MUNICIPAL PARKING STRUCTURE AND MTC FACILITY

CITY OF MINNEAPOLIS

PURCHASE ORDER #10014

Gateway

SOIL EXPLORATION COMPANY

soil exploration company

662 CROMWELL AVENUE
ST. PAUL, MN. 55114
PHONE 612/645-6446

a sister corporation to TWIN CITY TESTING AND ENGINEERING LABORATORY INC.

February 19, 1979

City of Minneapolis
211 City Hall
Minneapolis, MN 55401

Attn: Greg Finstad

Gentlemen

Subj: Municipal Parking Structure and MTC Facility
City of Minneapolis
Purchase Order 10014
#120-4204

Attached herewith are four copies of our report covering the preliminary subsurface soil exploration for the proposed parking structure. An additional copy will be sent as noted below. This work was done in accordance with our proposal dated January 16, 1979 and your Purchase Order #10014 dated January 24, 1979.

About 50% of the soil samples will be held at this office for one month and will then be discarded unless we are notified to hold them for a longer period of time.

The opinions expressed in this report are based on the conditions observed at the test boring locations. If different conditions are encountered between borings, we request that we be notified so that these new conditions can be reviewed.

Very truly yours

Steven D Koenes, P.E.

SDK/am

Encs

cc: 1-Boarman Architects Inc
Attn: Eugene C Nelson

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REPORT OF PRELIMINARY SUBSURFACE SOIL EXPLORATION

MUNICIPAL PARKING STRUCTURE AND MTC FACILITY

CITY OF MINNEAPOLIS

PURCHASE ORDER #10014

#120-4204

INTRODUCTION

The proposed parking structure and MTC facility is currently in the preliminary design stages. The exact building size and number of stories has not been determined at this time.

In accordance with our proposal dated January 16, 1979 and your subsequent Purchase Order #10014 dated January 24, 1979, a preliminary subsurface soil exploration has been made. The exploration consisted of four soil test borings. The results of the borings were then reviewed relatively to foundation types and depths, allowable soil bearing pressures and other design considerations that may be influenced by the subsurface soil conditions.

The purpose of this report is to present the results of the preliminary subsurface exploration data and our comments and opinions based on review of this data.

SITE AND SOIL CONDITIONS

Surface Conditions

The site is currently being used as an on-grade parking area. One small building is located along 3rd Street near the center of the block. We

were required to put down the borings on city property. Because of the large amount of snow, borings 1, 9 and 11 were put down in the street and boring 3 was put down on the sidewalk. The surface elevations at boring locations ranged from 96.3' at boring 3 to 101.8' at boring 9 indicating a slight downward slope in an easterly direction.

We have no information regarding past usage of the site and particularly any buildings that may have once occupied the site.

Subsurface Conditions

The subsurface conditions encountered at each test location are illustrated on the attached test boring logs.

A review of these logs suggest that a generlized soil and bedrock profile consists of up to 12' of fill underlain by sand to depths of 20' to 28' below existing grade in turn underlain by clayey sand and sandy clay glacial till to the depth of limestone. Limestone was encountered at depths varying from approximately 30' to 33.2' below existing grade.

The fill consisted primarily of silty sand with some clayey sand and fat clay. We were not able to sample the upper portion of the fill by means of standard penetration testing because of frozen material. The samples which were taken in the lower portion of the fill indicated the density was quite variable. The underlying sand varied from loose to dense. The sandy clay and clayey sand glacial till varied from medium to stiff.

A little gravel was encountered in the glacial till and we anticipate some boulders and cobbles may also be present.

The bedrock encountered on the site was limestone from the Platteville Formation Magnolia and Hidden Falls member. The core recovery in the area of borings 1 and 3 was extremely high. Core recoveries in boring 11 were also quite good however boring 9 encountered limestone slabs above the limestone and based on the recovery, the limestone was more fractured and weathered. The recoveries generally increased with depth.

GROUND WATER

Ground water was encountered in the borings at the time of the exploration. The water level information is shown on the attached boring logs. Based on the available information, it is our judgement, that the actual static ground water level is at a depth of approximately 22' to 27' below existing grade based on our measurements and observation while sampling. Drilling mud was used to advance the borings; therefore, water level information was very difficult to obtain.

The ground water level can be expected to fluctuate both seasonally and yearly.

