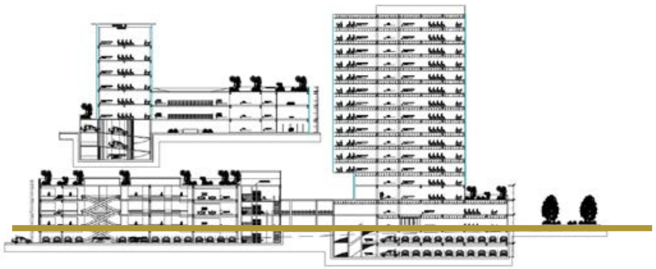
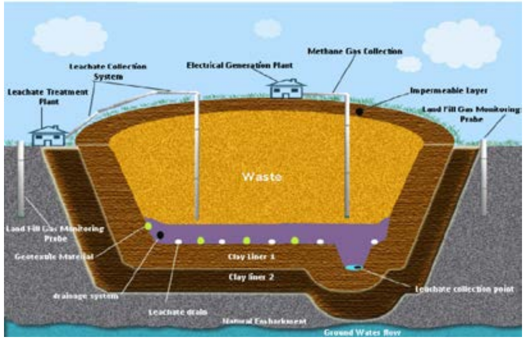
FOR ANY CIVIL & ENVIRONMENTAL PROJECT
Geotechnical Investigation

