Chapter 7
Field Survey of Natural Conditions at Gwadar

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7-1 General

The Japanese Study Team carried out the following field surveys during the period of 1978–1979, in order to supplement the available information on the natural conditions described in Chapter 6, and in order to obtain necessary data for planning the port and designing the port structures.

Sequence	Period	Season	Survey Item
I-1	September to October, 1978	Final period of southwest monsoon season	Water sampling, bed material sampling, topographic survey, sand sampling in surf zone, measurement of cliffs around Headland, wind observation.
I-2	January, 1979	Northeast monsoon season	Same as above, current observation with current meter.
II-1	May to June, 1979	Initial period of southwest monsoon season	Preparation for 2nd survey (settlement of measurement points, meter installation points, cliff measurement point, temporary BM, water sampling, bed material sampling.
II-2	June to August, 1979	Southwest monsoon season	Self-recording observation (tide, current and wave); visual wave observation; float tracing, water sampling, bed material sampling, suspended sand and drift sand accumulation.
III-3	August to December, 1979		Soil investigation, topographic and depth survey, stone survey.

The details of the above surveys are described in "Report on Field Survey of Natural Conditions" in the Appendix and in the other volume "Report on Subsoil Investigation".

For the marine condition survey, the Japanese Study Team showed the engineers of the Ports and Shipping Wing how to use the automatic recording observatory instruments for wave height, tide, and current, and how to obtain and analyze observation records. These instruments, which the team took to the field, and the consumable goods, such as recording paper and batteries, required for the successive observations of one year, were donated to the Ports and Shipping Wing after the second phase field survey. They will be able to learn the seasonal changes of waves, currents and tide by the successive observations, and this will provide more information for planning the operations of port facilities, as well as maintenance. The Japanese Study Team believes that sufficient technology transfer has been accomplished.

The Meteorological Agency has a plan to install an automatic recording anemometer on the roof of the residence of Coast Guards, and to start observation as an official observatory. However, it is desired that the Ports and Shipping Wing conduct their own observations, by installing a recording anemometer near the shore of the project site.

7-2 Meterological Conditions

(1) Winds

At Gwadar, the predominant winds blow in east-west direction. Diurnal variations of the winds, attributable to land and sea breezes are observed. The NE to W wind normally predominates in the morning, while SW wind predominates in the afternoon. A predominance of west wind is attributable not only to the southwest monsoon, but also to land/sea breezes.

(2) Eolian Sand

The surface soil consists of fine dry sand, easily blown away by winds over a speed of 5 m/sec. Eolian sand drifts can be prevented considerably by the construction of port facilities and buildings, as well as road pavement. Therefore, eolian sand is a far less important problem than drift sand due to wave and current action.

7-3 Sea Conditions

(1) Current

Wind driven currents, with the speed of 1 to 2 kt, predominate south of the Headland. Therefore, these wind currents change seasonally, east current predominating during the southwest monsoon season, and a west current predominating during the northeast monsoon season.

In the East Bay, the currents appear in the form of branched and counter currents, corresponding to the west and the east currents to the south of the Headland. The records obtained by a recording current meter show that currents observed are a combination of the permanent current together with the drift current caused by winds in the bay. The current speed is only about 5 cm/sec.

The tidal currents are the dominant currents in the bay. The dominant direction in the spring tide season is 260° during the flood tide and 80° during the ebb tide, when measured from the north in clockwise direction. They are nearly parallel to the face line of the groin and the channel. The maximum velocity of tidal current at 1 m above the sea bed (bottom current) is about 0.5 kt.

A harmonic analysis of tidal currents reveals that predominant components of semi-diurnal or diurnal (maximum current speed: 5 to 6 cm/sec) intersect with the channel either perpendicularly or diagonally. The groin has the effect of changing their direction to east-west.

When waves break near the shoreline, a current along the shore is produced between the breakers and the shoreline. This longshore current either matches or flows against the wave direction. The speed of the longshore current can be as high as 1 m/sec, moving bed materials by suspension or traction. However, it is active only down to the water depth of 1 m.

(2) Tides

Table 7-1 shows the four major tidal constituents which were revealed by harmonic analysis of the tidal observation records, obtained during 15 days in July and September of 1979.

Table 7-1 Harmonic Constants

Component	Amplitude	Lag measured by local meridian	Period	Tide
M_2	72.8 cm	282.6°	12^h25^m	Principal lunar semi-diurnal
S_2	27.7	303.9	12 00	Principle solar semi-diurnal
K_1	40.9	43.2	23 56	Luni- solar diurnal
O_1	25.0	54.8	25 49	Principal lunar diurnal

According to the Pakistan Tide Tables, the annual deviation of the monthly average tidal level at Karachi Port during this period is 4 cm (see Table 7-2). The annual deviation is supposed to be the same in a wide area because it is based on seasonal fluctuations. Therefore, the annual average tidal level was obtained by correcting the average tidal level during the observation period with the above value.

The tidal constants given in the Tide Tables are 80% in amplitude, and 0.6 to 0.8 hour behind in phase, when compared with the data obtained by the Japanese Study Team (see Table 7-3).

(3) Water Quality

The team sampled water at some depths below the water surface in a vertical section, and measured its temperature and specific gravity. The data obtained are summarized below.

Period of observation	Water temperature °C	Specific gravity	
		Observed value	Standard value (converted into 15°C)
Southwest monsoon season	21 to 29	1.025 to 1.026	1.028
Northeast monsoon season	23	1.026	1.028

Water temperature shows considerable variations during the southwest monsoon season. Vertically, a thermocline exists at approximately 1/3 of the water depth, from the water surface, and the layers above and below the thermocline have neither the same current direction nor the same speed. The water temperature of the thin layer above the thermocline changes considerably according to the diurnal variation of atmospheric temperature during this season of strong insolation.

The standard specific gravity after conversion to 15°C is uniform within this area, and remains almost constant (1.028) throughout the year. Therefore, the seasonal fluctuations of

Table 7-2 Seasonal Changes in Mean Level

No.	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	Jun. 1	Jul. 1	Aug. 1	Sep. 1	Oct. 1	Nov. 1	Dec. 1
4315–4327	0.0	–0.1	–0.2	0.0	+0.2	+0.3	+0.2	0.0	–0.1	–0.2	–0.1	0.0

Table 7-3 Comparision of Harmonic Constants

Component	(1) TIDE TABLES		(2) JST		Ratio of Amplitude		Phase difference	
	H	g	H	g	(1)/(2)	Rate	[(2) – (1)] /σ	Δh
	ft	°	ft	°				h
M_2	2.0	282	2.4	303	2.0/2.4	0.8	$\frac{(303-282)}{28.9}$	0.8
S_2	0.7	314	0.9	330	0.7/0.9	0.8	$\frac{(330-314)}{30.0}$	0.6
K_1	1.4	47	1.4	56	1.4/1.4	1.0	$\frac{(56-47)}{15.0}$	0.6
O_1	0.6	36	0.8	62	0.6/0.8	0.8	$\frac{(62-36)}{13.9}$	2.2

Table 7-4 Tide Levels

Tide Level	TIDE TABLES			JST	
	above DL		above MSL	above DL	above MSL
	(ft)	(m)	(m)	(m)	(m)
MLWL Sp.	1.5	0.46	–0.82	0.27	–1.01
MLWL Np.	2.9	0.88	–0.40	0.83	–0.45
MSL	4.2	1.28	0.00	1.28	0.00
MHWL Np.	5.5	1.68	0.40	1.73	0.45
MHWL Sp.	6.9	2.10	0.82	2.29	1.01
HHWL	8.9	2.71	1.43	2.94	1.66

specific gravity are attributable to changes of atmospheric temperature, mainly by insolation. It can be assumed that water quality is almost uniform in the entire East Bay.

A comparison of the water quality south of the Headland to that of the northern part of the Arabian Sea shows that the water in the East Bay is slightly diluted by the mixture of fresh and discharged water, but that the specific gravity of the water in the West Bay is high because of active evaporation in the shallow Bay.

The result of sampled water analysis shows that the content of sediments suspended from the sea bottom by wave and current action is extremely small, and it can be ignored except the area between the shoreline and breakers. Thus, sediment transport which is silting the channel is probably attributable to bedload transport.

(4) Waves

The predeominant waves in the Bay during the southwest monsoon season are from the Arabian Sea progressing northeast, and diffracted and refracted near the east edge of the Headland.

This swell is characterized by the wave direction of E to ESE and the period of 10 to 15 seconds with a significant wave hight of 0.25 to 1.00 m (maximum wave hight 0.50 to 1.50 m). The swell does not show obvious diurnal variations because its growth is influenced by the meteorological condistions of the Arabian Sea. The swell comes from the south side, with the angle not over 25° to the center line of the palnned groin and channel.

Although there are waves and swell during the northeast monsoon season, the details of this swell are unknown because no observations have been made. It is known, however, that the wave height and period are smaller than those of the swell during the southwest monsoon, and the wave direction is within 25° from the north side to the center line of the planned groin and channel.

The northeast monsoon produces wind waves in the bay in the morning, the swells coming from the southwest and predominating in the afternoon. Wave observation is being continued by the Ports and Shipping Wing to reliably select optimum design waves. For the present purposes, the swell during southwest monsoon season is selected as design wave; the height and the period of significant wave are 1.5 m and 12 seconds, respectively. They travel almost parallel to the center line of the planned groin and the channel due to the heavy refraction around the point.

(5) Seiche

From the tide record, the long-period oscillation peculiar to the bay caused by the wind, wave or swell was found in the bay. The current velocity (about 2 cm/sec) caused by long period waves may not be sufficient for causing a tidal current, but installation of the groin may be able to shift the current direction to an east-west direction and to deform the bay oscillation system.

7-4 Topography and Bed Materials

(1) Shore Topography

The sand bar on which Gwadar is situated is a tombolo. It is suspected to have been formed by sands which have accumulated in a calm area sheltered from the southwest swell.

The inclination of the longitudinal section of the shore is about 1/10 to 1/7. Southward currents predominate in the bay, and southward sediment transport is observed only in the extreme vicinity of the shoreline at the south end (behind the Headland), where the energy of the invading waves is small. As a result, the shore slope is sharp, and no large sand dune has developed. Some low cliffs have been formed by beach erosion.

(2) Sea Bed Material

The sea bed in the bay consists generally of silty materials. The median grain size is 0.05 to 0.07 mm, and no obvious local variations were found.

The team sampled bed materials, made a grain size analysis, and calculated median grain size, sorting coefficient (the degree of being sorted by waves and current), and skewness (ratio of grains larger than or smaller than average grain size). The team also studied the relation with waves at sampling locations. The following correlation was found between wave size and grain type:

Wave	Large	Small
Grain size	Large	Small
(M ϕ	Small	Large)
Sorting	Good	Not good
(σ ϕ	Small	Large)
Skewness	Many coarse grains	Many fine grains
(α ϕ	Negative	Positive)

Bed material characteristics are very important when considering grain transport by wave and current, especially for analysis of sedimentation of planned channels. At Gwadar, the cohesion of bed materials can be ignored, and electric and chemical actions can be neglected. Therefore, the bed material transport takes place in the form of so-called littoral drift.

(3) Beach Sand

Generally, beach sand contains large quantities of minute pieces (long and narrow) of shells. They have a large influence on the result of grain size analysis, and the characteristics are hard to grasp. The effective grain size is 0.1 to 0.2 mm, and the coefficient of uniformity is less than 2.5. Beach sand seems to show considerable resistance against shoreline drift and eolian sand. Therefore, shoreline drift and eolian sand do not seem very active.

(4) Retreat of Cliff

One of the important problems at Gwadar is the maintenance of the channel, to dredge the sediments which silt the channel. Bed sediments which silt the channel come from the sea bottom itself, the rivers, and the land.

This region belongs to a dry climate zone, but heavy rainfalls occur occasionally. Cliffs around the Headland consist of soft rocks and are easily eroded by rain, discharging a large amount of sediments onto the earth and into the shore. They can be a source of littoral drift and eolian sand. Therefore, the team tried to measure the retreat of cliffs several times. The measurement results are not quantitatively satisfactory because cliff erosion depended on the amount of

rainfall and the location. However, it seems that the retreat of cliffs cannot be ignored as the source of sediments, and a cause of damage to the roads around the Headland, after heavy rainfalls. Measures for protecting land facilities from drift also should be considered.

7-5 Subsoil Investigation

The team bored 10 holes, 7 holes on the centre line of the revetment and the groin at 150 to 250 m intervals, and 3 holes on the face line of the quay at 150 m intervals. This is important for determining the stability of the proposed structures, and the safety against sliding and settlement of the embankment. The team installed a rigid staging for boring work and conducted drilling and sampling with utmost care in order to avoid the disturbance of soil samples.

A separate report will be written on the soil investigation, with a summary of the results given here.

(1) Items of Investigation

1) Drilling location and drilling length

The drilling length is given in Table 7-5.

2) Drilling method

Staging: Pipe staging

Drilling: Rotary method

3) In-situ test and sampling

Standard penetration tests: 154 points

Undisturbed sampling: 41 points (Stationary piston sampler)
7 points (Denison Sampler)

4) Laboratory tests at site

Unconfined compression test
Undisturbed sample
Remolded sample

Natural water contents and Wet density: for unconfined compression test samples

5) Laboratory tests (Singapore, Kiso-Jiban Consultants)

Consolidation test

Tri-axial compression test (unconsolidated, undrained)

Unconfined compression test

Physical tests (water content, plastic limit, liquid limit, grain size analysis, density) for each sample.

Table 7-5 Drilling Length

(unit; meter)

Bore hole No.	1	2	3	4	5	6	7	8	9	10	3′
Drilled length	14.45	15.36	30.45	19.45	13.45	16.40	20.45	30.45	22.25	30.30	4.85

Total drilling length; 217.86m

Fig. 7-1 Location of Boreholes

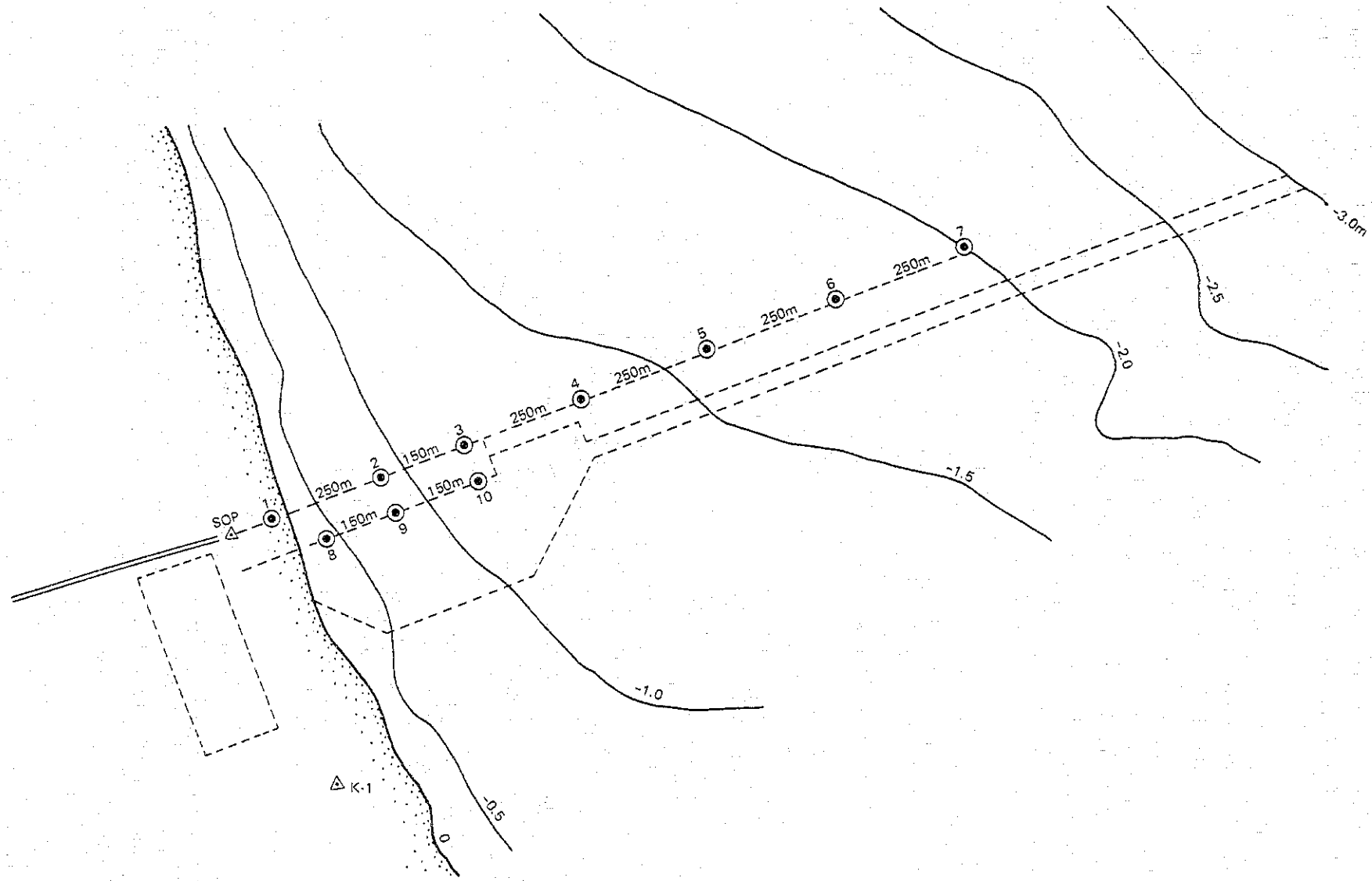
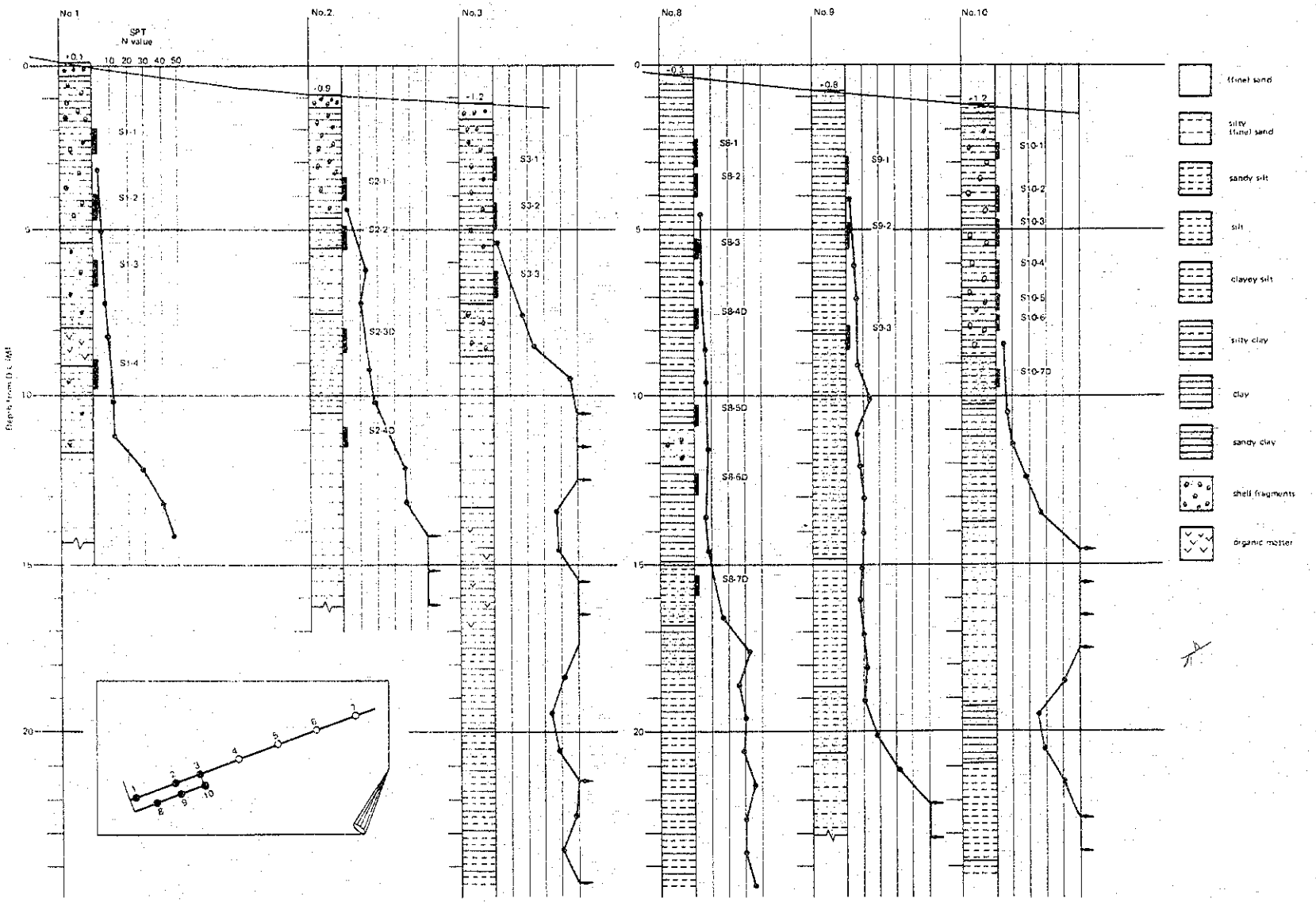


Fig. 7-2(a) Boring Logs [1]



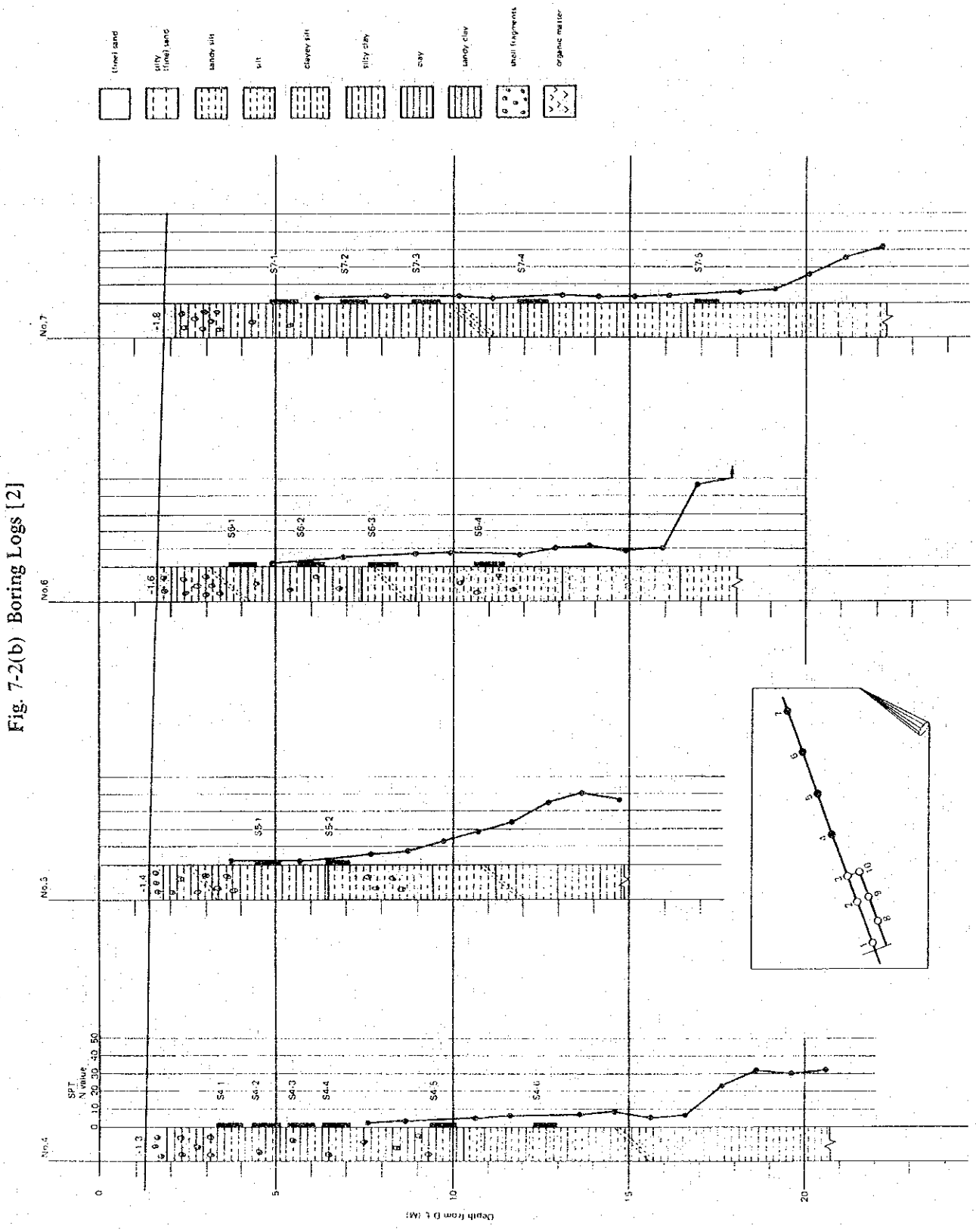


Fig. 7-2(b) Boring Logs [2]

Fig. 7-3(a) qu Value (Quay wall face line)

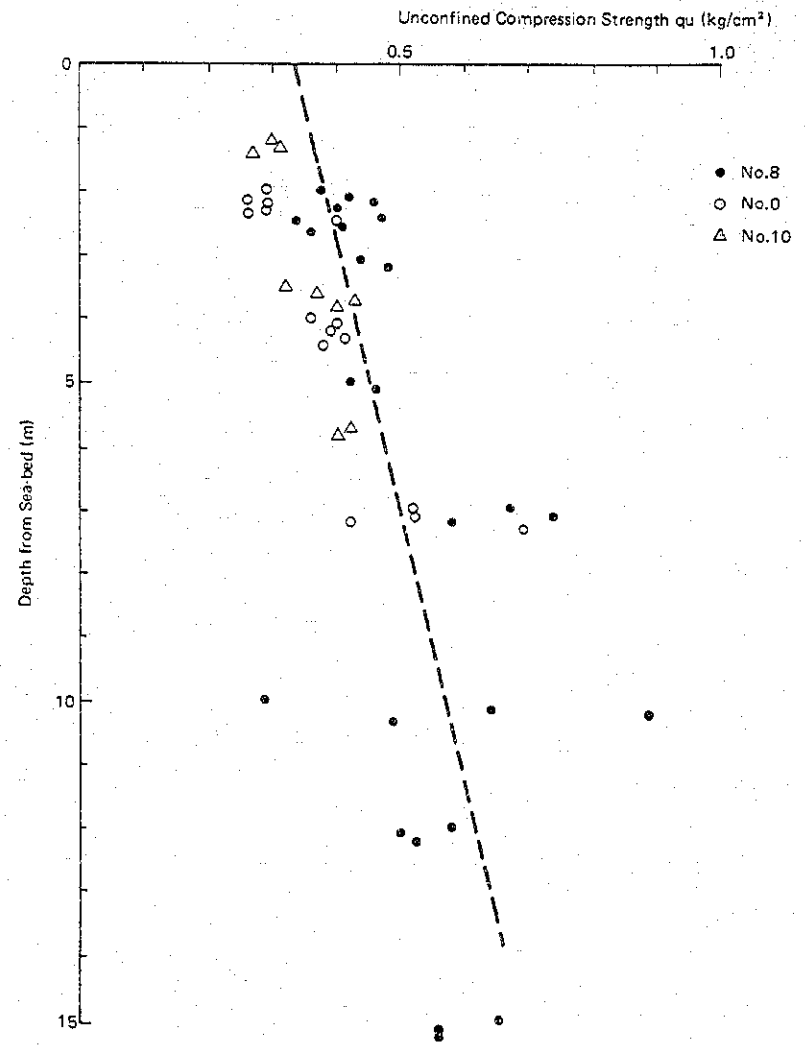


Fig. 7-3(b) qu Value (Groin face line)

