

PUBLIC WORKS DEPARTMENT

MINISTRY OF INTERIOR

FEASIBILITY STUDY

ON

SEWERAGE AND DRAINAGE IMPROVEMENT PROJECT

FOR

PHUKET MUNICIPALITY

IN

THE KINGDOM OF THAILAND

SOIL INVESTIGATION REPORT

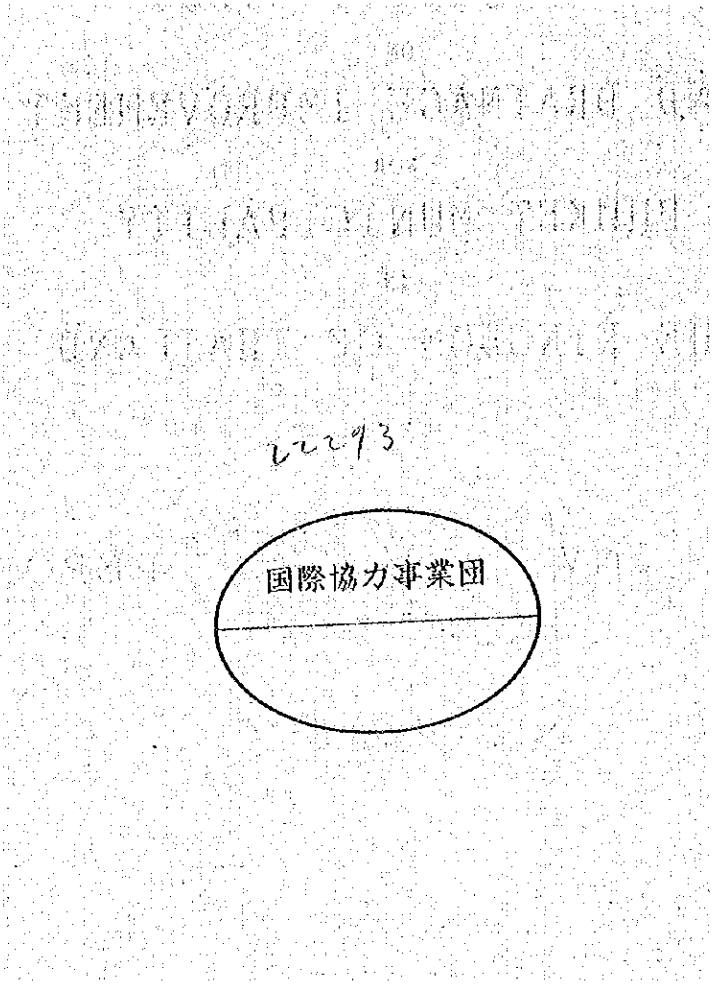
JICA LIBRARY



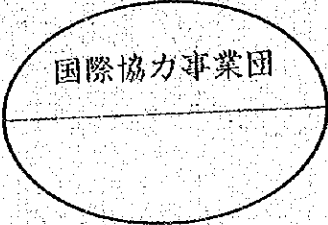
1090214(6)

JANUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY



22293



国際協力事業団

table of contents

	p
1. Report of Soil Investigation by JICA Study Team in October 1989	1
2. Existing Geological Data Before JICA Study Team	42

1. Report of Soil Investigation by JICA Study Team in October 1989.

SEWERAGE AND DRAINAGE IMPROVEMENT PROJECT

FOR

PHUKET MUNICIPALITY, PHUKET PROVINCE

REPORT NO. 32098

OCTOBER 1989

## CONTENT

	PAGE	
1. INTRODUCTION	1	
2. INVESTIGATION AND TESTING PROCEDURES	4-6	
3. COMMENT	7	
TABLE 1	SUMMARY OF SOIL ENGINEERING PROPERTIES	8-11
TABLE 2	GRAIN SIZE DISTRIBUTION	12
FIG. 1-9	SOIL BORING	13-21
FIG. 10	GENERALIZED SOIL PROFILE	22
FIG. 11-16	UNCONSOLIDATED UNDRAINED TRIAXIAL (UU) TEST RESULT	23-28
FIG. 17-20	UNCONFINED COMPRESSION TEST RESULTS	29-32
FIG. 21-28	GRAIN SIZE DISTRIBUTION	33-40
FIG. 29	BORING LOCATION MAP	41
APPENDIX A PHOTOGRAPHS		

## 1. INTRODUCTION

This report presents the subsoil investigation for the proposed "Sewerage and Drainage Improvement Project" for Phuket Municipality in Phuket Province, Thailand.

Nine borings were drilled along the main road in the Phuket City. The boring was stopped when the standard penetration test revealed of high resistance. The general soil engineering properties were carried out on the selective samples, i.e. water content, total unit weight, specific gravity, grain size, unconfined compressive strength, unconsolidated undrained triaxial test, Liquid limit and Plastic limit.

The field investigation and testing results are presented here in the report.

## 2. INVESTIGATION AND TESTING PROCEDURES

### 2.1 General

The drilling was performed in accordance with the conventional wash boring method. The bore hole was advanced by a chopping bit and pressurized water. Whenever the soft clay or loose sand encounters, the steel casing was driven into the weak layer to stabilize the bore hole.

### 2.2 Undisturbed Soil Sampling

A 3.0 inches diameter thin wall seamless steel tube was statically pushed into the cohesive soil. The recovery

undisturbed samples were carefully sealed with wax and stored in the cool place.

### 2.3 Standard Penetration Test (SPT)

A standard split barrel sampler (ASTM D-1586) was used. The sampler was seated at the bottom of stiff cohesive soil or cohesionless soil, and a 140 pounds hammer was freely dropped from 30 inches vertical distance (through a guide pipe). The number of blows at every 6-inch of penetration was recorded. Each test was stopped at 18 inches of penetration. The sum of blows of the last two tests (per foot) is taken as the standard penetration resistance; N value, which is an indication of the relative in-situ soil resistance. The test results are presented in the boring log figure 1-9.

### 2.4 Water Content and Total Unit Weight

Each representative soil specimen from the standard penetration was cut and shaped into a known volume. After the wet weight of soil was determined, the sample was oven dry for overnight and the dry weight was rescaled. The Total Unit Weight and water content were computed from the testing data. The testing results are presented in table 1.

### 2.5 Liquid Limit (ASTM D-423)

A clay sample was aired dry for overnight, the water was added and thoroughly mixed until the clay sample was in the paste state and placed into the Atterberg device. Count and drop the cup until to close the clay groove space of about 1 cm. The liquid limit of a clay sample is the water content



when the groove closes at 25 drops.

The test results are presented in table 1.

#### 2.6 Plastic Limit (ASTM D-424)

The excess sample from the liquid limit test was used in the test by rolling the clay sample on the glass surface, until the clay thread (1/8" diameter) appeared to crumble then the water content was taken and defined the plastic limit. The testing results are presented in table 1.

#### 2.7 Grain Size Test

A sandy soil sample was oven dried for overnight, about 200 g of dry sample was washed through no.200 sieve, the sample retained on the 200 sieve was reoven dried and sieved on a series number sieves. The sample retained on each sieve was weighed. The testing results are presented in table 2 and figure 21-28.

#### 2.8 Unconfined Compression Test

The tests were carried out with 3.5 cm diameter by 7.1 cm high undisturbed samples. The axial load was applied at the constant strain rate of 0.7 mm per minutes. The unconfined compressive strength ( $q_u$ ) was defined at failure or when 20% of strain was reached. The testing results are presented in the boring log and figure 17-20.

#### 2.9 Unconsolidated Undrained Triaxial Test (UU)

The clay specimen was 3.5 cm in diameter with 7.0 cm high. The confining pressure were approximately equal to  $\sigma$ ,  $2\sigma$ ,  $4\sigma$

where  $\sigma$  was the total overburden pressure. After applying the confining pressure, the specimen was slowly sheared to failure. The strength envelopes of the test results are presented in figure 11~16.

- 3.1 The nine borings reveal that, the soil profile along one section is varied, the uniform pattern of soil profile is hardly concluded from the investigation. The variation of soil strata can be the geological formation and disturbed by the past mining excavation and tail filling. However, figure 10 presents the generalized soil profile along one section for the preliminary study.
- 3.2 In order to verify the better soil profile, the shallow hand augering to 3~5 m deep should be carried out between the deep borings.
- 3.3 In the implement stage of the project, the intensive soil investigation should be carried out as recommended following;

Depth of boring : not over 10 m deep, except where the heavy structure is located.

Field Testing : Observation well, field permeability, density.

Soil Testing : Compaction, permeability, some consolidation.

TABLE 1 SUMMARY OF SOIL ENGINEERING PROPERTIES



Project : Sewerage and Drainage Improvement Project

Location: Phuket Municipality

Date : October 14, 1989

Boring No.	Depth (m)	Total Unit Weight $\gamma$ <sub>3</sub>	Water Content %	Liquid Limit %	Plastic Limit %	Specific Gravity	Unconfined Strength $\tau$ <sub>u</sub>
BH-1	1.5 - 1.95	1.98	17.2				
	3.0 - 3.45	1.93	26.7			2.68	
	4.5 - 5.0			59.4	28.2	2.67	3.6
	5.0 - 5.45	1.89	32.6				
	6.0 - 6.45	2.14	20.6				
	7.5 - 7.95	2.02	15.1				
	9.0 - 9.45	2.01	18.5				
	10.5 - 10.95	1.67	19.6	35.0	17.9		
	12.0 - 12.45	1.75	18.8				
	13.5 - 13.95	1.75	16.3				
	15.05 - 15.5	1.69	16.0				
BH-2	3.0 - 3.45	2.18	13.7				
	6.0 - 6.45	2.06	21.2				
	7.5 - 7.95	2.20	13.1			2.66	
	9.0 - 9.45	1.87	19.0	33.0	15.3	2.68	
	10.0 - 10.45	1.82	16.7				
BH-3	3.0 - 3.45	1.84	41.6			2.68	
	4.5 - 4.95	2.10	20.6				
	6.0 - 6.45	2.18	16.0	43.6	22.9		
	7.5 - 7.95	2.11	22.8				
	10.5 - 10.95	1.80	27.2				
	12.0 - 12.5			27.0	14.8	2.66	20.7
	12.5 - 12.95	1.82	21.4				

TABLE 1 SUMMARY OF SOIL ENGINEERING PROPERTIES



Project : Sewerage and Drainage Improvement Project

Location : Phuket Municipality

Date : October 14, 1989

Boring No.	Depth (m)	Total Unit Weight $t/m^3$	Water Content %	Liquid Limit %	Plastic Limit %	Specific Gravity	Unconfined Strength $t/m^2$
	13.5 - 13.95	1.81	19.3				
	15.0 - 15.5			27.4	15.5		
	15.5 - 15.95	1.80	17.3				
	16.5 - 16.95	1.75	19.1				
	18.0 - 18.45	1.75	18.2				
	19.55 - 20.00	1.73	17.8				
BH-4	1.5 - 1.95	1.87	30.6				
	3.0 - 3.45	2.18	17.2				
	6.0 - 6.5					2.67	
	6.5 - 6.95	2.06	17.3				
	9.0 - 9.45	1.90	20.6				
	10.5 - 10.95	1.71	39.8				
	12.0 - 12.5			27.2	15.7		19.1
	12.5 - 12.95	1.73	25.5				
	13.5 - 13.95	1.76	25.6				
	15.0 - 15.45	1.81	31.8				
	16.5 - 16.95	1.81	24.2	30.4	16.3	2.66	
18.0 - 18.45	1.79	22.5					
19.55 - 20.00	1.87	22.7					
BH-5	6.0 - 6.50	1.67	58.3	56.6	27.1	2.66	3.9
	9.0 - 9.45	2.05	26.0				
	10.5 - 10.95	2.15	13.9			2.68	
	12.0 - 12.5			30.6	15.5		28.8
	12.5 - 12.95	1.60	27.5				
	13.5 - 13.95	1.77	31.8				
	15.05 - 15.50	1.50	22.1				

TABLE 1. SUMMARY OF SOIL ENGINEERING PROPERTIES

7



Project : Sewerage and Drainage Improvement Project

Location: Phuket Municipality

Date : October 14, 1989

Boring No.	Depth (m)	Total Unit Weight $t/m^3$	Water Content %	Liquid Limit %	Plastic Limit %	Specific Gravity	Unconfined Strength $t/m^2$
BH-6	4.5 - 4.95	1.84	36.9	60.6	28.3	2.69	
	7.5 - 7.95	-	33.8				
	9.0 - 9.50	1.86	44.2	35.4	19.6		
	10.5 - 10.95	1.54	80.9				
	12.5 - 12.95	2.06	16.2				
	13.5 - 13.95	1.75	24.4				
	15.0 - 15.45	1.66	17.4	34.2	17.9	2.68	
	16.5 - 16.95	1.67	18.6				
	18.05 - 18.50	1.79	24.6				
BH-7	0.0 - 0.00	-	4.1				
	1.5 - 1.95	1.80	44.3				
	3.0 - 3.5			49.4	22.7	2.67	3.9
	3.5 - 3.95	1.80	25.9				
	4.5 - 4.95	1.77	26.9				
	6.0 - 6.45	1.66	31.6	62.6	28.3		
	7.5 - 7.95	2.00	31.3				
	9.5 - 9.95	1.98	16.5				
	12.0 - 12.45	1.84	22.0				
	13.5 - 13.95	1.95	19.5				
	15.0 - 15.45	1.99	17.8			2.67	
	16.5 - 16.95	1.74	13.7				

TABLE 1 SUMMARY OF SOIL ENGINEERING PROPERTIES



Project : Sewerage and Drainage Improvement Project

Location: Phuket Municipality

Date : October 14, 1989

Boring No.	Depth (m)	Total Unit Weight t/m <sup>3</sup>	Water Content %	Liquid Limit %	Plastic Limit %	Specific Gravity	Unconfined Strength t/m <sup>2</sup>
BH-8	1.5 - 1.95	1.97	29.5			2.67	
	3.0 - 3.45	1.72	55.7	25.0	13.6		
	4.5 - 4.95	1.72	57.0				
	6.0 - 6.50	1.55	57.2	28.2	15.7	2.67	3.3
BH-9	0.0 - 0.00	-	3.01				
	0.0 - 1.00	1.79	14.1				
	1.5 - 1.95	1.72	28.5				
	3.0 - 3.5			42.4	21.0	2.70	
	3.5 - 3.95	1.71	23.0				
	4.5 - 4.95	2.07	20.7	47.4	27.3	2.69	
	6.05 - 6.5	1.81	16.8				

TABLE 2 GRAIN SIZE DISTRIBUTION

PROJECT : Sewerage and Drainage Improvement Project for Phuket Municipality

LOCATION: Phuket Province

Date: October 1989

Boring No.	Depth m.	% OF FINER BY WEIGHT ON SIEVE NO.									
		1/2"	3/8"	4	10	20	40	60	100	200	
1	3.0 - 3.45	-	-	-	100.00	99.17	97.30	87.37	60.09	49.44	
	7.5 - 7.95	100.00	98.28	88.89	68.25	46.25	31.06	21.21	14.42	11.12	
2	3.0 - 3.45	-	100.00	99.55	98.04	65.00	47.64	25.75	15.76	10.95	
	7.5 - 7.95	-	100.00	86.12	55.33	37.77	30.27	23.16	16.16	12.35	
3	3.0 - 3.45	-	-	-	100.00	99.84	99.77	99.42	96.93	89.74	
	6.0 - 6.45	100.00	84.50	63.29	44.44	35.61	30.68	27.21	23.94	21.81	
4	3.0 - 3.45	-	100.00	94.96	74.35	49.96	34.26	25.26	20.83	18.32	
	6.0 - 6.50	-	100.00	97.01	71.01	44.36	29.98	20.76	15.59	13.02	
5	10.5 - 10.95	-	-	100.00	99.52	98.81	97.75	94.97	89.54	85.60	
	10.5 - 10.95	-	100.00	95.66	78.23	50.28	30.48	20.08	14.13	10.48	
6	12.0 - 12.50	100.00	96.04	91.56	74.91	55.69	40.27	25.42	15.10	12.08	
	3.0 - 3.50	-	-	-	-	99.93	99.85	99.33	98.59	97.99	
7	9.0 - 9.50	-	-	100.00	99.05	98.27	84.94	28.00	13.60	9.17	
	15.0 - 15.45	-	-	100.00	87.90	60.04	44.82	37.76	29.41	24.80	
8	1.5 - 1.95	100.00	95.00	92.62	86.82	83.93	77.11	59.09	23.44	8.56	
	3.0 - 3.45	-	-	-	-	-	100.00	99.77	91.60	80.14	
9	6.0 - 6.50	-	-	-	-	100.00	99.94	99.87	96.94	92.68	
	3.0 - 3.50	-	100.00	97.84	84.00	71.10	54.68	47.33	38.25	35.24	

