1.1 Geotechnical Investigation Report

.1 A copy of the detailed Geotechnical Investigation Report dated March 27, 2015, prepared by Ground Engineering Consultants Lts is attached.

.2 The Report, by its nature, may not reveal all conditions that exist or can occur on the proposed site. Should sub-surface conditions be found to vary substantially from those indicated in the Geotechnical Investigation Report, further geotechnical investigation will be required if soil condition not reflected in Geotechnical Report, changes in the design and construction of foundations will be made accordingly, with resulting credits or expenditures accruing to the Owner.

.3 Contractor to engage Ground Engineering Consultants Ltd to be on site to inspect piling installation and to confirm if soil conditions consistent with Geotechnical Report. If conditions vary inform the Departmental Representative.

END OF SECTION

TITLE: GEOTECHNICAL INVESTIGATION
PROPOSED AG CANADA MAINTENANCE
BUILDING ADDITION
SW 19-18-12 W2M
INDIAN HEAD, SASKATCHEWAN

CLIENT: CARCOANA ARCHITECTURE LTD.

FILE NO: GE-1518 DATE: MARCH 27, 2015

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GROUND ENGINEERING CONSULTANTS LTD.

CIVIL & GEOENVIRONMENTAL ENGINEERS

415 - 7th AVENUE • REGINA • SASKATCHEWAN • CANADA • S4N 4P1
TELEPHONE: (306) 569-9075 FAX: (306) 565-3677 EMAIL: groundeng@myaccess.ca

FILE: GE-1518 March 27, 2015

Carcoana Architecture Ltd.
1457 Albert Street
REGINA, Saskatchewan
S4R 2R8

ATTENTION: MR. LARRY CARCOANA, SAA, AAA, MAA, AIA, NCARB

Dear Sir:

SUBJECT: GEOTECHNICAL INVESTIGATION
PROPOSED AG CANADA MAINTENANCE BUILDING ADDITION
SW 19-18-12 W2M
INDIAN HEAD, SASKATCHEWAN

1.0 INTRODUCTION

This report presents the results of a site specific subsurface soils investigation and geotechnical analysis carried out at the above captioned site located in the Town of Indian Head, Saskatchewan. It is understood that the project includes construction of an addition to the north side of the existing maintenance building which covers an area of 50 x 65 square feet, approximately.

The objectives of this investigation were to provide the following information:

.1 To define the subsurface soil stratigraphy and engineering properties of the foundation soils including the groundwater regime at the site;

.2 To provide design recommendations for the most suitable and economical foundation system to support the proposed building addition;

.3 To provide recommendations with respect to the type of cement to use for concrete in contact with native soils;

.4 To comment on possible excavation and construction problems related to foundation construction with particular reference to groundwater conditions;

.5 To provide recommendations for floor slab design and construction;

.6 To provide recommendations on pertinent geotechnical issues identified during the subsurface investigation.

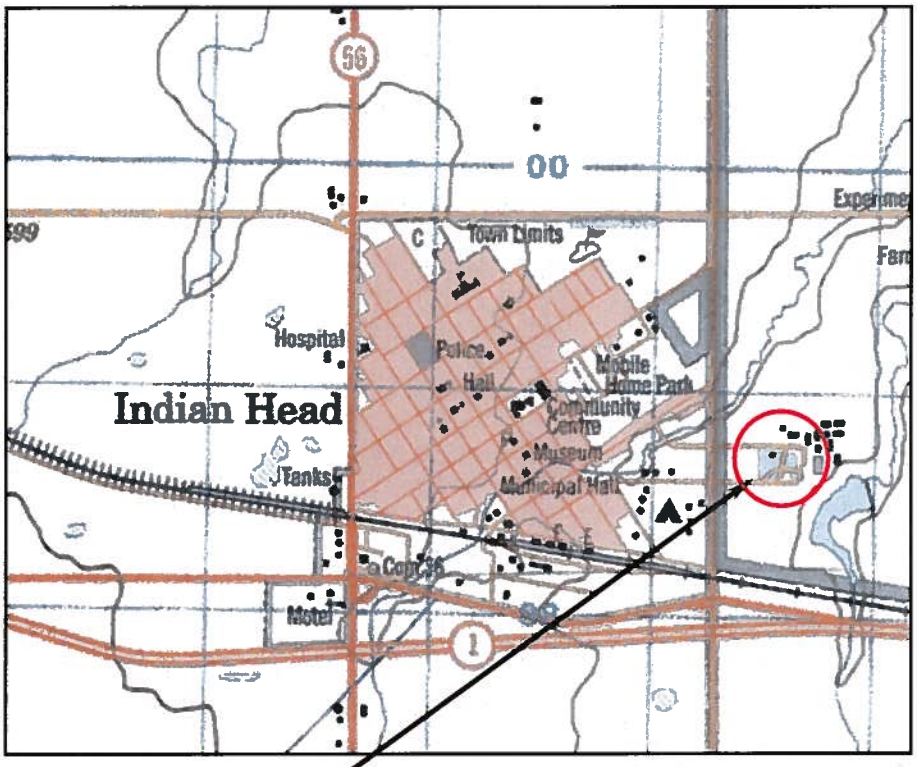
Authorization to proceed with this work was received in your e-mail dated February 27, 2015.

2.0 DESCRIPTION OF THE SITE

The study area shown in Figure 1 is located at the east side of the Town of Indian Head, Saskatchewan. The legal description of the property is SW 19-18-12 W2M. Fill has been placed in the past to achieve the existing grade elevations. The site topography is now relatively flat. Ground surface elevations vary up to 0.11 metres between the test hole locations.

3.0 FIELD AND LABORATORY INVESTIGATION

The subsurface conditions were investigated by drilling two (2) test borings at the locations shown on Drawing No. GE-1518-1. The test holes were drilled on March 12, 2015 using a truck-mounted, Brat 22 digger equipped with a 150 mm diameter continuous flight auger to depths of 10.7 and 12.2 metres below existing grade.



STUDY AREA

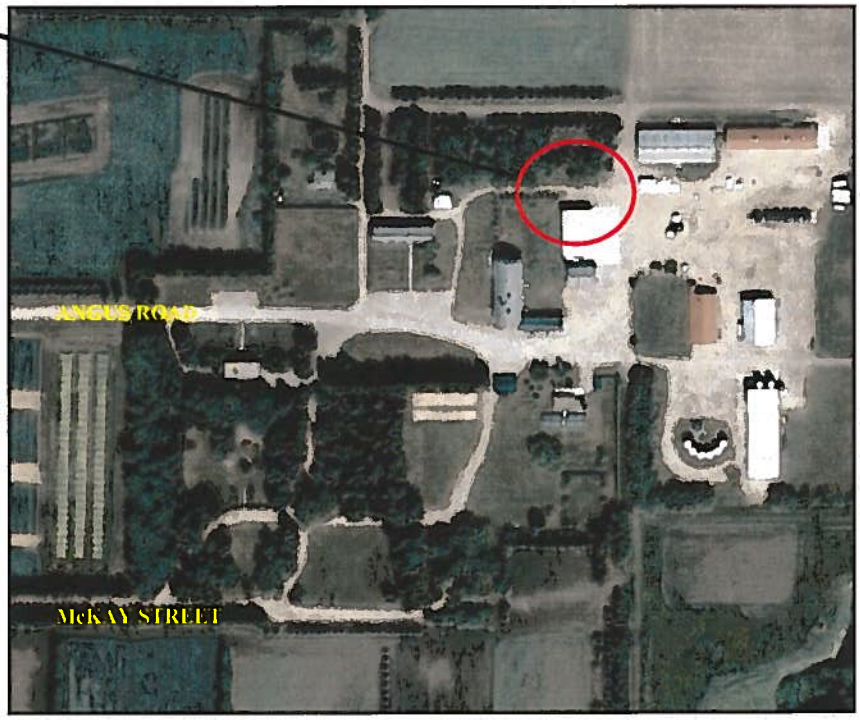


FIGURE 1

LOCATION OF STUDY AREA

Representative disturbed auger samples and undisturbed Shelby tube soil samples were recovered from the test borings and taken to our laboratory for analysis. Each soil sample was visually examined to determine its textural classification and a natural moisture content test was performed on each sample. An estimate of the undrained shear strength of the undisturbed soil was made using both a pocket penetrometer and a laboratory vane shear apparatus. In addition, Atterberg limits, unconfined compressive strength, dry density and sulphate content tests were completed on selected representative soil samples. Details of the soil profile, samples taken, laboratory test results and stratigraphic interpretations of the subsoils are appended to this report on Drawing Nos. GE-1518-5 to -7, inclusive.

The ground surface elevations at the test hole locations were established by representatives of Ground Engineering Consultants Ltd. and are referenced to an assumed datum of 100.00 metres described as the top of the existing floor slab at the north Maintenance Building bay entrance.

4.0 GEOTECHNICAL ANALYSIS

4.1 Stratigraphy

The drilling information indicates that the site is overlain by fill materials which extend to depths of 0.3 to 0.9 metres below existing grade. The surficial fill consists of highly plastic, silty clay with variable quantities of sand, gravel and building rubble (concrete).

The surficial fill is underlain by a stratified drift unit. The drift unit is comprised of clayey till, highly plastic clay and fine grained sand layers which extend to depths of 6.9 to 7.3 metres.

The stratified drift unit is underlain by a glacial till stratigraphic unit which extends to the maximum depth penetrated in the test borings (12.2 metres). The till is a heterogeneous mixture of clay, silt, sand and gravel with numerous wet sand and gravel lenses and occasional cobblestones and boulders.

4.2 Groundwater

The drilling information indicates there is a shallow water table at this site. The soils encountered at this site are generally clayey and cohesive. However, the wet sand lenses are cohesionless and subject to sloughing. Test Holes 101 was left open for 1.5 hours, after which, the water level was measured at a depth of 4.9 metres below grade. The water level in Test Hole 102 was measured at a depth of 6.7 metres, immediately after completion of drilling. Piezometers were not installed to monitor the long term groundwater levels.

5.0 DISCUSSION

5.1 Fill Materials

It is not known exactly when the fill materials were placed on the subject property or if the fill was compacted during placement. The fill appears to be well consolidated. Atterberg Limit test results indicate that the clay fill is highly plastic with an average Liquid Limit of 77 percent and an average Plasticity Index of 51 percent.

5.2 Stratified Drift Unit

The stratified clayey till and highly plastic clay layers are stiff in consistency with undrained shear strengths in the order of 60 to 100 kPa.

5.3 Till Stratigraphic Unit

The till stratigraphic unit encountered at this site is oxidized and hard. The term till on the borehole logs indicates that the material originates from geological processes associated with glaciation. These processes produce a material that is heterogeneous in composition and as such, the till may contain pockets and/or seams of material such as sand, gravel, silt or clay. Wet sand lenses were encountered a varying depths as noted on the test hole logs. Till often contains cobbles (75 to 200 mm) or boulders (over 200 mm), therefore, contractors may encounter them during excavation even if they are not evident in the test borings. In Test Hole 102, a cobblestone was encountered at a depth of 10.9 metres. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample

descriptions may be applicable to a very limited area; caution is therefore essential when dealing with sensitive excavations in till material.

6.0 FOUNDATION CONSIDERATIONS

It is understood that the proposed building addition is a basementless, single storey structure. Since the building is basementless, a bored concrete pile and grade beam type of foundation system is recommended. Our detailed design recommendations for bored concrete piles are presented below:

6.1 Bored Concrete Piles

.1 The piles may be constructed as straight shaft piles designed to develop load carrying capacity on the basis of side friction only. Friction piles should be designed using the ultimate skin friction values and applicable geotechnical resistance factors for Limits State Design provided in Table 1, below.

TABLE 1

RECOMMENDED LSD CRITERIA FOR FRICTION TYPE BORED CONCRETE PILES

ASSUMED ELEVATION* metres	SOIL TYPE	Ultimate Skin Friction (kPa)	GEOTECHNICAL RESISTANCE FACTOR (compression)	GEOTECHNICAL RESISTANCE FACTOR (tension)
Above 97.8	Fill / Drift	0	0.4	0.3
97.8 to 93.2	Drift	80		

* Ground Surface Elevation is 99.8 to 99.9 metres, Assumed, approximately.

.2 The upper 2.0 metres of pile length or maximum depth of fill, whichever is greater, should be discounted insofar as side friction carrying capacity is concerned. It is recommended that the minimum pile shaft diameter be 400 mm and the minimum pile length be 6.0 metres to ensure that an adequate pile cross-section is maintained for the full drilled depth. Bored concrete piles should be designed so that they do not extend below Elevation 93.2 metres, assumed (approximately 22 feet below existing grade) to avoid problems with groundwater seepage and sloughing.

.3 On the basis of the drilling information at this site, temporary steel casings may be required in order to maintain an open hole during excavation for constructing bored

concrete piles at this site. It is recommended that the steel reinforcement and concrete be placed immediately following completion of the pile excavations in order to minimize the potential for sloughing and/or ingress of groundwater into the pile excavations.

.4 Pile shafts carrying little or no bending moment should be reinforced with nominal vertical reinforcement in the form of intermediate grade deformed bars, composing about one-half (1/2) of one (1) percent of the cross-sectional area. The steel reinforcing cage should be projected or dowels set into the top of the caisson to tie into the foundation walls and/or columns.

.5 Concrete used for constructing piles may be placed using the free fall method and the slump should be specified as being not less than 100 mm. This will insure that voids do not exist in the finished pile foundation units. The concrete should remain fluid in the hole until the shaft is completely full in order to take advantage of the fluid pressure in the column of concrete which will develop high pressure against the soil and maximize the shaft's capacity.

.6 A minimum of 75 mm of rigid insulation should be placed on the inside of all perimeter grade beams to reduce the heat losses and to prevent drying of the soils.

7.0 EXCAVATION CONSIDERATIONS

Building excavations at this site will be in the fill material and drift unit. Conventional excavation procedures should therefore be applicable to the soils at this site. Contractors should be aware that concrete debris, cobblestones and boulders may be encountered in the fill material and till unit. Occupational Health and Safety Regulations require that any trench or excavation in which people must be cut back at least one (1) horizontal to one (1) vertical or a temporary shoring system must be used to support the sides of the excavation.

8.0 FLOOR SLAB CONSIDERATIONS

With the presence of fill areas and highly plastic subgrade soils, there is a potential for differential movement of grade supported floor slabs at this site. A structural floor system would be the more desirable alternative insofar as overcoming the potential problems

associated fill areas. Alternatively, if differential movement can be tolerated, the slab may be constructed as a grade supported slab on a prepared subgrade and granular base.

8.1 Structurally Supported Floor Systems

A structural floor system would be the most positive way to ensure satisfactory long term performance of the floor. We recommend the following items of work for construction of the structural slab.

.1 A minimum 150 mm cardboard void form should be placed beneath the floor slab.

.2 The void form should be covered with a minimum 6 mil polyethylene vapour barrier to deter moisture migration through the floor.

.3 Backfill against the perimeter grade beams should be placed in thin lifts (200 mm) and compacted to a minimum of 95% Standard Proctor density to minimize infiltration of surface water into the void space beneath the floor.

