Table - 2.5.1-13 Summary of seismic results

Type of Survey Work	Location	No. Map for Each Set	Marking (Drawing No.)	Scale
Seismic Survey	(a)New Port (South haft)	1 No	-SNW / 1 of 1	1:2500
	(b)West of Port	2 Nos.	-SNW / 1 of 2	1:2500
			-WCH / 2 of 2	1:2500
	(c)South of Port	4 Nos	-SCH / 1 of 4	1:2500
			-SCH / 2 of 4	1:2500
			-SCH / 3 of 4	1:2500
			-SCH / 4 of 4	1:2500

(6) Subsoil investigation

Plenty of borings were carried out in 1988 by Russian survey team as described previously. Therefore tens of additional borings were planned. The objective of these borings are as follows:

i) to inspect the accuracy of the soil investigation by Russia by means of comparison with additional borings
ii) to get the geotechnical information for the design of new wharf
iii) to make sure of the depth of rock foundation which affects the dredging cost for construction of new channel

The location of ten borings are shown by Fig. - 2.5.1-9(a). Figure - 2.5.1-9(b) shows the locations of BH-No.1 and No. 2 with the ones of past boring by USSR. All the data such as the disturbed and the undisturbed samples were brought back to the laboratory in Singapore. Table - 2.5.1-14 shows the particulars of bore holes. Table - 2.5.1-15(a) shows the quantity of soil investigation and summary of undisturbed samples respectively. The outcome for this soil investigation has been reported by the separate volumes.

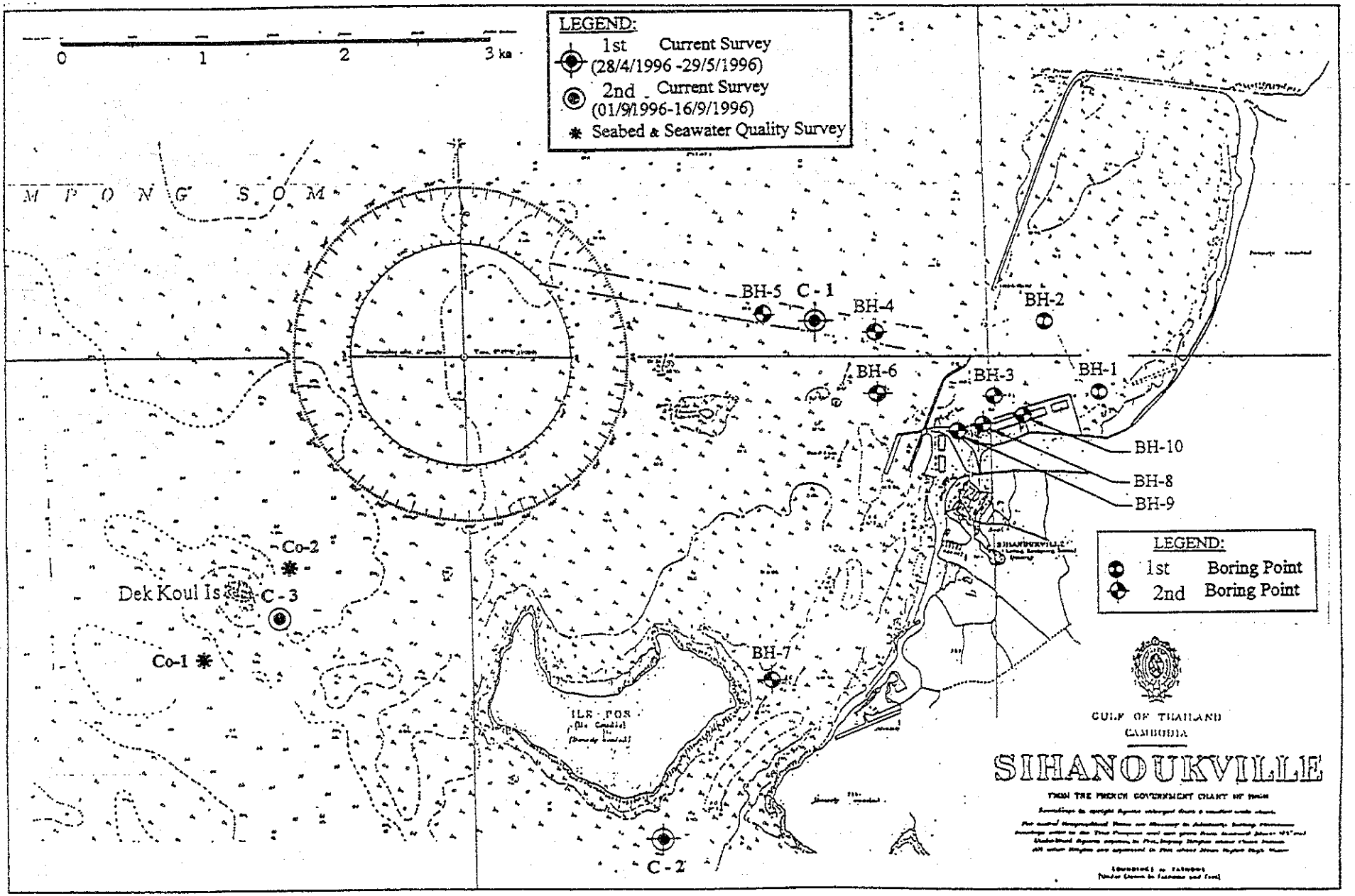


Fig.-2.5.1-9 (a) Location map of subsoil investigation survey

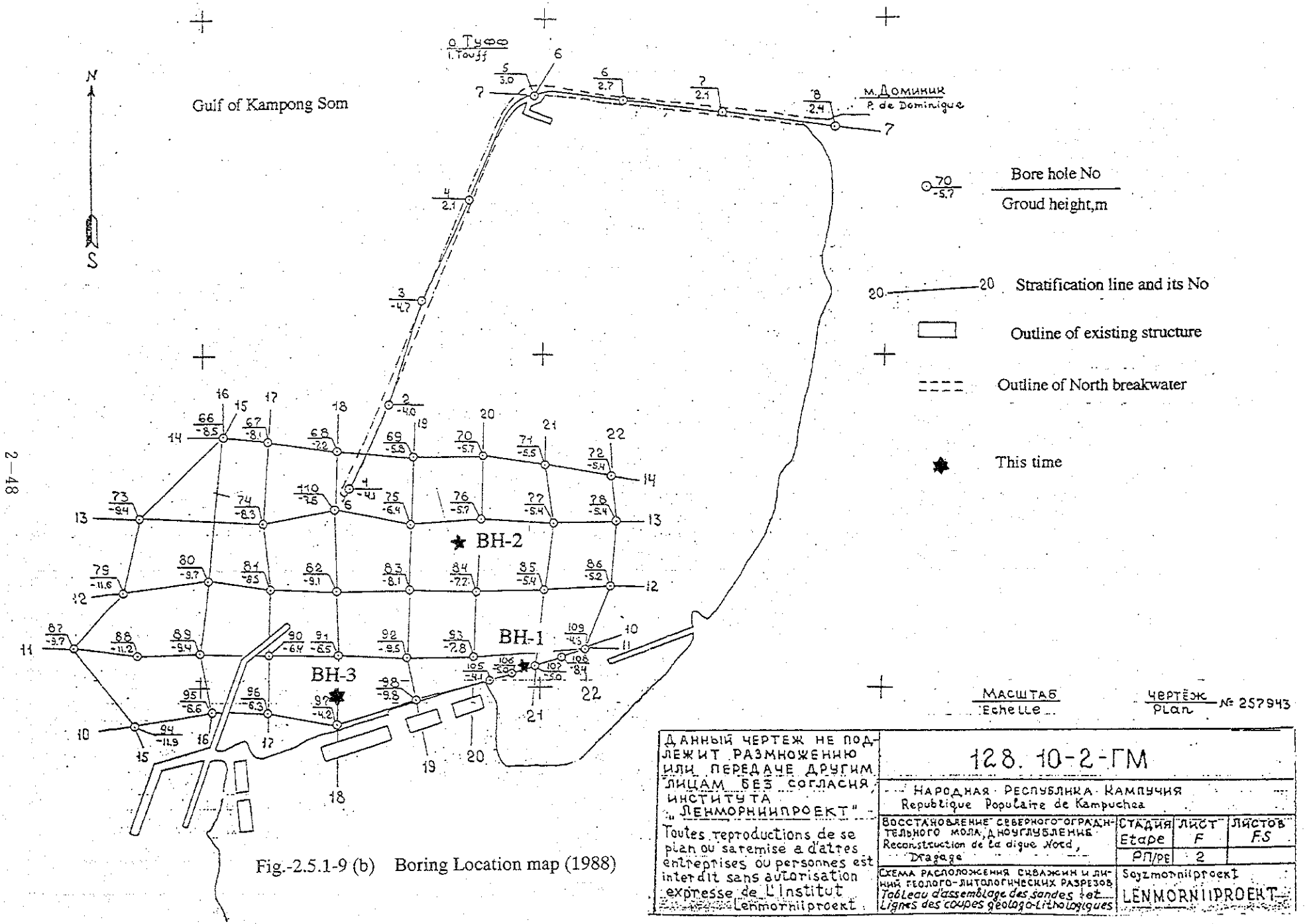


Fig.-2.5.1-9 (b) Boring Location map (1988)

Table - 2.5.1.14 Particulars of bore holes

BH No	Coordinates Nothing	Easing	Sea bed Elevation(m)
BH-1	N10° 38'55"	E103° 30'24"	-4.616
BH-2	N10° 39'10"	E103° 30'12"	-5.896
BH-3	N10° 38'50"	E103° 30'19"	-5.350
BH-4	N10° 39'06"	E103° 29'59"	-9.800
BH-5	N10° 39'10"	E103° 29'40"	-8.400
BH-6	N10° 38'49"	E103° 29'59"	-10.900
BH-7	N10° 37'42"	E103° 29'40"	-9.900
BH-8	N10° 38'45"	E103° 30'12"	+4.100
BH-9	N10° 38'45"	E103° 30'11"	+4.270
BH-10	N10° 38'46"	E103° 30'24"	+3.645

Table - 2-5-1-15(a) Quantity of subsoil investigation works

Boring No.	Total Depth	U.D.	D.S.	SPT	Unit W Test	Water Cont.	Specific . Grav.	Atter. Limit	G/size Anal.	UU Test
BH-1	17.58	2	15	16	15	17	17	4	17	2
BH-2	15.24	3	11	12	11	14	14	6	14	2
S/Total	32.82	5	26	28	26	31	31	10	31	4
BH-3	5.14	5	4	4	2	-	2	-	2	-
BH-4	1.39	3	1	2	2	-	2	-	2	-
BH-5	5.69	5	2	3	2	-	2	-	2	-
BH-6	1.0	-	2	2	-	-	-	-	-	-
BH-7	1.0	-	2	2	-	-	-	-	-	-
BH-8	11.35	-	12	12	8	-	8	-	8	-
BH-9	12.39	-	13	13	7	-	7	-	7	-
BH-10	21.10	-	20	21	12	-	12	-	12	-
S/Total	59.06	13	56	59	33		33	-	33	-

Table - 2.5.1.15 (b) Summary of undisturbed samples

Formation	Soil Layer/ Weathered zone	Bore hole No.	Depth (GL-m)
Alluvium	Silty Sand	BH-1	4.50-5.00
			7.00-8.00
		BH-2	3.00-4.00
			5.00-6.00
	Sandy Silt	BH-2	8.00-9.00
	Marine Clay	BH-3	0.00-0.10
			0.50-0.60
			1.00-1.10
			1.50-1.60
			2.00-2.10
		BH-4	0.10-0.20
			0.50-0.60
			1.00-1.10
		BH-5	1.00-1.10
			1.50-1.60
			2.00-2.10
			2.50-2.60
			3.00-3.10

Table - 2.5.1-17 shows the properties of subsoil material and Table - 2.5.1-18 shows the summary of laboratory test results.

a. BH-No.1 and BH-No.2

By comparison with the current bore logs and the past ones, Fig. - 2.5.1-10 was prepared and the results were quite the same as expected. Therefore, it can be possible to make use of the past results of soil investigation. Figure - 2.5.1-11 shows the stratum alongside the alignment at the New Port wharf being planned. Figure - 2.5.1-12 shows the stratum alongside the new basin and the channel. A legend used in the figures are briefed by Table - 2.5.1-16. According to the Fig. - 2.5.1-11, the depth of bearing stratum varies depending on the location and so additional borings seems necessary for the future detail design. Figure - 2.5.1-10 and Figure - 2.5.1-12 shows that the upper alluvium clay distributes around the ship channel and maneuvering basin and

the percentage of sand fraction of this layer is almost 70% which seems no obstacle for dredging work.

b. BH-No.3

Figure - 2.5.1-13 shows the bore log of BH-No3 which is done in front of the new wharf. The marine clay distributes from the top of sea bed to -8.6m. The sand fraction of this layer is around 50% , and the below is highly weathered rock foundation.

c. BH-No.4 and BH-No.5

Figure - 2.5.1-14 shows the bore logs of BH-No4 and BH-No5. Both figures shows that the distribution of upper marine clay distributes up to -11m ~ -12m. Therefore this layer will not be a obstacle for dredging work.

d. BH-No.6 and BH-No.7

Figure - 2.5.1-15 shows that the sea bed is composed of from highly weathered sandstone to moderately weathered sandstone because of high current caused by the flood and ebb tide.

e. BH-No.8, BH-No.9 and BH-No.10

Figure - 2.5.1-16(a), (b) and (c) shows the borelogs of New Port area. This area were reclaimed by the sandy material and it is still very loose. According to No.8 and 9, the completely weathered zone which seems to be a foundation, distributes from around -5 ~-6m.

Table - 2.5.1-16 Symbles used in the technical report fo engineering research, Vol.2, Geological research engineering (Extended port area)

t_{IV} yellow sandy loam with decayed stone, collurial deposits , fragment of concrete and aggregation of sandy loam, caly, sand. Consistence of sandy-loam, plastic loam, clay - from soft-plastic to hard-plastic. In the sand stone aggregation, there is saturated ground in high level, there is saturated ground in low level.

1a: Grey coloured gravel-sand with clod, collurial deposits, fragment of concrete, medium strength, saturated.

1 δ : Average sized grey-yellow sand with decayed stone detritus, medium strength, saturated

1 β : Fine sand with decayed stone, gravel, detritus, brick, cncrete, little vegetation, midium strength, saturated.

m_{IV}: 2 : Fine sand,; grey,yellow-grey, light grey, grey-green, yellow, with silt stratum, mussel, little gravel, medium strength, saturated

2a : Silt with sandy loam, grey, green, green-grey ewith mussel, big size sand, littel gravel. little vegetation, fluidity and thixiotropy

2 δ : Silt with loam; grey, green, green-grey with mussel, big-scale sand, little gravel. decayed stone, detrius, little vegetation, fluidity, little fluid-plastic, thixiotropy

2 β : Silt with clay, green, grey-green, little black with big-scale sand, mussel, little gravel, decayed stoe, little fluidity vegetation, thixiotropy.

m_{III} : 3a : Loam; (grey, yellow, green-grey) with fine sand, decayed stone, detritus with vegetation, fluid plastic.

3 δ : Loam (yellow,grey, dark grey, green), with decayed stone, detritus, sand stratum, clay, little vegettion, fluid plastic, soft plastic and medium - hard plastic, swelling and sodden in water.

3 β : Clay; (grey, brown, dark-brown, green with sandy stratum and cluster sand, little vegetation with rotten stone, mmedium hard plastic consistence,, aond sodden in water.

3 e : Fine sand; grey, yellow, dark brown, brown, green) with gravel, detritus, midium solidity and solidity, saturated

J 5 ; Sand stone (grey, light grey, yellow, dark-brown, rose, red-yellow, yellow-green), wet and water saturated sand, tight plastic clay

t IV	Ia	IB
Fraction (mm) in		
Grain size distribution		
>10	5	3
10-2	29	8
2-0.5	30	12
0.5-0.25	11	22
0.25-0.1	8	38
0.1>	7	17
ρ	2.68	2.69
ψ (°)	42	30
ψ (°)	38	28

ψ ; Internal friction,

ψ_c ; Internal friction under water

Ia : Silt & clay≒7%, Sand≒49%, Gravel≒29%, Cobble≒5%

Sand

IB : Silt & clay≒17%, Sand≒72%, Gravel≒8%, Cobble≒3%

Sandy soil

m Ⅳ	2	2a	2 σ	2B
Fraction (mm) in				
Grain size distribution				
> 2	7	23	14	4
2 - 0.5	15	10	1	
0.5 - 0.25	20	32	4	1
0.25 - 0.1	43	7	32	19
0.05 - 0.002	15	21	32	39
< 0.002		8	17	37
W (%)		35	41	67
WL(%)		31	39	63
WP(%)		25	27	40
IP		0.06	0.12	0.23
IL		1.67	1.17	1.17
ρs (g/cm3)	2.68	2.68	2.74	2.74
γ (g/cm3)		1.78	1.79	1.6
e		1.03	1.157	1.854
ψ (°)	32	19	11	11
C (kg/cm2)		0.03	0.1	0.1
E (kg/cm2)		35	22	18
Cv (cm2/sec)		4x10	5x10	8x10
ν		0.3	0.35	0.42

2 : Clay & Silt≒15%, Sand≒78%, Gravel≒7%
Sandy soil

2a: Clay≒8%, Silt≒21%, Sand≒ 49%, Gravel≒22%
Sandy soil

2 σ : Clay≒17%, Silt≒32%, Sand≒37%, Gravel≒14%
Sandy soil

2B: Clay≒37%, Silt≒39%, Sand≒20%, Gravel≒4%.
Fine-grained

m Ⅲ	3	3a	3B	3e
Fraction(mm) in				
grain size distribution				
2<				3
2 - 0.5	4	1	3	12
0.5 - 0.25	5	5	6	21
0.25 - 0.1	8	18	6	48
0.1 - 0.05	32	9	10	(<0.1) 16
0.05 - 0.002	41	47	44	-
< 0.002	10	20	37	-
W (%)	21	25	0.25	-
WL (%)	23	27	0.4	-
WP (%)	17	16	0.19	-
IP	0.06	0.11	0.21	-
IL	0.66	0.82	0.28	-
ρs (g/cm3)	2.7	2.73	2.74	2.7
γ (g/cm3)	2.04	1.96	2.02	1.34-1.64
e	0.607	0.739	0.691	-
ψ (°)	18	14	15	32
C (kg/cm2)	0.08	0.18	0.22	-
E (kg/cm2)	48	45	90	-
Cv (cm2/sec)	1.2x10-4	2x10-4	3.2x10-4	-
ν	0.3	0.35	0.42	-

3 : Clay≒10%, Silt≒41%, Sand≒49%
Sandy/silt intermediate

3a : Clay≒20%, Silt≒47%, Sand≒33%
Sandy/silt intermediate

3B: Clay≒31%, Silt≒44%, Sand≒25%
Sandy/silt intermediate

3e: Silt≒16%, Sand≒81%, Gravel≒3%.
Sandy soil

Table - 2.5.1-17 (a) Properties of subsoil material

Geological Formation	Soil Layers & Zone	Thickness (m)		N-Value		Description	Existence (at BHs)
		Range	Average	Range	Average		
UPPER ALLUVIUM	Silty Sand	8.50 - 10.00	9.00	0-3	1	This layer is deposits of natural earth material (eg. sand, silt) and waste/organic materials. The colour of this material is greenish grey. Material consists of fine-grained sand, silt, some small seashell fragments and organic matters. The sample is very soft and has high water content.	All Borcholes
LOWER ALLUVIUM	Sandy Silt	2.00 - 3.50	2.80	2 - 14	6	Colour of this material ranges from greenish grey to light grey. The strength of material (N-value) varies from firm to stiff. Material contains fine-grained sand, silt and some organic matters is found on the top part. The sample is non-homogeneous and has medium water content & low plasticity.	All Boreholes
	Sand	2.30	2.30	8 - 12	10	Colour of material is light grey. Material contains fine and well graded sand mixed with little silt. The strength of sand (N-value) is medium dense and sample has medium water content.	BH-1
	Sandy Clay	2.80	2.80	11 - 12	11	Colour of material is brown. Material consists of fine sand, clay and some silt. The sample is non-homogeneous with some traces of fine sand and silty clay mixing together.	BH-1
WEATHERED ROCK	Comple-tely Weathered Zone	0.48 - 3.24	1.86	36 - >50	>50	It is wholly decomposed form of parent rock which exists in colour of light grey or whitish grey. The original rock structure and rock texture are totally destroyed. Material is very dense, silty sand and the component included medium to fine-grained sand and silt. At BH-2, some small quarts gravel in 0.2cm size is found .Sample has low water content and can be deformed by hand pressure.	All Boreholes

Table - 2.5.1-17 (b) Properties of subsoil material

Geological Formation	Soil Layers & Zone	Thickness (m)		N-Value		Description	Existence (at BHs)
		Range	Average	Range	Average		
FILL	Silty Sand	2.00 - 3.00	2.50	5 - 8	7	Colour of material ranges from yellowish to brownish gray. Material consists of medium to fine sand, few gravels, some silt, clay and decayed wood or organic matters. Sand looks well graded and has high permeability. The sample has medium water content.	BH-8, BH-9, & BH-10
UPPER ALLUVIUM	Marine Clay	1.30 - 3.70	2.80	0 - 1	1	Colour of material is greenish gray. Material contains silt, clay, fine sand and some small seashells. Unhomogeneous sample with some traces of fine sand mixed with clayey silt. The bottom of layer contains more silt. Very soft, high water content. Material also consists of some metal materials which are analyzed by chemical test.	BH-3 BH-4, BH-5
	Sand	1.50 - 2.50	2.00	12 - 37	19	Colour ranges from lightly bluish gray to yellowish gray. Dense to very dense. Material consists of medium to fine sand and little silt. At BH-9, sand mixed with thin layer of sandy silt and few gravel fragments. The sample has high permeablity, high water content.	BH-7, BH-8, BH-9
	Silty / Clayey Sand	5.00 - 13.00	8.00	1 - 10	3	Colour is greenish gray. Material consists of fine to medium-grained sand, silt, clay, some small seashell fragments and organic matters. The sample is very loose and has the bad smell. Few small rock fragments are found on the top part of this layer at BH-9. With depth, heterogeneous sand mixed with traces of silt or clay and seashell fragments. The sample has high water content, high permeability.	BH-8, BH-9, & BH-10 BH-6
LOWER ALLUVIUM	Sandy Silt	2	2	4 - 32	18	Colour from grey to blackish grey. Firm to very stiff. Material contains silt, fine sand, some clay and trace of organic matters as decayed wood or carbon material. The sample is non-homogeneous and has medium water content, medium plasticity.	BH-10
WEATHERED SANDSTONE	Completely Weathered Zone	0.48 - 4.10	1.85	8 - 60	35	It is wholly decomposed form of parent rock which exists in colour of grey or yellowish/brownish grey. The original rock structure and rock texture are destroyed completely. Material is weak and contains medium to fine sand cemented weakly with silt. Medium sand as quartz sand has sub-angular to rounded shape. At BH-9, few sub-angular rock fragments of sandstone which is highly weathered are observed with some stains of iron oxides. Sample has low water content and can be deformed by hand pressure.	BH-5, BH-8, BH-9, & BH-10
	Highly Weathered Zone	0.09 - 1.84	0.63	> 100	> 100	Top layer is partially decomposed form of sandstone and material consists of rock fragments of sandstone which are friable, decomposed sandstone as cemented silty sand in which the original rock structure is preserved slightly. The strength of this layer is very hard and the sample has low water content.	BH-3, BH-4, BH-5, BH-8, & BH-9 BH-7

