach road (with sidewalks on either side, 8 m) having an aggregate length of 5.5 km from National Road Route 101 to Praia Mole Port.

② Two asphalt-paved intra-port roads, one having a width of 18 m and the other 9 m, with an aggregate area of 332,000 m^2.

③ Intra-port slab transportation concrete-paved road having an aggregate area of 40,000 m^2.

The slab transportation road is planned to be of the concrete pavement type partly because of heavy traffic and partly because the asphalt pavement, if employed instead, might inevitably increase the pavement thickness and incur much maintenance costs, although the concrete road is high in initial investment per m^2. Other roads are planned to be of the asphalt type which is inexpensive and easy to repair even when the non-uniform settling incidental to reclaimed land takes place.

(2) Railways

In the future, a railway will be branched off from the CVRD's Vitória-Minas Railway to Praia Mole Port. Until the end of the second stage, however, it is planned to use trailers for slab transportation.
For this reason, no railway is planned in the present project. In the future plan, however, it is expected to build a public wharf and use a railway for various goods and slab transportation. The port area must therefore have a space for railway extension.

5-5-2 Water supply and fire fighting facilities

The capacity of water supply and fire fighting facilities is planned to meet the peak-hour water demand from ships; buildings and also from fire-fighting services.

It is assumed that the domestic trade vessel will obtain 250 m^3 per day per bottom, the foreign trade vessel 500 m^3 per day per bottom, and that the number of vessels to be served per day is two (one each of foreign and domestic trade vessels) in the first stage and four (two each) in the second stage, and also that the water service hours will amount to 8 per day.

Water supply to the port office, maintenance shop, etc. is set at 0.2 m^3 per person per day, and the number of persons to be served per 8 hours per day is set at 300 in the first stage and 500 in the second stage.

The eight hours-a-day water consumption of ships and buildings is as specified in Table 5.5.1.

From Table 5.5.1, it is found that the daily water supply required is 810 m^3 in the first stage and 1,600 m^3 in the second stage. If a water supply system capable of serving even in the second stage is to be installed in the first stage, the water source having a supply capacity of 200 m^3 per hour must be procured.

In order to answer the above need, a 250 mm dia. main water pipe having a supply capacity of 200 m^3 per hour will be extended from outside source to a storage tank with a capacity of 500 m^3 which is to be installed at the entrance of the port. This tank is necessary when the primary waterline has failed or when the fire fighting service is required.

The water pressure at the service connection from which to supply water to the ship or building should be about 2.0 kg/cm^2 at the lowest.
Even for the fire-fighting service, 2.0 kg/cm^2 will do if the hydrant having an outlet size of 75 mm and the hose nozzle having a port size of 19 mm are used. The pressure, 2.0 kg/cm^2, is attained by elevating the storage tank position enough. Accordingly, no boosting pump is installed.

Table 5.5.1 Water demand

Item	1st stage	Master plan	
Supply to ship	750 m^3	1,500 m^3	1st stage : 250 m^3 x 1 ship + 500 m^3 x 1 ship = 750 m^3 Master plan: 250 m^3 x 2 ships + 500 m^3 x 2 ships = 1,500 m^3
Domestic water	60 m^3	100 m^3	1st stage : 0.2 m^3 x 300 persons = 60 m^3 Master plan: 0.2 m^3 x 500 persons = 100 m^3
Total:	810 m^3	1,600 m^3	

Table 5.5.2 Hydrants for supplying water to vessels

Name of berth	Hydrants		
	Diameter, mm	Hourly feed rate, m^3/hr.	Pitch
Coal berth	75	30	50 m
Slab berth	75	30	50 m
Small craft berth	50	15	40 m
Oil berth	75	30	2 hydrants on a loading platform

For the intra-port piping, 250 mm dia. primary mains are extended from the storage tank, and are split off into secondary mains of 200 mm dia. to the coal berth, slab berth and oil berth. The buildings and slab yards are served with 100 mm dia. service pipes. The sprinkler water for the coal yard will be available from the rain water stored in a sedimentation pond. A pipe line (diameter : 100 mm) should be laid to supply water to the pond when the amount of water in the pond is insufficient.