8.2 Grade Supported Floor Slabs

In most commercial buildings, a grade supported floor slab is placed because of the relatively high cost of a structural floor slab. In opting for a grade supported slab, the Owner must accept the risk. At this site, the risk is present because of the fill areas and potentially active clay subgrade. The following recommendations are given in an attempt to reduce differential movement of the grade supported floor slabs:

.1 The subgrade under a grade supported slab should be as uniform as possible. The subgrade should be proof-rolled with a heavy sheepsfoot or vibratory padfoot roller. Any soft or spongy areas should be excavated and filled with compacted granular material. A well graded pit run sand (Type 8) compacted to 95% Standard Proctor density is suitable for this purpose. Excessive compaction of the clay subgrade is not recommended because this will increase the swell potential of the clay. The clay subgrade should be at or preferably 1% to 2% above its optimum moisture content. In order to achieve this moisture content, moisture conditioning may be required. The total granular fill thickness under the floor slab should be a minimum of 600 mm. A well graded pit run sand (Type 8) compacted to 98% Standard Proctor

density may be used to fill within 150 mm below underside of the slab. The final 150 mm below underside of the floor slab should be a well graded granular base course (Type 33) compacted to a minimum of 100% Standard Proctor Density. Specifications for granular fill materials are included in Appendix B.

.2 The concrete slab in areas where only light floor loads are to be supported, may have a minimum thickness of 100 mm. The minimum 28 day concrete compressive strength should be specified as 25 MPa.

.3 It is recommended that the grade supported concrete slabs be designed as floating slabs, completely independent of the foundation walls and/or columns. Isolation joints should be provided at columns and walls to separate the grade supported floor slabs from any connection with the building or appurtenances. It is assumed that the floor slab will possess sufficient rigidity to distribute the loading across the floor slab. The floor slab must be stiff enough to distribute the contact stresses and yet strong enough to resist resulting moments. A generous amount of reinforcing running both ways on the top and bottom of the slab is desirable. Control joints (sawn or premolded) are recommended at a maximum spacing of about 4.5 metres.

.4 A layer of robust polyethylene sheeting should be placed between the granular base and the concrete slab to deter the migration of moisture through the floor.

9.0 OTHER

.1 Adequate drainage away from the building addition should be provided and maintained to minimize infiltration of water into the subgrade. The building site should be set at as high an elevation as possible in relation to the surrounding area.

.2 Test results on selected samples indicate that the soluble sulphate contents in the soil range from 0.06 to 1.11 percent by dry soil weight. Exposure Class S-2 is considered appropriate for design of concrete in contact with the native soil, as specified in CSA Standard CAN3-A23.1-09. Minimum requirements for Exposure Class S-2 are as follows:

.1 Cement Type: HS or HSb
.2 Maximum water to cementing materials ratio: 0.45
.3 Air Content: as per CSA CAN-A23.1-09 Tables 2 and 4
.4 Minimum specified Compressive Strength: 32 MPa at 56 days

.3 In the event that changes are made in the design, location or nature of the project, the conclusions and recommendations included in this report would not be deemed valid unless the changes in the project were reviewed by our firm. Modification to this report would then be made if necessary. Furthermore, it is recommended that this firm be allowed an opportunity for a general review of the final design plans and specifications in order to ensure that the recommendations made in this report are properly interpreted and implemented. If this firm is not allowed the opportunity for this review, we assume no responsibility for the misinterpretation of any of the recommendations.

.4 It is recommended that Ground Engineering Consultants Ltd. be retained to provide inspection services during construction of the foundation system for this project. This is to observe compliance with the design concepts, specifications or recommendations and to allow design changes in the event that the subsurface conditions differ from what was anticipated.

.5 This report has been prepared for Carcoana Architecture Ltd. and is intended for the specific application to the design and construction of the Proposed AG Canada Maintenance Building addition to be constructed at SW 19-18-12 W2M in the Town of Indian Head, Saskatchewan. The analysis and recommendations are based in part on the data obtained from the test hole logs. The boundaries between soil strata have been established at bore hole locations. Between the bore holes, the boundaries are assumed from geological evidence and may be subject to considerable error. Contractors bidding on the project works are particularly advised against reviewing the report without realizing the limitations of the subsurface information. It is recommended that Contractors should make such tests, inspections and other on-site investigations as is considered necessary to satisfy themselves as to the nature of the conditions to be encountered.

.6 It is recommended that the geotechnical workscope include the following services in addition to subsurface exploration and development of foundation design recommendations. These two services are:

i) geotechnical review of other design professionals' plans relative to their interpretation of geotechnical findings and recommendations, and;

ii) construction monitoring to observe construction activities in light of plans and specifications, and to help assure that unforeseen conditions are detected quickly to permit prompt corrective action and thus prevent minor problems from growing to major proportion.

.7 The soil samples from this site will be retained in our laboratory for 90 days following the date of this report. Should no instructions be received to the contrary, these samples will then be discarded.

10.0 CLOSURE

We trust that this report is satisfactory for your purposes. If you have any questions or require additional information, please contact this office.

Yours very truly
Ground Engineering Consultants Ltd.

Association of Professional Engineers & Geoscientists of Saskatchewan
CERTIFICATE OF AUTHORIZATION
Ground Engineering Consultants Ltd.
Number C0008
Permission to Consult held by:
Discipline Sk. Reg. No Signature
GEOTECHNICAL 6307

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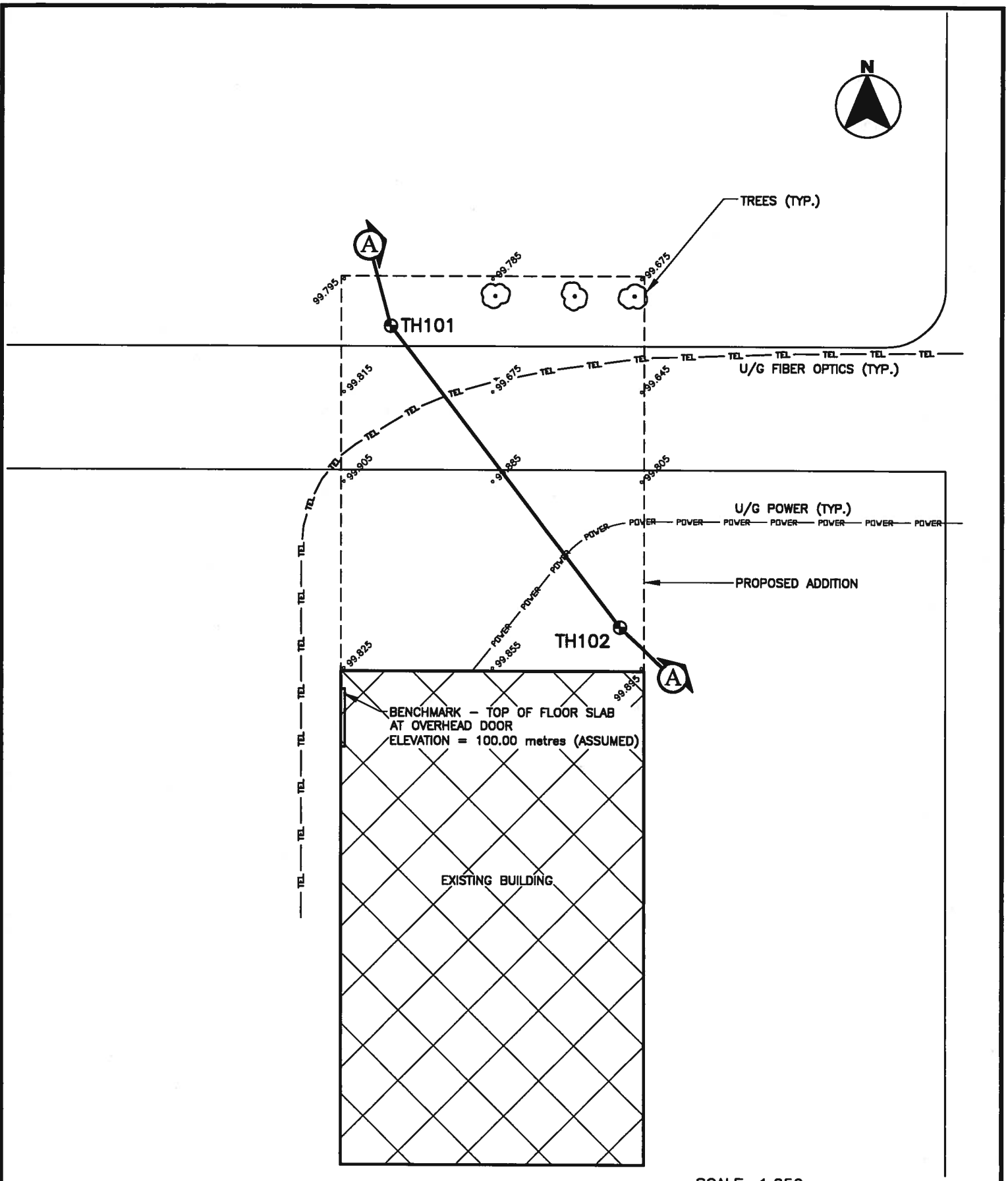
DRAWINGS



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GROUND ENGINEERING CONSULTANTS LTD.

CIVIL & GEOENVIRONMENTAL ENGINEERS
415–7th AVENUE
REGINA, SASKATCHEWAN, CANADA

SITE PLAN SHOWING LOCATION OF TEST HOLES
PROPOSED MAINTENANCE BUILDING ADDITION
SW 19–18–12–W2M
INDIAN HEAD, SASKATCHEWAN

CLIENT:	APPROVED:	DATE:	DWG. No.:
CARCOANA ARCHITECTURE LTD.	M. WURM	MARCH 27, 2015	GE–1518–1

ARCHIVE: 2015 FILES\2015 ENG.FILES\1518 GI CARCOANA ARCH INDIAN HEAD\DRAWINGS\1518 SITE PLAN.DWG

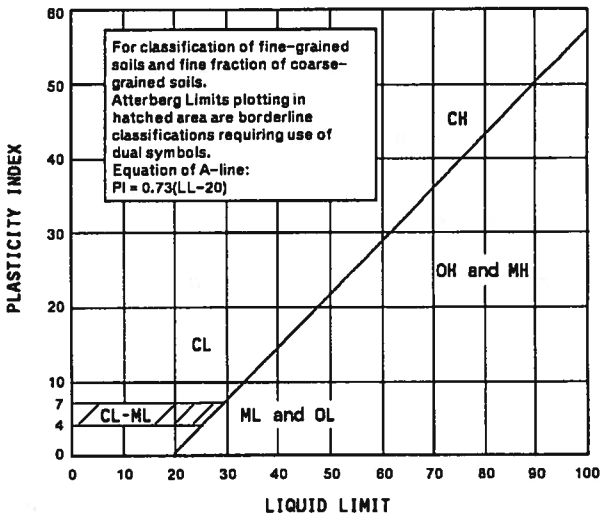
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 - 69 AND D 2488 - 69
(Unified Soil Classification System)

Major Divisions			Group Symbols	Typical Names	Classification Criteria
Coarse-grained soils More than 50% retained on No. 200 sieve *	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6: $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines	Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
Fine-grained soils 50% or more passes No. 200 sieve *	Silts and clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity	
	Highly organic soils		Pt	Peat, muck and other highly organic soils	

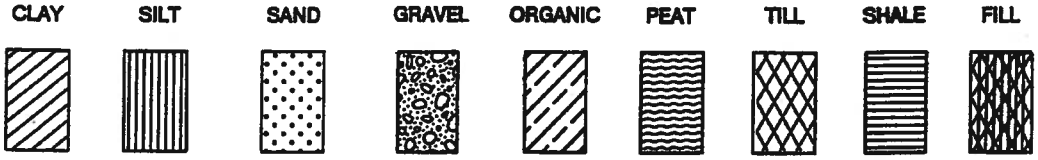
Classification on basis of percentage of fines
Less than 5% pass No. 200 sieve ..... GW, GP, SW, SP
More than 12% pass No. 200 sieve ..... GM, GC, SM, SC
5 to 12% pass No. 200 sieve ..... Borderline classifications requiring use of dual symbols

PLASTICITY CHART



*Based on the material passing the 75mm (3in) sieve.

SYMBOLS AND TERMS USED IN THE REPORT



The symbols may be combined to denote various soil combinations, the predominate soil being heavier.

RELATIVE PROPORTIONS

TERM	RANGE
Trace	0 – 5%
A Little	5 – 15%
Some	15 – 30%
With	30 – 50%

ASTM CLASSIFICATION BY PARTICLE SIZE

Boulder		> 300 mm
Cobble		300 mm – 75 mm
Gravel		75 mm – 4.75 mm
Sand		
	coarse	4.75 mm – 2 mm
	medium	2 mm – 425 um
	fine	425 um – 75 um
Silt		75 um – 5 um
Clay		< 5 um

DENSITY OF SANDS AND GRAVELS

DESCRIPTIVE TERM	RELATIVE DENSITY [1]	N VALUE STANDARD PENETRATION TEST [2]
Very loose	0 – 15%	0 – 4 Blows per 300mm
Loose	15 – 35%	4 – 10 Blows per 300mm
Medium Dense	35 – 65%	10 – 30 Blows per 300mm
Dense	65 – 85%	30 – 50 Blows per 300mm
Very Dense	85 – 100%	> 50 Blows per 300mm

CONSISTENCY OF CLAYS AND SILTS

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa) (CFEM, 2nd Edt., 1985)	N VALUE STANDARD PENETRATION TEST [2]	FIELD IDENTIFICATION (ASTM D 2488–84)
Very Soft	<12	< 2 Blows per 300mm	Thumb will penetrate soil more than 25 mm
Soft	12 – 25	2 – 4 Blows per 300mm	Thumb will penetrate soil about 25 mm
Firm	25 – 50	4 – 8 Blows per 300mm	Thumb will indent soil about 6 mm
Stiff	50 – 100	8 – 15 Blows per 300mm	Thumb will indent, but only with great effort (CFEM)
Very Stiff	100 – 200	15 – 30 Blows per 300mm	Readily indented by thumbnail (CFEM)
Hard	>200	> 30 Blows per 300mm	Thumb will not indent soil but readily indented with thumbnail

NOTES: 1. Relative Density determined by standard laboratory tests.
2. N Value – Blows/300mm of a 620N hammer falling 762mm on a 50mm O.D. Split Spoon.

SYMBOLS AND TERMS USED IN THE REPORT (continued)

GROUNDWATER

▼ Water level measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soil, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious waterbearing soil are present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.

▽ Water level determined by piezometer installation – In all soils the levels can be considered reliable groundwater levels.

