THE KINGDOM OF THAILAND
FEASIBILITY REPORT
ON
BANGKOK METROPOLITAN AREA
TOWN GAS DISTRIBUTION PROJECT

(APPENDIX)

DECEMBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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REPORT ON SOIL AND FOUNDATION INVESTIGATION

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REPORT ON SOIL AND FOUNDATION INVESTIGATION

INTRODUCTION

1. Purpose

The investigation described in this report was performed to obtain typical soil profiles and soil properties at selected locations to use in a preliminary study of the geotechnical aspects of the feasibility of a town gas supply system for the city of Bangkok.

2. Authorization

This investigation was conducted under a grant to the Asian Institute of Technology by the Japan International Cooperation Agency.

3. Scope

The scope of this investigation was as outlined in the proposal from the Asian Institute of Technology to the Japan International Cooperation Agency in October 1974 and modified in a letter from A.I.T. to J.I.C.A. dated November 5, 1974.

TEST BORINGS

1. Number and Depth

Ten (10) test borings were drilled at location selected in the field by Mr. K. Okamoto of the Japan International Cooperation Agency. The locations of the bore holes are indicated on Figs. 1, 2 and 3.

Four of the test borings were drilled to depths exceeding 30 meters using rotary drilling equipment. Six test borings were drilled to a depth of 5.3 meters below the existing ground surface using a manually operated auger. A summary of the test borings is given as follows:

Table 1 - Test Borings Performed

Boring No.	Location	Type	Depth
2	Plant Site	Rotary	31.5 m.
3	Plant Site	Rotary	30.4 m.
4	Transmission Line	Manual	5.3 m.
5	Transmission Line	Manual	5.3 m.
6	Transmission Line	Manual	5.3 m.
7	Transmission Line	Manual	5.3 m.
8	Transmission Line	Manual	5.3 m.
9	Gas Holder	Rotary	30.4 m.
11	Transmission Line	Manual	5.3 m.
12	Klong Crossing	Rotary	30.4 m.

2. Boring Logs

Logs of the deeper test borings, Boring Nos. 2, 3, 9 and 12 are presented in Figs. 4 through 7. Logs of the shallower test borings, Boring Nos. 4, 5, 6, 7, 8 and 11 are presented in Figs. 8 and 9.

3. Samples Obtained

In each of Test Boring Nos. 2, 3, 9 and 12, 7.6 cm. diameter undisturbed thin walled tube samples (Shelby Tubes) and 0.5 meter in length were obtained at three depths, two (2) spaced in the soft clay and one (1) in the stiff clay. In addition, in each of these Test Borings, several split spoon samples were obtained at depth intervals throughout the stiff clay.

The Standard Penetration Test was performed as each of the split spoon samples was obtained and the N value was recorded on the Boring Log. N is the number of blows of a 63.6 kg. (140 lb.) hammer falling 76.2 cm. (30 in.) required to drive a standard 5.1 cm. (2 in.) diameter sampler a distance of 30.5 cm. (12 inches).

One (1) undisturbed tube sample was obtained from the bottom of each of Test Boring Nos. 4, 5, 6, 7, 8 and 11.

LABORATORY TESTS PERFORMED

1. Identification Tests

All samples were identified visually. The liquid limit and plastic limit of a sample of the soil

Table 2 - Soil Properties

Bore Hole No.	Sample No.	Depth. m.	PL %	w %	LL %	γ_t t/m^3	G	Q_u t/m^3
2	2-1	4.0-4.7	39.1	110.4	111.0	1.40	2.77	2.9
2	2-2	12.0-12.6	30.8	63.7	77.3	1.59	2.73	6.8
2	2-3	18.0-18.6	27.8	28.1	73.7	1.95	2.73	13.5
3	3-1	4.0-4.7	40.8	103.8	102.0	1.41	2.67	3.1
3	3-2	12.0-12.7	30.9	74.7	69.0	1.52	2.72	6.0
3	3-3	18.0-18.5	22.0	35.2	68.2	1.82	2.76	22.5
4	4-1	4.7-5.3	23.7	59.5	57.9	1.64	2.71	-
5	5-1	4.7-5.3	32.7	95.6	87.5	1.51	2.74	-
6	6-1	4.7-5.3	26.4	58.1	57.6	1.66	2.71	-
7	7-1	4.7-5.3	28.1	78.1	63.7	1.59	2.76	-
8	8-1	4.7-5.3	28.4	77.0	74.1	1.58	2.73	-
9	9-1	4.3-4.6	25.9	76.3	53.1	1.55	2.72	2.2
9	9-2	10.0-10.6	32.1	76.6	81.5	1.55	2.63	4.8
9	9-3	19.0-19.6	23.0	43.8	63.2	1.79	2.69	14.5
11	11-1	4.7-5.3	26.0	72.9	66.5	1.62	2.75	-
12	12-1	4.6-5.2	23.9	56.9	70.8	1.57	2.67	1.3
12	12-2	12.0-12.6	33.5	75.6	84.8	1.55	2.73	8.0
12	12-3	20.2-20.6	19.5	26.8	49.7	1.93	2.74	12.5

Notes: PL = Plastic limit,
LL = Liquid limit,
G = Specific gravity,
w = Natural water content,
γ_t = Total unit weight,
Q_u = Unconfined compressive strength

from each undisturbed tube were obtained. These determinations were performed in accordance with ASTM Designation D423-66 and D424-59 (1971) respectively.

The grain size distribution of a sample of soil from each undisturbed tube sample was determined in accordance with ASTM Designation D422-63 (1972) and the results of these determinations are presented in Figs. 28 through 33.

The Specific Gravity of the soil solids in a sample of soil from each undisturbed tube sample was determined in accordance with ASTM Designation D854-58 (1972) and the natural water content and total unit weight of a sample from each undisturbed tube were determined.

The results of all of these identification tests are included in Table 2.

2. Unconfined Compression Tests

The unconfined compressive strength of a sample of soil from each undisturbed tube sample in Boring Nos. 2, 3, 9 and 12 was determined according to ASTM Designation D2166-66 (1972). Samples 3.5 cm. in diameter by 7.1 cm. high were shear at a constant strain rate of 1% min. The unconfined compressive stress plotted against axial strain are presented in Figs. 10 through 21. One-half of the unconfined compressive strength is often used as an estimate of the undrained shear strength of soils.

3. Consolidation Tests

Six (6) one dimensional consolidation tests were performed on the undisturbed samples from Borings 2 and 3. These tests were performed on samples 6.5 cm. in diameter and 2.00 cm. original height, drained from both the top and the bottom in accordance with ASTM Designation D2435-70 using pressure increments as specified by the J.I.C.A.

Compression vs. time readings were taken and the coefficient of consolidation (C_v) estimated by both the log of time and the squareroot of time fitting method for each loading increment. The results of consolidation tests are presented in Figs. 22 through 27. The compression index (C_c) values reported are based on the compression between successive load increments.

CONCLUSIONS

1. Soil Profile

Based on the Boring Logs obtained, the soil profile at all locations is typical of the Bangkok area and consists of from 0.5 to 2.0 m. of miscellaneous fill or medium clay with root holes

over a dark grey soft clay deposit. The soft clay overlies a deposit of stiff clay encountered at a depth of from 14.5 to 17 meters in Boring Nos. 2, 3, 9 and 12. A dense sand deposit was reported below the stiff clay, in these borings and the stiff clay varied in thickness from 4 meters in Boring No. 3 to 16½ meters in Boring No. 2. A typical soil profile in the Bangkok area would consists of a stiff surface crust of weathered clay up to 4 meters in thickness overlying a deposit of soft, highly compressible, dark grey clay extending to a depth of approximately 10 to 15 meters below the ground surface. The soft clay overlies a deposit of stiff of varying thickness. Below the stiff clay, a dense fine sand and gravel stratum is typically encountered.

2. Soft Clay

The soft clay at a depth of about 5 meters in all borings except No. 12 and at 12 meters in Boring No. 3 was found to have a natural water content in excess of the liquid limit. This indicates that the soil would have a very low shear strength and would approach the consistancy of viscous liquid if remolded. The natural water content became less than the liquid limit as the depth into the soft clay increased.

The consolidation tests on the soft clay samples from Boring Nos. 2 and 3 indicate that the material is highly compfessible at pressures much in excess of the existing overburden pressure.

3. Stiff Clay

The clay unqerlying the soft clay is medium stiff to stiff in consistancy. The consolidation tests on samples from Boring Nos. 2 and 3 indicate that the material has low to moderate compressibility and is over-consolidated.

FACTORS RELATED TO TOWN GAS PROJECT

1. Pipe Line

(a) Trenches

All but very shallow trenches should be thoroughly braced for safety. The bottom of trenches which penetrate through the upper weather zone may be unstable. Trench bottoms in the soft clay will probably become very muddy and will be difficult to work in. Proper compaction of material excavated from trenches used as back fill will be difficult at natural moisture contents. It syould be assumed that the ground water level is at or above the upper clay surface and provisions for dewatering the trenches must be made.

(b) Settlement

Settlement of a pipe line could result from at least the following three causes: (1) General surface subsidence from deep well pumping, (2) Addition of loads over or adjacent ot the pipe line and (3) Back-filling the ttench with heavier material.

Surface subsidence due to deep well pumping is known to be occurring in Bangkok and while resulting settlements will generally be uniform the effect of subsidence should be considered.

The most severe danger of detrimental settlement of a pipe line would result from the placement of surface loads adjacent to or on top of the back filled ditch. Loads resulting from fill placed over or adjacent to the pipe line, roadway embankments crossing the pipe line and other superimposed loads could cause large settlements and detrimental differential settlements at critical locations.

Settlements of the pipe line could result if the trench would be back-filled with material considerably denser than the natural soil (e.g. compacted sand). Such settlement would be uniform and probably not large, but this should be further investigated for cases of deep trenches.

2. Foundations

Medium weight structures and pipe line along crossing would probably be founded on piles (e.g. pre-cast concrete) driven into the stiff clay. Heavy structures would probably be founded on piles driven through the stiff clay into the underlying sand. The pile design loads should be estimated based on further more detailed test borings at exact locations of structures and laboratory tests. Final design pile loads should be based on pile load tests on selected piles driven in the field.

Small light structures (valve boxes, gage houses, etc.) could possibly be founqed on spread footings based in the upper weathered zone or on short friction piles.

The use of fill to raise the level of any site should be considered carefully in relation to possible large resulting settlements and downdrag or negative skin friction loads on piles through the fill.

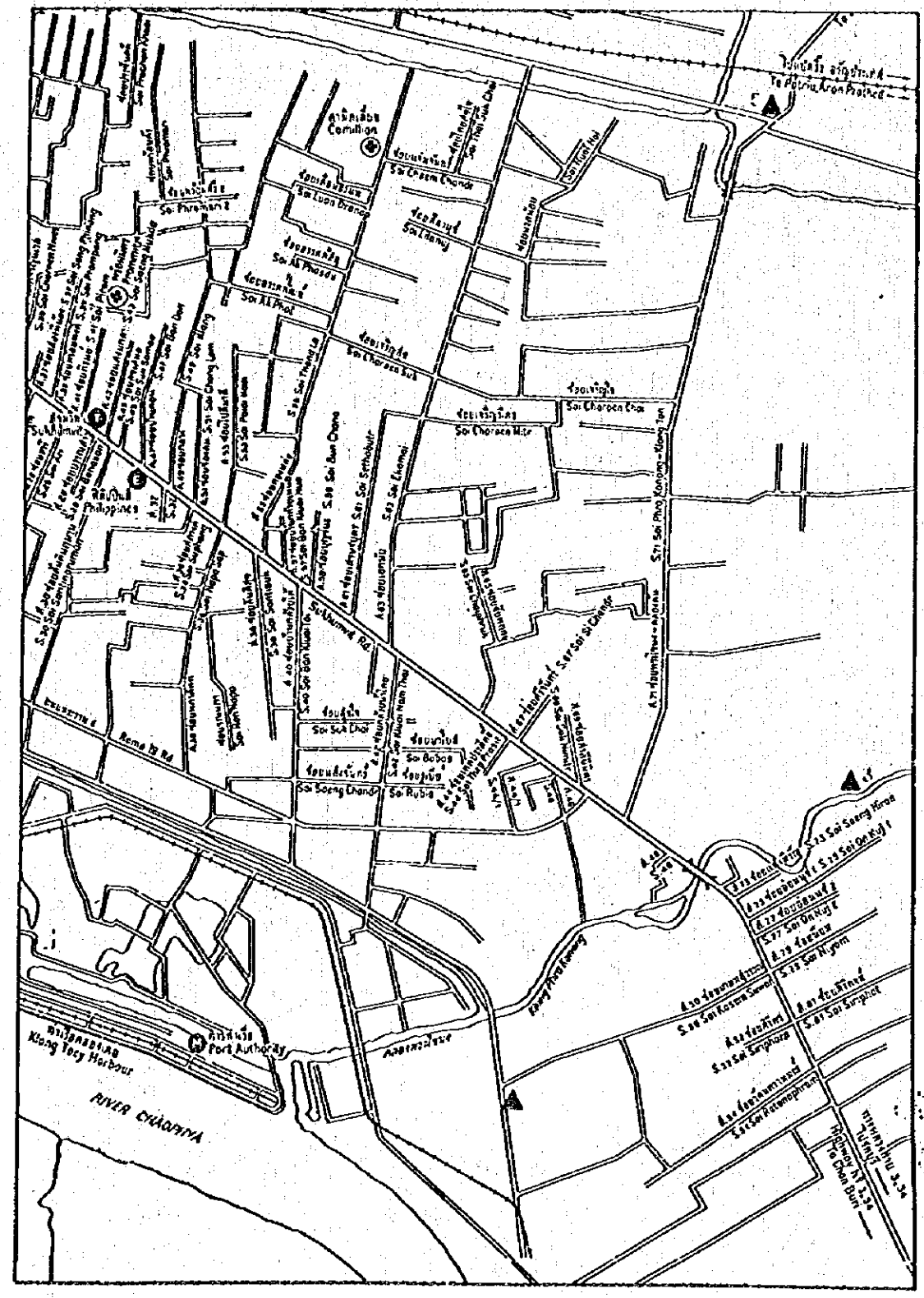

Comilon
Sukhumvit Rd.
Rama IV Rd.
Port Authority
Klong Toey Harbour
RIVER CHAOPHYA

Fig. 1

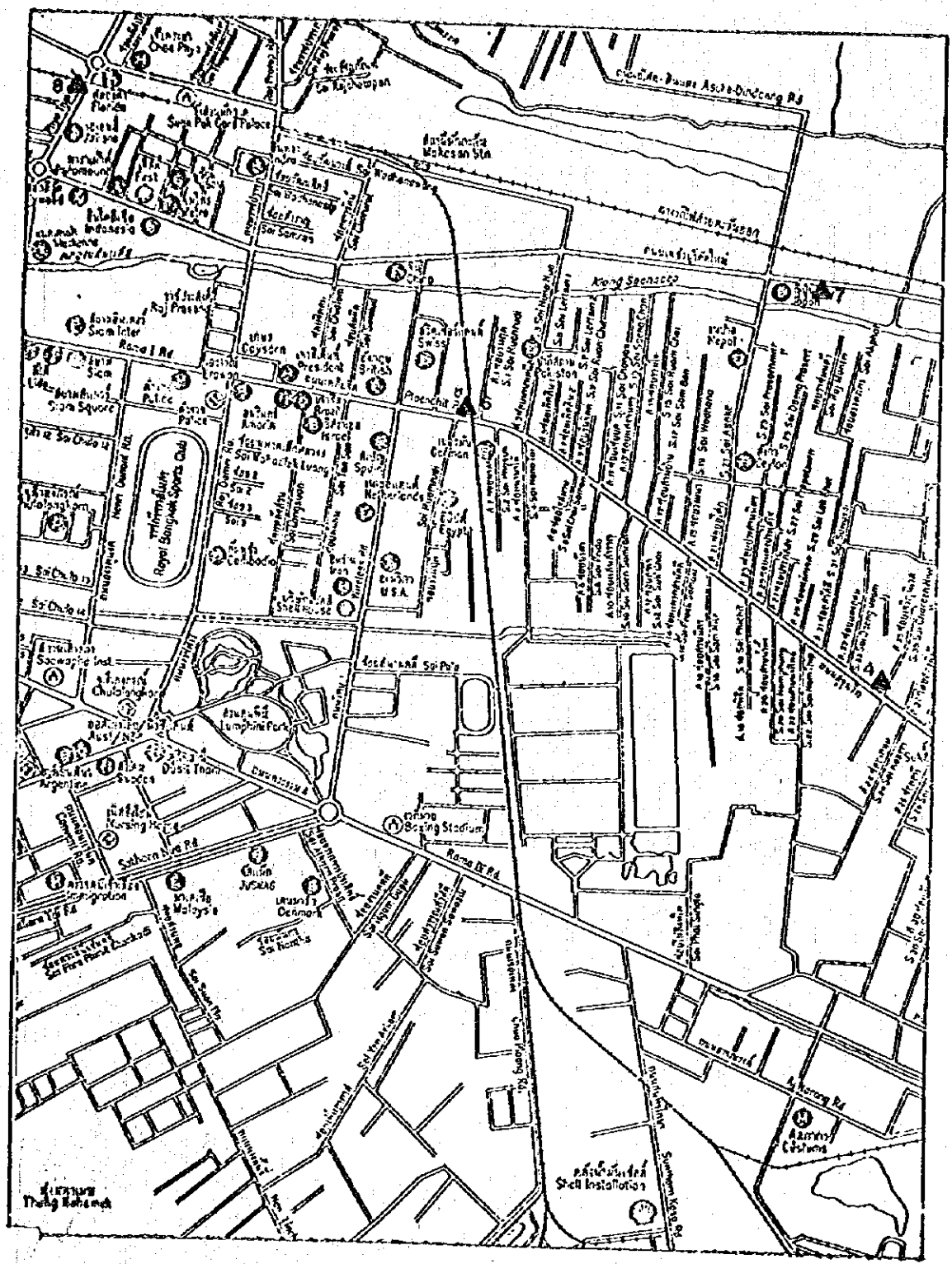


Fig. 2

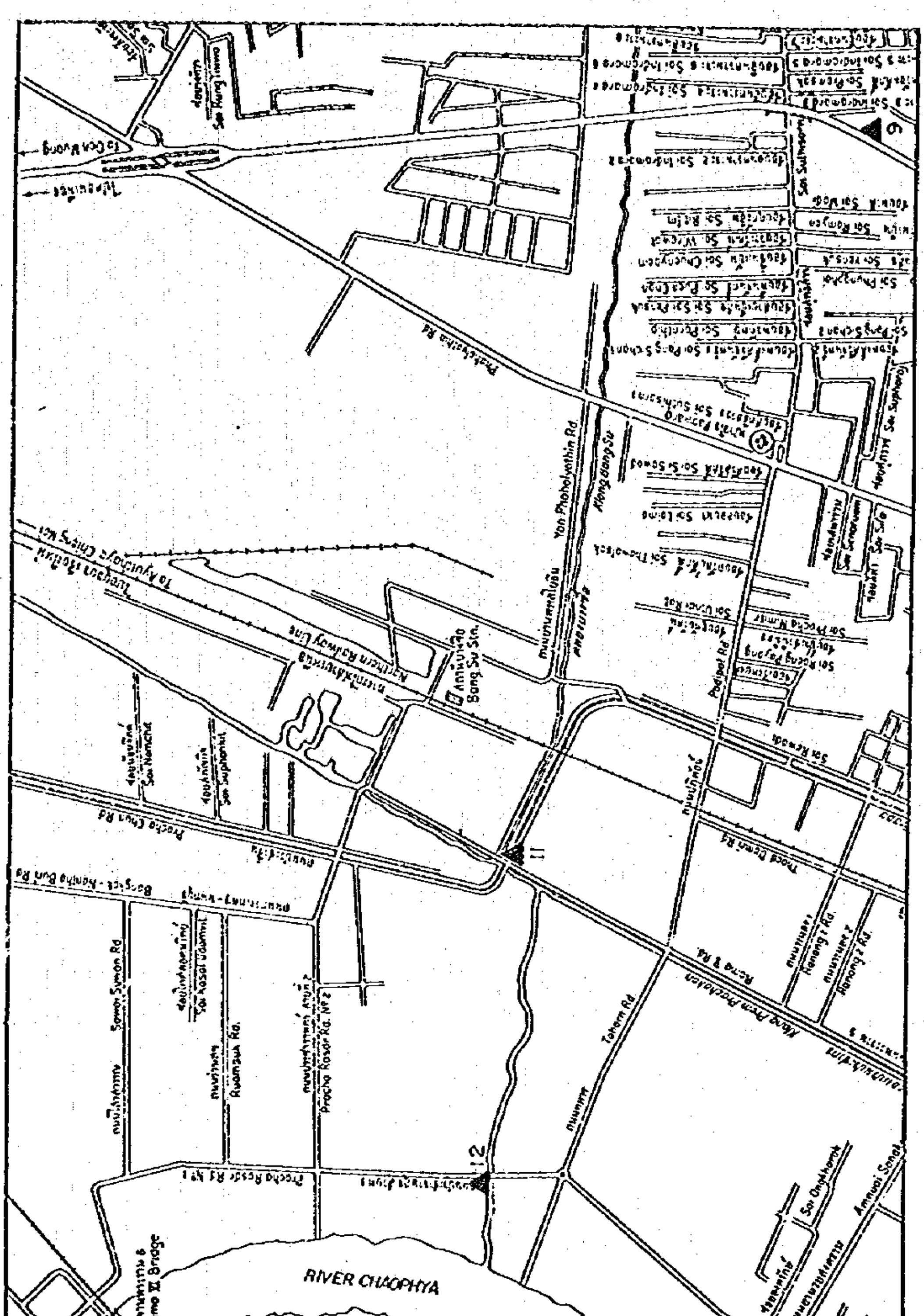

RIVER CHAOPHYA
Phaholyothin Rd.
Northern Railway Line
Bang Su Stn.
Rama VI Bridge
9
11
12

Fig. 3

ASIAN INSTITUTE OF TECHNOLOGY

LOG BORING NO. 2

PROJECT : Town Gas — DATE COMMENCED Nov. 11, 1974

LOCATION : Soi 50 Sukhumvit Rd., Klong Tuey — DATE FINISHED Nov. 12, 1974

PA = POWER AUGER; DH = DRIVE HAMMER; WO = WASHING; RB = ROCK BIT; ST = SHELBY TUBE; D = DISTURBED SAMPLE; U_p = UNDISTURBED SAMPLE; SS = SPLIT SPOON

● Standard Penetration ▲
○ △

DEPTH m	GRAPHIC LOG	SAMPLING METHOD	RECOVERY	SOIL DESCRIPTION
0		PA		Brownish grey, medium CLAY with some root holes
5		ST		Dark grey, soft to medium-soft CLAY with some small shells (12.0 m)
10		WO		
		ST		
15		WO		Grey, stiff CLAY
		ST		
20		WO		Yellowish brown/grey/some red, stiff to hard CLAY
		SS		
25		WO		
		SS		
		WO		
30		SS		Yellowish brown, stiff CLAY
				Yellowish brown/grey, dense, fine SAND
35				END OF BORE HOLE
40				

