



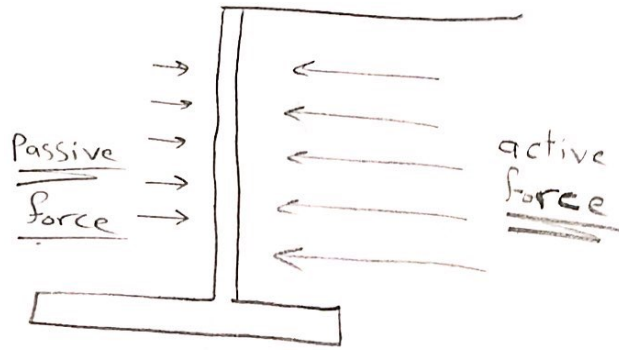
Lateral Earth Pressure

× شامل جميع السلايدات وشرح الدكتور
والأمثلة

lateral earth pressure:-

* في هذا السابتر في مصطلحين مهمين لازم نعرفهم:-

- ① active ← وهي القوة المؤثرة من السويل على الجدار
- ② pasive ← وهي القوة المقاومة لقوة (active) والقادمة من الجدار



* بشكل عام القوى التي بتاثر على الجدار بتكون عامودية و أفقية :-

$$\sigma_v' = \gamma h$$

قانون بتعرفة من أيام السويل

$$\sigma_h' = k_o \sigma_v'$$

ضربنا σ_v' بمعامل ثابت عشان نحطينا σ_h'

* طيب شو هي الـ (k_o) :-
هي معامل ثابت يساوي نسبة التغير في (σ_h') على (σ_v')

$$k_o = \frac{\sigma_h'}{\sigma_v'}$$

عندي أكثر من قانون للـ (k_0) :-
كل واحد يستخدم حسب حالة معينة :-

① For (normally consolidated clay) and (Granular soil) :-

$$k_0 = 1 - \sin \phi'$$

② For over consolidated clay :-

$$k_{o,c} = \frac{k_{N,c}}{\left(\frac{\sigma_p'}{\sigma_o'} \right)^{\sin \phi}}$$

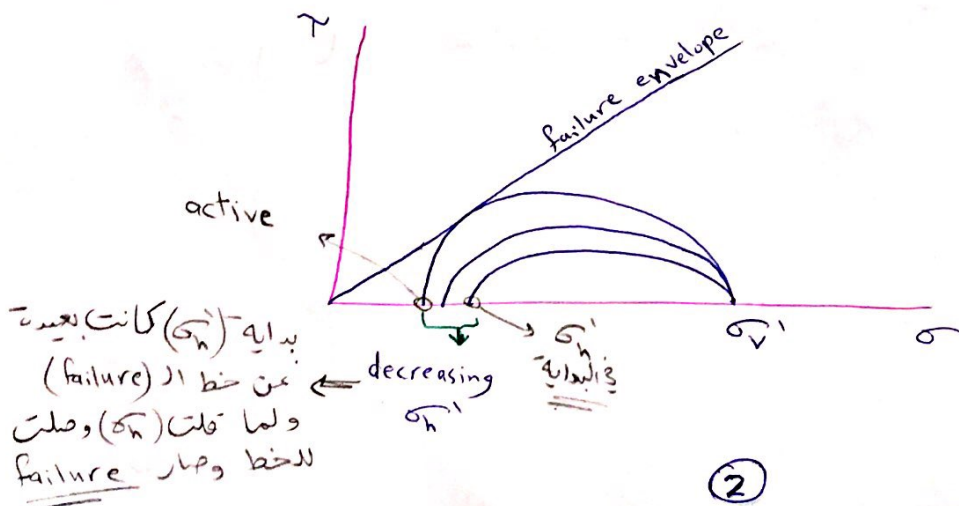
$\downarrow$ $\downarrow$
 normal $\left(\frac{\sigma_p'}{\sigma_o'} \right)$
 consolidation

③ for elastic analysis :-

$$k_0 = \frac{\nu}{1 - \nu} \rightarrow \text{poisson's ratio}$$

* نرجع لموضوعي (σ_h', σ_v')

في حالة تقليل (σ_h') ممكن نوصل لحالة الـ failure
والرسمه بتوضح كل شي :-



Failure ← active حالة
و حالة passive

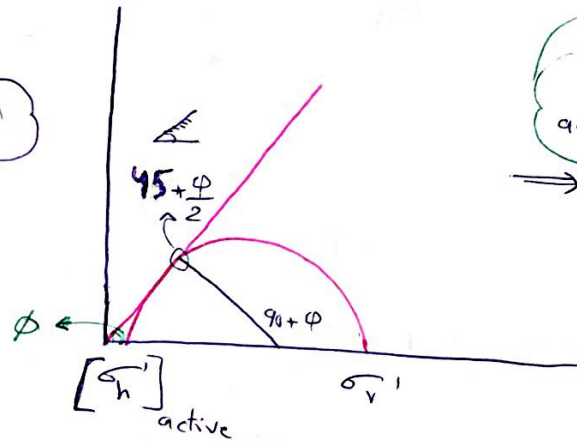
← فهناك قيمة (K) لكل وحدة ربح تختلف :-

Rankine coefficient

$$K_A = \frac{1 - \sin \phi}{1 + \sin \phi} = \tan^2 \left(45 - \frac{\phi}{2} \right) \rightarrow \text{for active}$$

$$K_P = \frac{1 + \sin \phi}{1 - \sin \phi} = \tan^2 \left(45 + \frac{\phi}{2} \right) \rightarrow \text{for passive}$$

Decreasing σ_h'

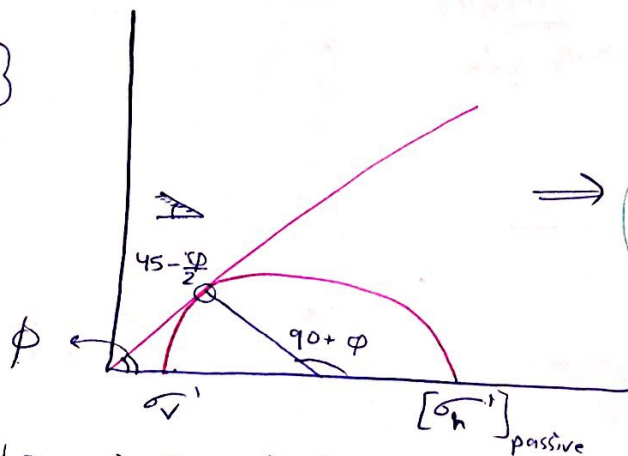


هاي الرسمة في حالة ال active
وبالتالي قيمة

$$[\sigma_h]_{\text{active}} = K_A \sigma_v' - 2c\sqrt{K_A}$$

في حالة كان ال cohesion
صفر يلغي هاد الترم

increasing σ_h'

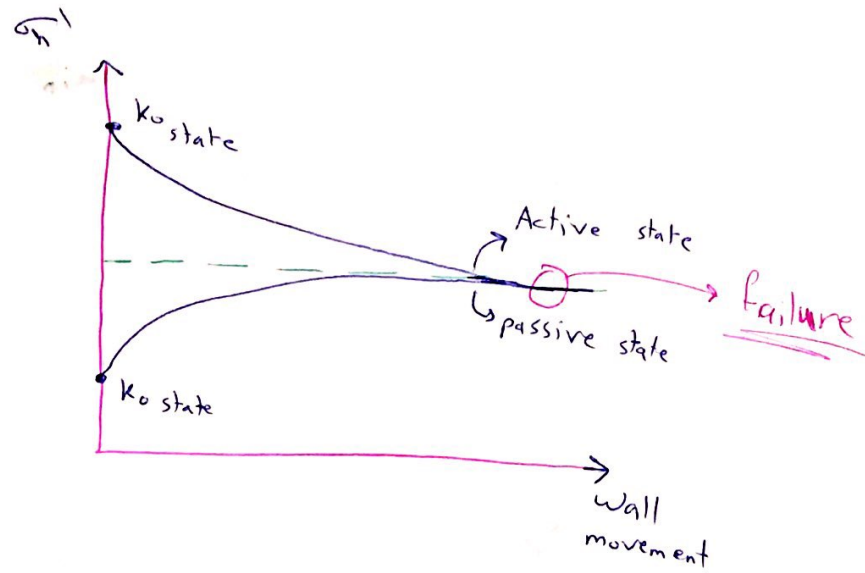


هاي الرسمة في حالة
ال Passive وبالتالي قيمة

$$[\sigma_h]_{\text{passive}} = K_P \sigma_v' + 2c\sqrt{K_P}$$

بقدر يلغي هاد الترم
إذا كان cohesion = 0

هون زنا بدي أزيد نسبة ال (sigma_h) راسها في حالة (Passive) و بيميني أزيد المقاومة
مو أقلها

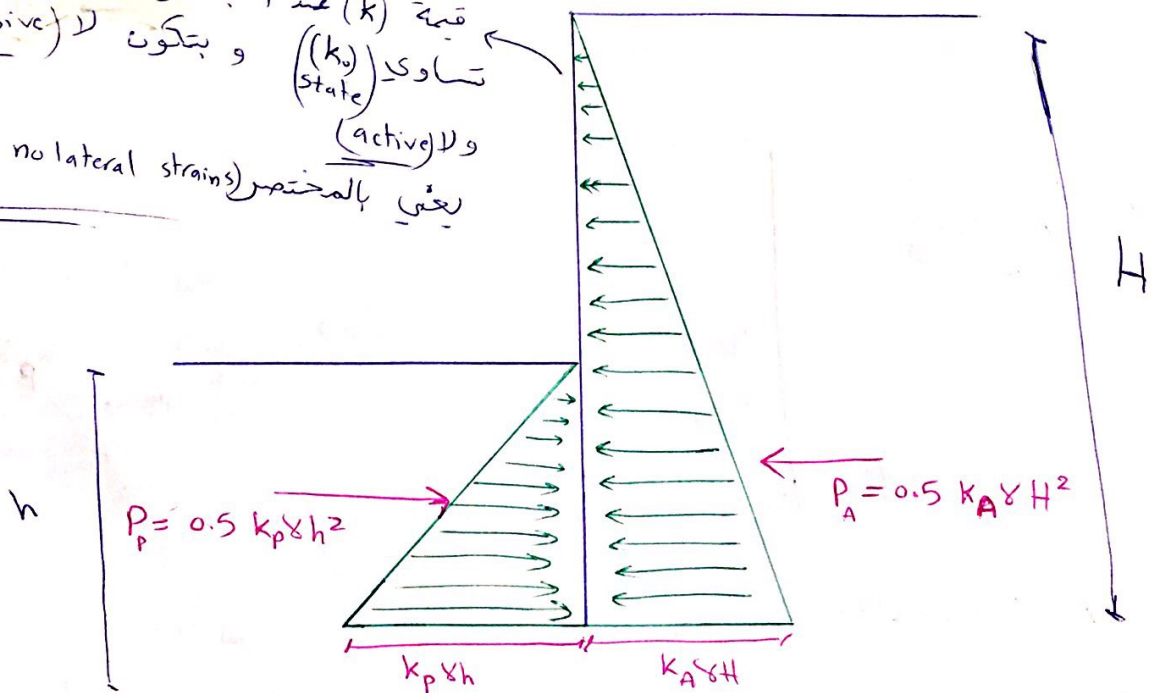


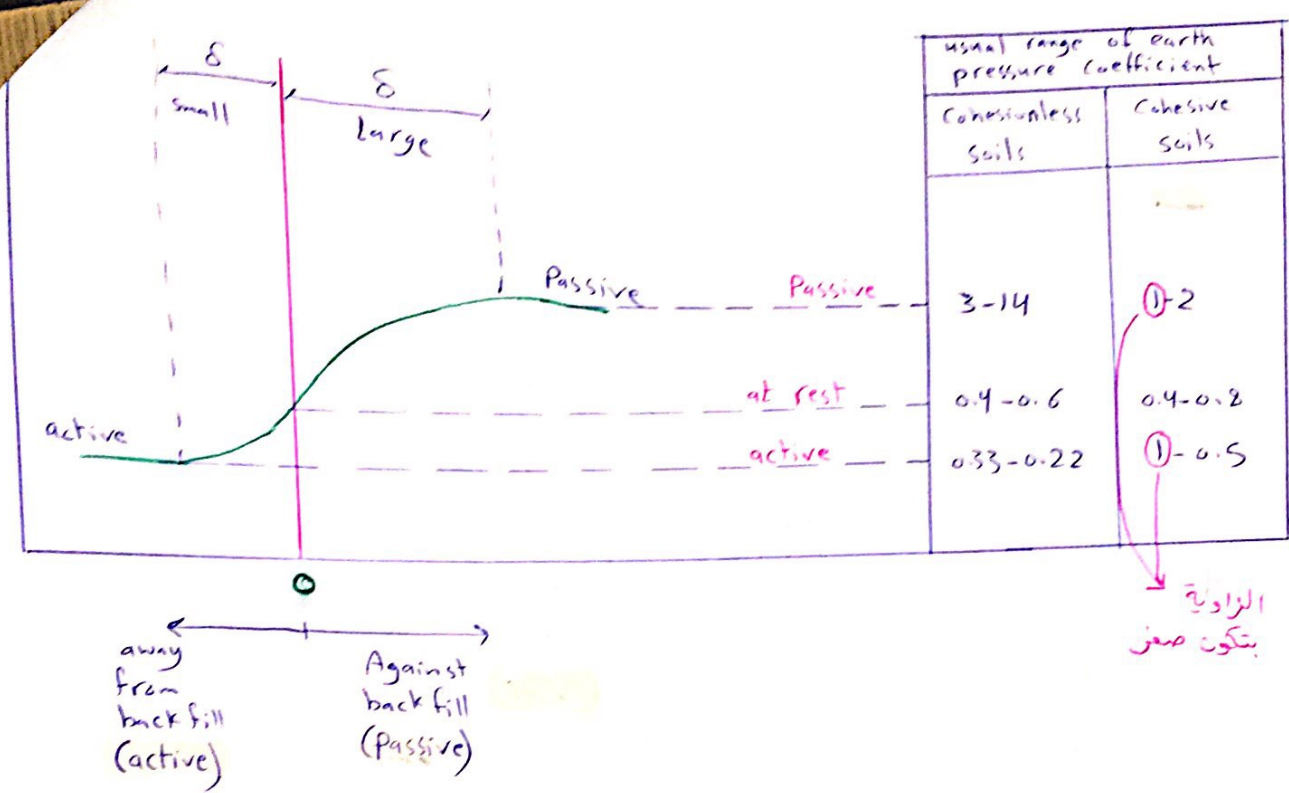
* العلاقة بين k_A و k_P :

$$k_A = \frac{1}{k_P}$$

* طبق بما إننا عرفنا كيف نطلع $[a_h]$ في حالة الـ Passive و الـ active هلا بدّي أعرف الـ (resultant force) المؤثر على الجدار والي هو ساوي (P_A) ، (P_P)

