OVER

CITY OF CORNWALL

64-F-282 M

(Co. of Stormont)

REPORT
ON
FOUNDATION INVESTIGATION FOR PROPOSED STRUCTURE ON BROOKDALE AVENUE AT THE C.N.R. CROSSING CORNWALL, ONTARIO

64-F 282M

DAMAS AND SMITH LIMITED
CONSULTING ENGINEERS

SEE NOTE ON PAGE OVERLEAF

Submitted By

ASSOCIATED GEOTECHNICAL SERVICES LIMITED
211 Davenport Road, Toronto 5, Ontario.

January 9, 1964.

OVER

NOTE:

INFORMATION ABOUT SUBSOIL CONDITIONS IN ADJACENT AREAS CAN BE FOUND IN THE FOLLOWING REPORTS

W.P. 102-59 BROOKDALE AVE & HWY 401
also (63-F-125) BY ~~RACEY~~ McCALLUM

W.P. 259-60 BROOKDALE AVE &
60-F-36 SOUTH RAISIN RIVER
(FOUNDATION SECTION)

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APPENDIX

SECTION I

INTRODUCTION

The purpose of this report is to present the results of a foundation investigation made in connection with the proposed structure on Brookdale Avenue - C.N.R. crossing in Cornwall, Ontario.

The study was authorized by Damas and Smith Limited, on behalf of Mr. R. C. Adams, P.Eng., City Engineer for the City of Cornwall.

SECTION 2

DISCUSSION OF PROCEDURES

A primary drilling program consisting of four boreholes and six dynamic cone probes was carried out in the vicinity of the proposed structure during the month of November 1963. In order to obtain additional data at the site, the initial program was extended to include 14 additional dynamic cone probes.

The borehole locations for this investigation were referenced to the centreline of the existing Brookdale Avenue. The chainage at the intersection with the centreline of the C.N.R. tracks was taken as 42 + 20. The chainage increased in a southerly direction. The borehole and dynamic cone probe locations are shown on the plan in the Appendix.

The elevation of each borehole and dynamic cone probe was determined by spirit level using the top of the northermost rail at the centreline of the road as a benchmark with an assumed elevation of 199.5.

The boring and sampling operations for this project were carried out using a Boyles screw feed, trailer-mounted drilling rig. A farm tractor was used to expedite the moving of the drilling rig to the off-road locations. The field boring was carried out under the full-time supervision of a qualified Soils Engineer.

The soil borings were performed by standard wash boring sequences. In this procedure, drill casing is driven into the soil by a 350 lb. hammer to a depth of 5 feet or to a change in stratum. Comparative soil density changes were noted by observing the number of blows required to drive the casing. All the soil contained inside the casing was thoroughly washed out to the bottom of the casing and the resultant wash water observed to further determine stratum changes. Sampling tools were then lowered to the bottom of the hole and samples taken. Additional lengths of casing were used as required and the procedure repeated.

Attempts were made to obtain samples of cohesionless soil by means of a 2" O.D. standard split-spoon sampler. The standard penetration test using a 140 lb hammer falling 30 inches was recorded for each foot of sampler penetration. All samples were visually examined on the site, then placed in jars and forwarded to the Engineering Office.

Undisturbed samples of cohesive soil were obtained in 2" I.D. Shelby tubes in conjunction with a piston sampling apparatus. Upon removal from the borehole, these samples were classified, sealed with wax and forwarded to the Engineering Office.

Insitu measurements of clay shear strength were made in the boreholes with a 2" by 4" vane and a torqometer calibrated in increments of 20 inch-lbs. The accuracy of these shear strength determinations, by estimating the readings of torque to the nearest 5 inch-lbs, was ± 25 lbs per sq. ft. A thrust bearing was used to take the weight of the drill rods in most measurements of shear strength.

Samples of bedrock were obtained by diamond drilling using an Ax size core barrel.

All soil tests were carried out in the soils laboratory of Associated Geotechnical Services Limited. They primarily included moisture content, strength and consolidation determinations. The strength tests consisted of unconfined compression and unconsolidated, undrained triaxial tests. The consolidation testing was carried out on a Geonor apparatus utilizing a sample area of 10 sq. cms.

SECTION 3

DISCUSSION OF SITE

3.1 Geographic Location

The proposed bridge site is located on Brookdale Avenue in the northwest portion of the City of Cornwall, Ontario. Brookdale Avenue is one of the major traffic arteries from Highway 401 into the City of Cornwall. The site is located about 3/4 mile south of Highway 401.

3.2 Geology of the Site Area

The Pleistocene and Recent geology of the general geographic area have been described by E. B. Owen in Paper 51-12 of the Geological Survey of Canada. The general sequence of glacial and postglacial events described by Owen are as follows. During the advance and retreat of the last continental ice sheet, deposits of till textured soil were heaped up on the bedrock to form irregular hills and ridges. During the retreat of the ice sheet from the area, the rugged topography of the hills and ridges was somewhat subdued by the deposition of granular outwash on top of the till by the glacial meltwaters. Further subduing of the relief was accomplished by deposition of flat-lying marine sediments (mostly clay capped with a thin layer of sand) in the immediate postglacial land submergence under the Champlain Sea.

Limestone bedrock of the Ordovician Period was found at the site at a depth of approximately 32 feet below ground surface.

3.3 Soil Conditions

The soils at the site are shown in cross-section in the appendix.

The soils at the site were found in the following order below ground surface:

1. 0.5 to 1.5 feet of topsoil,

2. 1.0 to 1.6 feet of brown fine sand,

3. Stiff to soft grey clay to a maximum depth of 33 feet below ground surface,

4. Medium dense grey sand, some silt and gravel,

5. Medium dense grey coarse sand (Borehole 1 only),

6. Very dense grey sand, some silt and gravel, till texture, (Borehole 1 only),

7. Black limestone bedrock.

The topsoil and brown fine sand strata, being of shallow depth, were not investigated other than in the field by visual classification and penetration resistance, both of which are summarized on the Borehole Logs.

Beneath the brown fine sand layer a deep stratum of marine clay was encountered. The clay stratum was found to be silty and weathered to a brown colour near ground surface. The middle third of the clay stratum was characterized by the presence of numerous tiny black nodules. Occasional red nodules were encountered in the lower portions of the stratum. The clay appeared to be massive at natural moisture content, but upon drying, thin horizontal laminations became visible. Thin horizontal sand seams were encountered in Borehole 2 at 29 feet and in Borehole3 at 8 feet. The continuity of these sand seams has not been investigated.

The strength of the clay layer was found to vary with depth as shown on Figure 1 overleaf. There appeared to be a 5 ft thick stiff upper crust beneath which the clay had a vane shear strength of about 400 to 700 p.s.f. down to a depth of 22 feet. Below this depth the shear strength increased. The sensitivity of the clay was found for the mostpart to exceed 8. Numerous unconfined compression and triaxial tests were carried out on the thin walled tube piston samples. The results of these tests have been plotted in detail on the stress-strain charts in the appendix and in summary on the Borehole Logs and on Figure 1 overleaf. In general, the laboratory tests were found to agree reasonably well with the field vane results when the laboratory tests gave low failure strains.

Moisture content and unit weight determinations were carried out on the thin walled tube samples as indicated on the Borehole Logs. The majority of moisture contents in the clay varied between 70 and 80 percent, however, values below this range were found in the desiccated crust. In addition, occasional moisture contents above 80 percent were found in the deeper clay regions. The unit weight of the clay was found to vary from a maximum of 110 lbs/cft. in the desiccated crust to a minimum of 92.5 lbs/cft. in the deeper sections.

In order to determine the settlement characteristics of the clay layer under the load of an approach embankment fill, consolidation tests were carried out on samples 5 and 7 from Borehole 2.

CLIENT CITY OF CORNWALL

JOB. NO. 6333 LOCATION BROOKDALE AT C.N.R

BOREHOLE NUMBER ______ DEPTH ______

SAMPLE NUMBER ______ DATE ______

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CLAY STRENGTH — DEPTH CHART

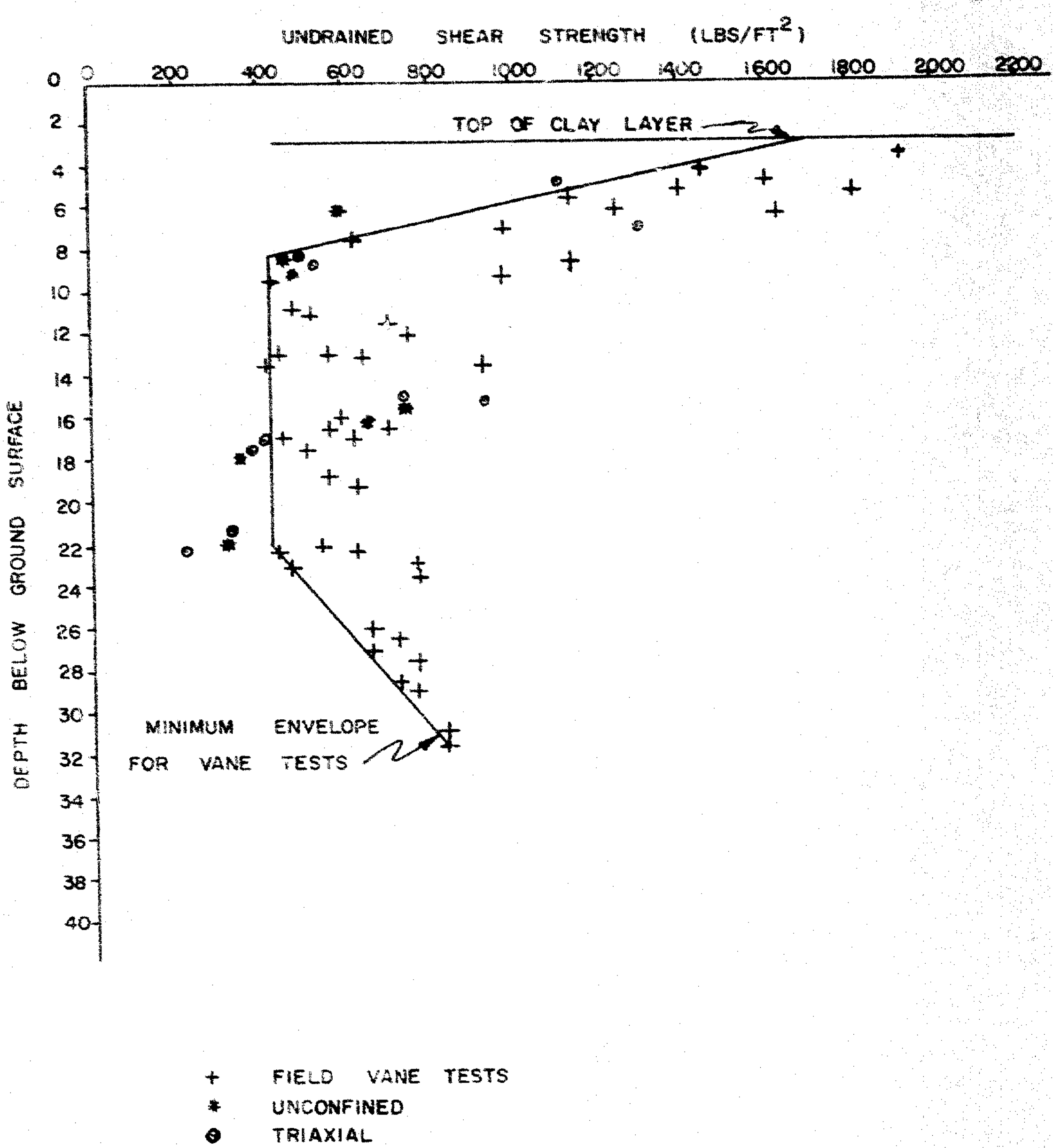

FIGURE 1

The results of these tests indicate a preconsolidation pressure of about 0.7 t.s.f. in excess of the existing overburden. Plots of consolidation versus load for each sample are included in the appendix.

A number of dynamic cone probes were driven at various locations in order to determine the approximate depth of clay over the site area. The results of most of these probes are indicated on the profile on Drawing No.1 in the appendix. Liberally interpreted contours of the bottom of the clay layer have been plotted on the plan on Drawing No. 1. As can be seen on this plan, the maximum depth of clay appears to be beneath the railway. The depth of clay diminishes and disappears both north and south of the tracks.

Beneath the clay, a medium dense stratum of grey sand, some silt and gravel was found in all boreholes. The penetration resistance of this soil varied from 9 to 13 blows per foot. The thickness of this stratum varied from 3 to 5 feet and was underlain by bedrock in Boreholes 2, 3 and 4. In Borehole 1, it was underlain by 5.5 feet of medium dense grey coarse sand and 7 feet of very dense till-textured soil. Two split-spoon samplers taken in the till indicated a penetration resistance of over 80 blows per foot for this soil.

3.4 Water Conditions

At the time of this investigation, the ground water table was found to lie with a few inches of the ground surface It can be expected to remain at this level for most of the year.

Artesian water conditions were encountered under the clay in Boreholes 1 and 2, both north of the tracks. The maximum static load measured in the boreholes was 193.6 in Borehole 1 and 193.7 in Borehole 2. The flow at ground level (about elevation 192) was estimated to be about 3 gallons per minute in both boreholes.

3.5 Bedrock Conditions

Black limestone bedrock was encountered in all boreholes at elevations varying between 156.6 in Borehole 4 to 158.0 in Borehole 2. However, some of the dynamic cone probes, namely CP2, CPA and CPB indicate that bedrock lies at a somewhat lower elevation near the railway. The bedrock appeared to be sound and capable of supporting high loads. The upper surface was found to be relatively free of weathering. Thus in our opinion, the bearing capacity of the bedrock would be 25 t.s.f.

SECTION 4

DISCUSSION OF OVERPASS STRUCTURE

4.1 General

Prior to commencing this soils investigation, the Consulting Engineers had prepared a preliminary layout of an overpass structure to replace the existing Brookdale Avenue grade crossing. The bridge was to be a 3 span continuous structure with piers at chainage 41 + 80 and 42 + 60 and abutments at chainage 40 + 44 and 44 + 00. The top of the existing railway embankment is about 7 feet higher than the surrounding ground level at elevation 192, thus in order to provide the required railway clearance, the approach fills to the structure would be about 34 feet high at the abutments.

When the field soils data became available, it was apparent that both stability and settlement problems could be expected with high earth fill approach embankments. In view of the complexity of calculations imposed by the variability of the strength and depth of clay at the site, a conservative simplification of the insitu soil strengths was made for purposes of stability calculations. As a result, the earth fill dimensions presented in this report, while satisfactory for determination of the most economic type of structure, should be reviewed in detail for the final arrangement of the structure.

4.2 Approach Fills

4.2.1 Stability

In view of the substantial depth of sensitive soft marine clay encountered at the site, it was apparent that the use of stabilizing berms would be required for the contemplated approach fill embankments. In as much as the berms would be necessary between the abutments and the railway tracks as well as perpendicular to the embankment centreline, the length of berm required to stabilize the fill must be considered by the bridge designer prior to locating the piers and abutments of the structure. In view of the interrelationship between the height of approach fill and length of span, a series of embankment design calculations were carried out to determine the necessary fill dimensions for various heights of fill.

The approach embankment design was carried out using the charts and other data contained in "The Design of Embankments on Soft Clay" by B. Jackson. The shear strength of the clay was taken as 400 p.s.f. throughout the layer. This was consistent with the minimum envelope of field vane shear strengths determined in the 4 boreholes. The increase in soil shear strength in the desiccated crust was ignored because it had a small influence on the total shearing resistance as well as being necessary for the simplified calculations. The shearing resistance of the embankment fill was also ignored because the incompatibility of failure strain between the fill and clay foundation would not permit shearing resistance mobilization. For the purposes of these preliminary designs, the thin sand seams encountered in Boreholes 2 and 3 were assumed to be localized and discontinuous. However, these latter assumptions would have to be confirmed in the field prior to the construction of embankments in excess of 10 feet high. In view of the consequences of an embankment shear failure, a safety factor of 1.50 was used for the embankment design.

The results of the stability analyses are indicated on Figures 2 to 4 overleaf. In summary, these charts indicate the following:

1. Assuming embankment side slopes of 2 horizontal to 1 vertical, the maximum height of fill that can be built without stabilizing berms is 12 feet.

2. The length and height of stabilizing berm required varies with the depth of clay as shown on the charts. In general, longer berms are required for increasing depths of clay.

3. Assuming the potential failure surface to reach a maximum depth of 20 feet into the clay layer, the maximum height of fill that can be built with one berm is 23 feet and the maximum height of fill with two stabilizing berms is 34 feet.

A plan and profile for the maximum height of fill that can be constructed at the Brookdale site on the present profile grade and still satisfy the railway clearance requirements has been included as Drawing No. 2 in the appendix. It should be noted that the geometry of the fill has been based on the maximum probable depth of failure and has not been adjusted for shallower depths of clay.

4.2.2 Settlement

High approach fill embankments will impose a stress on the soft clay subsoil that will result in settlements of the embankments. In order to determine the amount of this

CLIENT CITY OF CORNWALL

JOB. NO. 6333 LOCATION BROOKDALE AT C.N.R.

BOREHOLE NUMBER ______ DEPTH ______

SAMPLE NUMBER ______ DATE ______

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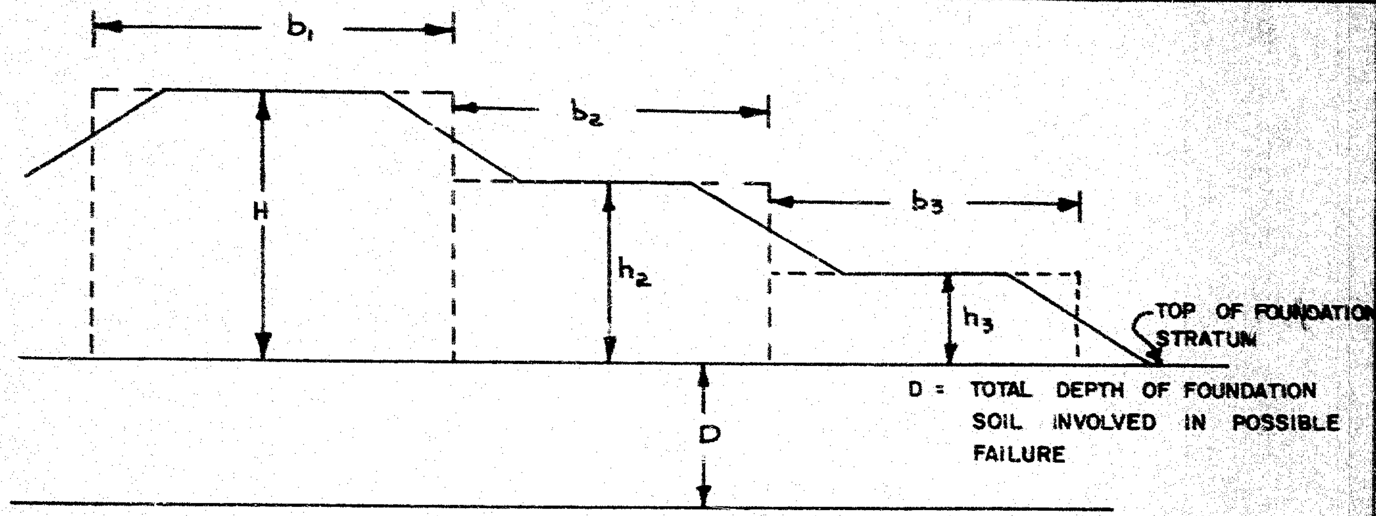


