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GEOCRES No. 40J3-6

DIST. 1 REGION

W.P. No. 5-60-01

CONT. No. 72-210

W. O. No.

STR. SITE No. 6-120

HWY. No. 18

LOCATION Canard River Bridge

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

CRM: 110 LAB. BLDG

Ontario
Department of Transportation and Communications

MEMORANDUM

40J-34

TO: Mr. B. R. Davis,
Bridge Engineer,
Bridge Office,
Admin. Bldg.
ATTENTION: Mr. S. McCombie

FROM: Foundation Section,
Design Services Branch,
Room 107, Lab. Bldg.

DATE: July 7, 1971

OUR FILE REF.

IN REPLY TO JUL 15 1971

SUBJECT:

40J3-6
GEOCRES No.

FOUNDATION INVESTIGATION REPORT
For
Canard River Bridge on Hwy. #18
3.5 miles North of Amherstburg
District 1 (Chatham)
W.O. 71-11053 -- W.P. 5-60-00
CONTRACT 72-210 01

Attached, we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above structure site.

We believe that the factual data and recommendations contained therein, will prove adequate for your design purposes. Should additional information be required, please feel free to contact our Office.

A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER

AGS/ht
Attach

cc: Messrs. B. R. Davis
F. G. Allen
D. W. Farren
W. Zonnenberg
F. C. Brown
A. P. Watt (2)
J. Roy
B. J. Giroux
B. A. Singh

Foundations Files
Gen. Files

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FOUNDATION INVESTIGATION REPORT
For
Canard River Bridge on Hwy. #18
3.5 miles North of Amherstburg
District 1 (Chatham)
W.O. 71-11053 -- W.P. 5-60-00

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1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation for the proposed new crossing of the Canard River and Hwy. 18. The request was contained in a memo from Mr. T. P. Hodgson, Bridge Location Engineer, dated May 27, 1971.

An investigation was subsequently carried out by this Section to determine subsoil conditions at the site of the proposed structure and approaches. Presented in this report are the results of our field and laboratory investigations, together with recommendations pertaining to structure foundations and to the stability of the approach embankments.

2. DESCRIPTION OF THE SITE:

The site investigated is located approximately 150 ft. to the east, or upstream of the existing bridge, which is the present Hwy. 18 crossing of the Canard River, about 4½ miles north of Amherstburg, Ontario. The general terrain at the crossing is flat, low-lying and swampy. There are no distinct river banks, and the flow in the river is very sluggish. The existing structure is a 5-span Bailey Bridge supported on concrete abutments and timber pile bent piers. The width of the structure is 28 ft. Formerly, the structure consisted of a 5-span steel beam type bridge with a concrete deck, 40 ft. wide, supported on concrete abutments and 4 intermediate double rows of timber piles. This structure was replaced by the present Bailey Bridge following structural failure of the upper portions of some of the timber piles, in 1970. The deck level of the existing bridge is about 25 ft. above the river bed. The average

..... 2.

2. DESCRIPTION OF THE SITE: (cont'd) ...

river water level at the time of the investigation was approx. elevation 574.0.

The new alignment will require a crossing through water of about 1000 ft.±. The new bridge will be 350-400 ft. in length. The remainder of the water crossing will be on an embankment causeway.

3. FIELD INVESTIGATION PROCEDURES:

A total of 7 borings were carried out during the course of the investigation. Boreholes were advanced using a conventional diamond drill adapted for soil sampling purposes. Since all boring took place on the water, the drill was mounted on a suitable raft. 'Disturbed' samples were recovered by means of a 2-inch O.D. split-spoon sampler which was driven 18 inches into the soil by means of a hammer imparting an energy of 350 ft. lbs. per blow. 'Undisturbed' samples were recovered by means of 2-inch I.D. Shelby tubes pushed into the soil hydraulically or by hand. Where possible, field vane tests were carried out at elevations 12 inches below the various sample depths.

Boreholes were surveyed in the field by personnel from S.W. Region, Engineering Surveys Section. The locations and elevations of all borings are shown on the accompanying Drawing 71-11053A.

4. LABORATORY TESTING:

All samples were carefully inspected in the laboratory and subjected initially to visual classification tests. Tests were then performed on selected samples to determine the following physical properties.

Grain-Size Distribution
Atterberg Limits
Natural Moisture Content
Unconfined Shear Strength

..... 3.

