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No. 8

THE FEASIBILITY STUDY ON THE 7TH BERTH CONSTRUCTION PROJECT

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THE PORT OF HODEIDAH

YEMEN ARAB REPUBLIC

JAPAN INTERNATIONAL COOPERATION AGENCY

SDF

83-001

THE FEASIBILITY STUDY ON THE 7TH BERTH CONSTRUCTION PROJECT

FINAL REPORT

THE PORT OF HODEIDAH

YEMEN ARAB REPUBLIC

JANUARY 1983

PREFACE

In response to the request of the Government of the Yemen Arab Republic, the Government of Japan decided to conduct a survey on the Project to construct the 7th Berth of the Port of Hodeidah and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to Yemen a survey team headed by Mr. Masao Ohno, Executive Director of the Overseas Coastal Area Development Institute of Japan several times.

The team exchanged views with the officials concerned of the Yemeni Government over the project and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Yemen Arab Republic for thier close cooperation extended to the team.

January 1983

Keisuke Arita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

January 1983

Mr. Keisuke Arita
President
Japan International Cooperation Agency

Dear Mr. Arita:

It is my great pleasure to submit herewith a report on the Construction Project of the Port of Hodeidah, Yemen Arab Republic.

The Japanese study team, headed by myself, conducted a survey on the Project in Yemen Arab Republic four times from November 1981, at the request of the Japan International Cooperation Agency. The findings of the feasibility study and our proposition on the port construction are included in this report. The study shows that the importance of the Project is very high so that I hope the Project be executed steadily.

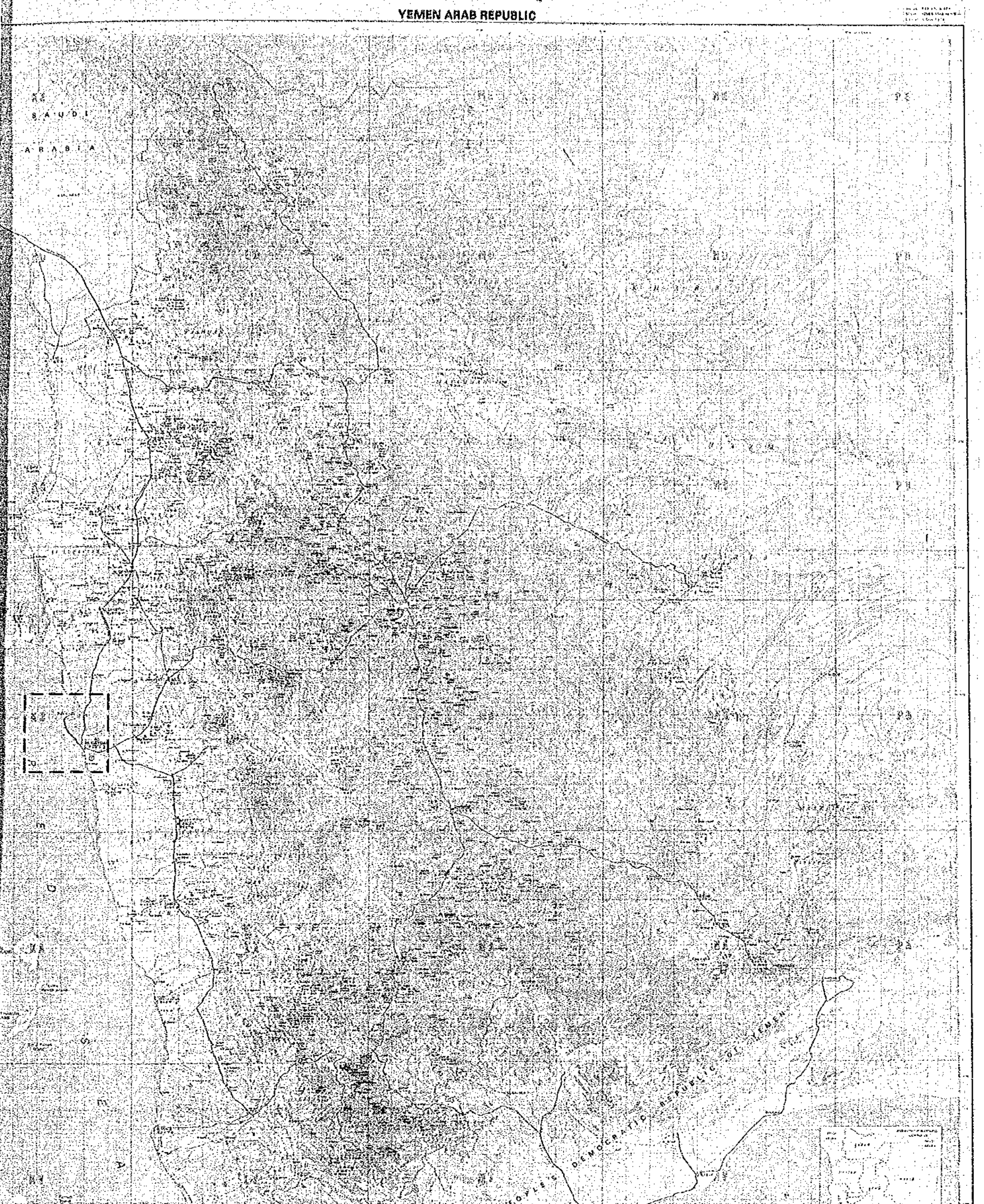
On behalf of the Japanese study team and myself, I would like to express my deepest appreciation to the Government of Yemen Arab Republic and various organizations concerned the Project for their unlimited cooperation, assistance and warm hospitality extended to the team during our stay in Yemen Arab Republic.

My indebtedness also is great to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs and the Japanese Embassy in Yemen Arab Republic for giving us valuable suggestions and assistance in the field study and in preparation of this report.

Sincerely yours,

Masao Ohno

Masao Ohno
Project Manager
Japanese Study Team for the Construction
of the Port of Hodeidah
(Executive Director, the Overseas Coastal
Area Development Institute of Japan)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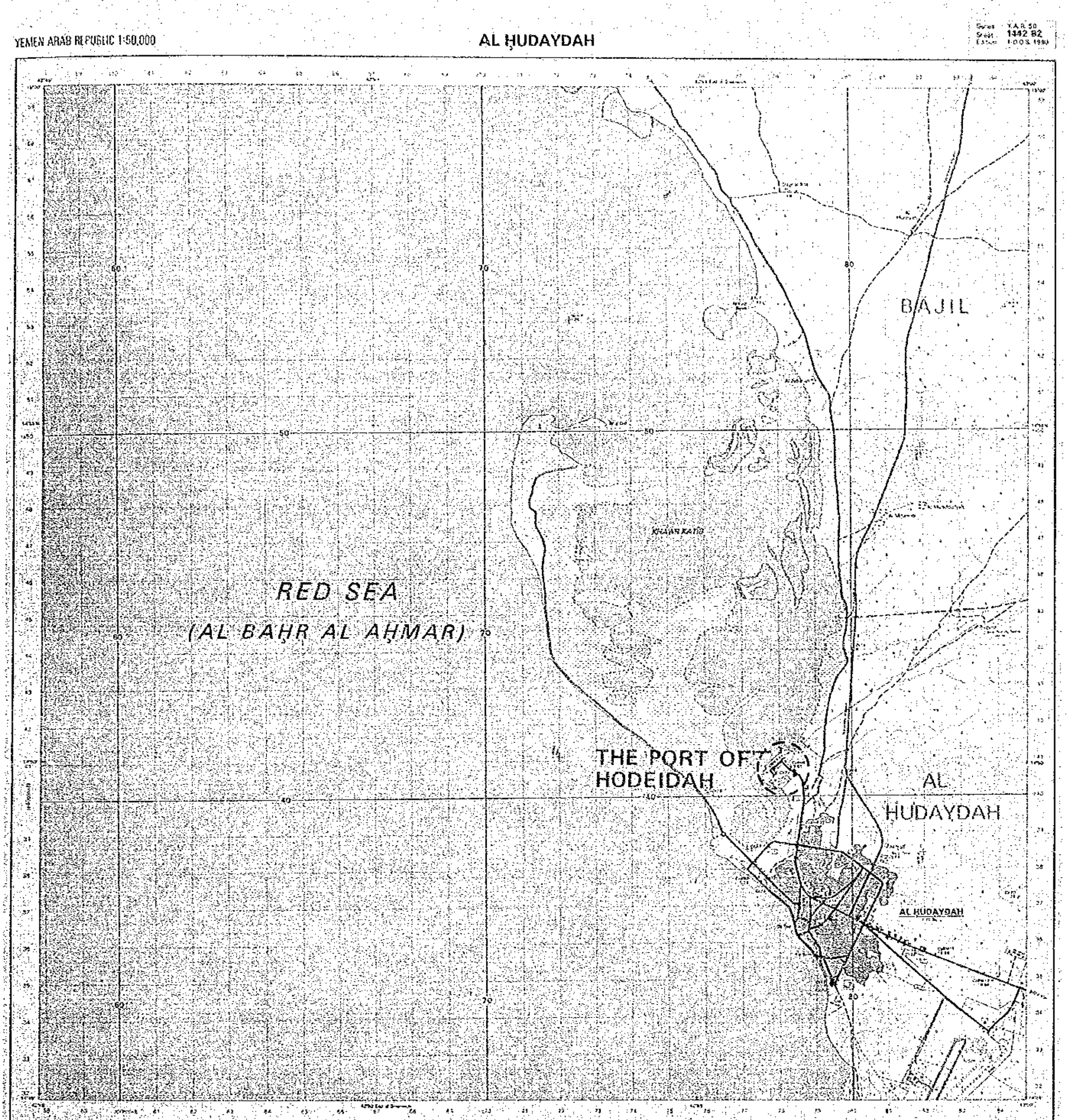
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AL HUDAYDAH
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(AL BAHR AL AHMAR)
BAJIL
THE PORT OF
HODEIDAH
AL
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AL HUDAYDAH
SCALE 1:50,000

Exchange Rate

1 YR = 1/4.5 US$

1 US$ = ¥220

where YR = Yemen rials

US$ = U.S. dollars

ABBREVIATIONS

In this report, the following abbreviations are used:

Abbreviations	Full Name
YAR	the Yemen Arab Republic
CYDA	the Confederation of Yemen Development Associations
PMAC	the Ports and Marine Affairs Corporation
MPW	the Ministry of Public Works
CPO	Central Planning Organization
UNDP	United Nations Development Program
YR	Yemen Riyal
US$	United States Dollar
UNIDO	United Nations Industrial Development Organization

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CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

(1) General

This report consists mainly of the following;

1) Master Plan for Hodeidah port; target year 2000
2) Urgent Plan (as component of Master Plan); target year 1986
3) Economic and financial analysis for the Urgent Plan
4) Management and operation of container terminal

(2) Natural Condition

1) A soft sandy silt strata, 4 to 5 meters thick, covers approximately two thirds of the base of the planned 7th Berth. It is considered that this strata will sink rapidly when loaded. Preloading will be necessary before commencement of pavement work on the 7th Berth apron.

2) Tidal harmonic analysis was performed on the tidal observation data using a computer. Tidal levels are obtained as follows.

Indian spring high water: D.L. + 0.88 m
(Design high water level)
Mean sea level: D.L. + 0.44 m
Datum line: D.L. ± 0.00 m

It is recommended that the newly proposed tide levels mentioned above be substituted for the tide levels which have been used in Hodeidah.

3) Dredging of the approach channel to a depth of −12 m for the further development of the Hodeidah Port may cause siltation problems.
Estimation of siltation rates are very difficult due to a lack of more precise engineering data. Therefore, the execution of periodical observations as follows is recommended.

a) Continuous observation of wind, wave, littoral current and tide.
b) Periodical soundings at the mouth of Kathib Bay and the approach channel
c) Observation of littoral sand drift
d) Measurements of the sedimentation rate
e) Bottom grab sampling
f) Currents measurements in Kathib Bay

(3) **Cargo Volume Forecast**

According to a cargo volume forecast for the YAR based upon the 2nd Five Year Plan (target year 1986), Hodeidah port will in the following years handle the following amounts of cargo:

Unit: Million tons

Year	Actual Record 1980	1986	2000
Cargo volume	1.88	2.57	5.82

(4) **Master Plan, Short Term Plan and Construction Cost**

The Port of Hodeidah should be developed as the liner ship (in which category container ships are included) calling port of the YAR. The Port of Mocha on the other hand, should be operated so as to realize the full potential of its existing port facilities.

It is recommended that the following wharves be developed at the Port of Hodeidah by the following target years, to supplement already existing facilities.

And the construction cost of each Plan is as follows.

(Unit: 10^3 US$)

	Year	Conventional Berth	Container Berth	RO/RO Berth	Construction Cost
Short Term Plan (Urgent Plan)	1986	–	one Water depth 10 m Berth length 250 m	one Water depth 7.5 m Berth length 160 m	Local Currency 11,977 Foreign Currency 30,718 Total 42,695
Middle Term Plan	1993	one Water depth 10 m Berth length 200 m	one Water depth 12 m Berth length 250 m	–	Local Currency 51,076 Foreign Currency 80,839 Total 131,915
Master Plan	2000	two Water depth 10 m Berth length 200 m	one Water depth 12 m Berth length 250 m	–	Local Currency 53,603 Foreign Currency 68,251 Total 121,854

(Year 1981 Price)

Dimensions for a channel and turning basin are as follows:

	Channel width	Channel depth	Diameter of basin
Short Term Plan (Urgent Plan)	100 m	10 m	–
Middle Term Plan	200 m	12 m	500 m
Master Plan	200 m	12 m	500 m

It is recommended that the proposal for a water depth of −12 m be re-examined when the time draws near for actual implementation, in order to reassess the proposal in light of changing conditions.

(5) Short Term Plan

It is urgently required that a 10 m deep, 250 m long container berth (7th berth) and a 7.5 m deep, 160 m long RO/RO berth be added to Hodeidah Port's present facilities so as to maintain effective port operations in the face of increasing cargo volumes and increasing numbers of containers (Urgent Plan). Since construction will last for 30 months, it should be commenced during 1982.

1) Full scale container terminal operation system around the year 1990

The 7th berth should be such that it can be operated jointly with the 6th berth. A chassis system is not recommended for the Port of Hodeidah because several shipping companies will be using the same terminal. Only after carefull comparison of the straddle carrier system and the transfer crane systems, keeping in mind the characteristics of operation systems, should one of these two systems be chosen for the Port of Hodeidah.

2) Management and operation of the full scale container terminal

Yard planners and cargo handling equipment operators should receive thorough training at already well functioning container terminals. The proposed Hodeidah container terminal should be managed and operated by a single organizational body, directly employing a full workforce of well trained and experienced personnel.

(6) Economic Analysis

The economic effects expected from this project area: 1) reduction of port congestion that would result from increasing cargo volumes under the influence of the YAR's future economic growth: 2) the modernization of shipping through the rapid progress of containerization in the Red Sea area.

As for these benefits, the internal rate of return is 15.6%, calculated from analysis of the cost benefit derived from reduction of waiting time in direct relation to transportation. A widely held opinion is that feasibility requires a rate at least 15%. From this, it can be seen that this project is quite feasible from a economic view-point.

(7) Financial Analysis

The profitability of this project is evaluated by analyzing costs and revenues. The result is 7.7% under the present tariff. From this result, the financial position of PMAC can be judged satisfactory during execution of the project. Therefore, this project is feasible from a financial view point.

RECOMMENDATIONS

1. One container berth (7th berth) in the Port of Hodeidah should be constructed and put into operation by the year 1986 in order to handle increasing containerlized cargo.

   The 7th berth should be constructed so that it can be operated jointly with the 6th berth. Therefore, the 7th berth should be constructed adjacent to the 6th berth. Also, the RO/RO berth should be located adjacent to the 7th berth.

2. The container terminal, comprised of the 6th and 7th berths, should be operated under a single organizational body.

3. A field survey on channel siltation should be conducted. It is expected that siltation at the channel will occur when the channel is deepened.

SUMMARY

SUMMARY

CHAPTER 1. BRIEF STUDY OF THE YEMEN ARAB REPUBLIC

The YAR is located in the southwest corner of the Arabian Peninsula. The country extends over approximately 200,000 km^2, its terrain being largely mountainous. Population is currently estimated at 8,540,119 according to the CYDA census of February 1981. About 16% of this total are migrant workers employed outside the YAR.

As for the national balance of payments, worker's remittances are a principal source of foreign exchange.

During the past several years, the YAR's external financial position has continually to weakened, with sharply rising imports and worker reduced remittances.

The YAR has four sea ports, Hodeidah, Ras Kathib, Mocha, and Salif. The port of Hodeidah is the main port, handling over 70% of the country's cargo traffic.

CHAPTER 2. GEOGRAPHICAL AND NATURAL CONDITIONS OF THE PORT OF HODEIDAH

The Port of Hodeidah is located at latitute 14°50'N and longitude 42°56'E, facing towards the Red Sea. It is the largest port in the Yemen Arab Republic and lies at the south end of Kathib Bay. It is well protected by a long finger of land. The western lowlands of the Yemen Arab Republic including Hodeidah are called 'Tihama', with a climate under the maritime influence of the Red Sea.

The coastal lowlands of Tihama generally receive less than 400 mm rain and annual rainfall in Hodeidah is estimated at less than 100 mm. It is a hot desert climate with a mean temperature of 30°C, the annual mean relative humidity being 65% in Hodeidah.

Strong southerly winds are predominant in the winter season, from October to April. Wind waves come from the south with wave heights generally less than 2 m, but occasionally reaching 2.5 ~ 3 m. During the summer season, northerly breezes prevail but there are occasional violent squalls. These violent squalls cause the maximum wave heights of 4.0 ~ 5.0 m in the outer sea of Hodeidah Port. These waves come from north or northwest.

The maximum offshore current at Hodeidah is less than 0.6 knots, with a south to north direction in the winter season, and from north to south in the summer season.

In the nearshore zone, sediment transport takes place due to currents generated mostly by wind and waves.

Tidal harmonic analysis was performed using a computer based on the tidal observation data and the tidal levels are obtained as follows.

- Indian spring high water; D.L. + 0.88 m
  (Design high water level)
- Mean sea level; D.L. + 0.44 m
- Datum line; D.L. ± 0.00 m

It is recommended that the tide levels which have been used in Hodeidah be revised in accordance with the newly proposed tide levels mentioned above.

Small to moderate earthquakes have been reported along the axis of the Red Sea. An effective peak acceleration of firm ground can be considered less than 0.1 g at Hodeidah. But it is desirable to use an effective peak acceleration value of 0.1 g for the design purpose.

Soil conditions of the planned 7th Berth are summerized as follows.

1) The upper layer, from the seabed down to a depth of approximately 2 to 2.5 meters are including dredged fill from the channel and the basin.
2) The second layer of very soft sandy silt with a thickness of between 4 to 5 meters are considered to be sunk rapidly when loaded. Preloading will be necessary before commencement of pavement work on the 7th Berth apron.
3) The base of dense or stiff sandy silt and/or silty sand strata below the second layer are considered durable as the foundation for the planned 7th Berth quay.

Sediment transport is mainly caused by northward longshore littoral drift due to waves generated by the strong southerly winds in the winter season. The sediments caused by incessant wave action have formed finger shaped sand spit. The large, and continually growing finger of land reveals a majority of northward littoral drfit.

Growth of the finger will be very slow and the sea bed at the entrance of Kathib Bay will remain balanced. Siltation of the approach channel will not occur in the near future. But the dredging of the approach channel to a depth of −12 m as part of the development of Hodeidah Port will cause a new siltation problem.

Siltation rate estimates are very difficult to make present because of the absense of more precise engineering data. Therefore, execution of the following periodical observations is recommended.

1) Continuous observation of wind, wave, littoral current and tide
2) Periodical soundings at the mouth of Kathib Bay and the approach channel
3) Observation of littoral sand drift
4) Measurements of the sedimentation rate
5) Bottom grab sampling
6) Currents measurements in Kathib Bay

CHAPTER 3. PRESENT SITUATION OF THE PORT OF HODEIDAH

In the Port of Hodeidah, the total land space for cargo handling and open storage is about 410,000 m^2, of which about 110,000 m^2 is used for general cargo, 170,000 m^2 for timber goods and 130,000 m^2 for container cargo.

In addition, land in reserve and vacant land amounts to 230,000 m^2.

Main Port facilities and average cargo handling efficiency are as shown in the Tables 3-1 and 3-2.

Table 3-1 Berth Dimensions

Berth No.	Length	Water depth
Berth 1	90 m	–3.0 ~ –9.7 m
Berth 2	160 m	–9.7 m
Berth 3	160 m	–9.7 m
Berth 4	166 m	–9.7 m
Berth 5	195 m	–10.0 m
Berth 6	195 m	–10.0 m
Oil Berth for Ships of 5,000 DWT		–7.0 m
Oil Berth for Ships of 15,000 DWT		–10.0 m

Table 3-2 Average Cargo Handling Efficiency

Unit: tons/day/ship

Ship	Cargo	Cargo handling efficiency
General Cargo Ships	General Cargo	660
	Bagged Flour	1,030
	Bagged Cement	1,140
Reefer Carrier	Reefer Cargo	460
Bulk Carrier	Bulk Wheat	1,720

The port of Hodeidah surpasses all others in the YAR in the number of calling ships as shown in the Table 3-3.

Table 3-3 Number of Calling Ships

Port \ Year	1979	1980	1981
Hodeidah	982	847	880
Ras Kathib	160	176	259
Mocha	85	147	105
Salif	(unknown)	68	(unknown)
Total	1,227	1,238	1,244

CHAPTER 4. CARGO TRAFFIC FORECAST

The cargo traffic forecasts made in this Feasibility Study are for 1986, target year of the Urgent Plan and for the year 2000, target year of the Master Plan, as well as for 1993 when another new berth will be required for the Port of Hodeidah, following completion of the 7th berth under the Stage Construction Plan.

For 1986, Urgent Plan target year, cargo traffic forecasts were made by two methods.

One is a macroscopic forecast based on correlation between import values and cargo volume. The other is the accumulation cargo traffic forecast for each commodity calculated on the basis of the production and consumption in each sector under the Second Five-Year Plan.

Cargo traffic forecasts for the year 1993 and for the year 2000 were based mainly on the GDP growth rate and population growth rate for the period from 1986 to 2000. The cargo volume forecast is shown in the Table 4-1.

For the forecast of container cargo traffic the volume of containerizable cargo of each commodity was first calculated for each of the target years and was then multiplied by the rate of containerization which was determined with reference to the containerization trends in domestic service routes of neighboring countries, and YAR.

To estimate the number of container vans, at first the number of stuffed containers was determined from the projections for container cargo. The number of container vans is estimated by adding the number of empty containers, estimated from the number of stuffed containers. The container cargo forecast is shown in the Table 4-2.

In estimating the volume of cargo to be handled at the Port of Hodeidah, cargo was assigned to the Hodeidah zone (Ports of Hodeidah, Ras Kathib and Salif) and the Mocha zone (Port of Mocha) mainly on the basis of population in each zone, and then assigned to the ports of Hodeidah, Ras Kathib and Salif, taking into account the characteristics of the commodities, cargo handling capacities of each port, etc.