Human Activities

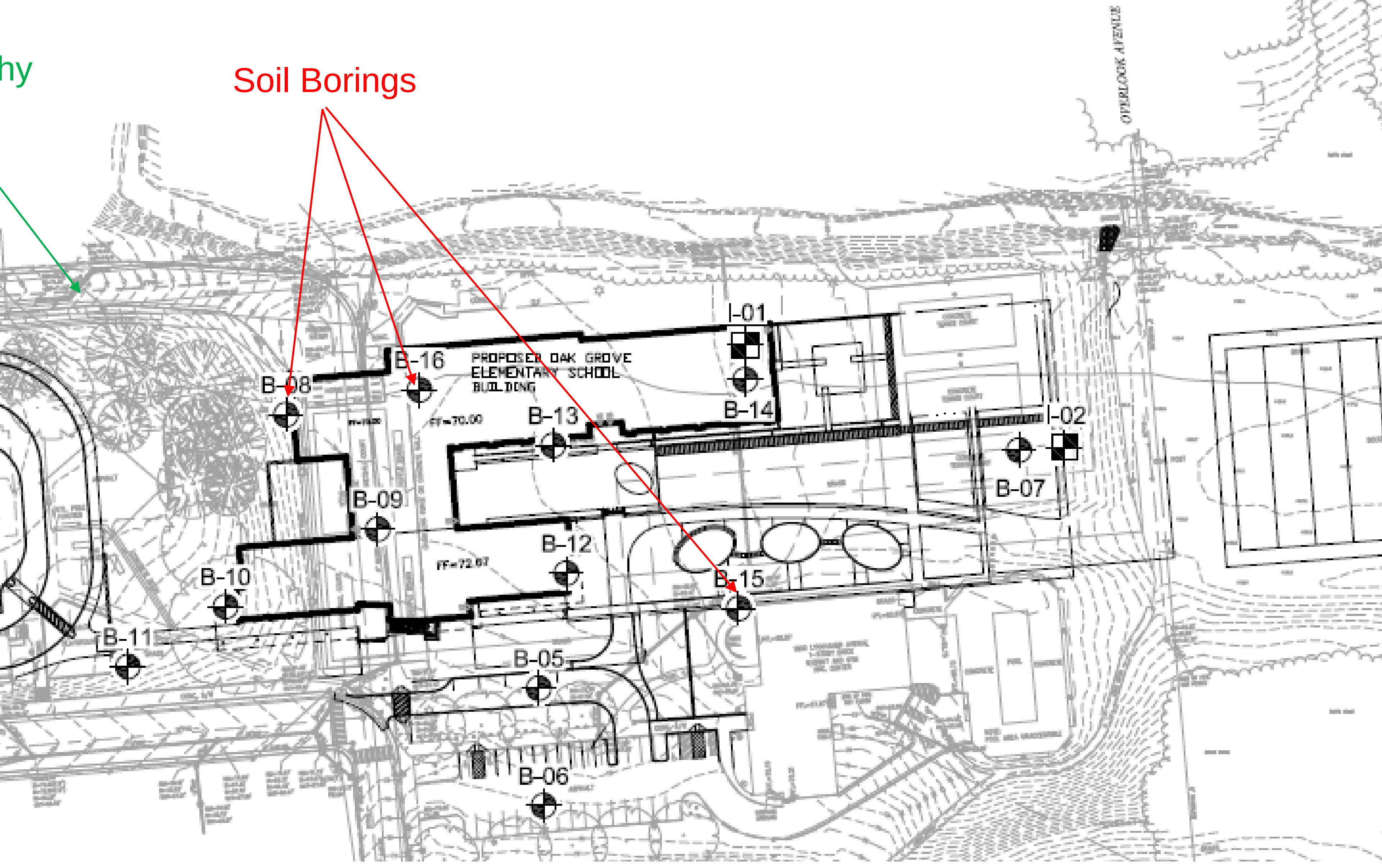




Geotechnical Investigation

1- Map of the Project Location

Geotechnical Report Production



Geotechnical Investigation

MEASUREMENTS OF MATERIAL PROPERTIES

Soil Properties

1. **Physical properties**
2. **Index Properties**
3. **Hydraulic Properties**
4. **Mechanical Properties**

MEASUREMENTS OF MATERIAL PROPERTIES

Methods of Measurement

1- In-Situ Testing Methods

2- Laboratory Testing Methods

3- Empirical Correlation's

Terzaghi & Peck (1948): $C_c = 0.009 (w_c – 10\%)$

Skempton (1944): $C_c = 0.007 (w_c – 7\%)$

$D_{10} =$

1. In-Situ Testing Methods

Geotechnical Investigation

THE STANDARD PENETRATION TEST (SPT)   ASTM D1586

- The SPT is one of the most popular and economical means to obtain subsurface information.

- The testing method was standardized in 1958 as ASTM D1568

The test consists of:

* A 140 lb driving mass falling from a height of 30 in.

* Drive the standard split spoon sampler a distance of 18 in. into the soil

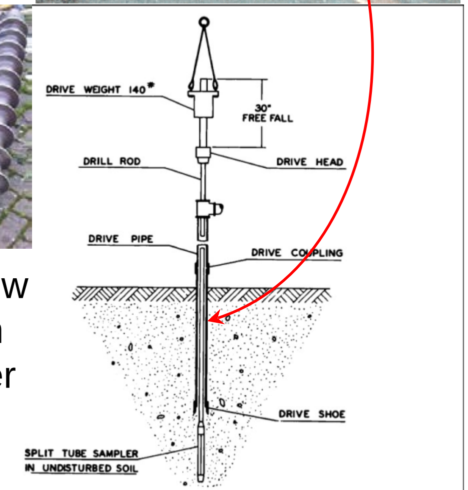
* Counting the number of blows (N) to drive the sampler 12 in.
(6 in. + 6 in.)

* The boring log should show "refusal" and should be halted if:

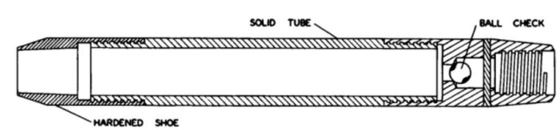
a- 50 blows are required for any 150 mm increment
b- 100 blows are obtained
c- 10 successful blows produce no advance