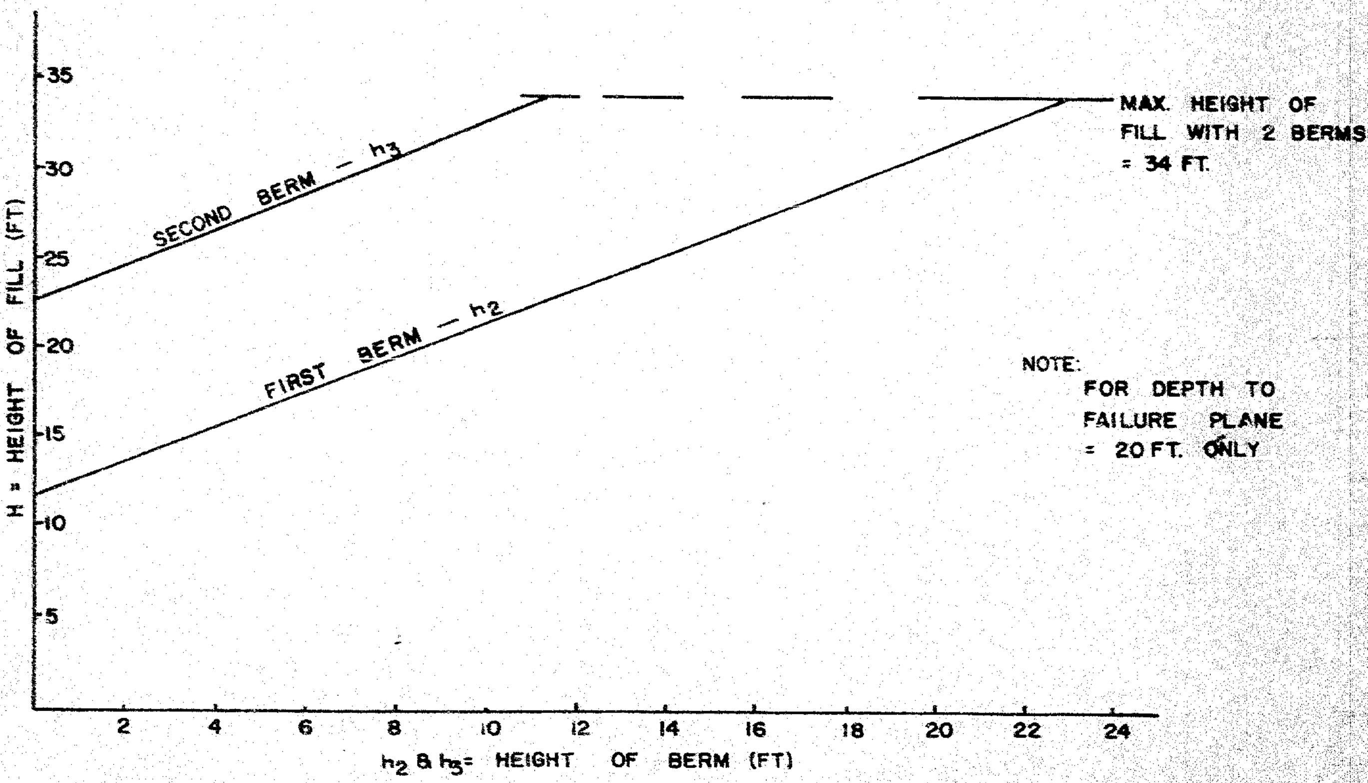
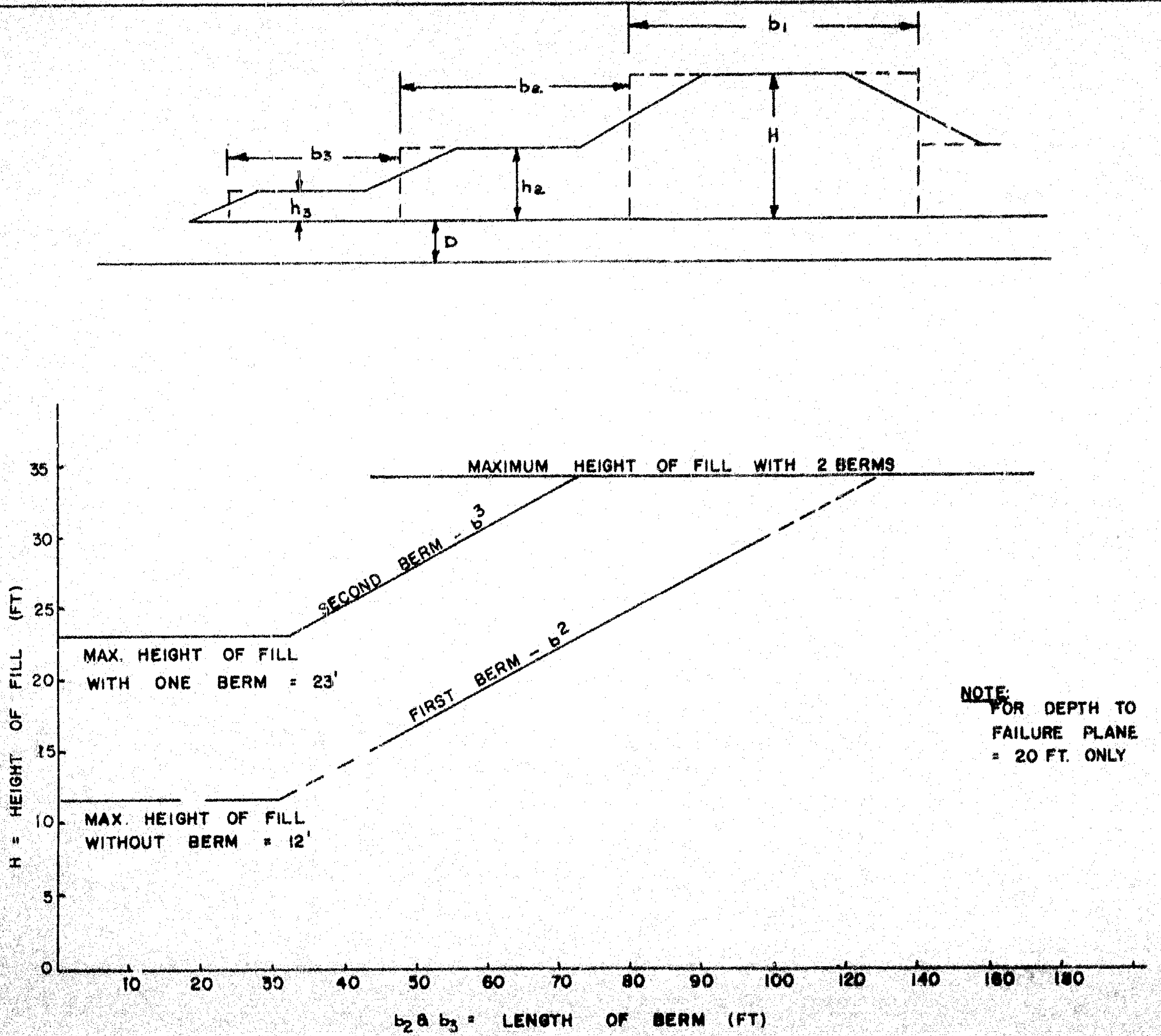


FIGURE 2



CLIENT CITY OF CORNWALL
JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.
BOREHOLE NUMBER DEPTH
SAMPLE NUMBER DATE

ASSOCIATED GEOTECHNICAL SERVICES Limited

CHART SHOWING LENGTH OF BERMS REQUIRED

FIGURE 3

CLIENT CITY OF CORNWALL

JOB. NO. 6333 LOCATION BROOKDALE AT C.N.R.

BOREHOLE NUMBER ______ DEPTH ______

SAMPLE NUMBER ______ DATE ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

CHART SHOWING FILL HEIGHT- LENGTH OF BERM DEPTH OF FAILURE RELATIONSHIP

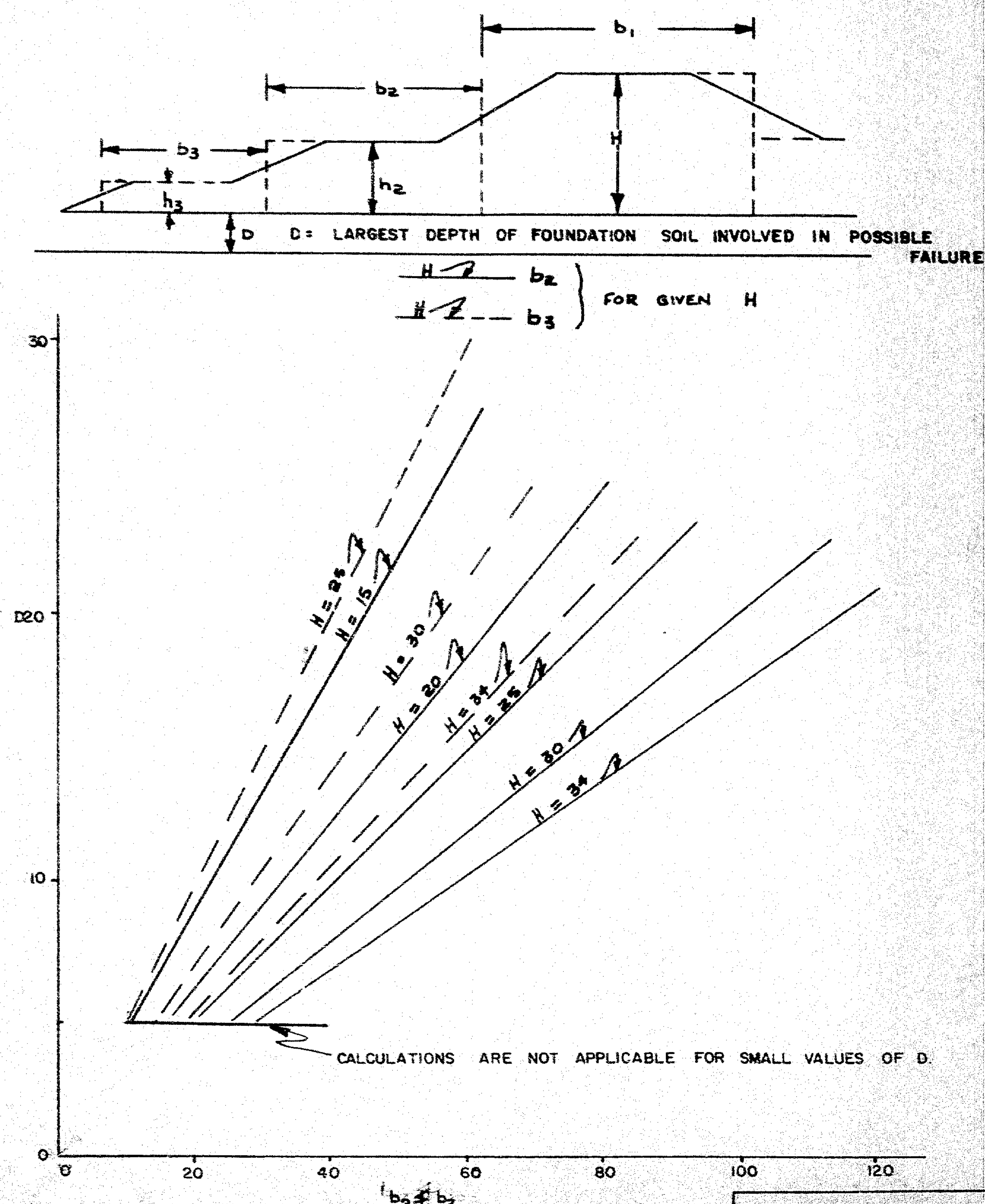


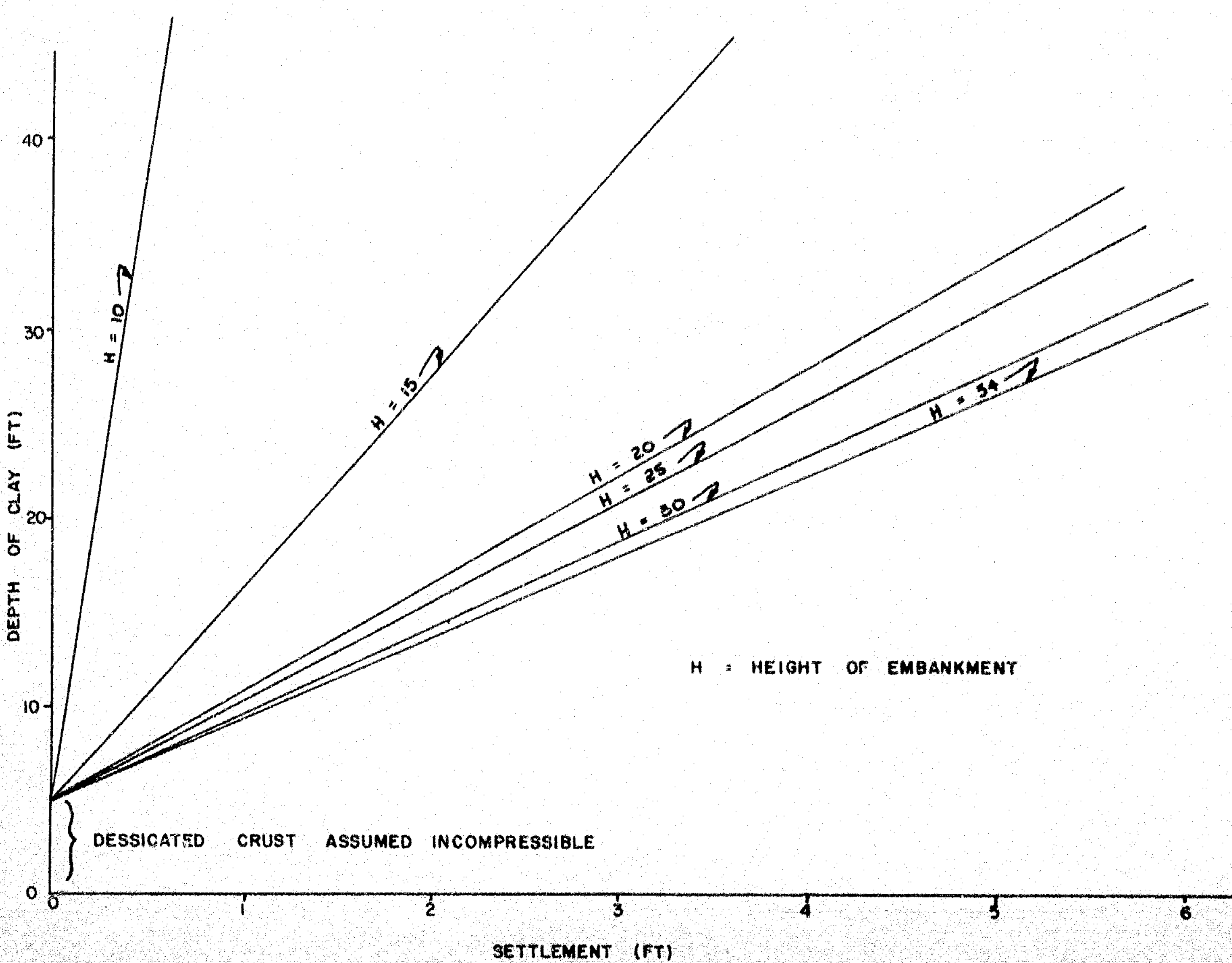
FIGURE 4

settlement, a number of calculations were carried out by conventional methods for varying conditions of fill height and clay depth. The calculations were based on consolidation tests carried out on samples 5 and 7 from Borehole 2. The vertical stress beneath the centreline of the embankment was determined from Osterberg's charts. The results of the calculations are summarized on Figure 5 overleaf. The settlement to be expected for the maximum size of approach embankments is illustrated on profile in Drawing No. 2 in the appendix.

In order to calculate the settlement at any given point on the approach fill, it was first necessary to determine the stress change in the clay along a vertical line through this point. This was done by means of Boussinesq's theory, which assumes the clay to behave as a semi-infinite homogeneous, isotropic and elastic material. In our calculations, the method described by J. O. Osterberg in his paper "Influence Values for Vertical Stress in a Semi-Infinite Mass due to Embankment Loading" has been applied to this settlement.

The magnitude of preconsolidation loading of the clay was determined by the Casagrande method from the consolidation curves (see appendix). For the purposes of these settlement calculations, the clay stratum was assumed to have had a preconsolidation loading of 0.7 t.s.f. in excess of the existing overburden pressure.

The rate of settlement is normally computed on the basis of time curves plotted from the different loading increments in the consolidation tests. From these curves, the coefficient of consolidation C_v is obtained. On the basis of the C_v, the rate of settlement is computed. On this project, however, because of the small increments of loading necessary to prevent squeeze out of the sample in the consolidation tests, the C_v values obtained from the tests are too erratic to permit an accurate assessment of the rate of settlement for this approach fill. A much better guide is provided by local experience with embankments on similar soils. In this respect, the Department of Highways has instrumented the Brookdale Avenue approach fills to Highway 401 (about 3/4 mile north of the proposed Brockdale and C.N.R. Overpass) where a 22 ft high embankment rests on similar clay. Settlement at this site has taken place rapidly. For a fill height of 22 ft, 2.15 ft of settlement has taken place within 72 weeks after construction and is still continuing. Thus the fill at Brookdale - C.N.R. Overpass can be similarly expected to settle rapidly.



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

BOREHOLE NUMBER ______ DEPTH ______

SAMPLE NUMBER ______ DATE ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

FILL HEIGHT – CLAY DEPTH – SETTLEMENT CHART

FIGURE 5

Settlement of the railway track due to the stress imposed on the clay by the approach embankments will not be significant.

4.3 Spread Footings

Considering the use of spread footings for the piers of this structure, it becomes immediately obvious that the low bearing capacity and high settlement of the clay would preclude the use of spread footings for this structure.

4.4 Piles

The presence of a deep layer of soft marine clay dictates the use of pile supported foundations for piers or abutments placed within several hundred feet of the railway tracks. For these locations, we recommend that low displacement end bearing piles, such as H-piles or pipe piles placed into the very dense soil or bedrock be employed for the foundation of this structure.

Considering the use of H-piles, it is expected that the bedrock or very dense till textured soil will be fully capable of supporting the maximum design loading (including negative skin friction) for H-piles, provided that the piles are driven to refusal. Refusal may be taken as a penetration resistance of 12 blows or more to the inch using a D-12 Delmag hammer. Refusal can be expected at approximately the following elevations:

North abutment	(40 + 40)	-	elevation 158
North pier	(41 + 80)	-	elevation 158
South pier	(42 + 60)	-	elevation 154
South abutment	(44 + 00)	-	elevation 156

In view of the considerable settlements associated with high embankment fills at this site, an allowance for negative skin friction must be made when considering the load bearing capacity of the piles.

The negative skin friction force will be a function of the height of embankment fill and the depth of the clay at the pile cluster location. The negative skin friction due to the fill can be calculated from the following formula:

$$Q' = \frac{A}{n} \gamma H$$

where Q' = the load acting on each pile

A = the area included within the boundaries of the pile cluster

n = the number of piles

H = the height of the fill

γ = the unit weight of the fill

The negative skin friction due to consolidation in the clay layer can be calculated as follows:

$$Q''max = \frac{LHS}{n}$$

where $Q''max$ = the maximum value of the skin friction drag

L = circumference of the pile cluster

H = thickness of the clay layer

S = the average shearing resistance of the clay

n = number of piles in the cluster

The total negative skin friction can then be computed as $Q = Q' + Q''$.

The approach fill settlement studies indicate that a settlement of over 5 ft can be expected with a fill height of 32 feet. In order to reduce the maintenance associated with such settlements, it is conceivable that the Consulting Engineers may wish to lengthen the bridge. Thus, in order to estimate the length of piles required for additional piers, we have prepared the following table :

Chainage	Estimated Pile Tip Elevation For H-piles Driven to Refusal
37 + 20	180
37 + 70	180
38 + 20	175
37 + 70	170
39 + 20	164
39 + 70	158
40 + 20	158
40 + 70	158
41 + 20	158
43 + 20	155
43 + 70	155
44 + 20	155
44 + 70	162
45 + 20	163
45 + 70	165
46 + 20	165
46 + 70	166
47 + 20	165

SECTION 5

DISCUSSION OF SUBWAY STRUCTURE

In view of the stability and settlement problems associated with high approach fill embankments, the Consulting Engineers requested an outline of the problems associated with a subway structure.

A profile of the road underpassing the railway is shown on Drawing No. 3 in the appendix. As can be seen on the profile, the excavation for the road would reach a maximum depth of 26 feet below the track elevation or 18 feet below ground level.

A stability analysis based on Taylor's curves and using a clay shear strength of 400 p.s.f. indiates that 4 : 1 side slopes would be required for short term stability of the roadway excavation. In the event that the subway structure is given more than a cursory consideration, a detailed stability analysis in terms of effective stress would have to be carried out prior to finalizing the excavation side slopes.

One of the major problems associated with a subway structure would be artesian water control. The low submerged unit weight of the clay, 35 lbs/cft and the high artesian head (elevation 194) would result in a hydrostatic pressure of 600 lbs/ft^2 (at elevation 157) in excess of the weight of the overburden for the deepest excavation. Thus, in order to prevent uplift of the bottom of the excavation during construction, it will be necessary to lower the artesian water pressure to less than the weight of the overburden with an adequate margin of safety. In our opinion, this could only be done effectively through a deep well pumping system. Considering the excavation to be backfilled up to pavement grade, (elevation 178 beneath the tracks) the hydrostatic pressure will be reduced to about 350 lbs/ft^2 in excess of the weight of overburden. As a result, in order to prevent upheaval of the roadway, full-time artesian water pressure control will have to be maintained during the life of the structure. We are of the opinion that this could only be accomplished by continuous pumping from deep wells.