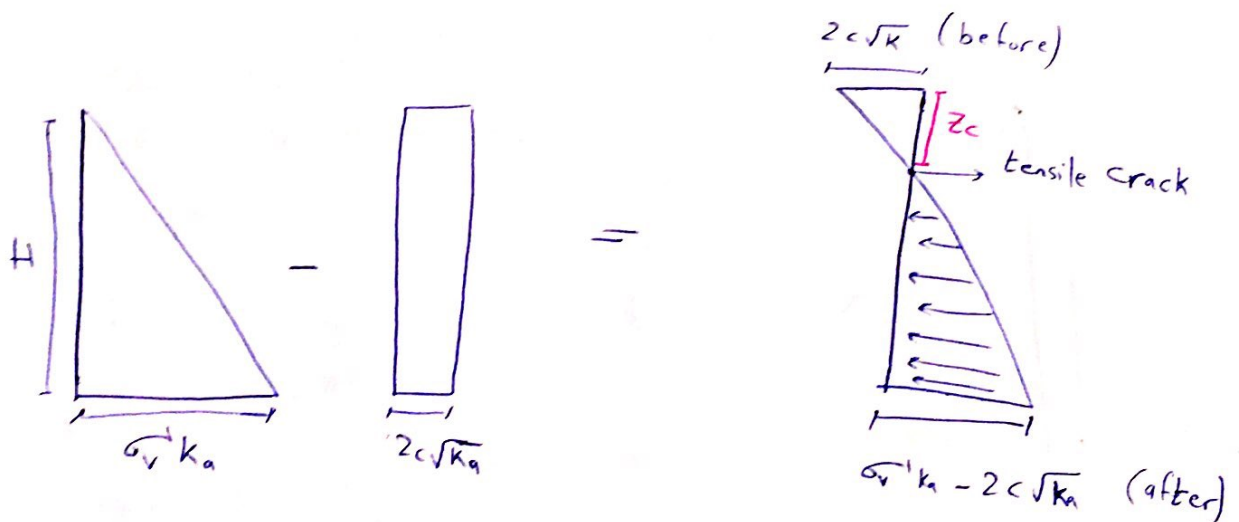
قيمة (k) عند الجدار (ساوي (k_0) state) و بتكون الـ Passive ولا active يعني بالمختصر $(k_0 \text{ state} = \text{no lateral strains})$





من خلال الرسم الي بصيغة (4) نستنتج انه ال (resultant force) هي عبارة عن مساحة السطح المؤثر.

لكن في حالة كان عني Cohesive



الاشتقاق

$$z_c = \frac{2c'}{\gamma \sqrt{k_a}}$$

$$\sigma_a = 0$$

$$\sigma_a = k_a \gamma z - 2c \sqrt{k_a}$$

$$0 = k_a \gamma z - 2c \sqrt{k_a}$$

$$z = z_c = \frac{2c \sqrt{k_a}}{\gamma k_a}$$

$$= \frac{2c}{\gamma \sqrt{k_a}}$$

(5)

* Before Tension Crack

الرسمة التي بالمقدمة
لدي قبل نستنتج الاشتقاق

$$P_a = \int_0^H \sigma_A' dz = \int_0^H \gamma z k_a dz - \int_0^H 2c' \sqrt{k_a} dz$$

$$= \left[\frac{1}{2} \gamma H^2 k_a - 2c' H \sqrt{k_a} \right]$$

* After Tension Cracks

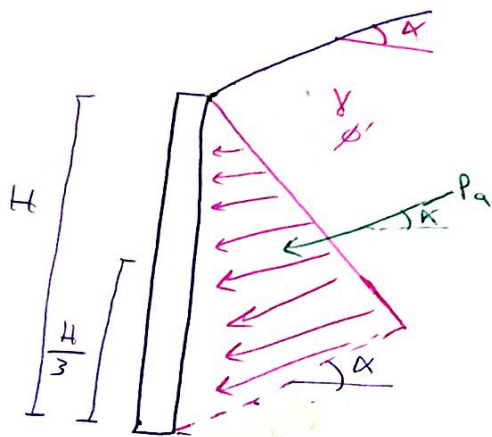
$$P_a = \frac{1}{2} (H - z_c) (\gamma H k_a - 2c' \sqrt{k_a})$$

$$P_a = \frac{1}{2} \left(H - \frac{2c'}{\gamma \sqrt{k_a}} \right) (\gamma H k_a - 2c' \sqrt{k_a})$$

الاشتقاق مطلوب ويبين كل
عنه

$\bar{z} = \frac{(H - z_c)}{3}$ above the bottom of the wall

(Coefficient for sloped ground) هو هذا الشاير في آخر موضح في هذا الشاير هو



في حالة كان ارتفاع السور أكثر من الجدار
وبشكل زاوية مقدارها (A) وبالتالي
قوانين k_a , k_p , (z_c) رح تتغير:-

$$k_a = \cos A \frac{\cos A - \sqrt{\cos^2 A - \cos^2 \phi'}}{\cos A + \sqrt{\cos^2 A - \cos^2 \phi'}}$$

$$k_p = \cos A \frac{\cos A + \sqrt{\cos^2 A - \cos^2 \phi'}}{\cos A - \sqrt{\cos^2 A - \cos^2 \phi'}}$$

$$z_c = \frac{2c'}{\gamma} \sqrt{\frac{1 + \sin \phi'}{1 - \sin \phi'}}$$

(6)

× بالنسبة لاستنتاج H في صفحة 5 :-

... if $P_a = 0$:-

$$P_a = \frac{1}{2} \gamma H^2 K_a - 2cH \sqrt{K_a}$$

$$0 = \frac{1}{2} \gamma H^2 K_a - 2cH \sqrt{K_a}$$

$$H = \frac{2c \sqrt{K_a} \gamma}{\gamma K_a}$$

× ملاحظة ! -

$$K_a = K_p = 1$$

← في حالة Total

$$K_a = K_p = 1$$

← في حالة $S_u = C_1$



ESA → Effective stress analysis

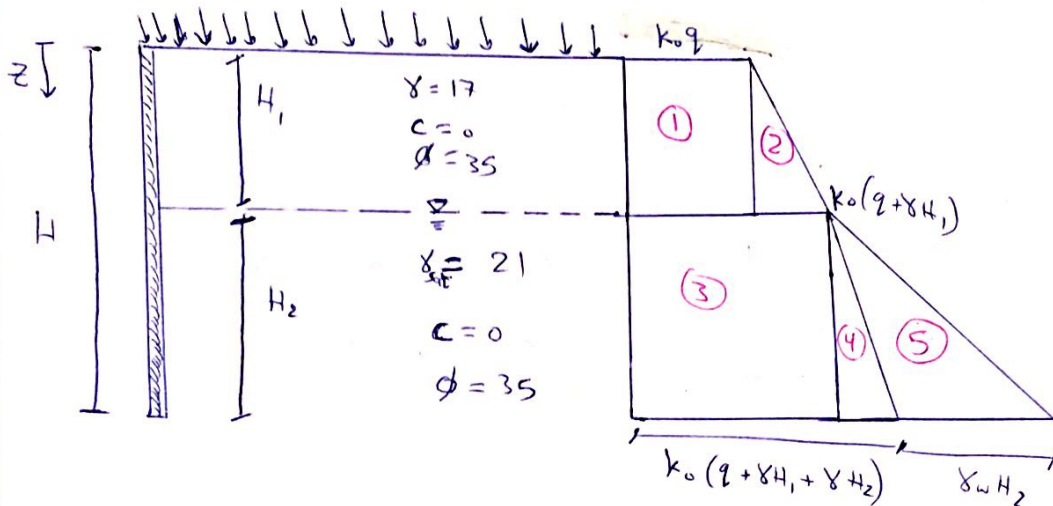
TSA → Total stress analysis

→ هاتي الاختصارات
موجود بالكتاب
التاني صفحة 10



* Examples :-

- 1) If the wall is prevented from movement. Determine the total force acting the wall and line of action the total force,
 $q = 50 \text{ kPa}$, $H_1 = 5 \text{ m}$, $H = 12 \text{ m}$, $\gamma_{\text{sat}} = 21 \text{ kN/m}^3$, $\gamma_{\text{dry}} = 17 \text{ kN/m}^3$
 $c = 0 \text{ kPa}$ and $\phi = 35^\circ$



السؤال هون بدون تأثير ال (Cohesion) ال
 و بدو احسب ال (P) الي حكيئا بتعتمد على مساحة كل شكل :-

$$A_1 = k_0 q H_1 = 0.426 \times 50 \times 5 = 106.5$$

$$A_2 = \frac{1}{2} k_0 \gamma H_1^2 = 0.5 \times 0.426 \times 17 \times 25 = 90.525$$

$$A_3 = k_0 (q + \gamma H_1) H_2 = 0.426 \times (50 + (17 \times 5)) \times 7 = 402.57$$

$$A_4 = \frac{1}{2} (k_0 \gamma' H_2^2) = \frac{1}{2} (0.426 \times (21 - 9.81) \times (7)^2) = 116.79$$

$$A_5 = \frac{1}{2} \gamma_w H_2^2 = \frac{1}{2} \times 9.81 \times (7)^2 = 240.345$$

$$k_0 = 1 - \sin 35 = 0.426$$

القوانين هيا
 ثابتة في حالة
 كانت (C) صفر

تابع الحل

segment	A_i (area)	x_i (centroid)	$A_i x_i$ (kN.m/m)
(1)	106.5	$7 + \frac{5}{2}$	1011.75
(2)	90.525	$7 + (5 \times \frac{1}{3})$	784.55
(3)	402.57	$\frac{7}{2}$	1408.995
(4)	116.79	$(7 \times \frac{1}{3})$	272.51
(5)	240.345	$(7 \times \frac{1}{3})$	560.805
	$\Sigma A = 956.73$		$\Sigma M = 4038.61$



$$\bar{x} = \frac{4038.61}{956.73} = 4.22 \text{ m}$$

ملاحظة :-
على حل الدكتور ممكن
تلاقى حسابات ال area
مختلفة لانه تقسيمه الدكتور
غير ... لكن مجموع ال area
و مجموع ال moment نفسه
و ال $(\bar{x})$ نفسه

في حالة كان عندي نوعين مختلفين من السويل يعني عندي قسيتين ر
هيك بدى احسب k_1, k_2, k_3 حسب عدد الطبقات
و اتعامل مع كل طبقة بار (k) الخاصة منها

- 2) a 6-m high retaining wall is to support a soil with unit weight $\gamma = 17.4 \text{ kN/m}^3$, soil friction angle $\phi' = 26^\circ$ and cohesion $c' = 14.36$. Determine the rankine active force per unit length of the wall both before and after the tensile crack occurs and determine the line of action of the resultant in both cases.

Solution:-

(Determine rankine active force

أول شي جملة)

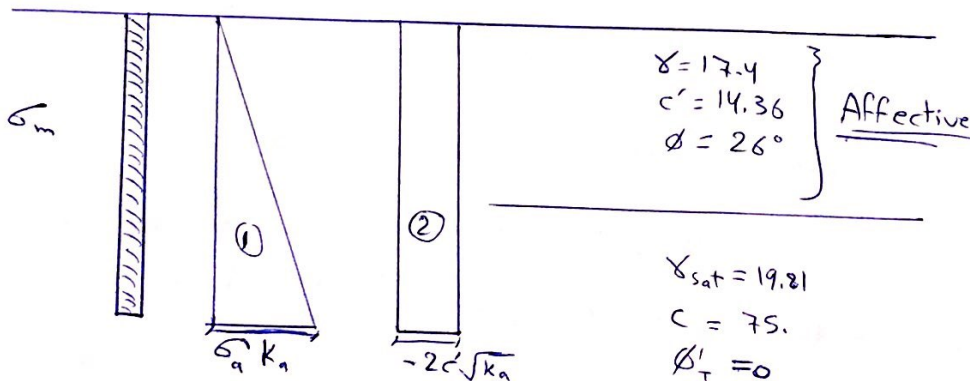
ماي يعني ممكن

تكون active

وممكن تكون Passive

والفوق بينهم فقط الإشارة

وال Passive ما يعني ابدأ من Cracking



Active - ESA

$$k_a = \frac{1 - \sin \phi}{1 + \sin \phi} = \frac{1 - \sin 26}{1 + \sin 26} = 0.39$$

$$A_1 = (0.39 \times 6 \times 17.4) \times 0.5 \times 6 = 122.148$$

$$A_2 = \left(-2 \times 14.36 \times \sqrt{0.39} \right) \times 6 = -107.61$$

$$P_a = 122.148 - 107.61 = 14.54$$

تابع الحل

$$x = \frac{(122.48 \times \frac{6}{3}) - (107.61 \times \frac{6}{2})}{14.54} = \boxed{-5.35}$$

After tensile cracks :-

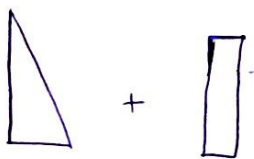
$$z_c = \frac{2c}{8 \sqrt{k_a}} = \frac{2 \times 14.36}{17.4 \sqrt{0.39}} = 2.64 \text{ m}$$

$$P_a = \frac{1}{2} (H - z_c) (\sigma_a)$$

$$= \frac{1}{2} (6 - 2.64) (40.71 - 17.93) = 38.22 \text{ kN/m}^3$$

$$\bar{x} = \frac{H - z_c}{3} = \frac{6 - 2.64}{3} = 1.12 \text{ m}$$

TSA :-



$$\sigma_a = 19.81 \times 6$$

$$(-2c) = (-2 \times 75)$$

$k_a = 1$ $\rightarrow$ Total TSA

Before tensile crack :-

$$P_a = \left(\frac{1}{2} \times 6^2 \times 19.81 \right) - (2 \times 75 \times 6) = -543.42 \text{ kN/m}$$

$$\bar{x} = \frac{\left(\frac{1}{2} \times 6^2 \times 19.81 \right) \times \frac{6}{3} - ((2 \times 75 \times 6) \times \frac{6}{2})}{-543.42}$$

$$= 3.65 \text{ m}$$



Sheet pile

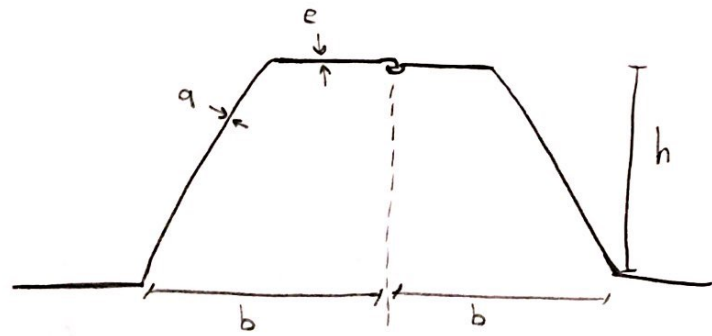
What is the meaning of sheet pile?

