

Appendix 3.8 Results of Geological Surveys

I INTRODUCTION

In May 1994, Japan International Cooperation Agency (JICA) authorized Asian Engineering Consultants Co., Ltd (AEC) to carry out a site investigation for their project entitled Road Disaster Prevention Plan in Thailand (RDPP). The scope of investigation was limited to the following tasks :

- Drill exploratory boreholes within sliding mass at the specified locations.
- Perform standard penetration test (SPT) within soil mass and, collect soil and rock samples for laboratory testing.
- Conduct classification tests on soil samples.

II LOCATION

A total of 9 boreholes designated as BH 1 through BH 9 as summarized below were drilled. The location of each borehole is shown in Fig. 1(a) through Fig. 1(i). In the field, the exact location of each borehole was selected and marked by the JICA engineer prior to drilling at respective location.

BH 1	Route 1095	km 161.35
BH 2	Route 109	km 24.65
BH 3	Route 1149	km 5.80
BH 4	Route 1256	km 25.35
BH 5	Route 1256	km 40.15
BH 6	Route 1256	km 45.60
BH 7	Route 4	km 44.70
BH 8	Route 410	km 76.42
BH 9	Route 410	km 97.80

III FIELD INVESTIGATION

• Soil Boring

Soil boring was performed to different depth at all locations except borehole BH 6 and BH 9 where rock coring only was performed. Drilling was carried out by rotary boring through the bottom of the borehole. Two rotary boring machines were employed to drill all boreholes. The hole was first advanced by a casing 1 m long, then by fish tail bit followed by jetting water pumped through the hollow drill rods and bit. Soil debris was then carried upwards by the raising water between drill rods and the borehole wall.

• Standard Penetration Test

Standard penetration test (SPT) conforming to ASTM D 1586-84 was performed in all boreholes drilled through soil material. The test was performed at an interval of 1 m. The test was carried out by driving a split spoon barrel of 50.8 mm outside diameter and 34.9 mm internal diameter into the soil by a 63.5 kg free falling weight through

a distance of 760 mm. Number of blows were recorded for every 150 mm penetration until either 450 mm have been penetrated or 50 blows applied. The sum of blows for second and third 150 mm penetration is termed as the standard penetration resistance (SPT-N).

Disturbed soil samples from standard penetration tests were collected for subsequent laboratory testing and kept in polythene bags to retain natural water content.

- *Rock Coring*

Rock coring was performed exclusively for two boreholes (BH 6 and BH 9) located along highway route 1256 in the North and route 410 in the South. In another two locations namely, BH 1 and BH 2 rock coring followed the soil boring.

Rock coring was accomplished using triple tube core barrel (NW) and diamond bit to permit maximum recovery of all core. The bit used was NMLC (76 mm outside diameter) and core size obtained was 54 mm diameter.

Rock cores thus obtained were placed in wooden core boxes for preservation until transportation to the laboratory.

Following the instruction of JICA, the actual amount of drilling carried out by AEC compared to the amount of drilling as stipulated in contract is summarized below:

Bore Hole No	Route No	km	Contract drilling (m)		Actual drilling (m)		Remarks
			Soil	Rock	Soil	Rock	
BH 1	Route 1095	km 161.35	5	5	10.50	6.50	Vertical
BH 2	Route 109	km 24.65	5	5	8.52	4.28	Vertical
BH 3	Route 1149	km 5.80	10	-	10.45	-	Vertical
BH 4	Route 1256	km 25.35	5	5	13.95	1.50	Vertical
BH 5	Route 1256	km 40.15	5	5	21.58	-	Vertical
BH 6	Route 1256	km 45.60	5	5	-	15.00	80° from vert.
BH 7	Route 4	km 44.70	10	-	15.45	-	Vertical
BH 8	Route 410	km 76.42	5	5	10.05	-	Vertical
BH 9	Route 410	km 97.80	5	5	-	5.00	75° from vert.
Total drill meterage			55	35	90.50	32.28	

- *Installation of Open Stand Pipe*

A total of 7 open stand pipes (38 mm diameter) were installed at the bottom of the each borehole except for borehole BH 6 and BH 9 which were drilled at an inclination of 80 degree and 75 degree respectively from the vertical. At borehole BH 1, galvanized steel pipe with perforation at bottom 1 m was installed whereas the remaining 6 stand pipes were of PVC type with bottom 1 m perforation.

IV LABORATORY INVESTIGATION

Laboratory investigation was carried out on the representative samples of disturbed soil obtained from boreholes. The number and type of test was decided by JICA. Following type of laboratory tests were performed on selected samples:

- Natural water content ASTM D 2216-80
- Particle size analysis ASTM D 422-63
- Atterberg limits ASTM D 4318-84

The results of laboratory investigation are summarized in Table 1.

TABLE 1
RESULTS OF LABORATORY TESTS

Location : km 161.35 Route : 1095 Borehole : BH 1

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 2	3.00 - 3.45	14.0	33.0	20.8	12.2	97	88	81	72	57	51	CL
SS - 4	5.00 - 5.45	14.3	34.0	20.2	13.8	76	63	55	48	41	36	SC
SS - 6	9.00 - 9.45	6.9	Insufficient sample			47	31	22	17	14	12	GC ?

Location : km 24.65 Route : 109 Borehole : BH 2

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 3	3.00 - 3.45	22.4	Insufficient sample			100	96	77	50	40	37	SC
SS - 4	4.00 - 4.45	27.7	50.2	34.4	15.8	100	98	81	45	31	27	SC
SS - 5	6.33 - 6.75	21.7	49.1	38.2	10.9	100	98	85	54	41	36	SC
SS - 6	7.00 - 7.45	19.7	46.5	37.1	9.4	100	99	85	54	42	36	SC
SS - 7	8.00 - 8.45	18.0	44.9	31.8	13.1	100	98	81	43	28	23	SC

Location : km 5.80 Route : 1149 Borehole : BH 3

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 3	3.00 - 3.45	29.5	36.7	27.4	9.3	100	96	83	64	40	30	SC
SS - 4	4.00 - 4.45	35.8	42.4	30.4	12.0	100	95	93	75	59	52	CL
SS - 6	6.00 - 6.45	21.8	30.4	26.3	4.1		100	84	44	29	23	SM-SC
SS - 7	7.00 - 7.45	16.2	35.4	31.5	3.9		100	90	63	46	39	SM-SC
SS - 8	8.00 - 8.45	24.8	35.9	27.1	8.8		100	88	63	45	37	SC

TABLE 1 (Continued)
RESULTS OF LABORATORY TESTS

Location : km 25.35 Route : 1256 Borehole : BH 4

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 2	2.00 - 2.45	30.0	37.6	27.4	10.2	100	98	95	86	50	40	SC
SS - 3	3.00 - 3.45	31.6	44.7	30.6	14.1			100	99	88	72	CL
SS - 6	6.00 - 6.45	27.5	38.2	30.4	7.8	100	99	96	89	83	76	CL-ML

Location : km 40.15 Route : 1256 Borehole : BH 5

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 2	2.00 - 2.45	31.1	40.6	32	8.6			100	88	77	73	CL
SS - 6	6.00 - 6.45	26.7	40.5	24.3	16.2	100	99	99	94	85	79	CL
SS - 9	9.00 - 9.45	25.3	38.7	29.6	9.1	100	88	76	57	50	46	SC
SS - 13	13.00 - 13.45	24.4	39.1	28.7	10.4			100	89	73	73	CL

Location : km 44.70 Route : 4 Borehole : BH 7

Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 2	2.00 - 2.45	14.2	46.5	32.8	13.7	99	76	71	60	57	57	CL
SS - 3	3.00 - 3.45	16.1	44.8	33.4	11.4	100	94	91	82	73	72	CL
SS - 4	4.00 - 4.45	10.7	44	33.2	10.8	92	71	62	48	43	41	SC
SS - 5	5.00 - 5.45	19.3	45.7	33.5	12.2	100	96	95	89	82	80	CL
SS - 9	9.00 - 9.45	12.1	44.9	30.6	14.3	100	99	98	90	84	82	CL

Location : km 76.42 Route : 410 Borehole : BH 8

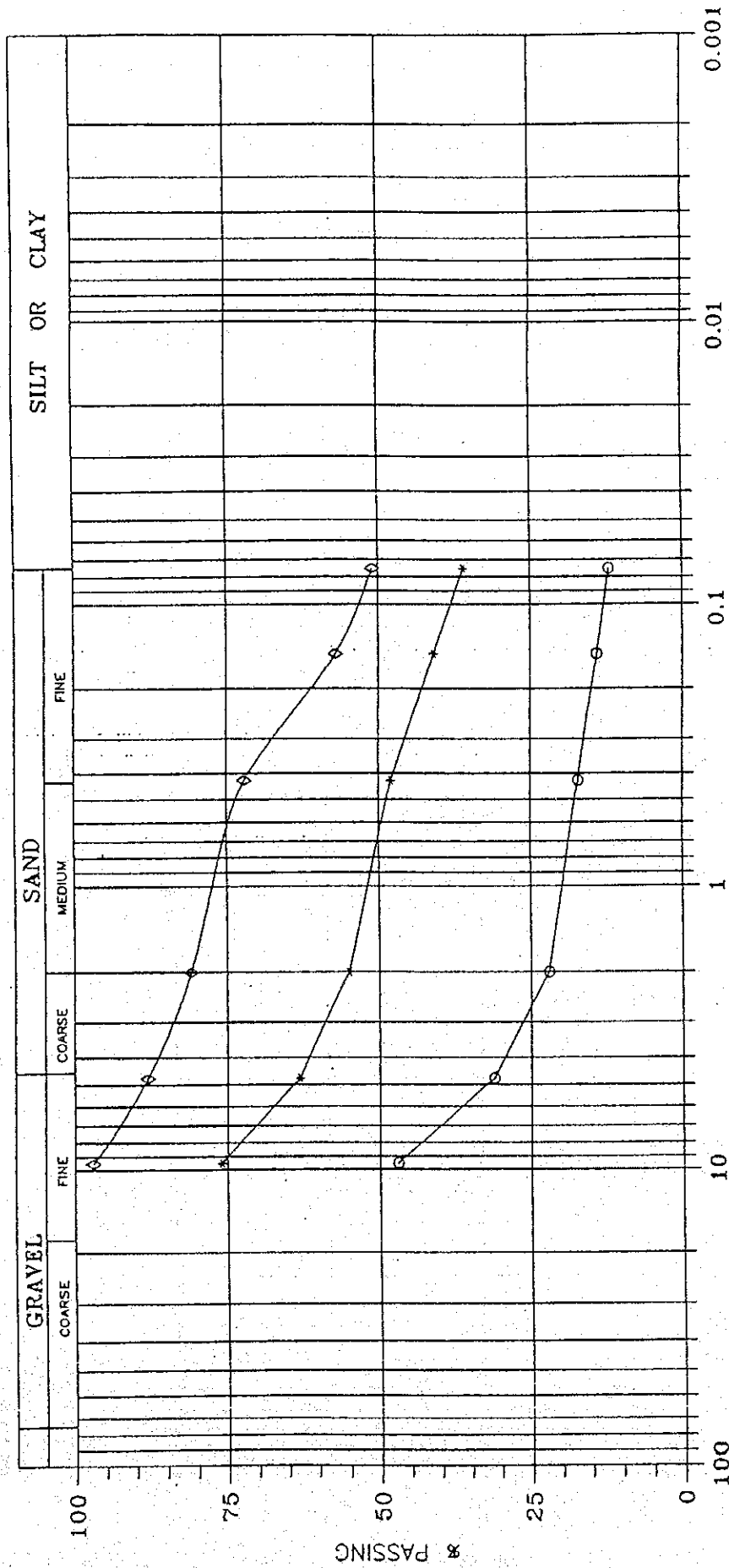
Sample No.	Depth (m)	W _n (%)	Atterberg Limits (%)			Sieve Analysis % Passing (US standard sieves)						USCS Group
			LL	PL	PI	3/8"	# 4	# 10	# 40	# 100	# 200	
SS - 4	4.00 - 4.45	15.3	37.8	24.0	13.8	71	57	41	25	21	19	SC
SS - 7	7.00 - 7.45	10.2	40.9	26.3	14.6	72	54	44	29	24	22	SC

Source : Geo-Technology Consultants Co., Ltd.

Notes :

W_n = Natural water content ; LL = Liquid limit ; PL = Plastic limit ; PI = Plasticity index
 USCS = Unified Soil Classification System SS = Split Spoon Sample

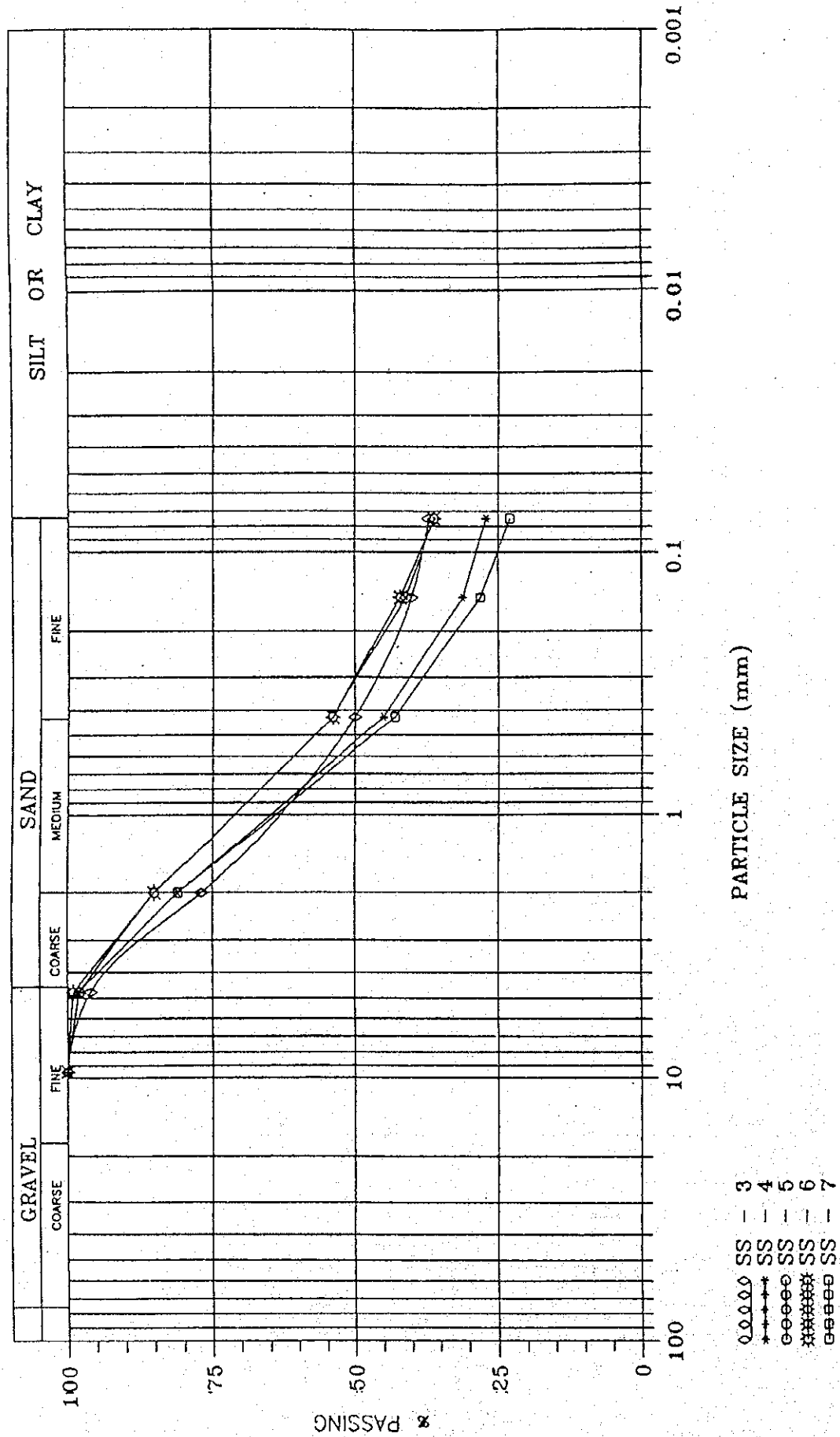
Particle Size Distribution (BH - 1)



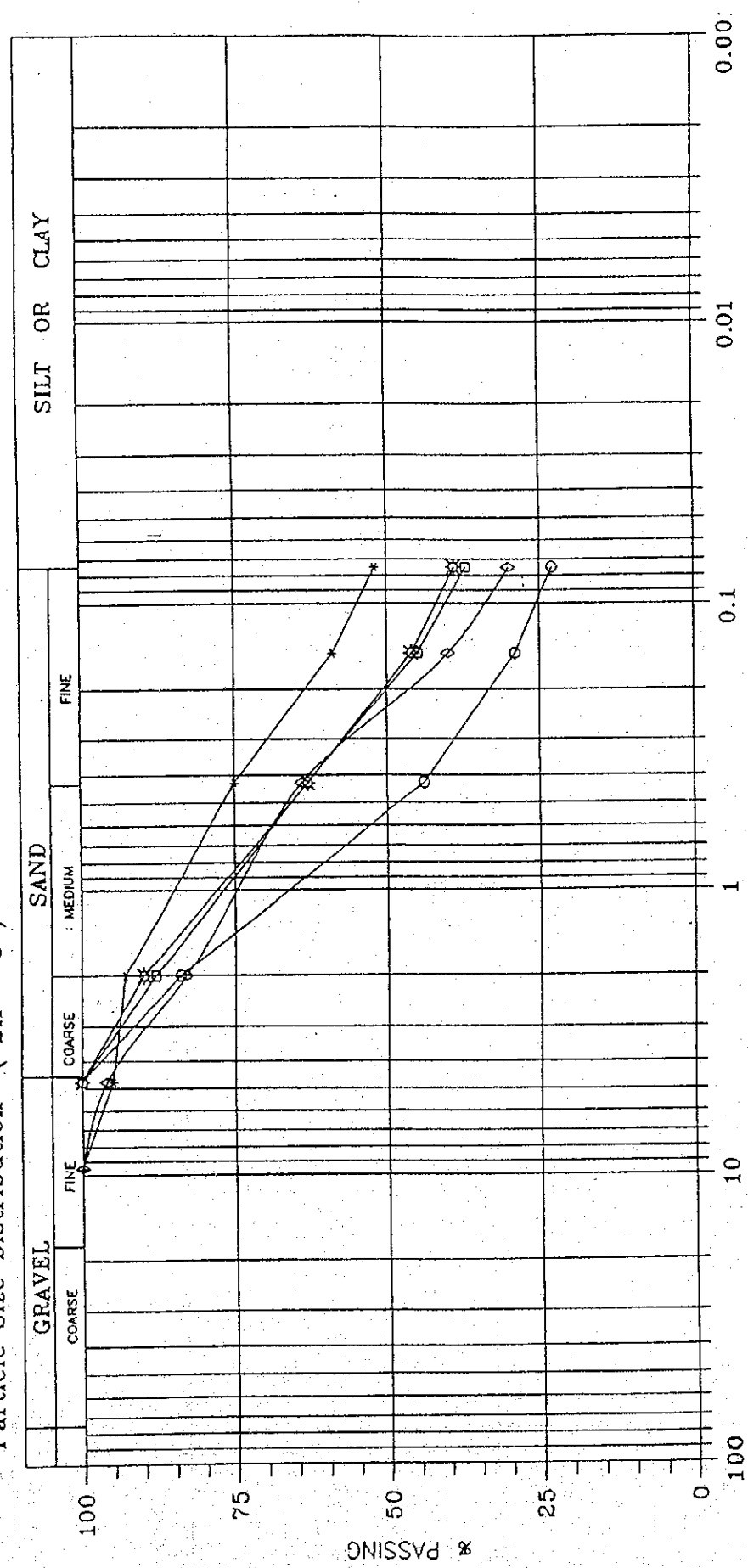
PARTICLE SIZE (mm)

00000 SS - 2
 ++* SS - 4
 00000 SS - 6

Particle Size Distribution (BH - 2)



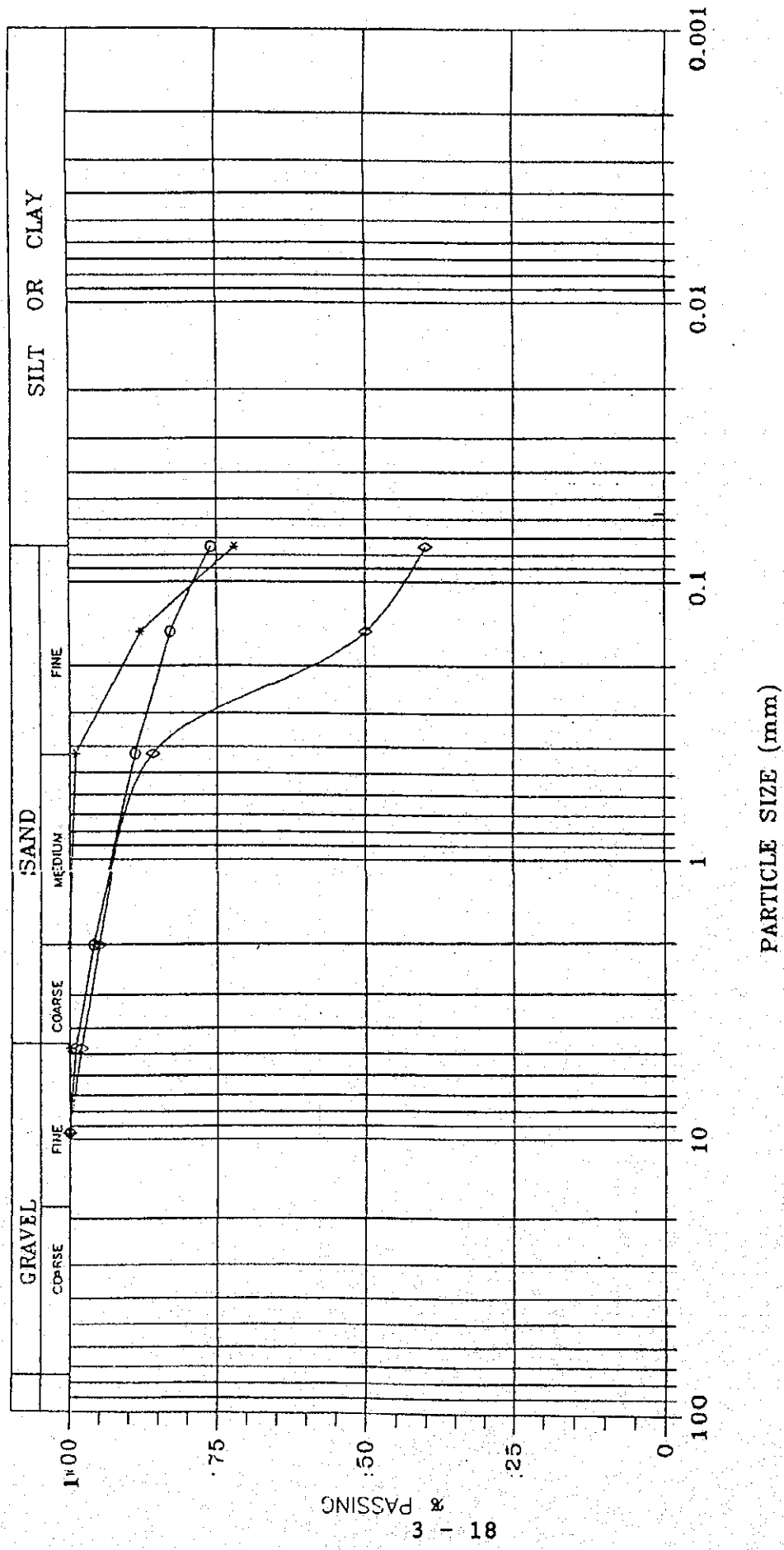
Particle Size Distribution (BH - 3)