Table 4-1 Cargo Volume Forecast

Unit: 1,000 tons

Commodity \ Year	1986		1993		2000	
	YAR	Hodeidah	YAR	Hodeidah	YAR	Hodeidah
Cereal	610	390	833	472	1,130	640
Sugar	200	90	281	214	400	330
Cement	500	–	141	–	Export 500	–
Liquid Petroleum (transported in metal drums)	80	–	80	–	80	–
Fertilizer	20	10	26	23	40	40
Other cargo	1,450	960	2,040	1,498	2,860	2,590
Petroleum	1,400	1,120	1,970	1,576	2,770	2,220
Total Import	4,260	2,570	5,371	3,783	7,280	5,820
Total Export	–	–	–	–	500	–
Total Total	4,260	2,570	5,371	3,783	7,780	5,820

Note: Include container cargo

Table 4-2 Container Cargo Forecast

	1986	1993	2000
Container Cargo Volume (thousand tons)	590	1,296	1,487
Number of Container Vans (thousand TEU)	49	108	141

CHAPTER 5. MASTER PLAN AND SHORT TERM PLAN

(1) Direction of YAR Port and Shipping Development

Since the four ports of YAR, Salif, Hodeidah, Ras Kathib and Mocha are all interdependant, it is important that the Master Plan for the port Hodeidah be formulated by considering the functions alloted to each of the other ports.

In general, the number of calling ports must be minimized on voyages in order to maintain a fleet's economic profitability. At the same time, a liner port must have sufficient markets, customs facilities, shipping agents, stevedoring services and warehouses etc. in its vicinity. At present Hodeidah port receives liner ships and is furnished with the abovementioned functions. However, as will be explained later, conditions pertaining to all three of the other ports are not favorable for receiving liner ships.

It would thus be most advantageous to develop Hodeidah as the liner port for YAR. Among liner ships that sail in the area of the Red Sea, the number of container ships are gradually increasing. Middle class containers ships with a loading capacity of 500 – 750 TEU are the most numerous in this region. It thus seems appropriate to plan Hodeidah's port development, for the time being at least, to accommodate this class of ship.

A Master Plan for the target year of 2000 would more appropriately aim at accommodating larger class vessels.

The present situation and the direction of future development among the four ports are as follows:

1) The port of Salif is a deep sea port with excellent natural conditions. This port handles mainly bulk cargo such as rock salt, cement, wheat etc. Liner ships calling infrequently at this port, because it lacks the full range of port supporting functions necessary for a liner ship port. It is thought that there is little potential for this port to develop into a liner ship port in the future. One reason for this is that the distance between Salif and Hodeidah, about 70 km, is too short for liner ships calling at Hodeidah to bother calling on the same voyage of Salif.

2) Ras-Kathib functions as part of the port of Hodeidah. There are no wide areas within the port, though there are three pontoons for berthing. Judging from its geographical location, it would be very hard to develop this port independantly of the port of Hodeidah.

3) The port of Mocha is located approximately 250 km south of the port of Hodeidah and is equipped with two –7.5 m berths, a lighter's wharf and warehouses. Its port facilities are well developed, second only to Hodeidah port's. Still, there are no facilities or functions for receiving liner ship calls, so liner ship cargo destined for Mocha port's hinterland (Ibb and Taize) is transported by road from the port of Hodeidah. Although upgrading the port of Mocha into a liner ship port is not feasible, continued development by providing well organized and well operated port facilities is recommended.

4) The port of Hodeidah with Sanna as its hinterland, is the major port of YAR. This port is equipped with five −10 m deep berths, 12 warehouses, one cold storage warehouse, a silo complex, and one container berth. The port also meets all the requirements of a liner ship port: large cargo demand, sufficient port workforce, customs office, shipping agents, cargo handling equipment, etc.

The volume of container cargo at the port has recently been increasing. In light of this, the port should continue to be developed both as a port receiving liner container ships as well as a port for conventional ships.

(2) Master Plan

1) Number of Berths

Based on a cargo volume forecast concerning the port of Hodeidah for the target year 2000, 8 conventional berths and 4 container berths will be required, including existing berths.

The water depth required for container berths will vary according to trends in sizes of ships sailing the Red Sea area. At present −12 m berths are being planned in order to accommodate large size full container ships.

2) Layout

It is important that the site encompassed in the port Master Plan be selected not only through consideration of the current target, but also with an eye towards possible but unspecified future expansion of the port plan. Furthermore, the Port Master Plan should be drawn up with the goals of securing coordinated operation with existing facilities, providing safe ship maneuvering, and taking into account geographical conditions. Based on these considerations, the Master Plan as shown in Figure 5-1 has been selected from among several alternatives.

3) Channel and Turning Basin

Channel depth and width will depend upon the size of ships passing through the channel, and sea and weather conditions. Possible dimensions for these facilities, planned for service by the year 2000, are as follows: The channel should be 200 m wide and the turning basin will have a diameter of 500 m;

(3) The Port Development Plan

The port development plan should be implemented in phases, as cargo volumes increase, with the goal of completing construction of all facilities by the Master Plan target year of 2000. In consideration of the cargo volume forecast and ship size trends, and in addition to the berths currently in existence, the following phased expansion and construction is required.

1) By 1986, the construction of one 10 m deep, 250 m long container berth will be required to accommodate 500 – 750 TEU container carriers and shallow draft 1,800 TEU container carriers.

2) By 1990, expansion of the fully operating abovementioned container berth will be required;

3) By 1993, construction of one additional conventional berth and one additional container berth will be required.

Names, target years and Figures are shown below in accordance with the above phases:

Name	Target Year	Layout
Short Term Plan Phase I (Urgent Plan)	1986	Figure 5-2
Short Term Plan Phase II	1990	Figure 5-3
Middle Term Plan	1993	Figure 5-4

(4) Construction Plan

1) Design

The structural design in the Short Term Plan is based on the conditions in the Table 5-1.

Table 5-1 Design Conditions

Object vessel	25,000 D.W.T.
Ship's berthing velocity	0.15 m/sec
Length of quay wall	250 m
Water depth of berth	−11.0 m
Top elevation of berth	+2.47 m
Tidal level	H.W.L. +0.88 m
	L.W.L. ±0.00 m
Surcharge load	Under normal circumustances 3.0 t/m^2
	in the case of on earthquake 1.5 t/m^2
Seismic coefficient	Kh = 0.1
Life span of structure	50 years

As to the structure of berth, steel sheet pile cellular cofferdam type and steel pipe type sheet pile quaywall are examined and compared from the viewpoint of workability and construction cost. The conclusion is that the steel sheet pile cellular cofferdam type is the suitable structure.

2) Construction Schedule

As to the construction schedule of the Urgent Plan, 3.5 years is required to complete all the processed including detailed designing and bidding and other preparations before the berth is put to service. The actual construction is estimated to take 30 months, (See Table 5-2).

3) Construction Cost

The construction cost of the Urgent Plan (year 1986) is 42,695,000 US$, that of the Middle Term Plan is 131,915,000 US$ and that of the Master Plan is 121,854,000 US$ (each 1981 price). (See Table 5-3)

Table 5-2 Construction Schedule of Urgent Plan

				'82						'83						'84						'85						'86					
No.	Description	Unit	Quantity	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
1	The 7th berth	m	250																														
2	Reclamation	m^3	271,000																														
3	Pavement	m^2	31,000																														
4	Container crane	sum	1																														
5	Controll office	sum	1																														
6	Ro/Ro berth	sum	1																														
7	Passenger building	sum	1																														
8	Dredging	m^3	85,000																														
9	Road	m	850																														
10	Mobilization & Demobilization	sum	1																														
11	Engineering study	sum	1																														
12	Supervision	sum																															

Table 5-3 Construction Cost of Each Stage Plan and Total

L/C Local currency
F/C Foreign currency

Unit: 10^3 US$
( ) 10^3 YR

Description	Total					1986				1990				1993				2000			
	Unit	Q'ty	Amount	L/C	F/C	Q'ty	Amount	L/C	F/C	Q'ty	Amount	L/C	F/C	Q'ty	Amount	L/C	F/C	Q'ty	Amount	L/C	F/C
Container Berth	m	750	40,875	9,085 (40,885)	31,790	250	12,418	2,760 (12,423)	9,658					250	14,228	3,162 (14,230)	11,066	250	14,229	3,163 (14,232)	11,066
General Cargo Berth	m	600	29,491	6,555 (29,498)	22,936									200	9,830	2,185 (9,832)	7,645	400	19,661	4,370 (19,666)	15,291
The Ro/Ro Berth	sum	1	1,850	283 (1,274)	1,567	1	1,850	283 (1,274)	1,567												
Reclamation	$10^3 m^3$	2,862	7,009	4,451 (20,029)	2,558	271	4,046	2,762 (12,429)	1,284	132	1,980	1,320 (5,940)	660	2,459	983	369 (1,660)	614				
Dredging	$10^3 m^3$	13,135	30,194	9,215 (41,467)	20,979	85	179	80 (360)	99					13,050	30,015	9,135 (41,107)	20,880				
Pavement	$10^3 m^2$	734.7	121,251	83,039 (373,675)	38,212	31	5,141	3,521 (15,844)	1,620	153.7	25,360	17,368 (78,156)	7,992	225	37,125	25,425 (114,412)	11,700	325	53,625	36,725 (165,263)	16,900
Revetment	m	260	73	62 (279)	11									160	45	38 (171)	7	100	28	24 (108)	4
Temporary Revetment	m	700	199	169 (760)	30									700	199	169 (760)	30				
Road	m	3,600	11,467	7,852 (35,333)	3,615					2,500	7,837	5,367 (24,151)	2,470	1,100	3,630	2,485 (11,182)	1,145				
Temporary Road	m	850	78	66 (298)	12	850	78	66 (298)	12												
Container Crane	set	6	27,030	0	27,030	1	4,505	0	4,505	1	4,505	0	4,505	2	9,010	0	9,010	2	9,010	0	9,010
Building	sum	1	7,463	5,973 (26,882)	1,490	1	287	233 (1,052)	54	1	3,588	2,870 (12,915)	718	1	1,196	956 (4,303)	240	1	2,392	1,914 (8,612)	478
Utility	sum	1	2,920	438 (1,971)	2,482					1	1,040	156 (702)	884	1	626	94 (423)	532	1	1,254	188 (846)	1,066
Mobilization & Demobilization	sum	1	29,077	2,173 (9,780)	26,904	1	9,231	690 (3,105)	8,541	1	3,692	276 (1,242)	3,416	1	9,231	690 (3,105)	8,541	1	6,923	517 (2,328)	6,406
Sub-Total			308,977	129,361 (582,131)	179,616		37,735	10,395 (46,785)	27,340		48,002	27,357 (123,106)	20,645		116,118	44,708 (201,185)	71,410		107,122	46,901 (211,055)	60,221
Engineering & Supervision	sum	1	12,766	5,314 (23,913)	7,452	1	1,918	556 (2,502)	1,362	1	1,920	1,094 (4,923)	826	1	4,644	1,788 (8,046)	2,856	1	4,284	1,876 (8,442)	2,408
Physical Contingency	sum	1	29,266	13,249 (59,622)	16,017	1	3,042	1,026 (4,618)	2,016	1	4,623	2,817 (12,677)	1,806	1	11,153	4,580 (20,610)	6,573	1	10,448	4,826 (21,717)	5,622
Total			351,009	147,924 (665,666)	203,085		42,695	11,977 (53,905)	30,718		54,545	31,268 (140,706)	23,277		131,915	51,076 (229,841)	80,839		121,854	53,603 (241,214)	68,251

Fig. 5-1 Master Plan for the Port of Hodeidah
(The year 2000)

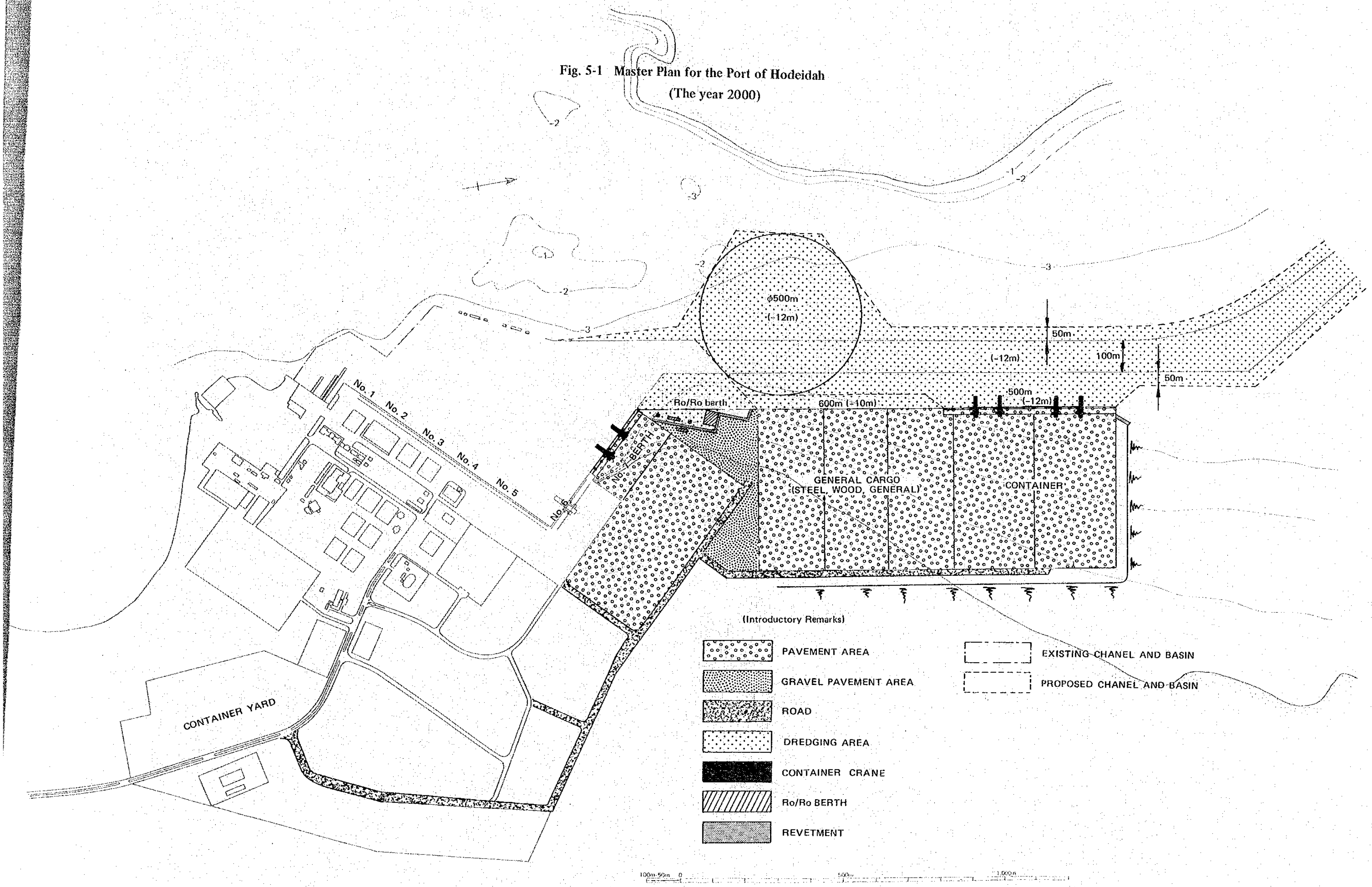


Fig. 5-2 Urgent Plan for the Port of Hodeidah
(The year 1986)

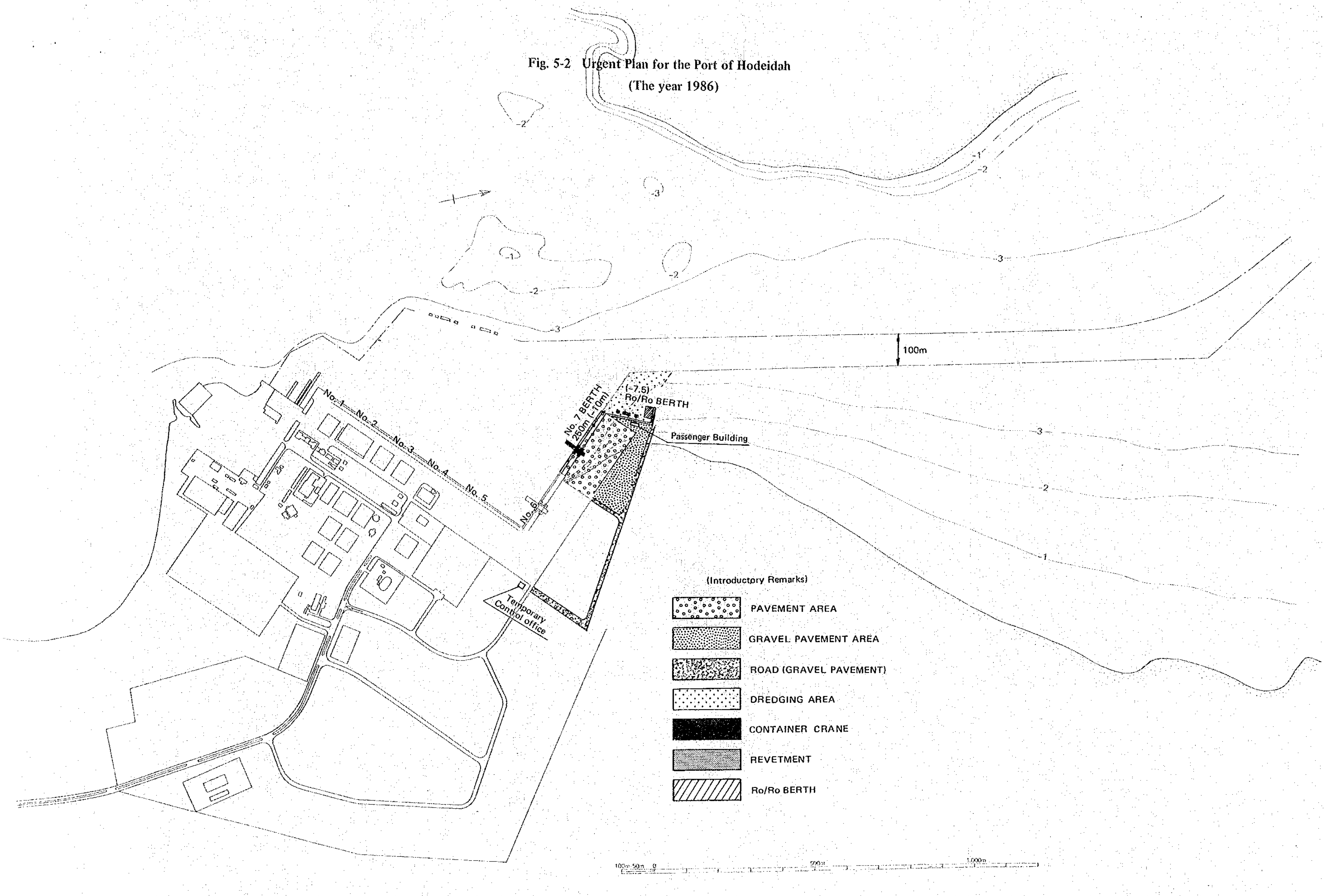


Fig. 5-3 Short Term Plan Phase II for the Port of Hodeidah
(The year 1990)

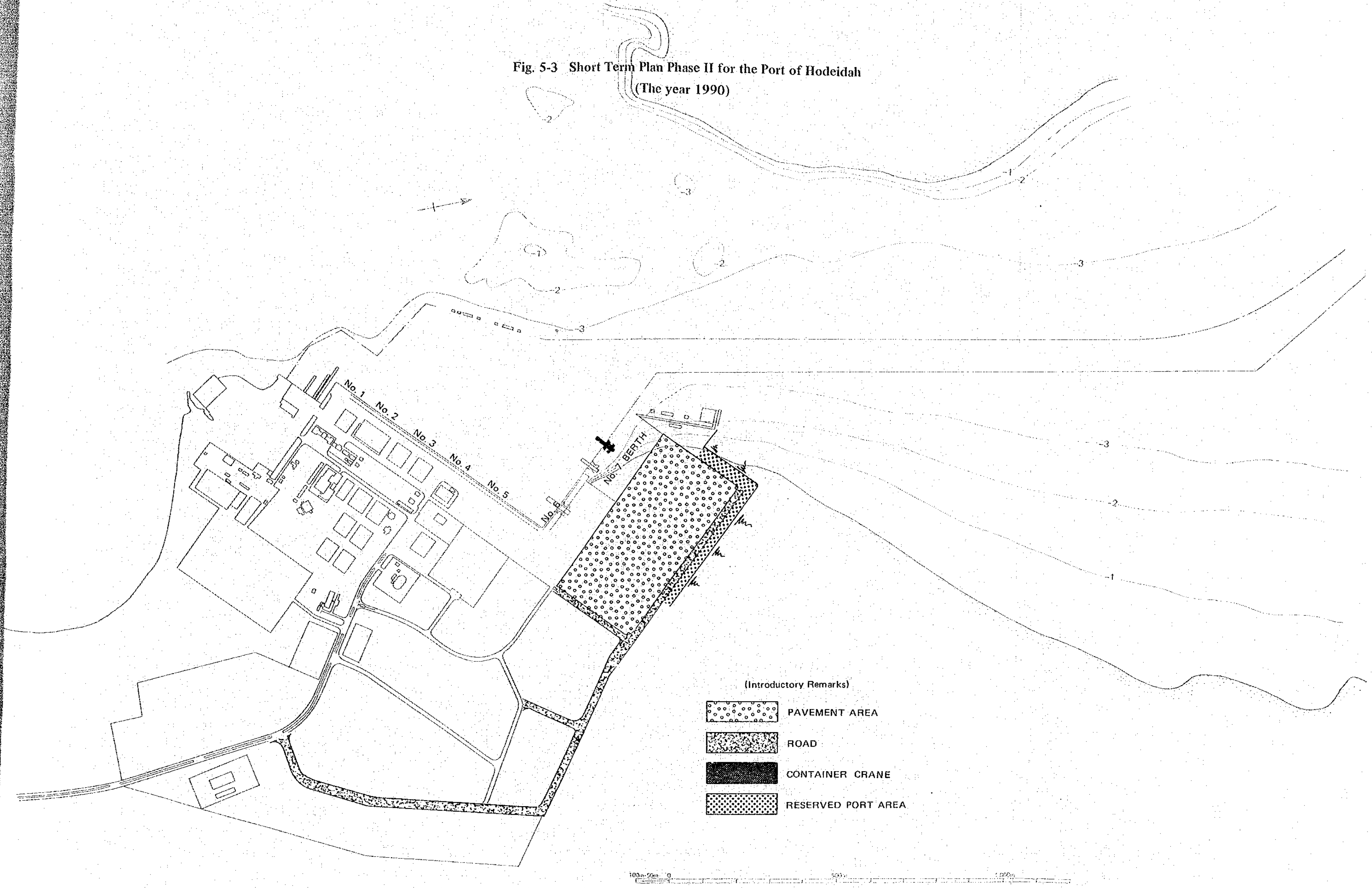
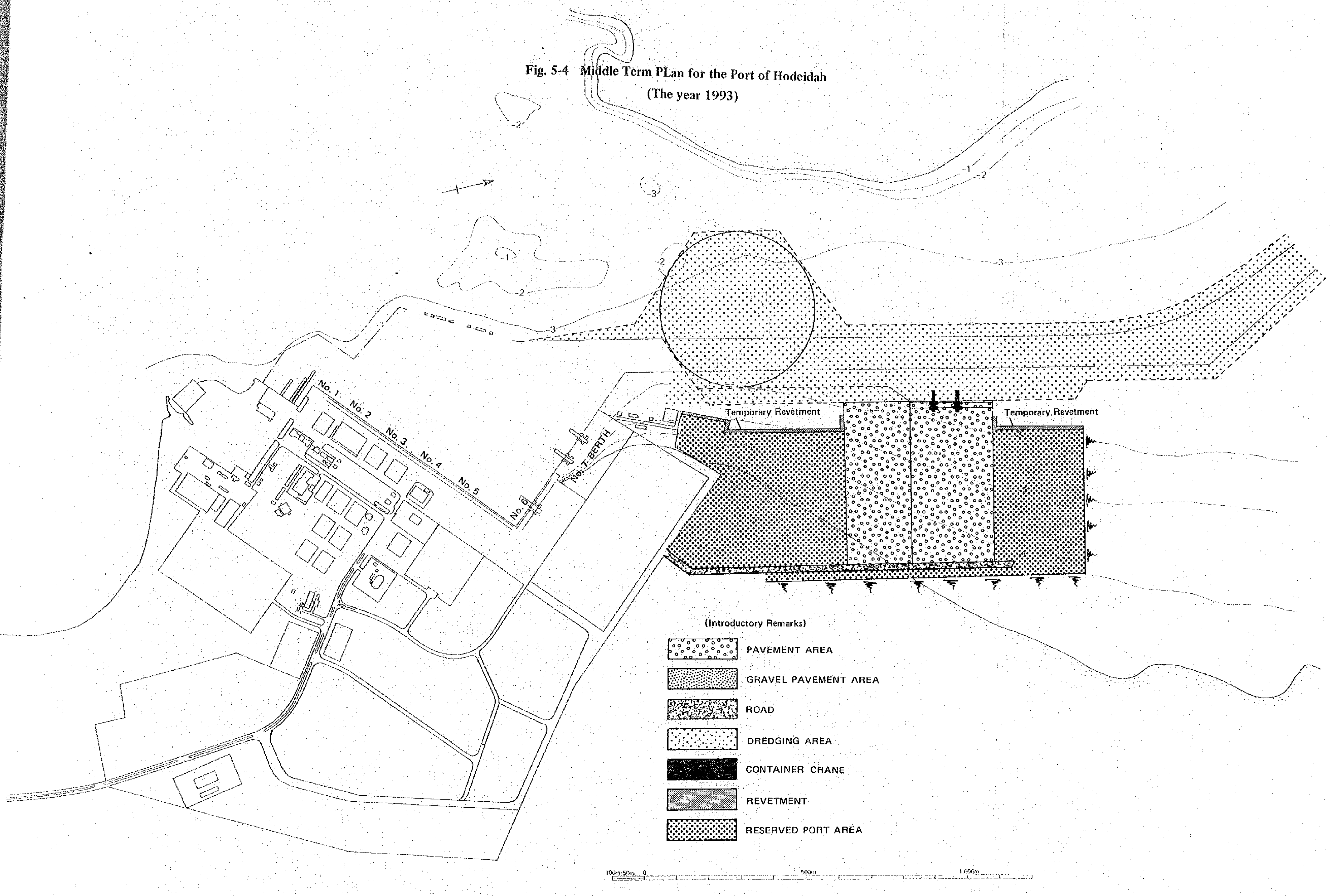


