DEEP FOUNDATIONS

Dr. Youssef Gomaa Youssef

Pile Parameters from Driving Analysis: Hiley Formula

$$R(S+c/2) = \eta W_h h$$

R = pile resistance

S = pile set

c = temporary elastic compression

η = efficiency factor

W_h = hammer weight

h = drop height

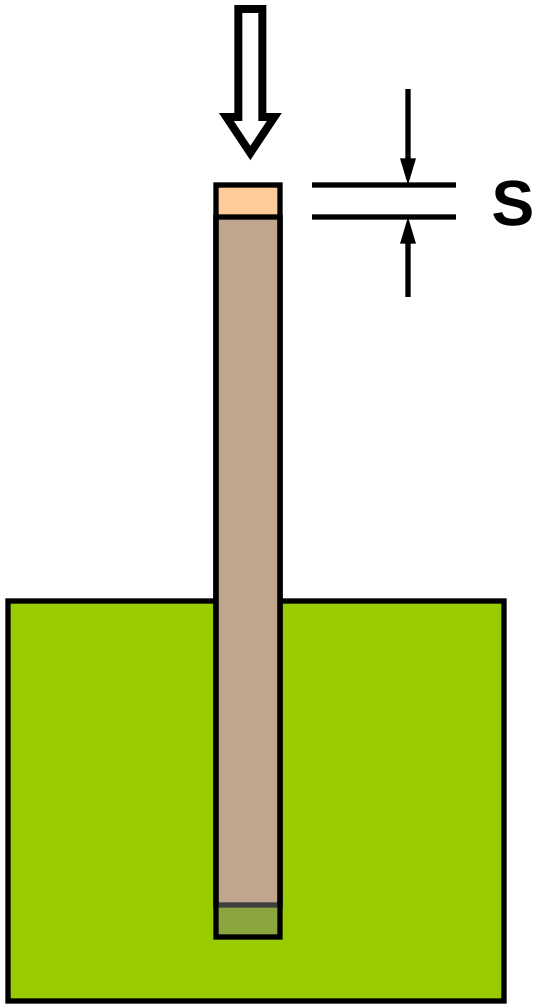
Temporary Elastic Compression

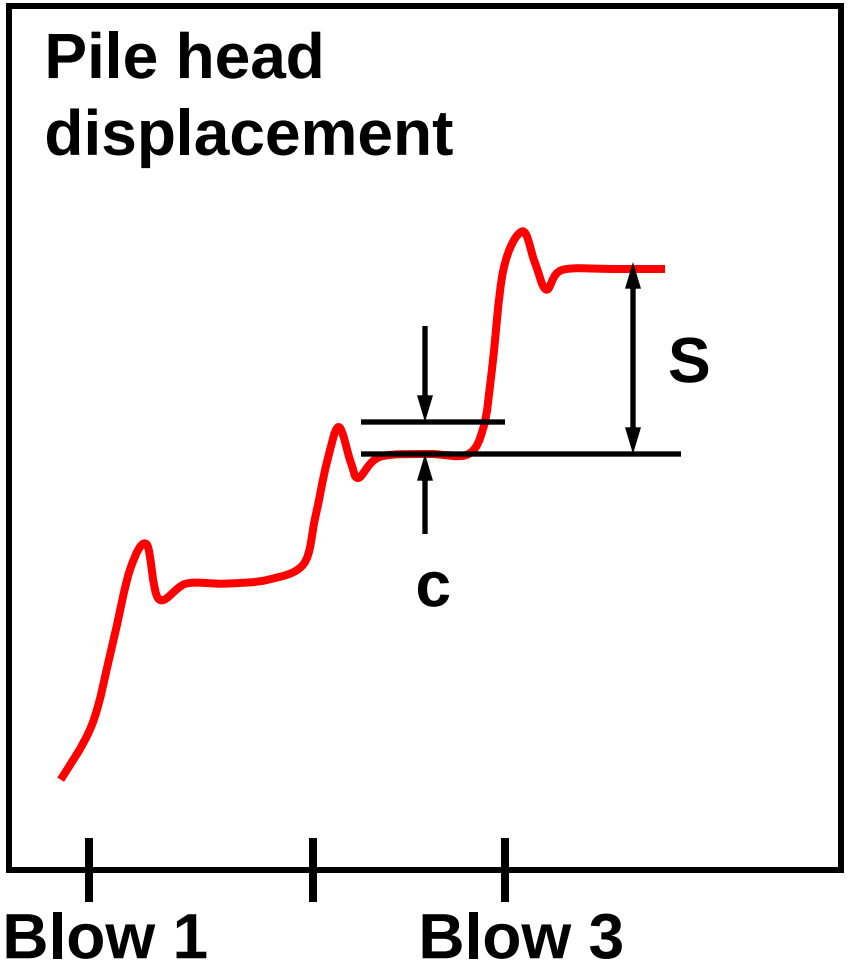
- Temporary elastic compression includes:
  - **Elastic compression of pile , C_p**
  - **Elastic compression of Soil, C_q**
  - **Elastic compression of Pile driving cap, C_c**