APPENDIX

CLIENT	CITY OF CORNWALL
JOB NO.	6333
LOCATION	BROOKDALE AT C.N.R.
CO-ORDINATES	39+70 100' EAST OF ℄ OF RD.
ELEVATION (SURFACE)	191.8
(COLLAR)	
DATUM	
DATE (STARTED)	19/11/63
(FINISHED)	20/11/63
COMPILED	J.K.
RIG. NO.	1
TYPE	DD
FIELD SUP.	J.K.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL

▲ - VANE SHEAR (NATURAL)
○ - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION
+ - UNCONFINED COMPRESSION
⊕ - TRIAXIAL QUICK

ABBREVIATIONS:

UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST

SS - SPLIT SPOON
ST - SHELBY TUBE
TWP. - THIN WALLED PISTON
DB - DIAMOND BIT

C - CONSOLIDATION TEST
M - MECHANICAL ANALYSIS
T - TRIAXIAL COMPRESSION
K - PERMEABILITY
U - UNCONFINED COMP.
PCF - POUNDS PER CUBIC FOOT
WN - NATURAL WATER CONTENT

ASSOCIATED GEOTECHNICAL SERVICES Limited

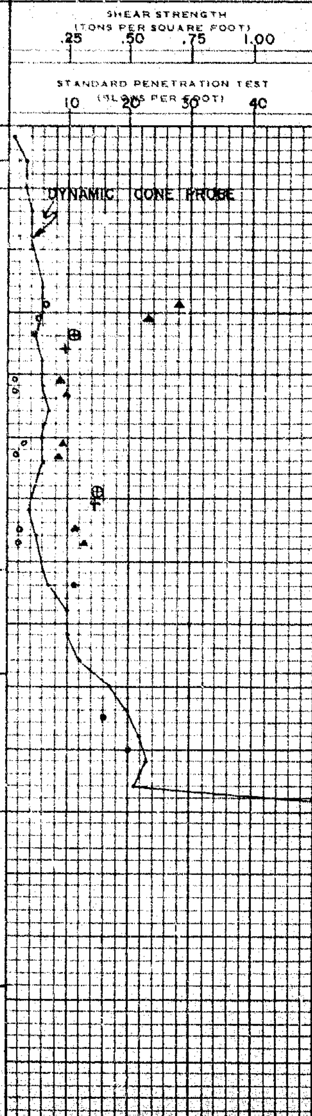
OFFICE BOREHOLE LOG

BOREHOLE NO. 1

BORING LOG — FIELD TESTS — SAMPLING — LABORATORY — TESTS — REMARKS

Depth Feet	Elev. Feet	Description	Penetration Resistance (Blows per Foot)	Sample Number	From Feet	To Feet	Type	Recovery Length Rec. / Dist. Driv.	Remarks
1.4	190.4	TOPSOIL	5	1	0	1.5	SS	10/18	
2.5	189.3	BROWN FINE SAND	10	2	1.5	3.0	SS	18/18	TRIED VANE AT 3.5 BUT PEBBLE IN WAY
		GREY SILT WITH CLAY TO GREY CLAY WITH SILT	3	3	5.0	6.7	SS	10/20	
				1A	8.0	9.9	TWP	20/22	SAMPLE 1A OBTAINED FROM BOREHOLE 1A 3' WEST OF B.H.1
				4	10.0	11.7	ST	0/20	SAMPLE RECOVERED WITH SPLIT SPOON
				5	14.0	15.9	TWP	21/22	VANE RESULTS AT 10.3 & 10.9 OBTAINED IN B.H. 1A
17.9	173.9	MEDIUM DENSE GREY SAND SOME SILT AND GRAVEL	11	6	18.0	19.5	SS	10/18	
22.0	169.8	MEDIUM DENSE GREY COARSE SAND	16	7	23.0	24.5	SS	10/18	
			20	8	24.5	26.0	SS	18/18	
27.5	164.3	VERY DENSE GREY SAND, SOME SILT AND GRAVEL TILL TEXTURE	90	9	29.6	31.1	SS	3/18	
			83	10	31.1	32.[illegible]	SS	3/12	
34.5	157.3	LIMESTONE BEDROCK		11	33.6	38.6	DB	3'8"	
				12	38.5	43.4	DB	5'4"	END OF BOREHOLE AT 43.4 FT

Water observation: 193.5, 192.5, 193.6



LABORATORY: UNIT WEIGHT PCF (DY) 100 110; ATTERBERG LIMITS WP WN WL 60 80

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
BOREHOLE NO. 2

CLIENT: CITY OF CORNWALL
JOB NO. 6333 LOCATION
CO-ORDINATES 40+76 100' EAST OF ℄ OF RD.
ELEVATION (SURFACE) 191.9 (COLLAR) DATUM
DATE (STARTED) 21/11/63 (FINISHED) 22/11/63 (COMPILED) J.K.
RIG. NO. 1 TYPE D.D. FIELD SUP. J.K.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL
▲ - VANE SHEAR (NATURAL)
○ - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION
+ - UNCONFINED COMPRESSION
⊕ - TRIAXIAL

ABBREVIATIONS:
UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS - SPLIT SPOON
ST - SHELBY TUBE
TWP. - THIN WALLED PISTON
DB - DIAMOND BIT
C - CONSOLIDATION TEST
M - MECHANICAL ANALYSIS
T - TRIAXIAL COMPRESSION
K - PERMEABILITY
U - UNCONFINED COMP.
PCF - POUNDS PER CUBIC FOOT
WN - NATURAL WATER CONTENT

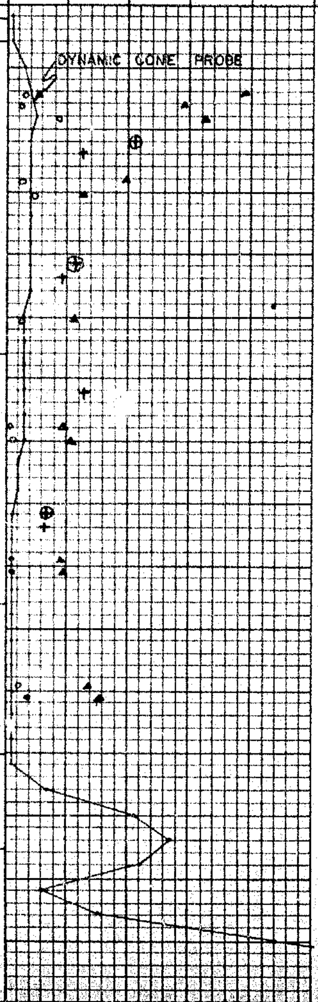
BORING LOG

DEPTH FEET	ELEV. FEET	DESCRIPTION
0.5	191.4	TOPSOIL
1.5	190.4	BROWN FINE SAND
14.0	177.9	BROWN TO GREY SILT WITH CLAY TO GREY CLAY WITH SILT
24.0	167.4	GREY CLAY WITH BLACK NODULES
30.0	161.9	GREY CLAY
33.9	158.0	LOOSE GREY SAND, SOME SILT AND GRAVEL
		LIMESTONE BEDROCK

WATER OBSERVATION: 193.7

FIELD TESTS

SHEAR STRENGTH (TONS PER SQUARE FOOT) .25 .50 .75 1.00
STANDARD PENETRATION TEST (BLOWS PER FOOT) 10 20 30 40

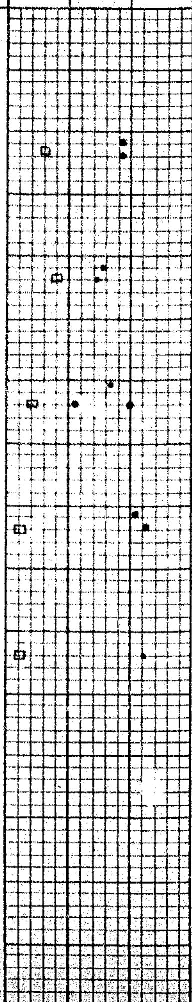


SAMPLING

PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	CONDITION	DEPTH FROM FEET	DEPTH TO FEET	TYPE	RECOVERY LENGTH REC./DIST. DRIV.	TESTS	REMARKS
1	1	DISTURBED BUT REPRESENTATIVE	0	1.5	SS	10/18		
7	2	DISTURBED BUT REPRESENTATIVE	1.5	3.0	SS	16/18		
	3	UNDISTURBED	5.0	6.3	TWP	16/16		
	4	UNDISTURBED	10.0	11.9	TWP	22/22		
	5	UNDISTURBED	15.0	16.5	TWP	18/18	C	WP = 32 % WL = 62 % (UNDRIED)
	6	UNDISTURBED	20.0	21.9	TWP	22/22		
	7	UNDISTURBED	25.0	26.9	TWP	22/22	C	
	8	UNDISTURBED	29.0	30.6	TWP	18/19		SAMPLE CONTAINS THIN (1/8") HORIZONTAL FINE SAND SEAMS
10	9	DISTURBED BUT REPRESENTATIVE	30.6	32.5	SS	18/23		
	10	UNDISTURBED	33.9	36.3	DB	2'2"		NOTE: BEDROCK APPEARS TO BE DEEPER AT THE CONE PROBE.
	11	UNDISTURBED	36.3	41.7	DB	5'0"		END OF BOREHOLE AT 41.7

LABORATORY TESTS

UNIT WEIGHT PCF (DRY) 100 110
ATTERBERG LIMITS WP × — ● WN — ○ WL 60 80



ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
BOREHOLE NO. 3

CLIENT: CITY OF CORNWALL
JOB NO.: 6333 LOCATION:
CO-ORDINATES: 43+98 100' WEST OF RD
ELEVATION (SURFACE): 192.9 (COLLAR): DATUM:
DATE (STARTED): 25/11/63 (FINISHED): 26/11/63 COMPILED: J.K.
RIG. NO.: 1 TYPE: D.D. FIELD SUP.: J.K.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL
▲ - VANE SHEAR (NATURAL)
O - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION
+ - UNCONFINED COMPRESSION
⊕ - TRIAXIAL

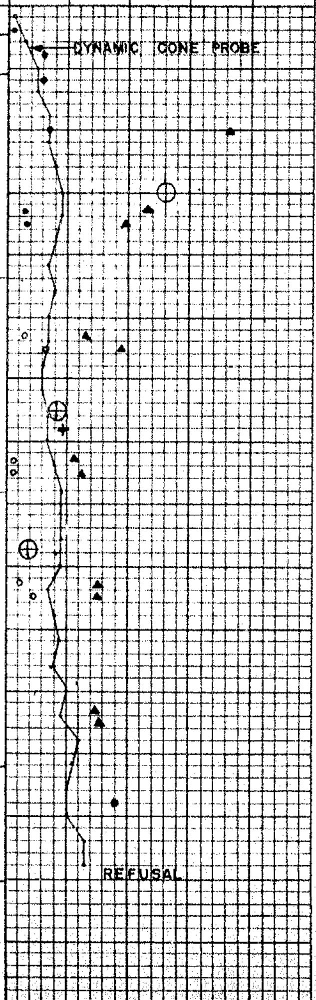
ABBREVIATIONS:
UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS - SPLIT SPOON; ST - SHELBY TUBE; TWP. - THIN WALLED PISTON; DB - DIAMOND BIT
C - CONSOLIDATION TEST; M - MECHANICAL ANALYSIS; T - TRIAXIAL COMPRESSION; K - PERMEABILITY; U - UNCONFINED COMP.; PCF - POUNDS PER CUBIC FOOT; WN - NATURAL WATER CONTENT

BORING LOG

DEPTH FEET	ELEV. FEET	WATER OBSERVATION	DESCRIPTION
1.2	191.7		TOPSOIL
2.8	190.1		BROWN FINE SAND
11.0	181.9	GWL	BROWN TO GREY SILT WITH CLAY TO GREY CLAY WITH SILT
19.5	173.4		GREY CLAY WITH BLACK NODULES
30.1	162.8		GREY CLAY
35.1	157.8		GREY SAND WITH SILT TRACE OF GRAVEL
			BLACK LIMESTONE BEDROCK

FIELD TESTS

Shear strength (tons per square foot): .25, .50, .75, 1.00
Standard penetration test (blows per foot): 10, 20, 30, 40

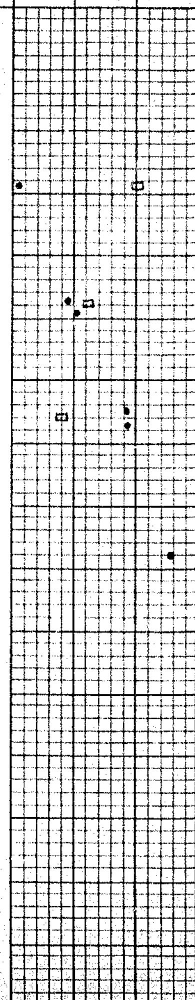


SAMPLING

PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	DEPTH FROM FEET	DEPTH TO FEET	TYPE	RECOVERY LENGTH REC./DIST. DRIV.	REMARKS
5	1	0.0	1.5	SS	4/18	G.W.L. MEASURED 48 HRS. AFTER COMPLETION.
6	2	1.5	3.0	SS	10/18	
6	3	3.0	4.5	SS	10/18	
	4	5.8	7.6	TWP	22/22	SAMPLE CONTAINS HORIZONTAL 1/4"–1/2" THICK FINE SAND SEAMS
	5	11.0	12.9	TWP	22/22	
	6	16.0	17.9	TWP	20/22	
	7	21.0	22.9	TWP	20/22	SAMPLE FAILURE AT 4% STRAIN
	8	26.0	27.9	TWP	20/22	
18	9	31.0	32.5	SS	12/18	
	10	35.1	39.9	D.B.	4' 3"	END OF BOREHOLE AT 39.9

LABORATORY TESTS

Unit weight PCF γ: 100, 110
Atterberg limits: WP x —●— o WL; WN: 60, 80



CLIENT CITY OF CORNWALL
JOB NO. 6333 **LOCATION** BROOKDALE AT CNR
CO-ORDINATES 44+76 109' EAST OF ℄ OF RD.
ELEVATION (SURFACE) 193.1 **(COLLAR)** **DATUM**
DATE (STARTED) 22/11/63 **(FINISHED)** 25/11/63 **(COMPILED)** J.K.
RIG. NO. 1 **TYPE** D.D. **FIELD SUP.** J.K.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL
▲ - VANE SHEAR (NATURAL)
○ - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION

ABBREVIATIONS
UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS - SPLIT SPOON
ST - SHELBY TUBE
TWP. - THIN WALLED PISTON
DB - DIAMOND BIT
C - CONSOLIDATION TEST
M - MECHANICAL ANALYSIS
T - TRIAXIAL COMPRESSION
K - PERMEABILITY
U - UNCONFINED COMP.
PCF - POUNDS PER CUBIC FOOT
WN - NATURAL WATER CONTENT

ASSOCIATED GEOTECHNICAL SERVICES
Limited

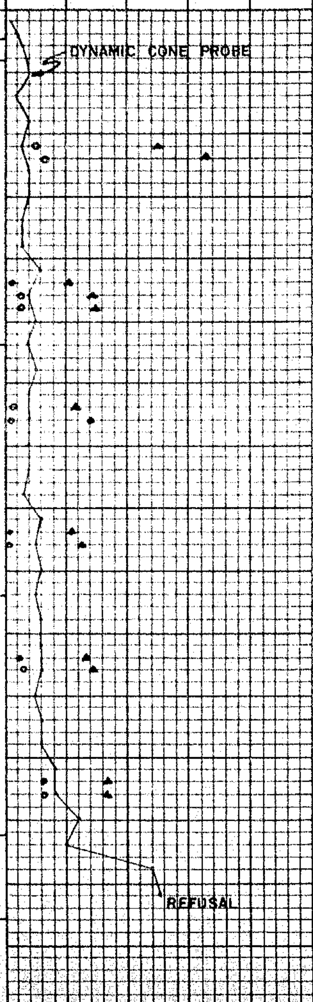
OFFICE BOREHOLE LOG
BOREHOLE NO. 4

BORING LOG

DEPTH FEET	ELEV. FEET	DESCRIPTION
		TOPSOIL
1.2	191.9	BROWN FINE SAND
2.0	191.1	BROWN TO GREY SILT WITH CLAY TO GREY CLAY WITH SILT
13.5	179.6	GREY CLAY WITH BLACK NODULES
23.5	169.6	GREY CLAY WITH OCCASIONAL RED NODULE
33.2	159.9	GREY SAND SOME SILT AND GRAVEL
36.5	156.6	BLACK LIMESTONE BEDROCK

FIELD TESTS

SHEAR STRENGTH (TONS PER SQUARE FOOT): .25 .50 .75 1.00
STANDARD PENETRATION TEST (BLOWS PER FOOT): 10 20 30 40



SAMPLING

PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	DEPTH FROM FEET	DEPTH TO FEET	TYPE	RECOVERY LENGTH REC./DIST. DRIV.
2	1	4.0	5.5	SS	18/18
PUSH	2	9.0	10.5	SS	18/18
PUSH	3	14.0	15.5	SS	18/18
PUSH	4	19.0	20.5	SS	18/18
PUSH	5	24.0	25.5	SS	18/18
PUSH	6	29.0	30.5	SS	18/18
9	7	34.0	35.5	SS	6/18
	8	36.5	42.2	D.B	5'2/5'9"

LABORATORY TESTS

UNIT WEIGHT PCF: DY
ATTERBERG LIMITS: WP X — ● WN — ○ WL; 60, 80

REMARKS

W_N AT 35.0' = 13.5%

END OF BOREHOLE AT 42.2 FT

CLIENT: CITY OF CORNWALL

JOB NO.: 6333 LOCATION: BROOKDALE AT C.N.R.

CO-ORDINATES: CHNG. 42+81 — 15' WEST

ELEVATION (SURFACE): 199.4 (COLLAR) ______ DATUM ______

DATE (STARTED): 13/12/63 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

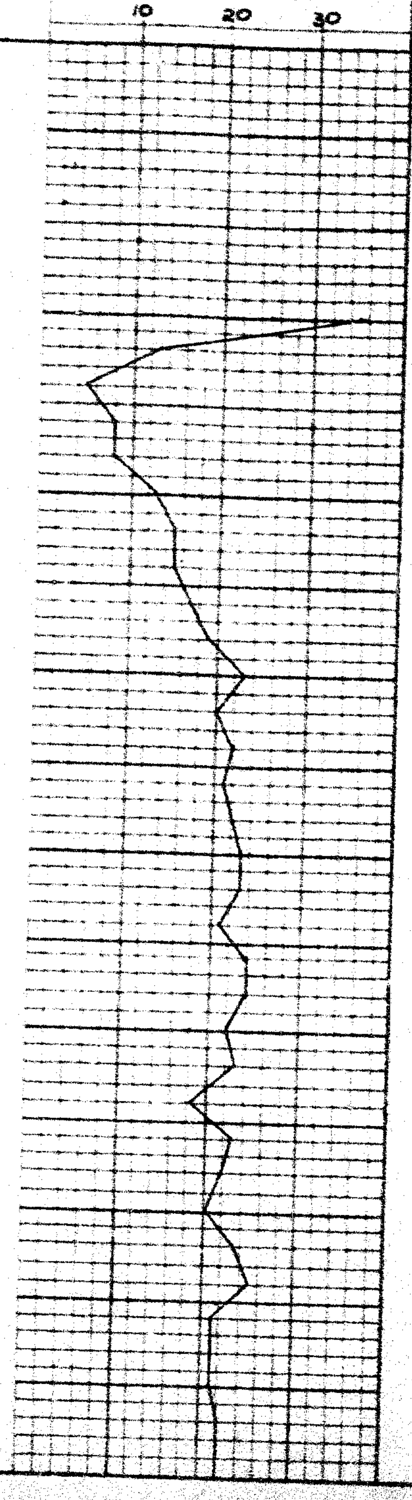
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #A

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS



Depth scale: 5, 10, 15, 20, 25, 30, 35, 40

ROAD FILL TO 7FT.

FT	TO FT	Nº OF BLOWS
40	41	22
41	42	22
42	43	24
43	43.8	78

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE # B

BOREHOLE NO.

CLIENT: CITY OF CORNWALL

JOB NO.: 6383 LOCATION: BROOKDALE AT C.N.R.

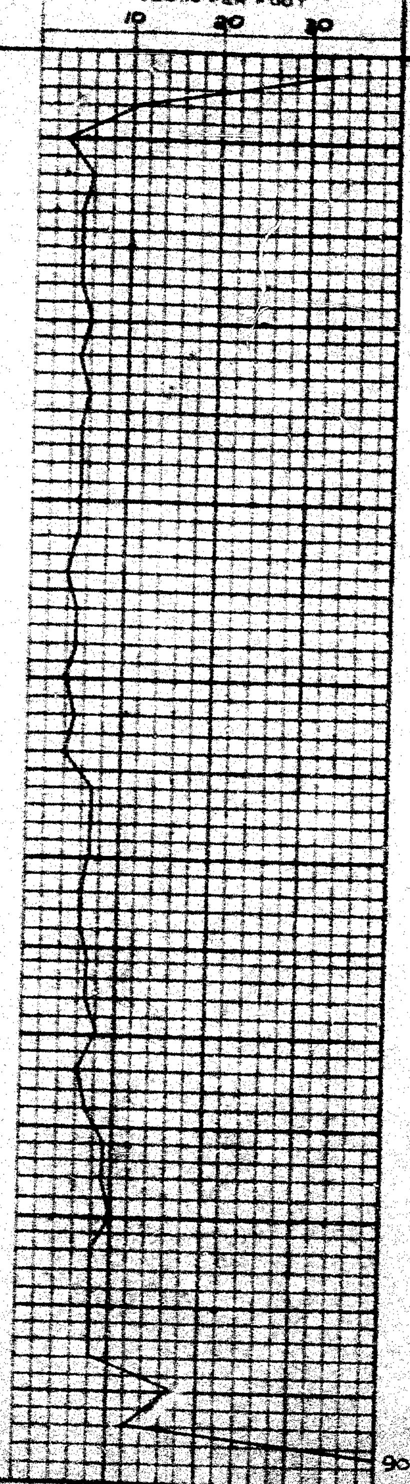
CO-ORDINATES: CHNG. 43+81 — 15' WEST

ELEVATION (SURFACE): 195.0 (COLLAR): ______ DATUM: ______

DATE (STARTED): 13/12/63 (FINISHED): ______ (COMPILED): ______

RIG. NO.: ______ TYPE: ______ FIELD SUP.: ______

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT	SAMPLE NO.	CONDITION	REMARKS
6							
10							
15							
20							
25							
30							
35							
40							50 BLOWS FOR LAST 1" AT 40FT



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 44+70 — 15' WEST

ELEVATION (SURFACE) 193.8 (COLLAR) ______ DATUM ______

DATE (STARTED) 13/12/63 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

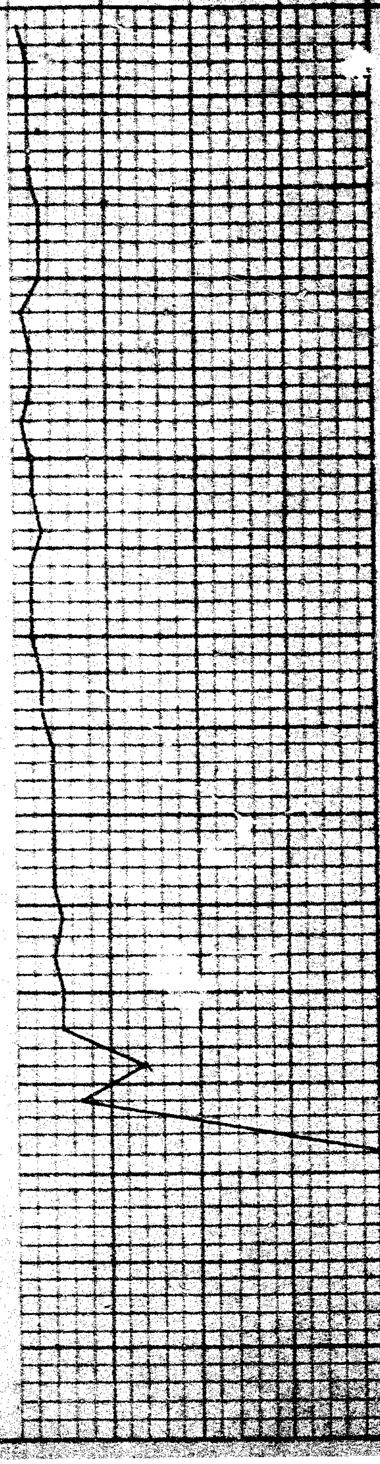
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE "C"