* N should be corrected for the increase of the overburden pressure

Hollow Stem Auger

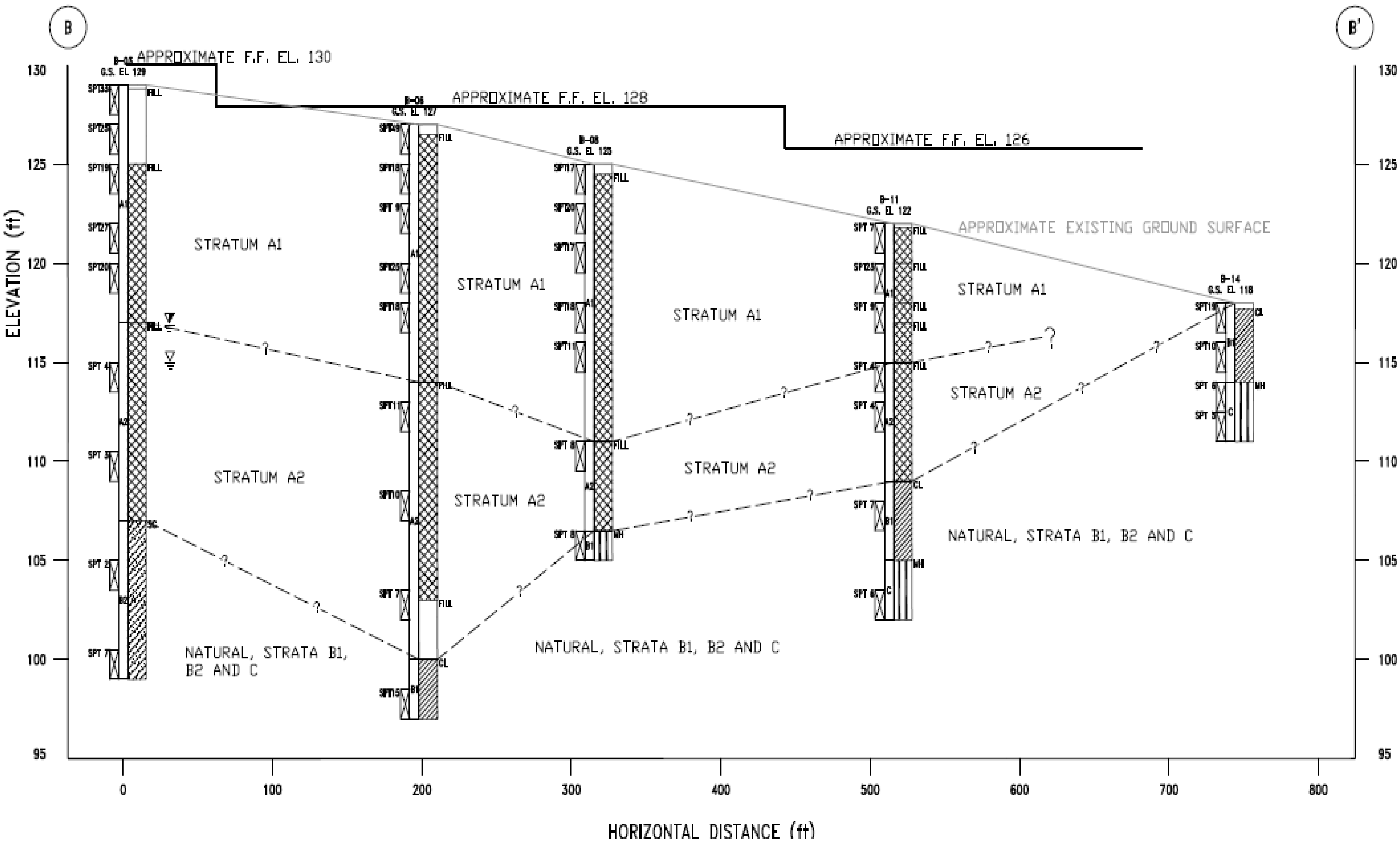


Driving sample



Solid tube sampler

4- Profile of Soil Layers:



Standard Penetration Test (SPT)

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.