Fig. 5-4 Middle Term PLan for the Port of Hodeidah
(The year 1993)



(5) Full Scale Container Terminal

1) Selection of Container Handling System

There are at present three kinds of container handling systems: the Chassis system; the Straddle carrier system; and the transfer crane system. A comparison of these three systems in terms of economy and handling is summarized in Table 5-4. Each system can be roughly evaluated as follows;

a The chassis system is an excellent system from the standpoint of simplicity and efficiency, however it has very low productivity in terms of area, requiring a very large yard. Furthermore, if the container terminal is used by several shipping companies, as is the case at the port of Hodeidah, then the chassis provided by the various companies using the yeard are likely to be mixed together, causing possible confusion in the yard. This system is therefore not recommended for the port of Hodeidah.

b The straddle carrier system is used by various ports around the world, as it is a very flexible and mobile system. However it requires highly trained operators and mechanics.

c The transfer crane system is suitable for handling a high volume and constant flow of containers. In many cases it is possible to apply a computer controlled automatic operation system to this system. However, it will not be possible to employ this system at the port of Hodeidah for the time being.

2) Management and Operation

Management and operation systems for a full scale container terminal should be designed so that a single organizational body oversees operation of the whole terminal and directly employs a well trained and experienced work force.

3) Training

The key staff responsible for managing ship cargo, yard operations, documentation, and inventory control should be trained by being put directly in charge of an actual job at an already developed container terminal for a period of at least three months.

In this way they can obtain full and detailed knowledge of operation procedures. Handling equipment operators and mechanics also should be trained through actual experience. It is therefore recommended that handling equipment be purchased in advance of the terminal's opening (three months or so) to be used for this purpose.

Table 5-4 Comparison of Systems

Item \ System	Chassis	Straddle Carrier	Tyre-Mounted Transfer Crane	Rail-Mounted Transfer Crane
Storage Capacity	△	○	◎	◎
Initial Cost	△	○	◎	◎
System Simplicity	◎	○	△	△
Handling Efficiency	◎	○	△	○
Wharf Efficiency	△	◎	△	△
Mobility of Operation	◎	○	△	△
Container Damage	◎	△	○	○
Maintenance Cost	○	△	◎	◎
Flexibility of Operation	◎	◎	△	△
Expandability	◎	○	△	△
Adaptability of Automation	△	△	○	◎
Loading to Railway	△	△	○	◎

◎: excellent, ○: good, △: questionable

CHAPTER 6. URGENT PLAN

(1) Necessity of the 7th Berth

The Port of Hodeidah will have to be urgently developed by 1986 to successfully meet expected increases of general and container cargo. A study of the feasibility of this urgent development plan is presented below.

The number of ship calls and the berth occupancy rate for each year, from 1982 until 1986 has been calculated using the cargo volume forecast, statistics for average loaded/unloaded cargo volumes, and statistics for average handling efficiencies by ship type. Figures for loaded/unloaded cargo volumes and handling efficiencies are calculated from records of actual ship calls at the Port of Hodeidah. According to these calculations, the berth occupancy rate for the 6th container berth will increase to about 70% if the 7th berth is not constructed. Severe port congestion will ensue. It is therefore highly recommended that one container berth (7th berth) should be constructed by 1986 to forestall this possibility.

(2) Analysis of Port Congestion

A simulation test to be used in forecasting port congestion has been carried out for two cases; 1) where additional berths are to be constructed in phases according to a Master Plan and Short Term Plan; 2) where an additional berth is not constructed.

According to the results of the simulation test, the maximum waiting time for general cargo ships and container ships will be about 30 hours with no additional berths, and about 20 hours; if additional berths are constructed in phases as mentioned in the Short Term Plan. This waiting time is permissable in light of present waiting times.

(3) Facility Plan

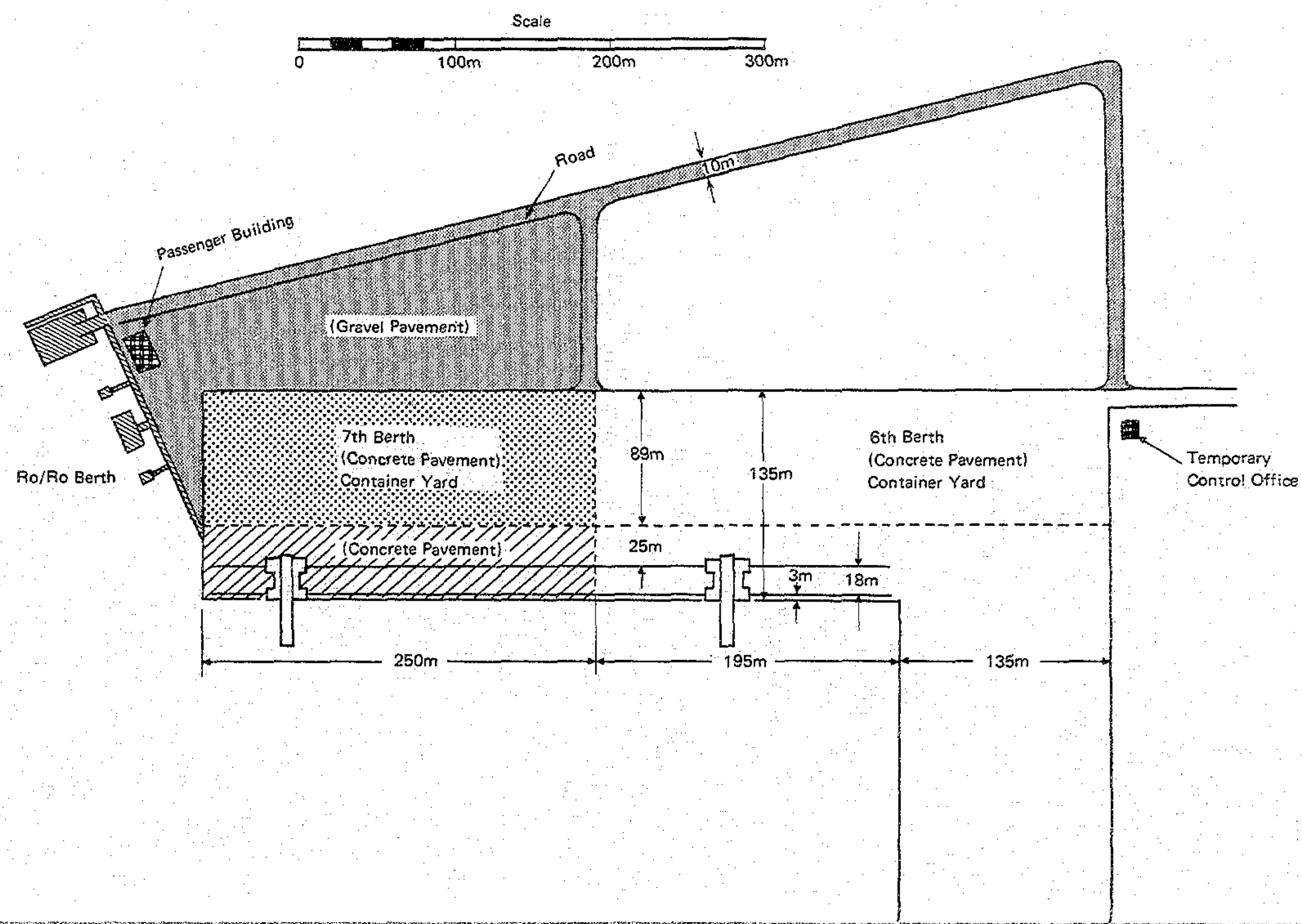
A 10 m deep, 250 m long container berth is required in order to accommodate 500 – 750 TEU container vessels and shallow draft 1,800 TEU container vessels.

The 7th berth should be constructed along the same alignment as the 6th berth so that both berths can be operated together as a compound terminal. A crane and foundation for the crane should also be installed in such a way that they can be used for both berths.

In 1986, full scale terminal operations will not be necessary since the total number of containers handled at both berths will be only 75,000 TEU per annum. This is substantially less than the terminal's minimum full scale capacity of 100,000 TEU per annum.

In handling these 75,000 TEU containers yearly, it will be necessary to have a container yard with 3,800 slots, so a 17,000 m^2 area behind the 135 m wide apron has been selected for this purpose. In view of the demands and specifications of the above mentioned facilities, the Short Term Plan Phase I (Urgent Plan) shall be as shown in Figure 6-1.

Fig. 6-1 Layout of Urgent Plan



(4) Economic Analysis

The topic of this chapter is the economic feasibility of the 7th Berth Construction Project.

The economic effects expected from this project are: 1) reduction of port congestion that would result from increasing cargo volumes under the influence of the YAR's future economic growth; 2) modernization of shipping through the rapid progress of containerization in the Red Sea area. These economic effects were evaluated by cost and benefit analysis, assuming a project life of 25 years and using 1983 as the base year. In terms of benefits, an evaluation was made concerning reduction of ship waiting costs. Additional economic benefits will include encouragement of regional development in the vicinity of the port, increasing demand for related industries, and an increase in employment through continuation of port construction. In terms of costs, construction, operation, maintenance and repair costs were adopted. To estimate the price for all benefits and costs, boder prices (international prices) were evaluated.

As a result, an IRR of 15.6% was obtained. From this it can be seen that this project is quite feasible from a economic view point.

(5) Financial Analysis

The purpose of financial analysis is to analyze how the costs and profits of a project affect the financial position of the project's management body in light of its past and present financial situation, then to propose measures to make the management body financially more secure.

The profitability of the 7th Berth Construction Project of the Port of Hodeidah has been evaluated through analysis of costs and revenues.

For the revenues, only those expected from the 7th berth were used. The RO/RO berth, will be constructed by 1986 to the west corner of the 7th berth.

The new RO/RO berth is expected to be operated together with the 7th berth. Thus, revenues to be obtained from the new RO/RO berth will be added to those from the 7th berth.

For the costs, construction cost, operation cost, costs of maintenance and repair, and depreciation were used.

25 years was assumed in calculating the FRR for the project. The result is 7.7% under the present tariff.

Judging from this result, the financial position of PMAC is expected to be satisfactory even during execution of this project. Therefore, this project is feasible from a financial view point.

(6) Port Management and Operation

1) Operation system

A system of port operation similar to that at present is recommended for the Urgent Plan (target year 1986), as the number of containers will remain small at 75,000 TEU.

Imported containers will be stacked in a temporary open storage yeard in accordance with the "import yard decking plan", after being unloaded from ships in accordance with the "unloading sequence list". Next, the stacked containers will either be transported to consignees as door-to-door service, then emptied and stacked in the open storage yard, or if the containers contain mixed cargo thus will be immediately emptied and stacked in the open storage yard. On the other hand, export containers (including empty containers) will be received in the open storage yard, and then stacked prior to ship arrival in the container yard situated immediately behind the berth apron, as per the "export yard decking plan". Finally, the containers will be loaded on ship in accordance with the "loading sequence list".

2) Management

It is recommended that present operation procedures be continued under the Urgent Plan, whereby each individual stevedore furnishes key staff and cargo handling equipment, while the central labor office employs the remaining workers. Management and workers should all be well trained and must all work on fixed schedules since they will operate highly complex handling equipment.

3) Training

The 7th berth gantry crane operator must first master the basic operation of the 6th berth crane, and should then refine his skills on, and familiarize himself with the new crane.

PURPOSE OF STUDY

Purpose of Study

1. Background of Study

Yemen Arab Republic imports most goods, including daily necessaries, thus its seaports are very important in transporting cargoes. Yemen Arab Republic has four seaports, the largest of which is the Port of Hodeidah. It handles most general cargoes. However, the Port of Hodeidah has recently been congested. Therefore, in order to reduce the Port's congestion and to strengthen its cargo handling capacity, expansion of the Port of Hodeidah is in progress. Two new berths (5th and 6th) were added in December 1981.

Yemen Arab Republic is still in need of a new container berth to smoothly handle rapidly increasing volumes of container cargoes expected in the future as part of the worldwide trend toward cargo containerization.

For this purpose, the Government of Yemen Arab Republic has requested the Government of Japan to study the feasibility of the 7th berth construction project at the port of Hodeidah.

Japan International Cooperation Agency dispatched a survey mission in September 1981 and a field survey mission in December 1981 to Yemen Arab Republic.

2. Purpose of Study

The Study aims at conducting a feasibility study for the new container berth (No. 7) as an urgent project based on the study of the Port of Hodeidah by the year 1986, and also formulating a long-term plan of the Port by the year 2000.

Matters to be studied are as follows;

- Natural conditions
- Port planning
- Forecast on port demand
- Basic design
- Cost estimation
- Economic analysis
- Financial analysis
- Terminal operation

3. Formation of the Survey Team

3-1 Methods of Investigation

Methods of investigation are generally classified into verbal, field observation and collection of informative materials. Names of the authorities and organizations visited by the team for hearing and collecting informative materials are listed below.

The Ministry of Public Works

Central Planning Organization

The Ports and Marine Affairs Corporation

The Confederation of Yemen Development Association
United Nations Development Program
Central Bank of Yemen
Yemen Oil and Mineral Resources Corporation
Ministry of Finance
Customs Department

3-2 Survey Team

(1) First Field Investigation

The first field investigation was conducted for a period of about one month from July 9 to August 12, 1982.

The members of the team are follows:

Mr. Masao OHNO (Project Manager)
Executive Director
The Overseas Coastal Area Development
Institute of Japan (OCDI)

Mr. Akio OGO
(Team Leader, Port Planning)
Director, OCDI

Mr. Takashi HASHIKAWA
(Traffic Forecast)
Deputy Director, OCDI

Mr. Hiroshi OKAMOTO
(Natural Condition)
Hydraulic Engineer, OCDI

Mr. Nobuyuki MATSUDA
(Structural Design and Cost Estimate)
Civil Engineer, OCDI

Mr. Yoshiaki TAHIRA
(Economic Analysis)
Deputy Director, OCDI

Capt. Tsutomu NISHIDA
(Container Terminal Planning)
Operation Expert, OCDI

(2) Interim Report

For the Interim report, a team was dispatched to Yemen Arab Republic during 14 days from March 30 to April 12, 1982. The members of the team are as follows:

Mr. Masao OHNO (Project Manager)
Executive Director, OCDI

Mr. Akio OGO
(Team Leader, Port Planning)
Director, OCDI

Mr. Masayuki FUJIKI
(Structural Design and Cost Estimate)
Civil Engineer, OCDI
Capt. Tsutomu NISHIDA
(Container Terminal Planning)
Operation, Expert, OCDI

(3) Second Field Investigation

The second field investigation was conducted for a period of about three weeks from May to , 1982.

The members of the team are follows:

Mr. Masao OHNO (Project Manager)
Executive Director, OCDI
Mr. Tadahiko YAGYU
(Port Planning)
Deputy Director, OCDI
Mr. Tadashi OHTANI
(Economic and Financial Analysis)
Deputy Director, OCDI
Mr. Tomoo AMANO
(Economic Analysis)
Civil Engineer, OCDI

(4) Explanation and Conference on Draft Final Report

The explanation and conference on the draft final report was held for a period of 19 days from August 12 to August 30, 1981.

The members of the team are follows:

Mr. Masao OHNO (Project Manager)
Executive Director, OCDI
Mr. Tadashi OHTANI
(Financial Analysis)
Deputy Director, OCDI
Mr. Tomoo AMANO
(Economic Analysis)
Civil Engineer, OCDI

3-3 Counterparts

Anwar Al Harazi	General Manager of Projects and Loans Department, CPO
Jamal Mohamed Abdo	Under Secretary, MPW
Mohamed A. Zabara	Director General of MPW and Representative of PMAC
Ali H. Al Habori	Chirman of PMAC

Capt. Mohammed A Moghuni	Director of Operation, PMAC
D.H. Rama Rao	Chief Engineer, PMAC
Ali Shary	Head of Account Depertment, PMAC

3-4 Progress of Investigation

(1) The progress of first field investigation is as follows:

November	29 (Sun.)	Tokyo
	30 (Mon.)	→ Athens
December	1 (Tue.)	→ Sana'a
	2 (Wed.)	Courtesy visit at the Embassy of Japan and MPW.
	3 (Thu.)	Sana'a → Hodeidah
	4 (Fri.)	Discussion in the team
	5 (Sat.)	Discussion with PMAC, The field investigation of the Port of Hodeidah and Ras Kathib.
	6 (Sun.)	Explanation of Inception report to PMAC
	7 (Mon.)	Project Manager : Hodeidah → Sana'a Rest : Explanation of Questionnaire to PMAC officers
	8 (Tue.)	Rroject Manager : Sana'a → Cairo Rest : Explanation of Questionnaire to PMAC officers
	9 (Wed.)	Project Manager : Cairo Rest : The field investigation of the Port of Salif
	10 (Thu.)	Project Manager : → Tokyo Rest : The field investigation of the Port of Mocha
	11 (Fri.)	Discussion in the team
	12 (Sat.)	Discussion with PMAC about Interim Report
	13 (Sun.)	Hodeidah → Sana'a
	14 (Mon.)	Data collection, Preparation of Record of Discussion
	15 (Tue.)	Signing of Record of Discussion Courtesy visit at the Embassy of Japan and MPW etc.
	16 (Wed.)	Sana'a → Athens
	17 (Thu.)	Athens
	18 (Fri.)	→ Tokyo

(2) The progress of interim report is as follows:

February	2 (Tue.)	Tokyo →
	3 (Wed.)	→ Cairo →
	4 (Thu.)	→ Sana'a
		Courtesy visit to the Embassy of Japan, CPO and MPW.
		Explanation of interim report to CPO, and MPW.
	5 (Fri.)	Explanation of interim report to PMAC.
	6 (Sat.)	– ditto –
	7 (Sun.)	Discussion with PMAC about interim report
	8 (Mon.)	Hodeidah → Sana'a
	9 (Tue.)	Discussion with MPW about interim report
	10 (Wed.)	Discussion with CPO about interim report
	11 (Thu.)	Signing of Record of Discussion
		Courtesy visit to the Embassy of Japan.
	12 (Fri.)	Sana'a → Cairo
	13 (Sat.)	Cairo →
	14 (Sun.)	→ Tokyo

(3) The progress of second field investigation is as follows:

May	4 (Tue.)	Tokyo →
	5 (Wed.)	→ Sana'a
	6 (Thu.)	Courtesy visit to the Embassy of Japan, MPW, CPO and UNDP.
	7 (Fri.)	Discussion in the team
	8 (Sat.)	Data collection in CPO, UNDP.
	9 (Sun.)	Sana'a → Hodeidah
	10 (Mon.)	Explanation of Questionnaire to PMAC,
		The field investigation of the Port of Hodeidah and Ras Kathib.
	11 (Tue.)	Hodeidah ↔ Salif The field investigation of the Port of Salif
	12 (Wed.)	Hodeidah ↔ Mocha The field investigation of the Port of Mocha
	13 (Thu.)	Hodeidah → Sana'a
	14 (Fri.)	Project Manager : Sana'a → Cairo
		Rest : Discussion in the team
	15 (Sat.)	Project Manager : Cairo → Rest : Data collection in CPO
	16 (Sun.)	→ Tokyo Rest : – ditto –
	17 (Mon.)	Data collection in CPO and UNDP
	18 (Tue.)	Discussion with MPW
	19 (Wed.)	Sana'a → Athens
	20 (Thu.)	Athens →
	21 (Fri.)	→ Tokyo

(4) The progress of explanation and discussion of the draft final report is as follows:

October	21 (Thu.)	Tokyo →
	22 (Fri.)	→ Sana'a
	23 (Sat.)	Courtesy visit to the Embassy of Japan and MPW.
	24 (Sun.)	Explanation of the draft final report to MPW and CPO.
	25 (Mon.)	Explanation of the report to the Embassy of Japan
	26 (Tue.)	Explanation of the report to PMAC
	27 (Wed.)	Discussion with CPO, MPW and PMAC about the report
	28 (Thu.)	Interview of UNDP
	29 (Fri.)	Discussion in the team
	30 (Sat.)	Discussion with PMAC
		Signing of Record of Discussion
		Courtesy visit to the Embassy of Japan.
	31 (Sun.)	Sana'a → Cairo
November	1 (Mon.)	Cairo →
	2 (Tue.)	→ Tokyo

CHAPTER 1

BRIEF STUDY OF YEMEN REPUBLIC

CHAPTER 1. BRIEF STUDY OF THE YEMEN ARAB REPUBLIC

1-1 General Aspect

1-1-1 Location and Area

The YAR is located on the southwest corner of the Arabian Peninsula. The country is bordered by Saudi Arabia to the north, the People's Democratic Republic of Yemen to the south, the Red Sea to the west where the country's ports are located, and the great Arabian desert to the east.

The country extends over approximately 200,000 km^2, its terrain being largely mountainous.

1-1-2 Population

(1) General

The census of 1975 was the first accurate population count in the YAR. At the fine of that census, the nation's population was 6,492,530. Population is currently estimated at 8,540,119 according to the CYDA census of February 1981.

About 73% of the labor force is rural and engaged directly in agriculture. Another 16% of the total is comprised by migrant workers employed outside of the YAR. Most of them are working in Saudi Arabia.