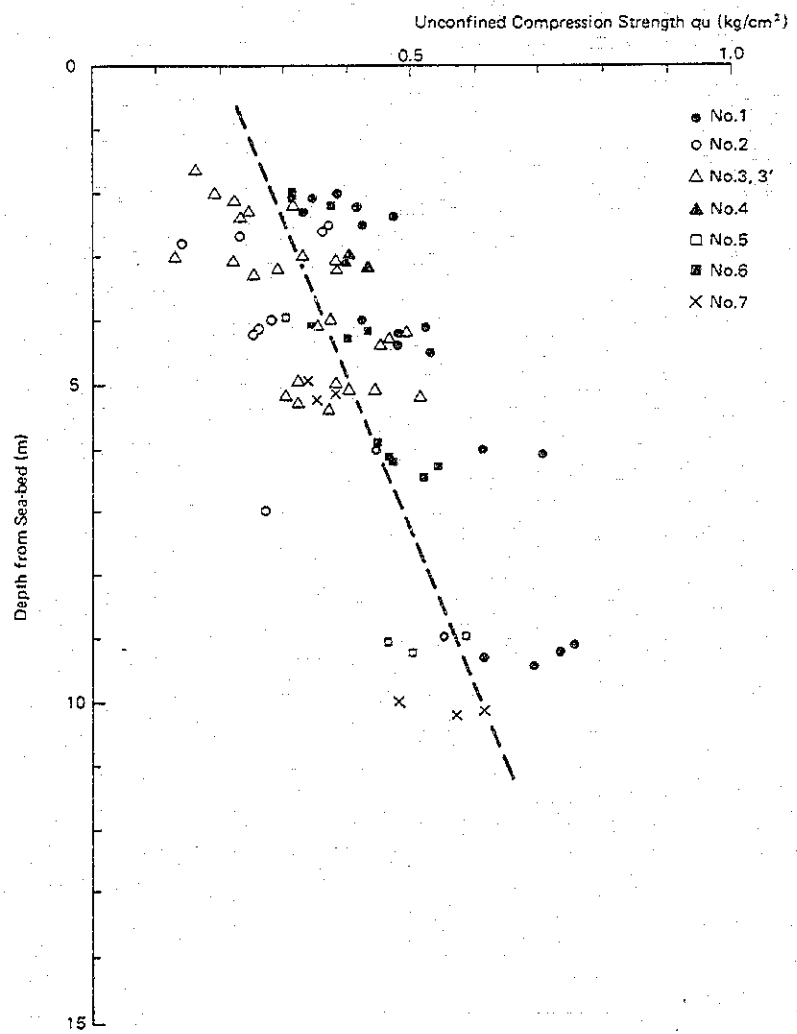


Table 7-6 (a) Characteristics of Soil (1)

Borehole No.		1				2					3, 3′						
Sample No.		1	2	3	4	1	2	3D(T)	3D(B)	4D	1	1′	2	2′	3′	3	4′
Sample depth	m	2.00 ~ 2.80	4.00 ~ 4.80	6.00 ~ 6.76	9.00 ~ 9.84	2.50 ~ 3.20	4.00 ~ 4.70	7.00 ~ 7.40	7.40 ~ 7.80		1.60 ~ 2.30	2.00 ~ 2.73	3.00 ~ 3.80	3.00 ~ 3.84	4.00 ~	5.00 ~ 5.82	5.00 ~ 5.85
Visual soil description			Silty Clay	Clayey Silt	Silty Clay	Silty Clay	Clayey Silt	Sandy Clayey Silt	Clayey Silt		Silty Clay with Sand		Silty Clay	Clayey Silt	Silty Clay	Silty Clay	Clayey Silt
Unified soil classification			CL	CL		CL	CL	ML-CL	CL		CL		CL	CL		CL	CL
Natural water content (site)	%	30.8	28.1	20.7	27.1 ~ 28.6	30.4	27.2				30.9	30.8	30.4	29.6	26.7		25.7
Ditto (lab)	%		26.7	21.8	(31.8)	29.5	21.4	22.1	19.0		27.4		29.4	26.0	26.5	28.3	23.8
Specific Gravity			2.742	2.734	2.699	2.719	2.705	2.706	2.728		2.728		2.723	2.716		2.717	2.721
Wet density (site)	g/cm³	1.92 ~ 1.93	1.99 ~ 2.00	2.10 ~ 2.12	1.94 ~ 1.98	1.94 ~ 1.97		2.04 ~ 2.07				1.93 ~ 1.95	1.89 ~ 1.96	1.96	2.00 ~ 2.02		2.01 ~ 2.02
Ditto (lab)	g/cm³		2.01	2.10		1.96	2.09	2.07	2.14				1.96			1.99	
Dry density	g/cm³		1.59	1.72		1.51	1.72	1.70	1.80				1.51			1.55	
Natural void ratio			0.728	0.586		0.796	0.570	0.596	0.517				0.809			0.752	
Liquid limit	%		32.6	27.6		34.7	24.4	22.0	27.0		27.4		35.9	31.7		33.0	27.7
Plastic limit	%		16.3	14.0		15.2	12.5	16.6	15.0		15.4		14.8	15.1		13.7	13.6
Plasticity index			16.3	13.6		19.5	11.9	5.4	12.0		12.0		21.1	16.6		19.3	16.6
Diameter at 60%	μm		7.7	18		6.9	27	39	17		8.4		7.8	9.5		7.0	16
Unconfined compression Strength (site)	kg/cm²	0.33 ~ 0.47	0.42 ~ 0.53	0.61 ~ 0.70	0.55 ~ 0.75	0.23 ~ 0.37	0.25 ~ 0.28	0.27			0.16	0.19 ~ 0.31	0.13 ~ 0.29	0.33 ~ 0.38	0.35 ~ 0.49		0.32 ~ 0.51
Ditto (lab)	kg/cm²														0.47		
Angle of internal friction	°		0	0		0	0		0				0	0		0	0
Cohesion	kg/cm²		0.26	0.34		0.17	0.77 (1.45)		0.77 (1.90)				0.17	0.22		0.19	0.24
Preconsolidation pressure	kg/cm²		1.7	2.4	2.3	1.0								1.2		1.0	(1.5)
Compression index			0.21	0.17	0.30	0.23	0.10						0.23	0.21		0.23	0.17

Table 7-6 (b) Characteristics of Soil (2)

Borehole No.		4								5			6				7				
Sample No.		1	2	3	4(T)	4(B)	5(T)	5(B)	6	1	2		1	2	3	4	1	2	3	4	5
Sample depth	m	2.00 ~ 2.78	3.00 ~ 3.85	4.00 ~ 4.85	5.00 ~ 5.50	5.50 ~ 5.87	8.00 ~ 8.35	8.35 ~ 8.80	11.00 ~ 11.67	3.00 ~ 3.74	5.00 ~ 5.69		2.00 ~ 2.87	4.00 ~ 4.78	6.00 ~ 6.86	9.00 ~ 9.87	3.00 ~ 3.78	5.00 ~ 5.83	7.00 ~ 7.82	10.00 ~ 10.87	15.00 ~ 15.72
Visula soil description				Silty Clay	Silty Clay	Clayey Silt	Silty Clay	Clayey Silt	Clayey Silt	Silty Clay	Clayey Silt		Silty Clay	Silty Clay	Silty Clay	Clayey Silt	Silty Clay		Silty Clay	Clayey Silt	Clayey Silt
Unified soil classification				CL	CL	CL	CL	CL	CL	CL	CL		CL		CL	CL	CL		CL	CL	CL
Natural water content (site)	%		28.3										31.2	33.1	30.0	25.7		32.3		26.5	
Ditto (lab)	%			28.1	26.3	22.9	25.3	23.4	30.4	30.5	20.4		31.3	32.5	31.8	22.8	30.2		30.5	27.0	26.5
Specific Gravity				2.754	2.716	2.709	2.742	2.722	2.758	2.759	2.722		2.732		2.740	2.699	2.756		2.750	2.734	2.748
Wet density (site)	g/cm³	1.93 ~ 1.97											1.97 ~ 1.99	1.93 ~ 1.94	1.94 ~ 1.97	2.02		1.91 ~ 1.94		1.99 ~ 2.04	
Ditto (lab)	g/cm³			1.99	2.02	2.06	2.04	2.07	1.98	1.97	2.11						1.96		1.96	2.00	2.01
Dry density	g/cm³			1.55	1.60	1.68	1.63	1.68	1.52	1.51	1.75						1.51		1.50	1.58	1.59
Natural void ratio				0.773	0.698	0.616	0.684	0.623	0.816	0.828	0.553						0.831		0.831	0.736	0.729
Liquid limit	%			33.2	31.8	27.7	31.0	27.0	36.0	36.1	24.0		36.7		39.1	23.3	35.0		36.3	30.0	29.5
Plastic limit	%			17.7	15.4	15.4	17.2	16.4	19.1	17.0	15.1		17.0		16.9	16.1	16.4		17.1	15.7	15.0
Plasticity index				15.5	16.4	12.3	13.8	10.6	16.9	19.1	8.9		19.7		22.2	7.2	18.6		19.2	14.3	14.5
Diameter at 60%	μm			6.1	7.5	13	10	19	5.6	5.0	21		5.5		4.5	36	6.0		4.6	11	11
Unconfined compression strength (site)	kg/cm²		0.39 ~ 0.43										0.31 ~ 0.37	0.30 ~ 0.43	0.44 ~ 0.54	0.46 ~ 0.58		0.33 ~ 0.38	0.48 ~ 0.61		
Ditto (lab)	kg/cm²			0.36 ~ 0.39	0.48 ~ 0.57		Mean 0.60	Mean 0.57		0.29 ~ 0.34							0.28 ~ 0.38		0.47 ~ 0.60	0.48 ~ 0.61	
Angle of internal friction	°			0	0	0			0	0	23		0	0	0	10	0		0		0
Cohesion	kg/cm²			(0.19)	0.26	0.23			0.23	0.17	0.24		0.19	0.19	0.23	0.26	0.18		0.26		0.32
Preconsolidation pressure	kg/cm²			1.4	1.7				1.8	1.2			1.1		(1.0)		1.2			1.7	2.3
Compression index				0.22	0.20				0.29	0.24			0.23		0.22		0.25			0.21	0.21

Table 7-6 (c) Characteristics of Soil (3)

Borehole No.		8								9					10								
Sample No.		1(T)	1(B)	2	3	4D	5D	6D	7D	1	2	3(T)	3(B)		1	2	3	4	5	6	7D(T)	7D(m)	7D(B)
Sample depth	m	2.00 ~ 2.40	2.40 ~ 2.86	3.00 ~ 3.74	5.00 ~ 5.62	7.00 ~ 7.65	10.00 ~ 10.58	12.00 ~ 12.62	15.00 ~ 15.60	2.00 ~ 2.82	4.00 ~ 4.82	7.00 ~ 7.28	7.28 ~ 7.35		1.20 ~ 1.70	2.50 ~ 3.31	3.50 ~ 4.30	4.80 ~ 5.61	5.70 ~ 6.20	6.30 ~ 6.80	8.00 ~ 8.25	8.25 ~ 8.45	8.45 ~ 8.55
Visual soil description		Silty Clay	Silty Clay	Silty Clay	Silty Clay	Clayey Silt		Silty Clay	Sandy Silt	Silty Clay			Clayey Silt			Silty Clay		Silty Clay		Silty Clay	Silty Clay	Sandy Clayey Silt	Silty Clay
Unified soil classification				CL	CL	CL		CL	ML				CL			CL		CL		CL	CL	CL	CH
Natural water content (site)	%	34.8	31.8	33.7 ~ 36.0	32.2 ~ 32.3	22.2		27.8		33.3 ~ 34.3	29.5	22.5	20.3		32.9		28.8		25.7				
Ditto (lab)	%			34.2	30.5	20.7		30.6	20.2	31.8			21.6			31.5		27.2		25.1	25.5	23.2	54.2
Specific Gravity				2.728	2.727	2.705		2.717	2.700	2.734			2.733			2.731		2.723		2.718	2.713	2.691	2.631
Wet density (site)	g/cm³	1.90	1.88 ~ 1.92	1.89 ~ 1.92	1.92	2.07 ~ 2.08	2.06 ~ 2.09	1.89 ~ 1.98	2.03	1.90 ~ 1.92	1.96 ~ 1.98	2.05 ~ 2.07	2.12		1.88 ~ 1.96		1.97 ~ 2.01		2.03 ~ 2.04				
Ditto (lab)	g/cm³			1.91	1.98	2.09		1.96	2.07							1.95		2.01		2.02	2.03	2.05	1.69
Dry density	g/cm³			1.42	1.52	1.73		1.50	1.72							1.48		1.58		1.60	1.62	1.66	1.10
Natural void ratio				0.917	0.797	0.562		0.797	0.568							0.842		0.723		0.695	0.677	0.617	1.40
Liquid limit	%			41.2	39.8	29.3		40.2					25.5			38.4		35.1		32.0	33.0	27.3	66.0
Plastic limit	%			18.3	16.4	14.0		16.2	NP				14.2			16.7		13.5		14.2	15.4	17.6	28.6
Plasticity index				22.9	23.4	15.3		24.0					11.3			21.7		21.6		17.8	17.6	9.7	37.4
Diameter at 60%	μm			4.3	5.9	14		6.0	52				21			5.6		6.7		7.8	8.7	37	5.5
Unconfined compression strength (site)	kg/cm²	0.38 ~ 0.46	0.34 ~ 0.47	0.44 ~ 0.48	0.42 ~ 0.46	0.58 ~ 0.74	0.49 ~ 0.89	0.50 ~ 0.58	0.56 ~ 0.65	0.26 ~ 0.40	0.36 ~ 0.41	0.42 ~ 0.52	0.69 ~ 1.21		0.27 ~ 0.31		0.32 ~ 0.40		0.40 ~ 0.42				
Ditto (lab)	kg/cm²															0.34 ~ 0.35		0.46 ~ 0.56				0.52	0.30 ~ 0.31
Angle of internal friction	°			0		0			22				0			0		0		0	0		
Cohesion	kg/cm²			0.21		0.33			0.78 (3.2)				0.42			0.17		0.24		0.22	0.18		
Preconsolidation pressure	kg/cm²				1.2					0.93			1.6			1.2		1.4					
Compression index					0.26	0.14		0.24		0.27			0.15			0.25		0.22				0.13	

(2) General Properties of Soil

The bed soil consists of silty clay or clayey silt to a considerable depth. It contains fine sand in some locations. Some layers contain a large amount of shell fragments and carbonized organics. Fig. 7-2 shows the boring logs.

Generally, the surface layer (down to several meters from the surface) is extremely soft. The N-values obtained by standard penetration tests were less than 5. The depth at which a hard clay layer or sand layer with N value over 20 varies among the holes. It ranges between DL-8 m and DL-20 m. Table 7-6 gives the typical soil properties.

(3) Physical Properties

Generally, the soil is characterized by little natural water content and a high wet density. The grain size is extremely small, and the specific gravity is slightly larger than the normal. The typical values of the major properties are given below.

Natural water contents:	19 – 36% (namely, 20 – 23% group and 27 – 33% group are found)
Specific gravity:	2.70 – 2.73
Wet density:	1.93 – 2.05 g/cm^3
Dry density:	1.50 – 1.70 g/cm^3
Natural void ratio:	0.58 – 0.81
Plasticity index:	11 – 25

(4) Mechanical Properties

The results of unconfined compression tests were uniformly about 0.4 kg/cm^2. No tendency was found for the strength to increase proportionally to depth. The cohension obtained by tri-axial compression tests (unconsolidated, undrained) was approximately 1/2 of unconfined compression strengths. The angle of internal friction was zero with almost all the samples. Fig. 7-3 shows the distribution of unconfined compression strengths in relation to depth.

The consolidation tests also show that the preconsolidation load is higher than the normally consolidated load by about 0.8–1.0 kg/cm^2. The compression index Cc is 0.15–0.26. The preconsolidation load was often unclear because the void ratio is generally small (0.5–0.9).

7-6 Reconnaissance of Construction Materials

7-6-1 Concrete Aggregate

(1) Investigation of Gravel at Suntsar

Gravel to be used for concrete aggregate for this project is available about 70 km away from Gwadar. The following sites are promising:

1) Area located about 2 km from Suntsar on Gwadar-Suntsar Road; near the second pump station (Site A)
2) Area located about 2 km from Suntsar on Jiwani-Suntsar Road

Properties of Gravel

Grain size

Table 7-7 shows the result of the sieve test given to all of the gravel (80 kg) sampled from the test pit at Site A.

Table 7-7 Sieve Analysis of Suntsar Material

Grain Size mm	Weight kg	Percentage %	Accumulated Percentage %
0.15 under	6.8	8.4	8.4
0.15 - 1.2	9.0	11.1	19.5
1.2 - 5	11.4	14.0	33.5
5 - 10	6.7	8.2	41.7
10 - 20	10.9	13.4	55.1
20 - 40	17.2	21.2	76.3
40 over	19.3	23.7	100

Shape

The gravel is generally flat, with flatness increasing proportionally to size. The quantity of long and narrow pieces is also large.

Deleterious Components

Gravels contain a considerable amount of calcite, especially among the 5–20 mm sizes. Gravels have a large amount of minute components (components below 0.15 mm account for 8.4%), and are covered with a considerable amount of mud.

Proposal for Gravel Utilization

Larger than 25 mm: This group can be used as concrete aggregate after crushing. It can be used also as cobbles for the foundations of buildings and machines.

5mm – 20 mm: This group can be used as aggregate material as it is. However, it contains clay balls.

Below 5 mm: It is possible to sort gravels of 1.2 mm – 5.0 mm and use them as fine aggregate. However, it will be hard because they must be washed to remove clay balls. This group can be used to supplement the sand at Gwadar which contains no grains over 2.5 mm. It is also possible to use this group for screenings.

It is not recommended to sort and crush gravels at Suntsar, where the climate and living environment is severe, but to carry all materials to Gwadar for sorting.

Absorption and Surface Moisture

Gravels left in their natural conditions are very dry, and the amount of absorption changes considerably, making it hard to determine the best weight of water per unit volume.

Therefore, it is advised to sprinkle water over gravels after sorting.

(2) Gravel at Koh-e-Medi

A rather high-quality gravel layer (about 1/2 m thick) exists on the north side of Koh-e-Medi. However, it is not suitable for concrete aggregate because of a high silt content. Presently, natives

sort the gravel manually, and use it for base course and pavement for roads.

(3) Sand at Gwadar

Sand containing a large amount of shell pieces exists about 5–6 km in the north of the project site near Old Jetty. Table 7-8 shows an example of sorting results.

Table 7-8 Sieve Analysis of Gwadar Sand

Grain Size mm	Weight g	Percentage %	Accumulated percentage %
0.15 under	39	1.7	1.7
0.15 - 0.3	664	29.0	30.7
0.3 - 0.6	524	23.0	53.7
0.6 - 1.2	495	21.7	75.4
1.2 - 2.5	445	19.5	94.9
2.5 - 5	100	4.4	99.3
5 over	15	0.7	100

The grain size distribution appears satisfactory. But, the groups over 2.5 mm consist almost entirely of shell pieces, the sand being contained only in the smaller grain size groups. However, the sand at Gwadar must be used in spite of the large shell content, because the only other choice is the small quantity at Suntsar. On the other hand, the sand at Gwadar is advantageous as a fine concrete aggregate, because it contains almost no fine grains (below 0.15 mm).

(4) Concrete Test Mixing

The team conducted seven types of test mixing, in order to judge the adequacy of Suntsar's coarse aggregates and fine aggregates, and Gwadar's fine aggregates, as concrete material. The team studied 28 day strengths, using three samples for each.

1) Description of Test

a) Materials

i) Cement — Ordinary Portland cement (produced in Pakistan)

ii) Coarse aggregates — Taken from Suntsar; two types (test Pits No. 1–No. 3 and No. 4–No. 5) 5–20 mm

iii) Fine aggregates — Taken from Gwadar (smaller than 5 mm)
Taken from Suntsar (0.15–5 mm and 1.2–5 mm)

b) Mix Proportion

Three weights of cement per unit volume –300, 330, and 360 kg/m^3– were used. The water cement ratio was changed within 50%–65% in order to obtain adequate slump and plasticity by test mixing. The ratio of fine aggregates among all aggregates was 35%. The details are given in Table 7-9.

c) Mixing

A half-size drum can was used for mixing. Prior to real mixing, mortar of the same mix proportion was mixed to prevent the loss of mortar during real mixing. However, this was omitted for No. 3.

d) Slump Test

The specifications of the Japan Society of Civil Engineers were used.

e) Test Piece

Circular cylinders (15 cm in diameter and 30 cm in height) were used.

f) Curing

Concrete was demolded on the day after being cast into cylinders. They were left to cure in water for more than 3 weeks.

g) Compresson Test

The compression test was conducted at Soil Mechanics and Hydraulics Laboratory, Karachi.

2) Results of Test Mixing

Fine aggregates have larger surface area for weight than ordinary grain shape sand because of an extremely large quantity of shell contents. It increases cement paste adhesion and requires approximately 360 kg/m^3 of cement to obtain ordinary slump and plasticity. Slump was insufficient and segregation was heavy at 300 kg/m^3 (weight of cement per unit volume). It is desirable to increase the ratio of fine aggregates to coarse aggregates because of rather flat coarse aggregates.

3) Obsevation of compressive strength (The strength data given here are the average of 3 samples ± standard deviation).

a) Difference atrributable to weight of cement per unit volume (mix. Nos. 3, 4, 5)

C = 360 kg/m^3 corresponds to σ_{28} = 222 ± 5 kg/cm^2. The strength decreases rapidly as the weight of cement per unit volume decreases. C = 330 corresponds to σ_{28} = 173 ±14 and C = 300 corresponds to σ_{28} = 137 ±10.

b) Difference attributable to aggregate origin (mix Nos. 1,5 and 2,4)

The difference between the test pits 1–3 and 4–5 was studied, and TP 4–5 showed greater test strength. The difference between the two at C = 360 kg/m^3 is especially large (TP1-3 = 163 ± 8 and TP4-5 222 ± 5). It is not possible to state that it is attributable only to the difference of aggregates.

c) Difference atrributable to fine aggregates (mix Nos. 5, 6, 7)

The 0.15–2.5 mm aggregates taken from Suntasar (not washed) showed extremely low strength. No. 5 and No. 6 may be considered almost equivalent.

4) Comprehensive Discussion on Mix Proportion

The best strength that can be expected with be σ_{28} = 200–220 kg/cm^2, even if the best materials available near the field are mixed with utmost care. A decrease in the weight of cement per unit volume, or insufficient washing, will lower the strength easily. Therefore, careful quality control is essential for concrete mixing. There appears to be no choice but to use Gwadar's fine aggregates, with an extremely high shell content. The best mix proportion must be determined after sufficient test mixing. The design strength should be about σ_{28} = 180 kg/cm^2.

7-6-2 Armouring Stone

Gwadar and the vicinity have no stone of high quality and high strength adequate for armouring the revetment and the groin. Shelly limestone that is found in some part of the Headland is the only material that can be used for this purpose, though not ideal. Shelly limestone is found in a zone of about 50 m in width and more than 1 km in length near the northern fringe of the east

part of the Headland. The team studied its properties by means of core sampling, using a small boring machine.

The results are as given below.

True specific gravity	2.69 – 2.71
Unit weight	1.82 – 2.02 ton/m^3
Porosity	7 – 27%
Compression strength	60 – 120 kg/cm^2 (when dry)
	40 – 95 kg/cm^2 (when wet)
Modulus of statical elasticity	$1.5 \times 10^4 - 4.5 \times 10^4$ kg/cm^2
Velocity of primary wave (Vp)	1.6 – 2.2 km/sec

The Los Angeles abrasion test given to crushed samples shows the abrasion weight reduction of 10–22% after 100 revolutions and 40–70% after 500 revolutions.

These tests indicate that this shelly limestone is characterized by a large amount of voids, relatively low strength and a large tendency for abrasion. It must be used in large blocks (more than 1 ton per piece) to protect them from being moved or crushed by waves. Stone must be added periodically in order to maintain the revetment function, because abrasion is expected to take place continuously.

(Reference) In Japan, highly dense and strong granite and andesite with compressive strength over 1,000 kg/cm^2 and specific gravity over 2.60 are used for such purposes.