N, Blows/ft: 10, 20, 30, 40, 50

Fig. 4

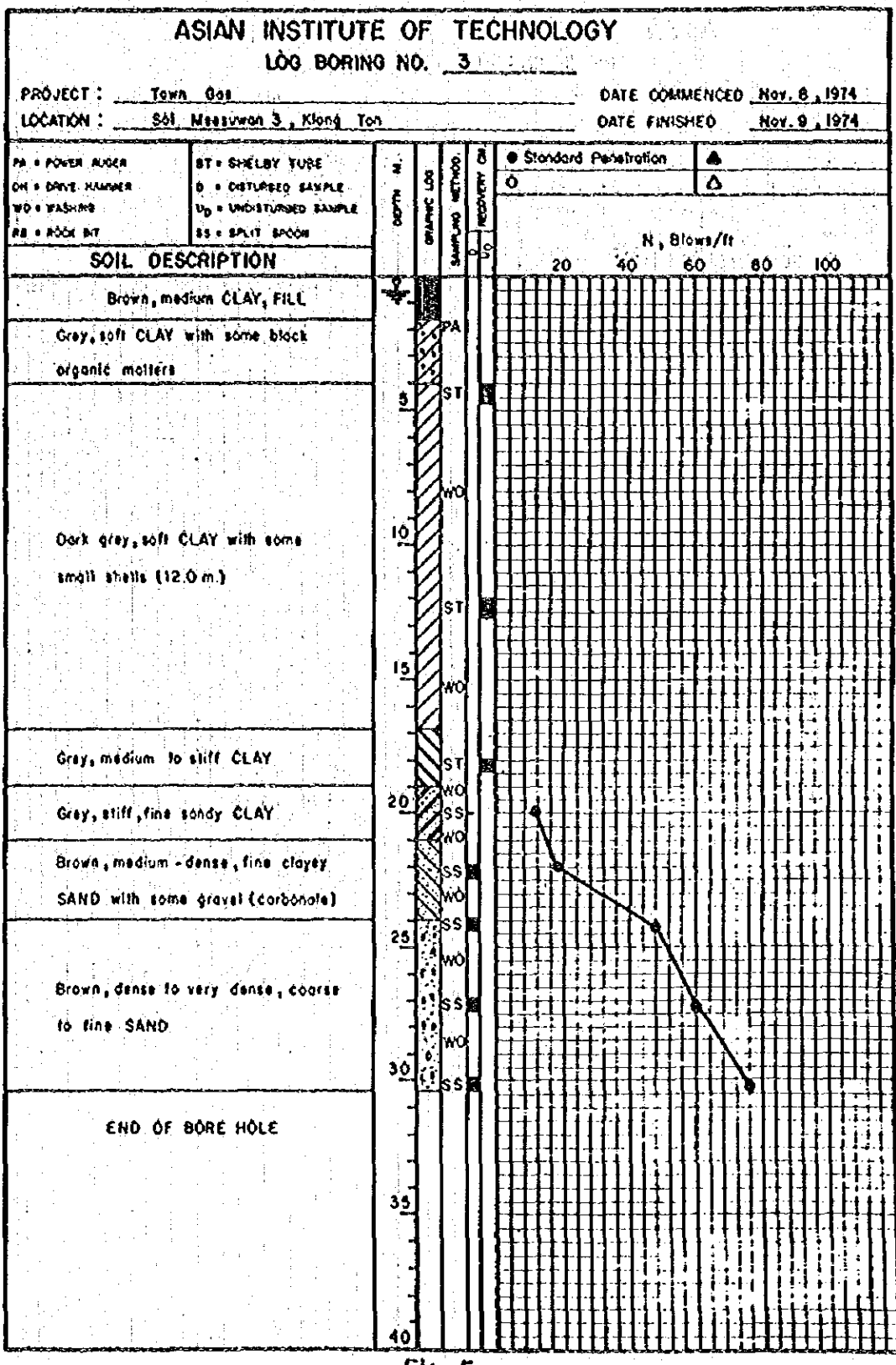

ASIAN INSTITUTE OF TECHNOLOGY
LOG BORING NO. 3
PROJECT : Town Gas
LOCATION : Soi. Meesuwan 3 , Klong Ton
DATE COMMENCED Nov. 8 , 1974
DATE FINISHED Nov. 9 , 1974
PA = POWER AUGER
DH = DRIVE HAMMER
WO = WASHING
RB = ROCK BIT
ST = SHELBY TUBE
D = DISTURBED SAMPLE
UD = UNDISTURBED SAMPLE
SS = SPLIT SPOON
SOIL DESCRIPTION
Brown, medium CLAY, FILL
Grey, soft CLAY with some black organic matters
Dark grey, soft CLAY with some small shells (12.0 m.)
Grey, medium to stiff CLAY
Grey, stiff, fine sandy CLAY
Brown, medium - dense, fine clayey SAND with some gravel (carbonate)
Brown, dense to very dense, coarse to fine SAND
END OF BORE HOLE
DEPTH
GRAPHIC LOG
SAMPLING METHOD
RECOVERY
Standard Penetration
N, Blows/ft
20
40
60
80
100
PA
ST
WO
SS
5
10
15
20
25
30
35
40

Fig. 5

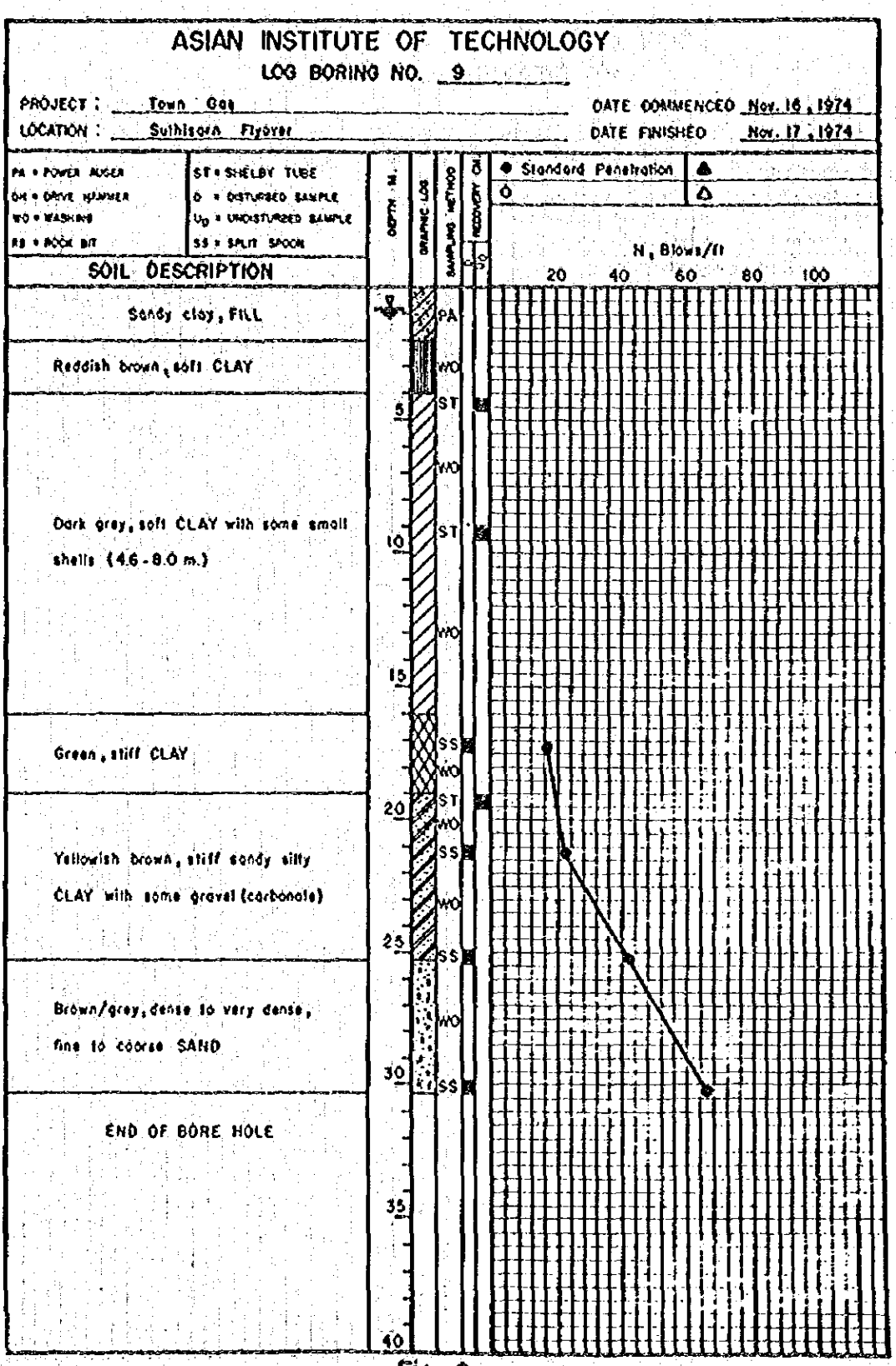

ASIAN INSTITUTE OF TECHNOLOGY
LOG BORING NO. 9
PROJECT : Town Gas
LOCATION : Suthisarn Flyover
DATE COMMENCED Nov. 16, 1974
DATE FINISHED Nov. 17, 1974
PA = POWER AUGER
DH = DRIVE HAMMER
WO = WASHING
RB = ROCK BIT
ST = SHELBY TUBE
D = DISTURBED SAMPLE
Up = UNDISTURBED SAMPLE
SS = SPLIT SPOON
SOIL DESCRIPTION
DEPTH - M.
GRAPHIC LOG
SAMPLING METHOD
DH
RECOVERY
Standard Penetration
N, Blows/ft
20
40
60
80
100
Sandy clay, FILL
Reddish brown, soft CLAY
Dark grey, soft CLAY with some small shells (4.6 - 8.0 m.)
Green, stiff CLAY
Yellowish brown, stiff sandy silty CLAY with some gravel (carbonate)
Brown/grey, dense to very dense, fine to coarse SAND
END OF BORE HOLE
PA
WO
ST
SS
5
10
15
20
25
30
35
40

Fig. 6

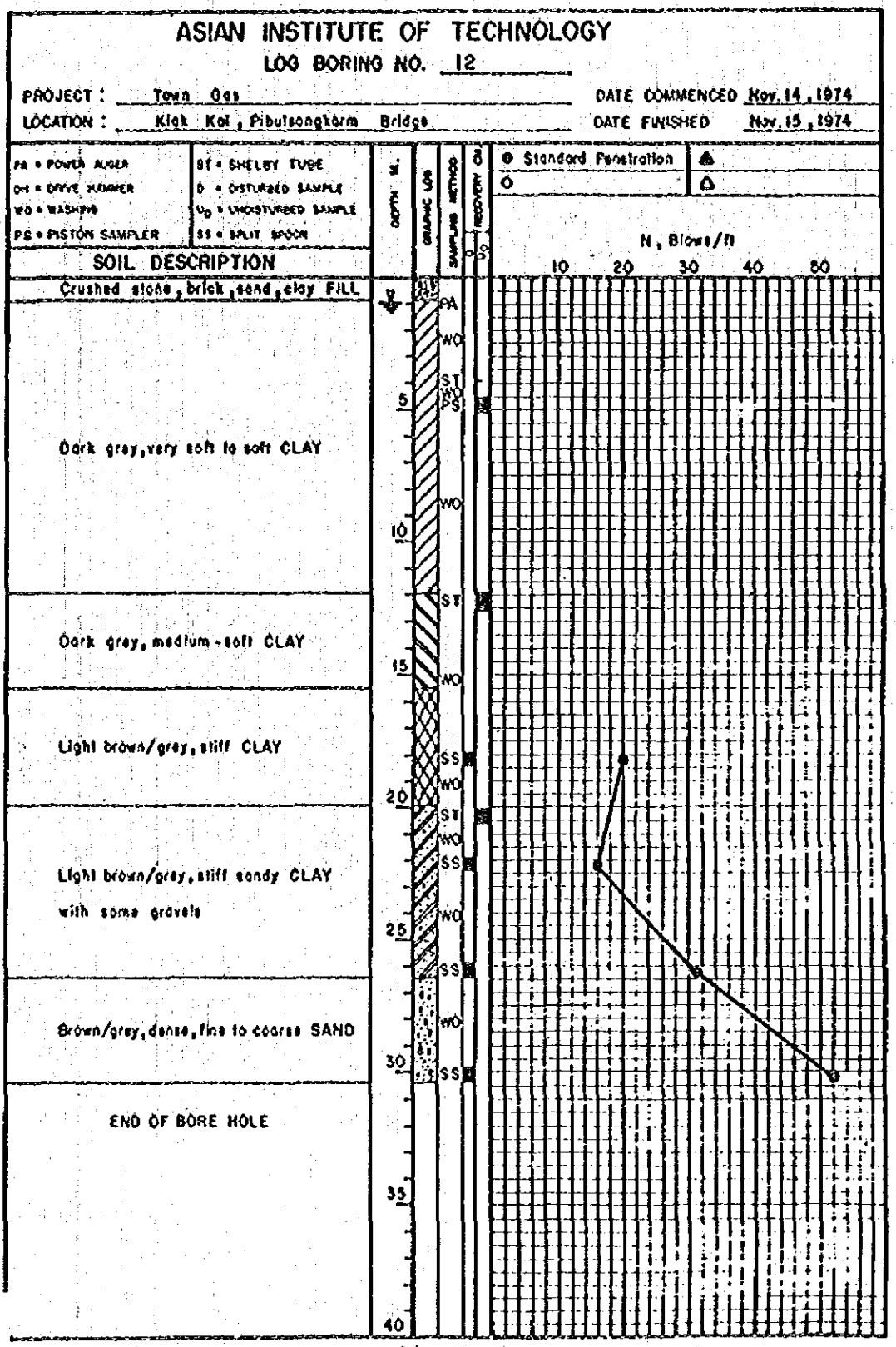

ASIAN INSTITUTE OF TECHNOLOGY
LOG BORING NO. 12
PROJECT : Town Gas
LOCATION : Kiak Kai , Pibulsongkram Bridge
DATE COMMENCED Nov. 14 , 1974
DATE FINISHED Nov. 15 , 1974
PA = POWER AUGER
DH = DRIVE HAMMER
WO = WASHING
PS = PISTON SAMPLER
ST = SHELBY TUBE
D = DISTURBED SAMPLE
UD = UNDISTURBED SAMPLE
SS = SPLIT SPOON
SOIL DESCRIPTION
Crushed stone , brick , sand , clay FILL
Dark grey, very soft to soft CLAY
Dark grey, medium - soft CLAY
Light brown/grey, stiff CLAY
Light brown/grey, stiff sandy CLAY with some gravels
Brown/grey, dense, fine to coarse SAND
END OF BORE HOLE
DEPTH M.
ORGANIC %
SAMPLING METHOD
% RECOVERY
Standard Penetration
N , Blows/ft
10
20
30
40
50
PA
WO
ST
PS
SS
5
10
15
20
25
30
35
40

Fig. 7

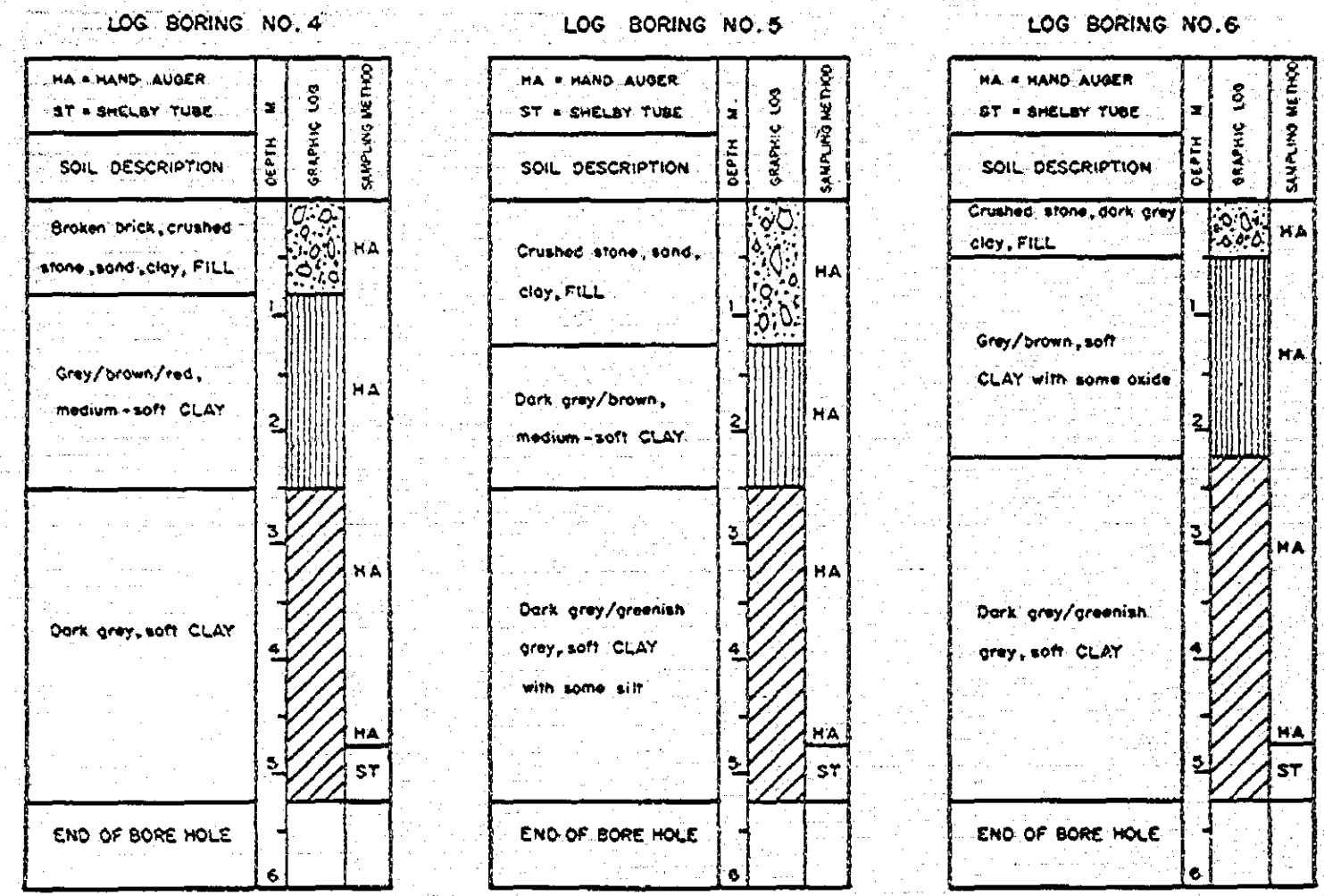
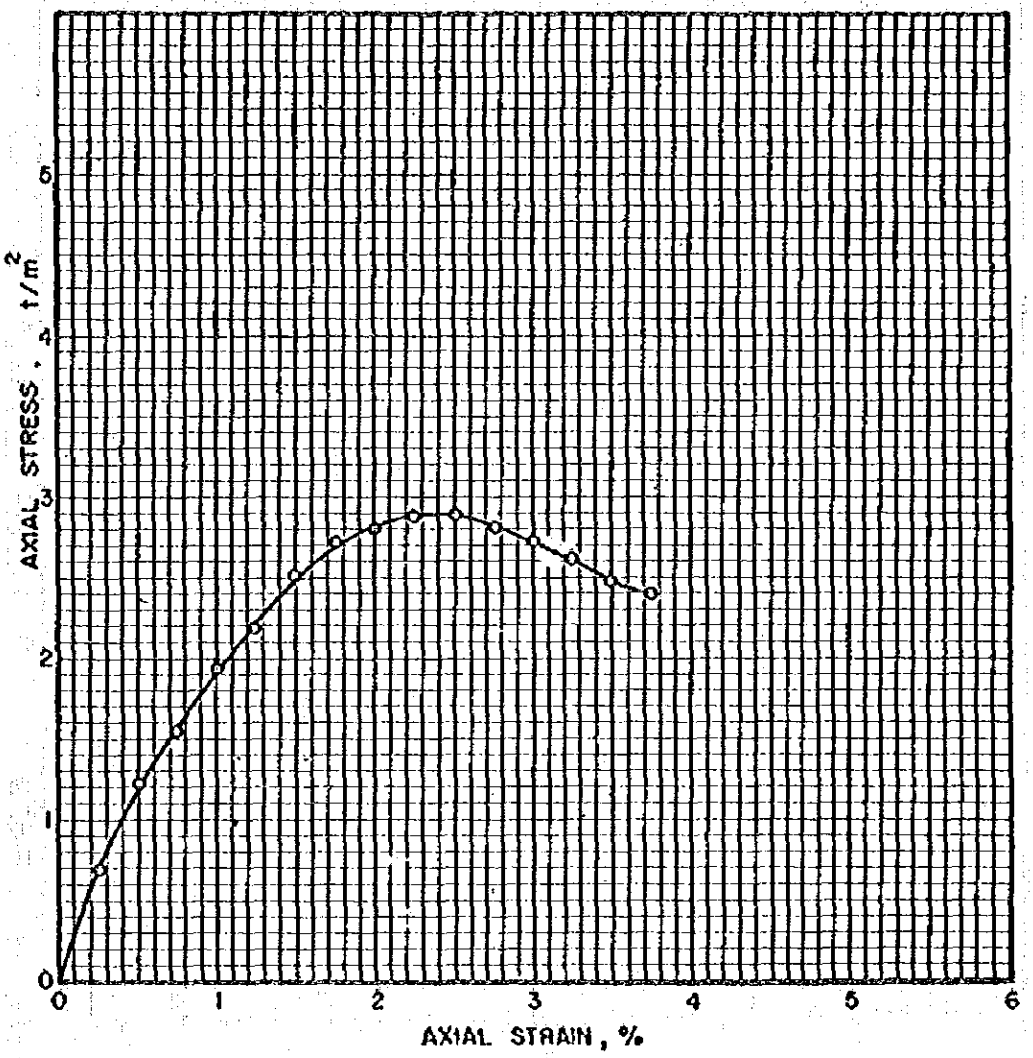

LOG BORING NO. 4
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Broken brick, crushed stone, sand, clay, FILL
Grey/brown/red, medium - soft CLAY
Dark grey, soft CLAY
END OF BORE HOLE
HA
HA
HA
HA
ST
1
2
3
4
5
6
LOG BORING NO. 5
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Crushed stone, sand, clay, FILL
Dark grey/brown, medium - soft CLAY
Dark grey/greenish grey, soft CLAY with some silt
END OF BORE HOLE
HA
HA
HA
HA
ST
1
2
3
4
5
6
LOG BORING NO. 6
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Crushed stone, dark grey clay, FILL
Grey/brown, soft CLAY with some oxide
Dark grey/greenish grey, soft CLAY
END OF BORE HOLE
HA
HA
HA
HA
ST
1
2
3
4
5
6

Fig. 8



TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH , m	4.3
SAMPLE NO.	2-1
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT, %	110.4
DRY UNIT WT. , t/m³	0.66
SATURATION, %	96

AIT		PROJECT : TOWN GAS	
TEST NO. U2-1	TESTED BY: C.K.F.	DATE: 1/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG: PP.	CHECKED: Sn	