4. LABORATORY TESTING: (cont'd) ...

Undrained Triaxial Shear Strength
Consolidation Characteristics
Bulk Density

The results of all tests are summarized on the Record of Borehole sheets contained in the Appendix. The results of undrained shear strength tests are plotted also on Fig. 3. The results of Atterberg Limit tests are plotted on Fig. 4.

5. SOIL TYPES AND SOIL CONDITIONS:

5.1) General:

Subsoil at the site was found to consist of a surface deposit of very soft muck, 4 ft. to 11 ft. thick, followed by a deposit of firm to very stiff clayey silt with traces of sand and gravel, 28 ft. to 38 ft. thick, followed by a deposit of hard glacial till consisting of clayey silt sand and gravel, 4 to 6 feet in thickness, overlying limestone bedrock. The elevation of the bedrock surface ranged from elevation 524 to elevation 525. The site was covered with water ranging in depth from 3 to 10 ft. The boundaries between the different soil types encountered are shown on the Record of Borehole sheets contained in the Appendix. The estimated stratigraphical profiles shown on Drawing #71-11053A are based upon this information. From ground level downwards the various soil types encountered are described in detail as follows:

5.2) Surficial Muck:

This deposit was encountered in all borings and covers the entire bed of the river for depths ranging in thickness from 4 ft. to about 11 ft. in thickness. The material consists of a mixture of fine grained inorganic particles, and organics and in consequence is cohesive in nature. The average moisture content was found to be about 165%, the range being 60% to about 300%. The undrained shear strength is estimated to range from almost zero to 300 p.s.f., this being based on Standard Penetration test results.

..... 4.

5. SOIL TYPES AND SOIL CONDITIONS: (cont'd) ...

5.3) Clayey Silt with Traces of Sand and Gravel:

This is the predominant deposit at the site and was observed in all borings for thicknesses ranging from 28 to about 38 feet. The material consists of clayey silt containing traces of sand and also traces of gravel. The consistency of the deposit ranges from firm to very stiff, being very stiff to stiff in the uppermost and lowest portions, with the central zone being generally firm. The thickness of the uppermost very stiff to stiff zone ranged from 3 to 10 ft. in B.H.'s 1, 2, 8 and 9, which were the holes closest to the edges of the river, whilst in the remaining borings 3, 5 and 7 the thickness was negligible. The thickness of the lower very stiff to stiff zone ranged randomly from zero to about 9 ft. in all holes. Consolidation tests carried out on samples obtained from the aforementioned upper and central zones indicated preconsolidation pressures of 2.30 TSF and 2.50 TSF respectively. Physical properties of the material as determined from field and laboratory tests are as follows:

		Min.	Max.	Average
Natural Moisture Content	(%)	14	26	21
Liquid Limit	(%)	18	33	29
Plastic Limit	(%)	14	19	17
Bulk Density	p.c.f.	126	133	128.5
Undrained Triaxial Shear Strength	p.s.f.	420	1445	690
Unconfined Shear Strength	p.s.f.	265	1860	650
Field Vane Shear Strength	p.s.f.	600	>2000	750
Sensitivity		1.7	3.2	2.2
Preconsolidation Pressure	t.s.f.	2.30 - 2.50		---
Compression Index		0.128--0.167		---

5.4) Clayey Silt, Sand and Gravel:

This deposit was observed in all borings, though it was completely penetrated only in three of these: Nos. 1, 5 and 9, where the thickness ranged from 4.5 ft. to 6.3 ft. The material consists of a heterogeneous mixture of clayey silt, sand and gravel. 'N' values as determined from Standard Penetration tests ranged from 54 to more than 100 blows/ft.,

..... 5.

5. SOIL TYPES AND SOIL CONDITIONS: (cont'd) ...

5.4) Clayey Silt, Sand and Gravel: (cont'd) ...

indicating a hard consistency. In B.H. #5 drilling techniques using diamond bits were necessary to penetrate this layer. Elsewhere, tricone or bicone bits were used which are not effective in bouldery soils. Thus, in B.H. #5 only, is there definite evidence of boulders in the stratum.

The average moisture content of the deposit was found to be about 9%. Mechanical analysis indicated the following grain size composition: Gravel 9% , Sand 34%, Silt 36%, Clay 21%.

5.5) Bedrock (Limestone):

Bedrock samples were recovered in AXT rock core samplers in B.H.'s 1, 5, and 9. The material was identified to be limestone. Recovery of rock core indicated that the upper 3 to 4 feet of the stratum is slightly weathered.

