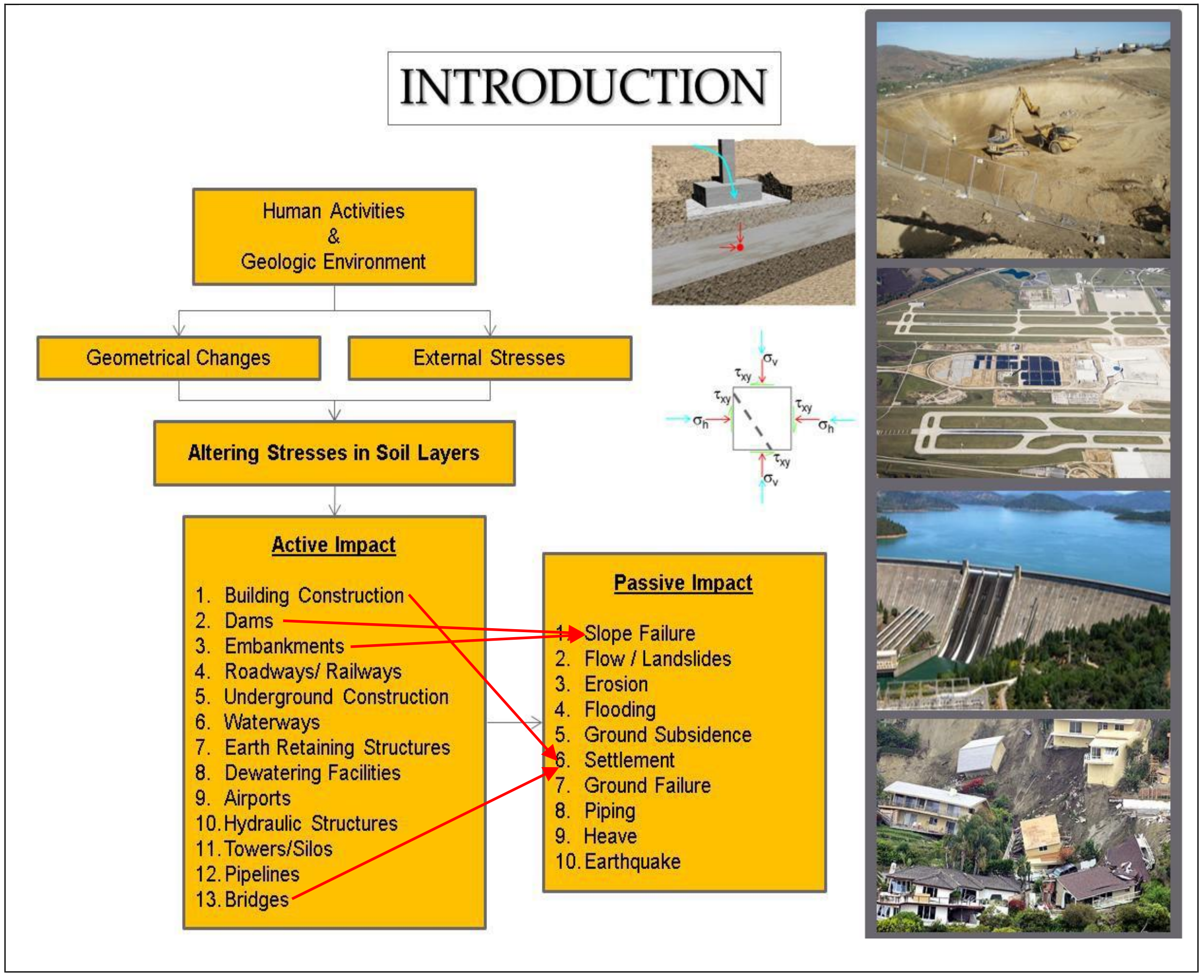
FAMU-FSU COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL & ENVIRONMENTAL
ENGINEERING INTRODUCTION

Fall 2024

What is Geotechnical Engineering?

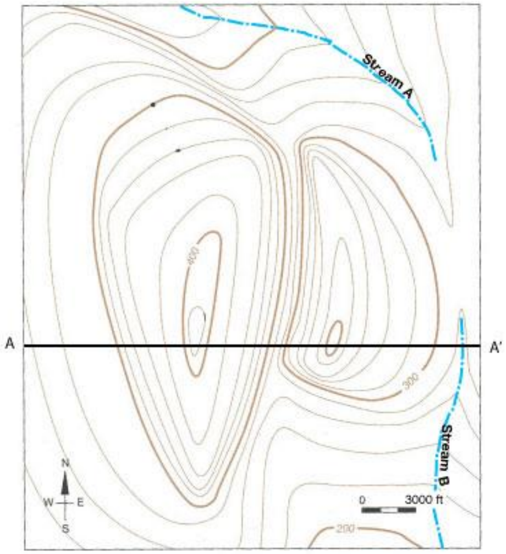
It is the art and the science of utilizing the scientific principles of the soil mechanics, rock mechanics, soil dynamics, and engineering geology to analyze and design different soil and soil-structure interaction systems.

To work on any geotechnical project, one needs to understand the interaction between the human activities and the geologic environment (**Why ??????????)**