Fig. 7-4 An Idea for the Use of Suntsar Material

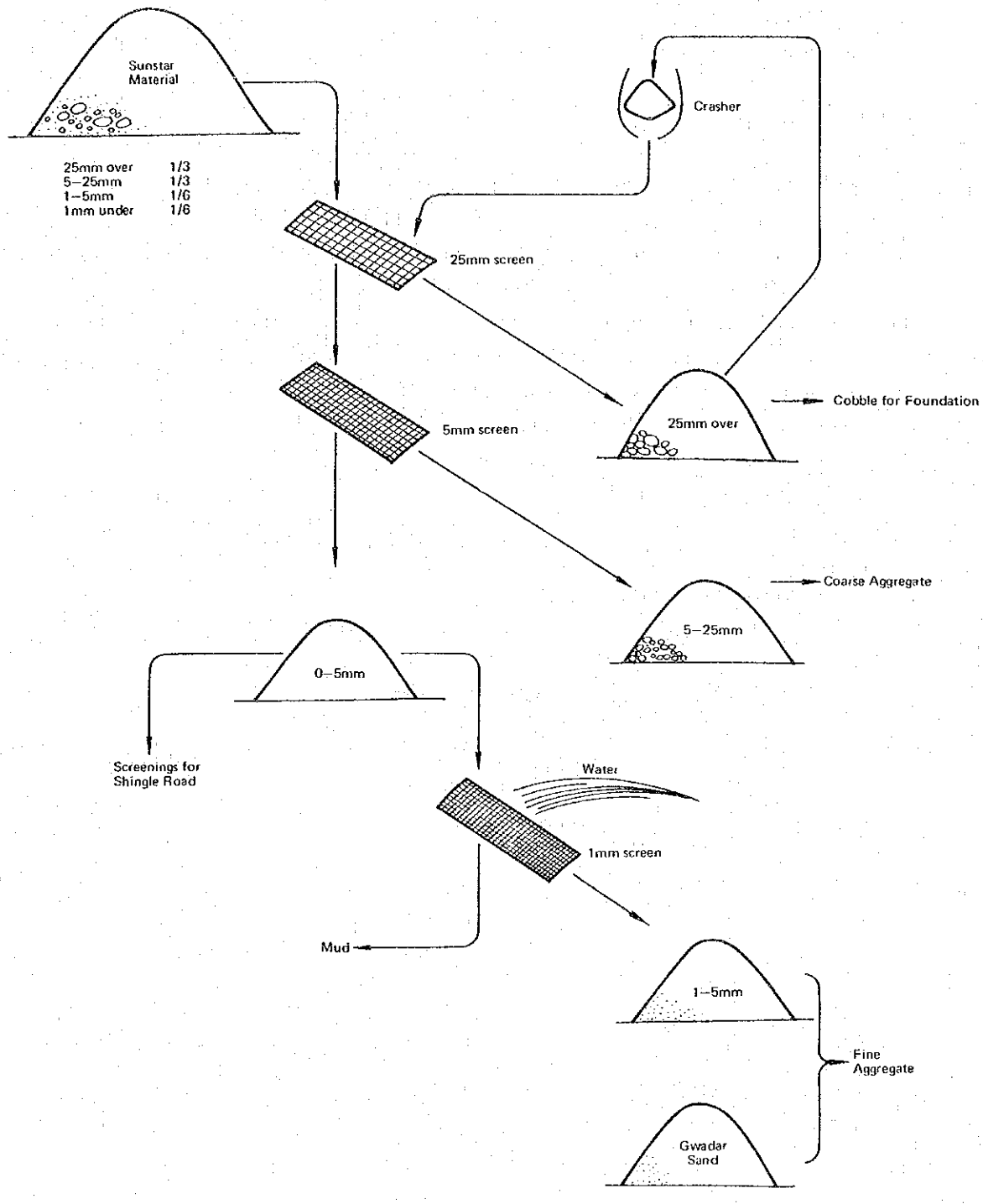


Fig. 7-5 Grain Size Curve (example)

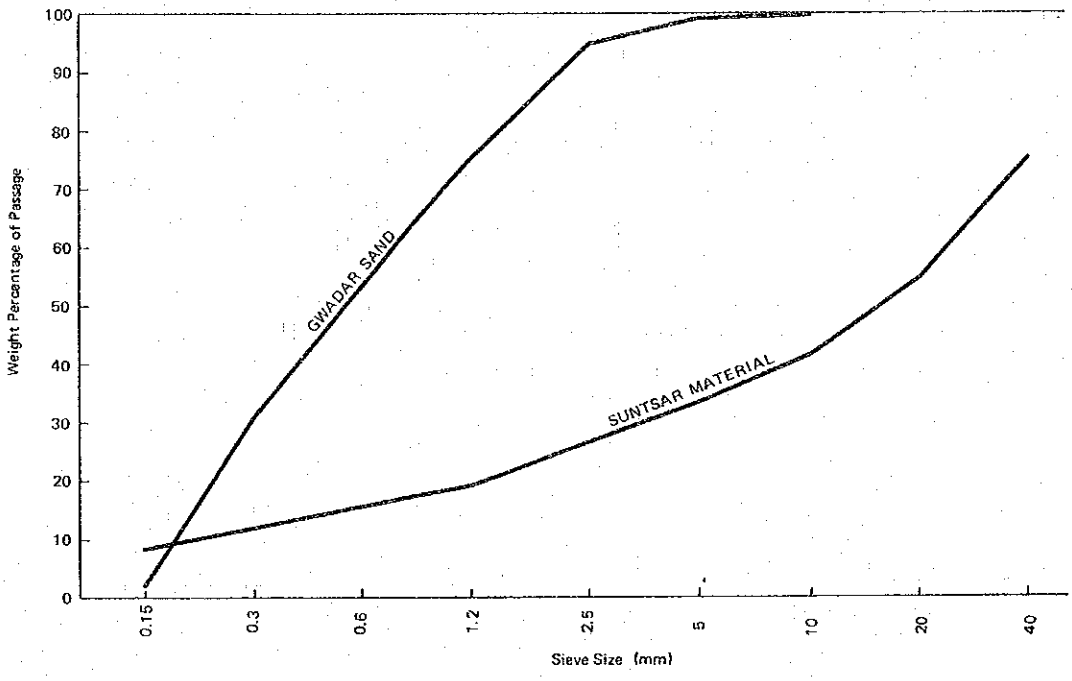


Table 7-9. Results of Mixing Test of Concrete

Mix No.	Used Gravel	Used Sand	Mix proportion (Upper; as mixed, Lower; specified mix)					Compression strength
			Cement kg / kg/m³	Water kg / kg/m³	Water cement ratio %	Coarse Aggregate kg / kg/m³	Fine Aggregate kg / kg/m³	(mean ± standard deviation) σ28 (kg/cm²)
1 C=360	Suntsar Tp1-3	Gwadar	7.45 / 345	4.28 / 198	57.5	25.3 / 1169	13.1 / 607	172 159 157 (163±8)
2 C=330	Suntsar TP1-3	Gwadar	6.83 / 315	4.10 / 189	60.0	26.0 / 1200	13.5 / 620	152 177 169 (166±12)
3 C=300	Suntsar TP4-5	Gwadar	6.20 / 288	4.03 / 187	65.0	26.8 / 1243	14.0 / 647	133 129 149 (137±10)
4 C=330	Suntsar TP4-5	Gwadar	6.83 / 321	4.10 / 193	60.0	26.0 / 1223	13.5 / 633	177 157 184 (173±14)
5 C=360	Suntsar TP4-5	Gwadar	7.45 / 344	4.28 / 198	57.5	25.3 / 1166	13.1 / 606	216 226 224 (222±5)
6 C=360	Suntsar TP4-5	Gwadar[1] Suntsar	7.45 / 350	3.91 / 184	52.5	25.3 / 1188	13.1 / 617	204 205 224 (211±11)
7 C=360	Suntsar TP4-5	Suntsar[2]	7.45 / 344	4.28 / 198	57.5	25.3 / 1165	13.1 / 606	127 117 124 (123±5)

1) Gwadar; 2.5mm under, Santsar; 1.0mm over, washed by water, each 1/2
2) Suntsar; 0.15mm–1.2mm 3/7, 1.2mm–5.0mm 4/7, not washed
3) Aimed unit weights of cement were 360 kg/m³ for mix Nos. 1, 5, 6 7, 330 kg/m³ for Nos. 2, 4 and 300 kg/m³ for No. 3
4) Specified mixes were calculated after testing the specific gravities of aggregates.

Chapter 8
Forecast for Fishery and Coastal Shipping in Gwadar

CHAPTER 8 Forecast for Fishery and Coastal Shipping in Gwadar

8-1 General

The future of the fishery and coastal shipping in Gwadar Mini-Port is forecast in this chapter through he analysis of the present situation and the socioeconomic condition of fishery in Gwadar.

8-2 Precondition for Forecast

The forecast has been made for a period of 30 years from 1976 to 2006. The first subject year, 1976, was selected because statistical and other information for the years 1976 and 1977 were completed to some extent.

The following three points were taken into consideration and realized in the forecast estimation:

(1) Records for the country and for Baluchistan Province in the last five years were compared with the targets of Five Year Plan. The information from these records were used for the limiting conditions of the forecast.

(2) Gwadar is a sole city that receives fresh water supply in the Baluchistan coast at present; it is supplied from an inland water source through a pipeline. However, the amount supplied from the water source is limited to 1,800 m^3 per day in the years from 1978 to 1979. In addition, some water is branched and supplied to Sur. Water supplies from groundwater and a desalination plant are available for the area but the former is not suited to the drinking because of its poor quality and the latter is not able to supply sufficient water for daily use since it serves as a test pilot plant. Though there is a future plan for increasing the water supply by expansion of the existing pipeline, the present water supply of 1,800 m^3/day imposed by the geographical conditions for this frontier district will be one of limiting conditions to increasing the population in the vicinity surrounding Gwadar. The minimum fresh water requirement in the desert areas in Arab and the Middle East is considered to be 5 imperial gallons (about 23 litres) per day. Therefore, judging from the present amount of water available, it is estimated that the population in the vicinity of this city in the early years of 21st century will be 80,000 at most, even though the other water is available.

(3) In Pakistan, records indicate that large-scale marine fishery is almost nonexistent, so that it is inevitable that the fishing grounds will be limited to a short or medium distance offshore for a considerable period of time. Fishing resources in the longshore fishing grounds of Baluchistan Province are estimated to be 400,000 tons maximum per year, according to the results of surveys conducted by a Soviet fishery survey vessel in 1966 and a Japanese fishery survey vessel in 1975.
Note:
Surveys were conducted by Soviet vessel R/V Akademik Knipovich and Japanese vessel Shoyo Maru. Annual available catches estimated in the Arabian Sea to the north of 15° N. Lat. by both vessels were 1.25 million tons per year. However, in view of operations by other neighboring

Table 8-1 Computed Forecast

- Population (Unit: in persons)

Year	Baluchistan Coast	Except Gwadar	Gwadar
1977	388,050	368,323	19,727
1978	409,240	388,511	20,729
1983	522,070	496,103	25,967
1990	742,190	706,203	35,987
1995	954,210	908,778	45,432
2000	1,226,010	1,169,452	57,358

- Fishermen (Unit: in persons)

1977	20,409 (17,636)	13,121 (11,139)	7,288 (6,297)
1978	20,994	13,496	7,498
1983	25,739	15,532	10,207
1990	30,669	17,165	13,504
1995	34,789	17,781	17,008
2000	39,445	18,032	21,413

Note: Numerals in the parentheses indicate those of reference data for 1977, and this applies also hereinafter.

- Vessel, Sailing & W/Motor (Unit: in boats)

1977	2,385 (2,349)	1,571 (1,544)	814 (796)
1978	2,441	1,608	833
1983	2,733	1,763	970
1990	3,201	2,021	1,180
1995	3,583	2,211	1,372
2000	4,011	2,414	1,597

- Vessel, W/Motor (Unit: in boats)

1977	372 (363)	210 (205)	162 (158)
1978	401	211	190*
1983	1,124	575	549
1990	1,605	805	800
1995	2,108	1,042	1,066
2000	2,809	1,429	1,380

Note: Numerals with * mark and after were calculated from the sailing decrease rates.

- Fish Catches (Unit: in M.T.)

1977	68,810 (68,848)	47,533 (47,980)	21,277 (20,868)
1978	72,200	46,982	25,218*
1983	141,540	78,782	62,758
1990	191,640	100,296	91,344
1995	242,510	120,867	121,643
2000	311,840	154,434	157,406

Note: Numerals with * mark and after were calculated from provincial increase rates, with motorization rates taken into account.
Numerals in parentheses are actual numbers.

countries, such as India, and of the southern limit of fishing ground near the Tropic of Cancer, it seems that 400,000 tons/year is an appropriate available catch estimation.

Comparison between the past records and the target plan

A comparison between the target of Five Year Plan and the records of the country and Baluchistan Province in the last 5 years based on the data outlined in Table 8-1 and Appended Table A 8-1 to A 8-9 is shown in Table 8-2.

By reviewing Table 8-2, two outstanding factors are apparent with respect to the development of coastal fishery of Baluchistan Province:

(1) In spite of a decrease in fishermen and the slow increase in the number of fishing crafts, the fish catch has been increasing, due to the rapid progress of fishing vessel motorization.

(2) However, there is a great difference in growth between the catches and the export amount of marine products, thus limiting the usable fish catch.

In consideration of the above factors, simulation for four cases has been conducted, as indicated in Table 8-3.

Table 8-2 Comparison between Past Record and Target

(Unit: In average annual %)

Item	Federal Result	Target	Provincial Result
GDP	4.1	7.0	4.1
GDP, agriculture[1)]	2.6	6.0	1.1
GDP, fishery[2)]	4.7	5.5*	6.3
Population	3.0	2.5	5.1
Labour force	2.5	2.9	6.5
Labour force, agriculture[1)]	3.0	2.5	6.5
Labour force, fishery[2)]	0.6	11.2	Δ6.0
Catches[2)]	9.1	6.8	12.8
Fishing crafts[2)]	4.5	8.5*	2.2
Total export amount	6.4	9.0	5.2
Export amount of marine products	12.2	13.3*	2.6

Note: For * marked figures, since concrete figures are not available from the data offered by Pakistan, simulation described later and its correlation necessary estimate figures are used.
Therefore, 1) means the primary industries in the simulation, and 2) is limited to marine fishery.

Table 8-3 Cases of Simulation

Condition	Case 1	Case 2	Case 3	Case 4
Limiting condition of maximum annual catches of 400,000 tons	Yes	No	No	No
Rate of vessel motorization (When Gradar Mini-Port is scheduled to be opened in 1983, compared with present)	20%	30%	40%	50%
Remarks	Appended Table A 8-2-(1) Simulation P8 – P14	Appended Table A 8-2-(2) Simulation P1 – P7	Appended Table A 8-2-(3) Simulation P8 – P14	Appended Table A 8-2-(4) Simulation P15 – P21

8-3 Forecast for Population and Production

The results of the simulation indicate that at least the following three common points exist concerning Baluchistan Province:

(1) Re-distribuiton and control of population in the coastal area will occur, but the effect of that in the increases in GPP and GDP is negligible.

(2) This growth can be expected on the basis of an annual mean growth rate of GDP of 4.64% from 1978 to 1983 and of 6.23% to the year 2000. Though this rate is lower than the 7.0% growth rate target of the Five Year Plan initiated in 1978, it seems that the progress and results of the Plan in the future will be governed by the economic trend of not only Pakistan itself, but also the world.

(3) Limiting the maximum catch to 400,000 tons/year or reducing the rate of motorization does little to change, the long-term fish catch predicted in several cases, as shown in Table 8-4.

Table 8-4 Forecast of Fish Catch

(Unit: thousand metric tons)

Year	Case 1		Case 2		Case 3		Case 4	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1983	371.1	141.5	395.7	166.1	420.2	190.6	444.8	215.2
1990	583.7	191.6	612.4	220.4	641.2	249.1	669.9	277.9
1995	820.1	242.5	852.3	274.7	884.5	306.9	916.7	339.1
2000	1,073.1	311.8	1,109.1	347.9	1,145.1	383.9	1,181.1	419.8
2006	1,344.0	430.4	1,385.3	471.7	1,394.3	480.7	1,394.3	480.7

Note: (1) shows the catch for the whole country, while (2) shows that of the Baluchistan Province.

A considerable increase in fish catch can be expected if motorization of fishing vessels on the Baluchistan coast increases about 20% or more from the present to 1983; their contribution to the increase in GDP is also significant.

The results of the calculations for Gwadar are shown in Table 8-1, and a comparison table based on the year 1977 is shown in Table 8-5.

Table 8-5 Future Index of Population and Fisheries

(Unit: in times)

Item		Balchistan Coast	Gwadar
Population	1977–83	1.35	1.32
	–90	1.91	1.82
	–2000	3.16	2.91
Fishermen	1977–83	1.26	1.40
	–90	1.50	1.85
	–2000	1.93	2.94
Fishing Crafts	1977–83	3.02	3.39
(with motor)	–90	4.31	4.94
	–2000	7.55	8.52
Catches	1977–83	2.06	2.95
	–90	2.79	4.29
	–2000	4.53	7.40

8-4 Forecast for Coastal Shipping

Most of the commodities and construction materials used in Gwadar are transported from Karachi. Among them, wheat, a controlled commodity, is transported by the National Shipping Corporation (NCS), a semi-governmental enterprise. Wheat is sold at a fixed price throughout the country, with its trasportation cost born by the government. Some other goods, suited to the sea transport but sent by truck presently, are expected to be transported by ship after the completion of the Mini-Port.

For forecasting the coastal shipping, 1983 is the target year for the basic commodity consumption as stated in the Five Year Plan. The plan uses the values shown below:

wheat: 125.96 kg/person/year

others: 233.02 kg/person/year

((Unit: kg) rice: 30.32, pulses: 9.44, sugar: 32.42, vegetable ghee: 7.91, milk: 66.06, meat: 9.38, vegetables: 38.70, tea: 1.00, fruit: 33.71, cloth: 4.08)

The regions supplied with goods brought to Gwadar include Gwadar City, Jiwani, and surrounding towns and villages. The population of this region was 46,994 according to the 1972 census, with 15,794 or 33.6% in the city area of Gwadar. If this propotion is maintained, the population of this region will be 61,700 and 64,700 in 1978 and 1979, respectively, and is

estimated to be 76,200 by 1983, using the predicted population growth in the city area of Gwadar.

(1) Wheat

The record of wheat transportation by NSC from Karachi to Gwadar and Pasni from January 1978 to January 1980 is shown in Table 8-6. According to this record, wheat transported to Gwadar totalled 3,300 tons for three voyages in 1978, and 4,099 tons for four voyages in 1979.

Wheat unloaded at Gwadar is delivered to inland towns such as Sur, Pishukan, Jiwani and Suntsar, as well as to the city area of Gwadar. From the coastal town of Pasni, wheat is transported by land to the towns of Ormara, Turbat, Tump, Mand, Buleda, Panjgur, and others. This distribution is much bigger than from Gwadar, with the unloaded quantity seven times greater. Accordingly, there are more sheds in Pasni than in Gwadar. By the data of wheat transportation and the population of the area, the wheat consumption per head in this region is compared with the national target in the Five Year Plan, with the result shown in Table 8-7. This indicates that the wheat consumption of this region is only 50% of the target consumption. Reasons for this low level are as follows:

1) The distance from Karachi
2) The difficulty in increasing the frequency of voyages because of the rough sea in the monsoon season and lack of berthing facilities
3) The difficulty in regular transportation service to neighbouring towns because of rough road

The cargo volume in 1983 is calculated with the assumption that the wheat consumption per head will not change until then:

76,200 persons x 126.0 kg/person x 1/2 = 4,800 tons

This requires five delivery voyages by NSC vessels. Here, it is considered that NSC will continue to ship wheat, using the same large vessels. Then, wheat will be unloaded from NSC vessel to small boats or lighters offshore, and landed at the quay.

(2) Other commodities

The cargo volume of other commodities are forecast on the assumption that half the amount recommended by the Five Year Plan for the forecast population will be transported by ship from Karachi to Gwadar.

76,200 persons x 233.02 kg/persons x 1/2 = 8,880 tons

Small coastal launches with a gross tonnage of 100 to 150 tons are considered to be most suitable for shipping these commodities since the water depth of the planned quay is 3.0 m. If the commodities are transported by boat with a maximum load of 200 tons (a gross tonnage of 150),the annual number of call will be:

8,800 tons ÷ 200 tons = 45.

Table 8-6 Cargo Volume Carried from Karachi (Jan. 1978 – Apr. 1979)

(Unit: in tons)

Name of Vessel	Sailing Date from Karachi	Cargo Loaded for Gwadar	Cargo Loaded for Pasni
Ziarat	Jan. 1, 1978	–	1,100
Ravi	Jan. 14, 1978	–	7,000
Ziarat	Feb. 11, 1978	1,100	–
Bhairab	Feb. 20, 1978	–	5,000
Ziarat	Mar. 11, 1978	1,100	–
Ziarat	Mar. 27, 1978	1,100	–
Karotua	Apr. 29, 1978	–	7,526
Lalazar	Oct. 31, 1978	–	4,775
Bhairab	Dec. 7, 1978	–	4,508
Ziarat	Jan. 24, 1979	1,000	–
Panjnad	Feb. 1, 1979	–	5,778
Ziarat	Feb. 6, 1979	1,000	–
Ziarat	Mar. 4, 1979	1,099	–
Al-murtaza	Mar. 15, 1979	–	9,549
Panjnad	Apr. 19, 1979	1,000	4,876
Shamas	Jan. 11, 1980	–	4,200
Safina-E-Arab	Jan. 19, 1980	1,000	3,420
Rostom	Jan. 30, 1980	–	1,000
Total		8,399	58,732
Average Cargo per Voyage		1,050	4,894

Source: National Shipping Corporation, Pakistan

Table 8-7 Wheat Consumption per Capita around Gwadar and Jiwani

Year	Population (persons)	Cargo Vol. (ton)	Per Capita (A) (kg)	Mean (B) (kg)	B/A
1978	61,700	3,300	53.5	116.3	2.2
1979	64,700	4,099	63.4	118.2	1.9
Mean					2.0

Source: National Shipping Corporation

8-5 Setting of Target for the Improvement Programme

8-5-1 Target Year for Programme

In respect to a request of the Pakistani Government, the target year of 1983 is set, the same as the target year of the Five Year Plan.

8-5-2 Forecast Fish Handling and Fishing Fleet

Target Year	Forecast Fish Handling	Number of Fishing Crafts	Number of Fishermen (persons)
1983	60,500 tons/year *-1	549 powered ships 421 sail boats Total 970	10,207

Notes:

Forecast fish catch (1983): 62,758 tons

Subsistence catch: 218*-2 kg x 10,207 persons = 2,225 tons

Planned amount of handling of catch: 62,758 − 2,225 = 60,533 ≒ 60,500 tons

*-1 Target of fish catch by the government of Pakstan for 1983 is 50,000 tons.

*-2 Mean fishermen consumption (subsistence catch) per person in Baluchistan coast in 1976, 1977 and 1978. (Refer to Appended Table A8-10.)

Chapter 9
Development Programme

Chapter 9 Development Programme

9-1 General

The following development programme has been formulated for the natural and socioeconomic conditions of Gwadar elucidated in the previous chapter.

(1) Gwadar will be developed as a central point for coastal fishing operations along the Baluchistan coast.

(2) At the same time, the establishment of a berthing facility for the transportation of living commodities from Karachi will be included in the programme.

(3) Gwadar will be prepared as the strategic point for regional development, with fishery as its key industry.

(4) For the initial phase of development, emphasis will be placed on the facilities related to fishery.

9-2 Selection for Optimum Site

The city of Gwadar is situated on a sand spit, with bays located on both the east and west sides of the spit. To the south is the Headland, over 100 m in height, which serves as an excellent shelter from wave action for the bays, during the southwest monsoon season. In selecting an optimum site, the characteristics of both bays were compared, as shown in Table 9-1.

The comparison of the bays is naturally subjective. A study of the various natural conditions revealed that the conditions of the East Bay are often superior to that of the West Bay; there is a smaller degree of wave influence in the southwest monsoon season, and the littoral drift appears to be less. In addition, the East Bay is more convenient for exporting the fish catch of Gwadar, the current fishing grounds are closer to the proposed port, and the center of the existing community is somewhat closer to the East Bay. For these reasons, the East Bay was selected for the location of the port facilities. The south side of the Bay was selected for the site, because it is less affected by waves during the southwest monsoon season.

As shown in Fig. 9-1 and Table 9-2, five alternative port plans centering around the south side are compared.

Plan-1 has slightly greater quantity of spoil, compared with the other alternatives, and maintenance dredging will be required in the future, but the site is close to the existing community and all facilities for the fishing port are concentrated at one location. Despite the need for a small grab dredger and a dump barge for maintenance dredging in the project, the construction and operation costs are apparently the lowest. For these reason, Plan-1 was adopted.

9-3 Layout for Port Facilities

9-3-1 Outline of Meteorology and Marine Conditions

The layout plan for port facilities, particularly the groin and channel, is prepared by considering the meteorology and the marine conditions near the tip of the groin. Details of the natural conditions are described in Chapter 6 and 7.

Table 9-1 Comparison between East and West Bays

	East Bay	West Bay	Remarks
1. Natural Conditions			
Winds NE Monsoon	X	O	
SW Monsoon	Δ	Δ	
Waves NE Monsoon	X	O	
SW Monsoon	Δ	X	
Current	Δ	–	No data in west day
Sea Bottom Materials	Silt Δ	Fine sand Δ	
Littoral Drift	Δ	X	
Wind-blown Sand	X	Δ	
Water Quality	X	O	The water of the East Bay is foul, because this Bay is mainly put to use.
Soil Conditions	Δ	–	No data in west bay
Erosion	X	O	
Siltation (access channel and basin)	X	Δ	
Slope of Profile of Shore	Sharp	Gentle	
2. Social Conditions			
Distance to Destinations (Karachi, Sri Lanka)	O	X	
Fishing Ground	O	X	
Existing Communities	Near	Far	
Hinter land	Wide	Narrow	
Reclamability	Δ	Δ	
3. Comparison between North and South Parts of the Bay	North part	South part	
Waves	O	X	
Water Depth	Shallow for some distance	Not shallow	
Shelter of Wave	O	X	

Notes: Legend
- O Good
- Δ Normal
- X Bad

Fig. 9-1 General Plan of Alternatives

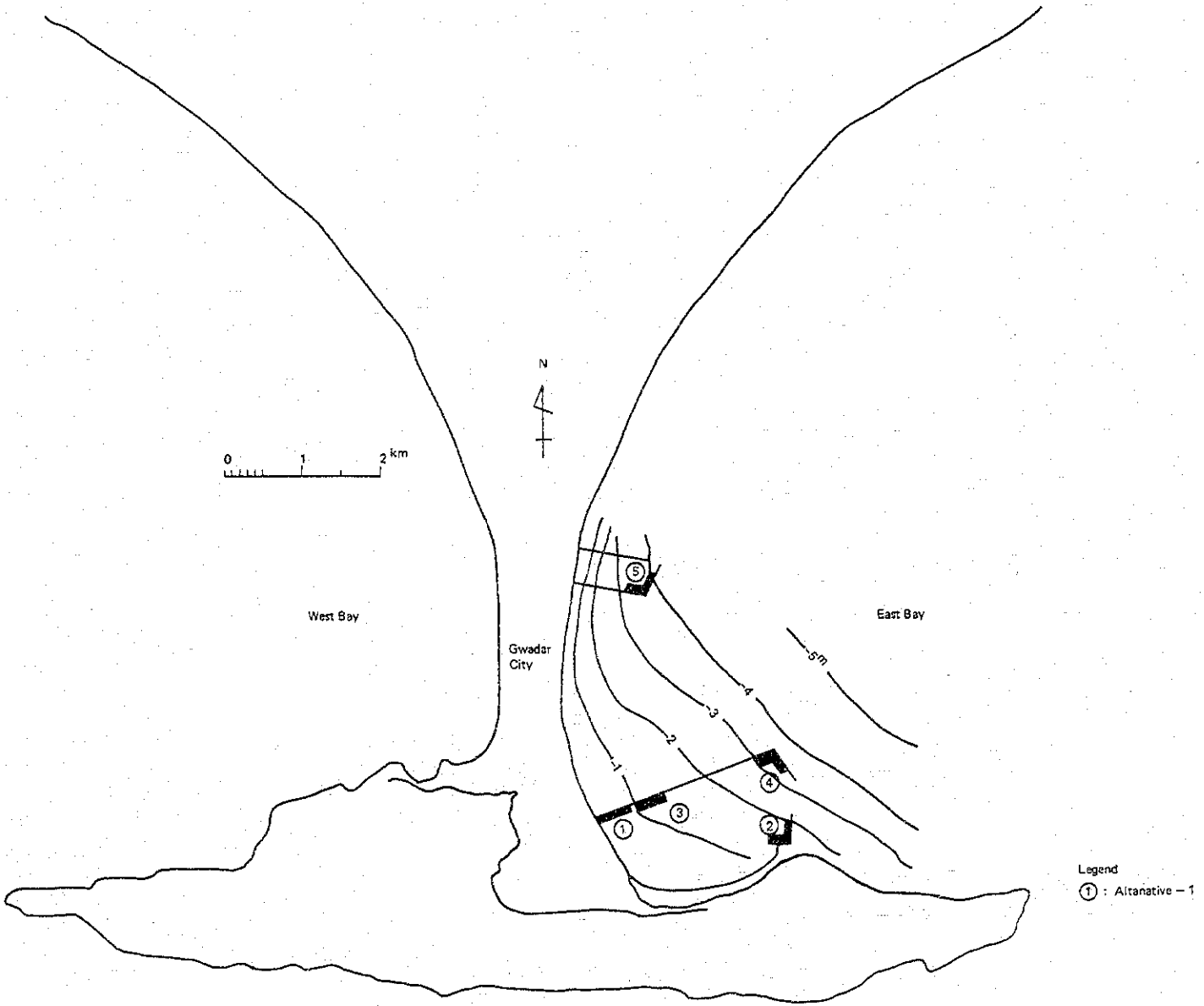


Table 9-2 Comparison of Alternative Plans

Item of Study	Plan - 1	Plan - 2	Plan - 3	Plan - 4	Plan - 5	Remarks
Spoil Quantity of Access Channel and Basin	357,000 m^3	105,000 m^3	254,000 m^3	--	--	
Length of Revetment and Groin	1,450 m	970 m	950 m	570 m	1,420 m	
Length of Breakwater	--	--	--	150 m	150 m	
Length of Quay and Transitional part of Revetment	520 m	620 m	550 m	570 m	570 m	
Land Reclamation	103,000 m^3	169,600 m^3	151,000 m^3	252,000 m^3	252,000 m^3	
Causeway	--	1,850 m	550 m	2,130 m	600 m	
Construction Cost	No. 5	No. 2	No. 4	No. 1	No. 3	No.1>No.2 ...>No.5
Merits	1. Close to the existing community 2. Convenient for fishing ports management	1. Little spoil	1. Spoil smaller in quantity than under Plan-1	1. Dredging, maintenance dredging unrequired	1. Dredging, maintenance dredging unrequired	
Demerits	1. Dredging of shallow water area required 2. Maintenance dredging required	1. Dredging required 2. Maintenance dredging required 3. Long causeway required 4. Far from the existing community	1. Dredging required 2. Maintenance dredging required 3. Relatively long causeway required	1. Breakwater required 2. Long causeway required	1. Breakwater required 2. Far from the existing community	

(1) Current

The direction of the predominant current during spring tide is 260° at flood tide and 80° at ebb tide (measured clockwise from the north), and is almost parallel to the channel and the groin. The maximum current velocity of the bottom layer (1 metre above sea bottom) is about 0.5 kt.

