SITE INVESTIGATION

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Foundation Engineering

- Analysis ⇨ Design ⇨ Construction
- As a foundation engineer, you need to consider
  - geotechnical/structural issues (involves geology, subsurface exploration, structure type and load type),
  - professional engineering issues (cost-constructability-reliability)
  - engineering modelling (how accurate and how reliable?).

Steps in Foundation Engineering

- Understand project and site
- Develop design criteria
- Identify possible foundation alternatives
- Conduct soil investigation
- Characterise site
- Engineering analysis to evaluate alternatives
- Develop recommendations and write reports
- Monitor design, construction and performance

Potential Problems Related to Foundation Design

- Bearing capacity failure of foundation (strength of soil)
- Differential settlement of foundation
- Excessive overall settlement of foundation
- Instability of foundation, embankment, slopes
- Sulphate attack on concrete (groundwater)
- Damage to surrounding structures due to excavation and dewatering an excavation
- Collapse of excavation as a result of excessive water in flow.

Site Investigation

A soil investigation program is necessary to provide information for design and construction and for environmental assessment.

Purposes:

1. To evaluate the general suitability of the site for the proposed project
2. To enable an adequate and economical design to be made
3. To disclose and make provision for difficulties that may arise during construction

Site Investigation Phases

- Phase-I: *Collection of preliminary information*
  - obtain information regarding the type of structure to be built and its general use.
  - A general idea of the topography and the type of soil
  - Geological survey maps etc.

Site Investigation Phases

- Phase-II: *Reconnaissance*
  - The engineer should always make a visual inspection of the site.
  - to provide a general picture of the topography and geology of the site.

Site Investigation Phases

- Phase-III: *Site Investigation*
  - consists of planning, making test boreholes and collecting soil samples
  - For a 30.5m wide building, depending on number of stories (1 to 5 stories) 3.5m to 24 m deep borings can be made.
  - For a multi story building borehole spacing is 10-30m.
  - The exploration cost is generally 0.1-0.5% of the cost of the structure.

Site Investigation Phases

- Phase-IV: Write a report
  - A clear description of the soils at the site
  - Methods of exploration
  - Soil profile
  - Test methods and results
  - The location of the groundwater.

Phases

- Phase IV.

  Information and/or explanations of;

  ✓ any unusual soil

  ✓Water-bearing stratum

  ✓Soil and groundwater condition that may be troublesome during construction.

  included.

Site Exploration Methods

- Test pits
- Boreholes
- Probes (in-situ tests) and geophysical.
  - Choice of method depends on budget, sampling requirements, extent of investigation and site conditions.

Test Pits

- Cheap method of investigation to shallow depth (backhoe to 4m depth, excavator to 5.5.m depth)
- Allows visual inspection of strata
- Limitations: undisturbed sampling difficult, collapse in granular soils or below ground water table.

Exploratory Borings in the Field

- Hand auger is a cheap, but slow method. Used for simple investigations (i.e. house foundations) or where access would otherwise be difficult. Undisturbed sampling is difficult.
- Auger boring is the simplest method of making exploratory boreholes.
- The soil samples obtained from such borings are highly disturbed. In some noncohesive soils or soils having low cohesion, the walls of the boreholes will not stand unsupported. In such circumstances, a metal pipe is used as a casing to prevent the soil from caving in.

Exploratory Borings in the Field

- Wash boring
  - a casing about 2-3m long is driven into the ground. The soil inside the casing is then removed by means of a chopping bit attached to a drilling rod. Water is forced through the drilling rod and exists at a very high velocity through the holes at the bottom of the chopping bit. The water and the chopped soil particles rise in the drill hole and overflow at the top of the casing through a T connection.
- Rotary drilling is a procedure by which rapidly rotating drilling bits attached to the bottom of drilling rods cut and grind the soil and advance the borehole. Can be used in sand, clay and rocks.
- Percussion drilling is another method of advancing a borehole particularly through hard soil and rock. A heavy drilling bit is raised and lowered to chop the hard soil.

Exploratory Borings in the Field

- *Borehole Support*
  - Steel casing- hydraulically pushed
  - Drilling mud- based on natural bentonite clay, which can be mixed in powder form to the drilling water to create a higher density suspension. Forms thin 'filter cake' on walls of hole which stabilises cohesionless soils against caving.

Procedures for Soil Sampling

- **Disturbed samples** which are representative and can be used for grain size analysis, liquid and plastic limits, specific gravity, compaction tests, moisture content, organic content determination and soil classification test performed in a lab.
- **Undisturbed samples** which are used for consolidation, permeability or shear strength tests.
  - More complex jobs or where clays exist
  - In sand is very difficult to obtain undisturbed sample

Procedures for Soil Sampling

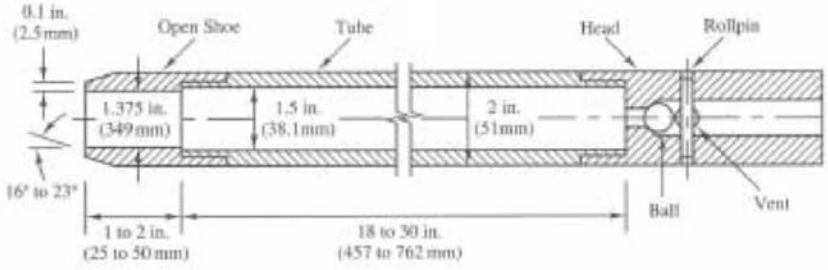
- *Disturbed samples*
  - Used for routine jobs to identify soils and determined index properties (particularly SPT)
  - Split barrel SPT sampler
  - California modified sampler
  - Augured samples

Soil disturbances occur from several sources during sampling such as

  - Friction between the soil and the sampling tube
  - The wall thickness of the sampling tube
  - The sharpness of the cutting edge
  - Care and handling during transportation of the sample tube.
- To minimize friction, the sampling tube should be pushed instead of driven into the ground.
- Sampling tubes that are in common use have been designed to minimize sampling disturbances.

Soil Samplers

- Types of soil sampler:
  - ShelbyTube: thin-walled seamless steel tube of diameter 50 or 75mm and length of 600-900mm.
    - o The bottom end of the tube is sharpened.
    - o The tubes can be attached to drilling rods.
    - o The drilling rod with the sampler attached is lowered to the bottom of the borehole and the sampler is pushed into the soil.
    - o The soil sample inside the tube is then pulled out.
    - o The two ends of the sampler are sealed and sent to the lab.
      - o The samples can be used for consolidation or shear tests.



Soil Samplers

- Types of soil sampler:
  - Standard sampler (Split Spoon Sampler): has an inside diameter of 35mm and an outside diameter of 50mm.
    - Has a split barrel which is held together using a screw-on driving shoe at the bottom end and a cap at the upper end.
    - The thicker wall of the standard sampler permits higher driving stresses than the Shelby tube but does so at the expense of higher levels of soil disturbances.
    - Split spoon samples are disturbed.
    - They are used for visual examination and for classification tests.

Soil Samplers

- Scraper Bucket
  - When soil deposits are sand mixed with pebbles, obtaining samples by split spoon may not be possible with a spring core catcher and a scraper bucket may be used.
  - The scraper bucket has a driving point and can be attached to a drilling rod. The sampler is driven down into the soil and rotated and the scrapings from the side fall into the bucket.

Soil Samplers

- Piston Sampler
  - When undisturbed soil samples are very soft or larger than 76.2mm in diameter, they tend to fall out of the sampler. Then piston samplers are used.
  - They consist of a thin wall tube with a piston. Initially, the piston closes the end of the thin wall tube. The sampler is lowered to the bottom of the borehole and the thin wall tube is pushed into the soil hydraulically past the piston. Then the pressure is released through a hole in the piston rod. To a large extent, the presence of the piston prevents distortion in the sample by not letting the soil squeeze into the sampling tube very fast and by not admitting excess soil. Consequently, samples obtained in this manner are less disturbed than those obtained by Shelby tubes.

- *Sample Storage*
  - Water retention – air tight containers, seal ends of thin wall tubes, plastic sleeves for core samples.
  - Mechanical protection – (Cores) steel trays with lids, plastic half tubes for support, foam inserts to indicate lost material.
- *Hole Closure*- safety- cap or backfill hole.
- *Observation of Water Tables*
  - The presence of a water table near a foundation significantly affects a foundation's load-bearing capacity and settlement. The water level will change seasonally. It is measured by piezometers by lowering them into the hole.

Boring Log

- During soil exploration all suitable details are recorded and presented in a boring log.
- Additional information consisting mainly of lab and field test result is added to complete the boring log.

SUMMARY

1. A site investigation is necessary to determine the nature of the soils at a proposed site for design and construction.
2. A soil investigation needs careful planning and is usually done in phases.
3. A number of tools are available for soil exploration. You need to use judgment as to the type appropriate for a given project.

WHY FIELD TESTS?

Sampling disturbances and sample preparation for lab tests may significantly impair the shear strength parameters. Consequently, a variety of field test have been developed to obtain more reliable soil shear strength parameters by testing soils in-situ.