Table - 2.5.1-18 (a) Summary of laboratory test results

Formation & Soil Name /Zone	BH No.	Type of Sample	Depth (m)	Natural Water Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Specific Gravity Gs	Atterberg's Limit			Grain Size Distribution (%)			Unconfined Compr. qu (ton/m^2)
								PL (%)	LL (%)	PI	Gravel	Sand	Silt & Clay	
UPPER ALLUVIUM Silty Sand	BH-1	SPT-1	1.00-1.45	54	1.62	1.21	2.64	-	-	-	-	79	21	
	BH-2	SPT-1		52	1.53	1.05	2.63	-	-	-	-	66	34	
	BH-1	SPT-2	2.00-2.45	49	1.73	1.42	2.62	-	-	-	-	76	24	
	BH-2	SPT-2		45	1.50	0.98	2.64	-	-	-	-	59	41	
	BH-1	SPT-3	3.00-3.45	40	1.90	1.53	2.62	-	-	-	-	78	22	
	BH-2	UD1	3.00-4.00	49	1.60	1.12	2.62	18	49	31	-	51	49	-
	BH-1	SPT-4	4.00-4.45	33	1.73	1.35	2.62	-	-	-	-	76	24	
	BH-2	SPT-3		35	1.80	1.22	2.62	-	-	-	-	56	44	
	BH-1	UD1	4.50-5.00	30	1.92	1.51	2.62	16	32	16	-	71	29	0.60
	BH-2	UD2	5.00-6.00	55	1.65	1.06	2.64	20	55	35	-	51	49	1.50
	BH-1	SPT-5	5.00-5.45	41	1.77	1.33	2.62	-	-	-	-	78	22	
	BH-2	SPT-4	6.00-6.45	48	1.98	1.45	2.63	-	-	-	-	64	36	
	BH-1	SPT-6		46	1.92	1.54	2.62	-	-	-	-	80	20	
	BH-2	SPT-5	7.00-7.45	52	1.96	1.25	2.63	-	-	-	-	62	38	
	BH-1	UD2	7.00-8.00	39	1.85	1.33	2.63	16	33	17	-	55	45	1.40
	BH-1	SPT-7	8.00-8.45	35	1.67	1.22	2.62	-	-	-	-	70	30	
	BH-1	SPT-8	9.00-9.45	32	1.91	1.43	2.62	-	-	-	-	72	28	
	Average			45	1.80	1.30	2.63	18	43	25	-	70	30	1.20
LOWER ALLUVIUM Sandy Silt	BH-2	UD3	8.00-9.00	65	1.58	0.93	2.64	18	56	38	-	38	62	0.90
	BH-2	SPT-6	9.00-9.45	49	1.99	1.29	2.65	12	30	18	-	27	73	
	BH-2	SPT-7	10.00-10.45	30	1.93	1.25	2.66	12	28	16	-	31	69	
	BH-1	SPT-9		28	1.68	1.17	2.65	-	-	-	-	66	34	
	BH-2	SPT-8	11.00-11.45	29	1.97	1.27	2.67	12	31	19	-	22	78	
	BH-1	SPT-10		32	1.64	1.12	2.64	11	29	18	-	52	48	
	Average			39	1.80	1.10	2.66	13	35	22	-	39	61	0.90
LOWER ALLUVIUM Sand	BH-1	SPT-11	12.00-12.45	28	1.73	1.31	2.64	-	-	-	-	88	12	
	BH-1	SPT-12	13.00-13.45	25	1.76	1.40	2.65	-	-	-	-	94	6	
	Average			27	1.75	1.36	2.65	-	-	-	-	91	9	
LOWER ALLUVIUM Sandy Clay	BH-1	SPT-13	14.00-14.45	23	1.70	0.98	2.65	-	-	-	-	60	40	
	BH-1	SPT-14	15.00-15.45	26	1.81	1.05	2.66	13	31	18	-	55	45	
	Average			25	1.76	1.02	2.66	13	31	18	-	57	43	
DELUVIUM Weathered Zone (Silty Sand)	BH-2	SPT-9	12.00-12.45	21	1.88	1.52	2.64	-	-	-	-	87	13	
	BH-2	SPT-10	13.00-13.45	18	1.92	1.58	2.67	-	-	-	-	93	7	
	BH-2	SPT-11	14.00-14.36	17	1.96	1.72	2.65	-	-	-	-	97	3	
	BH-1	SPT-15	17.10-17.55	20	1.90	1.65	2.64	-	-	-	-	90	10	
	Average			19	1.92	1.61	2.65	-	-	-	-	91	9	

Table - 2.5.1-18 (b) Summary of laboratory test results

Geological Formation	Soil Name & Zone	BH No.	Type of Sample	Depth (m)	Natural Water Content (%)	Bulk Density (Mg/m^3)	Specific Gravity Gs	Grain Size Distribution (%)			
								Gravel or Seashells	Sand	Silt	Clay
FILL	Silty Sand	BH-10	SPT-1	1.00-1.45	28	1.67	2.64	8	63	19	10
		BH-8	SPT-2	2.00-2.45	32	1.85	2.65	-	95	5	0
		Average			**30**	**1.76**	**2.65**	**8**	**79**	**12**	**9**
UPPER ALLUVIUM	Marine Clay	BH-4	UD2	0.40-0.70	55	1.78	2.77	27	44	18	11
		BH-3	SPT-2	2.30-2.75	61	1.71	2.66	-	45	36	19
		BH-5	UD4	2.50-2.80	52	1.65	2.68	1	27	57	15
		Average			**56**	**1.70**	**2.70**	**9**	**39**	**37**	**15**
	Sand	BH-8	SPT-3	3.00-3.45	45	1.73	2.64	-	96	4	0
		BH-8	SPT-4	4.00-4.45	51	1.75	2.66	-	95	5	0
		BH-9	SPT-5	2.00-2.45	37	1.77	2.67	-	93	7	0
		Average			**44**	**1.75**	**2.66**	**-**	**95**	**5**	**0**
	Silty/Clayey Sand	BH-9	SPT-2	5.00-5.45	38	1.80	2.69	4	52	28	16
		BH-10	SPT-3	3.00-3.45	42	1.78	2.75	9	66	14	11
		BH-8	SPT-5	5.00-5.45	39	1.68	2.61	-	80	18	2
		BH-10	SPT-5		35	1.85	2.68	-	88	12	0
		BH-8	SPT-7	7.00-7.45	33	1.70	2.66	2	74	13	11
		BH-10	SPT-7		36	1.76	2.67	-	91	9	0
		BH-8	SPT-8	8.00-8.45	41	1.90	2.70	1	66	12	21
		BH-9	SPT-8		45	1.87	2.72	6	39	36	19
		BH-8	SPT-9	9.00-9.45	43	1.85	2.68	2	66	19	13
		BH-9	SPT-9		44	1.88	2.72	4	72	12	12
		BH-10	SPT-9		40	1.78	2.76	-	79	19	2
		BH-9	SPT-10	10.00-10.45	46	1.76	2.72	6	48	32	14
		BH-10	SPT-11	11.00-11.45	48	1.75	2.65	21	67	26	5
		BH-10	SPT-13	13.00-13.45	47	1.73	2.67	1	59	27	14
		Average			**42**	**1.79**	**2.69**	**5**	**68**	**20**	**7**
LOWER ALLUVIUM	Sandy Silt	BH-10	SPT-15	15.00-15.45	39	1.75	2.70	-	20	46	34
		BH-10	SPT-16	16.00-16.45	35	1.77	2.61	-	53	31	16
		Average			**37**	**1.76**	**2.66**	**-**	**36**	**40**	**24**
SANDSTONE	Completely Weathered Zone (Silty Sand)	BH-8	SPT-10	10.00-10.45	31	1.88	2.72	14	64	13	9
		BH-10	SPT-18	18.00-18.45	28	1.92	2.69	-	69	29	2
		BH-10	SPT-19	19.00-19.45	21	1.90	2.63	-	88	11	1
		BH-10	SPT-20	20.00-20.45	18	1.89	2.64	-	55	19	26
		Average			**24**	**1.90**	**2.67**	**4**	**69**	**18**	**9**
	Highly Weathered Zone (Silty Sand)	BH-4	SPT-2	1.35-1.39	25	1.90	2.67	1	75	20	4
		BH-3	SPT-3	3.70-3.96	22	1.86	2.67	-	82	15	3
		BH-5	SPT-2	5.40-5.64	24	1.82	2.76	14	67	16	3
		BH-9	SPT-12	11.65-11.90	19	1.94	2.74	6	47	35	18
		BH-9	SPT-13	11.90-12.39	17	1.97	2.80	7	54	34	5
		Average			**20**	**1.91**	**2.73**	**6**	**65**	**24**	**5**

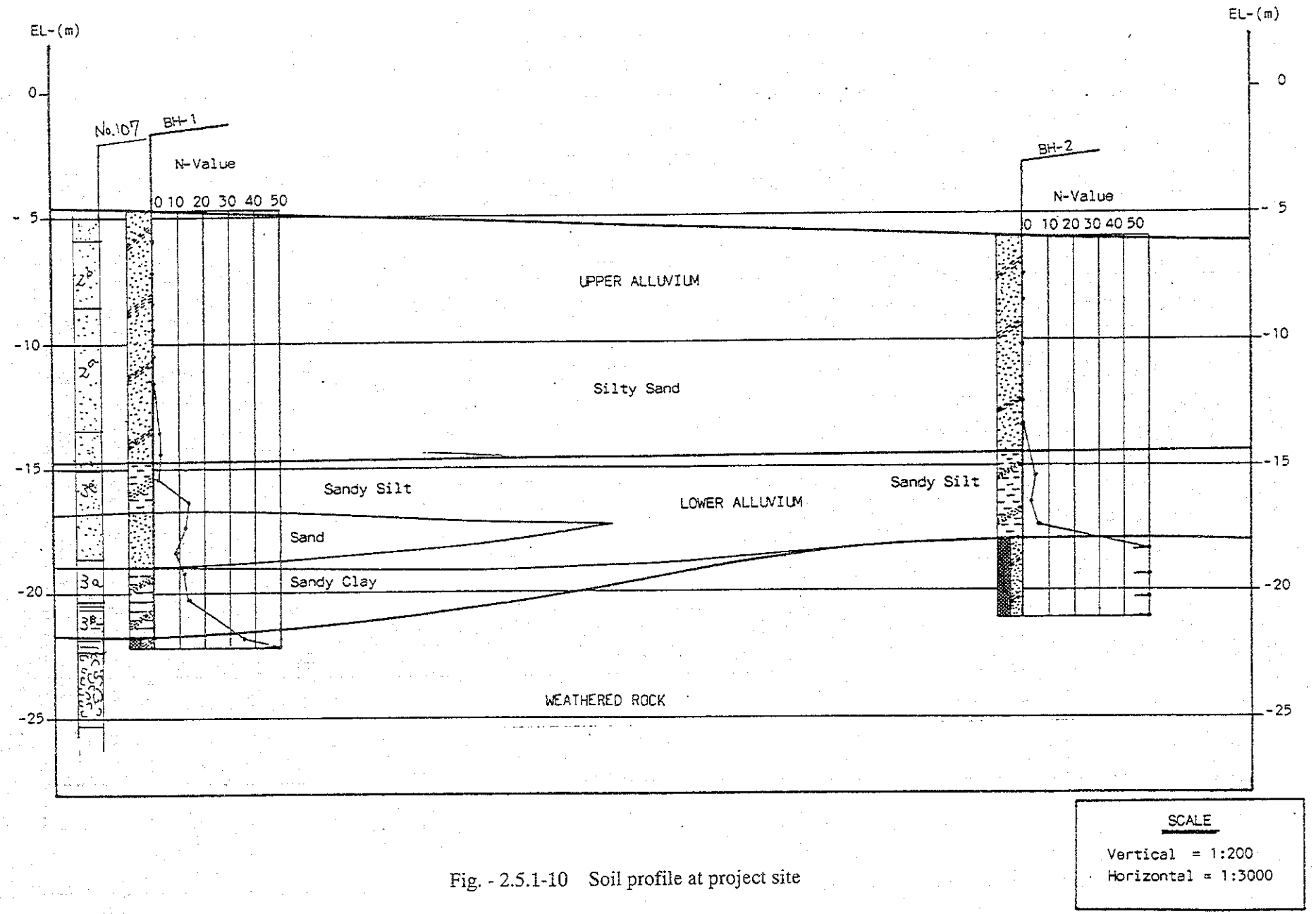


Fig. - 2.5.1-10 Soil profile at project site

BORING LOG

No.: BH-1

LOCATION : KPONG SOM PORT, SIHANOUKVILLE VILLAGE, CAMBODIA
DATE : FROM 26th May , 1996 TO 30th May , 1996

COORDINATES: N 1177559.796, E 55437.834
SEABED ELEVATION : - 4.616 m
SEA WATER LEVEL : 4.40 m

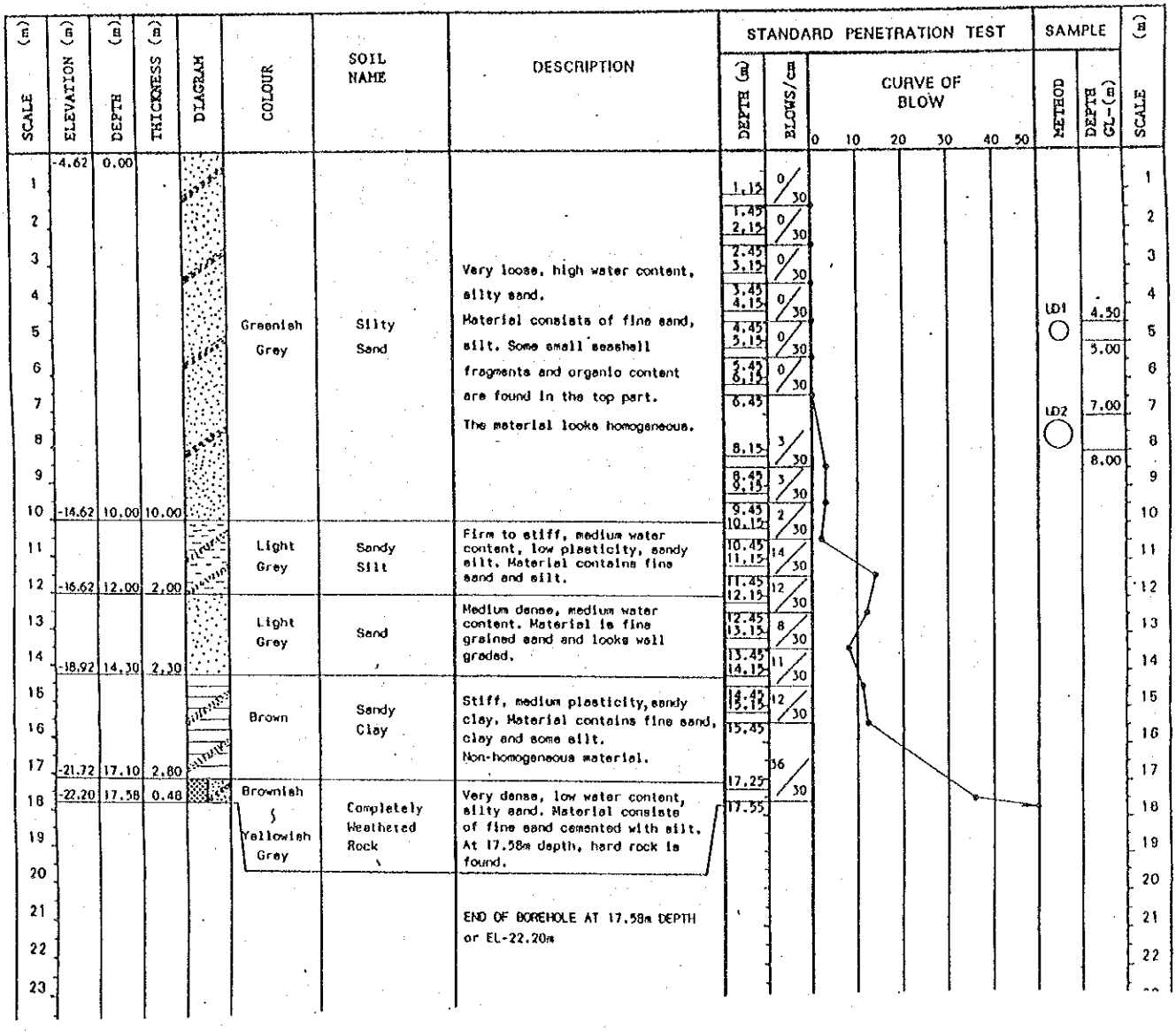


Fig. - 2.5.1-10 (a) Bore log (BH-No.1)

BORING LOG

No.: BH-2

LOCATION : KPONG SOM PORT, SIHANOUKVILLE VILLAGE, CAMBODIA
DATE : FROM 31st May , 1996 TO 1st June , 1996

COORDINATES: N 1178028.738, E 55091.478
SEABED ELEVATION : - 5.896 m
SEA WATER LEVEL : 5.80 m

SCALE (m)	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION
1–8	-5.90	0.00			Greenish Grey	Silty Sand	Very loose, high water content, silty fine sand mixed with small seashell fragment and organic content. The material is homogeneous.
8–12	-14.40	8.50	8.50		Light Grey ~ Greenish Grey	Sandy Silt	Firm, medium water content and low plasticity, sandy silt. Material consists of silt, fine sand and some organic matters. Non-homogeneous material.
12–16	-17.90	12.00	3.50		Light Grey ~ Whitish Grey	Completely Weathered Rock	Very dense, silty sand. Material contains medium to fine sand, silt and some small quartz gravels in 0.2-0.4cm size are found. From 14.30m depth, sand cemented strongly with silt.
16–18	-21.14	15.24	3.24				END OF BOREHOLE AT 15.24m DEPTH OR EL-21.14m

STANDARD PENETRATION TEST

DEPTH (m)	BLOWS/cm	CURVE OF BLOW (0 10 20 30 40 50)
1.15	0/30	
1.45		
2.15	0/30	
2.45		
4.15	0/30	
4.45		
6.15	0/30	
6.45		
7.15	0/30	
7.45		
9.15	5/30	
9.45		
10.15	3/30	
10.45		
11.15	6/30	
11.45	57/30	
12.15		
12.45	52/30	
13.15		
13.45	50/21	
14.15		
14.36	50/24	
15.00		
15.24		

SAMPLE

METHOD	DEPTH GL-(m)
UD1	3.00
	4.00
UD2	5.00
	6.00
UD3	8.00
	9.00

Fig. - 2.5.1-10 (b) Bore log (BH-No.2)

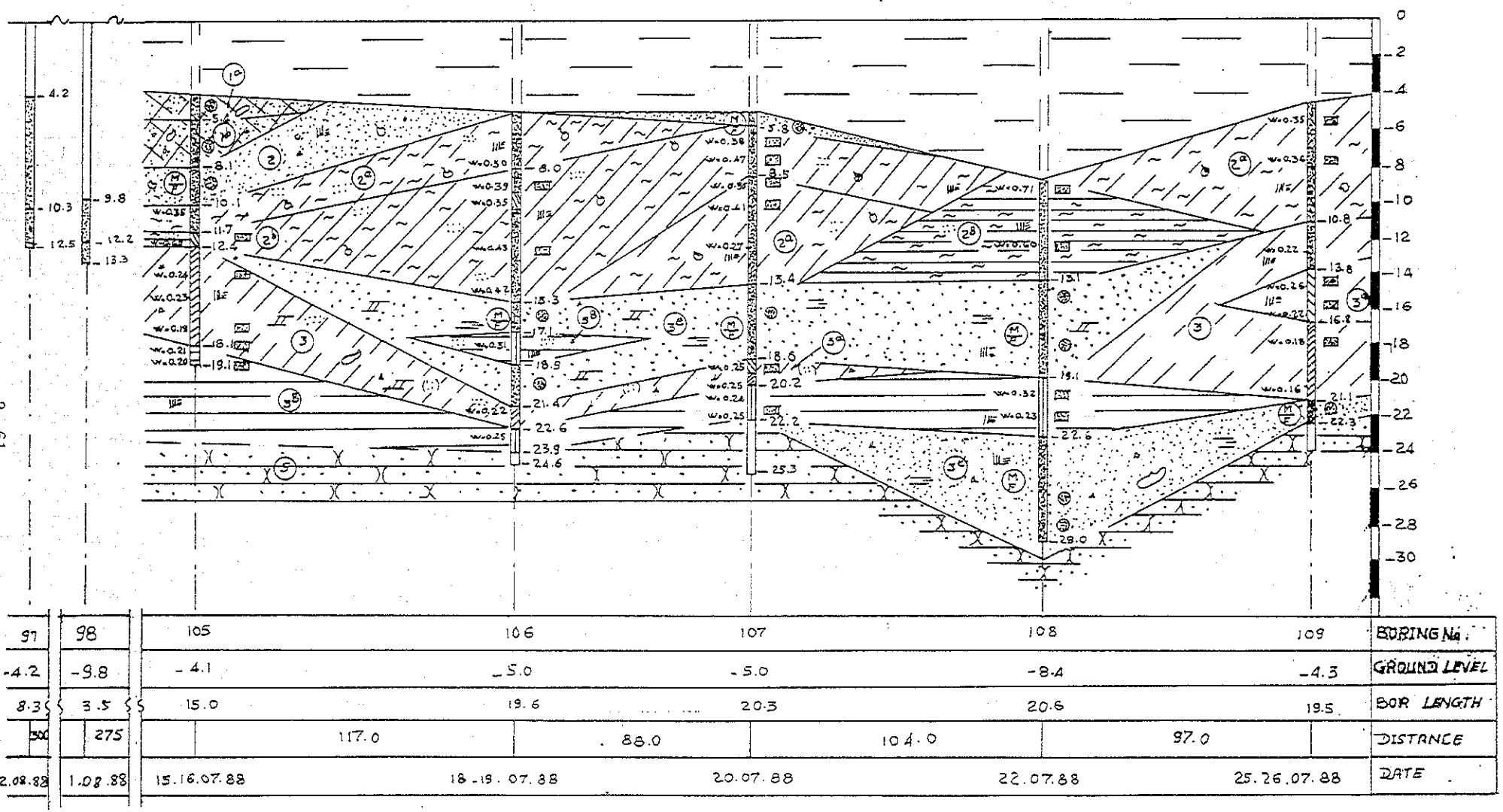


Fig. - 2.5.1-11 Stratification at new wharf planned

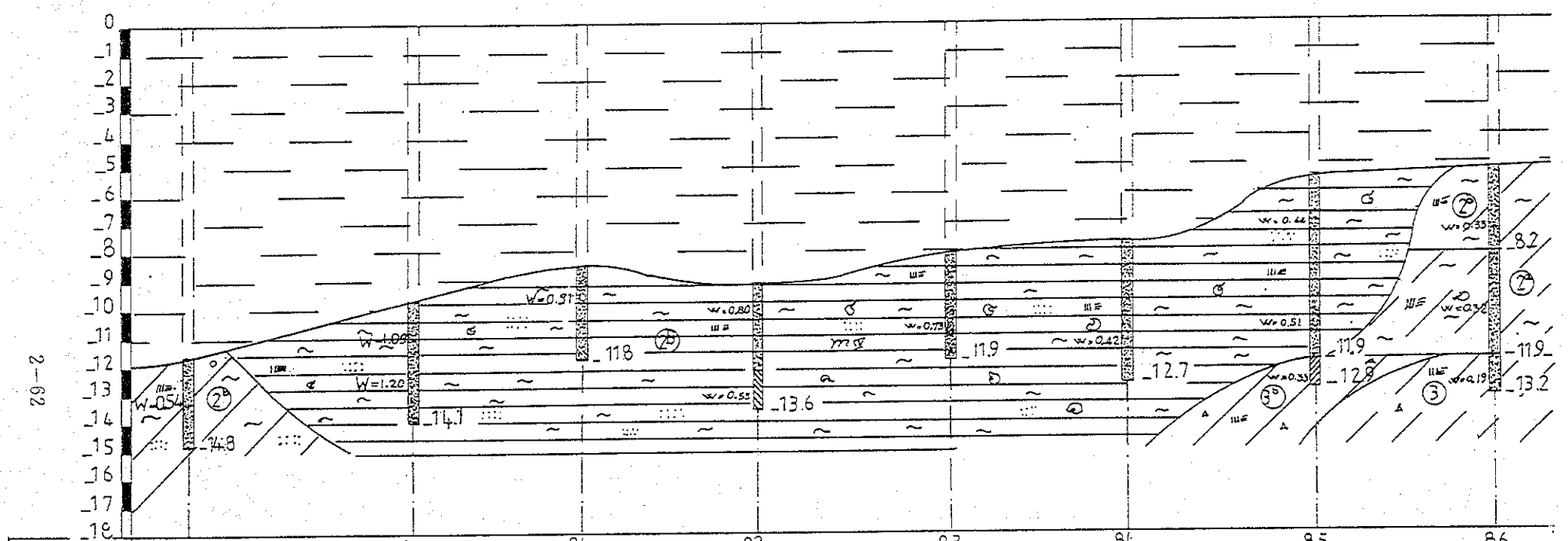


Fig. - 2.5.1-12 Stratification at new port basin

BORING LOG

No. : BH-3

LOCATION : SIHANOUKVILLE PORT, KPONG SOM, CAMBODIA

DATE : FROM 5/12/96 TO 5/12/96

GROUND ELEVATION : RL-5.35 m

GROUND WATER LEVEL : GL- 0.00 m

Scale (m)	Elevn RL (m)	Depth GL- (m)	Thickness (m)	Diagram	Colour	Soil Name	Description	Standard Penetration Test: Depth (m)	Blows/cm	Curve Of Blows (20 40 60 80)	Sample: Method	Sample: Depth GL-(m)	Scale (m)
1					Greenish Gray	Marine Clay	Very soft. High water content. High plasticity. unhomogeneous marine clay mixed with some traces of fine sand and a few of seashell fragments. From GL-2.00m, material contains more silt and the sample looks homogeneous. Some seabeds were collected for the chemical analysis.	1.45 / 1.75	1 / 30		○	0.10	1
2								2.45 / 2.75	1 / 30		○	0.30 / 0.70 / 1.00 / 1.30	2
3	-8.6	3.30	3.30								○	2.00 / 2.30	3
4					Reddish Brown	Highly Weathered Zone	Hard, medium water content, medium-grained sand cemented with silt and sub-angular rock fragments of sandstone which is highly weathered.	3.85 / 3.96	100 / 11				4
5	-10.5	5.14	1.84					5.10 / 5.14	100 / 4				5

