

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. J. McAllister, (2)
Reg. Structural Planning Supvr.,
Northern Region, North Bay.

FROM: Soil Mechanics Section,
Geotechnical Office,
West Bldg., Downsview.

ATTENTION:

DATE: January 15th, 1975.

OUR FILE REF.

IN REPLY TO

JAN 22 1975

SUBJECT:

FOUNDATION INVESTIGATION REPORT
Wolseley Bay Bridge, Hwy. #528,
District #13, North Bay,
Twp. of Scollard, Dist. of Sudbury,
W.O. ~~74-50120~~, Site 46-285.
80-16-08

41 I-87

GEOCRES No.

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

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

M. Devata

M. Devata,
Supervising Engineer.

MD/ma
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FOUNDATION INVESTIGATION REPORT
For
Wolseley Bay Bridge, Hwy. #528,
District #13, North Bay,
Twp. of Scollard, Dist. of Sudbury,
W.O. 74-50128, Site 46-285.

1. INTRODUCTION.

A request to carry out a foundation investigation at the above site was received from Mr. J.C. McAllister, Regional Structural Planning Supervisor, North Bay in a memo dated August 27th, 1974. Subsequently, a field investigation was carried out during the period December 12-13, 1974, under the supervision of Mr. T. Frost, Field Technician.

A total of three sampled boreholes were put down using a Hollow Stem Auger Machine (CME 750). Borehole #1 was advanced from the deck of the Bailey Bridge and was accompanied by a cone test. Borehole #3 was augered and sampled to a depth of 29 ft., and from that depth downwards a cone penetration test was carried out. Borehole #2 was a sampled borehole only.

This report contains a description of the site, subsoil conditions and our recommendations for the proposed crossing.

2. SITE DESCRIPTION:

The site is located where the Wolseley River flows into Wolseley Bay. The surrounding terrain is hilly and well-treed. Bedrock outcrops are found approximately three-hundred feet from the bridge site in the southeast, south and west directions. Frequent boulders, some up to three feet in size are found along the

river edge and scattered about the area. The river flow is moderate.

The existing bridge is a bailey bridge with a wooden deck, founded on abutments placed in the fill projecting into the river and surrounded by grouted rip-rap. A corrugated steel culvert is located behind each abutment. The old timber structure was destroyed when a truck went through it.

3. SUBSOIL CONDITIONS:

3.1) General.

The subsoil consists of granular fill, followed by a deposit of silty sand which is underlain by medium to coarse sand. Refusal to penetration was met at about 50 ft. depth. The boundaries between various soil strata and the results of our field and laboratory tests are shown on the Record of Borehole Sheets appended to the Report. The location of boreholes and a stratigraphical profile is shown on Drawing 74-50128-A which also is attached to the Report.

3.2) Fill.

The fill material essentially consists of sand, with some gravel and is 5-6 ft. in thickness. In Borehole #2 numerous boulders were encountered to a depth of 10 ft. below ground level. Occasional fragments of wood were also found in this borehole. In Borehole #3 only occasional boulders were encountered. However, this does not preclude the possibility of more frequent boulders. The relative density of the fill material, in general is compact.

3.3) Silty Sand to Fine Sand.

Underlying the fill material the subsoil deposit consists of silty sand to fine sand with varying amounts (traces of some) of gravel. The thickness of this deposit varies from 11 to 23 ft. Standard Penetration Tests indicate a loose to compact relative density. This material is susceptible to 'boiling' under an unbalanced hydrostatic head. Two grain-size analyses were carried out, and showed the following distribution (Fig. 1).

Gravel	0 - 1 %
Sand	52 - 90 %
Silt and Clay	10 - 47%

A 2.5 ft. thick layer of clayey silt to silty clay was intersected in Borehole #2 from a depth of 8.0 to 10.5 ft. Borehole #3 was terminated in this deposit.

3.4) Medium to Coarse Sand.

The silty sand to fine sand deposit was followed by a stratum of medium to coarse sand with traces of gravel. The material in general, became coarser with depth. The relative density ranged from compact in the upper portion increasing with depth to very dense in the lower portion of the stratum. In Borehole #2 numerous cobbles were encountered in the last 6 ft. of drilling. One grain-size analysis was carried out and showed the following distribution (Fig. 1).