LABORATORY TESTS

Two samples were selected for laboratory testing. The tests included determination of moisture, density and grain size distribution. The unconfined compressive strength was also determined on two sandy clay samples. The results of the laboratory tests are shown on the boring logs opposite the samples from which the tests were performed or on the attached sheets.

ENGINEERING REVIEW

Project Information

The following data represents our understanding of the project. It comprises an important part of our engineering review. This project is currently in a preliminary design stage. As more information becomes available, we request that you contact us for additional review of the foundation recommendations.

We understand that the proposed parking structure will be multi-story cast-in-place concrete with a post-tensioned slab system. Preliminary plans call for either usage of the entire block or only a portion of the block. If the entire block is used the parking structure would be on the order of three to five-stories. If only a portion of the block is used, the number of stories could increase to as many as nine.

No information regarding structural loads were available at the time of this report. Parking structures typically have large bay spacing and subsequently high loads. We estimate that maximum column loads could be as high as 100 kips per floor.

We have no information regarding lower floor elevation. We understand that no basement level parking is being planned. We estimate that first floor elevation will be at approximately existing grade.

Discussion

At the time of this preliminary exploration, we were not able to put down borings on the property itself. It is important, to complete the soil exploration prior to making final foundation recommendations. We do not anticipate the depth to bedrock will vary dramatically across the site. The depth and quality of fill materials on the site may however vary.

The fill encountered on the site should not be relied upon for support of the proposed parking structure. The fill encountered in the borings was quite variable in density (based on N value) and should be considered compressible.

Leaving the existing fill in the floor slab area may be feasible, provided, some settlement of the lower floor ccn be tolerated. Estimating settlement in fill is extremely difficult and will be mainly dependent on the exact soil types and density encountered within the actual building area. For preliminary purposes, we estimate that floor slab settlements could be on the order of 2". These settlements could be reduced by subcutting approximately 3' and placing 3' of clean compacted sand directly under the floor slab. The clean sand would also reduce potential frost heave problems in the floor slab.

Several foundation alternatives have been reviewed for the proposed structure. These include an excavate and refill program and conventional spread footing construction, excavate and refill plus Vibroflotation, drilled pier foundations and piling. All of the above procedures would be capable of providing support. The economics of one foundation system compared with others may vary with the size of the column loads.

Based on our past experience with similar foundations and similar soil conditions, it is our judgement, that supporting the structure on a deep foundation system of either drilled piers or driven piling would be more economical than an excavate and refill procedure, provided some settlement of the lower floor can be tolerated.

Preliminary Recommendations

The following recommendations are preliminary and should be reviewed by our office prior to finalizing construction plans.

Piles

It is our judgement, that driven piles would provide satisfactory support for the proposed parking structure. The limestone encountered at a depth of approximately 30' below grade should provide excellent pile support. It is our judgement, that a 100 ton working load capacity pile could be attained on or within the upper few feet of limestone.

A 9 5/8" O.D. heavy wall pipe pile driven with an end plate and filled with concrete should be capable of supporting up to 100 tons per pile.

These piles are currently available at a moderately good price and in our opinion would be one of the most economical pile types. Other pile types such as, H-piles and lighter wall pipe piles could be used if heavy wall pipe is not available. H-pile should have rock tips.

The piles should be driven with a hammer with a manufacturer's rated energy of greater than 25000 ft-lbs. A hammer of this size should be capable of driving the piles to required bearing on the limestone.

Testing to establish a driving criteria and that a 100 ton working load capacity can be attained should be performed. In our opinion, the Case-Goble Method of dynamic pile analaysis should provide enough information to establish the driving criteria and verify the 100 ton working load capacity.

Drilled Piers

A drilled pier foundation would also be capable of supporting the proposed parking structure. The drilled piers should be extended to the limestone. Based on the core recoveries, the limestone appears to be quite sound. Any loose slabs and weathered material should be removed and the pier should extend a minimum of 1' into the limestone. It is our judgement, that the limestone would be capable of supporting loads of up to 50 tons per square foot if observed and cored with a pneumatic drill to a minimum of 2 pier diameters.

The drilled piers should have a minimum diameter of 36" to allow proper observation of the bottom. The drilled piers should also be cased full depth during installation. The casings should be removed during concrete placement, always maintaining a positive head of concrete above the bottom of casing.

SITE OBSERVATION AND TESTING

The use of a pile foundation would require testing such as the Case-Goble Method of dynamic pile analysis and also full-time pile observation during the driving of production piles.

