FOUNDATION ENGINEERING

DEEP FOUNDATIONS

DEEP FOUNDATIONS

TYPES OF DEEP FOUNDATIONS:

1- PILES الخوازيق

2- CAISSONS القيسونات

أساسات خلوية تنفذ بالتغويص والحفر

3- PIERS الدعائم

أساسات الكبارى وهى خوازيق ذات قطر كبير أو قواعد ذات حجم كبير يجفف داخلها

Pile are used in

1- Upper soil is weak, compressible, or could not support the surface loads.

2- The loads are tension, horizontal, or inclined.

3- Problematic soils;

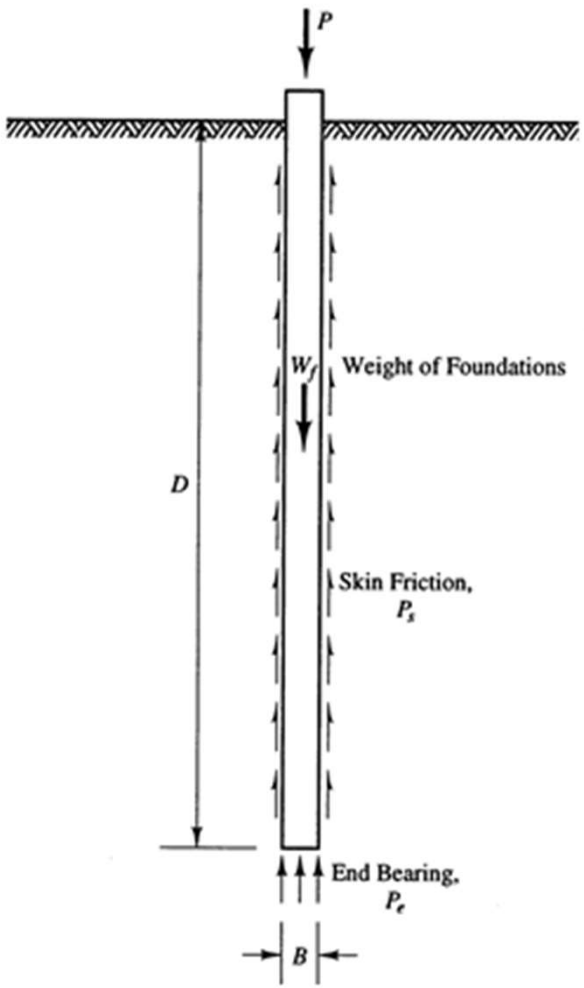
Swelling soils giving tension on the pile.

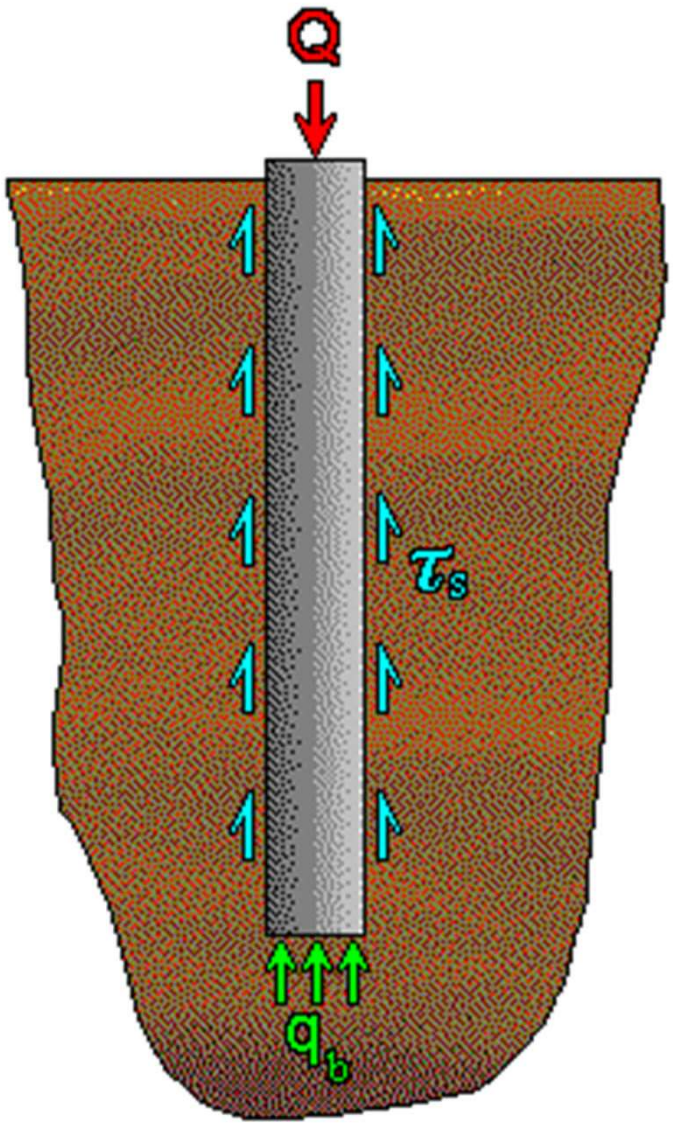
Collapsing soils, adding down-drag forces on the pile.

4- Scour under bridge piers.

5- Temporary or Permanent Excavation Side Support

Load Transfer





Pile Foundations

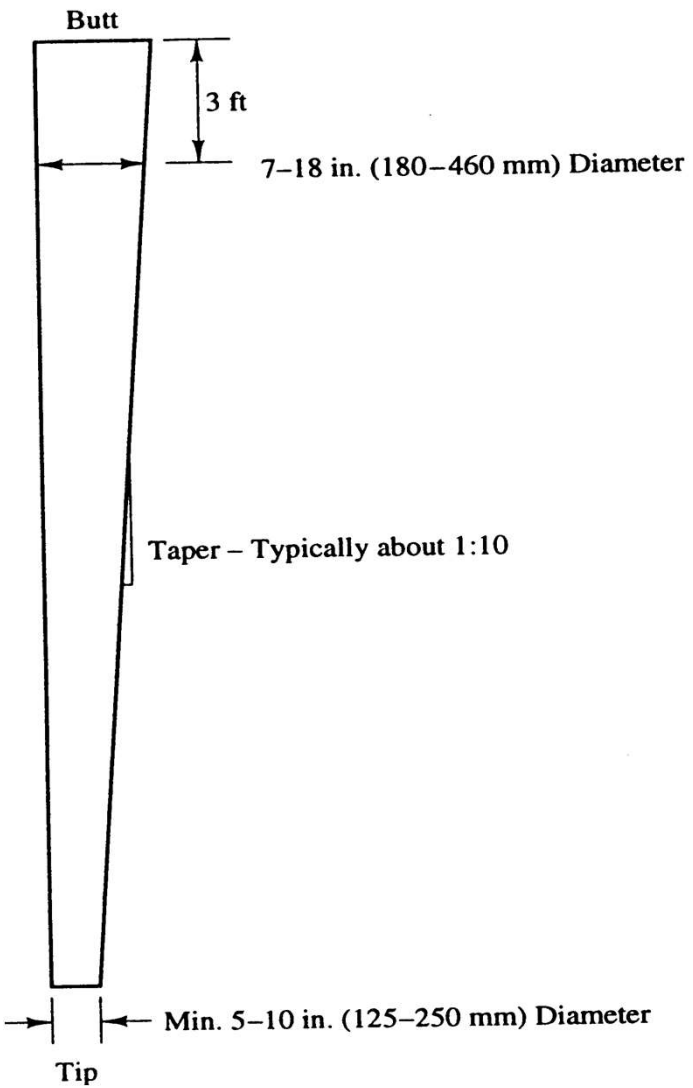
- Types of Piles
  - Materials
  - Typical Dimensions
- Installation Methods & Equipment
- Construction Procedures
- Typical Applications