The Table 5.5.2 shows the port sizes of hydrants, water supply rates, installation pitch of hydrants for supplying the vessels on the berth.

The hydrants on each berth are also used for the fire-fighting purposes. The sprinkler system in a building will be served with the same service pipeline that is connected to the building. Each of the outdoor fire hydrants has a diameter of 75 mm. Other fire-fighting facilities include tugboats.

5-5-3 Tugboats and tenders

It has been said that the horsepower rating of the tugboats is generally 10% of the deadweight tonnage of the vessel they are to tend on. The largest ship to enter Praia Mole Port is 120,000 DWT. Thus, the total horsepower of the tugboats to tow it is 12,000 HP. The relationship between the deadweight tonnage of a ship and the number of tugboats is as shown in Table 5.5.3.

From Table 5.5.3, it is found that three to four tugboats are required to marshall a 120,000 DWT vessel. If tugboats of 3,000 HP class are used, they should number four to deliver a total 12,000 HP. It is planned to prepare four tugboats of 3,200 HP for the first stage and to add one for the second stage by making an allowance for maintenance and repair, or five tugboats in all.

The tugboats and tenders necessary for Praia Mole Port are planned as listed in Table 5.5.4.

The tugboats must be equipped with a fire-fighting equipment. The equipment will consist of one nozzle (3,000 lit./min.) on top of the mast, two nozzles (1,500 lit/min./nozzle) on the oil house and one fire-fighting pump (180 m^3/hr.).

Table 5.5.3 Deadweight tonnage of tended vessel and number of tugboats

Ship size, D.W.T.	∿ 60,000	60,000 ∿ 120,000	120,000 ∿ 170,000
Number of tugboats	2	3	4

Table 5.5.4 Tugboats and service ships

Ship	Number of ships			Remarks
	1st stage	2nd stage	Master plan	
Tugboat	4	1	5	3,200 HP, 200 GT class
Pilot boat	1	1	2	30 GT class, max. speed, 15 kts.
Launch	1	-	1	30 GT class, max. speed, 15 kts.
Small boat	2	-	2	10 GT class, max. speed, 15 kts.

5-5-4 Communication facilities

The communication facilities required for port administration and management are composed of a VHF equipment for radio communication with vessels and a telephone system interconnecting the key intra-port and extra-port stations.

The VHF equipment is used to have communications with vessels entering and leaving the Port, with tugboats, shore facilities and vehicles. It has three channels for international use and two channels for domestic use. A VHF transmitter-receiver is installed at the port office.

The telephone system will have fourty channels in order to interconnect the port office, intra-port and extra-port facilities and berths. The telephone system to be located in the central control room for the purpose of coal handling operation control is included in the coal weighing / control facilities (5-4-2, (3)).

5-5-5 Port office, maintenance shop, etc.

The port office, maintenance shop and other appurtenances are planned as shown in Table 5.5.5. All these are constructed during the first stage.

Table 5.5.5 A Comprehensive list of buildings and structures

Buildings, structures	Dimension (Length x width x story)	Materials	Remarks
Port administration office	45m x 15m x 3F	Rainforced concrete	w/air conditioner and hot water supply
Locker room	33m x 10m x 3F	Ditto	w/shower room
Messroom	24m x 10m x 1F	Ditto	150 persons at a time
Maintenance shop			
without roof	30m x 12m x 1F	Steel frame	w/20t overhead crane, height = 12.0 m
with roof	20m x 11m x 1F	Ditto	6t overhead crane, height = 8.0 m
Machine shop	20m x 11m x 1F	Ditto	6t overhead crane, height = 8.0 m
Timber shop	20m x 11m x 1F	Ditto	6t overhead crane, height = 8.0 m
Tool house			
for coal	10m x 8 m x 1F	Ditto	
for slab	10m x 5 m x 1F	Ditto	
Garage	55m x 15m x 1F	Ditto	w/6t overhead crane and car washer
Gate house	10m x 5 m x 1F	Ditto	
Gas station	10m x 5 m x 1F	Ditto	
Drainage pump station	20m x 12m x 1F	Ditto	w/16t overhead crane, height = 10.0 m
Central control room	10m x 10m x 1F	Ditto	