Gravel	7 %
Sand	88 %
Silt & Clay	5 %

Refusal to augering and driving the cone was reached between elevations 53.8 and 57.5 ft., i.e. 48.5 to 50.7 ft. below the present road level. It is believed that either bedrock or boulders occur at this elevation.

The groundwater level at the time of investigation was approximately the same as the river water level which was 98.9 ft. (temporary elevation).

4. DISCUSSION AND RECOMMENDATIONS:

4.1) Pipe Arch Culvert.

The culvert should be designed and placed according to M.T.C. Specification. A minimum of 2-ft. thick suitable granular bedding, should be placed beneath the culvert. The bottom of the bedding should extend below the maximum frost penetration depth. Pipe arches exert greater pressures against the soil at the corner plates than elsewhere around the conduit. Excessive pressures at the corners require material of better bearing capacity which should extend far enough to transfer distributed pressures to the abutting embankment at acceptable bearing pressures.

Backfill for the pipe should also consist of acceptable granular material and should extend to a minimum height of 2 ft. above the pipe. Above this level native backfill may be used. To prevent piping through the bedding and backfill, 3 ft. thick clay seal should be provided at the upstream end of the culvert and a suitable filterblanket 3 ft. thick placed at the downstream end.

A dewatering scheme will be required to excavate below the groundlevel and place the bedding in the dry. The soil at the level of the proposed bedding is susceptible to 'boiling' under an unbalanced hydrostatic head. It will be necessary to drive

interlocking sheet piles or use a well-points system in order to achieve satisfactory dewatering. This would be a costly operation.

4.2) Timber Pile Bent Structure.

Alternatively, a timber pile bent structure may be constructed. Treated timber piles should be used at this site. For 45 ft. long No. 14 piles driven to approximate elevation 65, an allowable load of 20 tons per pile may be used for design purposes. For 55 ft. long No. 14 piles driven to refusal (at approximate elevation 55) an allowable load of 25 tons per pile may be used for design purposes. Due to the presence of boulders in the fill it will be necessary to remove all boulders and stones greater than 6" in size from the area where piles are to be driven. As an alternative, pre-augering technique will be necessary to advance piles through the existing fill containing boulders.

No dewatering scheme will be required in the case of a timber pile bent structure. Therefore, it is believed that this type of structure will be more economical than a pipe arch culvert. From the foundations point of view, a structure at this site would be more preferable than a culvert.

A. Prakash, P. Eng.,
Senior Engineer.



AP/ma

January, 1975.

APPENDIX I

RECORD OF BOREHOLE No 1

ORIGINATED BY TF

COMPILED BY TF

CHECKED BY _____

15 $\frac{20}{10}$ 5 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 2

W.P. W. O. 74-50128 LOCATION Sta. 12 + 26 5.3' RT ORIGINATED BY TF
 DIST. 13 HWY. 528 BORING DATE December 12th, 1974 COMPILED BY TF
 DATUM Temporary BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100					W_P W W_L				
							SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT %				
106.0±	Ground Level															
0.0	Fill		1	SS	11	100									Numerous boulders from 0-10f	
100.0			2	SS	15											
6.0			3	SS	5	90										
89.0			4	SS	17											
17.0			5	SS	60	80										
			6	SS	50/4	70										
			7	SS	20/0	60										
57.5																
48.5'	End of borehole Refusal Probable bedrock or boulders															
NOTE: Made four attempts before being able to penetrate the first 10 ft.																

NOTE: Made four attempts before being able to penetrate the first 10 ft.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

W.P. W. O. 74-50128 LOCATION Sta. 11 + 12 1' LT ORIGINATED BY TF
DIST. 13 HWY. 528 BORING DATE December 13th, 1974 COMPILED BY TF
DATUM Temporary BOREHOLE TYPE Hollow Stem Auger and Cone Test CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				
104.5	Ground Level															
99.0	Fill Sand, some gravel occasional boulder Compact	X	1	SS	18	100										
5.5	Silty Sand to Fine Sand Some Gravel	X	2	SS	24											
		X	3	SS	7											
		X	4	SS	4											
75.5	loose to compact															
29.0	End of Borehole															
	Probable med. to coarse sand some gravel															
	Dense to very dense															
53.8																
50.7	End of cone test Refusal Probable bedrock or boulders															