Types of Piles

- Timber Piles
- Steel Piles
- Concrete Piles
- Composite Piles

Timber Piles

- Southern Pine
- Douglas Fir
- Tapered Shape
- Butt dia. 6-16 inches
- 20-60 ft length
- 20-100k capacity



Timber Piles

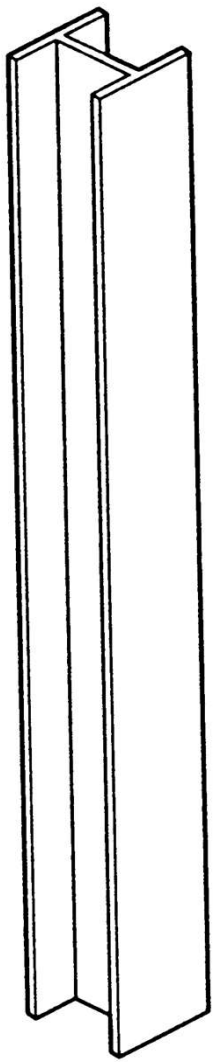
- Usually treated with preservatives before installation (Creosote)
- Longer serviceable life if completely submerged in water; cyclic wetting & drying causes decay
- Susceptible to damage during driving
- Steel bands near butt, steel shoe at tip

Steel Piles

- Easy to Splice
- Good choice when D>60ft
- Good choice in hard soils
- Expensive
- Noisier to drive
- Susceptible to Corrosion

Steel Piles

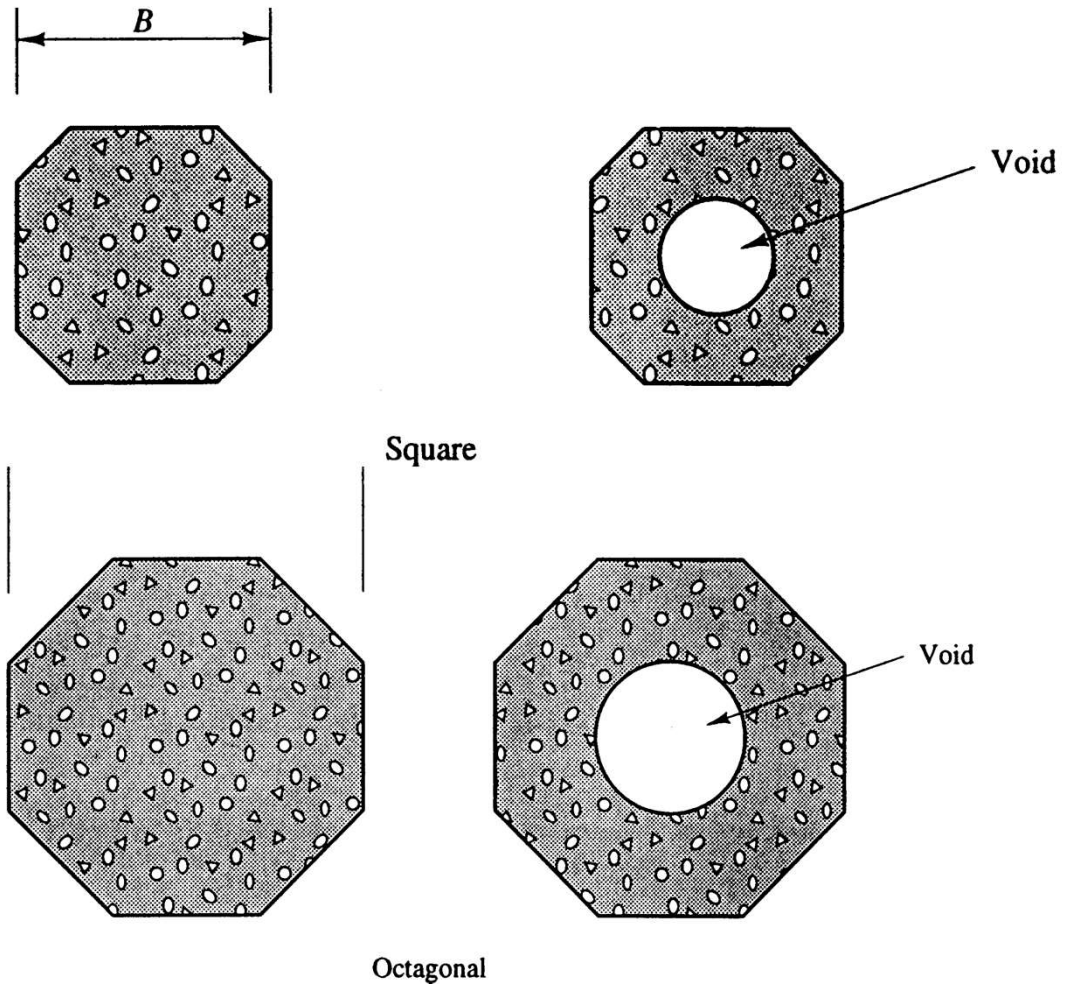
- H-piles
  - 50-150 ft length
  - 80-400 kip working loads
  - small displacement piles
- Pipe Piles
  - 100-150 ft length
  - 8-36 in diameter
  - closed or open end



Concrete Piles

- Reinforced Concrete
- Pre-stressed concrete
- Do not tolerate hard driving conditions
- Square or Octagonal Section
- 40-400ft long
- 10-24 inches width
- 100-800 kip working loads