DESCRIPTIVE SOIL TERMS

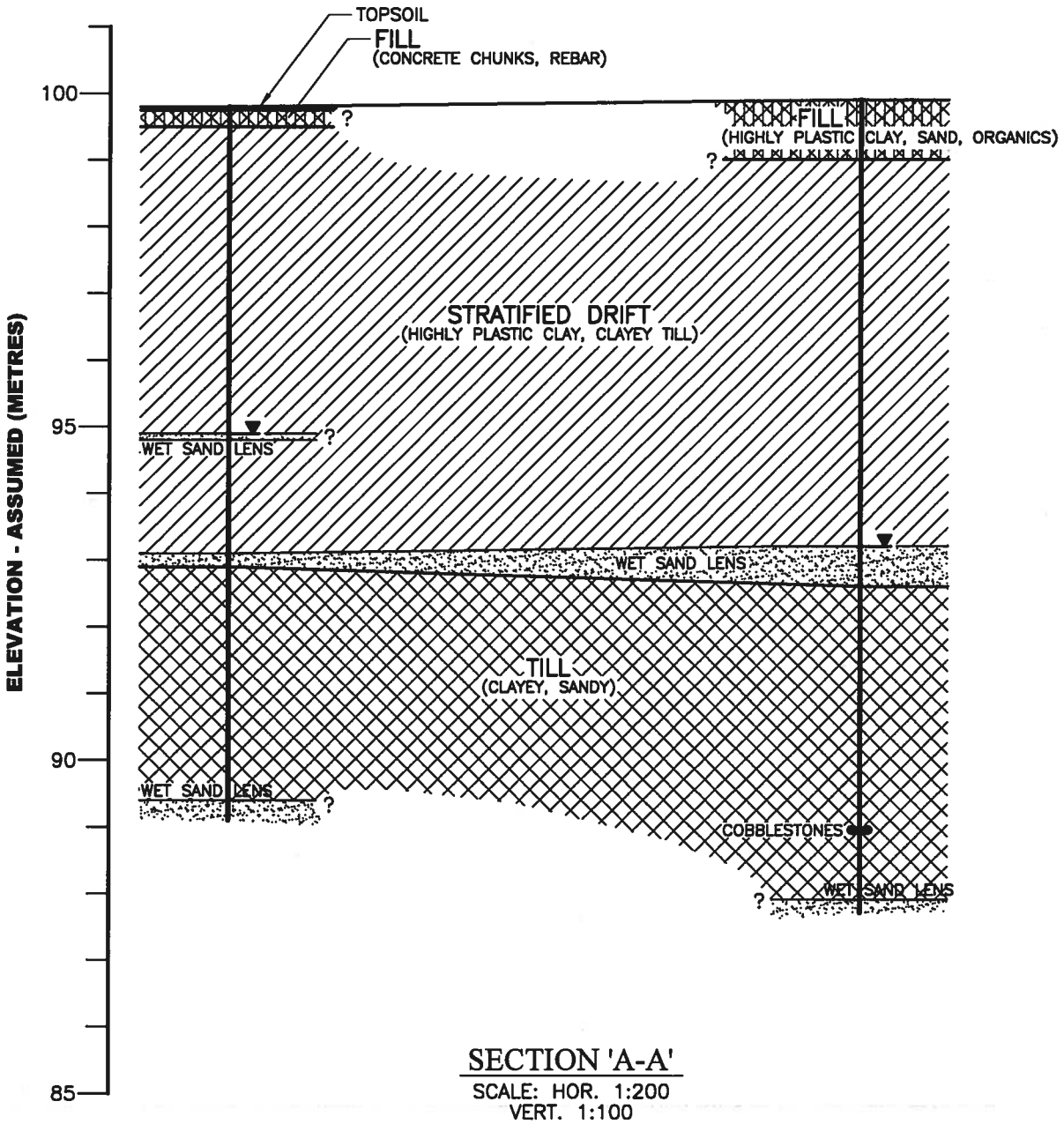
WELL GRADED	Having wide range of grain sizes and substantial amounts of all intermediate sizes.
POORLY GRADED	Predominantly of one grain size.
SLICKENSIDES	Refers to a clay that has planes that are slick and glossy in appearance; slickensides are caused by shear movements.
SENSITIVE	Exhibiting loss of strength on remolding.
FISSURED	Containing cracks, usually attributable to shrinkage. Fissured clays are sometimes described as having a nuggetty structure.
STRATIFIED	Containing layers of different soil types.
ORGANIC	Containing organic matter; may be decomposed or fibrous.
PEAT	A fibrous mass of organic matter in various stages of decomposition. Generally dark brown to black in color and of spongy consistency.
BEDROCK	Preglacial material.
DRIFT	Material deposited directly by glaciers or glacial melt-water.
ALLUVIAL	Soils that have been deposited from suspension from moving water.
LACUSTRINE	Soils that have been deposited from suspension in fresh water lakes.

DRILLING AND SAMPLING TERMS

SYMBOL	DEFINITION
C.S.	Continuous Sampling
Sy	75mm Thin Wall Tube Sample
Sy (2)	50mm Thin Wall Tube Sample
SPT (SS)	50mm O.D. Split Spoon Sample
BLOWS / 300mm	"N" Value – Standard Penetration Test
Bag	Disturbed Bag Sample
No.	Sample Identification Number
——►	Piezometer Tip
S.I.	Slope Indicator
SPG —►	Observed Seepage

LABORATORY TEST SYMBOLS

SYMBOL	DEFINITION
●	Moisture Content – Percent of Dry Weight
⊢—►	Plastic and Liquid Limit determined in accordance with ASTM D–423 and D–424
◆	Dry Density – t/m^3
■	Shear Strength – As determined by Unconfined Compression Test
▲	Shear Strength – As determined by Field Vane
▲	Shear Strength – As determined by Pocket Penetrometer Test
$\%SO_4$	Water Soluable Sulphates – Percent of Dry Weight
M.A.	Grain Size Analysis



SECTION 'A-A'

SCALE: HOR. 1:200
VERT. 1:100

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes, the boundaries are interpolated and may be subject to considerable error.

GROUND ENGINEERING CONSULTANTS LTD.
CIVIL & GEOENVIRONMENTAL ENGINEERS
415–7th AVENUE
REGINA, SASKATCHEWAN, CANADA

SITE PLAN SHOWING LOCATION OF TEST HOLES
PROPOSED MAINTENANCE BUILDING ADDITION
SW 19–18–12–W2M
INDIAN HEAD, SASKATCHEWAN

CLIENT:	APPROVED:	DATE:	DWG. No.:
CARCOANA ARCHITECTURE LTD.	M. WURM	MARCH 27, 2015	GE–1518–5

Project: Prop. Maintenance Building Addition	Location: SW 19-18-12-W2M	Test Hole No.:TH101
Project No.: GE-1518	Location: Indian Head, Saskatchewan	Drill Rig: Brat 22
Client: Carcoana Architecture Ltd.	Elevation: 99.80 m (Assumed)	Date Drilled: 12/03/2015

Sample Type: Shelby Tube | Disturbed | SPT Sample | Pail Sample | No Recovery | Jar Sample

Depth (m)	Sample Type	Sample No.	UCS	Soil Symbol	Soil Description	Elevation (m) (Assumed)
					0.00 m — 99.8 m TOPSOIL	
1.0		1			0.05 m — 99.7 m FILL - concrete debris	99.0
2.0		2	CL		0.30 m — 99.5 m STRATIFIED DRIFT - stratified layers of clayey till and highly plastic clay - fine grained sand layers at 4.9 to 5.1 and 6.7 to 6.9 metres - moist, stiff - dark grayish brown (2.5Y 4/2)	98.0
3.0		3				97.0
4.0		4				96.0
5.0						95.0
6.0		5				94.0
7.0		5A			6.90 m — 92.9 m TILL - clayey, sandy - moist, hard - oxidized, iron stains - sand lens at 10.4 metres - very dark grayish brown (2.5Y 3/2)	93.0
8.0		6				92.0
9.0		7				91.0
10.0		8				90.0
11.0					Test hole terminated at 10.7 m below grade.	89.0
12.0						88.0
13.0						87.0
14.0						86.0
15.0						85.0
16.0						84.0
17.0						83.0
18.0						82.0
19.0						81.0
						80.0

Dry Density (t/m3) 0.4 0.8 1.2 1.6
Sulphate Cont. (%) 0.2 0.4 0.6 0.8
Plastic M.C. Liquid 20 40 60 80
Blow Count 20 40 60 80
Vane Shear (kPa)
Pocket Pen (kPa)
Unconfined (kPa) 60 120 180 240

Notes:
1. Test hole was excavated on March 12, 2015 using a 150 mm dia. continuous flight auger.
2. Water level was measured at 6.1 metres immediately after completion of drilling. Test hole sloughed to 7.0 metres.
3. Water level was measured at 4.9 metres, 1.5 hours after completion of drilling. Test hole had sloughed to 6.7 metres.
4. Test hole was backfilled to surface with drill cuttings.

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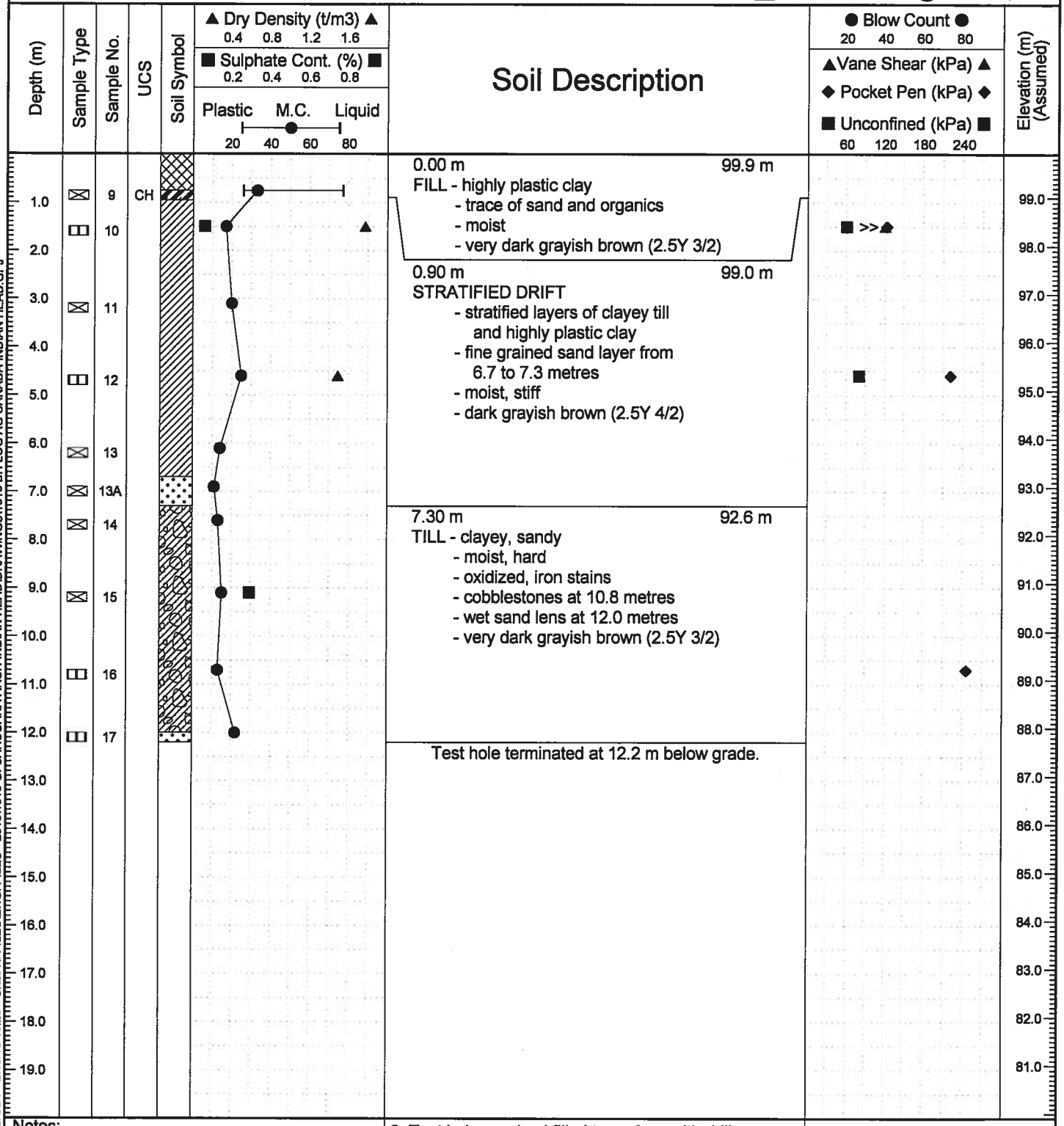
Logged By: R. Yaremko	Figure No.: GE-1518-6
Drawn By: M. Creary	Date Plotted: 27/03/2015
Reviewed By: M. Wurm	Page OF

Project: Prop. Maintenance Building Addition	Location: SW 19-18-12-W2M	Test Hole No.:TH102
Project No.: GE-1518	Location: Indian Head, Saskatchewan	Drill Rig: Brat 22
Client: Carcoana Architecture Ltd.	Elevation: 99.91 m (Assumed)	Date Drilled: 12/03/2015

Sample Type: Shelby Tube | Disturbed | SPT Sample | Pail Sample | No Recovery | Jar Sample



Notes:

1. Test hole was excavated on March 12, 2015 using a 150 mm dia. continuous flight auger.
2. Water level was measured at 6.7 metres immediately after completion of drilling. Test hole sloughed to 6.9 metres.
3. Test hole was backfilled to surface with drill cuttings immediately after completion of drilling.

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Logged By: R. Yaremko	Figure No.: GE-1518-7
Drawn By: M. Creary	Date Plotted: 27/03/2015
Reviewed By: M. Wurm	Page OF

APPENDIX A

Advantages of concrete filled steel pipe piles

The Steel Pipe Pile represents one of the finest means of providing piled foundations. The individual pipe can be selected in a number of wall thicknesses and diameters to tailor the capacity of the pile to each design load, to the supporting soil capacity and to the ease or difficulty of the driving conditions.

After completion of driving to the required bearing capacity and prior to filling with concrete, each pile can be checked visually for damage in driving, for plumb and for sweep or radius of curvature. In this respect, steel pipe piling is unique. It is subject to full visual observation.

Inspection can be accomplished in very long piles by lowering a safety light on a long drop cord into the steel shaft to inspect for any driving damage. An alternative is the use of a light and mirror to illuminate the interior for inspection. Such inspection methods are not possible with solid piles of steel, concrete, wood or any other structural material. From the time these solid units are driven below the ground surface, nothing is known for certainty of the plumb, curvature or possible damage due to driving or due to obstructions.

After completion of inspection, the steel pipe pile has an added flexibility in its column carrying capacity since the concrete strength can be varied to meet greater or less stringent load demands.

The concrete is placed under controlled conditions to attain the desired results. It is introduced into a thoroughly inspected form which is free of water or any other deleterious substance. This insures a structural integrity which is not possible with any other foundation except a controlled concrete pour in a reinforced pier or caisson.

Other advantages are: high loading capacities; low cost per ton of supported load; ease of driving due to stiffness of the pipe; ease of joining by welding; speed in driving long unspliced lengths, ability of steel to absorb hard driving, reuse of any sections above cut-off elevation, ready availability of pipe; great stability against buckling due to hard driving, high or unusual earth pressures or high loading.

Availability

Stelco Steel Piling Pipe is readily available in many wall thicknesses and diameters. Representative sizes are listed in Table II.

Driving

Steel pipe piling can be driven with or without a plate on the bottom end. Open end piling requires a more expensive cleanout procedure, but does eliminate ground heave in conditions where, in the designer's opinion, ground heave may present a problem.

The closed bottom-end pipe can be driven either with an internal mandrel or by top driving. When driving thin-walled pipe (1/8" to about 3/16" wall), the use of a mandrel ensures damage-free pipe. Mandrel driving requires the driving leads to be approximately double the pile length. Beyond a depth of about 40 feet this method is seldom economic.

Heavier walled pipe can be top driven. This method is particularly applicable when either long piles or hard driving is encountered. The required thickness of the wall is dependent upon the energy of the driving hammer, the ease of driving, the length of pile to be placed, and the imposed design loads.