  - **Note:**

Refer to E.C.P for estimation of elastic compression

Energy IN = Energy OUT





The efficiency factor

$$\eta = \frac{k\left(W_h + e^2 W_p\right)}{W_h + W_p}$$

W_p = pile weight

e = coefficient of 'restitution'

k = output efficiency of the hammer

Note:

Refer to E.C.P for e and k

The Hiley Formula

- Simple expression
- Requires driving efficiency of system
- Requires simple measurement of pile displacement near design depth, for regulated driving energy.

WARNING:

Good record in sands, not so good in clays

Remaining Design Considerations

- Negative Skin Friction

  "downdrag forces on piles"

- Group action
- Settlement

1. Negative Skin friction

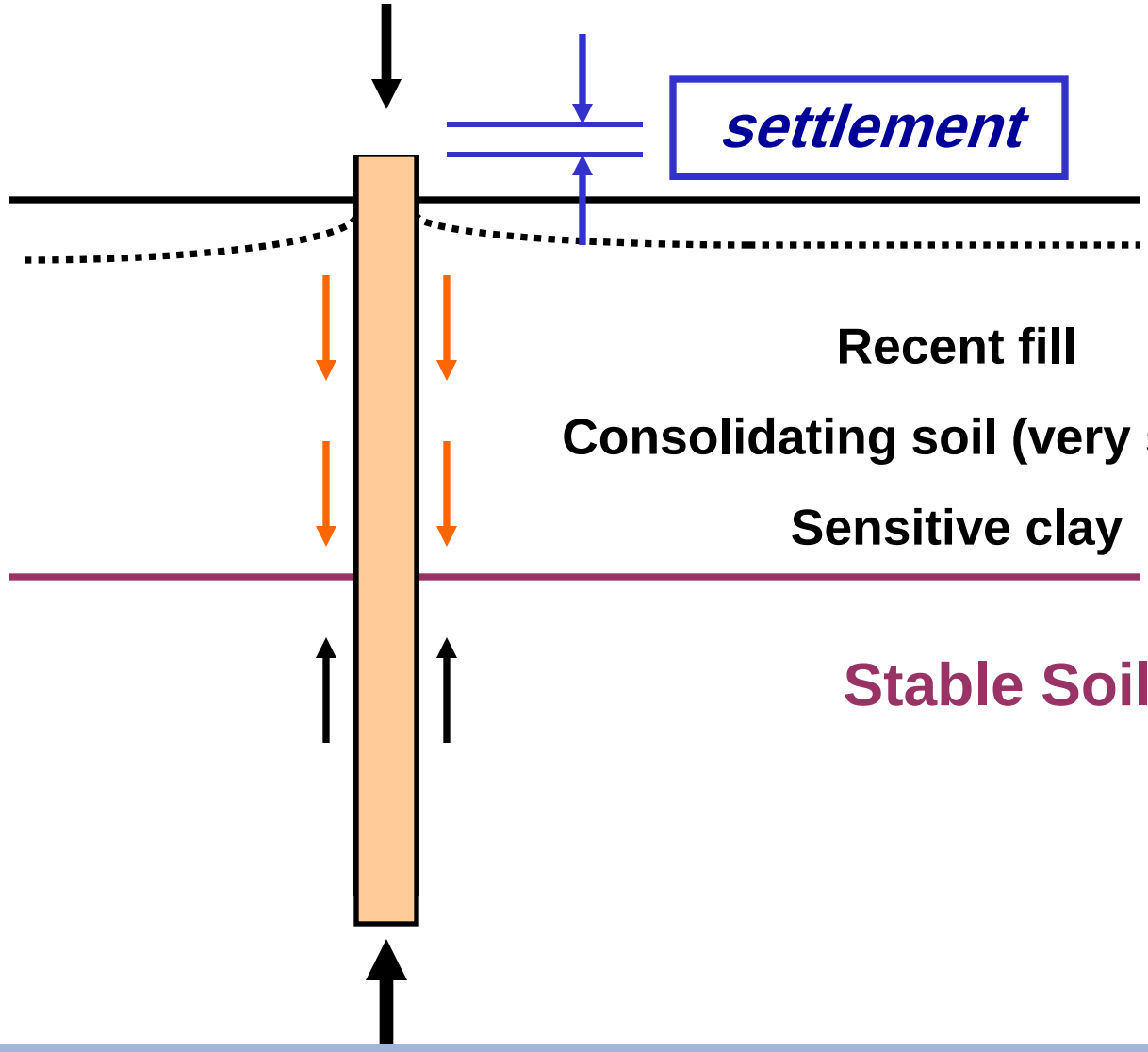
Adhesion factor may be negative!

