

How To Read and Understand a Geotechnical Report

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What is Geotechnical Engineering?

Geotechnical engineering is the branch of civil engineering concerned with the engineering behavior of earth materials. Geotechnical engineering is important in civil engineering, but also has applications in military, mining, petroleum and other engineering disciplines that are concerned with construction occurring on the surface or within the ground. Geotechnical engineering uses principles of soil mechanics and rock mechanics to investigate subsurface conditions and materials; determine the relevant physical/mechanical and chemical properties of these materials; evaluate stability of natural slopes and man-made soil deposits; assess risks posed by site conditions; design earthworks and structure foundations; and monitor site conditions, earthwork and foundation construction.

A typical geotechnical engineering project begins with a review of project needs to define the required material properties. Then follows a site investigation of soil, rock, fault distribution and bedrock properties on and below an area of interest to determine their engineering properties including how they will interact with, on or in a proposed construction. Site investigations are needed to gain an understanding of the area in or on which the engineering will take place. Investigations can include the assessment of the risk to humans, property and the environment from natural hazards such as earthquakes, landslides, sinkholes, soil liquefaction, debris flows and rockfalls.

A geotechnical engineer then determines and designs the type of foundations, earthworks, and/or pavement subgrades required for the intended man-made structures to be built. Foundations are designed and constructed for structures of various sizes such as high-rise buildings, bridges, medium to large commercial buildings, and smaller structures where the soil conditions do not allow code-based design.

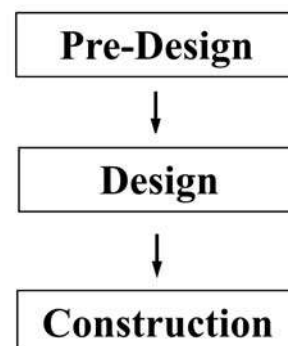
Foundations built for above-ground structures include shallow and deep foundations. Retaining structures include earth-filled dams and retaining walls. Earthworks include embankments, tunnels, dikes and levees, channels, reservoirs, deposition of hazardous waste and sanitary landfills.

Just kidding!



Who Reads Geotechnical Reports?

- Used by multiple parties, from pre-design to design and through construction.
 - Owners
 - Developers
 - Architects
 - Structural Engineers
 - Civil Engineers
 - General Contractors
 - Earthwork Contractors
 - Others



What is a Geotechnical Report to You?

- **If you're an owner or a developer:**

- It might be a risk management tool.
- Identify subsurface conditions that could increase development and construction costs.
- Identify subsurface conditions that could contribute to LEED credits



What is a Geotechnical Report to You?

- **If you're a civil engineer:**

- Soil boring logs and recommendations for topsoil stripping, excavation and filling – (for quantity estimation)
- Discussion of soils, groundwater, and infiltration for
 - Ponds
 - Below grade stormwater infiltration
 - Rain Gardens
 - Bioswales
 - Pervious pavements
- Pavement Subgrade Preparation
- Pavement Design Thickness
- Retaining Walls!!!

...Brief Tangent About Retaining Walls

- No one “owns” the complete package.
- Wall designer “assumes” parameters – on-site geotechnical engineer to confirm.
- Soil borings typically not requested.
- “After the fact” design.
- Testing responsibilities unclear.
- Sometimes not tied to other elements of the project (surface drainage behind walls, etc.)

Many lawsuits tied to retaining walls!