The drilled pier foundation would require full-time observation and close observation of the bottom of the shaft including coring to a minimum of 2 diameters.

REMARKS

The above recommendations for a pile foundation and drilled pier foundation are preliminary. Based on our review, it is our judgement, that the cost of these foundation types should be less than alternate types examined and also should be very competitive. The size of the column loads may effect the economics of the two systems slightly and therefore once the column loads have been established our recommendations should be reviewed.

FIELD EXPLORATION METHODS

Test Borings

Four soil test borings (#1, 3, 9 and 11) were put down between the dates of February 6 and February 9, 1979. The borings were put down at the locations shown on the attached sketch. The surface elevations were referenced to the top of hydrant located on the southeast corner of 4th Avenue and Washington. This elevation was taken as 829.54'.

Sampling

Soil sampling was done in accordance with ASTM: D 1586-67. Using this procedure, a 2" O.D. split barrel sampler is driven into the soil by a 140 lb weight falling 30". After an initial set of 6", the number of blows required to drive the sampler an addition 12" is known as the penetration resistance or N value. The N value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. Rock core samples were obtained by rotary drilling in accordance with ASTM: D 2113-70.

Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM: D 2488-69. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were submitted to a program of laboratory tests. Logs of the borings indicating the depth and identi-

fication of the various strata, the N value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are attached. Charts illustrating the soil classification procedure, the descriptive terminology and symbols used on the boring logs are also attached.

LIMITATIONS OF EXPLORATION

The recommendations and/or suggestions contained in this report are our opinions based on data which are assumed to be representative of the site explored, but because the area of the borings in relation to the entire area is very small, and for other reasons, we do not warrant conditions below the depths of our borings, or that the strata logged from our borings are necessarily typical of the entire site.

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Steven D. Koenes

Steven D Koenes, P.E.

Date 2-20-79 Reg.No. 13180

LOG OF TEST BORING

JOB NO. 120-4204 VERTICAL SCALE 1" = 4' BORING NO 1

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 826.7')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	FILL, mostly SILTY SAND, dark grayish brown, frozen to 3½', a layer of concrete at the surface	FILL			1	HSA				
5	SANDY CLAY, black, soft (CL) (may be fill)	FILL OR TOPSOIL			2	HSA				
7½	SAND, medium grained, a little gravel, light brown to brown, moist to 22' then waterbearing, loose to dense (SP)	COARSE ALLUVIUM	5		3	SS				
			11		4	SS				
			16		5	SS				
			14	▼	6	SS				
			21		7	SS				
26	SANDY CLAY, a little gravel, gray, stiff (CL-SC)	TILL								
30			13 / 0.5		8	SS				
	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 1 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	LIMESTONE, light brownish gray with a few lenses of brown	PLATTEVILLE FORMATION Magnolia Member	100%			BX				
			100%			BX				
		Hidden Falls Member								
39.7	End of Boring									

R = percent core recovery

*No measurement recorded due to presence of coring fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-9		27'	24½'	24½'	to	22'
2-9	11:00	39.7'	30.0'		to	*
2-9	11:15	39.7'	None		to	*
					to	

START 2-8-79 COMPLETE 2-9-79

METHOD 3¼ HSA 0' - 29' @ 11:00

BWC 0' - 30.0'

BX diamond bit-cored 30.0'-39.7'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 3

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 825.8')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mostly SILTY SAND, a little brick, gravel and concrete, dark brown, brown and dark grayish brown, frozen to 3', a concrete sidewalk at the surface	FILL		*	1	HSA				
			8		2	SS				
			19		3	SS				
			12		4	SS				
11½	SAND, medium to fine grained, a little gravel, light brown, moist, medium dense (SP)	COARSE ALLUVIUM	9		5	SS				
14½	SAND, medium to coarse grained, some gravel, brown, moist, dense (SP-SM)		22		6	SS				
20	SANDY CLAY, a little gravel, gray, stiff to rather stiff (CL)	TILL	19		7	SS	15	117		3800
			15		8	SS				
26	SILTY SAND, a little gravel, grayish brown, wet, dense (SM)				9	SS				
29.4										
30	LIMESTONE, light brownish gray with									

Continued on next page

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 3 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	LIMESTONE (Cont.), a few lenses of brown to about 38½' then gray, weathered and fractured at about 37½' - 38½'	PLATTEVILLE FORMATION Magnolia Member	100%			BX				
			100%			BX				
		Hidden Falls Member								
39.8	End of Boring									

R = percent core recovery

*A little water may exist below depth of about 26' based on observation while sampling.