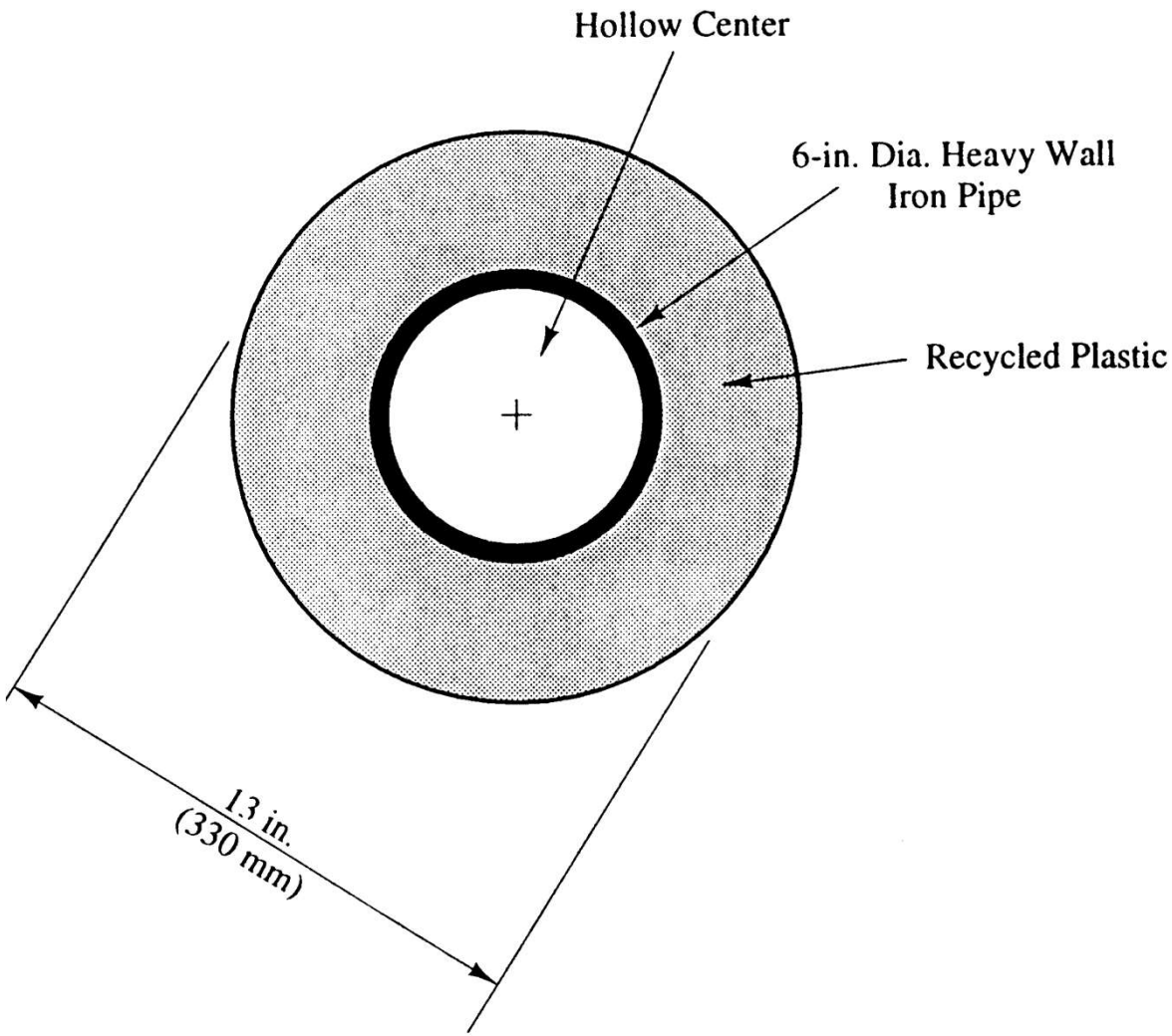
Concrete Piles



Composite Piles

- Concrete filled Steel Pipe Piles
  - Greater uplift capacity because of increased weight
  - Increased shear and moment capacity
- Plastic-Steel Composite Piles
  - Used in marine environments to increase resistance to borers, decay, abrasion
  - stronger than timber

Composite Piles



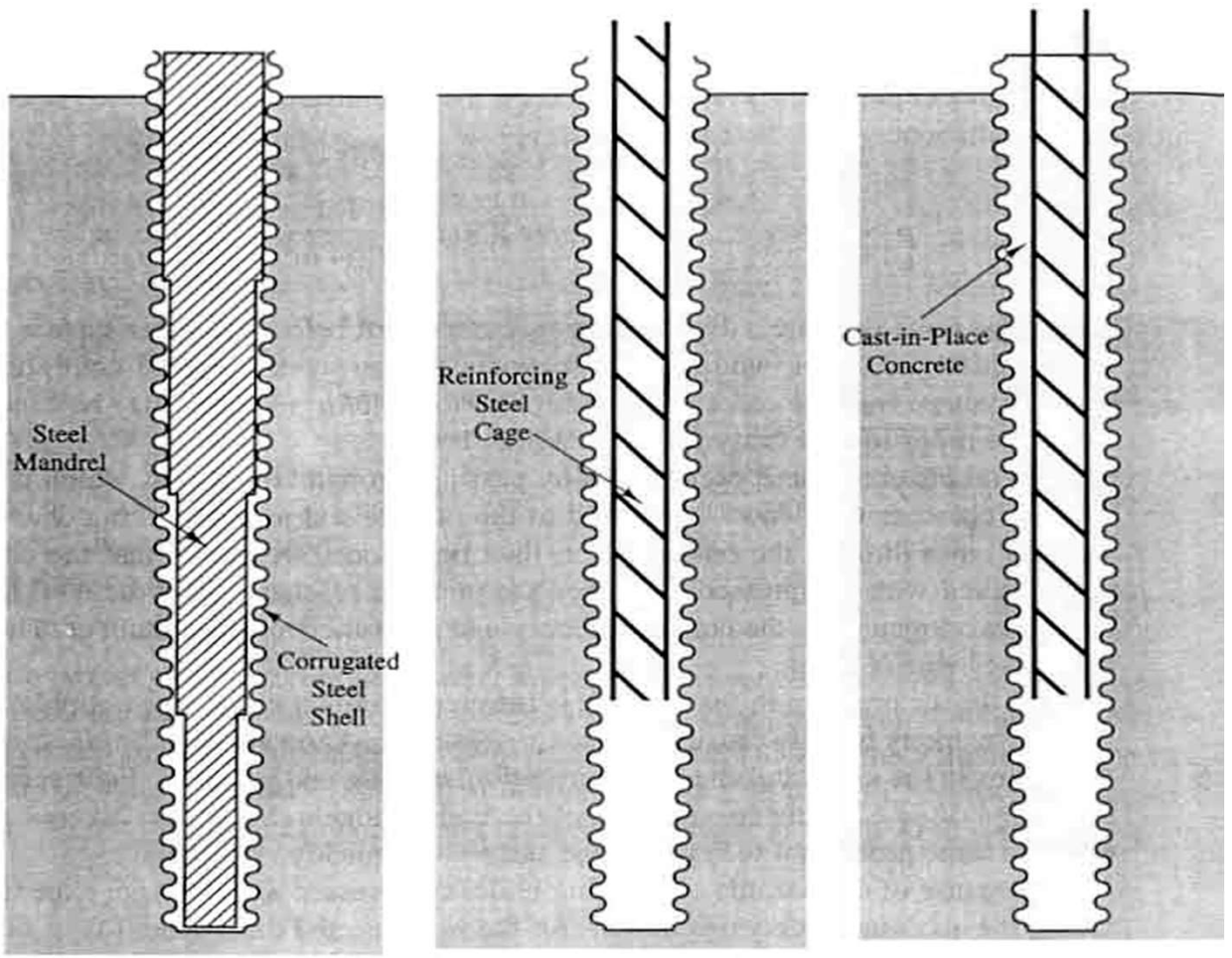
Construction Methods and Equipment

- Pile driving rigs
  - raise and support pile
  - has “leads” to guide the pile
  - hydraulic or cable actuators move “leads” into to desired alignment
  - supports the hammer

