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Soils and Geology Procedures for Foundation Design of Buildings and Other Structures

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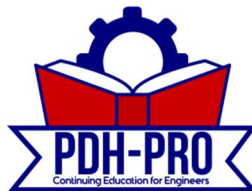
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Module 1: Design Fundamentals

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary objectives of a subsurface investigation and their impact on project risk management.
- **Evaluate** the critical components required in a comprehensive Subsurface and Design Investigation Report.
- **Select** appropriate analytical data and field measurements necessary to facilitate a detailed peer review of foundation designs.

Executive Summary: Foundation design is uniquely defined by the interaction between a structure and its supporting medium. Success depends on a comprehensive investigation that characterizes stratigraphy, groundwater, and engineering properties to mitigate risks of structural failure and excessive maintenance.

Design Purpose

This course provides technical guidance for the selection and design of foundations and associated features for:

- Buildings
- Retaining structures
- Machinery foundations

Note: Foundations for **hydraulic structures** are specifically excluded from this scope. Unlike other structural elements, foundation design is dependent on the complex interaction between the artificial structure and the natural supporting medium (soil and/or rock).

Scope of Application

While the technical procedures herein are directed toward military construction, they are sufficiently general for a wide variety of civil and industrial construction projects.

Technical Coverage Includes

- Fundamental **volumetric-gravimetric** relationships.
- Summaries of physical and **engineering properties** of soil and rock.
- General descriptions of **field and laboratory investigations**.



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- Design procedures for **excavated slopes and shoring**.
- **Empirical design equations**, simplified analytical methods, and soil property-index correlations.
- Practical **design examples** illustrating analytical methods.

💡 Design Tip: This material assumes a baseline familiarity with geotechnical engineering. Content focuses on application; therefore, design equations are presented with minimal theoretical derivation. For specialized topics like dewatering, pile foundations, or expansive soils, consult supplemental technical manuals for deeper analysis.

Objectives of Foundation Investigations

The primary goal of a foundation investigation is to define the subsurface stratigraphy and predict material behavior under structural loading.

Key Objectives

- **Risk Mitigation:** Reveal adverse conditions that could lead to construction difficulties or structural failure.
- **Cost Optimization:** Permit savings in design and construction through accurate material characterization.
- **Behavior Prediction:** Determine how subsurface materials will respond to specific structure loadings.

The complexity of the investigation should scale with the **nature of the subsurface materials** and the **size/cost of the structure**.

Report of Subsurface and Design Investigations

The final report must provide a transparent record of field/laboratory data, basic assumptions, and analytical procedures. This allows for a detailed peer review of the conclusions and recommendations.

⚠️ Safety Constraint: For major structures, the investigation report **shall** follow the standardized outline below to ensure all critical safety and design parameters are addressed.


Required Report Components

- **Site Description:** General topography, surface contours, structure location, and a plan map showing all boring locations.
- **Geology:** Detailed description of general and local site geology.



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- **Field Investigation Results:**
 - Graphic logs of all borings (foundation and borrow).
 - Piezometer data and groundwater observations.
 - Boring methodology, sampler types, and **Standard Penetration Test (SPT)** resistance.
- **Groundwater Conditions:** Data on seasonal variations and results of field pumping tests.
- **Laboratory Test Data:**
 - Summary tables of test values.
 - **Atterberg limits** plotted on a plasticity chart.
 - Typical **grain-size distribution** curves.
 - If tests were not performed, provide the specific basis (correlations/references) used for soil/rock properties.
- **Design Profile:** A generalized geologic profile showing design values for **shear strength** for each critical stratum.
- **Foundation Alternatives:** Evaluation and cost data for different foundation types considered.
- **Final Design Geometry:** Final size/depth of footings or mats and pile specifications.
- **Analytical Results:**
 - Computed **Factors of Safety (FS)** for bearing capacity.
 - Settlement analyses (including estimated differential settlement and swell).
 - Anticipated **dewatering requirements** (pumping rates and flow per foot of drawdown).
- **Construction Recommendations:** Specific precautions, fill/backfill sources, and **compaction requirements**.

 **Calculation Note:** When reporting bearing capacity and settlement, ensure all basic loading assumptions are explicitly stated to allow for verification against the procedures outlined in subsequent chapters.



Checkpoint Quiz

1. According to the guidelines for major structures, what is the mandatory requirement for presenting Atterberg limits in a subsurface report?

- a) They should be listed in a summary table only.
- b) They must be plotted on a plasticity chart.
- c) They are only required if expansive soils are present.
- d) They should be described in the narrative text of the geology section.

Answers: (b). Section 1-4e specifically requires this graphical representation for laboratory data.

2. Which of the following is NOT a primary objective of a foundation investigation as defined in Section 1-3?

- a) To determine the stratigraphy of subsurface materials.
- b) To calculate the exact cost of the superstructure materials.
- c) To reveal adverse conditions that could lead to failure.
- d) To permit savings in design and construction costs.

Answers: (b). Foundation investigations focus on the subsurface medium and the interaction with the structure, not the material costs of the superstructure itself.

3. When reporting on groundwater conditions for a major project, what specific data must be included?

- a) Only the depth at which water was first encountered during drilling.
- b) A single measurement taken 24 hours after boring completion.
- c) Data on seasonal variations and results of field pumping tests, if performed.
- d) The chemical composition and pH of the groundwater only.

Answers: (c). Section 1-4d mandates these details to ensure groundwater impacts are fully understood for design.



Module 2: Identification And Classification Of Soil And Rock

Learning Objectives

By the end of this section, you will be able to:

- **Classify** natural soil and rock deposits using the Unified Soil Classification System (USCS) and engineering criteria.
- **Evaluate** soil index properties—including Atterberg limits, relative density, and grain-size distribution—to predict foundation behavior.
- **Determine** rock quality using the Rock Quality Designation (RQD) and engineering classifications for intact rock.

Executive Summary: Accurate identification of subsurface materials is the cornerstone of foundation engineering. Engineers must distinguish between residual and transported soils, assess the plasticity and consistency of fine-grained materials, and evaluate the structural integrity of rock masses through RQD and uniaxial strength to ensure structural stability.

Natural Soil Deposits

The character of natural soil deposits is primarily a function of **parent material** and **climate**. Soils result from the weathering, mechanical disintegration, and chemical decomposition of rock.

- **Residual Soils:** Products of weathering that remain in place. These can form deep deposits in flat regions.
- **Transported Soils:** Weathered materials moved by gravity, ice, wind, or water. These are typically sorted by grain size during transport.

Table 2-1: A Simplified Classification of Natural Soil Deposits

Type of Deposit	Principal Engineering Characteristics
Residual (Shale, Sandstone, etc.)	Variable; properties depend on parent rock and degree of weathering.
Alluvial (Floodplain, Terrace)	Usually stratified; engineering properties can vary significantly over short distances.
Glacial (Till, Outwash)	Till is usually dense and unsorted; outwash is often well-graded and excellent for foundations.
Eolian (Loess, Dune Sand)	Loess is characterized by vertical root holes and potential for collapse upon wetting.
Marine (Shoreline, Deep Sea)	Often very uniform; shoreline deposits are usually dense, while deep-sea clays are often soft.
Colluvial (Talus, Landslide)	Heterogeneous and unstable; high risk for foundation movement.



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