

MEMORANDUM

To: Mr. A. McConnell,
Regional Functional Planning
Engineer,
Southwestern Region (London).

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

ATTENTION:

DATE: January 7, 1970

OUR FILE REF.

IN REPLY TO

JAN 15 1970

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For

St. Thomas Expressway and
Highway 126 Extension
City of St. Thomas
District No. 2 (London)
W.J. 69-F-113 -- W.O. 7192-68-101/102

At hand, we are forwarding to you the results of a foundation investigation carried out for the above mentioned project. The investigation was originally requested in a memo dated October 23, 1969, from Mr. R. L. Henton to Mr. J. Roy.

We believe the information contained in our report will be sufficient for your present purposes, though additional borings will probably be necessary when the project reaches the design stage.

Should further information be required, please contact this Office.

AGS/kieP
Attach.

cc: Messrs. A. McConnell (2)
H. A. Tregashock
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Foundations Files ✓
Gen. Files

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FOUNDATION INVESTIGATION REPORT
For
St. Thomas Expressway and
Highway 126 Extension
City of St. Thomas
District No. 2 (London)
W.J. 69-F-113 -- W.O. 7192-68-101/102

1. INTRODUCTION:

Preliminary soils information was requested by Mr. R. L. Hanton, Project Manager, London Region, at the sites of high fills and deep cuts along the proposed Hwy. #126 extension at St. Thomas. The memo containing the request, was dated October 28, 1969. Three typical areas were chosen for the investigation, among which the first and the second areas were ravines of the Kettle Creek, proposed to be transversed by fills of 40 - 55 ft. heights (near Stations 60+00 and 80+00). The third site is in the location of a proposed cut of some 24 - 25 ft. depth (around Station 110+00). On attached Drawing No. 69-F-113A, the investigated sites, together with the soil stratigraphy, are depicted.

Presented in the following paragraphs are the results of the investigations as well as some general conclusions concerning slope stabilities.

2. FIELD AND LABORATORY INVESTIGATIONS:

Four boreholes were carried out, placing two holes at the first, and one hole at each of the second and third investigated areas.

The borings were performed by using a Bombardier mounted continuous flight auger and a conventional diamond drill rig. Standard drilling and testing techniques were applied.

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

Upon arrival in the laboratory, soil samples were visually examined and classified. Some representative samples were further tested in order to determine Atterberg limits, moisture contents, grain-size distributions, undrained and drained shear strength characteristics. The results of the field and laboratory tests are compiled on the borelog sheets accompanying this report.

3. SUBSOIL CONDITIONS:

3.1) The area covered by Boreholes #1 and 2 was found to consist of granular materials. At the deeper elevations, however, the deposits contain an appreciable amount of fines, mainly in the non or slightly plastic silt range. The surficial layer, extending to 12 ft. depth, was identified to be fine sand becoming gravelly around 10 ft. The obtained penetration resistances averaging 15 blows per ft., correspond to a compact relative density. Underlying the sands, silty sands with traces of clay and gravel were observed having a very dense relative density with penetration 'N' values in excess of 100 blows per ft.

3.2) The soil stratigraphy of Borehole #3, placed on the 2nd investigated valley floor, consists of an approx. 18-ft. thick layer of clayey silt, followed by silty sands. The uppermost clayey silts contained random seams of pure silts and occasional sand and gravel particles. The laboratory undrained shear strength of this deposit varies between 1200 PSF and 3800 PSF and thus has a stiff to very stiff consistency. The average plastic limit of the stratum may be taken to be 18% and the liquid limit around 32%, with bulk densities of 127 PCF - 133 PCF. The underlying silty sand basically is a granular material; since, however, it contains some 10 - 12% of clay size particles, it shows slight plasticity. Standard penetration 'N' values of 100 blows for a few inches indicate very dense relative densities.

3. SUBSOIL CONDITIONS: (cont'd.) ...

3.3) The third area investigated near St. George St. was found to be underlain by silty clays and clayey silts down to some 65 ft. below ground level. The uppermost 12 ft. thick silty clay has very stiff consistencies and around 3200 PSF laboratory undrained shear strength. Below the depth of 12 ft. the material changes to clayey silts of stiff to very stiff consistency. Effective stress parameters of the strata were computed, based on stage loading tests. The average value of the effective angle of internal friction was taken to be $\phi' = 27^\circ$ with a cohesion intercept of approx. $C' = 200$ PSF.

3.4) Groundwater levels in the boreholes within the ravines were observed to coincide with the water levels of the Kettle Creek. No water was found in Borehole #4, down to the end of the boring. The ground elevation at this location was around 754.8 ft., some 30 - 100 ft. higher than the creek level.

4. DISCUSSION AND RECOMMENDATIONS:

The proposed Hwy. #126 extension (Brown, light blue and dark blue lines) at the City of St. Thomas will cross the ravines of Kettle Creek with 50 - 55 ft. high fills. Along the high grounds the proposal calls for cuts of up to 30 ft. depth.