# REGIONAL ENGINEERING CONSULTANTS CO., LTD.

## LOG BORING NO. BH-1

PROJECT : Sewerage and Drainage Improvement      DATE COMMENCED Oct. 1, 1989  
 LOCATION : Phuket Municipality, Komaraphat Road      DATE FINISHED Oct. 1, 1989

ABBREVIATIONS	GROUND ELEV.	M.	GRAPHIC LOG	DEPTH	M.	SAMPLING METHOD	TEST RESULTS
ST = UNDISTURBED SAMPLING	5.961						● UNCONFINED COMPRESSIVE STRENGTH $1/m^2$
SP = STANDARD PENETRATION TEST	WATER TABLE						▲ STANDARD PENETRATION TEST 81/30 cm
WO = WASH OUT	1.80						■ FIELD VANE SHEAR STRENGTH $1/m^2$
VS = FIELD VANE SHEAR TEST							
<b>SOIL DESCRIPTION</b>							
Brown, very loose coarse SAND (SP)						WO	
Brown, very loose fine SAND (SP)						WO	
Gray, medium CLAY (CH)				5		ST	3.6
Gray, soft fine sandy CLAY (CL)						WO	
Gray, loose coarse SAND (SP)						SP	21 (8, 12, 9)
Brown, hard silty CLAY with gravel sand and coarse sand (CL-GC)				10		WO	
						SP	10 (5, 4, 6)
						WO	
						SP	47 (17, 17, 30)
						WO	
						SP	54 (11, 18, 36)
						WO	
						SP	(22, 44, 36/3") ▲ 80/9"
				15		WO	
						SP	▲ 90 (32, 58)
End of Boring							
				20			



# REGIONAL ENGINEERING CONSULTANTS CO., LTD.

## LOG BORING NO. BH-2

PROJECT: Sewerage and Drainage Improvement      DATE COMMENCED: Sep. 30, 1989

LOCATION: Phuket Municipality, Thepkasatri Road      DATE FINISHED: Sep. 30, 1989

ABBREVIATIONS	GROUNDELEV.	M.	GRAPHIC LOG	DEPTH	M.	SAMPLING METHOD	● UNCONFINE COMPRESSIVE STRENGTH	1/m <sup>2</sup>	
UT = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VS = FIELD VANE SHEAR TEST	3.033								
	WATER TABLE						■ FIELD VANE SHEAR STRENGTH	1/m <sup>2</sup>	
	1.50								
SOIL DESCRIPTION									
								50	100
Earth fill of laterite		/							
C L A Y (GC)				WO					
Black, dense fine		.							
S A N D (SP)				SP		▲ 30 (7, 15, 15)			
Gray, loose clayey		/							
S A N D (SC)				5		SP		▲ 3 (1, 2) No recovery	
		.							
		/							
		.							
Gray, loose coarse		/							
S A N D (SP)						SP		▲ 14 (5, 8, 6)	
		.							
Gray-brown, stiff silty		/							
C L A Y (CL)						SP		▲ 13 (4, 5, 8)	
Hard weathered rock		D		10		WO			
		.				SP		▲ 40/4"	
End of Boring		/							
		.		15					

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH-3

PROJECT : Sewerage and Drainage Improvement

DATE COMMENCED Sep. 26, 1989

LOCATION : Phuket Municipality, Ratanakosin 200 Road

DATE FINISHED Sep. 26, 1989

ABBREVIATIONS ST = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VB = FIELD VANE SHEAR TEST	GROUND ELEV. 2,781 M. WATER TABLE 1.81 M.	GRAPHIC LOG	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH (t/m <sup>2</sup> )	
					10	20
SOIL DESCRIPTION					60	100
Brown, loose clayey fine SAND (SC)				WO		
Gray, very loose silty clayey coarse SAND (SM-SC)				WO		
			5	SP	2 (1, 1, 1)	
				WO		
Red to dark gray, medium gravelly CLAY and coarse Sand (CL-GC)				SP	7 (1, 3, 4)	
				WO		
				SP	5 (1, 2, 3)	
				WO		
Loose coarse SAND (SP)			10	ST	No recovery	
				WO		
Yellow, medium clayey silt (MH)				SP	8 (2, 3, 5)	
				WO		
				ST		20.7
				SP	28 (9, 12, 20)	
Yellow, stiff fine sandy silt (ML)				WO		
				SP	36 (4, 14, 22)	
				WO		
			15	ST		
				SP	53 (20, 25, 28)	
				WO		
				SP	45 (9, 17, 28)	
				WO		
Brown-yellow, hard sandy silt with some gravel (ML-GC)				SP	(14, 35, 55) 90	
				WO		
			20	SP	59 (11, 24, 35)	
End of Boring						

15  
Fig. 3 SOIL BORING

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH-4

PROJECT : Sewerage and Drainage Improvement

DATE COMMENCED Sep. 29, 1989

LOCATION : Phuket Municipality, Ong Sim Phai Road

DATE FINISHED Sep. 29, 1989

ABBREVIATIONS ST = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VS = FIELD VANE SHEAR TEST	GROUNDELEV. 2.519 WATER TABLE 1.10	M. M.	GRAPHIC LOG	DEPTH M.	SAMPLING METHOD	● UNCONFINED COMPRESSIVE STRENGTH	△ STANDARD PENETRATION TEST	■ FIELD VANE SHEAR STRENGTH
						t/m <sup>2</sup>	bls/30cm	t/m <sup>2</sup>
SOIL DESCRIPTION						10	50	20
Gray-brown, very loose fine SAND (SP)						50	100	
Dark gray, very loose coarse SAND (SP)								
Dark brown, hard silty CLAY (CL)								
End of Boring								

DEPTH (M)	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH (t/m <sup>2</sup> )	STANDARD PENETRATION TEST (bls/30cm)	FIELD VANE SHEAR STRENGTH (t/m <sup>2</sup> )
0.0 - 0.5	WO			
0.5 - 1.0	SP		5 (1, 2, 4)	
1.0 - 1.5	WO			
1.5 - 2.0	SP		2 (1, 1, 1)	
2.0 - 2.5	WO			
2.5 - 3.0	ST	No recovery		
3.0 - 3.5	SP		(0) No recovery	
3.5 - 4.0	WO			
4.0 - 4.5	ST			
4.5 - 5.0	SP		2 (1, 1, 1)	
5.0 - 5.5	WO			
5.5 - 6.0	SP		2 (1, 1, 1) No recovery	
6.0 - 6.5	WO			
6.5 - 7.0	SP		7 (2, 3, 4)	
7.0 - 7.5	WO			
7.5 - 8.0	SP		12 (3, 4, 8)	
8.0 - 8.5	WO			
8.5 - 9.0	ST	9.1		
9.0 - 9.5	SP		3 (8, 12, 22)	
9.5 - 10.0	WO			
10.0 - 10.5	SP		41 (9, 16, 25)	
10.5 - 11.0	WO			
11.0 - 11.5	SP		25 (5, 10, 15)	
11.5 - 12.0	WO			
12.0 - 12.5	SP		52 (8, 19, 33)	
12.5 - 13.0	WO			
13.0 - 13.5	SP		38 (9, 13, 25)	
13.5 - 14.0	WO			
14.0 - 14.5	SP		(15, 30, 50/4")	
14.5 - 15.0	WO			
15.0 - 15.5	SP		80/10"	

16  
Fig. 4 SOIL BORING



REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH-6

PROJECT: Sewerage and Drainage Improvement

DATE COMMENCED Sep. 28, 1989

LOCATION: Phuket Municipality, Ratanakosin 200 Road

DATE FINISHED Sep. 28, 1989

ABBREVIATIONS ST = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VS = FIELD VANE SHEAR TEST	GROUND ELEV. 2.10 WATER TABLE 1.06	M.	GRAPHIC LOG	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH $1/m^2$	
						50	100
Garbage Fill					WO		
					ST		
					WO		
					SP	▲ (0) No recovery	
					WO		
				5	SP	▲ (0)	
					WO		
					SP	▲ (0) No recovery	
					WO		
					SP	▲ (0) She	
Dark gray, very soft C L A Y (CH) with some shell					WO		
					ST		
					WO		
					SP	▲ (0) No recovery	
					WO		
				10	ST	Medium clay	
					WO		
					SP	▲ 13 (3, 18)	
					WO		
					SP	▲ 55 (14, 22, 33)	
Dark-grey-brown, very loose coarse S A N D (SP)					WO		
					ST		
					WO		
					SP	▲ 58 (9, 22, 42)	
				15	WO		
					SP	(12, 32, 53) 90 ▲	
					WO		
					SP	(12, 39, 41) 5" ▲ 180/31"	
					WO		
					SP		
Brown-yellow, very hard silty C L A Y (CH)					WO		
					ST		
End of Boring					WO		
				20			

Fig. 6 SOIL BORING

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH-7

PROJECT : Sewerage and Drainage Improvement

DATE COMMENCED Oct. 2, 1989

LOCATION : Phuket Municipality, Sam Kong

DATE FINISHED Oct. 2, 1989

ABBREVIATIONS ST = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VS = FIELD VANE SHEAR TEST	GROUNDELEV. 9.200 M.	WATER TABLE 1.30 M.	GRAPHIC LOG	DEPTH K.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH	STANDARD PENETRATION TEST	FIELD VANE SHEAR STRENGTH
						t/m <sup>2</sup>	Blows/30 cm	t/m <sup>2</sup>
SOIL DESCRIPTION						10	20	
Earth fill of clayey gravel						50	100	
Brown-gray, soft silty CLAY (CL)						WO		
						SP		(0)
						WO		
						ST		3.9
						SP		(0)
						WO		
						5		
						SP		8 (2, 3, 5)
						WO		
Gray-Red, medium silty CLAY (CL) some sand						SP		13 (4, 5, 8)
						WO		
						SP		11 (4, 5, 6)
						WO		
Yellow loose fine SAND (SP)						ST		
						10		
						SP		28 (8, 16, 22)
						WO		
						ST		9 (6, 5, 4) No recovery
						WO		
						SP		33 (12, 12, 20)
						WO		
Brown, hard clayey silt (MH)						SP		39 (14, 17, 22)
						WO		
						15		
						SP		47 (12, 20, 27)
						WO		
						SP		50, 6"
						SP		30, " No recovery.
End of Boring								
						20		

19  
Fig. 7 SOIL BORING

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH-8

PROJECT : Sewerage and Drainage Improvement DATE COMMENCED Oct. 3, 1989  
 LOCATION : Phuket Municipality, Kathu School DATE FINISHED Oct. 3, 1989

ABBREVIATIONS ST = UNDISTURBED SAMPLING SP = STANDARD PENETRATION TEST WO = WASH OUT VS = FIELD VANE SHEAR TEST	GROUND ELEV. Not known M. WATER TABLE 0.30 M.	GRAPHIC LOG	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH	STANDARD PENETRATION TEST	FIELD VANE SHEAR STRENGTH
					t / m <sup>2</sup>	BlS/30 cm	t / m <sup>2</sup>
SOIL DESCRIPTION					10	20	100
Brown, very loose fine SAND (SP)					WO	SP (0)	
Brown, soft fine sandy CLAY (CL)					WO	SP (0)	
Brown, very stiff silty CLAY (CL)					5	SP 3 (1,1,2)	
End of Boring						ST 3/3	
					10		

Fig 8 SOIL BORING

REGIONAL ENGINEERING CONSULTANTS CO.,LTD.					
LOG BORING NO. BH-9					
PROJECT		Sewerage and Drainage Improvement		DATE COMMENCED Oct. 3, 1989	
LOCATION		Phuket Municipality, Kathu Road.		DATE FINISHED Oct. 3, 1989	
ABBREVIATIONS		GROUNDELEV.		UNCONFINED COMPRESSIVE STRENGTH $t/m^2$	
ST = UNDISTURBED SAMPLING		Not known M.		▲ STANDARD PENETRATION TEST 6LS/30cm	
SP = STANDARD PENETRATOR TEST		WATER TABLE		■ FIELD VANE SHEAR STRENGTH $t/m^2$	
WO = WASH OUT		0.10 M.			
VS = FIELD VANE SHEAR TEST					
SOIL DESCRIPTION			DEPTH M.	SAMPLING METHOD	
				50	100
Earth fill of crushed stone				WO	
Brown, stiff coarse sandy CLAY (CL)				SP	▲ 10 (2, 4, 6)
				WO	
				ST	
				SP	▲ 10 (4, 4, 6)
				WO	
Brown, hard coarse sandy CLAY (CL)			5	SP	▲ 22 (5, 9, 13)
				WO	
				SP	▲ 51 (10, 20, 31)
End of Boring					
			10		