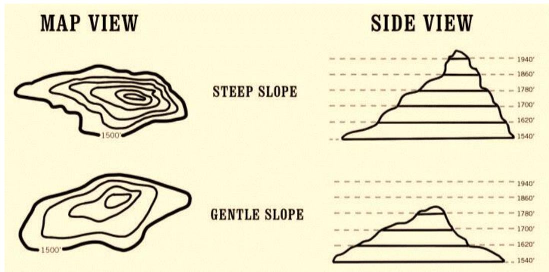


Contour Map, Proposed Project, Boring Locations, Soil Profile

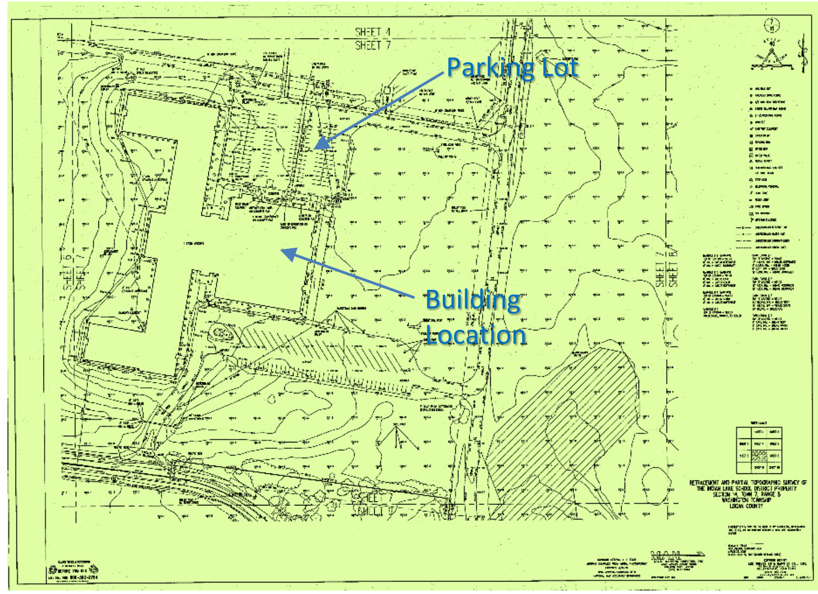
Contour Map



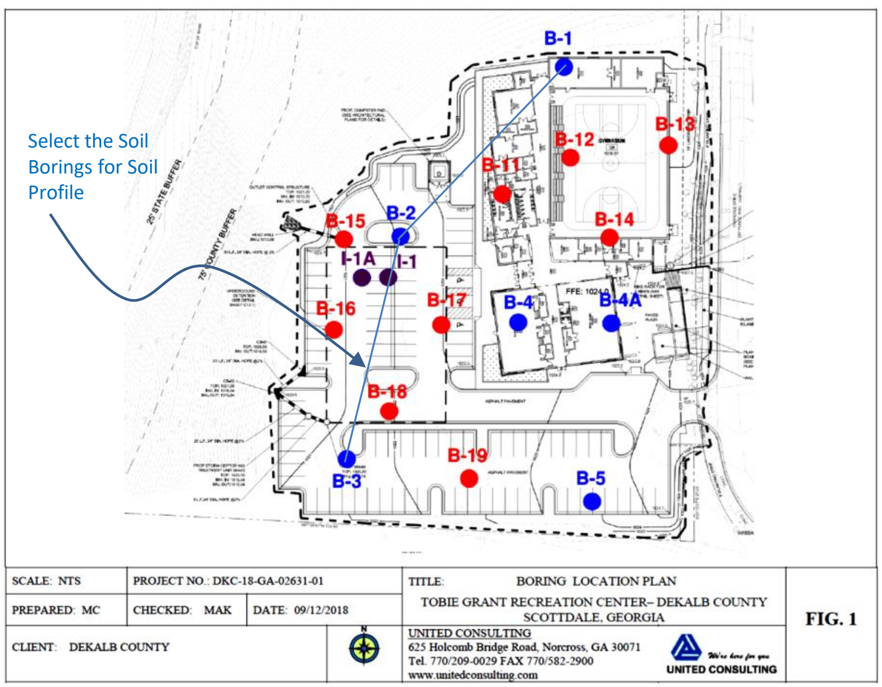
Interpretation of the Topo Maps



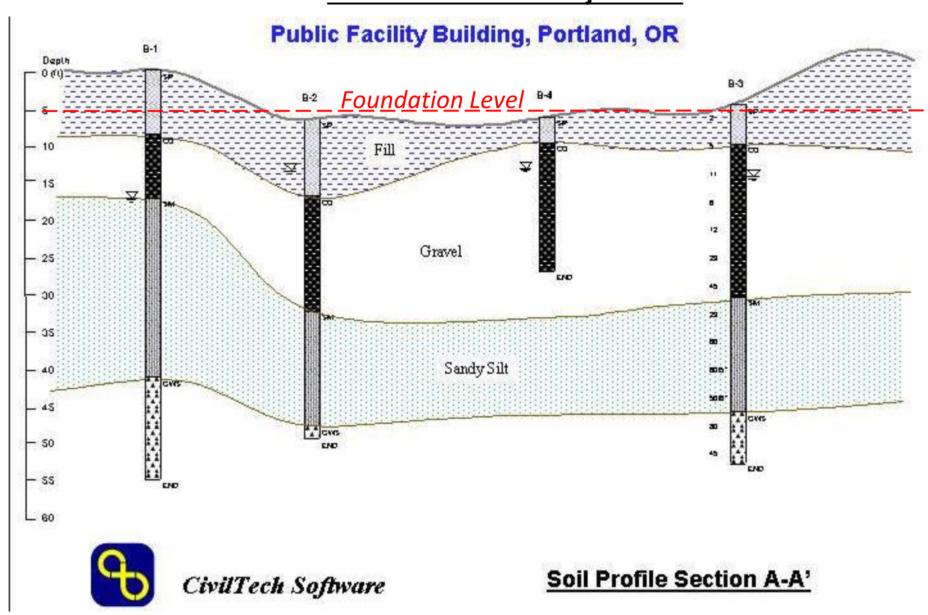
Contour Map & Location of the Project



Contour Map & Location of the Project & Soil Borings' Locations



Soil Profile at the Project Site



The Basis for an Adequate Assessment of any Project Geotechnical Investigation

Geotechnical Investigation

I. Site Exploration

The general objectives of the exploration program for any project are:

1. *Define the depth of the proposed foundation*
2. *Evaluate the load-bearing capacity of the foundation*
3. *Estimate the settlement*
4. *Identify potential foundation problems*
5. *Define ground water conditions*
6. *Predict lateral earth pressure*
7. *Establish method of construction*
8. *Determine suitability of the site material for construction*

II. Measurements of Soil Properties

III. Field Instrumentation

IV. Identify Engineering Problems

The site exploration program should include the following:

1-1 Data Collection

1. *Location and Type of structure*
2. *General use of the structure*
3. *Column load*
4. *Column spacing*
5. *Building code*
6. *Basement requirements*
7. *Topography maps*
8. *Geologic maps*
9. *Soil maps*
10. *Groundwater maps*
11. *Reports, Aerial photographs, satellite images, etc.*

1-2 Subsurface Sectioning:

This step includes the following:

1. Test pits (for shallow depths)
2. Auger boring (Manual, Mechanical)
3. Core boring

The depth and the interval of the subsurface sectioning is governed by:

1. Type of construction
2. Column Load
3. Column Spacing

Test boring is the most usable method

In planning and executing the test Boring you need to know:

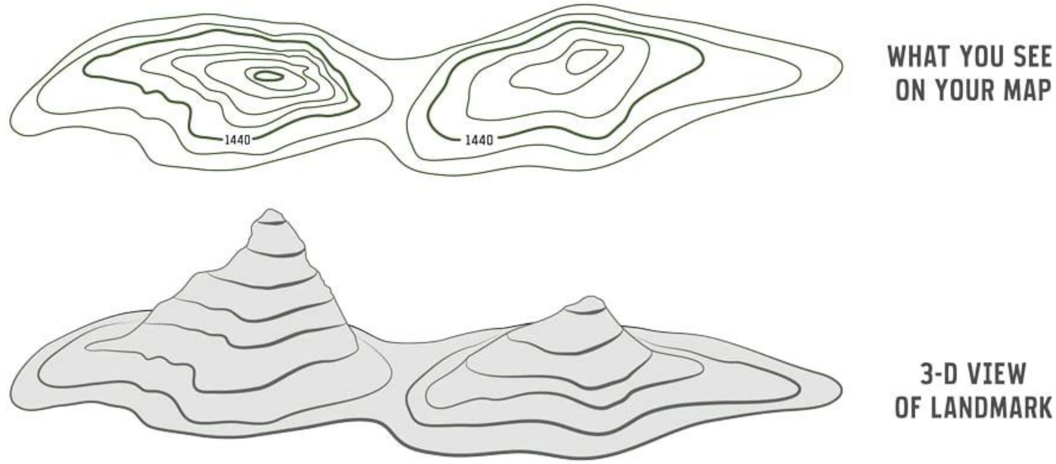
1- Equipment Selection

1. - Boring Spacing
2. - Boring Depths

Geotechnical Investigation

1- Surface Mapping

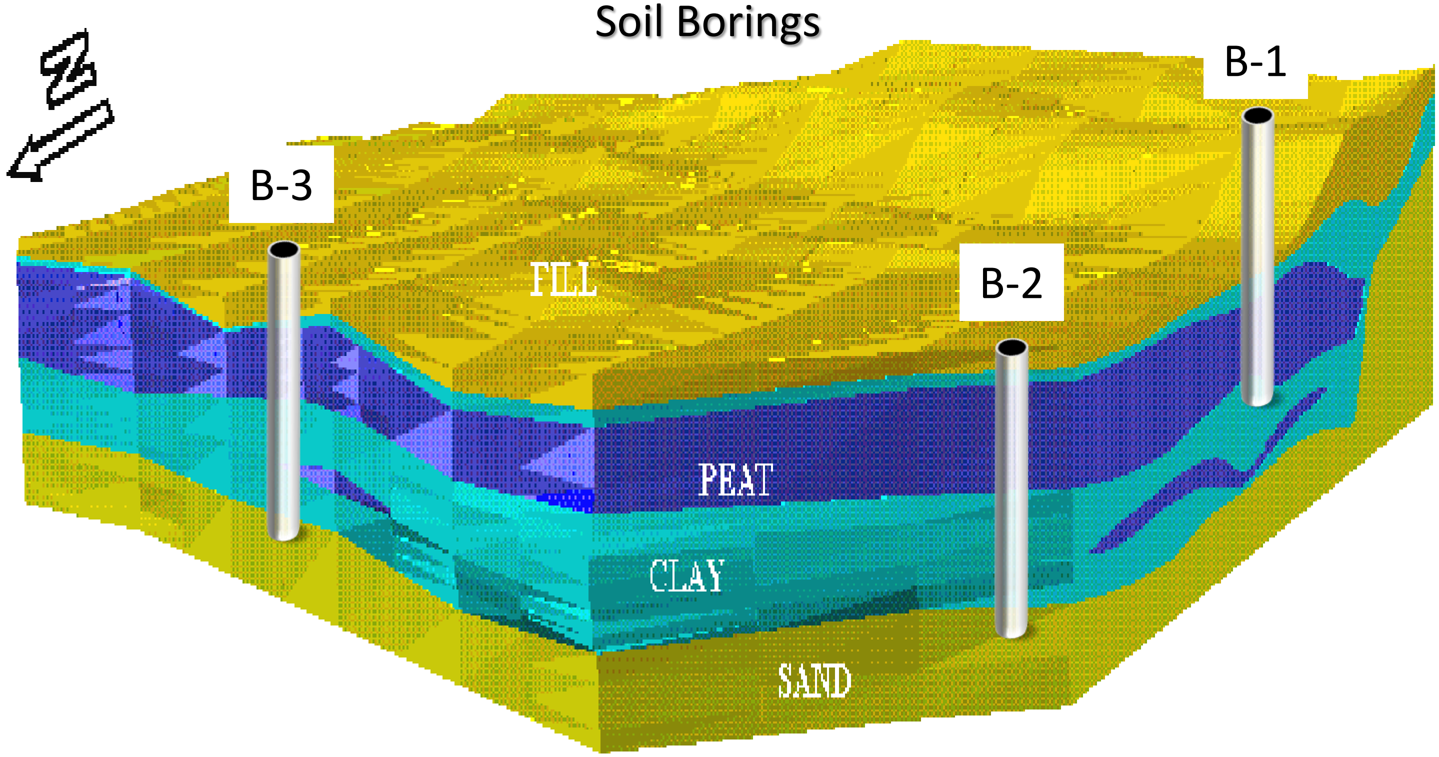
Surveying



2- Subsurface Sectioning

Soil Samples for Testing

Soil Borings



Boring Spacing

Depending on the area under study. Grid systems may be appropriate in uniform conditions. The spacing usually range from 30 ft to 1600 ft. The following spacing may be adopted for

wide range of constructions:

Multistory buildings	*30 ft to 100 ft*
Residential subdivision	*800 ft to 1600 ft*
Warehouses, Industrial plants	*60 ft to 200 ft*
Dams and Dikes	*130 ft to 260 ft*
Highways and railways	*800 ft. to 1600 ft.*

In general spacing may vary depending on the irregularity of the site geology.

Depth of Boring

Boring should be extended through any unsuitable foundation strata (unconsolidated fill, organic soils, compressible layers) until soil of acceptable bearing capacity is reached.
In general, boring should be extended to at least 1.5 to 2 times the minimum width of the loaded area.

In the case of vary heavy structures (bridges), boring in most cases are extended to bed rock, or at least one boring should be extended to bedrock.