Fig. 10

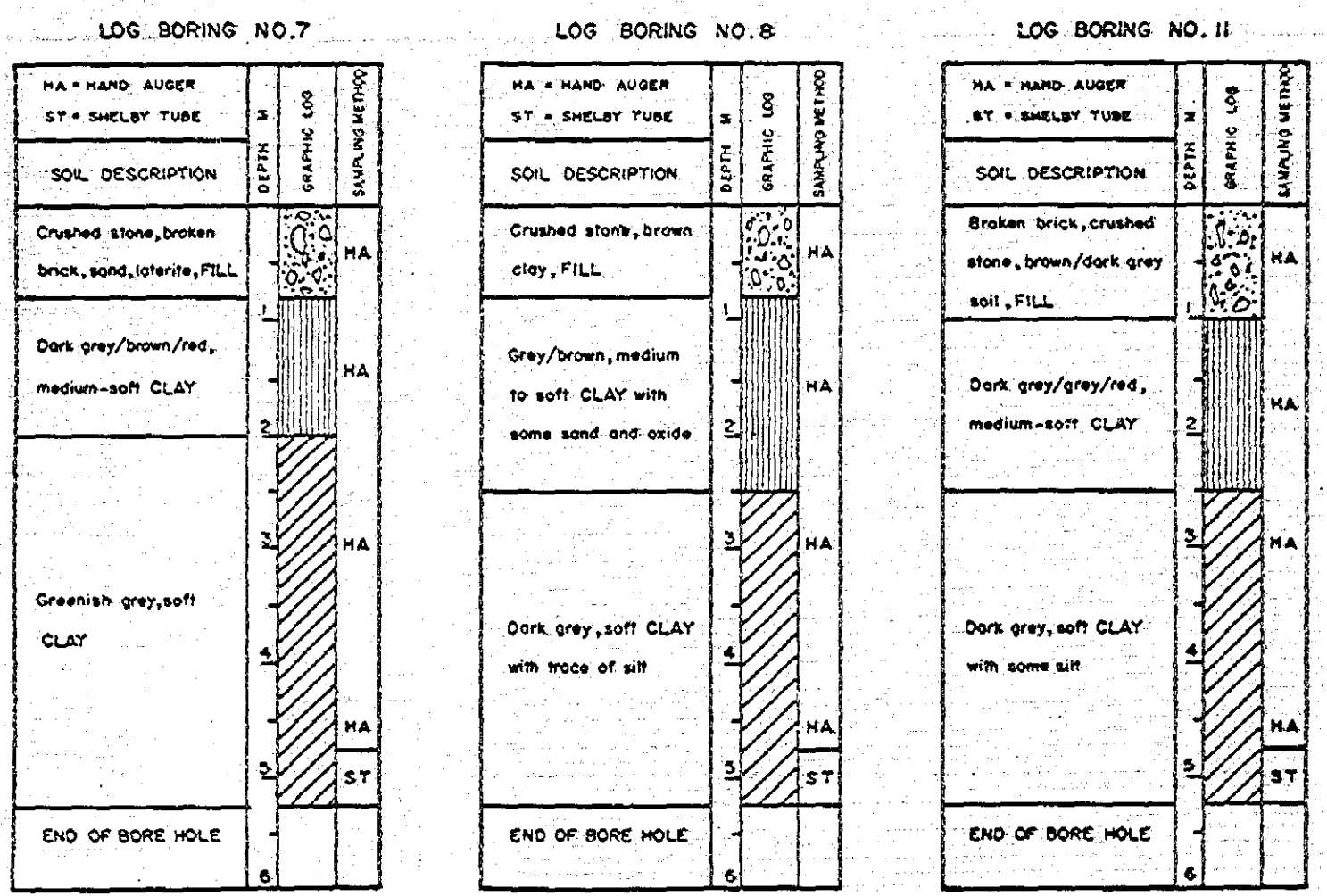
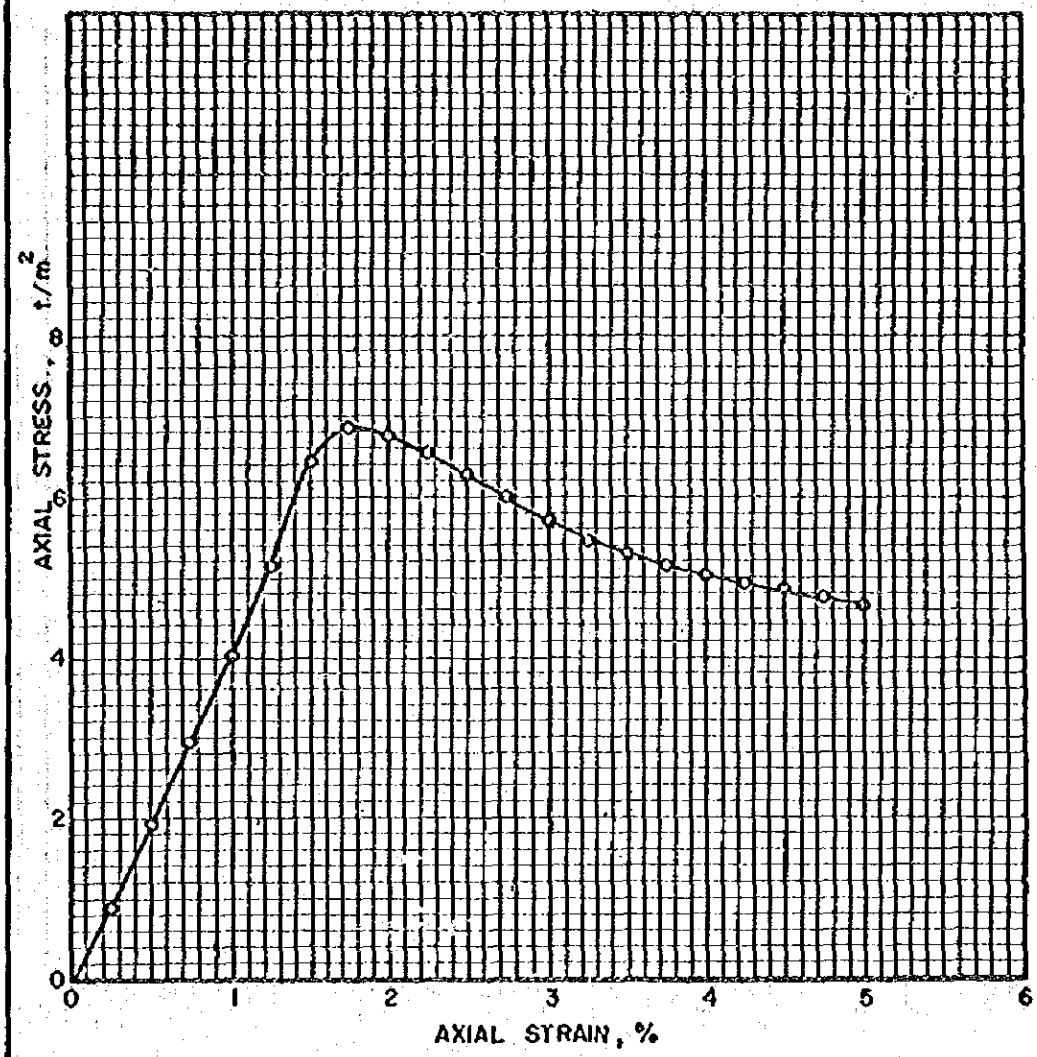

LOG BORING NO.7
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Crushed stone, broken brick, sand, laterite, FILL
Dark grey/brown/red, medium-soft CLAY
Greenish grey, soft CLAY
END OF BORE HOLE
HA
HA
HA
HA
ST
LOG BORING NO.8
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Crushed stone, brown clay, FILL
Grey/brown, medium to soft CLAY with some sand and oxide
Dark grey, soft CLAY with trace of silt
END OF BORE HOLE
HA
HA
HA
HA
ST
LOG BORING NO. 11
HA = HAND AUGER
ST = SHELBY TUBE
SOIL DESCRIPTION
DEPTH M
GRAPHIC LOG
SAMPLING METHOD
Broken brick, crushed stone, brown/dark grey soil, FILL
Dark grey/grey/red, medium-soft CLAY
Dark grey, soft CLAY with some silt
END OF BORE HOLE
HA
HA
HA
HA
ST

Fig. 9



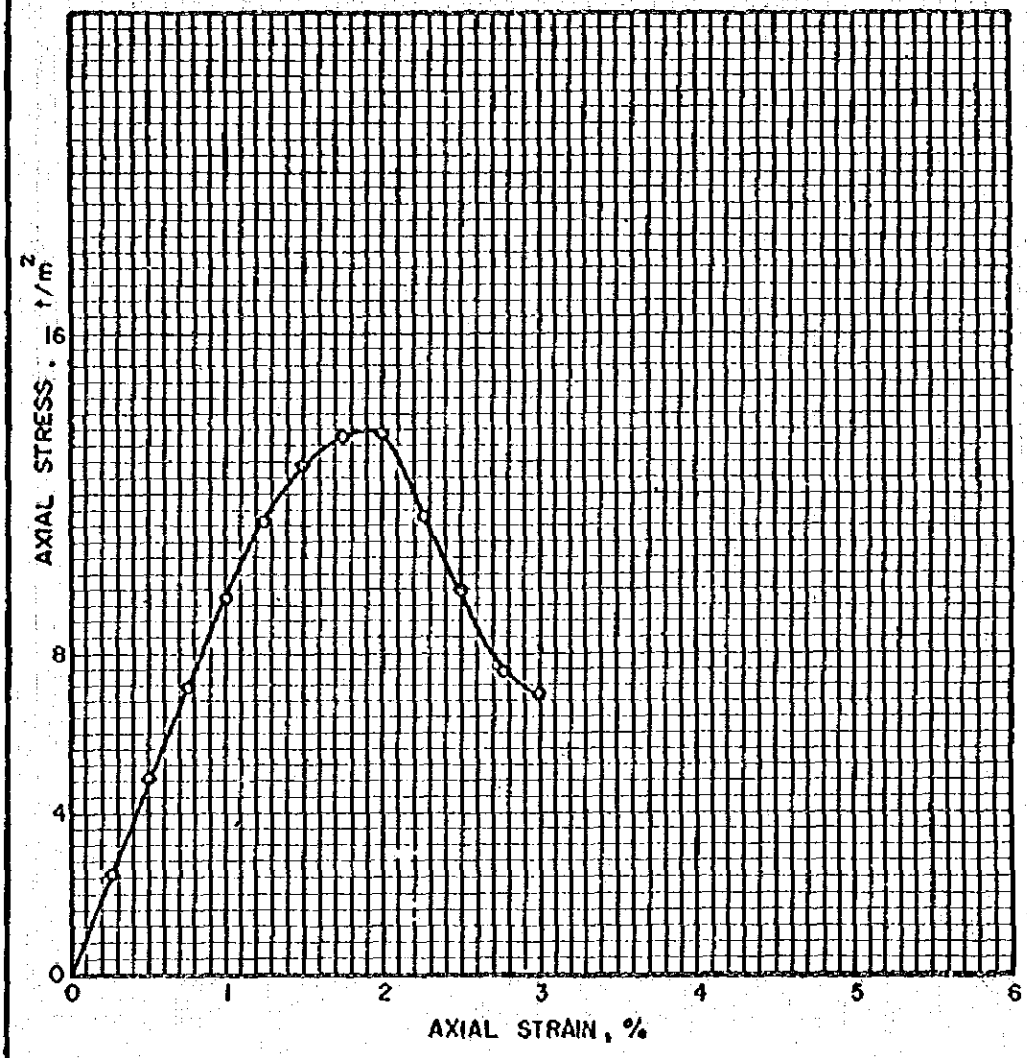
TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH, m	12.5
SAMPLE NO.	2-2
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER, cm	3.5
HEIGHT, cm	7.1
WATER CONTENT, %	63.7
DRY UNIT WT., t/m³	0.97
SATURATION, %	96

AIT		PROJECT: TOWN GAS	
TEST NO. U2-2	TESTED BY: C.K.F.	DATE: 1/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG: PP.	CHECKED: Sv	

Fig. 11



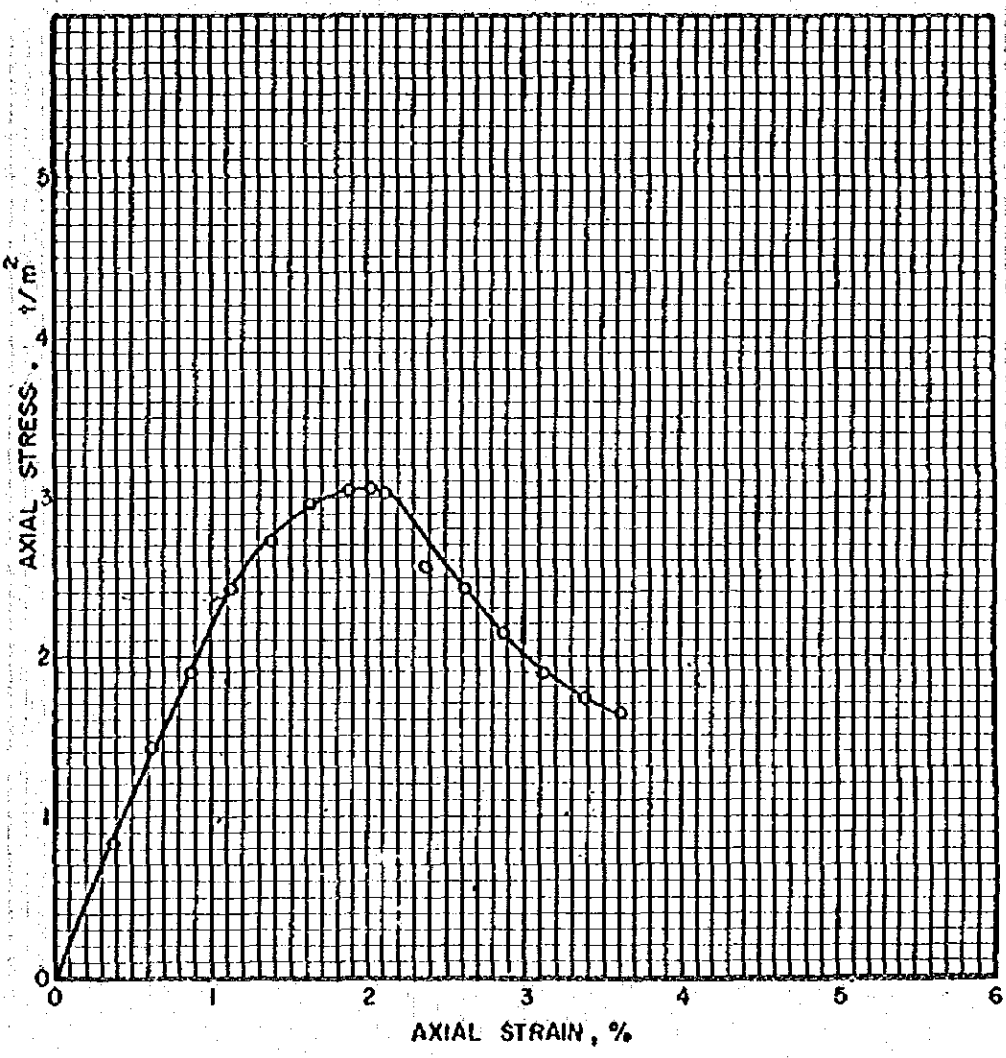
TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH , m	18.2
SAMPLE NO.	2-3
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT , %	27.5
DRY UNIT WT. , t/m³	1.53
SATURATION , %	98

AIT		PROJECT: TOWN GAS	
TEST NO. U2-3	TESTED BY: C.K.F.	DATE: 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG: PP.	CHECKED: SV.	

Fig. 12



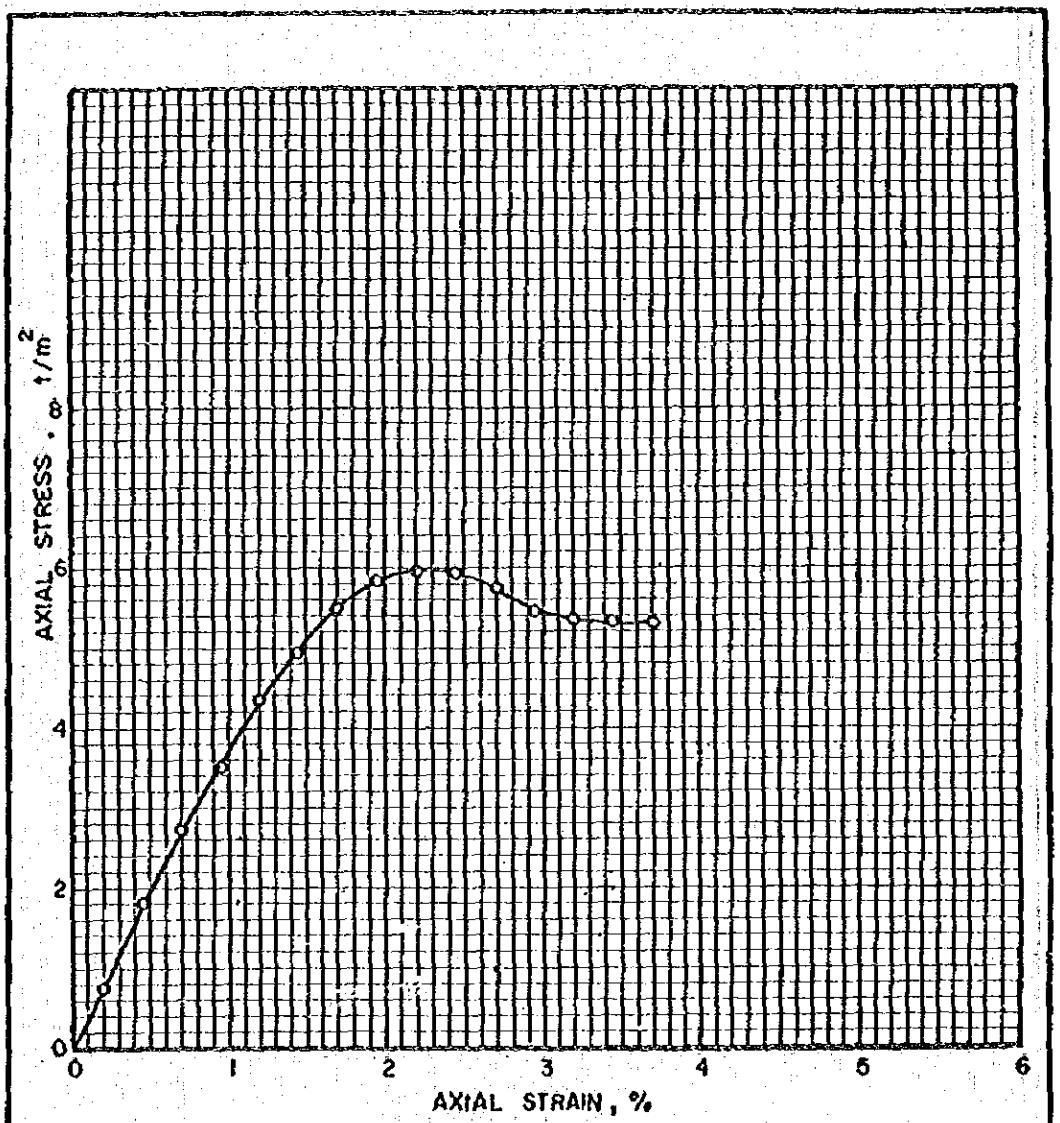
TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH , m	4.1
SAMPLE NO.	3-1
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT, %	103.8
DRY UNIT WT. , t/m^3	0.70
SATURATION, %	98

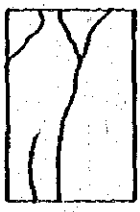
AIT		PROJECT: TOWN GAS	
TEST NO. U3-1	TESTED BY: C.K.F.	DATE: 1/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG: PP.	CHECKED: S.V.	

Fig. 13



TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH , m	12.5
SAMPLE NO.	3-2
CLASSIFICATION	

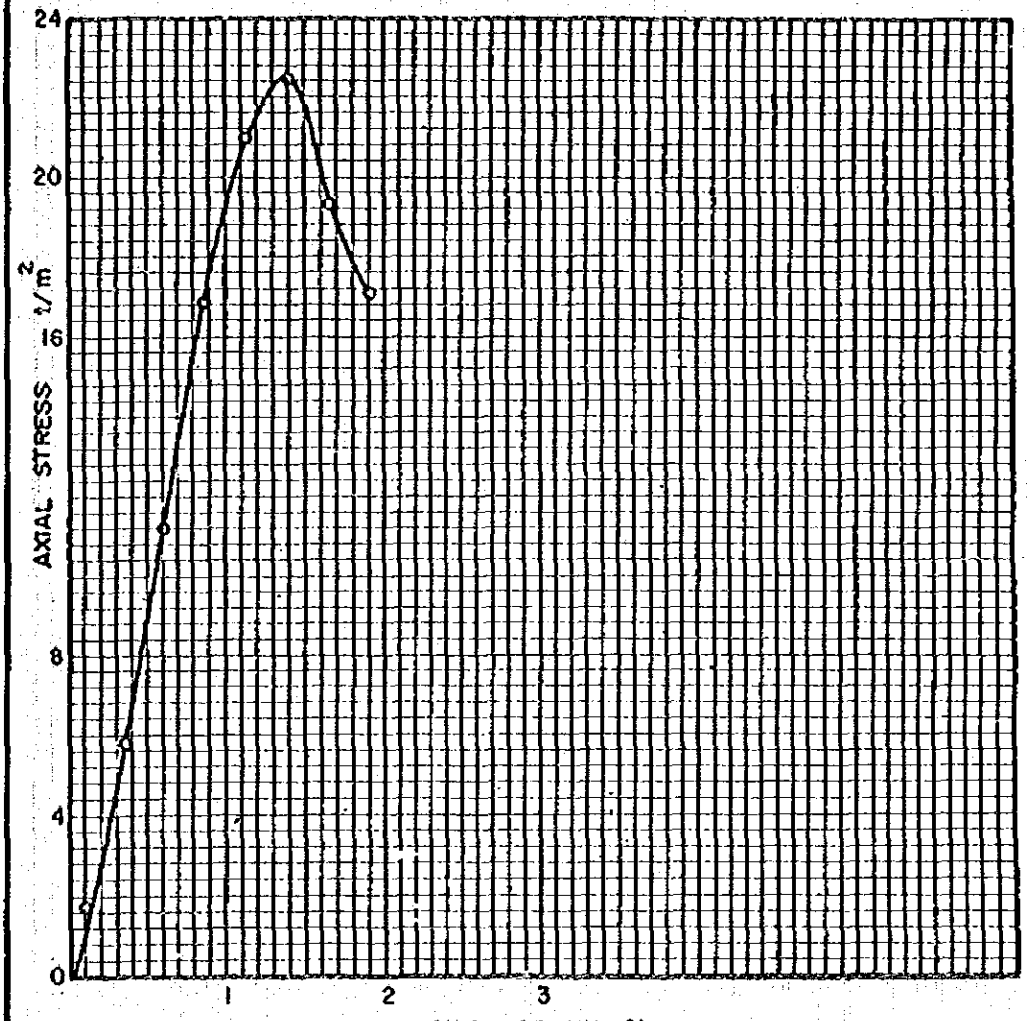
SAMPLE DESCRIPTION _____



INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT , %	74.7
DRY UNIT WT. , t/m^3	0.87
SATURATION , %	96

AIT		PROJECT : TOWN GAS	
TEST NO. U3-2	TESTED BY : C.K.F.	DATE : 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG : P.P.	CHECKED : Sv.	