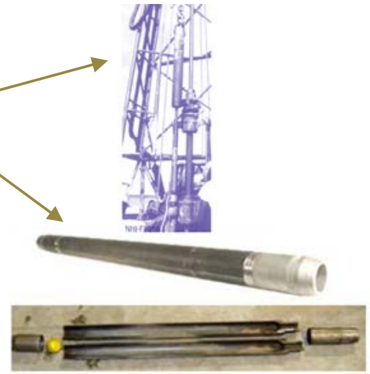
It is currently one of the most popular and economical in situ test to obtain subsurface information.

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:

1- Using a 140 lb driving mass (W) falling free from a height of 30 in. (h)
2- Driving the standard split spoon sampler a distance of 18 in. into the soil, and
3 - Counting the number of blows (N) to drive the sampler 12 in. (6 in.+ 6 in.).



Theoretical free-fall energy of the SPT hammer $E_{theoretical} = W.h$
$= (140\ lb)(30in) = 4200\ in\text{-}lb.$

- 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)

SPT vs. Relative Density of Sand — Meyerhoff (1956)

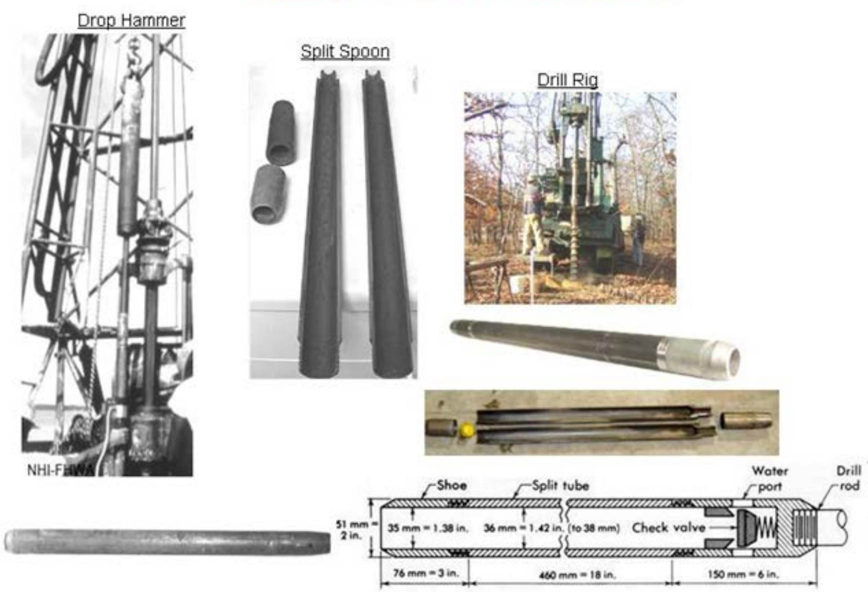
State of Packing	Relative Density	Standard Penetration Resistance (N)	Static Cone Resistance (q_c)	Angle of Internal Friction (ϕ')
	Percent	Blows / ft	Tsf or kgf/cm^2	Degrees
Very Loose	< 20	< 4	< 20	< 30
Loose	20 – 40	4 – 10	20 – 40	30 – 35
Compact	40 – 60	10 – 30	40 – 120	35 – 40
Dense	60 – 80	30 –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