The following empirical equations can be used to estimate the minimum depth of borings in office buildings:

$D_{boring} = 3\ S^{0.7}$ *(for light steel or narrow concrete buildings)*

$D_{boring} = 6\ S^{0.7}$ *(for heavy steel or wide concrete buildings)*

where S = number of stories in meter

1-3 Sample Recovery

Soil samples obtained during subsurface sectioning are either:

I. Disturbed
II. Undisturbed

Disturbed soil samples are used for:

- Grain size analysis
- Determination of index properties
- Organic content
- Specific gravity

Undisturbed samples are used for:

- As above
- Determining mechanical properties
- Determining hydraulic properties

Methods Of Sample Recovery

1. By hand
2. Split spoon
3. Scraper bucket
4. Thin wall tube (Shelby tube)

- Split spoon sampling method is used to obtain disturbed and undisturbed samples.
- The sampler is driven into the soil by a hammer.
- The weight of the hammer is 140 lb.
- The number of blows (N) required to penetrate the spoon of three 6 in. intervals are added and recorded.

This procedure is called the Standard Penetration Test (SPT)

Actually, the Standard Penetration Number N is the number of blows (N) of the last two intervals (12 in). The first interval (6 in.) is usually discarded (why ???).

<u>THE STANDARD PENETRATION TEST (SPT)</u>

The SPT which was developed in 1902 by Colonel Charles Gow of the Raymond Pile Company. Karl Terzaghi in 1947 recommended seating correction for the SPT values.

It is currently one of the most popular and economical in situ test to obtain subsurface information.

It is estimated that 85% to 90% of conventional foundation design in the USA is made using the SPT.

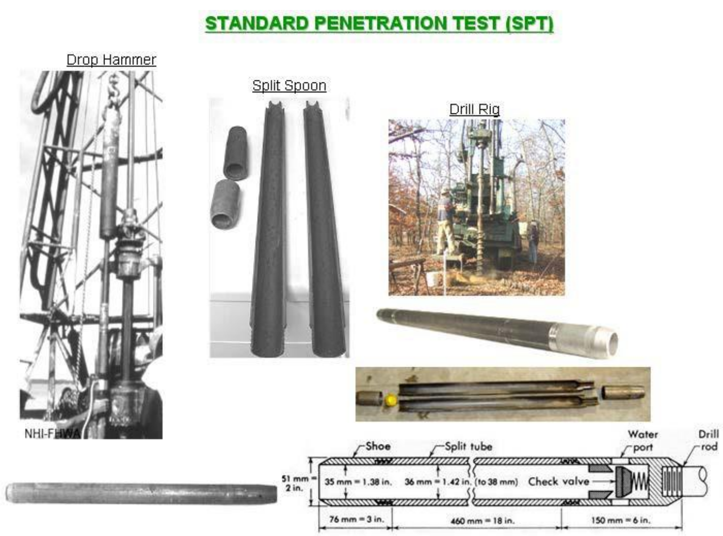
The testing method was standardized in 1958 as ASTM D1586.

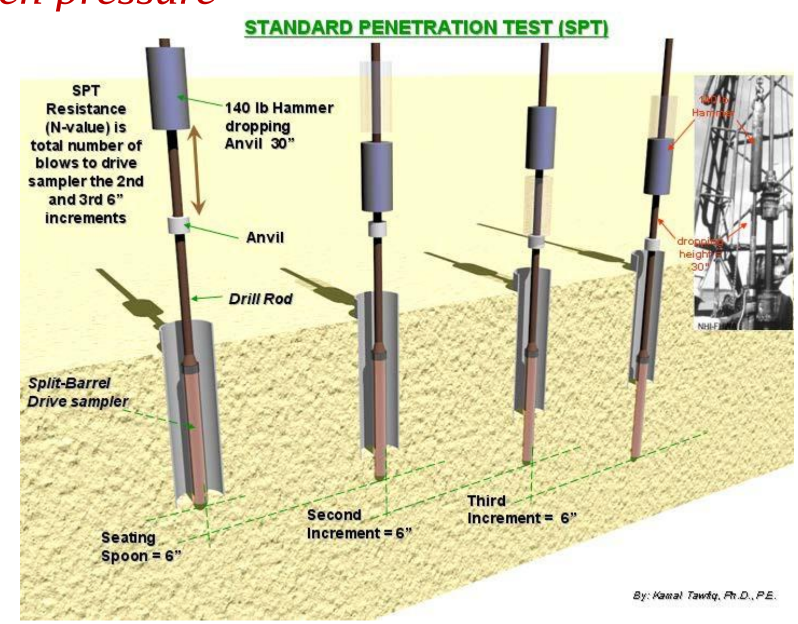
The test consists of:

- *Using a 140 lb driving mass (W) falling free from a height of 30 in. (h) to*
- *Drive the standard split spoon sampler a distance of 18 in. into the soil, and*
- *Counting the number of blows (N) to drive the sampler 12 in. (6 in. + 6 in.).*
- *Theoretical free-fall energy of the SPT hammer* $E_{theo} = W.h = (140\ lb)(30in) = 4200\ in\text{-}lb.$
- *The boring log should show "refusal" and should be halted if:*

