DEEP FOUNDATIONS

Dr. Youssef Gomaa Youssef

Textbook:

- Tomlinson, J.J., 1977. Pile Design and Construction Practice, Garden City Press Ltd., Letchworth.
- Canadian Foundation Engineering Manual, 1978, Canadian Geotechnical Society, Montreal.
- 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 = pile length, B = dia. or breadth of pile

1. Driven Piles

MATERIALS

- wood, precast concrete, steel

SECTIONS

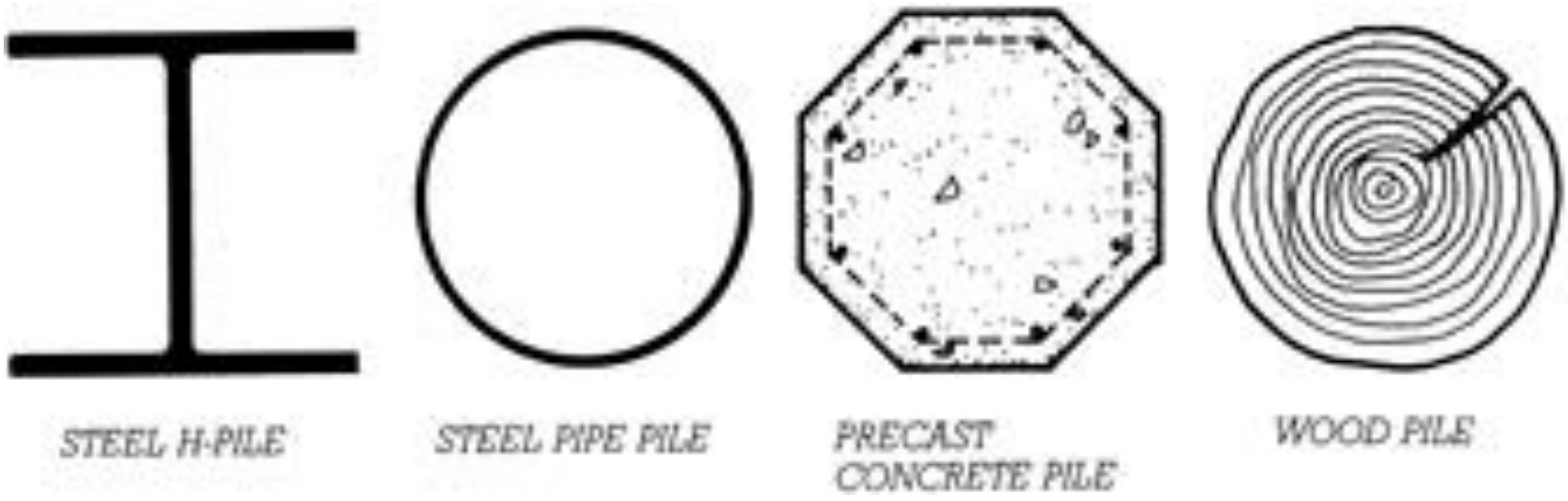
- octagons, solid circles, rings, H-sections