21  
Fig. 9 SOIL BORING



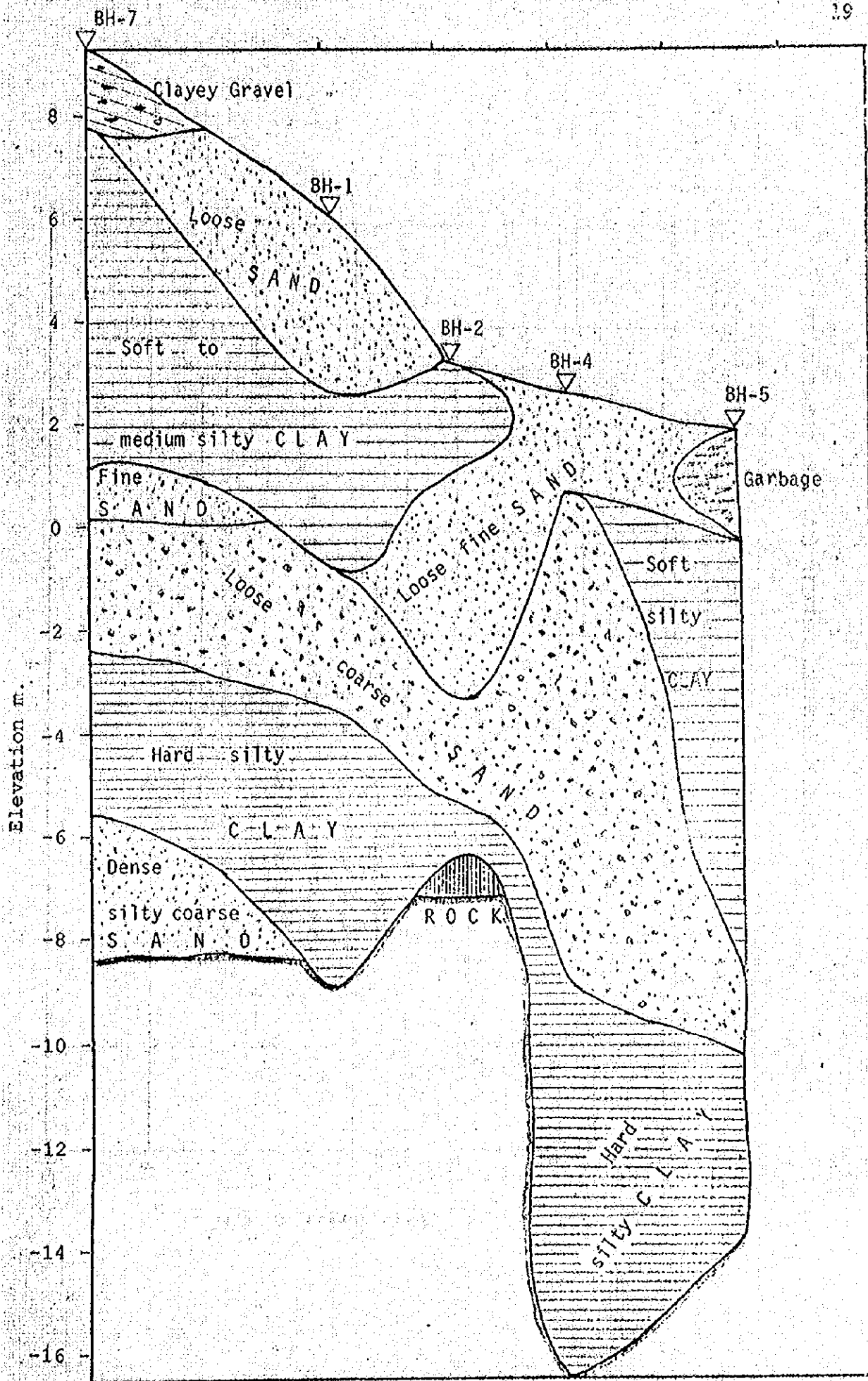


Figure 10 GENERALIZED SOIL PROFILE

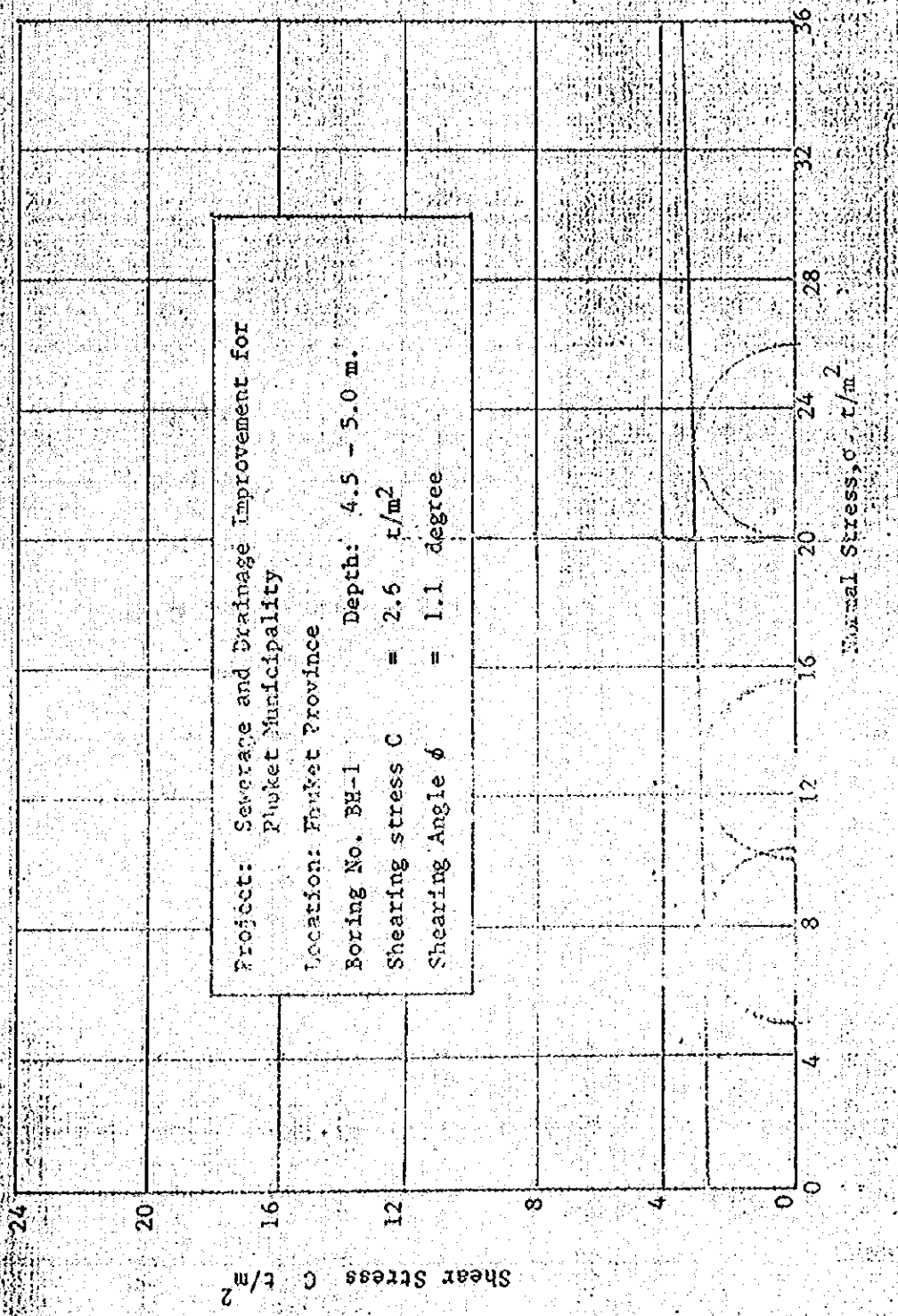


Fig. 11 UNCONSOLIDATED UNDRAINED TRIAXIAL (UU) TEST RESULT OF BE-1

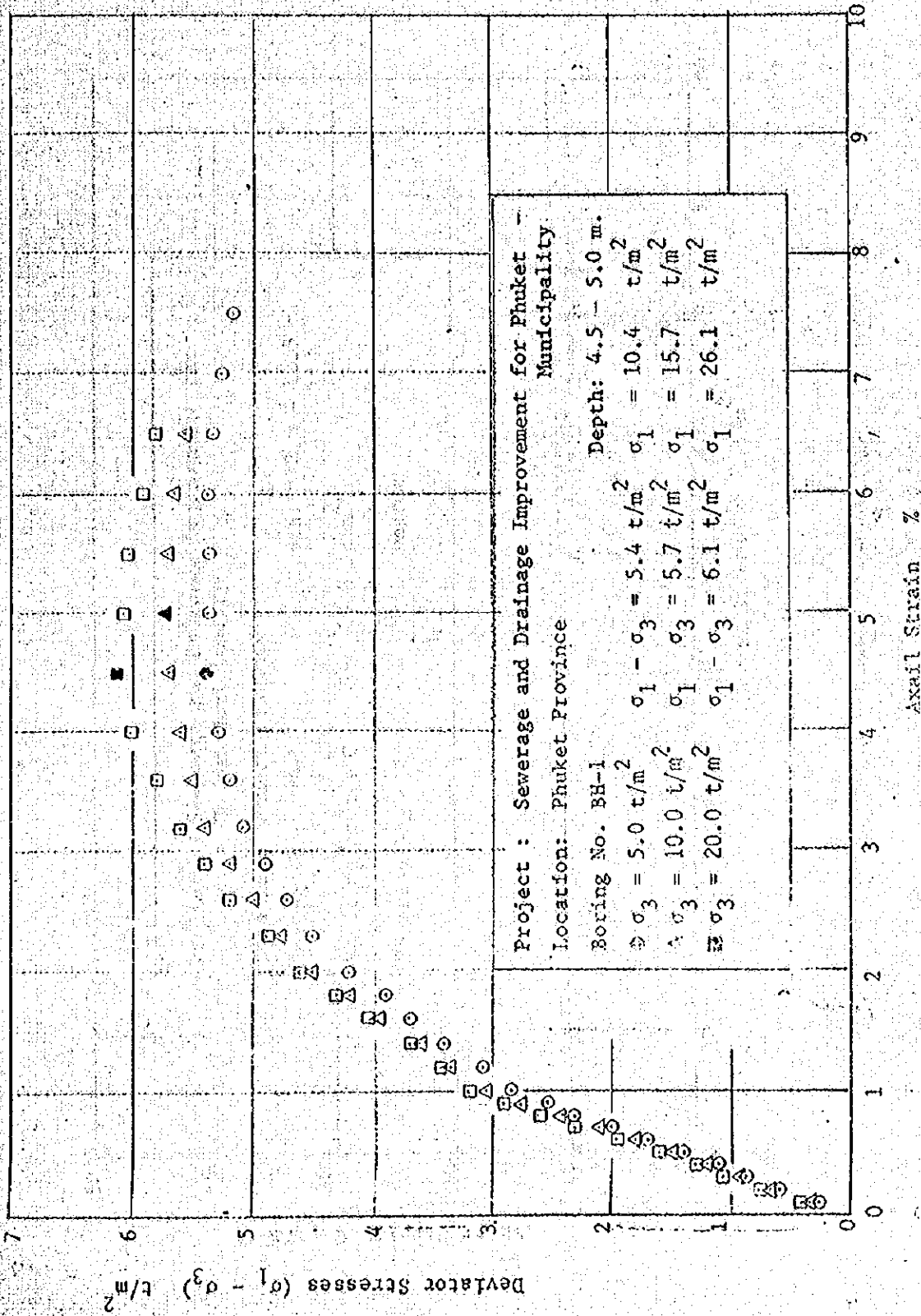


Fig. 12 STRESS - STRAIN OF UU TRIAXIAL TEST OF BH-1

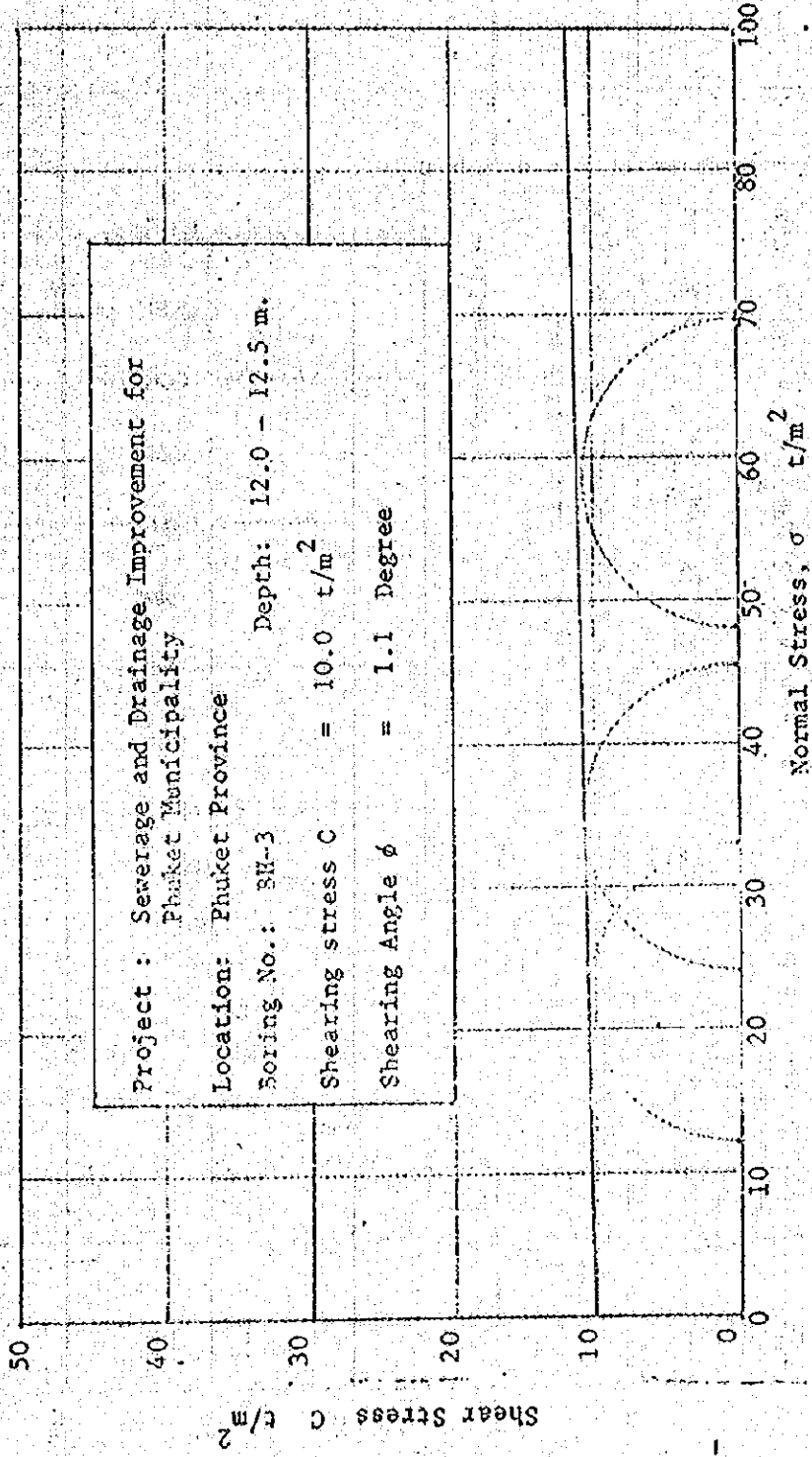


Fig: 13 UNCONSOLIDATED UNDRAINED TRIAXIAL (UU) TEST RESULT OF BH-3

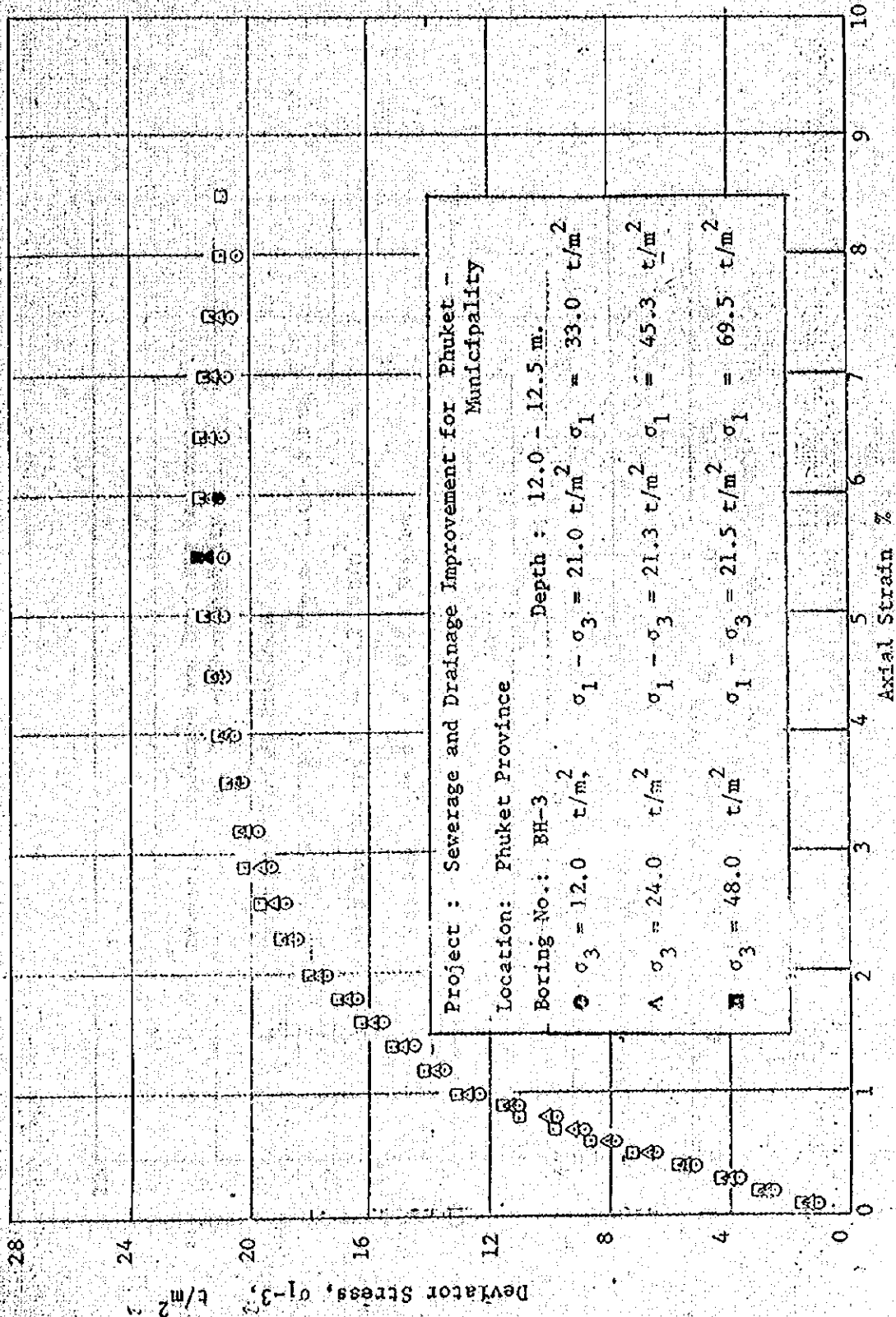


Fig.14 STRESS - STRAIN OF UU TRIAXIAL TEST OF BH-3

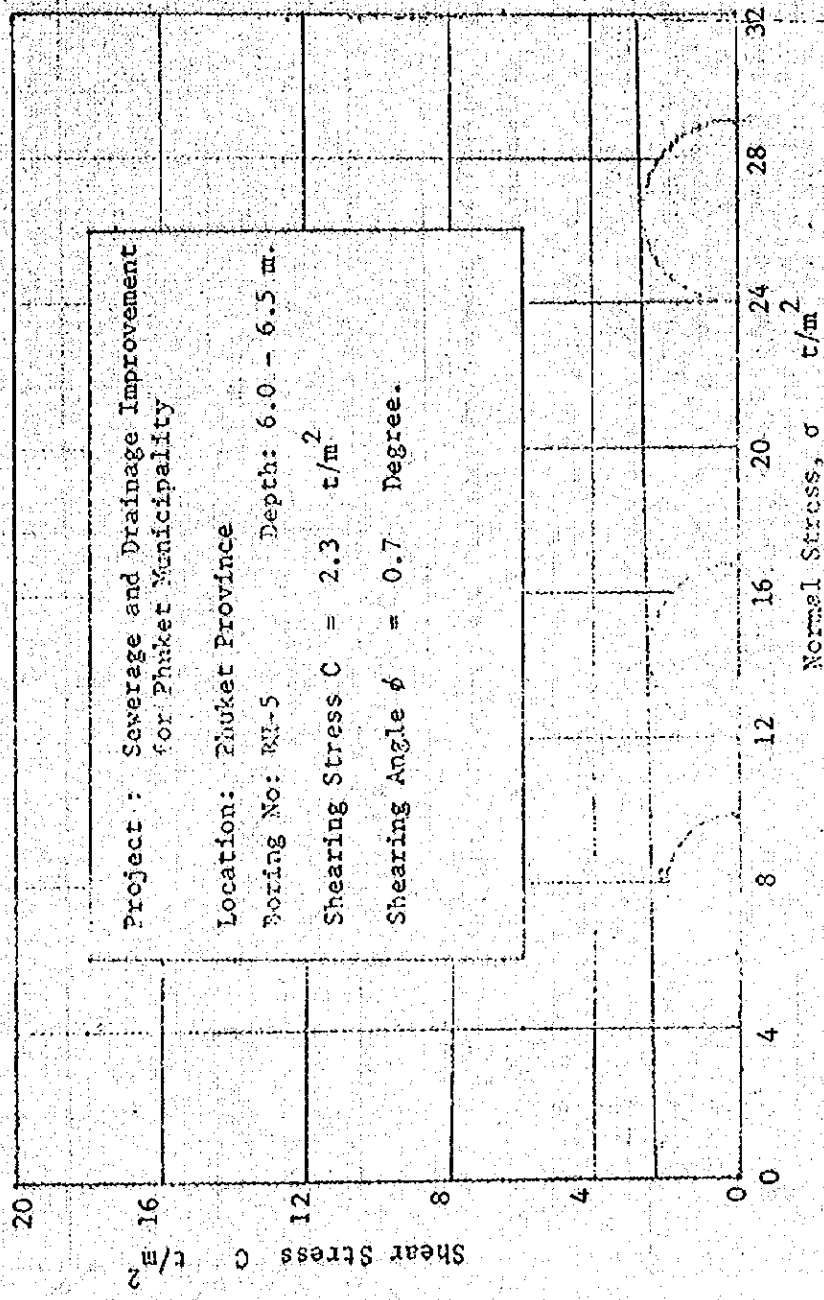


Fig. 15 UNCONSOLIDATED UNDRAINED TRIAXIAL (UU) TEST RESULT OF BH-5

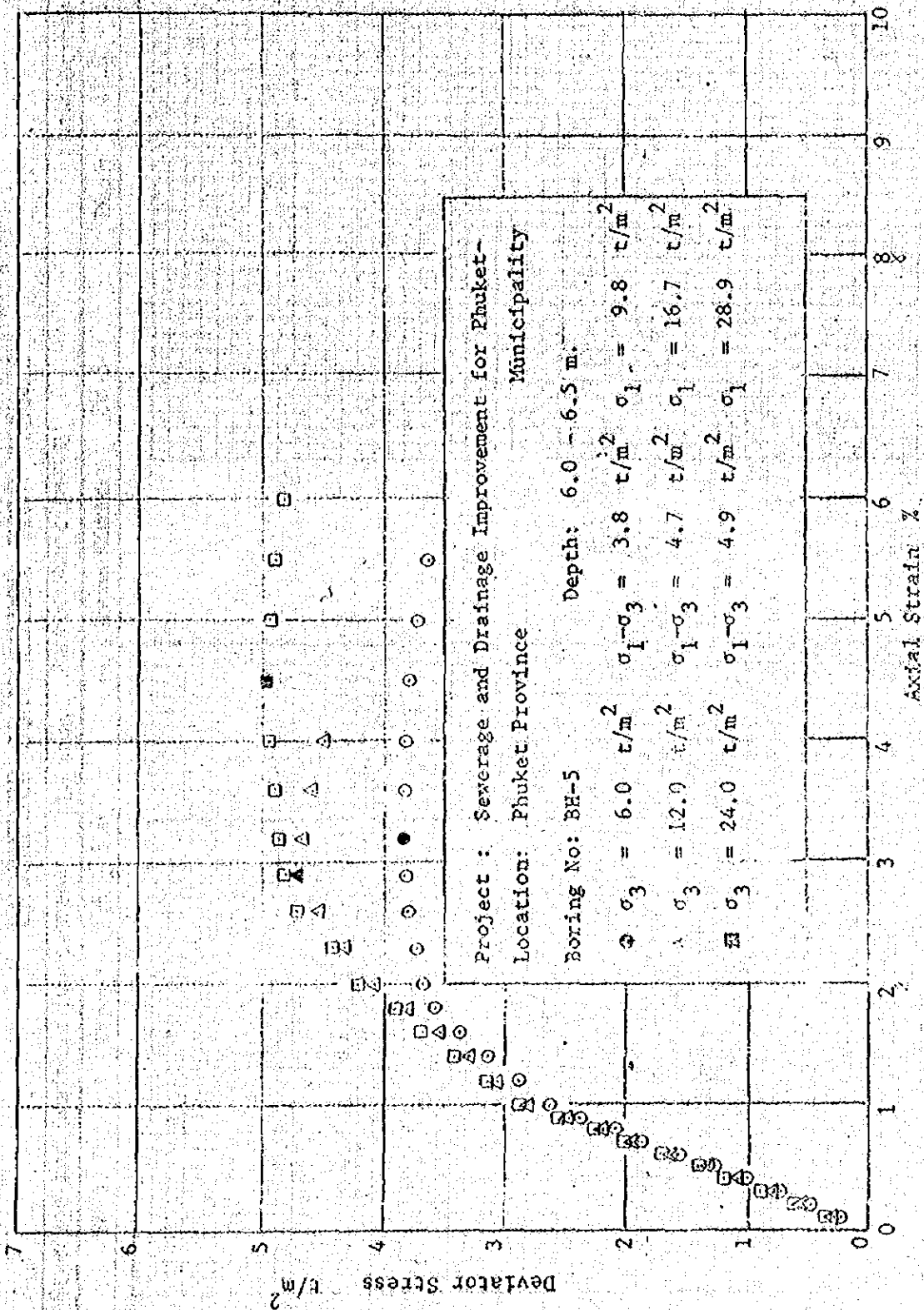


Fig. 16 STRESS - STRAIN OF UU TRIAXIAL TEST OF BR-5

# UNCONFINED COMPRESSION TEST RESULTS

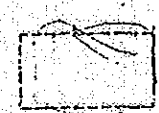
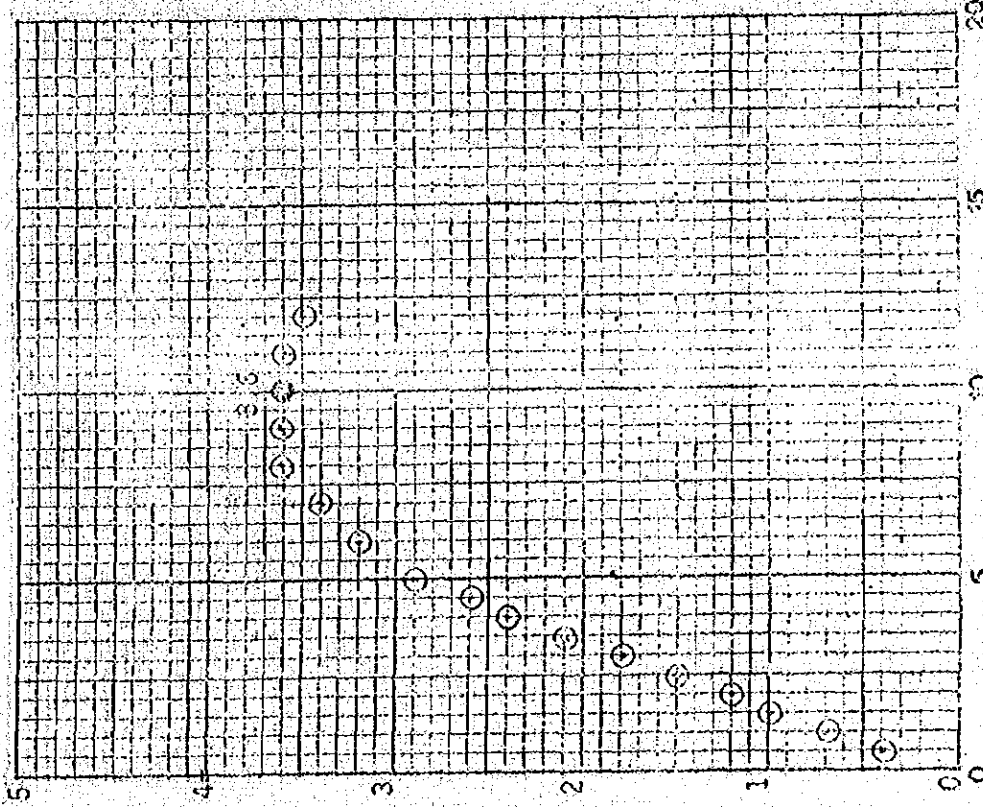
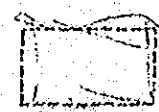
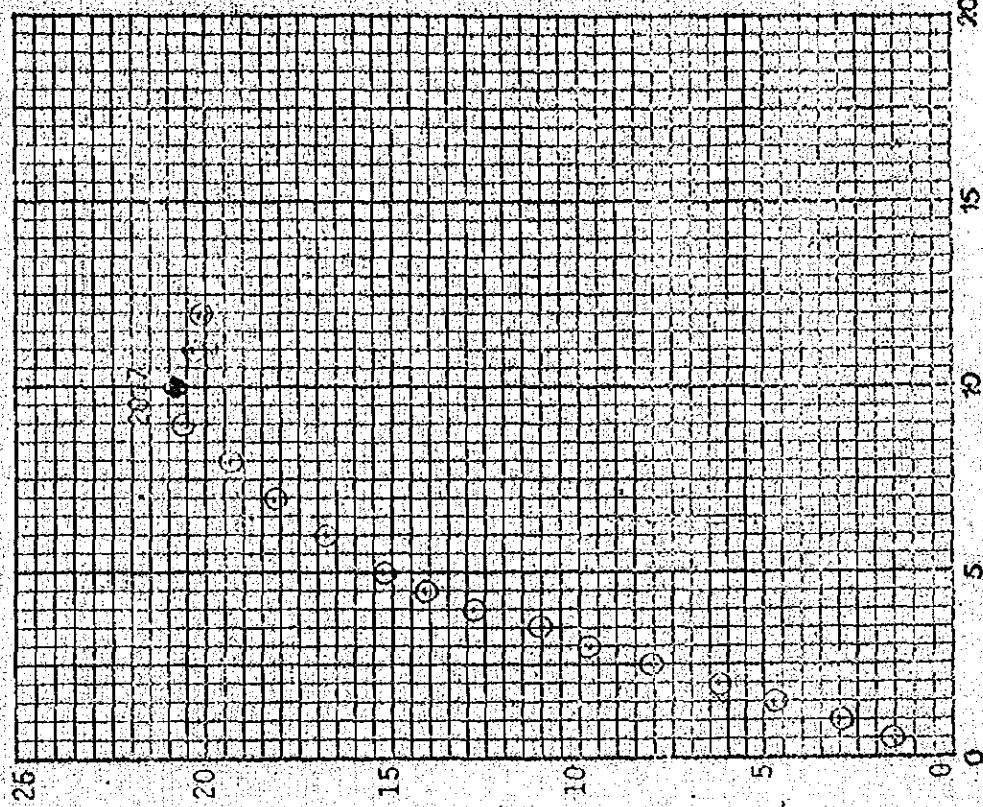