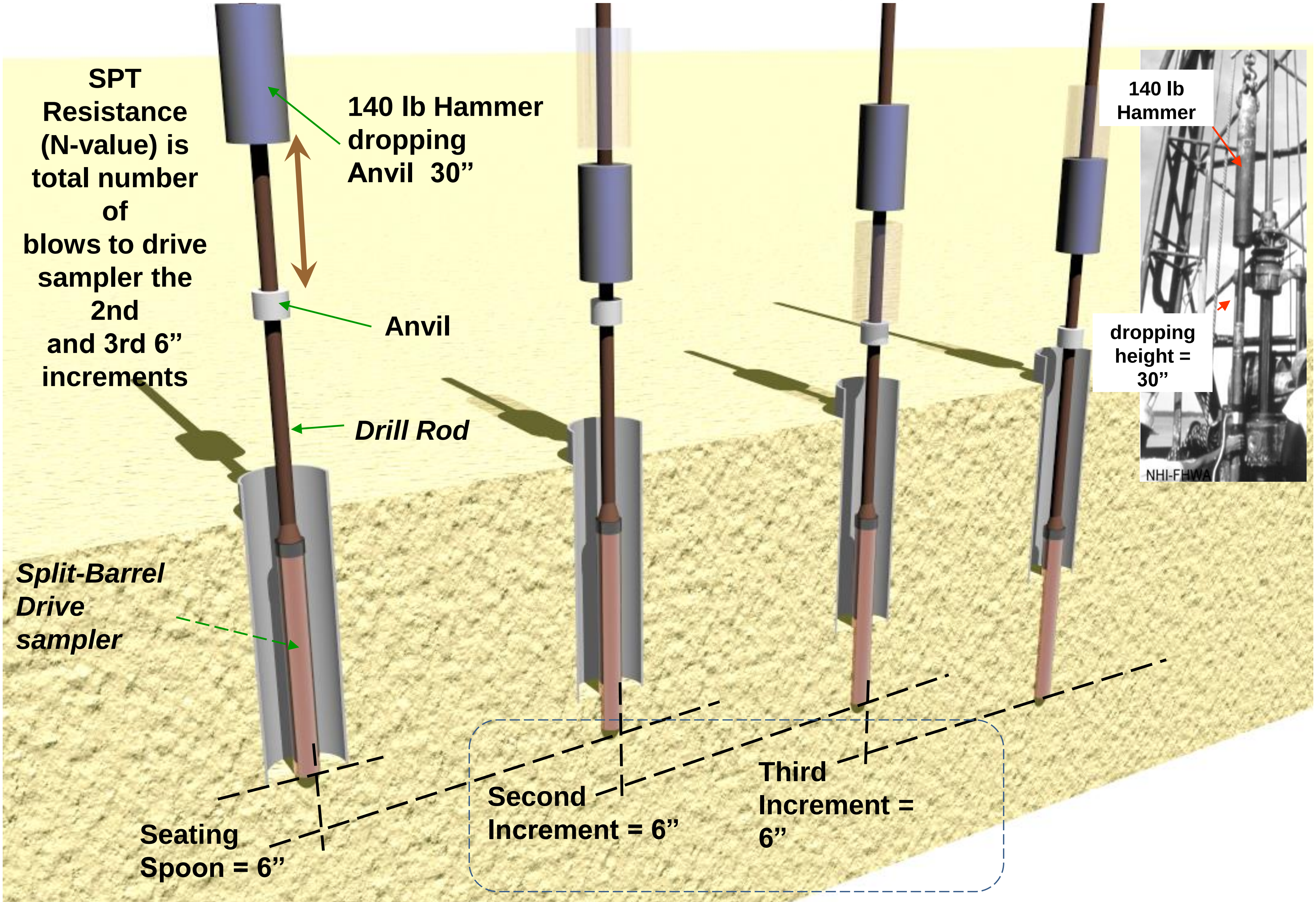
  a- 50 blows are required for any 150 mm increment b- 100 blows are obtained

  c- 10 successive blows produced no advance.
- *- N should be corrected for the increase of the overburden pressure*





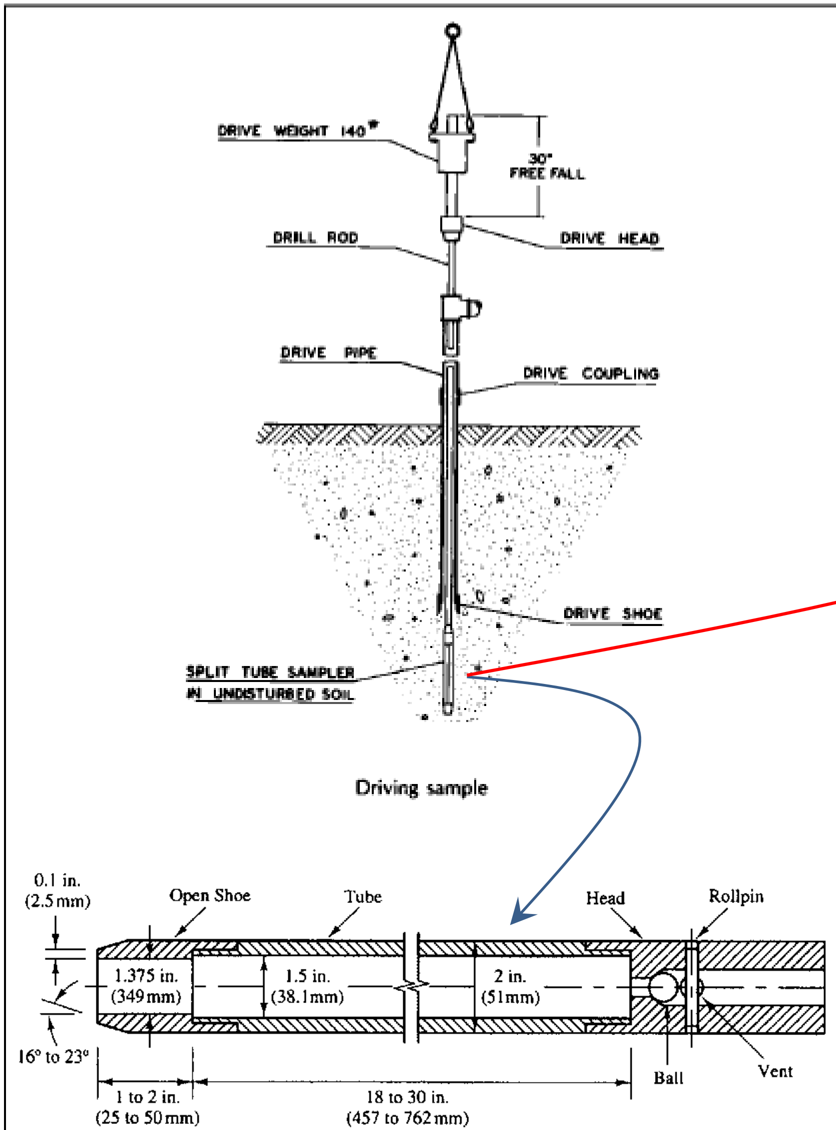
STANDARD PENETRATION TEST (SPT)



1. Record N for the all the increments (6"+6"+6")
2. You N_{field} value – is only for second and third increments
3. Correct N_{field} to N_{60} -- This is the value that you use in the design

$$N_{60} = 1.67\, E_m C_b C_r N$$

Soil Sampling - Split Spoon
Used in the Standard Penetration Test (SPT)



The SPT sampler (Adapted from ASTM D1586; Copyright ASTM, used with permission)

The following video shows the procedure of the
Standard Penetration Test
SPT

STANDARD PENETRATION TEST (SPT)

SPT vs. Relative Density of Sand

Meyerhoff (1956)

State of Packing	Relative Density	Standard Penetration Resistance (N)	Static Cone Resistance (q_c)	Angle of Internal Friction (ϕ')
	Percent	Blows / ft	Tsf or kgf/cm^2	Degrees
Very Loose	< 20	< 4	< 20	< 30
Loose	20 – 40	4 –10	20 – 40	30 – 35
Compact	40 – 60	10 –30	40 – 120	35 – 40
Dense	60 – 80	30 – 50	120 – 200	40 – 45
Very Dense	> 80	> 50	> 200	> 45