Fig. - 2.5.1-13 Bore log (BH-No.3)

BORING LOG

No. : BH-4

LOCATION : SIHANOUKVILLE PORT, KPONG SOM, CAMBODIA
DATE : FROM 10/12/1996 TO 10/12/1996

GROUND ELEVATION : RL-9.8 m
GROUND WATER LEVEL : GL- 0.00 m

Scale (m)	Elevn RL (m)	Depth GL- (m)	Thickness (m)	Diagram	Colour	Soil Name	Description	Standard Penetration Test: Depth (m)	Blows/cm	Curve Of Blows (20 40 60 80)	Sample: Method	Sample: Depth GL-(m)	Scale (m)
					Greenish Gray	Marine Clay	Very soft, high water content, high plasticity silty clay mixed with fine sand and seashell fragments. Material contains more silt and clay with depth and the sample looks homogeneous.				○	0.10 0.40 0.46 0.70 1.00	
											○		
											○		
1													1
	-11.1	1.30	1.30					1.30	70			1.30	
	-11.2	1.39	0.09		Yellowish Brown	Highly Weathered Zone	Hard, highly weathered sandstone is partially decomposed to silty fine sand with rock fragments are found in the bottom part.	1.39	5/1				
2													2

Fig. - 2.5.1-14 (a) Bore log (BH-No.4)

BORING LOG

No. : BH-5

LOCATION : SIHANOUKVILLE PORT, KPONG SOM, CAMBODIA
DATE : FROM 10/12/1996 TO 10/12/1996

GROUND ELEVATION : RL-8.4 m
GROUND WATER LEVEL : GL- 0.00 m

Scale (m)	Elevn RL (m)	Depth GL- (m)	Thickness (m)	Diagram	Colour	Soil Name	Description	Standard Penetration Test: Depth (m)	Blows/cm	Curve Of Blows (20 40 60 80)	Sample: Method	Sample: Depth GL-(m)	Scale (m)
1												1.00	1
											○	1.30 1.50	
											○		
2					Greenish Gray	Marine Clay	Very soft, high water content. High plasticity sandy clay mixed with silt and small seashell fragments. Sand is fine and the sample has bad smell. From GL-2.50m, material contains more silt and therefore material is firm and has low water content with depth. The sample has high permeability and looks homogeneous.					1.60 2.00	2
											○	2.70 2.80	
3											○	2.80	3
	-12.1	3.70	3.70					3.65				3.20	
4					Reddish Brown	Completely Weathered Zone	Very weak, completely weathered surface of sandstone contains some rounded hard cores cemented weakly with mottled silt.	3.95	10/30				4
5	-13.8	5.40	1.70					5.40					5
	-14.1	5.69	0.29		Yellowish Gray	Highly Weathered Zone	Hard, low water content, highly weathered sandtone. Material contains decomposed sandstone as silty fine sand and rock fragments.	5.64	100/24				
6													6

Fig. - 2.5.1-14 (b) Bore log (BH-No.5)

BORING LOG

No. : BH-6

LOCATION : SIHANOUKVILLE PORT, KAMPONG SAOM, CAMBODIA
DATE : 10th DECEMBER 1997

GROUND ELEVATION : BL-10.9 m
GROUND WATER LEVEL : GL-11.00 m

Scale (m)	Elevn BL (m)	Depth GL- (m)	Thickness (m)	Diagram	Colour	Soil Name	Description	Standard Penetration Test: Depth (m)	Blows/cm	Curve Of Blows (20 40 60 80)	Sample: Method	Sample: Depth GL-(m)	Scale (m)
	-10.9	0.04	0.04		Greenish Grey	Silty Sand	Very loose, High water content, High permeability, Poorly graded, silty sand mixed with seashell fragments.						
					Reddish Brown & Light Greenish Grey	Highly Weathered Sandstone to Moderately Weathered Sandstone	Moderately strong to strong, friable highly to mod. weathered sandstone. Top of weathered rock is highly weathered and the color is reddish brown. The thickness ranges from above ice to 2m. The rock surface has high porosity. The fresh rock surface is moderately weathered sandstone and the color of material is lightly greenish grey. The rock structure and texture are preserved with quartz sand has medium to fine-grained size. Some coarse sands as gravels are in sub-angular shape and cemented strongly with matrix of silt. Some veinlets of iron oxide is highly weathered and changed to dark brown color.						
1		1.00	0.96										1

Fig. - 2.5.1-15 (a) Bore log (BH-No.6)

BORING LOG

No. : BH-7

LOCATION : SIHANOUKVILLE PORT, KAMPONG SAOM, CAMBODIA
DATE : 10th DECEMBER 1997

GROUND ELEVATION : BL-9.9 m
GROUND WATER LEVEL : GL- 9.00 m

Scale (m)	Elevn BL (m)	Depth GL- (m)	Thickness (m)	Diagram	Colour	Soil Name	Description	Standard Penetration Test: Depth (m)	Blows/cm	Curve Of Blows (20 40 60 80)	Sample: Method	Sample: Depth GL-(m)	Scale (m)
	-9.9	0.04	0.04		Brownish Grey	Loose Sand	Loose, High water content, poorly graded, non-homogeneous, sub-angular and highly permeable sand mixed with a lot of corals & seashell fragments						
					Reddish Brown & Light Grey	Highly Weathered Sandstone To Moderately Weathered Sandstone	Moderately strong to strong, friable, weathered sandstone. Topped rock is highly weathered sandstone remaining medium to coarse-grained sand which is cemented weakly with some matrix of silt, the sample has high porosity Some gravels or coarse sand are found on rock surface and has the rounded shape caused by erosion of water. The fresh rock is strong and the color is light grey. The original rock texture and structure are preserved with inter-granular structure. Some tiny veins of silt or iron oxide are observed. The sample has medium to low water content and can not be broken by hand.						
1	-10.9	1.00	0.96										1

Fig. - 2.5.1-15 (b) Bore log (BH-No.7)

BORING LOG

No. : BH-8

LOCATION : SIHANOUKVILLE PORT

DATE : FROM 30/11/96 TO 02/12/96

GROUND ELEVATION : RL+4.13 m

GROUND WATER LEVEL : GL- 2.85 m

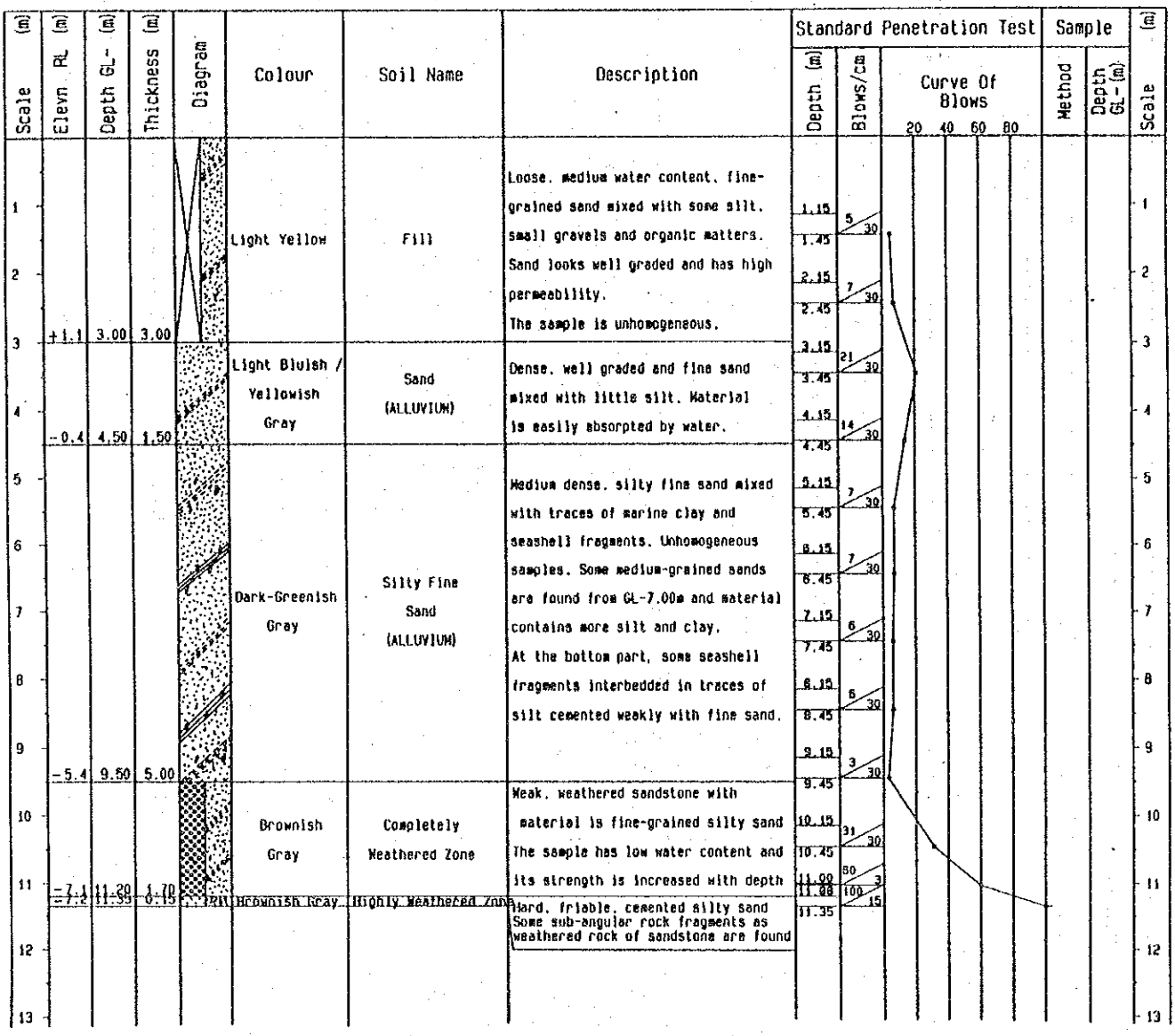


Fig. - 2.5.1-16 (a) Bore log (BH-No.8)

BORING LOG

No. : BH-9

LOCATION : SIHANOUKVILLE PORT, KAMPONG SAOM, CAMBODIA
DATE : FROM 03/12/1996 TO 04/12/1996

GROUND ELEVATION : AL+4.27 m
GROUND WATER LEVEL : GL- 2.65 m

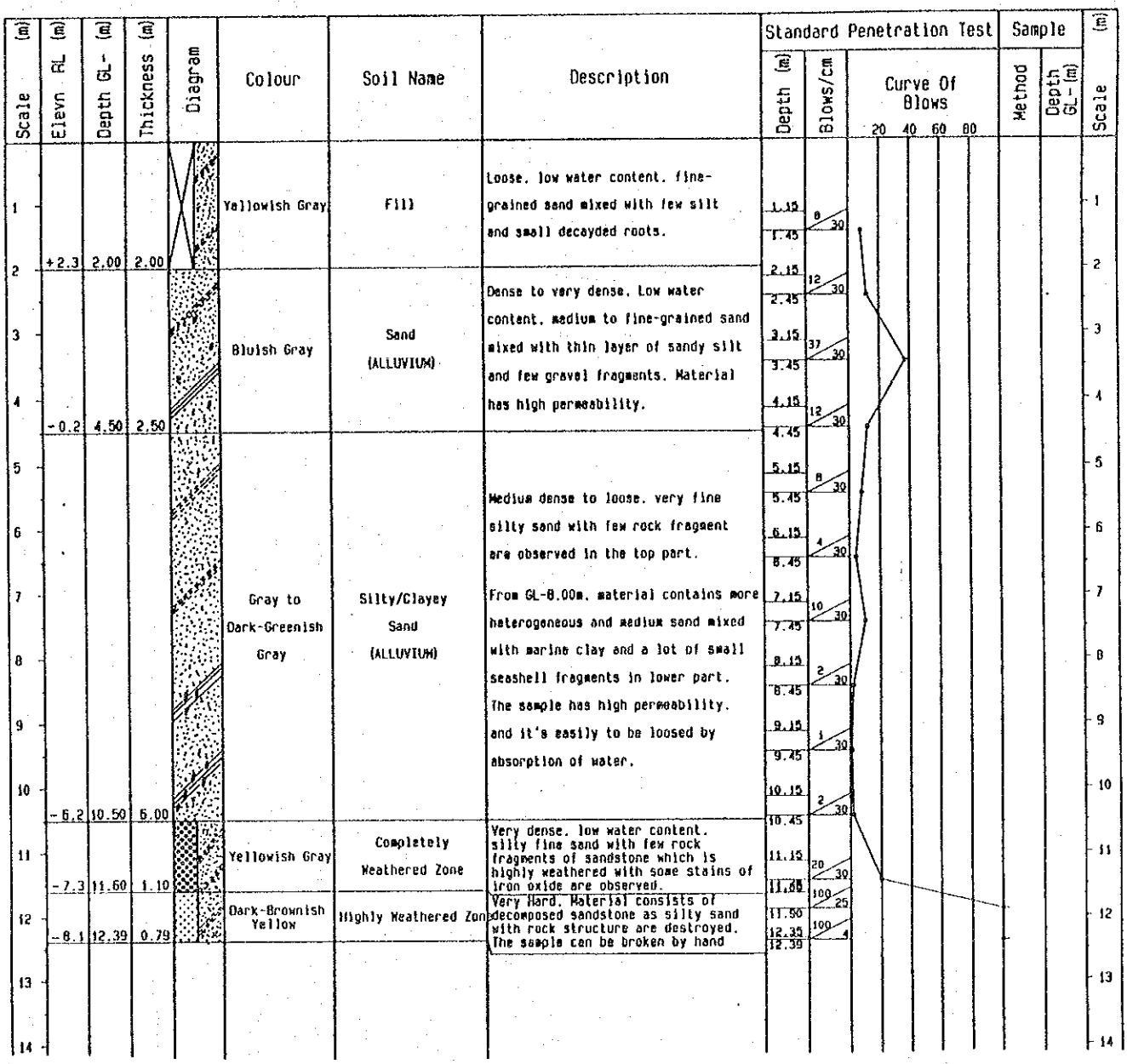


Fig. - 2.5.1-16 (b) Bore log (BH-No.9)

BORING LOG

No. : BH-10

LOCATION : SIHANOUKVILLE PORT, KAMPONG SAOM, CAMBODIA
DATE : FROM 14/12/96 TO 14/12/96

GROUND ELEVATION : RL+3.645 m
GROUND WATER LEVEL : GL- 1.55 m

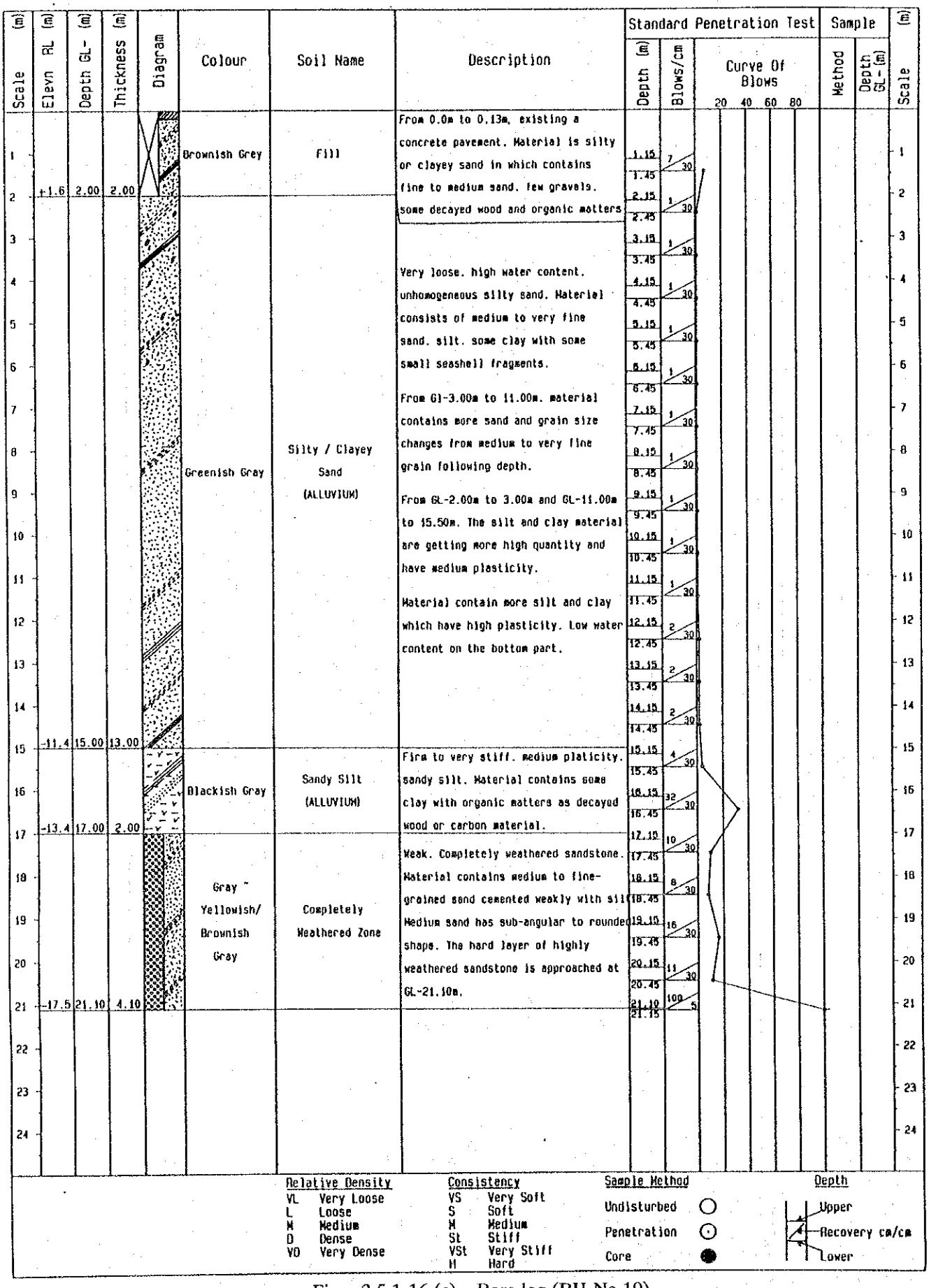


Fig. - 2.5.1-16 (c) Bore log (BH-No.10)

(7) Tidal observation and results of harmonic analysis

a. General

A sea level keeps on fluctuating all the times and its up-and-down movement with a long periodic fluctuation, excluding the short periodic one such as a waves, a swell, a seiche etc., is called as a tide. This fluctuation of tide is mainly caused by an astronomical gravity force like a lunar and a solar and then, such a tide, in particular, is defined as an astronomical tide.

The premier objective for tidal observation is to determine the mean sea level (MSL), which is important standard level for the topographic survey and the construction datum level (CDL) for marine work, for Sihanoukville Port.

Mean Sea Level

Since MSL is used as datum level of land surveying or various kinds of datum level, MSL should be constant. However MSL is likely to change by an atmospheric pressure, a wind, a density of sea water and so on. The MSL is obtained by averaging the every hourly tidal data and so depends on the duration of observation, e.g. a daily mean sea level, a monthly mean sea level, yearly mean sea level.

i)	Daily MSL;	As obtained by averaging a tidal data through 0 hour to 23 hours, it varies day by day.
ii)	Monthly MSL;	As obtained by averaging daily MSL through one month, it also varies month by month but more stable than the case of Daily MSL.
iii)	Yearly MSL;	As obtained by averaging the monthly MSL for twelve months, it varies year by year. The theoretically favorable period are said to be either 11 years 19 years.

MSL is most important datum level. However, as stated above, it is not easy to get 19 years data or even 11 years. Furthermore, a long period data may include the influence of ground movement. Thus 5 year data is practically used in Japan.

Construction Datum Level (for Marine Works)

Chart datum is usually utilized for the Chart. It must be possible lowest level so that the tide can not hardly ever be lower than it. According to Admiralty Tide Tables and Tidal Stream Tables (see 2.5.1, (3), b, 2)), the lowest low water in Cambodia is determined as 1.07m. It is presumed that Cambodia occurred such a lowest tide level in the past. Therefore the relationship between MSL and Chart Datum is :

Chart Datum = MSL - 1.07m (in Cambodia)

On the other hand Japan introduced the Indian Spring Low Water level, which is equal to the level below the sum of (Hm+Hs+H'+H0). And Construction Datum level is determined as the same as Chart Datum. The reason why Japan introduced the following equation is that if the lowest low water is introduced into the marine construction, the construction cost become high. Since the discrepancy between the lowest low water and CDL is nearly 40cm. It seems nominnent for the construction works and ship maneuvering.

Chart Datum = Construction Datum Level
= MSL - (Hm+Hs+H'+H0) (in Japan)

Hm; Principal lunar semidiurnal component
Hs; Principal solar semidiurnal component
H'; Luni-solar diurnal component
H0; Principal luar diurnal component
(Hm+Hs+H'+H0)=Majour four components

Therefore the majour four components are important constants for determining the CDL and they are obtained by the Harmonic Analysis.

Harmonic Analysis

When tidal data are plotted with a time, it is well known that a shape of tide curve become a cosine-shaped one. Therefore, on the assumption that a series of tide curve is composed of several tens of cosine curve with great regularities, both an amplitude and a phase lag of each curve (e.g. a harmonic constant) consisting of the tide curve are obtained by a harmonic analysis of tide, with which each curve is called as a tidal constituent.

A great deal of labour was needed to solve the equation of harmonic analysis in the distant past, but a appearance of computer made it easy to solve a complicated equation using the method of least square. By means of the harmonic analysis, the harmonic constants for the each tidal constituent are obtained. Among these harmonic constants, four majour constants, which are most influential to the shape of tide curve.

b. Tide observation

A tidal observation had been conducted by the Russian survey team from February to December, in 1988. However, the accuracy of those data are not obvious and furthermore Sihanoukville Port needs the reliable Mean Sea Level determined by the long term tide observation. In this sense, the automatic tidal gauge was set up for the long period observation at Sihanoukville Port.

i) Location of gauge

A location of the tide gauge was determined shown by Fig. - 2.5.1-17, considering the conditions of the easy maintenance, a sufficient depth against the tidal fluctuation, to be the sheltered area from the wave outside, not to be obstacle for the mooring of the ships.

ii) Setup of tide gauge

A new tide gauge, Fuess Type Long Term Tide Gauge (model; LFT-V) was set up on 13 May and the data collection was commenced from 20 May after some adjustment work. The schematic figure of the tide gauge structure is shown by Fig. - 2.5.1-18, in which the importance is the reference level of steel tape, e.g. M.S.L +2.920. As shown by this figure, there are 3 small holes to get the water in the pipe, but for the stuff of those holes by the growing of the shell, the kind of ' big window ' was prepared below the water level so as to clean up those holes. It is proposed to clean up every one month, when the record paper is refilled.

iii) Observation

The observation by the automatic tide gauge was started from 20 May. But, preceding the commencement of automatic observation, a visual tide observation by the tide staff, which was also set up nearby the automatic one, was commenced from 11 May for the possibility of automatic observation delay. Therefore, a practical commencement date of observation is 11 May and then the date of refill of recording paper after one month observation is determined on 13 June after consideration of some suspicions of errors in the visual observation.

iv) Technical transfer of tidal observation

A lecture for the technical transfer of tidal observation by means of the automatic tide gauge was given to three technical staff, Mr. Ty Sakun, Mr. Chhim Hor and Mr. Nourn Ratha, both on 11 and 13 of May. The lecture was carried out following the manual* of the tide gauge and the contents are as follows:

- Mechanism of automatic tide gauge
- Installation of tide gauge
- Observation of tide fluctuation by the automatic and visual one
- Methodology of recording paper refill and adjustment of pen position on it.
- Preparation for the harmonic analysis using computer
- Maintenance of the gauge

** Instruction Manual of Fuess Type Long Term Tide Gauge, Model: LFT-V, No.3, 38' 95-4

c. Results of harmonic analysis

Figure - 2.5.1-19 (a) to (c) shows the tidal fluctuation from 13 May to 16 October and Table - 2.5.1-19 shows the digital figures read from Fig. - 2.5.1-19 as an example for proceeding the digital data to the harmonic analysis.

Since the tide gauge was set up using MSL level, which was seemed to be set up by Russian survey team in 1988, the discrepancy between both the past and current one can be a reasonably negligible. Therefore, it seems rationale to use MSL set up in 1988.

Table - 2.5.1-20 shows the results of harmonic analysis using the data of Fig. - 2.5.1-19. The harmonic analysis was done three times by utilizing the data of 13 May to 13 June, 1 June to 2 July and 11 June to 12 July. According to Table - 2.5.1-20, the sum of the four majour tidal components, which are O1, K1, M2 and S2, and the discrepancy level of the mean sea level from the one established by USSR are shown bellow.