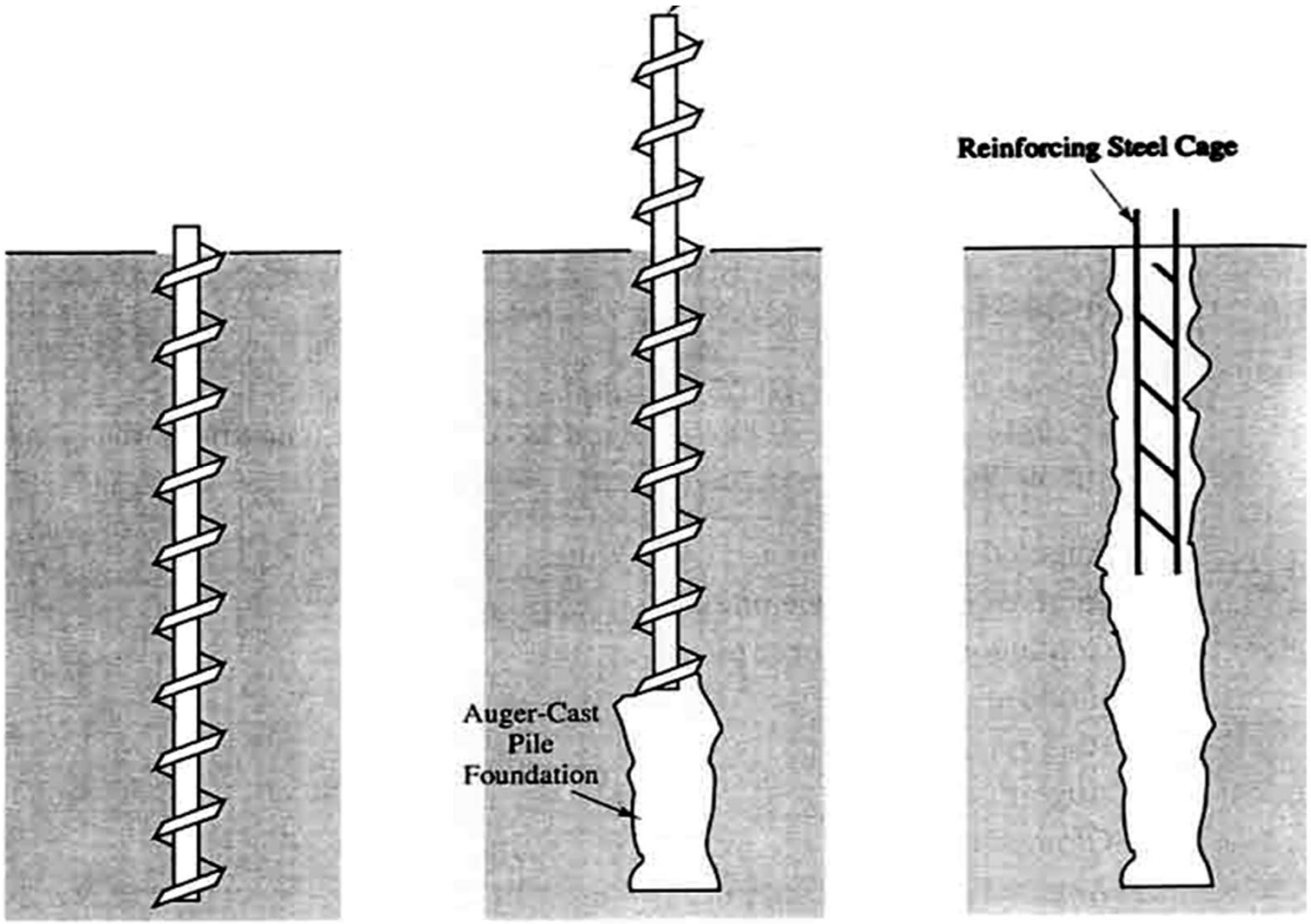
Pile Driving Hammers

- Drop Hammers
  - rarely used in US now
  - 3-12 blows/min
- Steam, Pneumatic Hydraulic Hammers
  - 60 blows/min
- Diesel Hammers (40-55 blows/min)
- Vibratory Hammers (150 Hz)

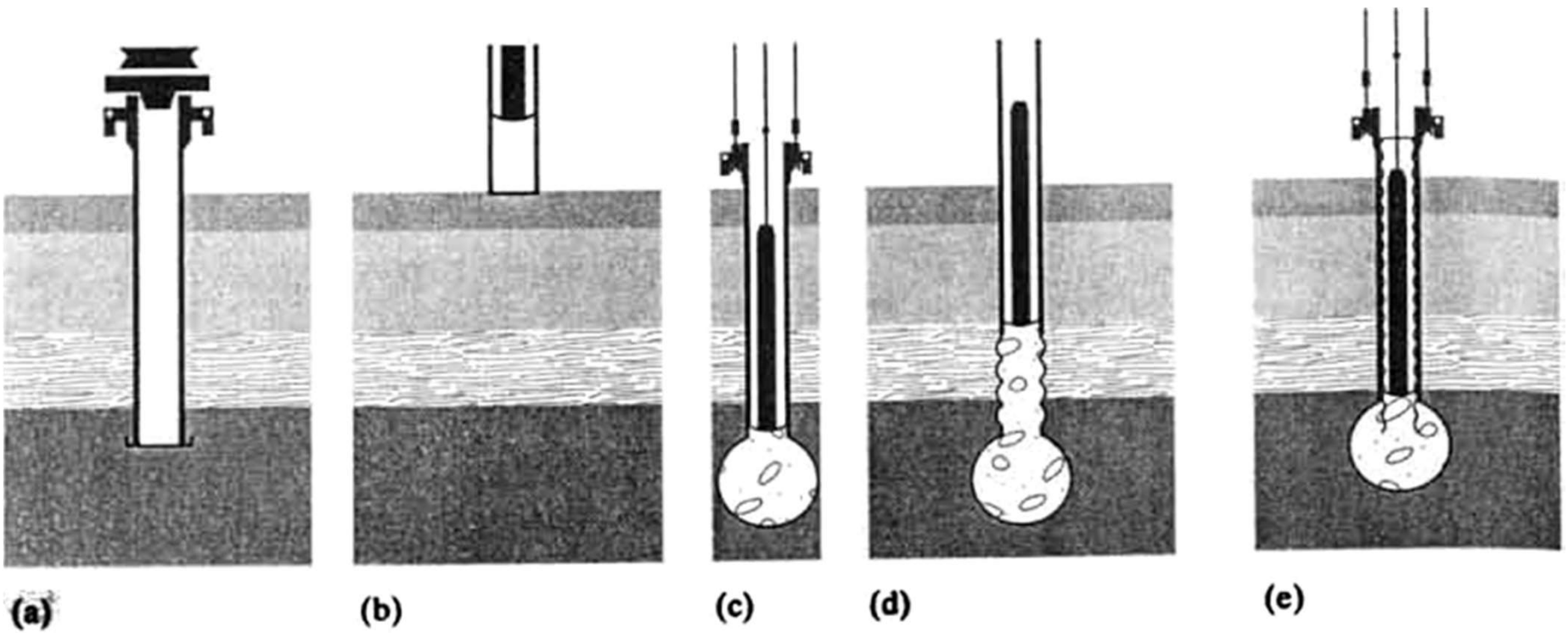
Thin Shells Filled with Concrete



Auger-Cast Piles



Pressure Injected Footings



Type of Piles According to Construction Methods

- Driven – Prefabricated Members driven into ground
- Bored– Drill Cylindrical Hole and insert reinforcing & fill with concrete
- Caissons – Prefabricated box or cylinder sunk into ground and filled with concrete

Type of Piles According to Construction Methods (Cont.)

- Mandrel driven shells – Thin corrugated steel shells driven into ground and filled with concrete
- Auger Cast Piles – Drill a slender cylindrical hole with hollow-stem auger and then pump grout through auger hole while auger is slowly retracted
- Pressure Injected Footings – Cast in place concrete that is rammed into the soil using a drop hammer

Driven Piles versus Bored Piles

Driven Piles	Bored Piles
Precast Members driven into soil	Cast-in-situ
Timber, steel, prestressed concrete, composite	Reinforced concrete
Maximum diameter~16 in.	Can be as large as 6-8 ft diameter
Used in groups “pile groups”	Used singly