SPT vs. Undrained Shear Strength

Soil Consistency	SPT N	S_u (psf)	S_u (kPa)
Very Soft	< 4	< 250	< 12
Soft	2 – 4	250 – 500	12 – 25
Medium	4 - 8	500 – 1000	25 – 50
Stiff	8 – 15	1000 – 2000	50 – 100
Very Stiff	15 – 30	2000 – 4000	100 – 200
Hard	> 30	> 4000	> 200

Terzaghi et al. (1996)

Corrections are normally applied to he SPT blow count to account for differences in:
energy imparted during the test (60% hammer efficiency) the stress level at the test depth

The following equation is used to compensate for the testing factors (Skempton, 1986):

$$N_{60} = 1.67\, E_m C_b C_r N$$

Field Number of Blows (N_{field})

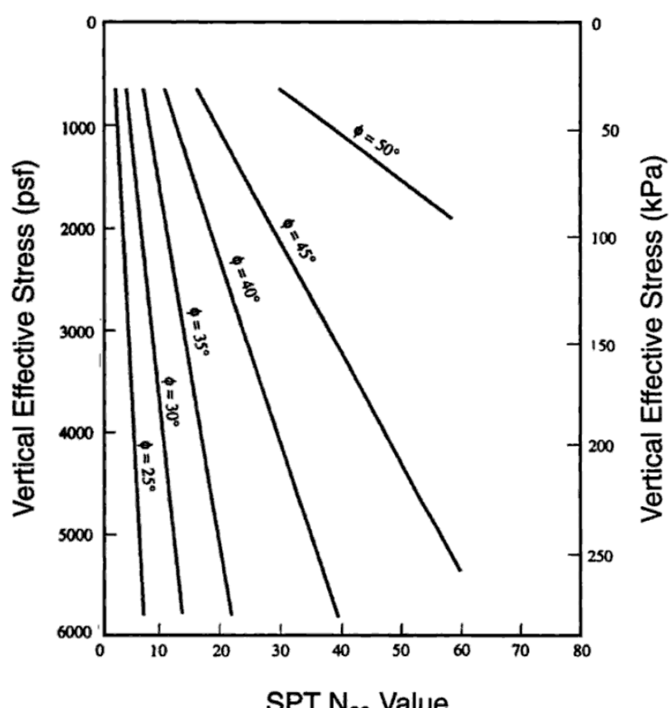
where N_{60} = SPT N-value corrected for field testing procedures

E_m = hammer efficiency (for U.S. equipment, E_m equals 0.6 for a safety hammer and equals 0.45 for a doughnut hammer)

C_b = borehole diameter correction (C_b = 1.0 for boreholes of 65- to 115-mm diameter, 1.05 for 150-mm diameter, and 1.15 for 200-mm diameter hole)

C_r = rod length correction (C_r = 0.75 for up to 4 m of drill rods, 0.85 for 4 to 6 m of drill rods, 0.95 for 6 to 10 m of drill rods, and 1.00 for drill rods in excess of 10 m)

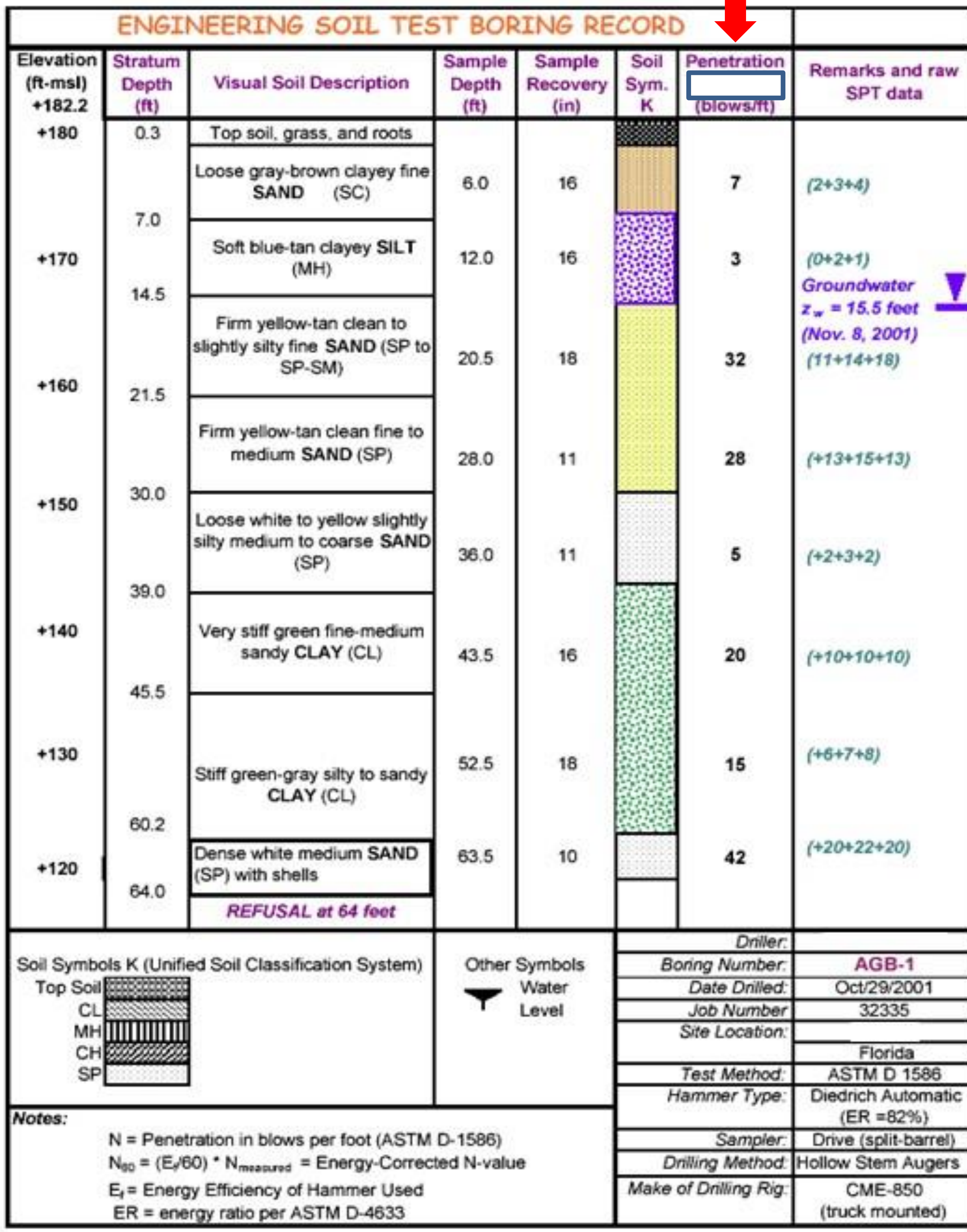
N = measured SPT N-value



Empirical correlation between SPT N_{60} value, vertical effective stress, and friction angle for clean quartz sand deposits. (*Adapted from DeMello, 1971; reproduced from Coduto, 1994.*)