Fig. 14



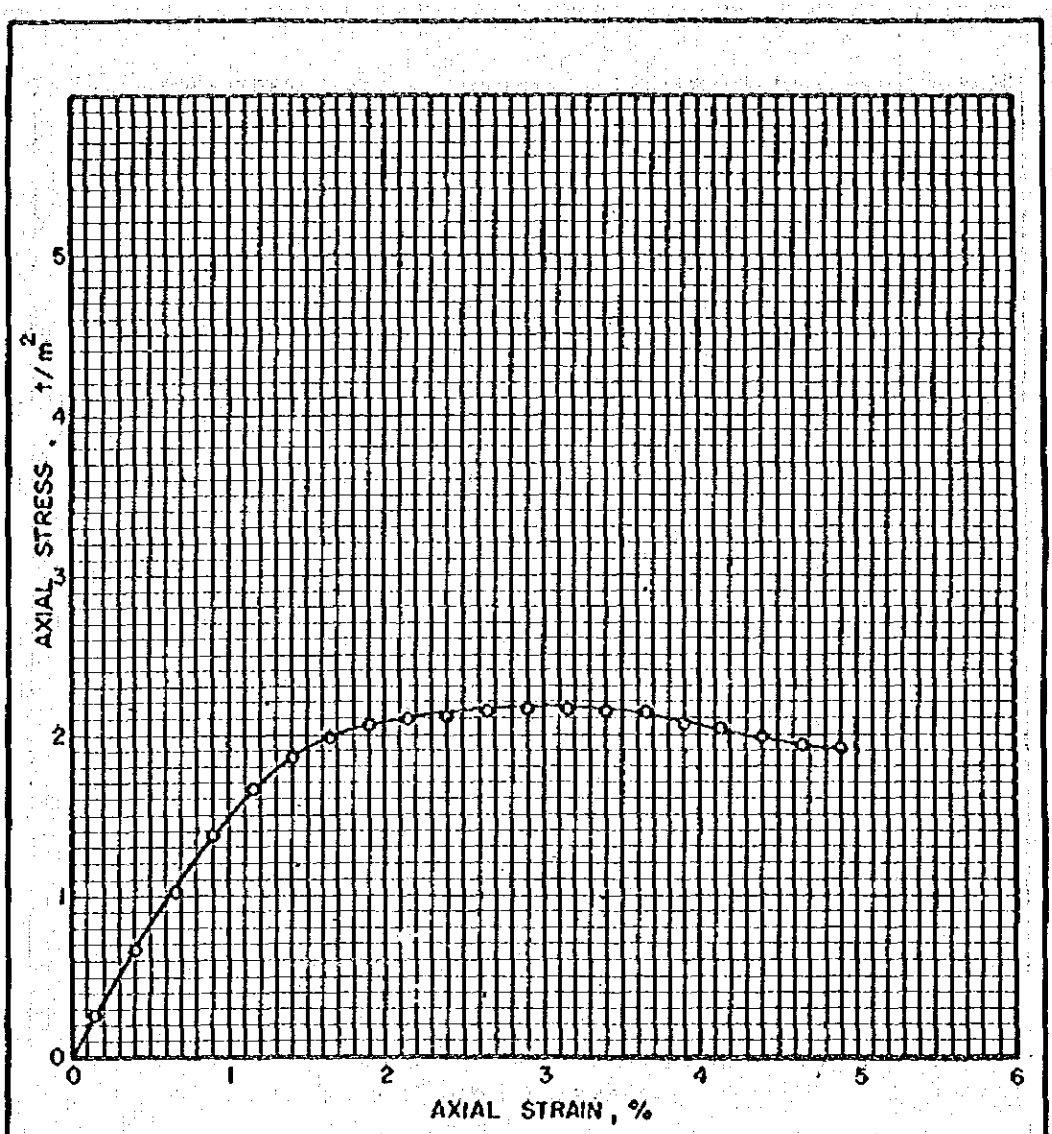
TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH, m	18.5
SAMPLE NO.	3-3
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER, cm	3.5
HEIGHT, cm	7.1
WATER CONTENT, %	35.5
DRY UNIT WT., t/m^3	1.35
SATURATION, %	94

AIT		PROJECT: TOWN GAS	
TEST NO U3-3	TESTED BY: Ng.	DATE: 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG: PP.	CHECKED: Sv.	

Fig 15



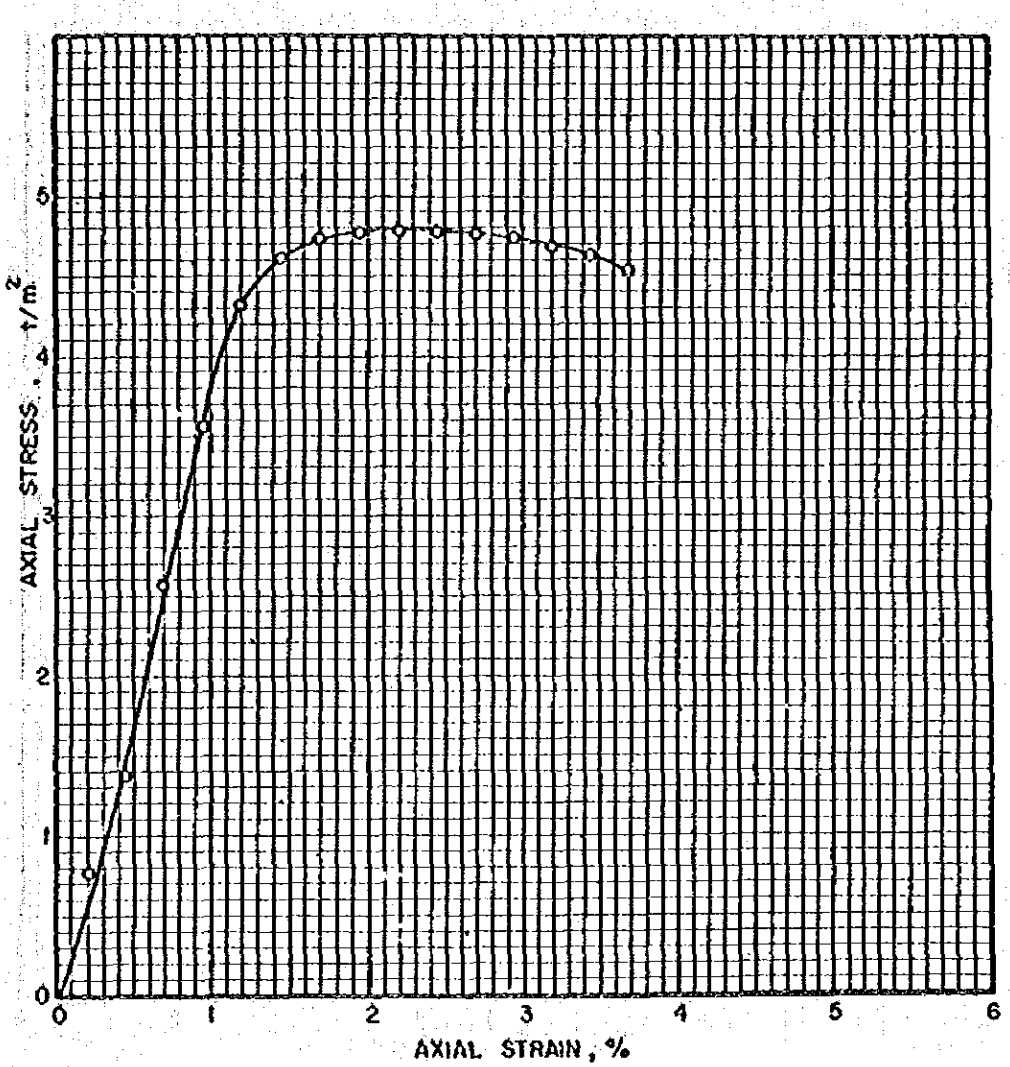
TYPE OF SPECIMEN	
BORING NO.	9
SAMPLE DEPTH , m	4.4
SAMPLE NO.	9-1
CLASSIFICATION	

SAMPLE DESCRIPTION _____

INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT , %	76.3
DRY UNIT WT. , t/m³	0.88
SATURATION , %	99

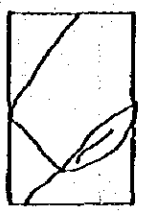
AIT		PROJECT : TOWN GAS	
TEST NO. U9-1	TESTED BY. C.K.F.	DATE : 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	CHKD. P.P.	CHECKED : Sv.	

Fig. 16



TYPE OF SPECIMEN	
BORING NO.	9
SAMPLE DEPTH , m	10.5
SAMPLE NO.	9-2
CLASSIFICATION	

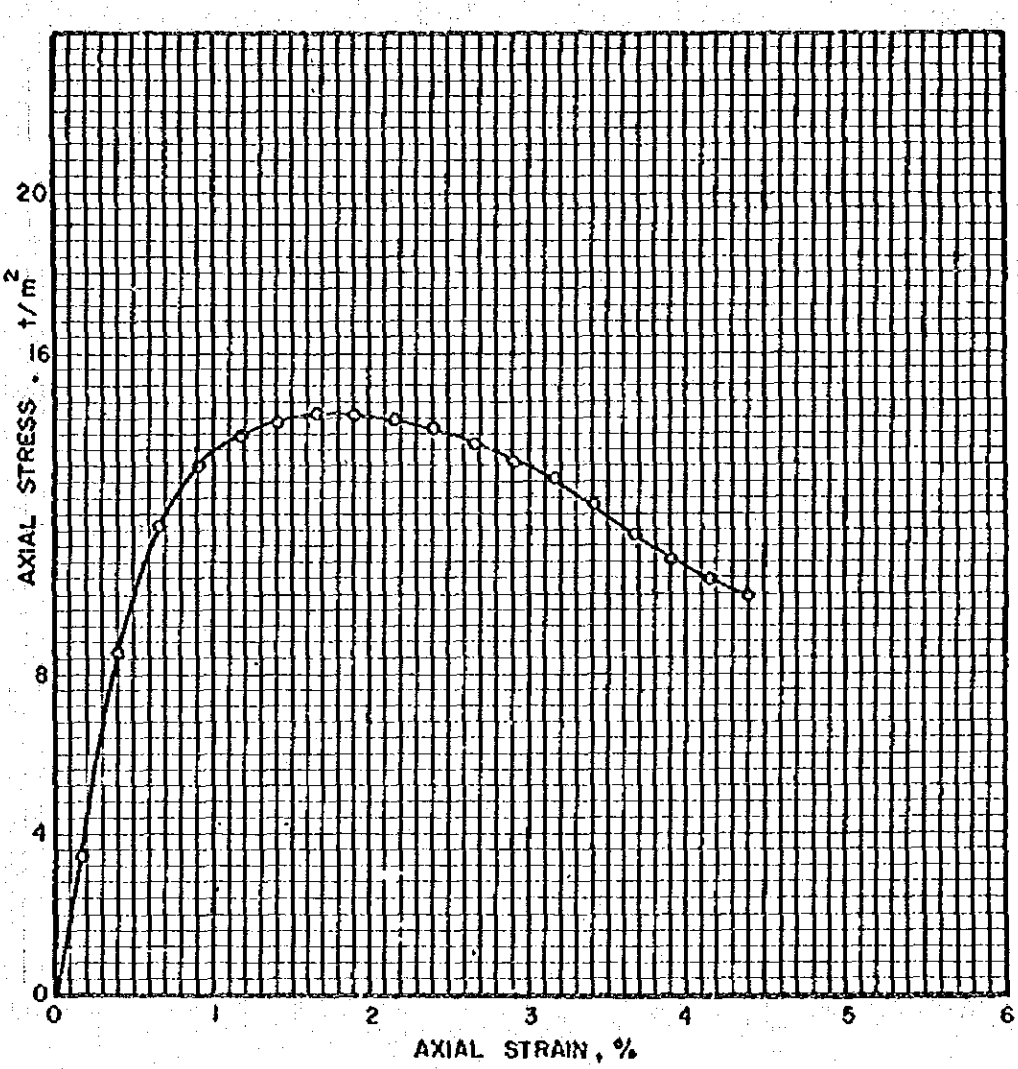
SAMPLE DESCRIPTION _____



INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT, %	74.6
DRY UNIT WT. , t/m^3	0.88
SATURATION, %	99

AIT		PROJECT : TOWN GAS	
TEST NO. U9-2	TESTED BY C.K.F.	DATE : 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG P.P.	CHECKED : Sv.	

Fig. 17



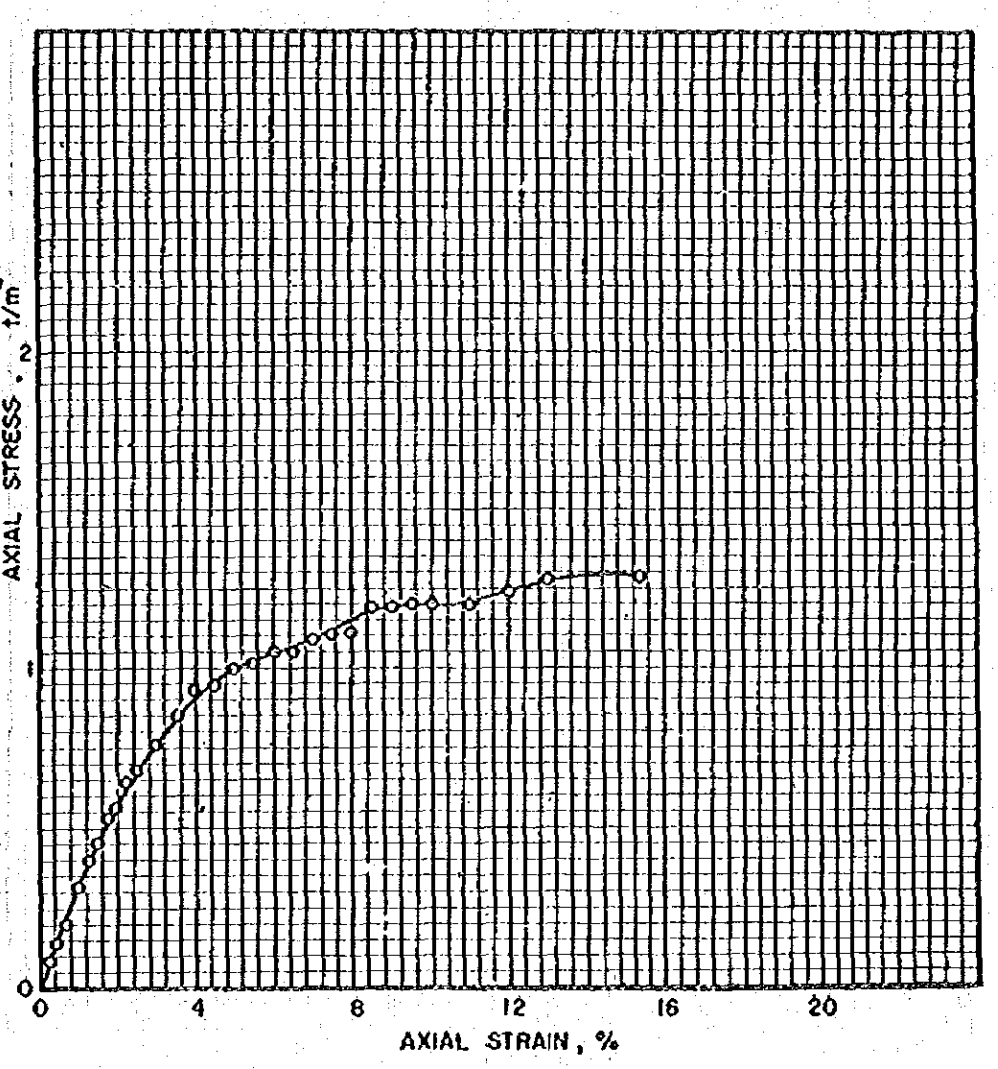
TYPE OF SPECIMEN	
BORING NO.	9
SAMPLE DEPTH , m	19.5
SAMPLE NO.	9-3
CLASSIFICATION	

SAMPLE DESCRIPTION

INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT , %	44.1
DRY UNIT WT. , t/m³	1.24
SATURATION , %	100

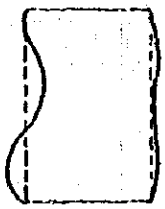
AIT		PROJECT : TOWN GAS	
TEST NO. U9 - 3	TESTED BY : C.K.F.	DATE : 6/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG : P.P.	CHECKED : Sv.	

Fig. 18



TYPE OF SPECIMEN	
BORING NO.	12
SAMPLE DEPTH , m	5.0
SAMPLE NO.	12-1
CLASSIFICATION	

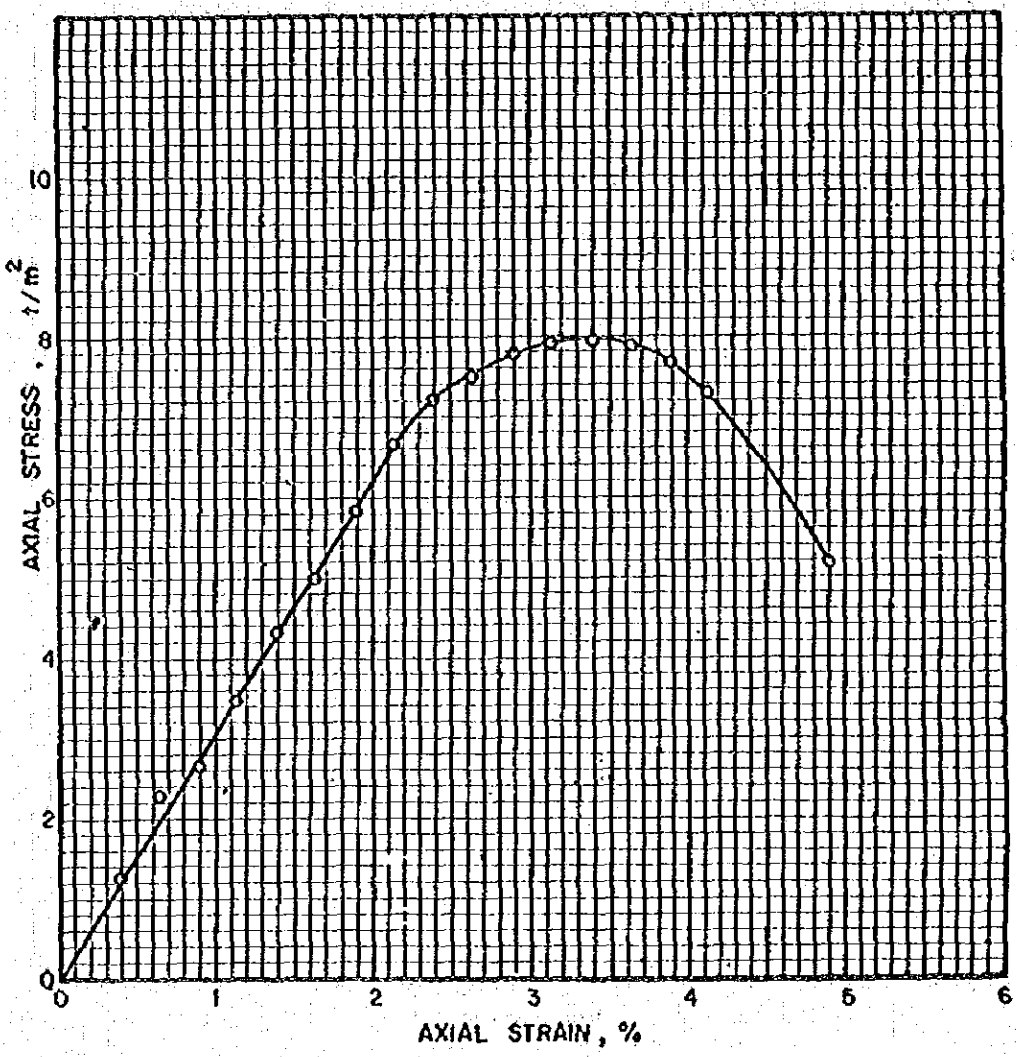
SAMPLE DESCRIPTION _____



INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT , %	56.8
DRY UNIT WT. , t/m³	1.00
SATURATION , %	96

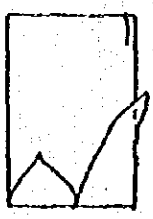
AIT		PROJECT : TOWN GAS	
TEST NO. U12-1	TESTED BY : C.K.F.	DATE : 5/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG : P.P.	CHECKED : Sv.	

Fig. 19



TYPE OF SPECIMEN	
BORING NO.	12
SAMPLE DEPTH , m	12.1
SAMPLE NO.	12-2
CLASSIFICATION	

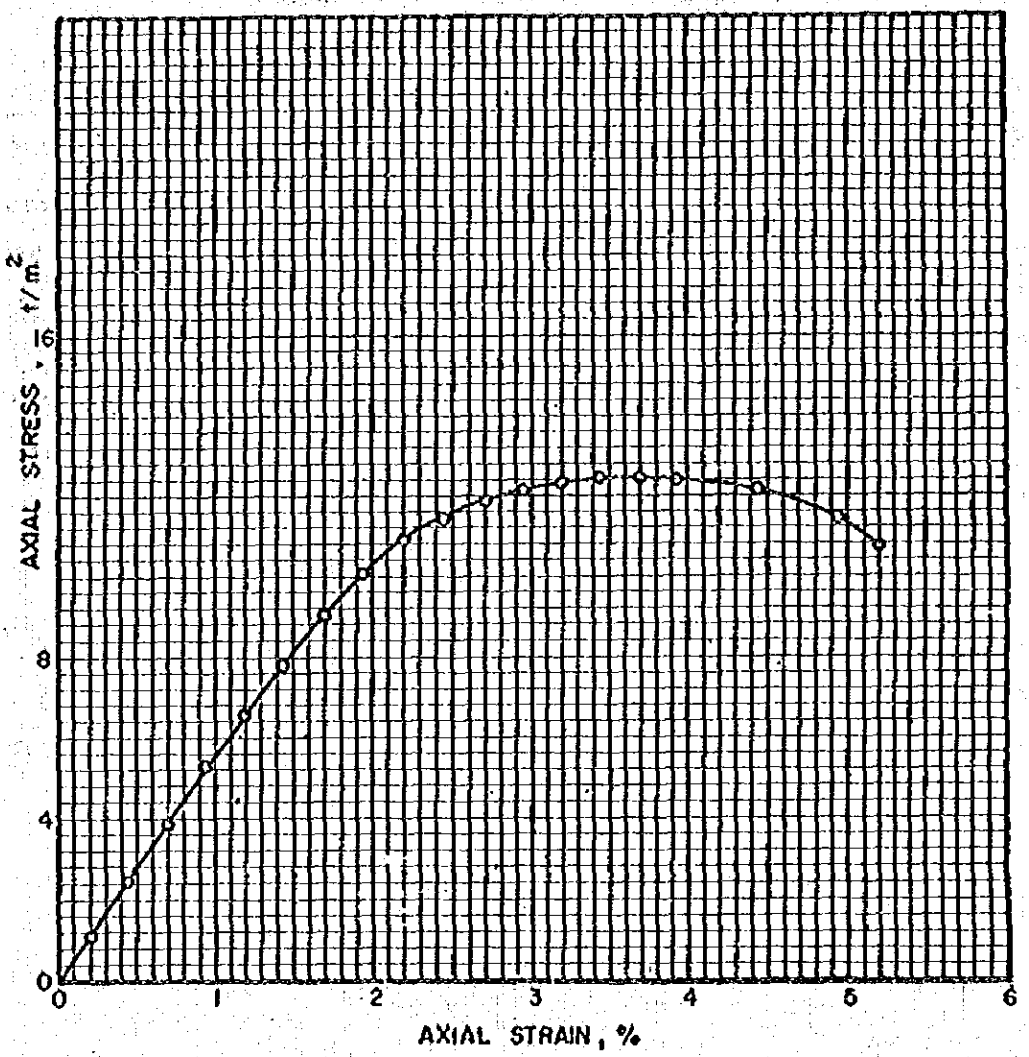
SAMPLE DESCRIPTION



INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT, %	73.9
DRY UNIT WT. , t/m³	0.69
SATURATION, %	97

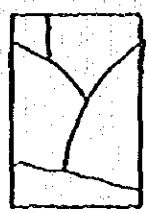
AIT		PROJECT : TOWN GAS	
TEST NO. U12-2	TESTED BY : C.K.F.	DATE : 1/12/74	UNCONFINED COMPRESSION TEST RESULTS
	DWG : P.P.	CHECKED : Sv.	