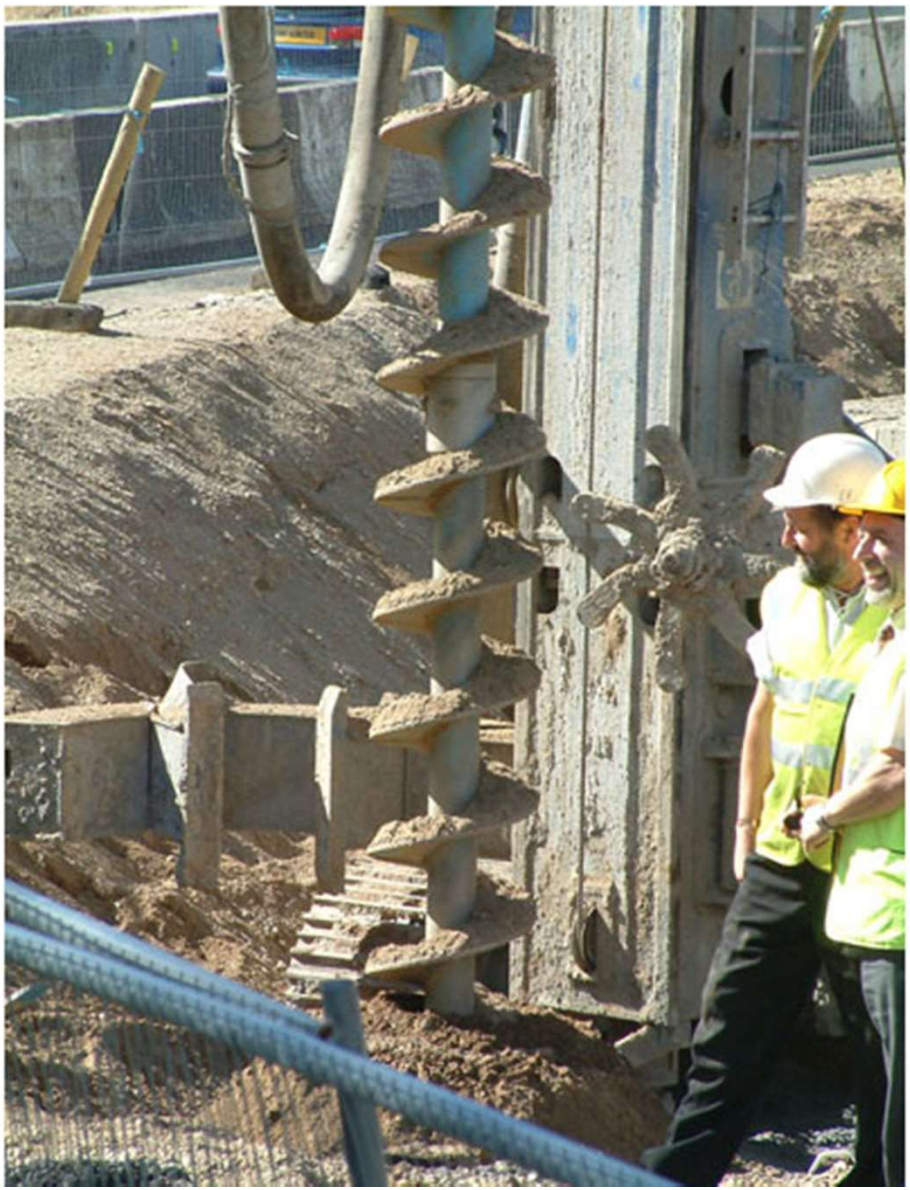
Driven Piles versus Bored Piles

Driven Piles

- Improve soil properties
- Not Effected by water
- It is good if there are part of piles above ground level

Bored Piles

- use in hard and dense soil



أهداء من

م/ احمد صابر

أحد خريجي الكلية

أهداء من

م/ احمد صابر

أحد خريجي الكلية

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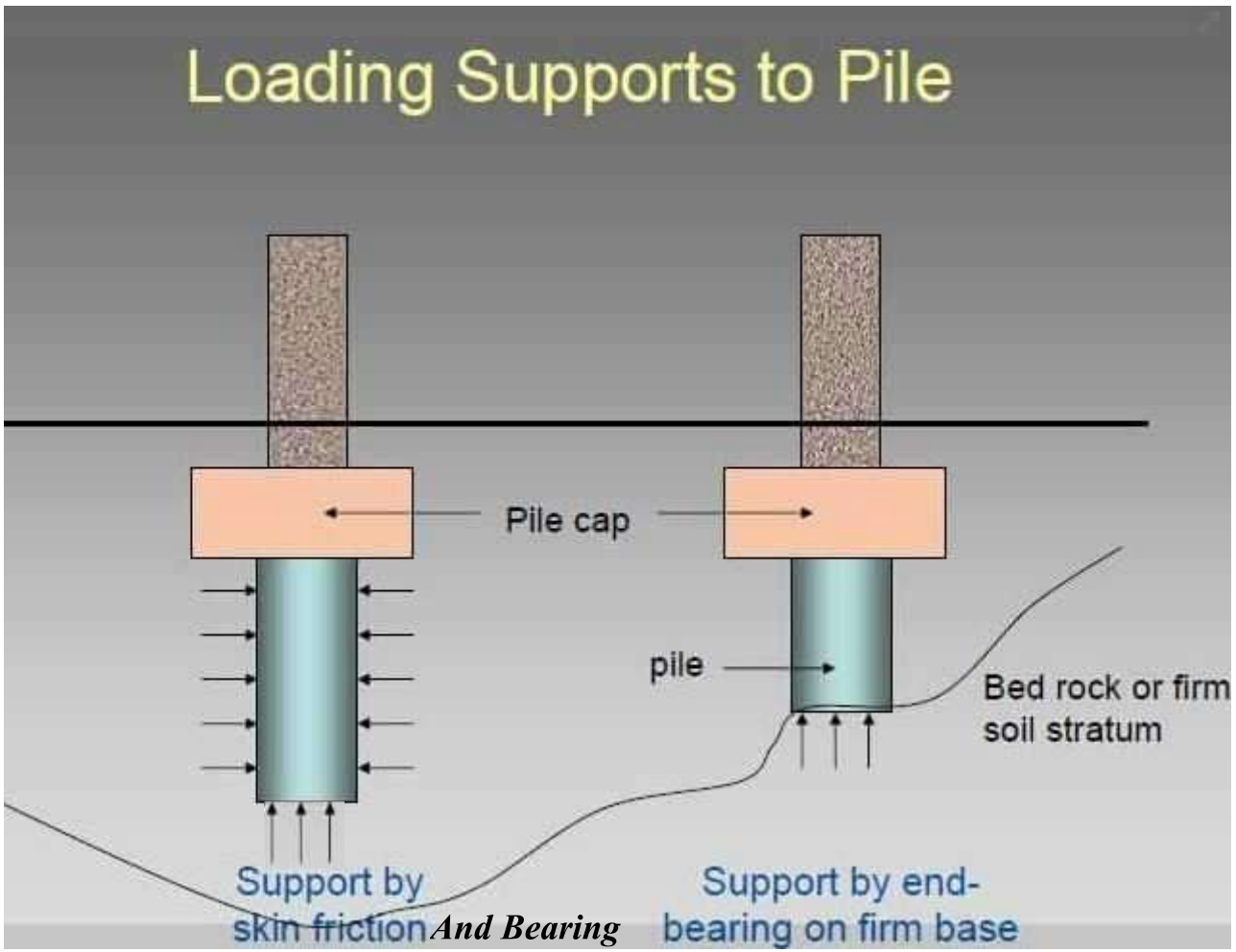
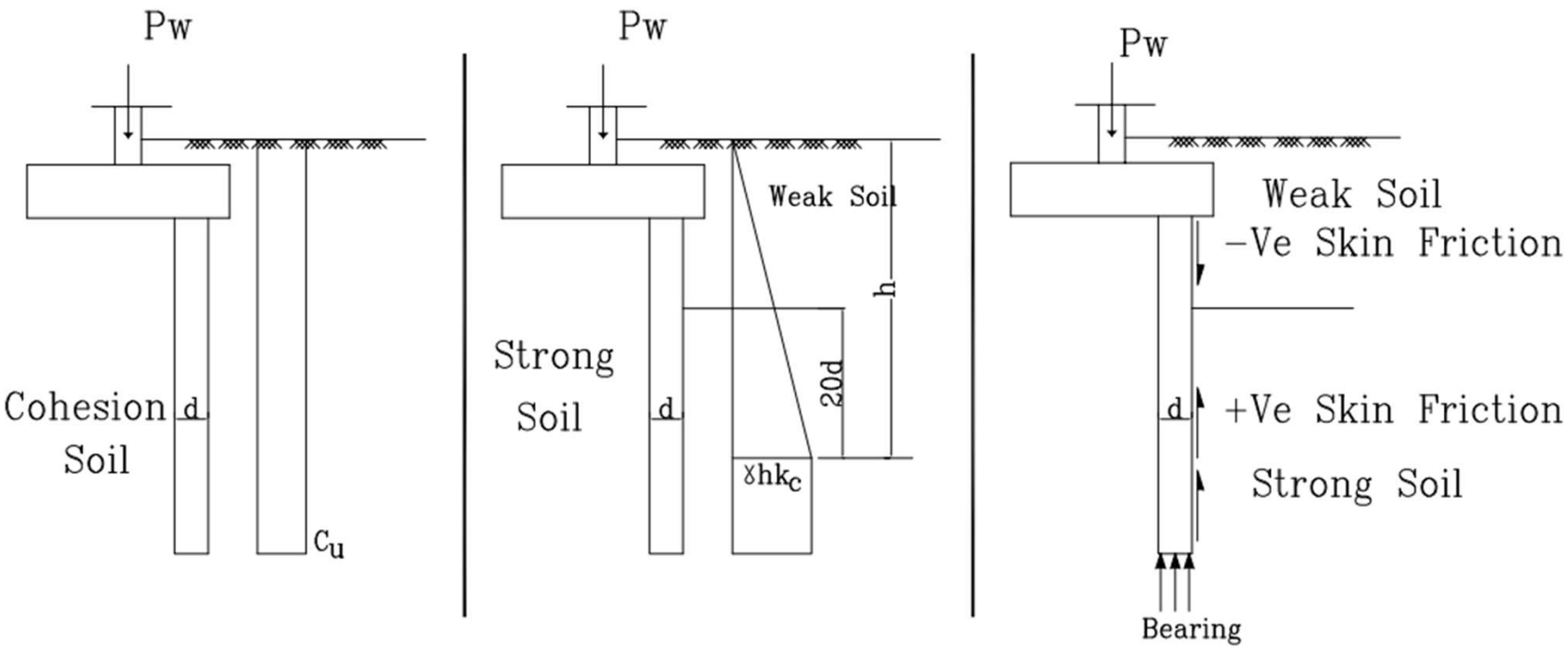