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

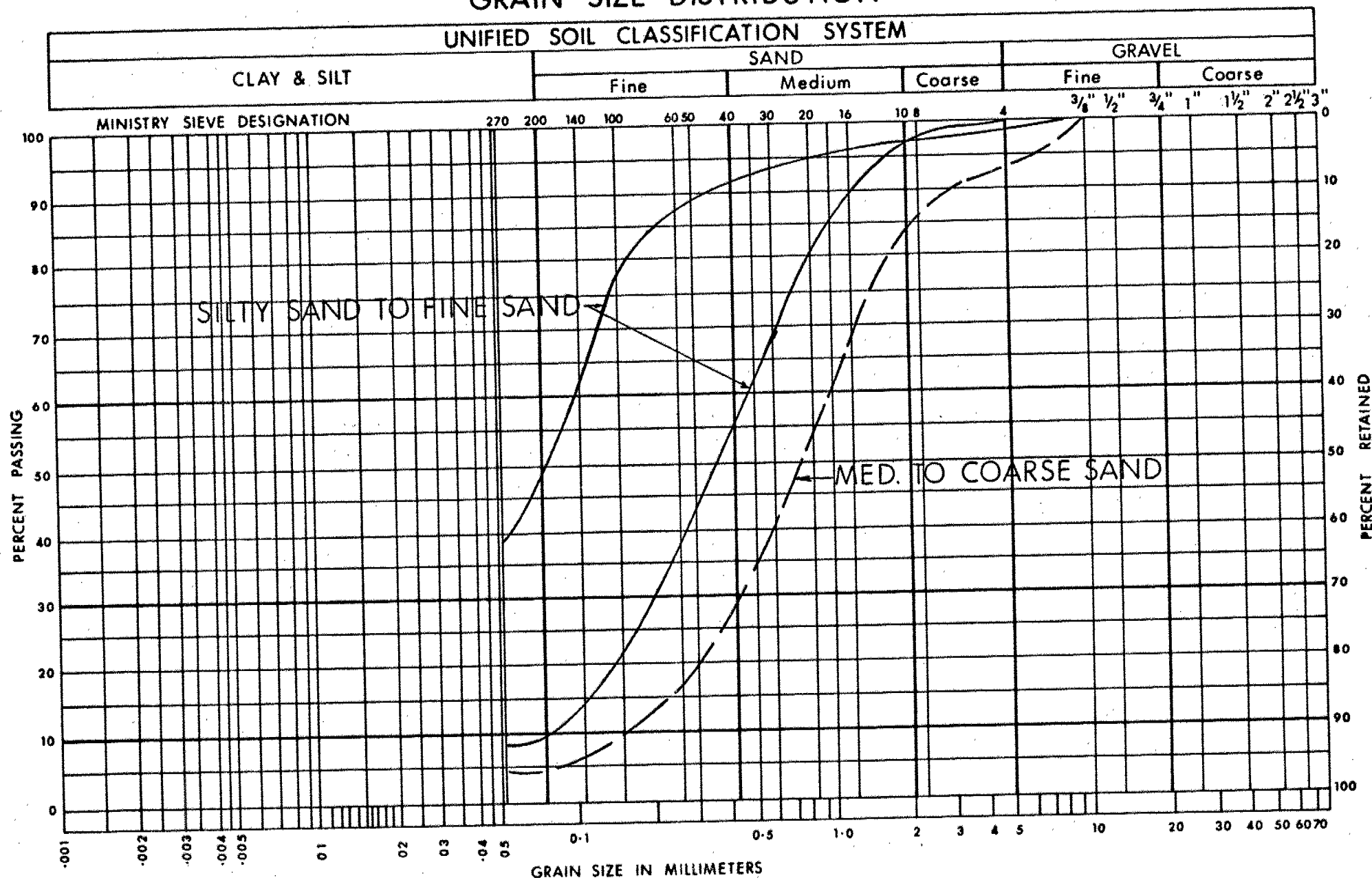


FIG. 1

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTPENETRATION RESISTANCE

'N'-STANDARD PENETRATION RESISTANCE : - 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>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" " ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTSOIL 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
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

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

OVERSIZE DRAWING