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							
25							
30							
							110 BLOWS FOR 6"
35							



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 45+70 – 15' WEST

ELEVATION (SURFACE) 193.7 (COLLAR) ______ DATUM ______

DATE (STARTED) 13/12/65 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

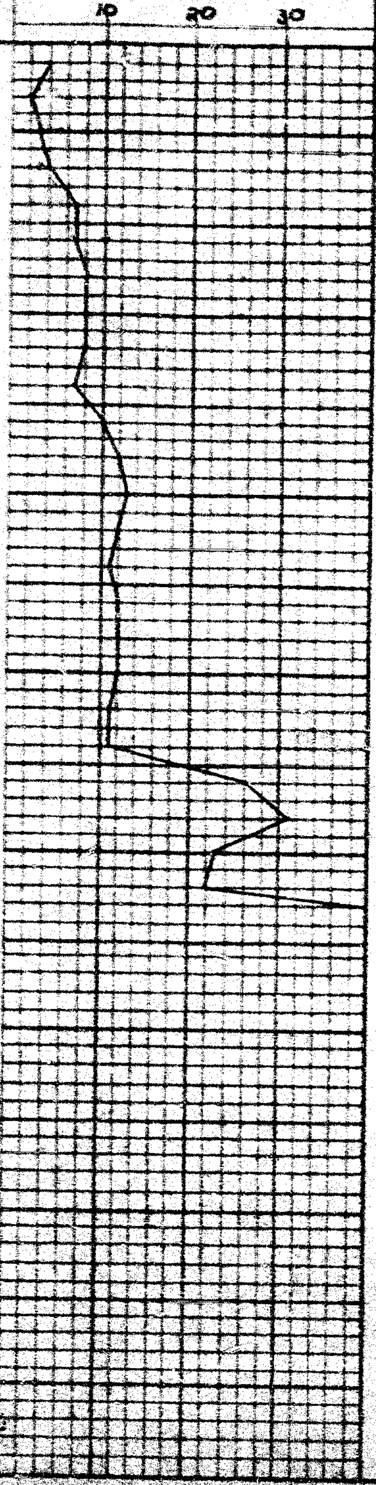
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #D

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
6							
10							
15							
20							
25							51
							69
							68
							91 BLOWS FOR 2" PENETRATION
30							
35							

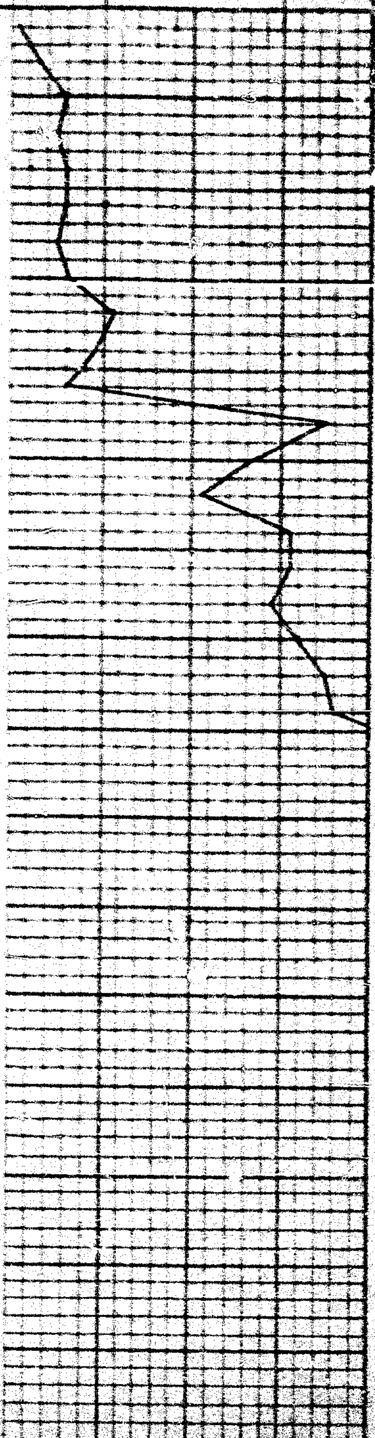


CLIENT: CITY OF CORNWALL
JOB NO.: 6335 LOCATION: BROOKDALE AT C.N.R.
CO-ORDINATES: CHNG. 46+70 – 15' WEST
ELEVATION (SURFACE): 193.6 (COLLAR): ______ DATUM: ______
DATE (STARTED): 7/12/63 (FINISHED): ______ COMPILED: ______
RIG. NO.: ______ TYPE: ______ FIELD SUP.: ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE #E
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							86
							60
							64
							66
25							59
							60
							95
							120 BLOWS FOR 6" PENETRATION
30							
35							



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 41+70 — 15' WEST

ELEVATION (SURFACE) 199.0 (COLLAR) ______ DATUM ______

DATE (STARTED) 14/12/63 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

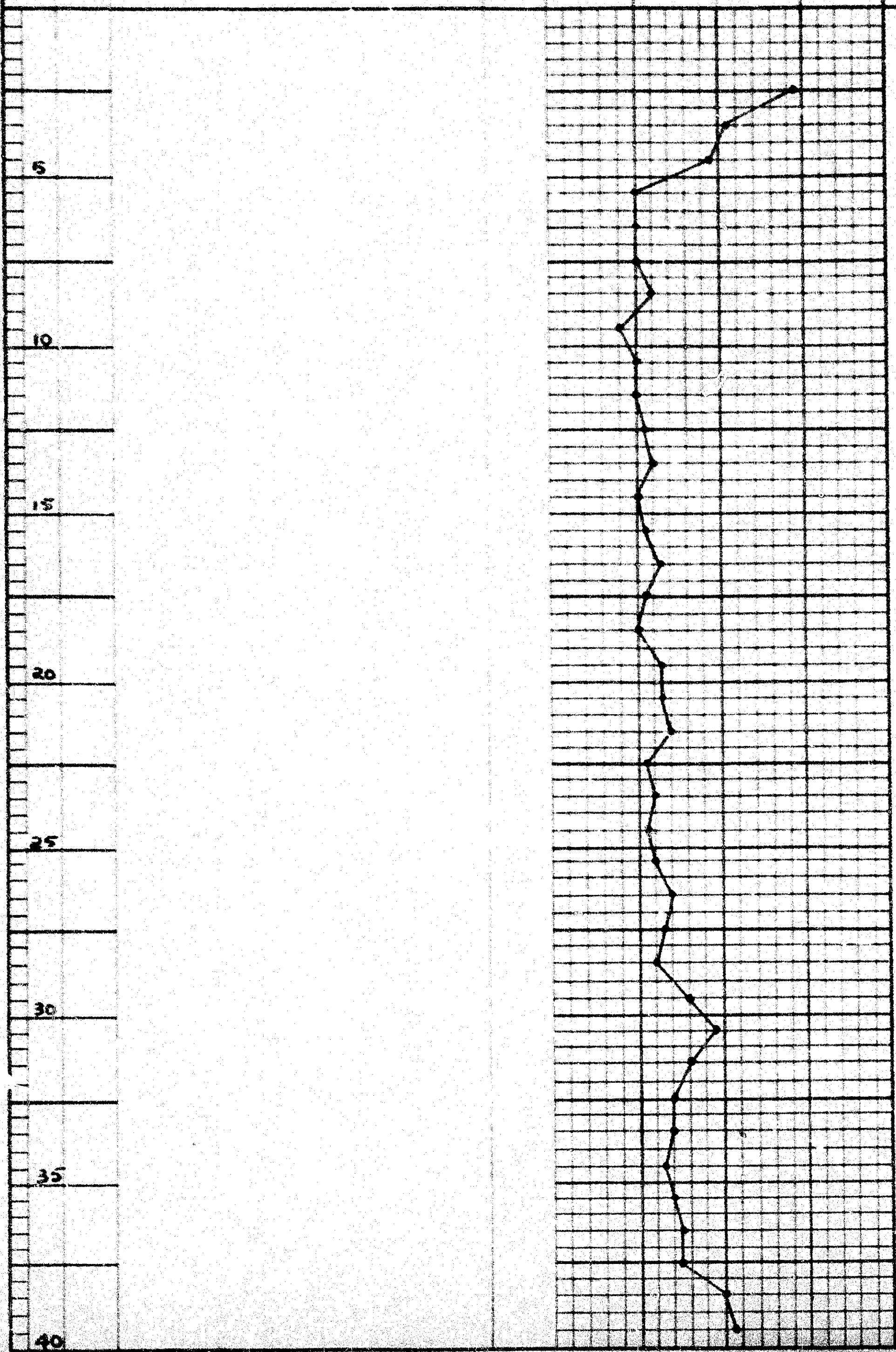
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #F

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
							180
							42



40'—41' = 40 BLOWS

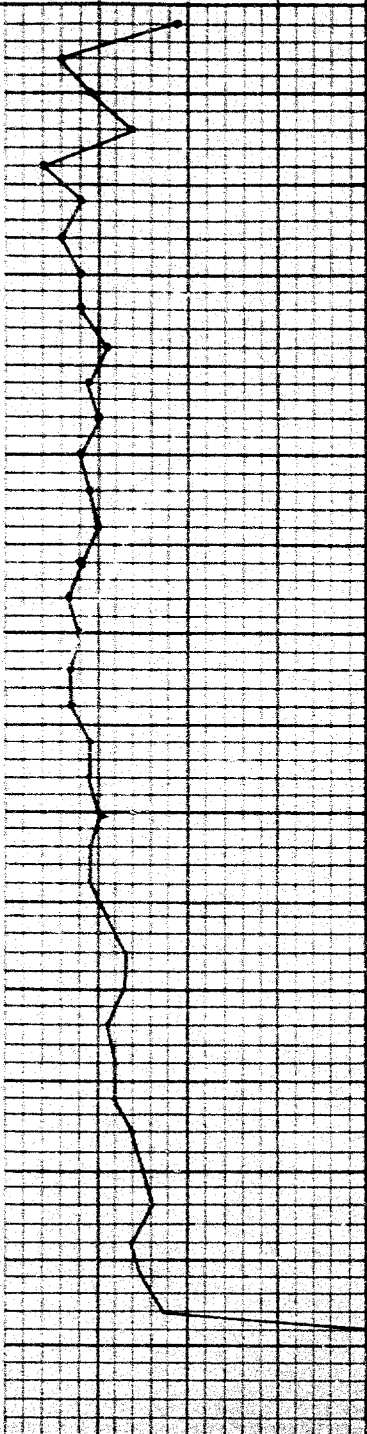
41'—41.3 = 110 BLOWS

CLIENT CITY OF CORNWALL
JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.
CO-ORDINATES CHNG. 40+70 – 15' WEST
ELEVATION (SURFACE) 196.3 (COLLAR) ______ DATUM ______
DATE (STARTED) 14/12/63 (FINISHED) ______ (COMPILED) ______
RIG. NO. ______ TYPE ______ FIELD SUP. ______

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE G
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							
25							
30							
35							75 BLOWS FOR 2"
40							



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 39+70 — 15' WEST

ELEVATION (SURFACE) 192.4 (COLLAR) ______ DATUM ______

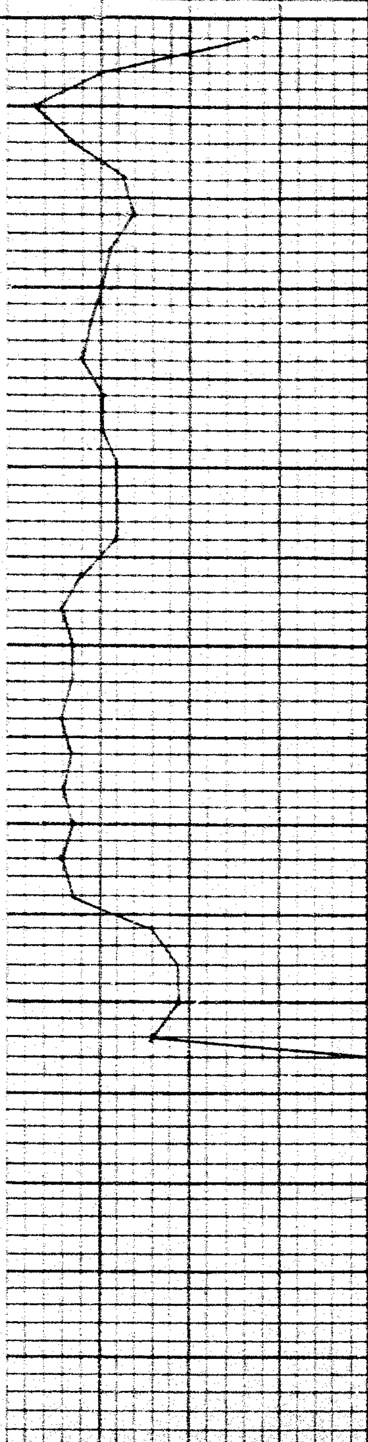
DATE (STARTED) 14/12/63 (FINISHED) ______ (COMPILED) ______

RIG NO. ______ TYPE ______ FIELD SUP. ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE H
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT 10 20 30	SAMPLE NO.	CONDITION	REMARKS



Depth (feet): 5, 10, 15, 20, 25, 30, 35, 40

Remarks:
44
56
57
87
74
88
120 BLOWS FOR 4"

CLIENT: CITY OF CORNWALL
JOB NO. 6353 LOCATION BROOKDALE AT C.N.R.
CO-ORDINATES CHGE. 38+70 — 15' WEST
ELEVATION (SURFACE) 192.5 (COLLAR) DATUM
DATE (STARTED) 14/12/63 (FINISHED) (COMPILED)
RIG. NO. TYPE FIELD SUP.

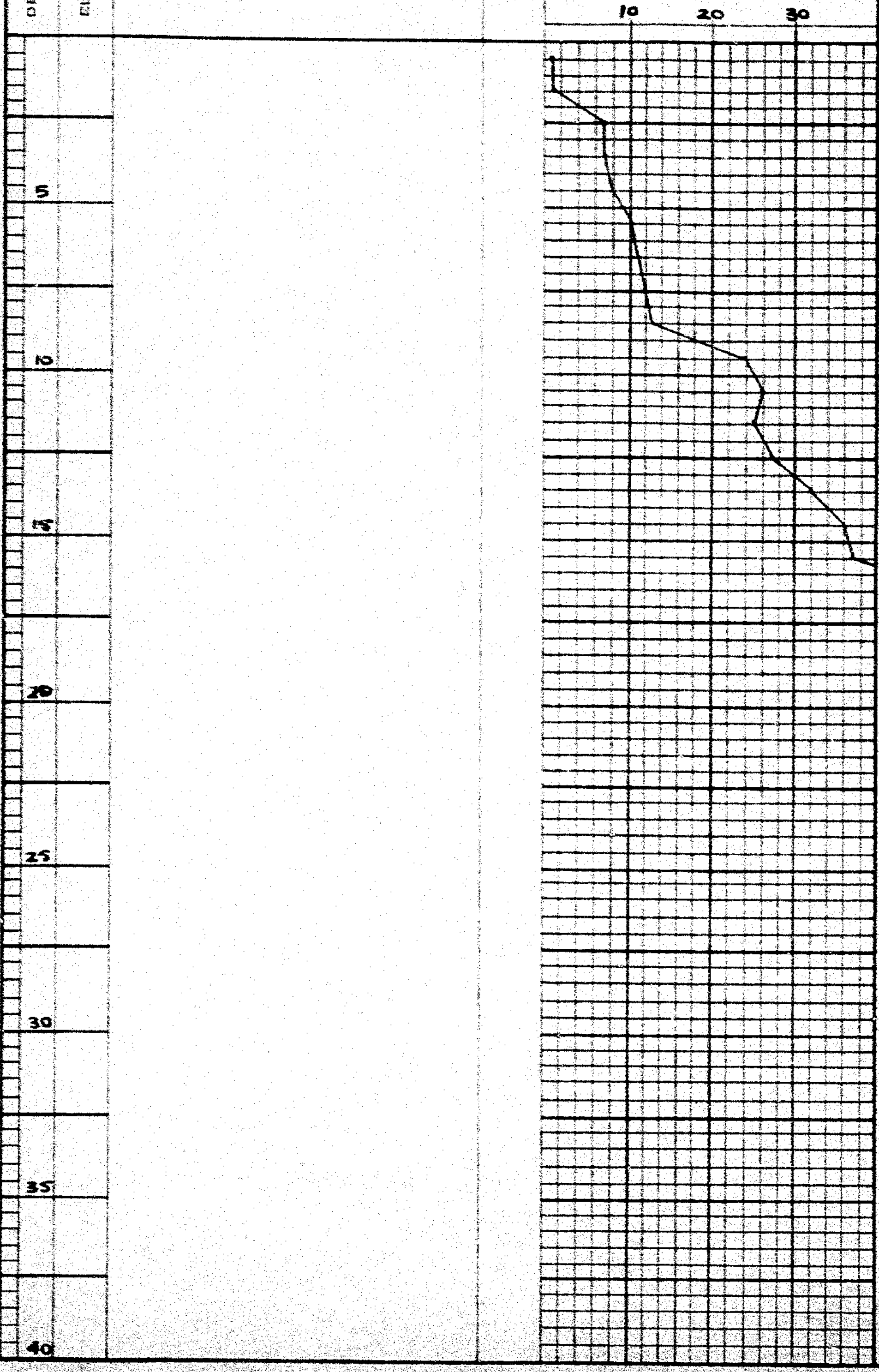
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE I

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT	SAMPLE NO.	CONDITION	REMARKS



REMARKS:

47
46
49
72
120 BLOWS FOR 8"

CLIENT: CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 37+70 — 15' WEST

ELEVATION (SURFACE) 193.4 (COLLAR) ______ DATUM ______

DATE (STARTED) 14/12/63 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

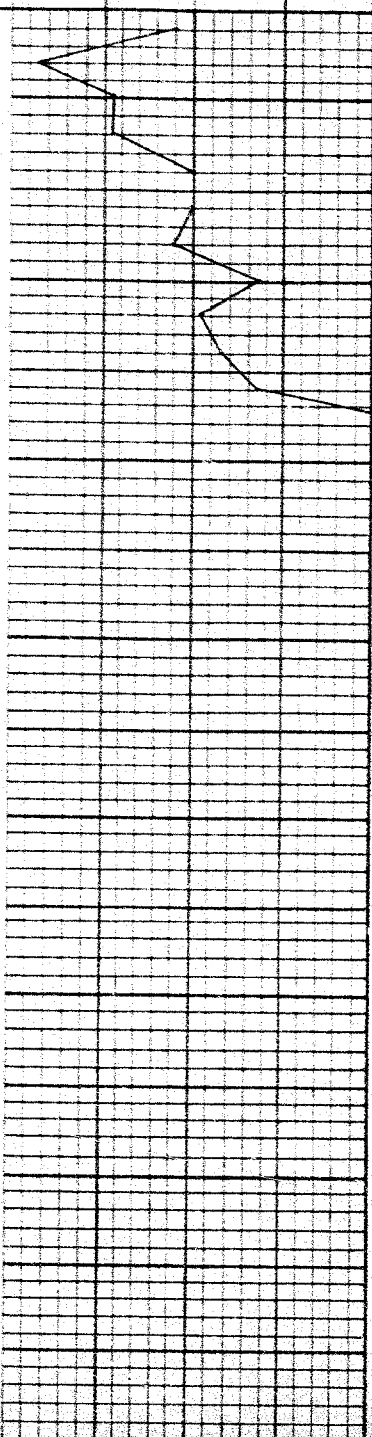
ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE J

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
							53
							93
							150 BLOWS FOR 8"
15							
20							
25							
30							
35							
40							



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 38 + 74 100' EAST OF ℄ RD.