Project: Sewerage and Drainage Improvement Location: Phuket Municipality	Date: October 17, 1989 Depth: 12.0 - 12.5 m.	Boring Number: BH-3
Boring Number: BH-1 Depth: 4.5 - 5.0 m.		
Stress, $t/m^2$	Stress, $t/m^2$	Strain, %
		
Strain, %	Stress, $t/m^2$	Strain, %
		

Fig. 17



# UNCONFINED COMPRESSION TEST RESULTS

Project: Sewerage and Drainage Improvement Boring Number: BH-4	Location: Phuket Municipality Depth: 12.0 - 12.5 m	Date: October 17, 1989 Depth: _____ m
---	---	--

Strain (%)	Stress (t/m <sup>2</sup> )
0	0
1	2
2	4
3	6
4	8
5	10
6	12
7	14
8	16
9	17
10	17.5
11	18
12	18.5
13	18.5
14	18.5
15	18.5
16	18.5
17	18.5
18	18.5
19	18.5
20	18.5

Fig. 18

# UNCONFINED COMPRESSION TEST RESULTS

Project: Sewerage and Drainage Improvement      Location: Phuket Municipality      Date: October 17, 1989  
 Boring Number: BH-5      Depth: 6.0 - 6.5 m      Boring Number: BH-5      Depth: 12.0 - 12.5 m

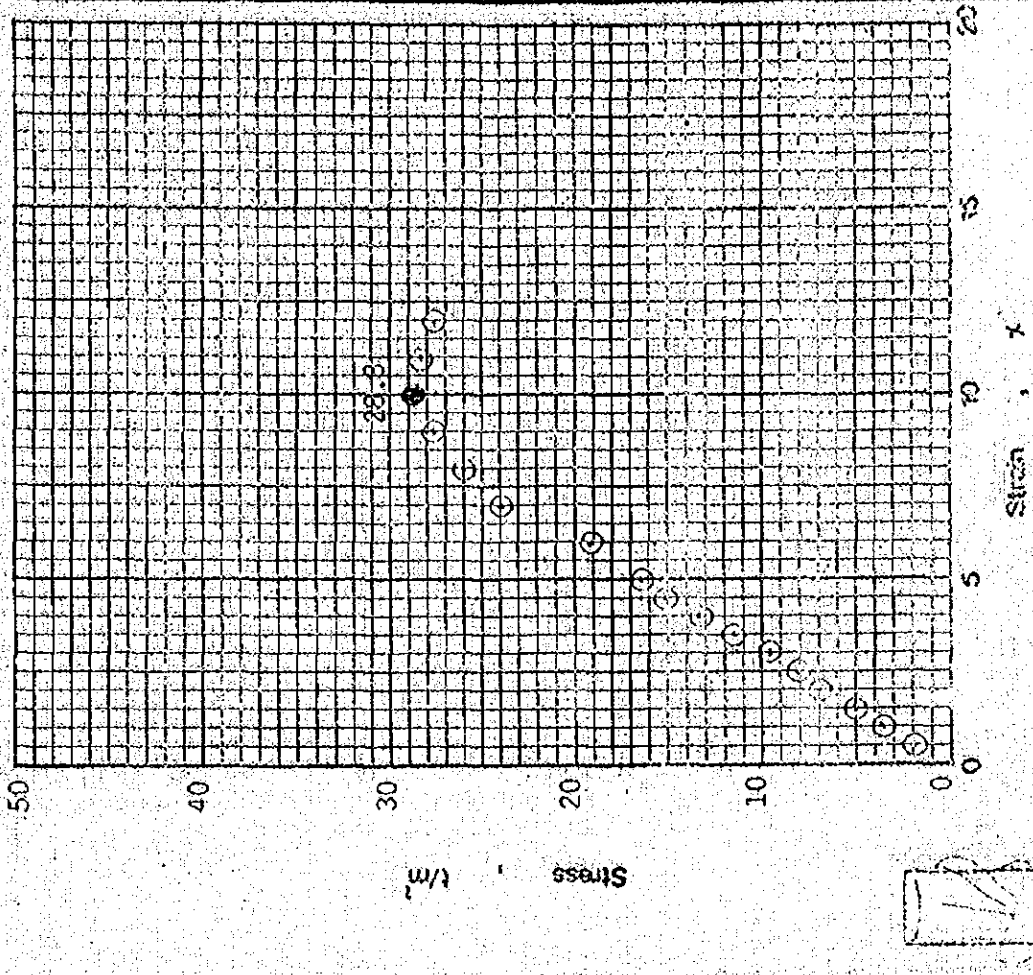
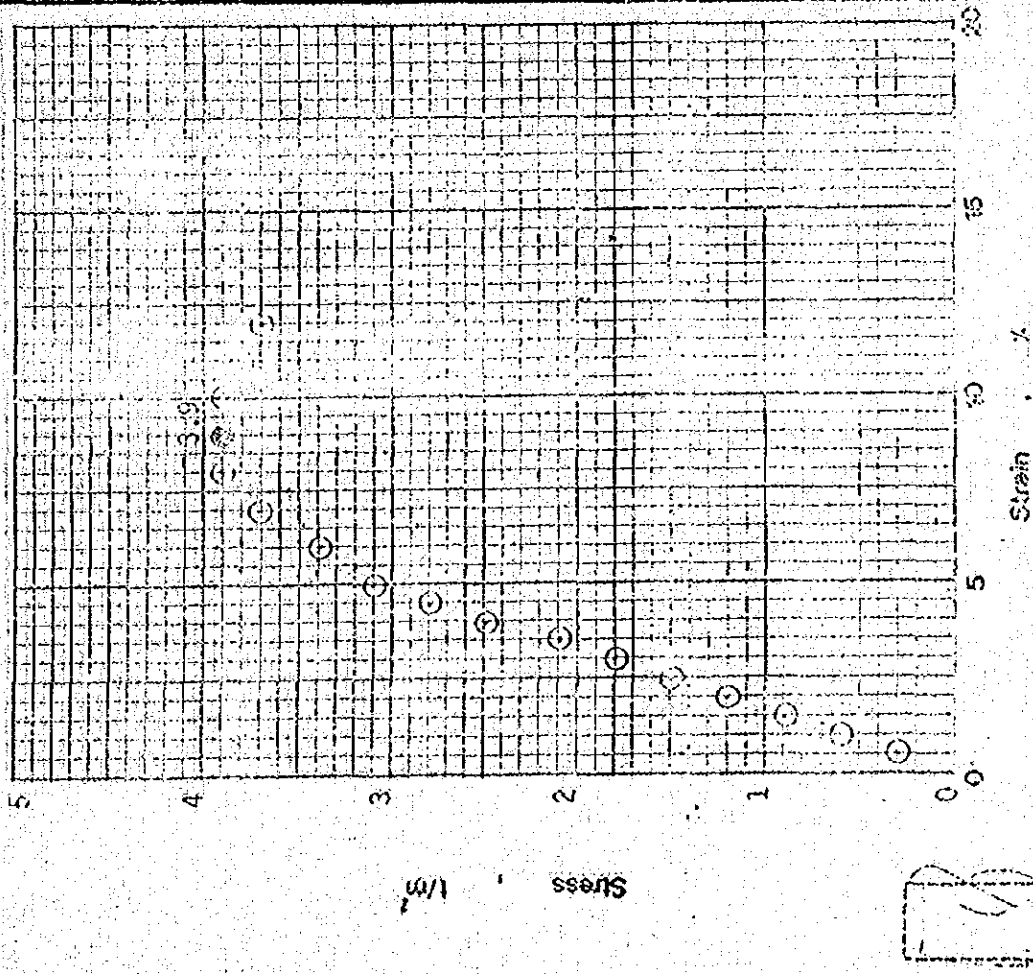