Fig. 20



TYPE OF SPECIMEN	
BORING NO.	12
SAMPLE DEPTH , m	20.5
SAMPLE NO.	12-3
CLASSIFICATION	

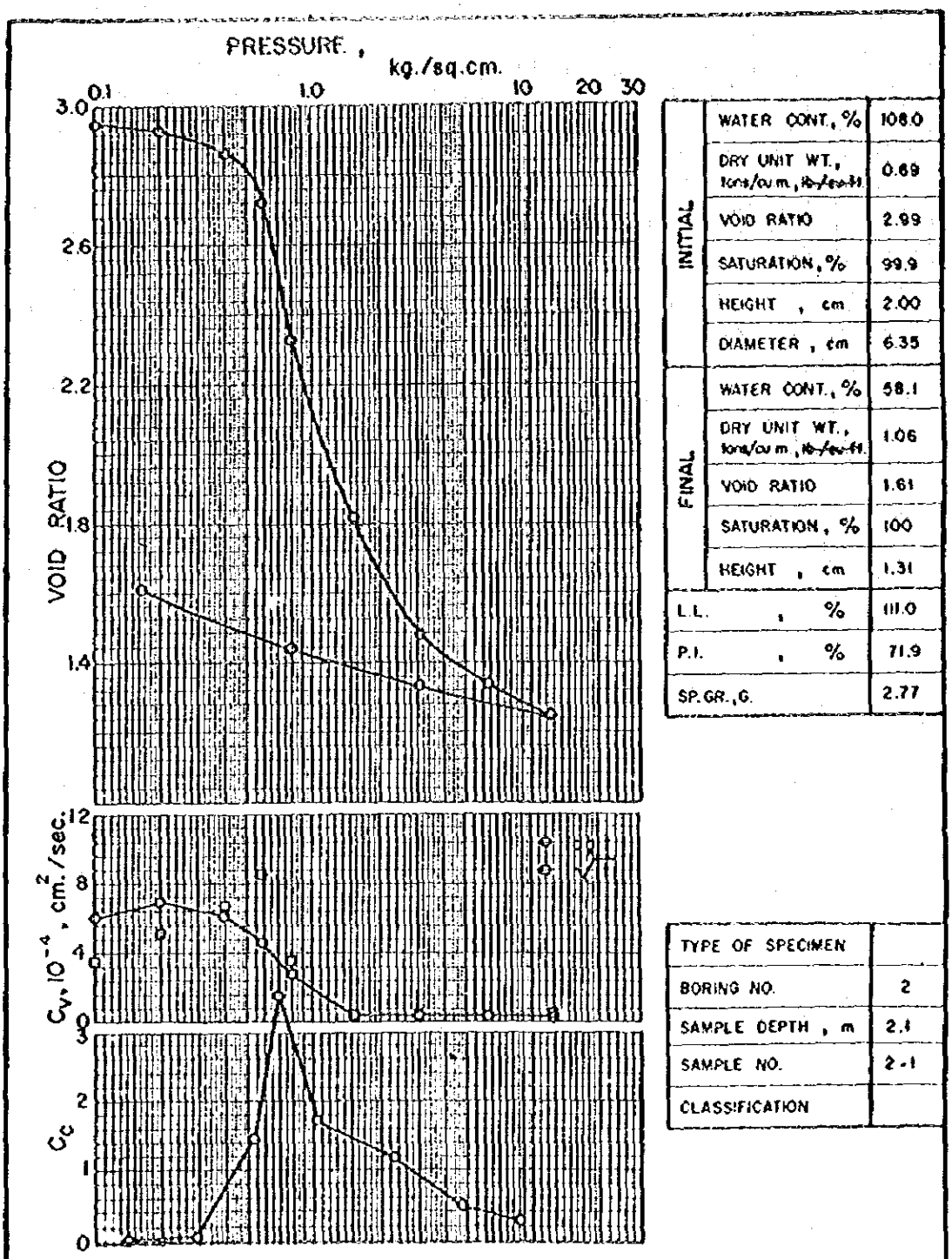
SAMPLE DESCRIPTION _____



INITIAL CONDITION	
DIAMETER , cm	3.5
HEIGHT , cm	7.1
WATER CONTENT, %	26.8
DRY UNIT WT. , t/m³	1.52
SATURATION, %	91

AIT		PROJECT: TOWN GAS	
TEST NO. U12-3	TESTED BY: C.K.F.	DATE: 5/12/74	UNCONFINED COMPRESSION TEST RESULTS.
	DWG: PP.	CHECKED: Sv.	

Fig. 21

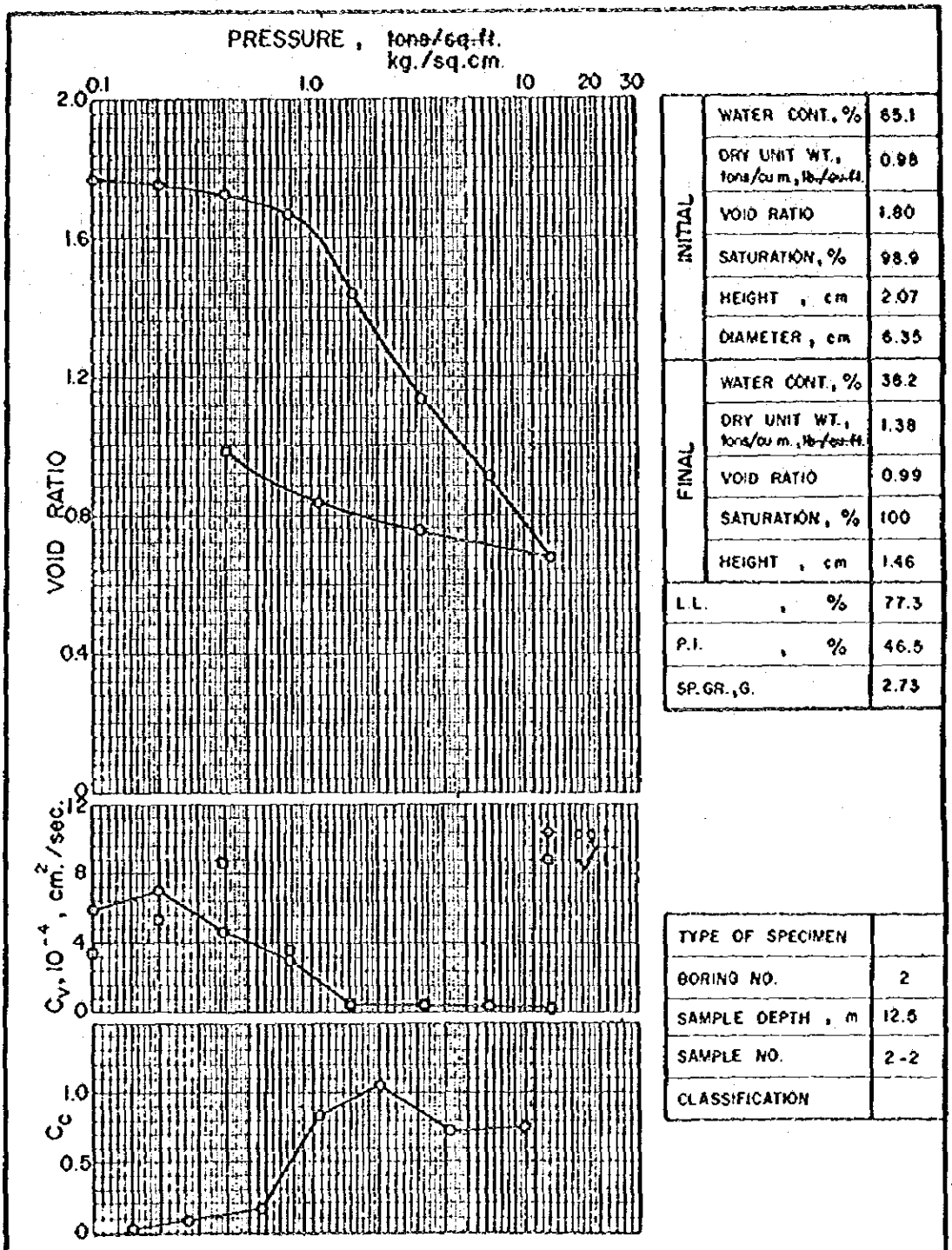


INITIAL	WATER CONT., %	108.0
	DRY UNIT WT., tons/cu m, lb/cu ft.	0.69
	VOID RATIO	2.99
	SATURATION, %	99.9
	HEIGHT , cm	2.00
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	58.1
	DRY UNIT WT., tons/cu m, lb/cu ft.	1.06
	VOID RATIO	1.61
	SATURATION , %	100
	HEIGHT , cm	1.31
L.L. , %		111.0
P.I. , %		71.9
SP.GR., G.		2.77

TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH , m	2.1
SAMPLE NO.	2-1
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C2-1	TESTED BY: AP.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DWG.: PP.	CHECKED:	

Fig. 22

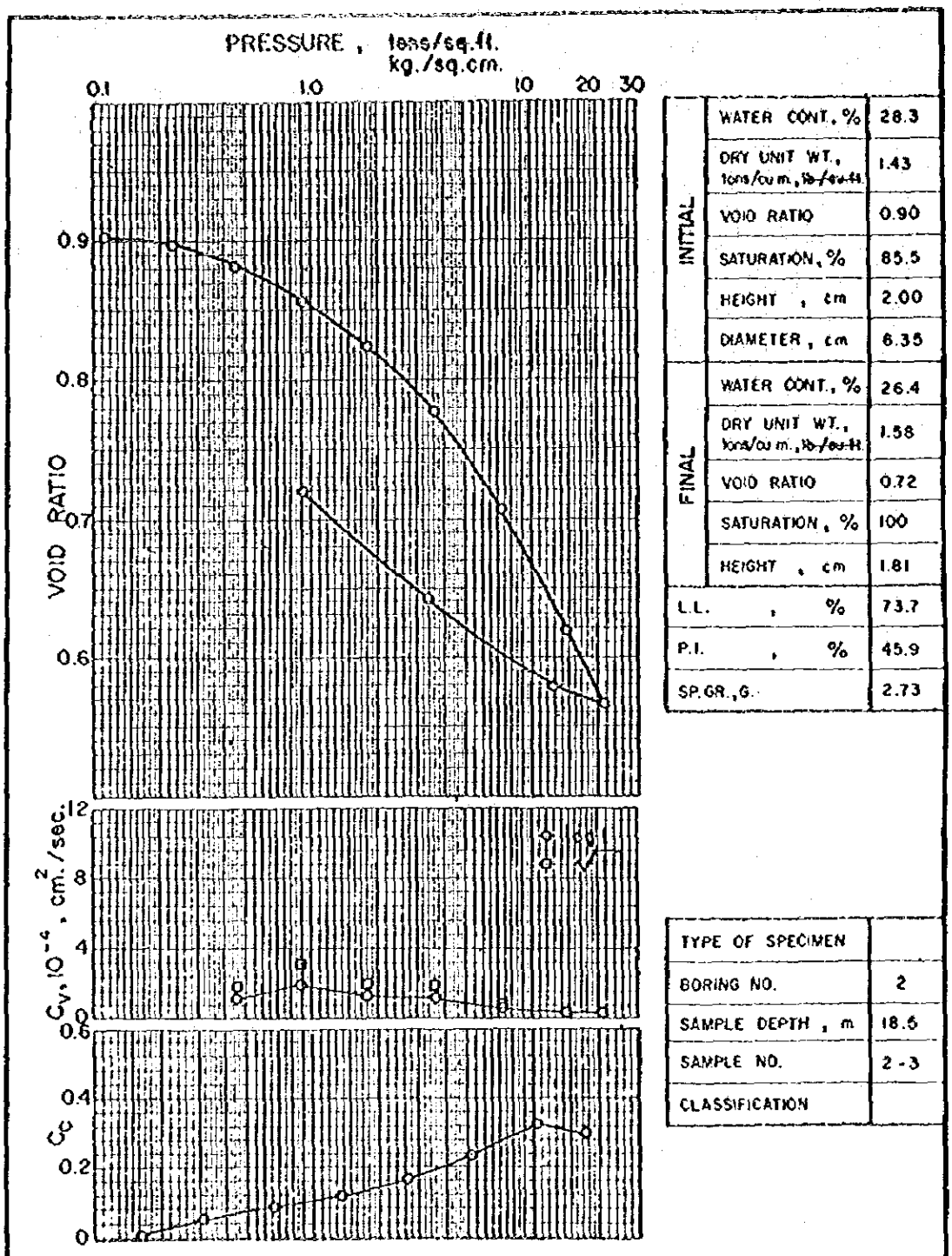


INITIAL	WATER CONT., %	65.1
	DRY UNIT WT., tons/cu m., lb./cu.ft.	0.98
	VOID RATIO	1.80
	SATURATION, %	98.9
	HEIGHT , cm	2.07
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	36.2
	DRY UNIT WT., tons/cu m., lb./cu.ft.	1.38
	VOID RATIO	0.99
	SATURATION , %	100
	HEIGHT , cm	1.46
L.L. , %		77.3
P.I. , %		46.5
SP.GR., G.		2.73

TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH , m	12.6
SAMPLE NO.	2-2
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C2-2	TESTED BY: AP.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DWG: PP.	CHECKED:	

Fig. 23

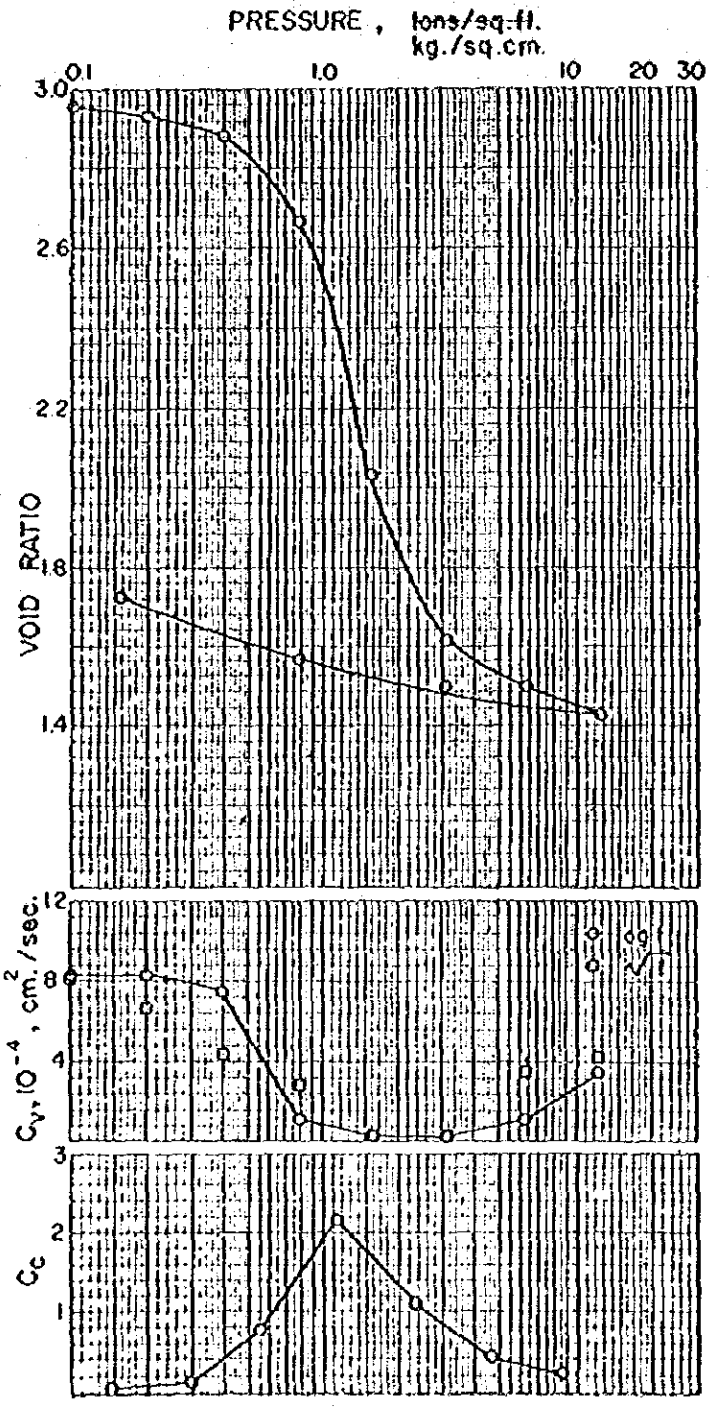


INITIAL	WATER CONT., %	28.3
	DRY UNIT WT., tons/cu m., lb./cu ft.	1.43
	VOID RATIO	0.90
	SATURATION, %	85.5
	HEIGHT , cm	2.00
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	26.4
	DRY UNIT WT., tons/cu m., lb./cu ft.	1.58
	VOID RATIO	0.72
	SATURATION , %	100
	HEIGHT , cm	1.81
L.L. , %		73.7
P.I. , %		45.9
SP.GR., G.		2.73

TYPE OF SPECIMEN	
BORING NO.	2
SAMPLE DEPTH , m	18.6
SAMPLE NO.	2 - 3
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C2 - 3	TESTED BY: AP.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DWG.: PP.	CHECKED:	

Fig. 24

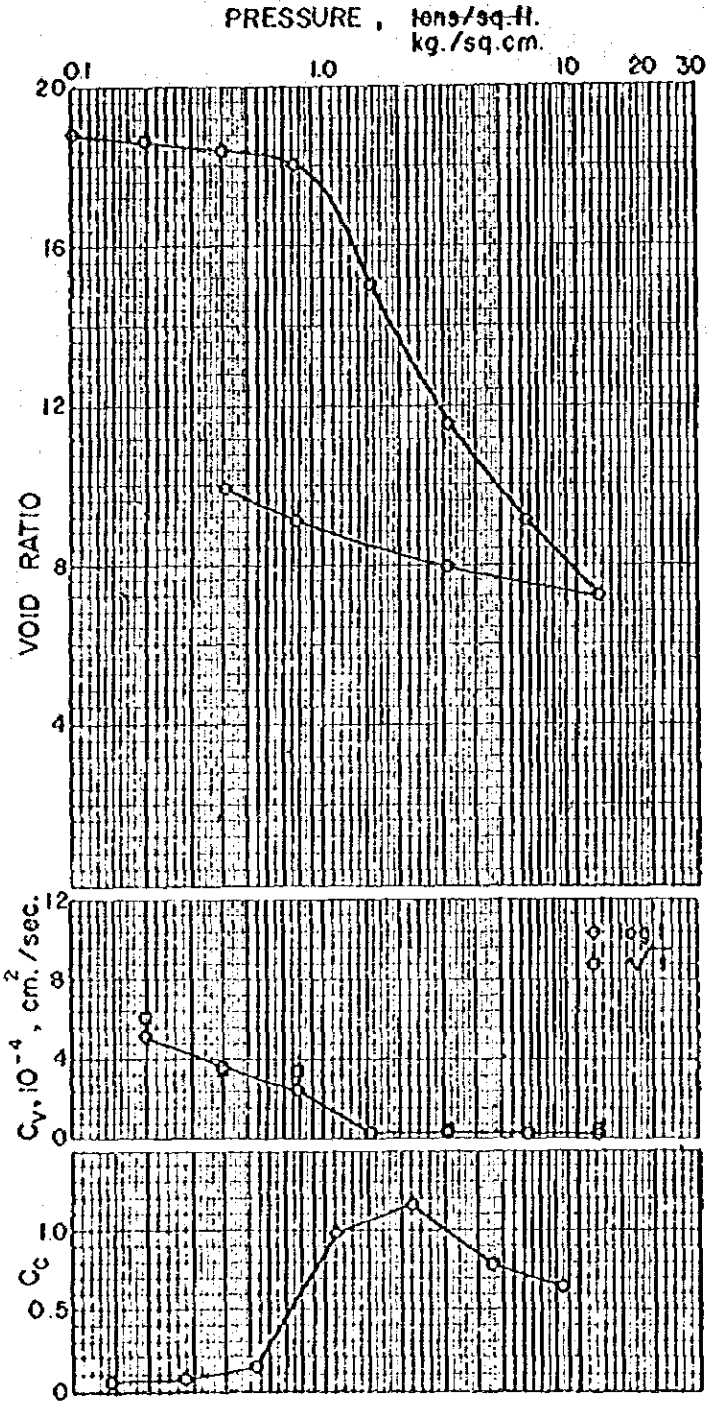


INITIAL	WATER CONT., %	110.9
	DRY UNIT WT., tons/cu m, lb/cu ft	0.67
	VOID RATIO	2.98
	SATURATION, %	99.3
	HEIGHT , cm	2.00
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	64.4
	DRY UNIT WT., tons/cu m, lb/cu ft	0.98
	VOID RATIO	1.72
	SATURATION , %	100
	HEIGHT , cm	1.37
L.L. , %		102.0
P.I. , %		61.2
SP. GR., G.		2.67

TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH , m	4.1
SAMPLE NO.	3-2
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C3-1	TESTED BY: A.P.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DRAG: P.P.	CHECKED:	