Table 1-1-1 shows the population breakdown by category of the YAR as reported in the 1975 Census and the 1981 CYDA Census.

Table 1-1-1 1975 Census and 1981 CYDA Census

Category	1975 Census	1981 Census
1. Recorded population within the country	4,540,230	6,439,363
2. Population of uncovered areas	294,500	NA
3. Un-enumerated population for technical reasons	260,000	705,978 (items 3 and 4)
4. Un-enumerated population for social reasons	163,800	
5. Number of migrants outside Yemen	1,234,000	1,394,778
Total population	6,492,530	8,540,119

Source: CPO

(2) Main cities

The main cities of the YAR and their populations are as follow;

Sana'a	211,150
Hodeidah	95,873
Taiz	87,689
Ibb	25,888
Dhamar	30,367
Hajjah	19,302

(CYDA census, Feb. 1981)

1-1-3 Economic

(1) Composition and growth of GDP

In the YAR, agriculture remains the single most important sector of the economy, contributing approximately 30 ~ 40% to the country's GDP. In recent years, however, the growth rate of agricultural production has fallen behind those of other sectors – especially trade, transport, and industry – resulting in a reduction in the share of agriculture in the gross domestic product.

In 1975, a five-year plan was instituted by the YAR government aimed at raising annual GDP growth to 8.2% by 1981. However, the annual growth rate actually achieved was 5.9%. This was attributed primarily to stagnation in the agricultural sector due to several factors; lack of irrigation, emigration of farm labour to urban centres or to neighbouring countries, numerous difficulties in marketing, storage and distribution of agricultural products, etc.

Real Growth of GDP by sectors during the First Five-Year Plan is indicated in Table 1-1-2.

Table 1-1-2 Real Growth of GDP by Sectors During the First Five-Year Plan (1975/1976–1980/1981)
(at constant base year prices)

(Unit: million YR)

Economic Activities	Base Year 75/76	Period of base & Terminal year					Annual Growth Rate % Achieved	Planned Average Annual Growth %	Ratio of Achieve-ment %
		76/77	77/78	78/79	79/80	80/81			
Agriculture, Forestry and Fisheries	2,011	1,850	1,653	1,926	2,008	2,111	1.0	5.5	18.1
Mines and Quarries	32	42	64	74	78	74	18.2	12.6	144.4
Manufacturing	257	274	309	361	416	448	11.7	11.0	106.4
Electricity and Water	17	17	22	28	37	43	20.4	20.4	100.0
Construction	283	373	511	581	480	469	10.6	14.4	73.6
Wholesale and Retail Trade	948	944	987	963	1,063	1,059	2.2	10.1	21.8
Catering	64	68	72	76	81	83	5.3	10.1	52.5
Transport and Communications	150	160	200	208	211	217	7.7	11.3	68.1
Financial Institutions	141	227	338	380	421	447	25.9	9.5	272.6
Real Estate and Business Services	207	193	221	226	241	265	5.1	3.6	141.7
Personal & Social Services	42	44	52	58	61	62	8.5	7.5	113.3
Less: Imputed Bank Services	134	211	305	260	405	417	–	–	–
Total of Business Sector	4,018	3,981	4,124	4,511	4,692	4,862	3.9	8.0	48.8
Government Services	509	451	585	672	760	834	10.4	10.0	104.0
Non-Profit Private Organizations	14	17	19	21	23	23	10.4	7.5	138.7
Customs Duties	394	737	887	774	843	836	16.2	–	–
GROSS DOMESTIC PRODUCT	4,935	5,186	5,615	5,978	6,318	6,555	5.9	8.2	72.0

Source: CPO

(2) Per capita GDP

Per capita GDP is about only 1,000 YR. For this reason many people (about 16% of the total population) have chosen to work abroad. (See Table 1-1-3)

(3) Balance of Payment

The YAR's balance of Payment is indicated in Table 1-1-5. Worker remittance is the YAR's principal source of foreign exchange.

During the first two years of the 1975 plan, the YAR's external financial position countinued to strengthen, but in the past two years this trend reversed. As imports rose sharply, worker remittance dropped.

Table 1-1-3 Per capita GDP

	77/78	79/79	79/80	80/81	1981
Population as of January lst (in thousands)	6,536	6,732	6,934	7,144	7,264
Per capita GDP (in Rial)	978	1,018	1,054	1,032	1,026

Source: CPO

Table 1-1-4 Annual Growth Rates of GDP in the First Five Year Plan 1976/77–1980/81

	76/77	77/78	78/79	79/80	80/81	Annual Achieved	Annual Planned
GDP	5.1%	8.3	6.5	5.7	3.9	5.9	8.2

Source: CPO

Table 1-1-5 Balance of Payments

(Unit: million YR)

	77/78	78/79	79/80	80/81	1981
1. Current Account	1,472.7	621.3	△1,480.4	△2,982.6	△2,989.4
Trade account	△4,102.7	△5,613.2	△6,925.5	△7,580.1	△7,820.4
(Exports)	(31.8)	(13.2)	(32.1)	(72.1)	(47.4)
(Imports)	(△4,134.5)	(△5,626.4)	(△6,957.6)	(△7,652.2)	(△7,867.8)
Invisible account	5,575.4	4,991.9	5,445.1	4,597.5	4,831.0
(Worker Remittance)	(6,350.7)	(5,595.0)	(6,118.4)	(4,935.8)	(4,444.2)
2. Capital Accounts	340.4	932.5	1,301.8	1,217.9	1,483.8
(Long-term loans)	(366.5)	(511.7)	(558.8)	(740.4)	(950.5)
(Short-term loans)	(–)	(410.6)	(592.0)	(181.0)	(455.8)
3. Errors and ommissions	199.5	452.8	169.4	△230.8	6.8
4. Balance of Payments position	2,012.6	764.0	△9.2	△1,996.8	△1,498.8
5. Monetary movement	△2,012.6	△764	9.2	1,996.8	1,498.8
(Central Bank)	(△1,733.0)	(△911.6)	(546.3)	(2,073.4)	(1,494.1)
(Commercial Banks)	(△279.6)	(147.6)	(△537.1)	(△76.6)	(4.7)

Source: CPO

1-1-4 Industry

Agriculture is the major industry in the YAR. The main crops are cereals, fruits, vegetables, sorghum, and millet. YAR is not self-sufficient in cereal production, and depends partly on imported grains, mainly wheat. The only non-agricultural resources are rock salt and limestone deposits.

Local handicrafts are still the main form of manufacturing. Weaving, tanning, dyeing, and food processing are practised in the old, traditional ways, with little use of mechanically generated power and only a few small factories. In recent years, however, the country has managed to construct manufacturing plants, mainly in food processing, construction materials, textiles, metal- and woodworking.

Table 1-1-6 Production of Main Crops

(Unit: 10^3 t)

	1978~1979	1979~1980	1980	1981
Barley	42	45	48	54.1
Wheat	63	63	65	69.6
Maize	46	48	49	53.2
Sorghum and millet	627	632	636	635
Potatoes	116	127	131	138
Vegetable	230	254	261	291.4
Grapes	49	55	56	64.3
Fruits	73	76	77	80.7

Source: CPO

Table 1-1-7 Major Industries

	1978	1979	1980	1981
Salt Extraction (Unit: 10^3 t)	58	73	154	64
Rock Quarrying (Unit: 10^3 m^3)	19	78	76	567
Ghee and Edible Oils (Unit: 10^3 t)	4	6	13	14
Soft Drinks (Unit: 10^3 boxes)	4,817	10,503	12,410	12,325
Spinning and Weaving (Unit: 10^3 yards)	2,094	4,747	5,410	3,428
Tanning (Unit: 10^3 skins)	306	393	299	—
Plastic Tubes (Unit: 10^3 m)	—	--	462	312

Source: CPO

1-2 Transportation

The vast majority of the YAR's population is settled in mountain farm villages and towns. There is therefore a certain demand for transport facilities connecting major towns within the mountainous region, as well as for facilities linking the mountains and the coast.

Yet even in the late 1950's, a modern transport infrastructure was almost completely lacking in the YAR. Toward the end of the decade, bilateral assistance, on a project-by-project basis helped launch the development of a modern transport system.

1-2-1 Highways

There are about 2,422 km of main roads in YAR. About 1,578 km of these are paved, and a further 699 km are under construction and slated to be paved; the remainder consists mostly of dirt roads.

The traffic movement between the YAR ports and their hinterland depends entirely on road transport. The port of Hodeidah is linked to the main cities (Sana'a, Taiz, Saadah, etc.,) by paved roads.

Table 1-2-1 Road Lengths from 1961–1981

(Unit: km)

Years	Index Number 1976=100	Annual Growth Rate in Total Roads	Total	Non-Asphalted Roads	Asphalted Roads
1961	16	–	231	266	231
69	30	83	423	404	423
73	72	140	1,016	585	431
74	74	3	1,044	599	445
75	75	1	1,054	609	445
76	100	34	1,413	648	765
77	125	25	1,771	728	1,043
78	132	6	1,872	759	1,113
79	138	4	1,943	796	1,147
80	156	13	2,220	798	1,402
81	171	10	2,422	844	1,578

Source: CPO

Distances by main roads between large cities are as follow:

Hodeidah	~	Sana'a	226 km
〃	~	Taiz	272 〃
〃	~	Saadah	468 〃
〃	~	Beidah	476 〃
〃	~	Dhamar	326 〃
〃	~	Ibb	308 〃
〃	~	Hajjah	130 〃
Sana'a	~	Taiz	256 km
〃	~	Beidah	268 〃
〃	~	Dhamer	100 〃
〃	~	Ibb	193 〃
〃	~	Hajjah	127 〃

1-2-2 Ports

The YAR has four seaports, the ports of Hodeidah, Ras Kathib, Mocha, and Salif. Of these the ports of Hodeidah, Ras Kathib, and Mocha are presently administrated and managed by the Ports and Marine Affairs Corporation (PMAC), established in April 1976. The Minister of Public Works exercises overall control over PMAC. The port of Salif is presently administrated and managed by governmental corporation.

(1) The Port of Hodeidah

The Port of Hodeidah is a new port, built between 1958 and 1961. Originally it had three berths, but later two more were added giving the present total of five. Hodeidah port is located centrally, handling over 70% of the country's cargo traffic.

(2) The Port of Ras Kathib

The port of Ras Kathib is an outer port of Hodeidah, opened in 1978. It mainly handles bulk cargo and lashes.

(3) The Port of Mocha

The port of Mocha is a small lighterage port. It is well-positioned to serve the prosperous Taiz district and handles about 8 ~ 10% of the YAR's total general cargo. It is situated approx. 250 km south of Hodeidah.

(4) The port of Salif

The port of Salif is a deep-water natural harbor with a modern mechanized, salt-loading pier. Besides it has two small pontoons handling cement, wheat, and bulk cargo. It is situated approx. 70 km north of Hodeidah.

(5) Facilities and Traffic Cargo

The major facilities of these ports are outlined in Table 1-2-2, while port traffic is indicated in Table 1-2-3.

Table 1-2-2 Major Facilities of the YAR's Ports

Name of Port	Principal Facilities	Remarks
Hodeidah	No. 1 Berth: 90 m long, –9.7 m deep No. 2 〃 : 160 m 〃 , 〃 〃 No. 3 〃 : 160 m 〃 , 〃 〃 No. 4 〃 : 166 m 〃 , 〃 〃 No. 5*1 〃 : 195 m 〃 , –10 m 〃 No. 6*2 〃 : 195 m 〃 , 〃 〃 Berths for tankers { 5,000 dwt –7 m deep / 15,000 dwt –10 m deep Warehouse 12 60 m x 50 m 8 60 m x 45 m 2 60 m x 97 m 1 60 m x 25 m 1 Cold storage 1 50 m x 32 m	*1, *2, No. 5 and No. 6 berth completed in Dec. 1981
Ras Kathib	Pontoon 27.45 m x 91 m 3 unit –8 m deep	No warehouse facilities
Mocha	No. 1 Berth: 150 m long, –7.8 m deep No. 2 〃 : 165 m 〃 , –7.8 m 〃 Old 〃 : 200 m 〃 , –4.7 ~ –2.5 m 〃 Warehouse 4 60 m x 50m 4	
Salif	Berth*3: 92.5 m long, –18 m deep Two small pontoons are available to handle cement, wheat, and bulk cargo	*3, Handles rock salt and cargo No warehouse facilities

Table 1-2-3 History of Cargo Traffic Through the YAR

(Unit: 10^3 t)

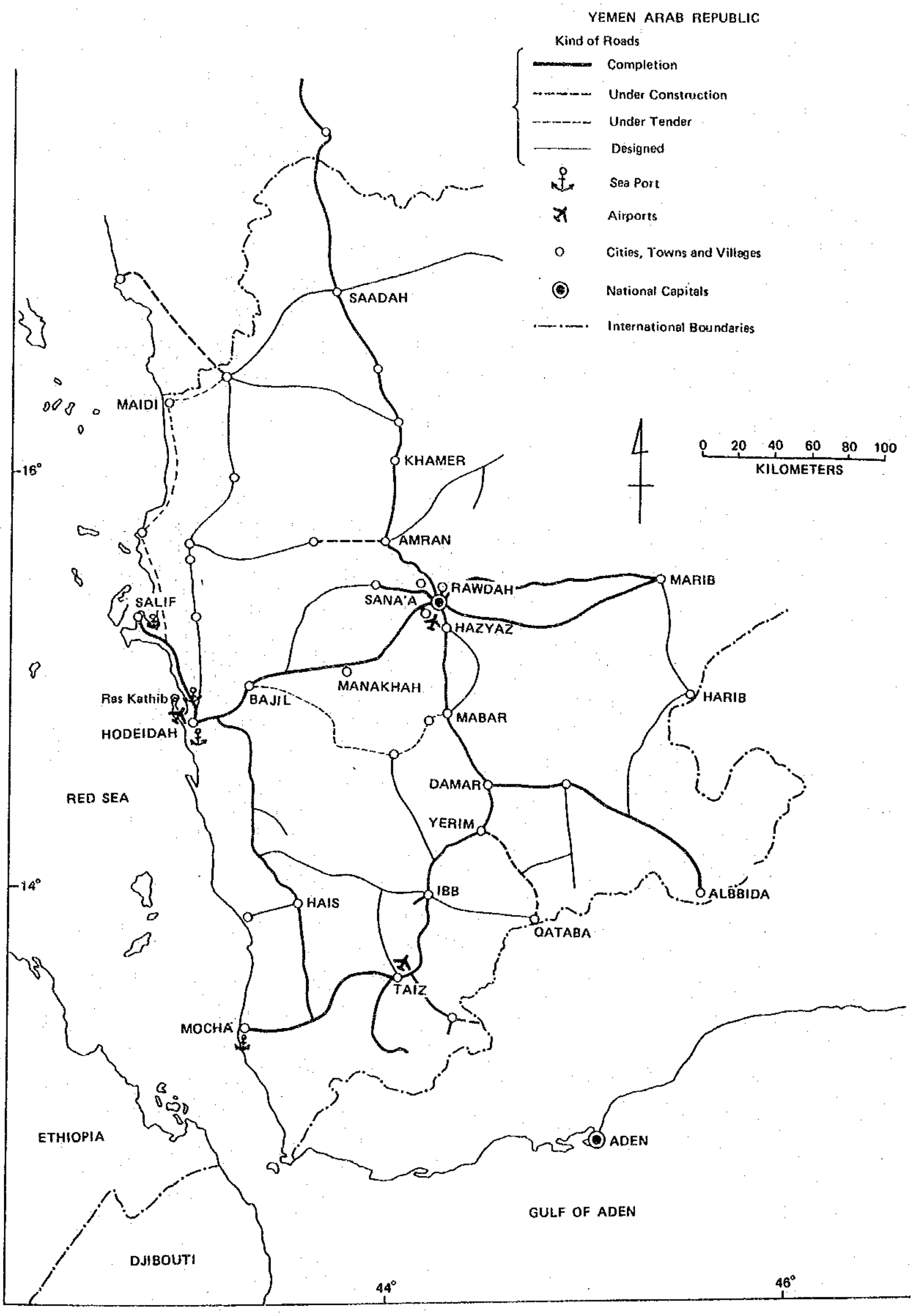
Name of Port \ Year	1977	1978	1979	1980	1981
Hodeidah Ras Kathib and Mocha					
Total	1,424	2,034	2,513	2,485	2,448
Import	1,039	1,598	1,925	1,866	1,898
Export	12	9	–	–	–
Petroleum	373	427	588	619	550
Salif					
Total	542	475	308	551	466
Grand Total	1,966	2,509	2,821	3,036	2,914

Source: CPO

1-2-3 Civil Aviation

The YAR has two international air ports, one each at Sana'a and Taiz. The airport at Hodeidah provides domestic service, while the small airfields at Saadah and Berat provide domestic service in the northern region.

Fig. 1-1-1 Road Network Map in YAR



CHAPTER 2
GEOGRAPHICAL AND NATURAL CONDITIONS OF THE PORT OF HODEIDAH

CHAPTER 2. GEOGRAPHICAL AND NATURAL CONDITIONS OF THE PORT OF HODEIDAH

2-1 Geographical Conditions

The Port of Hodeidah is, as shown in Fig. 2-1-1, located at latitude 14°50'N and longitude 42°56'E, facing the Red Sea. This, the largest port in the Yemen Arab Republic lies at the south end of Kathib Bay. It is well protected by a long finger of land and has an almost 16 km long channel. This finger begins at the northern coast of Hodeidah, extending in direction north-northwest, reaches approximately 14 km. The Greater Hodeidah Port are formed including the Port of Ras-Kathib located at the top of this finger.

Hodeidah, the second largest city in the Yemen Arab Republic after the capital Sana'a, has a population of almost 100,000 and is connected to Sana'a, Taiz and Mocha by the well-paved roads. Dwellings are tall and usually of stone with flat roofs. The town is close to the coast and mostly sandy. The western lowlands of the Yemen Arab Republic including Hodeidah are called 'Tihama', under the maritime influence of the Red Sea (See Fig. 2-1-2).

2-2 Natural Conditions

2-2-1 Precipitation

Meteorological statistics for Hodeidah are given in Table 2-2-1(1) ~ 2-2-1(3).

As shown in Table 2-2-1(1) ~ 2-2-1(3) and Fig. 2-2-1, the coastal lowlands of Tihama generally receive less than 400 mm rain and annual rainfall in Hodeidah is estimated at less than 100 mm. It is a hot desert climate with a mean temperature of 30°C, the annual mean relative humidity being 65% in Hodeidah.

2-2-2 Wind

Strong southwest winds are predominant in winter, from October to April. These strong winds sometimes cause heavy swell in Kathib Bay and make boatwork difficult. During the hot season, cool northerly breezes prevail in the afternoon, but occasional violent squalls and sandstorms are sometimes blow off the land. These squalls are experienced most frequently in August and September.

The only available wind data are also shown in Table 2-2-1(1) ~ 2-2-1(3). According to the U.S. Navy Marine Climatic Atlas of the World (Vol. 3, Indian Ocean, 1976), the directions of winds on Red Sea coasts are generally northerly for most of the year as shown in Fig. 2-2-2. This shows that there is some difference in wind conditions between Hodeidah (or the Yemen coastline) and the Red Sea.

Fig. 2-1-1 Location of the Port of Hodeidah

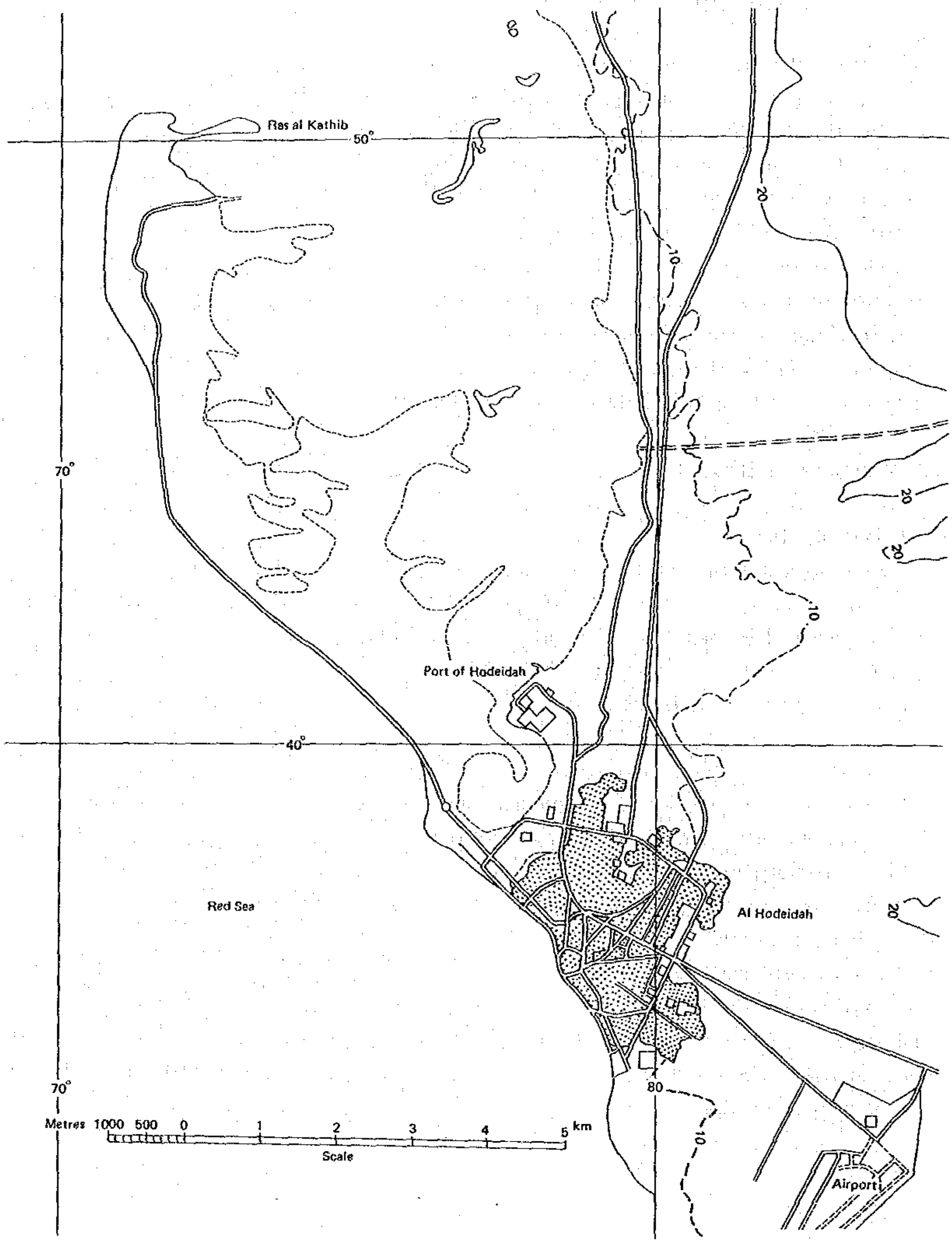


Fig. 2-1-2 Geographic Regions of the Yemen Arab Republic

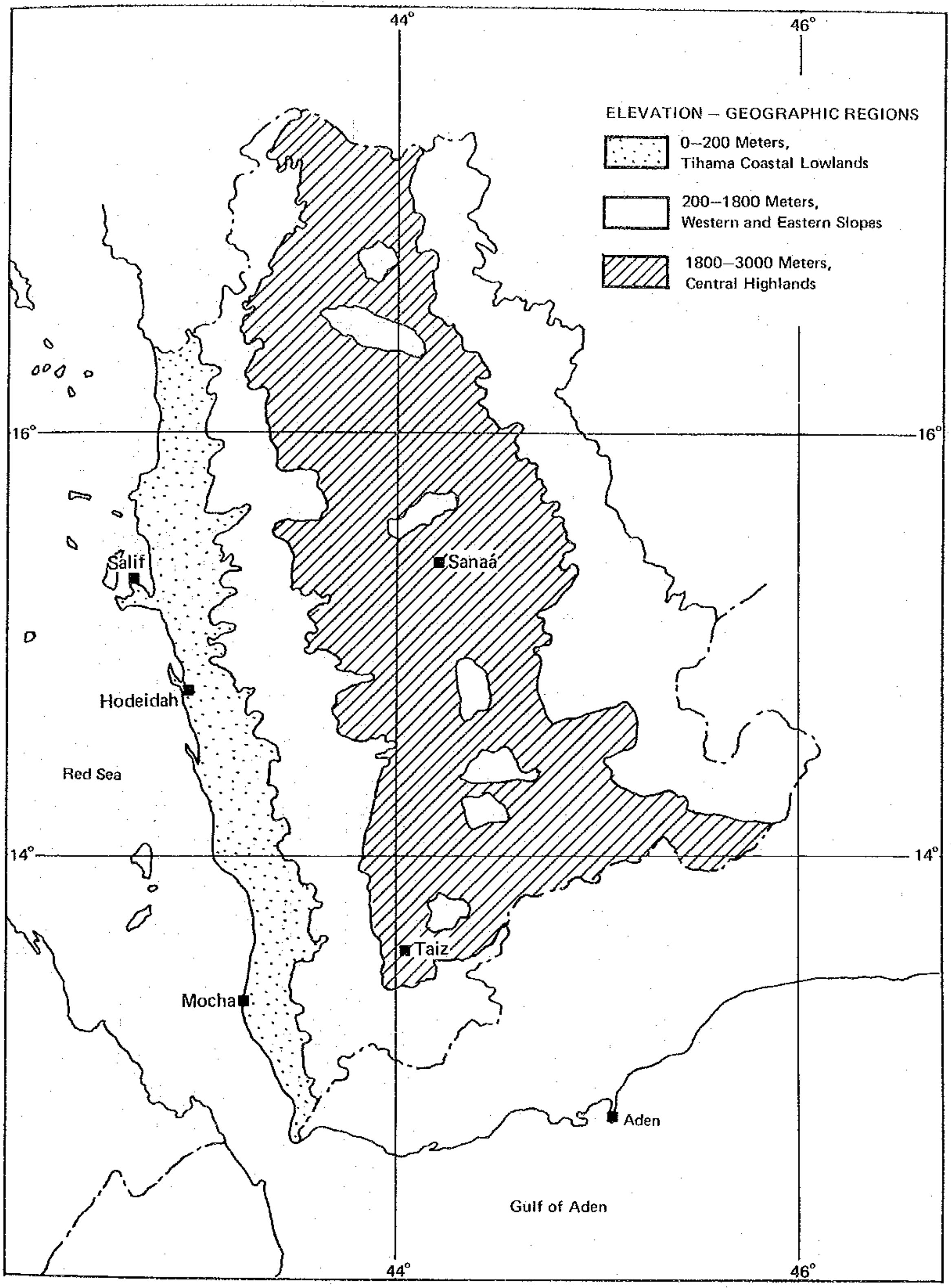


Table 2-2-1 (1) Temperature, Relative Humidity, Wind Speed and Rainfall in Hodeidah, 1978