ELEVATION (SURFACE) 191.6 (COLLAR) ______ DATUM ______

DATE (STARTED) 19/12/63 (FINISHED) ______ (COMPILED) ______

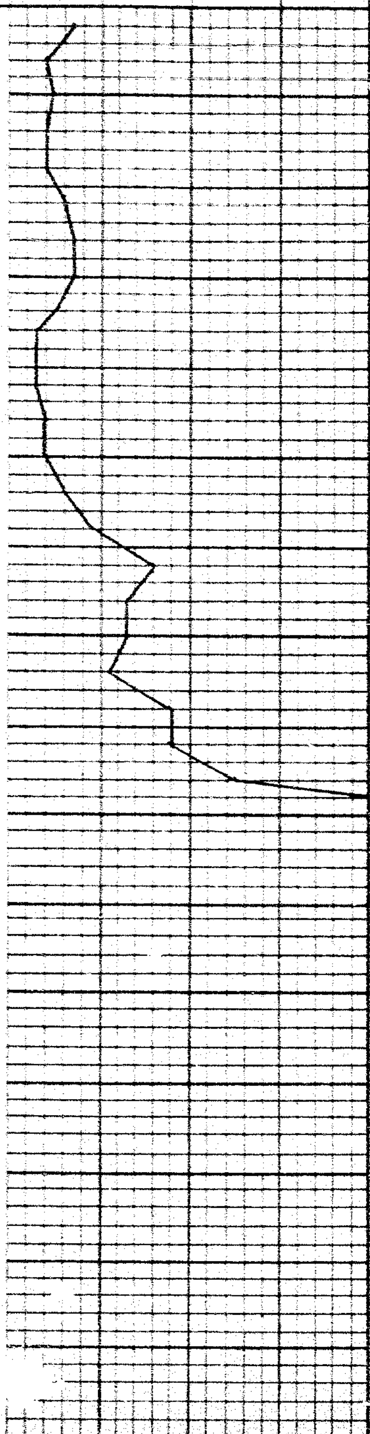
RIG. NO. ______ TYPE ______ FIELD SUP. ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE K

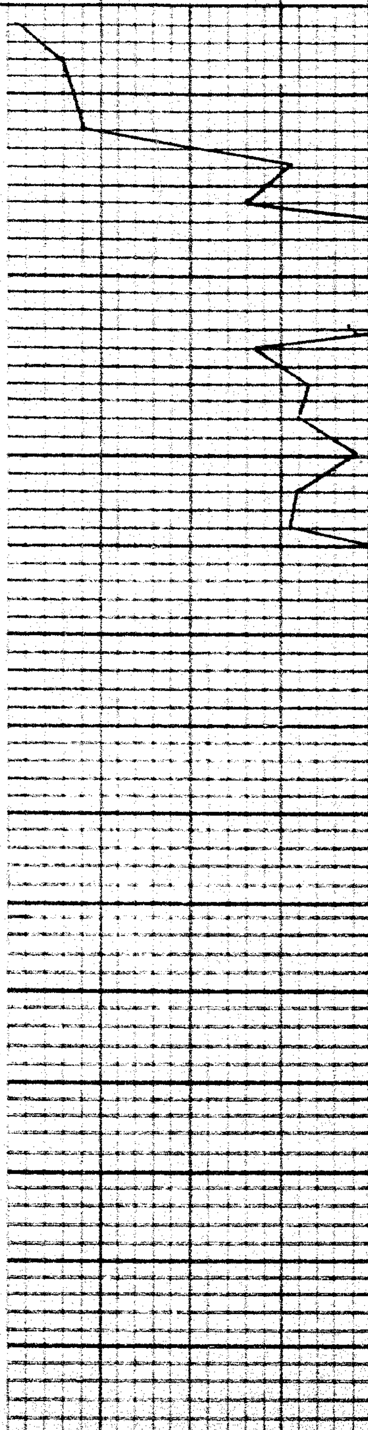
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							66
							72
25							67
							66
							170
							50 BLOWS FOR LAST 1"
30							
35							
40							



CLIENT: CITY OF CORNWALL	**ASSOCIATED GEOTECHNICAL SERVICES Limited**
JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.	
CO-ORDINATES CHNG. 37+58 100' WEST OF ℄ RD.	**OFFICE BOREHOLE LOG**
ELEVATION (SURFACE) 193.9 (COLLAR) DATUM	DYNAMIC CONE PROBE L
DATE (STARTED) (FINISHED) COMPILED	BOREHOLE NO.
RIG. NO. TYPE FIELD SUP.	

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
							43
							86
							46
10							
15							
							54
							140 FOR 9"
20							
25							
30							
35							
40							



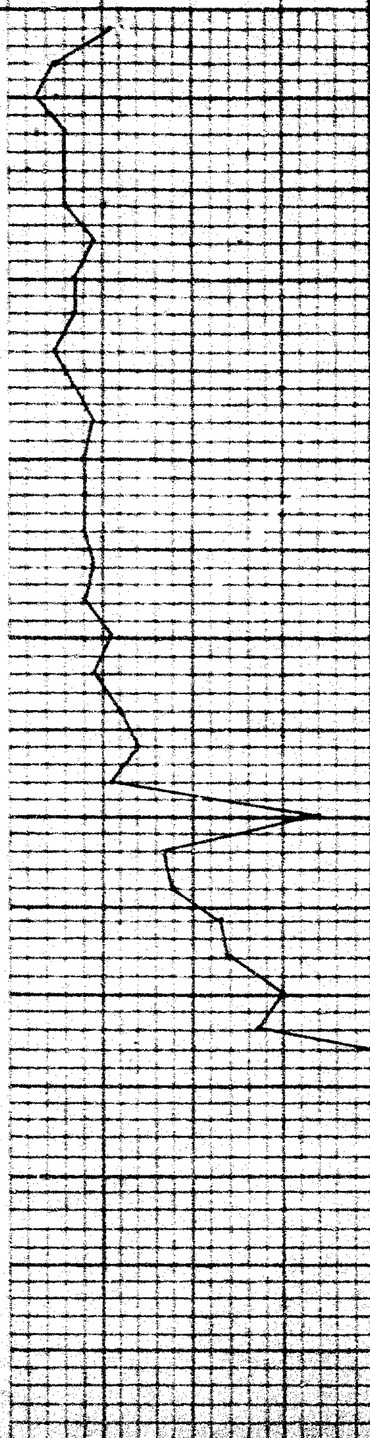
CLIENT: CITY OF CORNWALL
JOB NO.: 6333 LOCATION: BROOKDALE AT C.N.R.
CO-ORDINATES: CHNG. 45+70 100' WEST OF ℄ RD.
ELEVATION (SURFACE): 193.7 (COLLAR): DATUM:
DATE (STARTED): 19/12/63 (FINISHED): (COMPILED):
RIG. NO.: TYPE: FIELD SUP.:

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #M
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
6							
10							
15							
20							
25							
30							30 BLOWS FOR 2"
35							



CLIENT CITY OF CORNWALL

JOB NO. 6335 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 45+92 100' EAST OF ℄ RD.

ELEVATION (SURFACE) 193.8 (COLLAR) ______ DATUM ______

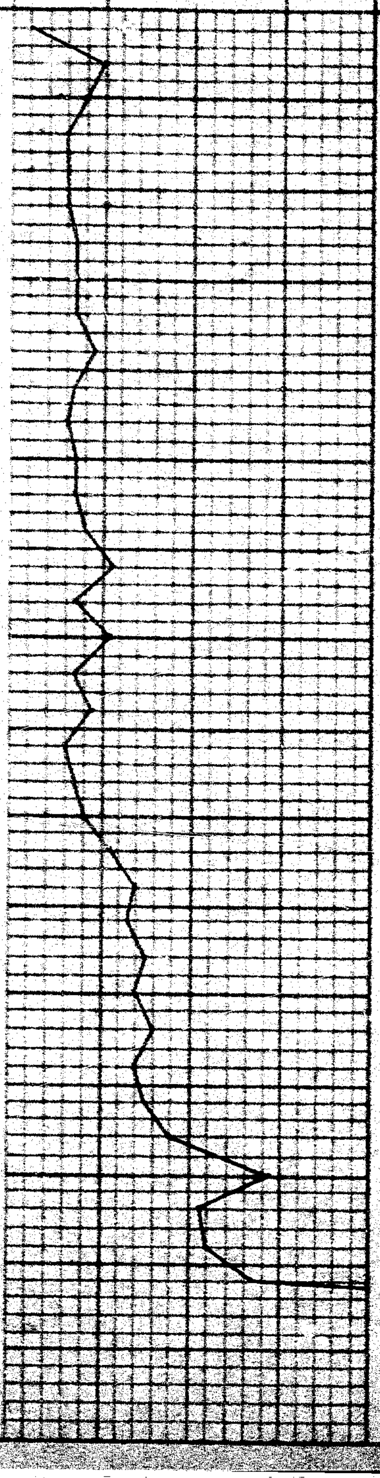
DATE (STARTED) 13/12/63 (FINISHED) ______ COMPILED ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

ASSOCIATED GEOTECHNICAL SERVICES
Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE #
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT 10 20 30	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							
25							
30							
35							75 BLOWS FOR 1"
40							



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CHNG. 37+00 — 10' WEST

ELEVATION (SURFACE) 194.9 (COLLAR) DATUM

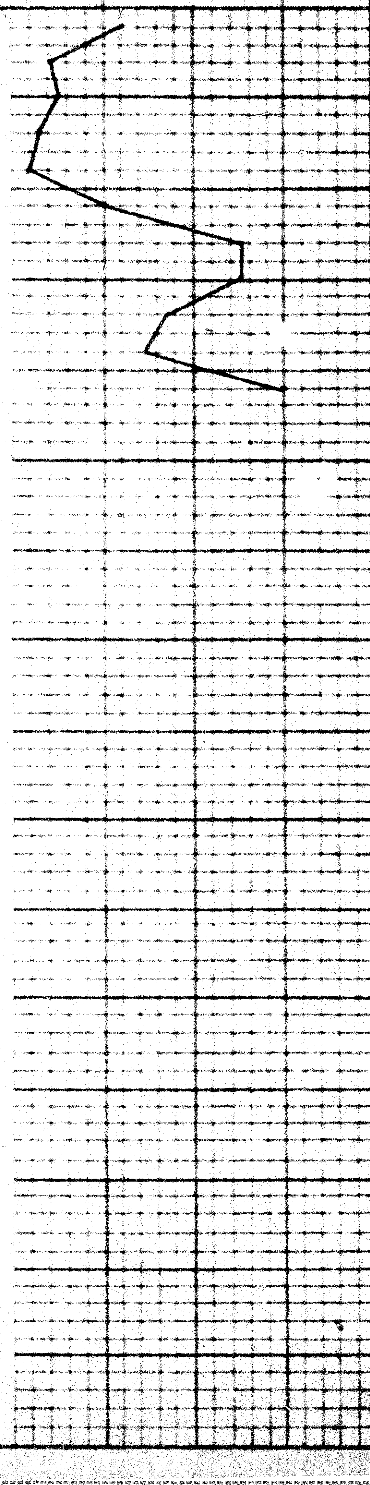
DATE (STARTED) 13/12/63 (FINISHED) COMPILED

RIG. NO. TYPE FIELD SUP.

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE #6
BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
6							
10							99 140 FOR 12"
15							
20							
25							
30							
35							



CLIENT: CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

CO-ORDINATES CH ON 47+50 – 10' EAST

ELEVATION (SURFACE) 193.6 (COLLAR) ______ DATUM ______

DATE (STARTED) 13/12/63 (FINISHED) ______ (COMPILED) ______

RIG. NO. ______ TYPE ______ FIELD SUP. ______

ASSOCIATED GEOTECHNICAL SERVICES Limited

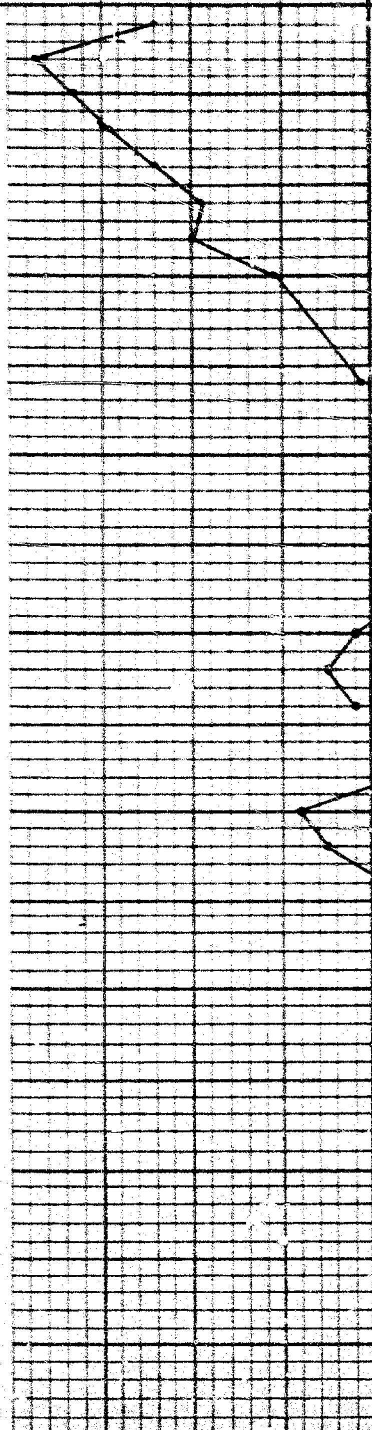
OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #6

BOREHOLE NO.

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS

Depth scale: 5, 10, 15, 20, 25, 30



REMARKS:

42
45
45
51
45
65
63
49
71
46
50
89
93
110
65
115 FOR 12"

CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

BOREHOLE NUMBER 2 DATE

SAMPLE NUMBER DEPTH

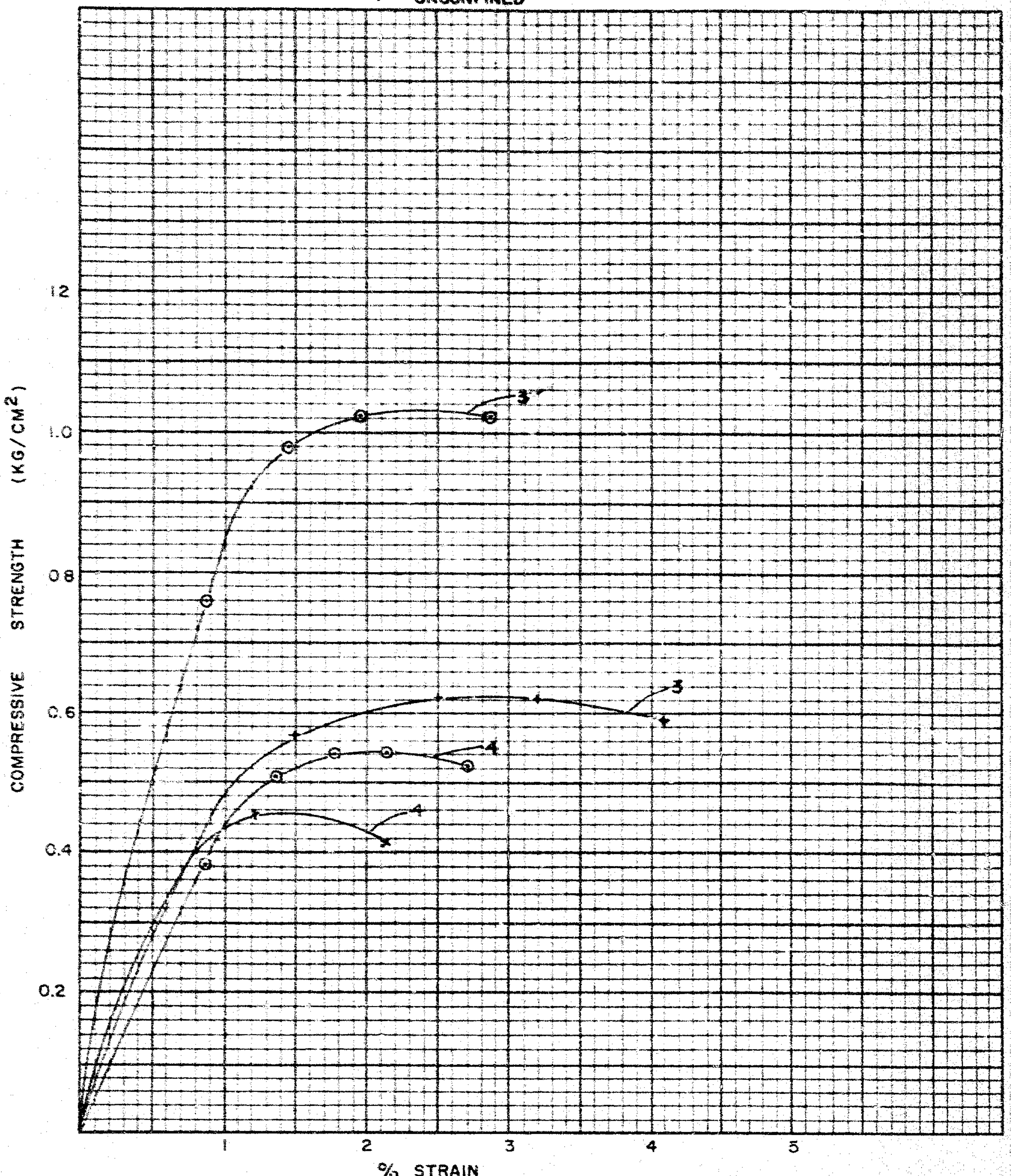
ASSOCIATED GEOTECHNICAL SERVICES Limited

SOIL MECHANICS LABORATORY

STRENGTH TESTS

⊙ QUICK TRIAXIAL

+ UNCONFINED



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

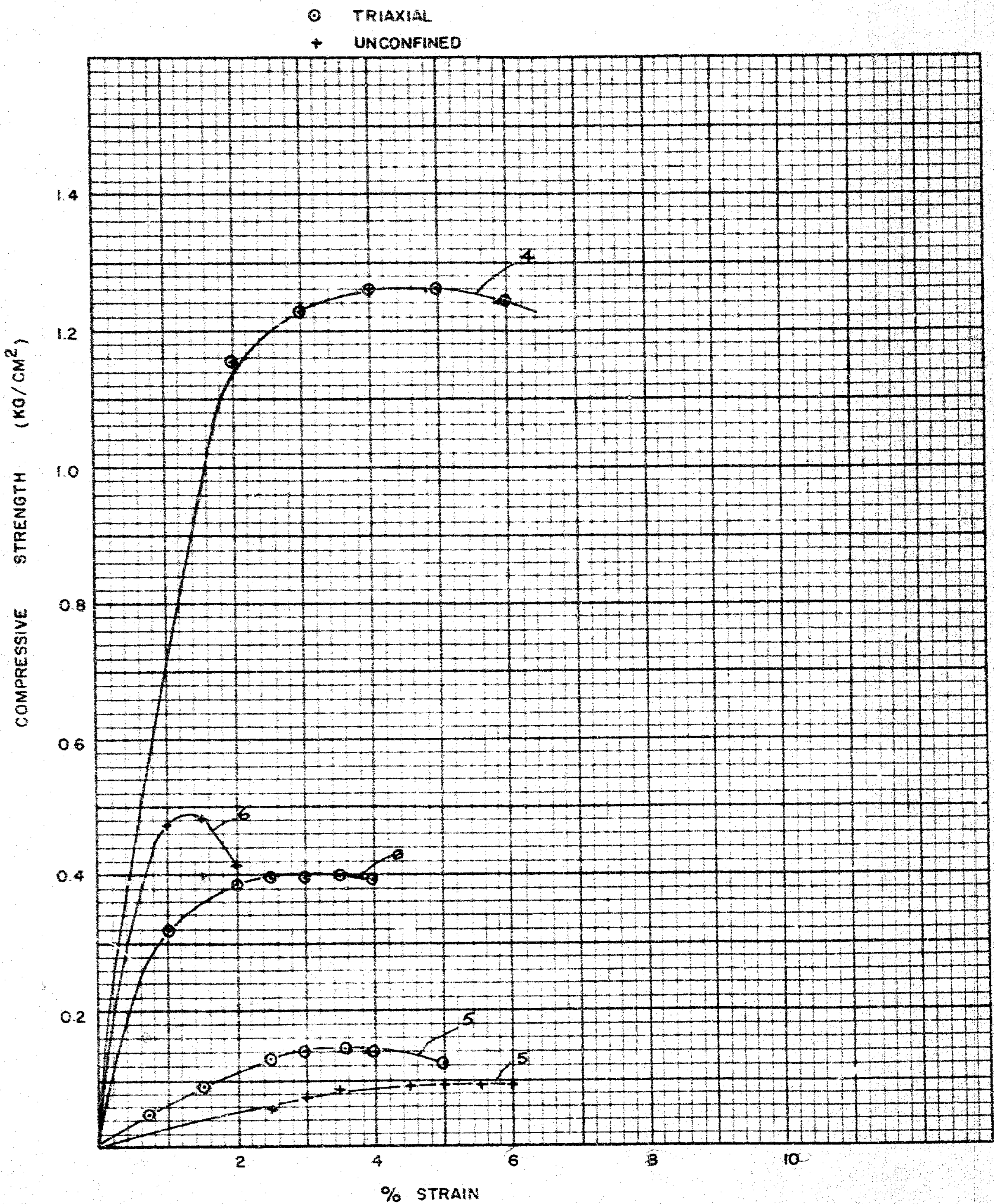
BOREHOLE NUMBER 3 DATE

SAMPLE NUMBER DEPTH

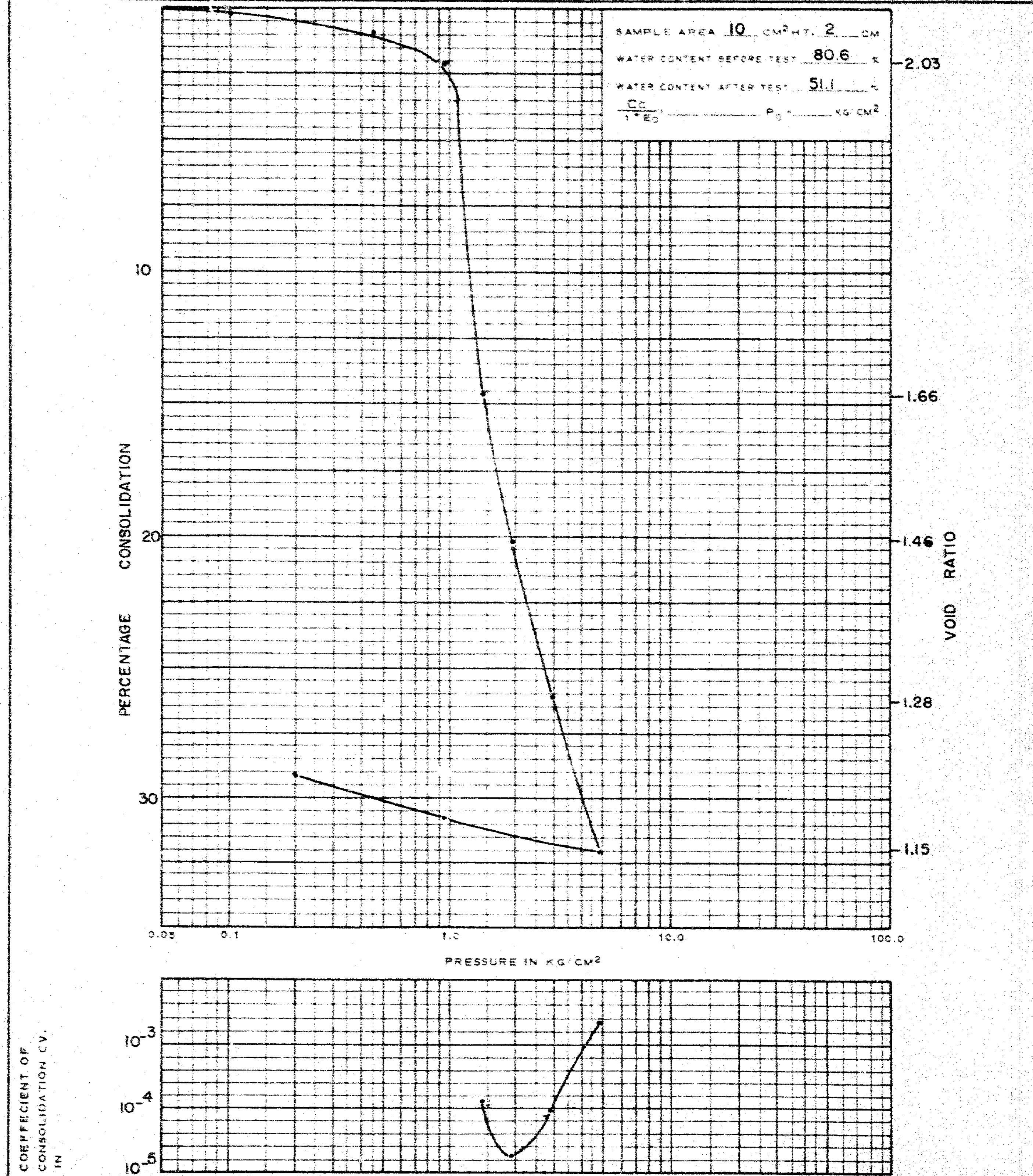
ASSOCIATED GEOTECHNICAL SERVICES Limited

SOIL MECHANICS LABORATORY

STRENGTH TESTS



CLIENT CITY OF CORNWALL	**ASSOCIATED GEOTECHNICAL SERVICES** Limited
JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.	
BOREHOLE NUMBER 2 DEPTH 16.0	**SOIL MECHANICS LABORATORY**
SAMPLE NUMBER 5 DATE 13/12/63	CONSOLIDATION TEST



CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AT C.N.R.