Fig. 25

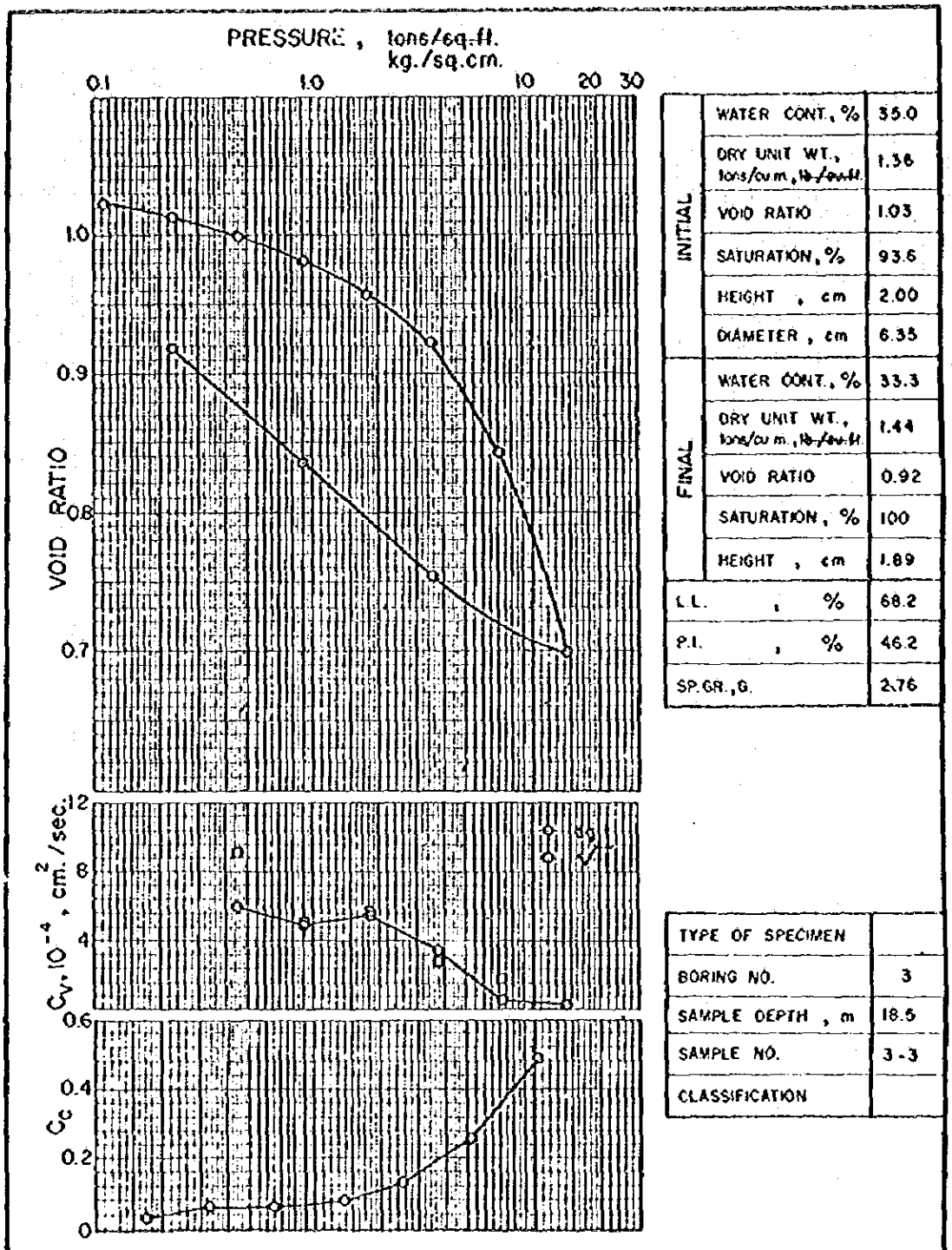


INITIAL	WATER CONT., %	68.4
	DRY UNIT WT., tons/cu.m., ~~lb/cu.ft.~~	0.94
	VOID RATIO	1.90
	SATURATION, %	98.0
	HEIGHT , cm	2.07
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	36.1
	DRY UNIT WT., tons/cu.m., ~~lb/cu.ft.~~	1.38
	VOID RATIO	0.98
	SATURATION , %	100
	HEIGHT , cm	1.40
L.L. , %		69.0
P.I. , %		38.1
SP.GR., G.		2.72

TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH , m	12.5
SAMPLE NO.	3-2
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C3-2	TESTED BY: A.P.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DWG.: P.P.	CHECKED:	

Fig. 26

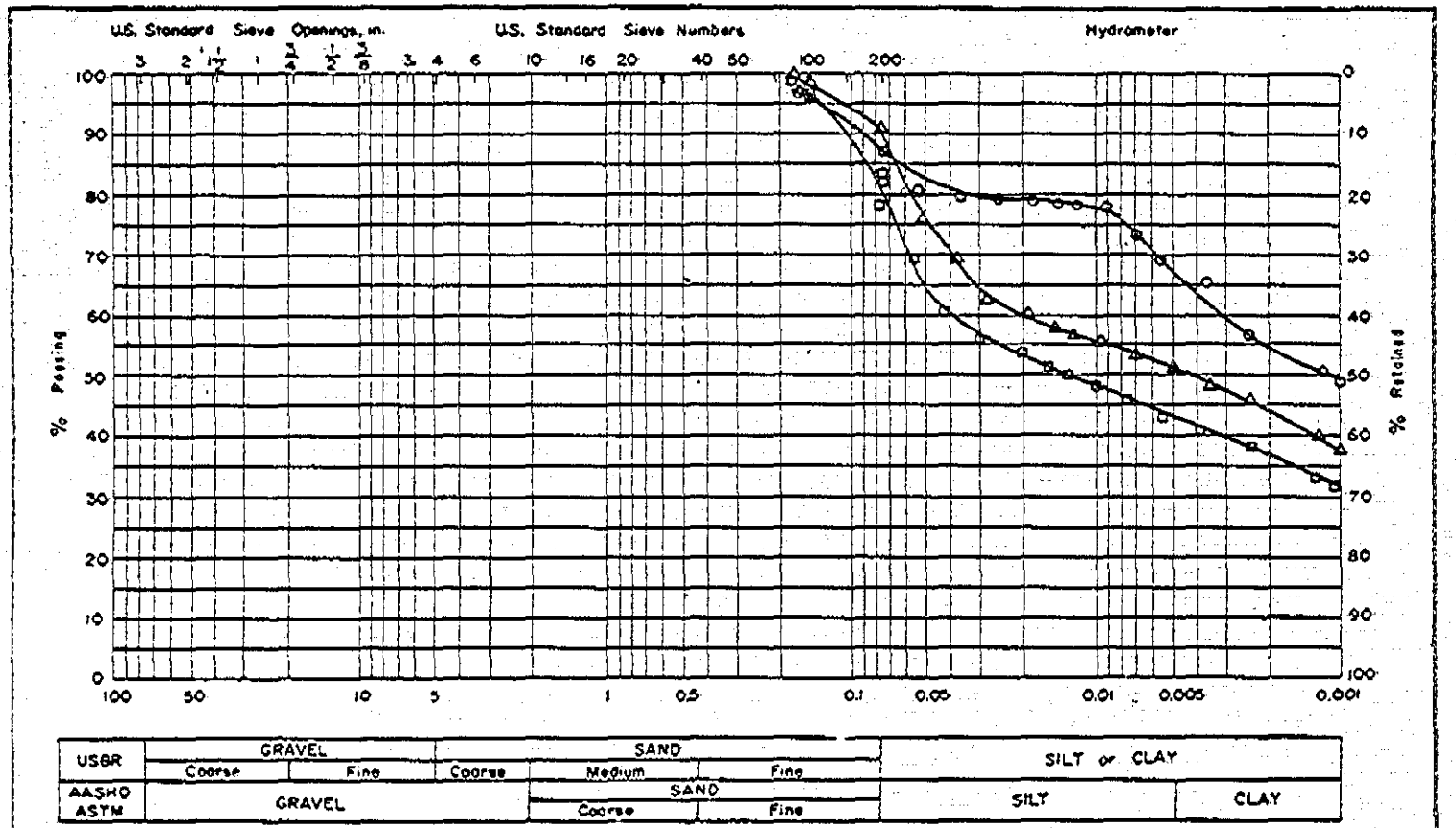


INITIAL	WATER CONT., %	35.0
	DRY UNIT WT., tons/cu m, lb/cu ft	1.36
	VOID RATIO	1.03
	SATURATION, %	93.6
	HEIGHT , cm	2.00
	DIAMETER , cm	6.35
FINAL	WATER CONT., %	33.3
	DRY UNIT WT., tons/cu m, lb/cu ft	1.44
	VOID RATIO	0.92
	SATURATION, %	100
	HEIGHT , cm	1.89
L.L. , %		68.2
P.I. , %		46.2
SP.GR., G.		2.76

TYPE OF SPECIMEN	
BORING NO.	3
SAMPLE DEPTH , m	18.5
SAMPLE NO.	3-3
CLASSIFICATION	

AIT		PROJECT: TOWN GAS	
TEST NO. C3-3	TESTED BY: A.P.	DATE: 15/12/74	CONSOLIDATION TEST RESULTS
	DWG: P.P.	CHECKED:	

Fig. 27



LAB. NO.	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST.%	CLASSIFICATION
P2-1	○	2-1	4	111.0	71.9	110.4	
P2-2	△	2-2	12	77.3	46.5	63.7	
P2-3	□	2-3	18	73.7	45.9	28.1	

GRAIN SIZE DISTRIBUTION

AIT

TOWN GAS

LAB NO.

FILE:

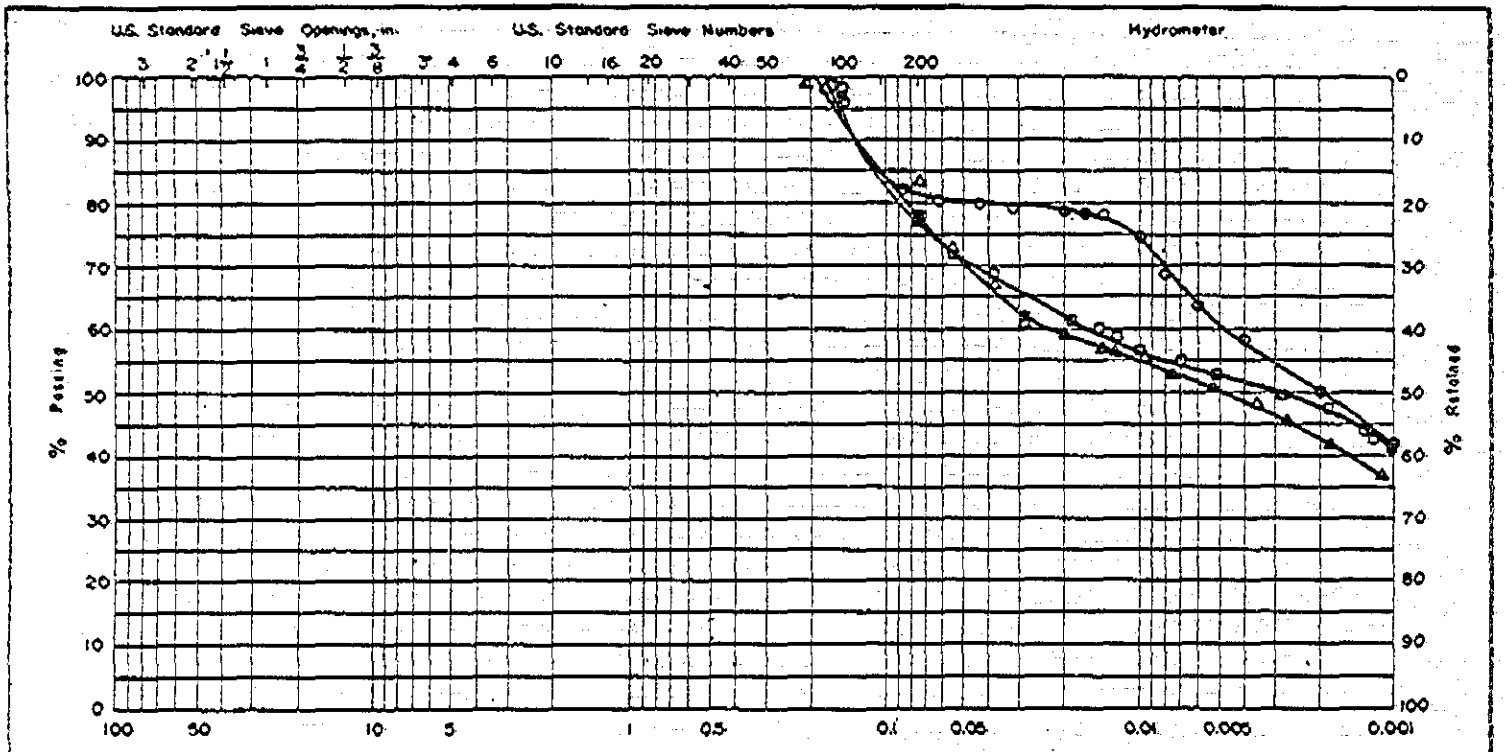
BY: NP.

DATE: 7/12/74

DWG: PP.

FORM 58 1-68

Fig. 28



LAB. NO.	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST%	CLASSIFICATION
P3-1	○	3-1	4	102.0	61.2	103.8	
P3-2	△	3-2	12	80.0	38.1	74.7	
P3-3	□	3-3	18	68.2	46.2	35.2	

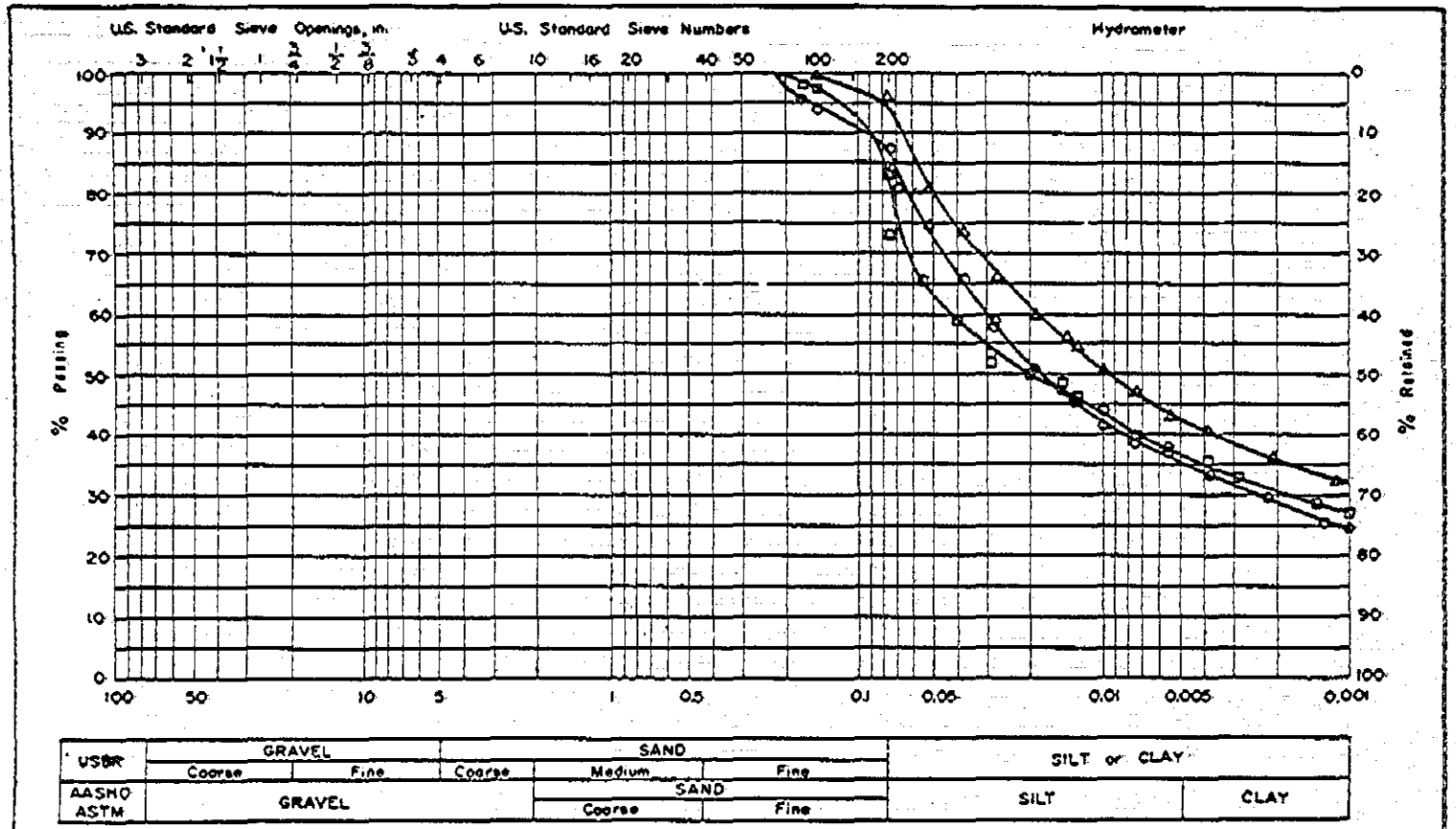
GRAIN SIZE DISTRIBUTION

AIT | LAB NO. | FILE:

TOWN GAS | BY: NP. | DATE: 8/12/74 | DWG: PP.

FORM 58 1 - 68

Fig. 29



LAB. NO.	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST.%	CLASSIFICATION
P4-1	○	4-1	5	57.9	34.2	59.5	
P5-1	△	5-1	5	67.5	54.8	95.6	
P6-1	□	6-1	5	57.6	31.2	58.1	

GRAIN SIZE DISTRIBUTION

AIT

LAB NO.

FILE:

TOWN GAS

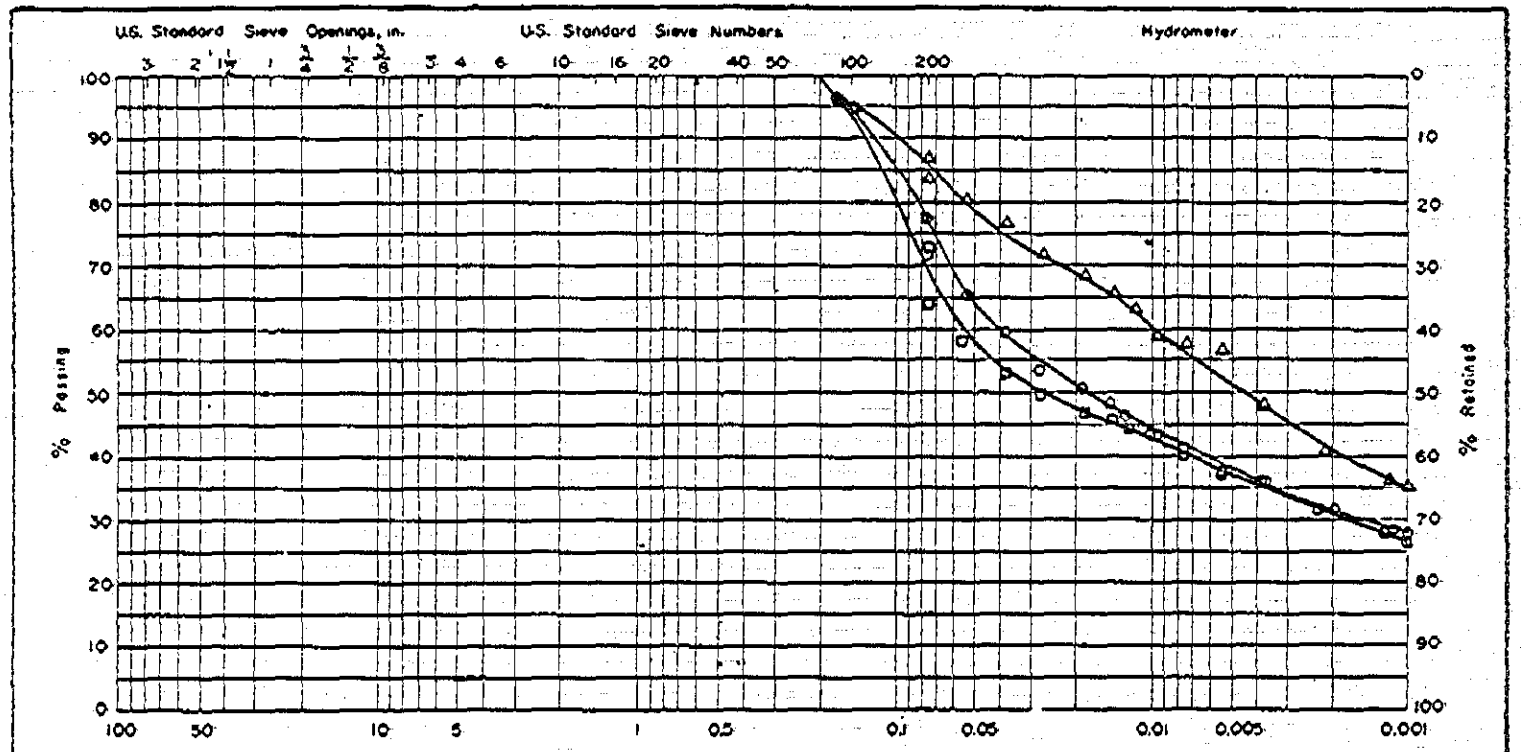
BY: NP

DATE 7/12/74

DWG: PP.

FORM 58 1-68

Fig. 30



LAB. NO.	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST.%	CLASSIFICATION
P7-1	○	7-1	5	63.7	35.6	78.1	
P8-1	△	8-1	5	74.1	45.7	77.0	
P11-1	□	11-1	5	66.5	40.5	72.9	

GRAIN SIZE DISTRIBUTION

A I T

TOWN GAS

LAB NO.