**No measurement recorded due to presence of coring fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-7	11:00	29½'	29½'	29½'	to	None*
2-8	12:20	39.8'	29.8'		to	**
2-8	1:20	39.8'	None		to	**
					to	

START 2-7-79 COMPLETE 2-8-79

METHOD 3¼ HSA 0' - 29½' @ 12:20

BWC 0' - 29.8'

BX diamond bit-cored 29.8'-39.8'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4204 VERTICAL SCALE 1" = 4' BORING NO 9

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 831.3')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	SILTY SAND, a little gravel, brown, a layer of concrete at the surface (SM) (may be fill)	FILL OR COARSE ALLUVIUM			1	HSA				
4	SAND, medium grained, a little gravel, light brown, moist to 27' then waterbearing, medium dense to dense to medium dense (SP)	COARSE ALLUVIUM			2	HSA				
			13		3	SS				MA
			14		4	SS				
			12		5	SS				
			21		6	SS				
			12	▼	7	SS				
28	SANDY CLAY, a little gravel, gray, medium (CL)	TILL								
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 9 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	SANDY CLAY (Cont.)		7		8	SS	24	102		1700
32	LIMESTONE SLABS, gray, with a few pieces of gravel	COLLUVIUM								
33.6±	LIMESTONE, light brownish gray with a few lenses of brown	SEE NOTE: Magnolia Member	77%			BX				
			80%			BX				
			100%			BX				
			95%			BX				
42.8	End of Boring									
	R = percent core recovery *No measurement recorded due to presence of coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

START 2-9-79 COMPLETE 2-9-79

METHOD 3¼ HSA 0'-29½' @ 4:00

BWC 0' - 32.0'

BX diamond bit-cored 32.0'-42.8'

CREW CHIEF Holan

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-9		27'	24½'	27'	to	27'
2-9	4:00	42.8'	32.0'		to	*
2-10	9:15	42.8'	None		to	*

SOIL EXPLORATION company
662 CROMWELL AVENUE SOIL EXPLORATION company ST PAUL, MN 55114

SE-2 (77-B) 4

LOG OF TEST BORING

JOB NO. 120-4204 VERTICAL SCALE 1" = 4' BORING NO. 11

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 828.9')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND and CLAYEY SAND, a little fat clay and gravel, brown, dark brown and gray, frozen to 6', a layer of concrete at the surface	FILL			1	HSA				
					2	HSA				
			3		3	SS				
12	SAND, medium grained, a little gravel, light brown, moist, medium dense to dense (SP)	COARSE ALLUVIUM	9		4	SS				
15½	SAND, fine grained, light brown, moist, dense (SP)		17		5	SS				MA
			20		6	SS				
21	SAND, medium grained, a little gravel, brown, moist to about 24' then waterbearing, medium dense (SP)			*						
			13		7	SS				
26	CLAYEY SAND, a little gravel, gray, medium, a layer of gravel below 32' (SC)	TILL								
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 11 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	CLAYEY SAND (Cont.)		8		8	SS				
33.2	LIMESTONE, light brownish gray with a few lenses of brown to about 41½' then gray	PLATTEVILLE FORMATION Magnolia Member	95%			BX				
			98%			BX				
		Hidden Falls Member								
43.0	End of Boring									

R = percent core recovery

*Water level shown (24') is an estimate based on observation while sampling.

**No measurement recorded due to presence of coring fluid.

START 2-6-79 COMPLETE 2-6-79

METHOD @ 1:30

3¼ HSA 0'-14½', BWC 0'-33.3'
BX diamond bit-cored 33.3'-43.0'

CREW CHIEF Holan

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
2-6	1:30	43.0'	33.3'		to	**
2-6	2:00	43.0'	None		to	**

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE ST PAUL MN 55114

SIEVE ANALYSIS TESTS

PROJECT Municipal Parking Structure and MTC Facility DATE 2-14-79

City of Minneapolis - P.O. #10014

REPORTED TO JOB NO. 120-4204

BORING NO.	9	11		
SAMPLE NO.	3	5		
DEPTH (ft)	10-11	15-16		
TYPE OF SAMPLE				
CLASSIFICATION (ASTM: D 2487) Symbol	SP-SM	SP		
Description	Sand	Sand		
MECHANICAL ANALYSIS: Dry Weight of Total Sample (grams)	183	171		
Based on Total Sample Gravel - % (On # 4)	1	0		
Based on - 4 Material Sand - % (# 4 – #10)	2	0		
(# 10 – #40)	71	27		
(# 40 – #100)	19	66		
(# 100 – #200)	2	3		
Fines - % (# 200 Down)	6	4		