Observation Term	Sum of 4 majour tidal components	△h from MSL
13 May to 13 June	58.2	-3.4
1 June to 2 July	59.6	-7.8
11 June to 12 July	60.7	-7.9
Average	59.5	-6.3
1988/USSR	60.1	0.0

Unit; cm

As shown above table, the average of four majour components obtained this time are approximately 60cm and the same to the one by USSR. Therefore accuracy of the harmonic analysis is reasonable and acceptable for the determination of the Construction Datum Level.

d. Conclusion

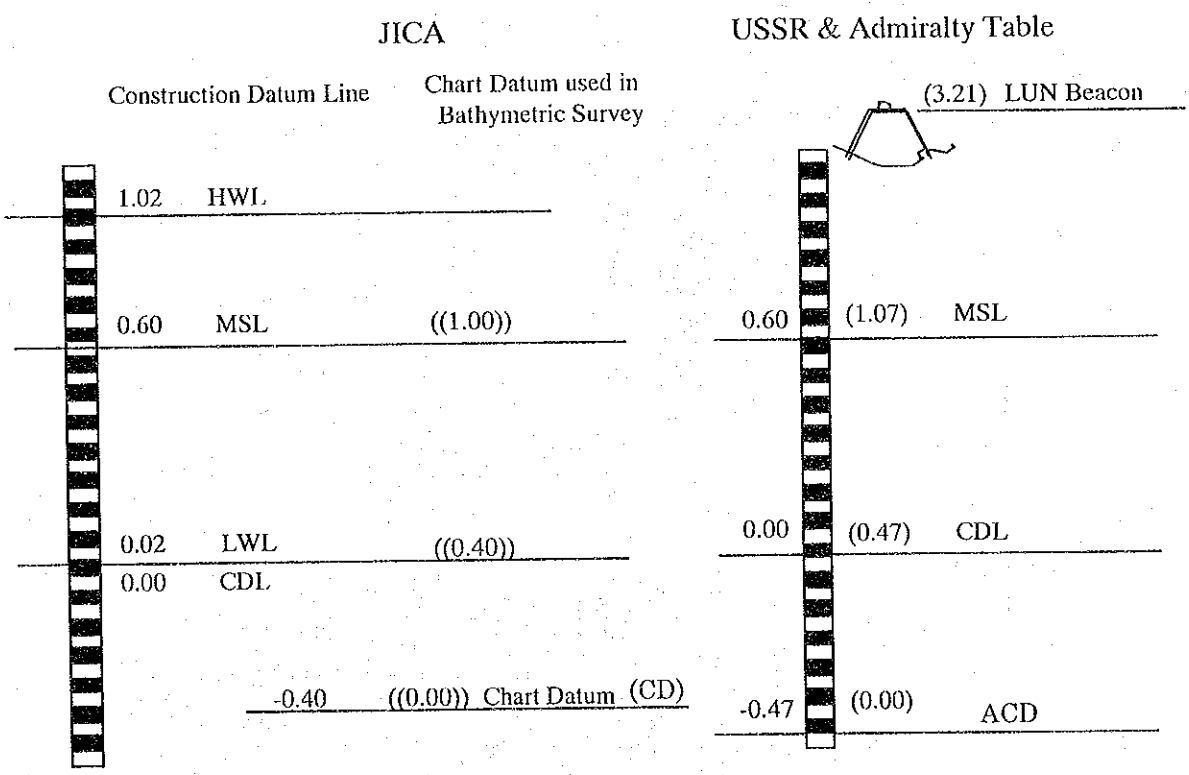
The table shown bellow describes the averaged level of HWL, LWL and the MSL from May to October. HWL and LWL are the tide level observed during the period from 2 days before and 4 days after the new moon and full moon. As to the mean sea level (MSL), the discrepancy from the MSL by USSR is less than 10cm. It means that the present MSL is acceptable for the moment.

	HWL	LWL	△h from MSL
May	+35	-58	-3.0
June	+38	-73	-7.4
	+46	-74	
July	+40	-81	-4.7
	+36	-65	
	+52	-65	
August	+32	-50	-3.8
	+45	-69	
September	+31	-46	+0.3
	+43	-46	
October	+62	-15	-
Average	+41.8	-58.4	-3.7

Unit; cm

Taking the results of harmonic analysis into account, the relationship between the Chart datum and the Construction Datum Level(CDL) are described bellow.

These relationship could be modified by the long term observation of 5 years.



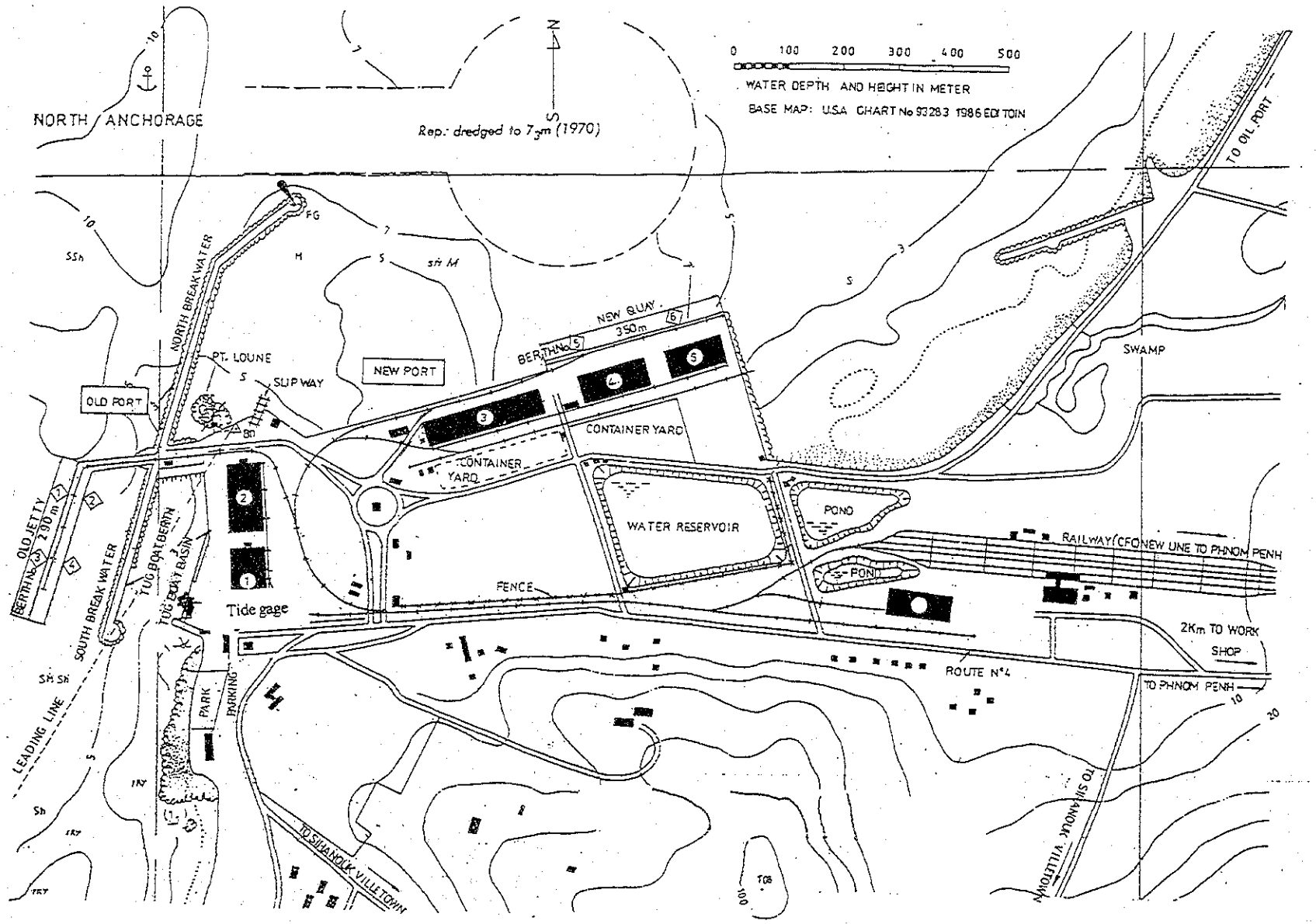


Fig. - 2.5.1-17 Location of tide gauge

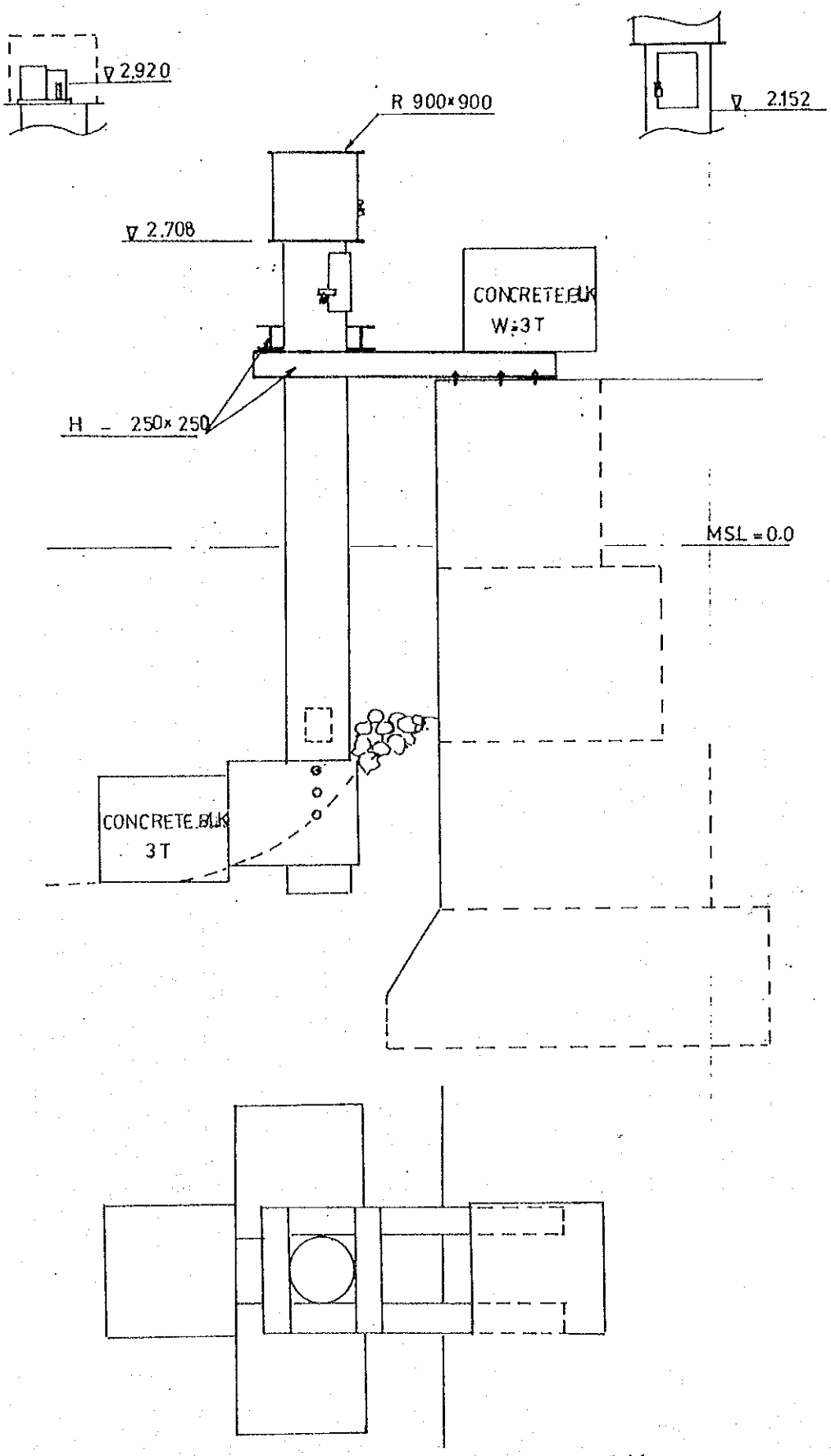


Fig. - 2.5.1-18 Schematic deployment figure of tide gauge

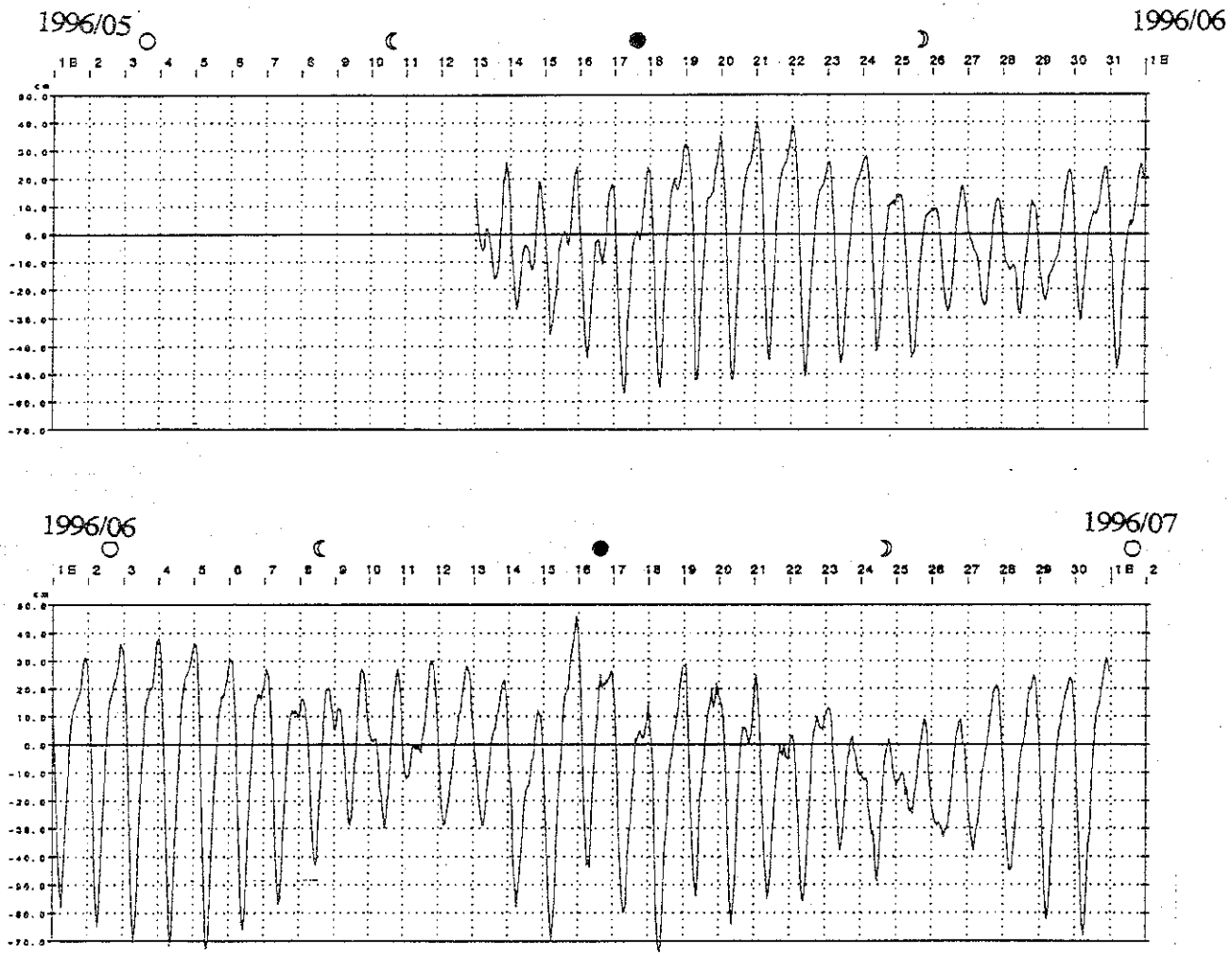


Fig. - 2.5.1-19 (a) Tidal observation results (May to June)

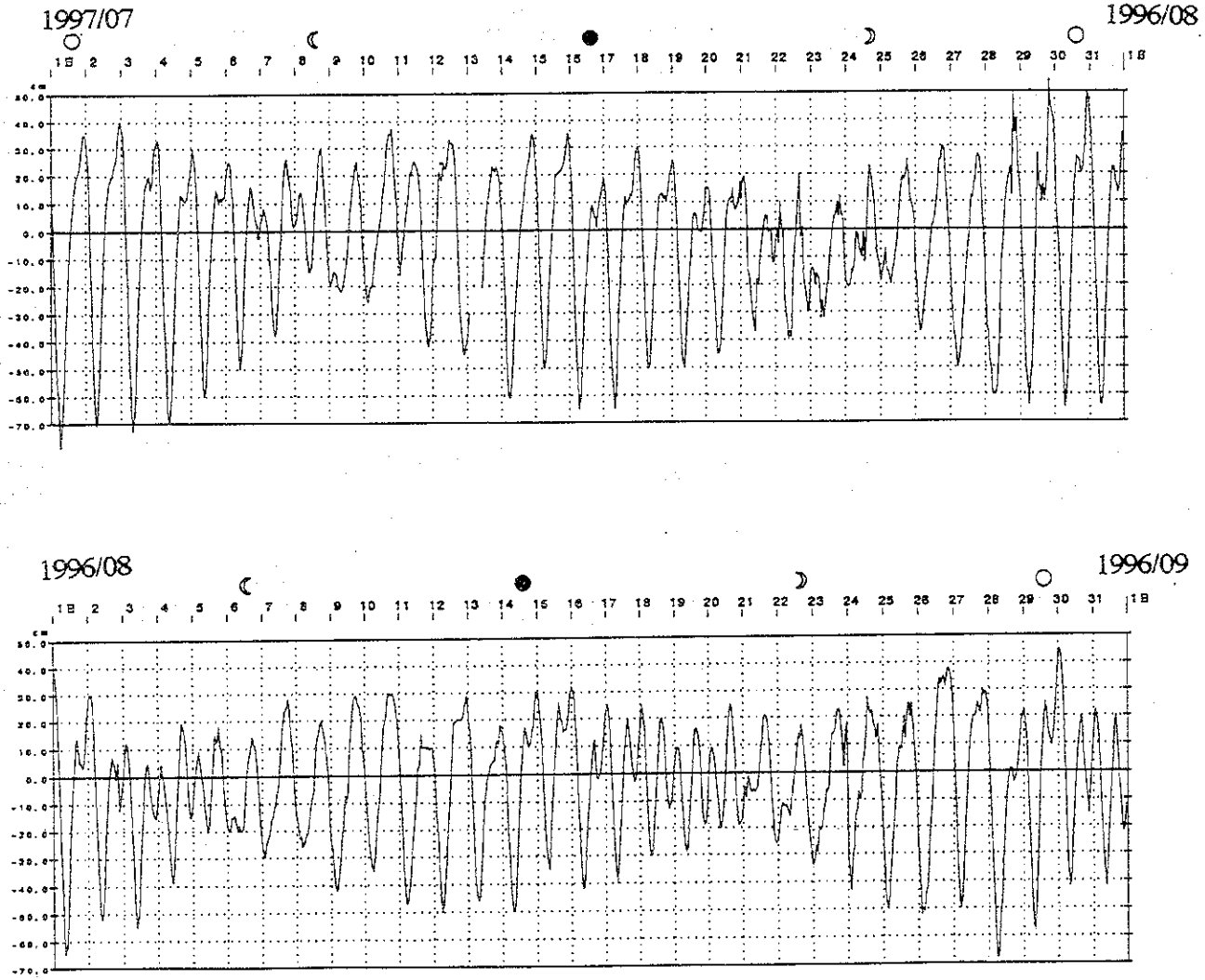


Fig. - 2.5.1-19 (b) Tidal observation results (July to August)

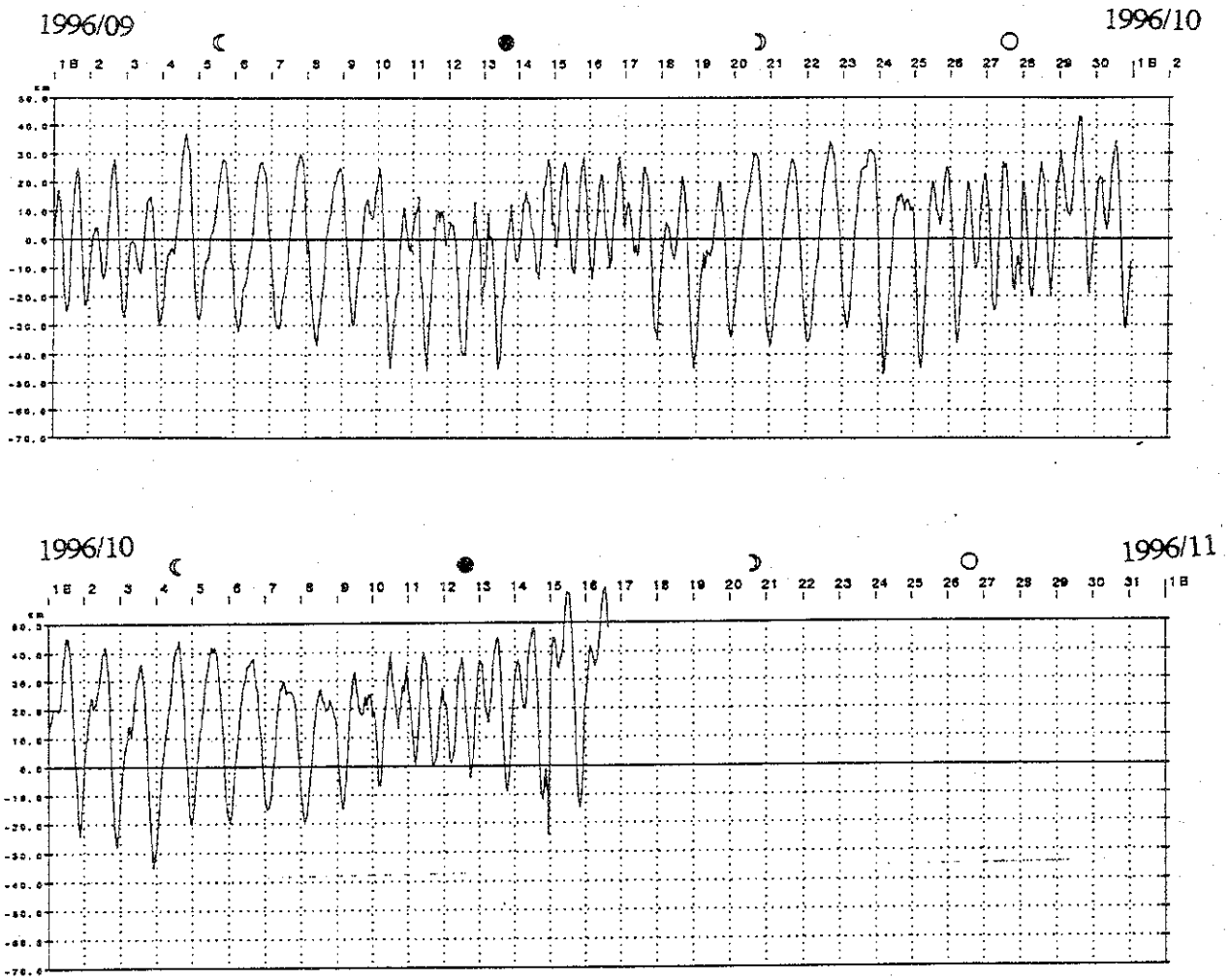


Fig. - 2.5.1-19 (c) Tidal observation results (September to October)

Table - 2.5.1-19 One month tide observation from 13 May to 12 June

Lat.; 10 deg. 38min. Long.; 103deg.29min. Observer;