CRAIG - for NC clay undergoing consolidation

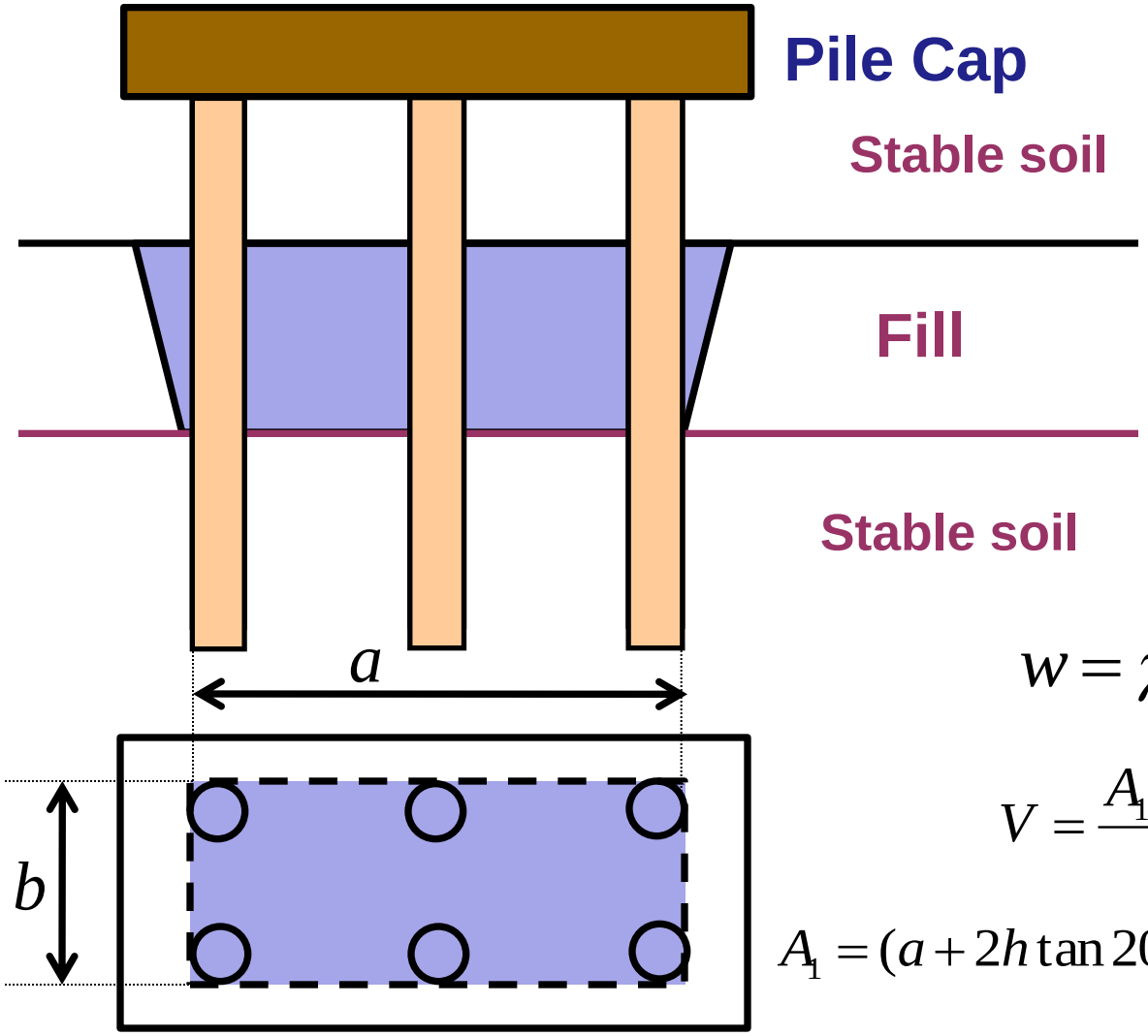
$$f_s = K_s(\sigma'_o)\tan\phi'$$

$$f_s \cong -0.25\sigma'_o$$

The Situation



Estimation of Downdrag force



$$w = \gamma * V$$

$$V = \frac{A_1 + A_2}{2} h$$

$$A_1 = (a + 2h\tan 20) * (b + 2h\tan 20)$$

Estimation of Downdrag force

Steps for design:

- Estimate single pile capacity
- Calculate the required number of piles, N
- Increase number of piles by one (for downdrag force due to negative skin friction), N_1
- Draw the arrangement of piles
- Estimate the downdrag force as before
- Check the number of required piles

$$N = \frac{P_{F.L.} + w}{P_{all}} < N_1$$

2. PILE GROUPS

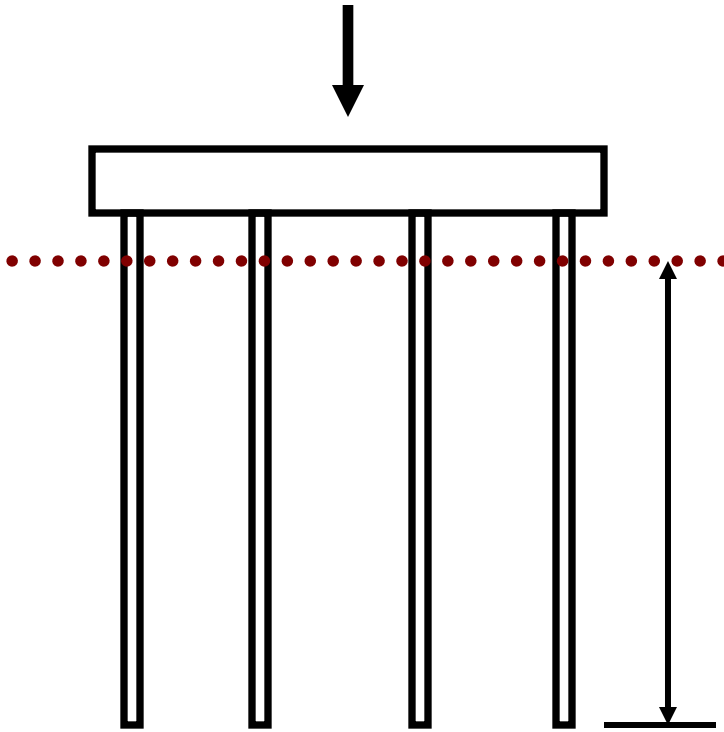
Group “efficiency”

Group capacity not always = Σ(pile capacities)

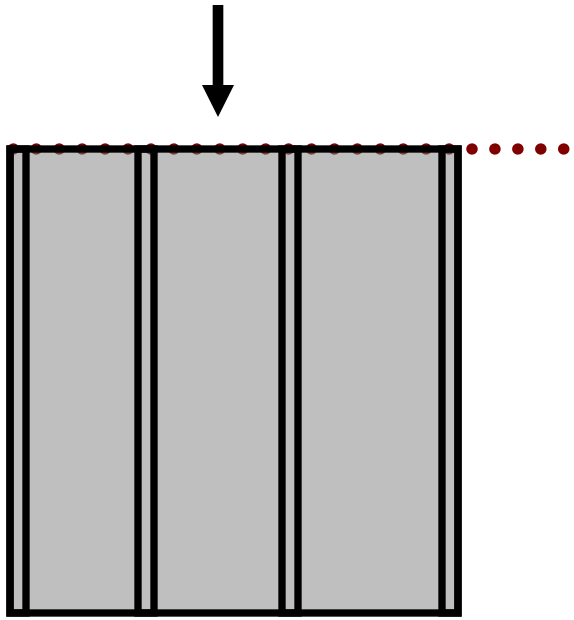
RATIO of group to Σ(pile capacities) = ***EFFICIENCY, η***

- close spacings in loose sand are ***efficient***
- close spacings in clay are ***inefficient***
- “**Block Action**” may determine Group capacity

Block Action



4x4 pile group, dia. d, spacing, s



Block base, $A_G = (3s + d)^2$,
Perimeter, $Per_G = 4(3s + d)L$

Calculations

- **For design**,
- Check the capacity of group is **<u>greater</u>** than Σ(pile capacities)

$$P_{G_{all}} = \frac{P_{G_{ult}}}{F.S.} = \frac{CN_c A_G + C_a L * Per_G}{F.S.}$$

$$P_{F.L.} + w \leq P_{G_{all}} \qquad \eta = \frac{P_{G_{all}}}{P_{F.L.} + w} \geq 1.00$$

<u>NOTE:</u> *unlikely to need except for close piles in saturated clays,* s < 4d

PILES - SUMMARY

Pile capacity depends largely on <u>installation</u>

1. Single Piles (a) STATIC ANALYSIS

<u>Sands</u>: f_{smax} and f_{bmax}

<u>Clays</u> - adhesion factor, α

- $f_b = 9c_u$

(b) CPT DATA

- better parameter evaluation

SUMMARY

1. Single Piles — **(c) Dynamic Analysis**

"driving" data used (gives capacity at the time of pile-driving)

2. Pile Groups — **Block Action** may diminish capacity, AND increase settlement