

#68-F-64
BRANTFORD
EXPRESSWAY
BRANTFORD
CITY

MEMORANDUM

To: Mr. J. Roy,
Regional Materials Engineer,
South-Western Region,
LONDON, Ontario.

FROM: Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

ATTENTION

DATE: September 19, 1968

OUR FILE REF

IN REPLY TO

SUBJECT:

FUNCTIONAL
SOIL INVESTIGATION REPORT
Along the
Proposed Brantford Expressway
City of Brantford
District No. 4 (Hamilton)
W.J. 68-F-64 -- W.P.(N11)

Attached, we are forwarding to you, our Functional Soil Investigation Report along the above expressway. The report outlines the subsoil conditions existing at the site and presents some general comments concerning structure foundations.

We believe that the factual data and recommendations contained therein, will be adequate for your immediate use. Should you require any additional information, please contact this Office.

AGS/YdeP
Attach.

A. G. Stermac
A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

cc: Messrs. E. R. Davis (2)
D. W. Farren
I. Campbell (2)
R. G. Gascoyne
H. Greenland
T. J. Kovich
B. A. Singh
Foundations Files
Gen. Files

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FUNCTIONAL
SOIL INVESTIGATION REPORT
Along the
Proposed Brantford Expressway
City of Brantford
District No. 4 (Hamilton)
W.J. 68-P-64 -- W.P. (N11)

1. INTRODUCTION:

In a memo dated August 30, 1968, Mr. J. Roy, Regional Materials Engineer, London Region, requested a soil investigation along the proposed Brantford Expressway. Since the project is still in the functional planning stage, the recent soil survey was intended to obtain general subsoil information only, at the proposed structures, near high fills and deep cuts. After the exact locations of the structures and the elevations of the proposed grades are decided upon, further field and laboratory investigations will be necessary in order to give specific foundation recommendations for the individual structures as to the type of foundations, settlements, stability of slopes, etc.

Presented in this report are the results of the investigations with some general conclusions concerning foundations.

2. DESCRIPTION OF THE SITE:

The investigated section of the proposed expressway is approx. 6 miles long. The terrain around the east portion of the line is mainly occupied by farms, industrial and commercial buildings; the middle and longest part of the line transverses the city proper; the westerly last mile or so crosses farmlands. The topography of the immediate vicinity of the proposed expressway is generally flat, except at the westerly portion, where it is a rolling and undulating countryside.

Geologically, the easterly half of the investigated area belongs to the Norfolk Sand Plain physiographic region; the westerly portion is known as the Horseshoe Moraines. The beds of

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

silts and sands of the Norfolk Sand Plain are considered to be deltaic in glacial Lakes Whittlesey and Warren. The deep varved silts were also deposited by Lake Warren during the recession of the Wisconsin glacier. The Horseshoe Moraines consist of knobby ridges of clay, and at this region it is more hilly and stony, containing more gravel and sand.

3. FIELD AND LABORATORY INVESTIGATIONS:

Some 23 sampled boreholes and adjacent to the borings, 23 dynamic cone penetration tests were carried out during the course of the field investigations. The locations of the boreholes were established by Messrs. K. G. Selby, Supervising Foundation Engineer, D.H.O., and R. W. Smith, Project Director of Dames and Smith Ltd., during a visit to the site. One conventional diamond drill, adapted for soil sampling purposes, and one Pennsylvania Flight Auger were employed for the borings. The locations and ground elevations of the boreholes are marked on attached Drawing #68-F-64A. The boreholes were tied to the coordinate system shown on the 1" = 100' plans, supplied by the consultant, Dames and Smith Ltd.

Split-spoon and, in the cohesive strata, "undisturbed" Shelby tube samples were taken at regular intervals. Standard penetration tests were performed according to conventional methods and penetration resistances recorded ('N' values - number of blows of a 140-lb. hammer falling freely a distance of 30 inches to advance a split-spoon sampler 12" into the subsoil). In situ field vane shear tests were carried out in the boreholes, where possible, using D.H.O. vanes. The holes were staked out and surveyed by the staff of District #4 (Hamilton).

All soil samples were identified and described upon recovery, and again in the laboratory. Laboratory tests were performed on representative samples to determine the natural moisture content ($w\%$), Atterberg limits ($w_L\%$, $w_P\%$), grain-size

cont'd. /3 ...

3. FIELD AND LABORATORY INVESTIGATIONS: (cont'd.) ...

distributions, undrained shear strength (C), and bulk densities (γ_g). The results of all field and laboratory tests are plotted on the borelog sheets appended to this report.

4. SOIL CONDITIONS:

4.1) General:

Stratified, heterogeneous materials form the overburden within the investigated depths. Two main strata of the subsoils may be discerned: the one with predominantly clayey silt particles, and the other with coarser grains of sandy silts and silty sands. Within these two deposits a large variety of sands, silts and clays were observed.

A detailed description of the subsoils follows:

4.2) Clayey Silt with Irregular Layers of Sand and Silt:

This material was found practically in every borehole along the length of the proposed expressway. The soils within this layer are mainly cohesive deposits, but they are interrupted very frequently by seams of sands and silts of various thicknesses. Thin brown and reddish-brown clay seams of intermediate and high plasticity were also encountered in random order. At certain locations the seams were found to be spaced quite regularly with a thickness of 1 - 2", resembling varved clays. In most of the boreholes, however, the stratification is erratic and irregular. Due to the sublayers and seams, the physical properties of the overall stratum vary widely. The maximum, minimum and average values of the Atterberg limits and bulk densities are tabulated as follows:

cont'd. /4 ...

4. SOIL CONDITIONS: (cont'd.) ...

4.2) Clayey Silt with Irregular Layers of Sand and Silt: -
(cont'd.) ...