The permanent bottom layer current is mainly governed by the ocean flows. This maximum ocean current is 0.03 m/sec, and is so slow that it may be neglected in comparison with tidal current.

(2) Waves

1) Yearly maximum waves

Siltation will be most severe when the highest waves occur (wave height: 1.5 m, period: 12 sec), and wave direction is about 80° to 90°. As the direction is nearly parallel to the groin and channel, the siltation is worst near the offshore end of the channel.

2) Wave during southwest monsoon

Waves in the SW monsoon occur very frequently with a wave height of 0.5 to 1.0 m, and period of 8 to 12 sec. These enter diagonally from the south, with an angle of 20 to 30° to the center line of groin and channel. There is a possibility of siltation due to sediment supplied from sea bottom or from the channel sides.

3) Wave during northeast monsoon

Waves from 0.3 to 0.8 m in height and 6 to 8 seconds in period will enter from slightly north of the groin and channel, with some wave sheltering effect by the groin expected.

4) Wave breaking

The current within the surf zone varies, depending upon the time and place. This complexity is caused by circulations that flow clockwise and counterclockwise alternately along the coast. This means that the groin must be built in the surf zone and offshore up to a depth of 2 metres.

(3) Bottom materials

An increase in resistance to the current by the cohesion of silty sand or sandy silt is not expected. In the southern part of the East Bay, the bottom materials are almost uniform throughout this area.

(4) Wind

The probability of occurrence of a west wind is 1/4, and an east wind somewhat less. Thus, prevailing winds blow in an east-west direction.

9-3-2 Layout Plan of Facilities

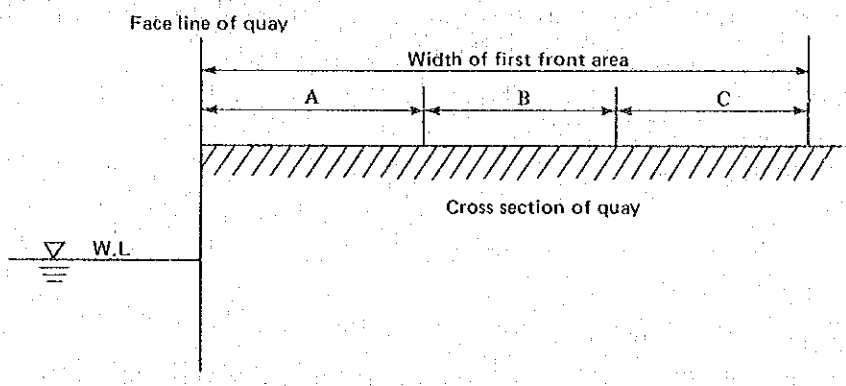
(1) Quay

Because of the Headland exceeding 100 m in elevation at the south side of Gwadar, the direction of the steady wind near the project site is west to east. In order that fishing crafts and other vessels do not collide with the pier, the face line of the quay is laid out in such a manner that it projects out from the land to the sea in a direction almost equal to the steady wind.

The seashore should be left natural to prevent the wave reflection and thereby to keep the basin calm.

It is generally said that the size of area shown in Fig. 9-2 is required as the first line area for the quay.

Fig. 9-2 Width of First Line Area



Utilization of Quay	Apron (A)	Area for Related Facilities (B)	Road (C)	Total
	m	m	m	m
Quay for landing	3 - 10	25 - 40	12 - 25	40 - 70
Quay for preparation for fishing operation	6 - 10	15 - 20	12 - 20	30 - 50
Quay for rest	6 - 10	0 - 20	12 - 20	20 - 50

To provide an area sufficiently large for the functions required for a fishing port, a quay width of 70 m was chosen, the largest of the said widths. Berths for fishing boats, coastal shipping and small oil tankers are planned.

(2) Groin and Revetment

The East Bay has a counterclockwise current and littoral drift with the same predominant direction, so that the face line of the revetment and groin are planned in east to west direction. For providing a balance between the dredging volume of future maintenance dredging and a decrease in construction cost, the present plan has the tip of the groin extending up to a water depth of 2 metres. Also, for preventing rough water in front of the quaywall due to the influence of waves along the groin, a spur embankment extending perpendicularly from the groin is planned for diminishing waves that may occur at that point.

(3) Breakwater (in the future)

A breakwater is not included in this plan since the influence of the invading waves to the fishing port facilities seems to be negligible. This is because the proposed port site is located in a protected region of the bay, and since a breakwater plan may interfere with the long range

improvement of Gwadar. For these reasons, the breakwater will be studied or reconsidered depending upon the conditions after opening the port.

(4) Access channel and basin

Due to littoral drift, even with the port protected by a groin, it will be necessary that dredging work shall maintain the channel and basin. Therefore, one important consideration for this project is the problem of siltation. Plans have been formulated with the width of the access channel set at 35 m and the basin at 200 m, but there will be need for careful maintenance dredging. For this reason, a simplified small grab dredger and dump barge have been incorporated in the project for the future maintenance dredging.

(5) Facilities related to fishery

To provide the port with the general functions of a fishing port, minimum required facilities have been assigned. These include land for a market, a refrigeration and freezing plant, land for offices and parking, and others. Only certain facilities will be located on the wharf (see Fig. 9-9).

(6) Fuel supply facility

At present, there is a trend towards motorization of the fishing boats, thus an increased need for kerosene. Also, if regional development further progresses around the fishing port, it seems that land transportation of oil, mainly by lorries from Karachi, will become less practical than it is now. Thus, a small oil tanker berth, oil tanks and oil supplying equipment are all included in this plan. For fire prevention and safety, this equipment is located at the end of the pier.

(7) Facility for coastal shipping

Berthing facility is planned for living commodities from Karachi. This berth will be adjacent to the fishing craft berth. Though the presently operating large NSC ships are not able to berth at this facility because of a 3 m water depth, large lighters and small cargo boats will be able to use this facility.

9-3-3 Review on Location of Construction

The proposed location of groin is based on the following evaluation standards using the results of investigation:

(1) Waves

The degree of influence of wave height is calculated from the data of wave height and probability of occurrence of waves on the basis of a 5-step evaluation using the following formula:

(Degree of influence of wave height) =
(Significant wave height) x (Probabily of occurrence)

For wave direction, a 5-step evaluation is made using the incident angles of wave attack to the face line of the planned groin. That is, a wave coming parallel to the channel is considered best and wave coming with angle of 90° to the channel is considered worst.

In making an overall review on waves, the wave height influence times the wave direction are computed and illustrated in Fig. 9-3.

(2) Currents

Currents are generally separated into tidal currents and other currents (hereinafter called residual current), and only the tidal current is evaluated here. The extremely variable direction and velocity of the residual currents, due to its influence from wind and offshore currents (ocean current and others), makes proper evaluation based on a short period of observation impossible.

In evaluating the tidal current, the current direction, and velocity will be considered. The current direction is equal to the major axis of the ellipse of the mean current during spring tide. The velocity and current direction are evaluated in five steps between minimum and maximum values. The direction is best if it is parallel to the face line of the proposed groin and worst if it is perpendicular. Overall evaluation for tidal current is made by calculating the "current velocity score times current direction score," with the results shown in Fig. 9-4.

(3) Bed materials

The median grain size is classified as silt, as it is between 0.05 mm to 0.07 mm in size. With the median grain size not of significance, the most important consideration is that of sea bed drift. A survey of the skewness of the sea bed material in October, 1978 was compared with a recent survey, to establish the change in skewness and the areas of potential change. A 5-step evaluation was made for each survey point, the result of which shown in Fig. 9-5.

It has been suggested that seasonal variations in the grain size skewness, as is the case there, is indicative of a potential for change in the sea bed depth, with the placement of an artificial barrier.

In addition, the drift of silts can result in a change in the depth of the bay, an important consideration for both seasonal variations and long term trends.

(4) Overall evaluation

Each influence value for the wave, the current, and the bottom materials of each survey point is given a weighted balance, that is, 3 for wave, 1 for tidal current, and 1 for bottom materials. The result are summed to make an overall score for each survey point. The results are classified into five steps, with the overall evaluation compiled in Fig. 9-6.

9-3-4 Plans for Mooring Facilities

(1) Conditions for Planning

- The quays for landing by large gill netters and for fishing operations are set at −3 m, as requested by the Pakistani Government.
- The landing facility for small fishing crafts is set at −1.5 m.
- The gill netters that have finished their operations, or are preparing for their fishing, will anchor in the basin.
- The small fishing boats which have completed their operations will make use of the natural seashore.
- On the days when no fishing operations are carried out, the gill netters will be moored in double file at the mooring facilities of the port. Small fishing boats will make use of the seashore.

Fig. 9-3 Assessment of Wave Conditions

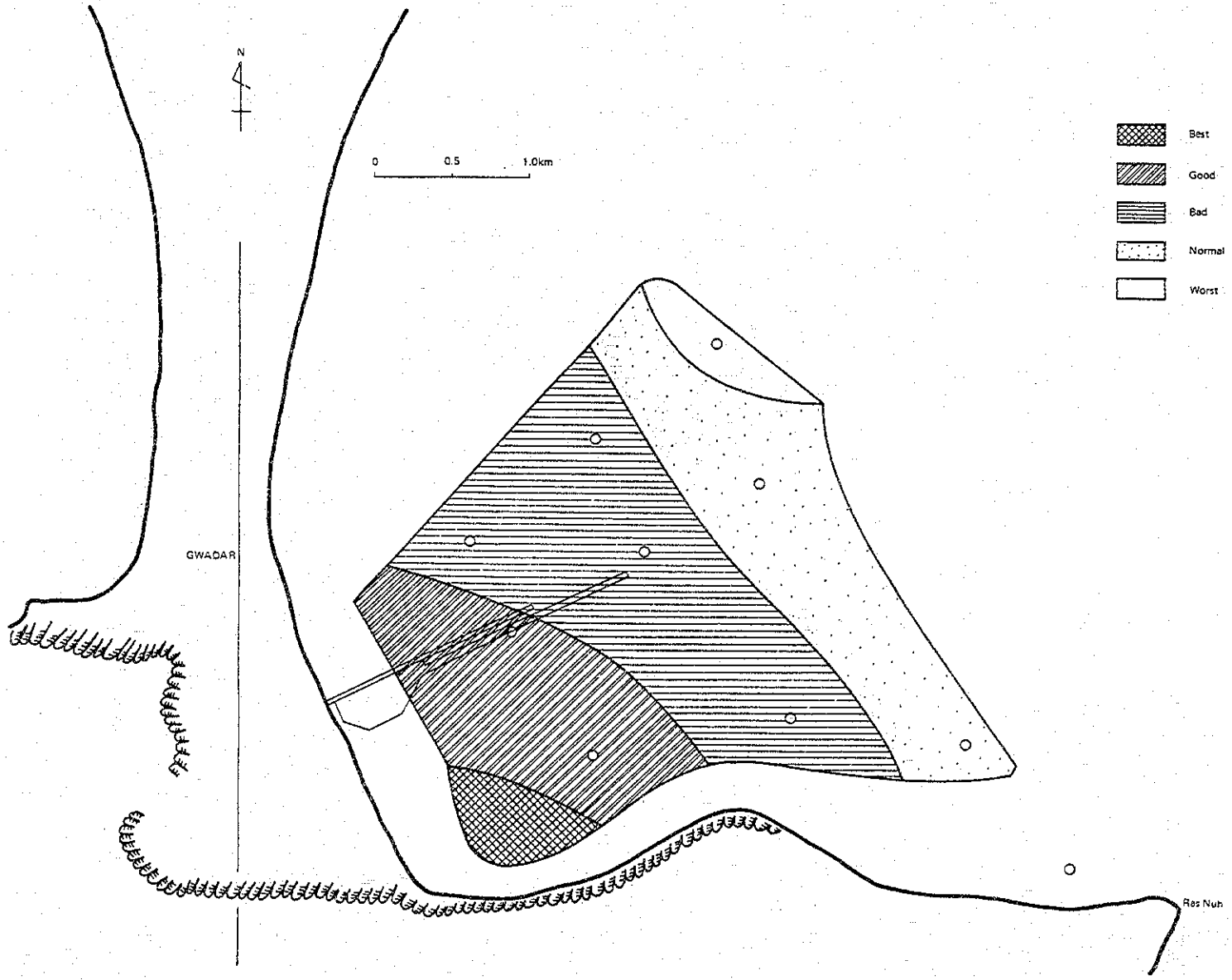


Fig. 9-4 Assessment of Current Conditions

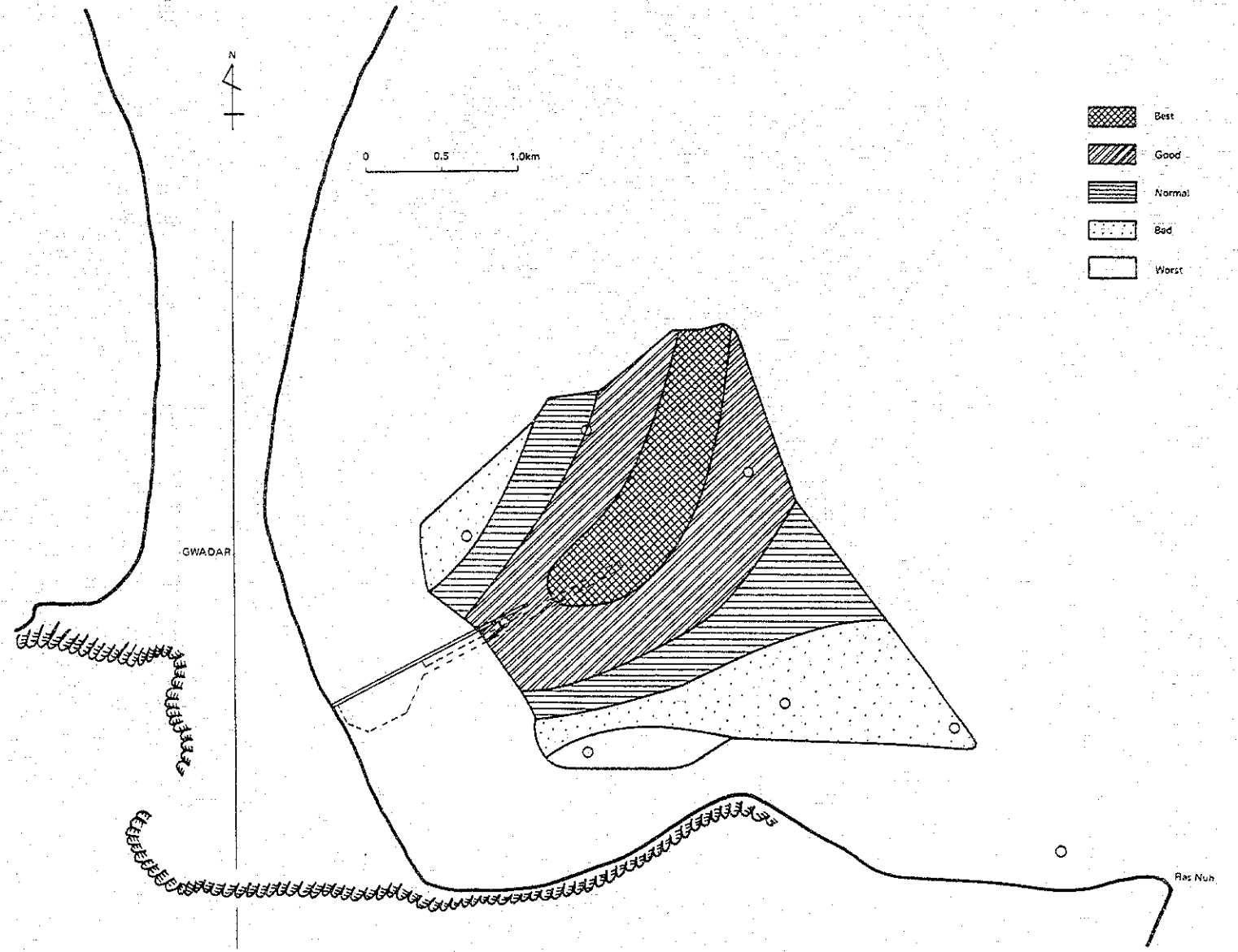


Fig. 9-5 Assessment of Bed Material

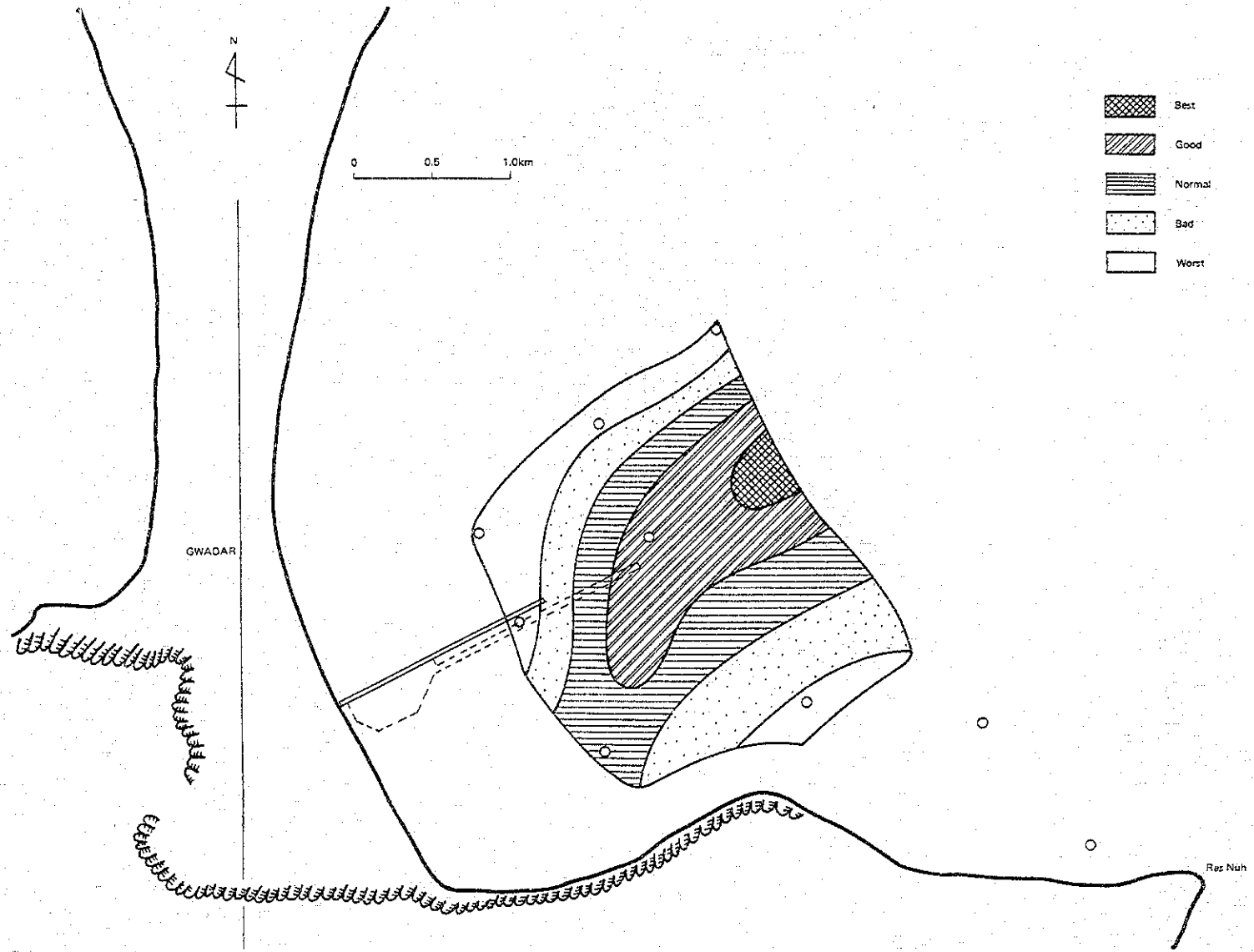
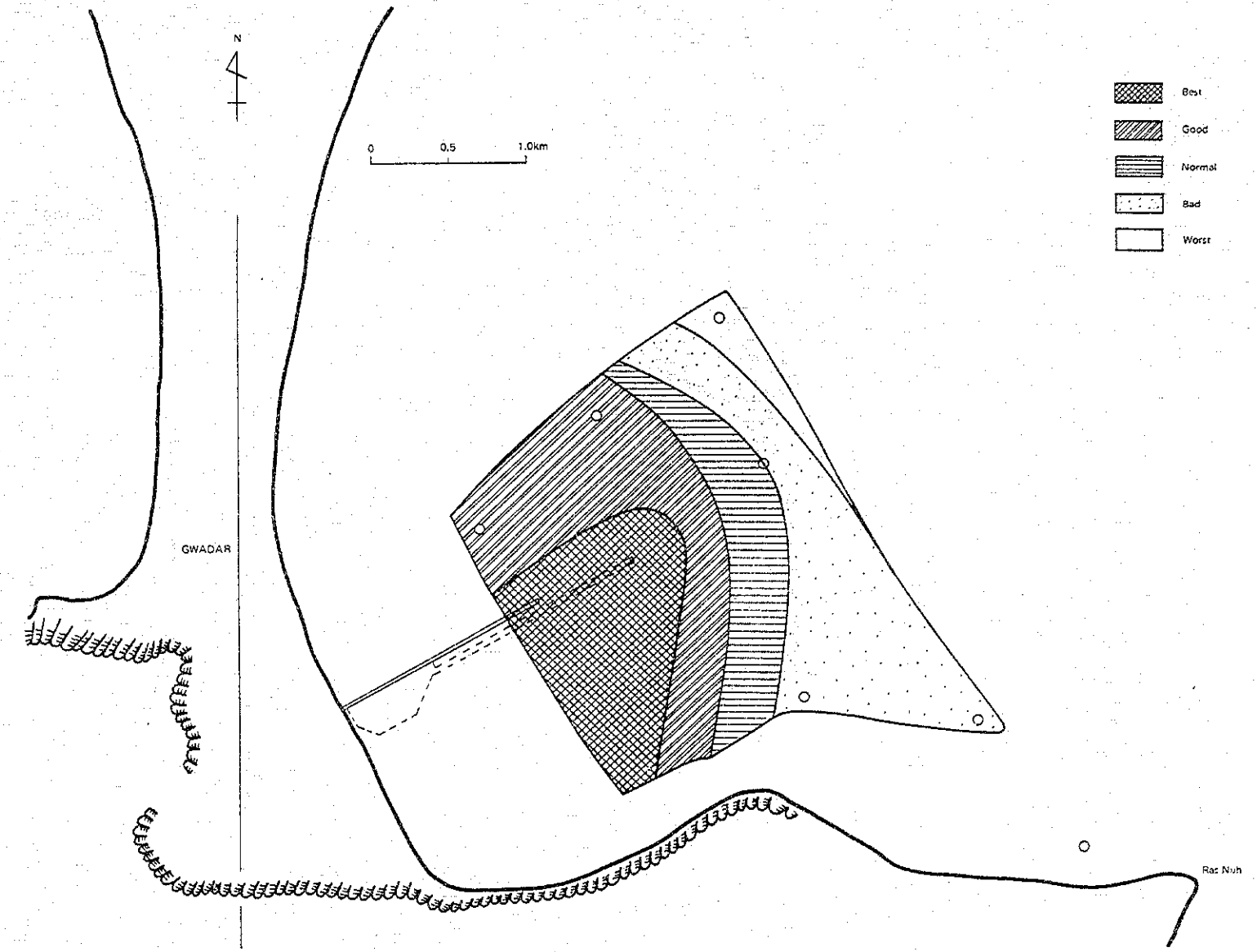


Fig. 9-6 Assessment of Total Sea Conditions



- Small coastal launches will load and unload at the –3 m quay, and will use the basin for anchoring.

9-3-5 Required Length of Mooring Facilities

The required length of the mooring facility is computed as shown in Table 9-3. A total of 230 m of berthing facility has been planned for large gill netters, including 140 m for landing operations, and 90 m of the quay for preparations. Another 70 m has been planned for small coastal launches. The remaining 100 m has been planned for small fishing crafts, with 60 m for the landing quay, and 40 m of the quay for preparations for fishing operations. Also, 30 m of the berthing facility with a water depth of 3 m has been planned for a small oil tanker at the end of the pier.