Sheets interlocking - steel or timber driven into the ground, forming a continuous sheet.

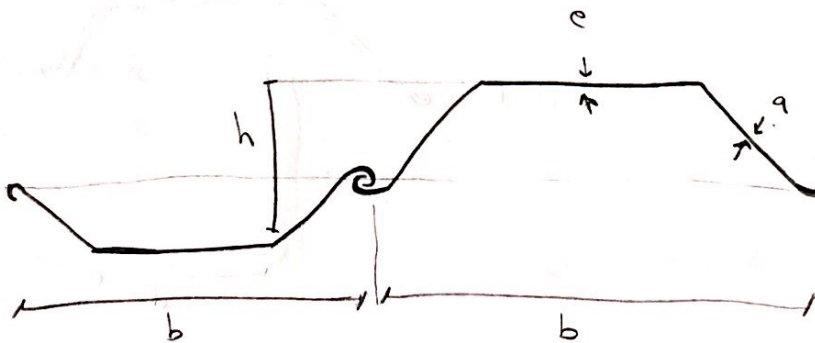
* The benefits of sheet pile:-

- ① resist lateral earth pressure
- ② used in excavations, waterfront structures
- ③ used in temporary works

* (شكل ال sheet pile) كيفية تحديد الأبعاد بكل شكل :-

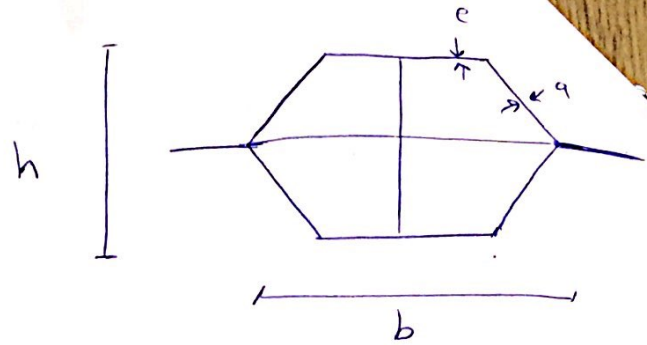


Z - Section

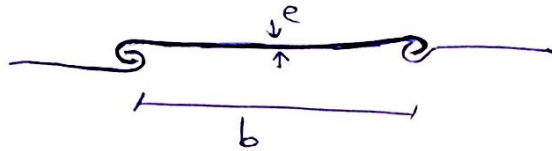


U - Section

①

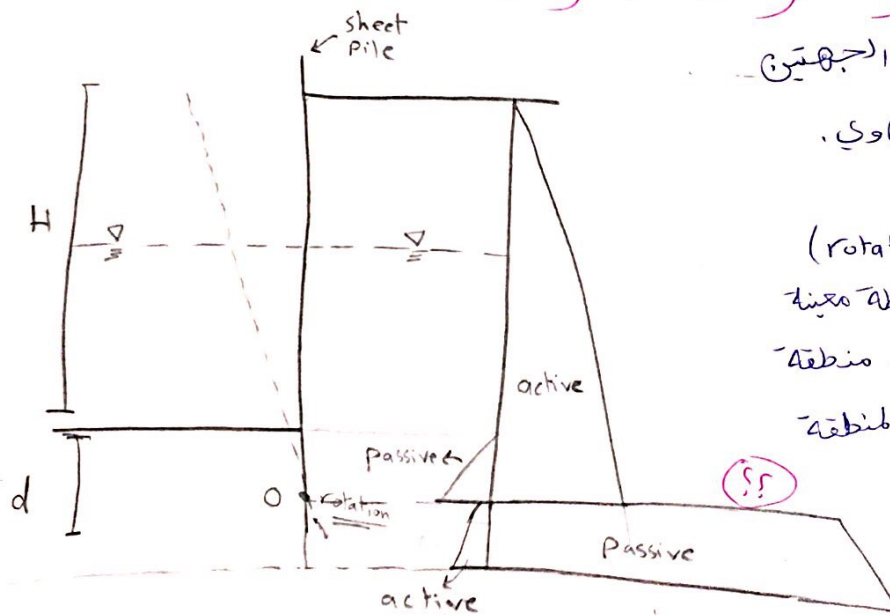


Box section



Straight section.

* Cantilever sheet piling Penetrating sandy soils:-



① اعتبرنا GWT متساوي على الجهتين
وبالتالي (hydrostatic prussure) متساوي.

② ينبغي إنا بهر عندي (rotation)
عند ال (failure) ويكون حول نقطة معينة
وهاد الدوران حدد عندي منطقة
ال (active) و ال (Passive) والمنطقة
اللي تحتهم بتكون عكسهم

③ دايماً منطقة ال (rotation) بالقرب من
نهاية الجدار

④ تستخدم في الارتفاعات من (٦-٧) م

⑤ بزيد عمق الحفر بمقدار
10% على أن لا يزيد
عن نصف المتر
(ملاحظة عمق الحفر = H)
to allow for over excavation

⑥ بفترض إنا بهر عندي لود مقداره
10 كيلو باسكال

⑦ بزيد عمق (d) بمقدار (20%)

← sand above clay ← أُو العكس
← sand above gravel ← أُو العكس

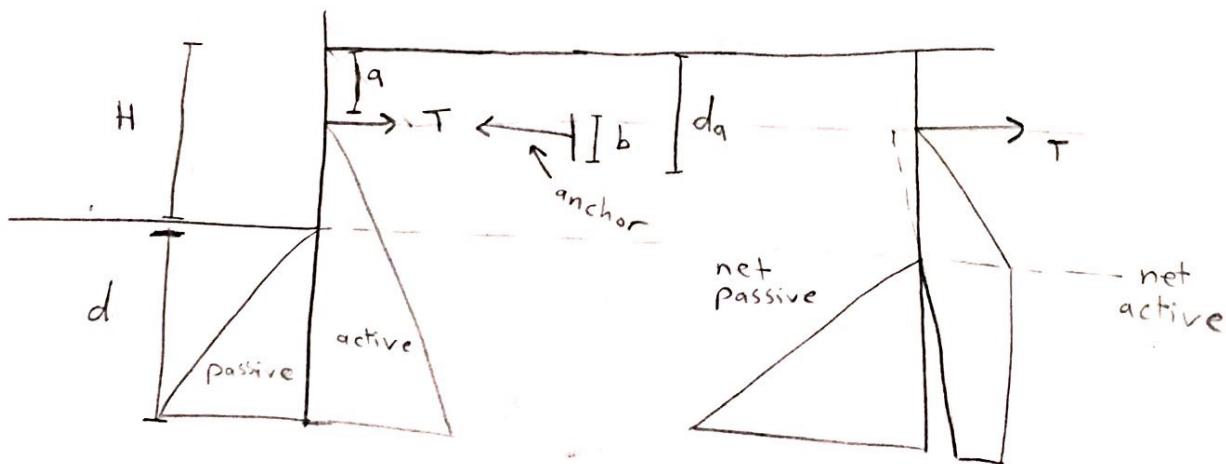
* إذا كانت الطبقة - عندي

(Affective stress analysis)

← اننا هون محير آخذ

* إذا كانت الطبقة - (Pure clay) ← باخذ (effective stress analysis) + (Total stress)

* Anchored or propped walls sheet pile wall :-



* بحسب الـ (net passive) إذا كان أكبر من الموجود تمام
لم إذا كان أقل باخذ أكبر 20%

لا تستخدم لارتفاعات أكثر من ٢م

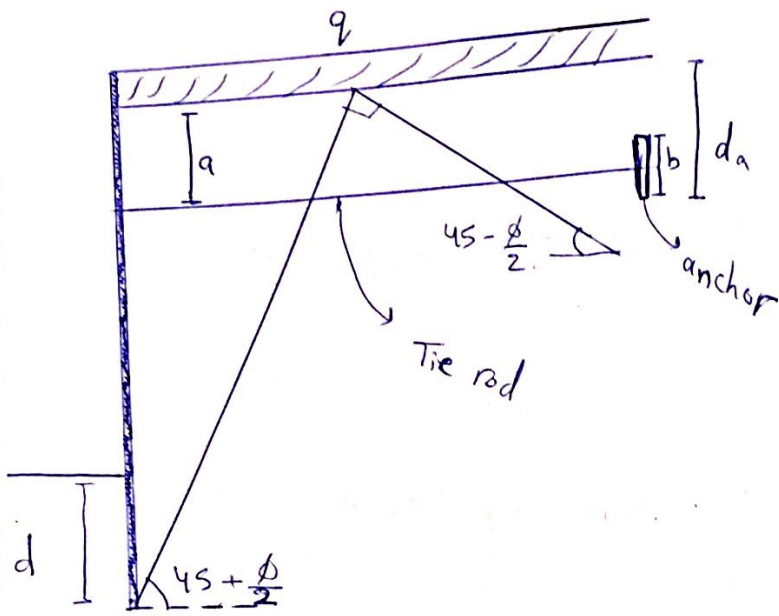
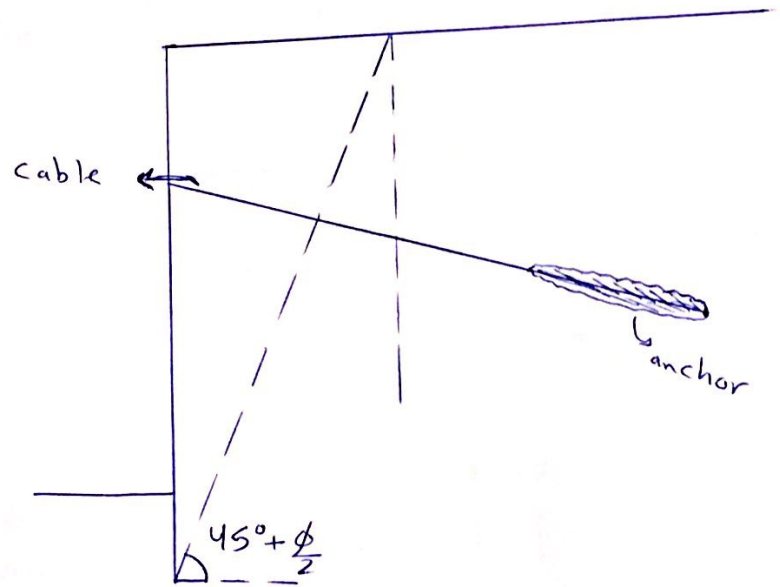


Plate Anchor



Ground Anchor

في كلتا الحالتين انا بدى اتجنب انه يصير عندي failure عن طريق
هاد الشرط :-

$$\frac{1}{2}(k_p - k_a) \gamma d_a^2 L - k_a q d_a L \geq T_s$$

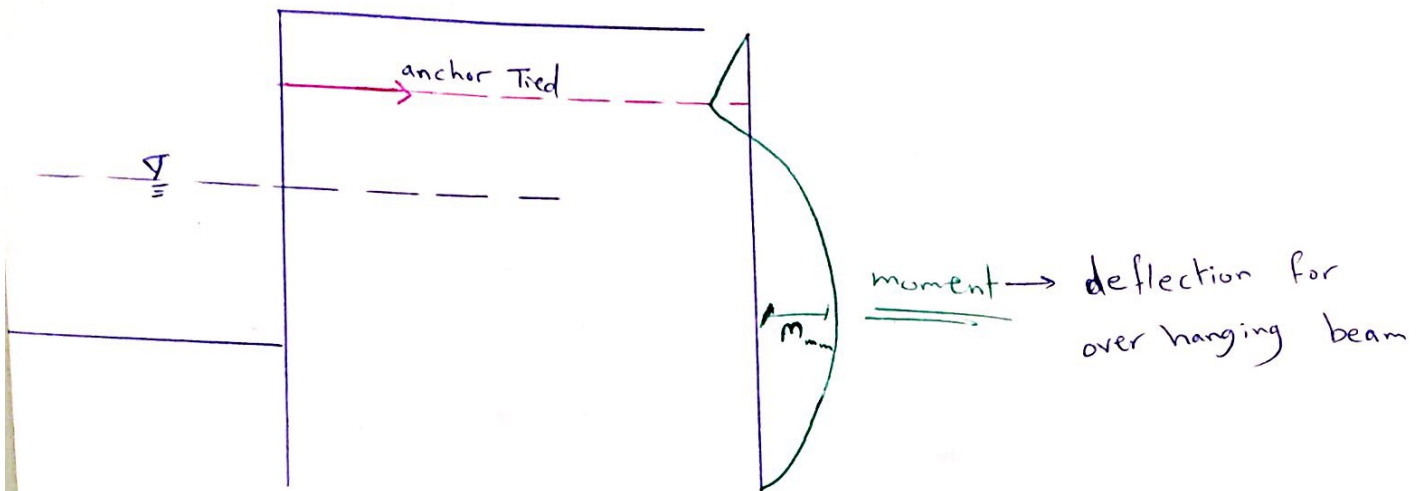
T_s : Tie force per unit length of wall

S : spacing of ties

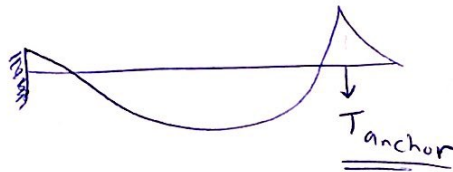
L : length of anchor per tie

q : surface surcharge pressure (u)