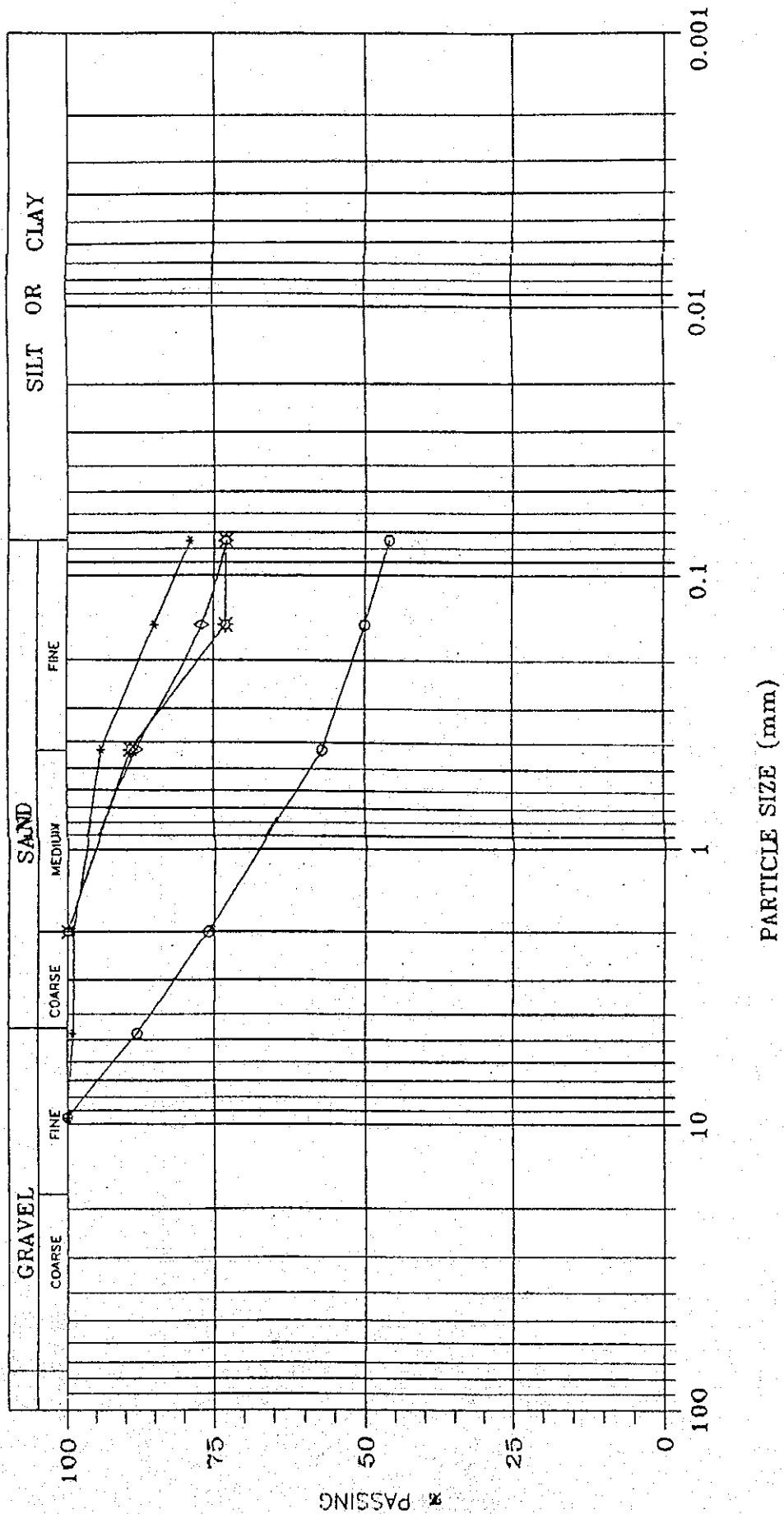
PARTICLE SIZE (mm)

- ○ ○ ○ ○ SS - 3
- * * * * * SS - 4
- □ □ □ □ SS - 6
- × × × × × SS - 7
- ◇ ◇ ◇ ◇ ◇ SS - 8

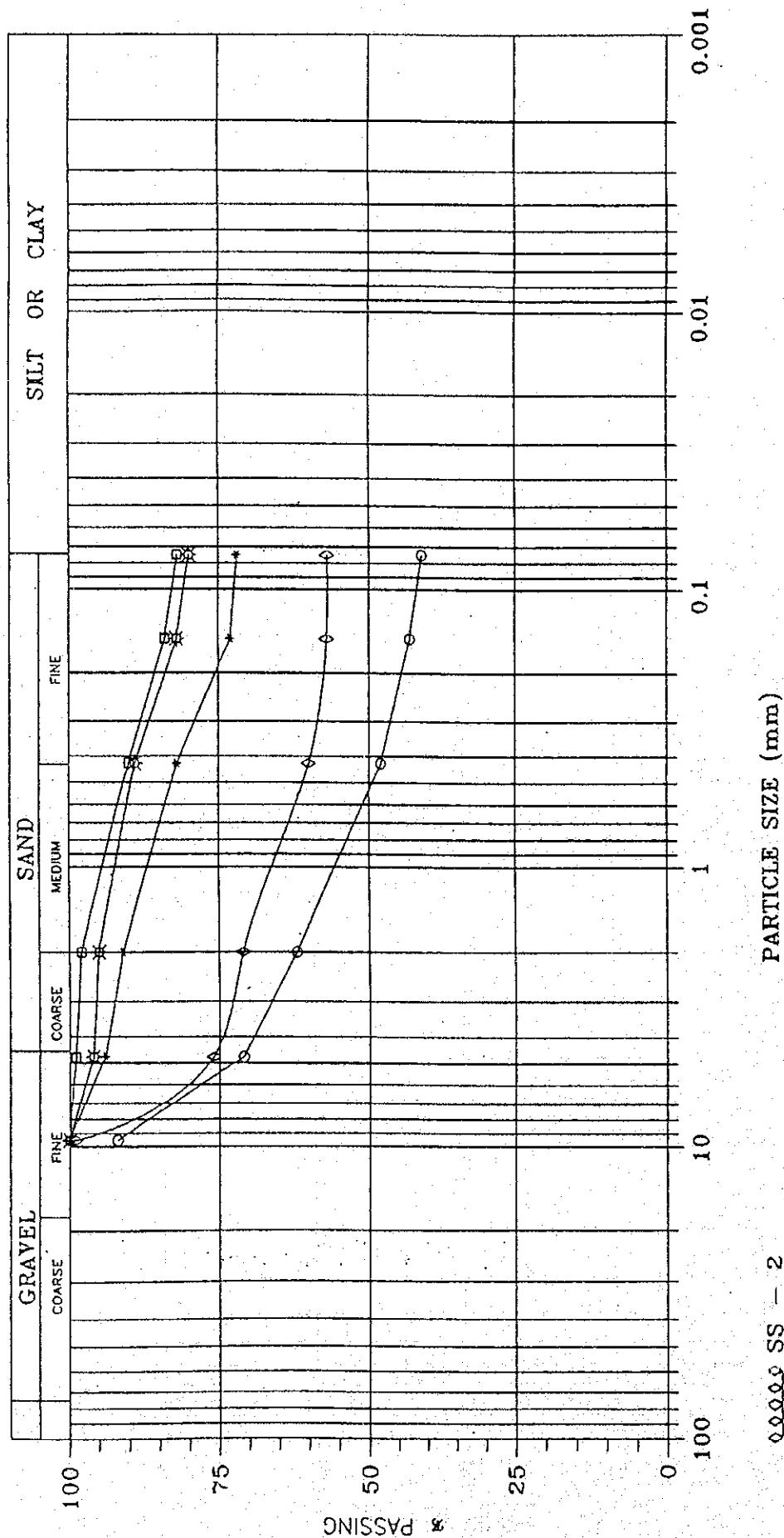
Particle Size Distribution (BH - 4)



Particle Size Distribution (BH - 5)



Particle Size Distribution (BH - 7)



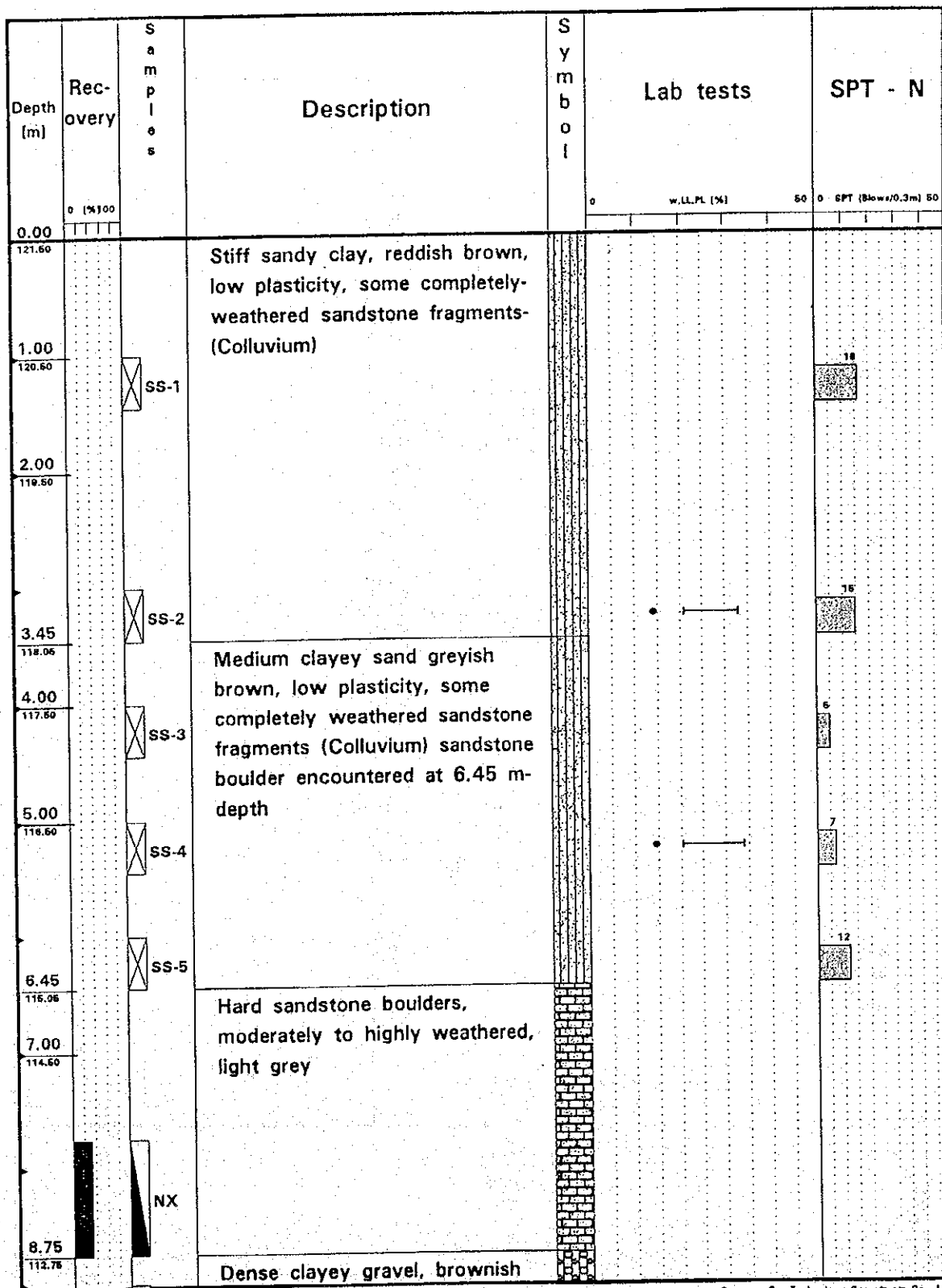
V BOREHOLE LOGS

All information on the soil and rock as to their physical property were recorded for every test depth in each borehole. Position of water table as measured 24 hours after boring is also recorded. Material properties as obtained from field and laboratory investigation were plotted against depth for each borehole. Borehole logs with relevant material properties incorporated in them are presented in Appendix - A.

The photographic records of important site activities and photographs of rock core samples are presented in Appendix - B.

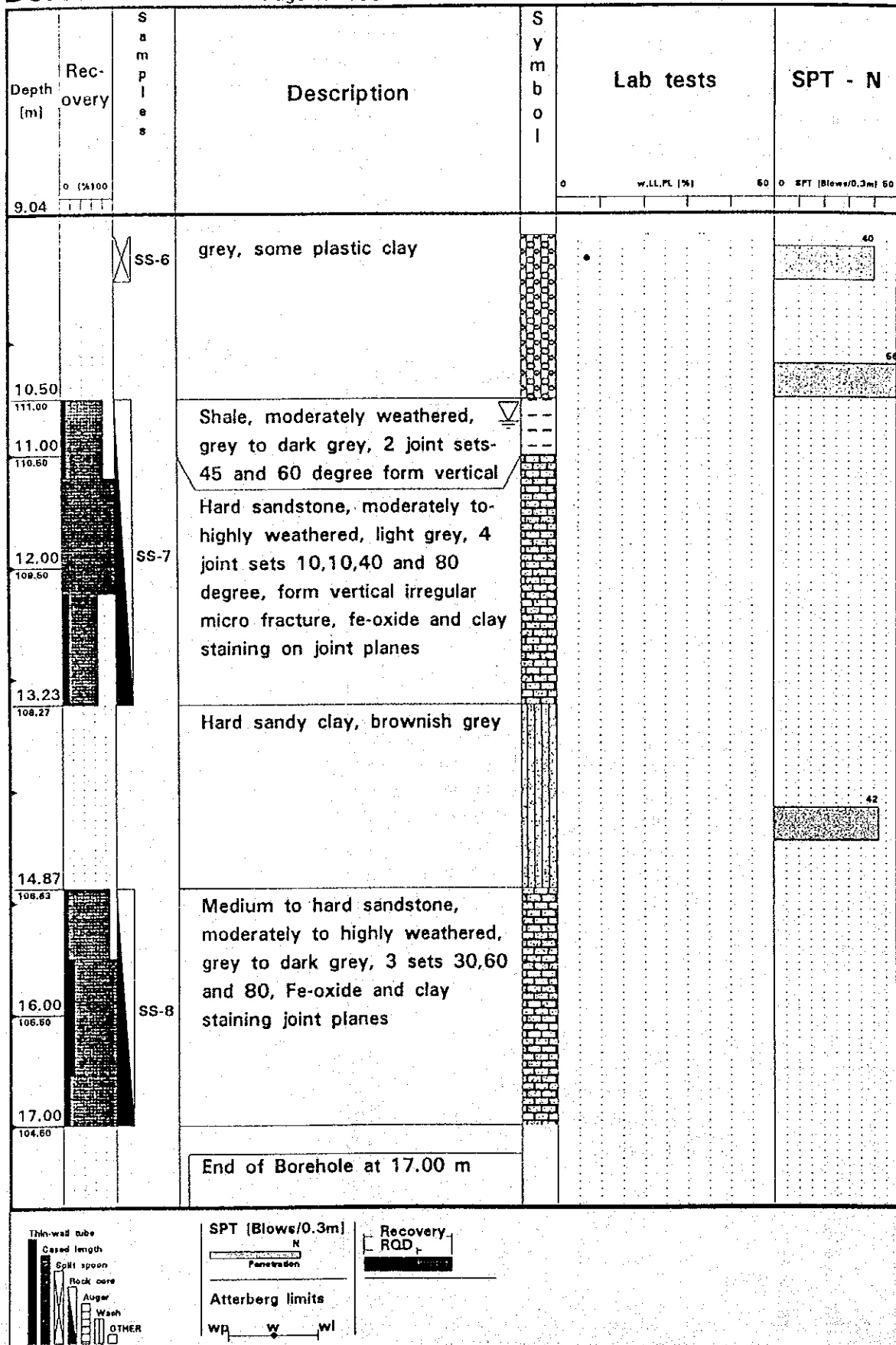
BOREHOLE LOG

Borehole: **BH-1** Project number: 4017
 Site location: Rt 1095 km 161.35 Left Vertical scale: 1:50
 Co-ords (x,y): Elevation [m]: 121.50
 G.W. Table [m]: 10.70 Date started: 16-05-94
 Date finished: 23-05-94 Total depth [m]: 17.00



Source : Geo-Technology Consultants Co., Ltd.

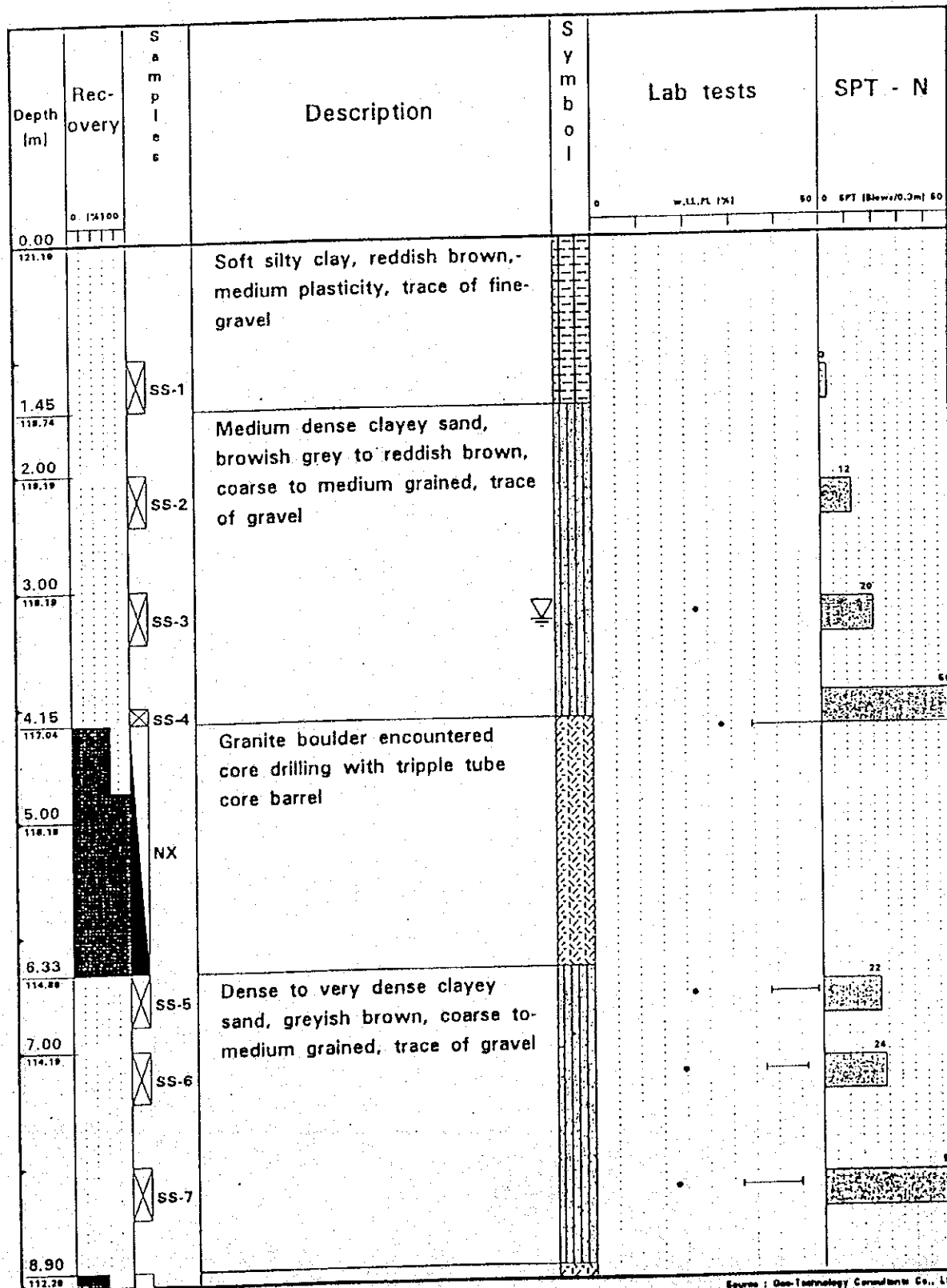
Borehole BH-1 Page 2 /Cont.



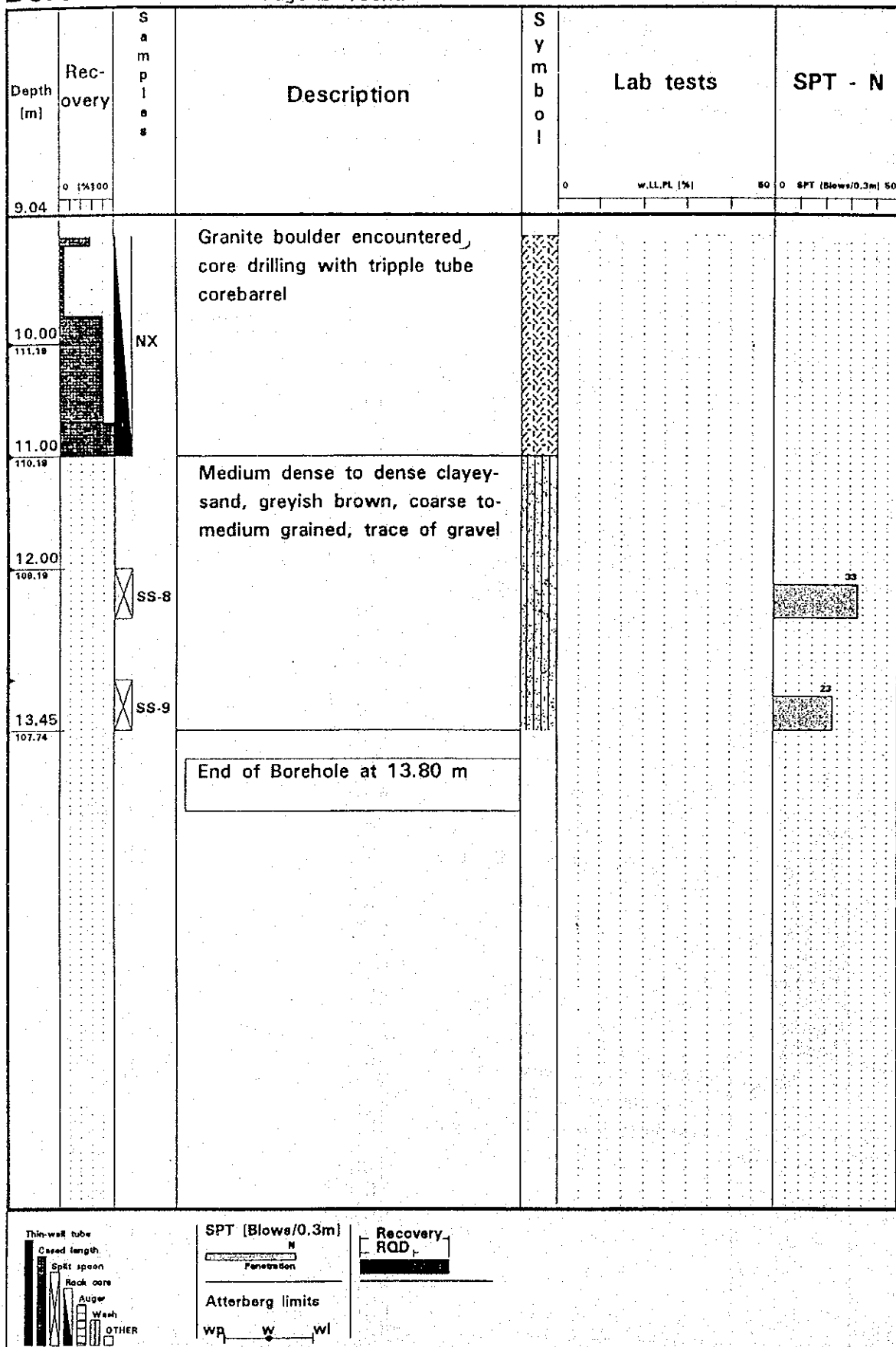
BOREHOLE LOG

Borehole: **BH-2**
 Site location: Rt 109 km 24.65 Left
 Co-ords (x,y):
 G.W. Table (m): 3.30
 Date finished: 04-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation (m): 121.19
 Date started: 25-05-94
 Total depth (m): 13.80



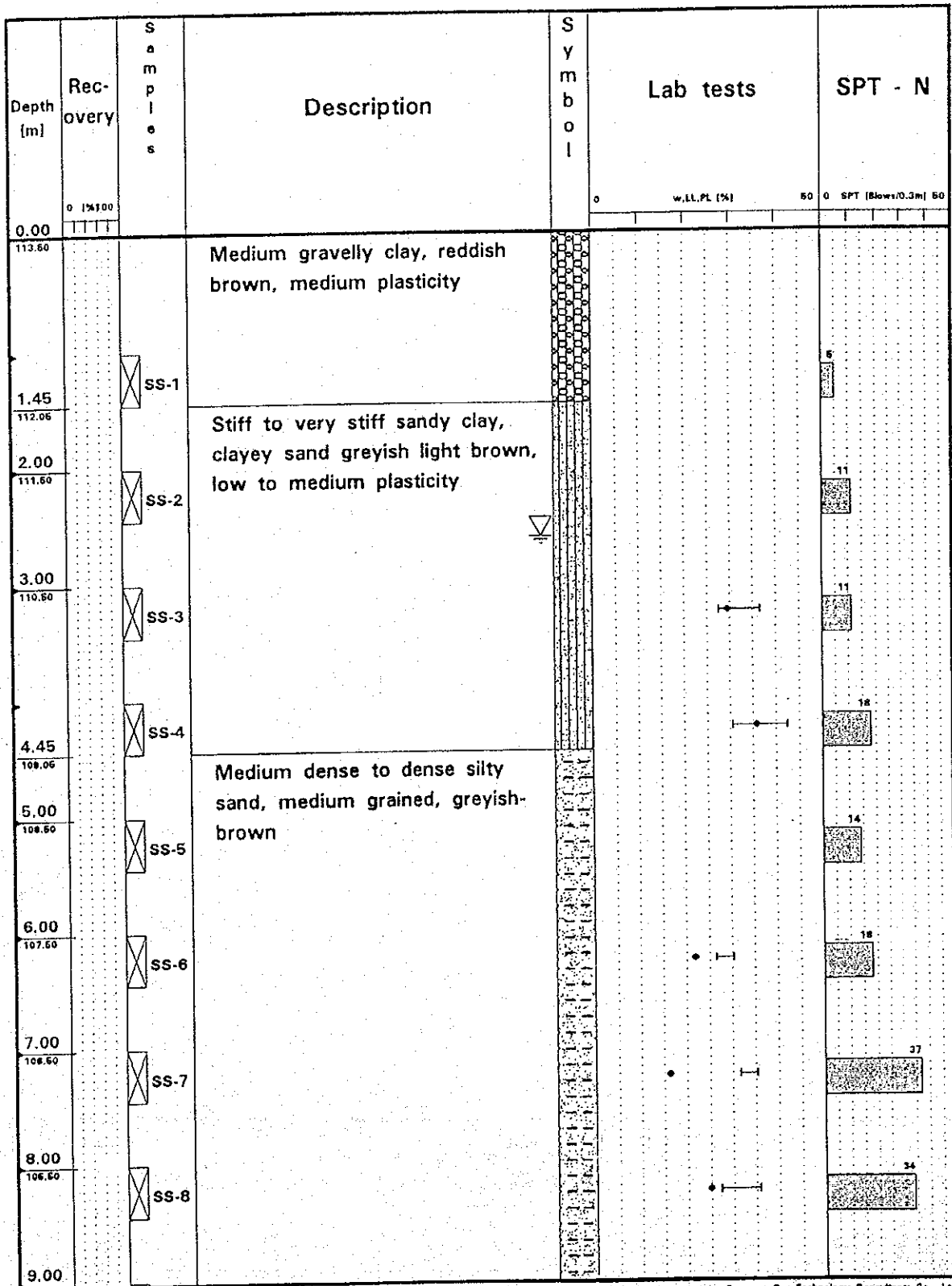
Borehole BH-2 Page 2 /Cont.