The types of ships envisioned for the design are given below:

(1) Length of berth

1) Fishing craft

- Gill netters

Water depth for design:	1.5 m to 3.0 m
G/T of using craft:	3 to 26 G/T
Average G/T of using craft:	14 G/T
Size of craft:	20.4 m in length, 4.5 m in breadth, 2.0 m in draft

The length of one berth will be 20.4 x 1.1 = 22.2 m for alongside berthing.

- Small fishing craft

Water depth for the design:	less than 1.5 m
G/T of using craft:	3 G/T and less
Average G/T of using craft:	2 G/T
Size of craft:	9.9 m in length, 2.3 m in breadth, 0.8 m in draft

The length of one berth will be 2.3 + 0.9 = 3.2 m for use with ships lined up in double file.

2) Small coastal launch

Water depth for design:		3.0 m
G/T of using launch:		100 to 200 G/T
Size of launch:	100 G/T:	21.0 m in length, 6.3 m in breadth, 2.6 m in draft
	200 G/T:	29.0 m in length. 7.4 m in breadth, 3.0 m in draft
Length of one berth:	100 G/T:	30 m
	200 G/T:	35 m

In this plan, 35 metres for one berth for 150 G/T launch has been adopted, taking into consideration future deepening plans.

The required number of berths is computed as follows:

Table 9-3 Required Lengths for Landing Facilities

Landing Quay

Type of Fishing Crafts	Planned Number of Fishing Crafts (ships)	Days of Trip (days)	Number of Standard Fishing Crafts (ships)	Morning Shift* (ships)	Hours used Quay per Ship a Day (hours)	Hours of Half-a-Day Opening of Fish Market (hours)	Number of Rotations	Average Berth Length (m)	Number of Berths Required	Length of Berth (m)
Gill Netters (Large)	549	15	36	36×2/3=24	1	4	4	22.2	6	140
Small Fishing Crafts	421	2	210	210×2/3=140	0.5	4	8	3.2	18	60

Note: * Ratio of morning to evening shift at 2:1.

Quay for Preparations for Fishing Operations

Type of Fishing Crafts	Number of Standard Fishing Crafts (ships)	Hours Quay Used (hours)	Hours Quay Used per Ship (hours)	Number of Rotations	Average Berth Length (m)	Number of Berths Required	Length of Berth (m)	Remarks
Gill Netters (Large)	24	6	1	6	22.2	4	90	
Small Fishing Crafts	140	6	0.5	12	3.2	12	40	

We assume that 150 days per year, due to the monsoon season, is available for navigation.

Required days per round trip:	6 days (4 days for travel + 2 days for unloading)
Number of calls:	45 calls per year
Required number of launches:	$\frac{45 \times 6}{150} \fallingdotseq 2$

Assuming that every three days operation from Karachi to Gwadar is available, the required number of berth might be only one berth. However, cargo will be shifted from NSC vessel to large lighters or small launchs offshore of Gwadar. Therefore, the required number of berths is two in this plan.

3) Small oil tanker

Water depth for design:	3.0 m
DWT of using tanker:	200 DWT
Size of tanker:	27.7 m in length, 6.4 m in breadth, 2.3 m in draft

The length of one berth will be 30 m.

The required number of berths is computed as follows:

Planned fishing days:	300 days per year
Fuel required at Gwadar per day:	100 kl
Fuel required at Gwadar per year:	30,000 kl
Required days per round trip:	5 days (4 days for travel + one day for unloading)
Annual navigation days:	150 days
Number of calls:	150 days ÷ 5 days = 30 calls
Required number of berths:	$\frac{30,000}{3 \times 200} = 5$

Assuming that daily operation from Karachi to Gwadar is available except in the monsoon season, the required number of berth will be only one berth on the plan. As oil capacity of tanks is 400 kl (for four days), when there is a temporary shortage of oil, land transportation by lorry should be vailable. In addition, during periods when the oil tankers cannot operate, fishing activities will also be curtailed, and oil use will drop.

9-3-6 Plans for Groin and Revetment

The plans for the groin and revetment are formulated with the following considerations:

(1) In the East Bay, the counterclockwise current is predominant, so it is conceivable that the direction of littoral drift is also the same.

(2) The port entrance will be to the east, the direction of vessel traffic. It is expected that there will be in the periphery of the port entrance some wave surges from the east, but it may be assumed that the effects of the surges will be reduced as they approach the site planned for the quay. If the periphery of the port entrance is enclosed by a breakwater, the seawater in the

area hemmed in by the breakwater will become stagnant, and the littoral drift across the port may shoal the access channel and the basin.

Therefore, the breakwater in the periphery of the port entrance will be planned after completion of the project, after consideration of the degree of the wave surge.

(3) The groin will be extended to a water depth of 2 m. The total length of the revetment and groin has been set at 1,530 m.

A set of navigation aids will be installed at the tip of the groin.

9-3-7 Access Channel and Basin

(1) Ships for the design

Large gill netters: 22.0 m in length, 4.8 m in breadth, 2.4 m in draft, and 26 in G/T.

(2) Width of access channel

1.5 times the length of the ship (L) for the design.

1.5L = 1.5 x 22.0 m = 33.0 m. The channel width is set at 35 m for this plan.

(3) Width of basin

The width of the basin has been so arranged that there will be an enough area for the passage and mooring of fishing crafts behind ships moored in double file.

1) Double file = (average ship length + clearance) + average ship length + water area occupied) = 2L + clearance + water area occupied = 2 x 22.0 m + 22.0 m x 0.2 + 22.0 m x 1.7≒ 86 m

2) Passage: 1L = 1 x 22.0 m = 22.0 m

3) Water area for ship maneuvering: 2L = 2 x 22.0 m = 44.0 m

4) Swing mooring: 2 x (L + 0.9 m) = 46.0 m

5) Total: 1) + 2) + 3) + 4) = 198 m ≒ 200 m

(4) Navigation aids

Buoy lights will be installed at the entrance to the access channel and at the corners of the basin.

9-3-8 Other facilities

(1) Small dredger

A small grab type dredger and a dumping barge will be built for future maintenance dredging.

(2) Road

The trunk road in the port area will have four lanes with a total width of 15 m, and will be provided with drainage. The road perpendicular to the trunk road, and the apron in front of the quay will be 10 m in width.

(3) Parking area

A parking area with a width of 10 m will be constructed behind the revetment.

9-4 Plan for Fishery Related Facilities

9-4-1 Conditions for planning

(1) A cold storage facility will be located close to the preparation quay to facilitate fishing operations.

(2) The water supply facilities will be designed so that water will be provided by a new pipeline connected from proposed site to a water supply tank of the city water service.

(3) For refueling, two oil tanks and a set of refueling facilities to supply oil for fishing craft will be provided.

(4) A fence will be set up along the boundary of the site of the fishing port, for convenience of administration of the fishing port. A gate and a guardhouse will be set at he boundary of the site.

(5) The sites for various fishery related facilites will be secured by developing leveled ground.

(6) A small coastal refrigeration ship will be built to transport frozen goods to Karachi.

9-4-2 Capacity of fishery related facilities

Standard Handling per Day	
Large gill netters:	36 ships x 6 tons per ship per day ≒ 215 tons per day
Small fishing boats:	210 ships x 1/6 ton per boat per day = 35 tons per day
Total:	250 tons per day

Judging from the records of 1976, 1977 and 1978, fluctuations in the fish catch are significant varying with the month as shown in Fig. 9-7 and Appended Table A 9-1. A check of the total of two consecutive months to eliminate extraordinary peaks in fishing productivity, the season of the greatest fish catch was from August to December in 1977.

The ratio between the average monthly catch for these peak five months and the average annual catch has been computed for analyzing the average daily and monthly catch. On the assumption that this ratio may also be used in the project target year of 1983, the average monthly catch and the average daily standard handling have been computed as follows:

Average monthly catch in peak five months of 1977:	7,358 tons
Annual catch in 1977:	64,348 tons
Coefficient of concentration in the peak months:	1/8.7
Annual catch in the target year:	60,500 tons
Standard handling per month in the target year:	60,500 ÷ 8.7 = 6,950 tons
Standard handling per day in the target year:	6,950 ÷ 25 days = 278 tons

There will be months in the busy fishing season when the facilities may not be able to deal with the fish catch, but the standard handling per day has been set at 250 tons as a balance between the productive and slack fishing seasons.

(1) Fish market

Handling capacity of fish per square meter of fish market: 100 kg/m^2

Size of market required: 250 tons ÷ 100 kg/m^2 = 2,500 m^2
One steel-framed fish market building measuring 20 m x 125 m is planned.

(2) Temporary Shed (for storage of containers used for the transport of fish): One building with a floor space of 2,000 m^2 will be constructed.

(3) Cold storage and freezing facilities

a) Ice making facility

The supply of ice per day will be the same as a quarter of the daily tonnage of fish caught by the large gill netters (see Appended Table A 9-2).

Ice making capacity: 215 tons x 1/4 = 50 tons

b) Ice storage facility

The capacity of ice storage per day shall be twice the daily ice making capacity.

Ice storage capacity: 100 tons at −5°C

c) Cold storage facility

It is assumed that the required cold storage volume will be a quarter of the tonnage of fish catch per day, with a storage capacity of four days.

250 tons x 1/4 x 4 days = 250 tons at −5°C (see Appended Table A 9-2).

d) Freezing facility

Daily capacity of freezing Shrimps and lobsters

The proportion of shrimps to the total fish catch of Gwadar in 1977 and 1978: 1,270 tons ÷ 33,960 tons = 0.037 or 3.7%.

The share of shrimps and lobsters in the standard handling of 250 tons per day:
250 tons x 0.037 = 9.25 tons

The quantity of shrimps to be frozen is assumed to be a quarter of the daily catch or 2.5 tons/day. The storage capacity of the freezer shall be sufficient for 20 days catch.

The freezing quantity: 2.5 tons x 20 days = 50 tons at −25 °C

(4) water supply facilities

The required water supply is 200 tons/day (see Appended Table A 9-3).

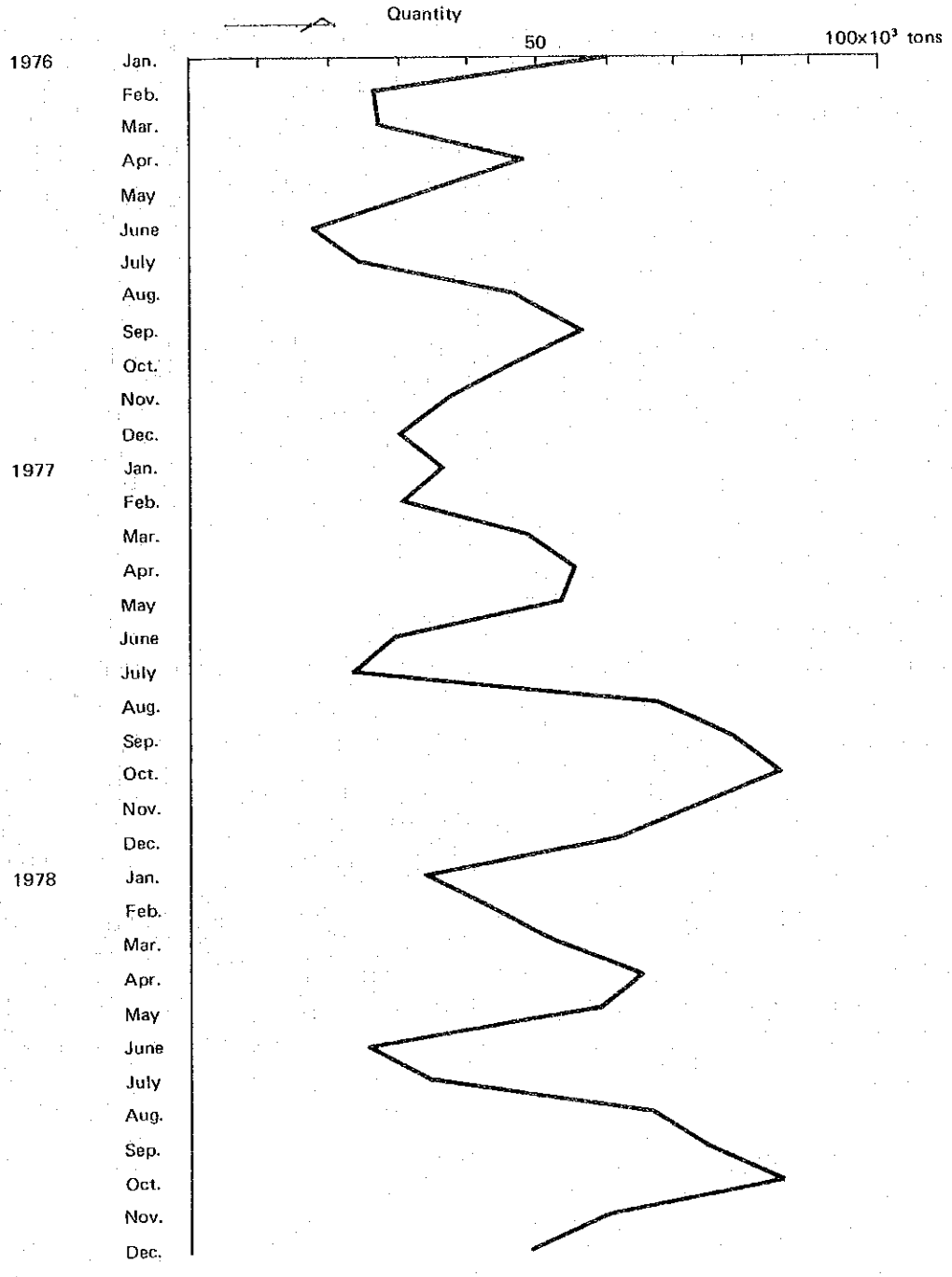
(5) Refueling facilities

a) Refueling

Refueling per ships per day for large gill netters

Horsepower:	120 HP
Fuel consumption per HP hour:	0.19 liters/HP hour (in navigation) 0.10 liters/HP hour (in fishing operation)
Average operation hours/trip/ship per 15 day trip:	2 days x 8 hours = 16 hours (in navigation) 13 days x 16 hours = 308 hours (in fishing operation)
Refueling/frequency/ship:	0.36 kilolitres/15 days (in navigation) 2.5 kilolitres/15 days (in navigation) Total 2.86 kl/15 days

Fig. 9-7 Monthly Production of Marine Fish on Baluchistan Coast



Refueling per day

Number of fishing crafts to be refueling: 36 ships

Refueling per day: 36 ships x 2.86 kl = 100 kl

b) Oil storage

The oil storage should be enough for four days, or four times the daily fuel requirement.

100 kl/day x 4 days = 400 kl

Two 200 kl oil tanks will be installed on the compound of the oil storage facilities, and oil will be piped to the quay valves for oil supply. (Two oil tanks, each 12 m in diameter and 2 m in height).

9-4-3 Other facilities

(1) Administration office

A two-storied reinforced concrete building with a total floor space of 800 square meters will be constructed.

(2) Fence and guardhouse

A fence with a length of 1,020 m, a gate and a guardhouse with a total floor space of 50 square meters will be constructed.

(3) Power distribution and lighting facilities

The ice making, ice storage, cold storage, and freezing facilities will be powered by an on-site generator. Power distribution lines for the area of the fishing port will be installed with electric lamps at necessary places. Electric power will be supplied by surplus power generated from the refrigeration facility.

(4) Public toilet

Two buildings with a total floor space of 100 square meters will be constructed.

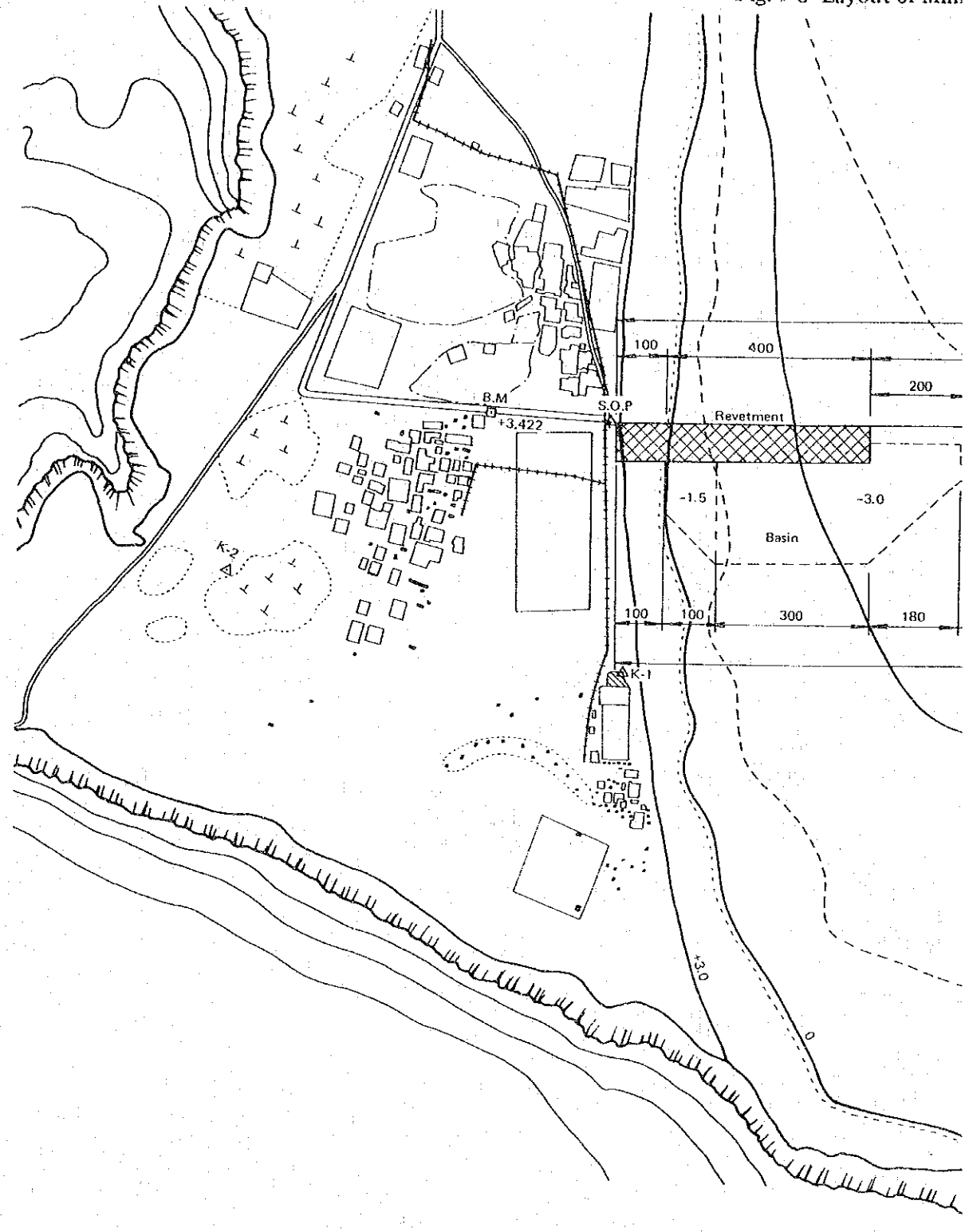
(5) Land for facilities related to the fishing industry

About 8.4 hectares of land will be developed for use as the site of the various fishery related facilities mentioned above, plus a commercial area for the sale of fishing gear, food and other good, a site for a marine production fabrication plant, a net drying yard, and a storage yard.

9-4-4 Layout of facilities

The details are shown in Fig.s 9-8 and 9-9.

Fig. 9-8 Layout of Mini



gth and Depth in Meter)

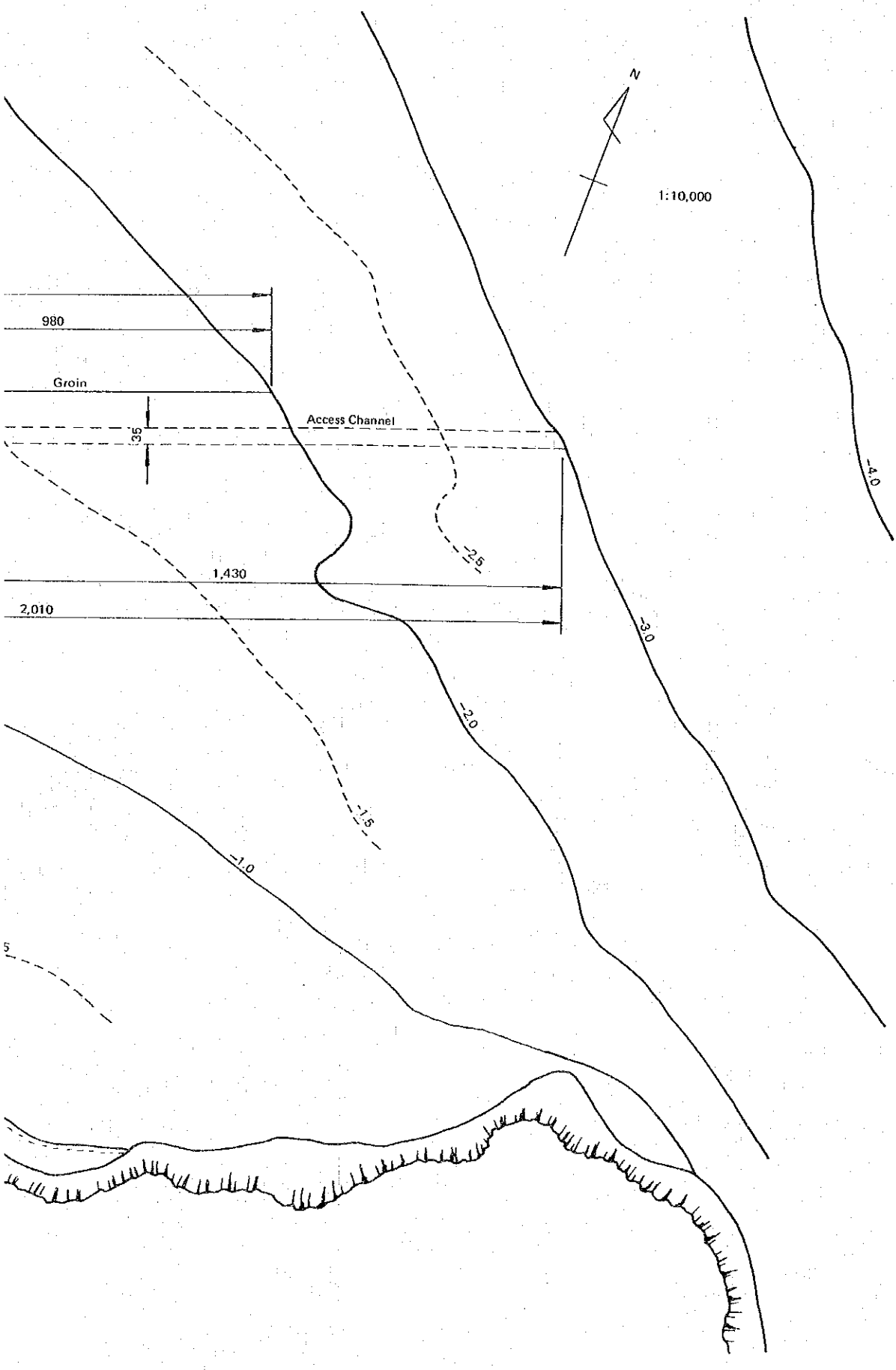
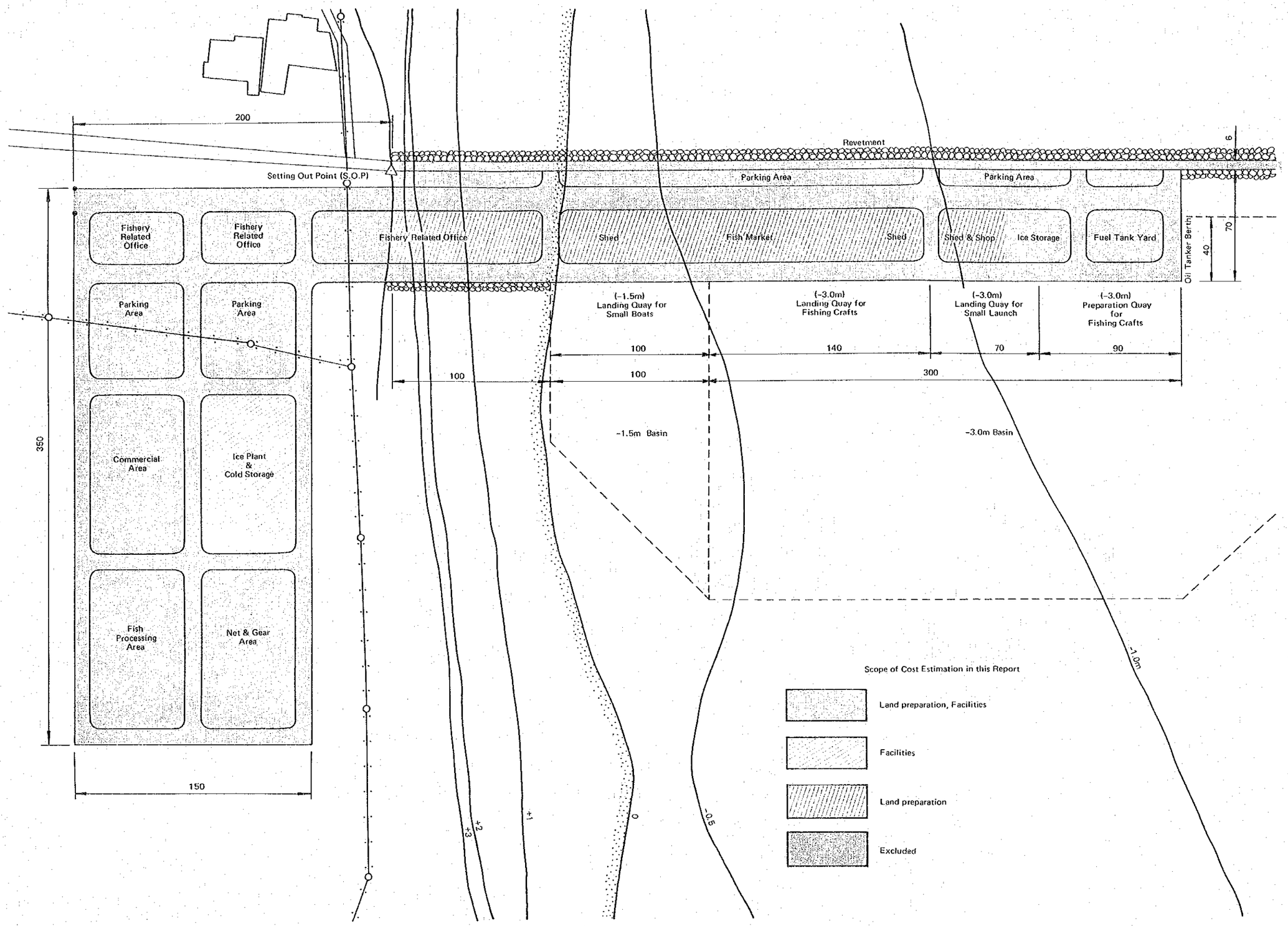


Fig. 9-9 Layout of Facilities



Chapter 10
Construction Plan

Chapter 10 Construction Plan

10-1 General

In conformance with the scale and layout of Mini-Port facilities described in Chapter 9: Development Programme, the actual construction plan is presented in this chapter. As already described in detail in Chapter 6, it was found out by the Japanese Study Team that the proposed site has poor soil conditions, in particular a low strength clay surface layer. For this reason, a piled wharf structure was adopted, after examination of the potential structural method. Also, in the execution of the construction work, the most critical point of caution will be that most of materials are not of adequate quality for construction, except the imported steel and the local cement.