BOREHOLE NUMBER 2 DEPTH 25 – 27

SAMPLE NUMBER 7 DATE

ASSOCIATED GEOTECHNICAL SERVICES
Limited

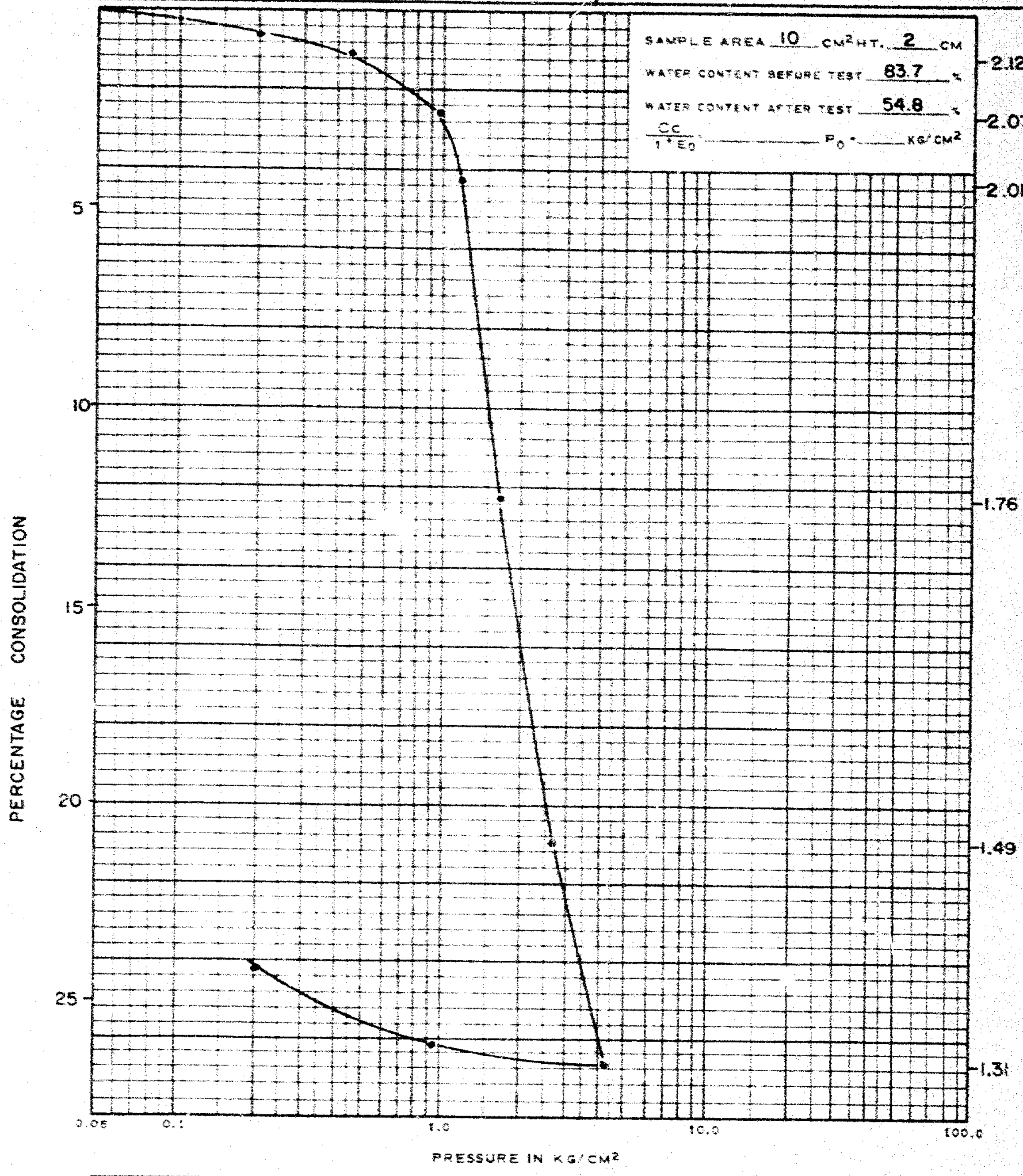
SOIL MECHANICS LABORATORY
CONSOLIDATION TEST

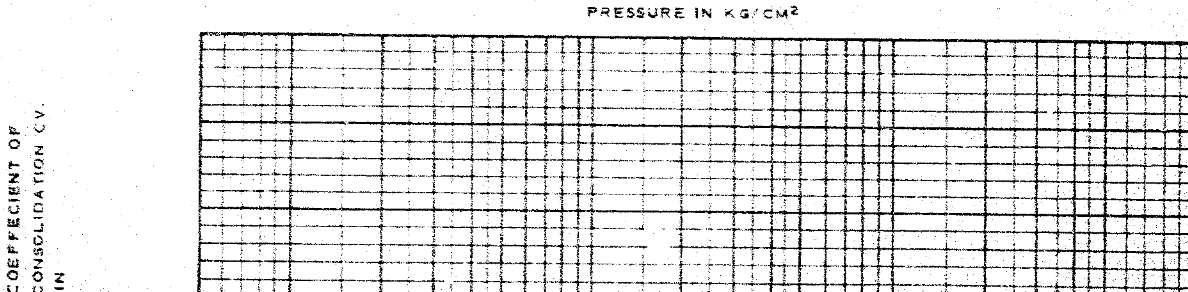
SAMPLE AREA 10 CM² HT. 2 CM

WATER CONTENT BEFORE TEST 83.7 %

WATER CONTENT AFTER TEST 54.8 %

$\frac{C_c}{1+E_0}$ = ________ P_0 = ________ KG/CM²





SOIL CLASSIFICATION SYSTEM

The following system was used to describe the various soils encountered at the site as determined by visual field examination and test. It was also used to classify those soils upon which a laboratory grain size determination had been made.

Soil Components	Particle Size
Clay	< .002 mm
Silt	> .002 mm < .06 mm
Sand	> .06 mm < 2.0 mm
Gravel	> 2.0 mm < 2 in.
Cobbles	> 2 in. < 6 in.
Boulders	> 6 in.

Descriptive Terms	Range of Proportions
and	greater than 40%
with	25% to 40%
some	10% to 25%
trace	less than 10%

Example

1. Silt (predominant type) with (25% - 40%) sand.

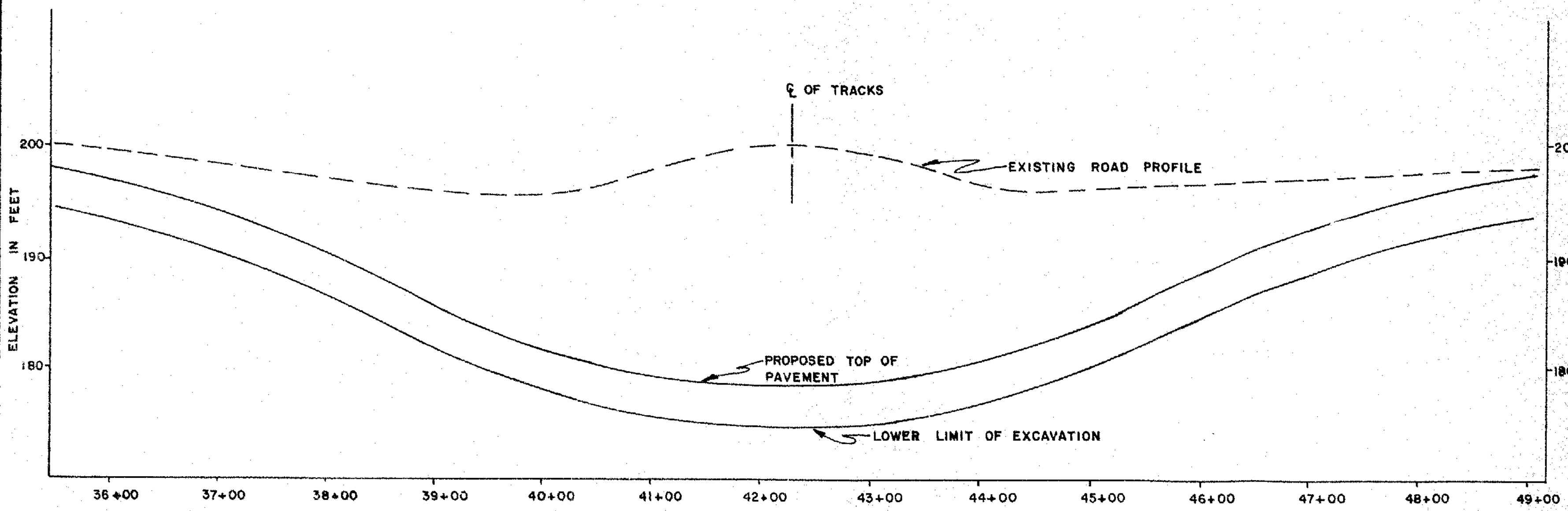
2. Sand and silt (predominant types), some (10% - 25%) gravel, trace (< 10%) clay.

STANDARD PENETRATION CLASSIFICATION

Relative Density of Sands as determined by Standard Penetration Tests		
N	D_d	Designation on Borehole Log
0 - 4	0 - 0.2	Very Loose
4 - 10	0.2 - 0.4	Loose
10 - 30	0.4 - 0.6	Medium Dense
30 - 50	0.6 - 0.8	Dense
Over 50	0.8 - 1.0	Very dense

Shear Strengths of Clays as determined by Standard Penetration Tests		
N	s psf	Designation on Borehole Log
2	250	Very Soft
2 - 4	250 - 500	Soft
4 - 8	500 - 1000	Medium
8 - 15	1000 - 2000	Stiff
15 - 30	2000 - 4000	Very Stiff
30	4000	Hard

CLIENT: CITY OF CORNWALL JOB NO. 6333 LOCATION: BROOKDALE AT C.N.R. PROJECT DATE FIELD INVESTIGATION DATE REPORT BY CHKD.	LEGEND	SCALES HORIZONTAL 1" = 100' VERTICAL 1" = 10'	ASSOCIATED GEOTECHNICAL SERVICES Limited DRAWING 3



PROFILE ALONG CENTRE LINE OF ROAD SHOWING LIMIT OF EXCAVATION FOR SUBWAY STRUCTURE

DAMAS AND SMITH LIMITED

CONSULTING ENGINEERS

WINNIPEG OFFICE
145 GERTRUDE AVENUE
WINNIPEG, MANITOBA
453-8759

LONDON OFFICE
36 WELLINGTON ROAD
LONDON, ONTARIO
434-0531

HEAD OFFICE
209 DAVENPORT ROAD
TORONTO 5, ONTARIO
924-9671

Head Office,
January 24, 1964.

Mr. R. C. Adams, P.Eng.,
City Engineer,
City Hall,
Cornwall, Ontario.

64-F-282 M

Dear Mr. Adams:

Re: Proposed Grade Separation at Brookdale Avenue

We wish to bring to your attention the following points in connection with the above project which will probably require further evaluation and definition prior to final design.

1. Subject to the approval of the Railway Company, provision for the two additional tracks may be arranged to be located under the side spans and the centre span length correspondingly reduced.

2. Additional soil borings will be necessary at the proposed location of the abutments in order to confirm the thickness of compressible clay as determined by probes.

3. Supplementary probes and borings are needed to confirm that the soil conditions on a satisfactory re-alignment of Brookdale Avenue are not significantly better than those found on the existing alignment.

4. In the course of our Pre-Engineering Study, a structural system utilizing precast concrete units was investigated as an alternative to the cast in place concrete deck proposed. In the final design, further consideration will be given to this type of construction.

5. Projected future traffic on Brookdale Avenue will be in excess of the estimated volumes referred to in the Report dated

January 15, 1964 which are based on the external traffic pattern. Final projections will be available in mid-February.

Yours very truly,

DAMAS AND SMITH LIMITED

R. W. Smith

RWS:gc

cc: Mr. C. W. Rump,
Board of Transport Commissioners,

Mr. W. C. Boyd,
Canadian National Railways,

Mr. A. H. Rabb,
District Municipal Engineer,
Department of Highways of Ontario,

Mr. A. Stermac,
Materials and Research Section,
Department of Highways of Ontario,

Mr. K. Kleinsteiber,
Department of Highways of Ontario.

DAMAS AND SMITH LIMITED

CONSULTING ENGINEERS

WINNIPEG OFFICE
345 GERTRUDE AVENUE
WINNIPEG, MANITOBA
453-8759

LONDON OFFICE
336 WELLINGTON ROAD
LONDON, ONTARIO
434-0531

HEAD OFFICE
209 DAVENPORT ROAD
TORONTO 5, ONTARIO
924-9671

Head Office,
January 14, 1964.

Mr. A. Stermac,
Materials and Research Section,
Department of Highways of Ontario,
Laboratory Building,
Downsview, Ontario.

Dear Mr. Stermac:

Re: Proposed Grade Separation
Brookdale Avenue and C.N.R.
Tracks, City of Cornwall, Ont.

We enclose herewith, for your information, a copy of the report on the foundation investigation at the above site. As you may know, Brookdale Avenue is desiganted a Connecting Link between Highway 401 and the Central Business District in Cornwall.

We are taking this step of submitting the above foundation report to you prior to any formal submission by the City of Cornwall for approval of the proposed grade separation project. We would appreciate your review of this report and we will call you for a discussion of the project that we propose later this week.

Yours very truly,

DAMAS AND SMITH LIMITED

R. W. Smith

RWS:gc
Encl.

DAMAS AND SMITH LIMITED

CONSULTING ENGINEERS

WINNIPEG OFFICE
345 GERTRUDE AVENUE
WINNIPEG, MANITOBA
453-8759

LONDON OFFICE
336 WELLINGTON ROAD
LONDON, ONTARIO
434-0531

HEAD OFFICE
209 DAVENPORT ROAD
TORONTO 5, ONTARIO
924-9671

Head Office,
March 2, 1964.

Mr. A. Rutka,
Materials and Research Section,
Department of Highways of Ontario,
Downsview, Ontario.

Dear Mr. Rutka:

Re: Brookdale Avenue C.N.R.
Grade Separation

Enclosed herewith are two (2) copies of a supplementary soils report for the above site. Will you kindly include this supplement with the foundation investigation report previously submitted.

Yours very truly,

DAMAS AND SMITH LIMITED

R. W. Smith

RWS:gc
Encls.

one copy sent to Ken Wernsteiber
March 3. 1964

AGS

ASSOCIATED GEOTECHNICAL SERVICES LIMITED

CONSULTING ENGINEERS

YOUR REF.

OUR REF.

211 DAVENPORT ROAD
TORONTO 5, ONTARIO
WA. 3-0271

March 2, 1964.

Damas and Smith Limited,
Consulting Engineers,
209 Davenport Road,
Toronto 5, Ontario.

Attention: Mr. R. W. Smith

Dear Sirs:

Re: Brookdale - C.N.R. Crossing
Cornwall, Ontario.

This letter discusses the results of field exploratory work at the above site carried out in the period from February 3, to February 13, 1964. The work described was requested by Damas and Smith Limited to supplement information on soil conditions as contained in our original report submitted on January 9, 1964. This letter should be considered an addendum to that report. This additional drilling was done by F. E. Johnson & Co. Ltd., under the supervision of Associated Geotechnical Services. The work consisted of three cone probes and four boreholes. Logs of these probes and boreholes accompany this letter.

The main intention of these explorations was (a) to determine if the depth of clay or the width of the clay filled valley decreased substantially to the west of the proposed centreline as was suggested by the original explorations and (b) to determine more definitely the soil condition and depth to bedrock under the proposed abutments.

On the basis of these additional explorations we have revised our original contour plan showing the bottom of the sensitive clay stratum. This revision, accompanying this letter, also shows soil profiles along the proposed centreline and along a line 250 feet west of and parallel to this proposed centre line. It is evident from the drawing that the decrease in width and depth of clay stratum is not significant within 250 feet west of the proposed centreline.

The four boreholes in the abutment areas indicate that the abutments will be founded over a soils profile which has a negligible depth of clay overlying the "till" soil. This "till" soil is variable in composition ranging from silt with sand some gravel to sand and gravel containing boulders. None of the boulders encountered exceeded 8 inches in size. Bedrock is approximately at elevation 155 under the south abutment and 159 under the north abutment.

We trust that this information is sufficiently detailed for your requirements.

Yours very truly

ASSOCIATED GEOTECHNICAL SERVICES LIMITED

R. Marttila

REM:ed

R. E. Marttila

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
BOREHOLE NO. 5

CLIENT: CITY OF CORNWALL
JOB NO.: 6333 LOCATION: BROOKDALE AVENUE
CO-ORDINATES: 37 + 70 17' E. OF ℄ EXISTING ROAD
ELEVATION (SURFACE): 193.3 (COLLAR): DATUM:
DATE (STARTED): 8 FEB 1964 (FINISHED): 11 FEB (COMPILED): 24 FEB
RIG. NO.: 1 TYPE: B.B.S. I FIELD SUP.: G.U.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL
▲ - VANE SHEAR (NATURAL)
○ - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION

ABBREVIATIONS:
UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS = SPLIT SPOON
ST = SHELBY TUBE
TWP. = THIN WALLED PISTON
DB = DIAMOND BIT
C = CONSOLIDATION TEST
M = MECHANICAL ANALYSIS
T = TRIAXIAL COMPRESSION
K = PERMEABILITY
U = UNCONFINED COMP.
PCF = POUNDS PER CUBIC FOOT
WN = NATURAL WATER CONTENT

BORING LOG / FIELD TESTS (SHEAR STRENGTH (TONS PER SQUARE FOOT); STANDARD PENETRATION TEST (BLOWS PER FOOT) 20 40 60 80) / SAMPLING / LABORATORY TESTS (UNIT WEIGHT PCF DY; ATTERBERG LIMITS WP × — WN ● — ○ WL) / REMARKS

DEPTH FEET	ELEV. FEET	DESCRIPTION	PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	DEPTH FROM FEET	DEPTH TO FEET	TYPE	RECOVERY LENGTH REC./DIST. DRIV.
		TOPSOIL						
1.5	191.8	MOTTLED BROWN SILT SOME SAND CLAY AND PEBBLES	7	1	2.5	4.0	S.S.	12/18
6.0	187.3		PUSH	2	5.0	6.0	S.S.	12/12
		DENSE TO VERY DENSE GREY SAND WITH SILT SOME GRAVEL TILL TEXTURE	23	3	10.0	11.5	S.S.	9/18
			97	4	15.0	16.0	S.S.	3/12
			>100	5	20.0	21.0	S.S.	5/12
23.0	170.3	SAND, GRAVEL AND BOULDERS	DRILL	6	23.0	23.5	R.C.	100%
			DRILL	7	28.0	31.0	R.C.	50%
			DRILL	8	31.0	36.0	R.C.	10%
39.0	154.3	BLACK LIMESTONE BEDROCK	DRILL	9	39.0	43.5	R.C.	100%
43.5	149.8	END OF BOREHOLE AT 43.5'						

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
BOREHOLE NO. 6

CLIENT: CITY OF CORNWALL
JOB NO. 6333 LOCATION: BROOKDALE AVENUE
CO-ORDINATES: 39 + 20 15' E. OF ℄ EXISTING ROAD
ELEVATION (SURFACE): 192.1 (COLLAR): DATUM:
DATE (STARTED): 4 FEB 1964 (FINISHED): (COMPILED):
RIG NO. 1 TYPE: B.B.S.1 FIELD SUP.: G.J.