5.6) Groundwater:

No artesian pressures were observed during boring operations. The groundwater level may be assumed to be equal to the prevailing riverwater level.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to construct a new structure at this site to replace the existing Bailey Bridge. The line presently proposed is known as Rev. Line 'G', and is some 150 ft. east of the ℄ of the existing structure. The total length of the water crossing is some 1000 ft., but the length of the new structure, as proposed, is about 400 ft. Thus the remainder of the crossing will be effected by means of a causeway embankment. The new profile grade is such, that the maximum height of the new approaches to the structure will be about 25 ft. above the existing river bed.

..... 6.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd) ...

6.2) Structure Approaches:

The main stability problem at this site is the existence of a surface layer of organic soil some 4 to 11 ft. in thickness between Stations 169 + 50 and 174 + 50. (The thickness of this layer in the remaining portions of the water crossing should be determined by the Regional Soils Section during the course of their routine soil investigation.) The material has a very low shear strength and could not support the proposed embankment, but is likely to cause a failure during construction, if it is not removed prior to placing the fill. Due to the fact, however, that portions of the organic layer have an average undrained shear strength of about 200 - 300 p.s.f. the deposit cannot be regarded as readily displaceable and must, therefore, be excavated and replaced with suitable granular fill to ensure future stability of the approach embankment. Figures 1 and 2 show the recommended treatment for the side slopes and forward slopes respectively.

Based on the assumption that all organic soil is removed and replaced with suitable granular fill, stability analyses in terms of total stresses were carried out with the following additional assumptions:

Fill (Above w.l.)	Bulk Density	γ = 125 p.c.f.
	Undrained Shear Strength	C = 1000 p.s.f.
Fill (Below w.l.)	Bulk Density	γ = 125 p.c.f.
	Angle of Friction	ϕ = 35°
Subsoil	Bulk Density	γ = 128 p.c.f.
	Undrained Shear Strength	C = 1200 p.s.f. Upper Zone
		750 p.s.f. Central Zone
		4000 p.s.f. Bottom Zone

The results of these analyses showed that the proposed embankments would be stable with 2:1 side and forward slopes.

..... 7.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd) ...

6.2) Structure Approaches: (cont'd) ...

All slopes should be protected against erosion by means of suitable rip-rap. This should be checked with the Hydrology Section.

6.3) Structure Foundations:

Provided that stable approach embankments are constructed as outlined above the proposed structure abutments may be constructed within the approach fill and supported on steel 'H' piles driven to bedrock (i.e. to elevation 525 ±).

The design load on such piles may be the maximum allowable for the particular steel section adopted. The intermediate spans of the structure should be supported on bents consisting of one or more rows of 'H' piles driven to bedrock as for the abutments. These should be capped at the underside of the deck and may be encased in concrete down to original ground level for aesthetic or other reasons.

Bouldery fill should not be placed at locations where piles are to be driven.

Due to the existence of a compressible cohesive stratum settlements due to consolidation of this layer will occur over a long term period. It is estimated that the magnitude of the maximum settlement under the fill adjacent to the abutment will be in the order of 6 inches. 50% of which should occur in less than 6 months. Thus, it would be advantageous if a period of at least 2 months should elapse prior to re-excavating for the abutment foundations.

7. MISCELLANEOUS:

The field work for this project was carried out during the period May 31 to June 11, 1971.

Equipment used was owned and operated by P.V.K. and Sons Ltd., under the supervision of Mr. W. Allcock, Engineering Student.

.....8.

7. MISCELLANEOUS: (cont'd) ...

This report was prepared by Mr. A. Barsvary, Senior Foundation Engineer, and Mr. K.G. Selby, Supervising Foundation Engineer.

July, 1971

APPENDIX

FORM OB-MT-● (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy.18 Rev. Sta. 169 + 58 ℄ ORIGINATED BY WA
W.P. 5-60-00 BORING DATE June 7, 1971 COMPILED BY WA
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing, AXT Rock Core CHECKED BY

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE
573.7	Water Level					
0.0 / 570.7	River Water					570
3.0 / 567.9	Muck Black					
5.8	Clayey silt with traces of sand & gravel Firm to Stiff		1	SS	4	
			2	SS	25	
			3	SS	14	560
			4	TW	PM	
			5	SS	6	
			6	TW	PM	550
			7	SS	4	
			8	TW	PM	
			9	SS	3	540
			10	TW	PM	
530.4						
43.3 / 525.4	Clayey silt, sand and gravel. Hard		11	SS	39	530
48.3	Limestone Bedrock		12	RC	70%	
			13	RC	100%	520
515.4						
58.3	End of Borehole					510

