DEEP FOUNDATIONS

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Textbook:


• Engineer Manual “DESIGN OF PILE FOUNDATIONS”, EM 1110-2-2906.
Why go deep?

[A] Near surface soils inadequate
• weak relative to applied loads
• erodible
  – watercourses, scour of soil

[B] Load orientation
• lateral loading – raked piles
• uplift loading - anchors

[C] Settlement concerns
Types of Deep Foundations

Deep foundations usually $L/B > 5$

$L = \text{pile length, } B = \text{dia. or breadth of pile}$

1. Driven Piles

MATERIALS
- wood, precast concrete, steel

SECTIONS
- octagons, solid circles, rings, H-sections

LIMITATIONS
Vibrations due to driving? Head room?
Pile material

- Steel; H-piles, Steel pipe
- Concrete; Site cast or Precast
- Wood; Timber
- Composite
Types of Deep Foundations

2. **Bored Concrete Piles**
   - Large diameter?
   - Increased base diameter?
     - underreamed
   - Excavation support?
     - Bentonite slurry
   - Limited practical depth
   - Soil restrictions
Caisson Installation Sequence

- Hole drilled with a large drill rig
- Casing installed (typically)
- Bell or Tip enlargement (optional)
- Bottom inspected and tested
- Reinforced
- Concrete placement (& casing removal)
Site Cast Concrete Piles

Cased Piles

Uncased Piles
Bentonite slurry

Weak soil, high WT

Concrete displaces fluid
Types of Deep Foundations

3. **Other**

- Driven cast in-situ piles
  - driven tube pile, filled with concrete
- Continuous flight augur piles
  - hollow augur string
  - concrete slurry inserted through tip as string withdrawn
- Etc, etc, etc
Cast in-situ piling

Reference http://www.keller-ge.co.uk/index.html
Types of Deep Foundations

For construction, piles may be subdivided into:

1. Displacement (or large-displacement) piles
2. Small-displacement piles
3. Non-displacement piles
NON-DISPLACEMENT PILE

Soil is removed

- The excavation may or may not be supported

DISPLACEMENT PILE

Soil is ‘displaced’ within the adjoining soil mass

- Displaced volume ≈ pile volume
SINGLE PILE LOAD CAPACITY

Capacity dependent on construction

- relaxation of field soil stresses?
  - less contact with side soil, less support

- Bentonite slurry used?
  - slippery side contact (smeared)

Stress relaxation expected for DISPLACEMENT PILES
SITE INVESTIGATION FOR PILING

1. Soil strength and stiffness
2. Soil chemical analysis \(\Rightarrow\) corrosion
3. Possible obstructions to installation
4. Potential for damage to adjoining structure due to “ground heave”
5. Vibrations
SITE INVESTIGATION FOR PILING

After-construction effects of:

1. Expansive soil
2. Negative friction / downdrag
3. Slope instability
1. **Geotechnical**
   - strength and stiffness
   ⇒ “serviceability”

2. **Pile structural** strength

3. **Pile material** “durability”
GEOTECHNICAL STRENGTH

Vertical compression loading:

ULTIMATE GEOTECHNICAL STRENGTH

- or capacity, $P_u$

\[ P_u = f_s A_s + f_b A_b \]
\[ f_s = \text{average, fully mobilized, "skin friction"} \]

\[ (= \text{INTERFACE friction and adhesion}) \]

\[ f_b = \text{ultimate base bearing pressure} \]

Dependent upon –

SOIL TYPE

SOIL PROFILE

PILE MATERIAL

INSTALLATION
Low load

\[ f_s = \tau_{\text{max}} \]

\[ f_s \ll \tau_{\text{max}} \]

Base resistance, \( f_b \), mobilized

Ultimate load

\[ f_s = \tau_{\text{max}} \]

for the full length
Calculations

Circular pile, length, L:

\[ P_u = \sum f_s (\pi D_l) + f_b (\pi D_b^2 / 4) \]

where \( D_b \) = diameter of base

Note 1: \( f_s \) may vary down the shaft

\( (add \ contributions) \)

Note 2: \( f_b \) only at base
The equivalent factor of safety is usually between 2 and 2.5 for static analysis based on good soil data and site investigation.