SYMBOLS: SILT, CLAY, SAND, GRAVEL, PEAT, FILL
▲ - VANE SHEAR (NATURAL)
○ - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION

ABBREVIATIONS:
UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS - SPLIT SPOON; ST - SHELBY TUBE; TWP - THIN WALLED PISTON; DB - DIAMOND BIT
C - CONSOLIDATION TEST; M - MECHANICAL ANALYSIS; T - TRIAXIAL COMPRESSION; K - PERMEABILITY; U - UNCONFINED COMP.; PCF - POUNDS PER CUBIC FOOT; WN - NATURAL WATER CONTENT

BORING LOG

DEPTH FEET	ELEV. FEET	DESCRIPTION
		TOPSOIL
1.0	191.1	BROWN SAND
3.0	189.1	GREY CLAY AND SILT
20.5	171.6	GREY SILT WITH SAND SOME GRAVEL TILL TEXTURE
24.0	168.1	SAND AND GRAVEL SOME SILT
36.5	155.6	BLACK LIMESTONE BEDROCK
40.7	151.4	END OF BOREHOLE AT 40.7'

FIELD TESTS / SAMPLING

SHEAR STRENGTH (TONS PER SQUARE FOOT): 0.25, 0.50, 0.75, 1.00
STANDARD PENETRATION TEST (BLOWS PER FOOT): 20, 40, 60, 80

PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	DEPTH FROM FEET	DEPTH TO FEET	TYPE	RECOVERY LENGTH REC. / DIST. DRIV.
2	1	5.0	6.5	S.S.	NIL
	2	7.0	8.5	S.T.	18/18
	3	10.0	11.6	S.T.	18/18
	4	15.0	16.5	S.T.	18/18
	5	20.0	20.5	S.T.	
9	6	20.5	22.0	S.S.	12/18
40	7	25.0	26.5	S.S.	2/18
	8	27.0	29.0	WASH	
	9	30.0	31.5	S.S.	15/18
	10	33.0	35.0	R.C.	-
43	11	35.0	36.5	S.S.	
	12	36.5	40.7	R.C.	100%

LABORATORY TESTS

UNIT WEIGHT PCF
ATTERBERG LIMITS: WP, WN, WL

REMARKS

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

BOREHOLE NO. 7

CLIENT: CITY OF CORNWALL
JOB NO.: 6333 LOCATION: BROOKDALE AVENUE
COORDINATES: 46 + 20 18'E. OF ℄ EXISTING ROAD
ELEVATION (SURFACE): 194.1 (COLLAR): DATUM:
DATE (STARTED): 11 FEB. 64 (FINISHED): 12 FEB (COMPILED): 24 FEB
R.S. NO.: 1 TYPE: BBS.1 FIELD SUP.: G.J.

SYMBOLS: SILT, GRAVEL, CLAY, PEAT, SAND, FILL
▲ - VANE SHEAR (NATURAL)
O - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION

ABBREVIATIONS: UNDISTURBED; DISTURBED BUT REPRESENTATIVE; FAIR; LOST
SS - SPLIT SPOON
ST - SHELBY TUBE
TWP. - THIN WALLED PISTON
DB - DIAMOND BIT
C - CONSOLIDATION TEST
M - MECHANICAL ANALYSIS
T - TRIAXIAL COMPRESSION
K - PERMEABILITY
U - UNCONFINED COMP.
PCF - POUNDS PER CUBIC FOOT
WN - NATURAL WATER CONTENT

BORING LOG / FIELD TESTS / SAMPLING / LABORATORY TESTS

Field tests: SHEAR STRENGTH (TONS PER SQUARE FOOT) 0.25, 0.50, 0.75, 1.00; STANDARD PENETRATION TEST (BLOWS PER FOOT) 20, 40, 60, 80. Laboratory: UNIT WEIGHT PCF; ATTERBERG LIMITS WP, WN, WL.

DEPTH FEET	ELEV. FEET	DESCRIPTION	PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	FROM FEET	TO FEET	TYPE	RECOVERY LENGTH REC./DIST. DRIV.
		TOPSOIL						
1.0	193.1							
2.5	191.6	BROWN SAND						
		BROWN TO GREY CLAY SOME SILT OCCASIONAL RED AND BLACK NODULES	3	1	5.0	6.5	SS	12/18
			PUSH	2	10.0	11.5	ST	18/18
14.0	180.1	MEDIUM DENSE GREY SAND AND SILT SOME GRAVEL TILL TEXTURE	12	3	15.0	16.5	SS	9/18
			20	4	20.0	21.5	SS	15/18
22.0	172.1	SAND, GRAVEL AND BOULDERS	90	5	25.0	26.0	SS	2/12
			DRILL	6	26.0	30.0	RC	10%
30.0	164.1	VERY DENSE GREY SAND WITH SILT, SOME GRAVEL	>100	7	30.0	31.0	SS	10/12
33.5	160.6	BLACK LIMESTONE BEDROCK	DRILL	8	33.6	34.9	RC	100%
			DRILL	9	34.9	40.0	RC	100%
40.0	154.1	END OF BOREHOLE AT 40.0'						

REMARKS

CLIENT: CITY OF CORNWALL
JOB NO. 6333 LOCATION: BROOKDALE AVENUE
CO-ORDINATES: 47 + 70 18' E. OF ℄ EXISTING ROAD
ELEVATION (SURFACE) 194.7 (COLLAR) DATUM
DATE (STARTED) 12 FEB 1964 (FINISHED) (COMPILED)
RIG. NO. 1 TYPE B.B.S. 1 FIELD SUP. G.J.

SYMBOLS: SILT, GRAVEL, CLAY, PEAT, SAND, FILL
▲ - VANE SHEAR (NATURAL)
O - VANE SHEAR (REMOLDED)
● - STANDARD PENETRATION

ABBREVIATIONS
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K - PERMEABILITY
U - UNCONFINED COMP.
PCF - POUNDS PER CUBIC FOOT
WN - NATURAL WATER CONTENT

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
BOREHOLE NO. 8

Depth (feet)	Elev. (feet)	Description	Penetration resistance (blows per foot)	Sample number	From (feet)	To (feet)	Type	Recovery
		TOPSOIL						
1.0	193.7	BROWN TO GREY CLAY & SILT TRACE TO SOME SAND IN UPPER TWO FEET	8	1	2.5	4.0	S.S.	18/18
				2	5.0	6.5	S.T.	18/18
7.0	187.7	GREY SAND SOME SILT OCCASIONAL COBBLES & BOULDERS	28	3	10.0	11.5	S.S.	18/18
				4	12.0	13.0	R.C.	50%
			15	5	15.0	16.5	S.S.	10/18
19.0	175.7	GREY SAND & GRAVEL	15	6	20.0	21.0	S.S.	10/12
				7	23.0	25.0	R.C.	50%
25.0	169.7	DENSE GREY SAND WITH SILT, SOME GRAVEL TILL TEXTURE	43	8	25.0	26.5	S.S.	12/18
			37	9	30.0	31.5	S.S.	15/18
36.0	158.7	BLACK LIMESTONE BEDROCK		10	36.0	40.5	R.C.	95%
40.5	154.2	END OF BOREHOLE AT 40.5'						

LABORATORY TESTS: UNIT WEIGHT PCF DRY; ATTERBERG LIMITS WP X —●— O WL, WN

REMARKS

CLIENT CITY OF CORNWALL

JOB NO. 6333 LOCATION BROOKDALE AVENUE

CO-ORDINATES 38+70 250' W. OF ℄ EXISTING ROAD

ELEVATION (SURFACE) 192.8 COLLAR DATUM

DATE (STARTED) 5 FEB. 1964 (FINISHED) 5 FEB. (COMPILED) 25 FEB.

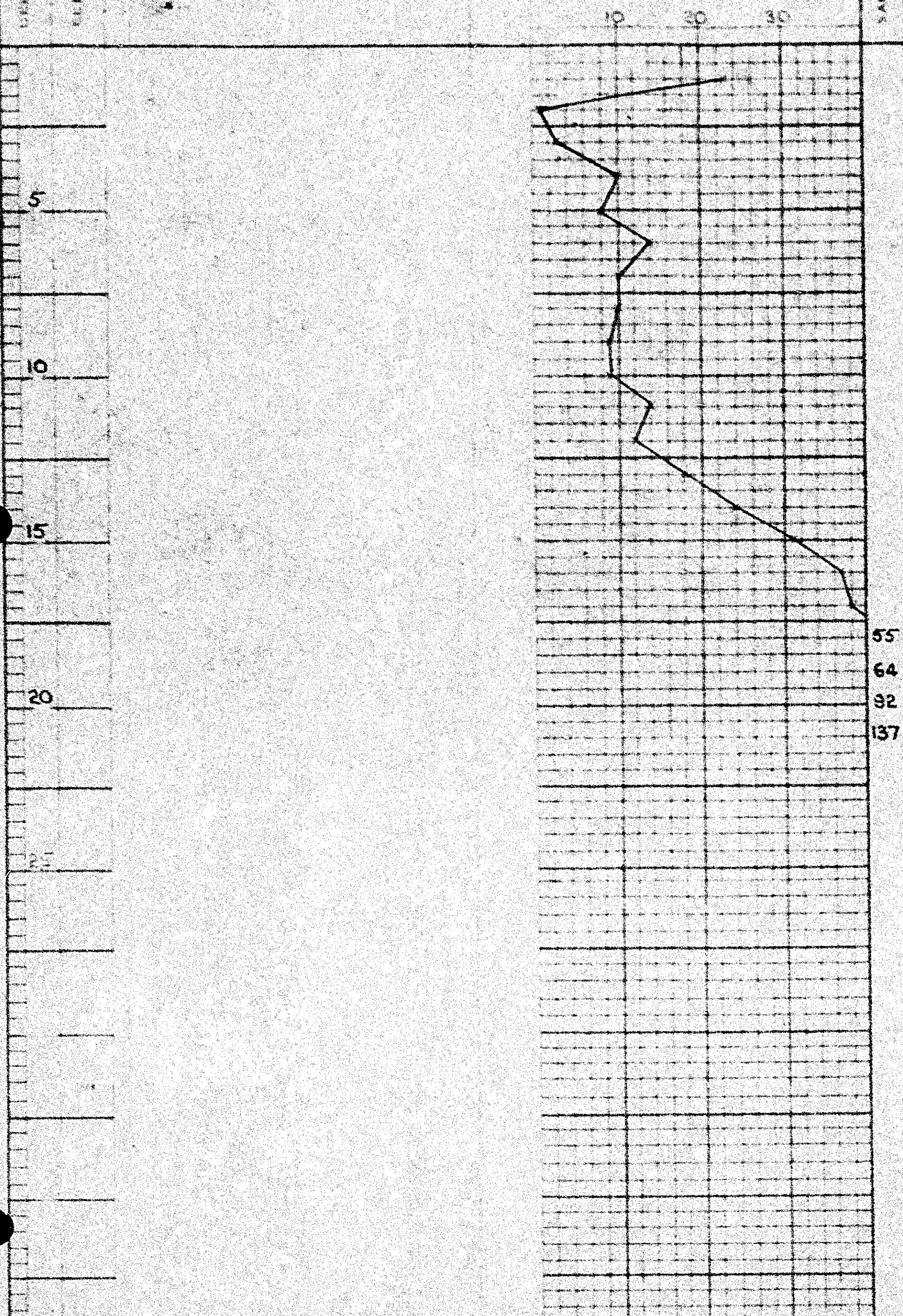
RIG NO. 1 TYPE B.B.S.1 FIELD SUP. G.J.

ASSOCIATED GEOTECHNICAL SERVICES
Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE #0

~~BOREHOLE NO.~~

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH (TONS PER SQ. FT.) / STANDARD PENETRATION BLOWS PER FOOT	SAMPLE NO.	CONDITION	REMARKS



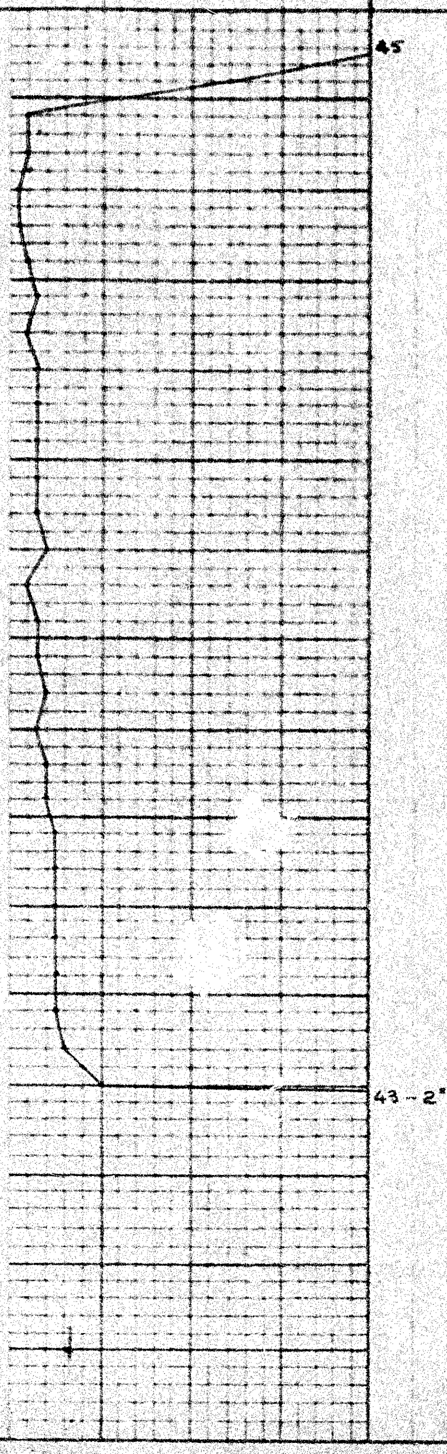
DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

CLIENT: CITY OF CORNWALL
JOB NO. 6333 LOCATION: BROOKDALE AVENUE
CO-ORDINATES: 42+20 250' W. of ℄ EXISTING ROAD
ELEVATION (SURFACE) 194.0 (COLLAR) DATUM
DATE (STARTED) 5 FEB 1964 (FINISHED) 5 FEB COMPILED 25 FEB.
RIG NO. 1 TYPE B.B.S. I FIELD SUP. G.J.

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG
DYNAMIC CONE PROBE # P
~~BOREHOLE NO.~~

DEPTH FEET	ELEV. FEET	DESCRIPTION	LOG	SHEAR STRENGTH TONS PER SQ. FT. / STANDARD PENETRATION BLOWS PER FOOT (10, 20, 30)	SAMPLE NO.	CONDITION	REMARKS
5							
10							
15							
20							
25							
30							
35							



DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

CLIENT: CITY OF CORNWALL

JOB NO. 6333 LOCATION: BROOKDALE AVENUE

COORDINATES: 45+70 250' W. OF EXISTING ROAD ℄

ELEVATION (SURFACE): 193.8

DATE (STARTED): 5 FEB. 1966 (FINISHED): 5 FEB. (COMPILED): 25 FEB.

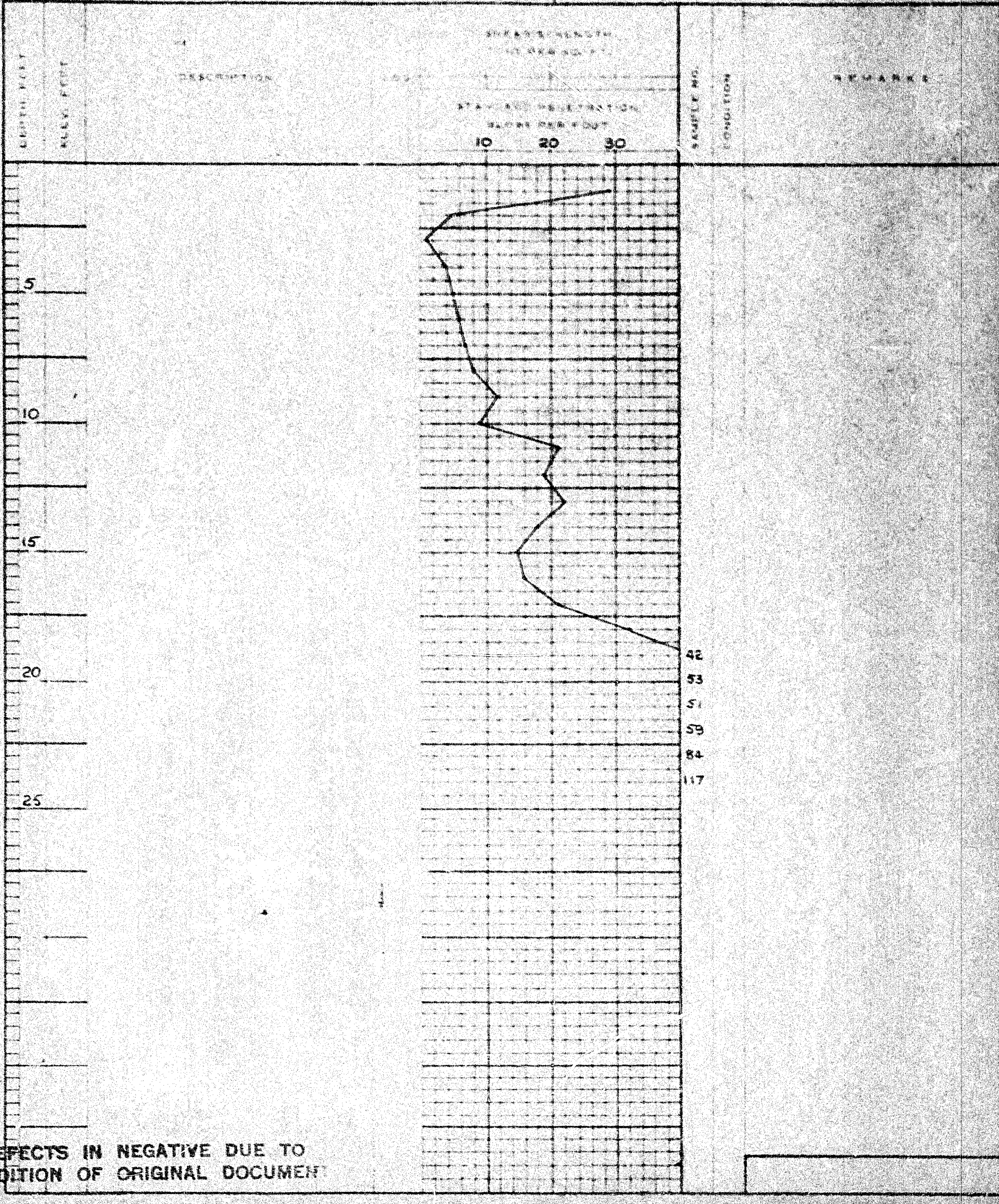
RIG NO.: 1 TYPE: B.B.S.1 (SUPERVISOR): G.J.

ASSOCIATED GEOTECHNICAL SERVICES Limited

OFFICE BOREHOLE LOG

DYNAMIC CONE PROBE #Q

BOREHOLE NO.



cc: Foundations Office (Rm. 110)

Mr. K. L. Kleinsteiber,
Municipal Bridge Liaison Engr.,
Bridge Division, Admin. Bldg.

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

January 26, 1966

Overhead Structure at C.N.R. Tracks,
Brookdale Avenue, City of Cornwall.
District 9

With reference to the letter of December 31, 1965, by Messrs. Damas and Smith, Ltd. to Mr. C. F. Adams, City Engineer, City of Cornwall, regarding the above subject, we wish to make the following comments:

It is indeed, very useful and important that careful observations be carried out at the above structure in order to evaluate its performance. Because of the very soft and sensitive nature of the clay in this area, difficulties have been experienced with a number of highway structures. This fact has been made known to Messrs. Damas and Smith, and they have adjusted their design accordingly. However, we feel that the entire problem of bridge abutment movements is not fully understood and, consequently, also unexplained. It has to be borne in mind that the abutments do not move towards the crossing, but away from it and such movement is not clearly and unambiguously understood. There are a number of hypotheses, but without further proof and better documentation, it is impossible to be very specific and explicit about the whole problem.

On page 1 of the Inter-Office communication attached to the afore mentioned letter, the following statement is made:

"Abutments were located where the settlement was estimated at 6" by the Soil Consultant. Experience on similar structures has indicated that the rotational movement of the abutment under these conditions is acceptable."

It is our opinion that this is not the right wording because it does not define the design criteria correctly. During the discussions held after the soils information became available, and in view of the problems we had with our structures, it was suggested that the structure designed by Messrs. Damas and Smith, Ltd., be lengthened so that the approach fills would not cause more than 6" of settlement. This criterion was chosen because it is believed

cont'd. /2 ......

that no movements of the abutments would occur under such conditions or if movements do occur, they would be within tolerable limits.

With respect to the observation of vertical movements - (page 3), we would like to get the details on the reference bench mark, or marks used for this operation.

AGS/MieF

A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER

cc: Foundations Office
Gen. Files

DAMAS AND SMITH LIMITED

CONSULTING ENGINEERS

HEAD OFFICE
10 CODECO COURT
DON MILLS, ONTARIO
447-5137

WINNIPEG OFFICE
345 GERTRUDE AVENUE
WINNIPEG, MANITOBA
453-8759

LONDON OFFICE
336 WELLINGTON ROAD
LONDON, ONTARIO
434-0531

YOUR REF.

OUR REF. File: 765

Head Office
December 31, 1965.

Mr. C.F. Adams, P.Eng.,
City Engineer
City of Cornwall
City Hall
Cornwall, Ontario.

Dear Sir:

Re: Overhead Structure at C.N.R. Tracks
Brookdale Avenue, City of Cornwall

In view of the soil conditions at the above site and the possibility of settlement of the embankment at the abutments of the bridge, we have set up permanent measurement points on the structure. Past experience has indicated that although the abutments are constructed on piled foundations, the consolidation of the foundation soil and settlement of the embankment causes a rotational movement of the abutments away from the structure.

In order to use the structure as a reference, all expansion gaps have to be measured, since we have found that at the small temperature variations the expansion is not distributed to each gap in proportion to span length. In addition to thermal changes, shrinkage must be considered. With these factors in mind we have established the procedure for measurement of the structure which will give suitable readings for subsequent analysis and evaluation of structural performance.

The enclosed memorandum covers the findings to date. Should any further information be required please let us know.

Yours very truly,

DAMAS AND SMITH LIMITED

37 - 5 8

R. W. Smith

RWS:ed
encl.
c.c. Mr. K. Kleinsteiber
Municipal Bridge Engineer.

12186

INTER-OFFICE COMMUNICATION

TO File **DATE** November 1965.