Months	Temperature (°C)		Relative Humidity (%)		Maximum Wind Speed (knots)	Rainfall (mm)
	Max.	Min.	Max.	Min.		
January	34.0	16.0	84	70	23	0
February	34.0	17.0	84	59	24	0
March	34.0	17.0	84	54	18	0
April	37.0	19.0	84	54	24	0
May	40.0	24.0	81	52	18	0
June	42.0	26.0	78	49	7	0
July	38.0	24.0	81	47	10	0
August	39.0	26.0	78	51	10	0
September	39.0	21.0	83	51	20	0
October	41.0	20.0	92	50	–	0
November	32.0	20.0	92	61	12	0
December	31.0	17.0	88	63	20	78.0

Source: Statistical Year Book 1979–1980.
Yemen Area Republic, Central Planning Organization, July 1981.

Table 2-2-1(2) Temperature, Relative Humidity, Wind Speed and Rainfall in Hodeidah, 1979

Months	Temperature (°C)			Relative Humidity (%)			Maximum Wind Speed (knots)	Rainfall (mm)
	Max.	Min.	Mean	Max.	Min.	Mean		
January	30.0	13.0	22.4	91	58	73	18	0
February	31.1	13.0	26.1	96	49	72	–	0
March	34.8	11.0	22.9	92	44	72	27	7.0
April	36.0	12.0	24.6	93	53	72	25	0
May	39.0	15.0	30.8	86	40	63	40	0
June	41.0	14.8	28.9	94	39	68	30	0
July	41.5	17.0	30.5	93	30	61	19	0
August	41.5	15.0	28.9	77	43	59	22	0
September	40.0	15.0	28.0	85	43	61	20	0
October	38.0	12.0	32.7	99	27	65	20	27.0
November	34.0	14.0	29.5	85	46	63	28	0
December	32.0	12.0	27.5	92	54	68	26	–

Source: Statistical Year Book, 1979–1980.
Yemen Arab Republic, Central Planning Organization, July 1981.

Table 2-2-1(3) Temperature, Relative Humidity, Wind Speed and Rainfall in Hodeidah, 1980

Months	Temperature (°C)			Relative Humidity (%)			Maximum Wind Speed (knots)	Rainfall (mm)
	Max.	Min.	Mean	Max.	Min.	Mean		
January	32.4	12.0	27.6	92	58	69	28	2.5
February	31.0	15.0	27.2	92	58	69	30	0
March	34.2	17.0	29.1	92	54	69	30	0
April	35.0	24.0	29.5	93	46	68	30	0
May	36.0	25.0	31.8	89	37	65	24	0
June	37.0	27.5	33.1	86	42	67	18	0
July	37.5	29.0	34.2	86	44	59	26	0
August	38.0	27.0	32.4	90	36	63	28	0
September	40.8	26.0	31.2	87	51	68	20	0
October	39.0	14.0	31.0	86	47	59	30	0
November	35.4	10.0	23.2	87	39	66	26	0
December	33.0	9.0	25.4	92	39	62	30	0

Source: Statistical Year Book, 1979–1980.
Yemen Arab Republic, Central Planning Organization, July 1981.

Fig. 2-2-1 Average Annual Rainfall

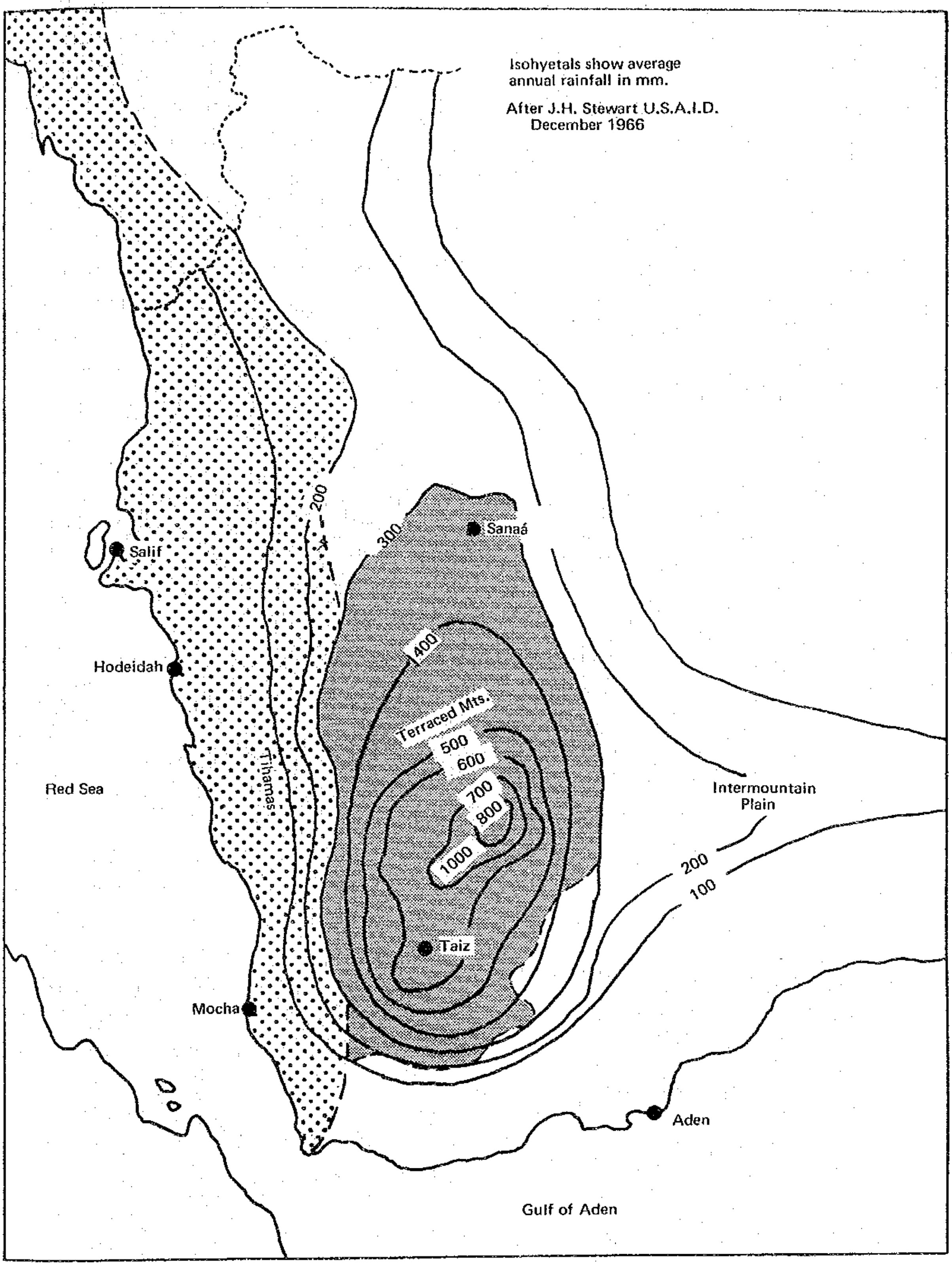
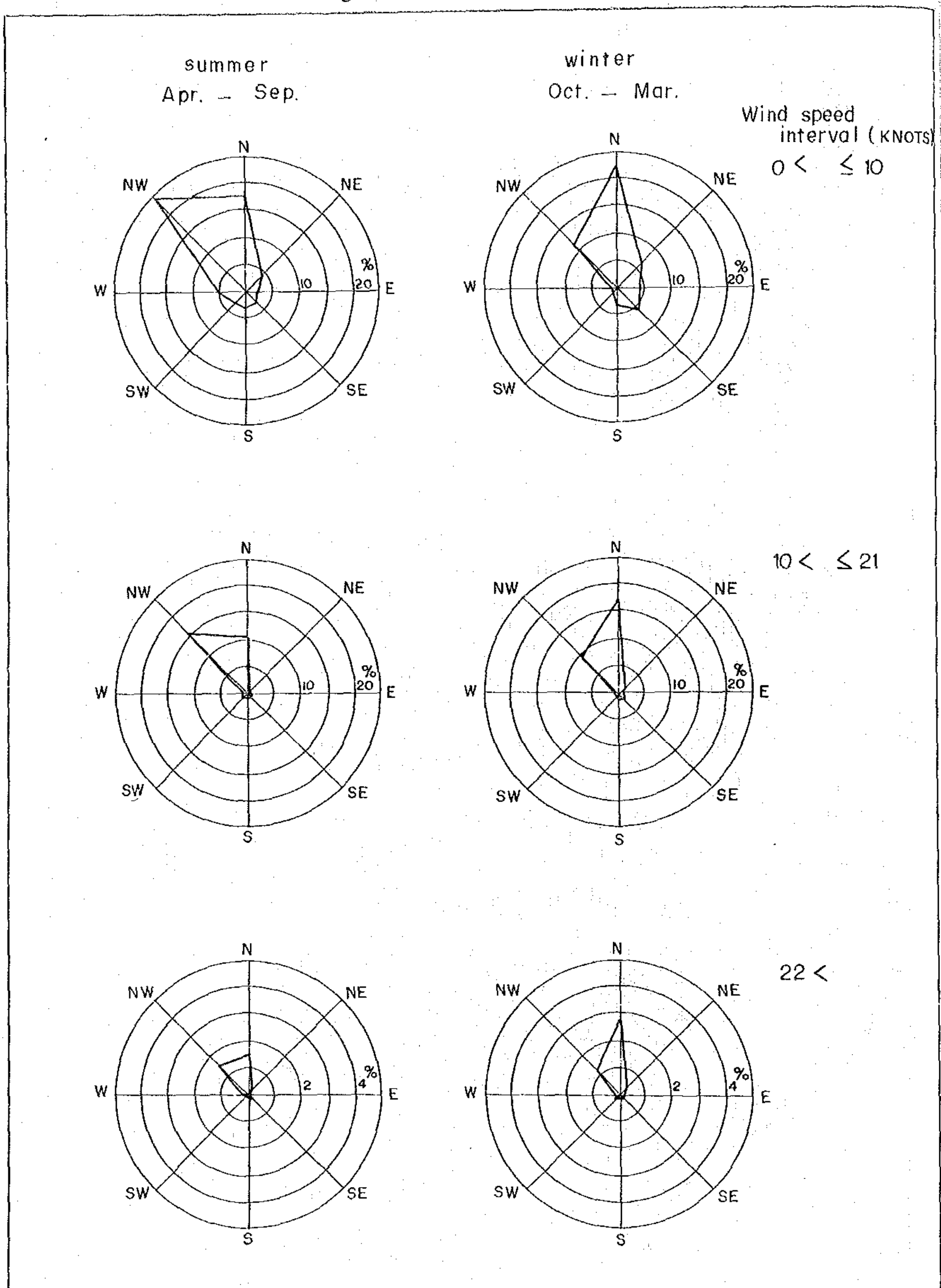


Fig. 2-2-2 Wind-Diagram (Red Sea)



Source : U.S. NAVY MARINE CLIMATIC ATLAS OF THE WORLD, VOL. III, INDIAN OCEAN, 1976

2-2-3 Tidal Conditions

The bench-mark for the construction of Hodeidah port facilities is located on the north side of Mosque and consists of a piece of 50 x 50 mm angle iron built into the side of minaret, about a meter above ground level. It has a level of +3.602 m. This is approximately 3.602 m above Chart Datum for Hodeidah.

Rinkai Construction Company made observation on the tidal range at Port Hodeidah during their construction work. A Kyowa-Shoko PET-2 tidal gauge was temporarily installed at the northern corner of the 6th berth. Observation data were continually recorded on an analogue recorder from December 30, 1980 to Feburary 11, 1981 and from March 15, 1981 to April 26, 1981.

This data is now available for estimation of tidal conditions at Port Hodeidah. Tidal harmonic analysis was performed using a computer and the tidal observation data. The data from January 10 to February 10, 1981 and from March 25 to April 25, 1981 were used for the tidal harmonic analysis. The detailed results are reported in "The tidal observation results and the harmonic analysis at the Port of Hodeidah".

According to this report, the 4 major components of tide and the mean sea level are as follows:

- o Mean sea level: D.L. + 0.44 m
- o The 4 major components;
  - Principal Lunar, M2: 31.68 cm
  - Principal Solar, S2: 8.52 cm
  - Lunisolor Diurnal, K1: 3.02 cm
  - Principal Lunar Diurnal, O1: 0.34 cm
- o Accumulation of 4 components; Zo: 43.56 cm

And the tidal levels are obtained as follows based on the above mentioned 4 major components.

- o Indian spring high water; D.L. + 0.88 m
  (Design high water level)
- o Mean high water; D.L. + 0.76 m
- o Mean sea water; D.L. + 0.44 m
- o Mean low water; D.L. + 0.12 m
- o Indian spring low water; D.L. ± 0.00 m
  (Datum Line)

It is recommended that the following tide levels, which have been used in Hodeidah, be revised in accordance with the figures proposed above.

- o Highest High Water, H.H.W.; +2.0 m
- o Mean High Water, M.H.W.; +1.4 m
- o Mean Water, M.W.; +1.0 m
- o Mean Low Water, M.L.W.; +0.6 m
- o Lowest Low Water, L.L.W.; ±0.00 m
  (Datum Line)

For the further development of the Hodeidah Port, it will be necessary to observe tide levels continuously using automatic tide gauge.

2-2-4 Waves and currents

There are no observation data of waves and currents for the Port of Hodeidah. The only available data are the wave and current characteristics described in the U.S Navy Marine Climatic Atlas of the World (Vol. 3, Indian Ocean) and in the Final Report of the Mocha Siltation Study.

According to the Marine Climatic Atlas, north to northwestern waves are predominant year-round while southern waves are smaller and less frequent as shown in Fig. 2-2-3. But reports from the PMAC and our own observations during the first field survey in December 1981 show that southern wind-waves are predominant, especially in winter season and that these waves causes littoral sand drift from south to north along the coastline. The reason that general wave characteristics such as wave direction and frequency distribution are different between the Yemen coastline and the Red Sea is, as mentioned before, that the winds characteristics differ. Therefore, it is desirable that care be used in applying Marine Climatic Atlas data to wind and wave estimations for the Yemen coastline. The relation between wave heights and periods are shown in Fig. 2-2-4.

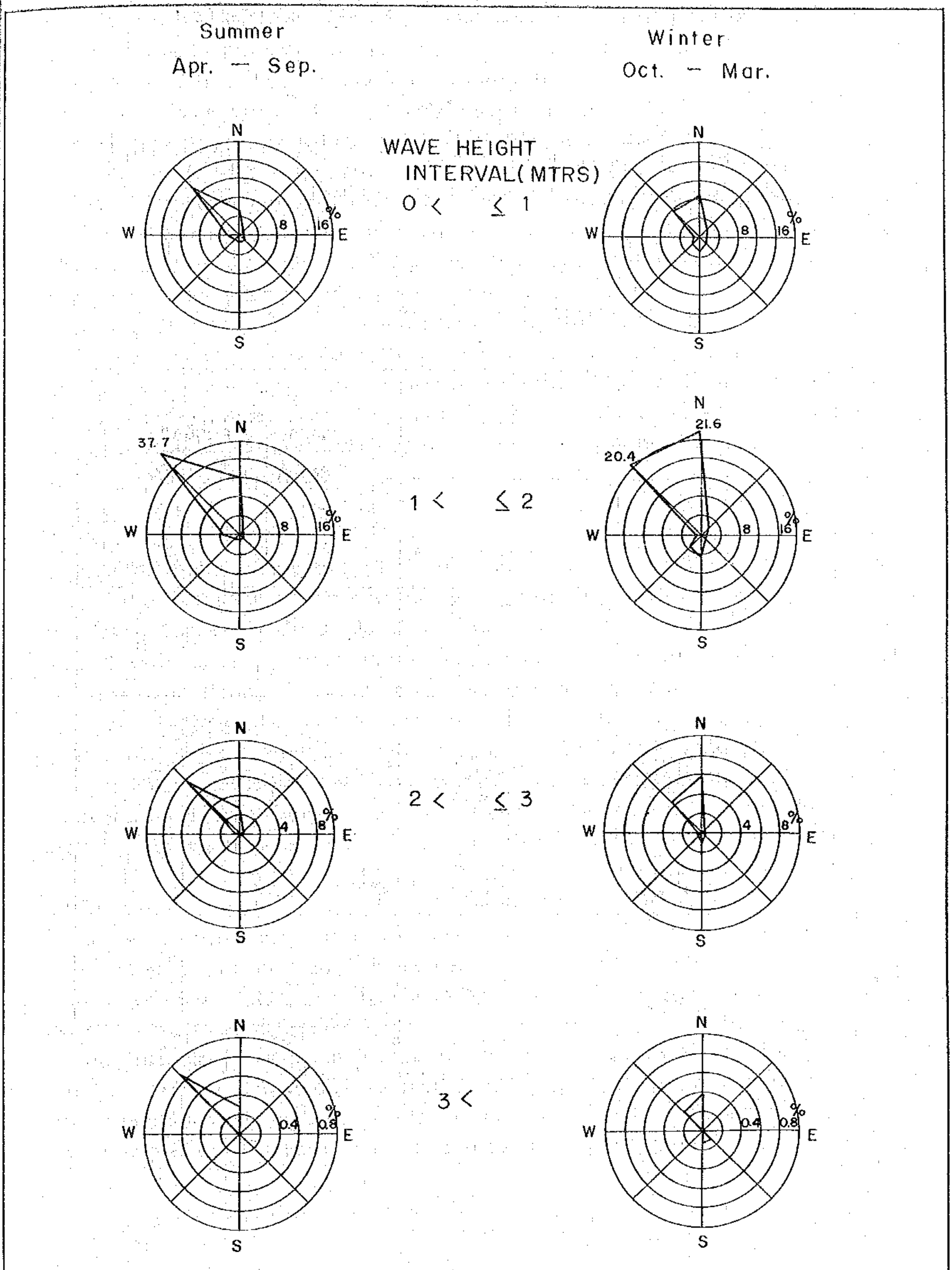
Offshore current data in the Red Sea are also mentioned in the Marine Climatic Atlas. Maximum offshore currents are said to be less than 0.6 knots, and their direction being from south to north in the winter season and from north to south in the summer season.

Waves and currents were observed at the Port of Mocha on February and March 1976 and the results of this observation are discribed in the Final Report of the Yemen Port Development Study, Mocha Siltation Study, May 1976. As subcontractor to Louis Berger – Kampsax on the Yemen Ports Development Study – Phase II, for which a contract was signed with the IBRD, the Danish Hydraulic Institute carried out an oceanographical engineering study of the Port of Mocha.

The field survey in Mocha consisted of a bathymetric survey of the area, continuous tide recordings, wave recordings, wind measurements, current observations, sampling of beach and sea bottom material and observation of beach characteristics.

The results of the observations of wind, waves, and currents are summarized as follows.