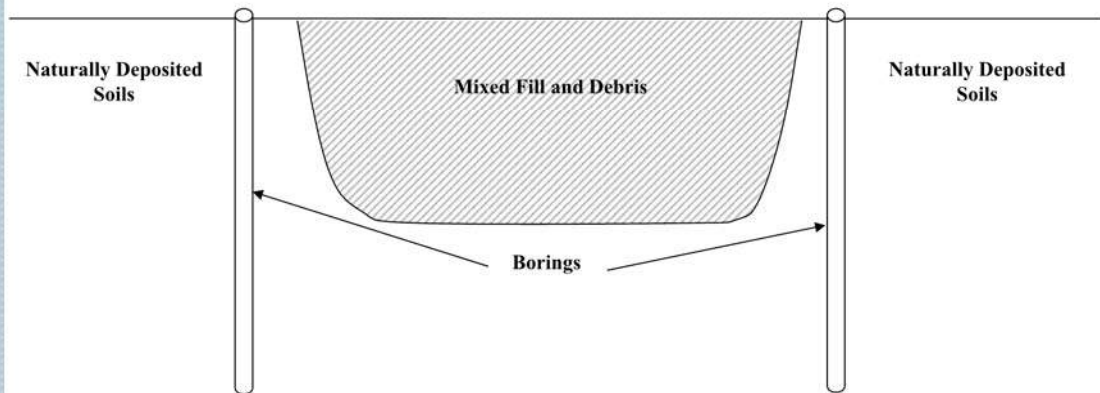
What is a Geotechnical Report to You?

- **If you're a contractor:**
 - Evaluate equipment needs.
 - Soil correction
 - Availability of on-site materials



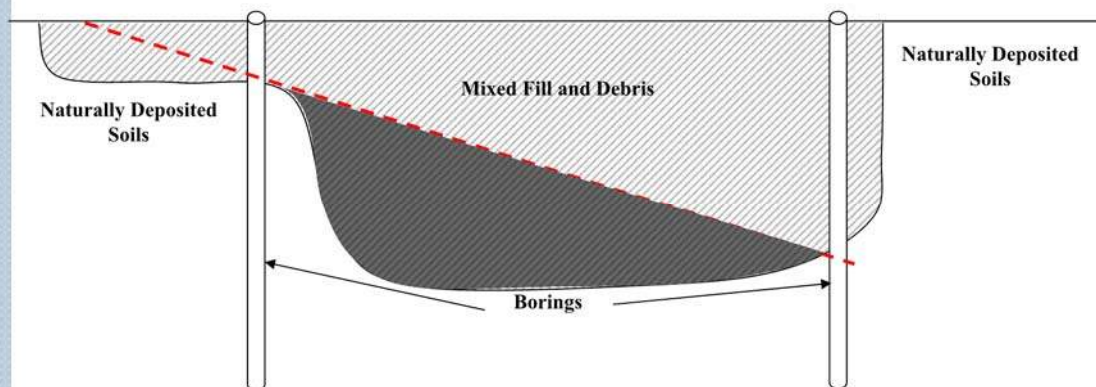
What is a Geotechnical Report to You?

- **If you're anyone associated with the project:**
 - A tool to assist in estimating costs.



What is a Geotechnical Report to You?

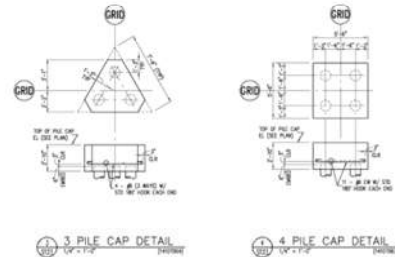
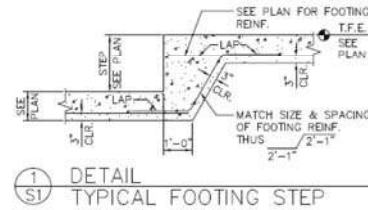
Or... ?



What is a Geotechnical Report to You?

- **If you are a structural engineer or architect:**

- It is a design tool.
- It might be an important component of the project specifications.
- It might even provide important design information helping to achieve LEED credits.



What Should the Report Contain?