BOREHOLE LOG

Borehole: **BH-3**
 Site location: Rt 1149 km 5+800
 Co-ords (x,y):
 G.W. Table [m]: 2.60
 Date finished: 09-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation [m]: 113.50
 Date started: 05-06-94
 Total depth [m]: 10.45



Borehole BH-3 Page 2 /Cont.

Depth (m)	Recovery	Samples	Description	Symbol	Lab tests	SPT - N
0 (N) 100					w, LL, PL (%)	0 SPT (Blows/0.3m) 50
9.04						
104.50		SS-9				47
10.45		SS-10				45
103.05			End of Borehole at 10.45 m			

Thin-wall tube

Cased length

Split spoon

Rock core

Auger

Wash

OTHER

SPT (Blows/0.3m)

N

Penetration

Atterberg limits

wp — w — wl

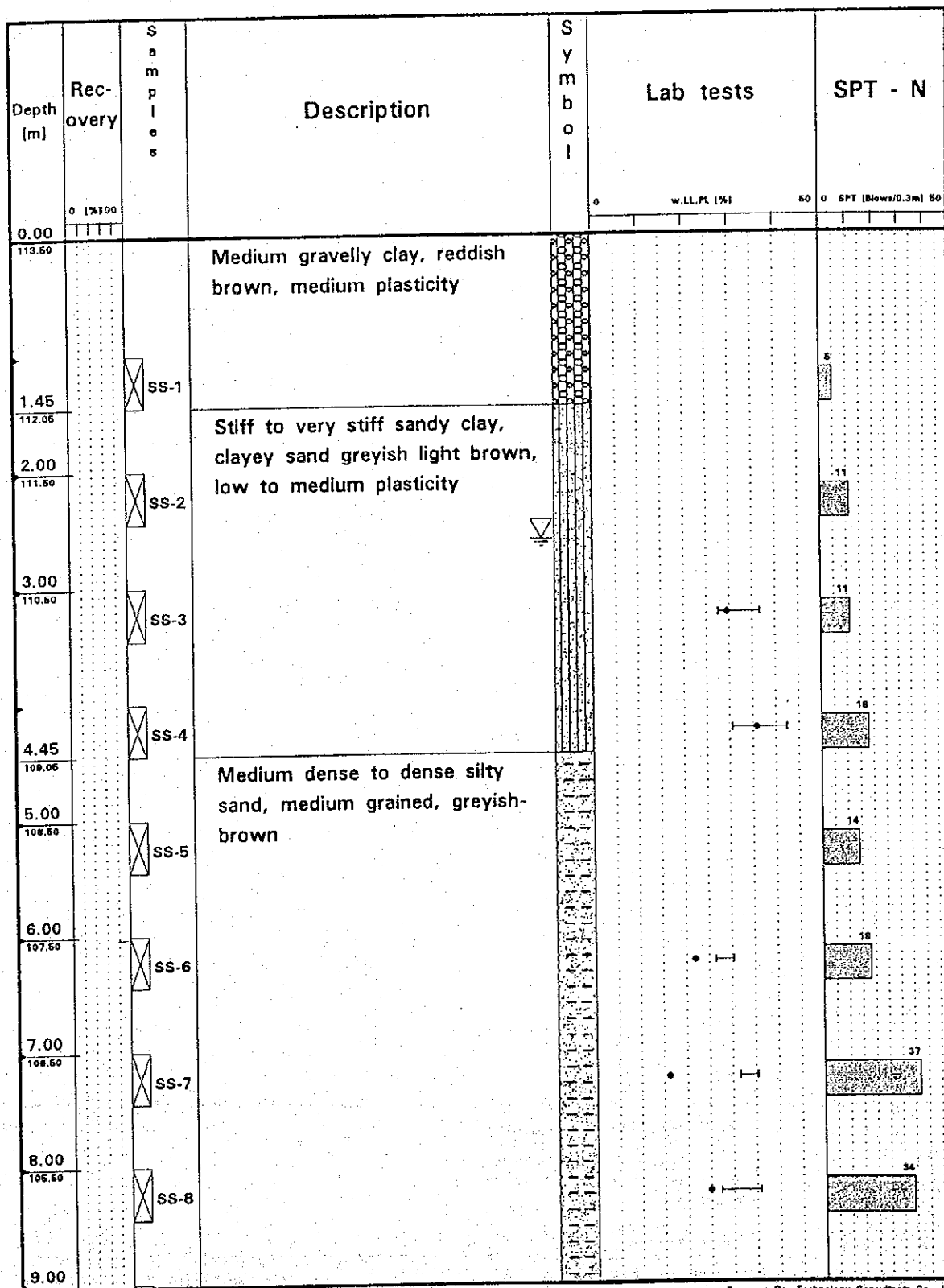
Recovery

RQD

BOREHOLE LOG

Borehole: **BH-3**
 Site location: Rt 1149 km 5+800
 Co-ords (x,y):
 G.W. Table [m]: 2.60
 Date finished: 09-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation [m]: 113.50
 Date started: 05-06-94
 Total depth [m]: 10.45



Source : Geo-Technology Consultants Co., Ltd.

Borehole BH-3 Page 2 /Cont.

Depth (m)	Recovery	S a m p l e s	Description	S y m b o l	Lab tests	SPT - N
9.04	0 (%)100				0 w,LL,PL (%) 50	0 SPT (Blows/0.3m) 50
104.50		SS-9				47
10.45		SS-10				45
103.06			End of Borehole at 10.45 m			

Thin-wall tube
Cased length
Split spoon
Rock core
Auger
Wash
OTHER

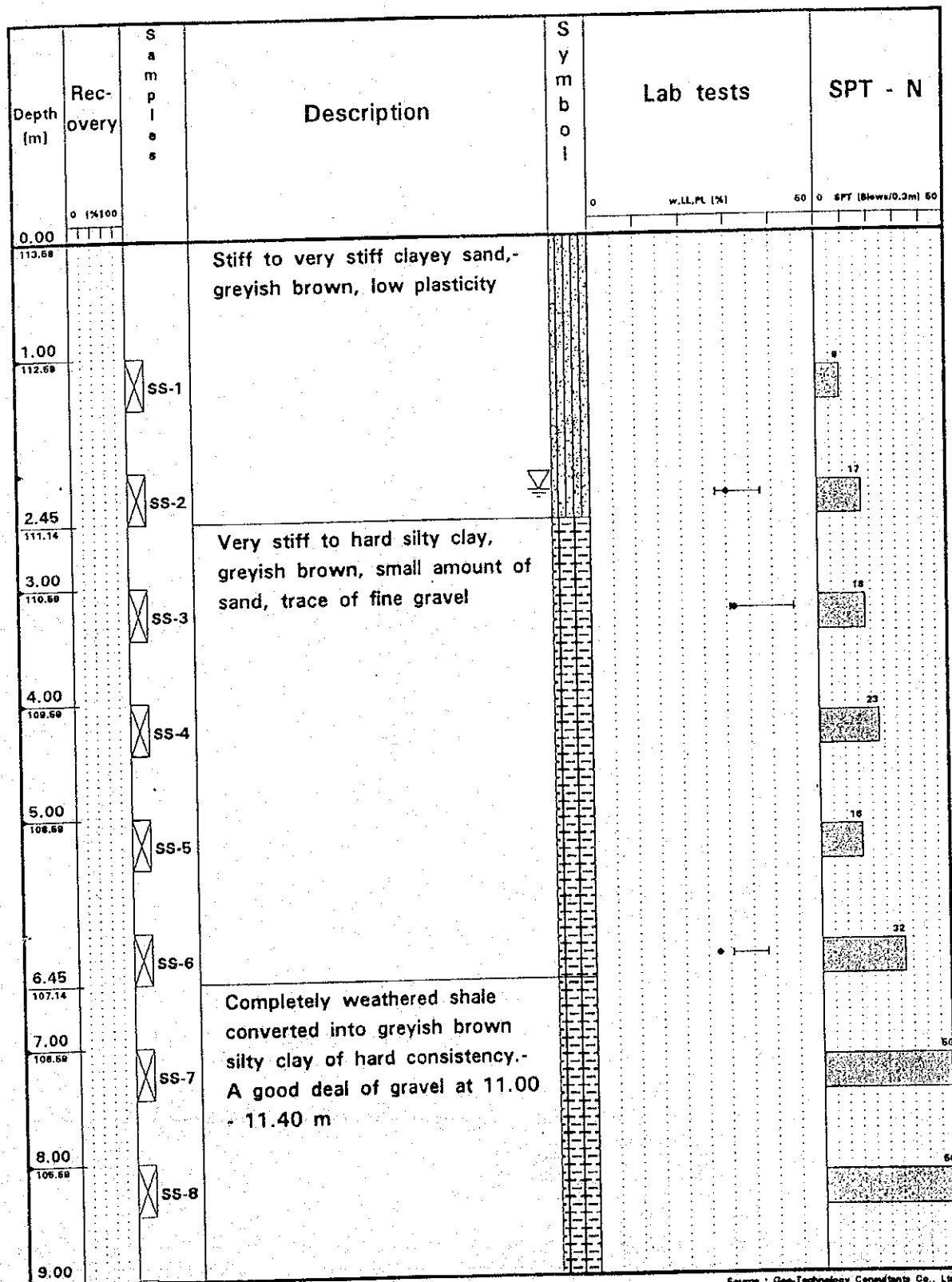
SPT (Blows/0.3m)
N
Penetration
Atterberg limits
wp — w — wl

Recovery
ROD

BOREHOLE LOG

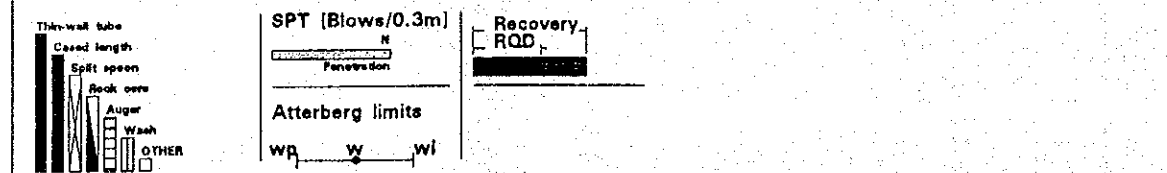
Borehole: **BH-4**
 Site location: Rt 1256 km 25.35 Left
 Co-ords (x,y):
 G.W. Table (m): 2.20
 Date finished: 13-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation (m): 113.59
 Date started: 10-06-94
 Total depth (m): 15.45



Borehole BH-4 Page 2 /Cont.

Depth (m)	Rec- overy	S a m p l e s	Description	S y m b o l	Lab tests	SPT - N
9.04	0 100				0 w.LL, PL (%) 50	0 SPT (Blows/0.3m) 50
104.68		SS-9				48
10.00						50
103.68		SS-10				
11.00						50
102.68						50
12.00		SS-11				50
101.68		SS-12				50
13.00						50
100.68		SS-13				50
14.00						50
99.68		SS-14				50
15.45		SS-15				50
98.14			End of Borehole at 15.45 m			



BOREHOLE LOG

Borehole: **BH-5** Project number: 4017
 Site location: Rt 1256 km 40.15 Left Vertical scale: 1:50
 Co-ords (x,y): Elevation (m): 93.78
 G.W. Table (m): 12.03 Date started: 31-05-94
 Date finished: 06-06-94 Total depth (m): 21.58

Depth (m)	Rec- overy	S a m p l e s	Description	S y m b o l	Lab tests	SPT - N
0.00	0 100				0 w.LL, PL (%) 60	0 SPT (Blows/0.3m) 60
93.78			Fill material, filled with slide debris of completely weathered-dark brown siltstone, uncompacted.			
1.00						
92.78		SS-1				
2.00						
91.78		SS-2				
3.00						
90.78		SS-3				
4.00						
89.78		SS-4				
5.00						
88.78		SS-5				
6.00						
87.78		SS-6				
7.00						
86.78		SS-7				
8.00						
85.78		SS-8				
9.00						

Source: Geo-Technology Consultants Co., Ltd.

Borehole BH-5 Page 2 /Cont.

Depth [m]	Recovery	Samples	Description	Symbol	Lab tests	SPT - N
9.04	0 (%)100				0 w.LL, PL (%) 50	0 SPT (Blows/0.3m) 50
9.4.78		SS-9				19
10.00		SS-10				21
11.00		SS-11				36
12.00		SS-12				21
13.00		SS-13				23
14.85		SS-14				40
16.00		SS-15	Completely weathered siltstone, dark brown, converted into dark brown silty clay of hard consistency.(original ground ?)			50
17.00		SS-16				50
18.00		SS-17				50
19.00		SS-18				50

Source : Geo-Technology Consultants Co., Ltd.

Borehole BH-5 Page 3 /Cont.

Depth (m)	Recovery	Samples	Description	Symbol	Lab tests	SPT - N
19.26	0 (%)				WLL, PL (%)	SPT (Blows/0.3m)
20.00		SS-19				
20.78		SS-20				
21.45		SS-21				
21.58		End of Borehole at sound rock (21.58 m)				

Thin-wall tube

Cased length

Spl. open

Rock core

Auger

Wash

OTHER

SPT (Blows/0.3m)

N

Penetration

Atterberg limits

WP W WL

Recovery

ROD

BOREHOLE LOG

Borehole: **BH-6** Project number: 4017
 Site location: Rt 1256 km 45.6 Vertical scale: 1:50
 Co-ords (x,y): Elevation [m]: 97.74
 G.W. Table [m]: Date started: 07-05-94
 Date finished: 09-05-94 Total depth [m]: 15.00

Depth [m]	Rec-covery	Samples	Description	Sym-bol	Lab tests	SPT - N
0.00	0 (%) 100				0 w.LL, PL (%) 50	0 SPT (Blows/0.3m) 50
0.74			Medium sandstone, highly weathered, reddish brown, 4 joint sets 70,30,45 and 10 degree from core axis, fe-oxide- and some clay stain on joint planes			
1.00						
1.74						
2.00			Hard sandstone, moderately weathered, reddish brown, coarse to medium grained, 3 joint sets 10,30 and 70 degree from core axis, fe-oxide and some clay staining on joint planes			
2.74						
3.42						
3.85						
4.39			Medium hard shale, highly weathered, reddish brown, 2 joint sets 30 and 70 degree from core axis, some parts decomposed to clay			
5.00						
5.74						
6.00			Medium hard siltstone, moderately weathered, reddish brown, 3 joint sets 10,10 and 70 degree from core axis, some shale fragments embedded, irregular cavity			
6.74						
7.80						
8.94			Medium hard sandstone, highly-weathered, reddish brown, 3 joint sets 10,10 and 40 degree from core axis, coarse to			

Source : Geo-Technology Consultants Co., Ltd.

Borehole BH-6 Page 2 /Cont.

Depth (m)	Recovery	Sample	Description	Sym	bol	Lab tests	SPT - N
9.04	0 (100)					w,LL,PL (%)	50 0 SPT (Blows/0.3m) 50
9.55 88.18			medium grained, fe-oxide and some clay staining on joint planes				
11.00 88.74			Medium hard sandstone, moderately to highly weathered, reddish brown, 4 joint sets 10-,40,60 and 80 degree				
12.00 88.74							
13.00 88.74			Medium hard sandstone, highly-weathered, reddish brown, 3 joint sets 10,40 and 70 degree from core axis				
13.85 83.89			Medium hard siltstone, moderately to highly weathered, reddish brown, 2 joint sets 45- and 70 degree from core axis				
14.85 82.89			Soft shale, highly weathered, reddish brown, 1 joint set 70 degree from core axis				
15.00 82.74			End of Borehole at 15.00 m				

Thin-wall tube
Cased length
Split spoon
Rock core
Auger
Wash
OTHER

SPT (Blows/0.3m)
N
Penetration
Atterberg limits
w_p w w_l

Recovery
RQD
Note : BH-6 was drilled 80-degree from vertical

BOREHOLE LOG

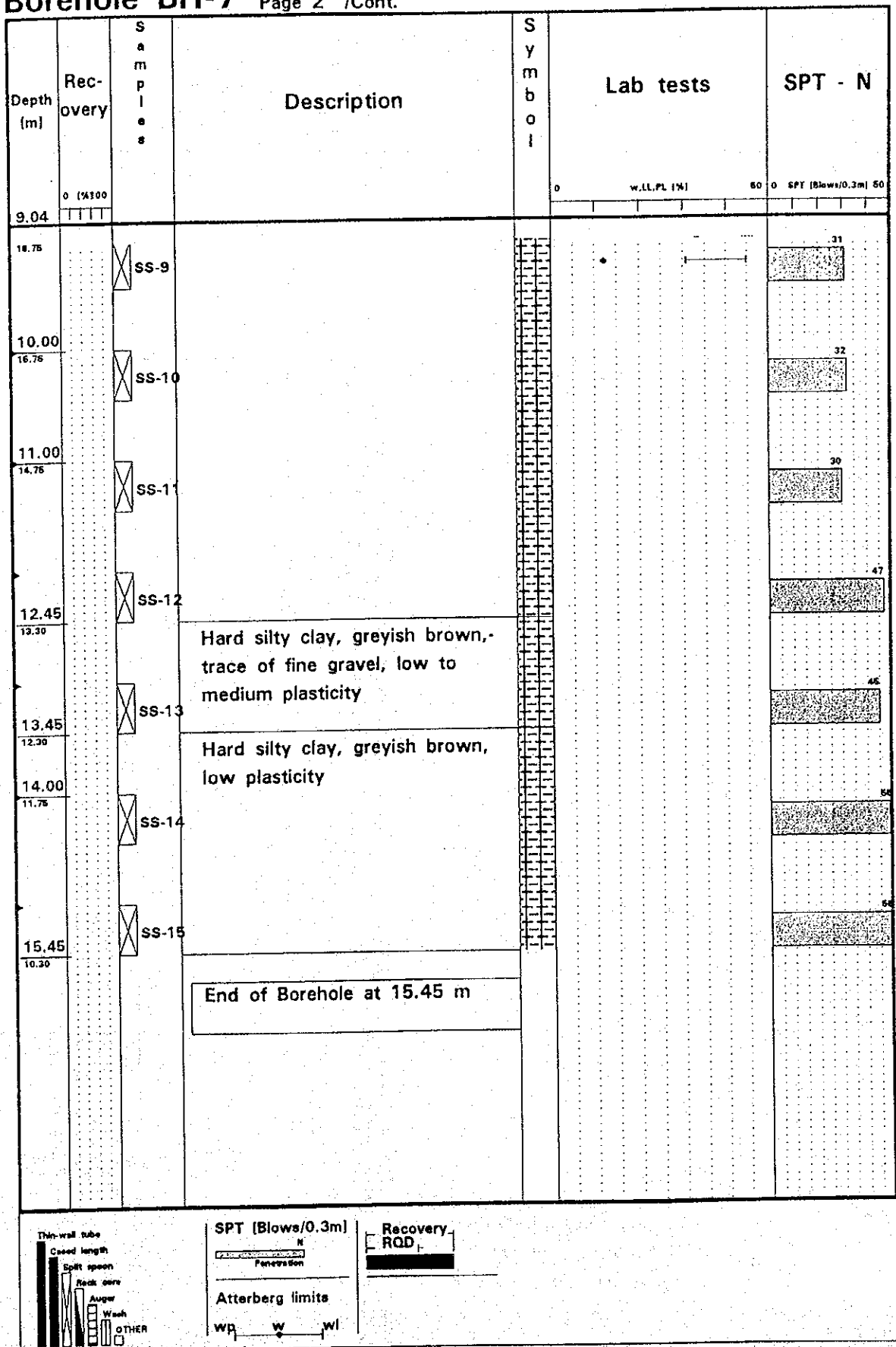
Borehole: **BH-7**
 Site location: Rt 4 km 44.7
 Co-ords (x,y):
 G.W. Table [m]: 3.20
 Date finished: 20-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation [m]: 25.75
 Date started: 18-06-94
 Total depth [m]: 15.45

Depth [m]	Rec- overy	S a m p l e s	Description	S y m b o l	Lab tests	SPT - N
0.00	0 (%)100				w,LL,PL (%)	0 SPT (Blows/0.3m) 50
25.75			Medium silty clay, greyish brown, low to medium plasticity, trace of sand			
1.45		SS-1				5
24.30			Stiff silty clay, greyish brown, low to medium plasticity			
2.45		SS-2				8
23.30			Very stiff silty clay, greyish brown, low plasticity			
3.00		SS-3				17
22.75						
4.00		SS-4				18
21.75						
5.45		SS-5				19
20.30			Very stiff silty clay, greyish brown, trace of fine sand			
6.00		SS-6				21
19.75						
7.45		SS-7				20
18.30			Hard silty clay, greyish brown, trace of fine sand			
8.45		SS-8				23
17.30			Hard silty clay, greyish brown, low plasticity			
9.00						

Source : Geo-Technology Consultants Co., Ltd.

Borehole BH-7 Page 2 /Cont.