LIMITATIONS

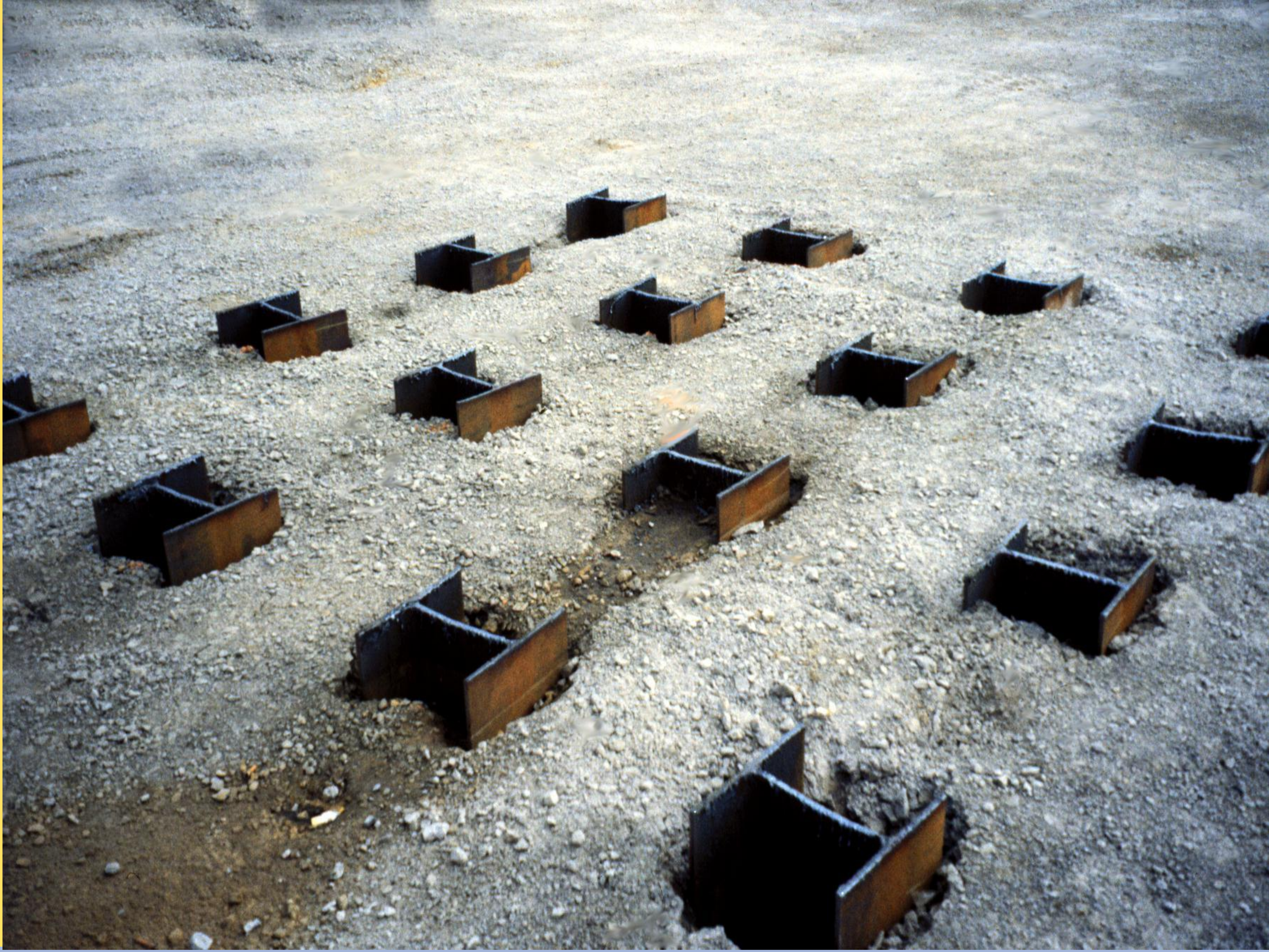
Vibrations due to driving? Head room?

Pile material

- Steel; H- piles, Steel pipe
- Concrete; Site cast or Precast
- Wood; Timber
- Composite



DRIVEN PILING



Types of Deep Foundations

2. Bored Concrete Piles

- Large diameter?
- Increased base diameter?
  - **underreamed**
- Excavation support?
  - **Bentonite slurry**
- Limited practical depth
- Soil restrictions