Loading Supports to Pile
Pile cap
pile
Bed rock or firm soil stratum
Support by skin friction
And Bearing
Support by end-bearing on firm base


Pw
Cohesion Soil
d
C_u
Pw
Strong Soil
Weak Soil
h
20d
d
γhk_c
Pw
Weak Soil
-Ve Skin Friction
d
+Ve Skin Friction
Strong Soil
Bearing

$$P_{all/pile} = \left(\frac{p_b * A_b + p_{s(+ve)} * A_s}{F.S}\right)\eta - p_{s(-ve)} * A_s \qquad t \qquad (1)$$

A_b Base Area = $\pi d^2/4$ For Circular pile

A_s Surface Area = πd For Circular pile

η Factor=1 if pile supported on sand

Factor if pile supported on clay ,depends on pile length

pile distance, and number of piles see fig (4-22)

F.S = 3 IF Loads (D+L)
F.S.= 2.50 IF Loads (D+L+W)
F.S.= 2.00 IF Loads (D+L+E)

a- If pile supported on sand

$p_b = p_0 * (N_q - 1)$ t/m^2 (Bearing stresses)

$p_0 = \sum \gamma h$

العلاقة بين معامل قدرة التحميل N_q وزاوية الاحتكاك الداخلى $\emptyset°$

لتربة غير متماسكة الحبيبات

$\emptyset°$ (degree)	25	30	35	40
N_q	15	30	75	150

$$\emptyset° \text{ (Driven pile)} = \frac{\emptyset° \, measure + \ 40}{2}$$

$$\emptyset° \text{ (Bored pile)} = \ \emptyset° \, measure - 3$$

$$p_S = \sum \gamma h \, K_C \tan \delta \qquad t/m^2 \qquad \text{(Skin Friction stresses)}$$

$K_C = 0.70$ up to 1.50 for Driven piles Take K=1

$K_C = 0.70$ up to 1.00 for Bored piles Take K=0.70

$\delta = \emptyset°$ For Concrete roughness surface

$\delta = \frac{3}{4}\emptyset°$ For Concrete piles

$\delta = 20°$ For Steel piles

b- If pile supported on Clay

$p_b = N_C * C_u$ t/m² (Bearing stresses)

C_u t/m² Unconfined cohesion

$N_C = 5(1+0.20\frac{B}{L})(1+0.20\frac{D}{B}) \geq 9$ B,L pile dimensions= Pile Diameter for circale

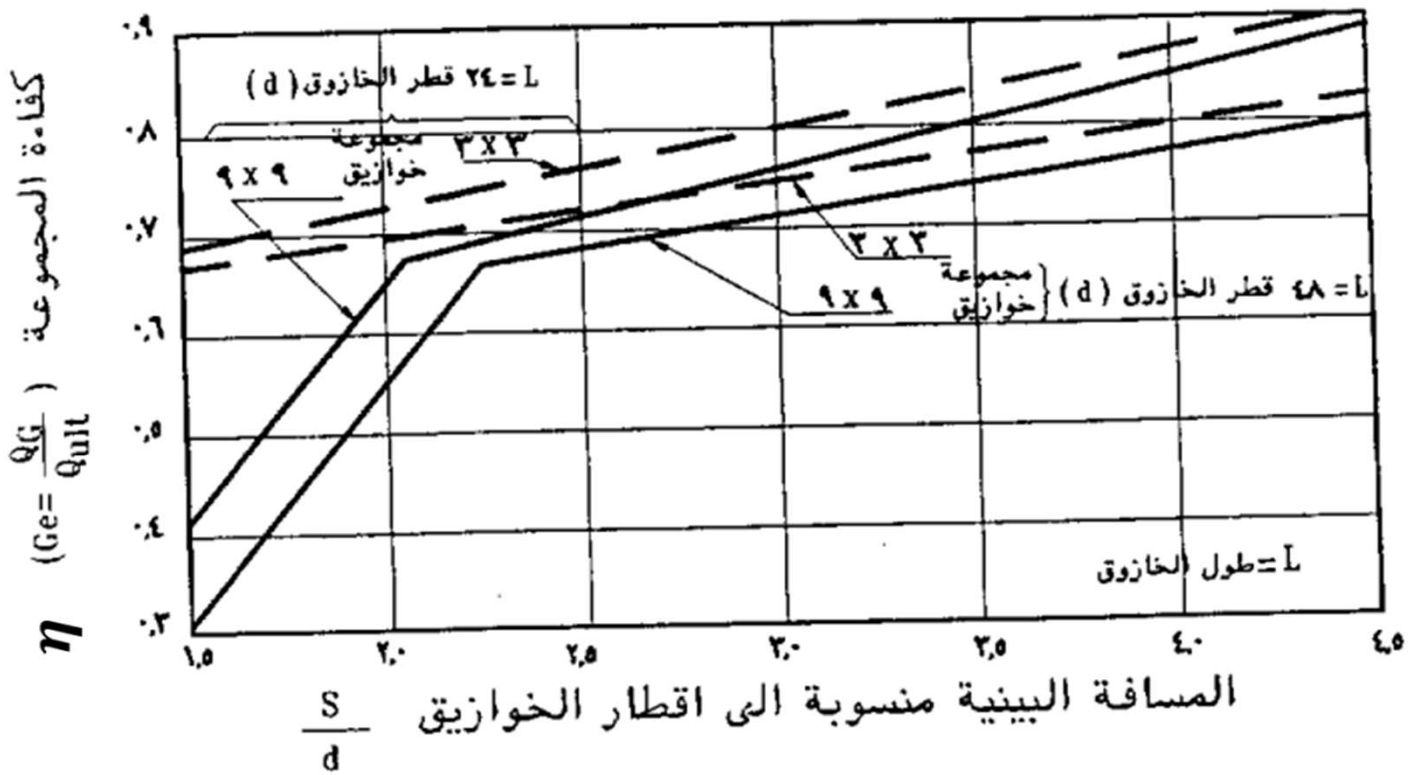
$D/B \geq 2.50$ D= Distance from ground to pile end(foundation depth)