FROM **REF. NO.** 765

SUBJECT Report on Abutment Movements - Brookdale Avenue C.N.R. Overhead - City of Cornwall, Ontario

1. INTRODUCTION

The overhead structure at the C.N.R. main tracks crossing Brookdale Avenue, City of Cornwall, was constructed between September 1964 and September 1965. The length of the structure was selected with respect to the soil conditions. Site soil conditions are described in a Report by Associated Geotechnical Services Limited dated January 9, 1964. A stratum of soft clay underlies the surficial soil stratum of sand. The greatest thickness of the soft clay is located at the railway and reduces in thickness in both directions along the road. Location for the piled abutments was determined by the estimates of settlement of the earth embankment approaches.

Abutments were located at stations where the vertical settlement was estimated at 6" by the Soil Consultants. Experience on similar structures has indicated that the rotational movement of the abutment under these conditions is acceptable. This Report describes the provisions made for measurement of movements and records measurements made to date.

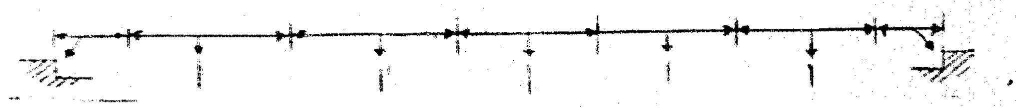
2. HORIZONTAL MOVEMENTS

All horizontal movement will appear at the expansion gaps of the bridge and mainly, if not totally, at the abutment expansion gaps. Consequently to observe this movement, periodic measurement of all expansion gap movements must be made.

In order to determine the actual abutment movements from the recorded expansion gap movements, the effect of concrete thermal and shrinkage length changes and the way in which these movements are distributed to the seven expansion gaps of the bridge, has to be allowed for.

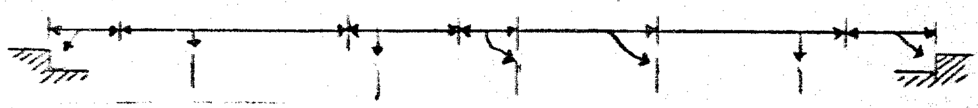
(a) Distribution of Expansion

Theoretically the movement of expansion gaps should be made up of a symmetrical distribution of adjacent spans as follows:



	N. Abut.	#3	#7	#10	#13	#16	S. Abut.	
Theoretical number of spans contributing to movement at expansion gaps	1-1/2	3-1/2	3-1/2	3	3	3	1-1/2	= 19

The following approximate distribution of expansion appears to be taking place in the field with small (± 20°F.) temperature variations, about 70°F.



Actual number of spans contributing to movement at expansion gaps	1-1/2	5	2-1/2	1	3	4	2	= 19

The apex of the bridge is approximately over Pier #9 and it appears that the movements are occurring more on the downhill ends of the bridge spans.

(b) Temperature

Using a coefficient of .000006 /°F
For a 10°F change the following movements occur:

N. Abutment	.051"
Pier #3	.118
Pier #7	.118
Pier #10	.102
Pier #13	.102
Pier #16	.102
S. Abutment	.051
	.644" / 10° F.

(c) Shrinkage

Using a coefficient of .0002 $^{in}/_{in}$, and assuming 90% has taken place before the first set of reading (September 3, 1965), the following shrinkage may occur :

N. Abutment	.017"
Pier #3	.039
Pier #7	.039
Pier #10	.034
Pier #13	.034
Pier #16	.034
S. Abutment	.017
	.214"

If the mean temperature of the concrete is estimated, then the expansion estimates may be computed. Comparing this estimate with the measured movement will give the abutment movement without shrinkage allowances.

This estimate of abutment movement should be inspected carefully against the actual movements occurring at each expansion gap, particularly the abutment expansion gaps, and due allowance made for shrinkage.

(d) Method of Measuring

On the east and west sides of each of the 7 expansion joints on the bridge, a pair of ramset nails have been driven and a cross filed on the top of each one. The measurement between the field crosses is recorded to 0.01".

3. VERTICAL MOVEMENTS

Tilting or settling of the abutments will be obtained from the tilting or settling of the wingwall. Consequently, ramset nails have been located at either end of each wingwall and these points should be levelled periodically, using benchmarks at the site.

4. RESULTS

A survey form is appended. Records of readings for the period to November 1965 are also appended. Results to date indicate that negligible movements have occurred at the abutments. Since the historical record is not extensive at this time, no conclusions can be drawn from the apparent performance of the structure to date.

BROOKDALE AVENUE C.N.R. OVERPASS

BRIDGE MOVEMENTS

Party ______________

Date ______________

Temp. ______________

1. Horizontal

Measure between filed crosses on nail and washers set in concrete on either side of expansion joints. Record to 0.01".

North Abutment	East side West side	
Pier #3	E. W.	
Pier #7	E. W.	
Pier #10	E. W.	
Pier #13	E. W.	
Pier #16	E. W.	
South Abutment	E. W.	

2. Vertical

Measure on top of nail and washer set in top of concrete wingwalls

North Abutment

East Wingwall	North end South	
West	North South	

Benchmark over Pier #2, nail and washer in west edge of sidewalk 221.75

South Abutment

East wingwall	North end	
	South	
West	North	
	South	

Benchmark overPier #17, nail and washer in east edge of curb 219.27

MEASUREMENTS AT BROOKDALE AVENUE OVERHEAD - C.N.R. TRACKS

		Sept. 3 75°F		Sept. 7 80°F		Oct. 8 50°F		Oct. 21 60°F		Nov. 2 25°F	
		gap in	change	gap in	change	gap in	change	gap in	change	gap in	change
N. Abut.	E.	9.36		9.36		9.43	.07	9.42	.06	9.52	0.16
	W.	8.48		8.48		8.57	.09	8.56	.08	8.67	0.19
#3	E.	10.07		9.06	-.01	10.35	.28	10.24	.17	10.58	0.51
	W.	9.66		9.64	-.02	9.92	.26	9.80	.14	10.12	0.46
#7	E.	10.11		10.11		10.30	.19	10.18	.07	10.50	0.39
	W.	10.33		10.32	-.01	10.50	.17	10.39	.06	10.70	0.37
#10	E.	8.86		8.85	-.01	8.97	.11	8.90	.04	9.16	0.20
	W.	9.68		9.67	-.01	9.74	.06	9.69	.01	9.92	0.24
#13	E.	10.45		10.44	-.01	10.66	.21	10.54	.09	10.88	0.33
	W.	9.80		9.78	-.02	9.98	.18	9.88	.08	10.20	0.40
#16	E.	10.30		10.30		10.51	.21	10.42	.12	10.68	0.38
	W.	11.12		11.11	-.01	11.30	.18	11.21	.09	11.47	0.35
S. Abut.	E.	11.25		11.25		11.34	.09	11.31	.06	11.44	0.19
	W.	7.64		7.64		7.69	.05	7.70	.06	7.80	0.16
Total:					-.10		2.15		1.13		4.33
N. Abut.	NE	218.45		-		218.45	-	218.45	-	218.44	-0.01
	SE	218.92		-		218.93	+0.01	218.92	-	218.92	-
	NW	217.54		-		217.54	-	217.54	-	217.54	-
	SW	218.00		-		218.00	-	218.00	-	218.00	-
S. Abut.	NE	214.92		-		214.92	-	214.92	-	214.92	-
	SE	214.37		-		214.38	+0.02	214.38	+0.01	214.37	-
	NW	216.01		-		216.01	-	216.01	-	216.00	-0.01
	SW	215.43		-		215.43	-	215.42	-0.01	215.42	-0.01

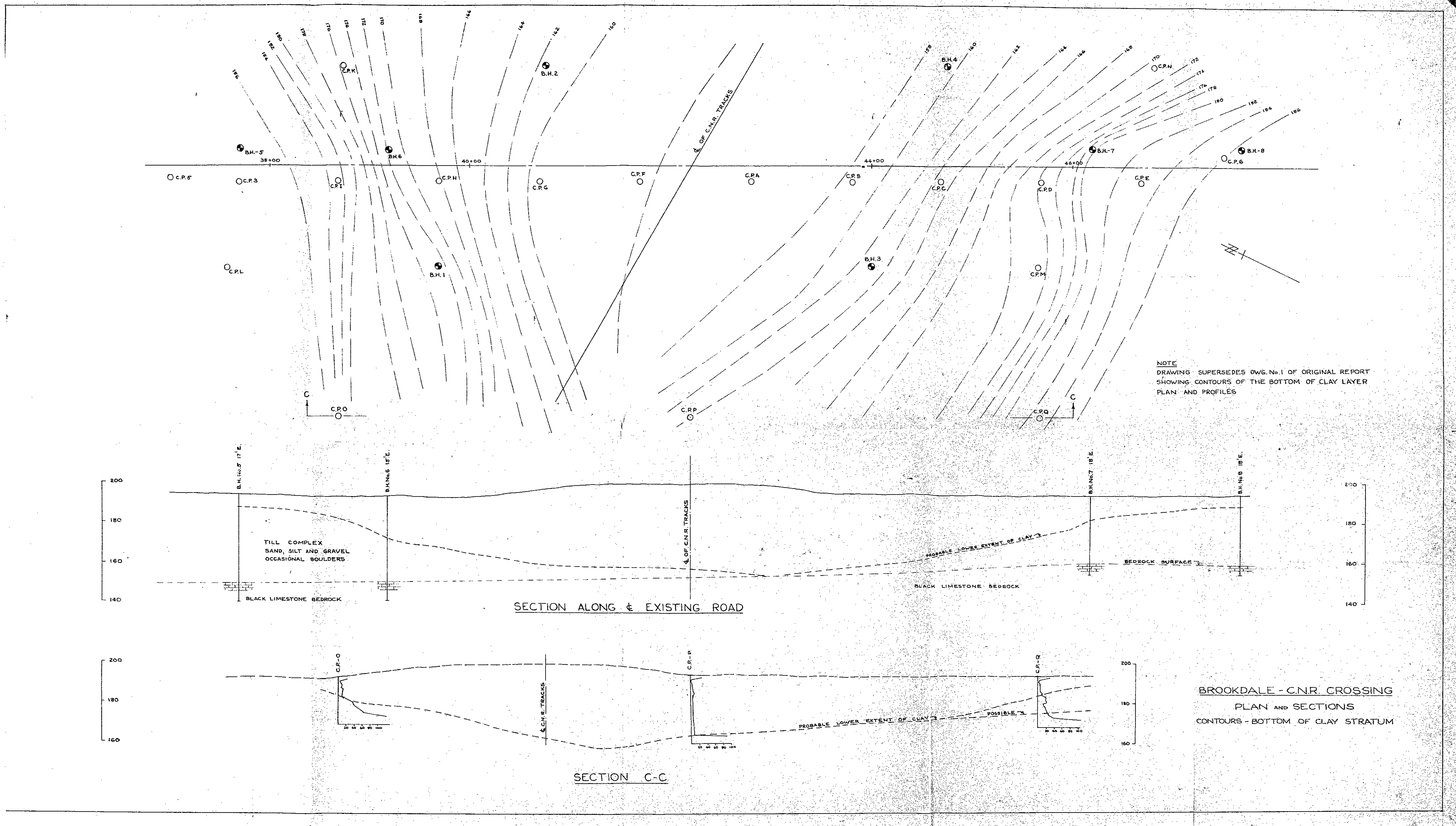
#64-F-282m

BROOKDALE

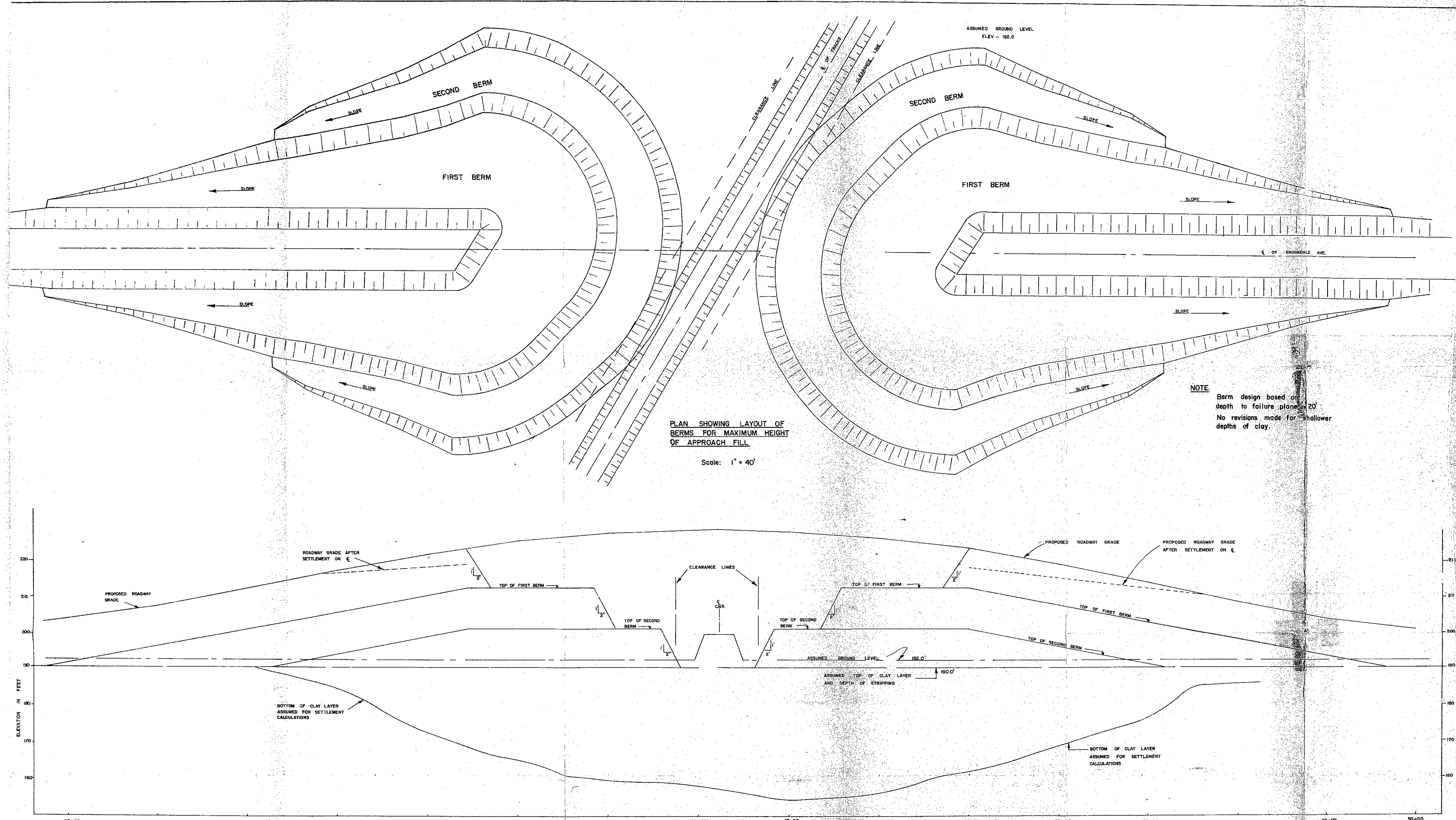
AVENUE C.N.R

CROSSING

CORNWALL



B.H.-5
B.H.6
B.H.1
B.H.2
B.H.3
B.H.4
B.H.-7
B.H.-8
C.P.K
C.P.5
C.P.3
C.P.I
C.P.N
C.P.G
C.P.F
C.P.A
C.P.B
C.P.C
C.P.D
C.P.E
C.P.6
C.P.L
C.P.M
C.P.O
C.P.P
C.P.Q
38+00
40+00
44+00
46+00
℄ OF C.N.R. TRACKS
C
NOTE
DRAWING SUPERSEDES DWG. No. I OF ORIGINAL REPORT SHOWING CONTOURS OF THE BOTTOM OF CLAY LAYER PLAN AND PROFILES
TILL COMPLEX
SAND, SILT AND GRAVEL
OCCASIONAL BOULDERS
BLACK LIMESTONE BEDROCK
PROBABLE LOWER EXTENT OF CLAY
BEDROCK SURFACE
SECTION ALONG ℄ EXISTING ROAD
PROBABLE LOWER EXTENT OF CLAY
POSSIBLE
℄ C.N.R. TRACKS
SECTION C-C
BROOKDALE - C.N.R. CROSSING
PLAN AND SECTIONS
CONTOURS - BOTTOM OF CLAY STRATUM



PLAN SHOWING LAYOUT OF BERMS FOR MAXIMUM HEIGHT OF APPROACH FILL

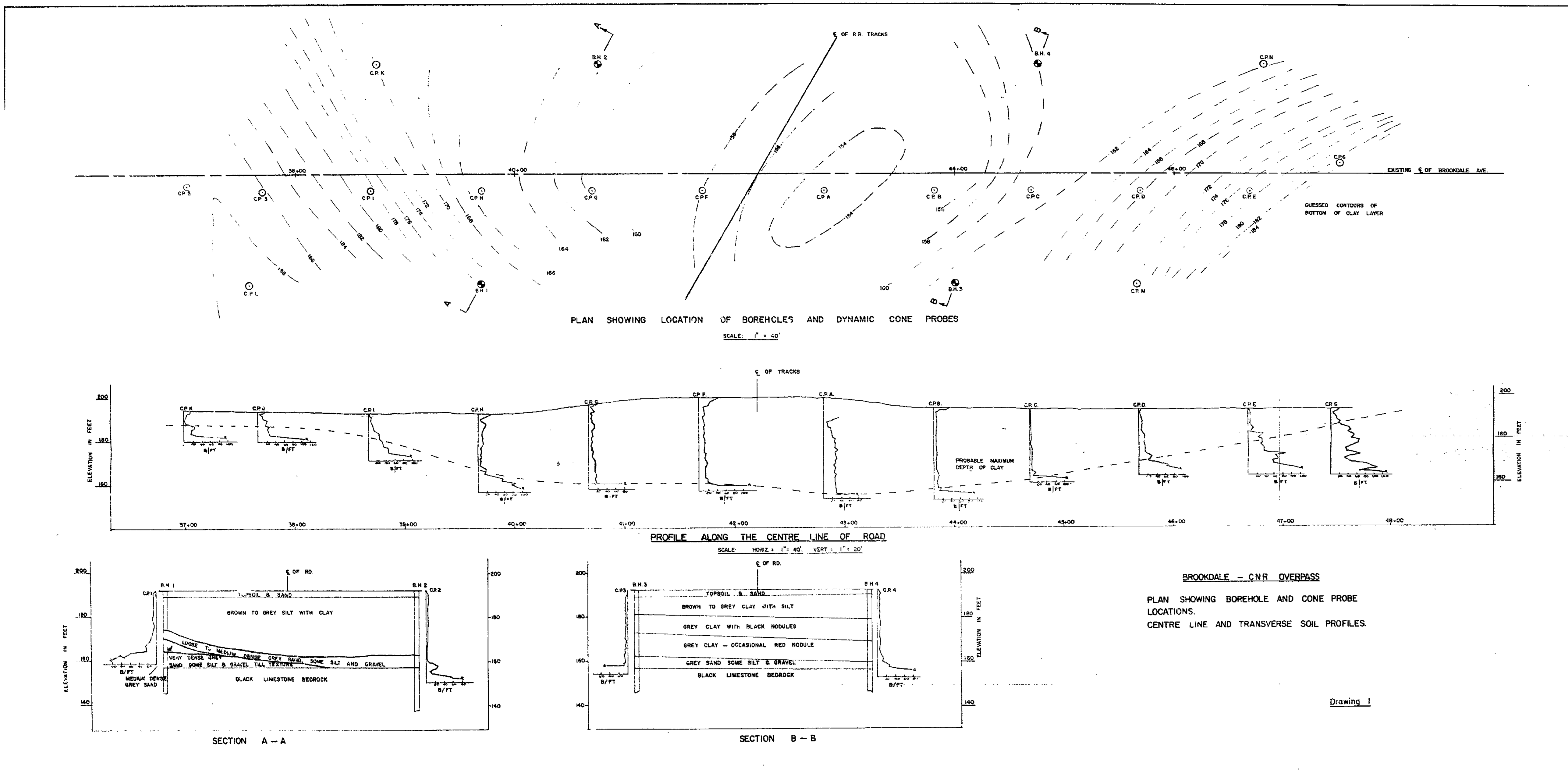
Scale: 1" = 40'

BROOKDALE AVENUE CENTRELINE PROFILE SHOWING EXPECTED SETTLEMENT

Scale: Horiz. 1" = 40'
Vert. 1" = 10'

BROOKDALE – CNR OVERPASS

Drawing 2



℄ OF R.R. TRACKS
B.H. 1
B.H. 2
B.H. 3
B.H. 4
EXISTING ℄ OF BROOKDALE AVE.
GUESSED CONTOURS OF BOTTOM OF CLAY LAYER
PLAN SHOWING LOCATION OF BOREHOLES AND DYNAMIC CONE PROBES
SCALE: 1" = 40'
℄ OF TRACKS
ELEVATION IN FEET
PROBABLE MAXIMUM DEPTH OF CLAY
PROFILE ALONG THE CENTRE LINE OF ROAD
SCALE: HORIZ. = 1" = 40' VERT = 1" = 20'
℄ OF RD.
TOPSOIL & SAND
BROWN TO GREY SILT WITH CLAY
LOOSE TO MEDIUM DENSE GREY SAND, SOME SILT AND GRAVEL
VERY DENSE GREY SAND SOME SILT & GRAVEL TILL TEXTURE
MEDIUM DENSE GREY SAND
BLACK LIMESTONE BEDROCK
SECTION A — A
BROWN TO GREY CLAY WITH SILT
GREY CLAY WITH BLACK NODULES
GREY CLAY — OCCASIONAL RED NODULE
GREY SAND SOME SILT & GRAVEL
SECTION B — B
BROOKDALE — CNR OVERPASS
PLAN SHOWING BOREHOLE AND CONE PROBE LOCATIONS.
CENTRE LINE AND TRANSVERSE SOIL PROFILES.
Drawing I