FILE:

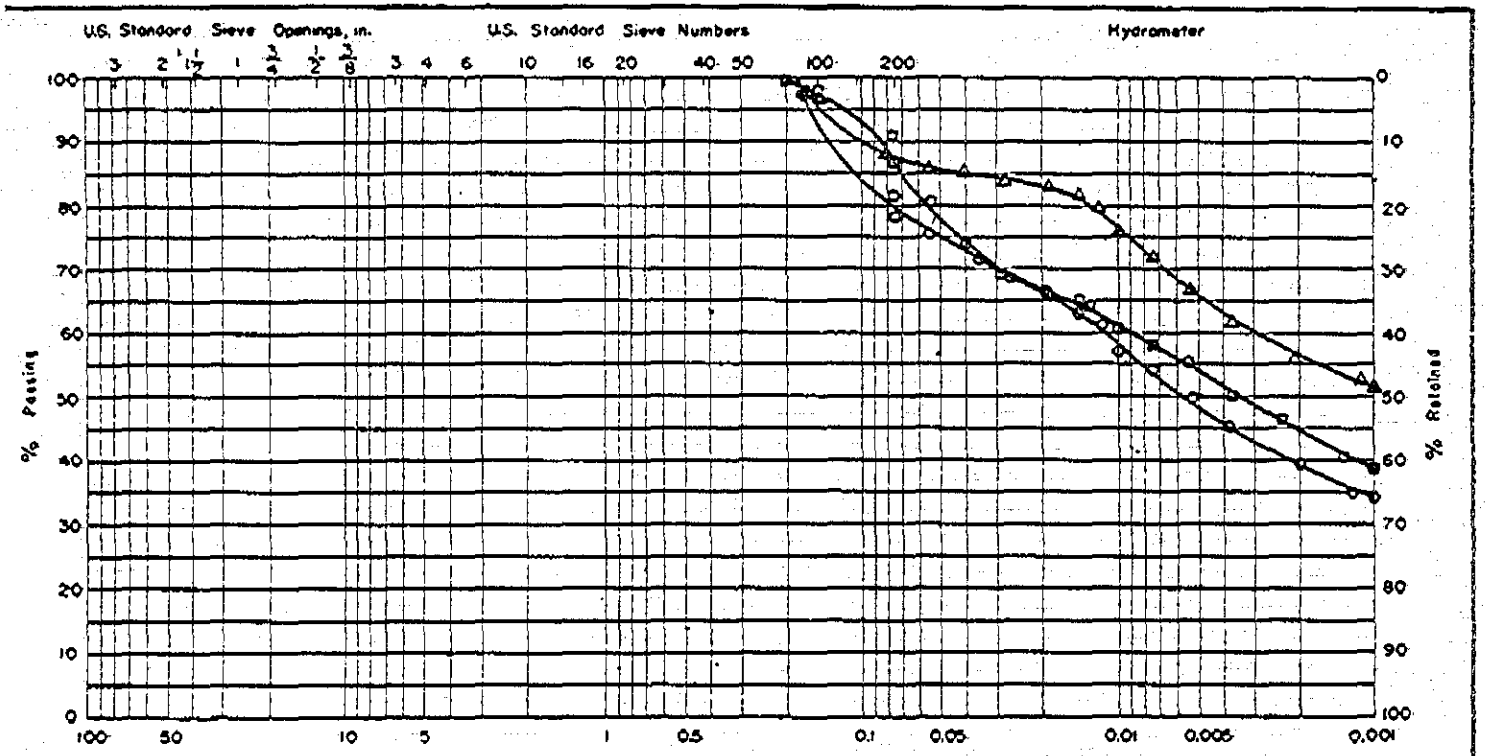
BY: N.P.

DATE: 5/12/74

DWG: PP.

FORM 58 1 - 68

Fig. 31



LAB. NO.	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST.%	CLASSIFICATION
P9-1	O	9-1	4	53.1	27.2	76.3	
P9-2	Δ	9-2	10	81.5	49.4	76.6	
P9-3	O	9-3	19	63.2	40.2	43.8	

GRAIN SIZE DISTRIBUTION

AIT

TOWN GAS

LAB NO.

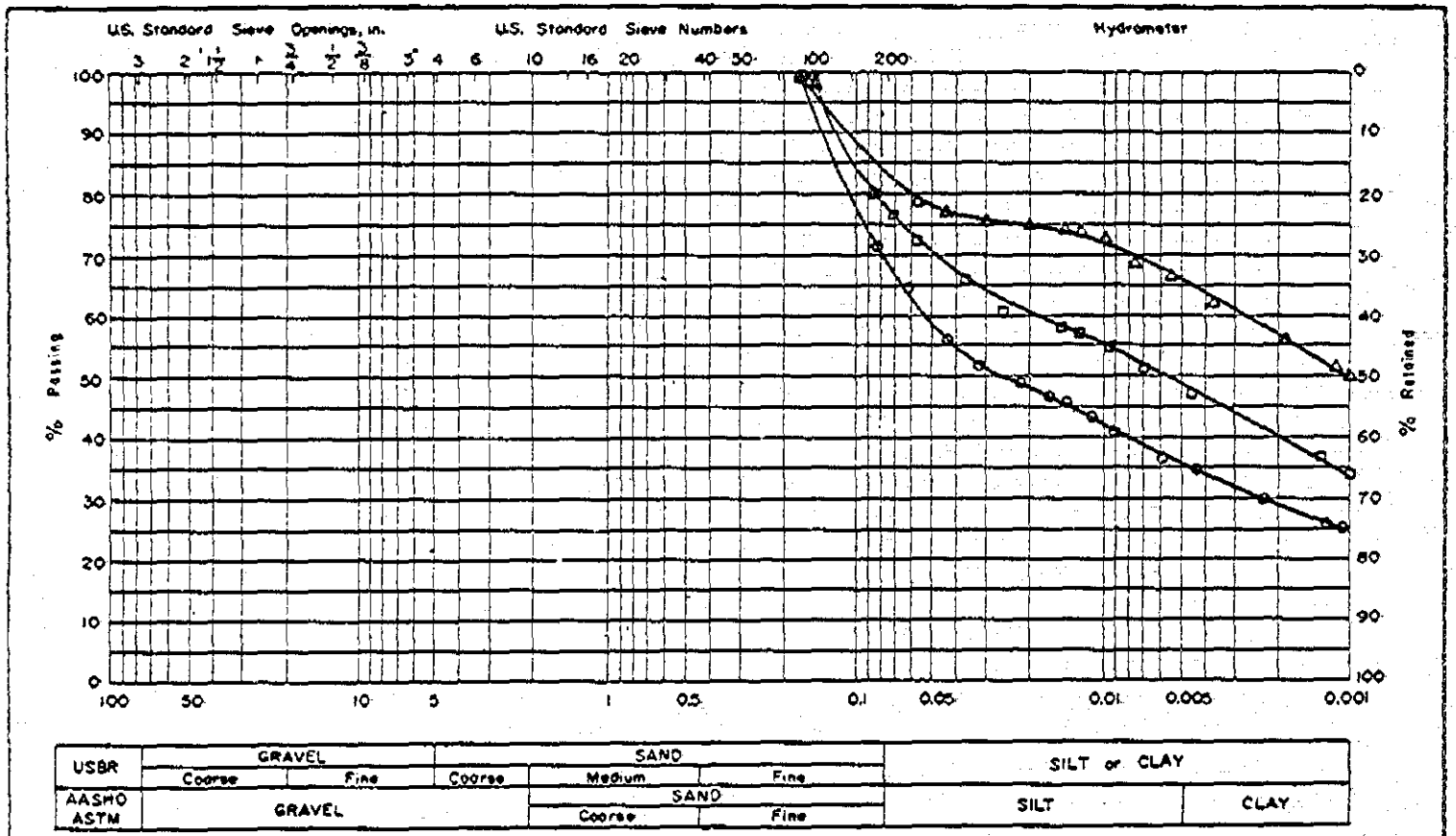
FILE:

BY: NP. DATE: 5/12/74

DWG: PP

FORM 58 1-68

Fig. 32



LAB. NO	SYM.	SAMPLE NO.	DEPTH m.	L.L. %	P.I. %	NATURAL MOIST.%	CLASSIFICATION
P12-1	○	12-1	4	70.8	46.9	56.9	
P12-2	△	12-2	12	84.8	51.3	75.6	
P12-3	□	12-3	20	49.7	30.2	26.8	

GRAIN SIZE DISTRIBUTION

AIT — LAB NO. — FILE:

TOWN GAS — BY: NP. — DATE: 8/12/74 — DWG: PP.

FORM 58 1 - 68

Fig. 33

APPENDIX B

INFERENCE FOR UNEVEN SETTLEMENT IN THE BANGKOK AREA

APPENDIX B

INFERENCE FOR UNEVEN SETTLEMENT IN THE BANGKOK AREA

INFERENCE ON UNEVEN SETTLEMENT

As factors causing uneven settlement, the following matters may be considered:

1) Uneven settlement of the ground occurs by the increased load due to earth filled directly above the buried pipe.

2) At some part of Bangkok City, the underground water level has been lowered due to new deep wells, and thus uneven settlement of the ground occurs.

It is considered that uneven settlement of the ground occurs by the abovementioned two factors, and this greatly affects the buried pipe. Therefore, the magnitude of uneven settlement will be inferred in each case.

1. Settlement of the ground due to earth fill

Almost all gas pipelines are planned to be buried under already constructed roads. The case of a newly constructed road or the case where earth is filled on the ground to a thickness of about 2.0 m will be considered.

According to the Terzaghi's consolidation theory, the settlement can be calculated by the following formula,

$$S = \frac{Cc}{1 + e_o} H \log \frac{P_o + \Delta P}{P_o}$$

where	S:	settlement in cm	
	Cc:	Compression index	1.73
	e_o:	Initial void ratio	2.42
	H:	Layer thickness	1,300 cm
	P_o:	Preceding load	0.84 kg/cm²
	ΔP:	Underground stress increased	0.109 kg/cm²

$$S = \frac{1.73}{1 + 242} \times 1{,}300 \log \frac{0.84 + 0.109}{0.84} \doteq 35 \text{ cm}$$

2. Settlement of the ground due to lowering of underground water level

In recent years the settlement of the ground due to the pumping up of underground water has come into serious question in the Bangkok City.

However, this problem is not in a state where any clear-cut solution is obtained at the present stage but great hopes are being placed on future investigation on this problem. Therefore, in this consideration, a solution will be inferred with reference to the past investigation results and other bibliographies.

The ground in the environs of Bangkok consists of a silted deposit extending more than 200 m depth as shown in Fig. A-1, and six water bearing layers present in the depths of about 35, 65, 85, 115, 150 and 200 m (Camp Dresser & McKee 1969). These water bearing layers are virtually in horizontal deposition and have an average thickness of about 20 m.

At the present time, underground water of about 600,000 m^3/day is pumped up from these layers in the Bangkok City (Camp Dresser & McKee 1969).

When the relation between the lowering of the underground water level and the ultimate settlement of the ground is calculated by two assumptive conditions, the results as shown in Figs. A-2 and A-3 can be obtained. The maximum possible settlement at this time occurs when in Case I the underground water level was lowered up to the lowermost part of the soft clay, and in Case II it was lowered up to the lowermost part of the stiff clay. In conclusion,

Case I: Though the underground water level is lowered, the clay is still in the saturated state, and the vertical effective stress increases.

Case II: While the pore water pressure of the sand layer at the foundation decreases proportional to the depth above the sand layer, the underground water level is not lowered.

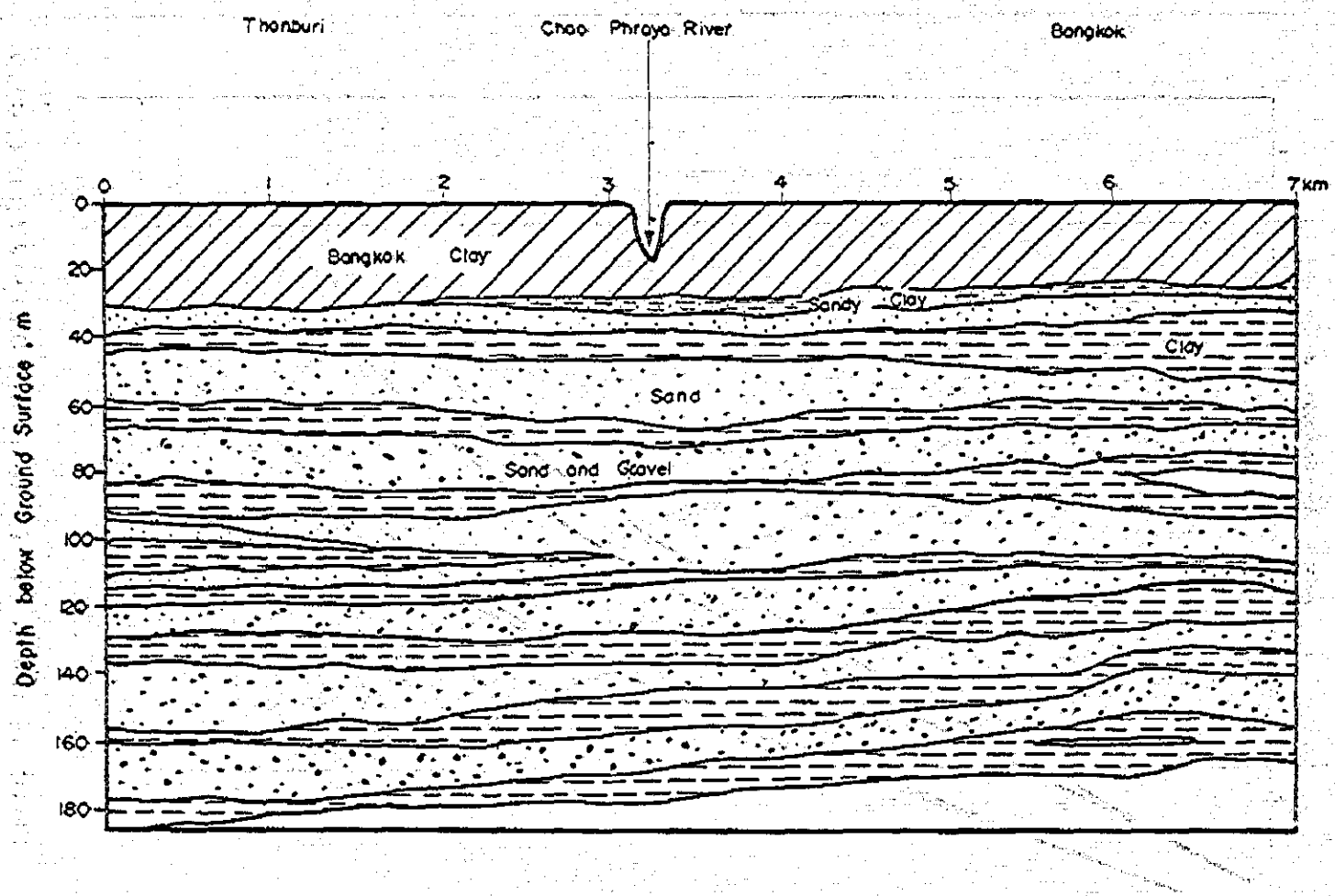
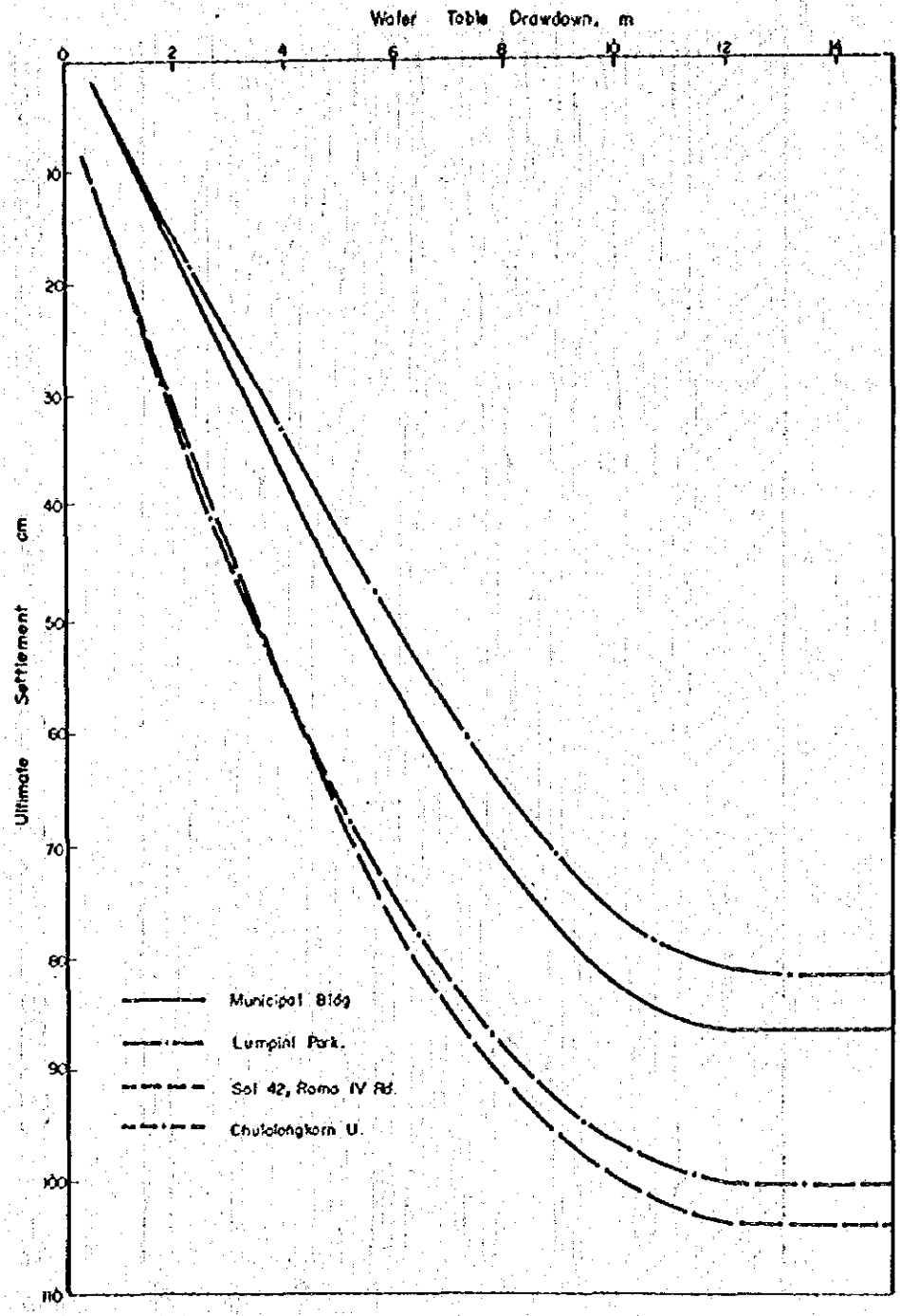


FIG. A – 1 GEOLOGIC CROSS-SECTION THROUGH THE BANGKOK AREA
(after MUKTABHANT, 1963)



EFFECT OF WATER TABLE DRAWDOWN ON ESTIMATED GROUND SETTLEMENT, CASE I (TITI PAVEENCHANA 1970)

FIG. A-2

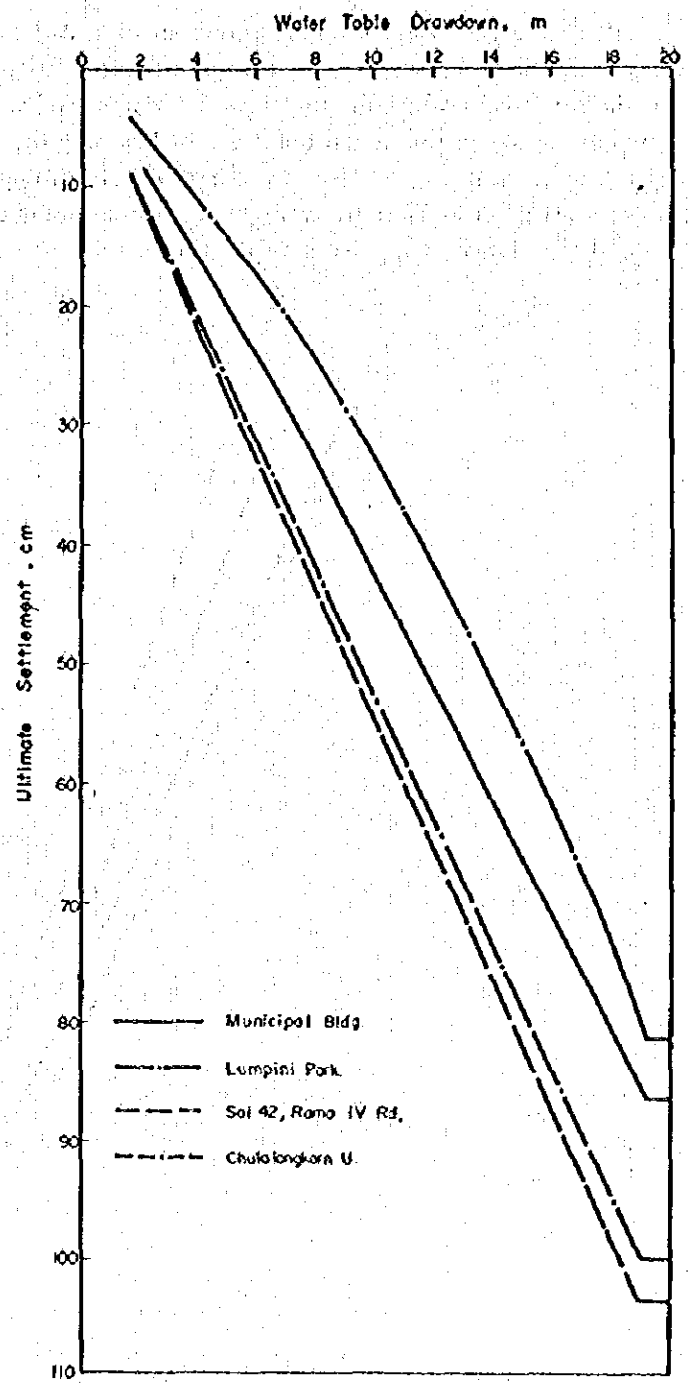


FIG. A-3 EFFECT OF WATER TABLE DRAWDOWN ON ESTIMATED GROUND SETTLEMENT, CASE II
(TITI PAVEENCHANA 1970)

The results obtained by calculating the water level are shown in Figs. A-2 and A-3 under these assumptions. As evident from these figures, the maximum ultimate settlement is about 1.0 m. These show, however, the settlement when the underground water level was lowered to the vicinity of the ground foundation. When the actual tendency of lowering the underground water level is observed, the state as shown in Fig. A-4 can be obtained. Accordingly, when the settlement of underground water level is set at 10 m by averaging the values obtained in past ten years, the settlement of the ground foundation is approximately 60 cm.