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %
10 20 30

○ = 113

BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
130	
128	
128	
127.5	

20
15 ◇ 5 % STRAIN AT FAILURE

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy.18 Rev. Sta. 170 + 55 27 Rt. ℄ ORIGINATED BY WA
W.P. 5-60-00 BORING DATE June 4, 1971 COMPILED BY WA
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE
573.8	Water Level					
0.0 / 570.3	River Water					570
3.5 / 565.3	Muck		1A	SS	1/6"	
			1B	SS	3	
8.5	Clayey silt with traces of sand and gravel. Firm to Hard		2	SS	44	560
			3	SS	18	
			4	TW	PM	
			5	SS	3	550
			6	TW	PM	
			7	SS	4	
			8	TW	PM	540
			9	SS	4	
530.3						
528.8	Clayey silt, sa. & gr.		10	SS	54	530
45.0	End of Borehole					
						520

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
WATER CONTENT %
10 20 30

○ =298.5
○ =233

BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
131	5 18 46 31
127	
	9 34 36 21

20
15 ⊹ 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy. 18 Rev. Sta. 170 + 92 o/s 28' Lt. ℄ ORIGINATED BY WA

W.P. 5-60-00 BORING DATE June 3, 1971 COMPILED BY WA

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE
573.9	Water Level					
0.0	River Water					570
565.4						
8.5	Muck		2	pushed NX casing into muck		
559.5						560
			1	SS	3	
14.4	Clayey silt with traces of sand and gravel		3	TW	PM	
			4	SS	6	550
			5	TW	PM	
			6	SS	3	540
			7	TW	NP	
			8	SS	25	
			9	SS	-	
530.9						
43.0	Clayey silt, sand and gravel. Hard		10	SS	128/6"	530
525.4						
48.5	End of Borehole Probable Bedrock					520

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %
10 20 30

o =143
o =64

BULK DENSITY γ P.C.F.: 128.5

REMARKS GR.SA.SI.CL.

20
15 ⊕ 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy.18 Rev. Sta. 172 + 00 ℄ ORIGINATED BY KW
W.P. 5-60-00 BORING DATE June 2, 1971 COMPILED BY WA
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE
574.0	Water Level					
0.0	River Water					570
564.0						
10.0	Muck					
560.2			1	SS	4	560
13.8	Clayey silt with traces of sand and gravel		2	TW	PM	
			3	TW	PM	
			4	TW	PM	550
	Firm to Stiff		5	SS	5	
539.0	- Boulder		6	TW	PM	540
35.0			7	SS	4	
531.2			8	SS	100/4"	
42.8	Clayey silt, sand and gravel.		9	SS		530
524.9	Hard		10	RC	55%	
49.1	Limestone Bedrock					
521.4						
52.6	End of Borehole					520

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %
10 20 30

o 61

BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
128	
128	

+ >2000

20
15 ⊹ 5 % STRAIN AT FAILURE
10

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy.18 Rev. Sta. 173 + 10 o/s 23' Rt. ℄ ORIGINATED BY WA
W.P. 5-60=00 BORING DATE June 10, 1971 COMPILED BY WA
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT
573.8	Water Level				
0.0	River Water				
563.9					
9.9					
559.8	Muck		1A	SS	2/6"
			1B	SS	6
14.0	Clayey silt with traces of sand and gravel. Firm to Stiff		2	TW	PM
			3	SS	4
			4	TW	PM
			5	SS	3
			6	TW	PM
530.6					
43.2	Clayey silt, sand and gravel. Hard		7	SS	77
525.8					
48.0	End of Borehole ~~Probable Bedrock~~				

ELEV. SCALE: 570, 560, 550, 540, 530, 520

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_p
WATER CONTENT —— w
w_p w w_L
WATER CONTENT % 10 20 30

o =232

BULK DENSITY γ P.C.F.: 127, 131, 127, 127

REMARKS GR.SA.SI.CL.