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS

SYMBOL	DEFINITION
C.S.	Continuous Sampling
P.D.	2-3/8" Pipe Drill
C.O.	Cleanout Tube
3¼ HSA	3¼" I.D. Hollow Stem Auger
4 FA	4" Diameter Flight Auger
6 FA	6" Diameter Flight Auger
2½ C	2½" Casing
4C	4" Casing
D.M.	Drilling Mud
J. W.	Jet Water
H. A.	Hand Auger
NXC	Size NX Casing
BXC	Size BX Casing
AXC	Size AX Casing
SS	2" O.D. Split Spoon Sample
2T	2" Thin Wall Tube Sample
3T	3" Thin Wall Tube Sample

LABORATORY TEST SYMBOLS

SYMBOL	DEFINITION
W	Moisture content - percent of dry weight
D	Dry density-pounds per cubic foot
LL, PL	Liquid and plastic limits determined in accordance with ASTM D 423 and D 424
Qu	Unconfined compressive strength-pounds per square foot in accordance with ASTM D 2166-66

Additional insertions in Qu column

Pq	Penetrometer reading-tons/square foot
Ts	Torvane reading-tons/square foot
G	Specific gravity - ASTM D 854-58
SL	Shrinkage limit - ASTM D 427-61
pH	Hydrogen ion content-meter method
O	Organic content-combustion method
M.A.*	Grain size analysis
C*	One dimensional consolidation
Qc*	Triaxial compression

*See attached data sheet and/or graph

WATER LEVEL

SYMBOL – ▼

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable ground water levels. In clay soil, it is not possible to determine the ground water 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 ground water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY

TERM	"N" VALUE
Very loose	0-4
Loose	5-8
Medium Dense	9-15
Dense	16-30
Very Dense	Over 30

CONSISTENCY

TERM	"N" VALUE
Soft	0-4
Medium	5-8
Rather Stiff	9-15
Stiff	16-30
Very Stiff	Over 30

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon.

RELATIVE PROPORTIONS

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

PARTICLE SIZES

Boulders	Over 3"
Gravel	
Coarse	¾"-3"
Fine	#4-¾"
Sand	
Coarse	#4-#10
Medium	#10-#40
Fine	#40-#200
Silt and Clay	Determined by plasticity Characteristics

Note: Sieve sizes shown are U.S. Standard

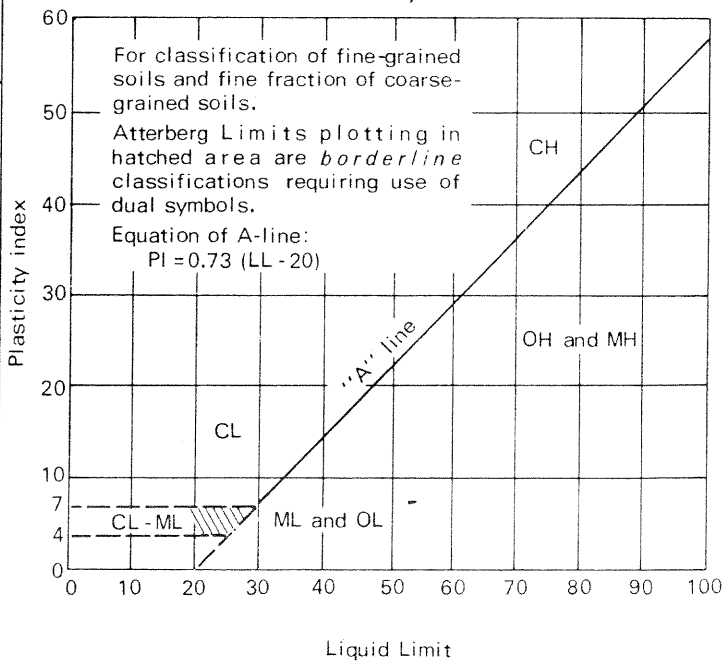
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 69 AND D 2488 – 69