$p_s = \alpha * C_u$ t/m² $\geq$ **10t/m²** (Skin Friction stresses)

α Factor as Shown

α	Driven	Bored
V.Soft Clay & Soft	1	1
Medium	0.75 → 1.00	0.40
Stiff	0.475 → 0.75	0.35
V.Stiff	0.325 → 0.475	0.30

take small value for safty



شكل رقم (٤-٢٢): كفاءة مجموعات الخوازيق فى التربة الطينية

$$G_e = 1 - \theta \frac{(n-1)m + (m-1)n}{90\,m\,n}$$

Where:

G_e = Group efficiency;

θ = $\tan^{-1}(D/S)$ in degrees;

D = Pile diameter (m);

S = Pile spacing (m);

n = Number of piles in a row;

m = Number of pile rows

$$P_{conc/pile} = 0.20 F_c\ A_b * Factor - (-ve\ Skin\ Friction) A_s \quad \text{t} \quad (2)$$

Factor = 1.00 If pile not Reinforced.

Factor = 1.15 If pile Reinforced.

$P_{all/pile}$ Take Smaller from 1, 2

$$\text{No. Of Piles} = \frac{Column\ Loads\ (DL + LL)\ *\ 1.05}{p/pile}$$

Check

$\mathbf{P}_{actual}$ / pile =

$$= \frac{\text{Column Loads} + \text{O.W Cap} + \text{O.W. Soil above cap} + (-\text{Ve Skin Friction on Cap}) + Surcharge}{\text{No Of Piles}}$$

- If Piles Support on Sand Called Bearing Piles

- If Piles Support on Clay Called Friction Piles

1- End bearing piles: خوازيق ارتكاز

Tip point carries most of the load.

نقطة الارتكاز تنقل معظم حمل الخازوق.

2- Friction Piles: خوازيق احتكاك

Side friction carries most of the load.

معظم حمل الخازوق ينتقل للتربة عن طريق الاحتكاك السطحي

جدول رقم (٣-٨) قيم زاوية مقاومة القص للتربة غير المتماسكة

اختبار الاختراق القياسى	الكثافة النسبية Relative density		زاوية مقاومة القص
عدد الدقات N / ٣٠ سم	الوصف	$D_r = \frac{e_{max} - e}{e_{max} - e_{min}}$	ϕ °
صفر – ٤	سائبة جداً very loose	صفر – ٠,١٥	٣٠ – ٢٧
٤ – ١٠	سائبة loose	٠,٣٥ – ٠,١٥	٣٢ – ٣٠
١٠ – ٣٠	متوسطة الكثافة medium	٠,٦٥ – ٠,٣٥	٣٦ – ٣٢
٣٠ – ٥٠	كثيفة dense	٠,٨٥ – ٠,٦٥	٤٠ – ٣٦
٥٠ <	كثيفة جداً very dense	٠,٨٥ <	٤٠ <

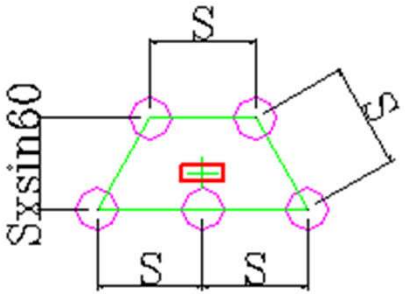
حيث:

N عدد الدقات من إختبار الإختراق القياسى

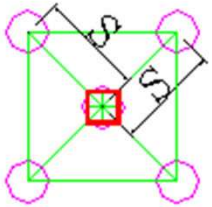
جدول رقم (٣- ٧) القيم الاسترشادية لمقاومة التماسك غير المصرفة للتربة الطينية (c_u) *

اختبار الاختراق القياسى	القوام		مقاومة التماسك c_u*	
عدد الدقات (N) / ٣٠ سم	الوصف	$I_c = \frac{w_L - w}{w_L - w_P}$	ك.نيوتن / م٢	كجم / سم٢
صفر- ٢	ضعيف التماسك جدا very Soft	صفر - ٠,٥	صفر- ١٢,٥	صفر- ٠,١٢٥
٢- ٤	ضعيف التماسك Soft	٠,٥- ٠,٦٢٥	١٢,٥- ٢٥	٠,١٢٥- ٠,٢٥
٤- ٨	متوسط التماسك medium	٠,٦٢٥- ٠,٧٥	٢٥- ٥٠	٠,٢٥- ٠,٥
٨- ١٥	متماسك Stiff	٠,٧٥٠- ١,٠٠	٥٠- ١٠٠	٠,٥- ١
١٥-٣٠	شديد التماسك جداً very Stiff	١,٠٠- (w_s=w)	١٠٠- ٢٠٠	١- ٢
٣٠ <	صلد hard	(w_s > w)	٢٠٠ <	٢ <

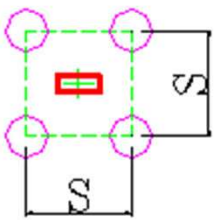
* c_u = ½ مقاومة الضغط الغير محاط (q_u) unconfined compressive strength