Sublayer	Liquid Limit (W_L)			Plastic Limit (W_p)			Bulk Density (γ)		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Silty Clay	50	36	38	21	19	20	128	123	125
Clayey Silt	33	20	25	22	14	18	133	124	130

The shear strength of the material shows even greater variations, so that quoting average figures would be misleading. To obtain strength characteristics at a particular location, reference is made to the borelog sheets. The consistency of the deposit, measured by the Standard Penetration tests, was found to range from stiff to hard, corresponding to undrained shear strength values between 1,000 PSF and above 4,000 PSF.

4.3) Silts, Sandy Silts and Silty Sands:

These soils are essentially non-cohesive granular materials. The samples taken within this layer showed that these soils are also stratified, indicating that they are parts of the glacio-fluvial deposits. The layer was encountered along the entire investigated area, either above or below the clayey silt. Some of the laboratory grain-size analyses resulted in curves falling mainly within the gravel and sand-size range; some tests, however, indicated almost pure silt-size grains. Within these two extremes, a great variety of grain distributions were observed. The relative density of the upper portion of the stratum generally ranges between loose and very dense, the lower portion usually between compact and very dense.

cont'd. /5 ...

4. SOIL CONDITIONS: (cont'd.) ...

4.4) Bedrock:

In B.H.'s #9A and #10A, near the east and west banks of Grand River, bedrock was encountered below the clayey silt overburden. The upper surface of the rock at the east bank was established to be at el. 605.5 ft.; at the west bank, at el. 607.6 ft. The bedrock was found to be almost pure Dolomite, and was proved by diamond drilling for depths of 5 ft. or over. The coring yielded rock cores of 100% recovery.

4.5) Groundwater Conditions:

The groundwater level was recorded at every borehole location, as shown on the borelog sheets. Observations were made by measuring the free water level in the borings, or by taking the elevations of the caved-in, wet granular deposits. Generally, the groundwater level ranges between 3 ft. and 15 ft. below prevailing ground surface.

No artesian conditions were noticed in the boreholes within the investigated depths.

5. DISCUSSION AND COMMENTS:

5.1) General:

(a) The purpose of the investigation was to provide subsoil information at the proposed structures, near high fills and deep cuts along the future Brantford expressway. The stratigraphical profiles at the locations of the boreholes are shown on Drawings #68-F-64B and C.

(b) Usually only one borehole was placed at or near each proposed structure. Due to this rather limited information, general remarks and comments are given concerning foundations, without going into any detailed recommendations. It is emphasized that after the exact locations of the structures become available, additional boreholes will be necessary at the footings to substantiate the present findings.

cont'd. /6 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.1) General: (cont'd.) ...

(c) The sandy silt, silty sand and sand layers are susceptible to conditions of unbalanced hydrostatic head. For the footing excavations within these layers below the water level, dewatering schemes, such as well-point system or interlocking sheet piles, will be required to prevent the excavation bottoms from "boiling". In the case of using sheet piles around the perimeter of the excavations, they should be driven to a level below the bottom of the excavation equal to the head of water above it, or into the underlying cohesive material - whichever distance is shorter.

(d) It appears that at some locations where the grade necessitates cuts of 10 - 20 ft. depth, slope stability problems might be encountered. These excavations will cut through the desiccated crusts, below which the shear strength of the soils are usually the lowest. Stability analyses, in terms of total and effective stresses, will have to be carried out for each individual case in order to arrive at a safe slope design.

(e) It is believed that the most economical footing for several structures will be the ones supported on piles. At this stage of the investigation no attempt is made to recommend pile lengths or safe design loads on piles. Pile loading tests will likely be necessary for piles supported within the overburden, to establish lengths of piles and allowable bearing capacities.

Some comments as to the foundations of the proposed structures follow:

5.2) Structure Foundations:

(a) Structure #1 (Expressway over C.N.R. Tracks):

Borehole #1 was drilled at the proposed location of this structure. Since the grade of the C.N.R. tracks remains unchanged,

cont'd. /7 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.2) Structure Foundations: (cont'd.) ...

(a) Structure #1 (Expressway over C.N.R. Tracks): (cont'd.)...

it appears possible to place the footings of the overhead at some 5 ft. below existing ground surface. At this location the footings will be supported on the desiccated material. Deeper excavations for the footings are not recommended on account of the low shear strength of the soils below el. 715 ft. 2 TSF safe loads may be employed on the footings at the recommended depth.

(b) Structure #2 (Henry St. over Expressway):

According to the profile along the centre-line of the proposed expressway - supplied by the consultant - there will be a cut of 7 - 8 ft. depth at the location of Structure #2. Based on the findings in borehole #2, soil conditions permit the design of spread footings at 4 - 5 ft. below finished grade. 2 TSF bearing pressure may be assumed on the footings for design purposes.

(c) Structure #4 (Expressway over C.N.R.) and
Structure #5 (Expressway over Grey St.):

Only one borehole, numbered 3A, was put near the proposed bridges. From the soil stratigraphy it appears that spread footings are feasible between el. 722 and 735 ft. A minimum of 4 ft. cover should be provided for the footings for frost protection. At above elevations 2 TSF design loads may be used on the footings. Lowering the footings below el. 725 ft. is not approved, since the shear strength of the layer is not sufficient for the economical design of spread footings.

(d) Structure #6 (Colborne St. near Expressway):

The grade of the expressway is proposed to be around el. 713 - 714 ft., some 19 - 20 ft. deeper than the existing ground surface at the location of Structure #6. Borehole #4, carried out just south of Colborne St., indicated that soil

cont'd. /8 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.2) Structure Foundations: (cont'd.) ...

(d) Structure #6 (Colborne St. near Expressway): (cont'd.)...

conditions do not warrant safe footing loads larger than approx. 1.5 TSF between el. 705 and 715 ft. at the location of borehole #4A at the north side of the proposed underpass; however, spread footings with allowable pressures up to 2 TSF may be designed some 4 - 5 ft. below proposed grade. From the limited data available at the present, it appears that spill-through type abutments might be supported on spread footings right below the zone of frost penetration. Additional borings will be required at the locations of the piers, to be able to decide whether spread footings or piled foundations will be applicable.