20
15 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy. 18 rev. Sta. 173 +34 o/s 29' Lt. ℄ ORIGINATED BY WA

W.P. 5-60-00 BORING DATE June 8, 19, 1971 COMPILED BY WA

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE) 1000 2000	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
573.5	Water Level									
0.0 570.2	River Water					570				
3.3 560.3	Muck					560				
13.2	Clayey silt with traces of sand and gravel. Firm to Stiff		1	SS	35					
			2	SS	19					
			3	TW	PM				131	
			4	SS	6	550				
			5	TW	PM					
			6	SS	5					
			7	TW	PM	540			126.5 128	
			8	SS	5					
531.3 529.8 43.7	Clayey silt, sa. & gr. End of Borehole		9	SS	71	530				
						520				

20
15 ⊹ 5 % STRAIN AT FAILURE
10

FORM CB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 71-11053 LOCATION Hwy. 18 Rev. Sta. 174 + 49 ℄ ORIGINATED BY WA
W.P. 5-60-00 BORING DATE June 9, 1971 COMPILED BY
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT
574.0	Water Level				
0.0 / 571.9	River Water				
3.1 / 567.8	Muck		1	SS	9
6.2	Clayey silt with traces of sand and gravel. Firm to V.Stiff		2	SS	39
			3	SS	22
			4	TW	PM
			5	SS	5
			6	TW	PM
			7	SS	4
			8	TW	PM
			9	SS	5
			10,11	TW,SS	PM,-
530.8					
43.2 / 526.3	Clayey silt, sand and gravel. Hard		12	SS	120/9"
47.7	Limestone Bedrock		13	RC	0%
			14	RC	95%
516.3			15	RC	100%
57[illegible].7	End of Borehole				

ELEV. SCALE: 570, 560, 550, 540, 530, 520, 510

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

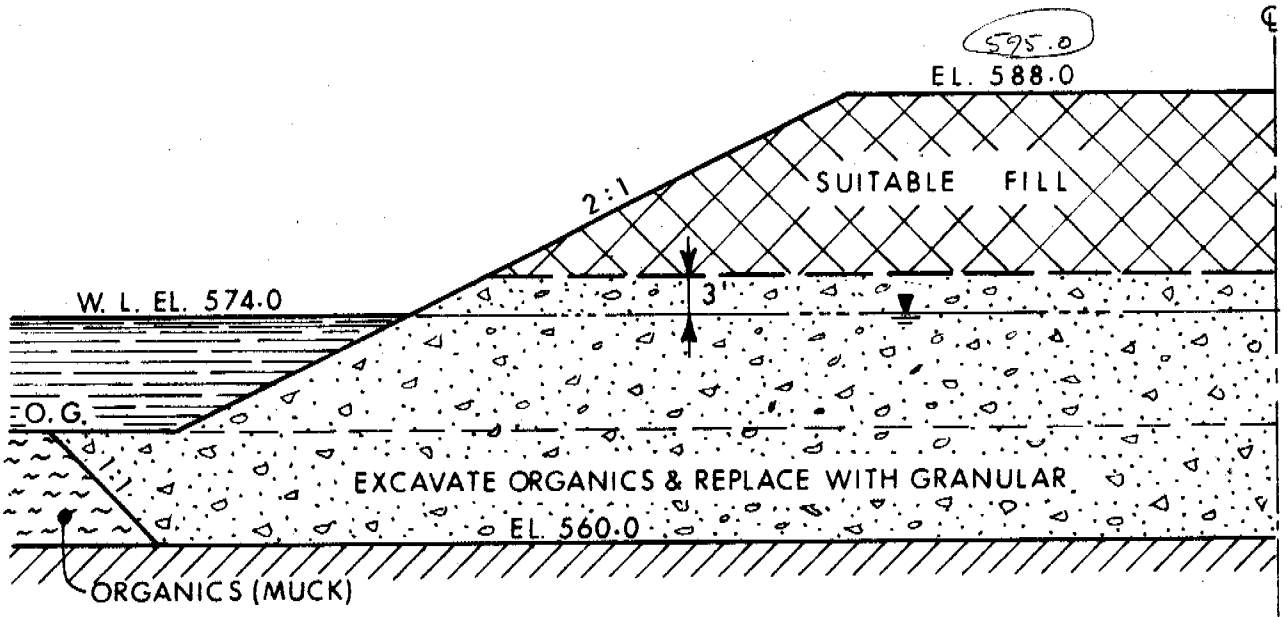
+ > 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %
10 20 30

BULK DENSITY γ P.C.F.
133
132
128.5
127

REMARKS
GR. SA. SI. CL.