Date	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	Sum	Mean
13	0.13	0.06	0.01	-0.03	-0.05	-0.06	-0.04	0.02	0.02	0	-0.04	-0.07	-0.12	-0.16	-0.14	-0.14	-0.12	0	0.05	0.18	0.21	0.22	0.26	0.18	0.37	
14	0.12	-0.06	-0.12	-0.18	-0.23	-0.27	-0.19	-0.16	-0.11	-0.09	-0.12	-0.12	-0.11	-0.09	-0.07	-0.15	-0.08	-0.06	-0.06	0.12	0	0.12	0.12	0.08	-1.71	
15	0.01	-0.04	-0.12	-0.22	-0.36	-0.32	-0.31	-0.22	-0.25	-0.14	-0.05	-0.06	0	0.01	0.01	-0.01	-0.04	-0.05	0.03	0.12	0.2	0.23	0.23	0.24	-1.11	
16	0	-0.09	-0.12	-0.26	-0.36	-0.42	-0.44	-0.37	-0.25	-0.19	-0.11	-0.03	-0.07	-0.02	-0.09	-0.07	-0.12	-0.05	-0.02	0.07	0.15	0.16	0.18	0.14	-2.38	
17	0.12	-0.06	-0.2	-0.29	-0.38	-0.46	-0.55	-0.57	-0.48	-0.32	-0.25	-0.14	-0.05	-0.02	0.01	-0.02	0	-0.02	-0.02	0.08	0.12	0.18	0.24	0.22	-2.86	
18	0.21	0.11	-0.04	-0.15	-0.33	-0.42	-0.52	-0.55	-0.47	-0.32	-0.19	-0.04	-0.02	0.08	0.14	0.15	0.2	0.18	0.16	0.16	0.19	0.23	0.3	0.32	-0.62	
19	0.32	0.31	0.27	0.23	0.18	0.12	-0.22	-0.52	-0.52	-0.47	-0.32	-0.21	-0.12	-0.02	0.09	0.13	0.08	0.14	0.1	0.18	0.23	0.26	0.28	0.35	0.87	
20	0.3	0.25	0.17	0.04	-0.1	-0.24	-0.37	-0.5	-0.52	-0.5	-0.35	-0.2	-0.07	-0.02	0.08	0.19	0.2	0.22	0.24	0.25	0.25	0.29	0.34	0.38	0.33	
21	0.4	0.38	0.32	0.23	0.09	-0.05	-0.21	-0.36	-0.43	-0.45	-0.38	-0.25	-0.12	0	0.1	0.15	0.2	0.24	0.23	0.25	0.26	0.29	0.31	0.35	1.55	
22	0.39	0.37	0.33	0.24	0.12	-0.03	-0.17	-0.32	-0.43	-0.51	-0.49	-0.4	-0.25	-0.15	-0.09	-0.02	0.06	0.12	0.15	0.16	0.17	0.18	0.21	0.23	-0.13	
23	0.25	0.26	0.22	0.12	0.05	-0.07	-0.19	-0.31	-0.41	-0.46	-0.45	-0.39	-0.3	-0.19	-0.08	-0.02	0.05	0.11	0.16	0.18	0.19	0.2	0.22	0.24	-0.62	
24	0.26	0.27	0.28	0.24	0.18	0.1	0.01	-0.12	-0.25	-0.36	-0.42	-0.38	-0.33	-0.22	-0.14	-0.05	0.02	0.08	0.1	0.11	0.11	0.12	0.13	0.14	-0.12	
25	0.13	0.14	0.14	0.12	0.05	-0.03	-0.1	-0.2	-0.3	-0.4	-0.44	-0.43	-0.41	-0.33	-0.22	-0.25	-0.08	-0.01	0.02	0.06	0.07	0.07	0.08	0.09	-2.23	
26	0.08	0.09	0.09	0.08	0.05	0	-0.07	-0.15	-0.2	-0.24	-0.27	-0.28	-0.26	-0.22	-0.151	-0.08	0.02	0.07	0.11	0.15	0.17	0.17	0.13	0.09	-0.621	
27	0.04	0.01	-0.02	-0.03	-0.05	-0.06	-0.07	-0.09	-0.13	-0.18	-0.23	-0.25	-0.26	-0.24	-0.18	-0.12	-0.05	0.02	0.07	0.11	0.13	0.12	0.11	0.06	-1.29	
28	-0.02	-0.06	-0.1	-0.11	-0.12	-0.13	-0.12	-0.11	-0.12	-0.15	-0.15	-0.14	-0.29	-0.23	-0.16	-0.11	-0.06	0	0.06	0.12	0.1	0.09	0.09	0.03	-1.69	
29	-0.05	-0.13	-0.17	-0.21	-0.23	-0.24	-0.21	-0.16	-0.14	-0.13	-0.12	-0.1	-0.09	-0.09	-0.04	-0.01	0.03	0.09	0.16	0.2	0.22	0.23	0.21	0.15	-0.83	
30	0.05	-0.05	-0.15	-0.25	-0.31	-0.3	-0.24	-0.18	-0.11	-0.05	0.01	0.04	0.06	0.08	0.07	0.07	0.09	0.11	0.16	0.2	0.22	0.24	0.24	0.17	0.17	
31	0.09	-0.05	-0.09	-0.3	-0.42	-0.48	-0.47	-0.42	-0.29	-0.18	-0.12	-0.06	0	0.03	0.05	0.03	0.05	0.1	0.14	0.19	0.22	0.25	0.24	0.2	-1.29	
1	0.13	0	-0.15	-0.3	-0.43	-0.52	-0.58	-0.52	-0.4	-0.27	-0.15	-0.06	0.03	0.09	0.12	0.13	0.15	0.16	0.18	0.2	0.26	0.3	0.31	0.3	-1.02	
2	0.24	0.12	-0.01	-0.17	-0.35	-0.52	-0.62	-0.65	-0.55	-0.42	-0.27	-0.15	-0.05	0.04	0.12	0.16	0.18	0.2	0.22	0.24	0.27	0.32	0.36	0.35	-0.94	
3	0.32	0.24	0.1	-0.05	-0.26	-0.44	-0.6	-0.71	-0.68	-0.58	-0.43	-0.26	-0.15	-0.05	-0.05	0.13	0.16	0.17	0.2	0.2	0.2	0.27	0.34	0.37	-1.56	
4	0.38	0.34	0.22	0.08	-0.11	-0.3	-0.49	-0.64	-0.72	-0.68	-0.53	-0.37	-0.26	-0.16	-0.05	0.1	0.16	0.2	0.24	0.25	0.26	0.28	0.3	0.34	-1.16	
5	0.36	0.36	0.32	0.21	0.05	-0.14	-0.35	-0.54	-0.69	-0.73	-0.7	-0.55	-0.39	-0.28	-0.17	-0.06	0.04	0.11	0.13	0.17	0.17	0.2	0.21	0.25	-2.02	
6	0.31	0.3	0.3	0.23	0.13	-0.02	-0.2	-0.38	-0.53	-0.63	-0.66	-0.6	-0.45	-0.3	-0.2	-0.1	0.01	0.1	0.14	0.15	0.18	0.17	0.16	0.19	-1.7	
7	0.22	0.27	0.26	0.24	0.17	0.05	-0.1	-0.25	-0.4	-0.51	-0.57	-0.54	-0.45	-0.32	-0.2	-0.01	-0.01	0.07	0.1	0.12	0.11	0.12	0.11	0.1	-1.42	
8	0.1	0.16	0.16	0.15	0.12	0.07	-0.01	-0.12	-0.24	-0.32	-0.4	-0.43	-0.4	-0.27	-0.18	-0.05	0.06	0.14	0.19	0.2	0.2	0.16	0.12	0.08	-0.51	
9	0.05	0.07	0.12	0.13	0.12	0.09	0.02	-0.05	-0.12	-0.2	-0.28	-0.29	-0.25	-0.15	-0.07	-0.04	0.1	0.2	0.25	0.27	0.26	0.22	0.16	0.1	0.71	
10	0.05	0.03	0.01	0.01	0.02	0.02	-0.02	-0.06	-0.15	-0.18	-0.24	-0.3	-0.28	-0.22	-0.15	-0.05	0.05	0.15	0.2	0.24	0.27	0.23	0.17	0.05	-0.15	
11	-0.04	-0.1	-0.12	-0.12	-0.1	-0.07	-0.01	0	-0.01	-0.02	0	-0.02	-0.03	0.01	0.05	0.09	0.15	0.22	0.28	0.3	0.29	0.26	0.18	0.1	1.29	
12	0.01	-0.1	-0.21	-0.26	-0.29	-0.28	-0.24	-0.2	-0.16	-0.012	-0.07	0	0.02	0.05	0.1	0.12	0.17	0.22	0.25	0.23	0.22	0.25	0.2	0.1	0.118	
Sum	4.96	3.4	1.7	-0.58	-3.15	-5.42	-7.68	-9.41	-10.04	-9.692	-8.79	-7.08	-5.47	-3.36	-1.491	0.09	1.67	3.23	4.22	5.46	5.9	6.43	6.54	5.99	-	
Mean	0.160	0.110	0.055	-0.019	-0.102	-0.175	-0.248	-0.304	-0.324	-0.313	-0.284	-0.228	-0.176	-0.108	-0.048	0.003	0.054	0.104	0.136	0.176	0.190	0.207	0.211	0.193	-0.728	-0.03

Table - 2.5.1-20 Harmonic constants at Sihanoukville Port in 1996

***** ANALYSIS OF TIDAL HARMONIC CONSTANTS *****

AREA : CAMBODIA
STATION : SIHANOUKVILLE
TIME ZONE : -7.00
LATITUDE : 10 38 0 N
LONGITUDE : 103 29 0 E
DURATION : MAY 13.-JUN.13.1996
METHOD OF ANALYSIS: T. I. METHOD FOR A MONTH

SYMBOLS	H (CM)	K (DEG.)	G (DEG.)	SYMBOLS	H (CM)	K (DEG.)	G (DEG.)
MM	1.74	151.2	155.0	K2	1.23	58.1	56.7
MSF	2.15	118.2	125.3	2SM2	0.19	241.2	251.4
Q1	4.06	83.3	78.7	MO3	0.41	233.2	223.2
O1	17.90	89.3	83.4	M3	0.35	34.3	28.2
M1	1.34	146.3	144.3	MK3	0.67	268.5	266.3
K1	24.13	122.2	124.0	MN4	0.26	150.8	138.8
J1	0.73	159.7	165.3	M4	0.80	181.0	172.8
OO1	3.34	83.3	92.8	SN4	0.46	96.4	91.6
P1	7.99	122.2	123.4	MS4	1.39	244.6	243.6
MU2	1.04	1.3	350.1	2MN6	0.09	355.3	339.3
N2	2.19	328.0	320.2	M6	0.30	46.4	34.2
NU2	0.42	328.0	320.7	MSN6	0.13	56.2	47.3
M2	11.66	347.8	343.8	2MS6	0.24	84.4	79.2
L2	0.72	244.5	244.2	2SM6	0.06	197.5	199.5
S2	4.52	53.1	56.1	A0	-0.034 (METER)		

$\Sigma(O_1+K_1+M_2+S_2) = 58.2$ cm

***** ANALYSIS OF TIDAL HARMONIC CONSTANTS *****

AREA : CAMBODIA
STATION : SIHANOUKVILLE
TIME ZONE : -7.00
LATITUDE : 10 38 0 N
LONGITUDE : 103 29 0 E
DURATION : JUN. 1.-JUL. 2.1996
METHOD OF ANALYSIS: T. I. METHOD FOR A MONTH

SYMBOLS	H (CM)	K (DEG.)	G (DEG.)	SYMBOLS	H (CM)	K (DEG.)	G (DEG.)
MM	5.63	57.5	61.3	K2	1.61	55.3	58.9
MSF	0.51	219.3	226.4	2SM2	1.34	329.5	339.6
Q1	4.02	88.3	78.6	MO3	0.70	220.8	210.9
O1	18.42	90.5	84.6	M3	0.17	35.7	29.6
M1	1.58	122.1	120.1	MK3	0.77	232.8	230.6
K1	24.24	120.5	122.3	MN4	0.29	169.8	157.9
J1	1.40	166.1	171.7	M4	0.52	162.6	154.5
OO1	3.41	143.8	153.2	SN4	0.28	117.6	112.7
P1	8.02	120.5	121.8	MS4	1.27	253.2	252.2
MU2	0.30	19.5	8.3	2MN6	0.22	115.3	99.2
N2	2.19	342.2	334.3	M6	0.23	113.5	101.3
NU2	0.43	342.2	334.8	MSN6	0.25	76.5	67.6
M2	11.11	348.9	344.8	2MS6	0.47	97.3	92.2
L2	0.74	263.0	262.7	2SM6	0.48	141.1	143.1
S2	5.91	55.3	58.3	A0	-0.078 (METER)		

$\Sigma(O_1+K_1+M_2+S_2) = 59.6$ cm

***** ANALYSIS OF TIDAL HARMONIC CONSTANTS *****

AREA : CAMBODIA
STATION : SIHANOUKVILLE
TIME ZONE : -7.00
LATITUDE : 10 38 0 N
LONGITUDE : 103 29 0 E
DURATION : JUN. 11.-JUL. 12.1996
METHOD OF ANALYSIS: T. I. METHOD FOR A MONTH

SYMBOLS	H (CM)	K (DEG.)	G (DEG.)	SYMBOLS	H (CM)	K (DEG.)	G (DEG.)
MM	5.32	63.9	67.7	K2	1.82	54.9	58.5
MSF	2.34	194.6	201.7	2SM2	1.31	295.6	305.8
Q1	3.79	81.5	71.8	MO3	0.80	218.1	208.1
O1	18.76	89.8	84.0	M3	0.21	95.7	89.5
M1	1.76	138.9	136.8	MK3	0.72	228.4	226.1
K1	24.18	120.2	122.0	MN4	0.25	147.1	135.1
J1	1.18	145.3	150.9	M4	0.70	167.7	159.6
OO1	2.11	122.8	132.2	SN4	0.07	302.3	297.5
P1	8.00	120.2	121.4	MS4	1.29	258.6	257.5
MU2	0.51	315.3	304.1	2MN6	0.22	155.3	139.3
N2	2.18	346.3	338.4	M6	0.20	106.1	93.9
NU2	0.41	346.3	338.9	MSN6	0.23	55.2	46.3
M2	11.08	348.2	344.1	2MS6	0.63	78.5	73.4
L2	0.60	226.4	226.2	2SM6	0.83	137.0	139.0
S2	6.70	54.9	57.9	A0	-0.079 (METER)		(Mean)

$\Sigma(O_1+K_1+M_2+S_2 = 60.7$ cm

$O_1 = H_0, K_1 = H', M_2 = H_m, S_2 = H_s, A_0 =$ mean

Table - 2.5.1-21 Hamonic constants at Sihanoukvill port

Observation term: 01/March - 30/ march, 1988

	M2	S2	H2	K2	K1	O1	P1	Q1	M4	M6	MS4
H (cm)	11.6	5.5	2.6	1.5	24.3	18.7	8.1	3.7	0.4	0	0.3
K (degree)	340.6	17.8	300.7	20.8	119.5	70.5	115.8	46.2	118.8	323.4	140.5
k'(degree)	343.6	20.8	303.7	23.8	121	72	117.3	47.7	124.8	332.4	146.5
g (degree)	336.5	20.8	292.8	24.4	121.3	64.6	117	36.5	110.6	311.6	139.4

$*\Sigma(M_2+S_2+K_1+O_1) = 60.1$ cm

Source; USSR, Vol.3, 128-10, p.33,1988

(8) Current survey

A current survey were carried out using a recording current meter RCM7 at three points shown by Fig. - 2.5.1-20. Figure - 2.5.1-21 shows the schematic deployment figure of current meters. An objective for the current survey is to collect the information of current feature around the surveying points and to reflect the results to the consideration of maneuverability of ship, the diffusion of muddy water and so on.

In reality, the Russian survey team conducted the current survey at around the area of Sihanoukville Port and the Oil Port in 1988. Both results are shown by Fig. - 2.5.1-22 and Fig. - 2.5.1-23, respectively. In accordance with these figures, the maximum speed at ebb and flood tide at the area from the south channel to the north breakwater was approximately 78 cm/sec and 92 cm/sec. And at the Oil Port area, 23 cm/sec in ebb tide, the 25 cm/sec in flood tide, respectively.

Figure - 2.5.1-24 shows the seabed material aground Sihanoukville Port surveyed by the Russian. Since the deposition of seabed material are strongly related to the current velocity and the size of material, the area where a fine material distributed means that the velocity of current is small and the area of mussel means rather higher current velocity. Thus the current velocity at the channel between the Koa Poah island and the land seems to be rather high.

Figure - 2.5.1-25 and Figure - 2.5.1-26 show the current survey results at the south existing port entrance channel (south channel, C-1) and the west New Port entrance channel (west channel, C-2) respectively. According to these figure, it is realized that the maximum velocity and frequent direction of the current at the south channel is approximately 50cm/sec and from northwest to north. At the west channel, the maximum velocity is approximately 50cm/sec and the main direction is from south to southwest.

Figure - 2.5.1-27 shows the trend of current velocity around the Dek KOUL island. From this figure, the value of velocity nearby the seabed is higher than the one nearby the seawater surface. The velocity of current flow is also getting higher, sometime to 80 cm/sec during the last 5 days causing Monsoon wind from the North-East.

The results of harmonic analysis of some constituents in both E-components and N-components are summarized by Table - 2.5.1-22 and presented in Fig. - 2.5.1-28(a)-28(b). From these data, the value of velocity nearby the seabed is higher than the velocity nearby the seawater surface. The velocity of current flow is also getting higher, sometime to 80cm/sec during the last 5 days causing by Monsoon wind from the North-East.

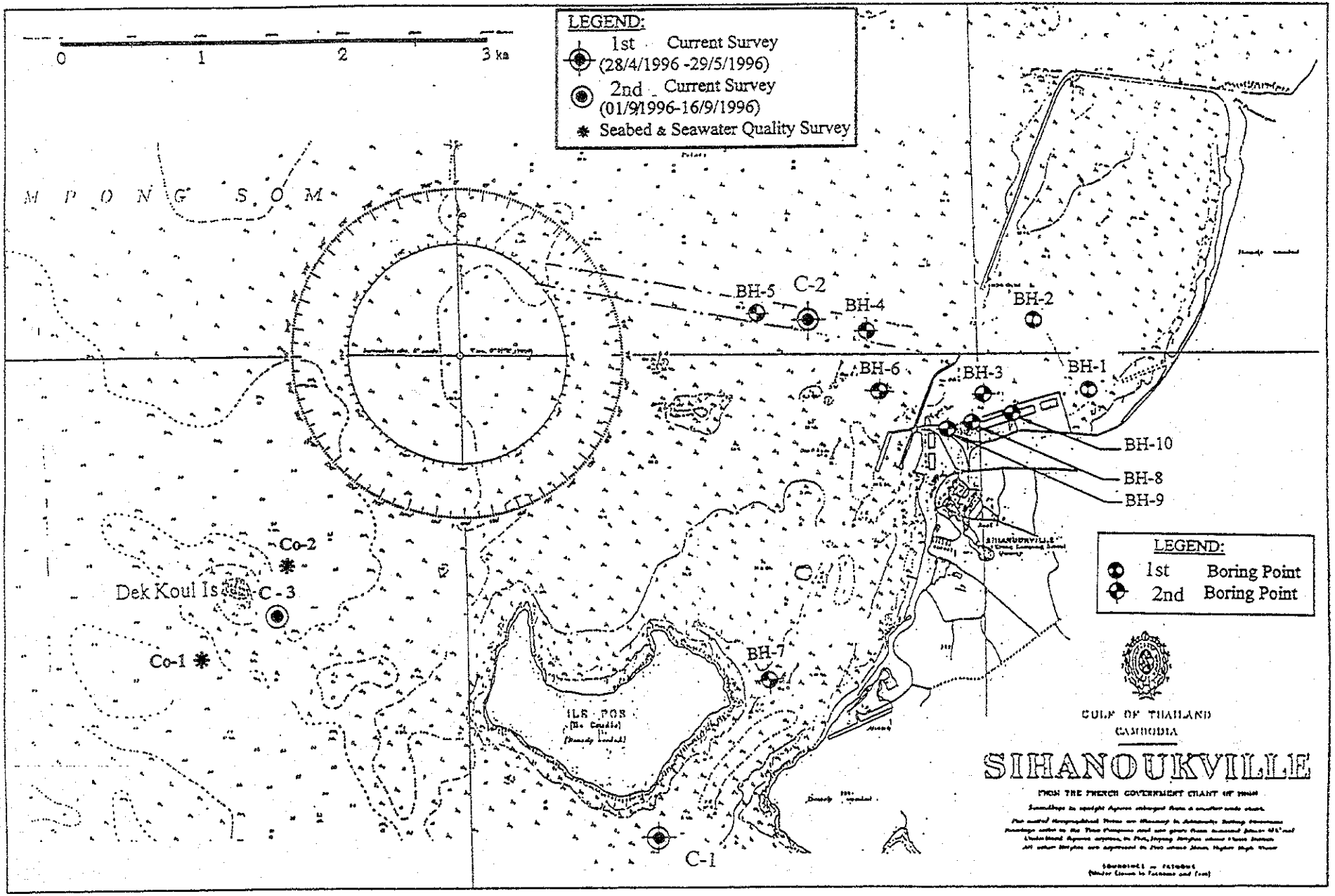
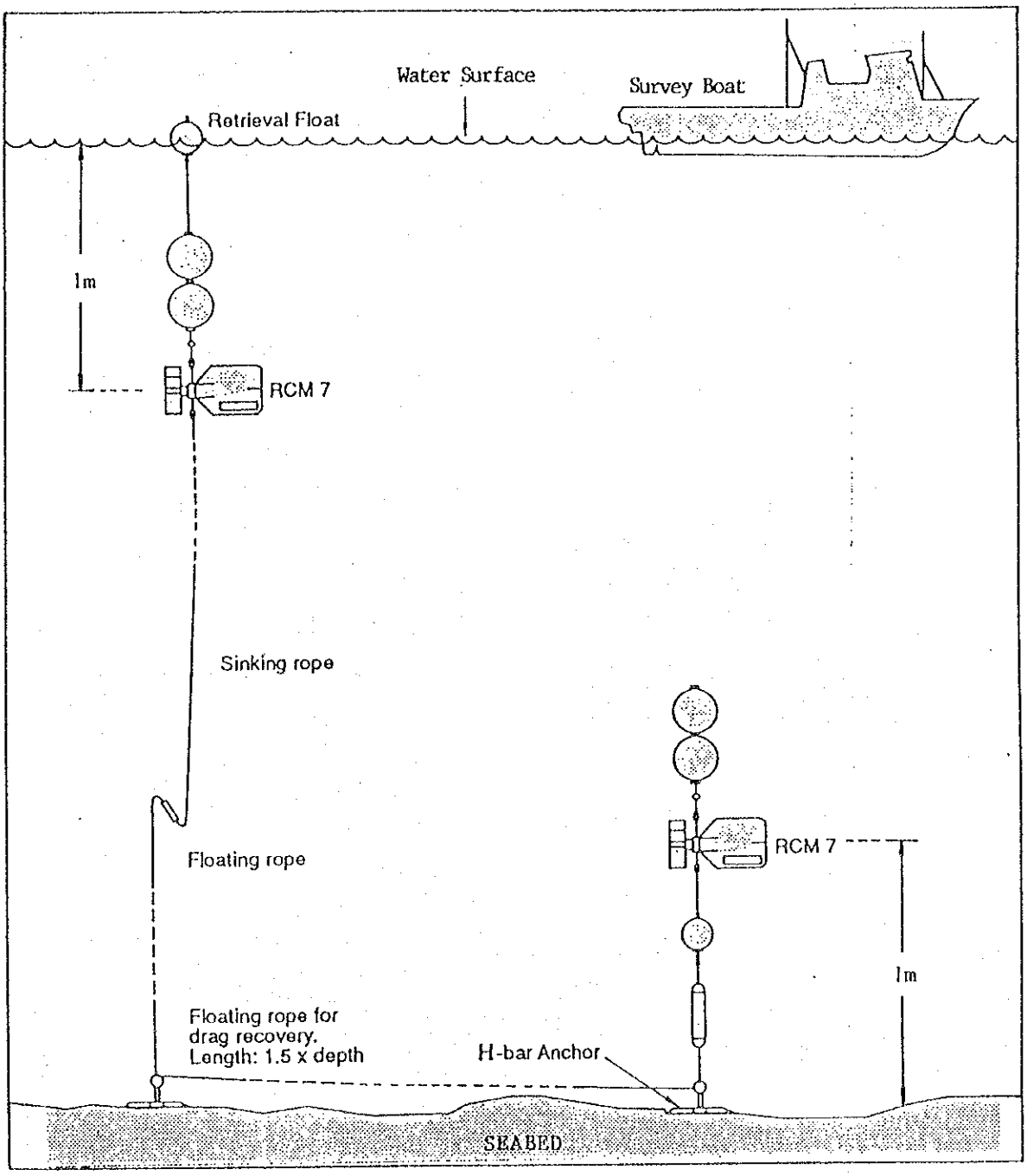


Fig. - 2.5.1-20 Location map of environmental survey



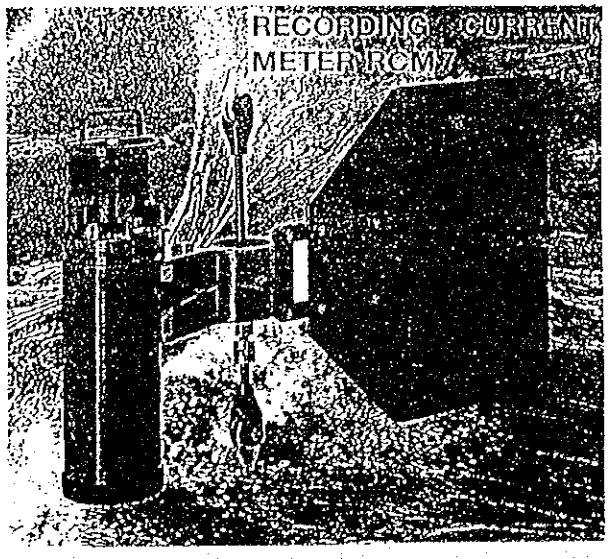
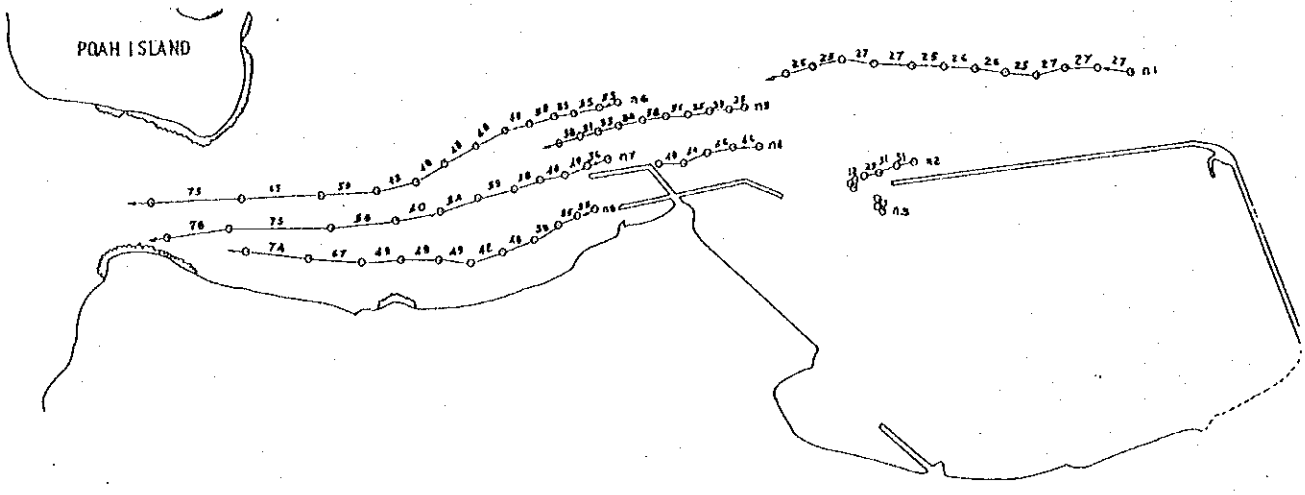
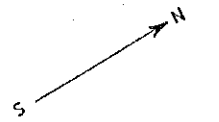