SPT vs. Undrained Shear Strength

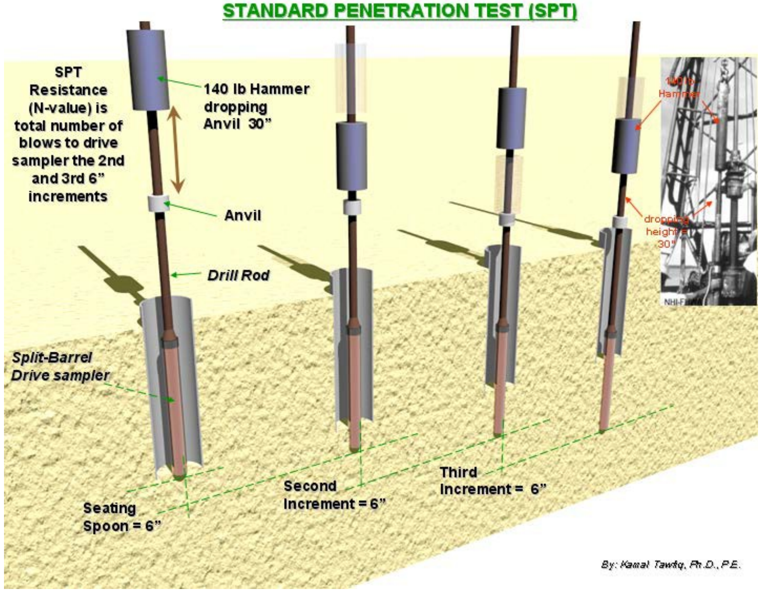
Soil Consistency	SPT N	S_u (psf)	S_u (kPa)
Very Soft	< 4	< 250	< 12
Soft	2 – 4	250 – 500	12 – 25
Medium	4 - 8	500 – 1000	25 – 50
Stiff	8 – 15	1000 – 2000	50 – 100
Very Stiff	15 – 30	2000 – 4000	100 – 200
Hard	> 30	> 4000	> 200

Terzaghi et al. (1996)

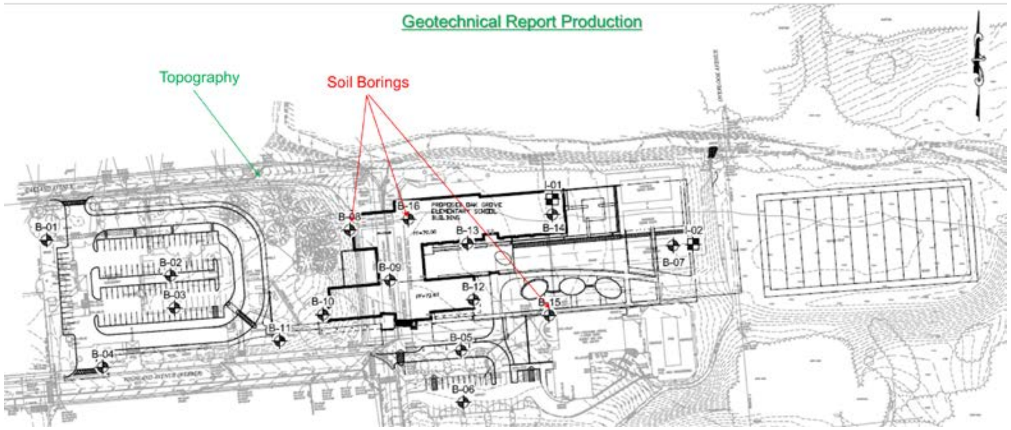
STANDARD PENETRATION TEST (SPT)