✗ بالنسبة للمومنت بطريقة method (d) free
 (د) دايما، باخذ المومنت حول ال anchor بد (c) و بطلع (d)



✗ $\therefore$ indeterminent ال

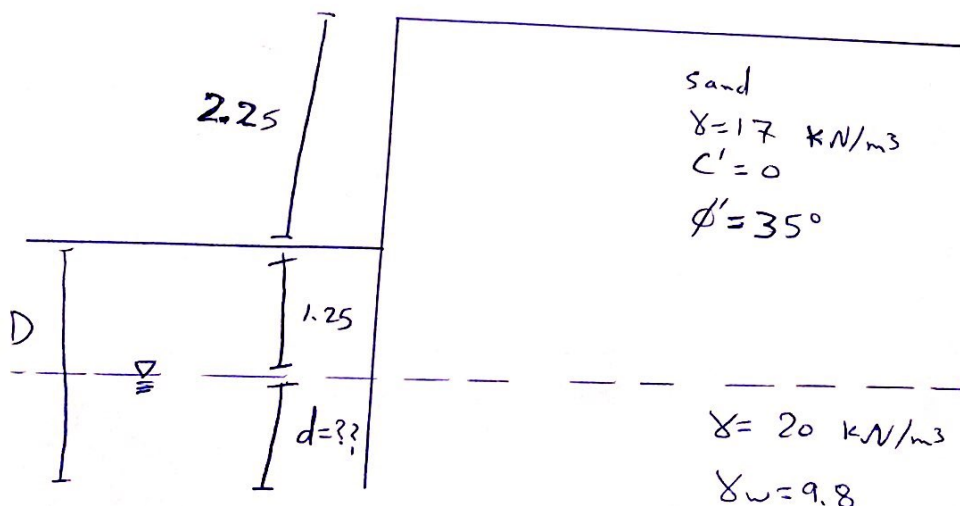


*Example:-

The sides of an excavation 2.25 deep in sand are to be supported by cantilever sheet pile wall, the water table being 1.25 m below the bottom of the excavation. The unit weight of the sand above the water table is 17 kN/m^3 and below the water table the saturated unit weight is 20 kN/m^3 , characteristic parameters are $c' = 0$, $\phi' = 35^\circ$ and $\delta = 0$. Allowing for surcharge pressure of 10 kN/m^2 on the surface.

required:-

determine the required depth of embedment of the piling to ensure a factor of safety of 2.0 with respect to gross passive resistance



$$F.S = 2$$

solution $\rightarrow$

(6)

$$= \frac{1 - \sin \phi}{1 + \sin \phi} = \frac{1 - \sin 35}{1 + \sin 35} = 0.27$$



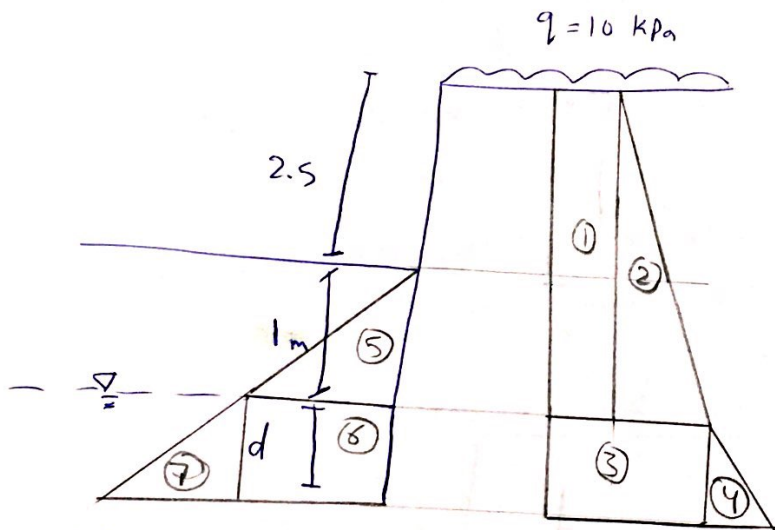
$$k_p = \frac{1}{k_a} = \frac{1}{0.27} = 3.7$$

* possible over excavation:-

$$= 10\% (2.25) = 0.225 \text{ m}$$

$$\text{use} = 2.25 + 0.225$$

$$= 2.475 \approx \text{use } \boxed{2.5}$$



segment	Area	Arm (m)	$M_c (\text{kN.m/m})$
①	$0.27 \times 10 \times 3.5$	$\frac{3.5}{2} + d$	$9.45d + 16.54$
②	$\frac{1}{2} \times 0.27 \times 17 \times (3.5)^2$	$\frac{3.5}{3} + d$	$28.11d + 32.8$
③	$0.27 (10 + 17 \times 3.5) d$	$\frac{d}{2}$	$9.38 d^2$
④	$\frac{1}{2} (0.27 \times (20 - 9.81)) d^2$	$\frac{d}{3}$	$0.458 d^3$
⑤	$\frac{1}{2} (3.7 \times 17 \times 1) \times \frac{1}{2}$	$d + \frac{1}{3}$	$-15.72d - 5.24$
⑥	$-3.7 \times \frac{1}{2} \times (17 \times 1) d$	$\frac{d}{2}$	$-15.72 d^2$
⑦	$-\frac{1}{2} (3.7 \times 10.2 \times d^2) \times \frac{1}{2}$	$\frac{d}{3}$	$-3.145 d^3$
$\Sigma \text{ force} = -74$			$\Sigma M = 0$

$$21.84d + 44.1 - 6.34d^2 - 2.687d^3 = 0$$

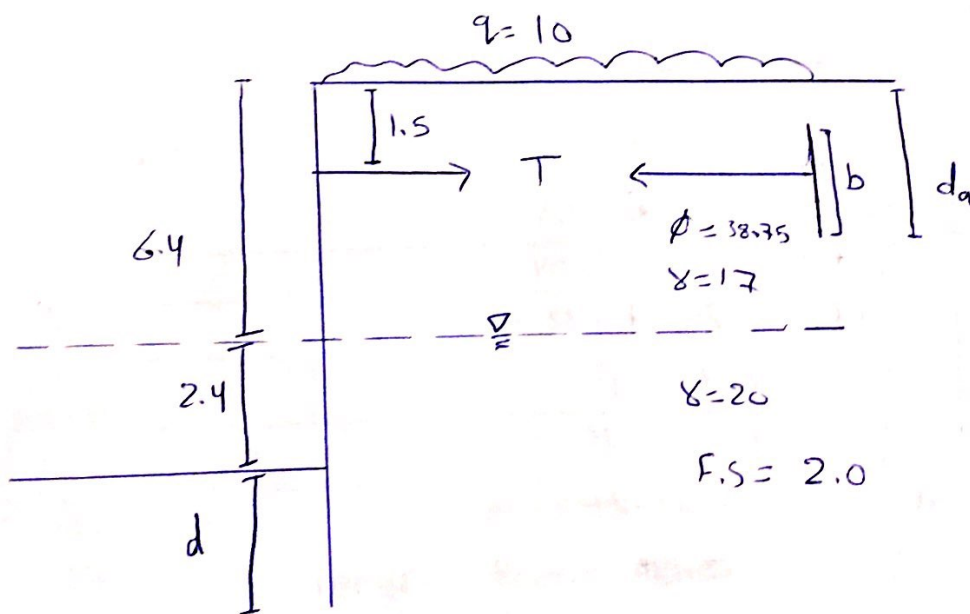
$$\boxed{d = 2.75 \text{ m}}$$

⑦

$$\begin{aligned}
 D &= 1.2 (d+1) + 0.25 \rightarrow \text{حاجي!} \\
 &= 1.2 (2.75 + 1) + 0.25 \\
 &= 4.75 \text{ m}
 \end{aligned}$$

* Example:-

Details of an anchored sheet pile wall are given in Figure, the design ground and water levels being as shown. The ties are spaced at 2.0 m centers. Above the water table the unit weight of the soil is 17 kN/m^3 and below the water table saturated unit weight ~~at the soil~~ is 20 kN/m^3 . Characteristic soil parameters are $c=0$, $\phi' = 38.75$ and is taken $\delta=0$. Determine the required depth of the ~~embedment~~ embedment and the force in each tie (a) for a factor of safety of 2.0 with respect to gross passive resistance and (b) Design a continuous anchor to support the ties using the values obtained in.



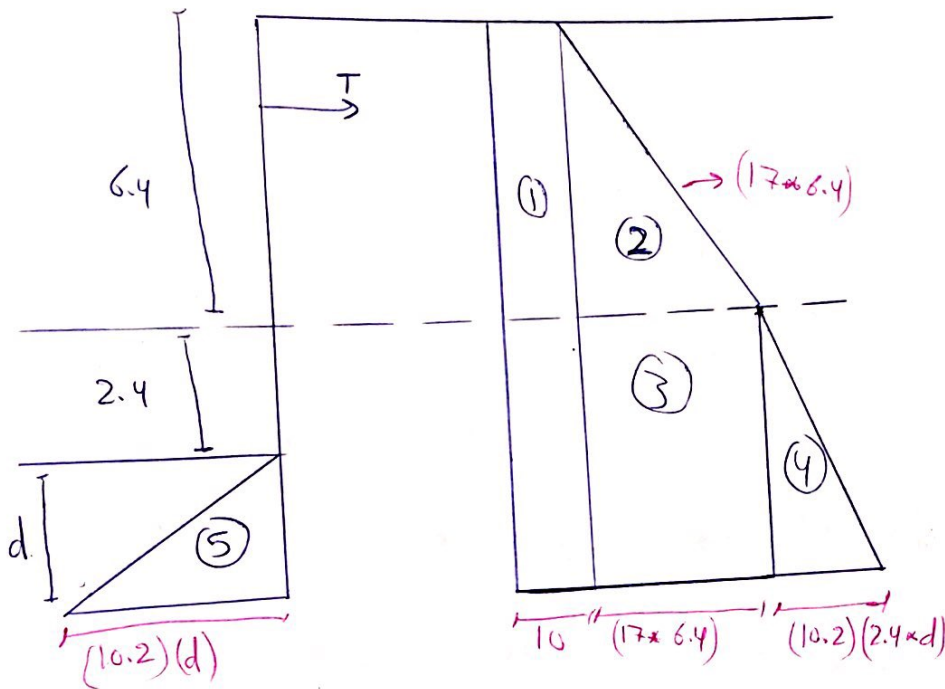
$$\begin{aligned}
 K_a &= 0.23 \\
 K_p &= 4.3465
 \end{aligned}$$

$$\underline{\underline{(d, T, b)}}$$

المطلوب مني: ايجاد

solution →

* لما حسب ال (arm) الجمع يكون حول ال (anchor)



Segment	Force (Area) (kN/m)	Arm (m)	Moment
(1)	$(0.23)(10)(8.8+d)$	$\frac{8.8+d}{2} - 1.5$	$1.15d^2 + 16.79d + 58.69$
(2)	$\frac{1}{2}(17 \times 6.4 \times 0.23)(6.4)$	$\frac{2}{3}(6.4) - 1.5$	221.55
(3)	$0.23 \times 17 \times 6.4 \times (d+2.4)$	$\frac{1}{2}d + 6.1$	$12.51d^2 + 182.647d + 366.305$
(4)	$\frac{1}{2}(0.23)(10.2)(d+2.4)^2$	$\frac{2}{3}(2.4+d) + 6.4 - 1.5$	$0.782d^3 + 11.37d^2 + 41.1d + 43.87$
(5)	$-\frac{1}{2}\left(\frac{4.3465}{1.2}\right)10.2d^2$	$\frac{2}{3}d + 6.5$	$-12.31d^3 - 120.07d^2$
			$\Sigma M = 0$

~~$11.4d^3 + 77.91d + 843.11 - 11.528d^3 = 0$~~

$$-11.46d^3 - 109.0d^2 + 240.5d + 691.1 = 0$$

$$d = 3.18 \text{ m}$$

$$T = 99.6 \text{ kN/m} \text{ for each tie}$$

Spacing $2m \phi$ to ϕ

$T =$ for each Tie

$= 2 \times (99.6) = 199.2 \text{ kN}$

↓
Spacing

for both

(9)

$$99.6 = \frac{1}{2} (4.3165 - 0.23)(17) (d_a)^2 - (0.23)(10) d_a$$

$$b = (1.72 - 1.5)(2) = 0.44$$

٤. ال (spacing) ما بينهما وبعوض بينهما (L)

~~Ans (7) Ovary is (Suture) sutured.~~

ساده ایست



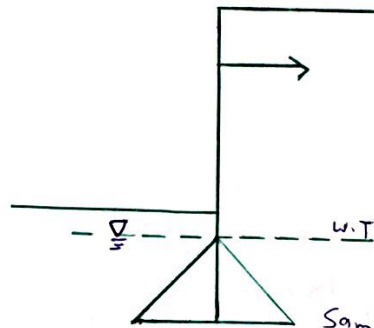
facts of seepage

* في هذا الموضوع بدأ بس نحتي عن حالتين لمستوى المياه:-

1) الحالة الأولى إذا كان مستوى المي متساوي على الجهتين

لا sheet pile :-

* the pore water prussure distribution will be hydrostatic and ~~back~~ will balance they can thus be eliminated from the calculations