Presenting SPT in the Geotechnical Report

SPT



ENGINEERING SOIL TEST BORING RECORD

Elevation (ft-msl) +182.2	Stratum Depth (ft)	Visual Soil Description	Sample Depth (ft)	Sample Recovery (in)	Soil Sym. K	Penetration (blows/ft)	Remarks and raw SPT data
+180	0.3	Top soil, grass, and roots					
		Loose gray-brown clayey fine **SAND** (SC)	6.0	16		**7**	(2+3+4)
+170	7.0	Soft blue-tan clayey **SILT** (MH)	12.0	16		**3**	(0+2+1) Groundwater z_w = 15.5 feet (Nov. 8, 2001)
	14.5	Firm yellow-tan clean to slightly silty fine **SAND** (SP to SP-SM)	20.5	18		**32**	(11+14+18)
+160	21.5	Firm yellow-tan clean fine to medium **SAND** (SP)	28.0	11		**28**	(+13+15+13)
+150	30.0	Loose white to yellow slightly silty medium to coarse **SAND** (SP)	36.0	11		**5**	(+2+3+2)
+140	39.0	Very stiff green fine-medium sandy **CLAY** (CL)	43.5	16		**20**	(+10+10+10)
+130	45.5	Stiff green-gray silty to sandy **CLAY** (CL)	52.5	18		**15**	(+6+7+8)
+120	60.2	Dense white medium **SAND** (SP) with shells	63.5	10		**42**	(+20+22+20)
	64.0	*REFUSAL at 64 feet*					

Soil Symbols K (Unified Soil Classification System)
Top Soil
CL
MH
CH
SP

Other Symbols
Water Level

Driller:	
Boring Number:	AGB-1
Date Drilled:	Oct/29/2001
Job Number:	32335
Site Location:	Florida
Test Method:	ASTM D 1586
Hammer Type:	Diedrich Automatic (ER =82%)
Sampler:	Drive (split-barrel)
Drilling Method:	Hollow Stem Augers
Make of Drilling Rig:	CME-850 (truck mounted)

Notes:

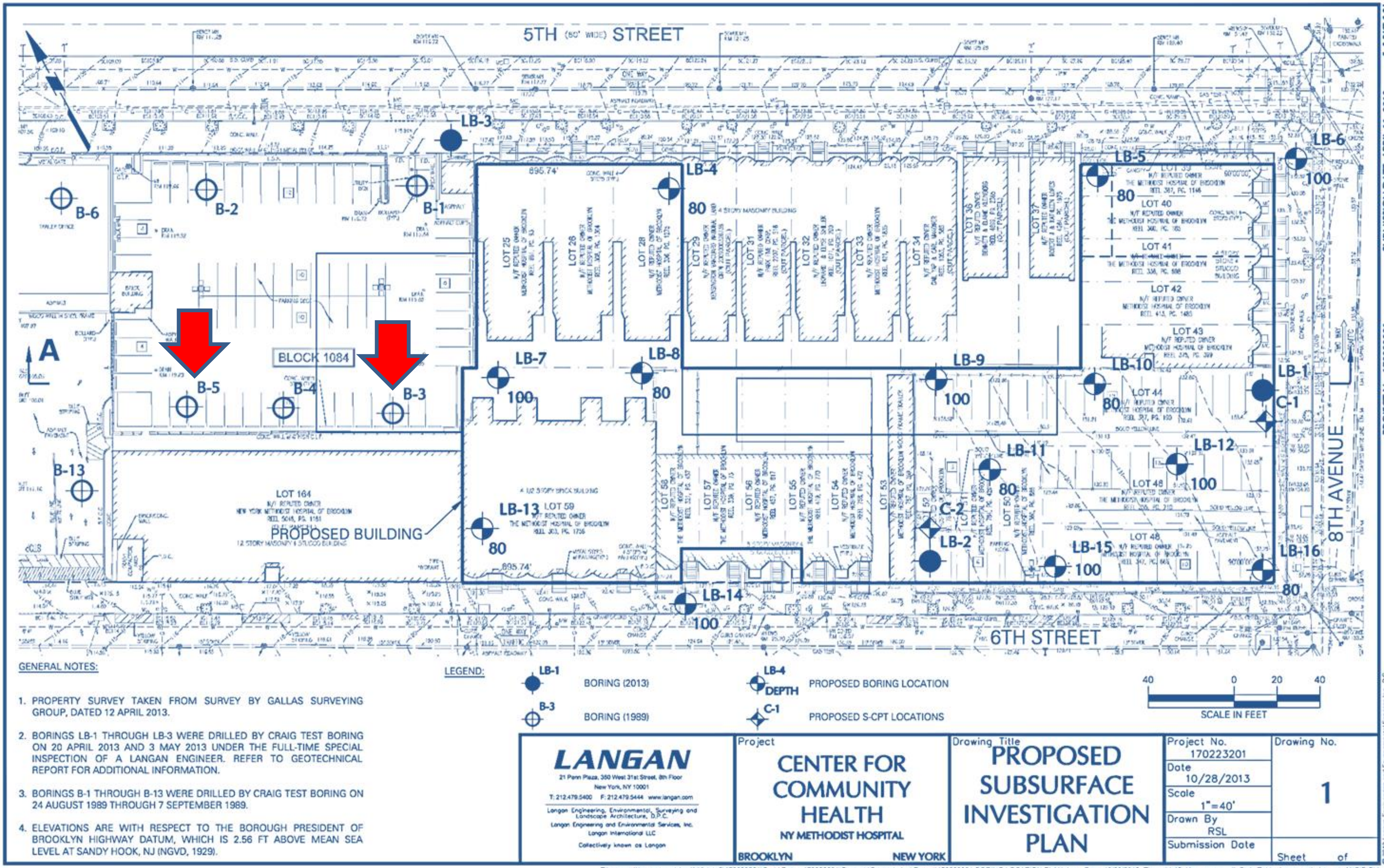
N = Penetration in blows per foot (ASTM D-1586)