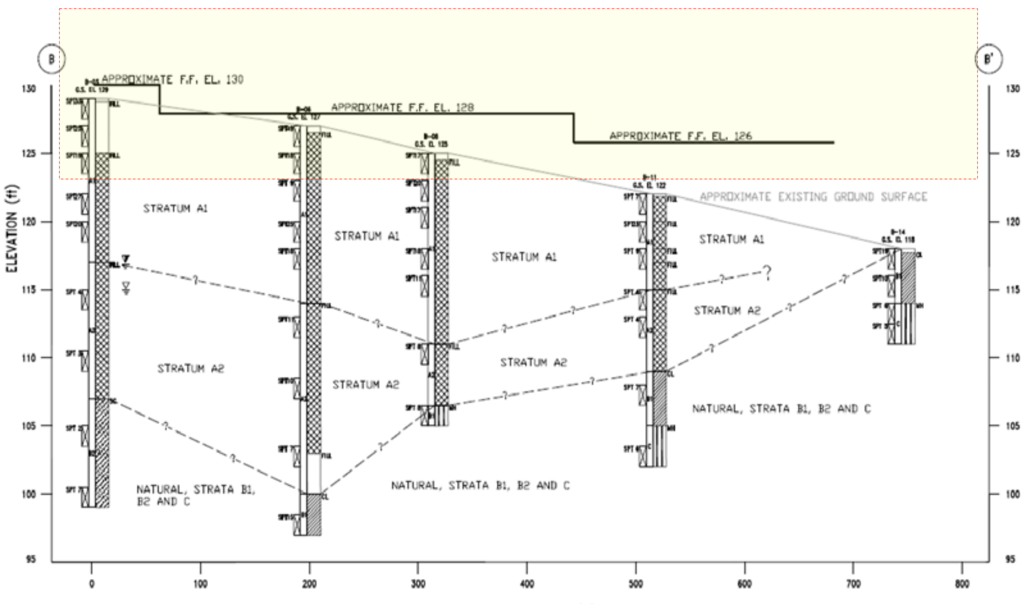


STANDARD PENETRATION TEST (SPT)



Soil Sub-sectioning





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					
		Loose gray-brown clayey fine **SAND** (SC)	6.0	16		**7**	*(2+3+4)*
	7.0						
+170		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)*
	39.0						
+140		Very stiff green fine-medium sandy **CLAY** (CL)	43.5	16		**20**	*(+10+10+10)*
	45.5						
+130		Stiff green-gray silty to sandy **CLAY** (CL)	52.5	18		**15**	*(+6+7+8)*
	60.2						
+120		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

2. Laboratory Testing Methods

MEASUREMENTS OF MATERIAL PROPERTIES

Methods of Measurement

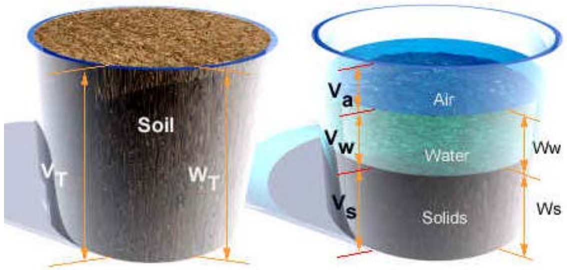
1- Laboratory Testing Methods

- Provide better control over the boundary conditions
- Different parameters can be determined individually or in combination
- Results can be produced

MEASUREMENTS OF MATERIAL PROPERTIES

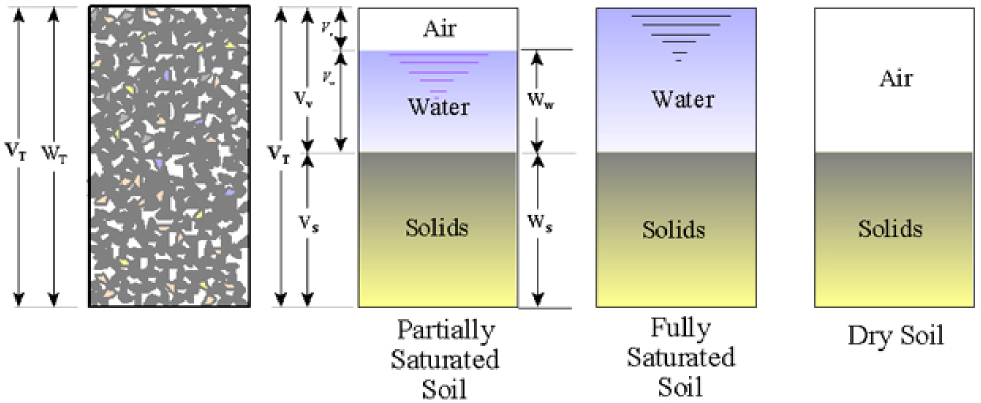
Soil Properties

1- Physical properties: Used to describe the soil. These properties are incorporated with the soil classification systems, and in some cases they are related to the mechanical properties



Phase Diagram

1. Specific gravity
2. Grain size
3. Density (Saturated, Partially saturated, submerged, minimum, maximum, relative, optimum moisture content)
4. Porosity
5. Degree of saturation
6. Void ratio
7. Moisture content



MEASUREMENTS OF MATERIAL PROPERTIES

Soil Properties

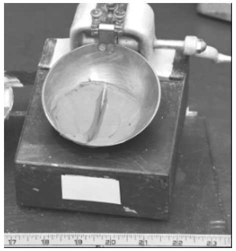
2- Index Properties: Used to classify the soil or to correlate with the mechanical properties.