Same hydrostatic prussure

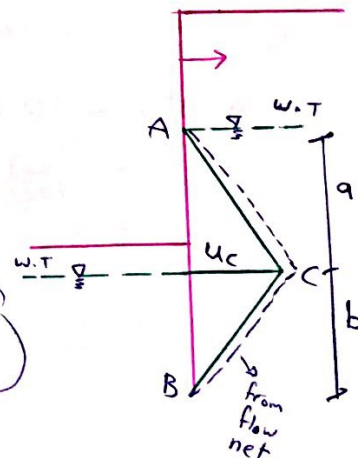
بنحل حل عادي مثل الأمثلة السابقة

* الحالة الثانية :- في حالة ما كان مستوى المي متساوي

* The maximum net prussure occurs opposite the lower water table level

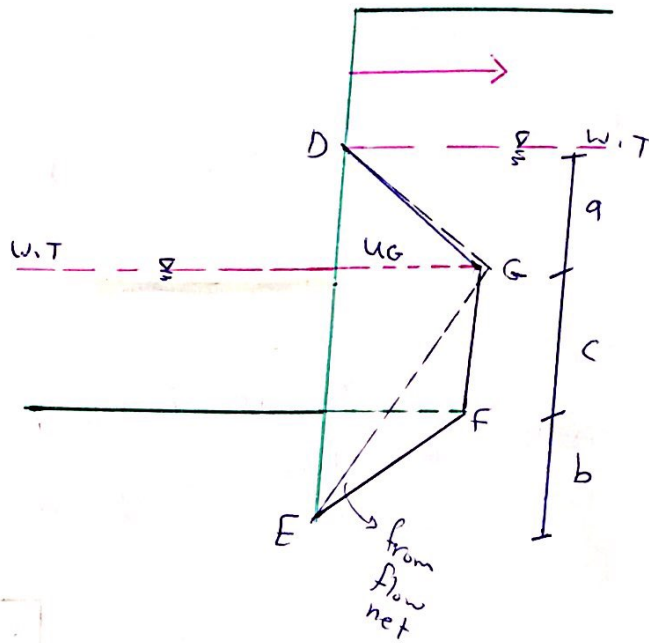
$$u_c = \frac{2ba}{2b+a} \gamma_w$$

هنا الحالة كانت مستوى المياه تحت مستوى الأرض

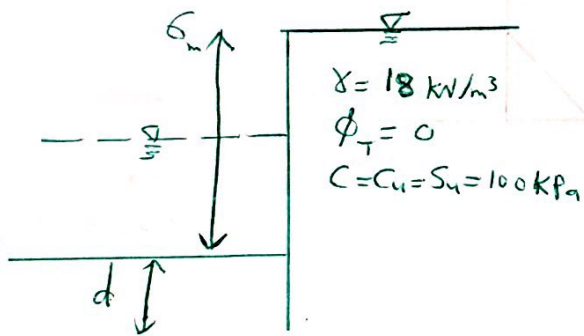


مسألة الثانية هـ إنه يكون مستوى المي فوق مستوى الأرضية

$$u_G = \frac{(2b+c)q}{2b+c+a} \gamma_w$$



Example:-



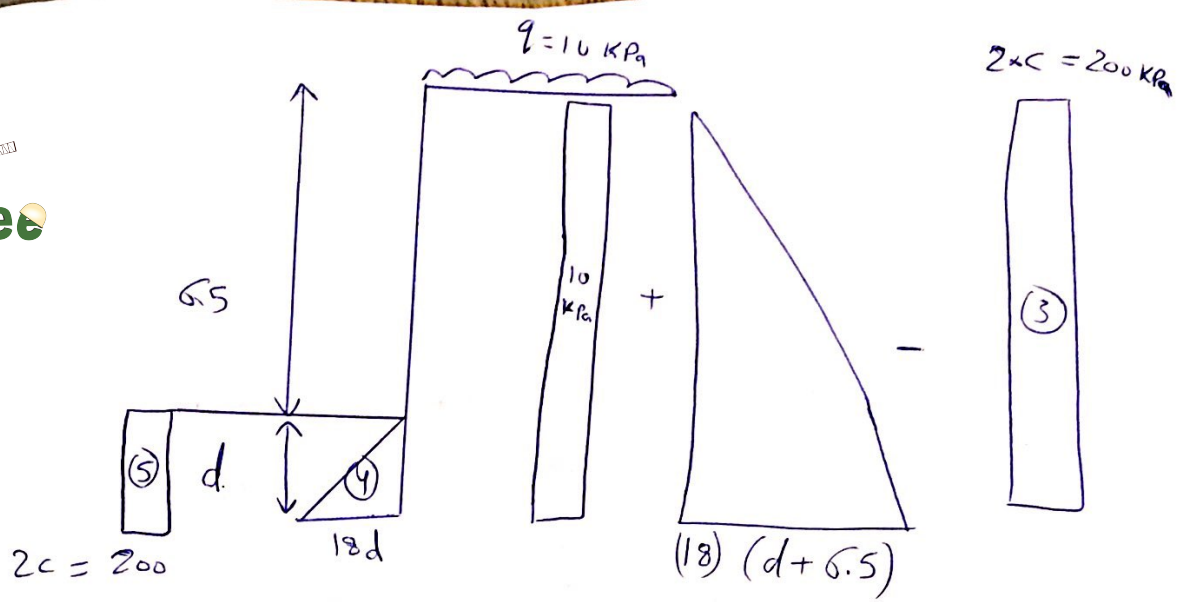
Solve without tensile cracks.

Solution:-

$$K_a = K_p = 1$$

$$\begin{aligned} \text{over excavation} &= 10\% H \\ &= \left(\frac{10}{100}\right)(6) \\ &= 0.6 > 0.5m \end{aligned}$$

take 0.5m



segment	Force (kN/m)	arm	moment (kN.m/m)
(1)	$(10)(6.5+d) = 65 + 10d$	$\frac{6.5+d}{2}$	
(2)	$(18)(\frac{1}{2})(d+6.5)^2$	$\frac{d+6.5}{3}$	
(3)	$-200(6.5+d)$	$\frac{6.5+d}{2}$	
(4)	$-\frac{1}{2}(18d)(d)(\frac{1}{2})$	$\frac{d}{3}$	
(5)	$-200d$	$\frac{d}{2}$	

$$d = 0.65 \text{ m}$$

$$d = 1.2 \times 0.65 = 0.78$$

آخر خطوة بنزله الـ 20% عند الـ (c) وبتعكس الـ active ← passive و active ← passive و إذا طلعت أكبر من (R) معناه (OK)

إذا كانت (R) سالبة ونسبة الزيادة برضو سالبة معناه إنه الاتمنى passive يعني بار safe side بس بنختار الأكبر

$$z_c = \frac{2c}{\gamma}$$

$$= \frac{2 \times 100}{18} = 11.3 \text{ m}$$

Sec #	Force (kN/m)	arm	moment (kN.m/m)
(1)	$10(6.5+d)$	$\frac{6.5+d}{2}$	$211.25 + 6.5d + 5d^2$
(2)	$-\frac{1}{2}(18d)(d)(\frac{1}{2})$	$\frac{d}{3}$	$-1.5d^3$
(3)	$-200 \times d \times \frac{1}{2}$	$\frac{d}{2}$	$-50d^2$
	$R = -225 \text{ kN/m}$		$-1.5d^3 - 45d^2 + 65d + 211.25 = 0$ $d = 2.83 \text{ m}$

* Try to solve with $c' = 10 \text{ kPa}$
 $\phi = 35^\circ$

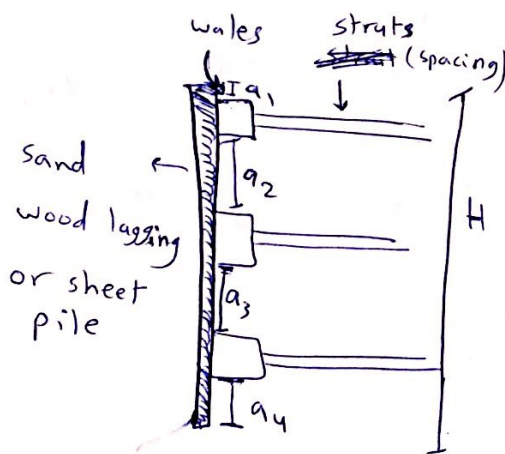
Braced excavation

Sheet piling or timbering is normally used to support the sides of:-

- ① deep
 - ② narrow
- } → excavations

* stability being maintained by means struts acting across the excavation.

* How we can protect this temporary excavations from collapse?
 → by a movable earth shield



$$c = 0 \iff (\text{fine} < 5\%) \iff (\text{clean sand}) \quad \text{If } \sigma_v > \frac{1}{2} \sigma_h$$

$$z_c = \frac{2c}{8\sqrt{K_a}} \iff (\text{tensile cracks}) \quad \text{If } \sigma_v > \frac{1}{2} \sigma_h$$

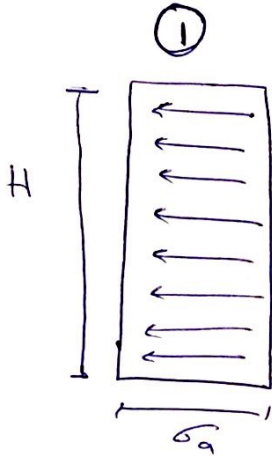
$$= \frac{2c}{8} \Rightarrow \sigma_q = 0$$



o.o (unsupported excavation) VL

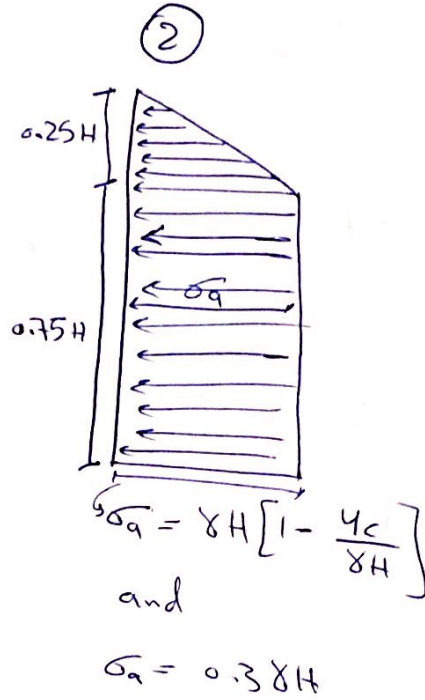
$$Z_c = \frac{4c}{8\sqrt{K_a}} \Rightarrow \frac{4c}{8}$$

* Pressure envelope for Braced-cut:-

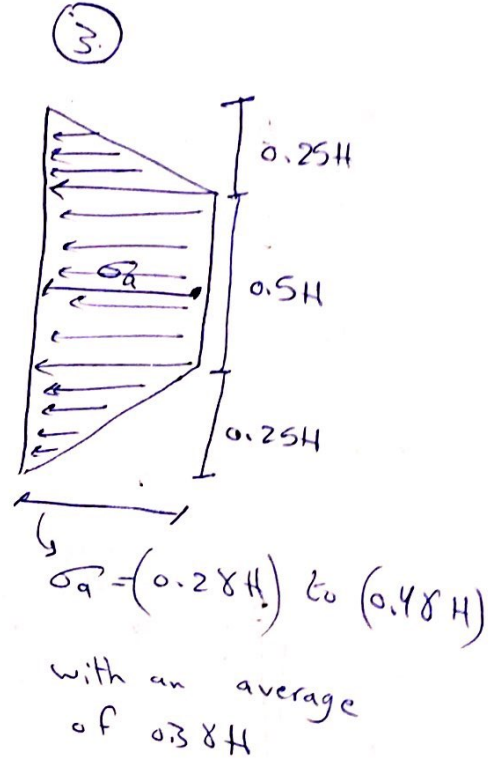


$$\sigma_a = 0.65 \gamma H K_a$$

↓
 في حالة الـ Sand
 VL



↓
 في حالة الـ clay

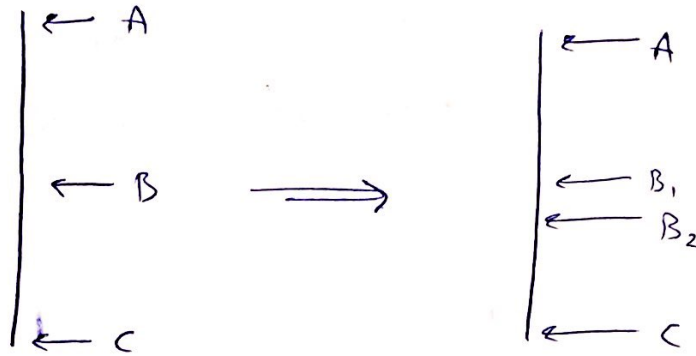


* في حالة الـ (sand) بدل ما نستخدم distribution
 ← بنستخدم equivalent مثل رسمه رقم (1)

* في حالة الـ (clay) عندي نوعين بجمدوا بشكل رئيسي على (c)
 ① hard ← أقل من (4) ← $\left[\frac{\gamma H}{c} < 4 \right]$ مثل رسمه رقم (2)

② soft to medium ← أكبر من (4) ← $\left[\frac{\gamma H}{c} \geq 4 \right]$ مثل رسمه رقم (3)

* بالنسبة لتوزيع ال (Force) على الجدار :-



بنقسم الجدار لقسمين و بنطلع ال (B) على كل طرف ،
والأمثلة راح توضح .