Fig. 2-2-3 Wave-Diagram (Red Sea)

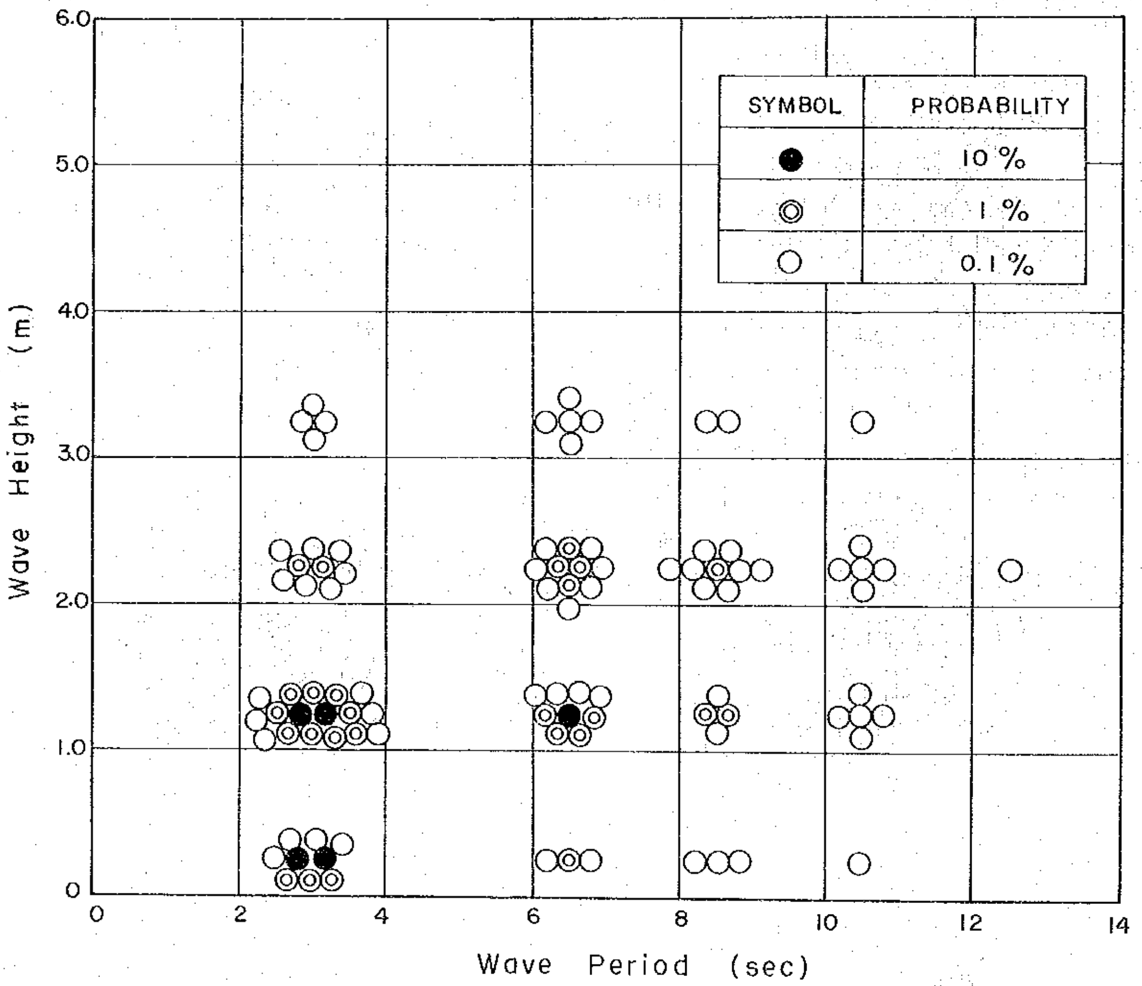


Source : U.S. NAVY MARINE CLIMATIC ATLAS OF THE WORLD, VOL. III , INDIAN OCEAN, 1976

Fig. 2-2-4 Relation Between Wave Hights and Periods (Red Sea)

Source : U. S. NAVY MARINE CLIMATIC ATLAS OF THE WORLD, VOL. III, INDIAN OCEAN, 1976

Total percentage of indefinite data is 17.1 %.



(1) Wind conditions

In the winter season, from October to March, winds constantly blow from the south; in the summer season, from June to September winds blow from the north and northwest. In the transition period from April to June winds change between southerly and northerly directions and sometimes blow from the west. Southerly winds are generally stronger than other winds.

Wind observations were performed at the top of the Mocha Development Board House (See Fig. 2-2-5) from March 8 through March 24, 1976. A hand held anemometer was used to measure wind speed. Wind direction varied between SSE and S. A regular daily variation of the wind speed was observed with a peak early to mid afternoon, with lows in the night and morning. Average daily peak wind speed for the recording period was 14 m/s. Only for 5 days of the field survey, the peak wind speed was below 10 m/s. Sand and dust storm occurred on six day of the recording period. The dust storm of March 20 was the most severe, lasting about 8 hours.

Fig. 2-2-6 shows a plot of the measured sustained wind speeds for the recording period. On the drawing, the daily maximum wind has been marked with a special symbol. It should be noticed that the measurements are not equally spaced in time, and that very few measurements were taken at night. Also, for some days, only one or two measurements were taken, preferably during peak wind speed periods.

(2) Waves

From February 15 through March 11, 1976 wave recordings were performed for ten minutes every four hours with an OSPOS wave pressure recorder. The recorder was installed at about 3 km offshore from the Mocha Development Board House (See Fig. 2-2-5). The water depth at the site is 9 meters at mean tide; the wave recorder was anchored 7 meters above the sea bottom. From March 11 through 24 the wave recorder was operated with another clockwork giving fifteen minutes of recording every three hours. A total of 106 such recordings were obtained.

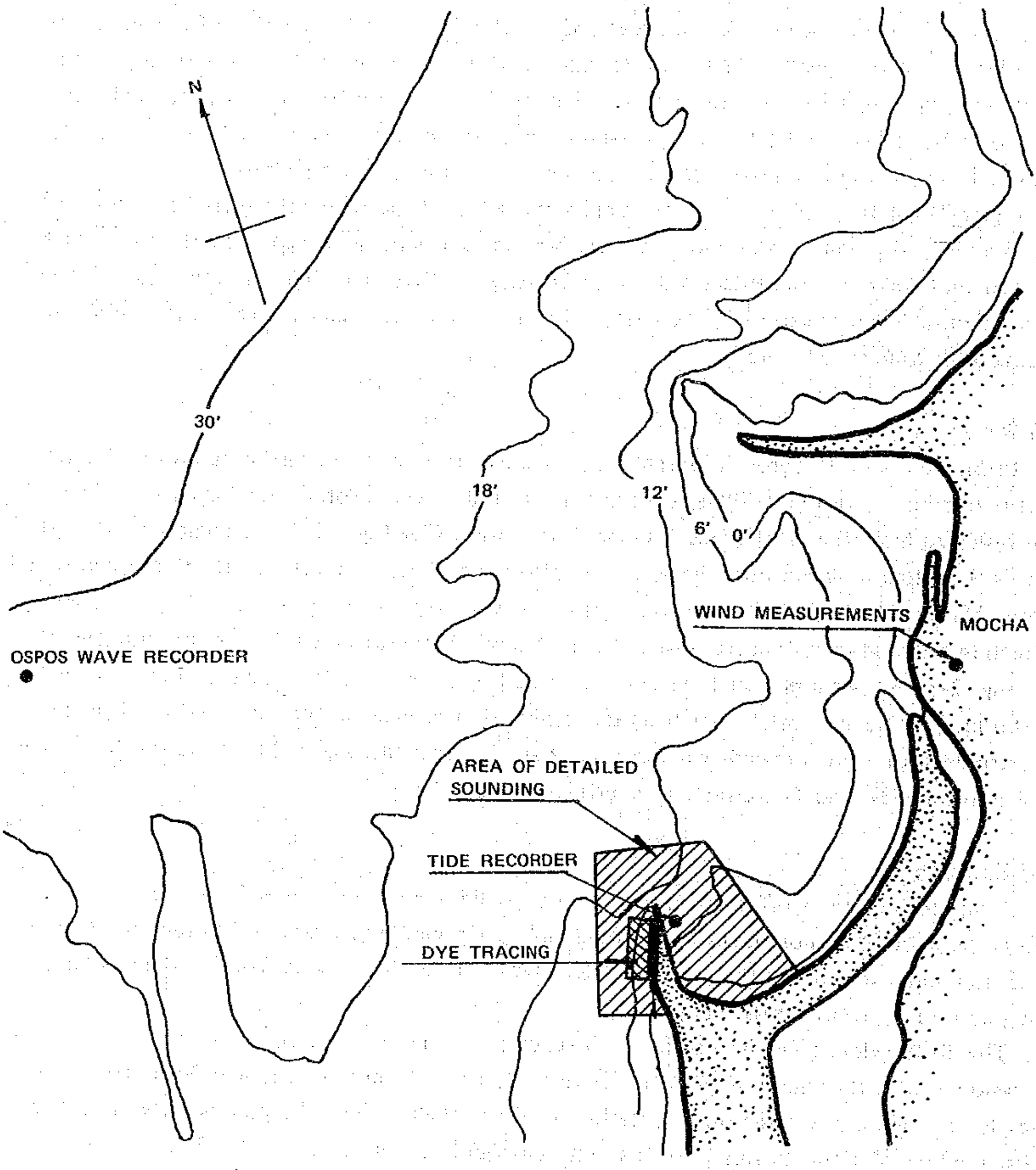
Fig. 2-2-7 shows a plot of the significant wave height Hs for each of the recordings having Hs > 0.6 m. The wave direction was from the south and the average period Tz varied between 4 and 6 seconds with a predominant wave period of about 5 seconds. Fig. 2-2-8 shows the frequency distribution of Hs and Tz for the 71 records having Hs > 0.6 m.

(3) Currents

Longshore currents off the pier are generated by tides, wind and waves. In the nearshore zone where sediment transport takes place, wind and wave generated currents were prevalent. Current measurements were performed by DYE TRACINGS in the littoral drift zone at the west side of the pier on two occasions (See Fig. 2-2-5).

The drift velocity in the northerly direction along the pier was about 0.4 m/s on the first occasion, where the wind was from the south at a speed of 16 m/s and the significant wave height was 1.3 m offshore. On the other occasion the drift velocity along the pier was about 0.21 m/s with wind speed about 10 m/s from the south and significant wave height of 1.0 m offshore.

Fig. 2-2-5 Location of Measuring Stations at Mocha Port



SOURCE: YEMEN PORT DEVELOPMENT STUDY MOCHA SILTATION STUDY, LOUIS BERGER-KAMPSAX, FINAL REPORT, MAY 1976

Fig. 2-2-6 Measured Wind Speed at Mocha Port

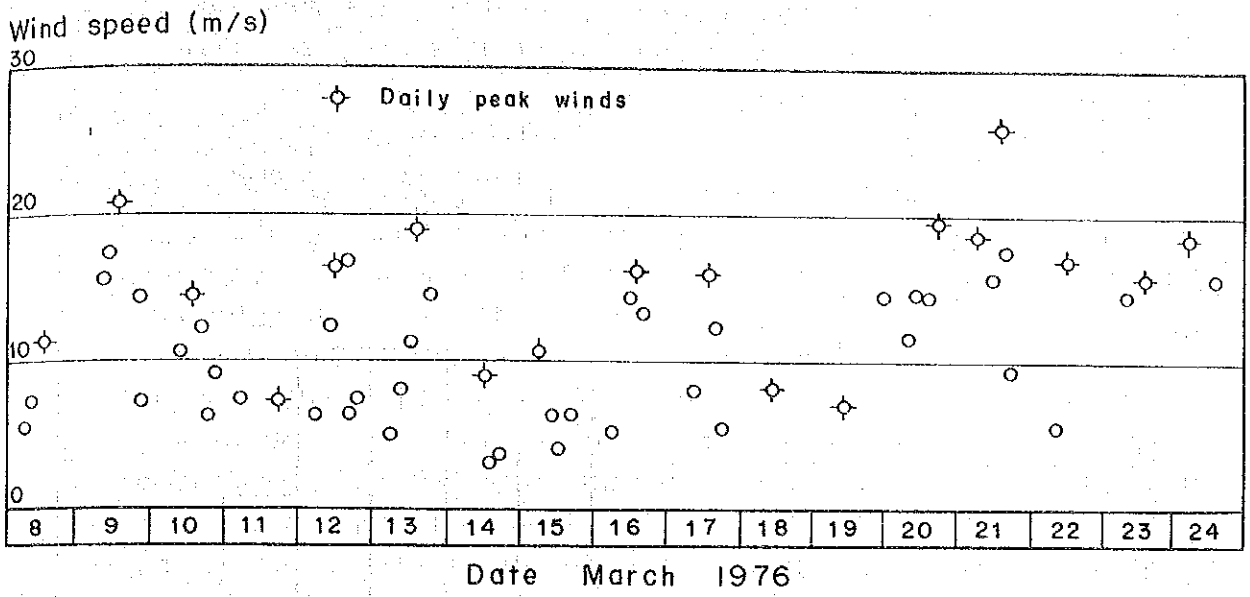
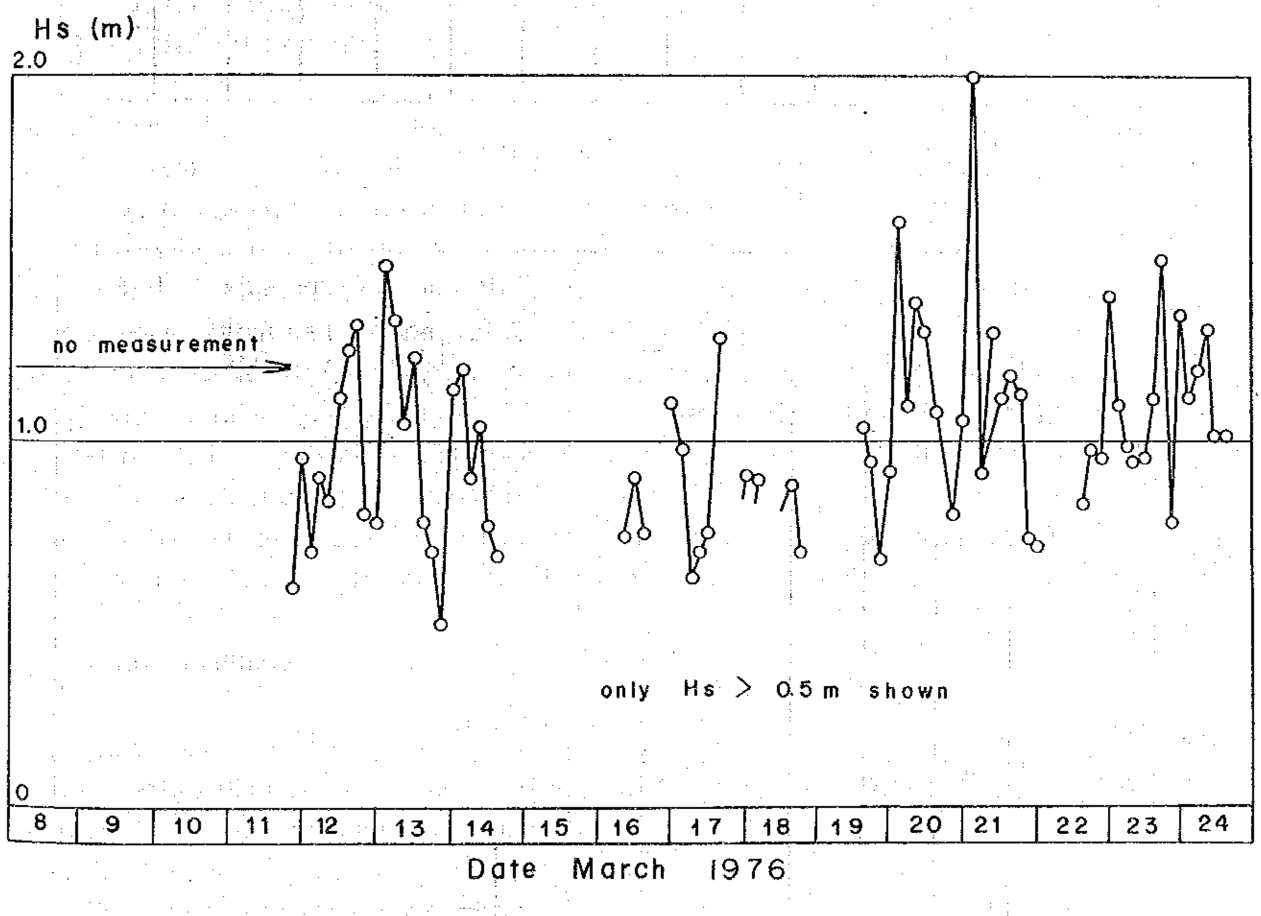


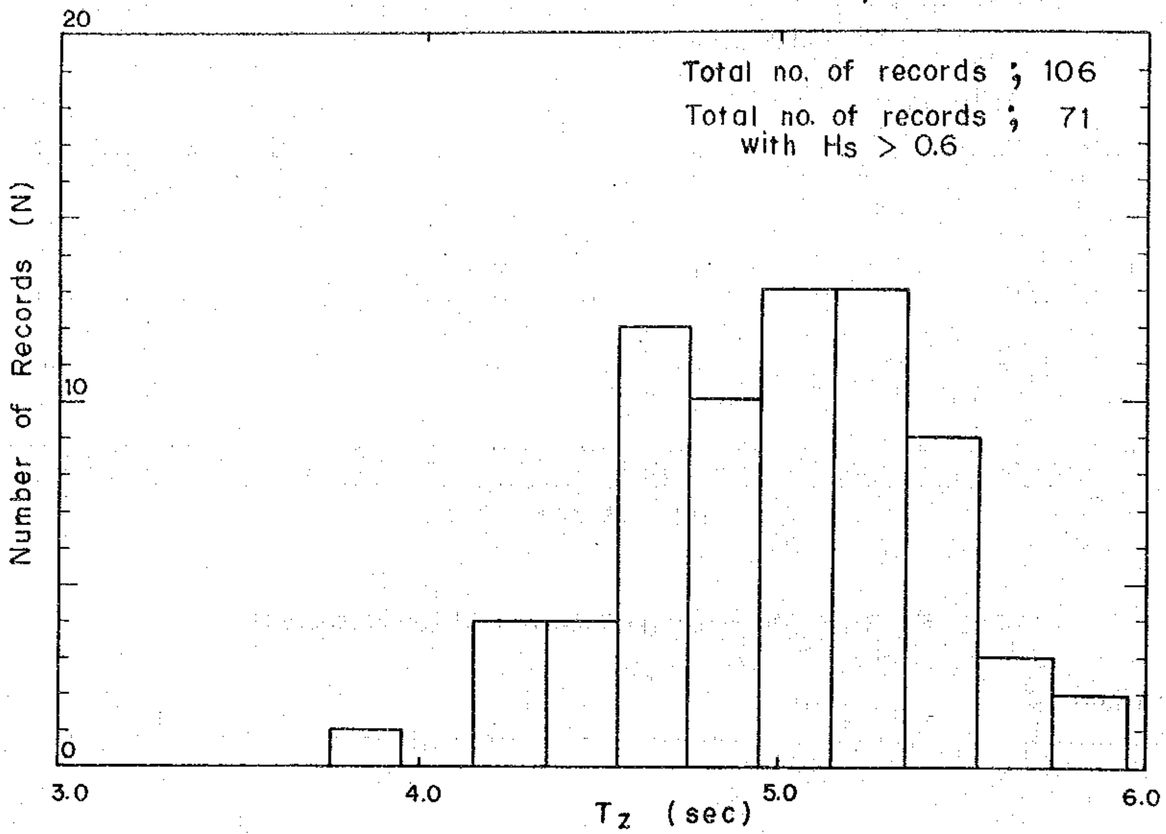
Fig. 2-2-7 Measured Significant Wave Height at Mocha Port

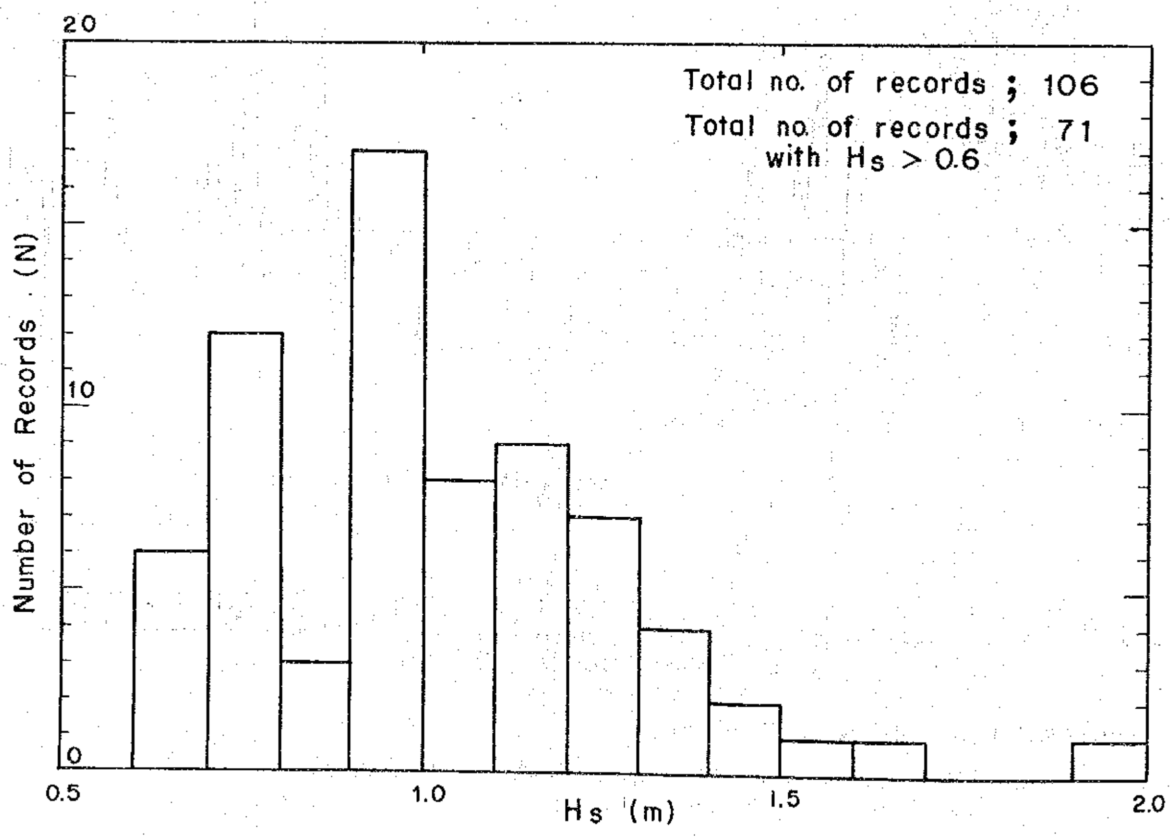


Source : Louis Berger - Kampsax,
Final Report of Yemen Port Development Study
Mocha Siltation Study, May 1976

Fig. 2-2-8 Frequency Distribution of Hs and Tz

Source: DANISH HYDRAULIC INSTITUTE, THE FINAL REPORT OF THE MOCHA SILTATION STUDY, MAY 1976





(4) Summary

The wind and sea conditions of the Port of Mocha located about 180 km south of Hodeidah along the costline are, as mentioned above, considered quite similar to those of the Hodeidah Port. Therefore, these observation data from the Mocha Port are very useful in understanding the characteristics of the oceanic conditions of the Hodeidah Port in the winter season and their influence on littoral sand drifts.

It can be summarized the sea conditions at the Hodeidah Port as follows:

1) Strong southerly winds are predominant in the winter season, from October to April. Wind waves come from the south with wave heights generally less than 2 m, but occasionally have 2.5 m – 3.0 m.
2) During the summer season, northerly breezes prevail but occasional violent squalls, most frequently in August and September are observed off the land. These violent squalls cause the maximum wave heights in the outer sea of the Hodeidah Port. It can be seen from Marine Climatic Atlas that the maximum wave heights are 4.0 – 5.0 m and that these waves come from north or northwest.
3) Maximum offshore current at Hodeidah is less than 0.6 knots and the direction is from south to north in the winter season; from north to south in the summer season.
4) In the nearshore zone, sediment transport takes place due to currents generated mostly by wind and waves. Drift velocities in northerly direction are measured at about 0.4 m/s and 0.21 m/s with south winds, of 16 m/s and 10 m/s and significant wave heights of 1.3 m and 1.0 m, respectively.

2-2-5 Seismicity

The Yemen Arab Republic is situated outside the two global belts of high seismic activity, but small to moderate earthquakes have been reported along the axis of the Red Sea. According to "The Seismicity of the Earth 1953 – 65", an earthquake of class d (M = 5.3 – 5.9) was reported in December 1960 only 30 km west of Hodeidah. In addition, it is better to assume that a large-scale earthquake may happen because global belts run close to the Yemen Arab Republic. Seismic data for the Red Sea and the Gulf of Aden are listed on Table 2-2-2 and Fig. 2-2-9.

Based on Table 2-2-2 and Fig. 2-2-9, the effective peak acceleration of firm ground can be considered to be less than 0.1 g at Hodeidah. Because a large scale earthquake might happen and horizontal acceleration of the ground surface is usually amplified, it is desirable to use an effective peak acceleration value of 0.1 g for design purpose. In addition to this, structural designs must also take account of the magnification factor of the structure.