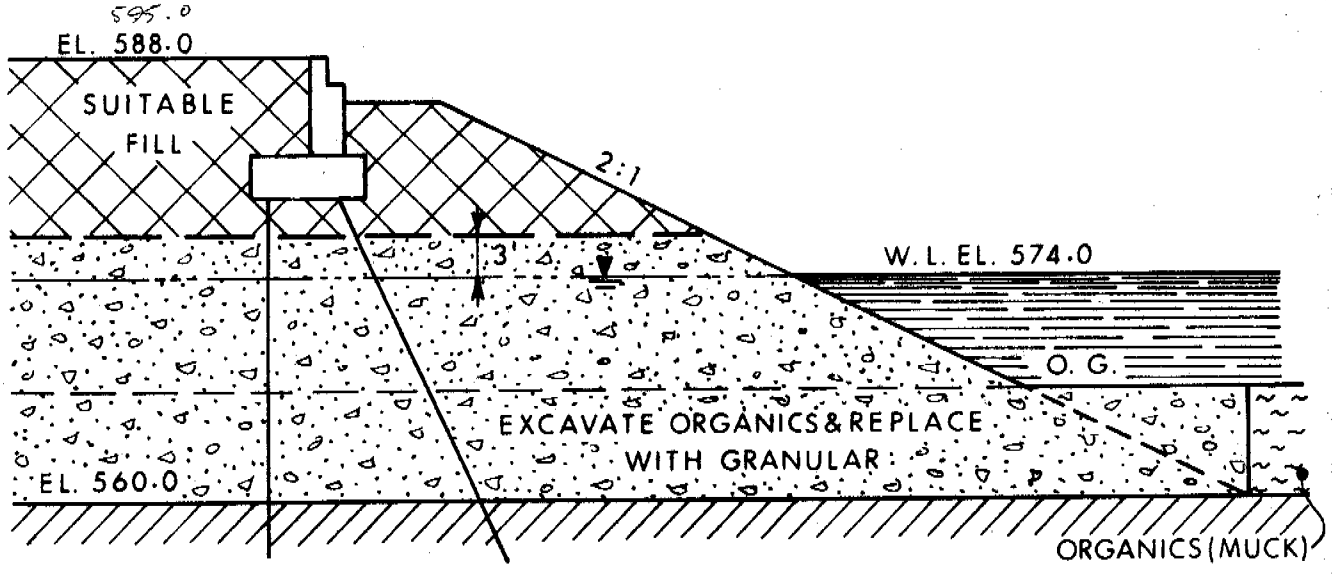
20
15 5 % STRAIN AT FAILURE
10



RECOMMENDED TREATMENT FOR SIDE SLOPES

CROSS SECTION

FIG. 1

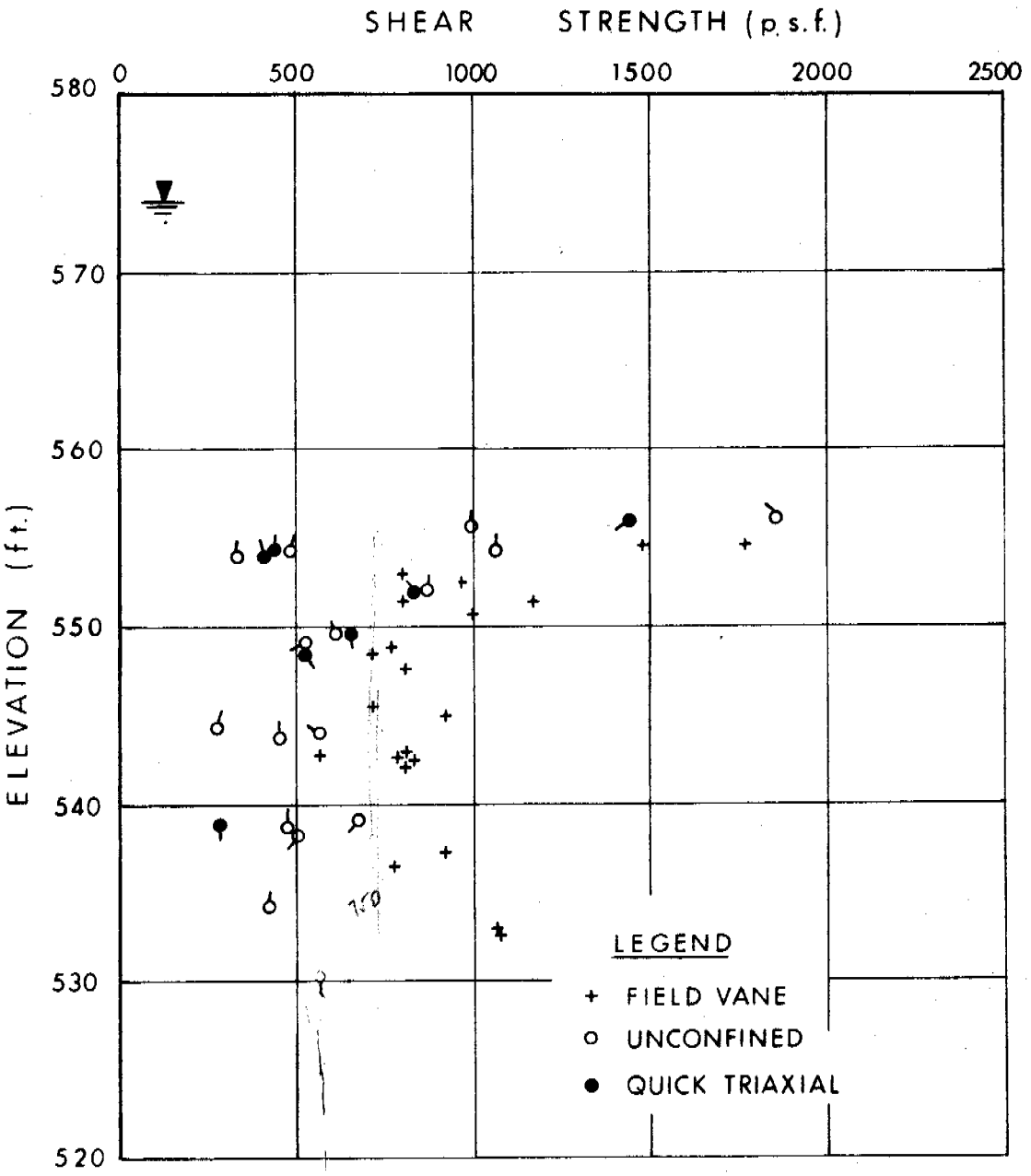


RECOMMENDED TREATMENT FOR FORWARD SLOPES

LONGITUDINAL SECTION

FIG. 2