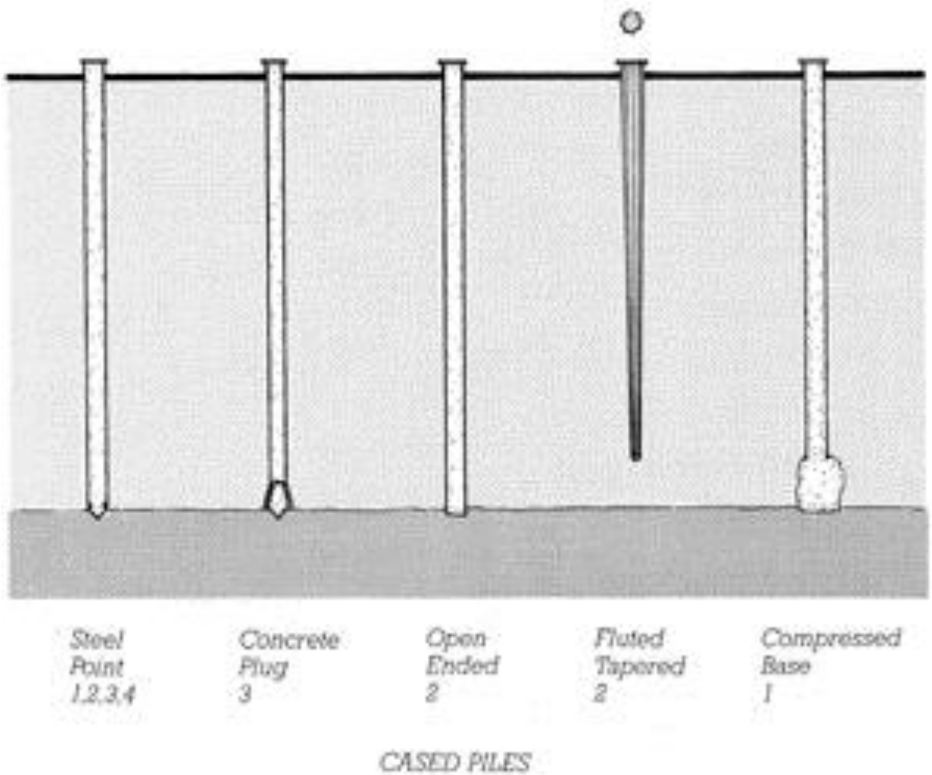
Caisson Installation Sequence

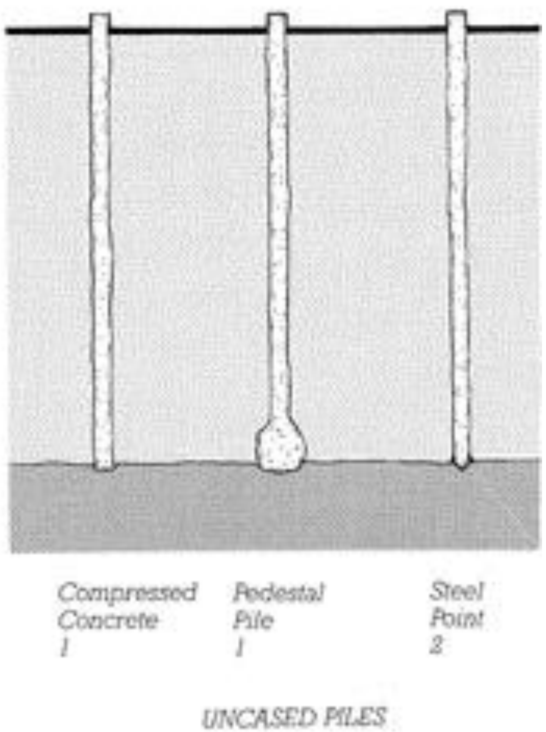
- Hole drilled with a large drill rig
- Casing installed (typically)
- Bell or Tip enlargement (optional)
- Bottom inspected and tested
- Reinforced
- Concrete placement (& casing removal)