Stability analyses of the proposed fills and cuts were carried out by an electronic computer using the circular arc failure criterion. Strength parameters of the subsoils were expressed in terms of total stresses for the analysis of the fills, and in terms of effective stresses for the cuts. The results of the calculations indicated that no stability problems will be encountered, by building fills up to a height of 60 ft. and cuts of 30 ft., provided that they are constructed with slopes of 2 horizontal to 1 vertical.

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

Some settlements will occur under the proposed high embankments. Within the ravine covered by Boreholes #1 and 2 - (Sta. 50+00 - 60+00), granular materials form the overburden, thus settlements will take place within a short period of time and will likely be completed during construction. At the ravine between Sta. 75+00 and 90+00 (Borehole #3) an approx. 18-ft. thick cohesive compressible layer was found to overlie the granular deposit. Settlements within this 18-ft. layer will spread over a longer period, lasting probably 3 - 4 years. Settlement computations, based on laboratory consolidation tests, will be necessary at the time of the final investigation, in order to evaluate the magnitude and the rate of settlement under various heights of fills.

5. MISCELLANEOUS:

The field work was carried out during the period November 26 - December 2, 1969, by using machinery owned and operated by Dominion Soil Investigation Ltd.

The field work was supervised, and this report written, by Mr. A. K. Barsvary, Senior Foundation Engineer.

Mr. K. G. Selby, Supervising Foundation Engineer, reviewed the report.

January 1970

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO		RECORD OF BOREHOLE No.1		FOUNDATION SECTION	
MATERIALS & TESTING OFFICE					
JOB	69-F-113	LOCATION	Sta 58 + 00 10' Lt. Dark Blue Line	ORIGINATED BY	AKB
W.P.	N11	BORING DATE	Nov. 27, 28, 1969	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Auger & Washboring	CHECKED BY	<i>AKB</i>

SOIL PROFILE		STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w _L PLASTIC LIMIT — w _P WATER CONTENT — w			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							○ UNCONFINED		+ FIELD VANE			● QUICK TRIAXIAL				
											20 40 60					
665.6	Ground Level															
0.0	Sand & sandy gravel		1	SS	16	660										
	Compact		2	SS	13											
653.6			3	SS	17											
12.0	Silty sand to silt, traces of gravel & clay.		4	SS	100/6"	650									5 50 40 5	
	Very Dense & hard		5	SS	100/7"										7 63 29 1	
	Grey		6	SS	100/2"	640										
629.2			7	SS	100/4"	630										
36.4	Hammer Bouncing End of Borehole		8	SS	100/0"											

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 69-F-113

LOCATION

Sta. 78 + 45 \varnothing Dark Blue Line

ORIGINATED BY AKB

W.P. N11

BORING DATE

November 26, 1969

COMPILED BY

AKB

DATUM

Geodetic

BOREHOLE TYPE

Auger

CHECKED BY

AKB

SOIL PROFILE		STRAT. PLT	SAMPLES		BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY Y P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			20	40	60	80	100	w_p	w			
670.4	Ground Level						2000	4000				20	40	60		
0.0	Clayey silt, seams of silt, traces of sand and gravel		1	SS	13							0			131	
			2	TW	PH							0			133	
	Very stiff to stiff		3	SS	13	660						0				
	Dark Grey		4	TW	PH							0			127	
652.4															130	
18.0	Silty sand with clay, traces of gravel		5	SS	50/2"	650						0				8 42 38 12
			6	SS	100/6"							0				
	Very Dense		7	SS	100/5"	640						0				14 41 34 11
	Dark Grey		8	SS	100/5"							0				
			9	SS	100/5"	630						0				6 44 40 10
			10	SS	100/6"							0				
622.4																
48.0	Medium Sand															
618.9	Dense Grey		11	SS	37	620						0				
51.5	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 69-F-113