Fig. 19

# UNCONFINED COMPRESSION TEST RESULTS

Project: Sewerage and Drainage Improvement	Date: October 17, 1989
Location: Phuket Municipality	
Boring Number: BH-7	Depth: 3.0 - 3.5 m.
Boring Number: BB-8	Depth: 6.0 - 6.5 m.

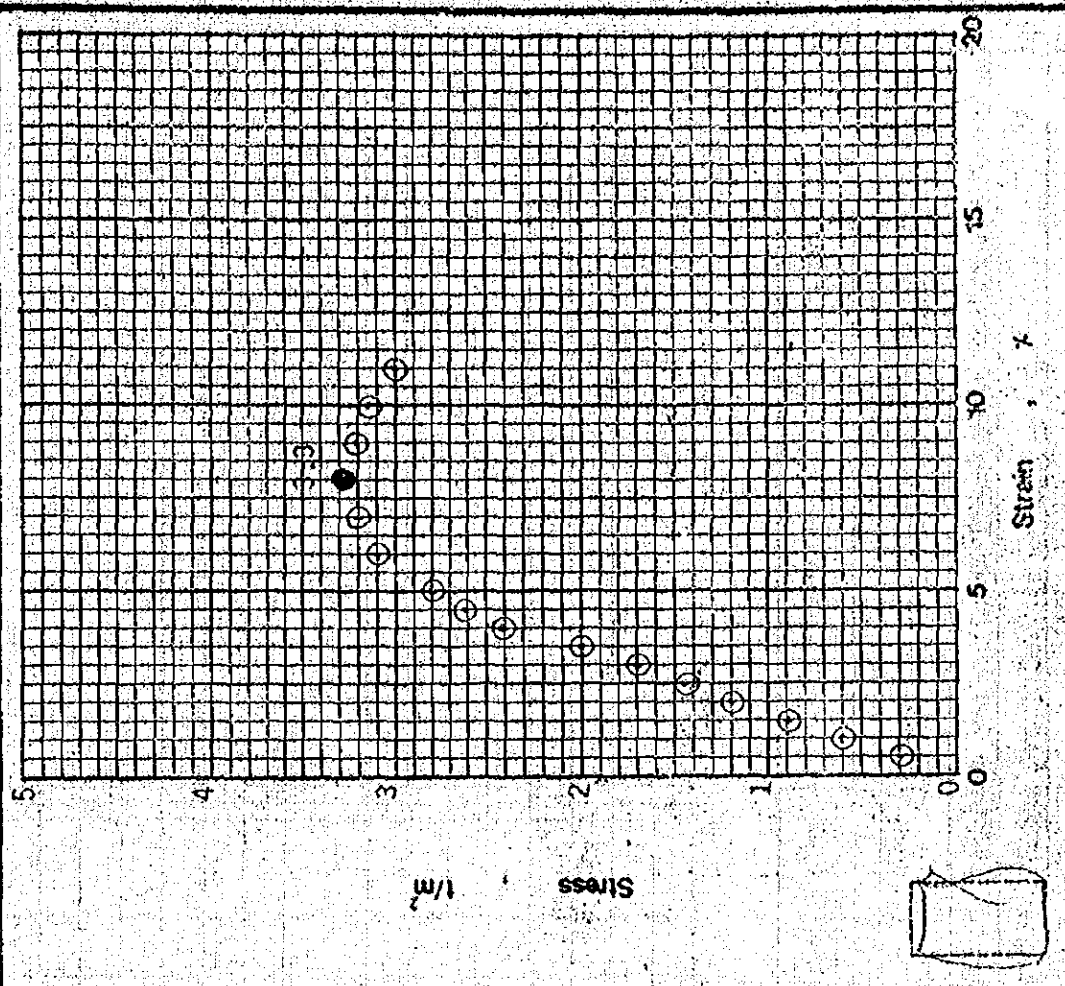
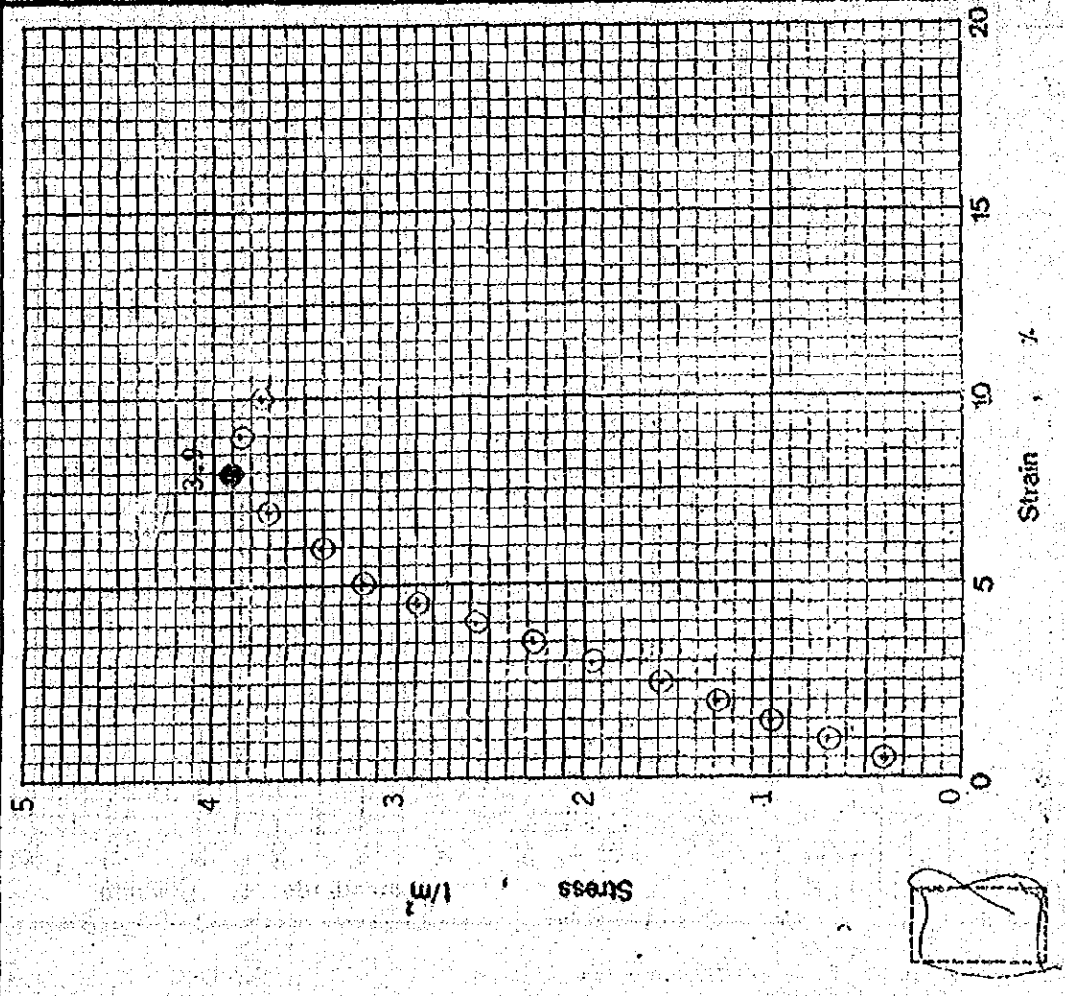
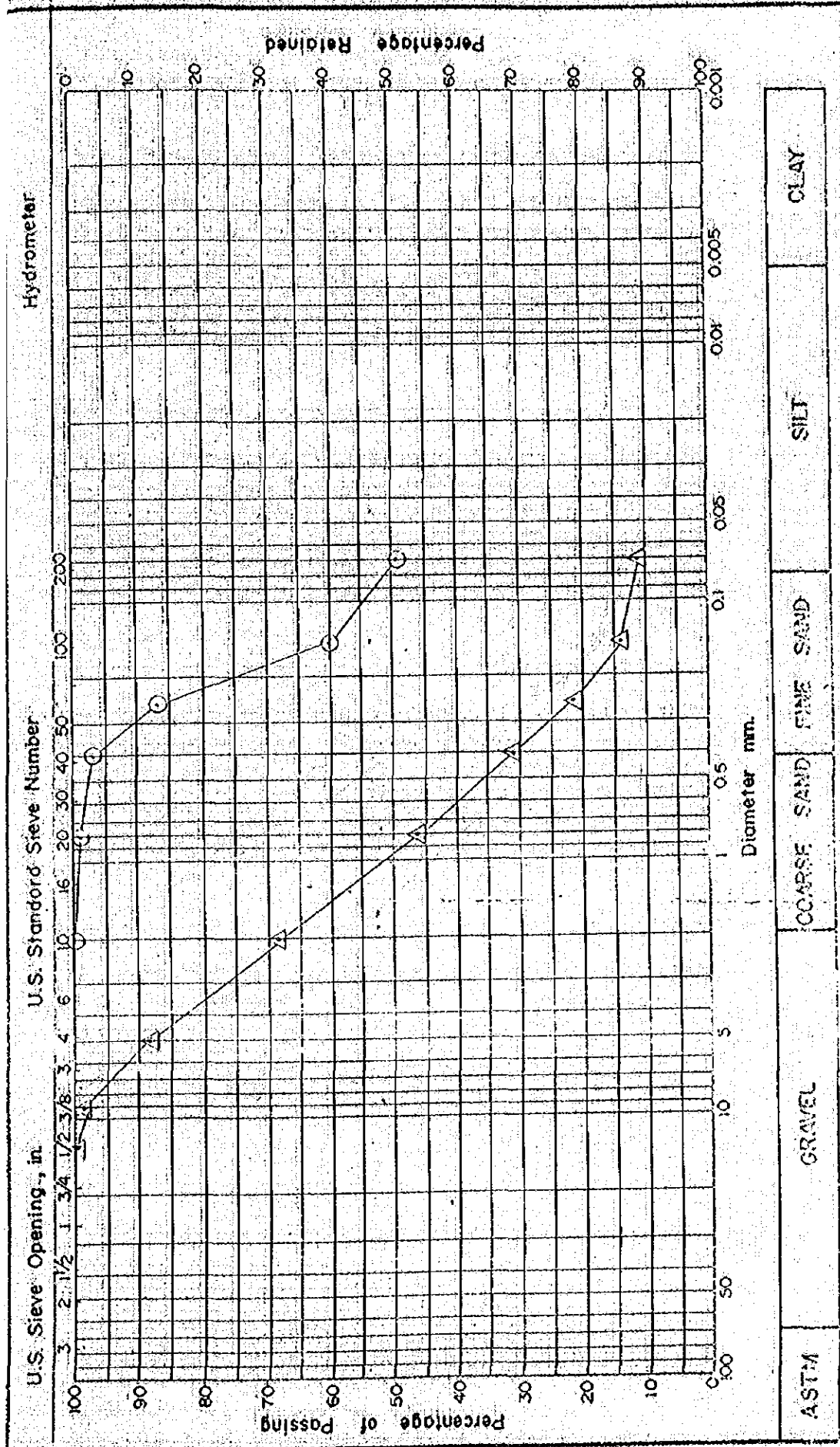
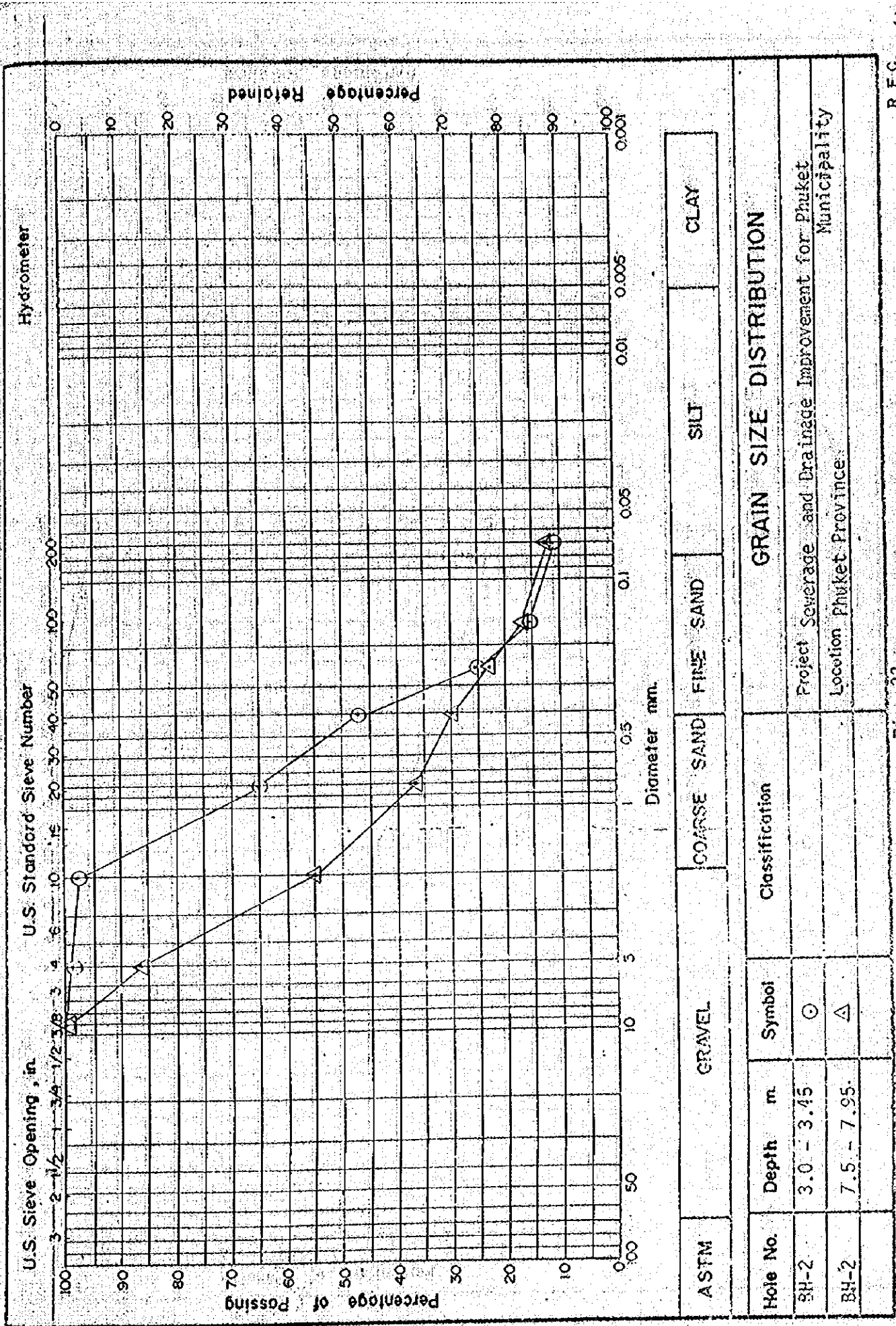