Site Cast Concrete Piles

Cased Piles

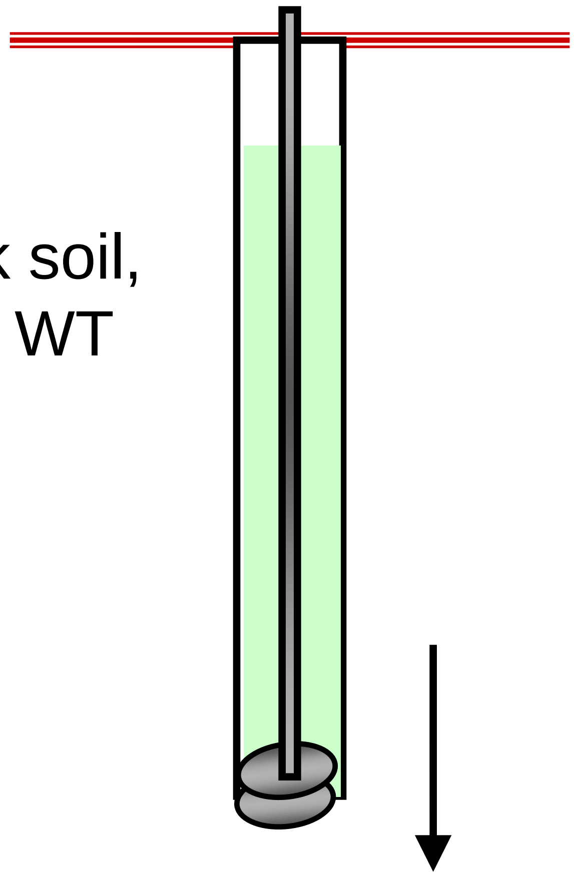
Uncased Piles

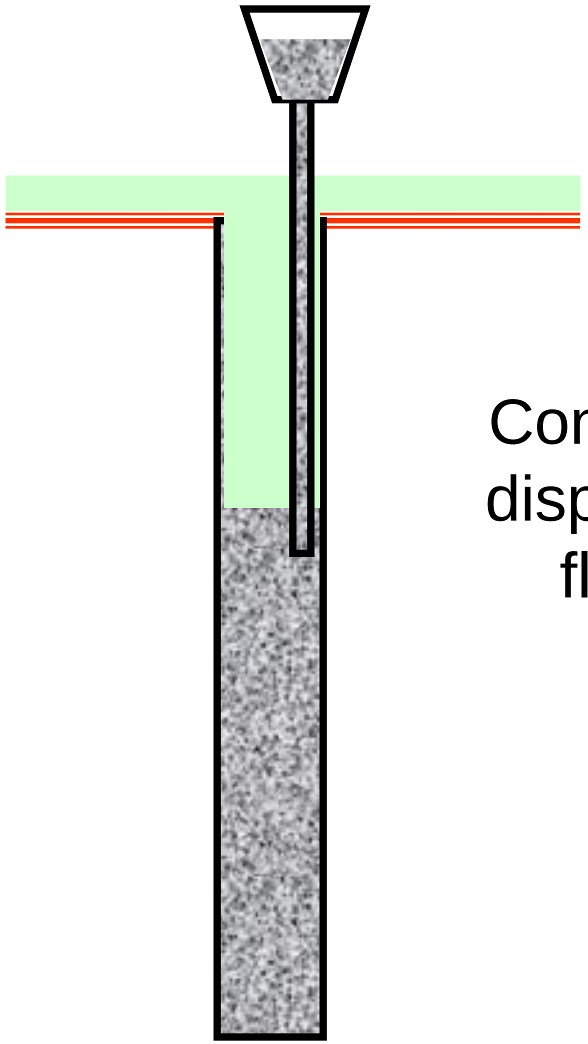




Bentonite slurry

Weak soil,
high WT





Concrete
displaces
fluid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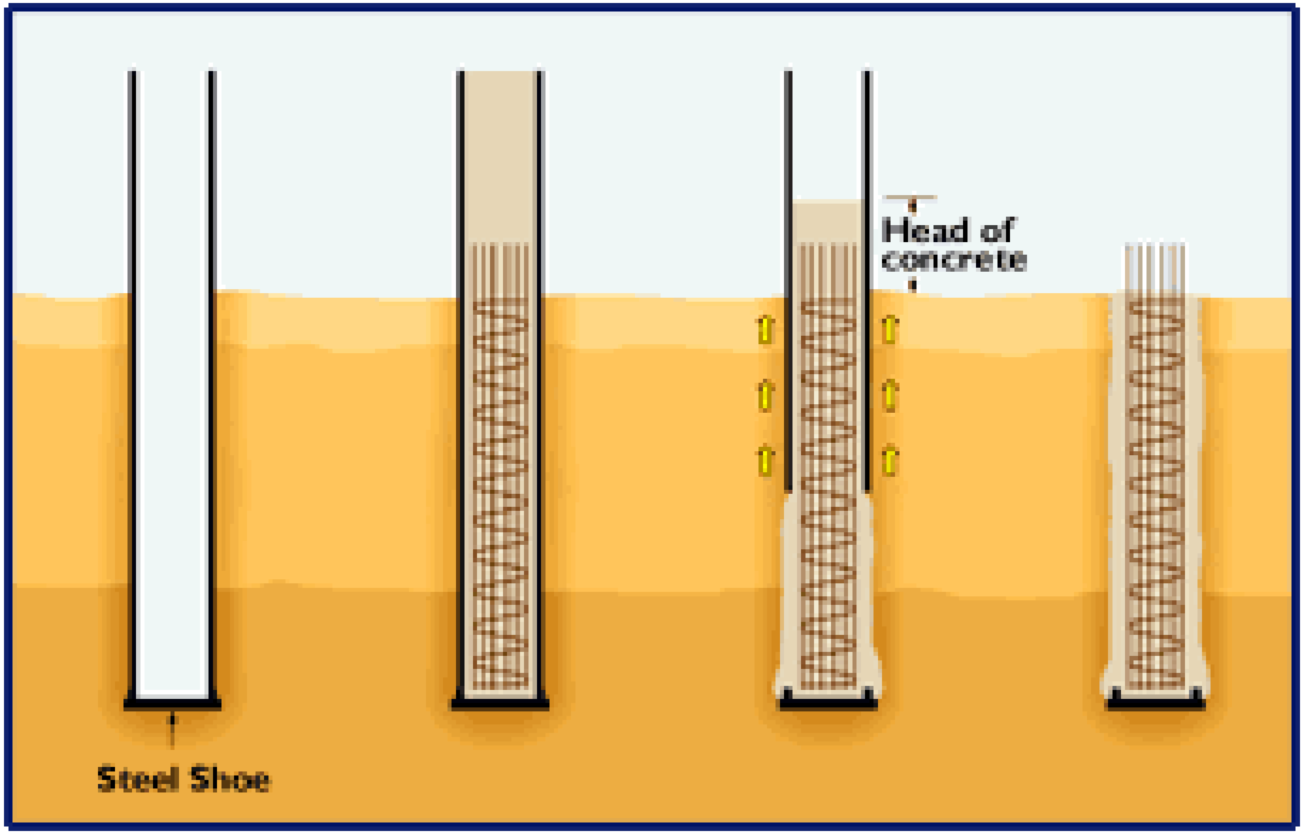
Types of Deep Foundations

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

PILES - design

1. **Geotechnical**

   - strength and stiffness

     $\Rightarrow$ "serviceability"

2. **Pile structural** strength

3. **Pile material** "durability"

GEOTECHNICAL STRENGTH

Vertical compression loading:

ULTIMATE GEOTECHNICAL STRENGTH

- or capacity, P_u

$$P_u = \overline{f_s} A_s + f_b A_b$$

f_s = average, fully mobilized, “skin friction” (= *INTERFACE* friction and adhesion)