Also, construction machinery suitable to the scale and scope of the construction work may not be available in Pakistan, so except for a few items, it will be necessary to bring most of the heavy machines and marine construction equipment from foreign countries. A construction plan is described in this chapter, with a special focus on these problems.

10-2 List of Facilities

Facilities included in the construction plan are listed below.

Class	Name of Facilities	Principal specifications
Port Facilities	Wharf	Piled wharf: 470 m long, including 370 m long quay (3 m deep) and 100 m long quay (1.5 m deep) The wharf transition from land to sea is 100 m long (riprap work)
	Basin	Area: 112,100 m^2 (including 97,000 m^2 for 3.0 m deep portion and 15,000 m^2 for 1.5 m deep portion)
	Channel	35 m (width) x 1,430 m (length)
	Revetment	500 m long stone-mound with parapet and coping
	Groin	980 m long stone-mound and 50 m long spur with coping
	Ancillary facilities of quaywall	Fenders, mooring posts, lamps
	Navigation aid	One lighthouse, light buoys
	Apron	12 m wide concrete slab
	Land reclamation	28,300 m^2
	Roads	Total of 6,300 m^2 with asphalt penetration pavement
	Parking area	Total of 4,600 m^2 with gravel paving
	Maintenance dredger	Nonpropelling grab type with 0.8 m^3 grab capacity, 80 m^3 self-propelling barge

Class	Name of Facilities	Principal specifications
Fishery related facilities	Ice plant	Ice-making capacity of 50 tons/day Ice-storing capacity of 100 tons
	Freezing plant	Freezing capacity of 10 tons/day Storing capacity of 50 tons
	Refrigerator	Capacity of 250 tons
	Auxiliary facilities of plant	Generator, building, foundation for machines and building, fuel tanks, water supply facilities
	Fueling facilities	400 kl for ships
	Water supply facilities	For ships
	Refrigeration ship	100 gross tonnage, amount of transport is 50 tons/trip

Also, for calculating the construction cost, the following items are included in addition to the construction, purchasing and installation of the above facilities:

a) Temporary works required for the construction
b) Transporting and towing cost for ships, materials, equipment and plants; and marine transport insurance for them
c) Engineering and supervising fees

However, the following items are excluded from the estimation of the construction cost which may be required for the work, but will be separately handled for reference:

a) Price escalation
b) Import tax and duties
c) Insurance related to work (insurance for construction and third party)

10-3 Design Conditions

10-3-1 Elevation

1) Land reclamation — Present water depth: 0 to 1.2 m; height of reclamation: 3.0 m
2) Wharf — Present water depth: 0 to 1.2 m; height of crown: +3.0 m; design water depth: 3.0 m (1.5 m partially)
3) Revetment — Present water depth: 0 to 1.2 m; height of top of coping: +3.0 m; height of top of parapet: +4.5 m

4) Groin — Present water depth: 1.2 to 2.0 m; height of top of coping: +3.0 m; width of crown: 6.0 m

5) Basin — Present water depth: 0 to 1.3 m; design water depth: 3.0 m (1.5 m partially); width: 200m

6) Access channel — Present water depth: 1.3 to 3.0 m; design depth: 3.0 m; width: 35 m

7) Draft of ships — Gillnetters: 2.4 m; Sailboats: 1.0 m

Note: The altitude of the reference B.M installed by the Japanese Study Team is +3.422 m.

10-3-2 Natural Conditions

(1) Wave

The significant wave height is assumed to be 1.5 m with a period of 12 sec.

(2) Current

The maximum speed is assumed to be 0.25 m/sec (0.5 kt).

(3) Tidal Levels

Tidal levels obtained by the Japanese Study Team are as follows:

HWL : +2.29 m
MSL : +1.28 m
LWL : +0.27 m

(4) Seismic Coefficient

As described in Paragraph 6-6 (earthquakes) of Chapter 6, a horizontal seismic coefficient of $k_h = 0.1$ will be applied in this area in consideration of the importance of the structures.

(5) Soil Conditions

The angle of internal friction of backfilling is assumed to be $\phi = 30°$. A cohesion of c = 2.0 t/m^2 is assumed for existing ground in a certain depth.

10-3-3 Load and Allowable Stress

(1) Surcharge: 1.0 t/m^2 normally, and 0.5 t/m^2 in seismic case

(2) Residual Water Level: +1.0 m

(3) Allowable Stresses of Steel:

Kinds	Standards	Codes	Allowable stresses
Steel pipe pile	JIS A 5525	STK 41	1,400 kg/cm^2
Reinforcing bar	JIS G 3312	SD 30	1,200 kg/cm^2
Ordinary steel	JIS G 3101	SS 41	1,400 kg/cm^2

However, allowable stresses shown above can be increased by a maximum of 50% when considering short-term loading, such as earthquakes.

(4) Allowable Stress of Concrete

In consideration of difficulty in obtaining good aggregate for concrete and difficulty in curing of concrete under high temperature conditions, design standard strength of σ_{28} = 180 kg/cm^2 and allowable stress of 60 kg/cm^2 shall be used. Allowable stress can be increased for earthquake using the same method as steel.

10-4 Structural Design

10-4-1 Wharf

(1) Selection of Structure

As clarified recently by the soil investigation conducted by the Japanese Study Team and stated in detail in Paragraph 7-5, soil conditions of the proposed site for the wharf are poor, where soft clay stratum with unconfined compression strength of about q_u = 0.4 kg/cm^2 exists from the sea bed to a depth of 10 m or more. The depth at which stiff clay stratum appears also varies among the boreholes. The stability against slip if a vertical wall type wharf were built on this soil is poor, and its safety factor is 1.0 to 1.1 in the ordinary case but drops to 0.7 for the seismic case, which means that a vertical wall wharf (gravity or steel sheet pile type) cannot be applied to this site. In addition, some problems are anticipated in applying other methods, such as soil improvement, which could increase the strength of clay.

A piled wharf is the most suitable structure for this site, considering the existing soil conditions. A pile jetty extends from the landfill shore facility, permitting a shallow slope of the landfill to insure stability against circular failure (see Fig. 10-4). At the Mini-Port, a minimum berth depth of 3 m is maintained, with the wharf rising to +3 m.

The safety factor against circular failure of a vertical wall on this site is shown in Fig. 10-1 (a).

(2) Structure of Piled Wharf

Considering strength, evenness in quality, ease in handling, and workability of piles, steel pipe are the most appropriate piles. Even though corrosion is anticipated since these piles are used in sea water, this will be no problem by adding a thickness for allowance against corrosion, by considering the annual amount of corrosion and the life of the pier, and adding the resulting thickness to the minimum steel thickness required for the pile strength. When the life is 30 years and annual rate of corrosion of external surface of steel pipe pile 0.1 mm, a corrosion margin of 3.0 mm will be sufficient, and additional painting or cathodic protection will not be required. The pile caps, the beams, and the slabs of the superstructure should be reinforced concrete. However, as already stated in Paragraph 10-3-3, since the proper fine aggregate is not available in the vicinity, and weather conditions for concrete placement are not good, then the allowable compression stress for design shall be no more than 60 kg/cm^2. Typical sections are shown in Figs. 10-2 to 10-5.

10-4-2 Groin

(1) Stability against Circular Failure

The subsoil along the face line of the groin, as well as the wharf, is soft clay to a certain depth, and is not favourable for banking. However, the stability of the banking against circular failure can be assured by keeping the gradient of the slope at 1:2. The diagram of the stability is shown in Fig. 10-1 (b).

(2) Settlement

The consolidation settlement of the ground after banking can be calculated by following formula:

$$S = \int_{h}^{h+H} \frac{e_1 - e_2}{1 + e_1} \, dz$$

where S : Settlement in a layer between h and h + H in depth
e_1 : Void ratio of soil under the normally consolidated condition
e_2 : Void ratio of soil after banking
z : Depth below sea bed

According to the results of laboratory tests, the mean values of e_1 and e_2 are 0.70 and 0.65, respectively. The thickness of the layer to be consolidated is estimated at 10 m. Using these values and the formula above, we calculated the probable final settlement as 0.30 m. This value is small for settlement by consolidation.

(3) Armouring Stone for Revetment and Groin

1) Materials to be used

Of the shelly limestone obtainable in the Headland, each limestone should have a weight greater than 1 ton. From the tests conducted by the Japanese Study Team (Sept., 1979), the mean apparent specific gravity of the shelly limestone is 1.93. This is about the same value of the specimens examined by the WAPDA.

(Reference) Water and Power Development Authority West Pakistan "Gwadar Fish Harbour Material Exploration Report", November, 1973.

2) Required unit weight of stone

$$W = \frac{\gamma_r H^3}{K_D(S_r-1)^3 \cot\alpha}$$

where, W: Minimum weight of stone (t)

γ_r: Bulk density of stone in air (t/m^3)

S_r: Specific gravity of stone in respect to sea water

α: Angle of slope

H: Significant wave height to be used for design (m)

K_D: Constant to be determined by armouring stone and damage ratio

Actual values are:

$$\gamma_r = 1.93,\ S_r = \frac{1.93}{1.03} = 1.87,\ \alpha = 26.6^\circ\ (=\tan^{-1}\frac{1}{2}),\ H = 1.5\ m$$

therefore,

$$W = \frac{1.93 \times 1.5^3}{K_D \times 0.87^3 \times 2.0} = 4.95 \times \frac{1}{K_D}$$

Concerning constant K_D, a value of K_D equals 5.1, corresponding to a 1% to 5% damage ratio as proposed by Hudson will be used.

The required weight of stone is given by W = 4.95/5.1 = 0.97 tons. Thus, stones heavier than 1 ton should be used as armouring stone. The above calculations are made for the case where the waves reach perpendicularly to the mound. However, according to this project, the wave direction is considered to be approximately parallel to the groin, so that the wave force may be reduced accordingly. No adjustment will be made here, since the proper angle of wave attack is still unknown. Thus, armouring stone is considered to be appropriate if each stone is heavier than 1 ton.

(Reference) R.Y. Hudson, Laboratory Investigation of Rubble-Mound Breakwater, Proc. ASCE, Vol. 85, W.W.3, 1959.

Fig. 10-1(a) Diagram of Circular Failure (Quay Wall)

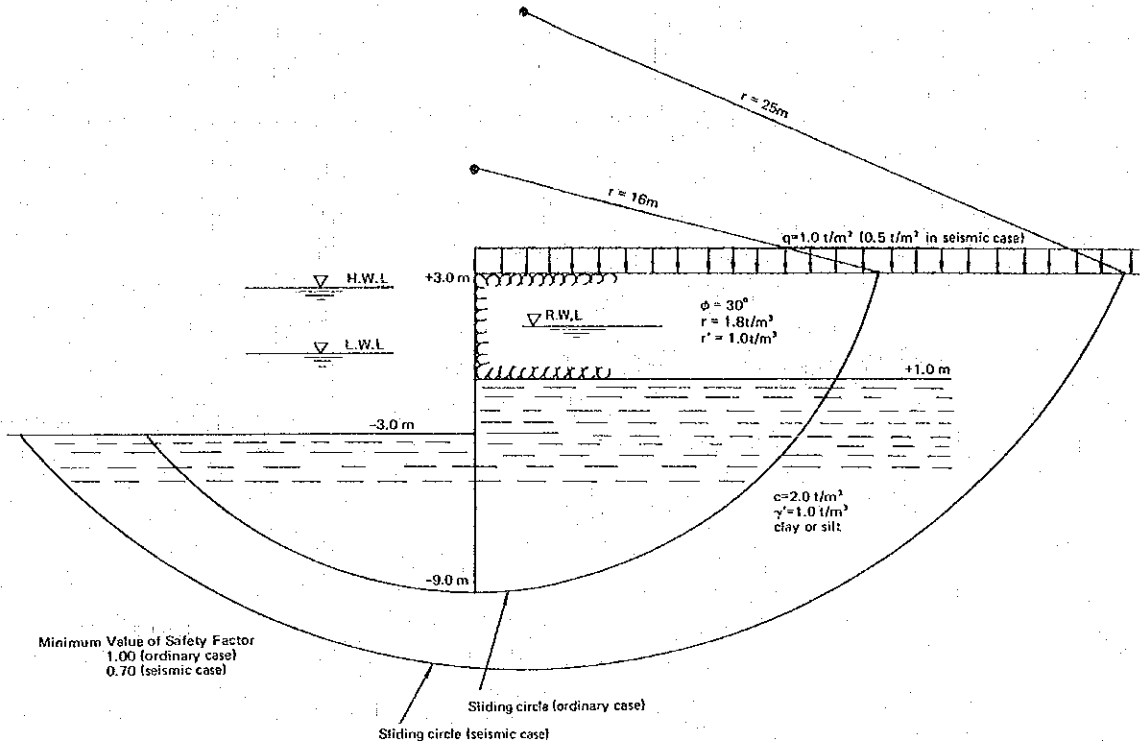
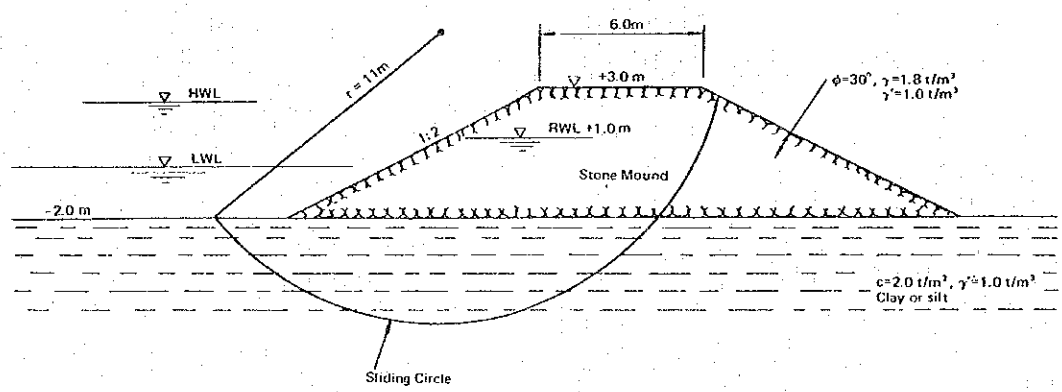
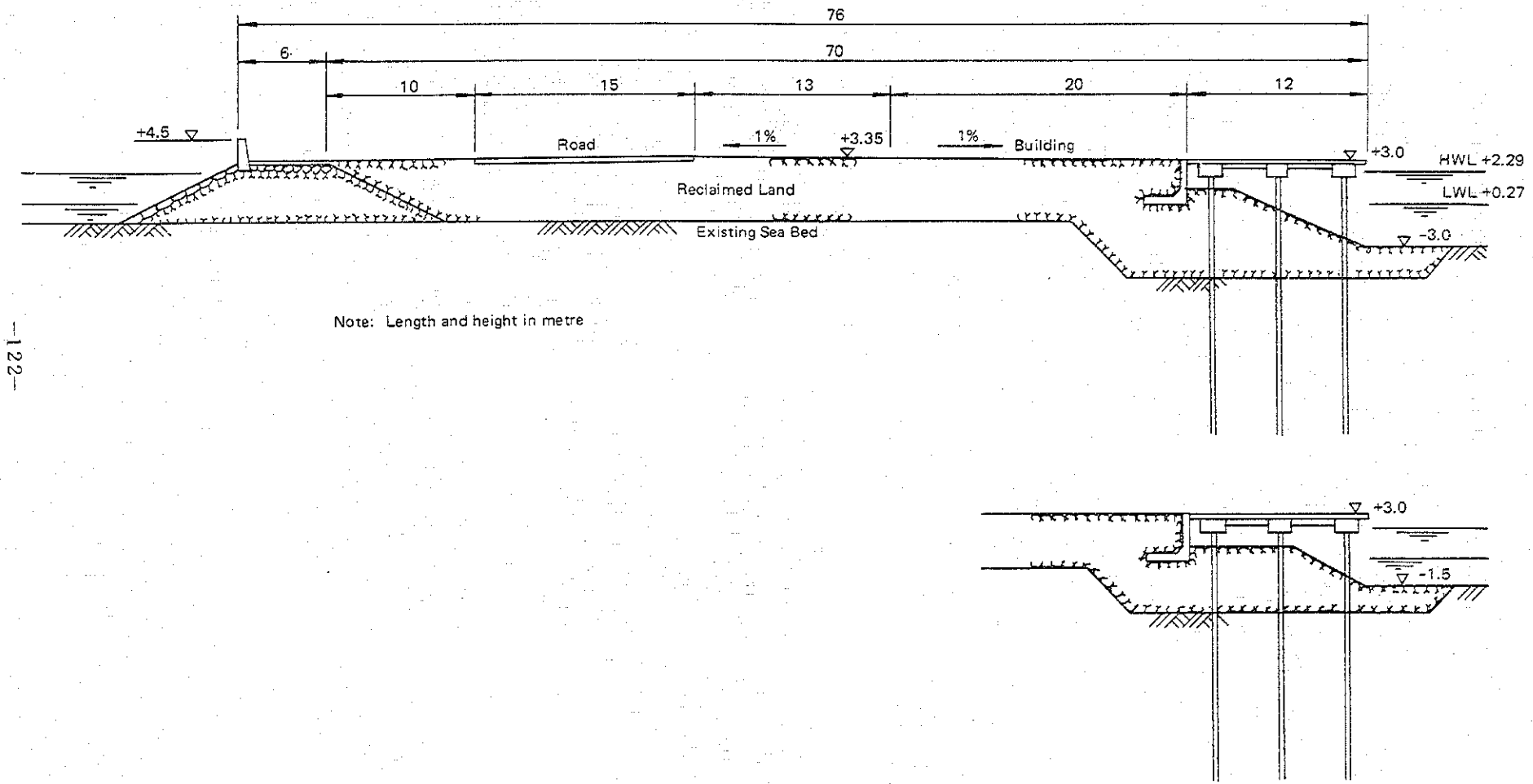


Fig. 10-1(b) Diagram of Circular Failure (Groin)



Minimum Value of Safety Factor
1.40 (ordinary case)
1.02 (seismic case)

Fig. 10-2 Typical Cross Section



Note: Length and height in metre

Fig. 10-3 Cross Section of Groin

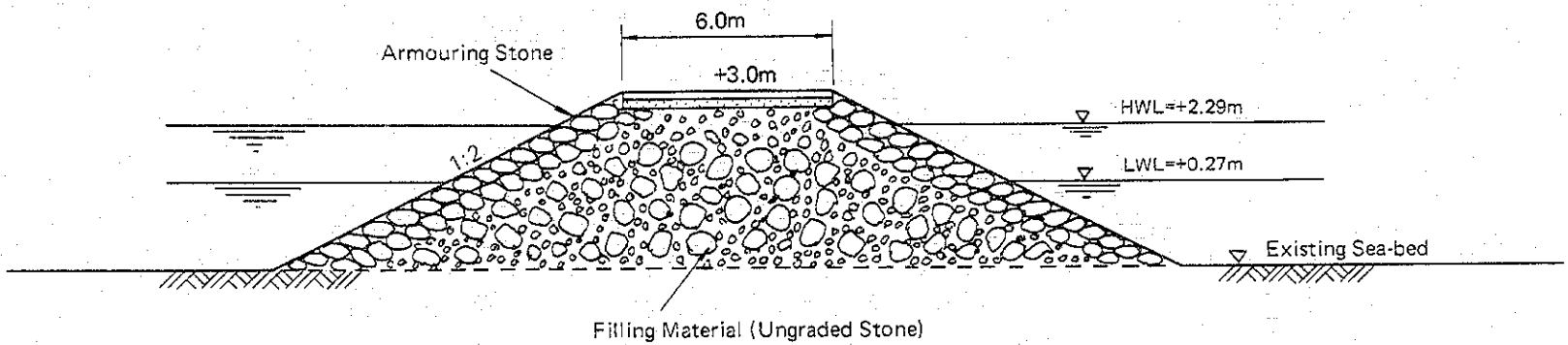


Fig. 10-4 -3.0M Landing Facility

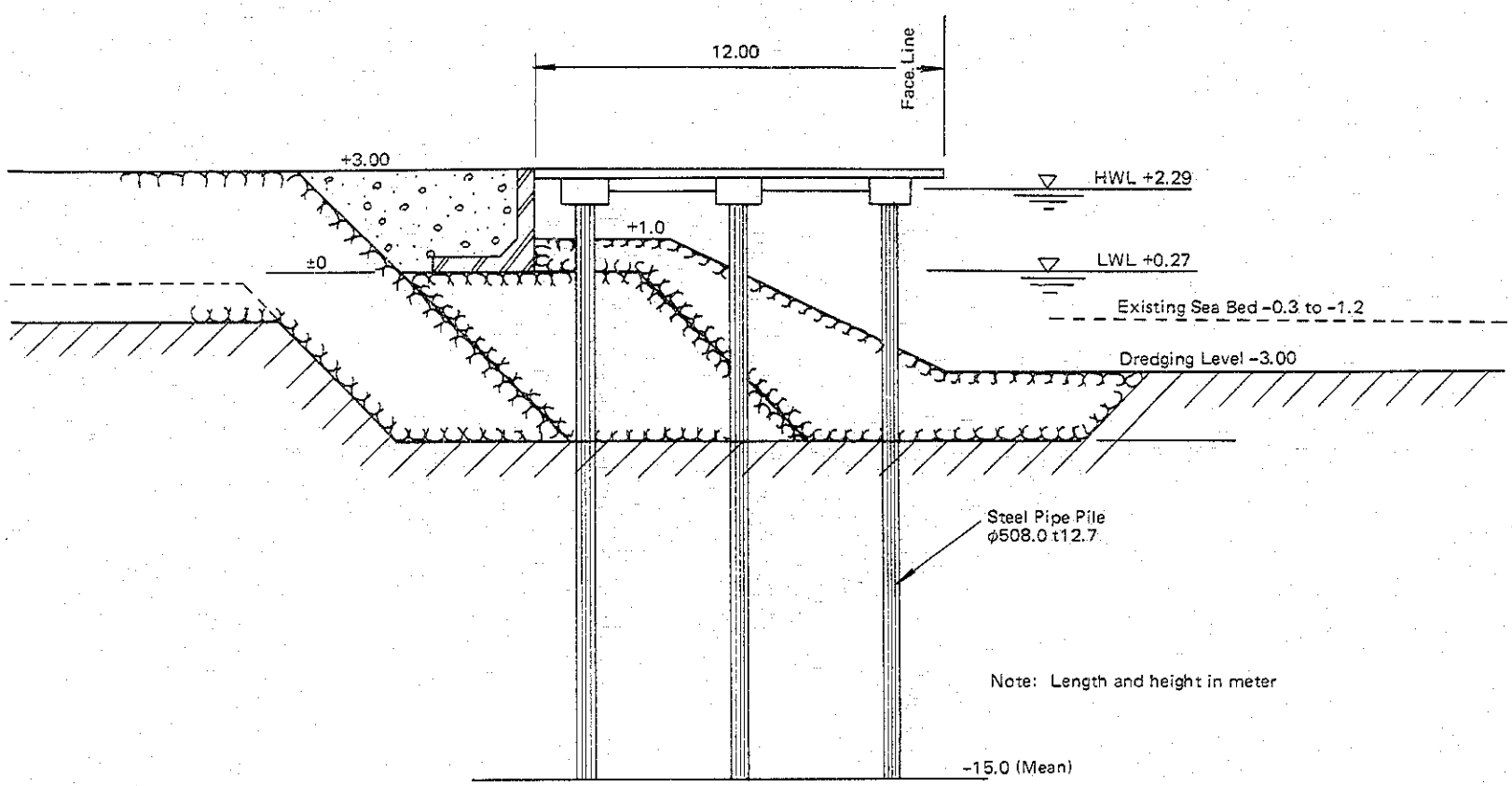
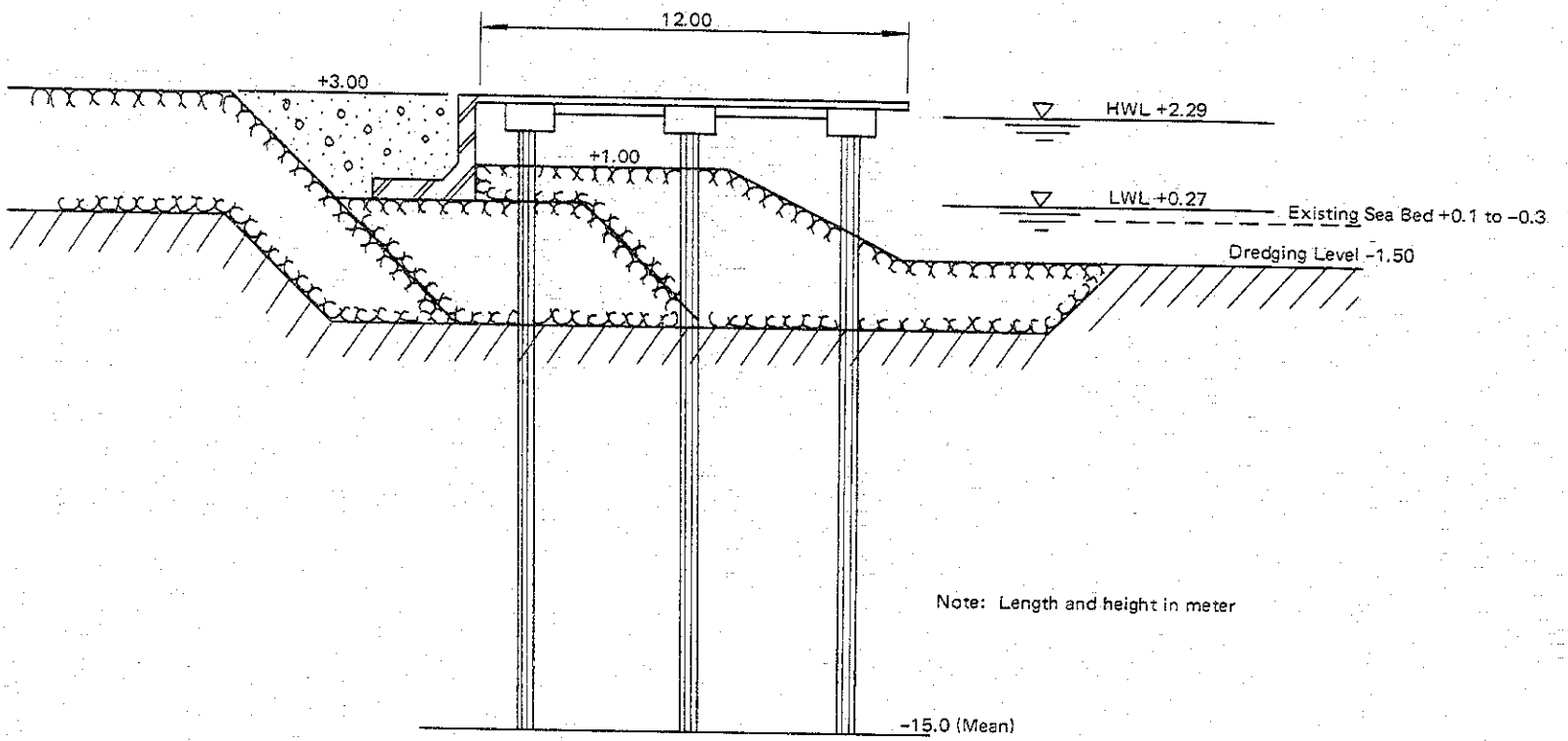


Fig. 10-5 -1.5 M Landing Facility



10-5 Fishery Related Facilities

The outline of fishery related facilities, such as ice making, freezing, refrigerating facilities, and a refrigeration vessel is shown below.

