

**53:139 Foundation Engineering  
The University of Iowa  
Spring Semester, 1998**

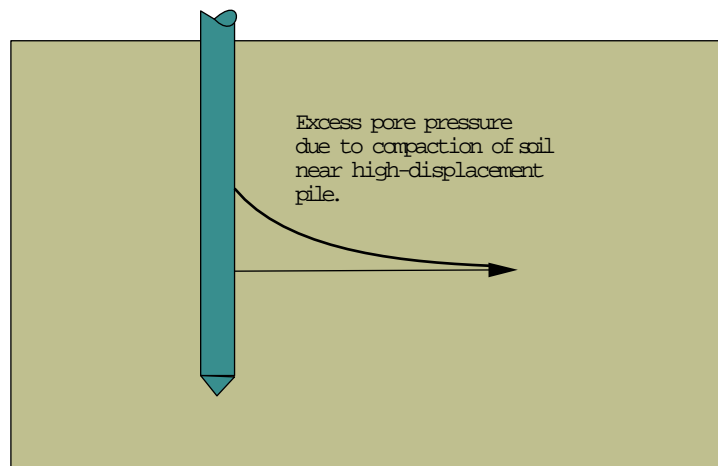
**Lecture #21: Pile Foundations**

**I. Changes in Soil as a Result of Pile Driving**

- The process of constructing shallow foundations does not radically alter the properties of nearby soils. Neither does the process of constructing drilled shaft foundations significantly alter such in-situ soil properties as the relative density, or the lateral stress in the soil.
- Consequently, these soil properties measured in the SSE are representative of those that will exist following construction of the foundations.
- The same comments do not hold for soils in the vicinity of driven piles:
  - The pile driving process can potentially generate large stresses and deformations in the nearby soil.
  - The pre-construction soil properties are thus not necessarily representative of the post-construction properties.
  - This is an important source of uncertainty in pile foundation analysis and design.

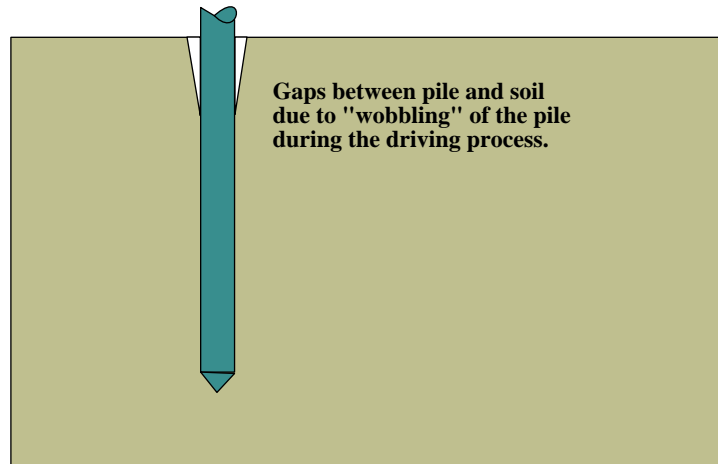
**A. Changes in Cohesive Soils**

1. Soil within a few pile diameters can undergo large shear deformations. For many cohesive clay soils which tend to be highly sensitive to remolding, this leads to significant loss of strength in the short term.
2. Compression and Excess Porewater Pressure. Driving of high displacement piles strongly compresses adjoining soils, and leads to a buildup of excess porewater pressure.



**Figure 1:** Buildup and distribution of excess porewater pressure near a high displacement pile.

- This temporary buildup of excess porewater pressure (pwp), coupled with the sensitivity of the clay, causes the soil to lose a good fraction of its shear strength in the short term.
  - This excess pwp dissipates over a time scale of a few weeks to a few months. As this occurs, the adjoining soil consolidates and increases its strength. The final strength can exceed the initial undisturbed shear strength of the soil. This behavior reflects the thixotropic nature of many clay soils.
  - Thus, while piles may drive quite easily into saturated clay soils, after awhile the soil “sets up” or “freezes” in conjunction with the dissipation of the excess porewater pressure.
3. Loss of Side Contact Between Pile and Soil.
- Piles wobble during the driving process. With stiff clays, this can lead to the formation of gaps between the pile and the soil.
    - Soft, saturated clays that become disturbed will flow into these gaps;
    - Stiffer, non-saturated clays generally will not flow into these gaps;
    - These gaps have been observed to depths of 8–16 pile diameters;
    - The possibility of these gaps means that skin friction is not reliable in this zone for stiff clays.



**Figure 2:** Gaps between stiff soil and pile resulting from wobbling of the pile during the driving process.

### B. Pile-Driving Induced Changes in Cohesionless Soils

- Since excess pwp dissipates very rapidly in cohesionless soils, the soil regains its strength very rapidly;
- During driving of high-displacement piles, adjacent soils are strongly compressed, causing a buildup of lateral effective stresses. With time, these stresses may relax due to the viscoelastic nature of soils;
- During the driving of piles, adjacent soils are also strongly sheared, causing a tendency to dilate. This tendency to dilate increases the lateral effective stresses in the soil, and increases the friction between the pile and the soil. This makes it more difficult to drive piles;
- The bottom line, is that the process of driving piles into sand re-arranges and densifies the structure, causing it to gain shear strength.