$N_{60} = (E_f/60) * N_{measured}$ = Energy-Corrected N-value

E_f = Energy Efficiency of Hammer Used

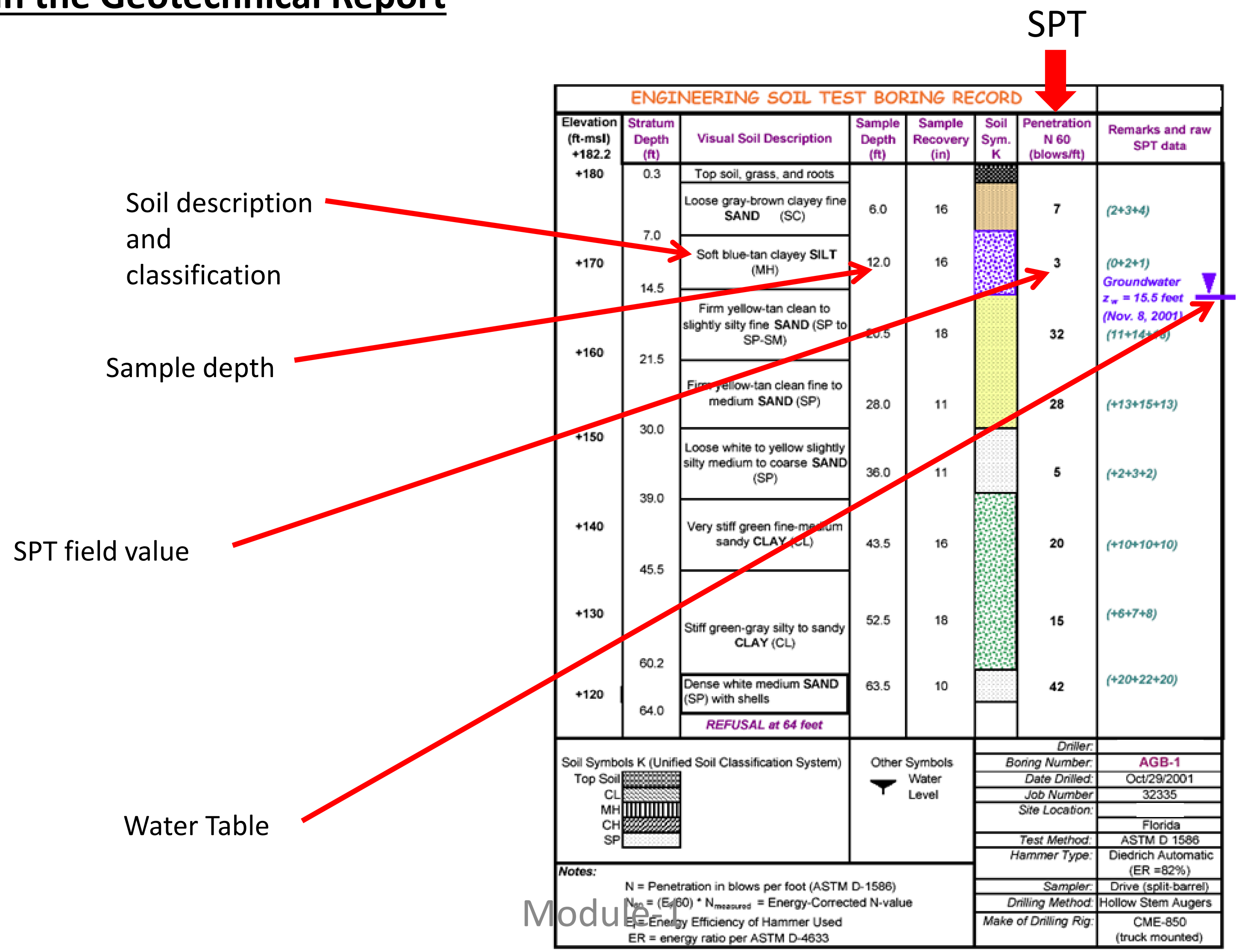
ER = energy ratio per ASTM D-4633

Soil Boring Map



3- Boring Log:

Presenting SPT in the Geotechnical Report



ENGINEERING SOIL TEST BORING RECORD

Elevation (ft-msl) +182.2	Stratum Depth (ft)	Visual Soil Description	Sample Depth (ft)	Sample Recovery (in)	Soil Sym. K	Penetration N 60 (blows/ft)	Remarks and raw SPT data
+180	0.3	Top soil, grass, and roots					
	7.0	Loose gray-brown clayey fine **SAND** (SC)	6.0	16		7	(2+3+4)
+170	14.5	Soft blue-tan clayey **SILT** (MH)	12.0	16		3	(0+2+1) Groundwater z_w = 15.5 feet (Nov. 8, 2001)
+160	21.5	Firm yellow-tan clean to slightly silty fine **SAND** (SP to SP-SM)	20.5	18		32	(11+14+18)
	30.0	Firm yellow-tan clean fine to medium **SAND** (SP)	28.0	11		28	(+13+15+13)
+150	39.0	Loose white to yellow slightly silty medium to coarse **SAND** (SP)	36.0	11		5	(+2+3+2)
+140	45.5	Very stiff green fine-medium sandy **CLAY** (CL)	43.5	16		20	(+10+10+10)
+130	60.2	Stiff green-gray silty to sandy **CLAY** (CL)	52.5	18		15	(+6+7+8)
+120	64.0	Dense white medium **SAND** (SP) with shells	63.5	10		42	(+20+22+20)
		REFUSAL at 64 feet					

Soil Symbols K (Unified Soil Classification System): Top Soil, CL, MH, CH, SP

Other Symbols: Water Level

Driller:	
Boring Number:	AGB-1
Date Drilled:	Oct/29/2001
Job Number	32335
Site Location:	Florida
Test Method:	ASTM D 1586
Hammer Type:	Diedrich Automatic (ER =82%)
Sampler:	Drive (split-barrel)
Drilling Method:	Hollow Stem Augers
Make of Drilling Rig:	CME-850 (truck mounted)

Notes:

N = Penetration in blows per foot (ASTM D-1586)

N_{60} = (E_r/60) * $N_{measured}$ = Energy-Corrected N-value

E_r = Energy Efficiency of Hammer Used

ER = energy ratio per ASTM D-4633

Profile of Soil Layers: