Geotechnical Design Parameters

This module provides guidance on how to utilize information from borings, laboratory testing, and other investigative methods to develop geotechnical design parameters and geotechnical design models.

Proper site characterization requires the GP to:

1. Define the soil and rock stratigraphy and characteristics of the geologic units, along with their variations across the site, including the groundwater condition
2. Establish appropriate and justifiable design parameters at the design element (e.g., pile foundation location)
3. Characterize hazards that may impact design, construction, and performance

Items 1 and 3 are addressed elsewhere in the Geotechnical Manual (e.g., Soil and Rock Logging Manual, seismic-related modules, Landslides module, Rockfall module), as is development of individual design parameters, such as rock strength or a soil friction angle (see Soil Correlations module).

When considering design parameters, it is important to distinguish between “variability” and “uncertainty” in the context of site characterization. The term “variability” is used to represent the range or disparity of actual properties, or measurements of a property, within a site or layer. The term “uncertainty” is used to represent the level of confidence one has in estimates of a specific property or design parameter.

Variability of site stratigraphy and soil or rock properties is site specific and nothing can be done to reduce their variability. In contrast, the uncertainty (i.e., confidence in accuracy) associated with stratigraphy, a specific property, or design parameter can often be reduced by additional borings, sampling, and testing. Measurements of parameters should be considered estimates taken from a large population of possible values rather than a deterministic measurement of actual conditions.

The GP should ensure that the quantity and quality of measurements made for a site or stratum will result in proper assignment of design parameters, considering the sensitivity of each parameter in relation to the design methodology. Statistical measures using the Coefficient of Variation (COV) are available to evaluate the likelihood of having a representative collection of measurements (See GEC No. 5, Chapter 11). Using these methods, the GP can determine if the level of uncertainty is acceptable, and if not, can increase sampling and testing to increase the sample size. In areas of highly variable geologic conditions (e.g., Franciscan Formation) additional borings may only further confidence that inter-boring interpolation is not possible and that borings should be used as discrete data points.

Most design modules (or their references) provide direction on the types of investigations required, such as borehole locations and quantity, material sampling, and testing. The level of investigation is typically commensurate with the type of improvement being designed/constructed, its cost, and consequence of failure.

Measurements required to determine design parameters may be direct or indirect. Direct measurements do not require transformation or conversion to produce the design parameter, such as:

- Field pocket penetrometer or torvane tests to determine su or qu for soils;
- Laboratory unconfined compressive strength, qu for rock or su for soils;
- Direct shear tests or triaxial tests to determine effective stress shear strength parameters, c' and ϕ', for soils
- Consolidation tests to determine the compression index, Cc, recompression index, Cr, and preconsolidation stress, $\sigma p'$, for soils.

Indirect measurements require transformation to produce an estimate of the actual design parameter, such as:

- SPT N-values to determine ϕ' or unit weight for soil
- Point load strength index, Is, to estimate qu for rock;

Use the Soil Correlations module as appropriate to process indirect measurements. When employing a mixture of direct and indirect measurements and there are differences between the two, more weight/confidence should be applied to the direct measurements.

Developing the Design Model

The design parameters established via drilling, sampling, testing, and analysis are used to establish realistic and justifiable design models at specific locations of a site (e.g., at a pier foundation). The design model will likely be a simplification of the actual site conditions necessary to practicably apply to a design methodology. Design models should characterize the variability and uncertainty of the design parameters so they are well understood, discussed among the design team, and addressed. The GP should consider the following when evaluating the applicability of a design model.

1. Is the model consistent with available measurements from the site, with consideration of variability of soil/rock properties?
2. Is the model consistent with the geologic setting?
3. Is the model appropriate for the intended use?
4. Is this model compatible with the applicable design and analysis methods?
5. Is the model consistent with known experience at the site?

Develop the design model by:

1. Developing preliminary profiles or cross-sections to characterize the general stratigraphy at the site based on qualitative (field) descriptions of soil/rock type.
2. Establishing horizontal and vertical limits of preliminary “design layers” where conditions are considered consistent, or with defined variation (e.g., Bent 2, Sta. X to Sta. Y, etc.).

3. Processing field and laboratory measurements to determine the required design parameters for each design layer, and plotting the measurements versus depth or elevation for each layer.
4. Reviewing and revising the cross sections and profiles to be consistent with the field observations, field measurements, laboratory test results, and anticipated design methodologies.

Figure 1 presents an example site profile.

Preliminary cross-sections and profiles based on field observations will likely contain more layers than needed for design. This happens because initial stratigraphy models based on field interpretations will consider visual and textural characteristics (e.g., color, minor gradation variations) that may have negligible effect on design parameters (e.g., strength).

For sites with uniform stratigraphy and consistent properties, larger design layers are likely appropriate, and will simplify design and evaluation. For sites with variable stratigraphy and/or properties, multiple design layers are likely appropriate to capture the variability and influence of the variation of the assigned design parameters.

The geotechnical design methodologies used by the Department use geotechnical resistance factors that rely on estimates of the mean value for design parameters (see AASHTO 10.4). Selecting design parameters that exceed those that exist at the site will result in increased risk of unacceptable performance. Selecting design parameters that are substantially less than those that exist will lead to increased costs from excessively conservative design or construction issues. Therefore, the selected design parameters should be near the mean value of representative samples with the following considerations:

- If the investigation yields large quantities of high quality measurements with little variability, select design parameters that are at the mean value.
- In cases with few measurements, highly variable measurements, select design parameters that are less than the mean value.
- Measurements of questionable quality should be excluded from the data population used for design parameter calculations.

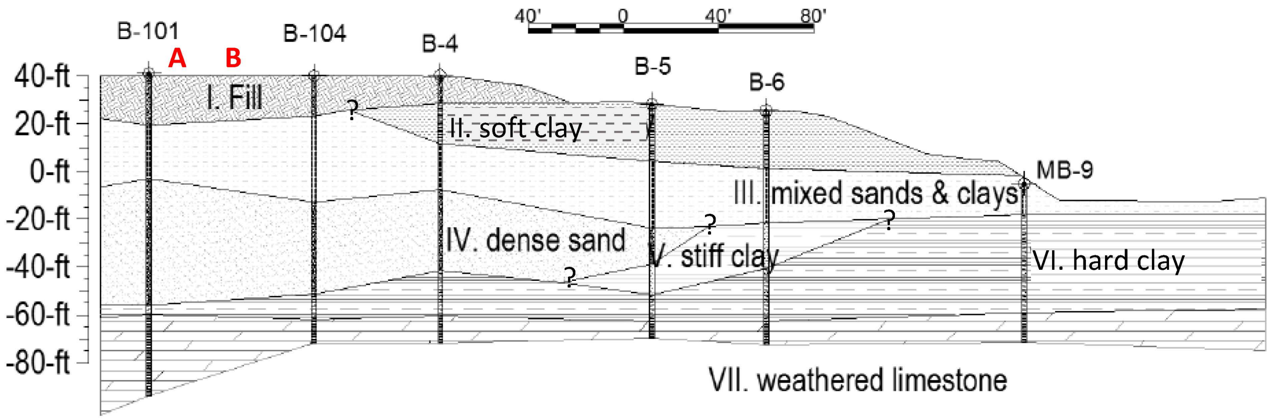

Figure 1: Example Site Profile

Best practices for geotechnical design:

1. A foundation design at location A should consider the design parameters from B-101 and B-104, but should rely more heavily on B-101 if inconsistencies exist between the two borings.
2. A foundation design at location B should consider the design parameters from B-101 and B-104 equally.