For any given weight of steel, the pipe pile presents the stiffest shape possible. The radius of gyration of the pipe is the same in all directions. The pile drives straighter than other shapes and keeps drift, out of plumb and sweep to a minimum.

Placing concrete

The requirements of placing concrete in the bottom of a closed bottom-end pipe can be costly if too restrictive. By common practice, in pipes up to 18" in diameter, the pipe is considered to be the chute or spout acting to prevent segregation. If the designer wishes to increase protection against segregation in these smaller diameter pipes (and in any event for diameters of 20 inches or greater) it is recommended that about two feet of strong dry grout be first placed in the bottom of the pile. This grout is placed by free fall regardless of the pile length. The remainder of the pile is filled with a stiff concrete (1 1/2" to 2" slump).

Once again, this concrete is placed without the use of an "elephant trunk" or other special device. It should be noted that some of the larger aggregate in the concrete will penetrate the bottom grout layer to give a pile of uniform high strength.

Piles 12 3/4 x 0.281 wall filled in the above manner have been load tested to greater than 300 tons with no damage to the shaft, and 10 3/4 x 0.250 wall piles have been tested to over 400 tons before failure.

Field splices

Stelco steel piling pipe can be manufactured in any length up to 80'. If pile lengths longer than 80' are required, or if transportation problems dictate shorter pipe lengths than required, field welding is employed. Stelco piling pipe is supplied with bevelled ends to facilitate splicing.

In a bearing pile, it is not essential to have full penetration welds or expensive chill rings and back-up plates. The ends of two adjoining piles are placed in flush contact and then joined with a circumferential fillet weld. In this way, longitudinal compression due to driving and loading is transferred directly across the splice by the end of one pipe bearing on the other. Tensile forces and bending moments induced during driving are easily resisted by the fillet weld.

For any carrying capacity, the splicing of steel piling pipe requires less time and materials than that required for structural shapes. Also, unlike concrete or wood piles, there is little wastage with steel piling pipe since sections cut-off above elevation can be reused.

Load capacity

Soil

The ultimate load capacity of any pile regardless of its column capacity depends upon the surrounding soil in which it is placed. The 1965 National Building Code Section 4.2.2.16 (1), Properties of Soils and Capacities of Foundations is one specification which provides the designer with a number of means for determining the maximum design capacity of a pile. These are: load tests, local experience, or properties of the soil by an appropriate soils investigation.

It is imperative for the designer to remember that the structural column capacity of the pile must be tailored to equal the imposed load which in turn must not exceed the supporting capacity of the soil.

The supporting soil capacity of a friction pile may be taken as the frictional resistance between its surface and the ground with which it is in permanent contact.

Pipe column

The concrete filled steel pipe pile has a very wide range of capacities. The pipe is readily obtained in a number of diameters (5⁹⁄₁₆" to 36"), and wall thicknesses (⅛" to ⅝"). The cast-in-place concrete can be easily varied in strength (3^{KSI} to 5^{KSI} concrete is readily available from most pre-mix plants). The cost of the pile per ton of bearing capacity can be kept to a minimum by adjusting the pipe diameter, the pipe wall thickness, and the concrete strength to suit the driving conditions and bearing capacity of the soil. In this way, the least total cost of the piled foundation is obtained.

From past experience, most concrete filled steel pipe piles in Canada have been driven in the small diameters, i.e., 10¾ and 12¾", with wall thicknesses from 0.219 to 0.281 inches. 3^{KSI} concrete has been used in most cases, although there is presently a trend to higher strength concrete. The larger diameters and thicker walls have generally been used for special conditions.

Lateral support

The 1965 National Building Code presently permits any pile driven into soils other than peat or soft clay to be designed as a short column. Research reported in "Norwegian Experiences with Steel Piles to Rock" by Dr. Lawrence Bjerrum confirms that pipe piling will not undergo column (Euler) buckling provided that

$\frac{I}{A^2} \geq \frac{f^2}{4CE}$ where:

I = Moment of inertia of the transformed cross-section of the concrete filled steel pipe pile,
A = Transformed cross-section area,
f = Yield stress of steel,
E = Young's Modulus of elasticity for steel,
C = Modulus of horizontal compressibility of surrounding soil.

If the yield stress of the pipe (f) is less than or equal to 52,000 psi and "C" is at least 75 psi (a soft clay), the above reduces to:

$\frac{I}{A^2} \geq 0.3$.

In the majority of cases, I/A^2 exceeds 0.3 and the concrete-filled steel pipe pile can be considered as a short column for design purposes. In concrete design, a short column is one in which the unsupported length (h) divided by the outside diameter (d) is 10 or less.

Corrosion of steel pipe piles

The 1965 National Building Code states that steel piles shall have a thickness 1/16" greater than that needed for design requirements unless evidence indicates that corrosion is not a problem. On steel H-piles or sheet steel piles, corrosion can take place on all faces of the member (i.e. two faces of a thickness). On a steel pipe pile, corrosion can take place only on the exterior surface. Hence when making a corrosion allowance in design, the outside diameter is assumed to be reduced by 1/16".

In 1962, the U. S. Department of Commerce released a study on "Corrosion of Steel Piling in Soils", by Melvin Romanoff. This extensive field survey of steel piles located in all types of soil for up to 40 years concluded that:

1. No appreciable corrosion occurs when piles are located in undisturbed soils or below the water table (regardless of the soil types or properties encountered).

2. Above the water table and in fill soils, corrosion is not serious. The areas of pitting in the worst cases are localized and small in area.

3. With the exception of piling exposed to sand erosion, salt water, or tides with high oxygen content in the splash area, *corrosion did not reduce the structural capacity of any pile examined.*

External pressure

The empty steel pipe pile should be strong enough to resist the active earth pressure and the ground water pressure to which it is subjected. The collapse resistance of an empty steel pipe is generally great enough to handle all external earth and any fluid pressures.

For conservative design, particularly in clays, the external earth pressure can be taken as: $p = wh$
where p = External pressure
w = unit weight of soil
h = height of soil at point of calculation

This external pressure should be kept less than the collapse pressure tabulated below.

Table I
External Uniform Collapse Pressure
(33,000 psi minimum yield strength)

Ratio Diameter / Wall Thickness	External Collapse Pressure
10	5300
15	3933
20	2950
25	2360
30	1967
35	1551
40	1012
45	744
50	513
55	389
60	300
65	236
70	189
75	154
80	126
85	105
90	89
95	75
100	65
105	56
110	49
115	43
120	37
125	33

Load tests

The 1965 National Building Code permits a pile to be load tested as a means of verifying its design load capacity (see Section 4.2.2.17 (2)). According to the NBC, the allowable pile load is one-half of the maximum test load applied to the pile. A further stipulation is that the allowable load cannot exceed the load which causes a ½" permanent settlement. As explained in the section "Pipe Column", the above allowable load based on tests need not be reduced when applied to piles which are inspected before the concrete has been poured. When applying test results to uninspected piles, a 25% reduction must be applied to the allowable load determined as above.

Extensive load testing has been carried out on concrete-filled steel pipe piles, both end bearing and friction type. One load test was carried out on two piles at the Steel Company of Canada's Swansea Works in Toronto. The piles were 12.75 O.D. x 0.281 steel tubes filled with 4000 psi high-early strength concrete.

Test pile #1 had a 1" steel plate (13 ½" in diameter) welded across the bottom end to act as a point. The pile was driven 47'8" by a #0 Vulcan Hammer to the surface of a shale layer. Fifteen blows were required for the last inch of penetration.

Testing began two days after driving was completed by applying 20 ton load increments up to a maximum load of 160 tons. The pile was not tested to destruction. The maximum load remained in place for 28 hours and was then removed in 20 ton increments. After unloading was complete, the permanent settlement was 0.474".

Test pile #2 at Swansea was equipped with a 24" x 24" x 1" steel plate point. This pile was driven by the same hammer to the shale layer and refusal was reached at a depth of 35'5". It was also noted that the pile went out of plumb by approximately ½"/foot in driving. Loading of the pile started 9 days after driving was complete and followed the same procedure as pile test #1. After the 160 ton load was removed the pile rebounded to its original elevation for zero permanent settlement. Loading increased the total out of plumbness by ¼".

The Michigan State Highway Department carried out an extensive pile testing program between 1962 and 1965. A twelve inch closed bottom-end pile with a 0.179" wall was top end driven to a depth of 67 feet and loaded to 390 tons. Load test capacity was not available for subjecting the pile to greater loads. At 390 tons, there was failure due to settlement of the pile as a unit into the end supporting glacial till, but no damage to the column shaft capacity was evident.

Western Foundation Corporation (N.Y.) reported that a 10¾ x 0.250 wall pile with 3,000 psi concrete was load tested to over 400 tons in a soil formation prior to failure. This load is equivalent to full tri-axial stressing in accordance with the Richart formula (see section on "Column Strength").

Load tables

Table II lists the section properties of Stelco steel piling pipe and the enclosed concrete core while Table III gives the allowable column strength of concrete filled steel pipe piles.

The tabulated load capacity of a concrete filled steel pipe pile is based upon the 1965 National Building Code, Section 4.5.4A.25 (1) for a "short" column. As explained under "Pipe Column", a short column is one having $h/d \leqq 10$. For this condition, the allowable steel stress is 16.6^{KSI} for steels with a yield of 33^{KSI} or greater and the allowable concrete stress is $0.24\ f'_c$. Three concrete strengths are tabulated—3, 4 and 5^{KSI}. For other strengths, the designer can compute the column capacity of the piles using the above listed stresses.

In some instances, a corrosion allowance may be deemed necessary (see section on "Corrosion"). The corrosion reduction factor in the last column of Table III is based on an assumed loss of 1/16" on the outside pipe diameter. The allowable loads tabulated would be reduced by the corrosion reduction factor.

Table II Properties of Stelco steel pipe and concrete core

Pipe			Area		Moment of inertia		Radius of gyration		Section modulus
outside diameter (in.)	wall (in.)	weight (lbs./ft.)	steel ($in.^2$)	concrete ($in.^2$)	steel ($in.^4$)	concrete ($in.^4$)	steel (in.)	concrete (in.)	steel ($in.^3$)
8.625	0.125	11.35	3.34	55.09	30.15	241.50	3.006	2.094	6.99
8.625	0.134	12.15	3.57	54.85	32.22	239.43	3.002	2.089	7.47
8.625	0.141	12.78	3.76	54.67	33.82	237.83	3.000	2.086	7.84
8.625	0.156	14.11	4.15	54.28	37.22	234.42	2.995	2.078	8.63
8.625	0.164	14.82	4.36	54.07	39.02	232.62	2.992	2.074	9.05
8.625	0.188	16.94	4.98	53.44	44.36	227.29	2.984	2.062	10.29
8.625	0.203	18.26	5.37	53.06	47.65	224.00	2.978	2.055	11.05
8.625	0.219	19.66	5.78	52.64	51.12	220.53	2.973	2.047	11.85
8.625	0.250	22.36	6.58	51.85	57.72	213.93	2.962	2.031	13.38
8.625	0.277	24.70	7.26	51.16	63.35	208.30	2.953	2.018	14.69
8.625	0.312	27.70	8.15	50.28	70.48	201.16	2.941	2.000	16.34
8.625	0.322	28.55	8.40	50.03	72.49	199.16	2.938	1.995	16.81
8.625	0.344	30.42	8.95	49.48	76.84	194.80	2.930	1.984	17.82
8.625	0.406	35.64	10.48	47.94	88.74	182.91	2.909	1.953	20.58
8.625	0.438	38.30	11.27	47.16	94.66	176.99	2.899	1.937	21.95
10.750	0.125	14.18	4.17	86.59	58.89	596.66	3.757	2.625	10.96
10.750	0.134	15.19	4.47	86.29	62.97	592.58	3.754	2.620	11.71
10.750	0.141	15.98	4.70	86.06	66.13	589.42	3.751	2.617	12.30
10.750	0.156	17.65	5.19	85.57	72.85	582.69	3.746	2.609	13.55
10.750	0.164	18.54	5.45	85.31	76.42	579.13	3.743	2.605	14.22
10.750	0.188	21.21	6.24	84.52	87.01	568.53	3.735	2.593	16.19
10.750	0.203	22.87	6.73	84.04	93.56	561.99	3.730	2.586	17.41
10.750	0.219	24.63	7.25	83.52	100.48	555.06	3.724	2.578	18.69
10.750	0.250	28.04	8.25	82.52	113.71	541.83	3.713	2.562	21.16
10.750	0.279	31.20	9.18	81.58	125.87	529.67	3.703	2.548	23.42
10.750	0.307	34.24	10.07	80.69	137.42	518.13	3.694	2.534	25.57
10.750	0.344	38.23	11.25	79.52	152.38	503.16	3.681	2.515	28.35
10.750	0.365	40.48	11.91	78.85	160.73	494.81	3.674	2.505	29.90
10.750	0.438	48.24	14.19	76.57	188.95	466.60	3.649	2.468	35.15
10.750	0.500	54.74	16.10	74.66	211.95	443.60	3.628	2.437	39.43
12.750	0.125	16.85	4.96	122.72	98.79	1198.42	4.464	3.125	15.50
12.750	0.134	18.06	5.31	122.37	105.68	1191.54	4.461	3.120	16.58
12.750	0.141	18.99	5.59	122.09	111.01	1186.20	4.458	3.117	17.41
12.750	0.156	20.98	6.17	121.50	122.39	1174.82	4.453	3.109	19.20
12.750	0.164	22.05	6.48	121.19	128.42	1168.79	4.450	3.105	20.14
12.750	0.188	25.22	7.42	120.26	146.38	1150.83	4.442	3.093	22.96
12.750	0.203	27.20	8.00	119.67	157.50	1139.71	4.437	3.086	24.71
12.750	0.219	29.31	8.62	119.06	169.27	1127.94	4.431	3.078	26.55
12.750	0.250	33.38	9.82	117.86	191.82	1105.39	4.420	3.062	30.09
12.750	0.281	37.42	11.01	116.67	214.03	1083.18	4.410	3.047	33.57
12.750	0.312	41.45	12.19	115.49	235.90	1061.31	4.399	3.031	37.00
12.750	0.330	43.77	12.88	114.80	248.45	1048.76	4.393	3.022	38.97
12.750	0.344	45.58	13.41	114.27	258.13	1039.08	4.388	3.015	40.49
12.750	0.375	49.56	14.58	113.10	279.33	1017.88	4.377	3.000	43.82
12.750	0.406	53.53	15.74	111.93	300.21	997.00	4.367	2.984	47.09
12.750	0.438	57.59	16.94	110.74	321.42	975.80	4.356	2.968	50.42
12.750	0.500	65.42	19.24	108.43	361.54	935.67	4.335	2.937	56.71
14.000	0.188	27.73	8.16	145.78	194.57	1691.18	4.884	3.406	27.80
14.000	0.210	30.93	9.10	144.84	216.31	1669.44	4.876	3.395	30.90
14.000	0.219	32.23	9.48	144.46	225.14	1660.60	4.873	3.390	32.16
14.000	0.250	36.71	10.80	143.14	255.30	1630.44	4.862	3.375	36.47
14.000	0.281	41.17	12.11	141.83	285.04	1600.70	4.851	3.359	40.72
14.000	0.312	45.61	13.42	140.52	314.38	1571.36	4.841	3.344	44.91
14.000	0.344	50.17	14.76	139.18	344.24	1541.50	4.830	3.328	49.18
14.000	0.375	54.57	16.05	137.89	372.76	1512.98	4.819	3.312	53.25
14.000	0.438	63.44	18.66	135.28	429.49	1456.25	4.797	3.281	61.36
14.000	0.500	72.09	21.21	132.73	483.75	1401.99	4.776	3.250	69.11
16.000	0.188	31.75	9.34	191.72	291.90	2925.09	5.591	3.906	36.49
16.000	0.219	36.91	10.86	190.20	338.06	2878.94	5.580	3.890	42.26
16.000	0.250	42.05	12.37	188.69	383.66	2833.33	5.569	3.875	47.96
16.000	0.281	47.17	13.88	187.19	428.72	2788.27	5.558	3.859	53.59
16.000	0.312	52.28	15.38	185.69	473.24	2743.75	5.548	3.844	59.16
16.000	0.344	57.52	16.92	184.14	518.64	2698.35	5.537	3.828	64.83
16.000	0.375	62.58	18.41	182.65	562.08	2654.91	5.526	3.812	70.26
16.000	0.438	72.80	21.41	179.65	648.74	2568.25	5.504	3.781	81.09
16.000	0.500	82.77	24.35	176.71	731.94	2485.05	5.483	3.750	91.49
20.000	0.250	52.73	15.51	298.65	756.43	7097.55	6.983	4.875	75.64
20.000	0.281	59.18	17.41	296.75	846.29	7007.70	6.972	4.859	84.63
20.000	0.312	65.61	19.30	294.86	935.26	6918.73	6.962	4.844	93.53
20.000	0.344	72.22	21.24	292.92	1026.21	6827.77	6.950	4.828	102.62
20.000	0.375	78.60	23.12	291.04	1113.46	6740.52	6.940	4.812	111.35
20.000	0.406	84.96	24.99	289.17	1199.90	6654.08	6.929	4.797	119.99
20.000	0.438	91.51	26.92	287.24	1288.23	6565.76	6.918	4.781	128.82
20.000	0.469	97.83	28.78	285.38	1372.95	6481.03	6.907	4.765	137.30
20.000	0.500	104.13	30.63	283.53	1456.85	6397.12	6.897	4.750	145.69
20.000	0.562	116.67	34.32	279.84	1622.24	6231.74	6.875	4.719	162.22
20.000	0.625	129.33	38.04	276.12	1786.95	6067.02	6.854	4.687	178.70

