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International Building Code - Soils And Foundations

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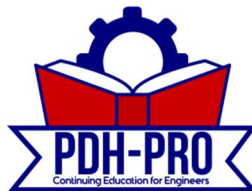
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Course Section: Soils and Foundations

Learning Objectives

After completing this section, the learner should be able to:

1. Identify when a foundation and soils investigation is required.
2. Explain how soil classification, groundwater, expansive soils, seismic risk, and fill conditions affect foundation design.
3. Apply basic code requirements for excavations, backfill, site grading, and compacted fill.
4. Interpret presumptive allowable foundation pressures and lateral resistance values.
5. Recognize major design requirements for footings, foundation walls, retaining walls, piers, and piles.
6. Distinguish between dampproofing, waterproofing, subsoil drainage, and groundwater control.
7. Explain how driven piles, cast-in-place piles, composite piles, and pier foundations differ in use and design considerations.
8. Recognize key seismic detailing requirements for pile and pier foundations.

1. General Scope and Design Basis

This section addresses the design and construction of building foundation systems in areas where foundations are not subject to scour or water pressure from wind and wave action. Where a building or foundation is subject to those water-related forces, the structural design must also address the applicable flood, wave, and lateral load requirements.

Foundation design relies on the interaction between the structure and the supporting earth materials. For this reason, the design of foundations, excavations, footings, piers, piles, and retaining elements must account for both structural loads and subsurface conditions. The code provisions in this section are based on allowable stress design concepts, allowable bearing pressures, allowable stresses, and prescribed design formulas.

The quality and design of structural materials used in excavations, footings, and foundations must also conform to the applicable structural provisions for loads, concrete, masonry, steel, and wood. Excavations and fills must be performed in a manner that does not undermine the building, adjacent structures, or foundation systems.

For seismic overturning, foundation proportioning must follow the applicable seismic design requirements when the foundation is proportioned using load combinations that include seismic effects. Where seismic overturning moments are calculated using the equivalent lateral-force method or modal analysis method, the foundation design must be coordinated with the applicable ASCE 7 seismic provisions.



2. Foundation and Soils Investigations

A foundation and soils investigation provides the engineering basis for evaluating the site and selecting an appropriate foundation system. The investigation may be required by the building official and, where required, must be conducted by or under the direction of a registered design professional.

A soils investigation is especially important where site conditions are uncertain, variable, or potentially unsuitable for conventional shallow foundations. It also becomes critical when the design relies on a higher allowable load-bearing value than the presumptive value allowed by code.

2.1 Conditions Requiring Investigation

A foundation and soils investigation is required or may be required under several conditions.

Questionable soil. If the classification, strength, or compressibility of the soil is in doubt, the building official may require an investigation. This applies when the design assumes that the soil can support greater loads than the presumptive values allowed by the code.

Expansive soil. In areas where expansive soils are likely, testing is required to determine whether expansive soils are present. Expansive soils can swell when wet and shrink when dry, causing heave, cracking, differential movement, and distress in foundation systems.

Groundwater. A subsurface investigation is required where the existing groundwater table is above, or within 5 feet below, the elevation of the lowest floor level when that floor is below finished grade adjacent to the foundation. This requirement is important because groundwater can create hydrostatic pressure against basement walls and slabs.

Pile and pier foundations. Pile and pier foundations must be designed and installed based on a foundation investigation and report. Deep foundations depend on subsurface conditions for end bearing, skin friction, lateral support, and drivability or constructability.

Rock strata. Where subsurface exploration indicates variations or questionable rock characteristics, enough borings must be performed to verify the soundness and load-bearing capacity of the rock. The borings must extend to a depth sufficient to confirm the foundation bed.

Seismic Design Category D, E, or F. Structures in higher seismic design categories require evaluation of geologic and geotechnical hazards, including slope instability, liquefaction, surface rupture, lateral spreading, lateral earth pressures, and potential reductions in soil-bearing capacity.

Building height. For buildings more than three stories or more than 40 feet above grade plane, the building official must request soil tests.