10-5-1 Ice Making and Storing Facilities

1) Ice plant

Ice making capacity:	50 tons/day
Type:	Rapid ice making
Weight of block ice:	150 kg each
Production cycle:	3 hours x 8 cycles
Rate of block ice production:	42 blocks/cycle x 8=336 blocks/day
Power required:	140 KW

2) Ice storage

Storage capacity:	100 tons
Cooling method:	Natural circulation system
Storing temperature:	−5°C
Power required:	15 KW

3) Floor area of building: 13 m x 20 m = 260 m^2

10-5-2 Freezing and Cold Storage Facilities

1) Freezer

Freezing capacity:	10 tons/day
Freezing method:	Forced circulation system
Freezing temperature:	−20°C (mean); −40°C (lowest)
Power required:	70 KW; refrigerator
	15 KW; unit cooler

2) Cold Storage I

Capacity of cold storage:	50 tons
Method of cooling:	Forced circulation system
Outdoor air temperature:	+33°C (mean)
Refrigerating temperature:	−25°C
Power required:	20 KW; refrigerator
	5.5 KW; unit cooler

3) Cold storage II

Capacity of cold storage:	250 tons
Method of cooling:	Forced circulation system
Outdoor air temperature:	+33°C
Refrigerating temperature:	−5°C
Power required:	30 KW; refrigerator
	11 KW; unit cooler

4) Floor area of building: 15 m x 35 m = 525 m^2

10-5-3 Water Cooling Facilities

The following cooling facilities will be needed for cooling the equipment shown above:

Required cooling capacity:	450,000 Kcal/hr
Volume of cooling water:	1,500 litres/min (90 m^3/hr)
Required make-up water:	22.5 litres/min (1.35 m^3/hr)
Type:	Cooling tower method, Required power: 1.5 KW x 2

Circulating pumps for cooling water: 45 m^3/hr, 5.5 KW x 2

10-5-4 Power Plant

Total power required for the equipment shown above is about 330 KW. However the capacity of the power plant should be 500 KW in consideration of efficiencies of motors and load factor of 85%. Outline of the power plant is shown below.

1) Generator unit driven by diesel engines: 250 KW x 2
   Cooling method of diesel engines is to be air of radiation cooled.
2) Fuel tank
   Fuel sufficient for operating the power plant for one week will be stored in the tank.
   Tank capacity: 20 m^3
3) Floor area of building: 10 m x 10 m = 100 m^2

10-5-5 Refregeration Vessel

Gross tonnage:	100 G/T
Dimensions:	30.00 m(L) x 6.20 m(B) x 2.30 m(D)
Crew:	8 persons
Speed:	12 knots
Fish storage:	130 m^3, 50 tons
Main engine:	800 PS
Generator:	170 PS x 130 KVA x 2
Refrigerator:	2 KW x 2, 11 KW x 2

10-5-6 Water and Fuel Supply Facilities

(1) Water Supply Facilities

1) Water supply pipeline for ice plant and fishing boats
   Capacity of water supply: 30 m^3/hr
   Method of water supply: By gravity from tanks
   Pipe diameter: 100 mm
2) Pipeline for taking sea water (water for cleaning)
   Capacity of intake: 10 m^3/hr
   Water supply pump: 1.5 KW
   Pipe diameter: 50 mm

(2) Fuel Supply Facilities

1) Fuel oil pipeline and equipment

Unloader from tanker:	3 in. simple loading arm with 50 m^3/hr capacity
Loader to fishing boats:	3 in. simple loading arm with 20 m^3/hr capacity
Pipe diameter:	80 mm

2) Storage tank

Tank capacity:	200 m^3 x 2

10-6 Construction Method

10-6-1 Materials

(1) Filling and Stone Material

1) Filling material for reclamation and groin

Of the cap rocks in the Headland, sound ones should be crushed to make each weight less than 500 kg. This material is available in the form of a relatively thin layer in a wide area of the Headland, so that this material easily can be collected by bulldozer. A major portion of the Headland material consists of white kaolinite-like soil or mudstone, but this cannot be used since it is soluble in water. Soil from sea bed is useless since it is silty or clayey. On the other hand, desert sand is too fine and cannot be compacted easily enough for heavy machinery. Thus, the use of desert sand is not desirable.

2) Armouring material for groin

In some part of the Headland, shelly limestone is available: only the hard shelly limestone should be crushed to about 1-ton weights. This material lies at the north fringe near the east end of the Headland, and at the south of the lighthouse. Blasting will be necessary for quarrying this material. Since this material is likely to be abraded if loads by wave strikes repeatedly, periodic supply of armour stone may be required. As an alternative scheme for armour stone, use of irregular concrete blocks may be effective. However, such concrete blocks are not advantageous with respect to cost and reliability in quality, since good aggregate is not available here, and curing of concrete is very difficult in this high-temperature dry region.

3) Road materials

For a road base and subbase, crushed stone of the Headland, or gravel in the north of Koh-e-Medi, is adequate. For screening, the fine portion of Suntsar material –smaller than 5 mm– or the crushed stone of the Headland, is appropriate.

4) Cobble for machine foundations

Suntsar gravel larger than 40 mm is probably appropriate for this purpose.

(2) Concrete Materials

1) Cement

Ordinary Portland cement or sulphate resisting cement, manufactured in Pakistan, will be used. If a cement meets the standard requirements, and is new and stored dry, either domestic or imported cement may be used. Both are available in Karachi.

2) Coarse aggregates

Only the aggregates taken at the Suntsar gravel deposit should be used. Since the aggregate contains flat shapes and harmful materials, such as mud, calcite, and clay balls, these characteristics should be taken into consideration for actual use. The quantity is sufficient for the concrete volume of this project (refer to Chapter 7 for details.).

3) Fine aggregates

Two aggregate types are considered, that taken from the north side of Gwadar City, and the Suntsar fine aggregate. Each has shortcomings, for example, the former has many shells, while the latter contains many minute particles. For the best available fine aggregate, the sand of Gwadar smaller than 2.5 mm may be mixed with sand of Suntsar greater than 1.0 mm, but this is excessively complicated for on-site work. Test mixing shall be conducted for both sands, and the best mix proportion shall be used for the project.

(3) Steel Material

1) Steel pipe piles

Piles shall be imported, since they are not manufactured in Pakistan.

2) Other steel materials

Steel material, such as reinforcing bars and structural steel, is manufactured domestically from imported raw materials or scrap, and is available in Pakistan. However, if such materials are intended for use as main structural members without certification, the strength and mechanical properties of the steel material must be tested to confirm satisfactory quality, before they are used.

10-6-2 Construction Machinery and Vessels

(1) Construction Machinery

In Pakistan various construction works for roads, buildings, and so forth have been carried out recently, and construction machines such as bulldozers, shovels, trucks, concrete plants and cranes have been used.

However, the quantity of these construction machines is not sufficient for this project, and most of them are imported and are very expensive. Thus, it appears to be very difficult to procure within Pakistan a large number of construction equipment for the long period required for this project, so that it is appropriate to consider bringing most of the machines from Japan or

other foreign country. However, transportation cost for construction equipment is very high, so that it is necessary to review all posibilities of procuring these machines within Pakistan or from neighboring countries prior to construction.

(2) Construction Vessels

The Port of Karachi owns some construction vessels, such as tugboats, crane barges, and dredgers, and utilizes them for maneuvering ships, handling cargo, and channel maintenance. Except those stated above, construction vessels are almost impossible to procure for this project. Thus, it is inevitable that the vessels are brought from Japan or another country.

10-6-3 Labour Forces

Most of labour forces available in Gwadar are engaged in fishing. In addition, the only construction labourers available are unskilled.

On the other hand, the construction labour force in Pakistan is relatively strong, and ordinary labourers can be easily found. Skilled workers, familiar with civil work machinery, and road, bridge and building construction, also can be secured. However, labourers, crews, and divers capable of marine works are few. Thus, the following consideration will be necessary in securing the labour forces required in this project:

Local Workers:	Labourers
	Skilled and semi-skilled labourers (masons, reinforcement workers, carpentors, operators, etc.)
Foreign Workers:	Skilled labourers (divers, crew, scaffolding men)
	Engineers
	Supervisors

10-6-4 Transportation of Construction Equipment and Materials

The transportation to Gwadar of the construction vessels and machinery from foreign countries, and the bringing of construction materials from Karachi, has many problems that must be considered. There is no port facility in Gwadar at present. In addition, the road between Karachi and Gwadar is very rough, so that trucks can run but transporting trailers loaded with large construction machinery is very difficult. It is important to transport a large number of construction equipment and materials quickly and safely to Gwadar, so the Japanese Study Team recommends the following transportation method:

(1) Transportation of construction vessels

Towing of construction vessels, such as dredgers, pile-driving barges, and pontoons, by tugboats directly from Japan or another foreign country to Gwadar is difficult in view of safety and economy. Therefore, the least expensive and the surest method is to load all construction vessels on a large-size submergible barge, bring it offshore of Gwadar, sink it by flooding with water, and pull off the construction vessels. Materials, such as steel piles, can be loaded on pontoons.

(2) Transportation of construction machinery

For transporting construction machinery, it is recommended to ship the machines on cargo vessels offshore of Gwadar, unload them to pontoons using derricks and a floating crane, transport them to shoreline, and unload the machinery on the beach.

(3) Transport of construction materials procured in Pakistan

Materials such as cement and reinforcing bars procured at Karachi can be transported by either land or marine shipping.

10-6-5 Execution

(1) Principal facilities and main works

The principal facilities to be constructed, and main works to be executed, are shown below:

1) Groin and revetment ····· riprap work, armour stone work, concrete work (parapet, coping)
2) Piled wharf ····· soil excavation and replacement, driving of steel pipe piles, bulkhead (L-shaped blocks), concrete work (beams and slabs)
3) Land reclamation ····· filling work
4) Access channel and basin ····· dredging work
5) Roads ····· asphalt penetration paving
6) Parking area ····· gravel paving

As listed above, the main works related to the construction of port facilities can be classified into riprap work, filling work, armour stone work, dredging work, pile-driving work, concrete work, and paving work.

(2) Quantity of works

The quantity of the main work by facility is shown in Table 10-1.

(3) Basic conception of construction methods

In the project area are few rainy days, and times of high wind of 10 m/s or more occur only infrequently. On the other hand, sea conditions affecting the construction work, such as high waves, may occur during monsoon. Also, due to the insufficient experience of the domestic laborers in marine work, foreign workers will be essential. Thus, on-land work must be selected as much as possible, and marine work limited to indispensable items, and kept to minimum.

(4) Outline of construction methods for main facilities is as follows:

1) Preparation and temporary work

Following preparation and temporary work is required for the execution of this project.

a) Preparation

Ordering of construction materials and equipment, and delivering them to the site. Contracting foreign and domestic labourer.

b) Temporary work

Field office and accommodations

Warehouses (material warehouse and explosives warehouse)

Workshops for steel reinforcing bars and concrete forms
Construction roads
Water supply and drainage
Electric power supply
Storage yard for machinery

2) Revetment and groin work

a) Riprap work

Rock materials ripped and excavated by bulldozer in the Headland will be carried by dump trucks, placed in the reclaimed area, and compacted by bulldozer. It is desirable to perform the riprap work in a stage as early as possible, in order to create a clam water area for subsequent piling and dredging work.

b) Armour stone work

1-ton rock taken by blasting in the Headland will be transported by dump trucks. Each stone will be installed on the revetment rubble mound using a crawler crane. For the groin, armour stones will be installed using a crawler crane on pontoons, since the width of groin is not sufficient for the crawler, and crowding of the riprap work shall be prevented. Pontoon installation should be performed under the direction of a diver.

c) Concrete work

Plain concrete should be cast in place for the coping and parapet.

3) Piled wharf

a) Excavation and replacement

Soil excavation should be done with a grab dredger, after driving steel pipe piles, the soil is replaced with selected fill material dumped from barges and cranes.

b) Driving steel pipe piles

Steel pipe piles should be driven by pile-driving barge with a diesel hammer, since driving from land is difficult.

c) Bulkhead

Dumping of the foundation stone will be done from land, if possible, but partially from the sea in order to shape the designed slope. The base of the riprap must be leveled by divers in advance. The retaining wall is an L-shape, and is installed after producing blocks in a yard. Backfilling must be done immediately after installation of the wall.

d) Concrete work

For performing concrete work, there are two methods; either the pile cap is cast in place, and the beams and slabs are installed after fabication in the block yard, or all portions of the structure cast in place.

In the case of casting in place all portions of the concrete, the tide would cause many problems, and the quality control is difficult. Therefore, installation after precasting the beams and slabs in advance in block yard may be desirable. In addition, since the labourers will be unfamiliar with marine construction, it is undesirable to choose the cast in place method.

4) Land reclamation work

Reclamation work will be performed exactly in the same manner as riprap work for revetment and groin, and carried out at the same time.

5) Dredging work for access channel and basin

For dredging the access channel and basin, either a grab dredger or a pump dredger can be used, but a grab dredger is more suitable for this project because of the cohesion of the soil and volume of earth to be dredged. The channel and basin shall be dredged slightly in excess of -3 m, to insure an adequate safety factor against an unevenly dredged sea bed. The dredged spoil will be barged offshore for dumping.

6) Roads

Crushed subbase materials will be laid, levelled, and compacted by bulldozer, the pavements made using the asphalt penetration method, and roads finished by rolling and compacting by macadam roller.

7) Parking area

The parking area will be paved with gravel. The base material should be levelled and compacted by bulldozer and roller.

8) Others

For fishery related facilities, such as the ice plant, the cold storage and refrigeration plant, the machines will be imported, and the piping, installation and building construction work performed at the site.

(5) Construction Machinery and Vessels

Construction machinery and vessels required for this project are shown in Table 10-2, which is arranged to utilize each machine in accordance with the work schedule stated in previous paragraphs.

(6) Labour Plan

The number of workers and engineers required at the peak time of this project are shown in Table 10-3.

(7) Construction Schedule

About two years seem to be necessary for this construction project, in view of scale of construction. Its time schedule is shown in Table 10-4. In this case, the critical works are the riprap work, the reclamation work, and the armour stone work.

10-7 Construction Cost

10-7-1 Estimate Conditions

Construction costs are estimated basing on the following conditions:

1) Estimate of construction costs is based on the prices of 1979.
2) Unit prices of construction materials and labour wages are based on the data obtained through the site survey.
3) For domestically produced materials to be carried from Karachi, the transportation expenses to the construction site are included.
4) Import materials are assumed to be brought from Japan, for which transportation costs and insurances have been estimated.

5) Construction machinery and construction vessels are assumed to be brought from and returned to Japan after completion. Thus, round-trip transportation expenses and insurances are included in the estimate.
6) Taxes such as import duties and enterprise taxes are not included.
7) Land rent and compensation for land acquisition related to this project are not included.
8) Insurance premiums related to the work are not included.
9) Rates and prices are Pakistani rupee for local currency and Japanese yen for foreign currency.
10) Exchange rates between Pakistani rupee, Japanese yen and US dollars are assumed to be as follows:

$1.00 USD = Rs 10 = ¥200

10-7-2 Construction Cost

The construction costs for the Mini-Port of Gwadar are as follows: (Breakdown for each facility is shown in Table 10-5)

	1,000 yen	$ USD
(1) Preparation and temporary work:	159,000	(795,000)
(2) Port facilities:	2,838,300	(14,191,500)
(3) Fishery related facilities:	1,028,200	(5,141,000)
(4) Engineering & supervising:	170,000	(850,000)
(5) Physical contingency:	304,500	(1,522,000)
TOTAL	4,500,000	(22,500,000)

It is required to add a price escalation to the above construction cost. If 30% escalations for three years is assumed, the construction cost will be 5,850 million yen ($29,250,000 USD).

Table 10-1 Quantities of Main Works

Kind of Works / Facilities	Quantity	Rubble work or reclamation m^3	Armour stone work m^3	Pile driving piles	Concrete work m^3	Base course work m^3	Asphalt pavement m^2	Dredging m^3
Groin	1,030 m	78,800	20,200		1,300	2,300		
Revetment	500 m	23,300	3,100		1,350	900		
Transitional part of wharf	100 m	4,400	500		250	400		
−3.0 m Steel pipe piled wharf	370 m	51,700		216	3,000			34,400
−1.5 m Steel pipe piled wharf	100 m	11,000		63	800			7,500
Land	28,300 m^2	112,200						
Access channel and Basin	160,000 m^2							321,000
Road	630 m					3,200	8,800	
Parking Area	4,600 m^2					1,700		
Total		281,400	23,800	279	6,700	8,500	8,800	362,900

Table 10-2 Construction Equipment

Name	Specification	Number	Remark
Dump Truck	11 t	20	Stone work
Bulldozer	21 t	4	Ditto
Ditto	14 t	2	Ditto
Wheel Loader	2.1 m^3	5	Ditto
Backhoe	0.4 m^3	1	Gravel deposit
Crawler Crane	40 t	2	Armouring
Crawler Drill	Air Consumption 10 cm^3	2	Stone quarry
Hand Hammer	20 kg	2	Ditto
Compressor	10 m^3	2	Ditto
Portable Crushing Plant	40 t/hr	1	Concrete aggregate
Concrete Plant	0.5 m^3	1	
Engine Generator	100 KVA	1	Crusher
Ditto	20 KVA	1	Concrete plant
Agitator truck	3 m^3	2	Concrete work
Concrete Pumping Car	60 m^3/hr	1	Ditto
Macadom Roller	10 t	1	Road compaction
Truck	11 t	1	Soil work
Ditto	4 t	1	Ditto
Non-Propelling Grab Dredger	6 m^3, 800 PS	1	Dredging
Self-Propelling Floating Windlass	5 t, 90 PS	1	Ditto
Dump Barge	300 m^3	2	Ditto
Tug Boat	45 t, 300 PS	1	Ditto
Ditto	50 t, 350 PS	1	Towing
Floating Crane with a Diesel Hammer	50 t, 300 PS	1	Piling, lifting
Flat Barge	500 t	2	Armour Stone and Pipe Piles
Ditto	200 t	1	Boading a Crawler Crane
Diver Boat	4.9 t, 30 PS	1	

Table 10-3 Labour Plan

	Local (persons)	Foreign (persons)
Operator	15	
Driver	24	
Driller	8	
Mason	20	
Carpenter	15	
Scaffolding man	6	2
Steel worker	10	
Welder	3	
Mechanic	4	2
Labour	85	
Diver		3
Crew	8	15
Foreman	10	
Engineer		8
Supervisor		2
Total	208	32

Table 10-4 Construction Schedule

Kind of Works	Quantity	1st Year												2nd Year											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation and Temporary Work																									
Revetment																									
Rubble work	23,300 m³																								
Armour stone work	3,100 m³																								
Concrete work	1,350 m³																								
Transitional part of wharf																									
Rubble work	4,400 m³																								
Armour stone work	500 m³																								
Concrete work	250 m³																								
Groin																									
Rubble work	78,800 m³																								
Armour stone work	20,200 m³																								
Concrete work	1,300 m³																								
−1.5 m Piled wharf																									
Excavation work	7,500 m³																								
Pipe pile driving	63																								
Foundation work	11,000 m³																								
L type block work	180 m³																								
Slab concrete work	620 m³																								
−3.0 m Piled wharf																									
Excavation work	34,400 m³																								
Pipe pile driving	216																								
Foundation work	45,300 m³																								
L type block work	700 m³																								
Slab concrete work	2,300 m³																								
Land Reclamation	112,200 m³																								
Dredging of access channel and Basin	321,000 m³																								
Road Pavement	8,800 m²																								
Parking area pavement	4,600 m²																								
Fishery related facilities	Sum																								
Clearance	Sum																								

Table 10-5(1) Construction Cost (¥)

Unit: in thousand ¥

Facilities	Unit	Quantity	Local Currency		Foreign Currency		Total	
			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
Preparation and Temporary Works				48,800		110,200		159,000
Temporary Buildings (office, lodgings, warehouse etc.)	L.S	1		31,600		51,800		83,400
Machines, Electricity, Water Supply Equipment	L.S	1		1,200		5,100		6,300
Temporary Road	L.S	1		16,000		53,300		69,300
Port Facilities				470,900		2,367,400		2,838,300
Revetment	m	500	76	38,000	184	92,000	260	130,000
Transitional Part of Wharf	m	100	69	6,900	161	16,100	230	23,000
Groin	m	1,030	96	98,900	384	395,500	480	494,400
−1.5 m Wharf (Pier)	m	100	225	22,500	805	80,500	1,030	103,000
ditto (Bulkhead)	m	100	72	7,200	298	29,800	370	37,000
−3.0 m Wharf (Pier)	m	370	240	88,800	830	307,100	1,070	395,900
ditto (Bulkhead)	m	370	83	30,700	300	124,700	420	155,400
Land Reclamation	m^2	28,300	1.3	36,800	5.2	147,200	6.5	184,000
Dredging of Access Channel and Basin	m^3	321,000	0.2	64,200	1.0	321,000	1.2	385,200
Road	m	630	5.5	3,500	13.5	8,500	19	12,000
Parking Area	m^2	4,600	0.3	1,400	0.7	3,200	1.0	4,600
Navigation Aids, Ancillaries	L.S	1		3,000		17,200		20,200
Vessels for Maintenance Dredging	L.S	1				66,000		66,000
Towing Construction Crafts	L.S	1				504,000		504,000
Transportation of Construction Material and Equipment	L.S	1		69,000		254,600		323,600
Fishery Related Facilities				144,800		883,400		1,028,200
Ice Plant, Refrigerator and Cold Storage Facilities (Including Cooling and Generating Facilities)	L.S	1		90,000		500,000		590,000
Water Supply Facilities	L.S	1		4,800		16,000		20,800
Oil Supply Facilities	L.S	1		25,000		10,000		35,000
Refrigeration Vessel	Boat	1				220,000		220,000
Transportation	L.S	1		25,000		137,400		162,400
Engineering and Supervise	L.S	1				170,000		170,000
Physical Contingency	L.S	1		57,500		247,000		304,500
Total				722,000		3,778,000		4,500,000
Contingency (Price Escalation)	(%)	(30)		(220,000)		(1,130,000)		(1,350,000)
Grand Total				(942,000)		(4,908,000)		(5,850,000)

Amounts in parentheses are based on the assumption that the rate of escalation is 30% per three years.

Table 10-5(2) Construction Cost ($)

Unit: in US$

Facilities	Unit	Quantity	Local Currency		Foreign Currency		Total	
			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
Preparation and Temporary Works				244,000		551,000		795,000
Temporary Buildings (office, lodgings, warehouse etc.)	L.S	1		158,000		259,000		417,000
Machines, Electricity, Water Supply Equipment	L.S	1		6,000		25,500		31,500
Temporary Road	L.S	1		80,000		266,500		346,500
Port Facilities				2,354,500		11,837,000		14,191,500
Revetment	m	500	380	190,000	920	460,000	1,300	650,000
Transitional Part of Wharf	m	100	345	34,500	805	80,500	1,150	115,000
Groin	m	1,030	480	494,500	1,920	1,977,500	2,400	2,472,000
−1.5 m Wharf (Pier)	m	100	1,125	112,500	4,025	402,500	5,150	515,000
ditto (Bulkhead)	m	100	360	36,000	1,490	149,000	1,850	185,000
−3.0 m Wharf (Pier)	m	370	1,200	444,000	4,150	1,535,500	5,350	1,979,500
ditto (Bulkhead)	m	370	415	153,500	1,500	623,500	2,100	777,000
Land Reclamation	m^2	28,300	6.5	184,000	26	736,000	32.5	920,000
Dredging of Access Channel and Basin	m^3	321,000	1	321,000	5	1,605,000	6	1,926,000
Road	m	630	27.5	17,500	67.5	42,500	95	60,000
Parking Area	m^2	4,600	1.5	7,000	3.5	16,000	5	23,000
Navigation Aids and Ancillaries	L.S	1		15,000		86,000		101,000
Vessels for Maintenance Dredging	L.S	1				330,000		330,000
Towing Construction Crafts	L.S	1				2,520,000		2,520,000
Transportation of Construction Material and Equipment	L.S	1		345,000		1,273,000		1,618,000
Fisheries Related Facilities				724,000		4,417,000		5,141,000
Ice Plant, Refrigerator and Cold Storage Facilities (Including Cooling and Generating Facilities)	L.S	1		450,000		2,500,000		2,950,000
Water Supply Facilities	L.S	1		24,000		80,000		104,000
Oil Supply Facilities	L.S	1		125,000		50,000		175,000
Refrigeration Vessel	Boat	1				1,100,000		1,100,000
Transportation	L.S	1		125,000		687,000		812,000
Engineering and Supervise	L.S	1				850,000		850,000
Physical Contingency	L.S	1		287,500		1,235,000		1,522,500
Total				3,610,000		18,890,000		22,500,000
Contingency (Price Escalation)	(%)	(30)		(1,100,000)		(5,650,000)		(6,750,000)
Grand Total				(4,710,000)		(24,540,000)		(29,250,000)

Amounts in parentheses are based on the assumption that the rate of escalation is 30% per three years.

Chapter 11
Development Effects

Chapter 11 Development Effects

11-1 General

As described in Chapters 2 and 3, at present no facilities for a fishing port exist despite the vital fishing activities that are taking place in Gwadar, which is the most remotely located in Baluchistan Province, the most underdeveloped province among four provinces in Pakistan. It is very clear that developing a Mini-Port in this rural district will greatly contribute to the promotion of fishing industry as well as the regional development, and development effects are considered to be immeasurably high. As such, the direct development effects considered are listed below.

(1) As a result of development of the Mini-Port and its related facilities, fishing boats will be able to berth and discharge their catches, and replenish themselves with ice, water and fuel, thus increasing their operating efficiency and expanding their fishing time. This will contribute to the improvement of fishing productivity in the region; at a time when there is a trend towards larger and motorized fishing boats, the availability of a modern fishing port will greatly accelerate the increase in fish catch and increase the protein supply in the region and in Pakistan.