BOREHOLE LOG

Borehole: **BH-8**
 Site location: Rt 410 km 76.42
 Co-ords (x,y):
 G.W. Table [m]: 3.25
 Date finished: 22-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation [m]: 44.00
 Date started: 21-06-94
 Total depth [m]: 10.05

Depth [m]	Recovery	Samples	Description	Symbol	Lab tests	SPT - N
0.00	0 100				0 w,LL,PL [%] 50	0 SPT (Blows/0.3m) 50
0.00						
1.00			Stiff to hard silty clay, greyish-brown, low plasticity, mixed with gravel, percentage of gravel less than 10%			7
2.00		SS-1				37
3.00		SS-2				26
4.00		SS-3				13
5.00		SS-4				28
6.00		SS-5				37
7.00		SS-6				36
7.75		SS-7				65
9.00		SS-8	Hard silty clay, greyish brown, trace of fine gravel, low plasticity (Original ground ?)			

Source : Geo-Technology Consultants Co., Ltd.

Borehole BH-8 Page 2 /Cont.

Depth [m]	Rec- overy	S a m p l e s	Description	S y m b o l	Lab tests	SPT - N
9.04	0 (%)100				w,LL,PL (%)	0 SPT (Blows/0.3m) 50
35.00		SS-9				49
10.05		SS-10				50
33.95			End of Borehole at 10.05 m			

Thin-wall tube

Cased length

Split spoon

Rock core

Auger

Wash

OTHER

SPT (Blows/0.3m)

N

Penetration

Atterberg limits

WP W WL

Recovery

RQD

BOREHOLE LOG

Borehole: **BH-9**
 Site location: Rt 410 km 97.8
 Co-ords (x,y):
 G.W. Table [m]: 0.00
 Date finished: 26-06-94

Project number: 4017
 Vertical scale: 1:50
 Elevation [m]: 35.00
 Date started: 26-06-94
 Total depth [m]: 5.00

Depth [m]	Recovery	Samples	Description	Symbo	Lab tests	SPT - N
0.00	0 1%100				0 w.LL.PL (%) 60	0 SPT (Blows/0.3m) 60
36.00			Medium hard schist, highly weathered, light grey, 3 joint sets 25,45 and 60 degree from core axis, Fe - oxide staining and clay filling in some joint	ΛΛ		
1.00				ΛΛ		
34.00				ΛΛ		
2.00				ΛΛ		
33.00				ΛΛ		
3.50				ΛΛ		
31.60			Hard schist, moderately to highly weathered, light grey to grey, 3 joint sets 20,30 and 80 degree from core axis	ΛΛ		
5.00			End of Borehole at 5.00 m	ΛΛ		
30.00				ΛΛ		

Thin-wall tube

Cased length

Split spoon

Rock core

Auger

Wash

OTHER

SPT (Blows/0.3m)

N

Penetration

Atterberg limits

WP W WL

Recovery

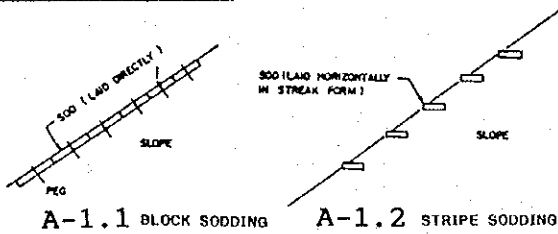
RQD

Note : BH-9 was drilled 75-degree from vertical

Appendix 4

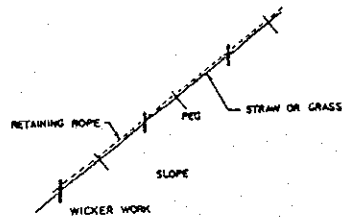


Appendix 4.1 Illustration of Restoration Measures

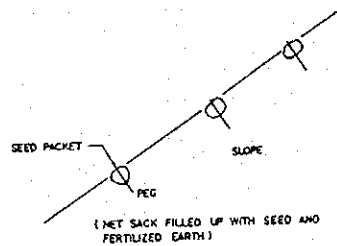


A-1.1 BLOCK SODDING

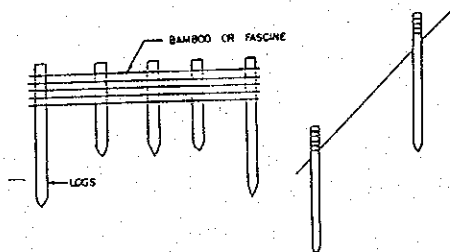
A-1.2 STRIPE SODDING



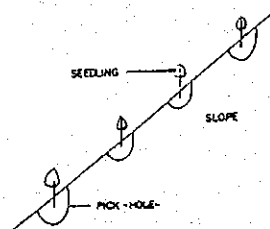
A-2.1 EROSION CONTROL WORK WITH LOCAL MATERIAL



A-2.2 SEED PACKET WORK

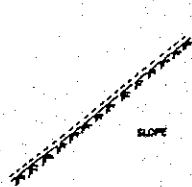


A-3.1 WICKER WORK

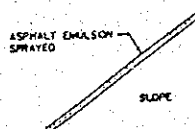


A-3.2 PICK - HOLE SEEDLING WORK

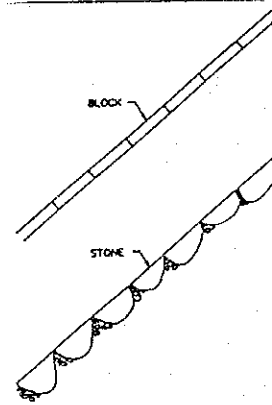
SLURRY OF SEED, FERTILIZER, FIBER, ETC.
SPRAYED TO THE WHOLE SURFACE



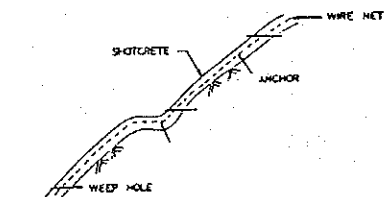
A-4.1 SEED SPRAYING WITH PUMP (HYDROSEEDING)



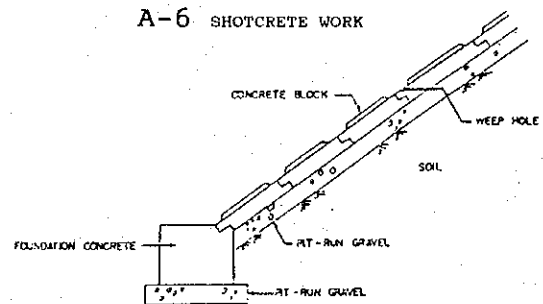
A-4.2 SEED-MIX SPRAYED WITH GUN



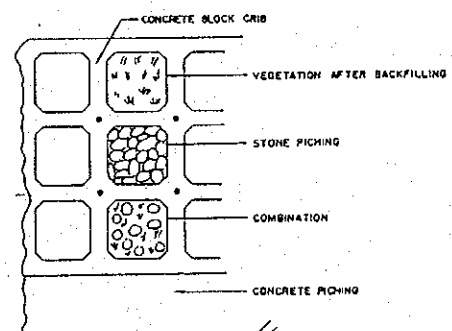
A-5 STONE OR BLOCK PITCHING



A-6 SHOTCRETE WORK

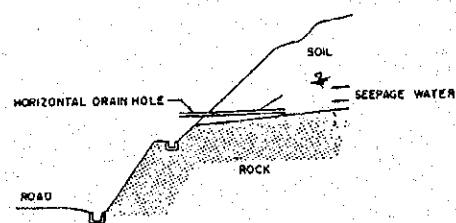
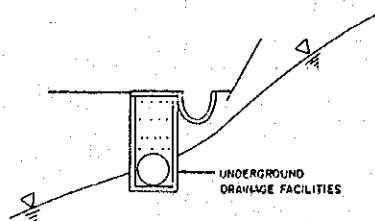
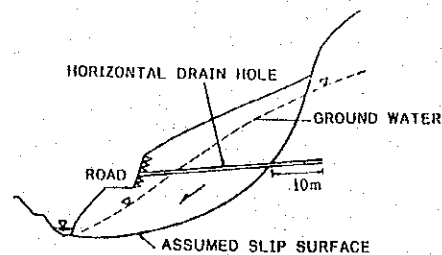
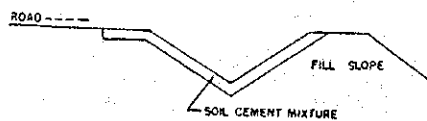
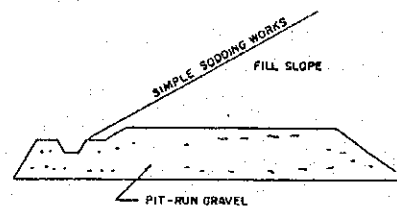
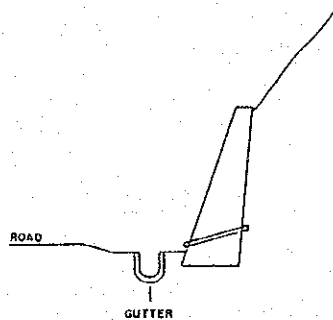
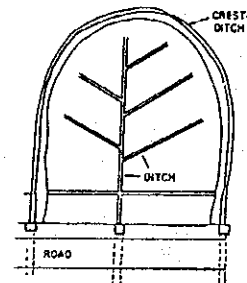
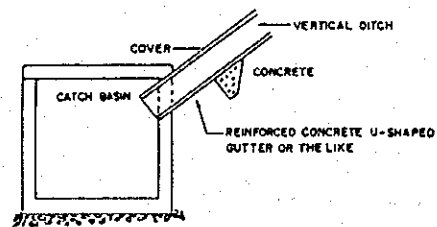
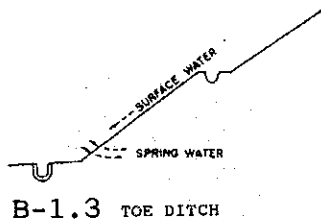
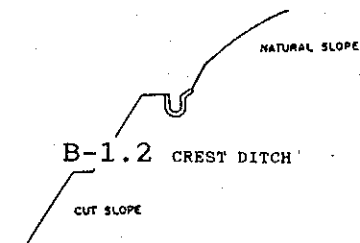
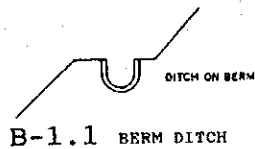


A-7 CONCRETE BLOCK PITCHING



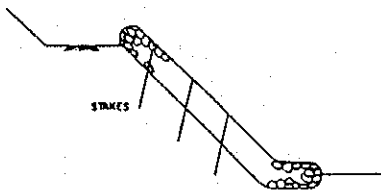
A-8 CRIBWORK

Slope Surface Protection

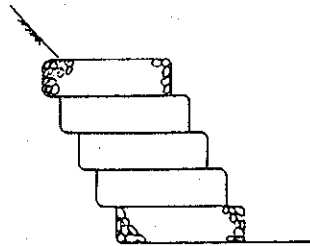


B-5.2 UNDERGROUND DRAINAGE WITH BLANKET

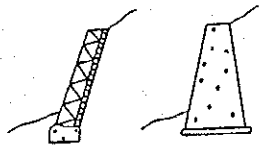
Slope Drainage



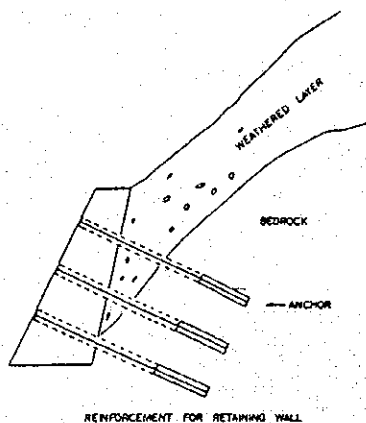
C-1.1 CYLINDER GABION



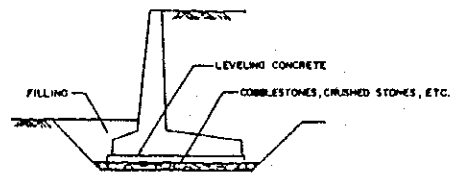
C-1.2 MAT GABION



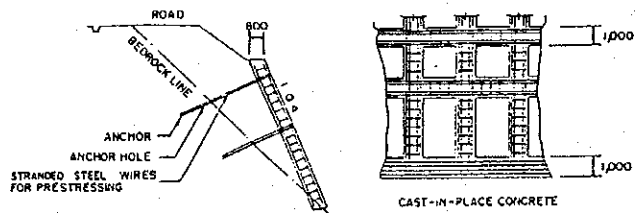
C-2.1 GRAVITY TYPE RETAINING WALL



C-2.2 GRAVITY TYPE RETAINING WALL WITH ANCHOR

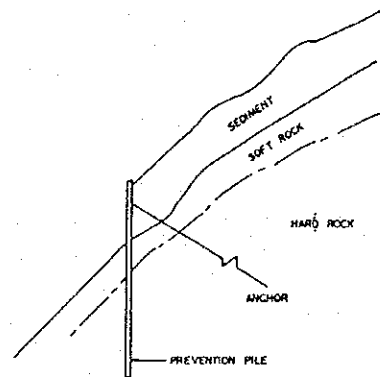


C-2.3 T-SHAPED RETAINING WALL



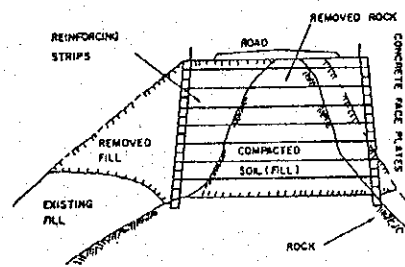
C-2.4 CRIB RETAINING WALL

C-2.5 CRIB RETAINING WALL WITH ANCHOR



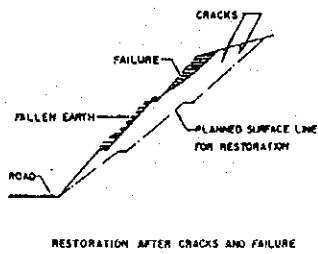
C-3.1 PREVENTION PILE

C-3.2 PREVENTION PILE WITH ANCHOR

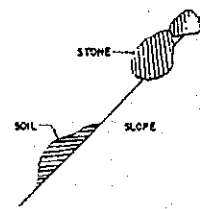


C-4 REINFORCED EMBANKMENT

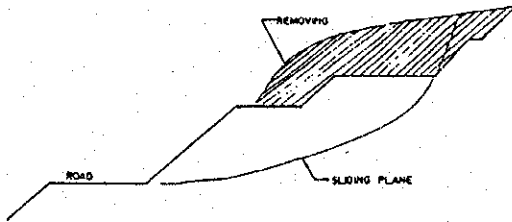
Slope Support



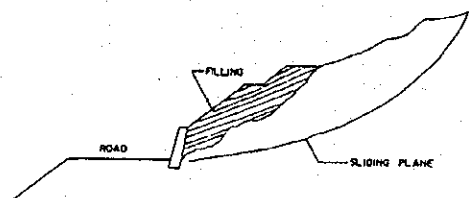
D-1 RECUTTING



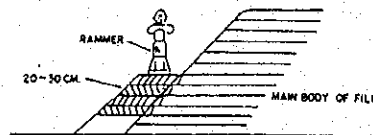
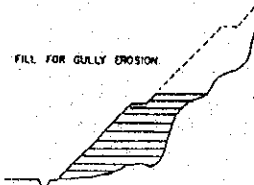
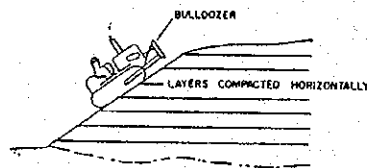
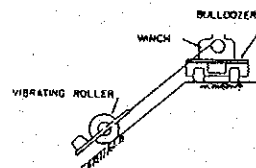
D-2.2 REMOVAL OF UNSTABLE MATERIAL



D-2.1 EARTH REMOVAL

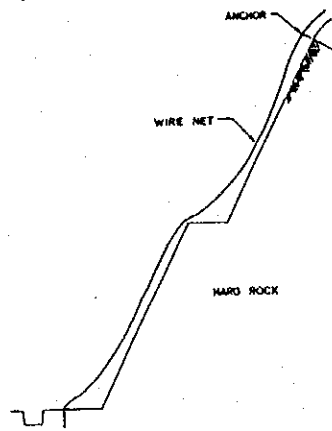


D-3 COUNTERWEIGHT FILL

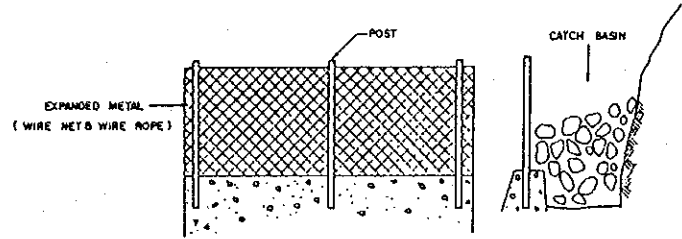


D-4 REFILLING WITH COMPACTION

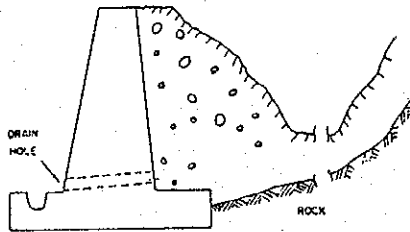
Slope Stabilization by Earth Work



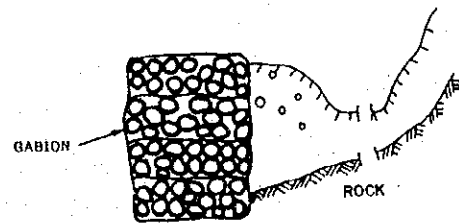
E-1 ROCKFALL PREVENTION NET



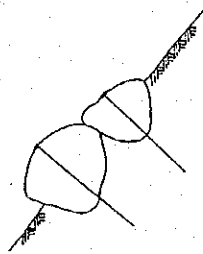
E-2 ROCKFALL PREVENTION FENCE



E-3.1 CONCRETE BARRIER FOR DEBRIS CATCH BASIN

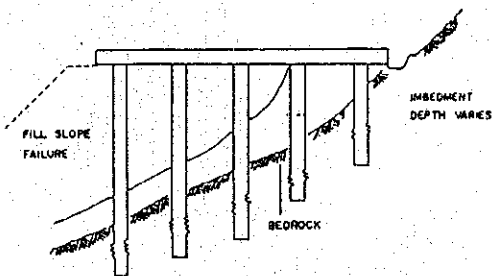


E-3.2 GABION BARRIER FOR DEBRIS CATCHBASIN

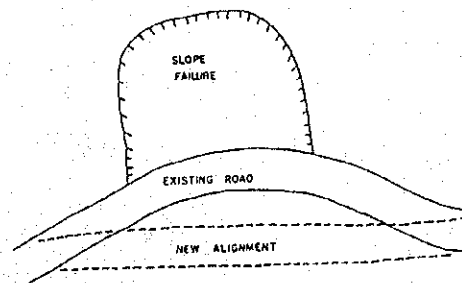


E-4 ROCK BOLT

Fig.6.1.5 Protection from Falling Rocks

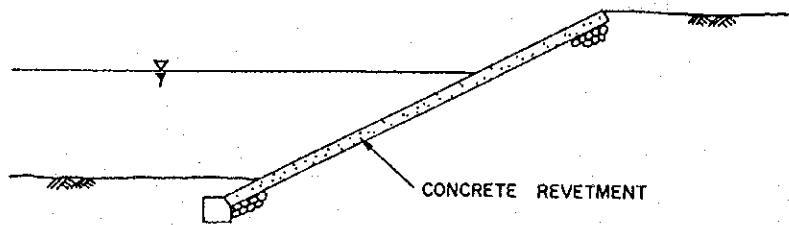


F-1.1 VIADUCT

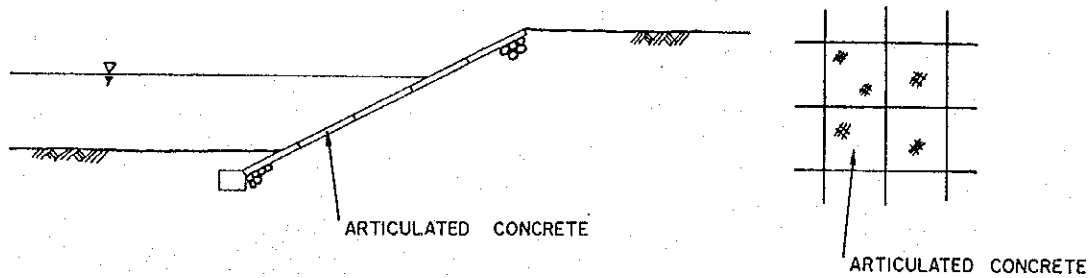


F-2 SHIFT OF ALIGNMENT

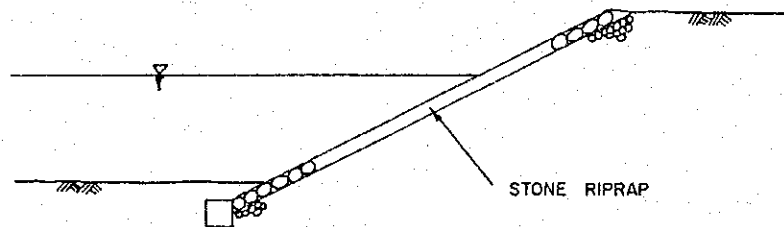
Others



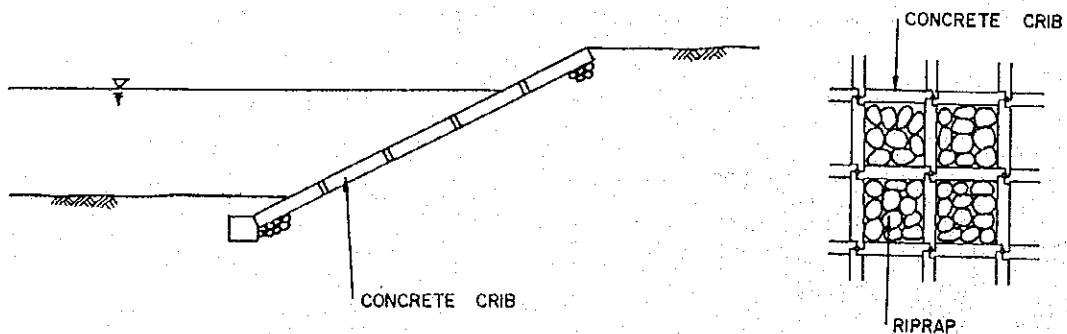
J-1.1 CONCRETE REVETMENT
K-1.1 CONCRETE REVETMENT



J-1.2 ARTICULATED CONCRETE REVETMENT
K-1.2 ARTICULATED CONCRETE REVETMENT

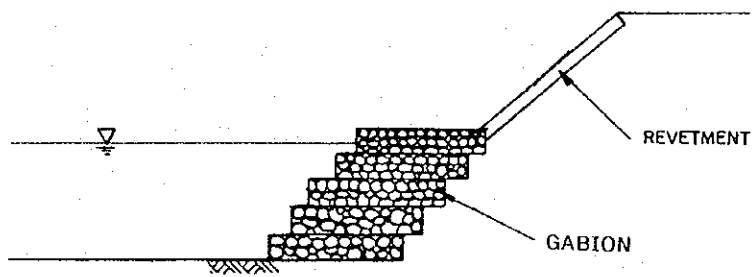


J-1.3 STONE RIPRAP REVETMENT (WITH MORTAR)
K-1.3 STONE RIPRAP REVETMENT (WITH MORTAR)

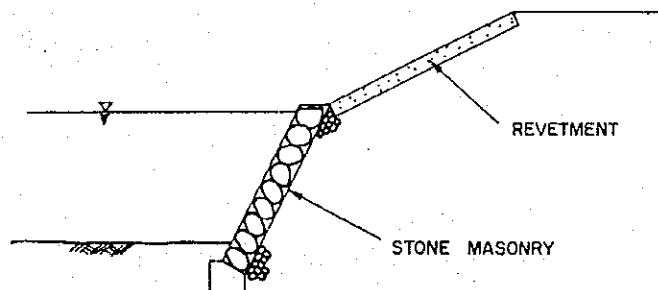


J-1.4 CRIBWORK WITH STONE RIPRAP
K-1.4 CRIBWORK WITH STONE RIPRAP

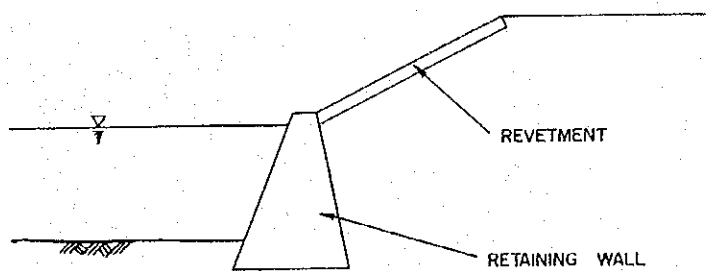
Securing of Abutment Fill Slopes and River Banks(1)