Fig. - 2.5.1-21 Equipment set-up of self-recording current meter

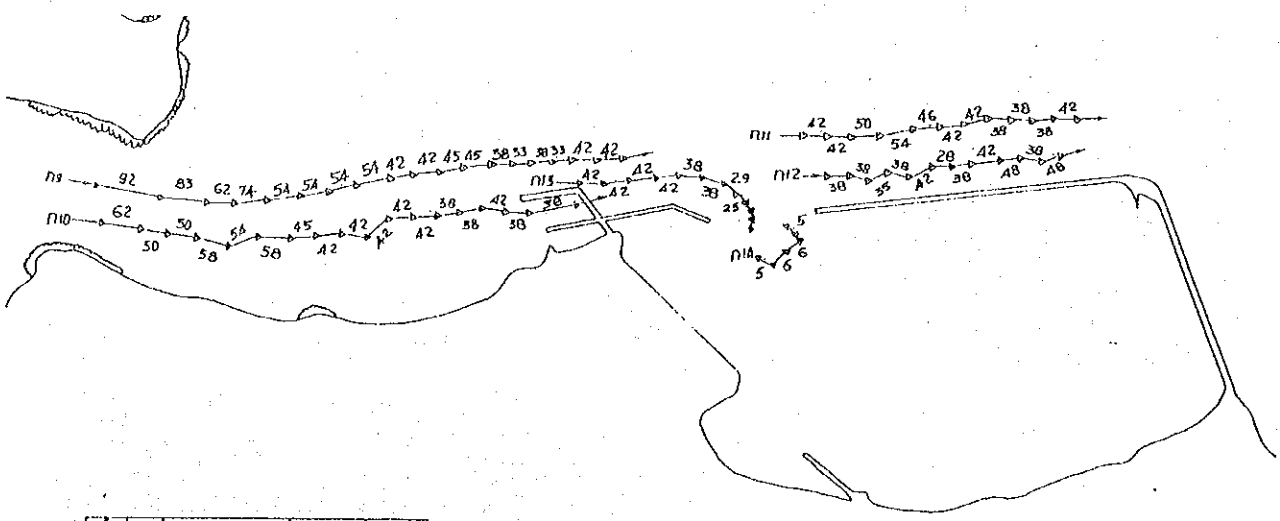


FLOATING N°	DATE	SPEED OF MOVEMENT CM/S AVERAGE	SPEED OF MOVEMENT CM/S MAX	PHASE OF HIGH TIDE	WIND M/S
n1	17.11	26	27	LOW TIDE	W - 5
n2	17.11	19	31	—"—	W - 3
n3	17.11	5	7	—"—	W - 3
n4	17.11	44	46	—"—	W - 5
n5	26.10	34	38	—"—	SW - 3
n6	18.10	47	73	—"—	W - 4
n7	18.10	47	78	—"—	W - 4
n8	18.10	47	74	—"—	W - 5



SYMBOLES
n1 FLOATING N°
—— DIRECTION OF MOVEMENT
o POINTS OF OBSERVATION
35 SPEED OF MOVEMEN Cm/s BETWEEN OBSERVATION POINTS

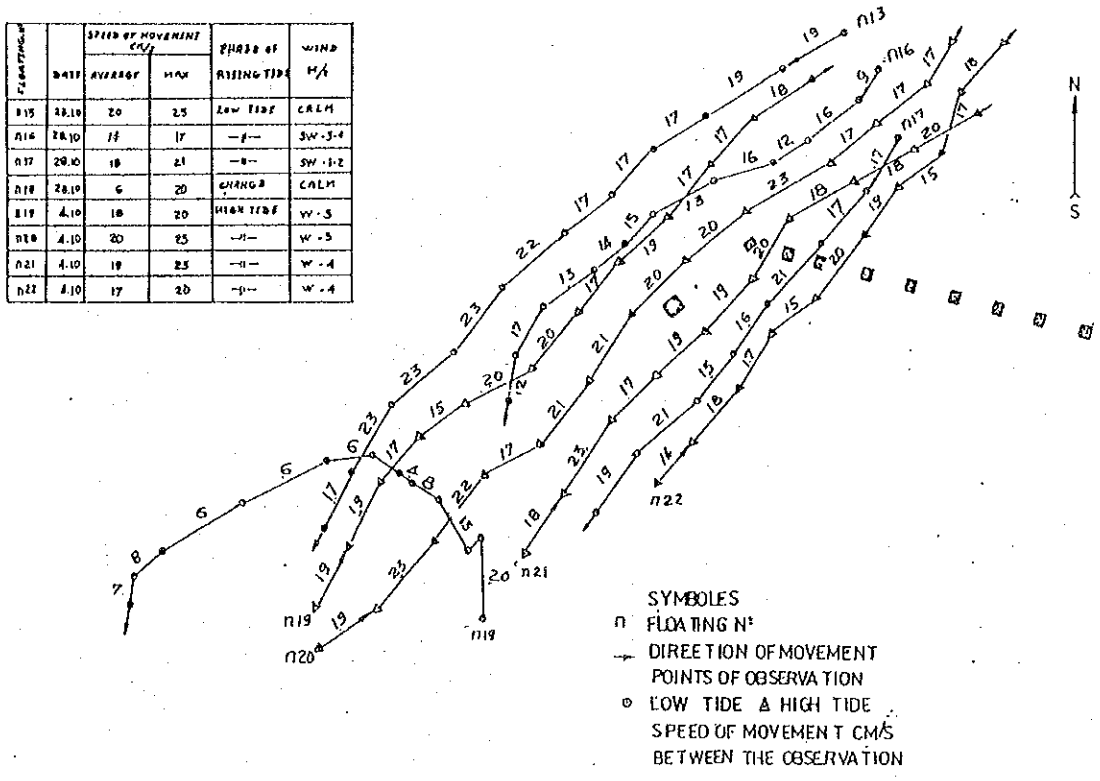
Fig. - 2.5.1-22 (a) Results of current survey by USSR in 1988 (Ebb tide)



FLOATING N°	DATE	SPEED OF MOVEMENT CM/S AVERAGE	SPEED OF MOVEMENT CM/S MAX	PHASE OF RISING TIDE	WIND N/S
n9	25.08	51	92	HIGH TIDE	E - 3
n10	25.08	46	62	—"—	E - 3
n11	25.08	43	54	—"—	E - 3
n12	25.08	39	48	—"—	E - 3
n13	27.07	27	42	—"—	NE - 4
n14	27.07	5	7	—"—	NE - 4

SYMBOLES
n9 FLOATING N°
— DIRECTION OF MOVEMENT
△ POINTS OF OBSERVATION
35 SPEED OF MOVEMENT CM/S BETWEEN THE OBSERVATION AT PHASE OF RISING TIDE

Fig. - 2.5.1-22 (b) Results of current survey by USSR in 1988 (Flood tide)



FLOATING N°	DATE	SPEED OF MOVEMENT CM/S AVERAGE	MAX	PHASE OF RISING TIDE	WIND M/S
n15	28.10	20	25	Low Tide	CALM
n16	28.10	14	17	—▲—	SW-S-4
n17	29.10	18	21	—●—	SW-S-2
n18	28.10	6	20	RISING	CALM
n19	4.10	18	20	HIGH TIDE	W-S
n20	4.10	20	25	—▲—	W-S
n21	4.10	19	25	—▲—	W-4
n22	4.10	17	20	—▲—	W-4

Fig. - 2.5.1-23 Results of current survey at oil port area in 1988

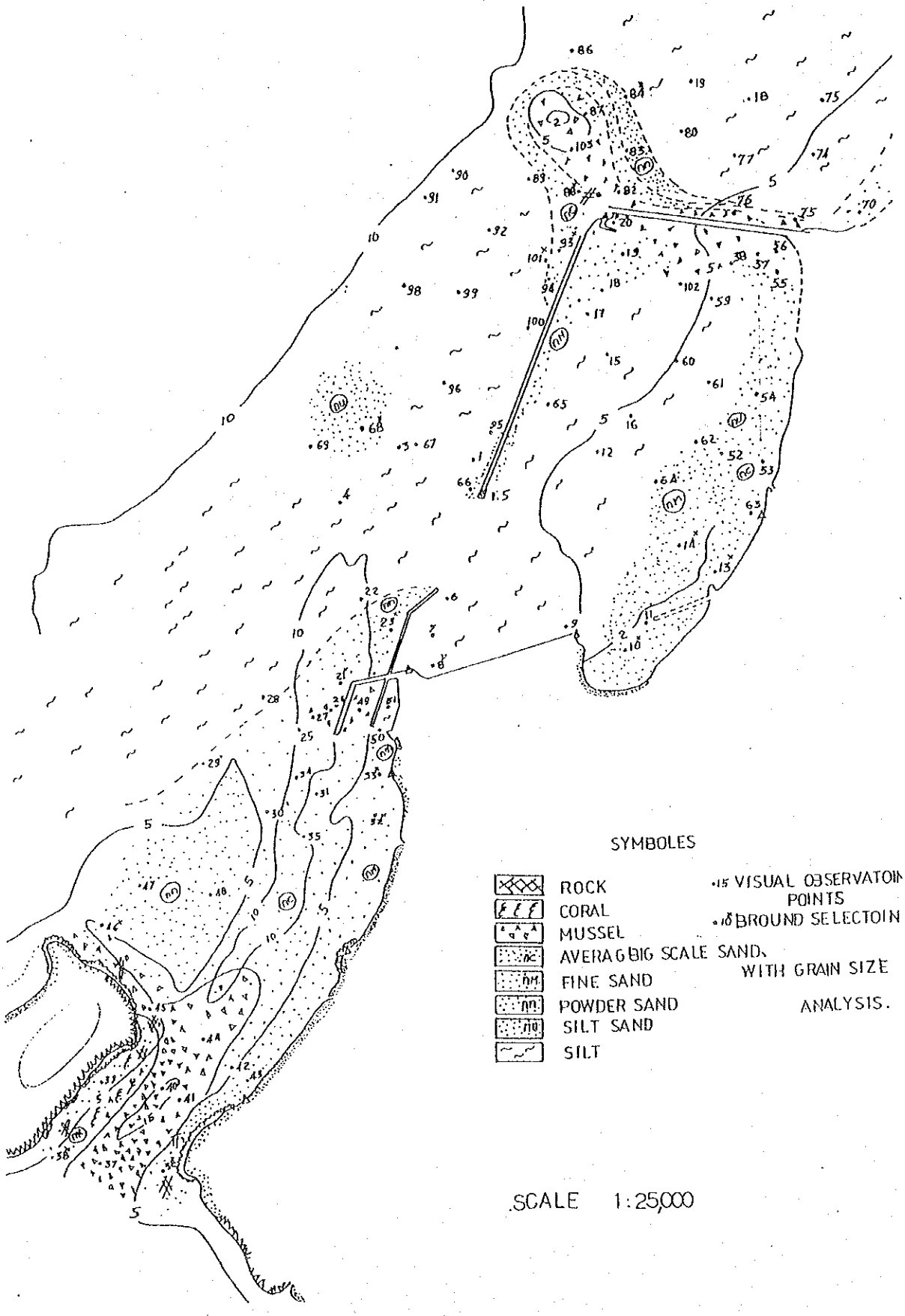


Fig. - 2.5.1-24 Seabed material by 1988 survey by USSR

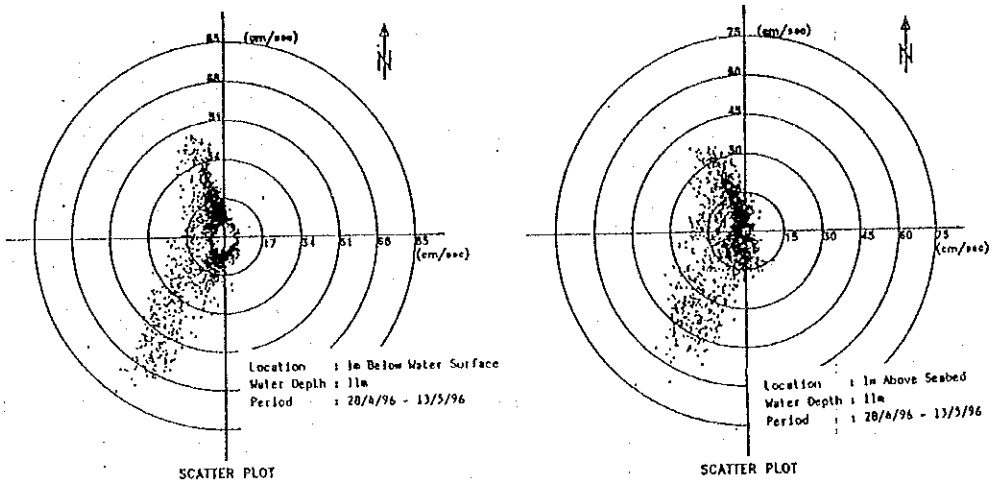


Fig. - 2.5.1-25 (a) Locus scatter plot of seawater at south existing port entrance channel C-1

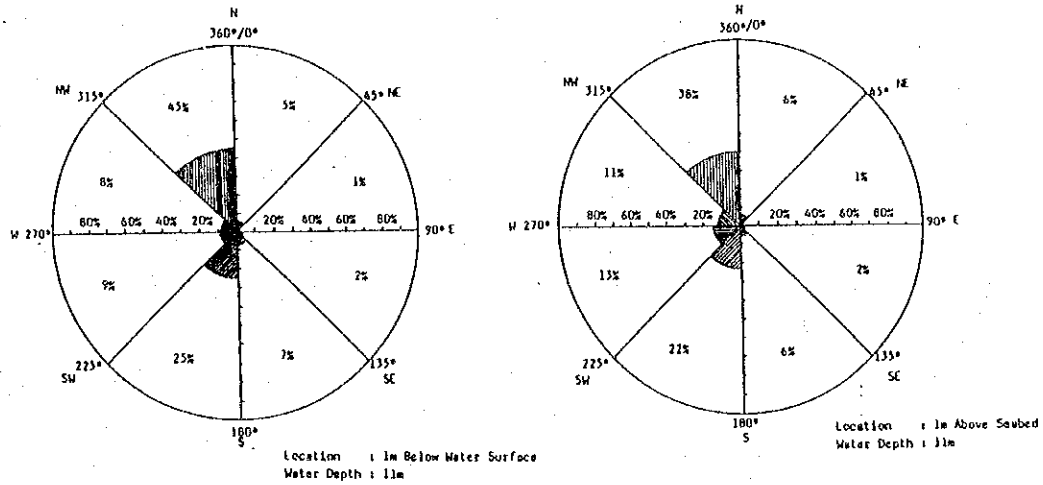


Fig. - 2.5.1-25 (b) Locus direction percentage exceedance chart at south existing port entrance channel C-1

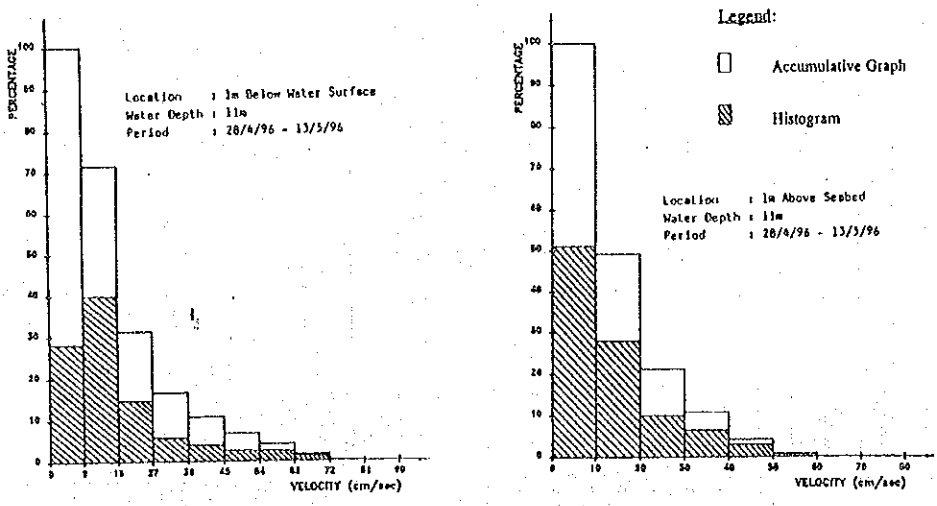


Fig. - 2.5.1-25 (c) Locus velocity percentage exceedance chart of seawater at south existing port entrance channel C-1

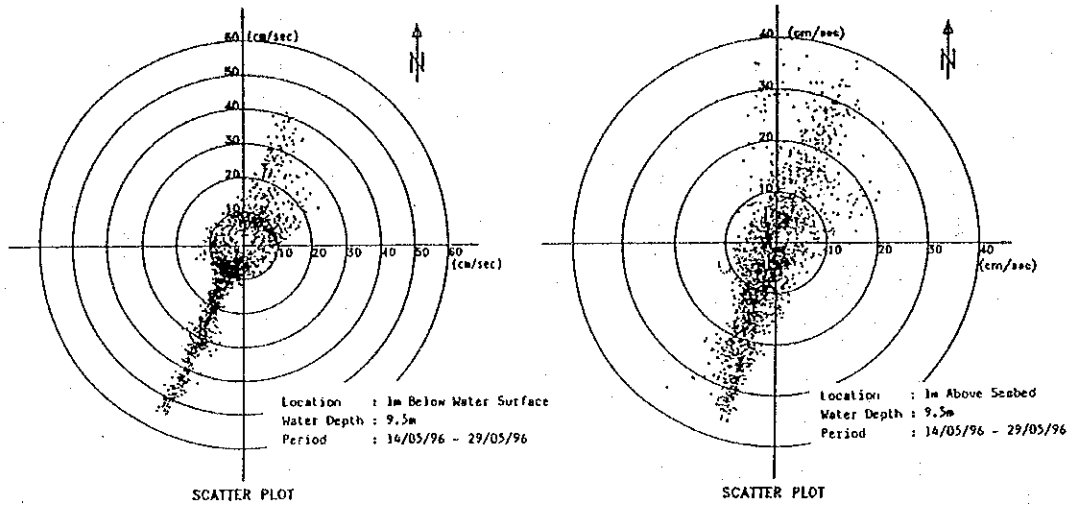


Fig. - 2.5.1-26 (a) Locus scatter plot of seawater at west new port entrance channel C-2

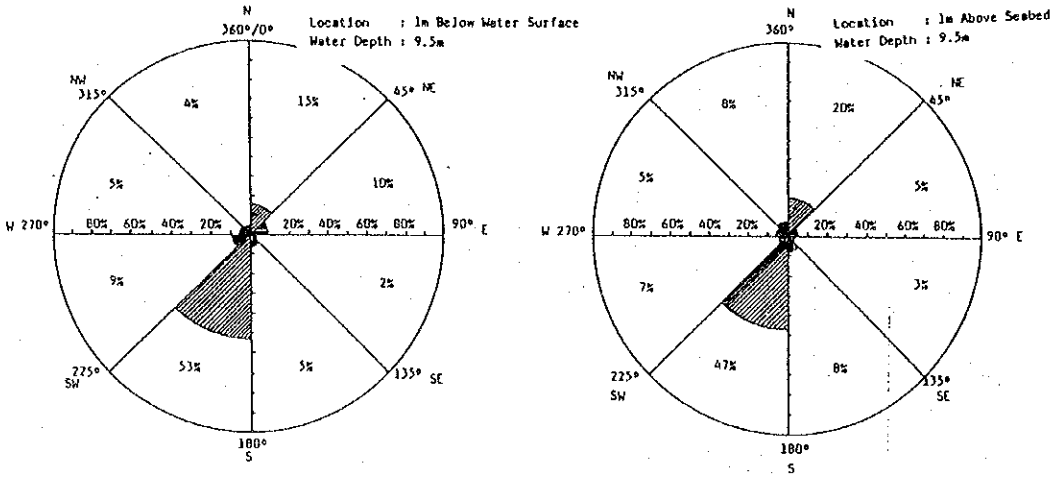


Fig. - 2.5.1-26 (b) Locus direction percentage exceedance chart at west new port entrance channel C-2

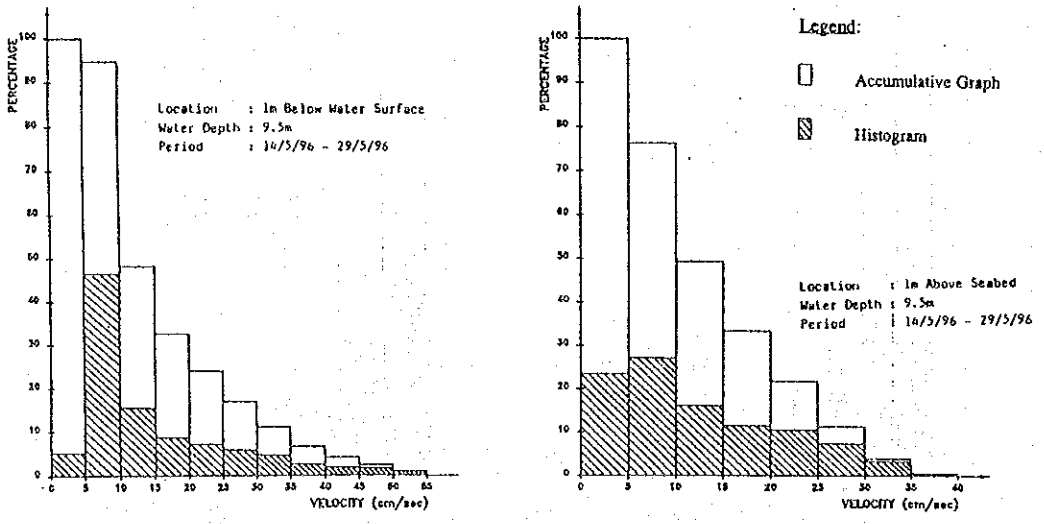


Fig. - 2.5.1-26 (c) Locus velocity percentage exceedance chart of seawater at west new port entrance channel C-2

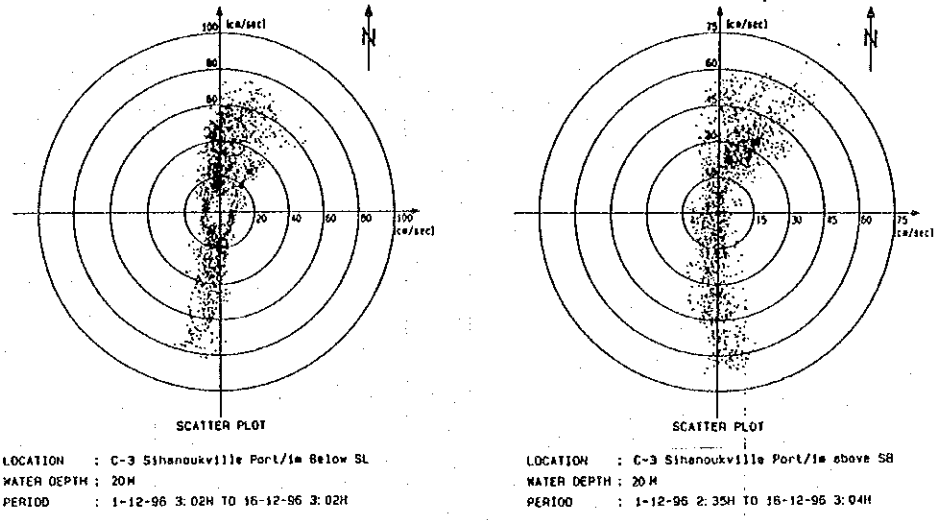


Fig. - 2.5.1-27 (a) Locus scatter plot of seawater at south-west of port C-3

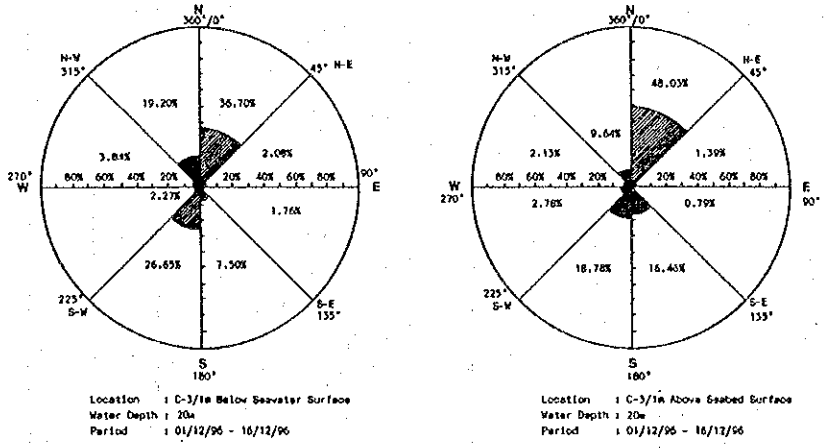


Fig. - 2.5.1-27 (b) Locus direction percentage exceedance chart at south-west of port C-3