JOB NO. 71-11053

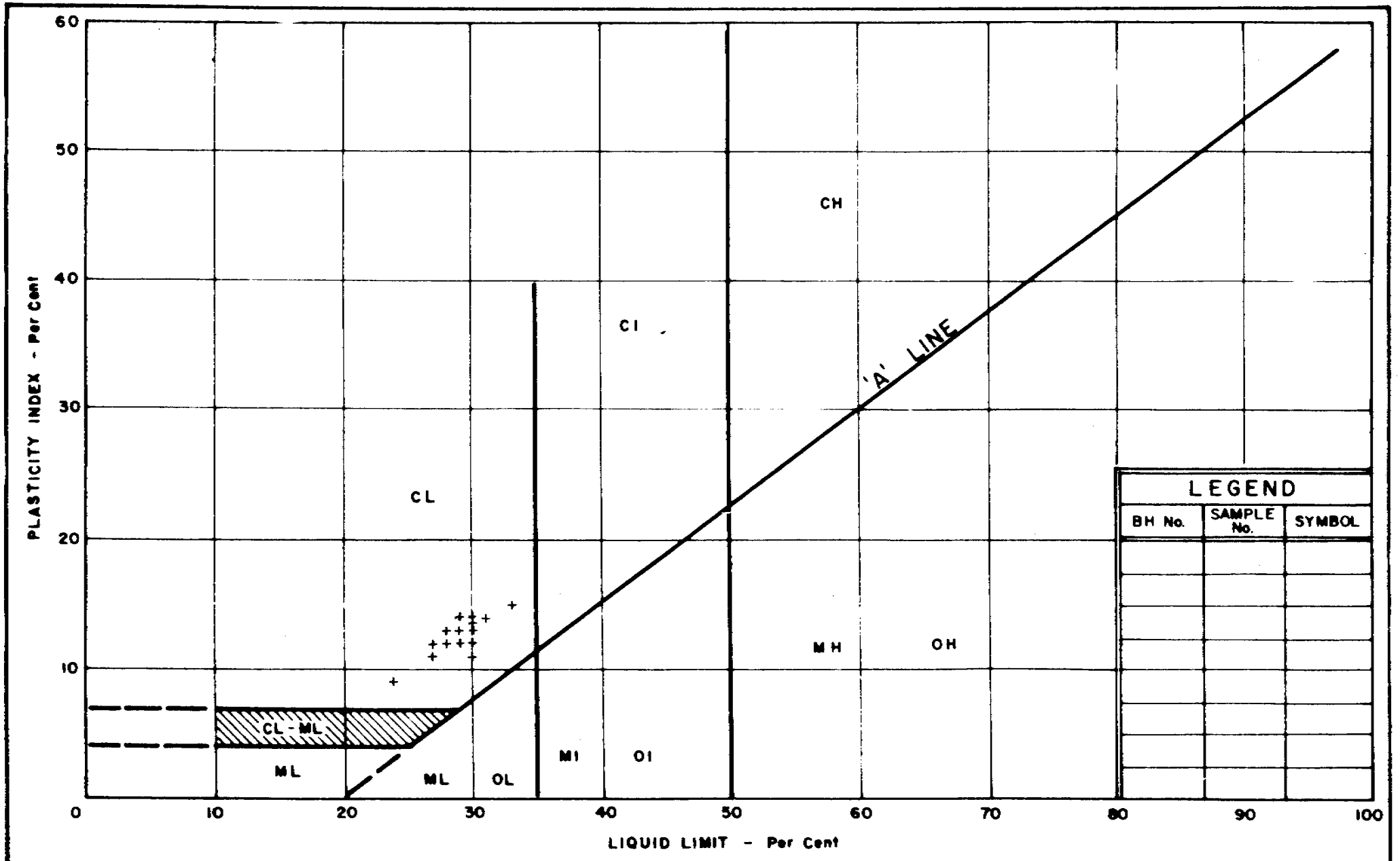


ELEVATION VS SHEAR STRENGTH

FIG. 3

JOB 71-11053

FORM OB–MT–252
REVISED JUL[illegible]1966



DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART

CLAYEY SILT

W.P. No. 5-60-00
JOB No. 71-11053