LOCATION

Sta. 109 + 80 ∇ Dark Blue Line

ORIGINATED BY AKB

W.P. Nil

BORING DATE

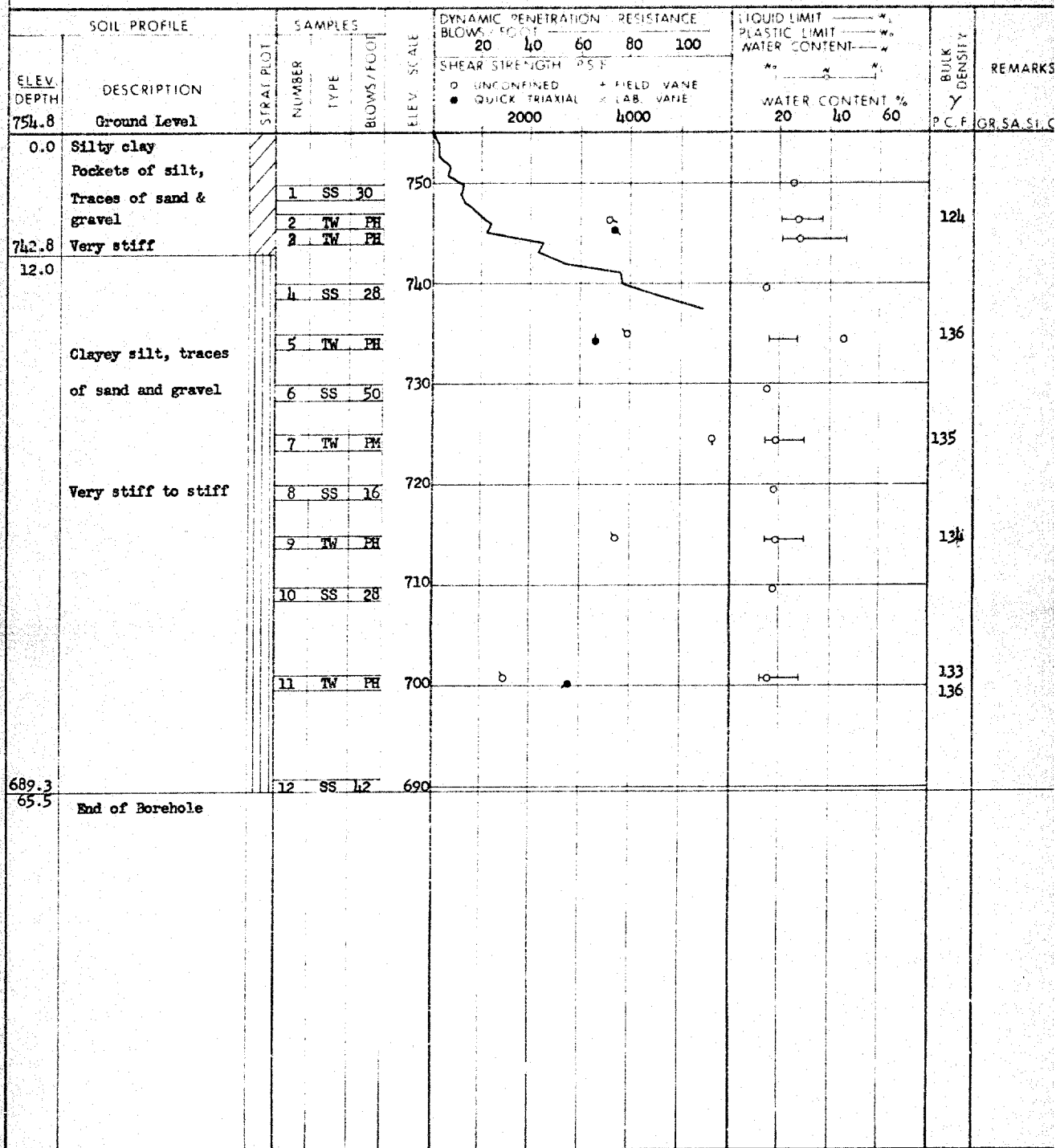
December 1 & 2, 1969

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE

Auger

CHECKED BY *AKB*

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

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

SOIL TESTS

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

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

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

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ 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

MEMORANDUM

To: Mr. A. McConnell,
Regional Functional Planning
Engineer,

LONDON Regional Office

ATTENTION: Mr. R. L. Hanton,
Project Manager

OUR FILE REF.

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

DATE: December 24, 1969

IN REPLY TO

SUBJECT: Re: Proposed St. Thomas Expressway -
W.O. 7192-68-101/102 -- W.J. 69-F-113

Following your request to Mr. J. Roy for a foundation investigation at the above mentioned site, and our subsequent meeting at the site, the necessary work has been completed by this Section and will be fully reported in about 3 weeks. Since we understand, however, that you have to complete your Functional Planning Report by the end of January, we are advising you of our results at this time in order not to hold you up.

Four borings were carried out at what were considered to be possible critical locations on proposed Hwy. #126 Extension - (Brown Line, Dark Blue Line, and Light Blue Line). Two of the borings were in the vicinity of Sta. 60+00 where fills up to 50 ft. in height may be required, and one boring was drilled in the vicinity of Sta. 80+00 where a fill of about 55 ft. may be required. One further boring was drilled in the vicinity of Sta. 110+00 where a cut of maximum depth about 30 ft. may be required. In all of the borings subsoil conditions were found to be such that no stability or other major construction problems are anticipated. We can therefore advise you that, for the purposes of your Functional Planning Report, it may be assumed that 2:1 slopes for both cuts and fills will be suitable for the entire Expressway and Hwy. #126 Extension, insofar as slope stability is concerned. No other major construction problems relating to foundations are foreseen by us.

KGS/MdeF

cc: Messrs. A. McConnell (2)
L. E. Walker
W. Zonnenberg
J. Roy

Foundations Files
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K. L. Selby
K. G. Selby,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

#69-F-113

W.O. 7192-68-101/102

H.W.Y. #26, EXTENSION

ST. THOMAS

EXPRESSWAY.