2-2-6 Soil Conditions

(1) Soil survey conducted by JICA

As part of the feasibility study on the 7th Berth Construction Project of the Hodeidah Port, bathymetric, geophysical, and geotechnic surveys were conducted by JICA from November 1981 to February 1982 to provide engineering desing data.

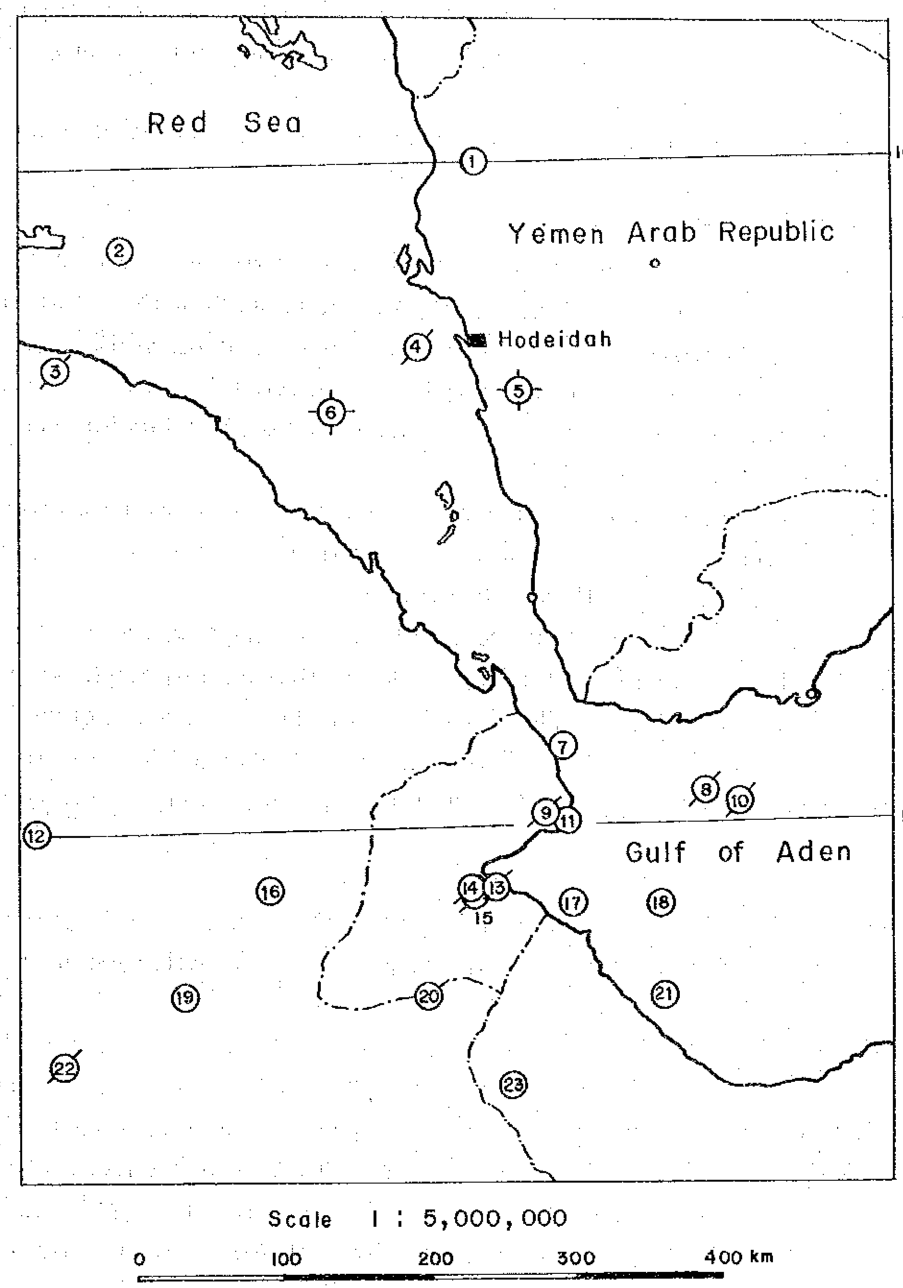
The surveys included a coastline survey of approximately 4 km; a tidal observation; a bathymetric survey covering the anchorage area and the navigation channel; six offshore borings and

Table 2-2-2 Seismic Data for Red Sea and Gulf of Aden

This table are prepared by Sir Alexander Gibb & Partners for the Inception Report of Hodeidah and Mocha Port Development to the PMAX, YAR.

No.	Data	Location	Magnitude, M
1	1941, Feb. 4	16N 43E	5.3–5.9
2	1921, Aug. 14	15.5N 40.5E	5.3–5.9
3	1957, Mar. 14	14.8N 40.2E	5.3–5.8
4	1960, Dec. 16	14.7N 42.6E	5.3–5.8
5	1959, Aug. 16	14.5N 43.1E	–
6	1958, Feb. 13	14.3N 42E	–
7	1930, Oct. 27	12.5N 43.5E	5.3–5.9
8	1961, June 20	12.2N 44.3E	6.1
9	1958, May 24	12.1N 43.6E	5.5
10	1960, Aug. 8	12.1N 44.5E	5.4
11	1941, Mar. 19	12N 43.5E	5.3–5.9
12	1942, Nov. 18	12N 40E	5.3–5.9
13	1961, Mar. 11	11.7N 43.0E	6
14	1960, Jan. 4	11.6N 42.8E	5.3–5.8
15	1963, Oct. 5	11.6N 42.8E	5.8
16	1929, May 18	11.5N 41.5E	6
17	1929, June 22	11.5N 43.5E	6
18	1930, Oct. 25	11.5N 44E	5.3–5.9
19	1938, Sept. 27	11N 41E	6
20	1945, Oct. 28	11N 42.5E	5.3–5.9
21	1926, Oct. 30	11N 44E	5.3–5.9
22	1961, June 2	10.6N 40.1E	5.8
23	1930, Oct. 24	10.5N 43E	5.3–5.9

Fig. 2-2-9 Seismicity of Red Sea and Gulf of Aden



Sources ;

- ○ Seismicity of the Earth 1954
- Ø Seismicity of the Earth 1953 to 1965
- ⌖ Seismicity of the Red Sea, Gulf of Aden and After triangle Phil. Trans. Roy. Soc. Lond.

This Fig. is prepared by Sir Alexander Gibb and Partners for the Inception Report of Hodeidah and Mocha Port Development to the PMAC..

Standard Penetration Tests at 1.5 m intervals each; and bottom grab samplings.

Soil samples obtained from SPT and bottom grab samplings were tested at a temporary field laboratory. Physical tests included specific gravity, moisture content, and grain size distribution tests. Undisturbed samples from thin wall samplings were subjected to unconfined compression tests in addition to physical tests.

Ground conditions at the proposed site can be estimated from the above soil surveys.

(2) Ground Conditions at the Proposed Site

A KANO KR-100 rotary drill rig mounted on a floating barge was used to drill 5 offshore boreholes (Nos. 1 to 5). At the site of foreshore 1, an on shore borehole (No. 6) was also drilled using the rotary drill rig. The locations of the borings and the water depth at the site are shown in Fig. 2-2-10 and Fig. 2-2-11. The results of these borings are shown in Fig. A-2-2-1 ~ A2-2-6.

Ground conditions at the proposed site were investigated by field explorations and laboratory soil tests. The results are summerized as follows.

Major results of field explorations are shown on the soil profile of the proposed site in Fig. 2-2-12(1), Panel Diagram. In Figs. 2-2-12(2) and 2-2-12(3), a breakdown of the panel diagram with 4 sectional soil profiles of the proposed site is shown.

As shown in Fig. 2-2-12(1), the subsurface ground can be categorized into 5 layers, i.e. (1) Loose Fine Sand, (2) Soft Sandy Silt and/or Clayey Silt, (3) Medium Silty Sand, (4) Intermediate Sandy Silt, and (5) Lower Sandy Silt. Each layer of the subsurface ground is stratified horizontally. Borehole Nos. 1 to 3 were drilled along the dredged area. Upper two layers (1) and (2) are taken out from the original ground. Descriptions on the major soil properties of each layer are as follows:

1) Loose Fine Sand

Dark greenish/brownish gray silty sand is very fine and poorly graded with fragments of shell. N value of the silty sand is in the range of 5 to 18. Relative density is loose to medium.

2) Soft Sandy Silt/Clayey Silt

Dark greenish gray alluvial sandy silt and/or clayey silt is very soft and with fragments of shell. Soil properties of the soft sandy silt and clayey silt are summerized in Fig. 2-2-13. From Fig. 2-2-13, unconfined compressive strength (qu) is in the range of 0.21 – 0.32 kg/cm^2 for clayey silt. For sandy silt, qu is in the range of 0.1 – 0.21 kg/cm^2. Moisture content varies mainly from 25 to 50%. Around borehole No. 4, brownish black peaty clay with 1.6 m in thickness is found below the sandy silt.

3) Medium Silty Sand

N-Value of medium to dense silty sand varies from 25 to 35. Silty sand is very fine and with fragments of shell.

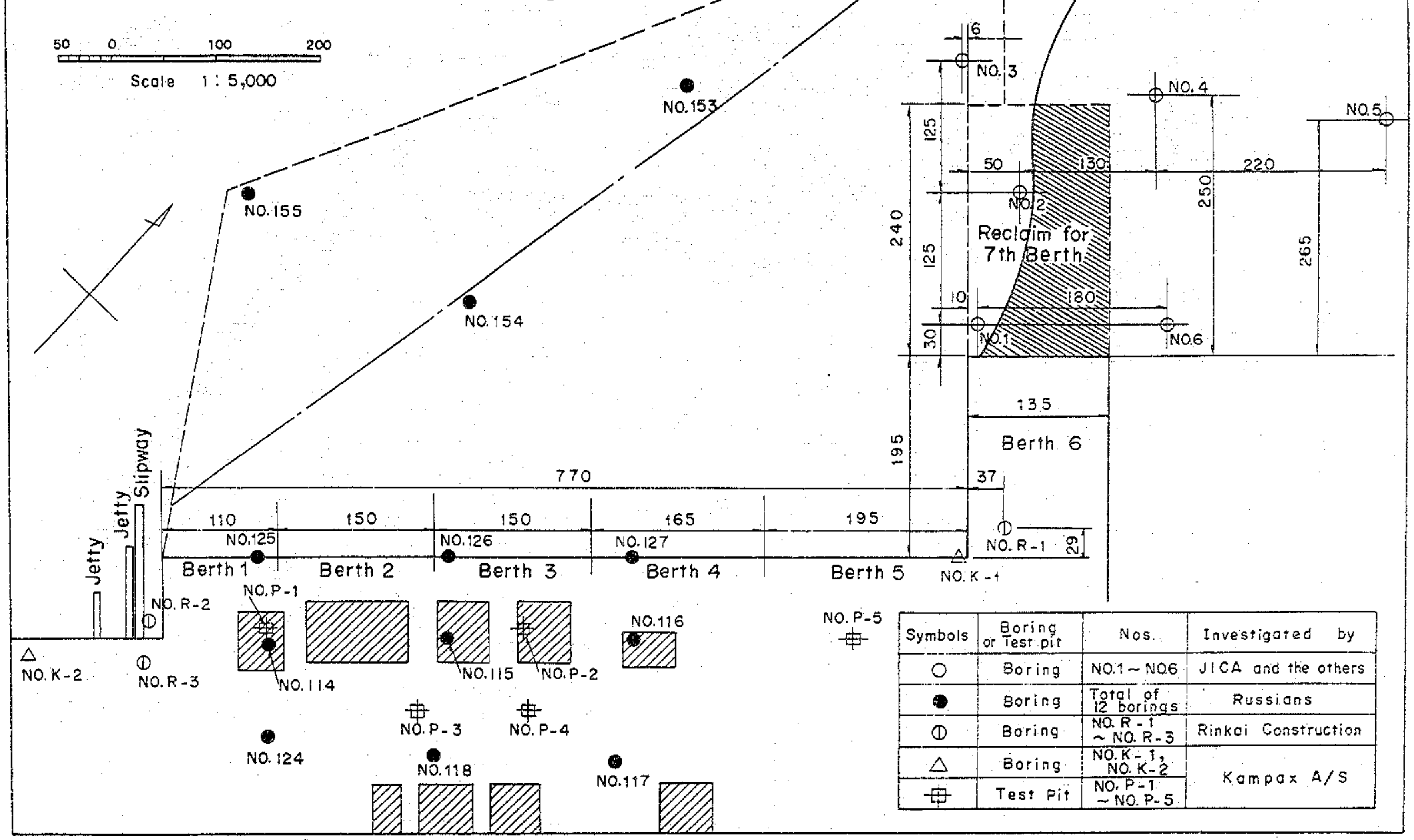
4) Intermediate Sandy Silt

Brown sandy silt is very stiff to hard in consistency corresponding to chiefly 25 – 35 N-values.

5) Lower Sandy Silt

Dark brownish gray lower sandy silt develops deeply which may belong to the Tertiary age. Gravelly sand and silty sand layers trace in this stratum. N-value of lower sandy silt

Fig. 2-2-10 Locations of Borings



Symbols	Boring or Test pit	Nos.	Investigated by
○	Boring	NO.1 ~ NO.6	JICA and the others
●	Boring	Total of 12 borings	Russians
⦶	Boring	NO. R-1 ~ NO. R-3	Rinkai Construction
△	Boring	NO. K-1, NO. K-2	Kampax A/S
⌖	Test Pit	NO. P-1 ~ NO. P-5	Kampax A/S