Fig. 20



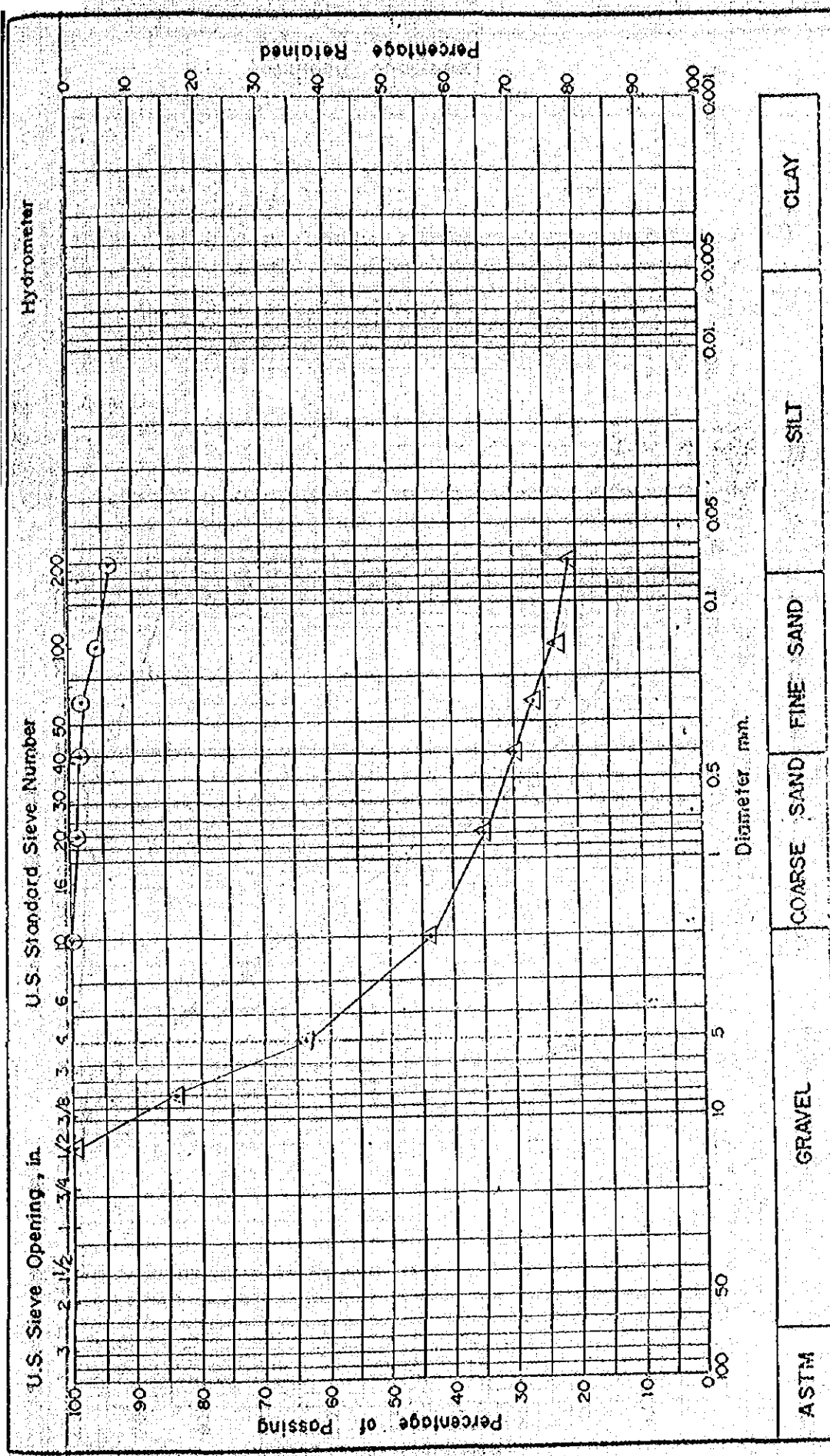
ASTM		GRAVEL		COARSE SAND		FINE SAND		SILT		CLAY	
<b>GRAIN SIZE DISTRIBUTION</b>											
Hole No.	Depth	m.	Symbol	Classification		Project					
SH-1	3.0-3.45		○			Sewerage and Drainage Improvement for Phuket Municipality					
SH-1	7.5-7.95		△			Location Phuket Province					

Fig. 21



GRAIN SIZE DISTRIBUTION	
Hole No.	Classification
BH-2	Project Sewerage and Drainage Improvement for Phuket Municipality
BH-2	Location Phuket Province

Fig. 22



ASTM		GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY
Grain Size	Grain Size	Grain Size	Grain Size	Grain Size	Grain Size	Grain Size	Grain Size
20 - 75	75 - 200	200 - 750	750 - 2000	2000 - 7500	7500 - 20000	20000 - 75000	> 75000

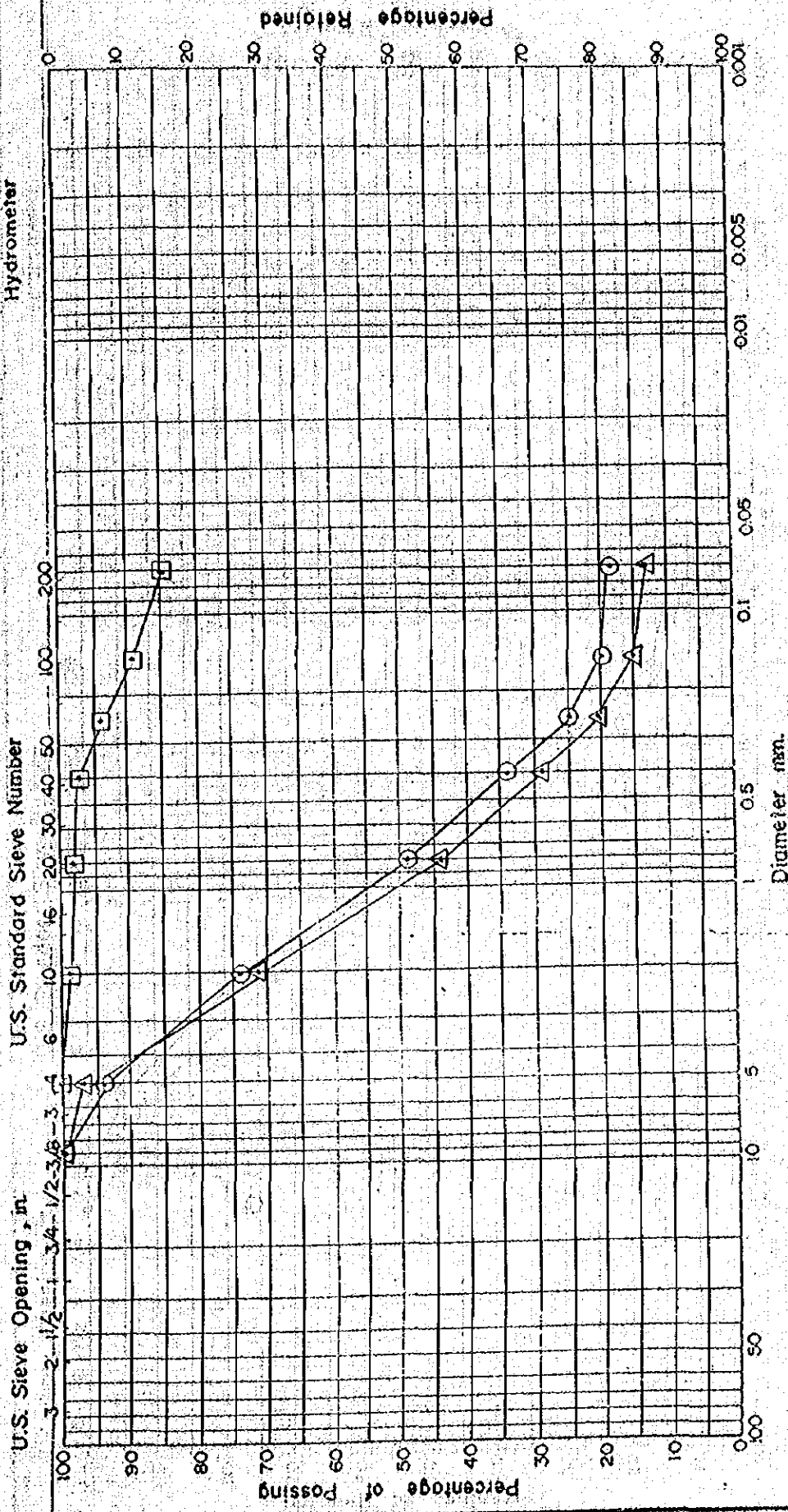
  

GRAIN SIZE DISTRIBUTION		
Classification	Project	Location
	Sewerage and Drainage Improvement for Phuket Municipality	Phuket Province

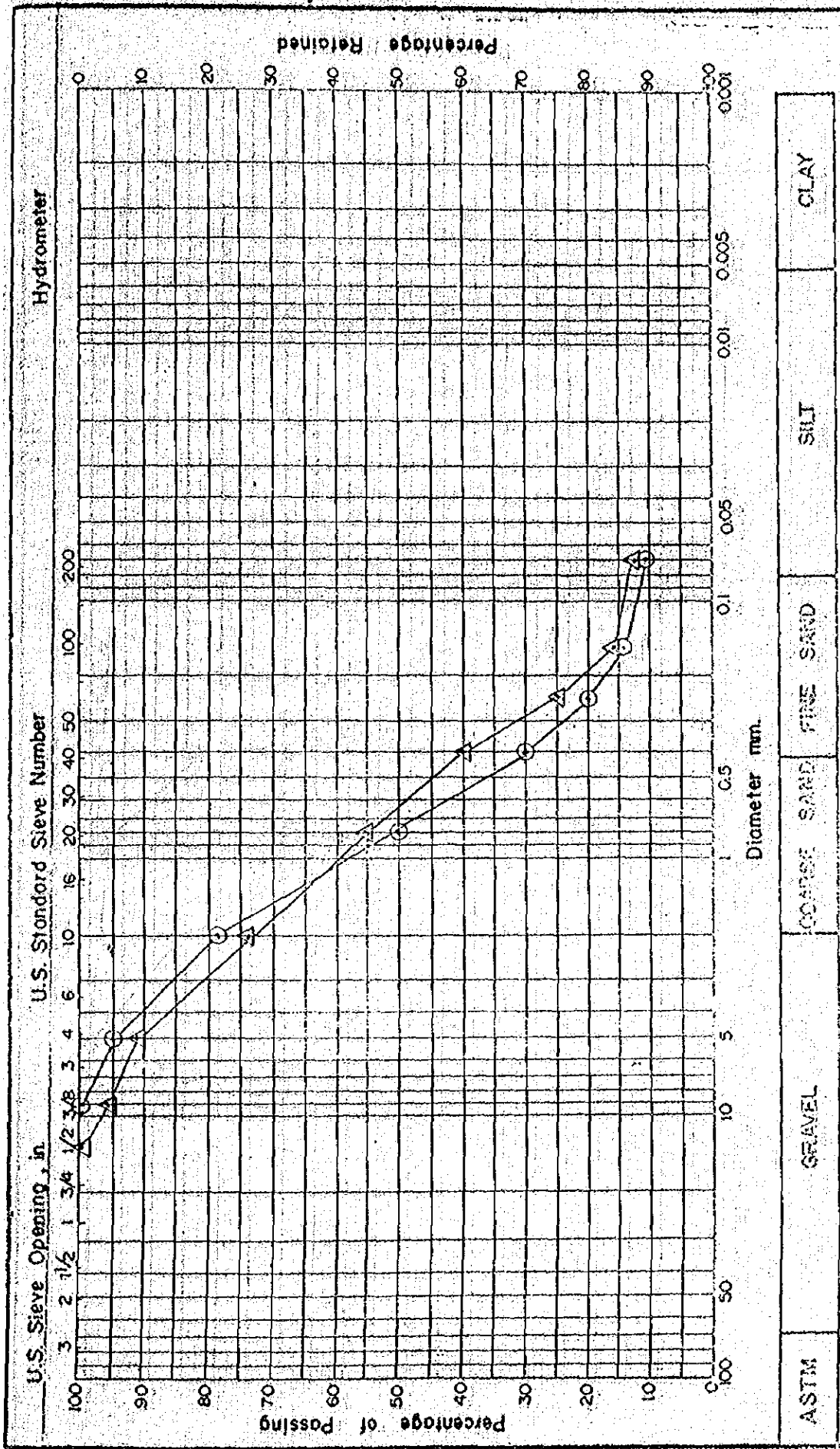
ASTM	Depth m.	Symbol
BH-3	3.0 - 3.45	○
BH-3	6.0 - 6.45	△

Fig. 23



GRAIN SIZE DISTRIBUTION		Classification	Project - Sewerage and Drainage Improvement for Phuket Municipality	
Note No.	Depth m.	Symbol	Location - Phuket Province	
BH-4	3.0 - 3.45	○		
BH-4	6.0 - 6.50	△		
BH-4	10.5 - 10.95	□		

Fig. 24



ASTM	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY
<b>GRAIN SIZE DISTRIBUTION</b>					
Note No.	Depth m.	Symbol	Classification		
BH-5	10.5 - 10.95	⊙		Project Sewerage and Drainage Improvement for Phuket	
BH-6	12.0 - 12.50	△		Location Phuket Province Municipality	

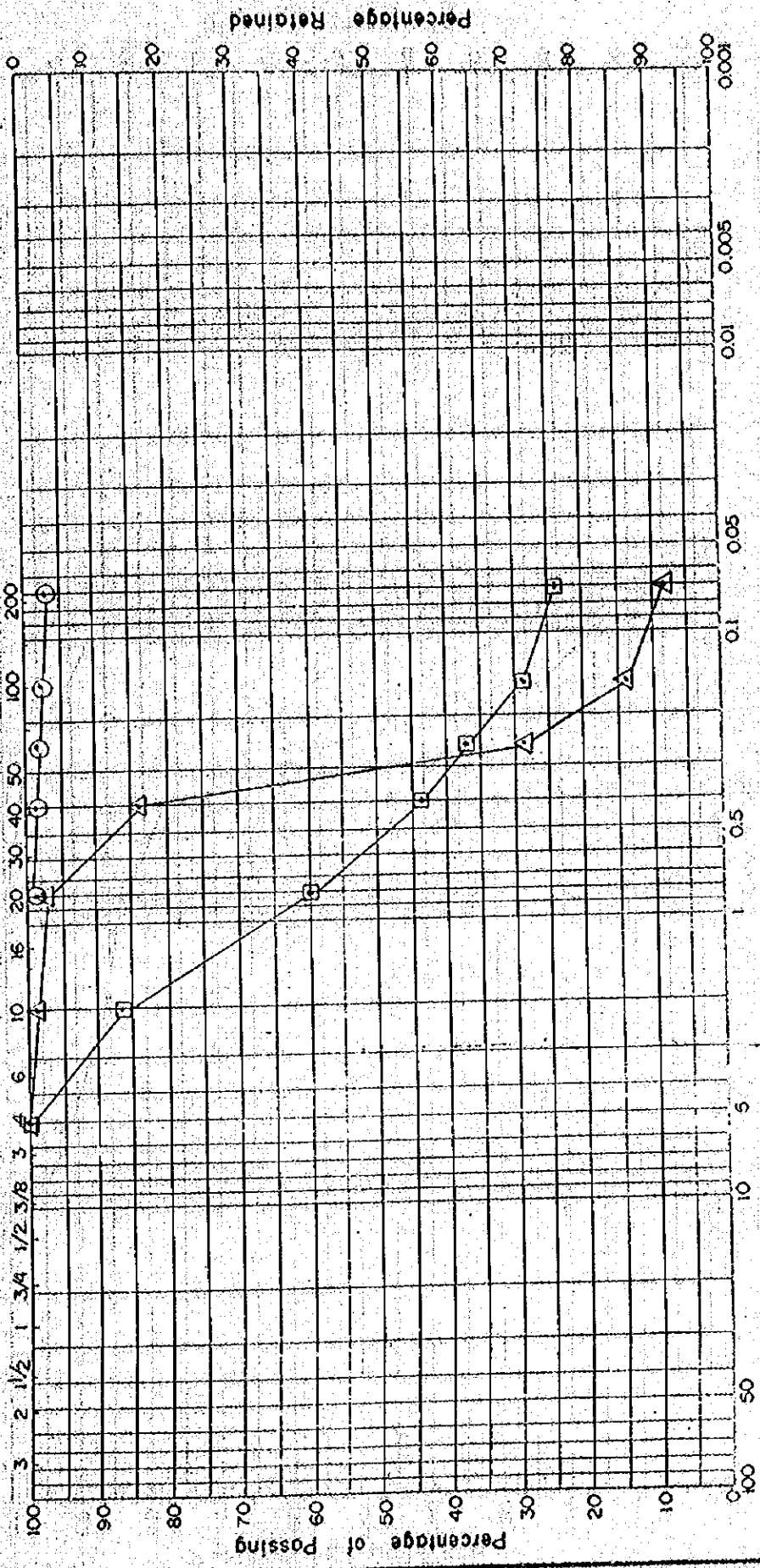
Fig. 25



Hydrometer

U.S. Standard Sieve Number

U.S. Sieve Opening, in.