FIG. 4

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

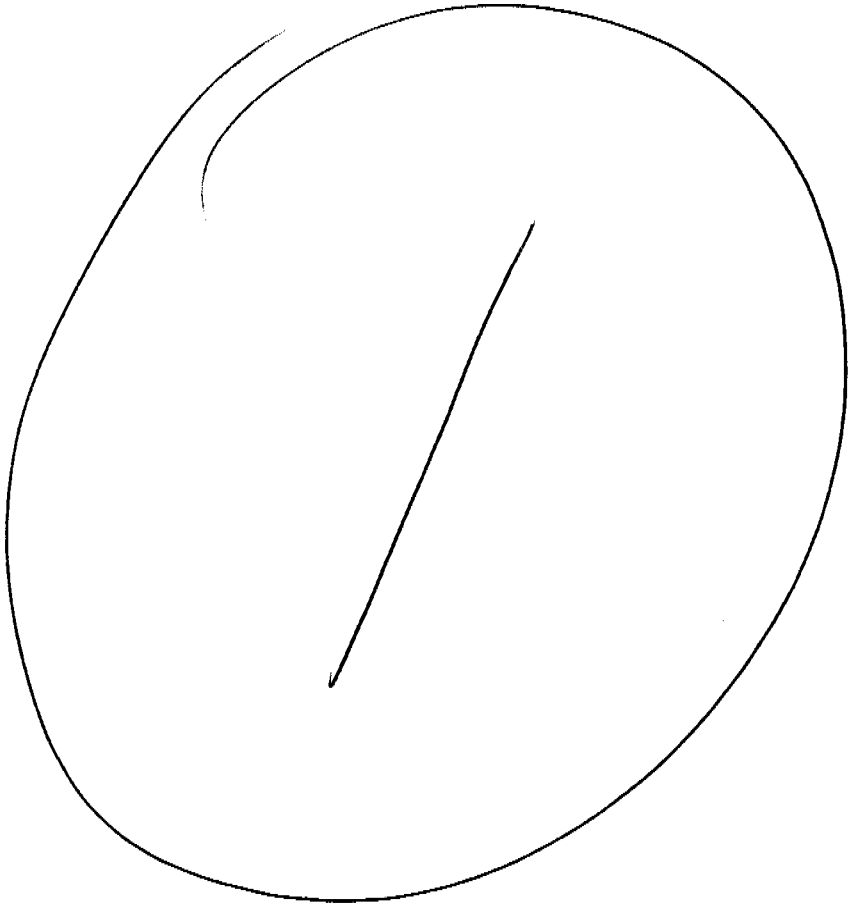
FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY. DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

35MM
DRAWING



35MM
DRAWING