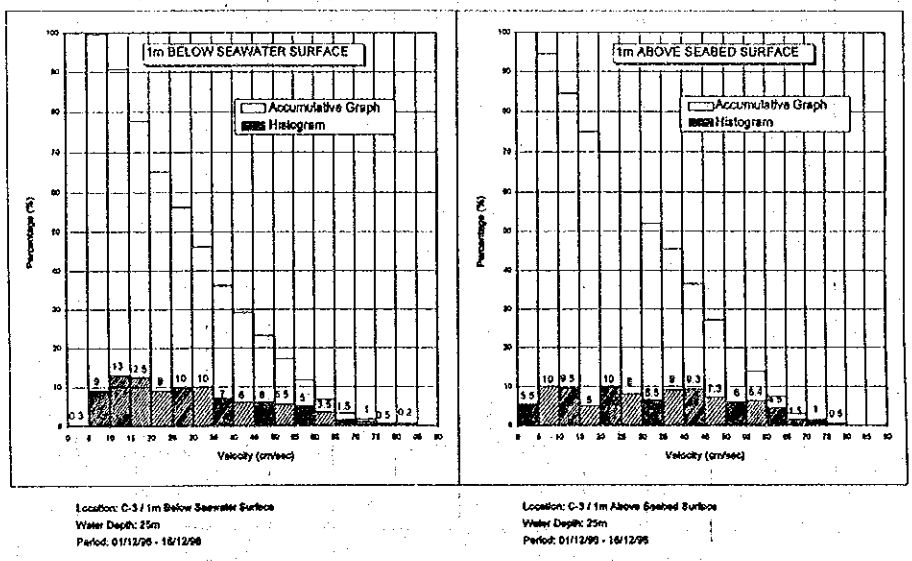


Fig. - 2.5.1-27 (c) Locus velocity percentage exceedance of seawater at south-west of port C-3

Table-2.5.1-22 Results of harmonic analysis at location C-3

Constituents	At C-3/1m Below the Sea Water Surface				At C-3/1m Above the Seabed				The Previous Results (At C-1 / C-2)			
	E-Component		N-Component		E-Component		N-Component		E-Component		N-Component	
Name	cm/sec	rag	cm/sec	rag	cm/sec	rag	cm/sec	rag	cm/sec	rag	cm/sec	rag
Q1	-	-	-	-	-	-	-	-	0.66	357.92	1.18	28.48
O1	11.88	160.70	1.74	323.30	11.90	150.40	2.86	326.40	3.74	312.59	6.78	321.47
P1	-	-	-	-	-	-	-	-	5.06	136.92	8.32	52.00
K1	21.18	215.00	3.16	17.00	21.42	202.30	2.94	5.10	7.49	298.95	5.71	351.98
N2	-	-	-	-	-	-	-	-	0.77	217.26	0.42	151.29
M2	6.16	335.90	0.31	119.80	5.84	304.70	0.25	91.10	3.31	226.58	8.41	214.41
S2	2.80	55.40	0.80	191.70	2.79	8.30	0.64	175.60	4.99	6.02	13.69	340.34
K2	-	-	-	-	-	-	-	-	5.82	329.15	14.88	304.07
M4	0.55	12.10	0.09	115.70	0.42	15.40	0.12	62.40	0.31	279.12	0.84	116.64
MS4	0.47	113.80	0.02	209.40	0.41	96.00	0.08	150.00	0.22	50.83	1.54	180.41
SO	-	-	-	-	-	-	-	-	-1.25	-	-3.93	-

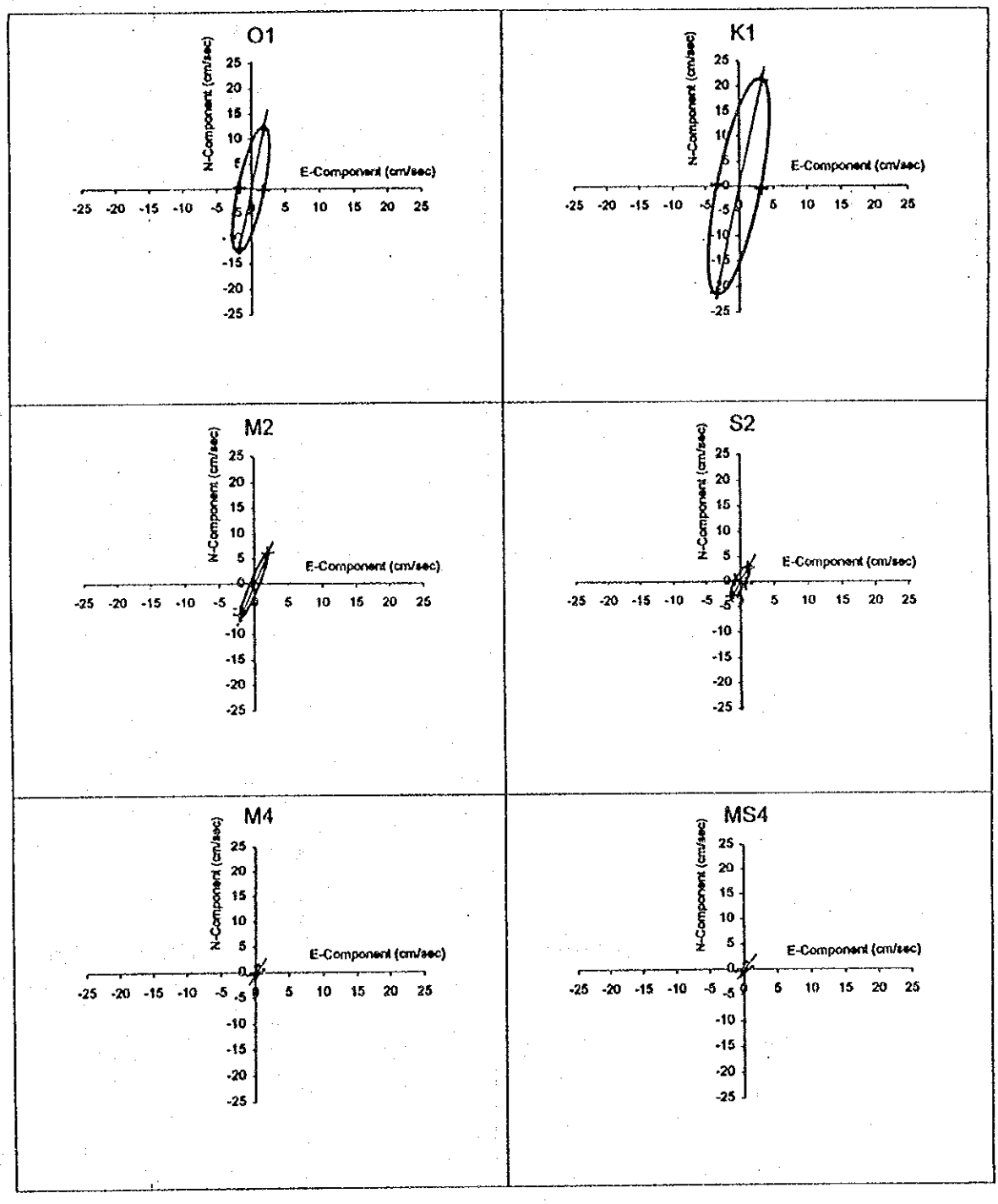


Fig. - 2.5.1-28 (a) Results of harmonic analysis
(1m below sea water surface)

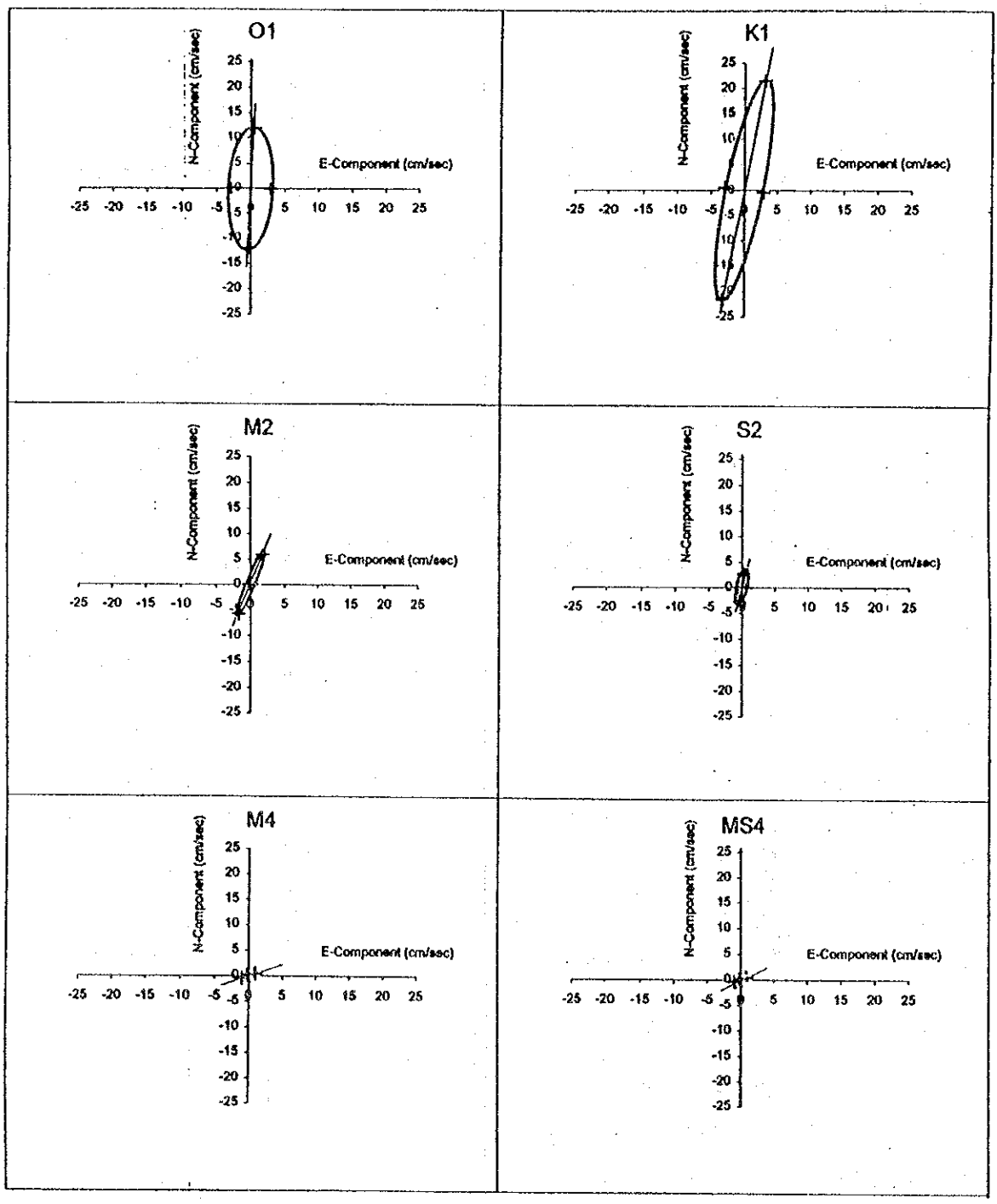


Fig. - 2.5.1-28 (b) Results of harmonic analysis
(1m above the seabed)

2.5.2 Administrative organization, and operation and management

(1) Outline of port administration system in Cambodia

There are two main international ports in Cambodia: Sihanoukville Port which is the only deep-water maritime port of the Kingdom of Cambodia and Phnom Penh Port which is the country's traditional river port. These ports are managed by port authorities which belong to the Ministry of Public Works and Transport (MPWT).

MPWT controls the administration and operations of traffic (except air) and construction in Cambodia, that is to say, roads, construction, inland and fluvial transport, railway, port and maritime commerce are under its control. The organization chart of MPWT is shown in Fig. - 2.5.2-1. At present, its organization is being reformed according to restructuring of the state apparatus. MPWT can be divided into two departments: Department of Public Works and Department of Transport. In addition, MPWT has 20 sectors, under the control of General Director, in which Sihanoukville Port and Phnom Penh Port are included.

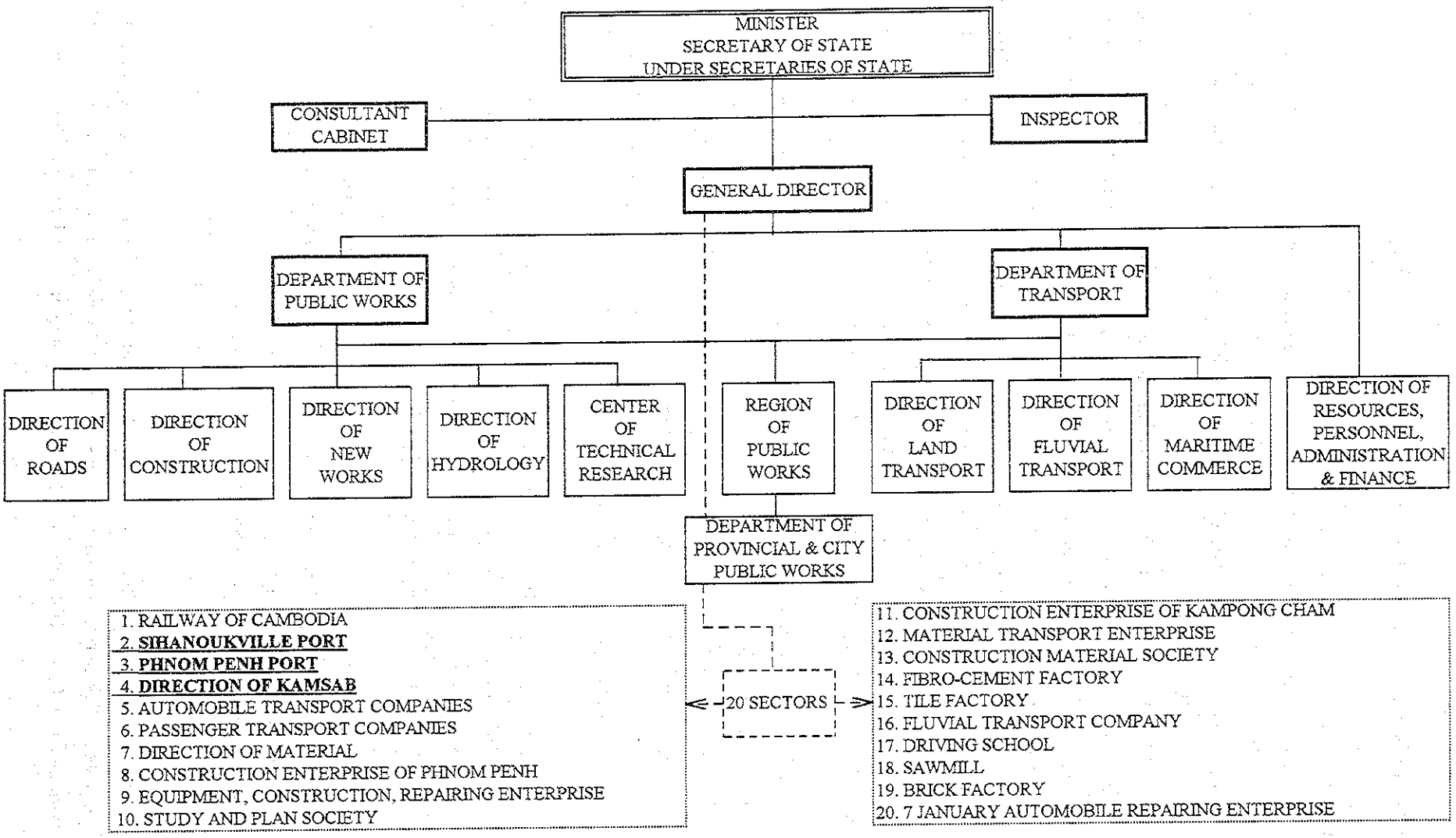
On Oct. 17, 1990, central Government issued a statement concerning the financial-autonomy of these port authorities. A summary of this statement is as follows:

- Port authority has the right to control and increase the activities or service.
- Port authority must be responsible for their activities.
- Director of port authority must manage the Government's property, material resources and labor force according to the principal.
- Director of port authority must do his best to make a profit, and pay the government tax and good salary of employees and worker on time.

Therefore, port authorities are financially independent from the central Government and undertake majority of port activities. They are, however, required to seek central Government approval for important matters such as budget, personnel assignment and port development. Also, there are many other agencies operating within the port as shown below :

- Customs -- Ministry of Economic and Finance
- Port police and immigration office -- Ministry of Interior and Security
- Quarantine (human) -- Ministry of Health
- KAMSAB (Kampuchea Shipping Agency & Brokers) -- Ministry of Public Works and Transport

The development of Sihanoukville Port began in the late 1950's, and port operation was started in 1960. This port is comparatively new. The port consists of three major ports: Old Port, New Port and Oil Port. Old Port and New Port are administrated by the Port authority of



Source : MPWT

Fig. - 2.5.2-1 Organization chart of Ministry of Public Works and Transport

Sihanoukuville. On the other hand, the Port authority of Sihanoukville is responsible for operation and maintenance of the berthing facilities and the channel and the docking operation including tug service in Oil Port.

In Cambodia, port area is not ordained by law. Therefore, the boundary of port area managed by Sihanoukville Port is not clear.

(2) Organization structure and function

Sihanoukville Port has authority to operate and administrate the port such as berth allocation, pilotage, tug, cargo handling, storage and delivery. The organization structure of Sihanoukville Port is shown in Fig. - 2.5.2-2.

The Port Director holds the highest position. Under the Port Director, two offices are established: Planning Office and Accounting/Finance Office. In addition, three division, namely Administration and Executive Division, Technique Division and Exploitation Division, are established and are headed by the three deputy Directors.

The main functions of each office are shown below.

- *Accounting/Finance Office*
  - To be in charge of financial affairs, accounting and the preparation of budget.

- *Planning Office*
  - To be in charge of port planning, annual planning and annual statistics.

- *Administration/Personnel Office*
  - To be in charge of personnel affairs, salary/wage payment, social benefit, employee training programs, port security, cleaning service of office buildings, waste disposal service for vessel and general affairs.

- *Business Office*
  - To enter contracts with consumers and companies.
  - To be responsible for preparing invoice of port service : navigation, handling, transportation and storage.

- *Technical Service Office*
  - To make plan for their maintenance, construction of port building and equipment and to be responsible for taking care of them
  - To make plan for buying spare parts and fuel.
  - To be in charge of spare parts, fuel and other port instruments.

- *Machinery/Transport Office*
  - To control, supervise and arrange cargo handling and transportation equipment.

- *Stevedoring Office*
  - To contact with Business Office and make daily cargo handling plan.
  - To organize the cargo handling equipment and carry out the cargo handling.

- *Warehouse/Tally Office*
  - To control the stored cargo, to assign warehouse and yard and to record cargo's flow through warehouse and yard.
  - To perform the activities related to cargo receiving and hand over.

- *Harbor Master Office*
  - To be responsible for vessel berthing -unberthing at port.
  - To perform pilotage, mooring, tugs and water supply service.

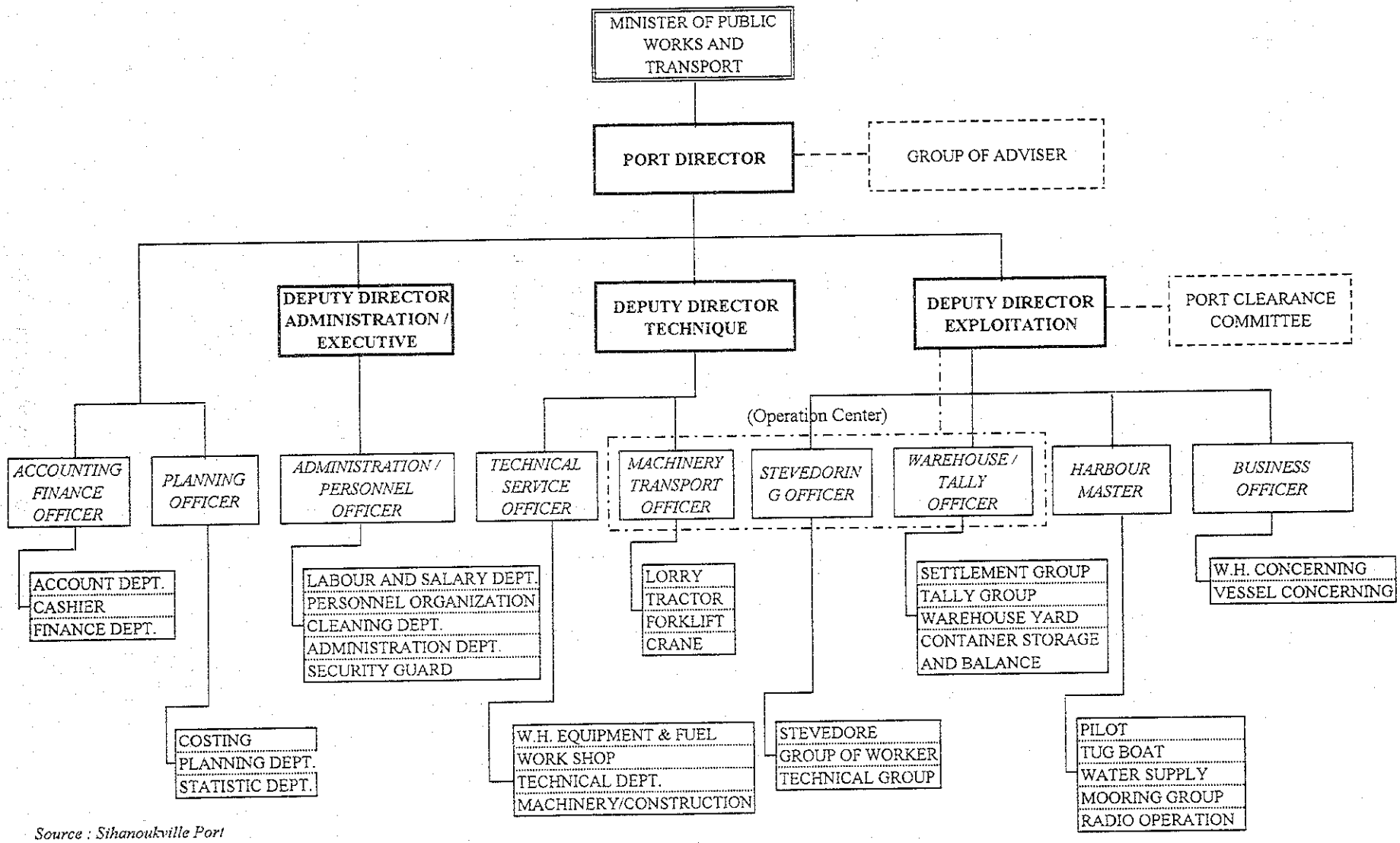
Port operation concerned with cargo handling and maritime services is carried out at six sections: Business Office, Technical Service Office, Machinery/Transport Office, Stevedoring Office, Warehouse/Tally Office and Harbor Master Office. The flow chart of port operation and related offices is shown in Fig. - 2.5.2-3.

(3) Personnel management

a. Number of personnel

The number of employees of Sihanoukville Port is 1,008 in total as of April 1996, which is a large number, as shown in Table - 2.5.2-1. This is because, as mentioned above, the port authority employs its own personnel to conduct cargo handling and maritime service by itself. Table - 2.5.2-2 shows the movement of employees during the years from 1991 to 1996. The total number of employees decreased in 1993, but it has remained constant since 1994.

The age structure of employees is shown in Table - 2.5.2-3 and Fig. - 2.5.2-4. The share of employees below age 40 represents 70%. The composition of the employees at Sihanoukville Port seems to be comparatively young. Also, the number of engineers is 12 as shown in Table - 2.5.2-4. This is rather a small number, considering the total number of employees and scale of the organization.