J-1.5 GABION

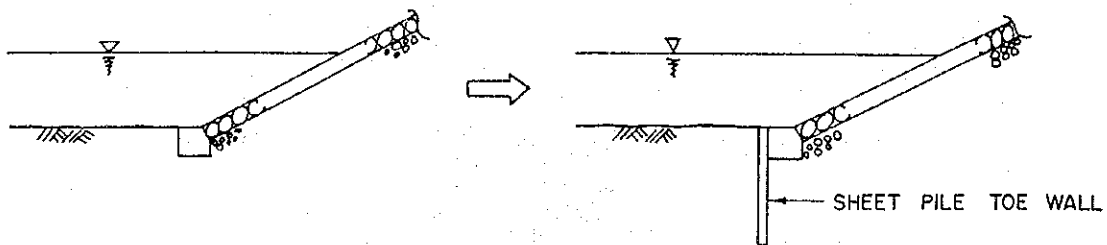


J-1.6 STONE MASONRY

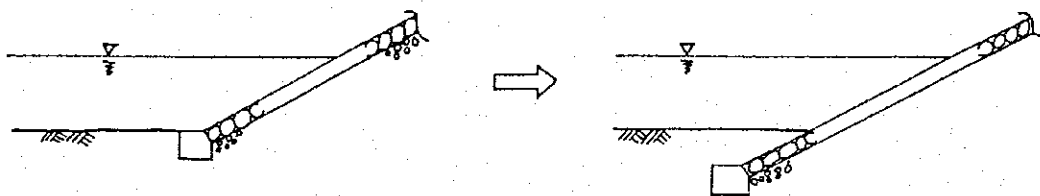


J-1.7 GRAVITY TYPE RETAINING WALL

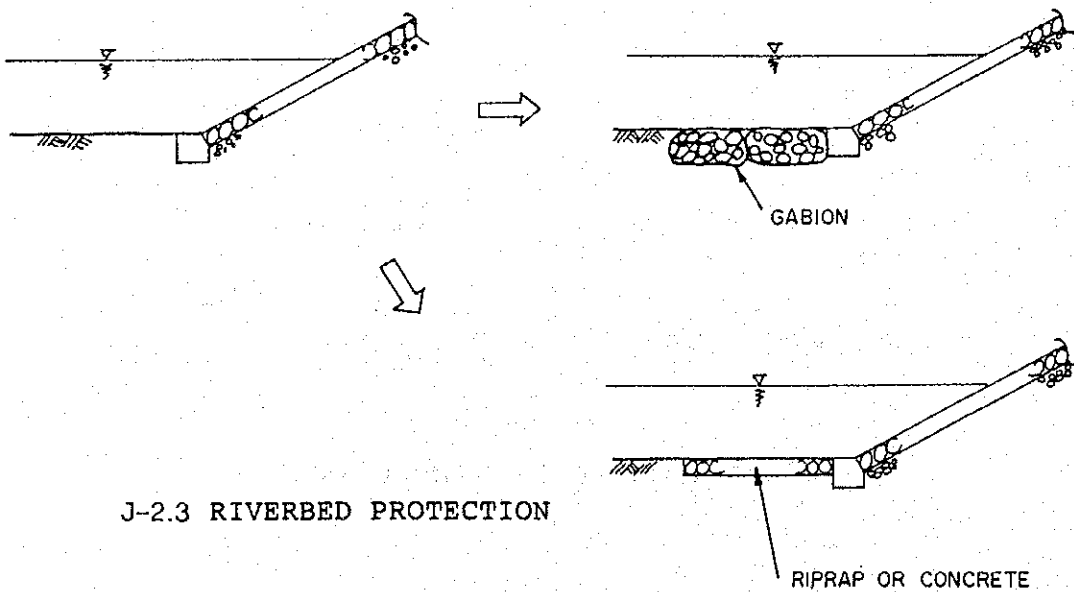
Securing of Abutment Fill Slopes and River Banks(2)



J-2.1 SHEET PILE TOE WALL

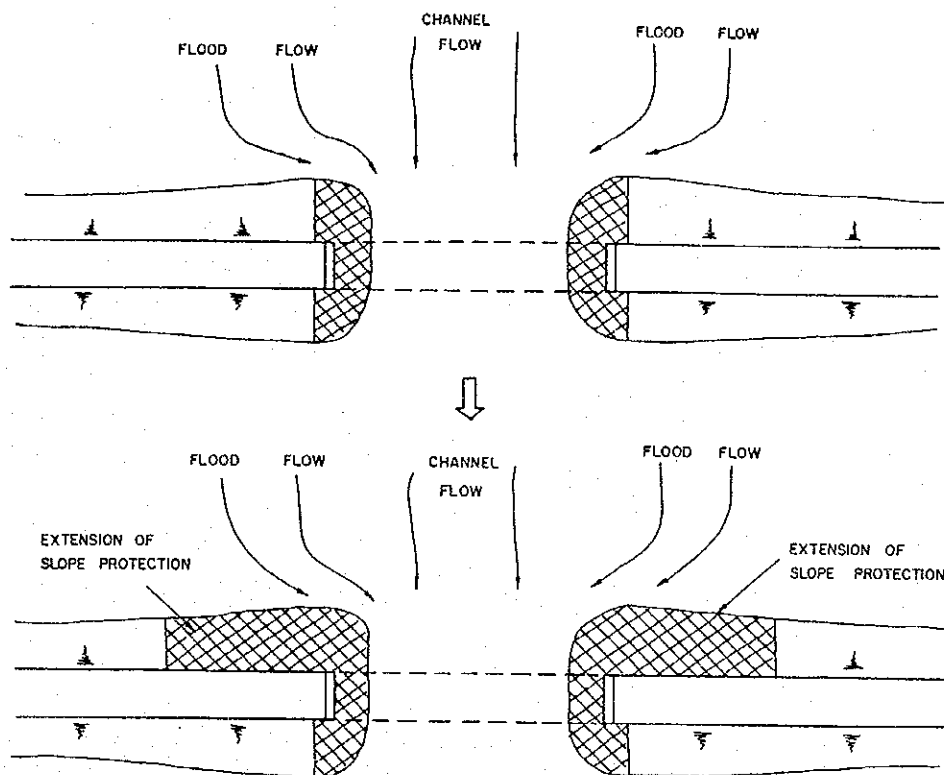


J-2.2 DEEP EMBEDMENT OF BASE



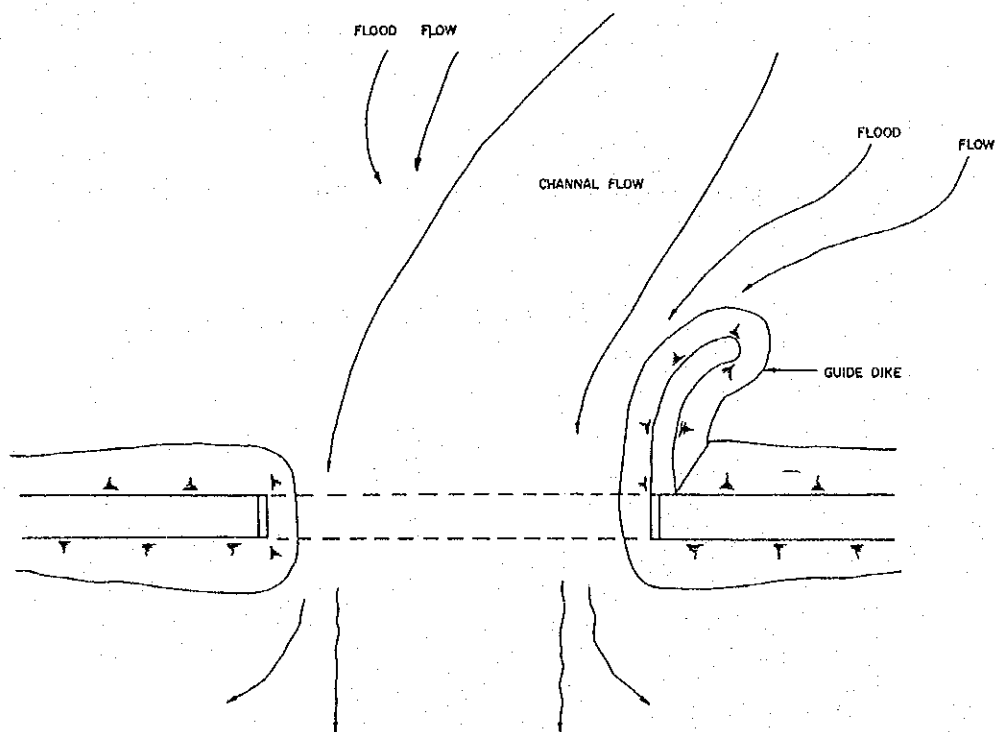
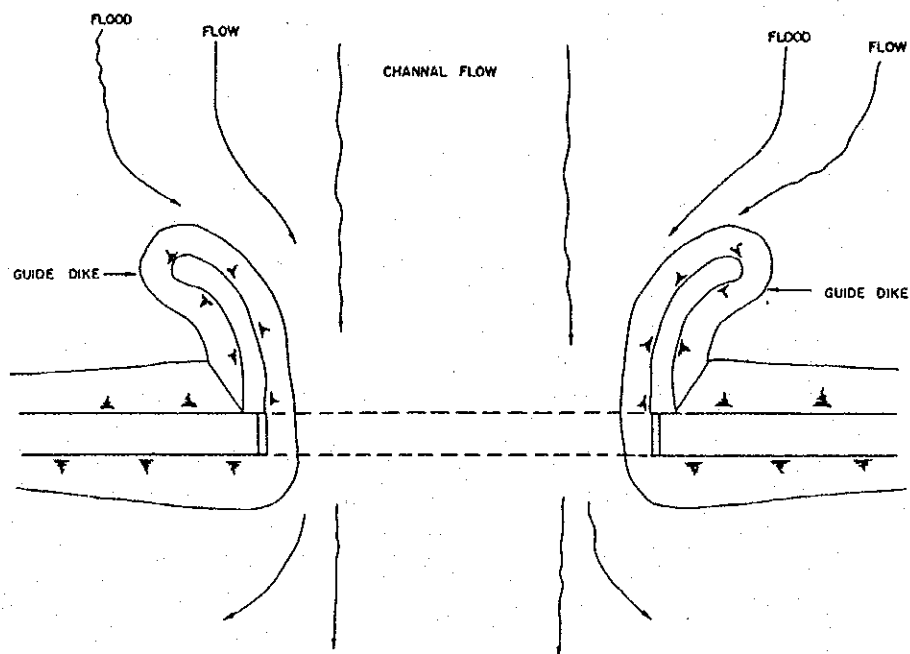
J-2.3 RIVERBED PROTECTION

Improvement of Existing Revetments



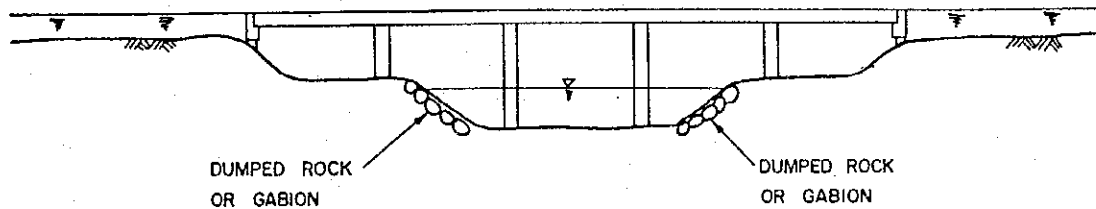
J-4 EXTENSION OF PROTECTION ON UPSTREAM SIDE

Extension of Fill-Slope Protection



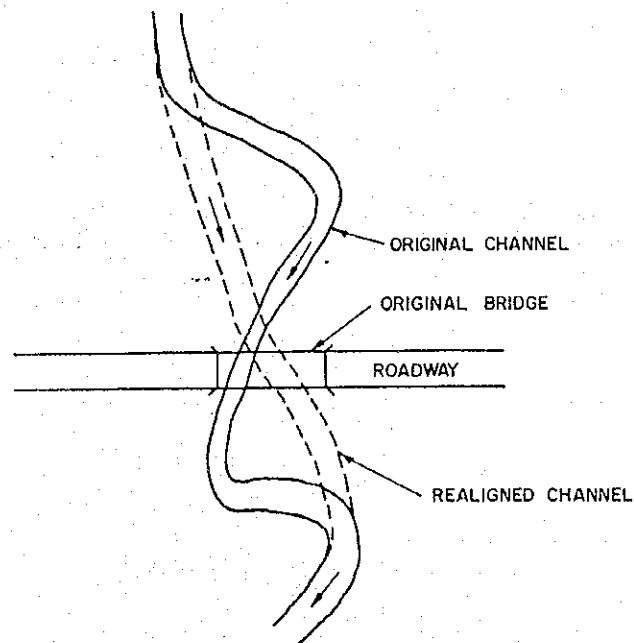
J-5 GUIDE DIKE
L-2 GUIDE DIKE

Water Flow Training



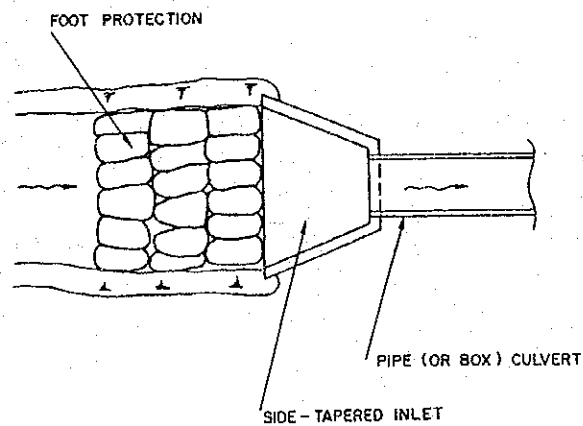
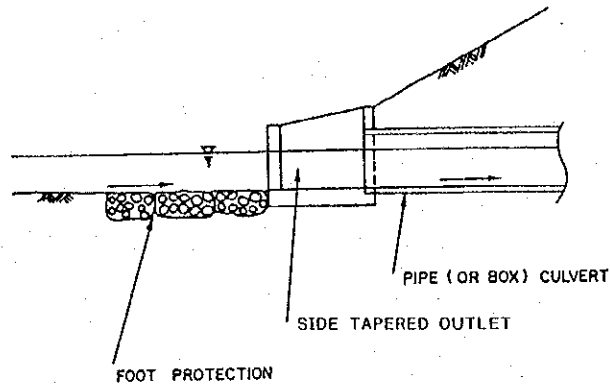
- L-1.1 STABILIZATION OF THE STREAM BANK WITH DUMPED ROCK
- L-1.2 STABILIZATION OF THE STREAM BANK WITH GABION

Fig.6.1.12 Stream Bank Stabilization

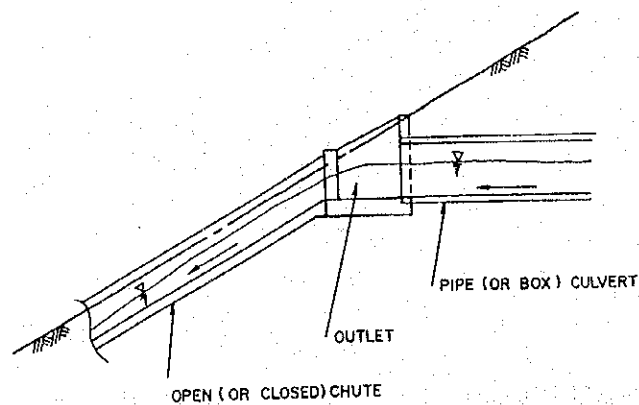


- L-3 REALIGNMENT OF THE TRAILWATER CHANNEL
- N-1 REALIGNMENT OF THE CHANNEL

Channel Realignment



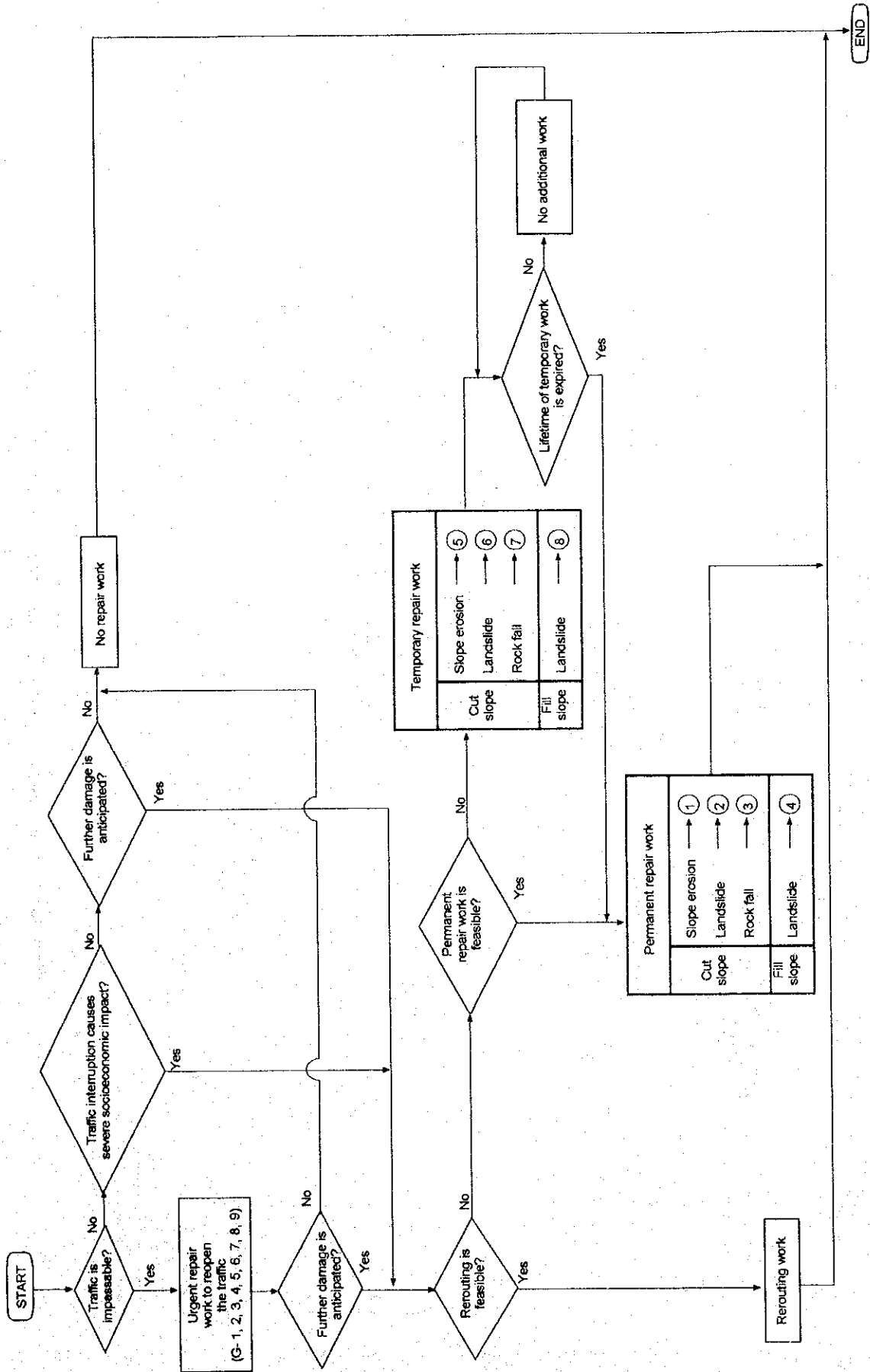
- O-1 SIDE-TAPERED INLET
- O-2 FOOT PROTECTION AT CULVERT ENTRANCE



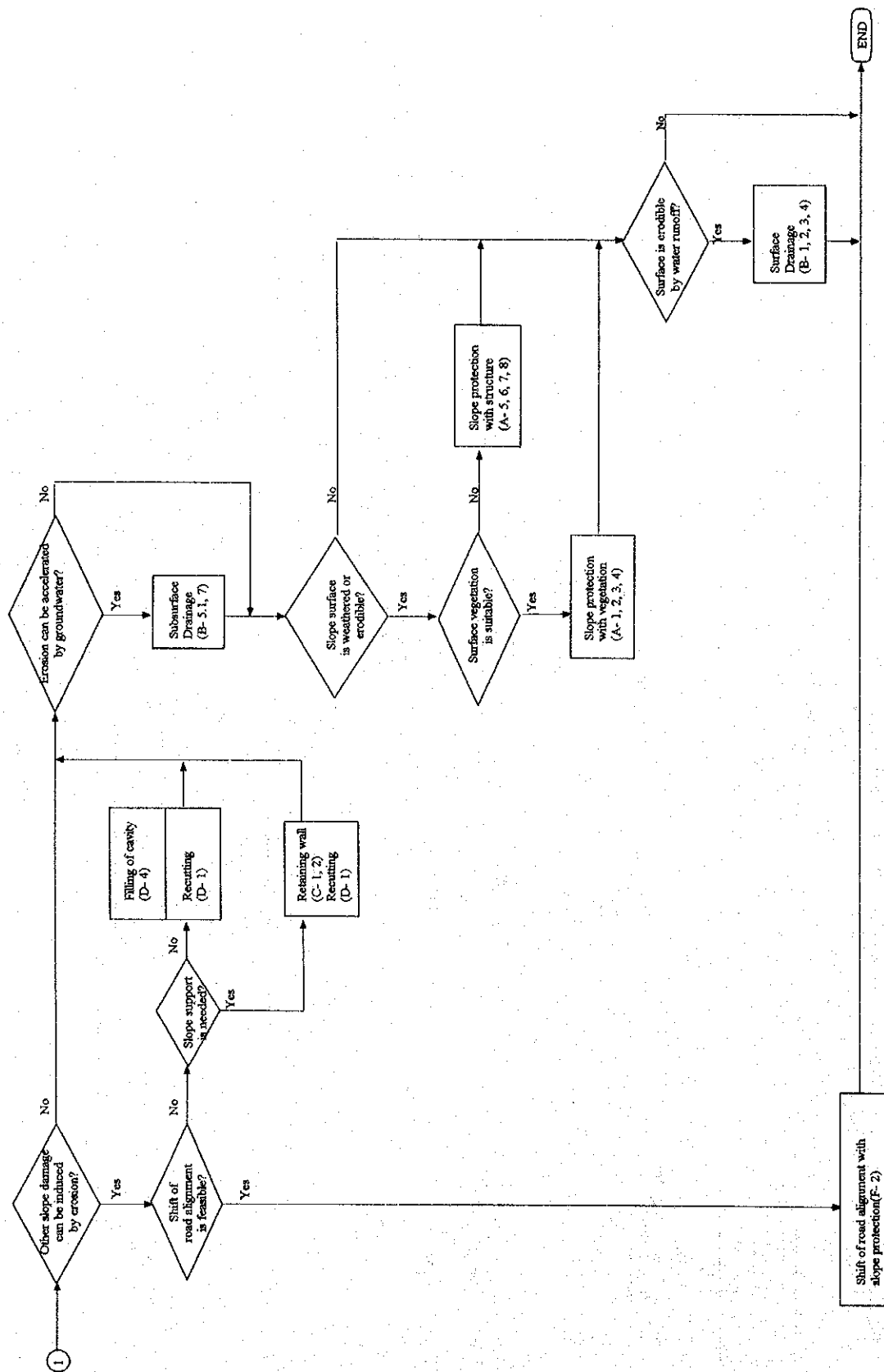
- O-5 SIDE-TAPERED OUTLET
- O-6 OPEN OR CLOSED CHUTE FOR TRAILWATER