- No national standard on exactly what a report should contain.
- Presents an interpretation of subsurface conditions.
- Discusses how the subsurface conditions will influence design and construction of the project.
- Presents geotech recommendations needed for design and construction of the project.
- Includes any project-specific tailored information that has been specifically requested by the design team. (e.g. analysis for Retaining Walls, Brownfields, and Infiltration)

Commonly Used Report Format

- Introduction/Project Information
- Testing
 - Field Exploration Program
 - Laboratory Testing Program
 - Subsurface and Site Conditions
- Discussion & Opinions
 - Engineering Recommendations
 - Construction Considerations
- General Qualifications
- Preliminary & Final Reports
 - Find this helpful – questions arise, design changes made, etc.

} **Basis of
Recommendations**

} **Project Specific**

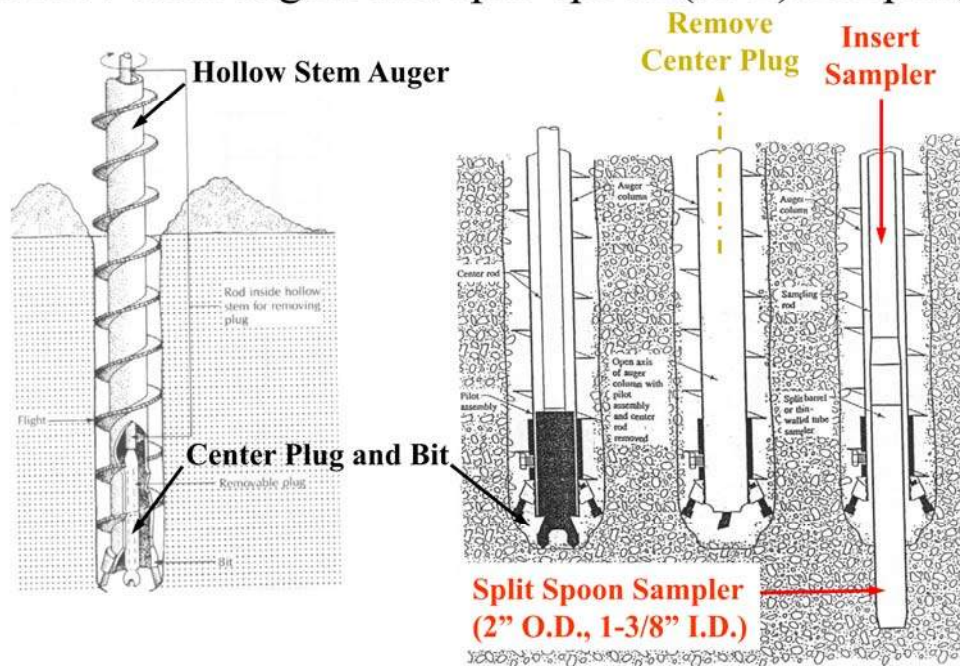
Field Exploration Program

Geotechnical Drill Rigs



Field Exploration Program

Hollow-stem augers and split-spoon (SPT) sampling



Field Exploration Program

Yay Videos!

Field Exploration Program

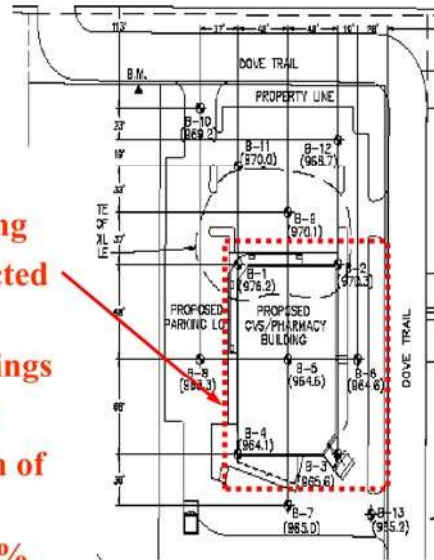
Sampling Limitations

- Site representation

Example:

- 5 borings for 13,000 sf building
- 1-3/8" diameter sample collected at each boring,
area sampled = $\pi * r^2 \times 5 \text{ borings}$
 $= \pi * (0.7" / 12")^2 \times 5 = 0.05 \text{ sf}$
- Area sampled as a proportion of the building area
 $= 0.05 \text{ sf} / 13,000 \text{ sf} = 0.00004\%$

- Typically do not sample continuously with depth



Soil Borings vs. Test Pits

- Large Scale View
- Disturbance



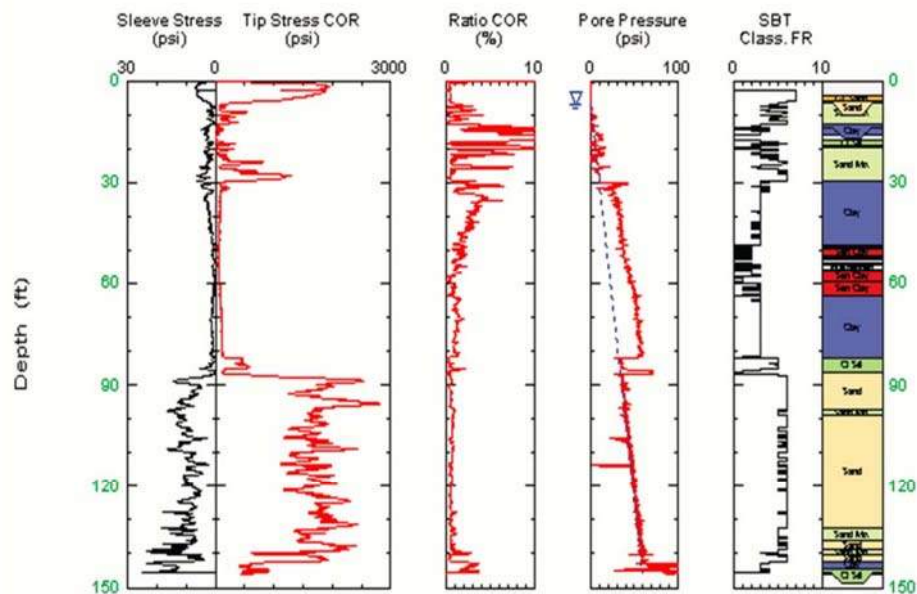
Field Exploration Program

CPT rig (piezocone)



Field Exploration Program

CPT rig (piezocone)





Laboratory Testing Program

- After the field exploration is completed, portions of the recovered soil samples are brought to the lab for visual/manual classification and testing.
- Routine Lab Testing
 - Water content = $\frac{\text{Weight of water}}{\text{Dry weight of soil}}$ %
 - Organic content
 - Dry density
 - Atterberg Limits
 - Gradations (Can help estimate infiltration rates)
- More Sophisticated Testing



The Soil Boring Log

- After completing the field and laboratory testing, the data are summarized on a boring log.
- The boring log is the basis of the recommendations in the report.
- There is no code or standard on how to draw boring logs, or what information a boring log should contain.

The Soil Boring Log



AMERICAN
ENGINEERING
TESTING, INC.