Source : Sihanoukville Port

Fig. - 2.5.2-2 Organization chart of Sihanoukville Port

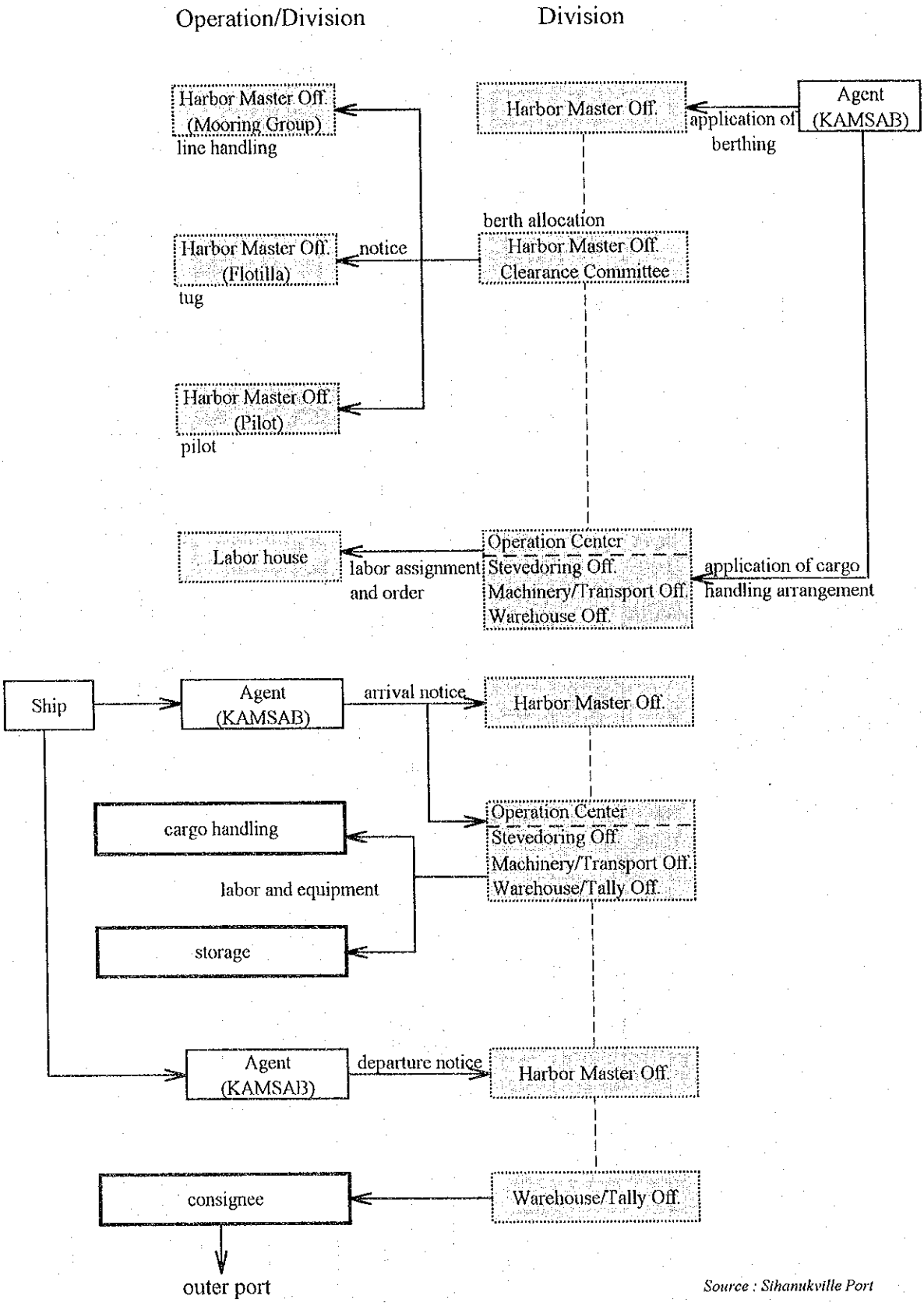


Fig. - 2.5.2-3 Flow of port operation

Table - 2.5.2-1 Number of employees of Sihanoukville Port

as of Apr. 1996

Office/class	Director & D. Director	Officer & D. Officer	Staff of Office & Service	Labor	total
Leader	4				4
Administration / Personnel		3	44	86	133
Accounting / Finance		3	10		13
Planning		2	8		10
Business		2	9		11
Technical service		1	15	114	130
Machinery / Transport		3	4	158	165
Stevedoring		2	3	357	362
Warehouse / Tally		2	7	98	107
Harbor Master		3	1	69	73
Total	4	21	101	882	1,008

Source : Sihanoukville Port

Table - 2.5.2-2 Number of employees of Sihanoukville Port (1991-1996)

Employ/year	Dec. 1991	Dec. 1992	Dec. 1993	Dec. 1994	Dec. 1995	Apr. 1996
Director, D. Director	5	5	4	3	4	4
Officer, D. Officer	21	21	20	20	21	21
Staff of Office & Service	101	101	101	102	102	101
Labor	1,022	896	854	882	882	882
Total	1,149	1,023	979	1,009	1,009	1,008

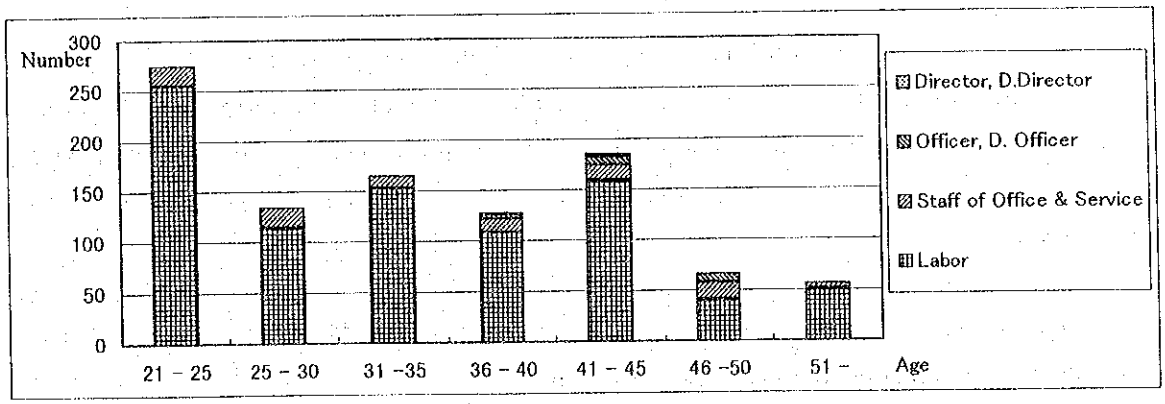
Source : Sihanoukville Port

Table - 2.5.2-3 Age structure of employees

as of Apr. 1996

Employ/Age	Total	21 - 25	25 - 30	31 -35	36 - 40	41 - 45	46 -50	51 -
Director, D. Director	4				1	3		
Officer, D. Officer	21				4	8	9	
Staff of Office & Service	101	20	19	12	14	15	16	5
Labor	882	255	115	153	108	159	41	51
Total	1,008	275	134	165	127	185	66	56
shear (%)	100.0%	27.3%	13.3%	16.4%	12.6%	18.4%	6.5%	5.6%

Source : Sihanoukville Port



Source : Sihanoukville Port

Fig. - 2.5.2-4 Age structure of employees

Table - 2.5.2-4 Number of engineers of Sihanoukville Port

Engineer	Number
Civil engineer	3
Chemical food engineer	1
Electrical engineer	1
Hydraulic engineer	2
Mechanical engineer	2
Economist	3
Total	12

source : Sihanoukville Port

b. Appointment and adoption of personnel

The Port Director is appointed by the Prime Minister. The Port Deputy Directors and Chiefs of office are recommended by the Port Director and appointed by the Minister of MPWT.

Concerning the adoption of personnel, there are two ways of recruitment. One way is to employ persons who are chosen by MPWT, the other way is to be hired by port authority. In case of the latter, port authority interviews the applicants and makes a selection. After approval of MPWT, port authority can recruit them.

c. Working conditions

Working hours are as follows:

- Office working hours

  Monday - Friday 7:00 - 11:30, 14:00 - 17:30

  Holiday Saturday, Sunday and National holidays (23 days)

  (Note : After May 1, 1996, Saturday became a holiday.)

- Port operating hours

  The present operating hours and shifts are shown in Table - 2.5.2-5.

Wage/salary consists of base-salary, family allowance, overtime allowance, region allowance, special allowance and so on. A special allowance is based on cargo handling revenue, in which wage/salary increases according to increased handling volume. In the last year, average wages per person per year was 4,242 thousand reiels. Also, the gap in wages between top and bottom is small.

At present, the mandatory retirement age is 55 years old. If employees retire, they will get six times as much as the basic monthly salary. Also Sihanoukville Port does not have a Labor Union, the same as other governmental organizations.

Table - 2.5.2-5 Port operating hours and closing days by each function

Function/Service	Operating hours and number of shifts		Closing days
Pilotage	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Tugs	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Berthing	12 hours	06:00 - 18:30	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Line handling	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Harbor master	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Customs	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Quarantine	18 hours 2 shifts	07:00 - 17:30 17:30 - 22:00	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Cargo handling (general cargo)	12.5hours 3shifts	07:00 - 11:30 14:00 - 17:30 19:00 - 23:30	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Cargo handling (container)	24 hours		Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1
Delivery	12.5 hours 3shifts	07:00 - 11:30 14:00 - 17:30 19:00 - 23:30	Apr. 13 - 15, Oct. 11 - 13, Oct. 30, 31, Nov. 1

Source : Sihanoukville Port

d. Training program

Sihanoukville Port has a training program for the purpose of development of human resources, as shown in Table - 2.5.2-6. Many plans concerning port management and operation are prepared.

(4) Port services performance

Performance of port services in the last year (1995), such as pilotage, tugs, water supply and garbage, is as shown in Table - 2.5.2-7. But Sihanoukville Port does not provide services for the supply of fuel and electricity to vessels and ship's guard.

(5) Tariff system

Dues, rates and charges that Sihanoukville Port collects from users of the port are decided by the Central Government. The present tariff came into effect on May 8, 1993 , when handling and storage charges of containers were described for the first time. Table - 2.5.2-8 shows the main rate of port tariff. It is classified into four categories : navigation charges & dues,

stevedoring charges, other charges (including handling and storage charges of containers) and hire of labor, facilities & equipment. All charges are expressed in US dollars.

Navigation charges & dues are charges for account of vessel. Pilotage and tug assistance charge are compulsory for all ships. Stevedoring charges are charges for discharging or loading cargoes. These rates are decided in detail for category of cargo and cargo operation and include the equipment and labors. If consignee brings the equipment or labors for handling the cargo, a stevedoring charge of 20% must be paid to the port.

Table - 2.5.2-6 Training program at Sihanoukville Port (1996-2000)

Description of training	Unit	year				
		1996	1997	1998	1999	2000
Technician requirement						
- Driving all kinds of vehicles	Person	40	40	20	20	20
- Computer operation	〃	15	10	5	5	5
- Diver	〃	2				
- Other technics	〃	10	8	6	5	5
Project educated						
- Computer	〃	15	10	5	5	5
- Port management	〃	4	4	4	4	4
- Container yard & ware housing	〃	8		8		8
- Port information system	〃	2		2		2
- Terminal container system	〃		4		4	4
- Port harbor engineering	〃	2		2		2
- Port magnetication	〃	3		3		3
- Vessel traffic system	〃	2		2		2
- Stevedoring	〃	10	5		5	5
- Port administration	〃	2		2		2
- Port Marketing	〃	2	2		2	2
- Port planning	〃	2		2		2
- Port financing	〃	2	1			1
- Port operation	〃	3		3		3

Source : Sihanoukville Port

Table - 2.5.2-7 Port service performance in 1995

a. Pilotage service

Number of persons in the section	6 persons			
Number of pilots	6 persons			
Pilot boats	using exclusive boats, using tug boats			
Number of crew on pilot boat including captain	7 persons			
Total number of pilots who went out for service in last year	1,192 ships			
Purchased year and price of pilot boats	1 boat	1980	price	13,280,859 Riels
Average cost of fuel for a pilot boat at one service	21 US$			

b. Tug service

Number of persons in the section	46 persons			
Average number of crews per boat including captain	13 persons			
Total number of ships which took the service in last year	1,706 ships			
Purchased year and price of tug boats	1 boat 1 boat 1 boat	1979 1995	price	34,050,000 Riels 650,000 US$
Average cost of fuel for pilot boat at one service	86 US$			

c. Water supply

Number of persons in the section	3 persons
Average number of persons per gang for water supply	3 persons
Total number of ships which took the supply in last year	77 ships
Purchased price of water par m3	1.9 US$
Revenue by water supply in last year	11,343 US$

d. Waste service

Number of persons in the section	51 persons (included other service)
Average number of persons per gang for waste service	3 persons
Number of waste disposal vehicles	1 tractor
Revenue from waste disposal in last year	4,903 US$

Source : Sihanoukville Port

Table - 2.5.2-8 (a) Port tariff: Navigation charges & dues

Tariff Item and Description				Normal	Addition	Minimum	Unit
Tonnage Charges (for each entry or department)				0.13*2			US$/GT.
Beathage Charges							
	At quay	Cargo Vessel	up to 5 days	0.23			US$/GT.
			more than 5days		0.003		US$/GT./hr.
		Tourist and Service Vessel		0.003			US$/GT./hr.
	At buoy	Cargo Vessel	up to 5 days	0.10			US$/GT.
			more than 5days		0.001		US$/GT./hr.
		Tourist and Service Vessel		0.001			US$/GT./hr.
	At anchorage	Cargo Vessel	up to 5 days	0.05			US$/GT.
			more than 5days		0.0005		US$/GT./hr.
		Tourist and Service Vessel		0.0005			US$/GT./hr.
Channel Dues		Commercial Vessel		0.31*2			US$/GT.
		Lighter Carrier		0.16			US$/GT.
Pilotage Charges		For commercial sea port		0.027			US$/GT.
		For refinery port		0.03			US$/GT.
		For each shifting		0.017			US$/GT.
		Minimum charges				100	US$
Tug Assistance Charges			Up to 1,000 GT.	83.0			US$/hr.
			From 1,001 to 4,000 GT.	149.0			US$/hr.
			From 4,001 to 10,000 GT.	165.5			US$/hr.
			From 10,001 to 15,000 GT.	215.0			US$/hr.
			More than 15,001 GT.		18.00		US$/hrs/1,000GT
Mooring & Unmooring							
	At quay		Up to 1,000 GT.	16.50			US$
			From 1,001 to 4,000 GT.	33.00			US$
			From 4,001 to 10,000 GT.	50.00			US$
			From 10,001 to 15,000 GT.	66.00			US$
			More than 15,001 GT.	83.00			US$
	At buoy		Up to 1,000 GT.	50.00			US$
			From 1,001 to 4,000 GT.	83.00			US$
			From 4,001 to 10,000 GT.	110.00			US$
			From 10,001 to 15,000 GT.	132.00			US$
			More than 15,001 GT.	149.00			US$
Charge for Opening & Closing Hatches							
	Hatch without beam		Up to 5,000 GT.	13.00			US$
			From 5,001 to 10,000 GT.	23.00			US$
			More than 10,001 GT.	36.00			US$
	Hatch with beam		Up to 5,000 GT.	26.00			US$
			From 5,001 to 10,000 GT.	46.00			US$
Charge for Cleaning and Sweeping Holds							
	Innocuous-cargo		More than 10,001 GT.	73.00			US$
			Up to 5,000 GT.	33.00			US$
			From 5,001 to 10,000 GT.	41.00			US$
			More than 10,001 GT.	56.00			US$
	Dangerous & poisonous cargo		Up to 5,000 GT.	53.00			US$
			From 5,001 to 10,000 GT.	83.00			US$
			More than 10,001 GT.	116.00			US$
Charge for Cleaning and Washing Ship's Decks			With water supply by ship	0.17			US$/m2
			With water supply by port	0.20			US$/m2
Charge for Dumping Service			At quay	20.00			US$/times
			At buoy	45.00			US$/times
Fresh Water Charges			Supplied from hydrant at quay	2.50			US$/m3
			Supplied by truck	3.75			US$/m3
Wharfage Charges			Cargo discharges or loading	0.30			US$/tons
			Passenger	0.18			US$/person
Other Charges			Clearance fee	100.00			US$/vessel
			Watchman fee	1.60			US$/person/hr.

Source : Sihanoukville Port

Table - 2.5.2-8 (b) Port tariff: Stevedoring charges (except containers)

1. Handling charge

Unit : US$/ton

Kind of cargo	(base) By ship's gear	From ship to			Warehouse to		Discharge at anchorage
		Truck & wagon	Warehouse	Ship or barge	Truck	Wagon	
1) Cargo in bulk, metal, ores gravel, block stone, food, fertilizer, salt, raw sugar	1.46	2.19	2.92	2.56	1.97	2.19	2.19
2-a) Cargo in bag packed in cotton, jute, paper, fad-nylon, rash bag	1.58	2.37	3.16	2.77	2.13	2.37	2.37
2-b) Cement, fortilizer	1.58	3.16	3.95	3.56	2.92	3.16	3.16
3) Machinery, equipment, empty container, empty drums, empty case, log wood	2.12	3.18	4.24	3.71	2.86	3.18	3.18
4) Cargo in drum, in cases or in bundles, coins bars, plates	2.32	3.48	4.64	4.06	3.13	3.48	3.48
5) Cargo in bales (raw cotton, raw jute, humps, rush paper, textiles, clothing materials, household utensils sundries	2.45	3.68	4.90	4.29	3.31	3.68	3.68
6) Swan timber, flooring stripes, wooden & bamboo wares	2.52	3.78	5.04	4.41	3.40	3.78	3.78
7) Cargo in baskets	2.65	3.98	5.30	4.64	3.58	3.98	3.98
8) Fragile materials cargo, in bottles, glass, ceramic pots, TV camera sets, valuable cargo	2.81	4.22	5.62	4.92	3.79	4.22	4.22
9) Fresh fruit, livestock, frozen products	2.92	4.38	5.84	5.11	3.94	4.38	4.38
10) Special and valuable cargo (gold, silver, diamond, motorcar, trucks heavy weight and long construction material	4.97	7.46	9.94	8.70	6.71	7.46	7.46

2. Extra charges of cargo handling

Item and description			Rate and charge to increase		Unit
Cargo	Weight	From 5t up to 10t	50		%
		From 10t up to 20t	100		%
		Over 20t	200		%
	Length	From 12m up to 16m	50		%
		From 16m up to 20m	100		%
		Over 20m	200		%
	Dangerous & poisonous		50		%
	For cargo cashed or hardened		40		%
	For cargo in small package below 10kg		30		%
	Frozen cargo or refrigerator		100		%
Work	Night shift	From 18:00 to 24:00	25		%
		From 00:00 to 06:00	50		%
	Sunday & holiday		50		%
Ship	Hold which depth over 3m		100		%
	Hold colder than 10 degrees to 0 degrees		50		%
Other	Using port's mobile crane			1.00	US$/ton
	(except have not ship's crane) Cargo run through the scale			0.50	US$/ton

Note : Addition to the rate and charge for above table(base)

3. Storage charge

Tariff item and description		Normal	Addition	Unit
Storage	In warehouse	0.20		US$/ton/day
		or 0.25		US$/m2/day
	In open space	0.10		US$/ton/day
		or 0.125		US$/m2/day

Source : Sihanoukville Port

Table - 2.5.2-8 (c) Port tariff: Other charges

1. Charge of containers

Tariff Item and Description			20 ft		40 ft		Unit
			Full	Empty	Full	Empty	
Cargo handling	Ship --- CY	Ship gear	57.00	30.00	85.00	45.00	US$/Unit
		Port crane	72.00	38.00	115.00	61.00	US$/Unit
	CY to truck		46.00	23.00	62.50	44.00	US$/Unit
	CY to wagon		57.50	28.75	78.50	55.00	US$/Unit
Storage			3.50	1.00	7.00	2.00	US$/Unit/day
Shifting or moving			25.00	15.00	38.00	22.50	US$/Unit
Delivery and receiving			1.00				US$/Unit

2. Other charges

Tariff item and description		Normal	Addition	Unit
Repackaging		1.00		US$/ton
	Dangerous and poisonous		50	%
	To shift cargo above 25m or 2m high		30	%
	For cargo cashed, hardened required extra work		50	%
	Fertilizer, cement, salt, etc.		30	%
delivery and receiving	Cargo in bag	0.50		US$/ton
	General cargo	0.70		US$/ton
	Vehicle	1.50		US$/unit

Source : Sihanoukville Port

Table - 2.5.2-8 (d) Port tariff: Hire of labor, facilities & equipment

Tariff Item and Description			Normal	Addition	Unit
Hire of Labor	Technical & Specialize Labor		3.00		US$/person/hr
	Non Specialize Labor		1.00		US$/person/hr
	Diver		35.00		US$/person/hr
	Direct contact with dangerous cargo			50	%
Hire of Facilities, Equipment	Tug		0.40		US$/hp/hr
	Lighter		1.40		US$/GT./day
	Mobile crane	Below 5t	16.50		US$/hr
		From 5t up to 10t	30.00		US$/hr
		From 10t up to 25t	40.00		US$/hr
		Over 25t		+1.50	US$/t/hr
Hire of Other Facilities (excluding labor)	Motor boat		33.00		US$/hr
	Lorry truck		5.00		US$/hr
	Trailer without Tractor		1.70		US$/hr
	Tractor		20.00		US$/hr
	Fork lift	Below 5t	10.00		US$/hr
		From 5t up to 15t	15.00		US$/hr
		Over 15t	25.00		US$/hr
	Air Compressor for Diver		15.00		US$/hr
	Port's VHF	Foreign country	4.00		US$/min
		In the country	1.30		US$/min

Source : Sihanoukville Port

(6) Financial situation

Sihanoukville Port is financially independent from the Central Government. The obtained revenue from port activities and port facilities are taxable. At present, main taxes payable to the Government are shown below.

1. Turnover tax ---------- 4%
2. Profit tax ---------- 20%
3. Patent
4. Tax on capital ---------- 4%
5. Depreciation tax ---------- 50%
6. Social benefit ---------- 3%

a. Income statement

The income statements of Sihanoukville Port between 1992-1995 are shown in Table - 2.5.2-9. The table was prepared to check the amount of the operating profit of the last four years. Also, the table includes working ratio, operating ratio of port operation and personnel expenses. Working ratio means the proportion of operation expenses excluding depreciation versus operating income, operating ratio means the proportion of operating expense versus operating income, and personnel expenses ratio means the proportion of operating expenses excluding depreciation versus personnel expenses.

Operating revenue, operating expenses and net operating income are shown in Fig. - 2.5.2-5. The net income and the net operating income in 1992 through 1995 increased and kept a profit. The operating ratio in each year was mostly less than 48% and the personnel expenses ratio in each year was 45% (maximum) and 34% (minimum). The working ratio was about 50% in a recent four year period (1992-1995). In order to secure sound operation efficiency, this figure should be lower than normal ratios of 50 - 60%. Also, the personnel expenses increases with the increase of operating revenue. This is because of the salary/wage system in which a commission of 20 per cent is given on handling revenue.

b. Operating revenue

Port service revenue of Sihanoukville Port 1992 -1995 is broken down into four categories: navigation , cargo handling, cargo storage and transport. The revenue share of each category is shown in Fig. - 2.5.2-6. Cargo handling revenue has been increasing and is about 63% of the total revenue in 1995.

Table - 2.5.2-9 Income statement of Sihanoukville Port

unit : Thousand Riels

	1992	1993	1994	1995
Operating Revenue	3,168,041	11,560,226	15,762,822	21,750,831
Port Service Revenue	3,071,049	11,428,838	15,566,174	21,248,233
Other Revenue	96,992	131,389	196,648	502,598
Operating Expenses	1,578,175	4,835,397	7,274,986	11,044,441
Personnel Cost	517,007	1,742,449	3,272,404	4,255,790
Social benefit	19,678	70,966	26,270	19,762
sub total	536,685	1,813,415	3,298,674	4,275,552
Maintenance and Repair	228,801	517,822	240,634	382,449
Purchase (fuel, materials, spare parts)	544,301	1,692,312	2,645,264	4,060,622
Tax	63,041	230,559	444,491	693,617
Other Expenses	120,890	381,658	378,710	1,001,502
Depreciation Cost	2,520	68,539	211,570	478,599
Amortization of Deferred Assets	81,938	131,092	55,644	152,100
Net Operating Income	1,589,866	6,724,830	8,487,836	10,706,390
Financial Revenue	0	0	2,363	4,000
Interest Income	0	0	2,363	4,000
Financial Expenses	0	0	0	66,132
Interest on Loons	0	0	0	36,708
Loss from Exchange	0	0	0	29,424
Net Financial Income	0	0	2,363	-62,132
Net Income before tax	1,589,866	6,724,830	8,490,199	10,644,258
Tax on Income	476,960	2,017,449	1,698,040	2,128,852
Net Income after Tax	1,112,906	4,707,381	6,792,159	8,515,406
Working Ratio (%)	50%	42%	46%	51%
Operation Ratio (%)	47%	40%	44%	48%
Personnel Expenses Ratio (%)	34%	38%	45%	39%

Source : Sihanoukville Port