Fig. 2-2-11 Locations of Boreholes

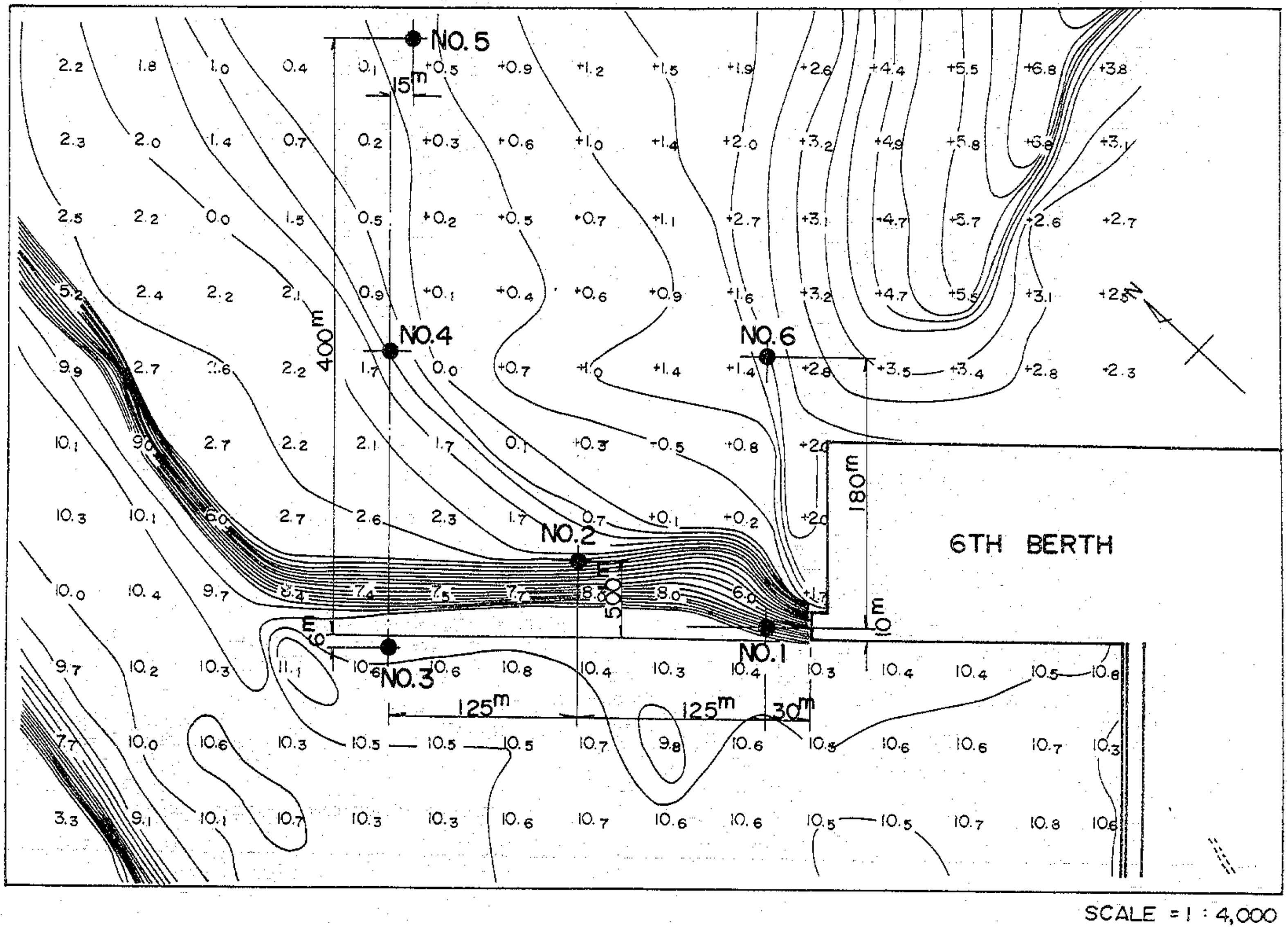


Fig. 2-2-12 (1) Panel-Diagram

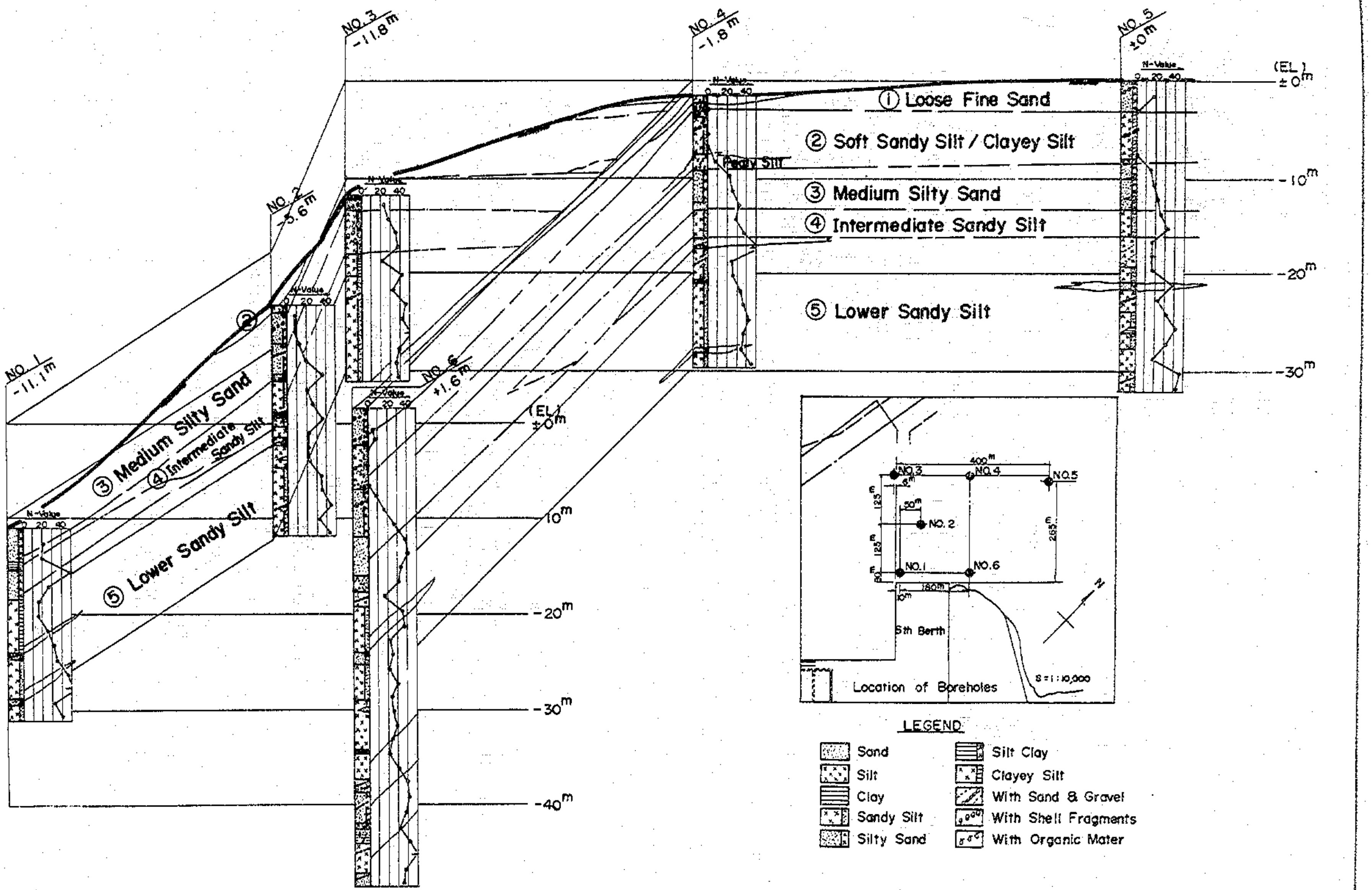


Fig. 2-2-12 (2) Soil Profile

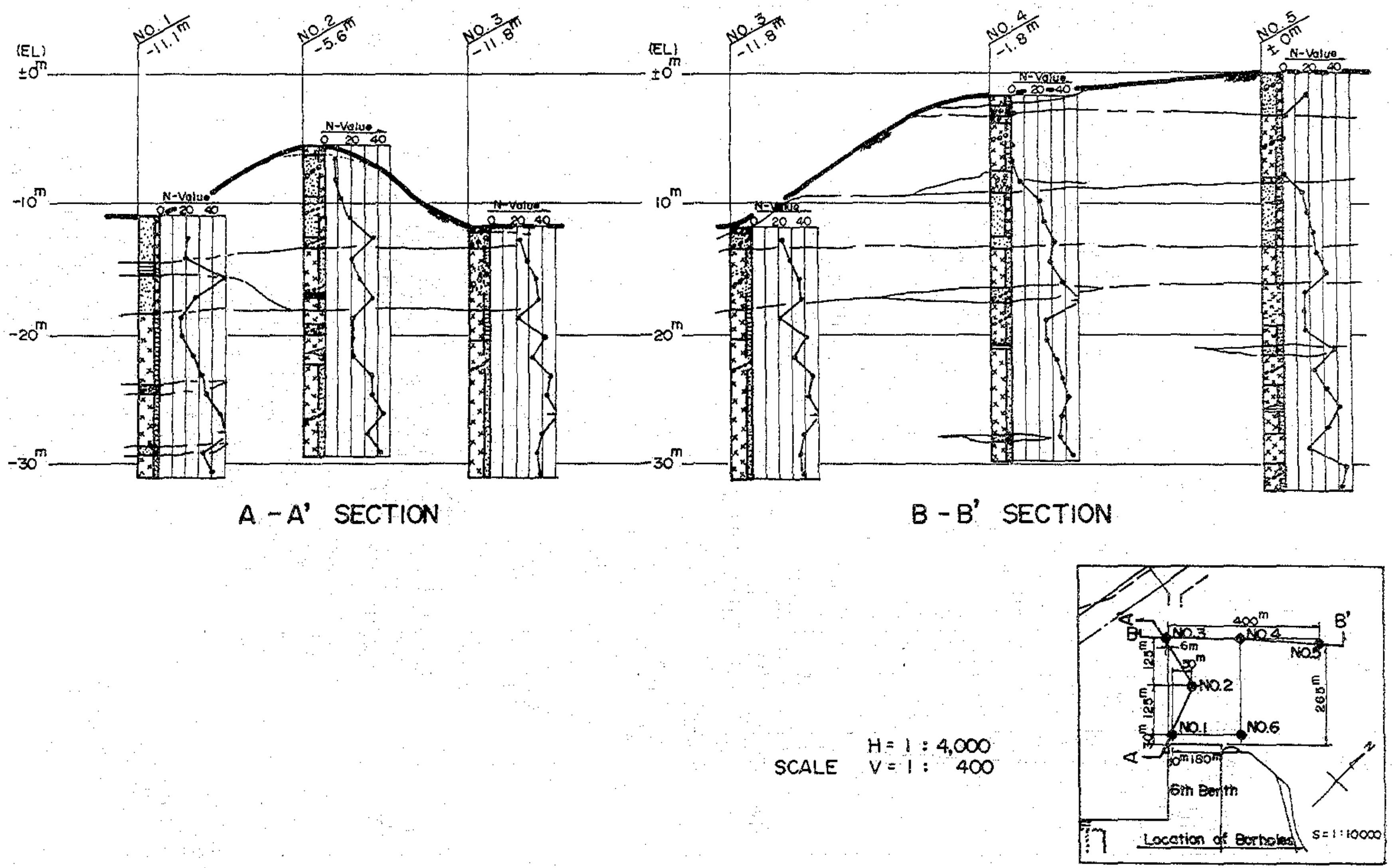


Fig. 2-2-12 (3) Soil Profile

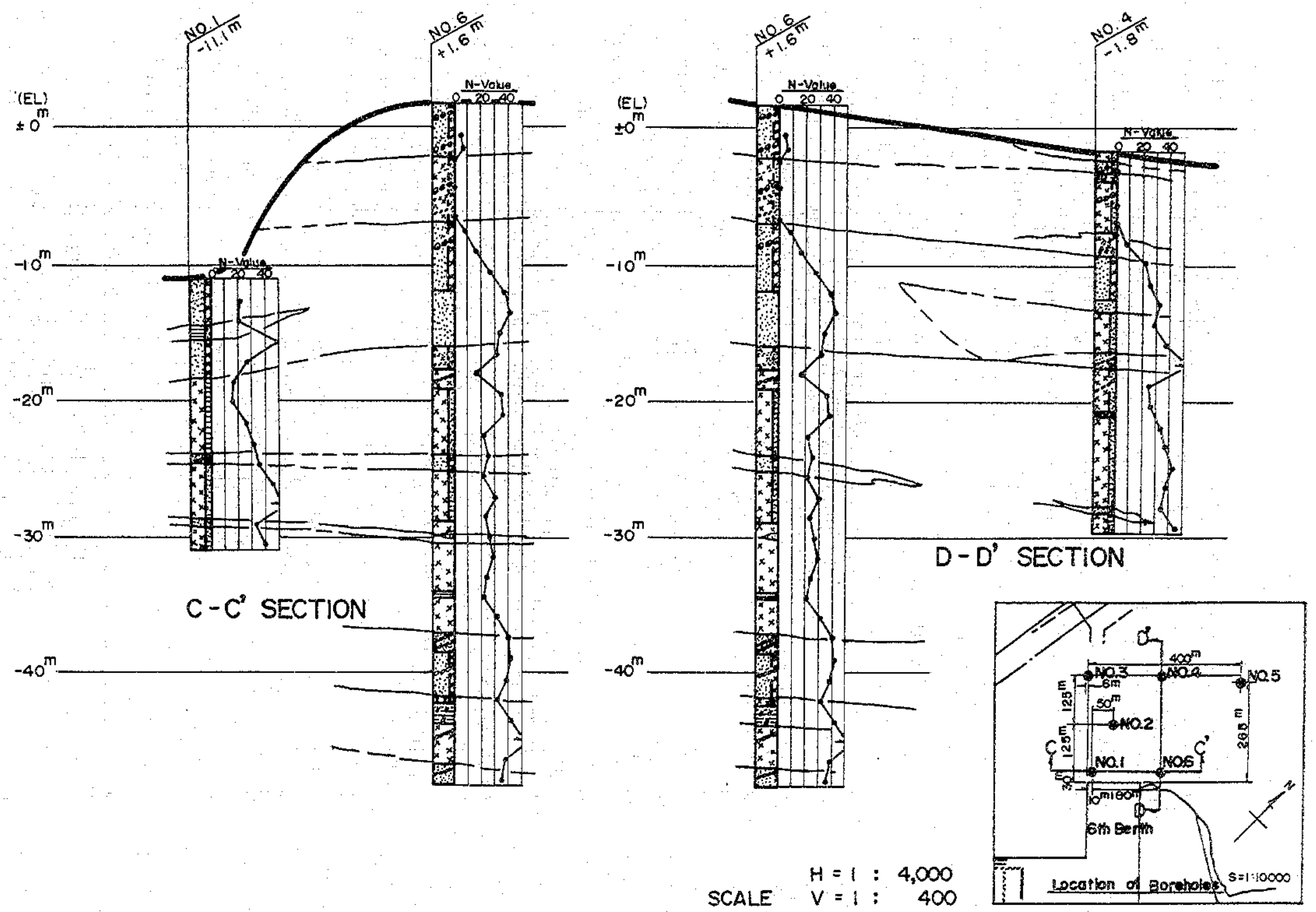
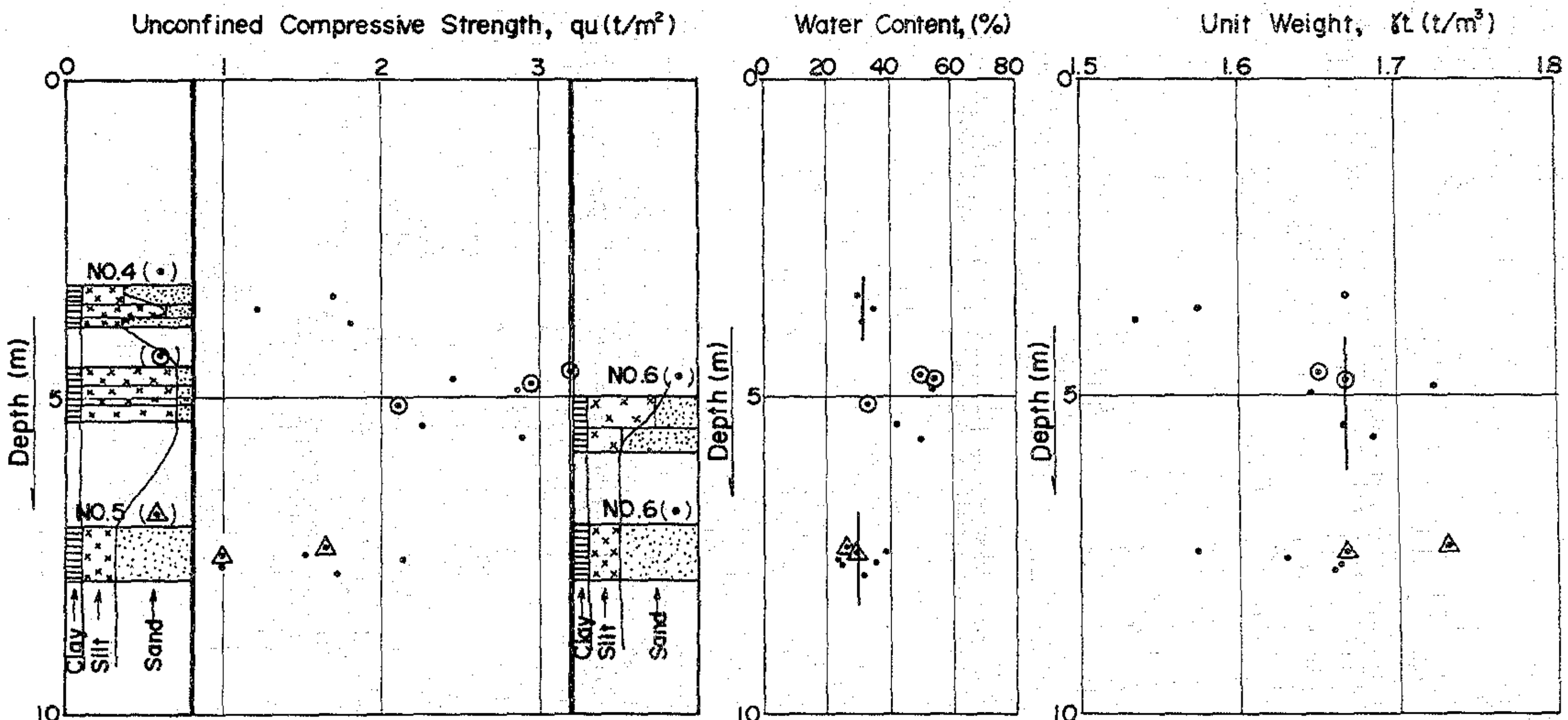


Fig. 2-2-13 Soil Properties of Soft Sandy Silt and Clayey Silt



varies chiefly from 20 to 50.

(3) Previous borings

A number of soil investigations have been carried out since 1958 by Russians, English Consultants and Rinkai Construction Co., Ltd. The results of these investigations are summarized as follows.

1) Russian borings

Since 1958 the Russians have carried out a number of soil investigations at the site. The descriptions of the soil strata encountered in these borings are given in Table 2-2-3 and the boring profiles contained no information of geotechnical data. The locations of the boreholes are shown in Fig. 2-2-10. The results of borings Nos. 153 and 154 show that the soil strata encountered during dredging for the 5th and 6th Berths were as follows. From the seabed down to a depth of 2 to 5 meters soft deposits of silt, loam and clay were present. Below this strata, loose-compact dusty sand with shell fragments was encountered with a thickness of 2 to 5 meters. Grayish dusty sand of mean density with shell fragments was encountered under the above mentioned strata with a thickness of between 2 and 3 meters.

The soft deposits of silt, loam and clay encountered in the top layer are considered unsuitable as the hydraulic fill of the Berth.

2) Borings by Rinkai's

In seeking a suitable construction method, Rinkai Construction Co., Ltd. made three borings for themselves during their construction work in March 1981. The locations of the borings are shown in Fig. 2-2-10 and the results are shown in Fig. A2-2-7. Very loose fine sand with shell fragments was found in the top layer with a thickness of approximately 7.5 meters. Below this strata, medium to dense fine sand or silty sand were present to a thickness of more than 10 meters. The top layer of very loose fine sand strata from +1.0 m to −6.5 m is assumed to be the dredged fill of the channel or the basin. These soil conditions are considered to be similar to those of the reclaimed area for the planned 7th Berth.

3) Borings excuted by English Consultant

In March 1976, some soil conditions were investigated by the English consultants Kampsax International A/S. A total of 5 test pits were bored to depths varying between 1.3 and 2.4 m. Two wash borings were carried out to depths of 12 and 18 m. A number of undisturbed and disturbed samples were taken. At 3 m intervals a disturbed sample was taken using a bailar. The locations of the borings and test pits are also shown in Fig. 2-2-10 and the results of the borings are shown in Fig. A2-2-8. The sand layer above −11 m is assumed to be loose compact sand.

(4) Summary

The summary of boring results are shown in Table 2-2-4. Soil conditions of the planned 7th Berth are summerized as follows.

1) The upper layer, from the seabed down to a depth of approximately 2 to 2.5 meters of borings Nos. 5 and 6, are including dredged fill from the channel and the basin of the 6th

Table 2-2-3 The Results of Russian Borings
(Nos. 114–118, 124–127 and 153–155)

Source: Port Development Study of YAR. Final Report (phase 2), August 1976
Descriptions of the soil strata encountered;

Layer No. 1: Grey soft-plastic silt with shell.
2: Dark grey soft-plastic sandy loam with shell.
3: Grey soft-plastic sandy clay.
4: Dark grey loose dusty sand with shell and rare gravel.
5: Grey and dark grey dusty sand of mean density with shell.
6: Dark grey plastic sandy loam with shell and rare gravel.
7: Brownish plastic and hard-plastic sandy clay.
8: Dusty yellow-brown dense sand.

Boring profiles:

Bor. No.	Level m	Layer No.
124	+ 1.4 to –10.7	5

Bor. No.	Level m	Layer No.
118	+ 0.9 to – 0.3	?
	– 0.3 to –12.1	5

Bor. No.	Level m	Layer No.
117	+ 1.0 to – 0.1	?
	– 0.1 to – 4.1	5
	– 4.1 to – 5.0	6
	– 5.0 to –11.1	5

Bor. No.	Level m	Layer No.
114	+ 1.3 to –13.2	5

Bor. No.	Level m	Layer No.
115	+ 0.3 to –14.4	5
	–14.4 to –14.6	7
	–14.6 to –17.1	8

Bor. No.	Level m	Layer No.
116	+ 0.2 to – 4.6	5
	– 4.6 to – 8.4	6
	– 8.4 to –11.5	5
	–11.5 to –15.0	8

Bor. No.	Level m	Layer No.
125	– 0.9 to – 9.5	4
	– 9.5 to –16.7	5
	–16.7 to –17.2	7
	–17.2 to –17.8	8
	–17.8 to –18.2	7
	–18.2 to –20.6	8
	–20.6 to –21.6	7
	–21.6 to –23.1	8

Bor. No.	Level m	Layer No.
126	– 1.9 to – 4.6	2
	– 4.6 to – 9.3	4
	– 9.3 to –15.2	5
	–15.2 to –16.6	7
	–16.6 to –17.2	8
	–17.2 to –18.0	7
	–18.0 to –18.2	8
	–18.2 to –18.8	7
	–18.8 to –20.7	8
	–20.7 to –21.2	7
	–21.2 to –22.1	8
	–22.1 to –22.5	7
	–22.5 to –23.9	8

Bor. No.	Level m	Layer No.
127	– 0.7 to – 1.5	1
	– 1.5 to – 2.4	3
	– 2.4 to – 6.7	4
	– 6.7 to –12.8	5
	–13.5 to –16.4	7
	–16.4 to –17.2	8
	–16.4 to –17.2	7
	–17.2 to –21.7	8
	–21.7 to –22.4	7
	–22.4 to –24.1	8

Bor. No.	Level m	Layer No.
155	– 3.3 to – 5.5	1
	– 5.5 to – 8.1	2
	– 8.1 to –11.8	4
	–11.8 to –13.3	5

Bor. No.	Level m	Layer No.
154	– 3.0 to – 4.9	2
	– 4.9 to –10.7	4
	–10.7 to –12.7	5

Bor. No.	Level m	Layer No.
153	– 3.1 to – 5.8	1
	– 5.8 to – 8.0	2
	– 8.0 to –10.3	4
	–10.3 to –13.6	5

Table 2-2-4 Result of Borings by JICA

Layer	Boring No.	N-value	Type of Soil	Relative Density	Color	Remarks
Upper layer	1	–	–	–	–	Excavated zone for the 6th Berth
	2	–	–	–	–	Excavated for the Channel
From seabed down to approximately 2 to 2.5 meter depth	3	–	–	–	–	Excavated zone for the Channel
	4	0	Sandy silt Silty sand	Very soft	Dark greenish gray	High water content with fragments of shell
	5	5~18	Silty sand	Medium to loose	Dark greenish brownish gray	Silty sand, Sand of fine grain size quartzitic in nature with shell fragments
	6	5~6	Silty fine sand	Loose	–	With shell fragments
Second layer	1	–	–	–	–	Excavated zone for the 6th Berth
	2	0~3	Sandy silt	Soft	Dark gray	Almost excavated for the Channel
From 2~2.5 m depth down to elevation −7.0~−8.0 m of 4~5 m thickness	3	–	–	–	–	Excavated zone for the Channel
	4	0	Sandy silt	Very soft	Dark gray	With fragments of shell, high water content
	5	0~2	Sandy silt	Very soft	Dark greenish gray	With fragments of shell, high water content
	6	0~1	Sandy silt	Very soft	–	With shell fragments
Below the second layer	1	18~50	Mainly silty sand	Medium to dense or stiff	Brownish gray or Brown	Silty sand of fine grain size, Clayey silt with fine sand
	2	12~44	Mainly silty sand	Medium to dense or stiff	Brownish gray	With fine gravels
Below the second layer with thickness of 10~20 m	3	21~50	Mainly sand or sandy silt	Medium to stiff	Grayish brown or Brownish gray	Sand of fine grain size, Silt with very fine sand or with fine gravels
	4	22~50	Mainly sandy silt	Dense and very stiff	Brown or Brownish gray	Silty fine sand with fragments of gravels
	5	16~45	Mainly sandy silt	Very stiff	Grayish brown of Brownish gray	Sandy silt with fine gravels, Low water content
	6	16~40	Mainly sandy silt	Stiff	–	–

Berth.

2) The second layer of very soft sandy silt with a thickness of between 4 – 5 meters is considered to be sunk rapidly by the dead load of pavement or the surcharge. Soil stabilization work for the foundation, such as preloading will be necessary. The soft bed zone of the planned 7th Berth are shown in Fig. 2-2-10.
3) The base of dense or stiff sandy silt and/or silty sand strata below the second layer are considered durable as the base for the planned 7th Berth quay.

2-2-7 Sedimentation

(1) Formation of the sand spit

The results of field observations at the tip of the sand spit during the first field survey show that sediment transport is mainly caused by northward longshore littoral drift due to waves generated by the strong southerly winds in the winter season.

The influence of ocean currents and tide which may cause sand transport can be considered small.

The transport occurs as a result of wave action within the nearshore regions. The strong southerly winds generate higher wave activity and stronger littoral drift than do the weaker winds which come from north and northwest in the summer season. The sediments caused by incessant wave action have formed this finger shaped sand spit. The large, and continually growing finger of land is a sand spit that dates from prehistoric times, and it is indicative of a majority of northward littoral drift. The fact that all of the sand spits along the Yemen coastline have northward shape also discloses a majority of northward littoral drift.

Littoral sediments often form sand banks behind the top of sand spit as the sand spit enlarge. Such is the case with the two sand banks behinds the top of this finger as shown in Fig. 2-2-14. It is thought that the sand banks are formed as a result of weakened littoral drift at the top of the sant spit, combined with southward littoral drift resulting from less frequent wave action coming from the north and northwest.

Soil samplings were taken at 3 points on the sand spit and grain size analyses were conducted. The locations of soil samplings are shown in Fig. 2-2-14. The results showed that grain size was fairly coarse, with a 0.25 ~ 0.50 mm median diameter (d50). This indicates that shoreline sediments at the finger and bottom sediments in the approach channel are composed of almost the same kind of sand. This is consistent with the above supposition.

The final report of the Mocha Siltation Study is very useful in understanding the sedimentation mechanism at the entrance of the Hodeidah Port because of the similarity in wind and wave conditions at the two locations. A northward sand spit is also formed at Mocha Port and grain size distribution at its top has almost the same shape as that of Hodeidah.

According to the report, the average sediment transport rate at the Mocha Port is estimated to be less than 150,000 m^3/year. It can be assumed that the same sediment transport rate occurs at the Hodeidah Port because of the similarity of geographic conditions, waves and currents, and grain size distribution. In this case, the finger will grow less than 10 m/year, maximum. Suspended loads of fine sand, silt and loam may also be transported from the south, but the major part of these fine sediments will be carried to the northern area across the entrance of Kathib Bay.

From these observations, it would seem reasonable to assume that the sea bed at the entrance of Kathib Bay will remain balanced.

(2) Siltation of the approach channel and basin in Kathib Bay.

The majority of suspended sediments will be carried to the northern area across the entrance of Kathib Bay, but part of them may bring about siltation in Kathib Bay due to ocean currents, tides, and southward littoral driff from north and northwest waves. Due to silting, less depth in the approach channel than charted has been recorded (indicated in the chart). Also, as shown in Table 2-2-5, the grain size (d50) of suspended sediments becomes progressively finer farther out from the mouth of Katib Bay toward the inner part of the bay. This indicates that fine sediments drift to the inner basin. The location of the bottom grab samplings are also shown in Fig. 2-2-14.

Table 2-2-5 Bottom sediment grain size in Kathib Bay

Location	BG-1	BG-2	BG-3	BG-4	BG-5
	BG-1′	BG-2′	BG-3′	BG-4′	BG-5′
Grain Size (d50) mm	0.026 ~ 0.03	0.026 ~ 0.028	0.16 ~0.4	0.2	0.2 ~0.28

The rate of sedimentation is considered to be small because of the infrequency of waves from the north and northwest in the summer season.

According to the records of PMAC, dredging of the channel and the basin has been executed since 1958. From 1958 to 1961, the Russians dredged the channel and the basin to a depth of 7.9 m below the datum. From 1974 to 1977, the channel and the basin were dredged to an elevation of −8.5 m. The channel, a part of the basin and the basin in front of the 5 and 6th Berths were dredged again to an elevation of −9.5 m from June 1980 to March 1981. But, it is difficult to estimate the siltation rate because of a lack of records on dredging quantity and water depth.

(3) Recommendation of a periodical field survey

Siltation mechanisms in the channel are generally influenced by factors such as geography, ocean currents, tides, sand drift, shipping, and soil conditions.

In case of the Hodeidah Port, finger growth will be fairly show – less than 10 m/year – and the sea bed at the entrance of Kathib Bay will remain balanced. Siltation problems will not occur in the near future.

The dredging of the approach channel to a depth of −12 m as part of the development of Hodeidah Port, however, may cause a new siltation problem. Siltation rate estimates are very difficult to make at present because of a lack of precise engineering data.

For this reason, periodical observation is recommended. One such plan is as follows: (Recommended sites for observation are also shown in Fig. 2-2-14).

1) Continuous observation of wind, wave, littoral current and tide

An observation tower will be constructed at Ras Kathib and the wind direction and velocity will be measured at the top of the tower. These measurement will be recorded automatically in the observation room. A wave meter will be installed the 10 km offshore from the tower. Desirable water depth for this site is at least 20 meters. Measured wave heights and periods will also be recorded automatically in the tower. Periodical survey of the littoral current will be executed by tracer at the nearshore zone of Ras Kathib. This survey will be conducted 4 times a year, to be continued for two years.

2) Periodical soundings at the mouth of Kathib Bay and the approach channel

The area for periodical sounding will include the whole of the approach channel and the mouth of Kathib Bay with the center of the area being fairway buoy No. 1. Sounding will be carried out twice a year and will be continued for more than 5 years.

3) Observation of littoral sand drift

The bed load and suspended load will be measured with bottom settled pits and with vertically settled pits. A bottom settled pit is a column with 40 cm diameter, 20 cm deep bottom plates. Ten to twenty pits are installed along a survey line extending vertically from the shoreline. A total of two to three lines are drown extending from the top of finger. The pits should be installed at one meter pitch depth. The vertically settled pits are called suspended sand traps and are made of bamboo. The traps have five to ten nodes and chambers and also have 3 x 6 (cm^2) windows in each chamber. The chamber can catch suspended sediments. These vertical sand traps are installed next to the column shaped pits.

Littoral sand drift surveys should be conducted every two or three months and could be continued for two or three years.

The colored fluorescent sand tracers are used to ascertain direction of the sand transport. They will be let out near the pits, and it is most desirable that this be done in winter or summer just before a storm.

4) Measurements of the sedimentation rate

The annual sedimentation rate will be estimated through water depth measurements in test channels that will be temporarily dredged. Two to three test channels will be dredged next to the approach channel. They will be ten to twenty meters in width and length. The bottom elevation of the test channel is −12 m from the datum line. Changes in water depth in the test channel should be measured twice a year, to be continued for more than five years.

5) Bottom grab sampling

Bottom grab sampling and grain analysis are useful in estimating sources of supplied sediments. Only one bottom sampling for every three years will be needed.

6) Current measurements in Kathib Bay

Current measurements in Kathib Bay during spring and neap tides are useful in estimating siltation rates.

Fig. 2-2-14 Observation Plan