* في حالة كان عندي طبقات متنوعة من ال sand و ال clay :-
باخذ ال average للطبقات :-

$$C_{av} = \frac{1}{2H} [\gamma_s k_s H_s^2 \tan \phi'_s + (H - H_s) n' q_u]$$

$$\gamma_{av} = \frac{1}{H} [\gamma_s H_s + (H - H_s) \gamma_c]$$

Where :-

H = Total height

γ_s = unit weight of sand

H_s = height of sand layer

k_s = a lateral earth pressure coefficient for the sand layer (≈ 1)

ϕ'_s = effective angle of friction of sand

q_u = unconfined compression strength of clay

n' = a coefficient of progressive failure (ranging from (0.5 - 1.0) average value = 0.75)



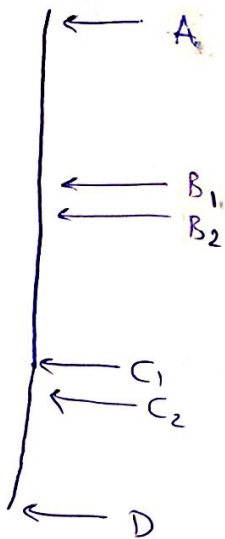
فان عندى عدة طبقات من ال clay :-

$$C_{av} = \frac{1}{H} (C_1 H_1 + C_2 H_2 + \dots + C_n H_n)$$

$$\gamma_{av} = \frac{1}{H} (\gamma_1 H_1 + \gamma_2 H_2 + \gamma_3 H_3 + \dots + \gamma_n H_n)$$

* كيفية حساب ال (force) على الجدار :-

* اقل مسافة (s) بين كل (struts) و الثاني من (2-3)



$$F_A = A(s)$$

$$F_B = (B_1 + B_2)(s)$$

$$F_C = (C_1 + C_2)(s)$$

$$F_D = D(s)$$

* لحساب ال (max bending moment) :-

$$M_{max} = \frac{As^2}{8} \text{ at level (A)}$$

$$M_{max} = \frac{(B_1 + B_2)s^2}{8} \text{ at level (B)}$$

$$M_{max} = \frac{(C_1 + C_2)s^2}{8} \text{ at level (C)}$$

$$M_{max} = \frac{Ds^2}{8} \text{ at level (D)}$$

* From these maximum moments, the section moduli are found for each level from,

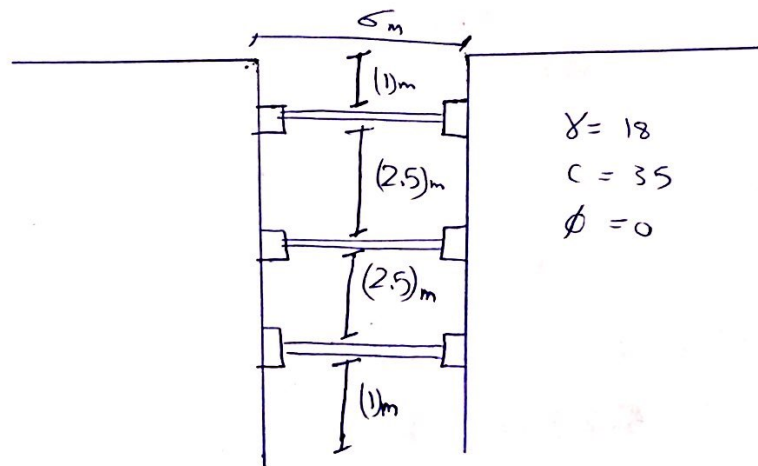
$$S = \frac{M_{max}}{\sigma_{all}}$$

Ex. 8.0

The cross section of long braced cut is shown:-

- 1) Draw the earth pressure envelope
- 2) Determine the struts loads at all levels
- 3) Select a suitable sheet pile section
- 4) Determine a design section modulus for the wales

The struts spacing is placed 3m and allowable stress for both wales and sheet pile is $170 \times 10^3 \text{ kN/m}^2$

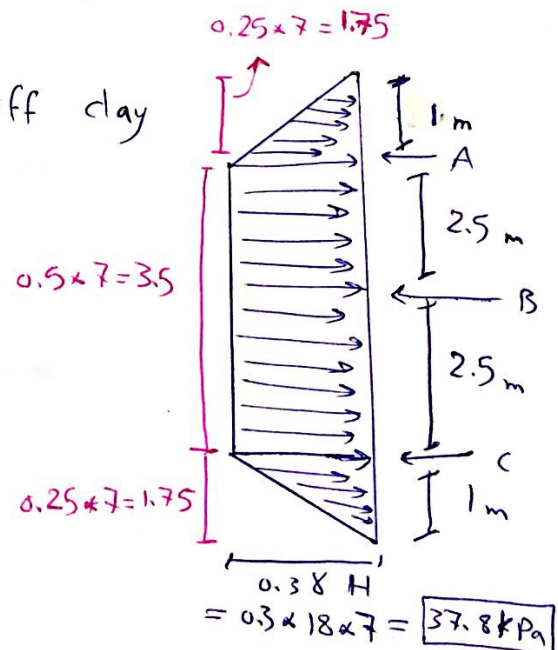


$$\begin{aligned}\gamma &= 18 \\ c &= 35 \\ \phi &= 0\end{aligned}$$

Solution :-

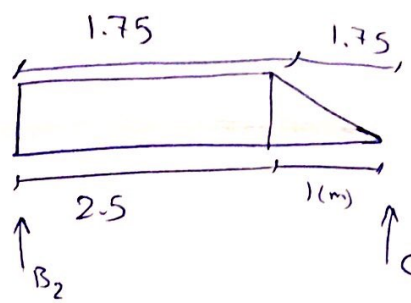
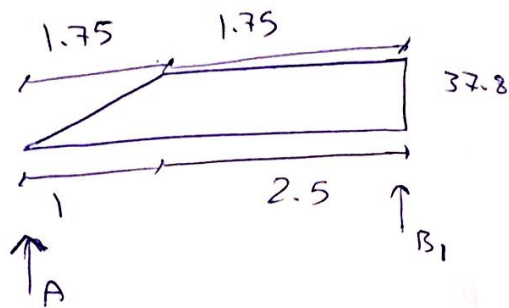
$$① \frac{\gamma H}{c} \leq 4$$

$$\frac{(18)(7)}{35} = 3.6 < 4 \Rightarrow \text{Hard and stiff clay}$$



(19)

②



$$\sum M_{B_1} = 0$$

$$-A(2.5) + \frac{1}{2}(1.75)(37.8)\left(\left(\frac{1}{3} \times 1.75\right) + 1.75\right) + \left((37.8)(1.75)\left(\frac{1.75}{2}\right)\right) = 0$$

$$A = 54.02 \text{ kN/m}$$

$$\sum F = 0 \Rightarrow B_1 = 45.2$$

$$B_2 = B_1 = 45.2$$

$$C = A = 54.02$$

$$F_A = A \times 3$$

$$= 54.02 \times 3 \text{ kN}$$

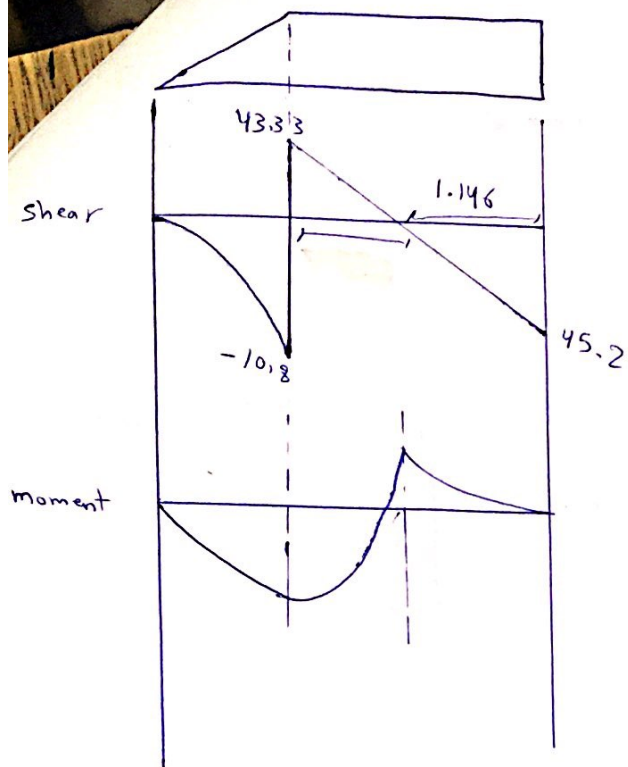
$$F_B = (B_1 + B_2)(3)$$

$$= (45.2 + 45.2)(3) \text{ kN}$$

$$F_C = F_A = 54.02 \times 3 \text{ kN}$$

تابع الحل





$$(3) S = \frac{M_{max}}{\sigma_{all}}$$

$$= \frac{27.02}{170 \times 10^3}$$

$$= 1.59 \times 10^{-4} \text{ kN/m}$$

$$= 15.9 \times 10^{-5} \text{ kN/m}$$

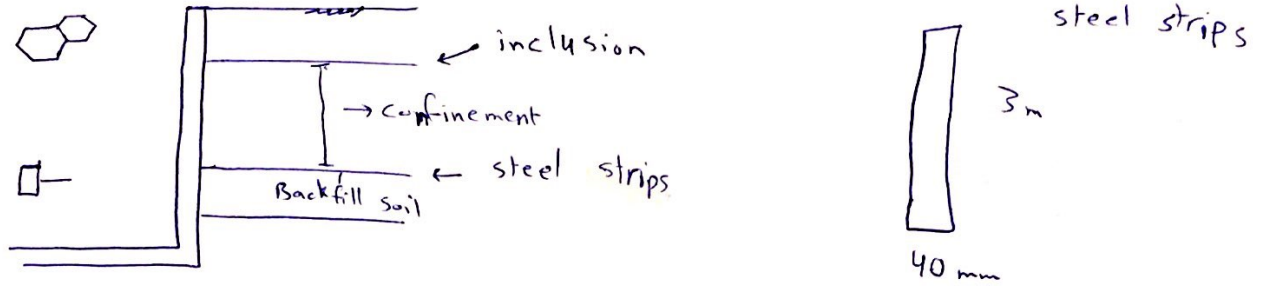
$$(4) M_{max} = \frac{(\beta_1 + \beta_2) S^2}{8}$$

$$= \frac{(45.2 \times 2) 3^2}{8} = 101.7 \text{ kN/m}$$

$$S = \frac{M_{max}}{\sigma_{all}} = \frac{101.7}{170 \times 10^3} = 0.59 \times 10^{-3} \text{ m}$$

* Mechanical Modification

- modification by inclusion and confinement
- Earth reinforcement



Inclusion so Metal strips
Fabrics
Rod

* يستخدم تسليح التربة لعدة أسباب منها :-

- ① إذا كان ال (sattment) للسويل عالي
 - ② إذا كانت التربة تعاني من sliding activity
 - ③ إذا السويل كان فيه slope instability
 - ④ السويل اللي بين (strips) 2 يتعرض لل Confinement
- بشكل عام بي ازيد قوة تحمل التربة

Required { external stability
Internal stability } → عشان نحافظ على سلامة المبنى



system called reinforcement soil

primary compared:-

1) fill - backfill

2) reinforcement $\rightarrow$ degradation to (2) type :-

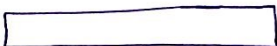
(1) Metal $\rightarrow$ corrosion

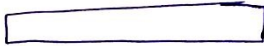
(2) Geotextile (ultra violet light reaction)

(3) tree roads $\rightarrow$ زراعة جوانب الطرق .

(3) facing

* Corrosions :-

 $t_0 =$ Initial thickness

 $t =$ thickness at any time

$t_0 - t = \Delta t$ loss in thickness because of corrosion

$$\Delta t = m y^n$$

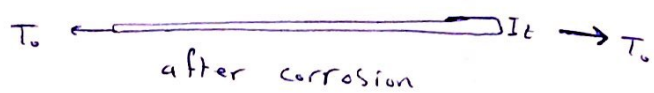
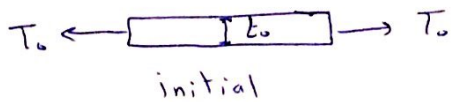
(m) and (n) constant

y : time in year

$$\Delta t (M_m) = 5.5 y^{0.6} \text{ min}$$

$$\Delta t (M_m) = 50 y^{0.6} \text{ max}$$

* Tensile strength :-



ΔT = loss of strength

Δt = loss of thickness

$$\frac{\Delta T}{T_0} \propto \frac{\Delta t}{t_0}$$

$$T = T_0 \left[1 - \frac{\Delta T}{T_0} \right] \rightarrow \text{Tensile strength after corrosion}$$

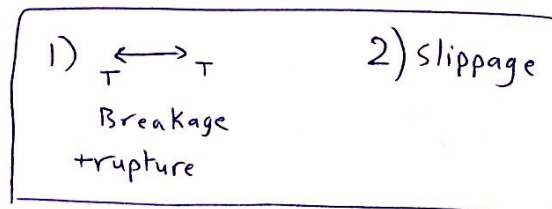
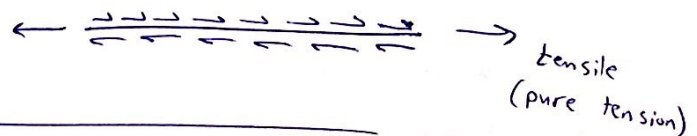
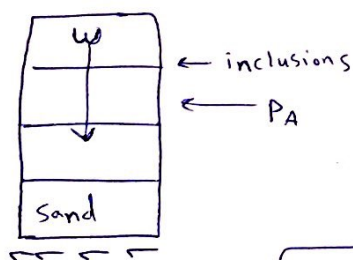
$$= T_0 \left[1 - k \frac{\Delta t}{t_0} \right]$$

k : heterogeneity factor $\rightarrow (0-2)$

* two way of design philosophy :-

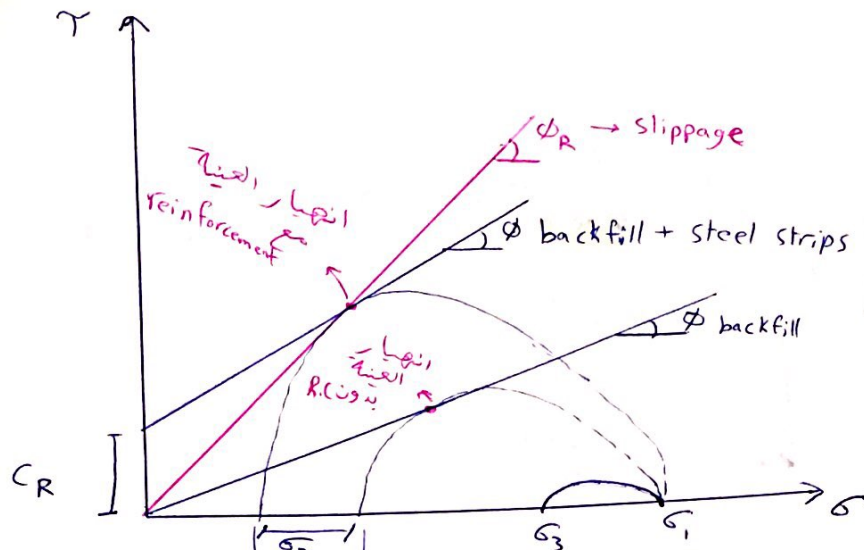
- 1) failure model $\rightarrow$ strength design
- 2) Deformation model $\rightarrow$ finite element