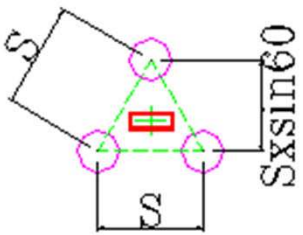
5 Piles



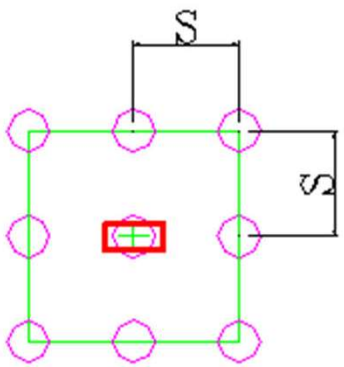
5 Piles



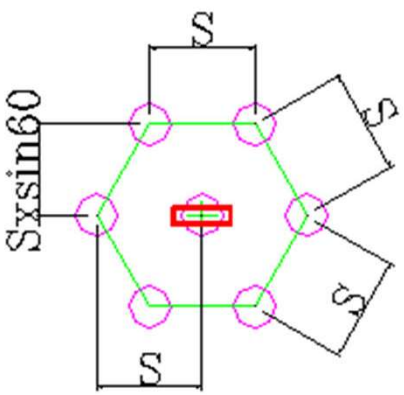
4 Piles



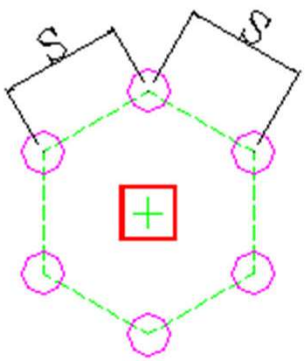
3 Piles



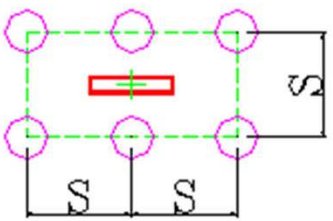
9 Piles



7 Piles



6 Piles



6 Piles

\+ CG Of Col & Pile Group

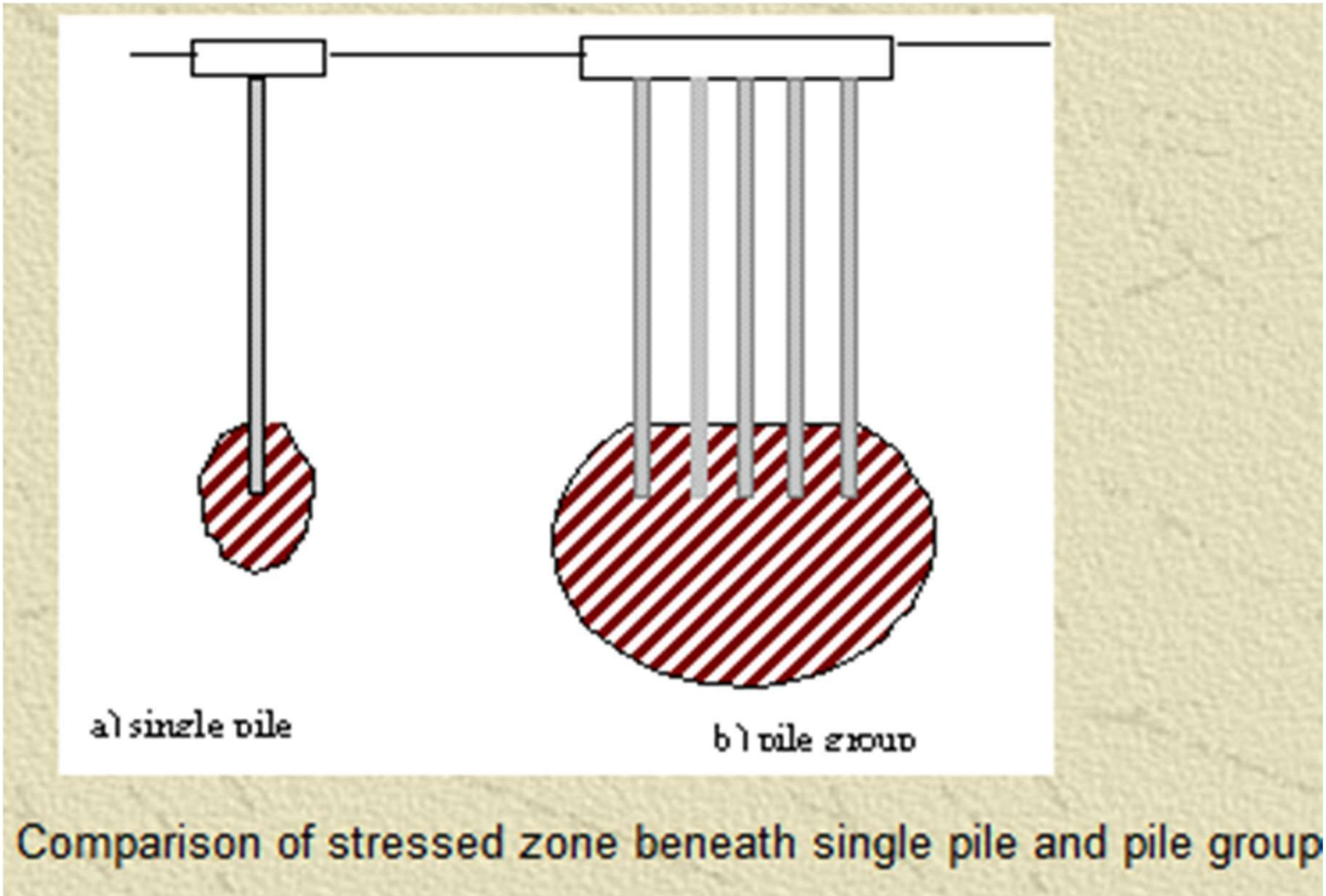
If Piles Rested on Clay or there are clay on effective

zone ,

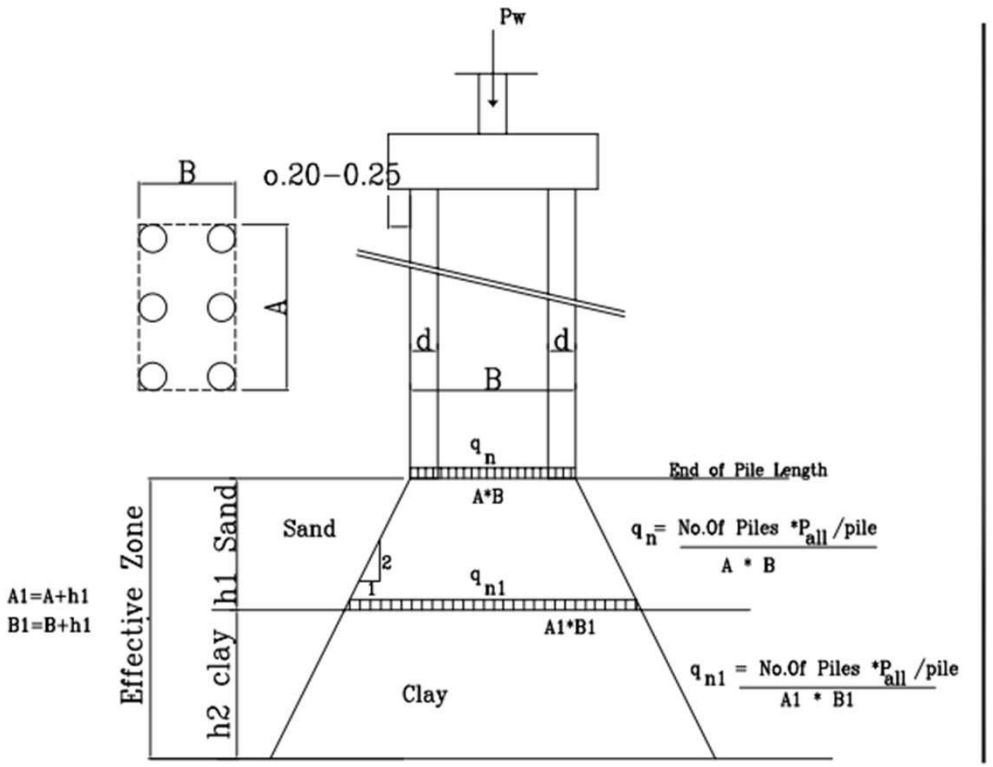
Check Block Failure

$$F.S = \left(\frac{P_b * A_b + P_{s(+ve)} * A_s - P_{s(-ve)} * A_s}{Pn} \right) \not< 2$$

A_b	Base Area	A*B
A_s	Surface Area	2*(A+B)*L



Comparison of stressed zone beneath single pile and pile group



Piles Suppourted on Sand above clay