2.2 Soil Classification

Soil classification provides a common engineering language for evaluating bearing capacity, settlement, drainage, lateral earth pressure, and constructability. Where classification is required, soils are classified using the Unified Soil Classification System as referenced by ASTM D 2487.

Expansive soils are identified using index properties and expansion testing. A soil is considered expansive when it meets the code criteria for plasticity index, percent passing the No. 200 sieve, clay-size fraction, and expansion index, unless expansion testing alone establishes the classification.

Key indicators of expansive soil include:

- **Plasticity index of 15 or greater**
- **More than 10 percent passing the No. 200 sieve**
- **More than 10 percent particles smaller than 5 micrometers**
- **Expansion index greater than 20**

Engineers should not treat expansive soil identification as a purely administrative requirement. Expansive soil behavior can control foundation selection, footing depth, slab design, moisture control, drainage, and long-term maintenance requirements.

2.3 Scope of Investigation

Soil classification must be based on observation and testing of materials encountered in borings, test pits, or other subsurface explorations. The investigation must be broad enough to evaluate:

- Slope stability
- Soil strength
- Depth and adequacy of load-bearing strata
- Moisture effects on bearing capacity
- Compressibility
- Liquefaction potential
- Expansiveness
- Groundwater conditions
- Settlement potential

The registered design professional determines the scope of borings, soundings, in-situ testing, laboratory testing, and sampling methods. Where exploratory borings are required, the code provides a minimum expectation of at least one exploratory boring to rock or to adequate depth below the load-bearing strata for every 2,500 square feet of built-over area, plus additional tests required by the building official.



2.4 Soil Report Requirements

A soil report should provide enough information for a design professional and building official to understand the subsurface basis of design. At a minimum, the report must include:

1. Locations of test borings and excavations.
2. A complete record of soil samples.
3. Soil profile information.
4. Water table elevation, if encountered.
5. Foundation type and design recommendations.
6. Bearing capacity for natural or compacted soils.
7. Provisions to mitigate expansive soils.
8. Mitigation measures for liquefaction, differential settlement, and varying soil strength.
9. Evaluation of adjacent load effects.
10. Expected total and differential settlement.
11. Pile and pier foundation information, where applicable.
12. Special design and construction requirements for expansive soils.
13. Compacted fill material properties and testing requirements.



Checkpoint Quiz

1. When may the building official require a foundation and soils investigation?

- A. Only when the building is located in a flood hazard area
- B. When soil classification, strength, or compressibility is in doubt
- C. Only when shallow foundations are prohibited
- D. When the building is less than one story tall

Answer: B. A foundation and soils investigation may be required when the building official determines that the soil classification, strength, or compressibility is uncertain or questionable.

2. Which condition requires a subsurface investigation related to groundwater?

- A. Groundwater is more than 20 feet below the lowest floor.
- B. The groundwater table is above, or within 5 feet below, the lowest floor level when that floor is below adjacent finished grade.
- C. The site has sandy soil but no basement.
- D. The building has a slab-on-grade floor above finished grade.

Answer: B. A subsurface investigation is required when groundwater is above, or within 5 feet below, the lowest floor level where that floor is below finished grade adjacent to the foundation.

3. Which of the following is one criterion used to identify potentially expansive soil?

- A. Plasticity index less than 5
- B. More than 10 percent passing the No. 200 sieve
- C. Less than 1 percent clay-size particles
- D. Expansion index less than 5

Answer: B. Expansive soil criteria include more than 10 percent passing the No. 200 sieve, along with other index and expansion properties.



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4. What information should be included in a soil report?

- A. Only the name of the contractor and the building address
- B. Only the proposed architectural floor plan
- C. Boring locations, soil profiles, groundwater information, foundation recommendations, bearing capacity, and settlement considerations
- D. Only the expected construction schedule

Answer: C. A soil report should document the subsurface investigation and provide the information needed to support foundation design, including soil profiles, groundwater conditions, bearing recommendations, and settlement considerations.



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