- Atterberg Limits or Consistency Limits (LL, PL SL)
- Moisture Content vs. Unit Weight Relationship (Compaction)
- Grain Size Distribution
- Relative Density D_r

Relative Density D_r

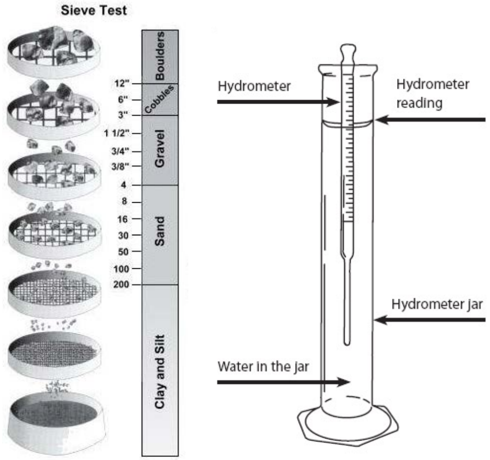
PL

LL



Proctor Test

Grain Size Distribution

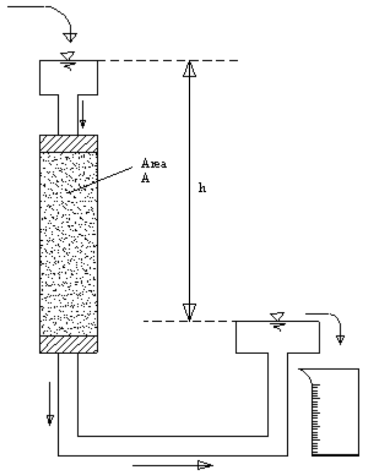


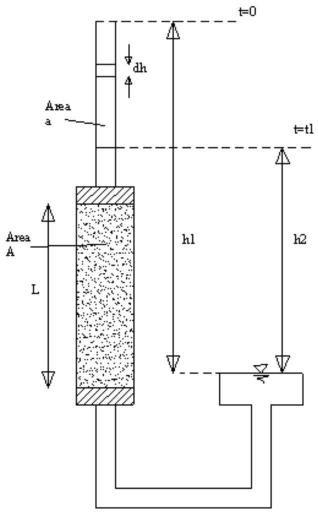
MEASUREMENTS OF MATERIAL PROPERTIES

Soil Properties

3- Hydraulic Properties

- Permeability or Hydraulic Conductivity (k)
- Infiltration Rate





Double Ring Infiltrometer

MEASUREMENTS OF MATERIAL PROPERTIES

Soil Properties

4- Mechanical Properties: To describe the behavior of the soil under different types of stresses

-Deformation Moduli – Young's Modulus (E) & Shear Modulus (G)

-Consolidation (C_c, C_s, C_v, P_c, m_v, K)
-Strength (c, ϕ) Unconfined Compression
Direct Shear,
Triaxial Compression

-California Bearing Ratio (CBR) or

-Lime Rock Bearing Ration (LBR)
used for pavement design

Consolidation Test

3. Empirical Methods

MEASUREMENTS OF MATERIAL PROPERTIES

Methods of Measurement

3- Empirical Correlations

- Correlations are usually based on **basic or index properties**
- These properties are correlated with the **mechanical & hydraulic properties**
- Used to provide basis for all engineering analysis
- Reduce the cost of geotechnical investigation
- Presented as ----- Tables, Charts, and Equations

For example Beyer formula for coefficient of permeability (k)

$K = C \cdot (d_{10})^2$

Where :

$C = 4.5 \times 10^{-3} \, \log \dfrac{500}{U}$

$U =$ Uniformity coefficient $= d_{60}/d_{10}$

$d_{10} =$ Effective diameter (mm)