Table II continued Properties of Stelco steel pipe and concrete core

Pipe			Area		Moment of Inertia		Radius of gyration		Section modulus
outside diameter (in.)	wall (in.)	weight (lbs./ft.)	steel ($in.^2$)	concrete ($in.^2$)	steel ($in.^4$)	concrete ($in.^4$)	steel (in.)	concrete (in.)	steel ($in.^3$)
22.000	0.250	58.07	17.08	363.05	1010.26	10488.76	7.690	5.375	91.84
22.000	0.281	65.18	19.17	360.96	1130.75	10368.27	7.679	5.359	102.80
22.000	0.312	72.27	21.26	358.87	1250.17	10248.86	7.669	5.344	113.65
22.000	0.344	79.56	23.40	356.73	1372.34	10126.67	7.657	5.328	124.76
22.000	0.375	86.61	25.48	354.66	1489.66	10009.36	7.647	5.312	135.42
22.000	0.406	93.64	27.54	352.59	1605.99	9893.03	7.636	5.297	146.00
22.000	0.438	100.87	29.67	350.46	1724.97	9774.05	7.625	5.281	156.82
22.000	0.469	107.85	31.72	348.41	1839.21	9659.81	7.614	5.265	167.20
22.000	0.500	114.81	33.77	346.36	1952.44	9546.57	7.603	5.250	177.49
22.000	0.562	128.68	37.85	342.28	2175.95	9323.07	7.582	5.219	197.81
22.000	0.625	142.68	41.97	338.16	2398.98	9100.03	7.560	5.187	218.09
24.000	0.250	63.41	18.65	433.74	1315.33	14970.69	8.397	5.875	109.61
24.000	0.281	71.19	20.94	431.45	1472.73	14813.30	8.386	5.859	122.73
24.000	0.312	78.94	23.22	429.17	1628.84	14657.19	8.376	5.844	135.74
24.000	0.344	86.91	25.57	426.82	1788.69	14497.34	8.364	5.828	149.06
24.000	0.375	94.62	27.83	424.56	1942.28	14343.74	8.354	5.812	161.86
24.000	0.406	102.31	30.09	422.30	2094.71	14191.31	8.343	5.797	174.56
24.000	0.438	110.22	32.42	419.97	2250.72	14035.30	8.332	5.781	187.56
24.000	0.469	117.87	34.67	417.72	2400.63	13885.39	8.321	5.765	200.05
24.000	0.500	125.49	36.91	415.48	2549.33	13736.68	8.310	5.750	212.44
24.000	0.562	140.68	41.38	411.01	2843.21	13442.81	8.289	5.719	236.93
24.000	0.625	156.03	45.90	406.49	3136.91	13149.11	8.267	5.687	261.41
26.000	0.250	68.75	20.22	510.71	1676.37	20755.41	9.104	6.375	128.95
26.000	0.281	77.19	22.71	508.23	1877.53	20554.25	9.094	6.359	144.43
26.000	0.312	85.60	25.18	505.75	2077.17	20354.61	9.083	6.344	159.78
26.000	0.344	94.26	27.73	503.20	2281.72	20150.05	9.072	6.328	175.52
26.000	0.375	102.63	30.19	500.74	2478.41	19953.36	9.061	6.312	190.65
26.000	0.406	110.98	32.65	498.28	2673.71	19758.06	9.050	6.297	205.67
26.000	0.438	119.58	35.17	495.76	2873.74	19558.03	9.039	6.281	221.06
26.000	0.469	127.89	37.62	493.31	3066.07	19365.70	9.028	6.265	235.85
26.000	0.500	136.17	40.06	490.87	3256.97	19174.79	9.017	6.250	250.54
26.000	0.562	152.69	44.91	486.02	3634.60	18797.16	8.996	6.219	279.58
26.000	0.625	169.38	49.82	481.11	4012.53	18419.23	8.974	6.187	308.66
30.000	0.250	79.43	23.37	683.49	2585.16	37175.67	10.519	7.375	172.34
30.000	0.281	89.19	26.24	680.62	2896.77	36864.06	10.508	7.359	193.12
30.000	0.312	98.93	29.10	677.76	3206.33	36554.50	10.497	7.344	213.76
30.000	0.344	108.96	32.05	674.81	3523.82	36237.00	10.486	7.328	234.92
30.000	0.375	118.65	34.90	671.96	3829.41	35931.40	10.475	7.312	255.29
30.000	0.406	128.33	37.75	669.11	4133.16	35627.66	10.464	7.297	275.54
30.000	0.438	138.29	40.68	666.18	4444.59	35316.22	10.453	7.281	296.31
30.000	0.469	147.92	43.51	663.35	4744.33	35016.48	10.442	7.265	316.29
30.000	0.500	157.53	46.34	660.52	5042.16	34718.64	10.431	7.250	336.14
30.000	0.562	176.70	51.98	654.88	5632.22	34128.59	10.410	7.219	375.48
30.000	0.625	196.08	57.68	649.18	6223.96	33536.83	10.388	7.187	414.93
32.000	0.250	84.77	24.94	779.31	3142.35	48329.57	11.226	7.875	196.40
32.000	0.281	95.20	28.00	776.25	3521.81	47950.12	11.215	7.859	220.11
32.000	0.312	105.59	31.06	773.19	3898.93	47573.00	11.204	7.844	243.68
32.000	0.344	116.30	34.21	770.04	4285.86	47186.06	11.193	7.828	267.87
32.000	0.375	126.66	37.26	766.99	4658.44	46813.47	11.182	7.812	291.15
32.000	0.406	137.00	40.30	763.95	5028.93	46442.98	11.171	7.797	314.31
32.000	0.438	147.65	43.43	760.82	5408.93	46062.98	11.160	7.781	338.06
32.000	0.469	157.94	46.46	757.79	5774.85	45697.05	11.149	7.765	360.93
32.000	0.500	168.21	49.48	754.77	6138.57	45333.33	11.138	7.750	383.66
32.000	0.562	188.70	55.51	748.74	6859.62	44612.28	11.117	7.719	428.73
32.000	0.625	209.43	61.60	742.64	7583.33	43888.54	11.095	7.687	473.96
34.000	0.250	90.11	26.51	881.41	3774.35	61822.96	11.933	8.375	222.02
34.000	0.281	101.20	29.77	878.15	4230.86	61366.50	11.922	8.359	248.87
34.000	0.312	112.26	33.02	874.90	4684.71	60912.64	11.911	8.344	275.57
34.000	0.344	123.65	36.37	871.55	5150.55	60446.81	11.900	8.328	302.97
34.000	0.375	134.67	39.61	868.31	5599.25	59998.05	11.889	8.312	329.37
34.000	0.406	145.67	42.85	865.07	6045.60	59551.74	11.878	8.297	355.62
34.000	0.438	157.00	46.18	861.74	6503.58	59093.73	11.867	8.281	382.56
34.000	0.469	167.96	49.41	858.52	6944.78	58652.57	11.856	8.265	408.52
34.000	0.500	178.89	52.62	855.30	7383.42	58213.84	11.845	8.250	434.32
34.000	0.562	200.71	59.04	848.88	8253.54	57343.76	11.824	8.219	485.50
34.000	0.625	222.78	65.53	842.39	9127.53	56469.73	11.802	8.187	536.91
36.000	0.250	95.45	28.08	989.80	4485.86	77962.12	12.640	8.875	249.21
36.000	0.281	107.20	31.53	986.34	5029.21	77418.88	12.629	8.859	279.40
36.000	0.312	118.92	34.98	982.90	5569.55	76878.50	12.618	8.844	309.42
36.000	0.344	131.00	38.53	979.34	6124.34	76323.75	12.607	8.828	340.24
36.000	0.375	142.68	41.97	975.91	6658.89	75789.12	12.596	8.812	369.94
36.000	0.406	154.34	45.40	972.48	7190.80	75257.25	12.585	8.797	399.49
36.000	0.438	166.36	48.93	968.94	7736.80	74711.25	12.574	8.781	429.82
36.000	0.469	177.98	52.35	965.53	8262.86	74185.12	12.563	8.765	459.05
36.000	0.500	189.57	55.76	962.11	8786.13	73661.81	12.552	8.750	488.12
36.000	0.562	212.71	62.57	955.31	9824.57	72623.37	12.531	8.719	545.81
36.000	0.625	236.13	69.46	948.42	10868.30	71579.69	12.509	8.687	603.79

Table III Allowable column strength of Stelco concrete filled steel pipe piling

Pipe		Area		Allowable column strength (kips)				Corrosion reduction factor (kips)
outside diameter (in.)	wall (in.)	steel ($in.^2$)	concrete ($in.^2$)	steel only	concrete filled steel pipe piling concrete strength $f'_c = 3ksi$	$f'_c = 4ksi$	$f'_c = 5ksi$	
8.625	0.125	3.34	55.09	55.4	95.0	108.2	121.4	14.1
8.625	0.134	3.57	54.85	59.3	98.7	111.9	125.0	14.1
8.625	0.141	3.76	54.67	62.4	101.6	114.7	127.8	14.1
8.625	0.156	4.15	54.28	68.9	107.8	120.8	133.8	14.1
8.625	0.164	4.36	54.07	72.4	111.1	124.1	137.0	14.1
8.625	0.188	4.98	53.44	82.7	121.0	133.8	146.6	14.1
8.625	0.203	5.37	53.06	89.1	127.2	139.8	152.5	14.1
8.625	0.219	5.78	52.64	96.0	133.7	146.3	158.8	14.0
8.625	0.250	6.58	51.85	109.1	146.3	158.6	171.0	14.0
8.625	0.277	7.26	51.16	120.5	157.1	169.3	181.5	14.0
8.625	0.312	8.15	50.28	135.1	171.1	183.1	195.0	14.0
8.625	0.322	8.40	50.03	139.3	175.0	187.0	198.9	14.0
8.625	0.344	8.95	49.48	148.4	183.7	195.5	207.3	14.0
8.625	0.406	10.48	47.94	173.7	208.0	219.4	230.8	14.0
8.625	0.438	11.27	47.16	186.7	220.3	231.5	242.7	14.0
10.750	0.125	4.17	86.59	69.3	131.5	152.2	173.0	17.5
10.750	0.134	4.47	86.29	74.2	136.2	156.9	177.5	17.5
10.750	0.141	4.70	86.06	78.0	139.8	160.5	181.1	17.5
10.750	0.156	5.19	85.57	86.2	147.6	168.1	188.6	17.5
10.750	0.164	5.45	85.31	90.5	151.8	172.2	192.6	17.5
10.750	0.188	6.24	84.52	103.5	164.2	184.4	204.7	17.5
10.750	0.203	6.73	84.04	111.6	171.9	192.0	212.1	17.5
10.750	0.219	7.25	83.52	120.2	180.2	200.1	220.1	17.5
10.750	0.250	8.25	82.52	136.8	196.0	215.7	235.4	17.5
10.750	0.279	9.18	81.58	152.3	210.7	230.2	249.7	17.5
10.750	0.307	10.07	80.69	167.1	224.9	244.1	263.4	17.5
10.750	0.344	11.25	79.52	186.5	243.4	262.4	281.4	17.5
10.750	0.365	11.91	78.85	197.5	253.9	272.7	291.5	17.5
10.750	0.438	14.19	76.57	235.2	290.0	308.2	326.4	17.5
10.750	0.500	16.16	74.66	266.9	320.1	337.9	355.6	17.5
12.750	0.125	4.96	122.72	82.3*	170.5	199.9	229.3	20.8
12.750	0.134	5.31	122.37	88.2	176.1	205.4	234.8	20.8
12.750	0.141	5.59	122.09	92.7	180.5	209.7	239.0	20.8
12.750	0.156	6.17	121.50	102.5	189.8	218.9	248.0	20.8
12.750	0.164	6.48	121.19	107.7	194.7	223.7	252.8	20.8
12.750	0.188	7.42	120.26	123.2	209.5	238.3	267.1	20.8
12.750	0.203	8.00	119.67	132.8	218.8	247.4	276.0	20.8
12.750	0.219	8.62	119.06	143.1	228.6	257.1	285.5	20.8
12.750	0.250	9.82	117.86	162.9	247.5	275.7	303.9	20.8
12.750	0.281	11.01	116.67	182.7	266.3	294.2	322.1	20.8
12.750	0.312	12.19	115.49	202.3	285.1	312.7	340.3	20.8
12.750	0.330	12.88	114.80	213.6	295.9	323.3	350.8	20.8
12.750	0.344	13.41	114.27	222.4	304.3	331.6	358.9	20.8
12.750	0.375	14.58	113.10	241.8	322.8	349.8	376.8	20.8
12.750	0.406	15.74	111.93	261.1	341.3	368.0	394.7	20.8
12.750	0.438	16.94	110.74	281.0	360.2	386.6	413.0	20.8
12.750	0.500	19.24	108.43	319.0	396.5	422.4	448.2	20.8
14.000	0.188	8.16	145.78	135.4	240.1	275.1	310.0	22.8
14.000	0.210	9.10	144.84	151.0	255.0	289.7	324.4	22.8
14.000	0.219	9.48	144.46	157.4	261.1	295.7	330.3	22.8
14.000	0.250	10.80	143.14	179.2	282.0	316.2	350.5	22.8
14.000	0.281	12.11	141.83	201.0	302.7	336.7	370.6	22.8
14.000	0.312	13.42	140.52	222.6	323.4	357.0	390.6	22.8
14.000	0.344	14.76	139.18	244.9	344.6	377.9	411.2	22.8
14.000	0.375	16.05	137.89	266.3	365.1	398.0	431.0	22.8
14.000	0.438	18.66	135.28	309.5	406.4	438.7	470.9	22.8
14.000	0.500	21.21	132.73	351.7	446.6	478.2	509.9	22.8
16.000	0.188	9.34	191.72	155.1	292.8	338.7	384.7	26.1
16.000	0.219	10.86	190.20	180.2	316.9	362.4	408.0	26.1
16.000	0.250	12.37	188.69	205.3	340.8	386.0	431.2	26.1
16.000	0.281	13.88	187.19	230.3	364.7	409.5	454.3	26.1
16.000	0.312	15.38	185.69	255.2	388.4	432.8	477.3	26.1
16.000	0.344	16.92	184.14	280.8	412.9	456.9	500.9	26.1
16.000	0.375	18.41	182.65	305.4	436.4	480.1	523.7	26.1
16.000	0.438	21.41	179.65	355.3	484.0	526.9	569.8	26.1
16.000	0.500	24.35	176.71	403.8	530.4	572.5	614.7	26.1
20.000	0.250	15.51	298.65	257.5	472.1	543.6	615.1	32.6
20.000	0.281	17.41	296.75	289.0	502.1	573.2	644.2	32.6
20.000	0.312	19.30	294.86	320.3	532.1	602.6	673.2	32.6
20.000	0.344	21.24	292.92	352.6	562.9	632.9	703.0	32.6
20.000	0.375	23.12	291.04	383.7	592.6	662.2	731.8	32.6
20.000	0.406	24.99	289.17	414.8	622.2	691.4	760.5	32.6
20.000	0.438	26.92	287.24	446.7	652.7	721.4	790.0	32.6
20.000	0.469	28.78	285.38	477.5	682.1	750.3	818.5	32.6
20.000	0.500	30.63	283.53	508.2	711.4	779.2	846.9	32.6
20.000	0.562	34.32	279.84	569.3	769.8	836.6	903.4	32.6
20.000	0.625	38.04	276.12	631.0	828.7	894.6	960.5	32.6

Table III continued Allowable column strength of Stelco concrete filled steel pipe piling

Pipe		Area		Allowable column strength (kips)				Corrosion reduction factor (kips)
outside diameter (in.)	wall (in.)	steel ($in.^2$)	concrete ($in.^2$)	steel only	concrete filled steel pipe piling concrete strength f'_c = 3ksi	f'_c = 4ksi	f'_c = 5ksi	
22.000	0.250	17.08	363.05	283.6	544.5	631.5	718.4	35.9
22.000	0.281	19.17	360.96	318.3	577.6	664.1	750.5	35.9
22.000	0.312	21.26	358.87	352.9	610.7	696.6	782.5	35.9
22.000	0.344	23.40	356.73	388.5	644.6	730.0	815.4	35.9
22.000	0.375	25.48	354.66	422.9	677.5	762.3	847.2	35.9
22.000	0.406	27.54	352.59	457.1	710.2	794.5	878.9	35.8
22.000	0.438	29.67	350.46	492.4	743.9	827.7	911.5	35.8
22.000	0.469	31.72	348.41	526.5	776.4	859.7	943.0	35.8
22.000	0.500	33.77	346.36	560.4	808.8	891.6	974.4	35.8
22.000	0.562	37.85	342.28	628.0	873.3	955.1	1036.9	35.8
22.000	0.625	41.97	338.16	696.3	938.5	1019.2	1099.9	35.8
24.000	0.250	18.65	433.74	309.7	621.4	725.4	829.3	39.1
24.000	0.281	20.94	431.45	347.7	657.7	761.0	864.3	39.1
24.000	0.312	23.22	429.17	385.5	693.8	796.6	899.3	39.1
24.000	0.344	25.57	426.82	424.4	731.0	833.1	935.3	39.1
24.000	0.375	27.83	424.56	462.0	766.9	868.5	970.1	39.1
24.000	0.406	30.09	422.30	499.5	802.7	903.7	1004.8	39.1
24.000	0.438	32.42	419.97	538.1	839.5	940.0	1040.5	39.1
24.000	0.469	34.67	417.72	575.4	875.1	975.0	1074.9	39.1
24.000	0.500	36.91	415.48	612.6	910.6	1010.0	1109.3	39.1
24.000	0.562	41.38	411.01	686.7	981.4	1079.6	1177.8	39.1
24.000	0.625	45.90	406.49	761.5	1052.8	1149.9	1247.0	39.1
26.000	0.250	20.22	510.71	335.8*	702.9	825.3	947.6	42.4
26.000	0.281	22.71	508.23	377.0	742.2	864.0	985.7	42.4
26.000	0.312	25.18	505.75	418.0	781.4	902.6	1023.7	42.4
26.000	0.344	27.73	503.20	460.3	821.8	942.3	1062.8	42.4
26.000	0.375	30.19	500.74	501.2	860.8	980.7	1100.5	42.4
26.000	0.406	32.65	498.28	541.9	899.7	1019.0	1138.2	42.4
26.000	0.438	35.17	495.76	583.8	939.7	1058.4	1177.0	42.4
26.000	0.469	37.62	493.31	624.4	978.4	1096.4	1214.5	42.4
26.000	0.500	40.06	490.87	664.8	1017.0	1134.4	1251.8	42.4
26.000	0.562	44.91	486.02	745.3	1093.9	1210.1	1326.3	42.4
26.000	0.625	49.82	481.11	826.7	1171.6	1286.6	1401.6	42.4
30.000	0.250	23.37	683.49	388.0*	879.4	1043.2	1207.0	48.9
30.000	0.281	26.24	680.62	435.6*	924.9	1088.0	1251.1	48.9
30.000	0.312	29.10	677.76	483.2	970.3	1132.7	1295.0	48.9
30.000	0.344	32.05	674.81	532.1	1017.0	1178.7	1340.3	48.9
30.000	0.375	34.90	671.96	579.4	1062.2	1223.1	1384.0	48.9
30.000	0.406	37.75	669.11	626.7	1107.3	1267.5	1427.7	48.9
30.000	0.438	40.68	666.18	675.3	1153.7	1313.2	1472.7	48.9
30.000	0.469	43.51	663.35	722.3	1198.6	1357.3	1516.1	48.9
30.000	0.500	46.34	660.52	769.2	1243.4	1401.4	1559.5	48.9
30.000	0.562	51.98	654.88	862.6	1332.6	1489.3	1645.9	48.9
30.000	0.625	57.68	649.18	957.2	1422.9	1578.1	1733.3	48.9
32.000	0.250	24.94	779.31	414.1*	974.4	1161.2	1348.0	52.2
32.000	0.281	28.00	776.25	465.0*	1023.0	1209.1	1395.1	52.2
32.000	0.312	31.06	773.19	515.7*	1071.5	1256.8	1442.0	52.2
32.000	0.344	34.21	770.04	568.0	1121.4	1305.9	1490.4	52.2
32.000	0.375	37.26	766.99	618.6	1169.7	1353.4	1537.1	52.2
32.000	0.406	40.30	763.95	669.0	1217.9	1400.8	1583.8	52.2
32.000	0.438	43.43	760.82	721.0	1267.5	1449.6	1631.8	52.2
32.000	0.469	46.46	757.79	771.2	1315.4	1496.9	1678.3	52.2
32.000	0.500	49.48	754.77	821.4	1363.3	1544.0	1724.6	52.1
32.000	0.562	55.51	748.74	921.3	1458.7	1637.9	1817.0	52.1
32.000	0.625	61.60	742.64	1022.4	1555.3	1732.9	1910.5	52.1
34.000	0.250	26.51	881.41	440.2*	1074.0	1285.3	1496.6	55.4
34.000	0.281	29.77	878.15	494.3*	1125.7	1336.1	1546.6	55.4
34.000	0.312	33.02	874.90	548.3*	1177.2	1386.9	1596.5	55.4
34.000	0.344	36.37	871.55	603.9	1230.4	1439.2	1648.0	55.4
34.000	0.375	39.61	868.31	657.7	1281.7	1489.7	1697.7	55.4
34.000	0.406	42.85	865.07	711.4	1333.0	1540.2	1747.4	55.4
34.000	0.438	46.16	861.74	766.7	1385.8	1592.1	1798.5	55.4
34.000	0.469	49.41	858.52	820.2	1436.8	1642.4	1847.9	55.4
34.000	0.500	52.62	855.30	873.5	1487.8	1692.5	1897.3	55.4
34.000	0.562	59.04	848.88	980.0	1589.4	1792.5	1995.7	55.4
34.000	0.625	65.53	842.39	1087.7	1692.2	1893.7	2095.3	55.4
36.000	0.250	28.08	989.80	466.3*	1178.1	1415.4	1652.6	58.7
36.000	0.281	31.53	986.34	523.6*	1232.9	1469.3	1705.7	58.7
36.000	0.312	34.98	982.90	580.9*	1287.5	1523.1	1758.6	58.7
36.000	0.344	38.53	979.34	639.8*	1343.8	1578.5	1813.1	58.7
36.000	0.375	41.97	975.91	696.9	1398.3	1632.1	1865.8	58.7
36.000	0.406	45.40	972.48	753.8	1452.6	1685.6	1918.5	58.7
36.000	0.438	48.93	968.94	812.4	1508.6	1740.7	1972.7	58.7
36.000	0.469	52.35	965.53	869.1	1562.7	1793.9	2025.1	58.7
36.000	0.500	55.76	962.11	925.7	1616.8	1847.1	2077.5	58.7
36.000	0.562	62.57	955.31	1038.6	1724.6	1953.2	2181.9	58.7
36.000	0.625	69.46	948.42	1152.9	1833.7	2060.6	2287.5	58.7

*These sections have $\frac{O.D.}{t} > \frac{3300}{Fy}$ and by C.S.A. S16-1965 are allowed only with concrete core.

(Concrete Filled)

TABLE OF BASIC LOAD CAPACITIES

For Concrete Strengths of 3000, 4000 and 5000 p.s.i. (28 Days)
Pipe—Minimum Yield Strength of 35000 p.s.i.
(A.S.T.M. Specs. A 252 Grade 2)

Pipe Dia.	Wall In.	Area Concrete	Bearing Capacity Concrete (Kips)			Area of Pipe Less 1/16" Wall	Bearing Capacity Pipe (Kips) fs=14000	Pile or Caisson Bearing Capacity Pipe+Concrete (Kips)		
			f'c—3000	f'c—4000	f'c—5000			f'c—3000	f'c—4000	f'c—5
8⅝"	.156	54.272	41.0	54.3	67.7	2.473	34.6	75.6	88.9	102.
	.188	53.456	40.0	53.5	66.6	3.289	46.0	86.0	99.5	112.
	.219	52.651	39.5	52.7	65.6	4.094	57.2	96.7	109.9	122.
	.250	51.849	38.9	51.8	64.9	4.896	68.5	107.4	120.3	133.
10¾"	.156	85.565	64.2	85.6	107	3.099	43.4	107.6	129.0	150.
	.188	84.541	63.4	84.5	106	4.123	57.7	121.1	142.2	163.
	.219	83.528	62.6	83.5	104	5.136	71.8	134.4	155.3	175.
	.250	82.516	61.9	82.5	103	6.146	86.0	147.9	168.5	189.
12¾"	.188	120.28	90.0	120	150	4.91	68.7	158.7	188.7	218.
	.219	119.07	89.3	119	149	6.12	85.6	174.9	204.6	234.
	.250	117.86	88.4	118	147	7.33	103.0	191.4	221.0	250.
	.312	115.47	86.6	115	145	9.72	136.0	222.6	251.0	281.
14"	.188	145.80	109	146	182	5.40	75.5	184.5	221.5	257.
	.219	144.47	108	144	181	6.73	94.2	202.2	238.2	275.
	.250	143.14	107	143	179	8.06	113.0	220.0	256.0	292.
	.312	140.50	105	140	176	10.70	150.0	255.0	290.0	326.
16"	.219	190.20	142	190	237	7.73	108	250	298	
	.250	188.69	141	188	236	9.24	129	270	317	
	.281	187.19	140	187	234	10.75	148	288	335	382
	.312	185.69	139	185	232	12.25	171	310	356	403
20"	.250	298.65	224	298	373	11.60	162	386	460	535
	.281	296.75	223	296	371	13.49	189	412	485	560
	.312	294.80	221	295	368	15.38	215	436	510	583
	.375	291.04	218	291	364	19.20	269	487	560	633
24"	.250	433.74	328	434	547	13.952	195	523	629	742
	.312	429.17	322	429	536	18.517	259	581	688	795
	.375	424.56	318	424	530	23.132	324	642	748	854
	.500	415.48	312	415	520	32.213	451	763	866	971
26"	.250	511.50	384	511	639	15.119	211	595	722	850
	.312	504.85	378	505	630	20.074	281	659	786	911
	.375	501.50	376	501	625	25.085	351	727	852	976
	.500	490.80	369	491	614	34.950	489	858	980	1103
30"	.250	684.70	513	685	855	17.472	244	757	929	1099
	.312	677.60	508	677	846	23.220	325	833	1002	1171
	.375	672.00	504	672	839	29.021	406	910	1078	1245
	.500	660.52	495	660	826	40.459	566	1061	1226	1392
36"	.250	991.50	744	991	1240	21.015	294	1038	1285	1534
	.312	982.90	736	983	1230	27.923	391	1127	1374	1621
	.375	975.91	732	976	1220	34.912	488	1220	1464	1708
	.500	962.12	722	962	1210	48.705	682	1604	1644	1892

APPENDIX B

3300 - 1 DESCRIPTION

1.01 The work shall consist of spreading and compacting screened or crushed aggregate on a prepared surface.

1.02 The following definitions shall apply for this specification:

(a) Mean:

The arithmetic average of a set of 'n' test results constituting the sample.

(b) Moving average:

The arithmetic mean of 3 consecutive test results.

(c) Sub-base aggregate:

The aggregate before mixing, when binder is to be added or the aggregate before spreading and compacting, when no binder is to be added.

(d) Sub-base mix:

The sub-base aggregate after mixing with binder and water but before spreading and compacting.

(e) Sub-base course:

The sub-base aggregate or sub-base mix in place on the road during and after spreading and compacting.

3300 - 2 MATERIALS

Aggregate

2.01 Sub-base aggregate shall be composed of sound, hard, and durable particles of sand, gravel and rock free from injurious quantities of soft or flaky particles, shale, loam, clay balls and organic or other deleterious material.

3300 - 3 CONSTRUCTION

General

3.01 (a) Sub-base course shall comply with the requirements listed in Table 1:

TABLE 1

Sieve Designation	Percent By Weight Passing Canadian Metric Sieve Series		
	TYPE		
	6	8	10
50.0 mm	100.0	100.0	100.0
2.0 mm	0 - 80.0	0 - 90.0	
400 um	0 - 45.0	0 - 60.0	
160 um	0 - 20.0	0- 25.0	
71 um	0 - 6.0	0 - 15.0	0 - 20.0
Plasticity Index (all types)	0 - 6.0		

3505 - 2 MATERIALS

Aggregate

2.01 Base aggregate shall be composed of sound, hard and durable particles of sand, gravel and rock free from injurious quantities of elongated, soft or flaky particles, shale, loam, clay balls and organic or other deleterious material.

3505 - 3 CONSTRUCTION

General

3.01 (a) Base course shall comply with the requirements listed in Table 1.

TABLE 1

SIEVE DESIGNATION	PERCENT BY WEIGHT PASSING CANADIAN METRIC SIEVE SERIES		
	TYPE		
	31	33	35
31.5 mm	100.0		
18.0 mm	75.0 - 90.0	100.0	100.0
12.5 mm	65.0 - 83.0	75.0 - 100.0	81.0 - 100.0
5.0 mm	40.0 - 69.0	50.0 - 75.0	50.0 - 85.0
2.0 mm	26.0 - 47.0	32.0 - 52.0	32.0 - 65.0
900 um	17.0 - 32.0	20.0 - 35.0	20.0 - 43.0
400 um	12.0 - 22.0	15.0 - 25.0	15.0 - 30.0
160 um	7.0 - 14.0	8.0 - 15.0	8.0 - 18.0
71 um	6.0 - 11.0	6.0 - 11.0	7.0 - 12.0
Plasticity Index	0 - 7.0	0 - 6.0	0 - 5.0
Fractured Face %	50.0 Minimum		
Light Weight Pieces %	5.0 Maximum		

(b) A tolerance of 3% in the percent by weight passing the maximum size sieve shall be permitted providing 100% of the oversize passes the 40.0 mm sieve for Type 31 base course and the 22.4 mm sieve for Types 33 and 35 base course.

3.02 The following shall apply to Department owned or controlled aggregate sources shown on the plans or as described in the Special Provisions:

(a) Overburden shall be removed from material deposits in accordance with Specification 2260 For Removal Of Overburden.

(b) Rock passing a 450 mm square opening screen and larger than the maximum specified size shall be crushed and incorporated simultaneously throughout the crushing operation.

(c) Stockpiles shall be constructed in accordance with Specification 3600 For Stockpiling Aggregates.

3.03 Binder, filler, and blender sand shall be provided in accordance with Specification 3400 For Binder, Filler And Blender Sand.

3.04 Binder, filler and blender sand shall be added using a separate conveyor system.

3.05 Binder, filler and blender sand feeds shall be accurately controlled and coordinated.

PART 1 GENERAL

1.1 Section Includes

Note: See Construction Drawings

.1 Excavation for building foundations in accordance with underground locates, construction drawings and Geotechnical Report. LOCATE EXISTING UNDERGROUND UTILITIES (conduit, piping, etc.).
.2 Excavation for asphalt paving, landscaping, gravel paving, and for granular base and sub-base material installation, as per recommendations of the Geotechnical Report.
.3 Excavation for site structures/footing trenches, underground utilities and roadways.
.4 Cutting and removal of existing asphalt and concrete paving (parking, sidewalk, etc.) as required, to allow for excavation of new foundation and tie-in existing.

1.2 Related Sections

.1 Section 014000 - Quality Control: Inspection of bearing surfaces.
.2 Section 015000 - Construction Facilities and Temporary Controls: De-watering excavations and water control.
.3 Section 312000 - Geotechnical Investigation Report.
.4 Section 312311 - Backfilling.
.5 Section 312312 - Trenching: Excavation for utility trenches.

1.3 Field Measurements

.1 Verify that survey bench mark and intended elevations for the Work as indicated.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 Preparation

.4 Identify required lines, levels, contours, and datum.
.5 Identify known underground, above ground, and aerial utilities. Stake and flag locations.
.6 Notify utility company to remove and relocate utilities.
.7 Protect above and below grade utilities, which are to remain.
.8 Protect plant life and other features remaining as a portion of final landscaping.
.9 Protect benchmarks and curbs from excavation equipment and vehicular traffic.

3.2 Excavation

.1 Excavate subsoil required to accommodate building foundations, paving, site structures, construction operations. **NOTE: locate underground utilities and protect them during construction.**
.2 Excavate to working elevation for piling work.
.3 Machine slope banks to 45 degrees.

.4 Excavation cut not to interfere with normal bearing splay of foundation.
.5 Grade top perimeter of excavation to prevent surface water from draining into excavation.
.6 Hand trim excavation. Remove loose matter.
.10 Remove lumped subsoil, boulders, and rock up to 0.25 cu m measured by volume.
.8 Remove foundations of existing building, which is to be removed by others.
.9 Notify Departmental Representative f unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
.10 Correct unauthorized excavation at no extra cost to Owner.
.11 Correct areas over excavated by error in accordance with Section 02223.
.12 Stockpile excavated material in area designated on site and remove excess material not being reused, from site.

3.3 Field Quality Control

.1 Field inspection will be performed under provisions of Section 014000.
.2 Provide for visual inspection of bearing surfaces. Refer to Section 014000 Quality Control and Section 312311 Backfilling.

3.4 Protection

.1 Protect excavations by methods required to prevent cave-in or loose soil from falling into excavation.
.2 Protect bottom of excavations and soil adjacent to and beneath foundation from freezing, in case work is being done during the cold season.

END OF SECTION

PART 1 GENERAL

1.1 Section Includes
.1 Building perimeter and site structure backfilling to sub-grade elevations.
.2 Site filling and backfilling.
.3 Fill under paving.
.4 Consolidation and compaction.
.5 Fill for over-excavation.
.6 Sheet vapour barrier and fill.

1.2 Related Sections
.1 Section 014000 - Quality Control: Testing fill compaction.
.2 Section 312000 – Geotechnical Investigation Report. Recommendations to be complied with.
.3 Section 312310 - Excavation.
.4 Section 312312 - Trenching: Backfilling of utility trenches.
.5 Section 033000 - Cast-in-Place Concrete: Concrete materials.

1.3 References
.1 ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
.2 ASTM D698 - Test Methods for Moisture, Density Relations of Soils and Soil Aggregate Mixtures, Using 5.5 lb. (2.49 Kg) Rammer and 12 inch (304.8 mm) Drop.
.3 ASTM D1556 Test Method for Density of Soil in Place by the Sand-Cone Method.
.4 ASTM D1557 Test Methods for Moisture Density Relations of Soils and Soil Aggregate Mixtures Using 10 lb. (4.54 Kg) Rammer and 18 inch (457 mm) Drop.

1.4 Samples
.1 Submit samples to requirements of Section 013300.
.2 Submit 4.5 kg sample of each type of Type fill to testing laboratory, in air tight containers.

PART 2 PRODUCTS

2.1 Fill Materials
.1 Type A: Granular sub-base, Saskatchewan Highways and Transportation Type 10.
.2 Type B: Granular base consisting of 18 mm maximum, Saskatchewan Highways and Transportation Type 33, crushed gravel with a minimum CBR of 60 and compacted to not less than 100 percent of Standard Proctor maximum Dry Density (ASTM D698).
.3 Type C: Sand: Natural river or bank sand; free of silt, clay, loam, friable or soluble materials, or organic matter; graded in accordance with ASTM C136 within the following limits:

Sieve Size	**Percent Passing**
4.75 mm	100
1.40 mm	10 to 100
300 micro m	5 to 90
150 micro m	4 to 30
75 micro m	0

.4 Type D: Pea Gravel: Natural stone; free of clay, shale, organic matter; in accordance with ASTM C136 to the following:
.1 Minimum Size: 6 mm
.2 Maximum Size: 16 mm

.5 Type E: Concrete sand.

.6 Type F: Sub-base: Sand material recovered from the site or new engineered granular fill, Saskatchewan Highway Standard Type 8, 10 or 12 A maximum 18 mm aggregate size, and compacted to 100 percent of the Standard Proctor Dry Density.

.7 Subsoil: Reused, free of gravel larger than 75 mm size, and debris.

2.2 Accessories

.1 Vapour Retardant: 10 mm (min.) membrane manufactured from virgin polyolefin resins, and when tested according to all requirements of ASTM E1745, shall meet the following minimum performance requirements:

.1 Maximum Water Vapour Permeance (ASTM E154 Sections 7, 8, 11, 12, 13, by ASTM E96, Method B or ASTM F1249).

.a As received: 0.0183 perms.

.b After Wetting and Drying: 0.0210 perms.

.c Resistance to Plastic Flow and Temperature: 0.0197 perms.

.d Effect Low Temperature and Flexibility: 0.0212 perms.

.e Resistance to Deterioration from Organisms and Substances in Contacting Soil: 0.0198 perms.

.2 Puncture Resistance (ASTM D1709): >3,500 grams.

.3 Tensile Strength ASTM E154, Section 9: 52 Lb. Force/Inch.

PART 3 EXECUTION

3.1 Examination

.7 Verify fill materials to be reused, is acceptable.

.8 Verify foundation perimeter drainage installation has been inspected.

.9 Verify underground tanks are anchored to their own foundation to avoid floatation after backfilling.

3.2 Preparation

.1 Generally, compact sub-grade to density requirements for subsequent backfill materials.

.2 Cut out soft areas of sub-grade not capable of insitu compaction. Backfill with Type D fill and compact to density equal to or greater than requirements for subsequent backfill material.

.3 Prior to placement of aggregate base course material at paved areas, compact subsoil to 95 percent of its maximum dry density in accordance with ASTM D698.

3.3 Backfilling

.1 Backfill areas to contours and elevations with unfrozen materials.

.2 Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy sub-grade surfaces.

.3 Granular Fill: Place and compact materials in continuous layers not exceeding 150 mm compacted depth.

.10 Soil Fill: Place and compact material in continuous layers not exceeding 200 mm compacted depth.

.11 Employ a placement method that does not disturb or damage foundation perimeter drainage, foundation damp proofing.

.12 Maintain optimum moisture content of backfill materials to attain required compaction density.

.13 Backfill against supported foundation walls. Do not backfill against unsupported foundation walls.

.14 Backfill simultaneously on each side of unsupported foundation walls until supports are in place.

.15 Slope grade away from building minimum 150 mm in 3 m, unless noted otherwise.

.16 Make grade changes gradual. Blend slope into level areas.
.17 Remove surplus backfill materials from site.
.18 Leave fill material stockpile areas completely free of excess fill materials.

3.4 Tolerances
.1 Top Surface of Backfilling Under Paved Areas: Plus or minus 25 mm from required elevations.
.2 Top Surface of General Backfilling: Plus or minus 25 mm from required elevations.

3.5 Field Quality Control
.1 Field inspection and testing will be performed under provisions of Section 014000.
.2 Tests and analysis of fill material will be performed in accordance with ASTM D698 and with Section 014000.
.3 Compaction testing will be performed in accordance with ASTM D1556 ASTM D1557 ASTM D698 and with Section 014000.
.4 If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.
.5 Frequency of Tests:
  .1 Excavated Surfaces: When undisturbed excavated surfaces are being prepared, make a series of three tests for each 500 square m area.
  .2 Backfill in Utility Trenches: Make three tests for every two lifts of compacted fill for each 500 square m area.
.6 Proof roll compacted fill surfaces under paving.

3.6 Protection of Work
.1 Protect finished Work under provisions of Section 015000.
.2 Re-compact fills subjected to vehicular traffic.

3.7 Schedule
.1 Interior Crawl Spaces (if any):
  1. Subsoil fill, compacted to 90 percent,
  2. Cover with Type C fill, 50 mm thick, compacted to 95 percent.
.2 Exterior Side of Foundation Walls and Over Granular Filter Material and Foundation Perimeter Drainage:
  1. Subsoil for upper 1 m, free draining backfill material to top of Type C fill above drain tile, 200 mm each lift, compacted to 90 percent.
.3 Fill Under Grass Areas:
  1. Subsoil, to 150 mm below finish grade, compacted.
.4 Fill Under Landscaped Areas:
  1. Subsoil fill, to 300 mm below finish grade, compacted
.5 Fill Under Light Duty Asphaltic Concrete Areas as per Geotechnical Investigation Report, and if not noted in the report, to be as follows:
  .1 Minimum 150 mm Type B fill material.
  .2 Type F as required.
.6 Fill Under Heavy Duty Asphaltic Concrete Areas as per Geotechnical Investigation Report, and if not noted in the report, to be as follows:
  .1 Minimum 240 mm Type B fill material.
  .2 Type F as required.

.7 Sub-Grade Preparation for Asphaltic Concrete Paving:

.1 Excavate to the required design elevation.

.2 Excavate and waste all debris, deleterious materials and organic soils that are exposed below the initial excavation depth. Scarify the sub-grade to a minimum average of 98 percent of Standard Proctor Maximum Dry Density.

.3 Re-establish the design sub-grade elevation (to the bottom of the pavement sub-base) by placement of Standard Proctor Maximum Dry Density.

END OF SECTION

PART 1 GENERAL

1.1 Section Includes

.1 Excavate trenches for utilities from outside building to municipal utilities (if any).
.2 Compacted bedding under and fill over utilities to sub-grade elevations.
.3 Backfilling and compaction.

1.2 Related Sections

.1 Section 014000 - Quality Control: Testing fill compaction.
.2 Section 015000 - Construction Facilities and Temporary Controls: Water control in excavations.
.3 Section 312313 - Site Grading: Topsoil and subsoil removal from site surface.
.4 Section 312310 - Excavation: General building excavation.
.5 Section 312311 - Backfilling: General backfilling.
.6 Divisions 22-23 - Mechanical: Sewer piping, water piping, gas piping, from building to municipal utilities, and Division 26 – Electrical

1.3 References

.1 ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
.2 ASTM D698 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5 lb (2.49 Kg) Rammer and 12 inch (304.8 mm) Drop.
.3 ASTM D1556 - Test Method for Density of Soil in Place by the Sand-Cone Method.
.4 ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10 lb (4.54 Kg) Rammer and 18 inch (457 mm) Drop.

1.4 Test Samples

.1 Submit samples in accordance with Section 014000.
.2 Submit 4.5 kg sample of each type of fill to testing laboratory, in air tight containers.

1.5 Field Measurements

.1 Verify that survey benchmark and intended elevations for the Work are as shown on Drawings.

PART 2 PRODUCTS

2.1 Fill Materials

.4 Materials as specified in Section 312311.

PART 3 EXECUTION

3.1 Examination

.5 Verify fill materials to be reused, is acceptable.

3.2 Preparation

.1 Identify required lines, levels, contours, and datum.

3.3 Excavation

.1 Excavate subsoil required for sanitary sewer, water, gas piping to municipal utilities.
.2 Cut trenches sufficiently wide to enable installation of utilities and allow inspection.
.3 Excavation shall not interfere with normal 45 degree bearing splay of foundations.
.4 Hand trim excavation. Remove loose matter.
.5 Remove lumped subsoil, boulders, and rock up to 0.25 cu m, measured by volume.
.6 Correct unauthorized excavation at no cost to Owner.

.7 Correct areas over excavated by error in accordance with Section 312310.

.8 Stockpile excavated material in area designated on site and remove excess material not being used, from site.

3.4 Bedding

.1 Support pipe and conduit during placement and compaction of bedding fill.

3.5 Backfilling

.1 Backfill trenches to contours and elevations with unfrozen materials.

.2 Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy sub-grade surfaces.

.3 Granular Fill: Place and compact materials in continuous layers not exceeding 150 mm compacted depth.

.4 Soil Fill: Place and compact material in continuous layers not exceeding 150 mm compacted depth.

.5 Employ a placement method that does not disturb or damage conduit duct in trench.