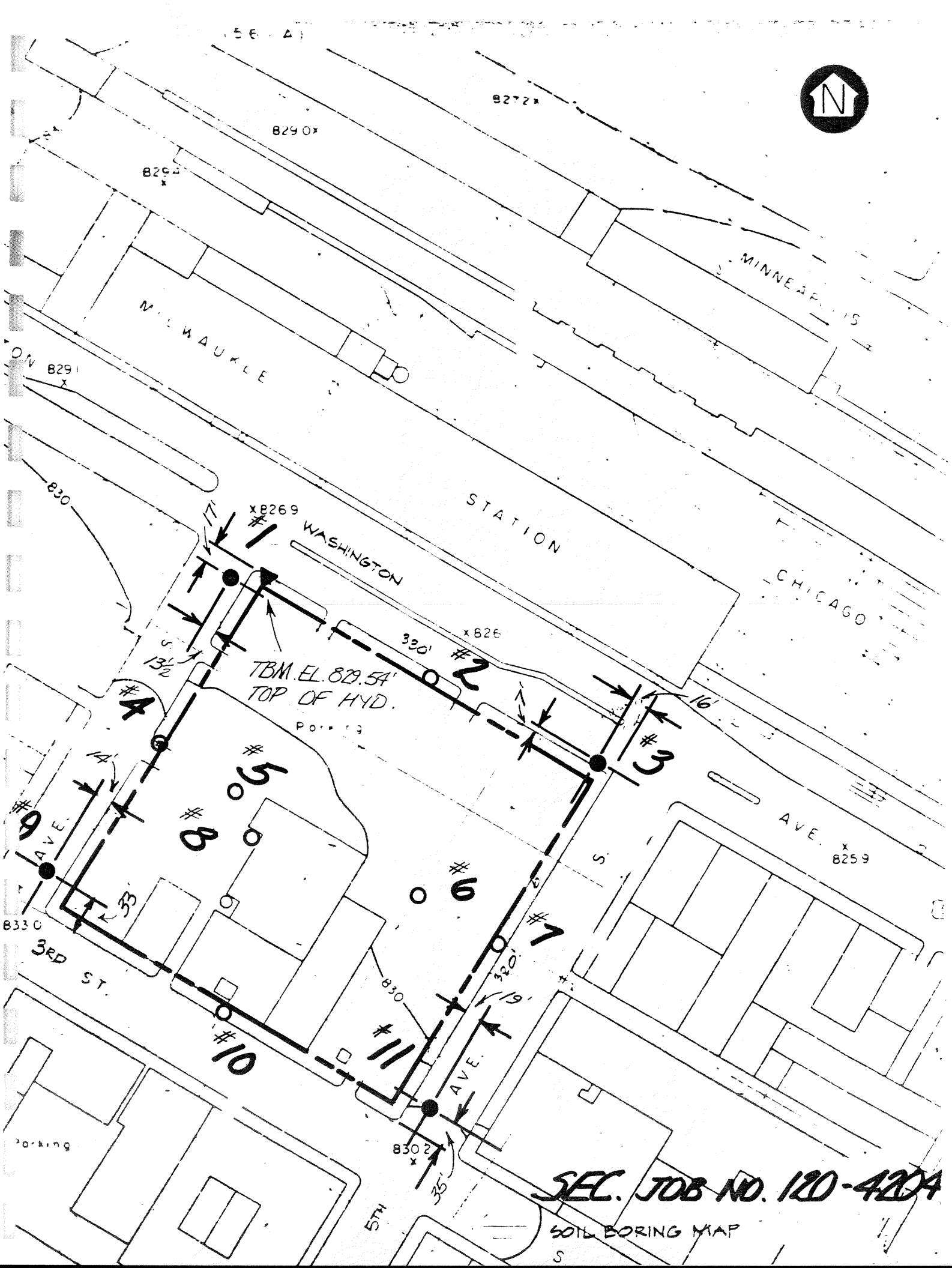
(Unified Soil Classification System)

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	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	$C_U = \frac{D_{60}}{D_{10}}$ 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	
	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	
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			

Plasticity Chart



*Based on the material passing the 3 in. (76 mm) sieve.


N
MILWAUKEE
MINNEAPOLIS
STATION
CHICAGO
WASHINGTON
AVE.
3RD ST.
5TH
TBM. EL. 829.54'
TOP OF HYD.
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
829.0
829.3
827.2
829.1
830
826.9
826
825.9
833.0
830.2
17'
13½'
16'
14'
33'
19'
35'
330'
320'
SEC. JOB NO. 120-4204
SOIL BORING MAP