Inlet and Outlet Control

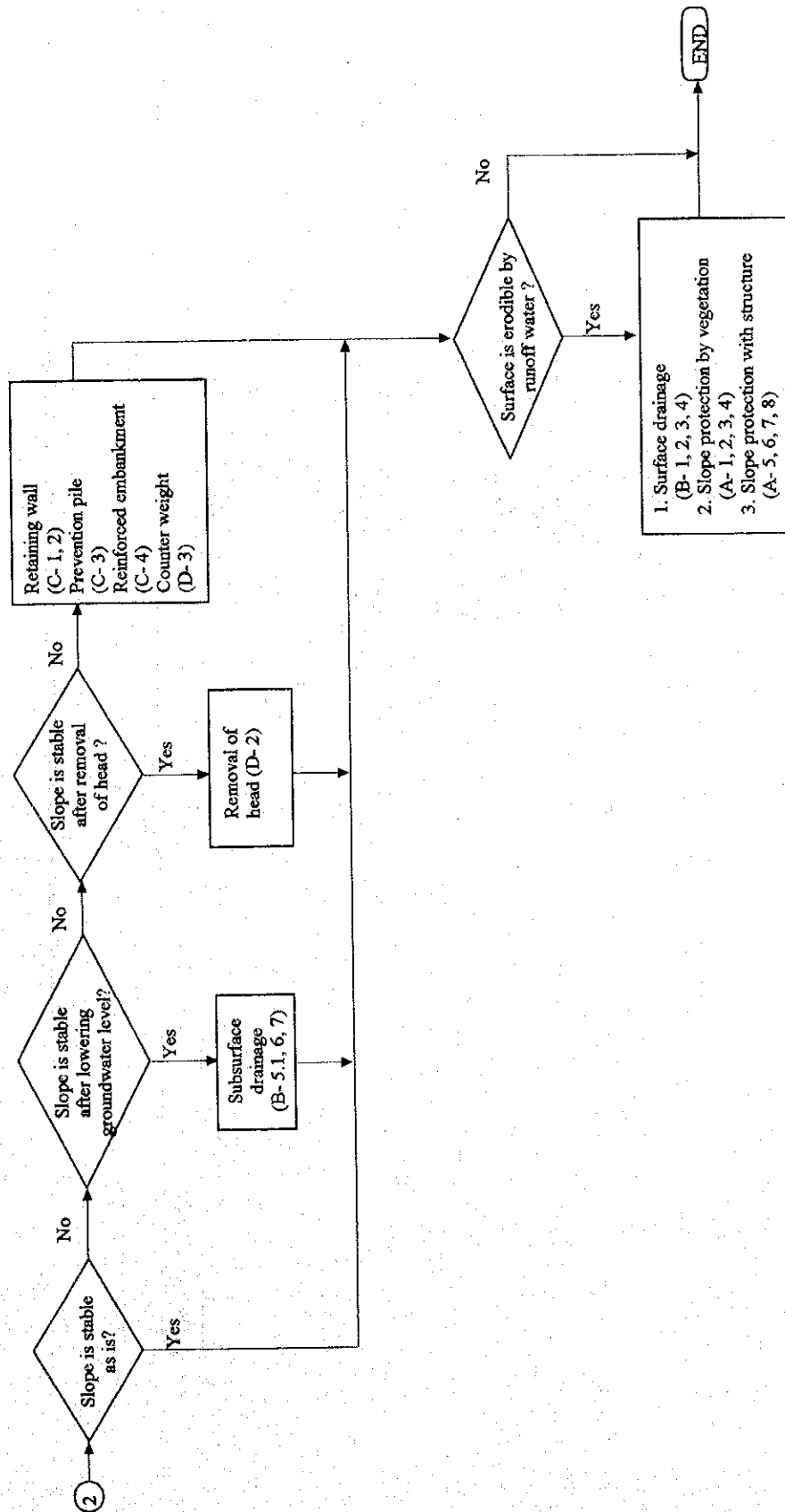
Appendix 4.2 Flowchart of Selection on Restoration Measure



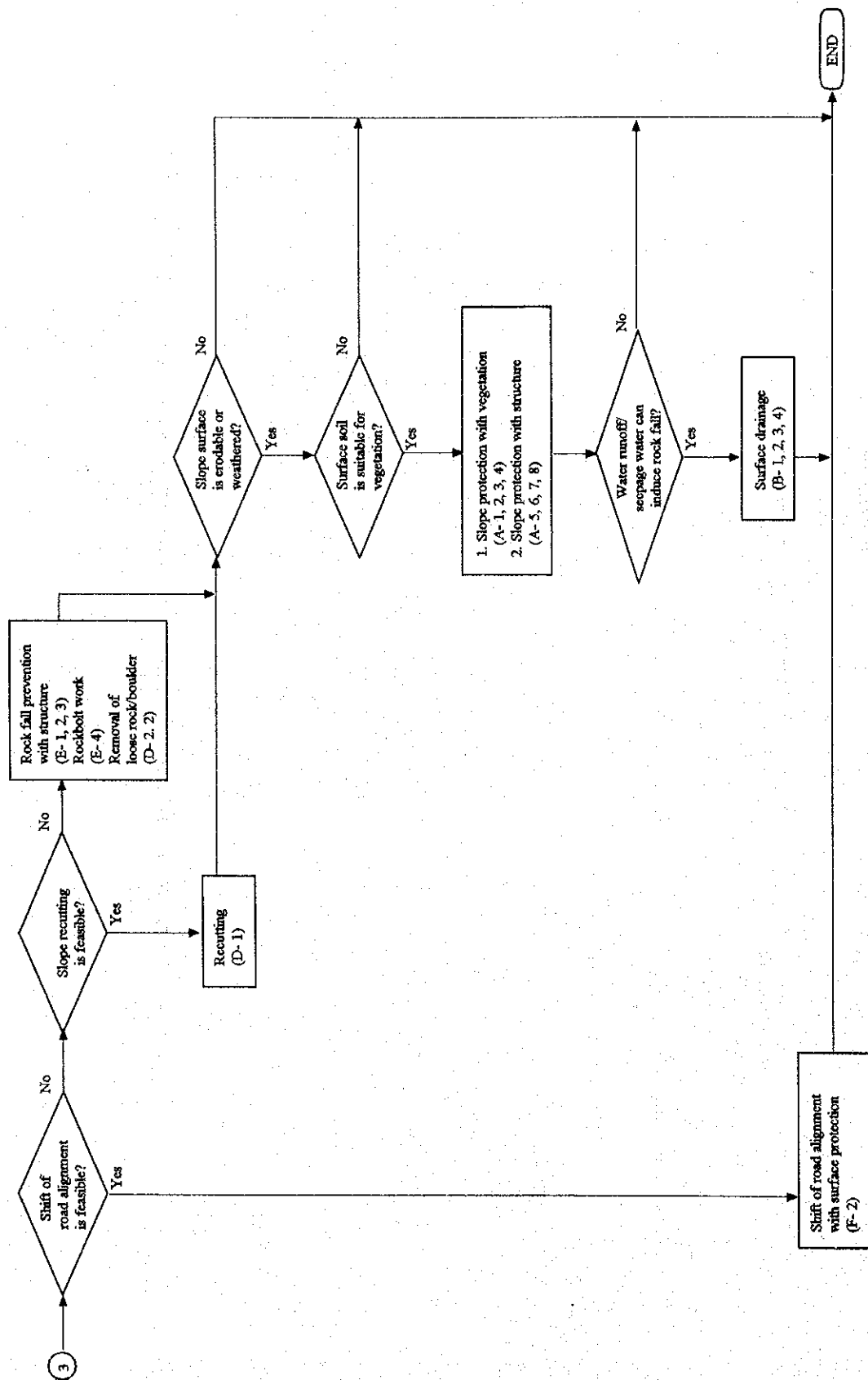
Selection of Restoration Measures for Slope & Embankments



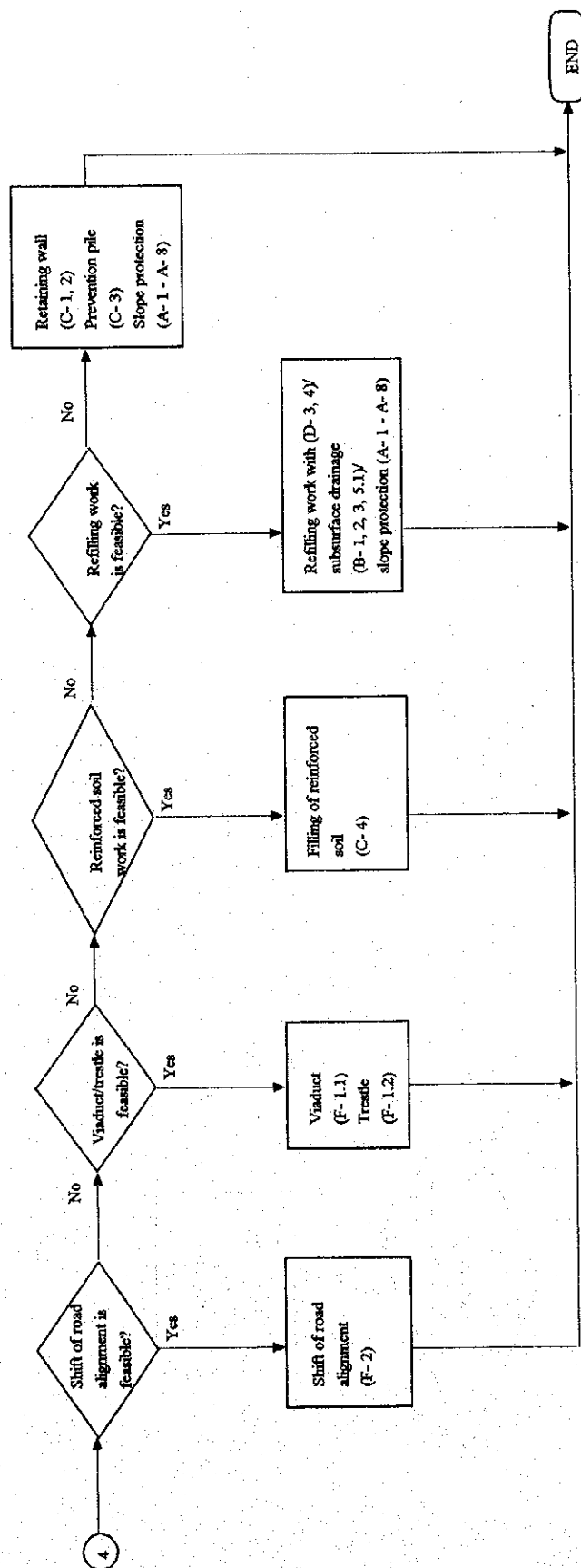
Selection of Anti-Erosion Measures for Cut Slopes Applying Permanent Repair Work



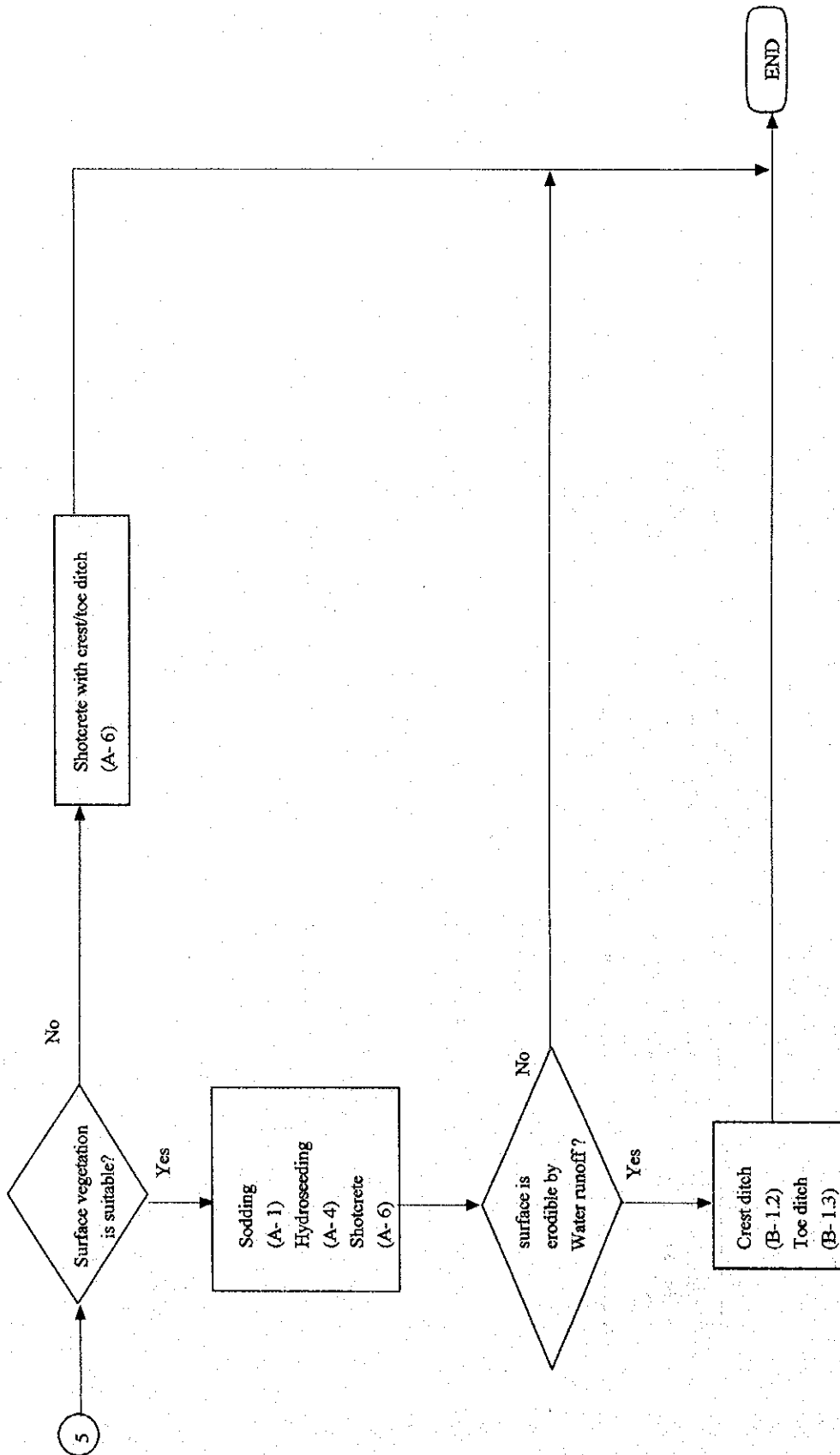
Selection of Restoration measures Applying Permanent Repair Work for Cut Slopes after a Landslide



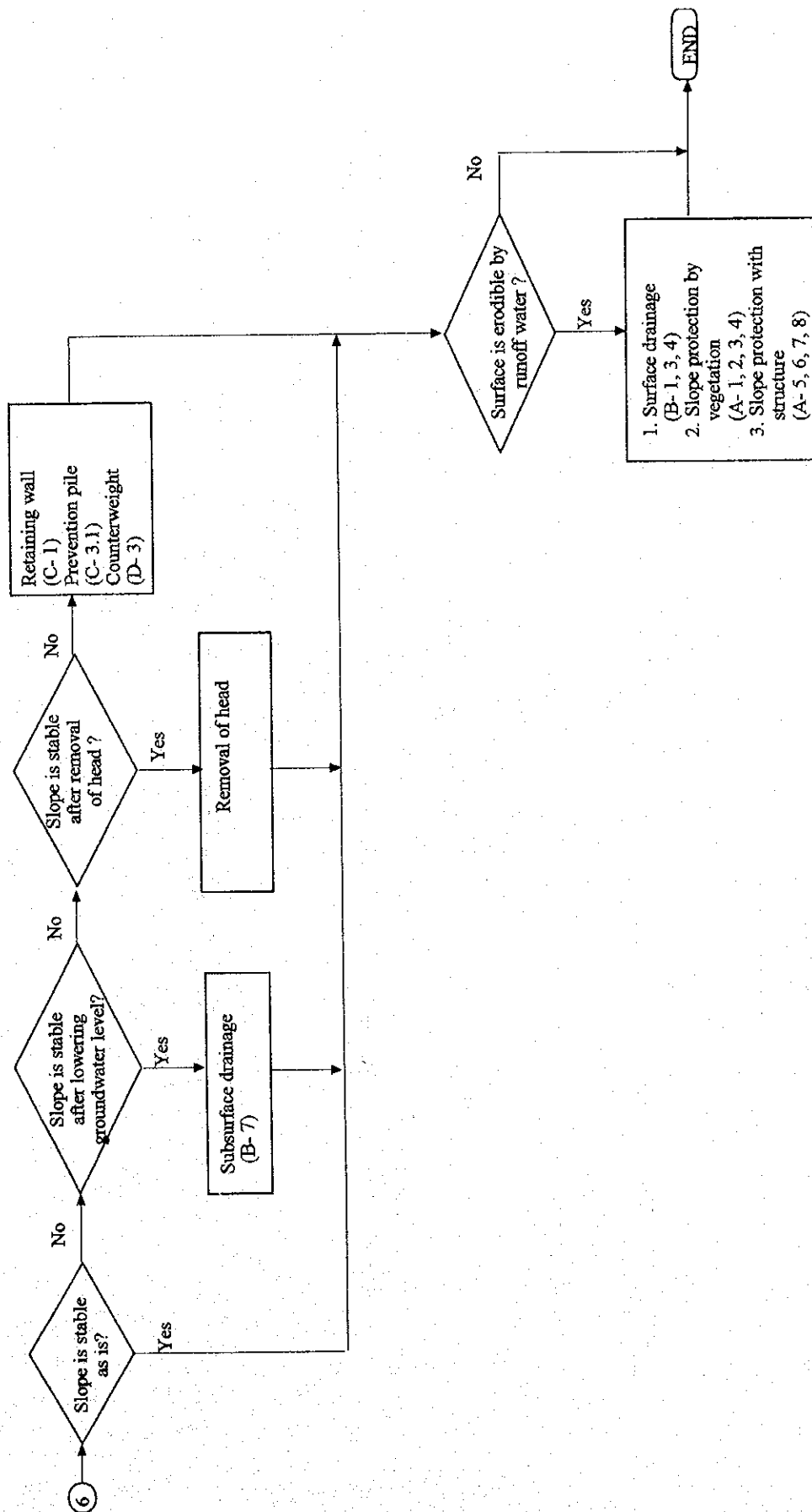
Selection of Restoration Measures Applying Permanent Repair Work for Cut Slopes after Rockfalls



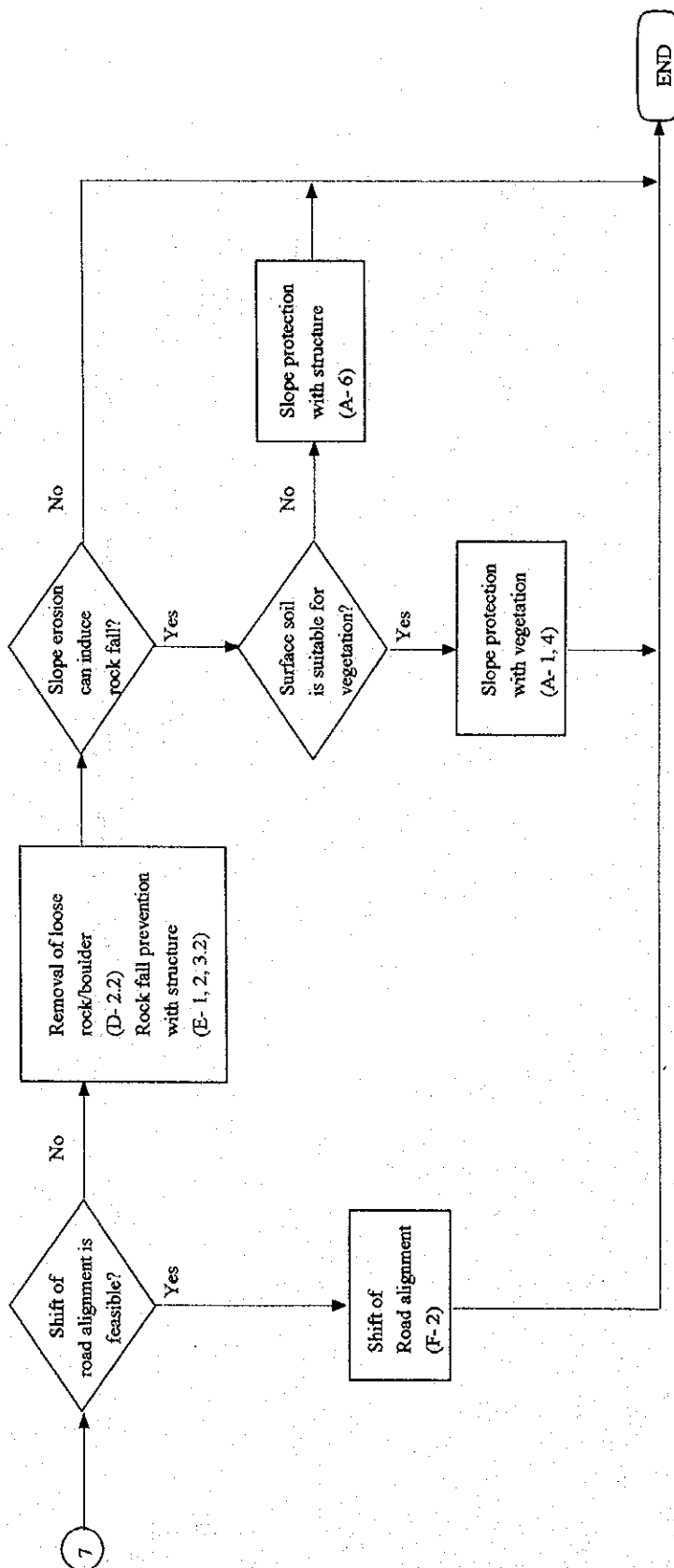
Selection of Restoration Measures Applying Permanent Repair Work for Fill Slopes after a Landslide



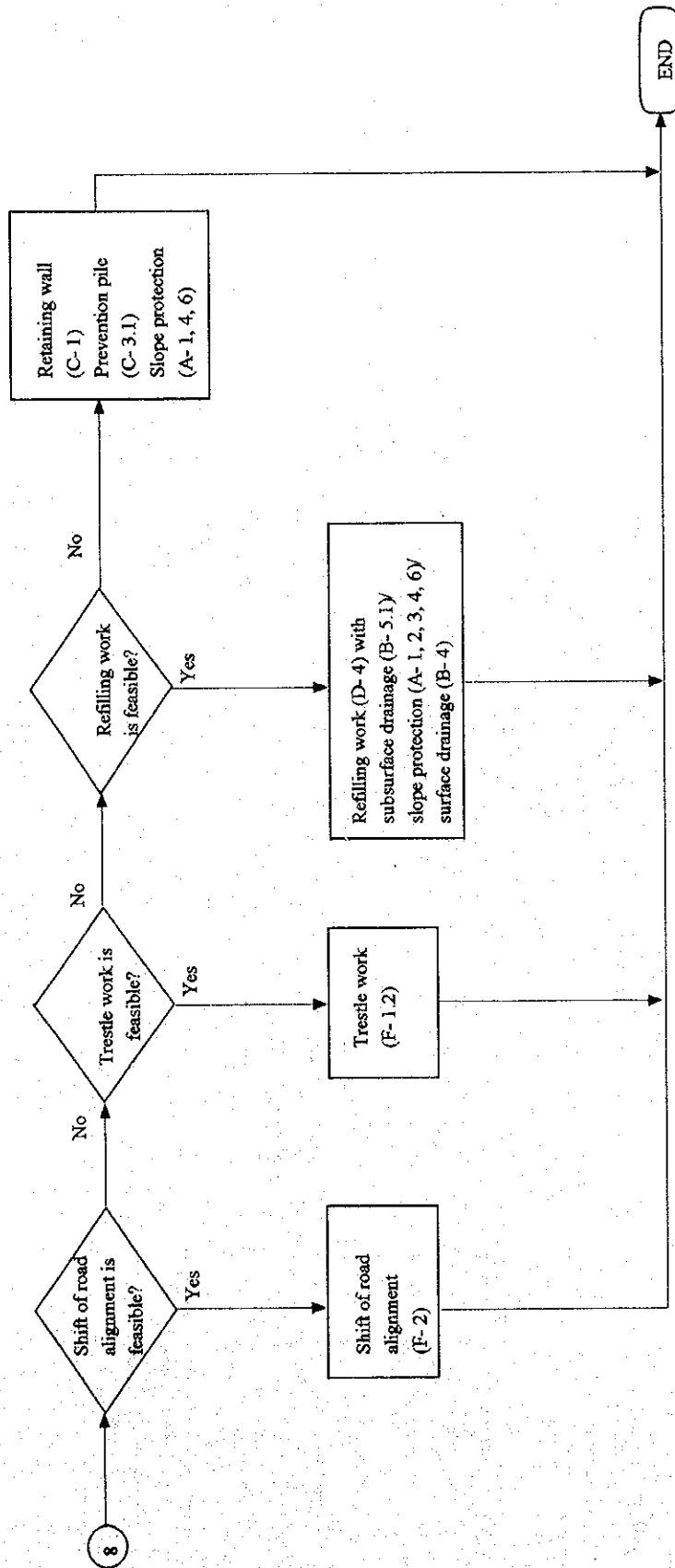
Selection of Anti-Erosion Measures Applying Temporary Repair Work for Cut Slopes