(e) Structure #8 (Expressway over T.E. & B. Railway):

The plan calls for some 30 - 35 ft. high approach embankments at this crossing to carry the expressway over the relocated T.E. & B. railway tracks. Two borings, numbered 6 and 6A, were located near the site, both showing similar stratigraphy. Under a 6 - 9 ft. deep mixed, loose fill, irregularly layered clayey silt soils were encountered having firm to hard consistency. The shear strength of these soils do not seem to be adequate for the economical design of shallow foundations, thus footings supported on piles are recommended. Steel tubular piles, driven to the hard silt layer will probably be the right answer, but as was mentioned earlier, pile loading tests will likely be suggested. A rough estimate indicates that a fill of 30 - 35 ft. height is stable with slopes of 2 horizontal to 1 vertical, but the stability should be checked during the final investigation.

(f) Structure #10 (Murray St. - Mohawk St. over Expressway:

The proposed grade of the expressway is around el. 660 ft., some 6 - 9 ft. below existing ground level. Soil conditions, indicated by boreholes #7, 7A and 7B, are not favourable for the

cont'd. /9 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.2) Structure Foundations: (cont'd.) ...

(f) Structure #10 (Murray St. - Mohawk St. over Expressway):
(cont'd.)...

economical design of shallow foundations, consequently footings supported on steel tube piles might be employed. Further boreholes at the exact locations of the footings will be necessary in order to determine length of piles and design loads.

(g) Structure #11 (Expressway over Erie Ave.):

Borehole #9B, drilled in the vicinity of the proposed Bridge #11, revealed sandy soils with loose to compact relative density, underlain by stiff clayey silts. Below the proposed grade of Erie Ave., around el. 640 - 650 ft., penetration blows of 8 - 10 were recorded. Such low values of shear strength do not warrant the design of spread footings within these elevations. Piled foundations are foreseen, necessitating additional boreholes at the proposed locations of the footings.

(h) Structure #12 (Expressway over Market St. - Erie Ave. Connection):

A 10 - 12 ft. deep mixed and partly organic fill covers this area as indicated by boring #9. Below this fill, between el. 642 ft. and 632 ft. the subsoil has adequate strength to support the bridge on spread footings, with design loads of 2 TSP. The same design load may be reached at a higher elevation, provided that the fill material under the footings is removed and replaced by well compacted granular backfill. The construction methods of such a foundation should comply with D.H.O. specifications.

Perched abutments may also be supported on piles, the pile caps being formed within the embankments. Pile lengths and design loads on piles ought to be determined by additional boreholes.

cont'd. /10...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.2) Structure Foundations: (cont'd.) ...

(1) Structure #13 (Expressway over Grand River):

Two boreholes, numbered 9A and 10A were carried out at the banks of the Grand River. In both holes coarse-grained soils were found to overlie the layered clayey silts, which in turn were followed by dolomite bedrock. The upper surface of the bedrock at the east bank was established at el. 605.5 ft., whereas at the west bank it was registered at el. 607.6 ft. It is recommended that the abutments as well as the piers of the proposed bridge be supported on end-bearing steel or precast concrete piles driven to sound bedrock. Assuming that all the piles are supported on such rock, the full structural strength of the particular pile section used may be utilized for design purposes. The stability of the approach embankments and the settlements due to the fills will need to be checked during the final foundation investigation. It is to be noted that fills with 2 horizontal to 1 vertical slopes appear to be stable up to 30 ft. height.

(2) Structure #15 (Expressway over T. H. & B. and C.N.R. Tracks):

The grade of the expressway is proposed to be around el. 705 - 708 ft. at the location of this bridge. Soil conditions, as observed in borehole #15, appear to be favourable for spread footing type foundations. The base of the footings should be between el. 660 ft. and 665 ft., provided that a minimum cover of 4 ft. is maintained for frost protection. 2 TSP safe pressures may be employed on such footings. Footings for spill-through type abutments may be placed within the approach embankments and supported on steel tube or steel H-piles. The approach fills with 2 horizontal to 1 vertical slopes, are believed to be stable; however, further analyses are suggested during the final investigation.

cont'd. /11 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

5.3) Evaluation of Boreholes at Fill and Cut Locations:

(a) Boreholes #3, 5, 8, 12, 13A, 13, 14A and 14, were drilled at the locations of proposed fills and deep cuts. The soil stratigraphy and test results of these boreholes may be seen on the accompanying borelog sheets. Some comments as to the stability of slopes and probable groundwater seepage are given below.

(b) The height of the proposed embankments at the locations of the boreholes varies between 7 and 10 ft. No stability problems are foreseen for the construction of such fills, provided they are built with standard slopes of 2 horizontal to 1 vertical.

(c) The depth of the proposed cuts at the vicinity of the boreholes ranges from 10 ft. to over 30 ft. The undrained shear strength of the soils indicates that the immediate overall stability of the slopes will be satisfactory with slopes of 2 horizontal to 1 vertical. In the case of excavations, however, it is the long-term stability which may be critical, consequently analyses will need to be carried out using effective stress parameters. It appears that some benching of the slopes may be required. Additional undisturbed soil samples will be necessary for the tests.

At the locations of boreholes #5, 13A and 14A the groundwater level was established at some 13 - 16 ft. higher than the design grade. The clayey silt stratum is essentially a cohesive material; therefore, no appreciable seepage is predicted within this layer.

Along the seams of silty sands and sands, however - assuming they are continuous - seepage forces can develop, resulting in erosions and local slip failures. Some remedial measures, such as intercepting or counterfort drains, ought to be contemplated.

cont'd. /12 ...