GRAIN SIZE DISTRIBUTION

Classification

Project Sewerage and Drainage Improvement for Phuket Municipality

Location Phuket Province

Note No.	Depth m.	Symbol
BH-7	3.0 - 3.50	○
BH-7	9.0 - 9.50	△
BH-7	15.0 - 15.45	□

ASTM	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY

Fig. 26

R.E.C.

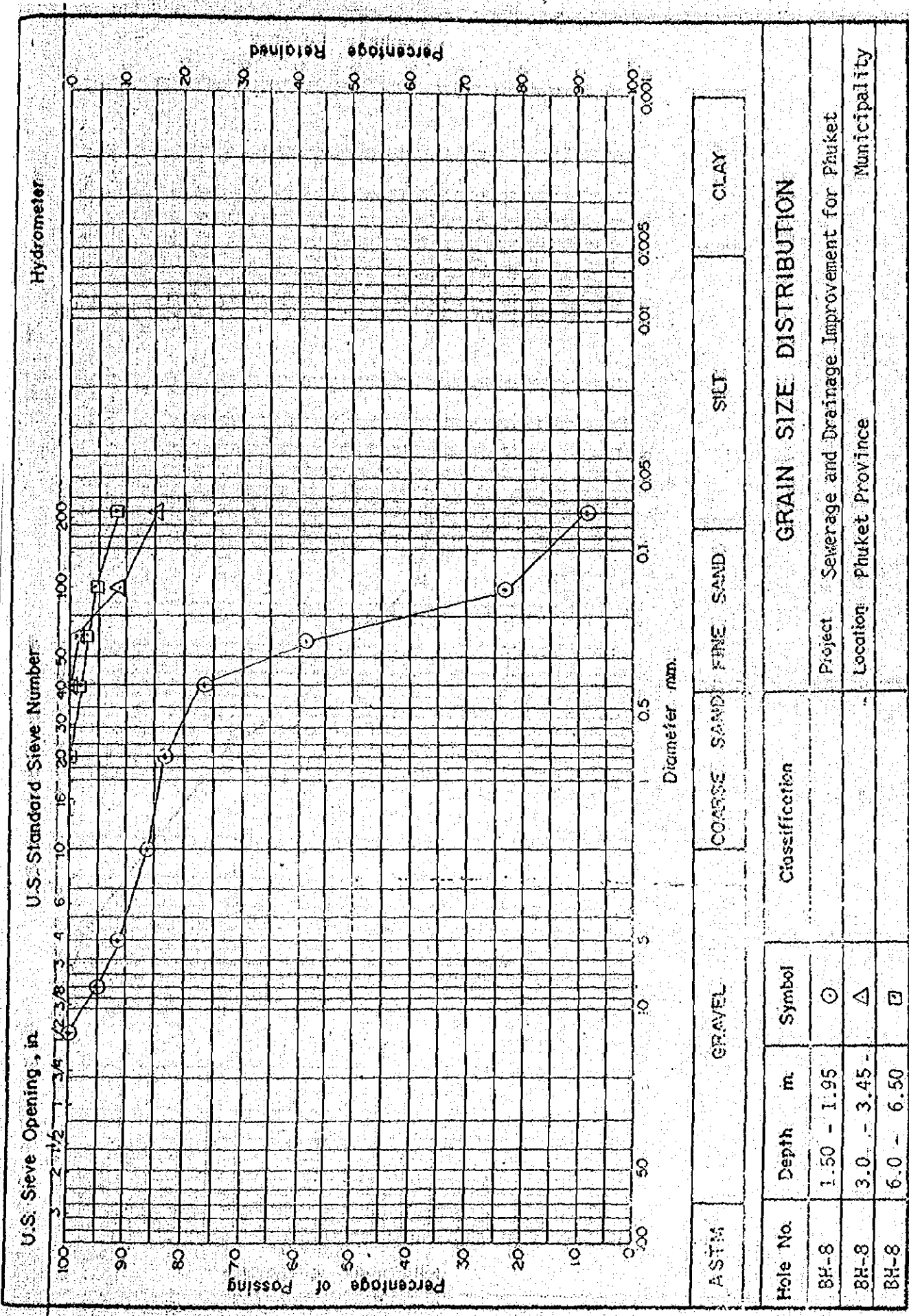


Fig. 27

R.E.C.

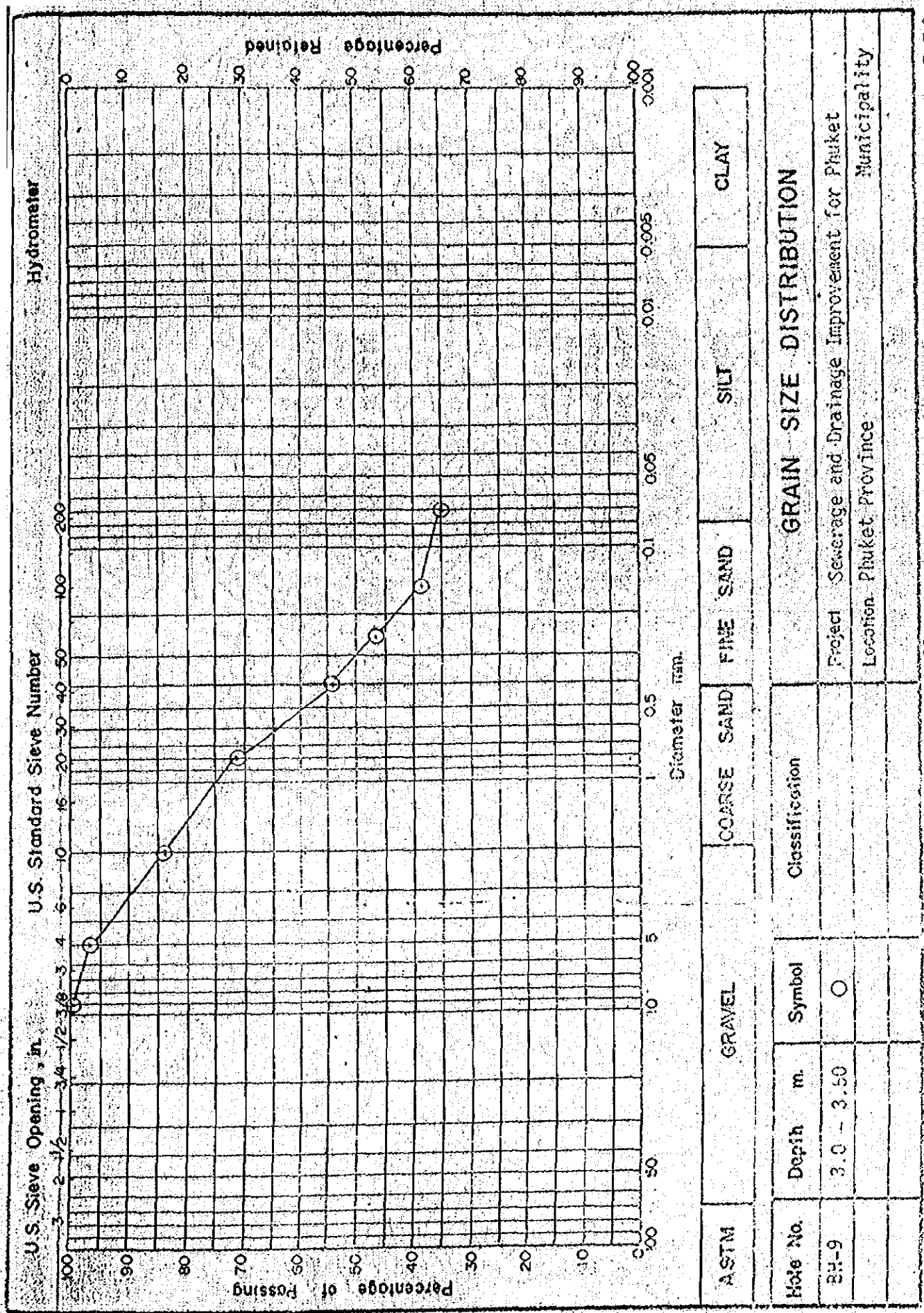


Fig. 28

R.E.C.