SUBSURFACE BORING LOG

AUT No: 12-02424		Log of Boring No. B-03 (p. 1 of 1)											
Project: _____													
DEPTH FEET	ELV. FEET	SURFACE ELEVATION	MATERIAL DESCRIPTION	GEOLOGY	N	SR	SAMPLE TYPE	REC IN	WC	sp	LL	PL	SL
1	1240.2	1240.4	FILL, silty sand with organics, fine to medium grained, dark brown, moist (SM)	FILL	3	M	SS	18					
2	1239.7			TOPSOIL									
3	1238.4		FILL, silty sand with gravel, fine to coarse grained, brown, moist (SM)	FINE ALLUVIUM	4	M	SS	14	17				
4	1235.9		SILTY SAND with organics, fine to medium grained, black, moist, very loose (SM)	COARSE ALLUVIUM	20	W	SS	18					4
5			LEAN CLAY with organics (roots), gray, soft (CL)		25	W	SS	24					
6			SAND, fine to medium grained, brown, waterbearing, medium dense (SP)		20	W	SS	16					
7					27	W	SS	10					
8					18	W	SS	11					
9					6	W	SS	16					
10	1229.4		SAND WITH SILT and gravel, fine to medium grained, waterbearing, medium dense (SP-SM)	FILL									
11	1228.4		Gravelly CLAYEY SAND, fine to coarse grained, brown, waterbearing, medium dense (SC)										
12	1225.9		Sandy LEAN CLAY with gravel, brown, very stiff (CL)										
13													
14			LEAN CLAY with sand, a little gravel, brown, firm (CL)										
15													
16	1217.4		Weathered bedrock with the fabric of sandy LEAN CLAY with gravel, brown, very stiff (CL)	WEATHERED BEDROCK									
17													
18													
19	1213.9		End of boring at 26.5 feet										
DEPTH: DRILLING METHOD													
0-24.5' 3.25" HSA													
DATE: 9/9/16 TIME: 1533 SAMPLED DEPTH: 6.5' CASING DEPTH: 4.5' CASING DEPTH: 4.7' DRILLING FLUID LEVEL: None WATER LEVEL: 3.7'													
DATE: 9/9/16 TIME: 1536 SAMPLED DEPTH: 6.5' CASING DEPTH: 4.5' CASING DEPTH: 4.2' DRILLING FLUID LEVEL: None WATER LEVEL: 3.2'													
DATE: 9/9/16 TIME: 1542 SAMPLED DEPTH: 6.5' CASING DEPTH: 4.5' CASING DEPTH: 4.2' DRILLING FLUID LEVEL: None WATER LEVEL: 2.9'													
BORING COMPLETED 9/9/16													
DR: MD LG: LL RJE: 87													
NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY OF THIS LOG													

How is the Boring Log Used?

- Summary of soil, bedrock, and groundwater conditions
- Develop understanding of engineering properties of the soils from the field and lab testing
 - Strength/Compressibility
 - Drainage/Frost Susceptibility
 - Other properties
 - Shrink/Swell
 - Corrosivity
 - Contamination

* Factor into
geotechnical
recommendations

Design Considerations

- Site preparation
- Foundation Recommendations
 - Allowable bearing capacity
 - Settlement – Typically 1-inch or less total, ½-inch differential
 - Frost protection – Is code enough?
 - Earth pressures
 - Lateral load resistance
- Floor Slab Support/Exterior Slabs – Vapor Retarder, NFS (Non-Frost Susceptible Soil), Subgrade Preparation
- Pavement/Roadway Support
- Stormwater Infiltration
- and more ...

Bearing Capacity & Settlement

- Geotechnical Engineers Have Equations Too!

$$q_{ult} = 1.3c' N_c + \sigma'_{zD} N_q + 0.4\gamma' B N_\gamma$$

$$\delta_c = \frac{C_c}{1 + e_0} H \log \left(\frac{\sigma'_{zf}}{\sigma'_{z0}} \right)$$

$$S_s = \frac{H_0}{1 + e_0} C_a \log \left(\frac{t}{t_{90}} \right)$$

Earth Pressure Design

γ_f = Equivalent Fluid Weight

$$\gamma_f = K_o \gamma$$

- K_o = At Rest Coefficient = 0.5 (From Poisson's Ratio)
- K_a = Active Coefficient = $0.33 (\tan^2 (45 - \phi/2))$
- K_p = Passive Coefficient = $3.0 (\tan^2 (45 + \phi/2))$
- Sand $\phi = 30^\circ$