5. DISCUSSION AND COMMENTS: (cont'd.) ...

Piezometric water level observations at the locations of steep cuts are recommended in order to obtain detailed groundwater data.

6. MISCELLANEOUS:

The field investigation, performed during the period July 24 to August 12, 1968, was supervised by Messrs. V. Korlu, A. Seppala and D. Davis, Project Foundation Engineers.

Equipment used was owned and operated by Dominion Soil Investigation Ltd., Toronto, and P. Van Cristofer Drilling Co., Burford.

Mr. A. K. Barsvary, Senior Foundation Engineer, was in charge of the entire project, and who also prepared this report. Mr. K. G. Selby, Supervising Foundation Engineer, reviewed the report.

September, 1968.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 68-5-01

LOCATION Co-ords. 8,700 N. 4,060 E.

ORIGINATED BY MS

W P

BORING DATE August 7 - 8, 1968

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Washboring, BI & NY Casing

CHECKED BY AKB

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — % PLASTIC LIMIT — % WATER CONTENT — %		H R K D E N S I T Y	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLLOT	NUMBER TYPE	BLOWS / FOOT	ELEV. SCALE	20	40	60	80	100		
703.5	Ground Level											Gr.Sa.Si.Cl
690	Silt to clayey silt, occasional seams of sand. Very stiff to hard.		1	SS	12	700						699.5
			2	SS	21							
			3	SS	56							
			4	SS	25	690						0 10 (90)
			5	SS	55							0 1 (99)
			6	SS	41							
			7	SS	7	680						
672.0			8	SS	51							0 0 (100)

31.5 End of Borehole

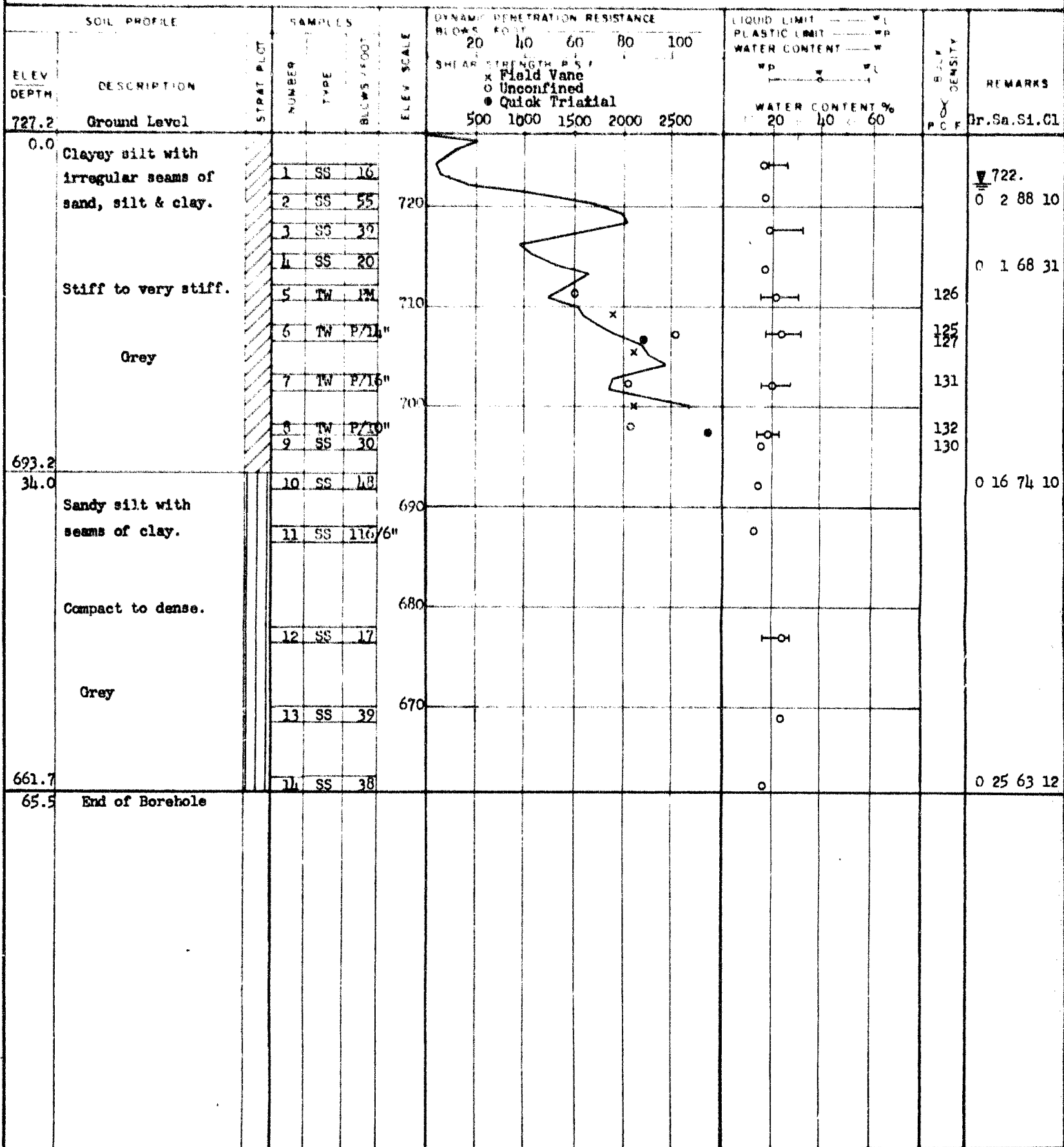
DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

APPENDIX I

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION
JOB 68-F-64
W P _____
DATUM Geodetic

RECORD OF BOREHOLE NO 1
LOCATION Co-ords. 20,860N 16,015 E.
BORING DATE July 24 & 25, 1968
BOREHOLE TYPE Auger

FOUNDATION SECTION
ORIGINATED BY VK
COMPILED BY AKB
CHECKED BY AKB



[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO 3

FOUNDATION SECTION

JOB 68-F-64 LOCATION Co-ordinates 15,260 N 17,240 E. ORIGINATED BY VK
W P Geodetic BORING DATE July 28, 1968 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Auger CHECKED BY /

SOIL PROFILE		STRAT. PLT	SAMPLES		BLOWS / FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		PLASTIC LIMIT	WATER CONTENT	WATER CONTENT %	SOIL DENSITY	REMARKS
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE			BLOWS	FOOT	20	40					
750.2	Ground Level														
0.0	Silty fine sand to silt with some sand and traces of clay.		1	SS	5										
			2	SS	24										
			3	SS	52										
	Brown & grey.		4	SS	146										
	Loose to very dense.		5	SS	68										
			6	SS	34										
			7	SS	102										
715.7			8	SS	46										
34.5	End of Borehole														

0 57 42 1
740

[illegible]

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT - W _L		REMARKS
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT - W _P	WATER CONTENT %	
733.5	Ground level							0r.Sa.Sl.C
0.0	Silty fine sand. Dense	1	SS	46				
723.4		2	SS	44				
10.5	Clayey silt with irregular seams of sand & silt. Stiff to hard. Grey	3	SS	22				
		4	TN	TM				
		5	SS	17				
		6	TN	TM				
		7	SS	22				
		8	SS	29				
687.9		9	SS	35				
46.0	Silty fine sand. Very dense.	10	SS	69				
673.4		11	SS	44				
59.5	End of Borehole							

[illegible]

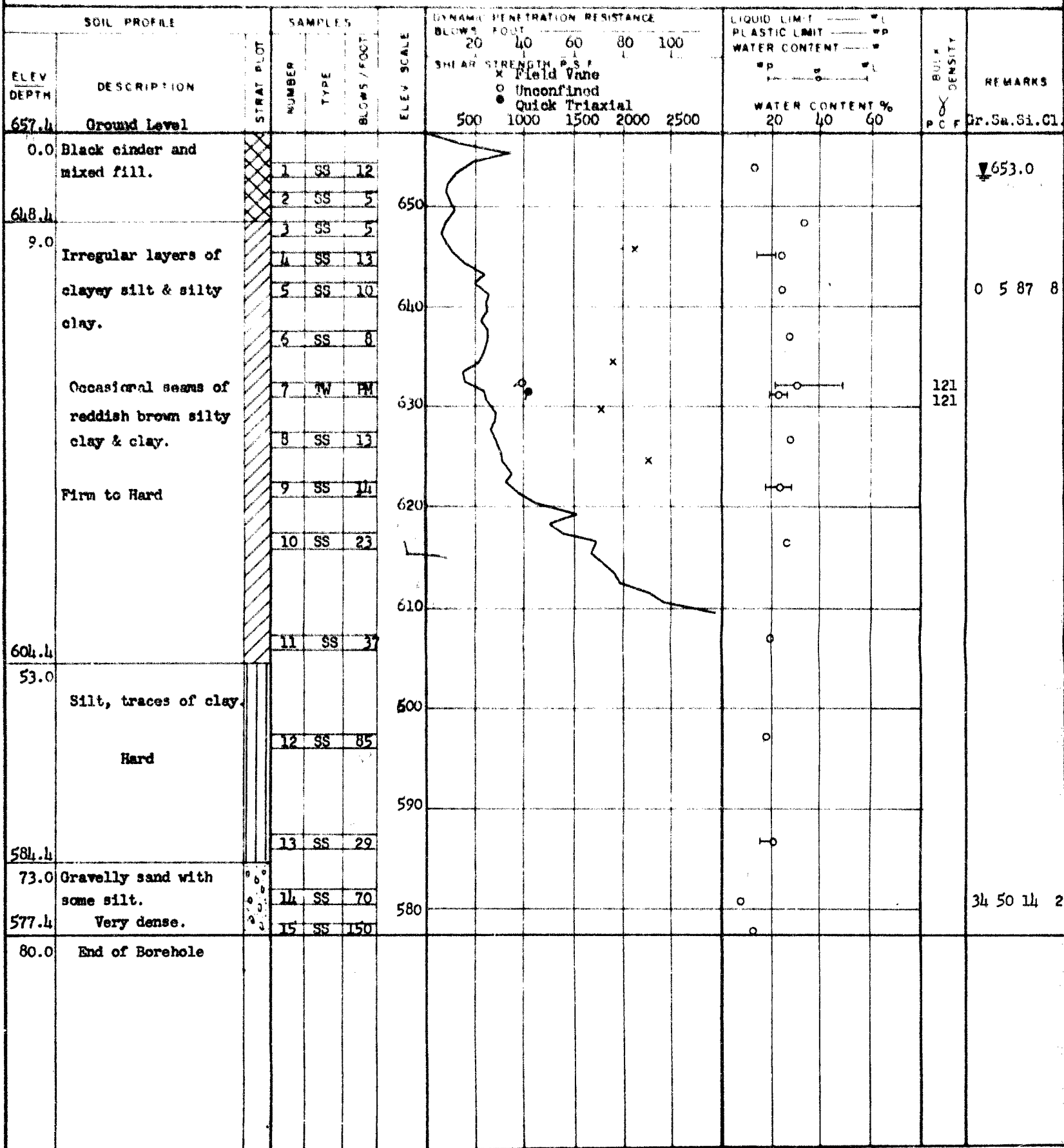
DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 68-F-64 LOCATION Co-ords. 10,850 N 14,375 E. ORIGINATED BY AMS
W P BORING DATE July 25 - 26, 1968 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY



DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 68-F-64

LOCATION Co-ords. 10,890 N. 12,700 E.

ORIGINATED BY VK

W P

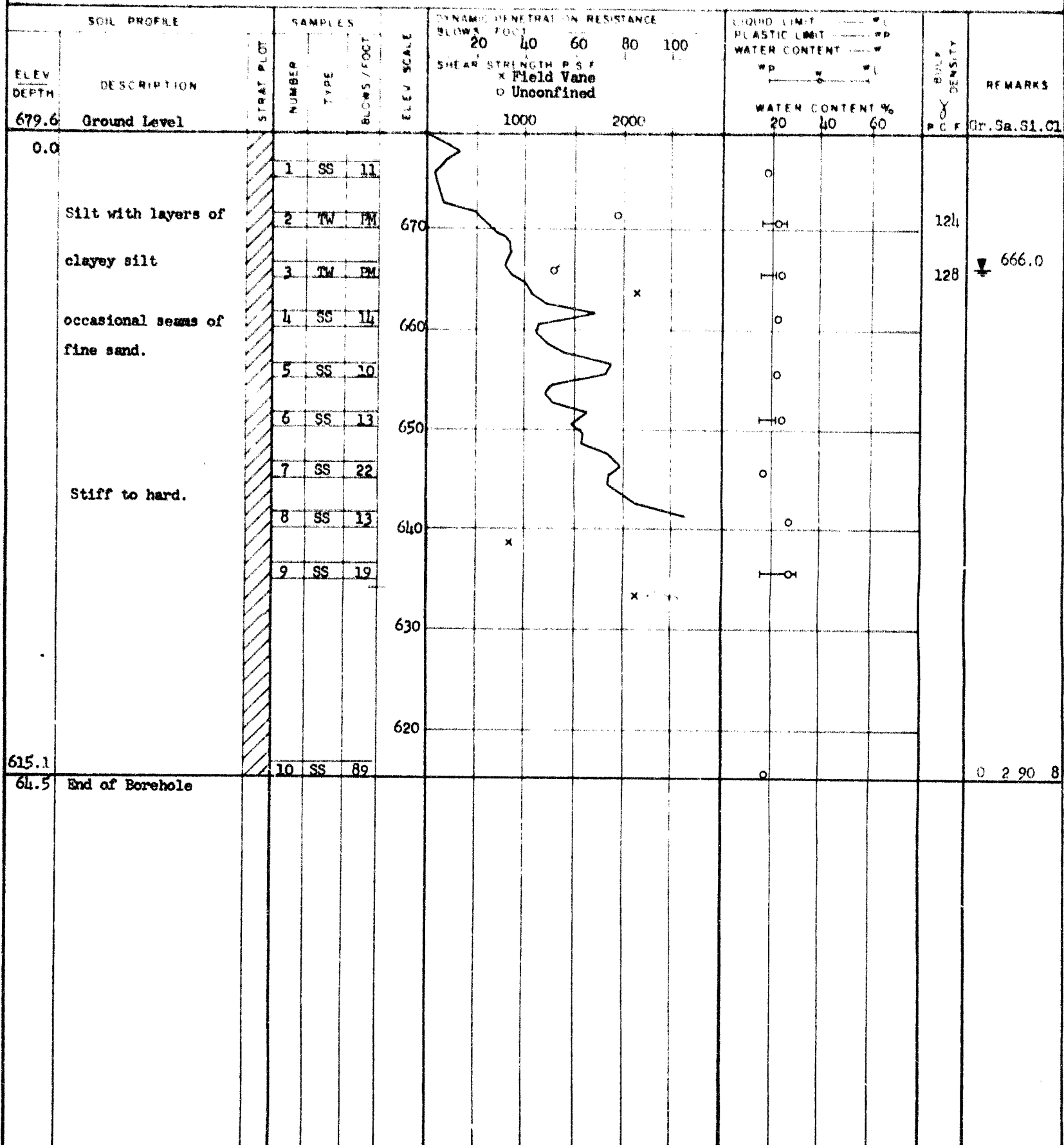
BORING DATE August 1, 1968

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Auger

CHECKED BY



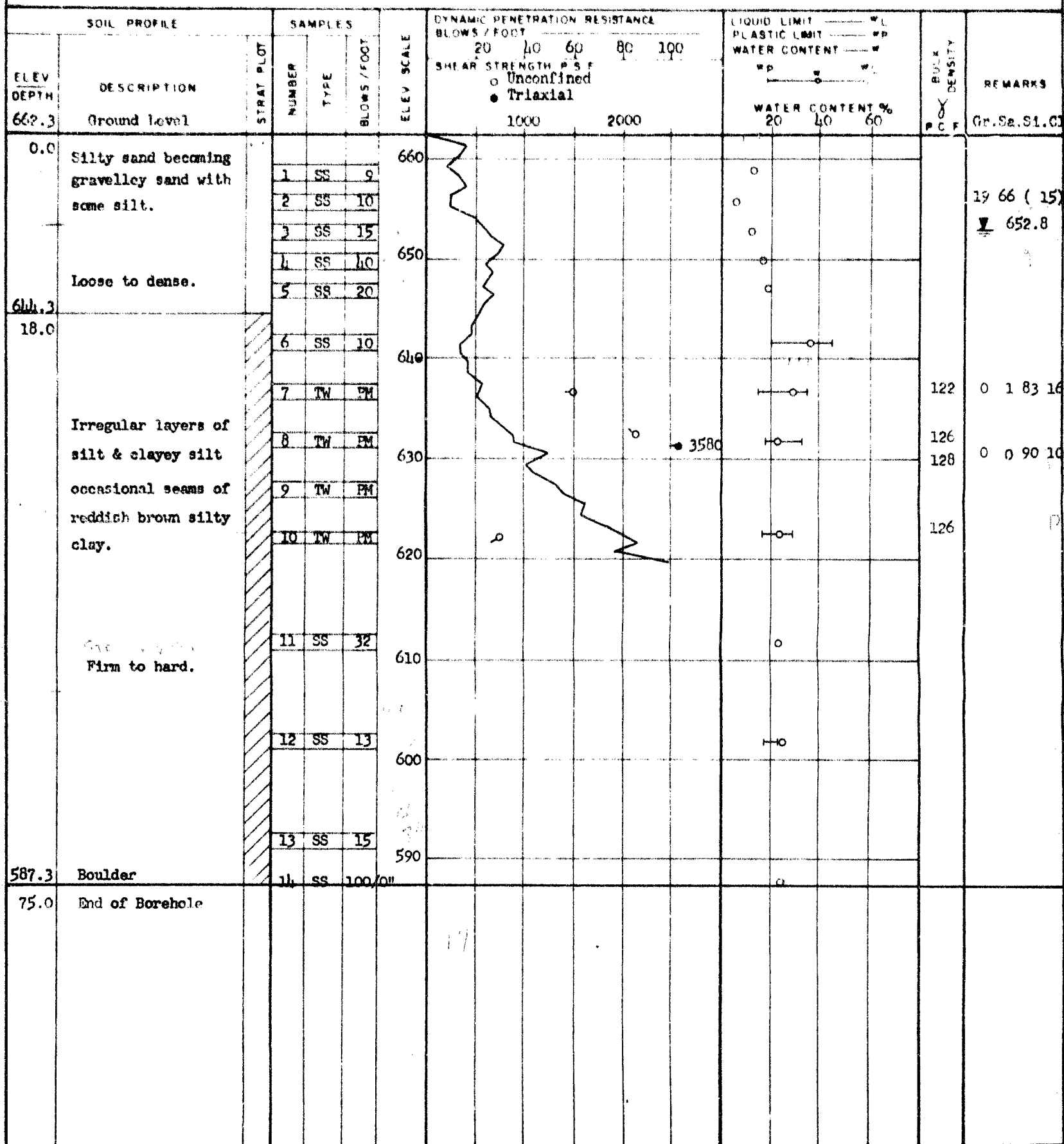
DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 68-F-64 LOCATION Co-ords. 11,070 N. 12,150 E. ORIGINATED BY AMS
W.P. BORING DATE July 31 Aug. 1/68 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY AKB



DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO 9

FOUNDATION SECTION

JOB 68-5-64 LOCATION Co-ords. 10,920 N. 9,890 E. ORIGINATED BY DD
W.P. BORING DATE Aug. 7, 1968 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Auger CHECKED BY

SOIL PROFILE		STRAT. PLOT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— % PLASTIC LIMIT ——— % WATER CONTENT ——— %		BULK DENSITY PCF	REMARKS	
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE		BLOWS / FOOT	20 40 60 80 100	20 40 60				
654.8	Ground Level										Gr. Sa. Si. Cl.	
0.0	Mixed fill of gravel, sand, silt, cinder and organic material.		1	SS	0	650					64.0 45.44 (11)	
643.3			2	SS	12							
			3	SS	22							
11.5	Sandy gravel with some silt.		4	SS	27							
633.3			5	SS	67							
			6	SS	22							
21.5	Irregular layers of clayey silt, reddish brown silty clay & seams of sand.		7	SS	59							
613.8			8	SS	26							
			9	SS	16							
41.0	Stiff to hard. Clayey silt with gravel. Hard. (Glacial Till)		10	SS	14							
606.3			11	SS	41							
			12	SS	192							
48.5	End of Borehole		13	TW	98							

DEPARTMENT OF HIGHWAYS - ONTARIO		RECORD OF BOREHOLE NO 98		FOUNDATION SECTION	
MATERIALS & TESTING DIVISION		LOCATION		ORIGINATED BY	
JOB 68-F-64		Co-ords. 10,990 N. 10,430 E.		DD	
W P		BORING DATE August 6, 1968		COMPILED BY AKB	
DATUM Geodetic		BOREHOLE TYPE Auger		CHECKED BY	
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	WATER CONTENT
659.3	Ground Level				
0.0	Silty sand becoming gravelly sand.	1	SS	8	
	Loose & Compact.	2	SS	20	
640.3		3	SS	8	
		4	SS	10	
19.0	Clayey silt occasional seams of reddish brown silty clay.	5	SS	22	
	Traces of sand.	6	SS	21	
		7	SS	12	
		8	SS	21	
		9	TW	P/G	
		10	SS	17	
		11	SS	14	
	Stiff to hard.				
606.8		12	SS	16	
		13	SS	66	
52.5	End of Borehole				

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 14

FOUNDATION SECTION

JOB 68-F-64 LOCATION Co-ords. 10,100 N. 3,320 E. ORIGINATED BY AMS
W.P. BORING DATE August 8, 1968 COMPILED BY AKB
DATE Geodetic BOREHOLE TYPE Auger CHECKED BY

SOIL PROFILE		SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — PL PLASTIC LIMIT — PP WATER CONTENT — W			SOIL DENSITY pcf	REMARKS
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE		20	40	60	80	100	W.P.	W.L.	W.C.		
725.4	Ground Level													
	C.O Silty sand to silt with irregular layers of clayey silt. Stiff to hard.	1	SS	11										Gr. Sa. Si. Cl 0 0 (100) 714.4
		2	SS	13										
		3	SS	23										
		4	SS	30										
		5	FW	PH										
		6	SS	19										
		7	SS	30										
691.9	Refusal	8	SS	102/1"										
33.5	End of Borehole													

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

DEPARTMENT OF HIGHWAYS - ONTARIO						RECORD OF BOREHOLE NO. 14A								FOUNDATION SECTION											
MATERIA 5 & TESTING DIVISION																									
JOB 68-F-64						LOCATION Co-ords. 9,380 N. 3,775 E.								ORIGINATED BY AMS											
W P						BORING DATE Aug. 8, 1968								COMPILED BY AKB											
DATUM Geodetic						BOREHOLE TYPE Washboring BX Casing								CHECKED BY											
SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT --- W _L			PLASTIC LIMIT --- W _P			WATER CONTENT --- W			BULK DENSITY			REMARKS		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	BLOWS / FOOT 20 40 60 80 100					WATER CONTENT % 20 40 60			Y X C F										
750.1	Ground Level																	Dr. Sa. Si. Cl.							
0.0	Sand with some silt.		1	SS	2																				
	Very loose to compact		2	SS	10																				
			3	SS	13	740												0 87 (13)							
737.1			4	SS	67																				
13.0			5	SS	30																				
	Clayey silt with irregular layers of silt & sand.		6	SS	11	730												▽ 729.							
	Occasional seams of silty clay & clay.		7	SS	39													0 10 (90)							
	Stiff to hard.		8	SS	20	720																			
			9	SS	41													0 7 (93)							
			10	SS	26	710																			
			11	SS	46	700																			
688.6			12	SS	37	690																			
61.5	End of Borehole																								

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 15

FOUNDATION SECTION

JOB 68-F-64

LOCATION Co-ords. 10,950 N. 2,520 E.

ORIGINATED BY DD

W P

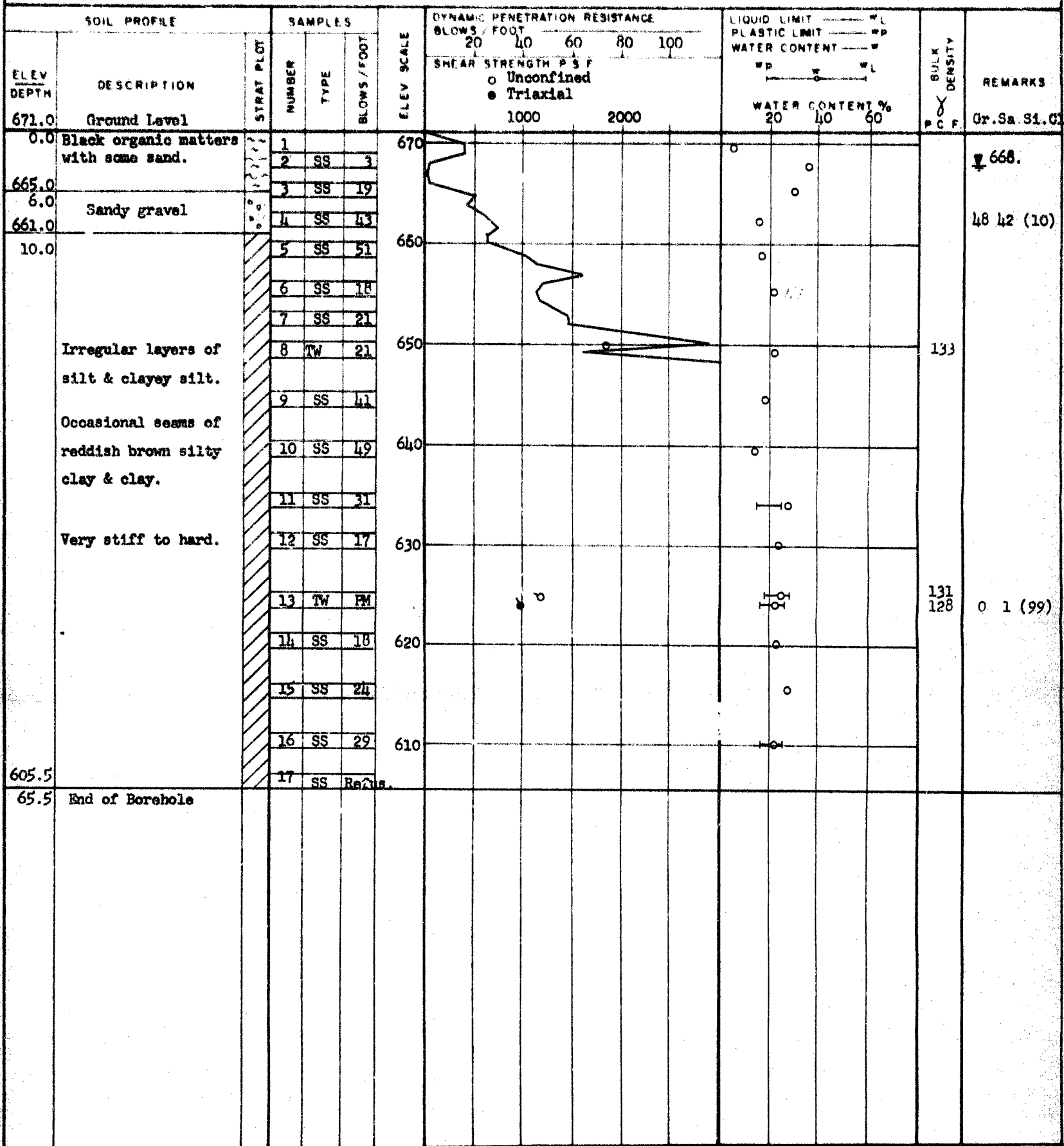
BORING DATE August 9 & 12, 1968

COMPILED BY AXB

DATUM Geodetic

BOREHOLE TYPE Auger

CHECKED BY



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 :-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
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

SS	SPLIT SPOON	TW	THINWALL OPEN
WS	WASHED SAMPLE	TP	THINWALL PISTON
SB	SCRAPER BUCKET SAMPLE	OS	OESTERBERG SAMPLE
AS	AUGER SAMPLE	FS	FORK SAMPLE
CS	CHUNK SAMPLE	RC	ROCK CORE
ST	SLOTTED TUBE SAMPLE		
	PH	SAMPLE ADVANCED HYDRAULICALLY	
	PM	SAMPLE ADVANCED MANUALLY	

SOIL TESTS

QU	UNCONFINED COMPRESSION	LV	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	FV	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
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_i	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 (YOUNG'S 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_0	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