* mechanics of reinforcement :-



احتمالات الانهيار

Consider a Backfill with $C=0 \rightarrow$ sand

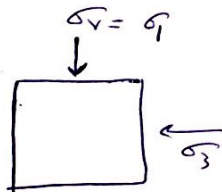


$$\sigma_h = k_R \sigma_v$$

$$\sigma_h = k_a \sigma_v$$

$$k_a = \frac{1 - \sin \phi}{1 + \sin \phi}$$

الفرق بين (σ_h) بدون Reinforcement و (σ_h) مع Reinforcement σ_R



Use Rankine theory:-

$$C_R = \frac{\sigma_R}{2\sqrt{k_a}}$$

$$= \frac{\sigma_R}{2} \sqrt{k_p}$$

$$\sin \phi_R = \frac{1 + F - k_a}{1 - F + k_a}$$

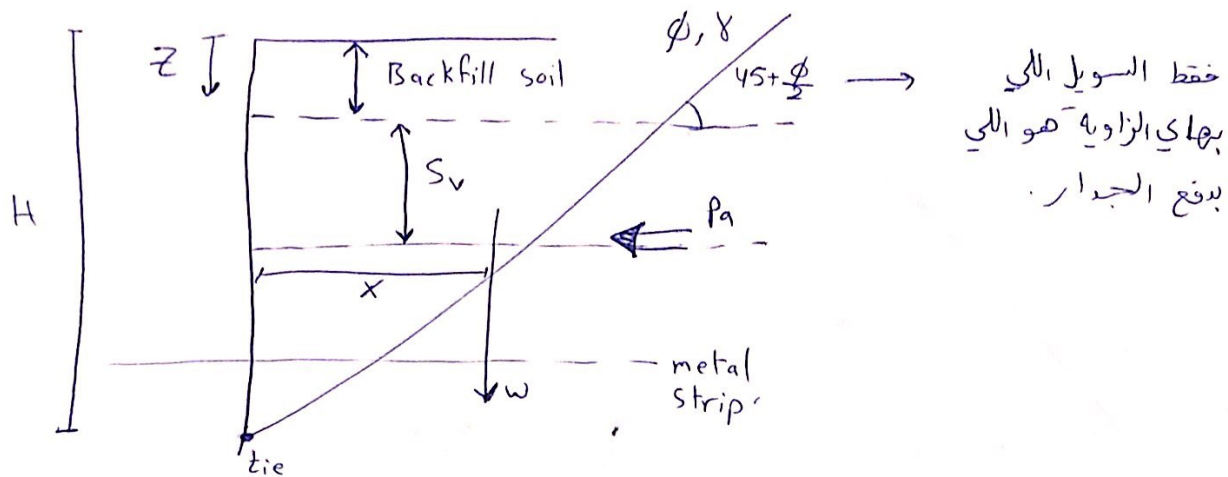
$$F = m$$

= friction between steel strips and soil

if $F = k_a \rightarrow \sin \phi_R = 1$
 $\phi_R = 90$ } failure occurs only by rupture

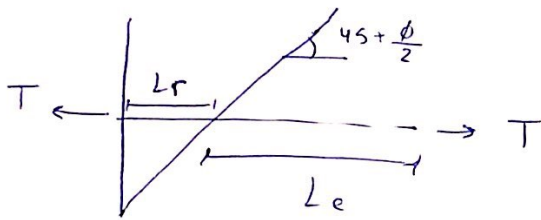
(25)

(*) Analysis of reinforced earth retaining wall



In situ soil

γ_2, ϕ_2, C_2



Tie Force per unit length of the wall

$T = \text{Active Earth pressure at depth } (z) \times \left(\text{Area of the wall to be supported by tie} \right)$

$$T = (\sigma_a) (S_v) (S_H)$$

where

σ_a = Active earth pressure

S_v = vertical spacing between ties

S_H = Horizontal spacing between ties.

Factor of safety against Tie ~~Failure~~ Failure ::

$$F.S. = \frac{(F_y)(w)(t)}{(\sigma_a)(s_v)(s_H)} > \underline{2.5 \text{ to } 3}$$

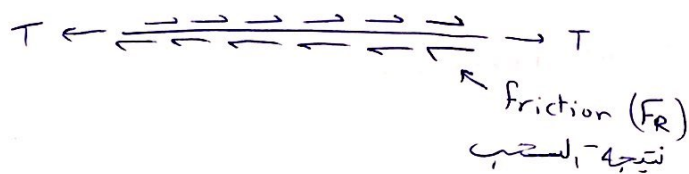
tie breaking

F_y = yield or breaking strength of the tie material

w = width of each tie

t = thickness of each tie

* Factor of safety Against tie Pull out ::



$$F_R = 2(L_e)(w)\sigma_v \tan \phi_m$$

$\phi_m \rightarrow$ friction angle for metal

L_e = Affective length

σ_v = Effective vertical pressure at z

$$F.S. = \frac{F_R}{T} = \frac{2(L_e)(w)(\sigma_v) \tan \phi_m}{(\sigma_a)(s_v)(s_H)}$$

- Total length of Tie :-

$$L = L_r + L_e$$

$$L_e = \frac{(F.S._{\text{pull out}})(\sigma_a)(s_v)(s_H)}{2(w)(\sigma_v) \tan \phi_m}$$

$$L_r = \frac{H-z}{\tan \left(45^\circ + \frac{\phi}{2}\right)}$$

(27)

(external stability :-)

1) overturning around tie :-

$$F.S_{\text{overturning}} = \frac{M_R}{M_o} = \frac{\sum W_2 X_2}{(P_a)(X_2)} > 2.3$$

$$P_a = \int_0^z \sigma_a dz$$

Sliding

$$F.S_{\text{sliding}} = \frac{(\sum W) \tan \delta + B C_a}{P_a}$$

$$\delta = \left(\frac{2}{3} \text{ up to } \frac{3}{3} \right) \phi$$

B = width or last L of reinforcement

$$C_a = K C_2$$

$$K = \left(\frac{1}{2} \text{ to } \frac{2}{3} \right)$$



Example :-
A 30' high retaining wall with galvanized steel strips reinforcement in a granular backfill has to be constructed.

Granular backfill :- $\phi_1 = 36^\circ$
 $\gamma_1 = 105 \text{ pcf}$

$$\phi_2 = 28^\circ$$

$$\gamma_2 = 110 \text{ pcf}$$

$$C_2 = 1000 \text{ psf}$$

Galvanized steel reinforcement :-

width of strip, $w = 3''$

vertical spacing, $S_v = 2' \text{ } \phi \text{ to } \phi$

Horizontal spacing, $S_H = 3' \text{ } \phi \text{ to } \phi$

$F_y = 35000 \text{ psi}$, $\phi_m = 20^\circ$

- consider factor of safety to breaking = 3

F.S for Pullout = 3

Required :-

- check for External and Internal stability. Assume the corrosion rate of steel to be 0.001 in/yr and life ~~of~~ span of structure only 50 yrs

*Solution

Internal stability :-

a) Tie thickness

$$T_{\max} = (\sigma_a)_{\max} S_v S_H$$

$$(\sigma_a)_{\max} = \gamma H K_a$$

$$= \gamma H \tan^2\left(45 - \frac{\phi}{2}\right)$$

$$T_{\max} = \gamma H \tan^2\left(45 - \frac{\phi}{2}\right) S_v S_H$$

$$t = \frac{\sigma_a S_v S_H}{w f_y} (F.S. Br.)$$

$$= \frac{\gamma H \tan^2\left(45 - \frac{\phi}{2}\right) S_v S_H}{w f_y}$$

$$t = \frac{(105)(30) \tan^2\left(45 - \frac{36}{2}\right)(2)(3)}{\left(\frac{3}{12}\right)(35000 \times 144)} = 0.01171'$$
$$= 0.14''$$

* Due to corrosion:

$$t = 0.14'' + (0.001 \text{ in/yr})(50)$$

$$= 0.14'' + 0.001 \times 50$$

$$= 0.19'' \approx 0.2''$$

Tie length ; $L = L_r + L_e$

$$L = \frac{H - z}{\tan(45 + \frac{\phi}{2})} + \frac{(F_{is \text{ pull out}})(\gamma z) k_a S_v S_H}{2 w \gamma z \tan \phi_m}$$

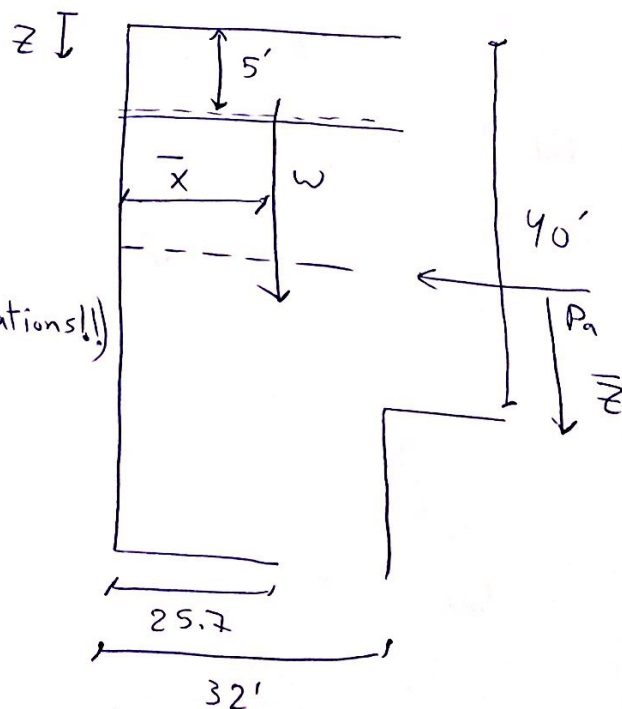
z'	L
5	38.427
10	35.89
15	33.34
20	30.79
25	28.25
30	25.7

sample of calculation

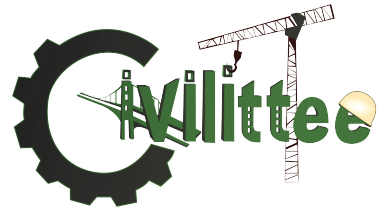
for $z = 5'$

$$L = \frac{30 - 5}{\tan(45 + \frac{36}{2})} + \frac{3(105)(5) k_a \times 3 \times 2}{2 \times \frac{3}{12} \times 105 \times 5 \times \tan 20}$$

for simplicity
use $L = 40'$ (for all locations!!)



* External stability



1) over turning

$$F.S_{ot} = \frac{W\bar{x}}{P_a\bar{z}}$$

$$W = \frac{\gamma H L}{(105)(30)(40)} = 126000 \text{ lb/ft}$$

$$\bar{x} = 20'$$

$$P_a = \frac{1}{2} \gamma K_a H^2 = \frac{1}{2} (105) (0.26) (30)^2$$

$$\bar{z} = \frac{H}{3} = \frac{30}{3} = 12285 \text{ lb/ft}$$

$$F.S_{ot} = \frac{126000 \times 20}{12285 \times 10} = 20.5 > 3 \quad \underline{\underline{ok}}$$

2) sliding

$$F.S_{sliding} = \frac{\sum W \tan \phi + BCa}{P_a}$$

$$= \frac{126000 \tan\left(\frac{2}{3} \times 28\right) + 40 \times \frac{2}{3} \times 1000}{12285}$$

3) let $\phi_{ult} = 60.971$ Psf

$$F.S = \frac{\phi_{ult}}{\sigma_v \text{ at } H} = \frac{60.971}{105 \times 30} = 19.3 > 3 \quad \text{safe}$$

(32)



Compaction

* هذا الملخص يشمل 95% من السلايدات
+ دفتر الدكتور كامل لهذا السباير

* بعض السلايدات لم يتم ذكرها هنا لكن قمت بكتابتها
ملاحظة للرجوع اليهم

* في نهاية الملخص ستجدون اهم القوانين لهذا السباير

Compaction

* Section (1)

Why we need compaction?

- [1] Improve the shear strength of soil and thus increase the bearing capacity of shallow foundations ; increase the factor of safety against possible slope failure of embankments and earth dams.
- [2] Increase elastic properties - such as young modulus and poisons ratio and thus Reduce ~~consolidation~~ the settlement of structures
- [3] Reduce compressibility - Reduce consolidation settlements.
- [4] Control permeability - land fill clay liners.
- [5] Reduce susceptibility to liquefactions
- [6] Reduce the shrinkage and swelling of soils



①

* Section (2.1) :-

* Name some construction that need soil compaction before building?

- (1) dam
- (2) retaining walls
- (3) highways
- (4) airports

they required
man-placed
soil or fill

why? to compact
a soil and
place it in
a dense state.

what is the
objective from
dense state?

- Decrease future
settlements
- increase shear strength
- Decrease permeability.

reduction of air voids
in the soil, with little
or no reduction in water
content, this process
must be confused with
consolidation, in which
water is squeezed out
under the action of
a continuous static load

what is it
mean?