(2) Through the arrangement of an ice plant, refrigerator and refrigeration vessel, the export of a large quantity of highgrade shrimp via Karachi will become possible, which will contribute to securing of more foreign currencies through exportation.

(3) Occasionally 150-ton class coastal steamers sail along the Makran coast, but they do not call at Gwadar due to the lack of a port facility. Since these steamers will be able to berth at the proposed Mini-Port, it will accelerate the use of coastal shipping as major means of transportation for the basic living commodities, in place of truck transport which is irregular and expensive.

(4) At present, coastal trade vessels of National Shipping Corporation (NSC) call at Gwadar three or four times a year to supply wheat. Though these vessels will be unable to approach Gwadar because of their draft even after the development of Mini-Port, larger barges may be used than before for cargo handling in the offing and they can perform unloading after berthing, so that cargo-handling time can be reduced and thus reduce the anchorage days of the vessels and save in operation cost.

In this chapter, the four items listed above will be treated as direct effects, and numerically analyzed as benefits within the allowable range. However, indirect and spread effects from the development of the Mini-Port are considerable, and should be considered.

11-2 Analysis Assumptions

In performing an analysis on the effects of the development, the following premises are made:

(1) The development effect will be computed as the difference between the case where the Mini-Port is operating and the case where there is no port facility at Gwadar. The analysis assumes the facility has a 30 year life.

(2) Fish catch and the number of fishing vessels in 1983 are as projected in Table 11-1, based on Table A 8-2.

Table 11-1 Forecast of Fish Catch and Vessels

Project	Fish Catch (tons)	Fishing Vessels		
		Powered Vessels	Non Powered Vessel	Total
With port	62,760	549	421	970
Without port	32,270	355	615	970

(3) Based upon Table A 8-2, the population of Gwadar in 1983 will be 26,000.

(4) Prices used for the calculations of costs and benefits are based on the prices of 1979, but fish prices are based on 1978 costs.

(5) Cost benefit analysis will be made for the project life of 30 years from 1981, the year scheduled for the beginning of the investment, to 2010.

11-3 Costs and Benefits

11-3-1 Costs

The scope of the costs includes the construction cost of the Mini-Port (Port facilities and fishery related facilities), costs required for maintenance, management and operation of the facilities, and costs of the other related facilities.

(1) Construction cost

The construction cost estimated in Paragraph 10-7-2 will be used, that is Rs 225,000,000 in total. A physical contingency is included in this total but price escalation is not.

Table 11-2 Cost (1)

Construction cost	Physical Contingency	Total
Rs 209,775,000	Rs 15,225,000	Rs 225,000,000

(2) Management, maintenance and operation costs

The annual management, maintenance and operation costs of the Mini-Port are as follows:

1) Management and operation costs including personnel expenses and miscellaneous expenses for the port facilities

2) Maintenance and repair costs including maintenance dredging cost for the port facilities

3) Operation costs including fuel cost, maintenance and repair cost, personnel expenses, and facility renewal cost for the fishery related facilities, excluding the refrigeration vessel

Table 11-3 Cost (2)

Management and operation Costs for Port Facilities	Maintenance and Repair Costs for Port Facilities	Operation Costs for Fishing Related Facilities	Total
Rs 222,000	Rs 1,139,500	Rs 6,454,500	Rs 7,816,000

(3) Costs of other related facilities

In addition to the port facilities of this Mini-Port, construction and purchasing costs of Rs 25,000,000 will be needed for other related facilities, which include the construction of a fish market, a temporary storage shed, an administration office, a fence and gate, roads, a parking area, freshwater tank and piping, fork lifts, trucks and other vehicles, ship building and repair yard, etc. In addition to the construction cost, there will be required an annual maintenance and management cost of Rs 1,250,000.

11-3-2 Benefits

The four major development effects already stated have been quantitatively analyzed. The annual benefits are tabulated as shown below:

Table 11-4 Benefits

Benefits from increased fishing production	Benefit
(1) National economic benefits obtained from the increase in fish catch	Rs 12,030,800
(2) Benefits obtained by exporting shrimps via Karachi	Rs 8,800,000
Sub-Total	Rs 20,830,800
Benefits from transportation of daily commodities	**Benefit**
(3) Benefits by transport of basic subsistence commodities by small cargo boats	Rs 3,060,000
(4) Benefits by wheat transport using NSC's coastal vessels	Rs 33,000
Sub-Total	3,093,000
TOTAL	Rs 23,923,800

As clearly indicated in Table 11-4, the national economic benefits expected to be obtained from the Mini-Port development are mostly related to fishing production, not an unexpected result in view of character of this project. However, one of the outstanding features is that the

projected benefit through the export of the shellfish is relatively high.

This suggests that, as a policy for promoting future fishing, it is important not only to increase the general fish catch, but also to more aggressively pursue the catching of shellfish, due to the high export value of this product.

Concerning the benefits related to the transportation of daily commodities, its total benefit appears small but cannot be ignored since it will bring about the utilization of this Mini-Port as a coastal traffic port, in place of the irregular service of the land transportation presently being used for the daily commodoties.

Benefit calculations have been conducted based on the following considerations.

(1) National economic benefits from fish catch

Based upon the actual records of fishing activities in 1978 (catch: 24,125 tons, sales: Rs 54,490,980), the increase of gross income from fishing is estimated, starting from 1983. The benefits are calculated by deducting the increment of invested cost, in accordance with the method shown below:

Benefit (B) :

$$B = GI - C$$

$$GI = Q_1 \cdot P - Q_0 \cdot P$$

$$C = C_1 - C_0$$

where GI : Increase of gross income
C : Increment of invested cost
C_0 : Invested cost without the Mini-Port
C_1 : Invested cost with the Mini-Port
P : Average price of fish
Q_0 : Fish catch without the Mini-Port
Q_1 : Fish catch with the Mini-Port

Applying the model case where a "Rachin" type fishing boat will be operated on a one-day trip basis, the annual invested cost is calculated by using average gross income, fishing boat building cost, fishing net purchase cost, engine purchase cost, life of boat and engine, and interest.

The required cost per fishing boat, consisting of fuel cost, maintenance and repair cost, capital cost, and crew's share, is calculated for all powered and sail boats.

(2) Benefits obtained by exporting shrimps via Karachi

In Gwadar, the average percentage of shellfish to the total fish catch has been 3.7% for 1977 and 1978. This percentage is estimated to be about 3.0% for 1983. Since fishery statistics for 1977 and 1978 indicate that the export quantity of frozen shrimps is 22% of total shellfish production (by fresh weight), the same percentage is assumed for the export of frozen shellfish, and the benefit is calculated by deducting the production cost in Gwadar and transporting cost between Gwadar and Karachi from the export price.

(3) Benefits from transport of basic commondities by small coastal launches

Presently, commodities other than wheat are transported by land. After the development of the Mini-Port, they shall be shipped by 150 ton coastal launches, which can berth at the port. The annual living commodities to be transported, such as food and clothing but excluding wheat, are projected at 8,880 tons, as shown in Paragraph 8-3 "Forecast of Coastal Shipping". Then, the transporting cost is calculated for truck transport and marine transport, and the difference between these two costs is found and used as the benefit.

(4) Benefits from wheat transport by NSC's coastal vessels

As mentioned, these vessels will not be able to berth at the Mini-Port, but lighters of larger size than previously used can transfer cargo from the vessel to the port. In addition, cargo handling time can be reduced since these barges are able to berth for unloading, so that the number of days at anchorage can be reduced accordingly. Thus, the reduction in operation costs of coastal vessels can be used as a benefit.

11-4 Economic Effects (evaluation)

The cost benefit analysis for 30 years, from 1981 to 2010, performed on the basis of costs and benefits derived in the previous section indicates that the Internal Rate of Return is 3.8%. This is an extremely poor return in terms of an economic industrial project. However, the port will bring forth not only measurable direct effects, but also an extremely large number of indirect and spread effects, as stated below. In addition, the Mini-Port is not strictly an economic project: the true objective is to assist in the social and economic development of this region, by means of the development of the Mini-Port in Gwadar.

11-5 Spread Effects

In addition to the direct benefits of the Mini-Port, other effects described here also should be considered.

(1) The construction of an ice plant and cold storage will raise the quality and freshness of the fish, which will contribute to an increase in fishermen's income as a result of a rise in fish prices and an expansion of domestic consumption of fish.

(2) It is expected that private investment of fishery related facilities in Gwadar will occur, and the quality of dried and salted fish will be improved by a modernization of facilities, which will also promote the production of canned foods and result in the expansion of domestic consumption and the increase of exports.

(3) An increase in exports will contribute to the securing of more foreign currency, and expansion of domestic consumption will increase the people's protein supplies.

(4) The port development will contribute to the stable supply of living commodities and induce stability in the commodity prices.

An additional spread effect is that the role of this Mini-Port is extremely important for the development of Baluchistan Province, and in particular Gwadar City. If no port development is made, fishing as main industry will become stagnated, transport and supply of living commodities will continuously experience difficulties, it will become difficult to cope with population increase, improvements in the living standards of the region will be inhibited, and the economic gap between Gwadar and other regions will be widened.

Gwadar is geographically isolated from other towns in the province, and it is said that the city is socially isolated. However, the development of the Mini-Port will expand the marketing of fish, and create closer relationships with other areas, thus stabilizing and reducing social tensions. Both economically and socially, the effects of the development of the Mini-Port are great, and can immeasurably contribute to the advancement of Gwadar, Baluchistan Province, and Pakinstan.

Table 11-5 Cost Benefit Table (I.R.R.=3.8%)

Unit: Rs. 1,000.-

Year		COST			Benefit	Discount Value (I.R.R.=3.8%)	
		Construction Cost	Maintenance & Operating Cost	Total		Cost	Benefit
1	1981	125,000		125,000		125,000	
2	1982	125,000		125,000		120,425	
3	1983		9,066	9,066	23,924	8,414	22,204
4	1984		9,066	9,066	23,924	8,106	21,390
5	1985		9,066	9,066	23,924	7,809	20,608
6	1986		9,066	9,066	23,924	7,524	19,855
7	1987		9,066	9,066	23,924	7,248	19,127
8	1988		9,066	9,066	23,924	6,983	18,426
9	1989		9,066	9,066	23,924	6,727	17,752
10	1990		9,066	9,066	23,924	6,481	17,103
11	1991		9,066	9,066	23,924	6,244	16,476
12	1992		9,066	9,066	23,924	6,015	15,874
13	1993		9,066	9,066	23,924	5,795	15,292
14	1994		9,066	9,066	23,924	5,583	14,732
15	1995		9,066	9,066	23,924	5,378	14,192
16	1996		9,066	9,066	23,924	5,181	13,673
17	1997		9,066	9,066	23,924	4,992	13,173
18	1998		9,066	9,066	23,924	4,810	12,692
19	1999		9,066	9,066	23,924	4,633	12,225
20	2000		9,066	9,066	23,924	4,463	11,778
21	2001		9,066	9,066	23,924	4,300	11,347
22	2002		9,066	9,066	23,924	4,142	10,931
23	2003		9,066	9,066	23,924	3,991	10,531
24	2004		9,066	9,066	23,924	3,845	10,146
25	2005		9,066	9,066	23,924	3,704	9,775
26	2006		9,066	9,066	23,924	3,568	9,416
27	2007		9,066	9,066	23,924	3,438	9,072
28	2008		9,066	9,066	23,924	3,312	8,739
29	2009		9,066	9,066	23,924	3,190	8,419
30	2010		9,066	9,066	23,924	3,074	8,113
Total		250,000	253,848	503,848	669,872	394,375	393,061

Chapter 12
Administration of Mini-Port

Chaper 12 Administration of Mini-Port

12-1 General

In Gwadar, the development of a Mini-Port is needed and has been long overdue, as it can serve as the foundation for the local fishing industry and livelihood of the city. In order to fully exploit the facilities which will be developed for this Mini-Port, its control and management are exceedingly important.

This Mini-Port, as it sounds, is small in scale. The major considerations for the port are how it may be effectively utilized by fishermen, who are the primary users of the Mini-Port, and what kind of system of control and management should be created. As things now stand, fishermen make free use of the natural shoreline for their operations.The Mini-Port, when its construction is completed, will function best under management, controls,and rules. In addition, there is a need to work out a system by which fishermen will be encouraged to make positive and effective use of the Mini-Port without problems.

12-2 Management and Operation

In respect to the control and management of the Mini-Port, this chapter will make use of the classification specified in Chapter 9. The facilities to be developed are categorized as "port facilities" and "fishery related facilities."

12-2-1 Port Facilities

The port facilities, which consist of mooring facilities, basin, groin, etc., are basically public and nonprofit in character, as they will be used not only by vessels related to fishery but by coastal vessels carrying living commodities. In order that the port functions may be maintained in the most desirable conditions with a fair management, it is desirable for the empowered local administrative body to take direct charge of the control and management of the port.

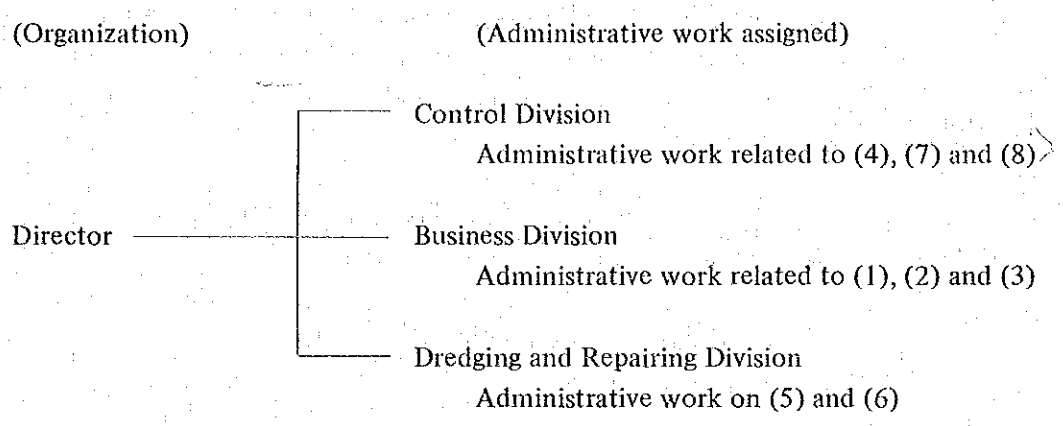
At present, this Mini-Port project is under the jurisdiction of the Ports and Shipping Wing as a federal government project. Upon completion it will be put under the control of the Fisheries Department of Baluchistan Province. It is expected that a management office will be established as a field agency of the Provincial Fisheries Department for the Mini-Port's control and management.

The following lines of control and management may be enumerated so as to maintain the port facilities in optimum condition at all times, to ensure safe ship entries and departures and smooth cargo handling.

(1) Control of ship entries and departures and coordination of berths
(2) Coordination of, and guidance on, work on the apron
(3) Maintenance of order in the port
(4) Guidance on the security and cleaning of the port area
(5) Maintenance and repair of port facilities
(6) Maintenance and dredging of channel and basin
(7) Administration on statistics

(8) Office administration, such as general affairs, accounting and control of the office building

A standard organization for the execution of such control and management is given below:



Presumably, no significant difficulties should be encountered in carrying out the above lines of business. In respect to fishing vessels associated with (1), (2) and (3), it would be practical and effective to seek the cooperation of a local fishermen's organization, to which reference will be made later. Taking note of the scale of the facilities and the volume of administrative work, it would be necessary for this organization to employ 15–20 persons, including a director. If the organization has direct charge of maintenance dredging, there would be a need for an additional 12 seamen for the grab dredger and the dump barge crew. In respect to maintenance dredging, a technical study will be in the next section, 12-3.

12-2-2 Facilities Related to Fishery

The fishery related facilities, consisting of a fish market, an ice plant, a refrigeration plant, and a cold storage, are for the handling, transaction, and storage of fish catch and for the supply of fuel and water.

For the smooth handling of fish catch, the charging of reasonable prices, the effective freezing and cold storage, and the water and fuel supply, it is desirable that the whole fishery related facilities which center upon the fish market are controlled and managed in one lot. From this point of view, it is advisable to commission the control and management to a local fishermen's association so as to encourage the efficient utilization of the facilities and the participation of fishermen.

At present, the Fishermen's Co-operative Society, which exists in Gwadar, is engaged in almost no activities. Given this situation, it is advisable to foster and strengthen this organization, and develop it into a body corporate (e.g., a fishermen's co-operative society under the Co-operative Societies Act) so that it may serve for the control and management of the fishery related facilities.

The only full-fledged fishing port available in Pakistan is Karachi, the facilities of which are placed under the control of Fisheries Department of the Sind Provincial Government. The fish market, ice-making facilities and refrigeration plant are controlled and managed under a subcontract with Fishermen's Co-operative Society Limited Karachi.

In addition to the control and management, it is desirable that the Fishermen's Co-operative Society, which would control and manage the fishery related facilities, would also carry out the following lines of business to work for the promotion of fishery and the upgrading of fishermen's welfare.

(1) Guidance on the modernization of fishery, such as the improvement of fishing techniques, fishing vessels and gear
(2) Development of a fund for loans and subsidies to fishermen
(3) Supply of fishing gear and other fishing equipment and materials
(4) Technical guidance on the qualitative improvement of dried fish and other processed goods
(5) Solicitation to fishery related industries to operate in Gwadar
(6) Surveys and studies on exportable and marketable fish.
(7) Public relations activities to boost fish consumption.

In general, the Pakistanis, excluding those living in the coastal area, do not regularly eat marine fish; it is probably difficult to change this dietary practice immediately. Thus efforts should be made in public relations activities to boost fish consumption.

12-3 Maintenance

There exist no major technical difficulties in the maintenance of this Mini-Port. It is estimated that the volume of channel and basin siltation will be large, so regular observation and dredging will be indispensable to maintain the Mini-Port.

In addition, training must be provided to the personnel required for the maintenance of the ice plant, freezing plant, refrigeration plant and refrigeration vessel.

12-3-1 Estimate of the Amount of Siltation in the Navigation Channel and the Basin

(1) Outline of the Mechanism of Siltation

From the viewpoint of coastal engineering, there are many questions that have yet to be solved in respect to the mechanism of siltation. During planning, it is difficult to have an accurate estimate of the post-dredging conditions. The following possibilities are indicated below:

1) Siltation is different between the channel and the basin
2) Siltation is not uniform in the channel or the basin
3) Seasonally, the siltation occurs in different places
4) The amount of siltation depends on the dredging method (three is a need to study an effective dredging method)
5) Silty sand or sandy silt will be transported in the form not of floatation but of drifting
6) Siltation is influenced by the wind direction and the waves reflected by the groin
7) Suspended mud will be negligible
8) Siltation is confined to the periphery of the dredged area adjacent to the existing seabed
9) The sides of the channel are deformed by waves, currents, and fluctuations in water pressure, the necessitating a greater amount of dredging
10) Vessels passing or crossing the channel cause the siltation to increase

As stated above, it is extremely difficult to estimate the amount of siltation. A preliminary estimate of the siltation is described below:

(2) Estimated Amount of Siltation

On the offshore side of the surf, the amount of sand drift by waves towards the shore may be calculated.

The equation indicative of the sand drift in the direction normal to the beach (on the offshore side of the wave-breaking line) is as follows:

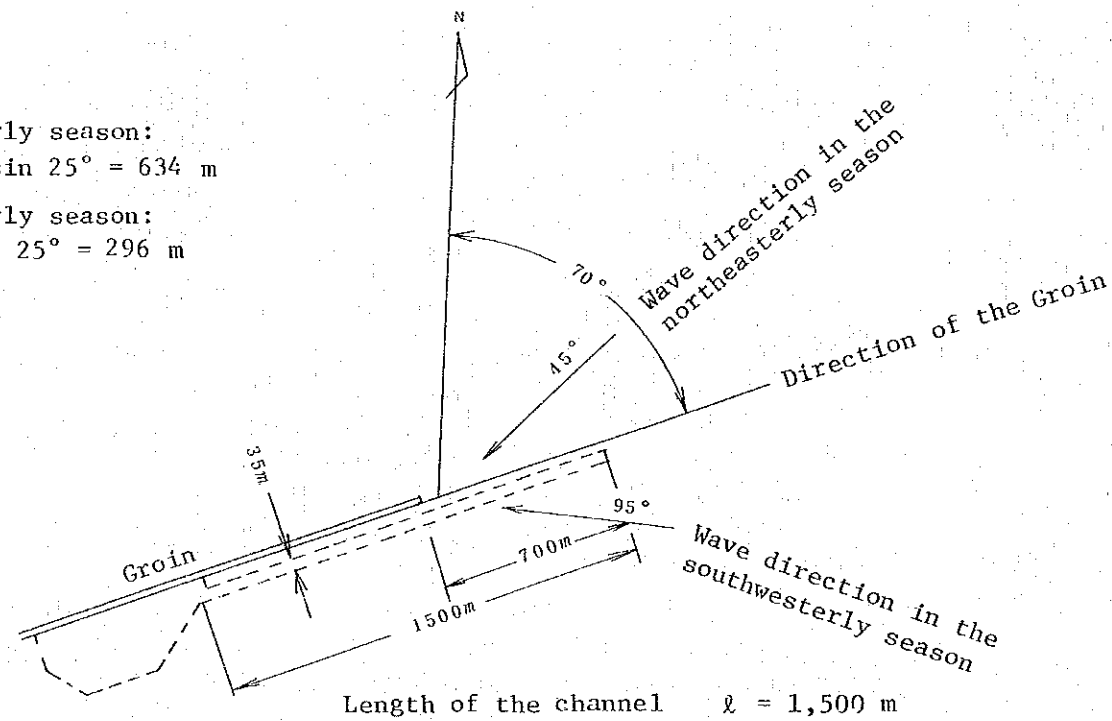
$$q_y = 1.41\,\phi^{6.90} \times 10^{-14}$$

$$\phi = \frac{\frac{\pi H}{T}\left(\sinh\frac{2\pi h}{L}\right)^{-1}}{\left(\frac{\sigma}{\rho}-1\right)^{0.4} g^{0.4} \upsilon^{0.2} d^{0.2}}$$

Incidentally, if it is assumed here that the wave direction at the tip of the groin in the southwesterly and northeasterly seasons is 95° and 45°, respectively (the angle clockwise from the north), the effective length (l′) of the groin will be 634 m and 296 m, respectively.

Southwesterly season:
1,500 m x sin 25° = 634 m

Northeasterly season:
700 m x sin 25° = 296 m



Length of the channel ℓ = 1,500 m

Area of the basin: S = 104,000 m^2

(Southweaserly season)

First, the average wave conditions of the southwesterly season are expressed as follows:

H (wave height):	0.6 m	σ (Specific density):	2.65 t/m^3
T (wave period):	11.0 sec	ρ (Water density):	1.025 t/m^3
h (water depth):	4.5 m	g (Acceleration of gravity):	9.8 m/sec^2
L (wave length):	71.2 m	υ (Kinetic viscosity coefficient of water):	0.01 cm^2/sec = 10^{-6} m^2/sec
d (grain size):	0.06 mm = 6.0 m x 10^{-5}		

Substituting all these factors in the above eqution:

$$\phi = 15.575$$

Therefore, the amount of sand drift is:

$$q_y = 2.368 \times 10^{-6}\ m^3/sec/m.$$

The monthly amount of sand drift is:

$$Q_y = 2.368 \times 10^{-6} \times 3.6 \times 10^3 \times 24 \times 30$$
$$= 6.094\ m^3/month/m.$$

Consequently, the monthly amount of sand drift in the channel is

$$Q = Q_y \times \ell' = 6.094\ m^3/month/m \times 634\ m = 3{,}845\ m^3/month.$$

If it is assumed here that the southwesterly season last for four months, the amount of sand drift in the channel during the season is,

$$Q_{SW} = 3{,}845\ m^3/month \times 4\ months = 15{,}381\ m^3.$$

The average silting velocity in the channel (35 m wide) is:

$$3{,}845\ m^3/month \div 1{,}500\ m \div 35\ m = 0.0732\ m/month.$$

(Northeasterly season)

The wave conditions of the northeasterly season are hypothesized as follows:

H = 0.5 m

T = 9.0 sec

L = 57.5 m

and the other conditions are hypothesized the same as in the southwesterly season.

$$q_y = 0.556 \times 10^{-6}\ m^3/month/m$$

Therefore,

$$Q_y = 0.556 \times 10^{-6} \times 3.6 \times 10^3 \times 24 \times 30 = 1.442\ m^3/month/m.$$

Consequently, the monthly amount of siltation in the channel is

$$Q = Q_y \times \ell' = 1.442\ m^3\ month/m \times 296\ m = 427\ m^3/month.$$

If it is hypothesized here that the northeasterly season lasts for two months,

$$Q_{NE} = 427\ m^3/month \times 2\ months = 854\ m^3.$$

The average silting velocity in the channel is

$$427\ m^3/month \div 700\ m \div 35\ m = 0.0174\ m/month.$$

Next, if it is hypothesized that the silting velocity in the basin (104,000 m^2 in water area) is half that of the channel,

$$0.0732\ m/month \times 1/2 = 0.0366\ m/month$$

in the southwesterly season, and

$$0.0174\ m/month \times 1/2 = 0.0087\ m/month$$

in the northeasterly season.

The silting amount in the basin during the southwesterly season is

0.0366 m/month x 4 months x 104,000 m^2 = 15,226 m^3.

Similarly, the amount in the northeasterly season is

0.0087 m/month x 2 months x 104,000 m^2 = 1,810 m^3.

The annual amount of siltation

	Southwesterly season	Northeasterly season	Yearly
Channel	15,381 m^3	854 m^3	16,235 m^3
Basin	15,226 m^3	1,810 m^3	17,036 m^3
Total	30,607 m^3	2,664 m^3	33,271 m^3

The aforementioned estimates on the amount of siltation should be revised on the basis of the data which are to be accumulated through the successive wave observation now under way.

12-3-2 Maintenance of Ice Plant, Freezing Plant, Cold Storage, Refrigeration Vessel, etc.

An ice plant, a freezing plant, a cold storage, a refrigeration vessel and other facilities are the large facilities which are to be constructed for the first time in Gwadar. For the operation of these facilities, there will be no need for sophisticated technology. However, constant maintenance in Gwadar is required; due to the severe natural conditions, many breakdowns and a reduction in the service life of the equipment will result from improper use.

To cope with this situation, there is a need to assign well-trained maintenance personnel. As training is complicated and time consuming, it is necessary to start their training at Karachi fishing port and other places one year before the completion of the facilities. Ideally, the maintenance personnel will be recruited from Gwadar City.

12-4 Port Charges

The fishing port of Karachi, the only full-fledged fishing port in Pakistan, was opened in 1959. It had been under the jurisdiction of the Marine Fisheries Department of the Ministry of Food and Agriculture until 1976, when it was placed under the control of the Sind Provincial Government. It has not yet become a practice to collect charges for the use of fishing port facilities, due to a wide variety of reasons.

Viewed from this point, it would seem extremely difficult to initially collect port fees for the use of facilities of the Mini-Port. It is desirable that these charges become a practice to offset the current expenses required for the maintenance and repair of the port facilities and thus to transfer this burden from the government to the users of the facility.