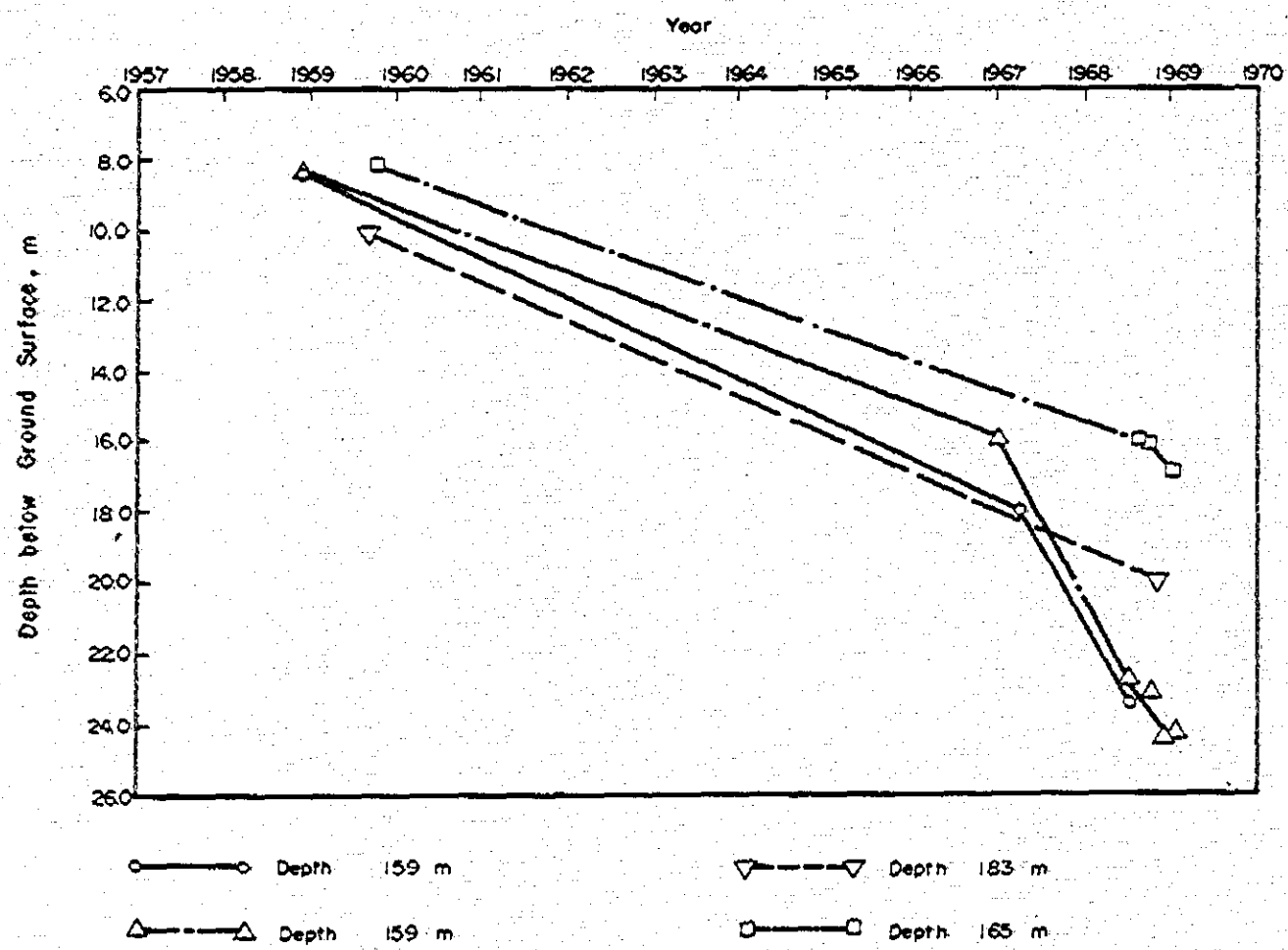


FIG. A-4

VARIATIONS IN STATIC WATOR LEVELS FROM 1958 TO 1969 IN WELLS TOPPING THE 150 METERS AQUIFER (TITI PAVEENCHANA 1970)

APPENDIX C

STRESS COMPUTATION OF UNDERGROUND LAYING PIPE

APPENDIX C

STRESS COMPUTATION OF UNDERGROUND LAYING PIPE

Example of stress computations of laid pipe:

As an example of stress computation of buried pipe, computation is made under the following technical data. Stresses of the buried pipe are considered to be consisting internal pressure, earth load, vehicular load, temperature and uneven settlement.

1) Technical data

Outside diameter of pipe	457.2 mm
Thickness of pipe	7.9 mm (allowance for corrosion of inner face 1.0 mm)
Material of pipe	API 5LX - X42
Stress at yield point	σ_p = 2,940 kg/cm²
Allowable stress	σ_{sa} = 1,764 kg/cm²
Internal pressure	P = 8.0 kg/cm²
Weight of unit volume of earth	γt = 1.6 t/m³
Temperature	Δt = 10°C
Earth cover	H = 1.5 m

2) Circumferential stress

2-1) Circumferential stress due to internal pressure σPH

$$\sigma PH = \frac{PDi}{2t} = \frac{8.0 \times 450}{2 \times 6.9} \approx 261 \text{ kg/cm}^2$$

2-2) Circumferential stress due to surcharged load

a) Surcharged earth load Wd

$$Wd = \gamma t \cdot H \cdot D = 1.6 \times 1.5 \times 0.457 = 1.097 \text{ t/m}$$

b) Vehicular load Wt

$$Wt = \frac{29.1 \cdot D \cdot (1+i)}{10 + H \tan\theta}$$

where i: impact coefficient 0.5

θ: load dispersion angle 45°

$$= \frac{29.1 \times 0.457 \times 1.5}{10 + 1.5 \times 1.0} = 1.735 \text{ t/m}$$

c) Surcharged load W

$$W = Wd + Wt = 2.832 \text{ t/m}$$

The circumferential stress σch due to the surcharged load is represented by the following formula,

$$\sigma ch = \frac{D\ell \cdot Kb \cdot W \cdot R \cdot E \cdot It \cdot 1/Zt}{E\,It + 0.061\,K\,R^4 + 2P \cdot D\ell \cdot R^3 \cdot Kx}$$

where	$D\ell$:	deflection time coefficient	1.0
	KbKx:	pipe bearing coefficients	0.125, 0.083
	Kh:	coefficient of horizontal ground reaction	0.5 kg/cm^3
	R:	radius of pipe	22.86 cm
	It:	geometrical moment of inertia of pipe wall	0.0274 cm^3/cm
	Zt:	section modulus of pipe wall	0.0794 cm^3/cm
	E:	Young's modulus	2.1 x 10^6 kg/cm^2

$$\sigma CH = \frac{1.0 \times 0.125 \times 2.832 \times 10 \times 22.86 \times 2.1 \times 10^6 \times 0.0274 \times 1/0.0794}{2.1 \times 10^6 \times 0.0274 + 0.061 \times 0.5 \times 22.86^4 + 2 \times 8.0 \times 1.0 \times 22.86^3 \times 0.083} = 716 \text{ kg/cm}^2$$

3) Axial stress

3-1) Axial stress due to internal pressure

$$\sigma PL = \frac{PDi}{4t} = \frac{8.0 \times 450}{4 \times 6.9} = 130 \text{ kg/cm}^2$$

3-2) Axial stress due to vehicular load

$$\sigma CL = \frac{0.322\,Wt}{Zp} \sqrt{\frac{E \cdot Ip}{Kv \cdot D}}$$

where Kv: coefficient of vertical ground reaction 0.5 kg/cm^3

Ip: geometrical moment of inertia or pipe 24,746 cm^3

Zp: section modulus of pipe 1,082 cm^3

E: Young's modulus 2.1 x 10^6 kg/cm^2

D: outside diameter of pipe 45.72 cm

$$\sigma CL = \frac{0.322 \times 1.735 \times 10}{1082} \sqrt{\frac{2.1 \times 10^6 \times 24746}{0.5 \times 45.72}} = 246 \text{ kg/cm}^2$$

3-3) Axial stress due to temperature fluctuations σTL

$$\sigma TL = \alpha \cdot E \cdot \Delta t$$

where α: linear-expansion modulus 1.2 x 10^{-5}

E: Young's modulus 2.1 x 10^6 kg/cm^2 = 1.2 x 10^{-5} x 2.1 x 10^6 x 10
= 252 kg/cm^2

3-4) Axial stress due to uneven settlement σSL

As has been described in Chapter 3, a few conditions under which uneven settlement would be caused to occur are considered. However, as a result of investigating the present state of Bangkok, it was decided to advance computation relative to the uneven settlement of the ground which is caused by lowering the underground water level due to pumping-up, etc.

The ground of the Bangkok City consists of uniformly laying soft clay deposition, and

therefore, in ordinary states, uneven settlement cannot be considered to happen. However, it may be conceived that the underground water level has been lowered by pumping-up, etc., and it has resulted in causing uneven settlement of the ground.

Now, assuming that the buried pipe undergoes deformation in the same degree as the consolidation settlement at the deepest part of the soft layer, the maximum axial bending stress σSL can be represented by the formula.

$$\sigma SL = \frac{1}{4} E \cdot D \cdot \beta \cdot \theta$$

where E: Young's modulus 2.1×10^6 kg/cm²

D: outside diameter of pipe 45.72 cm

β: $\sqrt[4]{\frac{Kv \cdot D}{4EI}}$ 0.00316 cm^{-1}

Kv: coefficient of vertical reaction of the ground 0.5 kg/cm³

θ: ground settlement angle S/L = 60/5000

S: uneven settlement 60 cm

L: (uneven settlement section distance)/2 5000 cm

$$\sigma SL = \frac{1}{4} \times 2.1 \times 10^6 \times 45.72 \times 0.00316 \times 60/5000 = 910 \text{ kg/cm}^2$$

4) Total stress

4-1) Circumferential stress

$$\sigma H = \sigma PH + \sigma CH = 261 + 716 = 977 \text{ kg/cm}^2 < \sigma sa = 1{,}764 \text{ kg/cm}^2$$

4-2) Axial stress

$$\sigma L = \sigma PL \pm \sigma CL \pm \sigma TL + \sigma SL = 130 \pm 246 \pm 252 + 910$$

$$= \begin{bmatrix} 1538 \\ 542 \end{bmatrix} \text{ kg/cm}^2 < \sigma sa = 1764 \text{ kg/cm}^2$$

4-3) Combined stress

When it is combined by the shearing strain energy rupture theory, the following formula

can be obtained,

$$\sigma = \sqrt{\sigma H^2 + \sigma L^2 - \sigma L \cdot \sigma H + 3\tau^2}$$

where σH: circumferential stress 977 kg/cm²

σL: axial stress $\begin{cases} 1538 \\ 542 \end{cases}$ kg/cm²

τ: shearing force 0

σ = 1348, 848 kg/cm² < σ_{sa} = 1764 kg/cm²

APPENDIX D

SCHEDULES FOR STUDY TEAMS

APPENDIX D

SCHEDULES FOR STUDY TEAMS

September	20 Friday	First group headed by Mr. Tanabe with Messrs. Mera, Maki, Otsuka and Yamaguchi arrive at Bangkok at 14:45 on AZ-789.
	21 Saturday	Studied following schedule
	22 Sunday	Studied actual
	23 Monday	Paid courtesy calls to the Embassy of Japan, J.I.C.A. Overseas Office, and N.E.A.
	24 Tuesday	Paid a courtesy call to Mr. Kruit of N.E.S.D.B. (Deputy Secretary General) Visited the Embassy of Japan and J.I.C.A. Overseas Office to brief on the schedule. Exchanged discussions with N.E.A. about how to conduct survey.
	25 Wednesday	Paid courtesy calls to Mr. Kamthon of E.G.A.T. (Deputy Chairman) and Mr. Priathai, the Assistant Deputy General Manager for Engineering (M.W.W.A.) Paid courtesy calls to O.E.C.F. Overseas Office and J.E.T.R.O. Trade Center. Exchanged discussions with N.E.A. about how to conduct survey.
	26 Thursday	Paid courtesy calls to Mr. Wanchai of D.T.E.C. (Director of Division of External Cooperation Office II), Mr. Paibulya of O.F.O. (Chemical Engineer), and Yazaki. Exchanged discussions with N.E.A.
	27 Friday	Second group with Messrs. Kanase, Ogo, Sakurai, Koshiba and Okamoto arrived at Bangkok 16:05 on JL-461. Introduction meeting was held between Thai and Japanese teams.
	28 Saturday	Discussions were held with N.E.A. Tidied up the materials and data.

September	29	Sunday	Tidied up the materials and data, including collection hereof.
	30	Monday	Paid courtesy calls to the Embassy of Japan and J.I.C.A. Overseas Office by the second group. Meeting was held among group members.
October	1	Tuesday	Liaison meeting was held with participation of Thai and Japanese teams. Paid a courtesy call to the Thai Toray Office.
	2	Wednesday	Paid a courtesy call to Mr. Ob, Thai Chamber of Commerce and Industry (Chairman) Patrolled in tle Bangkok City.
	3	Thursday	Patrolled in the Bangkok City.
	4	Friday	Messrs. Mera and Yamaguchi left Bangkok for Haneda on JL-714. Paid courtesy calls to Mr. Kongsay (Secretary to the Government of Bangkok Metropolis), Dr. Adisai of T.O.T. (Engineer in Charge of Outside Town Design), and Mr. Piboon (Chief Engineer of Metropolitan Telecommunication). Discussions were held with N.E.A. about how to conduct survey.
	5	Saturday	Tidied up the materials and data.
	6	Sunday	Tidied up the materials and data.
	7	Monday	Visited Mr. Somchai (Chief Construction Supervision)and Mr. Vilas (Director of Revenue Dept.) both at M.W.W.A. in order to obtain necessary materials and data. Thai and Japanese teams held meetings independently.
	8	Tuesday	A meeting was held with participation of Mr. Nitipat of N.E.A. (Secretary General) upon his return from U.S.A. Visited Mr. Somchai of M.W.W.A. in order to obtain materials and data and for questions and answers.
	9	Wednesday	In order to conduct survey to find out about a possible demand or town gas, parttime student workers were recruited and gave them instructions concerning the purpose, contents and method of the survey. Prepared various questionnaires.

October	10	Thursday	Mr. Maki left Bangkok for Haneda on TG-600. Visited Mr. P.Y. Chang Refining Manager of Bangkok Refinery and Mr. S.Y. Lu (Chief of Engineering Dept.) to solicit them for their cooperation. Investigated the roads where the consotruction would be carried out across Khlons. Surveyed demand for town gas and sampled at random.
	11	Friday	Visited Mr. Piasan (Manager of Efficiency Control Div.) at E.G.A.T. in order to obtain his responses to the questions previously submitted. Started surveying on the demand for town gas. Continued the road survey.
	12	Saturday	Tidied up the materials and data.
	13	Sunday	Patrolled in the Bangkok City by the joint study team consisting of Thai and Japanese teams.
	14	Monday	Visited Mr. Komthorn (Chief of Revenue Div.) at Tombri Branch, Municipal Water Works Bureau, for survey on the present metering and money collection system. Visited Dr. Boonyork (the Center of Chief of the Analyses of R.I.D.) to hear about the Khlon control. Continued survey on the demand for gas.
	15	Tuesday	Third group with Messrs. Sugiyama and Kojo arrived at Bangkok at 19:00 on KL-862. Visited the office of Mr. Boonruen, the Undersecretary to the Prime Minister to solicit him for his cooperation. Visited Habor Department to exchange questions and answers. A trip was made for the inspection of the area where the gas making plant is to be constructed. Continued survey on the demand for gas and made inspection of roads.
	16	Wednesday	Visited Mr. Chalitpakorn (Chief of Planning Div.) to ideas and comments in regard to city planning. Patrolled in the city and held a meeting among the Japanese group members.
	17	Thursday	Paid courtesy calls to the Embassy of Japan and J.I.C.A.

			Overseas Office by the third group. Visited Dr. Richardson (Div. of Geotechnical Engineering Associate Professor of A.I.T.) to talk about the soil nature. Visited Royal State Railway Mr. Thuen (General Manager) to solicit him for his cooperation. Started preparations for installation of raod survey meters.
October	18	Friday	Visited Labor Department and T.O.T. to exchange questions and answers. Continued preparations for installation of road survey meters. A meeting was held between Thai and Japanese teams.
	19	Saturday	Tidied up the materials and data.
	20	Sunday	Tidied up the materials and data.
	21	Monday	Installed road survey meters. Inspection trip was made to the railroad right of way. Collected relevant data.
	22	Tuesday	Continued installing road survey meters. Inspected the statistics of LPG accidents. Prepared and tidied up materials and data.
	23	Wednesday	Chulalongkorn Day (national holiday). Tidied up materials and data.
	24	Thursday	A survey was conducted on prospective town gas consumers and inspected raw materials for gas production and plant utilities. Discussions were held with A.I.T. about soil exploration. A meeting was held among group members.
	25	Friday	Discussions were held between M.E.A. about the status of underground objects and their maintenance. Inspected the area on which holder would be built. Selected nine trunk routes. Soil exploration was carried out in the presence of M.E.A. A meeting was held between Thai and Japanese teams.
	26	Saturday	Tidied up the materials and data.

October	27	Sunday	Tidied up the materials and data.
	28	Monday	Installed and removed road survey meters. Inspected trunk roads and other main roads under which water lines were installed. Selected typical areas. Visited O.E.C.F. to obtain materials and data.
	29	Tuesday	Installed and removed road survey meters. A meeting was held between A.I.T. and Japanese team about the method of soil exploration. Gathered materials and data. Selected typical areas.
	30	Wednesday	Installed and removed road survey meters. Recruited part-time student workers for road survey, and gave them instructions. Data and information relevant to the matter of finance and legal in Japanese enterprises were obtained, and had a hearing about actual transactions in regard thereto.
	31	Thursday	Visited Shell Office and retail stores in order to obtain materials and information. Made surveys on the typical areas No. 1, No. 2 and No. 3. Visited M.W.W.A. to check the matter in relation with finance, loan and taxation. Started off road survey.
November	1	Friday	Visited O.F.O. Investigated LPG prices. Visited E.S.S.O. and its retail stores in order to obtain data and information. Inspected the typical areas No. 7 and No. 8. A meeting was held with participation of Thai and Japanese teams.
	2	Saturday	Tidied up the materials and data.
	3	Sunday	Tidied up the materials and data.
	4	Monday	Installed and removed road survey meters. Selected and investigated the areas where the plane table survey was to be conducted. Inspected Government-controlled premises.

			Visited Thai-Obayashi Gumi, Ltd. to discuss construction cost. Visited the Branch Office of Mitsui Bank to get acquainted with the financial economic situation in Thailand. Request for aerial photograph of Bangkok was passed on to N.E.A.
	5	Tuesday	Installed and removed road survey meters. Investigated the areas where the plane table survey was to be conducted. Visited northern towns newly constructed.
	6	Wednesday	Installed and removed road survey meters. Inspected No. 2 holder premise. Visited Kallawis Engineering Co., for discussions about construction cost. Visited A.I.T. for signing of the contract for soil exploration.
November	7	Thursday	Visited Italian-Thai Co., to request for estimate on the construction cost. Inspected where soil exploration work was being carried out. Surveyed gas equipment manufacturers.
	8	Friday	Visited Bangchack Oil Refinery for additional investigation. Visited factories where a large quantity of gas is expected to be consumed, and high-class apartment houses to which town gas would be supplied by means of central system. Inspected main roads and plant premise. A meeting was held between Thai and Japanese teams.
	9	Saturday	Tidied up the materials and data.
	10	Sunday	Tidied up the materials and data.
	11	Monday	Removed road survey meters and surveyed gas appliances in use. A meeting was held among group members.
	12	Tuesday	Installed and removed road survey meters.
	13	Wednesday	Installed and removed road survey meters. Made preparations for inspecting degree of soil corroded. Visited Public Housing Corporation and Royal State Railway to obtain data and information.

November	14	Thursday	Visited N.E.A. to obtain data and information. Visited Thai-Obayashi Gumi, Ltd. to request it to submit cost estimate for piping work. Visited gas equipment manufacturers. Inspected the site where corroded soil was being tested. A meeting was held between Thai and Japanese teams.
	15	Friday	Visited E.G.A.T. to obtain data for economic calculations. Visited gas equipment manufacturers. Visited the site where corroded soil was being tested. A meeting was held between Thai and Japanese teams.
	16	Saturday	Tidied up the materials and data.
	17	Sunday	Tidied up the materials and data.
	18	Monday	Installed and removed road survey meters. Visited Bangkok Metropolitan Office to check the outline of city planning. Visited O.P.O. and Bangchack Oil refinery in order to check the status of petrochemical products. Visited J.E.T.R.O. Trade Center to check the status of energies in Thailand.
	19	Tuesday	Installed and removed road survey meters. Visited the Highway Department to obtain various data and information. Investigated the wholesale prices of piping materials. Investigated main roads and bridges.
	20	Wednesday	Prepared an interim report (draft) for N.E.A.
	21	Thursday	A meeting was held among group members to discuss the matters contained in the interim report.
	22	Friday	Visited the Metropolitan Traffic Planning to obtain various data and information related to traffic. Visited gas equipment manufacturers. Visited the National Parliament of Thailand (all group members). Revised the interim report.
	23	Saturday	Tidied up the materials and data.

November	24	Sunday	Tidies up the materials and data.
	25	Monday	Visited Thai-Obayashi Gumi, Ltd. for requesting cost estimation. Visited M.T.P. and N.S.O. to discuss the problems related to the town development. Inspected the status of LPG used in urban Hotels. Translated the interim report into English.
	26	Tuesday	Visited M.W.W.A. for requesting to provide us the section drawings of existing water lines. Visited gas equipment manufacturers. Completed untranslated part of the interim report.
	27	Wednesday	Reported to N.E.A. on the interim report.
	28	Thursday	Tidied up the materials and data.
	29	Friday	A meeting was held between Thai and Japanese teams.
	30	Saturday	Messrs. Kanase, Ogo, Sakurai and Koshiba left Bangkok for Haneda on JL-464. Tidied up the materials and data.
December	1	Sunday	Tidied up the materials and data.
	2	Monday	Inspected main roads and houses. Inspected the typical area No. 7.
	3	Tuesday	Visited the Embassy of Japan to explain the progress made in the case study. Visited Thai Obayashi Gumi, Ltd. to discuss the construction equipment to be leased. Inspected main roads. Inspected the typical area No. 4.
	4	Wednesday	Inspected main roads and the typical area No. 8. Visited N.E.S.D.B. for secretarial communications.
	5	Thursday	King's Birthday (national holiday). Collected the materials and data.
	6	Friday	Visited M.W.W.A. to obtain the data and information. Inspected main roads and the typical area No. 3.

December	7	Saturday	Fourth Group with Messrs. Iwasaki and Yamaguchi arrived at Bangkok at 19:00 on KL-864. Collected the materials and data.
	8	Sunday	A meeting was held at Bangkok Municipal Office to hear detailed explanations on the underground pipeline rotues.
	9	Monday	Paid courtesy calls to the Embassy of Japan, J.I.C.A. Overseas Office and J.E.T.R.O. Trade Center by the fourth group. Visited Bangchack Oil Refinery to study its financial affairs. Visited Bangkok Municipal Office to hear the present status of underground sewerage system. Visited Italian-Thai Co. to discuss cost estimation. Inspected valve fittings.
	10	Tuesday	Constitution Day (national holiday). Collected the materials and data.
	11	Wednesday	Visited Bangkok Municipal Office to check the drawings of underground sewerage lines.
	12	Thursday	Discussed with N.E.A. on cost estimation.
	13	Friday	Visited Thai Obayashi Gumi, Ltd. to discuss cost estimation. Messrs. Sugiyama and Kojo left Bangkok for Haneda on LH-642.
	14	Saturday	Tidied up the materials and data.
	15	Sunday	Tidied up the materials and data.
	16	Monday	Visited Mr. Nitipat (Secretary General of N.E.A.) at N.E.A. and discussed about: a) Training of Thai trainees to be conducted in Japan. b) Disposal of gas meters used for road survey. c) Comments of the Thai party about how the project should be proceeded hereafter. Visited M.W.W.A. to obtain the section drawings of water supply pipelines. Inspected crossings at kholons.

December	17	Tuesday	Studied various materials and data.
	18	Wednesday	Studied various materials and data. Mr. Okamoto left Bangkok for Haneda on TG-600.
	19	Thursday	Final discussions were made with Mr. Nitipat (Secretary ral of N.E.A.).
	20	Friday	Discussions were made with N.E.A. Tidied up the materials and data. Mr. Tanabe, Head of Japanese group, left Thai for Haneda on JL-452.
	21	Saturday	Tidied up the materials and data. Transacted the remaining affairs.
	22	Sunday	Transacted the remaining affairs.
	23	Monday	Mr. Otsuka left Bangkok for Haneda on SR-304. Transacted the remaining affairs.
	24	Tuesday	Messrs. Iwasaki and Yamaguchi left Bangkok for Haneda on JL-762.

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