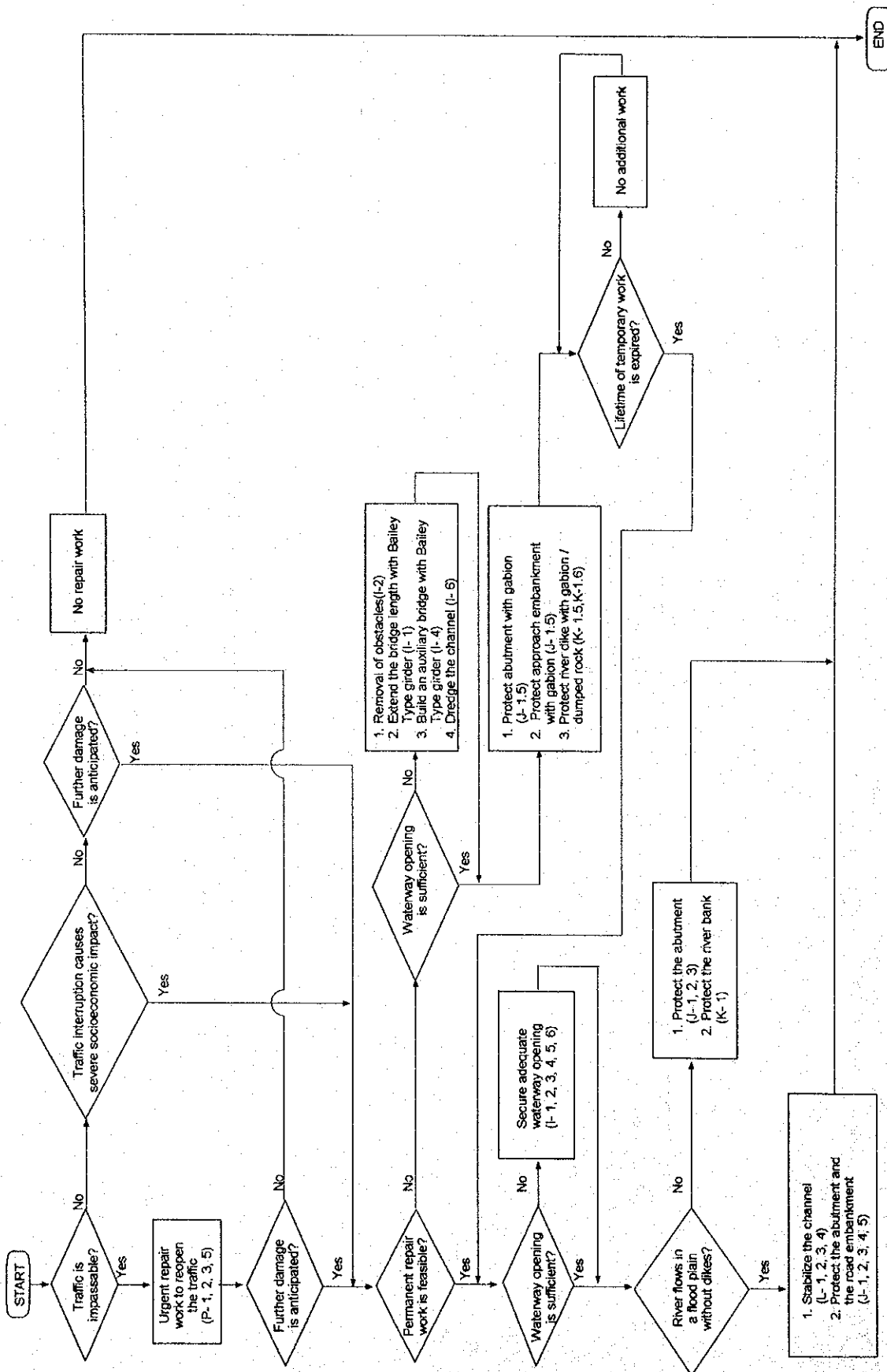
Selection of Restoration Measures Applying Temporary Repair Work for Cut Slopes after a Landslide



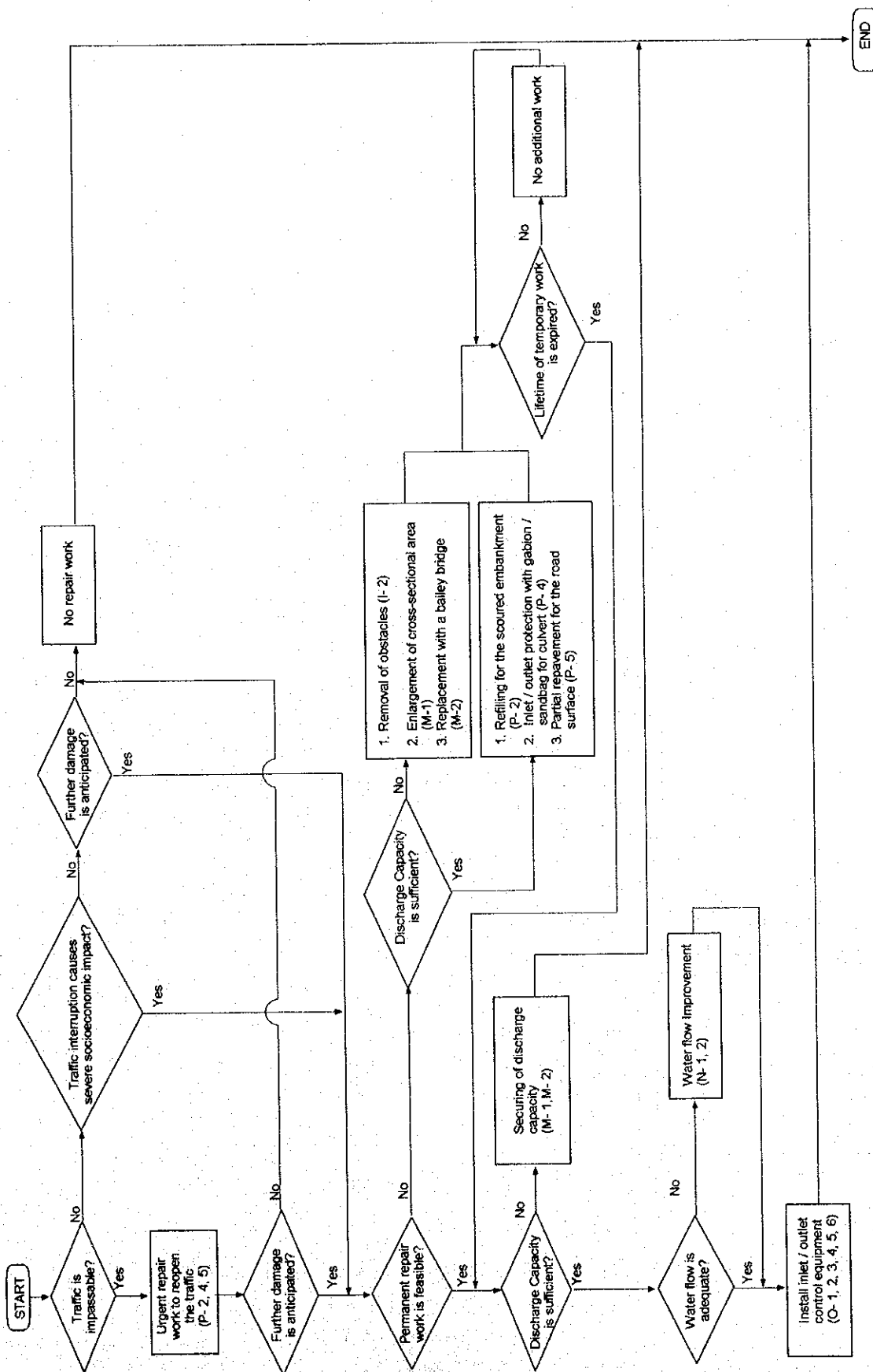
Selection of Restoration Measures Applying Temporary Repair Work for Cut Slopes after Rockfalls



Selection of Restoration Measures Applying Temporary Repair Work for Fill Slope after a Landslide



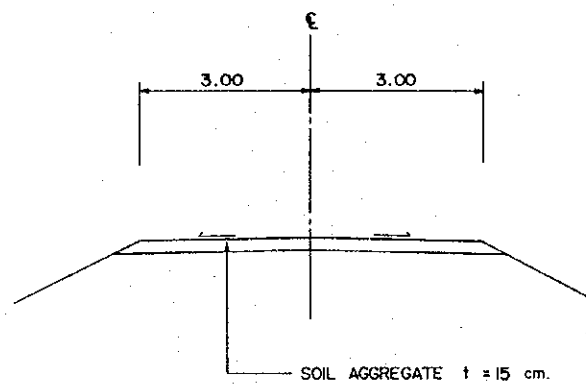
Selection of Restoration Measures for a Bridge Collapsing



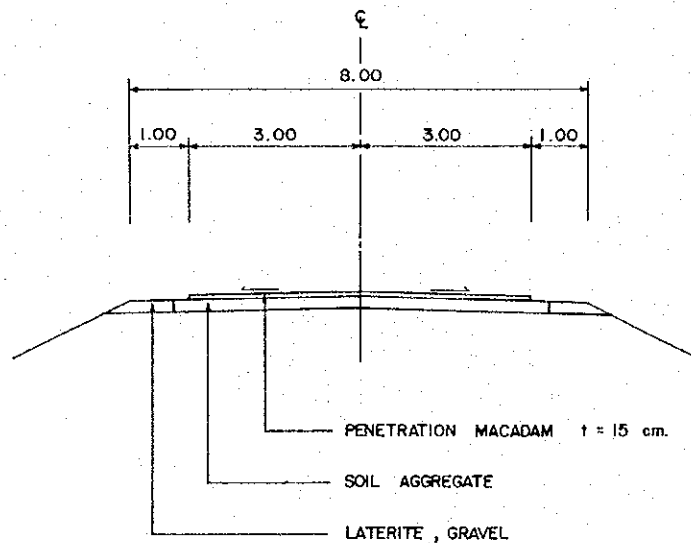
Selection of Restoration Measures for a Culvert Collapsing

Appendix 4.3 Standard Cross Section for Each Project Roads

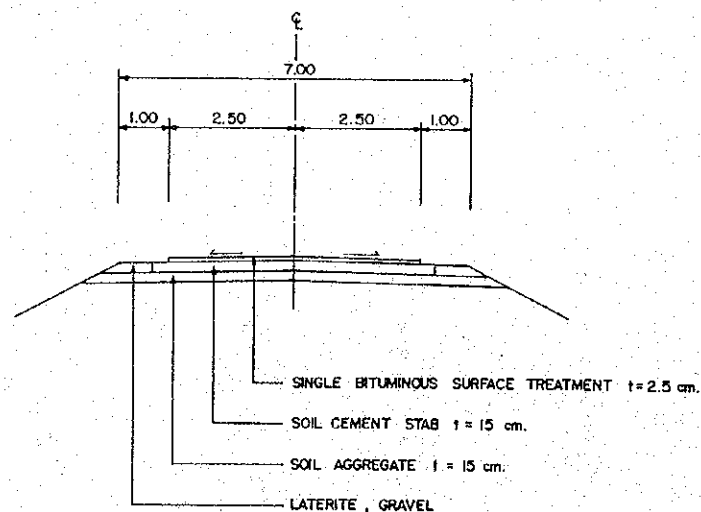
Route 109
Control No.0100



Route 109
Control No.0200

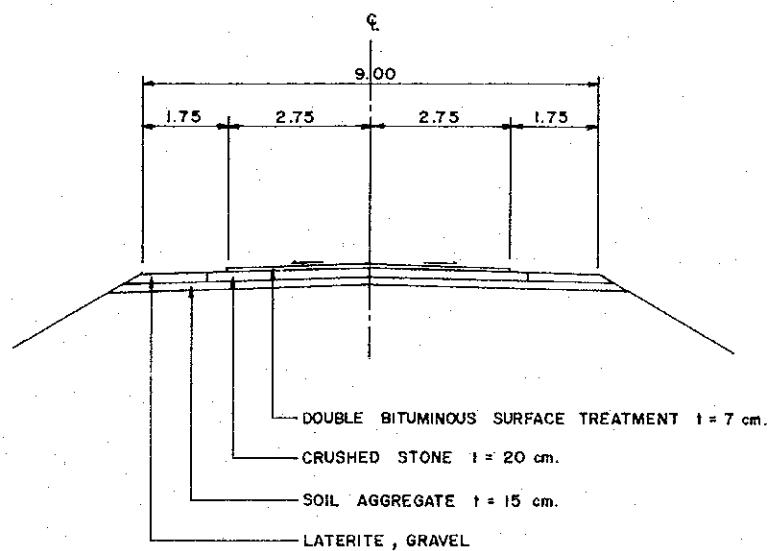


Route 1095
Control No.0500

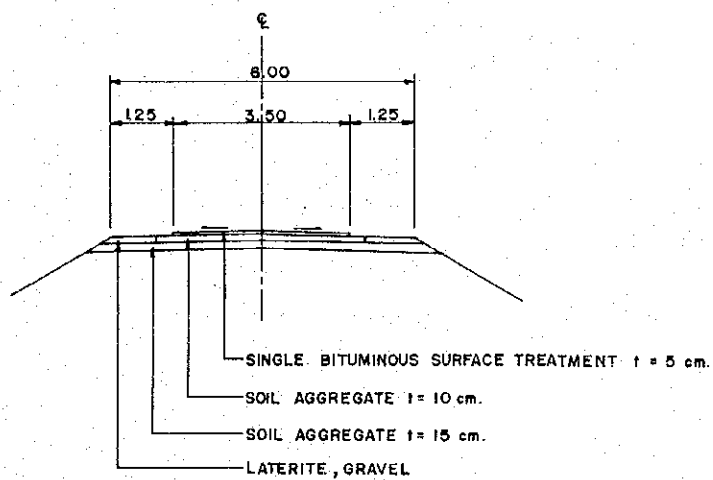


Standard Cross section (1)

Route 1149
Control No.0100

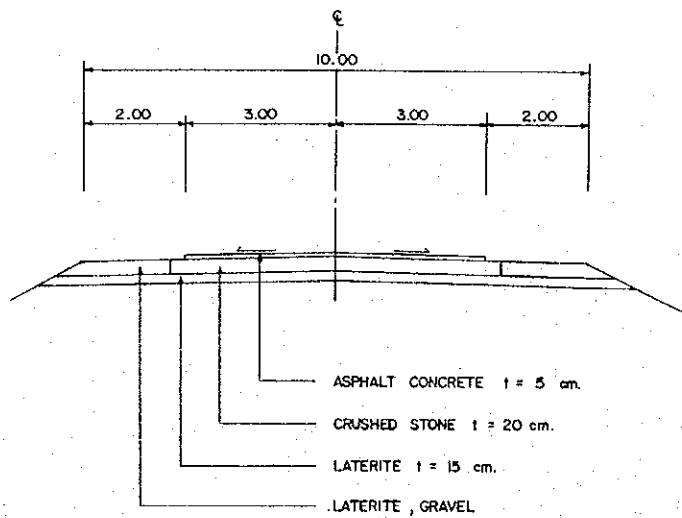


Route 1256
Control No.0101

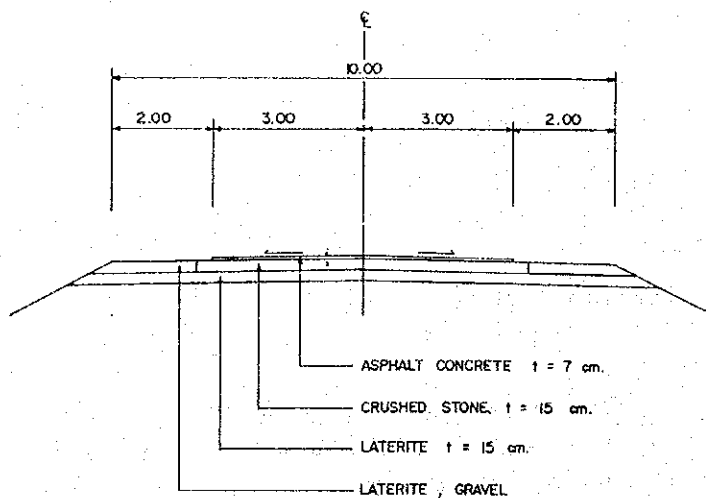


Standard Cross Section (2)

Route 4
Control No.3800

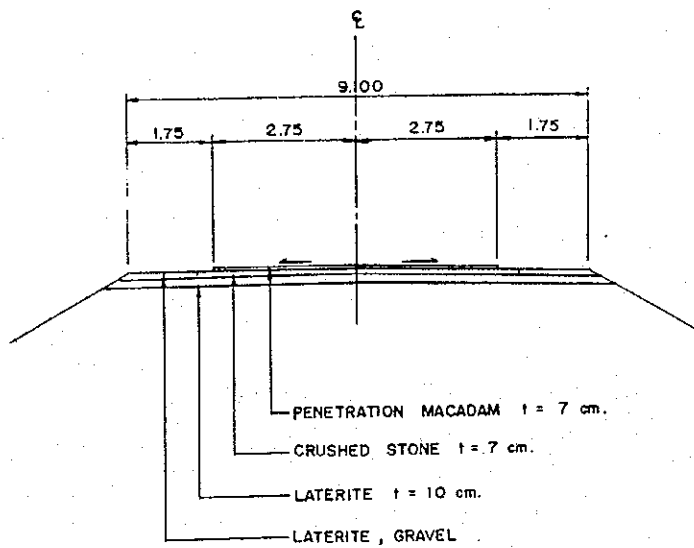


Route 4
Control No.3900

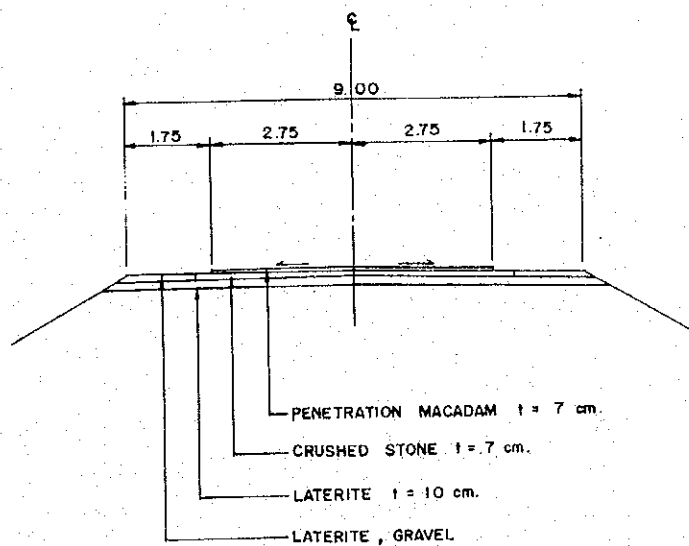


Standard Cross Section (3)

Route 410
Control No.0301

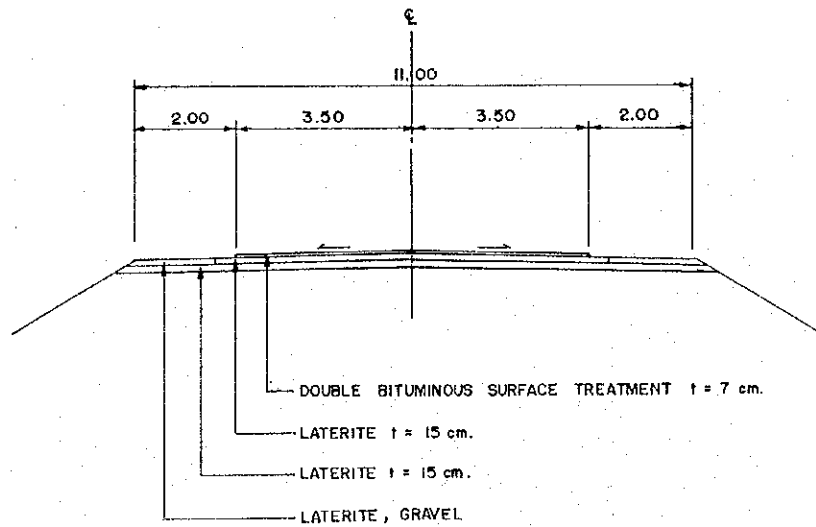


Route 410
Control No.0302

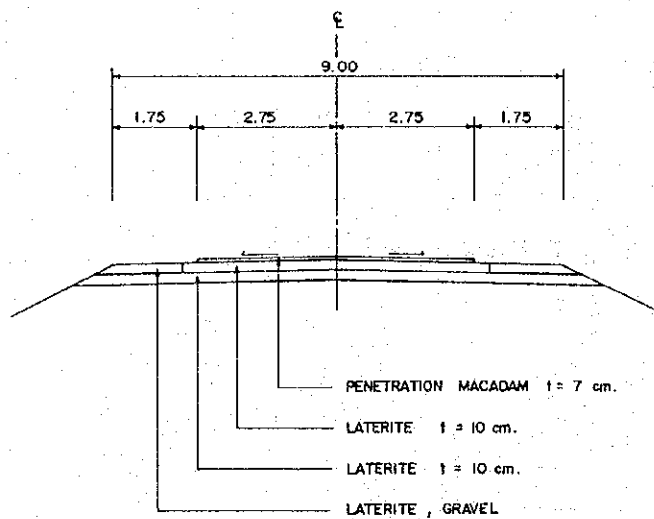


Standard Cross Section (4)

Route 410
Control No.0401

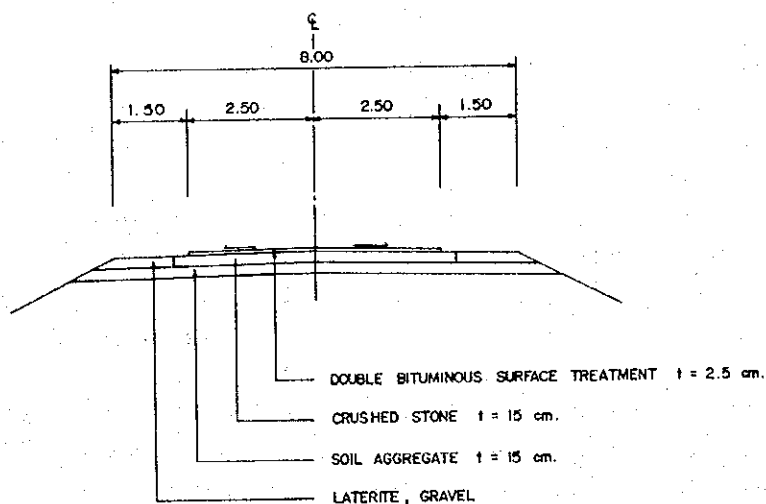


Route 410
Control No.402

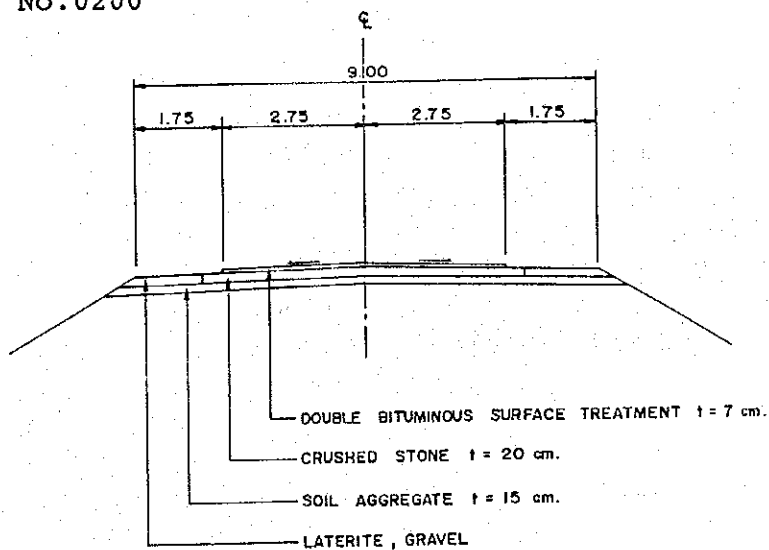


Standard Cross Section (5)