.6 Maintain optimum moisture content of backfill materials to attain required compaction density.

.7 Remove surplus backfill materials from site.

.8 Leave fill material stockpile areas completely free of excess fill materials.

3.6 Tolerances

.1 Top Surface of general backfilling: Plus or minus 25 mm from required elevations.

3.7 Field Quality Control

.1 Field inspection and testing will be performed under provisions of Section 014000, and Tests and analysis of fill material will be performed in accordance with ASTM D698.

.3 Compaction testing will be performed in accordance with ASTM D698 and with Section 014000.

.4 If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.

3.8 Protection of Work

.1 Protect finished Work under provisions of Section 015000.

.2 Re-compact fills subjected to vehicular traffic.

3.9 Schedule

.1 Underground Services

.1 Pipe and conduit bedding and immediate protective cover: Cradle half diameter of pipe or conduit using 100 mm depth of Type D fill. After pipe or conduit is in place, cover with 600 mm depth of Type D fill.

.2 Cable & cable duct bedding and immediate protective cover: Cover bottom of trench with 150 mm Type D fill. After cables and ducts are in place, side fill ducts with type D fill to top. Tamp around ducts with hand tampers, cover with 600 mm of same material.

.3 Remaining fill: In areas within buildings and where paving and walks occur, fill remainder with type D fill. In other areas, fill to sub-grade level using Type G fill.

.4 Compaction: Compact bedding and immediate protective cover to 95% density. In areas within buildings and where paving and walks occur, compact remainder of fill to 95% density. In other areas, compact remainder of fill to 85%.

.5 Notify Departmental Representative prior to backfilling trenches.

END OF SECTION

PART 1 GENERAL

1.1 Section Includes

.1 Remove topsoil and stockpile for later reuse, and remove excess from site.
.2 Excavate topsoil and stockpile for later reuse and remove excess from site.
.3 Grade and rough contour site.

1.2 Related Sections

.1 Section 312000 - Geotechnical Investigation Report
.2 Section 312310 - Excavation: Building excavation.
.3 Section 312311 - Backfilling: Building and site backfilling.
.4 Section 312312 - Trenching: Trenching and backfilling for utilities.

1.3 Project Record Documents

.1 Submit documents in accordance with Section 017839.

.2 Accurately record location of utilities remaining, re-routed utilities, new utilities by horizontal dimensions, elevations or inverts, and slope gradients.

1.4 Protection

.1 Protect benchmarks, roads, sidewalks, paving.
.2 Protect above or below grade utilities which are to remain.
.3 Repair damage.

PART 2 PRODUCTS

2.1 Materials

.4 Topsoil: Excavated material, graded free of roots, rocks larger than 25 mm, subsoil, debris, and large weeds.
.5 Subsoil: Excavated material, graded free of lumps larger than 150 mm, rocks larger than 75 mm, and debris.

PART 3 EXECUTION

3.1 Preparation

Note: Site grading complete, but will be disturbed by the new building addition. Undertake site inspection and document extent of topsoil removal and stock piling and extent of required re-contouring.

.6 Identify required lines, levels, contours, and datum.
.7 Identify known below grade utilities. Stake and flag locations.
.8 Identify and flag above grade utilities.

.9 Maintain and protect existing utilities remaining which pass through work area.
.10 Notify utility company to remove and relocate utilities.
.11 Upon discovery of unknown utility or concealed conditions, discontinue affected work; notify Departmental Representative.

3.2 Topsoil / Paving Excavation

.1 Excavate topsoil from areas to be further excavated, re-landscaped, or re-graded and stockpile in area designated on site, remove excess topsoil not being reused from site.
.2 Remove portions of existing paving (sidewalk)/curb as required, with provisions for re-connecting new paving (sidewalk) after new addition gets built.
.3 Do not excavate wet topsoil.
.4 Stockpile topsoil to depth not exceeding 2.5 m. Cover to protect from erosion.

3.3 Subsoil Excavation

.1 Excavate subsoil from areas to be re-landscaped or re-graded and stockpile in area designated on site remove excess subsoil not being reused from site.
.2 Do not remove wet subsoil.
.3 Stockpile subsoil to depth not exceeding 2.5 m.
.4 When excavation through roots is necessary, perform work by hand and cut roots with sharp axe.

3.4 Tolerances

.1 Top Surface of sub-grade: Plus or minus 25 mm.

END OF SECTION

PART 1 GENERAL

1.1 Section Includes
.1 Drilled cast-in-place augured piles.
.2 Supply only of dowels to superimposed concrete.
.3 Boring, pile shaft, concrete, reinforcing steel and other related work to provide complete foundation system.
.4 Placing steel shaft casings as required.
.5 De-watering of bored holes.
.6 Placing concrete and reinforcing steel and preparing piles for capping.
.7 Removal of waste materials from bored holes.

1.2 Related Sections
.1 Geotechnical Investigation Report Section 312000.
.2 Excavation Section 312310.
.3 Backfill Section 312311.
.4 Concrete Form Work Section 031000.
.5 Concrete Reinforcement Section 032000.
.6 Cast-in-Place Concrete Section 033000.

1.3 Reference Standards

.1 CAN3-A23.1 (Latest Edition), CSA A23.1-94 "Concrete Materials and Methods of Concrete Construction".
.2 CAN3-A23.2 (Latest Edition), CSA A23.2-94 “Methods of Test for Concrete".
.3 CSA G30.18-M92-(Latest Edition) "Billet Steel Bars for Concrete Reinforcement".
.4 CAN3-A23.3-(Latest Edition) "Design of Concrete Structures for Buildings".

1.4 Quality Assurance
.1 If required by Consultant, produce satisfactory proof of successful installation experience with this type of foundation in similar conditions and with piles of similar capacities.

1.5 Soils Conditions
.1 The soils information is provided in good faith for the Contractor's guidance. This Consultant assumes no liability for the accuracy of this information nor does the furnishing of this information relieve the Contractor of the responsibility for determining the nature of the site conditions for himself.
.2 See the Geotechnical Investigation Report Section 312000. Recommendation for bored and augured piles to be complied with.

1.6 Submittals
.1 Prior to commencement of work, submit shop drawings for reinforcing steel in accordance with Section 031300, Submittals.
.2 Submit Record Drawings survey of completed work indicated pile centers, top elevations and projecting steel layouts, prepared and signed by a Land Surveyor registered in the province.
.3 Submit "Supplementary Data" on each pile as follows;
    .1 Bottom elevation
    .2 Plumbness

.4 Submit Record Drawings and supplementary Data immediately upon completion of superimposed work.

1.7 Protection

.1 Provide steel shaft liners during inspections and manual excavation of piles. Size liners to suit shaft dimensions.

.2 Where shaft excavation requires continuous support to prevent sides sloughing in during placement of reinforcing steel and concrete, provide steel liner and leave in place at Owner's expense.

1.8 Inspection and Testing

.1 Inspection of piling work will be performed by an Inspection Agency appointed and paid by the Contractor.

.2 Concrete sampling and testing will be performed by a Testing Agencies appointed and paid by the Contractor. See Section 014000 Quality Control.

.3 Before placing any concrete, notify Inspection and Testing Agencies and the Departmental Representative in ample time to permit scheduling inspections and tests.

.4 Prior to commencement of work, submit statistically valid evidence of the past performance of the mix design to the Departmental Representative for review.

.5 Three concrete test cylinders will be taken for every 50 m3 or less of concrete placed, and at least three concrete test cylinders will be taken on any day when concrete is placed

.6 One additional test cylinder will be taken during cold weather concreting, and be cured on job site under same conditions as concrete it represents.

.7 Slump tests will be taken as necessary to verify quality of concrete. The concrete and atmospheric temperatures will also be recorded.

.8 Testing of concrete will be performed in accordance with CAN/CSA A23.2-94.

.9 At no cost to the Owner, retest as required due to defective materials or workmanship.

.10 Inspection firm may inspect shaft and bottom bearing prior to placement of concrete or reinforcing. Co-operate and schedule inspection visits.

1.9 Field Records

.1 Maintain accurate records of each pile placed, including the following;

- .1 Pile sizes and lengths.
- .2 Final bearing and head elevations.
- .3 Condition of base materials.
- .4 Tested concrete strengths; concrete slumps; date and time concrete placed.
- .5 Reinforcing details.
- .6 Shaft diameters.

.2 Submit three copies of field records to Departmental Representative.

PART 2 PRODUCTS

2.1 Reinforcing Steel

.1 Reinforcing Steel: deformed steel bars conforming to requirements of CSA G30.18-M94 (Latest Edition); 300 MPa yield strength for 10 M bars; 400 MPa yield strength for 15 M and larger.

.2 Reinforcement to conform to standards as specified under Section 03200 Concrete Reinforcement. Submit shop drawings of reinforcing steel to Consultant in accordance with the requirements of Section 032000.

.3 Length of reinforcement to be shown on drawings.

.4 No splicing in reinforcement permitted unless specifically shown on drawings or approved by Consultant. Where splices permitted length = 36 bar diameters minimum; adjacent spliced staggered minimum full lap length.

.5 Welding ties to main reinforcement not permitted.

2.2 Concrete Materials

.1 Cement: High Sulfate Resistant (HS) hydraulic cement conforming to CAN3-A5-93 (Latest Edition).

.2 Coarse and Fine Aggregates: Standard concrete type, conforming to CAN3-A23.1-94 (Latest Edition).

.3 Water: Clean and free of injurious amounts of oil, alkali, organic matter or other deleterious materials.

.4 As per CSA A23.1 1-M04, minimum 56 day compressive strength for concrete, 35 mpa, with a minimum water cement ration of 0.4.

2.3 Admixtures

.1 Air Entrainment: To CSA A266.1-M78 (Latest Edition) "Air Entraining Admixtures for Concrete".

.2 Chemicals: To CSA A266.2-M78 (Latest Edition) "Chemical Admixtures for Concrete"; water reducing, strength increasing Type WN - normal setting.

.3 Pozzolanic Mineral: To CSA A266.3-A23.5-M86 (Latest Edition) "Pozzolanic Mineral Admixtures for use in Portland Cement Concrete". Typcor Type F fly ash is permitted in piles only to a maximum of 15% of the cement content.

.4 Use of calcium Chloride in concrete is strictly prohibited.

2.4 Concrete Mix

.1 Mix concrete in accordance with the following;

UNIT	**MEASUREMENT**
Minimum compressive strength	35 MPa at 28 days
Aggregate size (maximum)	20 mm
Air content (Category 2)	4% to 7%
Slump	75 +/- 25 mm
Cement symbol	Type 50

Minimum cement content to e 280 kg/cubic meters.
Maximum free water/cement to be ≤ 0.40."

.2 Chemicals: To CSA A266.2-M78 (Latest Edition), "Chemical Admixtures for Concrete"; water reducing, strength increasing Type WN - Normal setting.

.3 Pozzolanic Mineral: To CSA A23.5-M86 (Latest Edition) "Pozzolanic Mineral Admixtures for use in Portland Cement Concrete". Fly ash is permitted in piles only and can be maximized providing w/cm ratio and strength requirements are met.

.4 Use of calcium chloride in concrete is strictly prohibited.

2.5 Casing

.1 Removable steel protective casing adequate for its function.

PART 3 EXECUTION

3.1 Examination

.1 Ensure that site conditions at each pile location are adequate to support piling equipment to properly install piles and permit load testing when required.

3.2 Preparation

.1 Locate foundations with reference to building lines and level.

.2 Protect any survey reference points during construction.

.3 Locate underground utility lines prior to the commencement of piling and be responsible for any disruptions.

.4 Provide necessary equipment including pumps, piping and temporary drains and trenches.

.5 Do no discharge drainage water into municipal sewers without municipal approval.

3.3 Installation

.1 Bore pile holes continuously until required depth is reached.

.2 Do not bore for adjacent piles less than 48 hours after piles have been formed unless piles are more than 1500 mm apart.

.3 Immediately following boring, install steel casings in excavations required to prevent cave-ins and water entry.

.4 If removable liner is required, withdraw liner as concrete is placed. Maintain at least 1.5 m depth of concrete in liner at all times.

.5 Remove boulders as encountered.

.6 Permit inspection of pile holes to verify bell dimensions and to confirm that required soil bearing values are available.

.7 Maximum permissible error in location 40 mm in any direction. Place piles not more than 2 percent of their lengths out of plumb or batter called for on drawings. Elevation of top of piles to be within 25 mm of elevation called for on drawings. Reinforcing steel clearances within 15 mm of dimensions called for on drawings.

.8 Where water is encountered, pump to maintain dry hole until concrete placement is completed.

.9 Reinforce in accordance with drawings. Place reinforcement and secure in position. Provide concrete cover in accordance with Clause 12, CAN/CSA-A231 (Latest Edition). Conform to CSA W186 for welding.

.10 Place concrete carefully using chutes or elephant trucks to direct concrete down shaft to minimize segregation.

.11 Place concrete by means of a tremie should an inflow of water occur that cannot be removed by pumping. Place to a height sufficient to affect a seal. Notify Departmental Representative prior to carrying out this work.

.12 Form pile tops at cut-off elevations. Length of friction piles indicated on drawings, to be from cutoff elevations where noted or underside of grade beams, pile caps or equipment bases.

.13 Ensure friction piles develop full friction value of soils encountered.

.14 Vibrate top 3.0 m continuously during placement.

.15 Upon completing concrete placement, fill reminder of hole with granular fill to minimum depth of 1.0 m above concrete.

.16 Cure concrete in accordance with CAN/CSA-A23.1 (Latest Edition).

.17 Provide cold weather protection as required to maintain temperature of 22° for 3 days or 10° for 5 days after placing concrete.

.18 Schedule work so that excavations are filled with concrete as soon as completed. If conditions prevent placement of concrete on same day, protect excavation overnight and allow for re-cleaning and re-inspection prior to placement of concrete.

.19 Minimum pile diameter as per drawings.

.20 Piles placed outside above tolerances may be rejected by the Departmental Representative. Place additional piles and pile caps as directed by the Departmental Representative to replace rejected piles entirely at the Contractor's expense.

.21 Bore piles using power augers to suit diameter and length of piles indicated on drawings. Use only personnel well experienced in this trade and provide to the Departmental Representative as requested, experience record of personnel actually engaged in the work. Remove all tailings and debris from area of bore holes prior to casting concrete. Cover bore hole to prevent loose materials falling in during removal. Distribute tailings from site or distribute on site as per Contractor's Instructions. After hole drilled, place reinforcing steel and concrete. Do not drill any holes, which cannot be reinforced and filled with concrete the same day as drilled.

.22 Place reinforcing steel in such a manner to prevent loose earth and debris from falling into the hole. Place reinforcing at proper elevation and hold during course of placing concrete. Placing of steel will not be allowed after the concrete is poured.

.23 Before commencing placing concrete, obtain Departmental Representative's approval of proposed method of transporting and placing concrete. Form piles projecting above grade with removable steel sleeves or wax coated cardboard fibre forms. Place concrete continuously to final cut-off elevation as soon as possible after hole drilled, cleaned out and reinforcing steel secured in position. Take every care to ensure that hole is completely filled with concrete. Concrete must be placed in the dry. Under no circumstances will tremie concrete be permitted. Protect tops of piles against loss of moisture. When concrete is being placed through a frozen ground surface, the diameter of the portion of the pile surface passing through the frozen ground shall be increased by 100 mm.

END OF SECTION