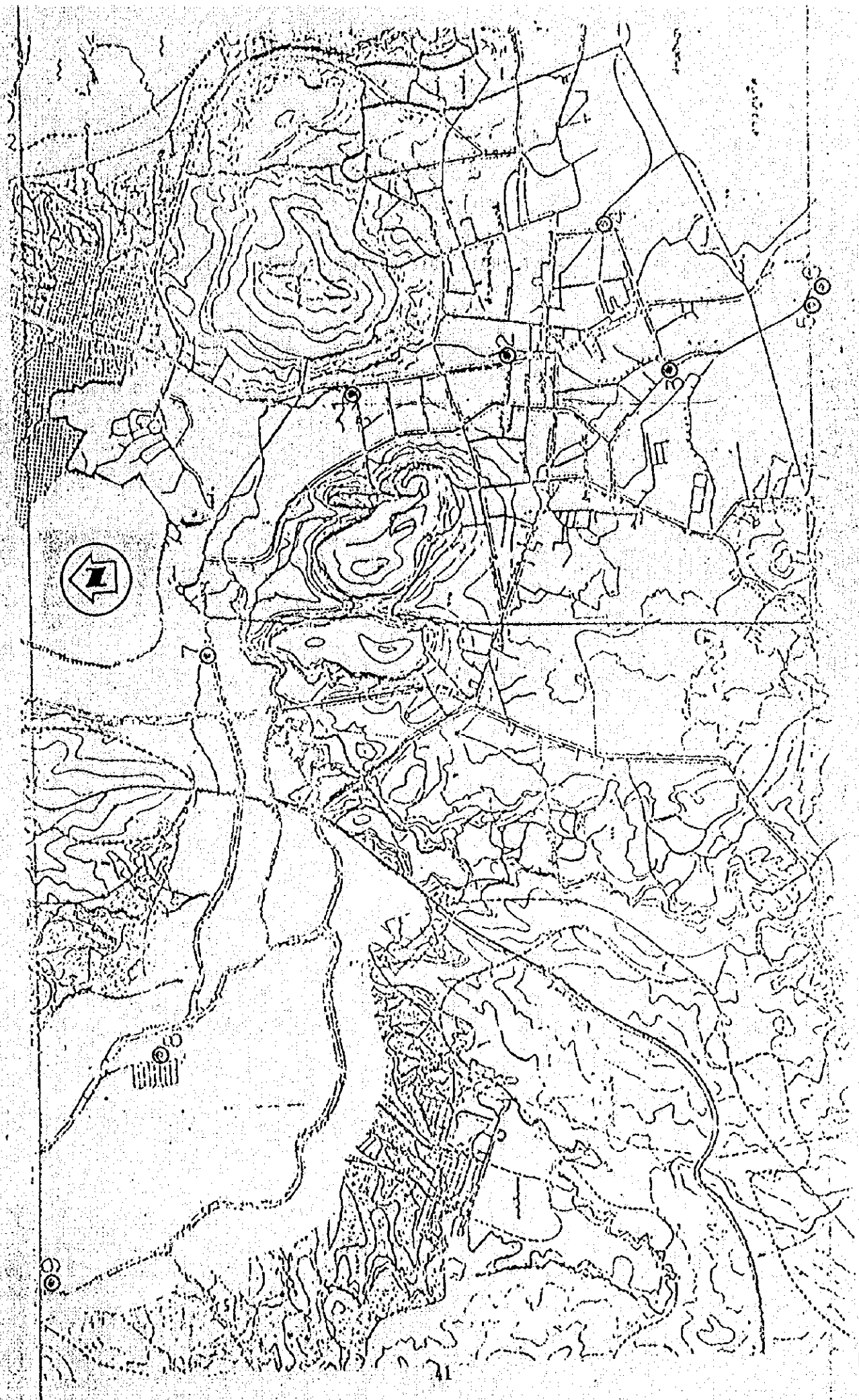


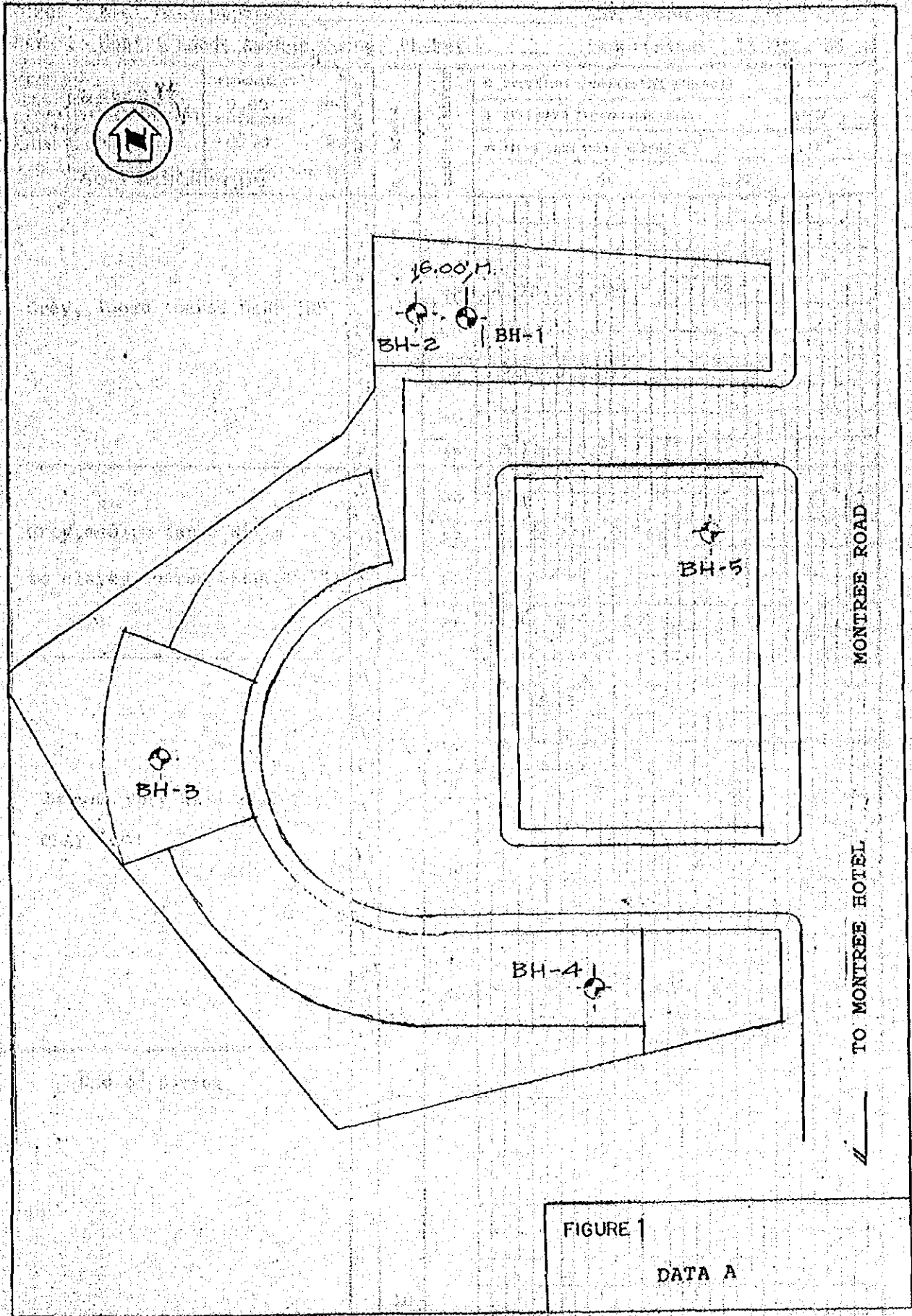
Fig. 29 SCRIAMS LOCATION MAP

2. Existing Geological Data Before JICA Study Team.

Data A

Data B

Data C



DATA A

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BH 1

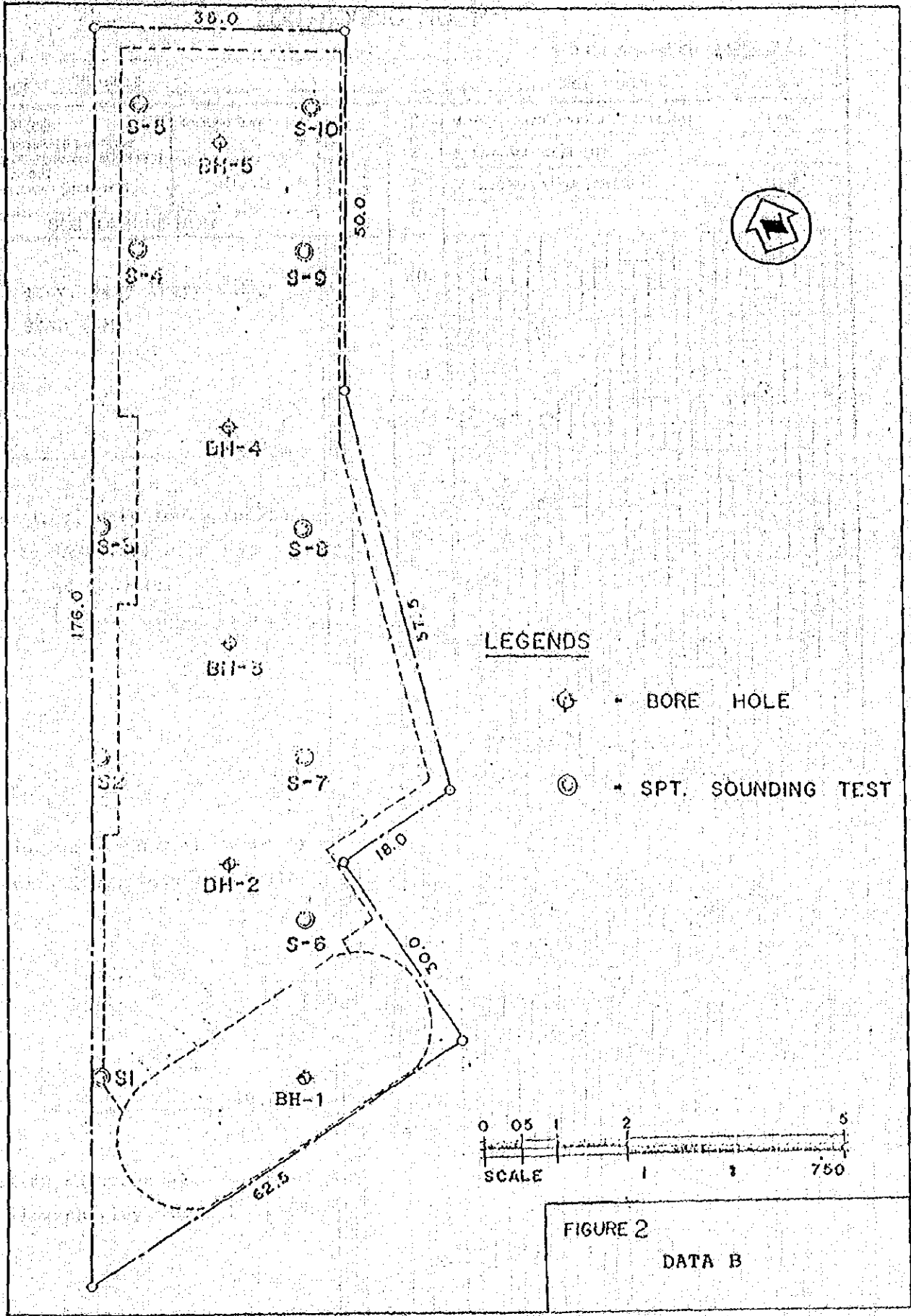
PROJECT : A.R. Mini Complex

DATE COMMENCED 12 Oct., 88

LOCATION : Montri Road, Amphur Muang, Phuket

DATE FINISHED 13 Oct., 88

ABBREVIATIONS		GROUND ELEV.	GRAPHIC LOG	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH t/m <sup>2</sup>	
ST = UNDISTURBED SAMPLING	SP = STANDARD PENETRATION TEST	0.00 WATER TABLE				M.	50
WO = WASH OUT	VS = FIELD VANE SHEAR TEST	-0.70	M.				
SOIL DESCRIPTION							
Grey, loose coarse SAND (SP)				WO			
				SP	▲ 10 (3, 4, 6)		
				WO			
Grey, medium dense silty to clayey coarse SAND (SC-SM)				SP	▲ 11 (5, 5, 6)		
				WO			
				SP	▲ 12 (5, 6, 6)		
Brown, very hard gravelly CLAY (CG)				WO			
				SP	▲ 22 (8, 8, 14)		
				WO			
End of Boring				SP	▲ 18 (6, 6, 12)		
				WO			
				SP	▲ 25 (9, 12, 14)		
End of Boring				WO			
				SP	▲ 44 (12, 20, 24)		
				WO			
End of Boring				SP	▲ 62 (25, 38, 47)		
				WO			
				SP	▲ 70 (21, 28, 42)		
End of Boring				WO			
				SP	▲ 75 (20, 30, 45)		
				WO			





**DATA B** REGIONAL ENGINEERING CONSULTANTS CO., LTD.  
LOG BORING NO. BH-1

PROJECT : \_\_\_\_\_ DATE COMMENCED: Feb. 12, 87  
LOCATION : Phuket DATE FINISHED: Feb. 13, 87

ABBREVIATIONS ST : UNDISTURBED SAMPLING SP : STANDARD PENETRATION TEST WO : WASH OUT VS : FIELD VANE SHEAR TEST	GROUND ELEV. M. WATER TABLE -0.90 M.	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH $1/m^2$	
				50	100
SOIL DESCRIPTION					
Dark grey, very loose silty fine SAND (SM)	4.00 m		WO		
			SP	N2(2, 1, 1)	
			WO		
			SP	N2(1, 1, 1)	
Dark grey, very loose to loose coarse SAND (SP) with some roots and gravels.	5.00 m		WO		
			SP	N2(2, 1, 1)	
			WO		
			SP	N3(1, 1, 2)	
Yellowish brown with seams of reddish grey, very stiff SILT (ML)	10.00 m		WO		
			SP	N10(4, 4, 5)	
			WO		
			SP	N5(6, 3, 2)	
Yellowish brown with seams of yellowish grey, hard SILT (ML)	16.00 m		WO		
			SP	N24(11, 11, 13)	
			WO		
			ST	12.8	
			WO		
			SP	N3(12, 18, 25)	
			WO		
			SP	(20, 45, 95) 110	
			WO		
			SP	(20, 40, 77) 117	
			WO		
			SP	N65(22, 28, 37)	
			WO		
			SP	(29, 50, 100/115) 150/115	
			WO		

DATA B

REGIONAL ENGINEERING CONSULTANTS CO., LTD.

LOG BORING NO. BII-1

PROJECT : \_\_\_\_\_

DATE COMMENCED Feb. 12, 87

LOCATION : Phuket

DATE FINISHED Feb. 13, 87

ABBREVIATIONS ST : UNDISTURBED SAMPLING SP : STANDARD PENETRATION TEST WO : WASH OUT VS : FIELD VANE SHEAR TEST	GROUND ELEV. M. WATER TABLE -0.90 M.	DEPTH M.	SAMPLING METHOD	UNCONFINED COMPRESSIVE STRENGTH $t/m^2$
				STANDARD PENETRATION TEST BLS/FT
SOIL DESCRIPTION				FIELD VANE SHEAR STRENGTH $t/m^2$
Yellowish brown with seams of yellowish grey, hard SILT (ML)				50
				100
23.50 m Dark grey with dots of yellowish brown, hard SILT (ML)				WO
				SP (39,95,50/5") 145/11" Δ
26.00 m				WO
				SP (42,100/4") 142/10" Δ
End of Boring				WO
				SP (38,100/7") 138/7" Δ
				25 WO
				SP (100/5,5)

TABLE 1 GENERAL SOIL ENGINEERING PROPERTIES

Project :

Location: Phuket

Bore Hole No.	Depth m	Water Content %	Total Unit Weight t/m <sup>3</sup>	Liquid Limit %	Plastic Limit %	Plasticity Index %
BH-1	1.5 - 2.0	38.2	2.07			
	3.0 - 3.5	32.1	2.00			
	4.5 - 5.0	20.1	2.11			
	6.0 - 6.5	16.6	2.16			
	7.5 - 8.0	13.8	2.20			
	9.0 - 9.5	23.3	2.18			
	10.5 - 11.0	26.2	1.76	24.6	15.0	9.6
	12.0 - 12.5	22.4	1.90			
	13.5 - 14.0	20.5	2.00			
	15.0 - 15.5	16.8	2.00			
	16.5 - 17.0	20.7	2.06	22.8	14.3	8.4
	18.0 - 18.5	19.7	2.03			
	19.5 - 20.0	18.3	2.09	24.4	14.5	9.8
	21.0 - 21.5	16.2	2.02			
	22.5 - 23.0	18.6	2.07			
24.0 - 24.5	17.8	1.84				

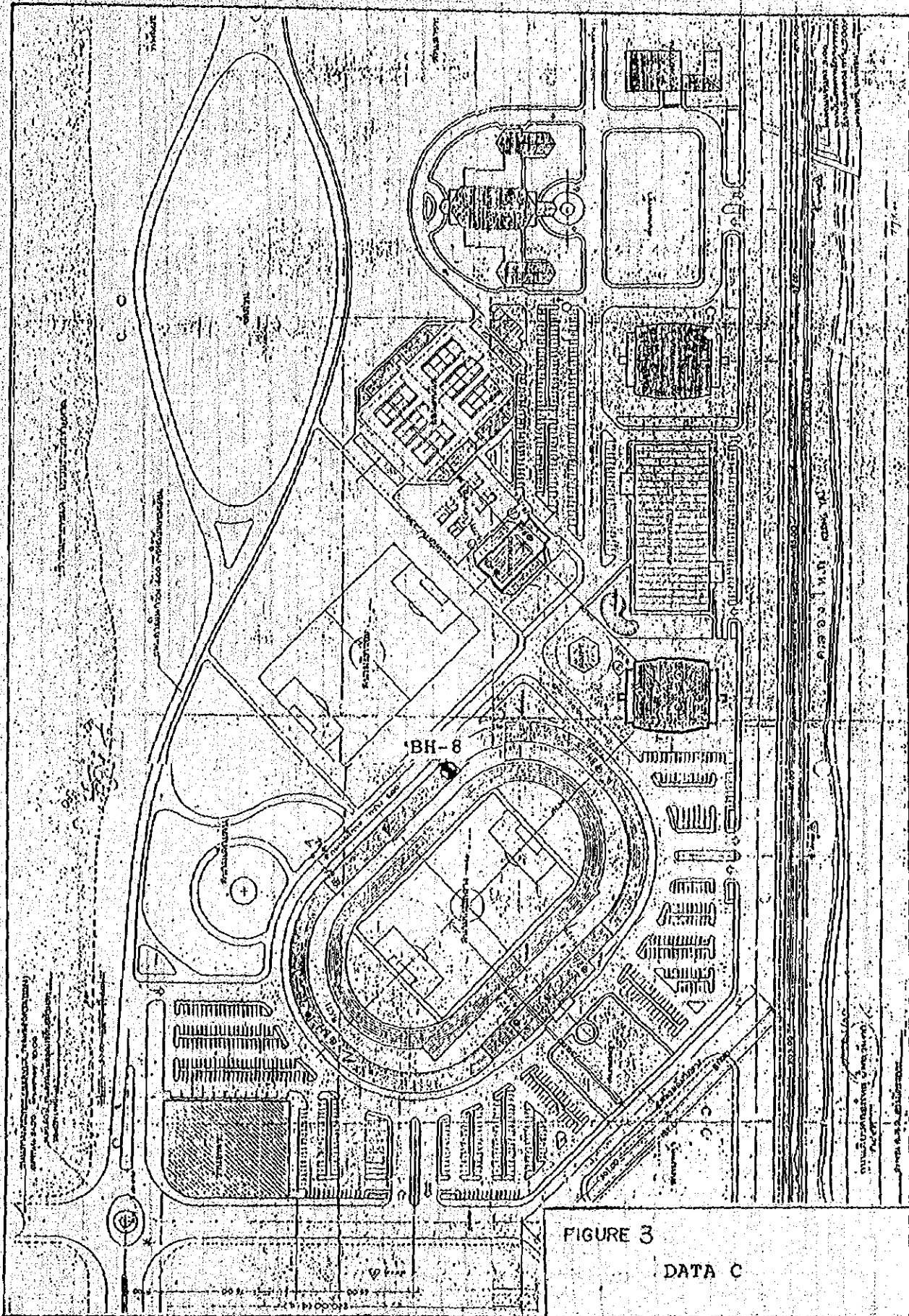


FIGURE 3  
DATA C

FIELD BORING LOG

SURVEY & BORING UNIT		LOCATION										JOB NO.	
Project		WATER LEVEL OBSERVATION		WATER LEVEL		WATER LEVEL		WATER LEVEL		WATER LEVEL		ABBREVIATION	
Client		WL 1.80 TO	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00	VS. 0.00
Province		BCR	AB	26NAD	26NAD	26NAD	26NAD	26NAD	26NAD	26NAD	26NAD	26NAD	26NAD
DEPTH (m)	FROM	TO	CORRECTION	RECORDED	CORRECTION	CORRECTION		CORRECTION	CORRECTION	CORRECTION	CORRECTION	CORRECTION	CORRECTION
						1	2						
1	0.00	1.50	YF										
2	1.50	3.00	PA										
3	3.00	3.60	IS										
4	3.60	4.50	PA										
5	4.50	5.00	YS										
6	5.00	6.00	PA										
7	6.00	6.50	YF										
8	6.50	7.50	PA										
9	7.50	8.00	YS										
10	8.00	9.00	PA										
11	9.00	9.50	ST										
12	9.50	10.30	PA										
TV TOR - VME (sec)													
LENGTH RECOVERED (cm)													
BORING NO. 5 SURFACE ELEVATION: 9.70 SAMPLE DESCRIPTION: - Very soft organic top soil - dark grey silty clay - Same as above - Same as above - Very soft dark grey silty clay - Medium light grey silty clay - Silty grey and reddish brown clay, trace of sandy clay													

SURVEY & BORING UNIT		FIELD BORING LOG										JOB NO.		
CABLE NO.	DEPTH (m)	WATER LEVEL OBSERVATION		TEMP.		CASING		SPLITSPON SAMPLE		TV	LENGTH RECOVERED (cm)	BORING NO.	SURFACE ELEVATION	ABBREVIATION
		WL	V.S. or WD	Vs. (sec)	Op	6	5	4	3					
FROM	TO	W.L.	I.C.R.	VS. (sec)	OP	6	5	4	3	2	1	ACR	DIAG	FI
TO	FROM	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)	VS. (sec)
7	10.50 - 11.00	ST												
	11.00 - 12.00	PP												
8	11.00 - 12.45	SS												
	12.45 - 13.50	PP												
9	13.50 - 14.00	SS												
	14.00 - 15.00	PP												
10	15.00 - 15.45	SS												
	15.45 - 16.50	PP												
11	16.50 - 16.95	SS												
	16.95 - 18.00	PP												
12	18.00 - 18.45	SS												
	18.45 - 19.00	PP												

- Still yellow and redish brown clay; trace of silty to very fine sand.  
 - Still yellow silty clay.  
 - Same as above  
 - Same as above  
 - Same as above  
 - Flared yellow and gray silty clay. Trace of calcareous.

LIB