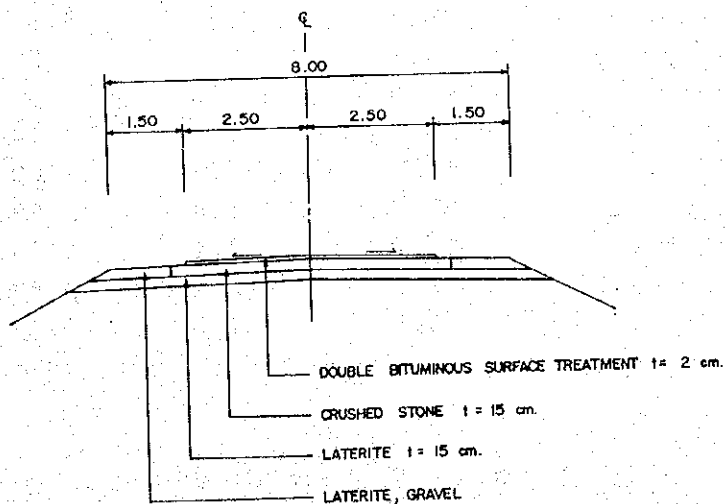
Route 4015
Control No.0201



Route 4107
Control No.0200



Route 4058
Control No.0100



Standard Cross Section (6)

Appendix 4.4 Discharge Capacity

Spot No.	n	A	P	R	i	Qc	Q
1256/2/3	0.05	220.8	52.2	4.23	0.020	1663.4	169.5
4/2/3	0.03	44.0	24.0	1.83	0.020	310.7	32.9
4015/1	0.03	322.7	132.4	2.44	0.030	3374.3	100.1
4015/4	0.05	112.7	41.0	2.75	0.020	625.5	455.1
4015/5	0.04	45.0	67.0	0.67	0.020	122.0	313.7
4015/c1	0.04	80.0	30.0	2.67	0.025	608.1	263.0
4015/c2	0.04	276.0	58.0	4.76	0.020	3680.9	183.2
4107/1/2	0.035	57.5	30.5	1.89	0.020	354.5	335.5
4058/1	0.045	57.0	31.0	1.84	0.010	190.1	188.5

Where,

- n = Roughness Coefficient ($\text{sec}/\text{m}^{1/3}$)
- A = Cross-sectional Area of Water Flow (m^2)
- P = Length of Wetted Perimeter (m)
- R = A/P : Hydraulic Radius (m)
- i = Hydraulic Gradient
- Qc = Discharge Capacity (m^3/sec)
- Q = Discharge Volume (m^3/sec)

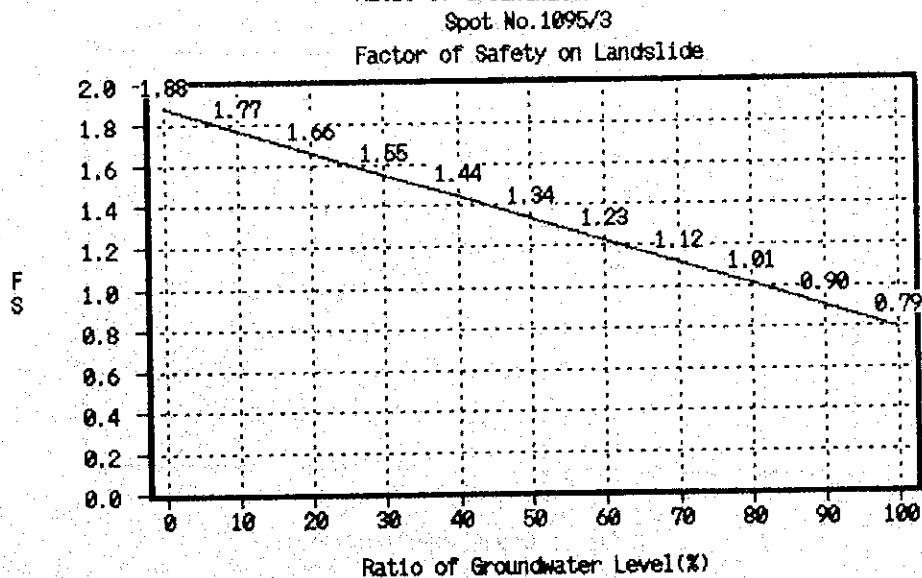
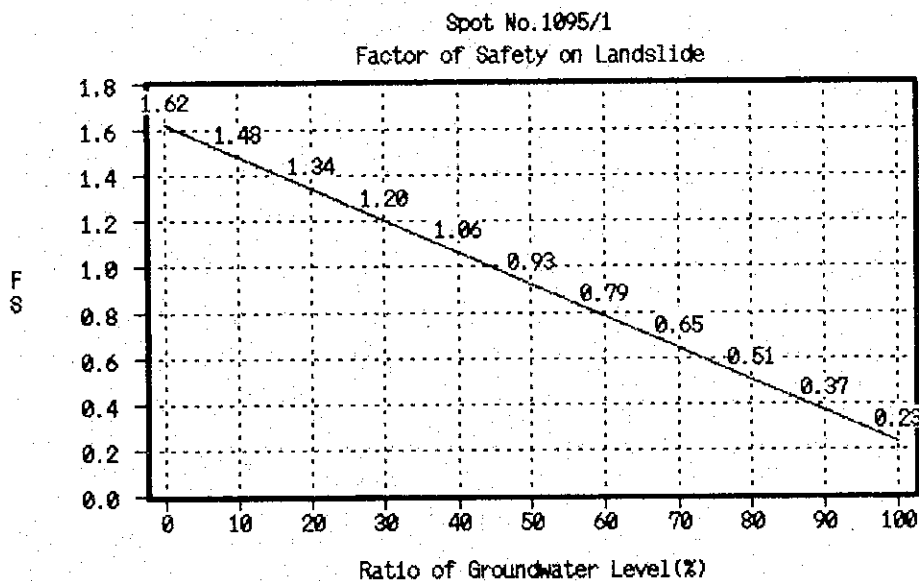
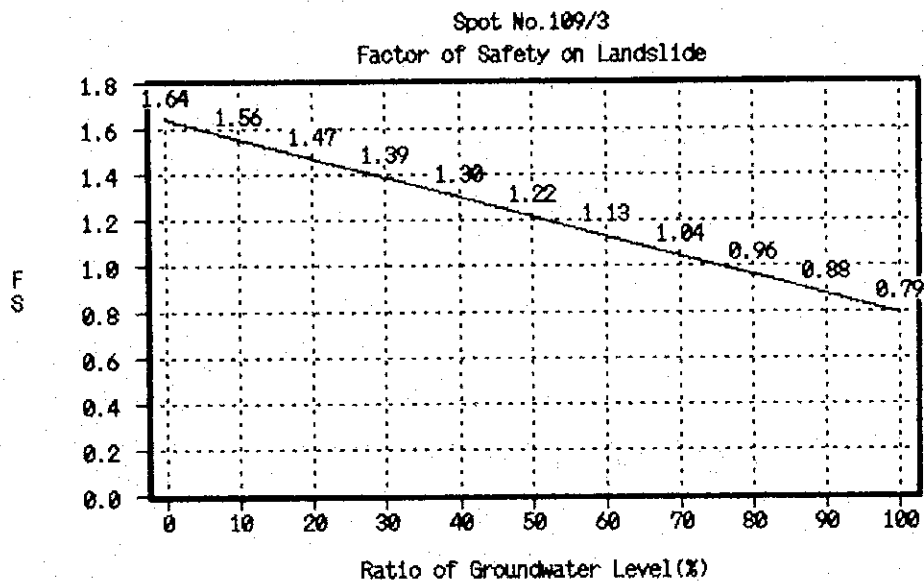
Appendix 4.5 Ratio of River Flow Blockade by Pier

Spot No.	W	B	N
1256/2/3	36.5	1.4	3.84
4/2/3	19.5	0.7	3.59
4015/1	96.8	3.5	3.62
4015/4	35.0	1.1	3.14
4015/5	59.0	1.7	2.88
4015/C1	27.5	1.4	5.09
4015/C2	53.0	2.4	4.53
4107/1/2	28.2	0.7	2.48
4058/1	29.5	1.0	3.39

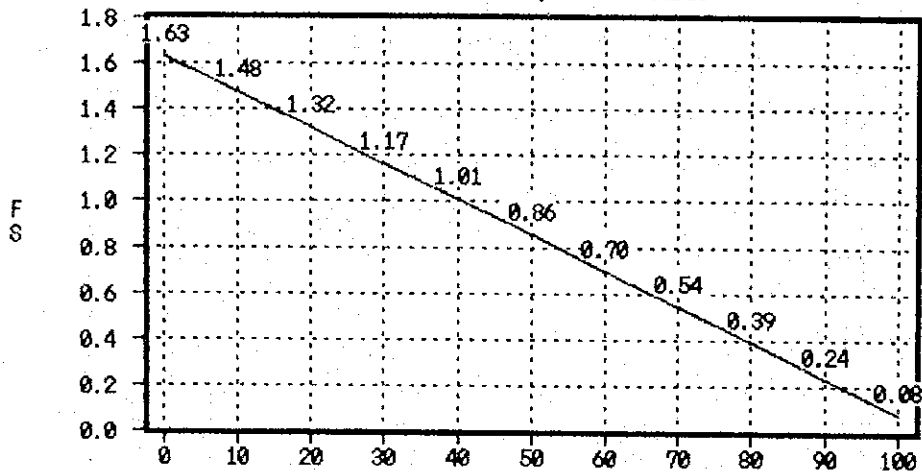
Where,

- W = Width of Water Flow at Flood Level (m)
- B = Total Sectional Width of Piers (m)
- N = Ratio of River Flow Blockade by Pier

Appendix 4.6 Factor of Safety on Landslide

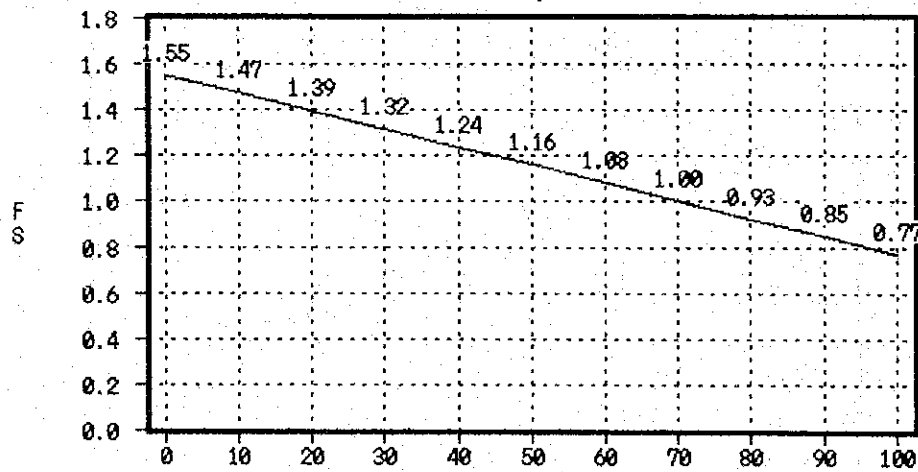


Spot No.1095/4
Factor of Safety on Landslide



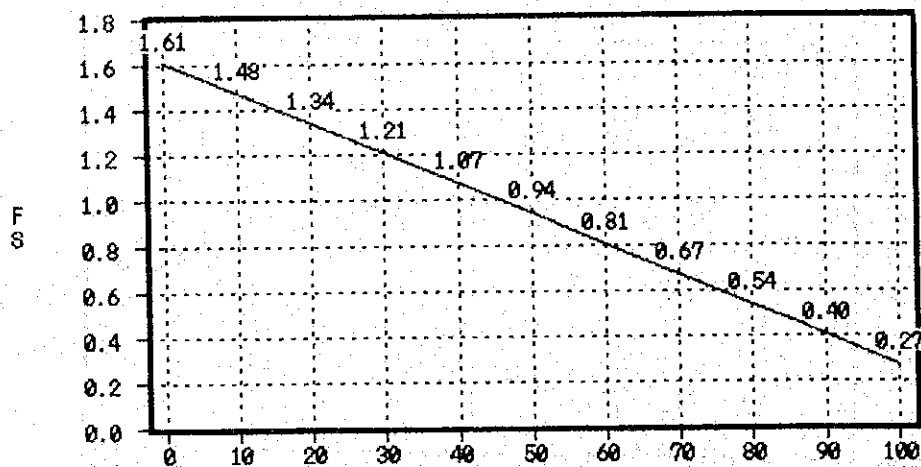
Ratio of Groundwater Level(%)

Spot No.1149/1
Factor of Safety on Landslide



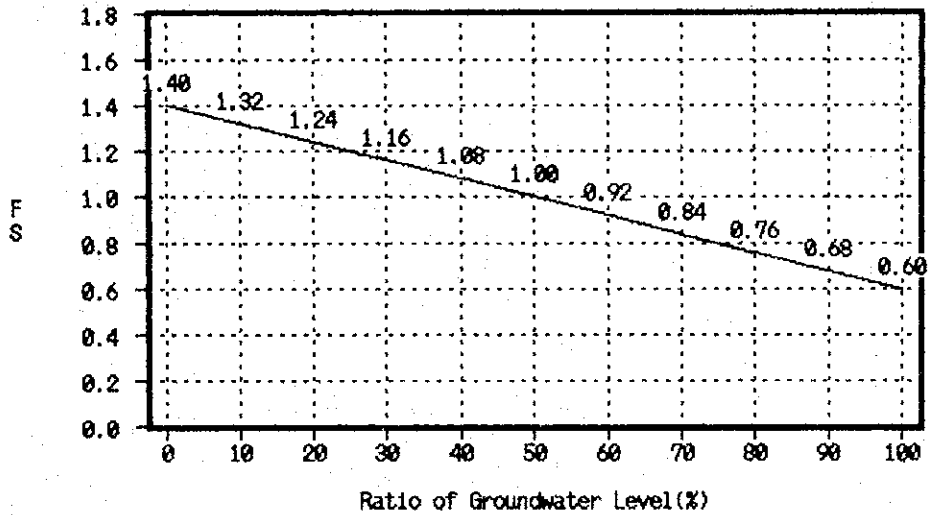
Ratio of Groundwater Level(%)

Spot No.1256/5
Factor of Safety on Landslide

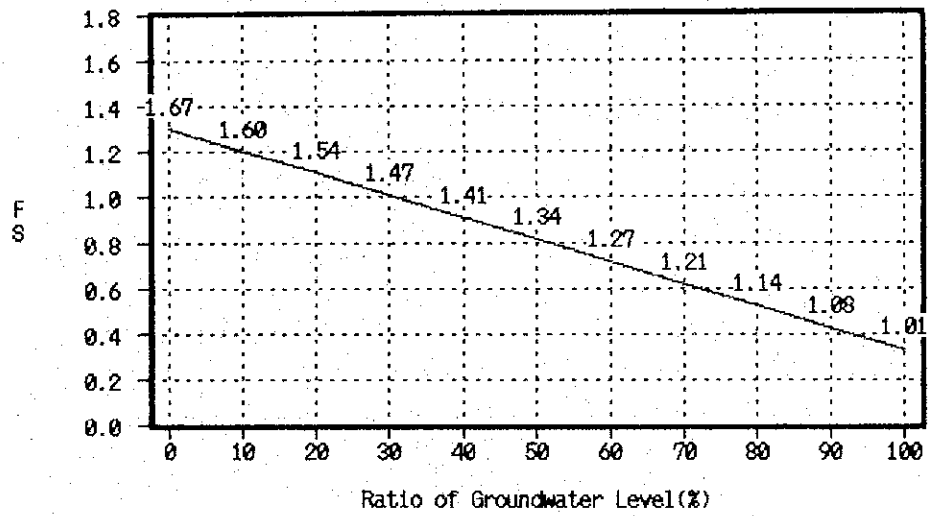


Ratio of Groundwater Level(%)

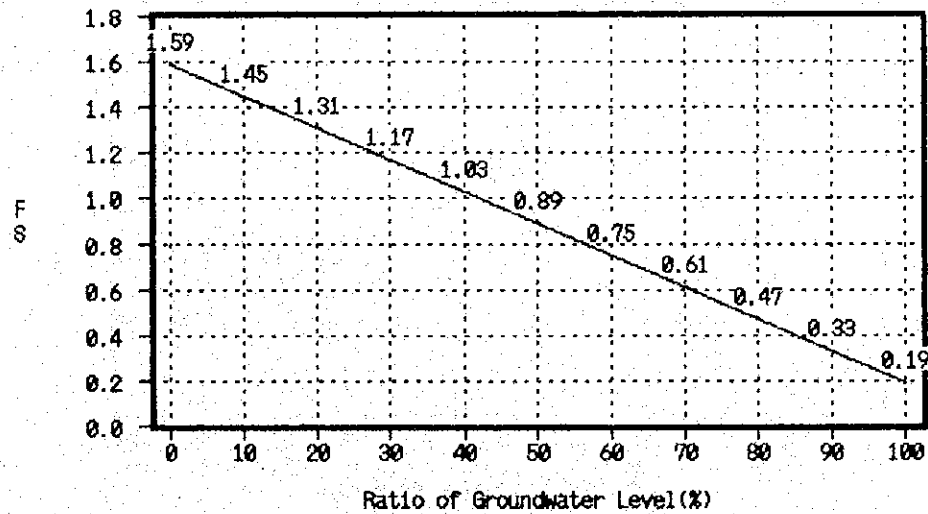
Spot No.1256/6
Factor of Safety on Landslide



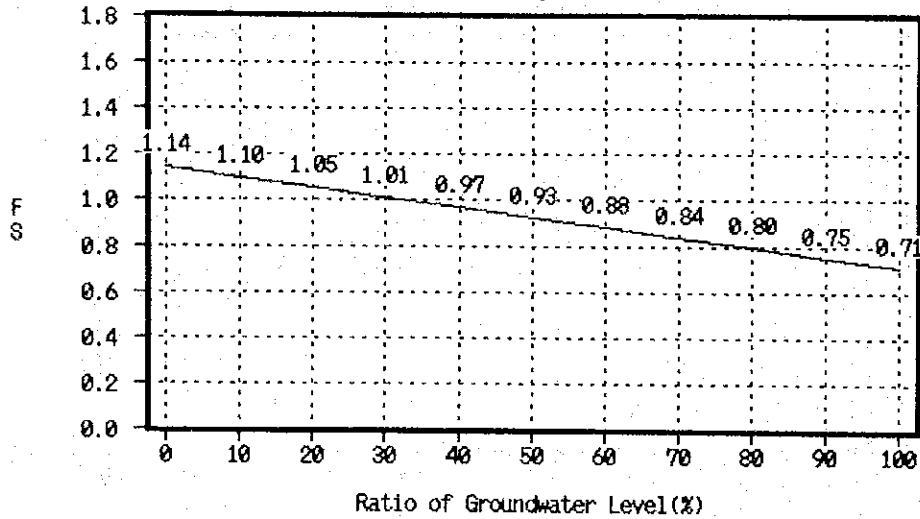
Spot No.1256/7
Factor of Safety on Landslide



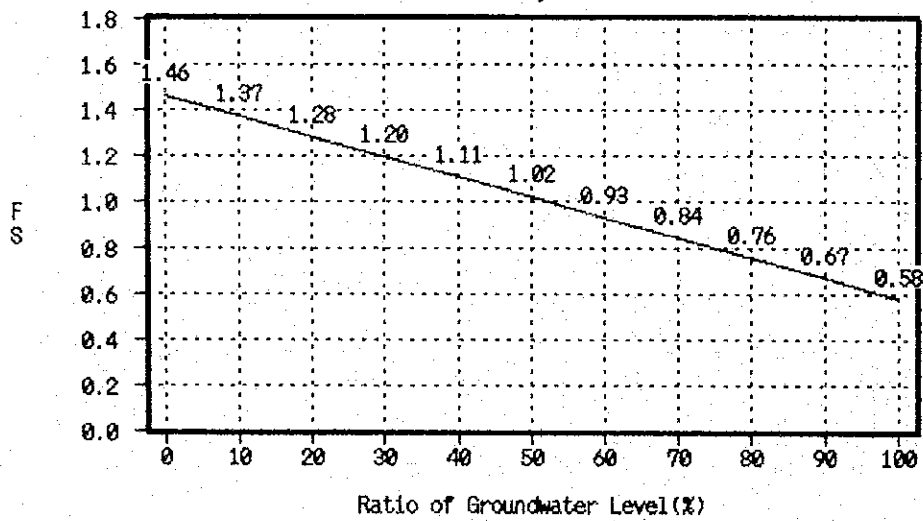
Spot No.1256/8
Factor of Safety on Landslide



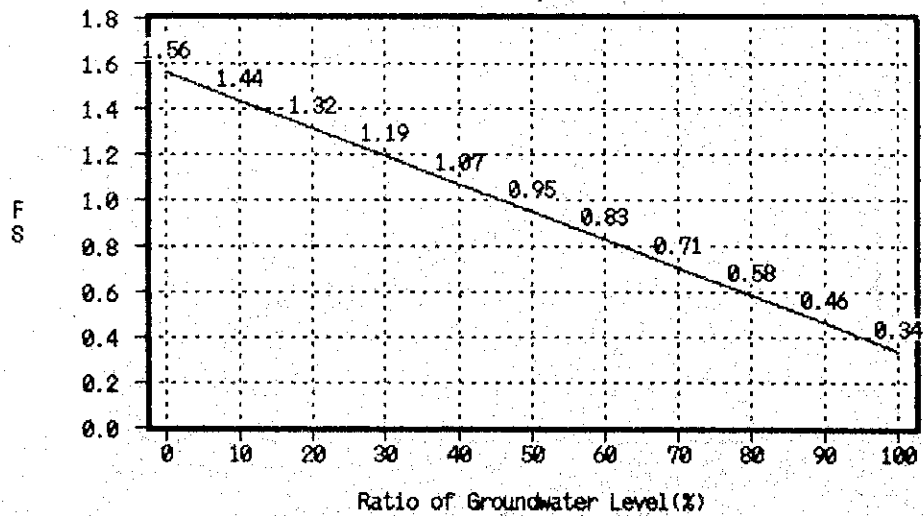
Spot No.1256/11
Factor of Safety on Landslide



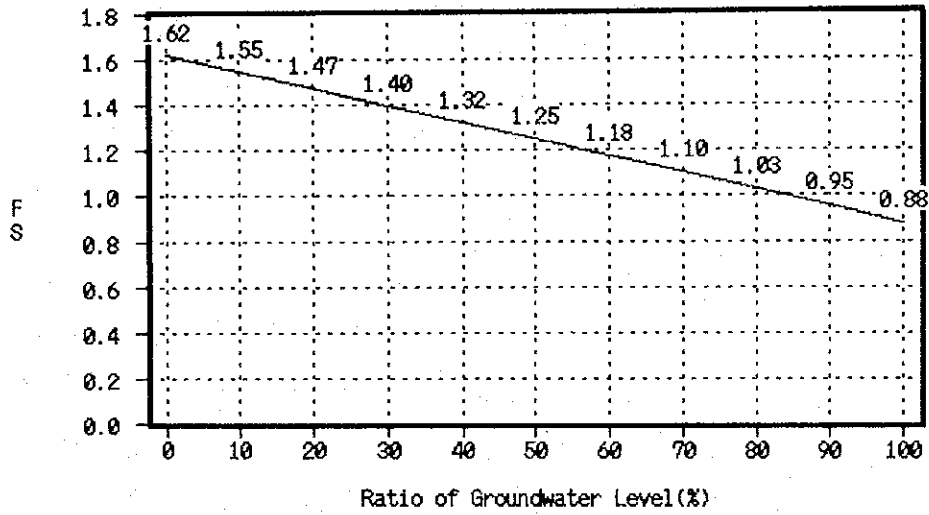
Spot No.4/1
Factor of Safety on Landslide



Spot No.410/2
Factor of Safety on Landslide



Spot No.410/3
Factor of Safety on Landslide



Spot No.410/6
Factor of Safety on Landslide