f_b = ultimate base bearing pressure

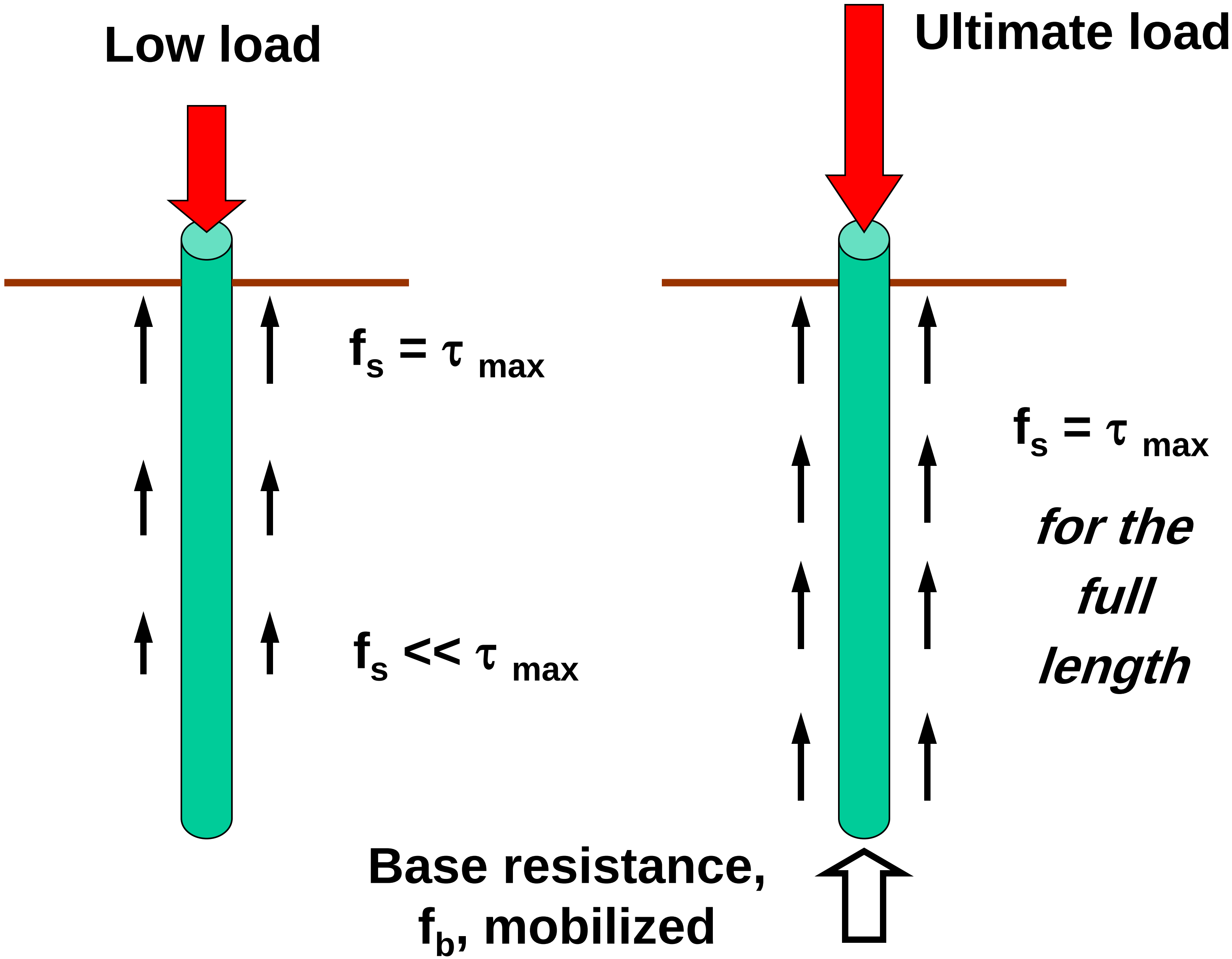
Dependent upon –

SOIL TYPE

SOIL PROFILE

PILE MATERIAL

INSTALLATION


Low load
Ultimate load
$f_s = \tau_{max}$
$f_s << \tau_{max}$
$f_s = \tau_{max}$
for the full length
Base resistance, f_b, mobilized

Calculations

Circular pile, length, L:

$$P_u = \Sigma f_s(\pi D l) + f_b(\pi D_b^2/4)$$

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***