Example: At Rest Condition, Sand backfill, Moist Weight $\gamma_f = 120$ pounds per cubic foot (pcf)

$$\gamma_f = 0.5 (120 \text{ pcf}) = 60 \text{ pcf}$$

Earth Pressure Design

Movement Required to Establish Active and Passive Conditions

Example – 10-ft Wall = H

Active Condition

$$\text{Loose Sand} = 0.002H = \frac{1}{4}''$$

$$\text{Stiff Clay} = 0.01H = 1\frac{1}{4}''$$

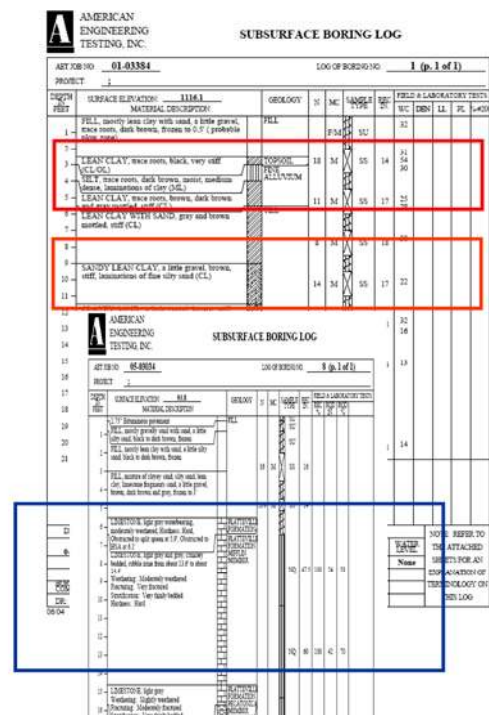
Passive Condition

$$\text{Loose Sand} = 0.01H = 1\frac{1}{4}''$$

$$\text{Stiff Clay} = 0.02H = 2\frac{1}{2}''$$

Note: Safety Factor of 1.5 to 2.0 applied to passive case for design

- Effects of construction equipment/soil disturbance
- Are existing on-site soils reusable as fill
 - Drying/wetting of soil?
- Susceptibility to disturbance
- Impact of groundwater
- Bedrock excavation





Getting the Geotechnical Report You Want and Need: The RFP Process



The First Element: The Request For Proposal (RFP)

The RFP is an important element, but often given little importance, conveying little or no information to the Geotechnical Engineer to use in preparing his proposal.

- The RFP should describe the following elements:
 - Intended use of building
 - Finished floor elevation
 - Number of stories, future vertical expansion
 - Building footprint, possible future expansion
 - Type of construction
 - Basement, full or partial
 - Loading docks



The First Element: The Request For Proposal (RFP)

RFP Contents, continued

- Structural loads, walls and columns (max/min, live/dead), floor loads (live, dynamic, forklifts, storage, etc.)
- Allowable maximum total and differential settlement
- Moisture sensitive floor coverings
- Condition of existing buildings, pavements
- New pavements
- Other site features: retaining walls, stormwater management features (infiltration vs. detention/retention)



The First Element: The Request For Proposal (RFP)

- Defining the scope of the geotechnical exploration program:
 - Number and locations of the borings and/or test pits
 - Benchmark to be used for elevations
 - Piezometers
 - Routine testing and sampling: split spoons and thin wall tubes
 - Special field testing
 - Types and number of laboratory tests
 - Sample retention



General Qualifications/Limitations

- Recommendations limited to design information on which report is based
- If changes are made in the design, the geotechnical engineer should be contacted and allowed to review and possibly revise the report recommendations
- Not giving a warranty of subsurface conditions
 - Not all soil layers can be detected in a boring
 - Conditions change between borings



Concluding Remarks

- The owner, design engineers, and construction manager must have a sound understanding of the purpose of a geotechnical report, and the methods by which the report is generated.
 - Convey project needs in well-defined RFP
 - Understand the data and recommendations presented by geotechnical engineer
 - Communicate design information / design changes
- Contact the geotechnical engineer for clarifications



Thank you for the opportunity to speak
with you today.

Further Questions? Please contact us.



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