* What is the ~~pur~~ purpose of laboratory compaction? section (3.1)

- (1) to determine the proper amount of mixing water to use when compacting the soil in the field
- (2) to determine the resulting degree of denseness which can be ~~expressed~~ expected from compaction at this optimum water

What is the meaning of impact compaction (proctor test)?

a hammer dropped several times on a soil sample in a mold

and the mass of hammer

* height of drop

* number of drops

* number of layers of soil

* volume of the mold

→ are specified

What are the differences and common between standard and modified Proctor test?

differences

height of drop

size of hammer

number of layer

Energy

Common

number of blows

Mold size

Why we need modified proctor-test in some cases?

[1] to increase the maximum dry density

[2] to decrease the optimum water content

Proctor test establish that compaction is a function of four variable.
mention them?!

[1] Dry density (ρ_d) or dry unit weight γ_d

[2] Water content w

[3] Compactive effort (energy E)

[4] Soil type (gradation, presence of clay minerals, etc) - - -

[3]

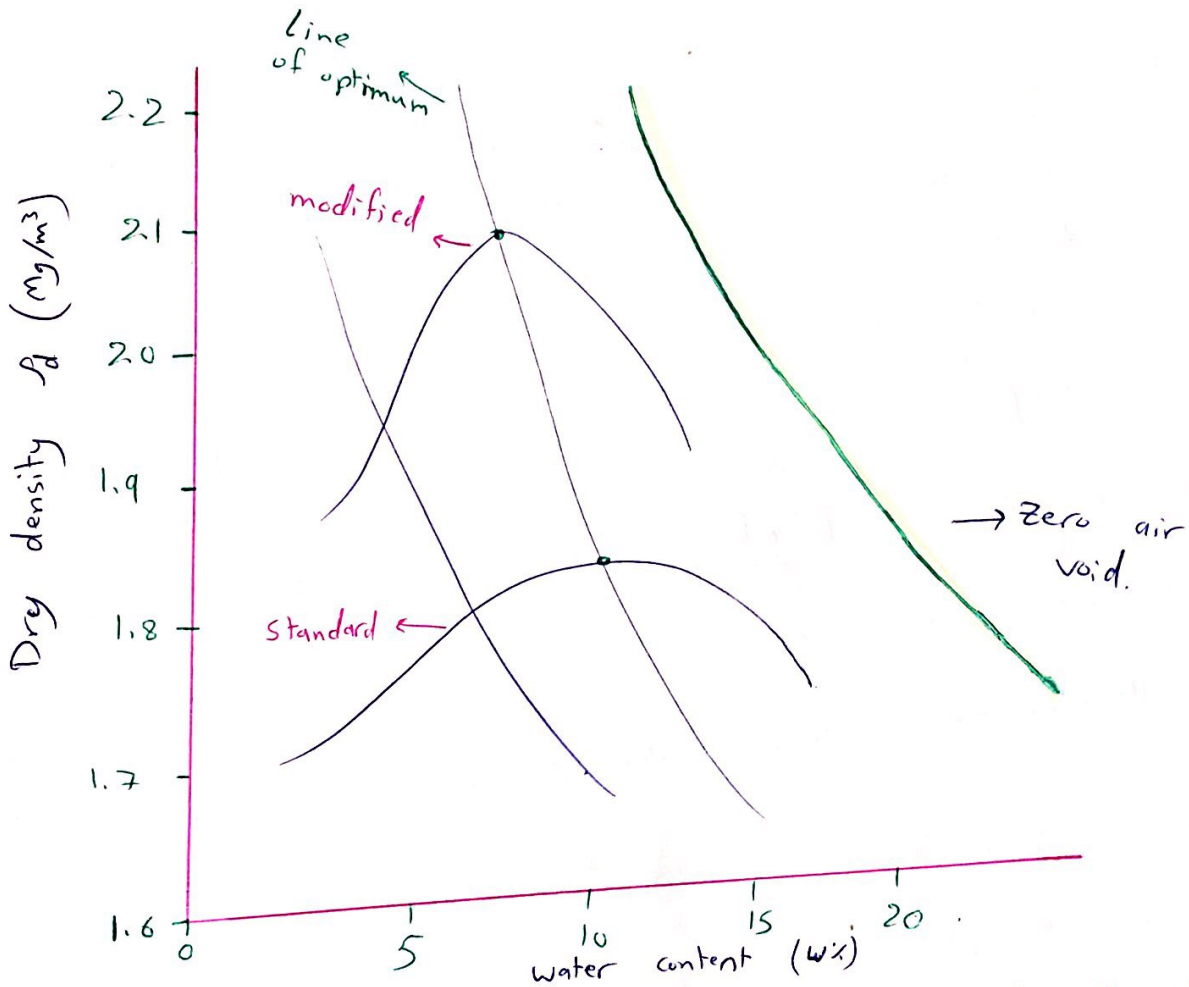
$$E = \frac{\text{weight of hammer} \times \text{Height of drop of hammer} \times \text{Number of blow per layer} \times \text{Number of layers}}{\text{Volume of mold}}$$

* القانون هاد لحساب ال (energy) في (standard test) و يجب مراعاة التحويل في الوحدات :

1 ft → 12 in

1 ft → 0.3048 m

1 in → 2.5 cm



* هاي الرسمة احت بامتحان السويل نفسها و كان عليها (7.5) علامات و كان اول ~~سؤال~~ سؤال شو اسم ال (curve) ؟

Compaction curve

اسم ال (curve) ←

تابع اسئلة على الرسمة →

تالي سؤال كان ~~سؤال~~ اسم الخط الي باللون الأخضر

اسمه Zero - air void

تالت سؤال كان نحسب (لا) ال optimum modified ؟
 طبعاً رسمي متى دقيقه بس رح اعتبر انه ρ_d الي بالرسمه
 تساوي 2.1

$$\rho_d = \rho_d \times 9.81 = 2.1 \times 9.81 = 20.601$$

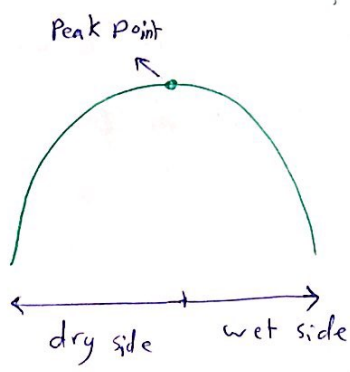
هنا بالنسبة لشرح الرسمه :-
 الرسمه بتبين العلاقة بين ال (dry density) و ال (water content) في حالة ال compaction
 لل (standard) و ال (modified)

بالنسبة لخط (Zero air void) ← يكون عندي Fully saturated = 100%

وهذا الخط theoretical و متى موجود بالواقع (ما عندي compaction)

نقطه ال (Peak point) :-

نفسه ال (max) الي هون
 بس بالمختبر وما الها
 علاقه بالواقع .



عند ال (Peak point) يكون عندي (maximum dry density) ρ_{dmax} او (optimum water content) (w_{opt}) او (optimum moisture content) OMC

كلهم ~~سواء~~ الأسماء لنفس النقطه

هو خط بنرسمه بسر بكل نقاط ال Peak لكل ال Compaction 3

الرسمه لنفس نوع السويل

و شرط يكون موازي لـ (Zero air Void)

* كل نقطة بار curve بتمثل عملية اختبار واحدة لل Compaction

و بكيفي اعمل (4-5) اختبارات عشان ارسوم ال curve

و عشان يربط معي بختار عينتين wet

و عينتين dry

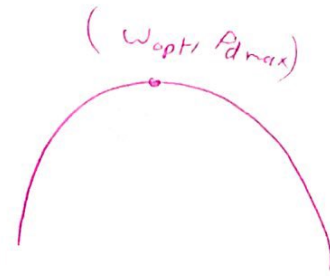
ونسبة تغير مقدار ال water content = 2%

(Optimum water content) ← اقل من ال (Plastic limit)

* Typical values of maximum dry density are around $1.6-2 \text{ Mg/m}^3$ with maximum range $1.3 \rightarrow 2.4 \text{ Mg/m}^3$

* Typical optimum water contents are between $10\% \rightarrow 20\%$ with maximum range $5\% \rightarrow 40\%$

* في البداية نسبة المي بتزيد ونسبة
~~تغلف~~ الجزيئات بالمى بتزيد
 وبتبلىش تزييد الكثافة حتى توصل
 لل (max) المي هي (Peak Point) ← أعلى قمة
 بعدين ~~بتبلىش~~ بتبلىش تقل الكثافة بعد
 ال Peak وبتزيد نسبة المي أكثر



هنا الحكي
 يلخصه للسلايد هاد

* in dry side :- (Below w_{opt})

as the water content increase, the particles develop larger and larger water films around them, which ~~that~~ tend to lubricate the particles and make them easier to be moved about and reoriented into a denser configuration.

* At w_{opt} :-

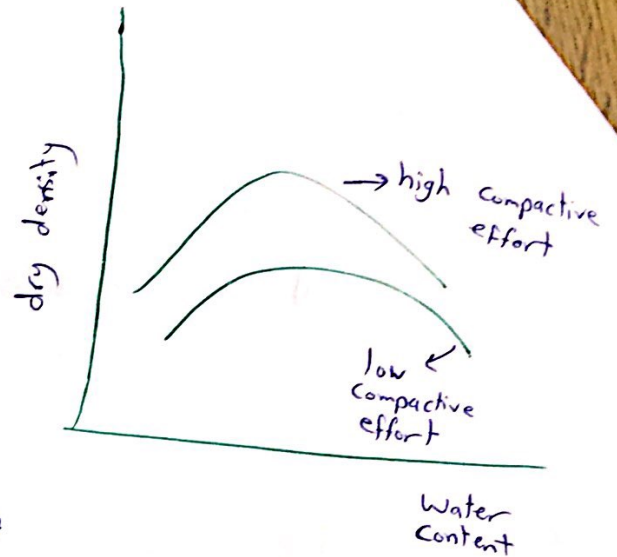
The density is at the maximum, and it does not increase any further

* above w_{opt} (wet side) :-

Water starts to replace soil particles in the mold, and $\rho_w > \rho_s$ the dry density start to decrease.

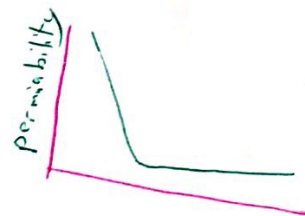
* سلايد (24, 25) ← ارجعولهم بالسلايدات ~~بار~~ introduction

* in dry ~~density~~ side
the soil tends to be more
flacculated (random) for
compaction as compared
on the wet side.



* increasing compactive effort ~~the~~
tends to disperse (parallel, oriented)
the soils, especially on the dry side

* increase the water content results in a decrease in permeability
on the dry side of the optimum moisture content
and a slight increase in permeability on the wet side
of optimum.



* Increasing the compactive effort reduce the permeability
since it both increase the dry density thereby reducing
the voids available for flow, and increases the orientation
of particles.

* العلاقات بسلاية (29, 30, 32) ← شوفوهم

* Swelling of compacted clays is greater for those compacted dry of optimum. They have a relatively greater deficiency of water and therefore have a greater tendency to adsorb water and thus swell more.

✳ إضافة الماء بزيادة الحجم
تقليل الماء يقلل ~~الحجم~~ الحجم.

✳ تابع من سلايات الدكتور مسلايد (33, 34, 35, 36)

بالنسبة - (section 5.1) ارجعوا للسلايدات لانه بس يحكي عن المعدات والآلات التي بنستخدمها بال (Compaction)

* Section 5.2 :-

* بما إنه عنا عدة آلات ومعدات عشان نعمل compaction للسوييل لازم نراعي عدة عوامل مهمة يتساعدنا على اختيار الآلة الصح :-

1) characteristics of the compactor:-

- Mass, size
- Operating frequency and frequency range

2) characteristics of the soil :-

- Initial density
- Grain size and shape
- Water content.

3) Construction procedures:-

- Number of passes of the roller
- lift thickness
- frequency of operation vibrator
- Towing speed

5.2.3 Roller Passes

معناها إنه كم مرة لازم (أشفي) فوق الأرض بال (roller) عشان أحقق (compaction) المطلوب.

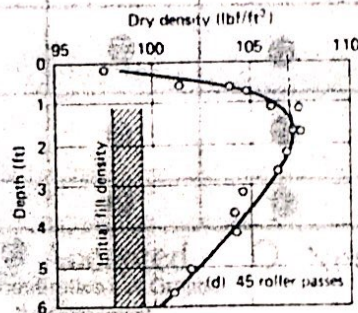
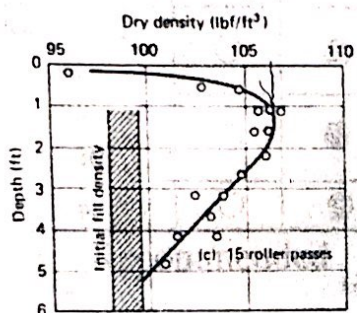
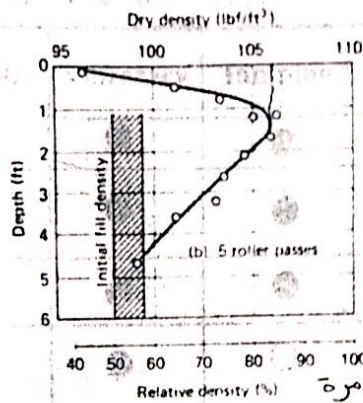
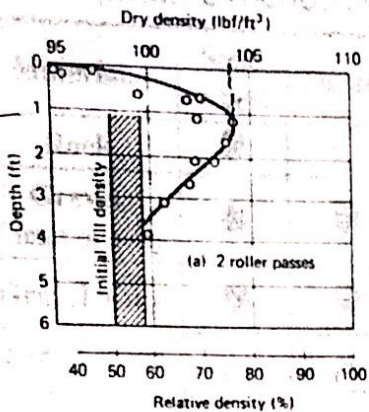
When compacting past five or so coverages, there is not a great increase in density

لا مشي شرط أفضل أمشي فوق الأرض رايح جاي عشان أحقق (compaction) لأنه ممكن زجيبها من ثاني مرة

• 240 cm thick layer of northern Indiana dune sand

• 5670 kg roller operating at a frequency of 27.5 Hz.

Holtz and Kovacs, 1981



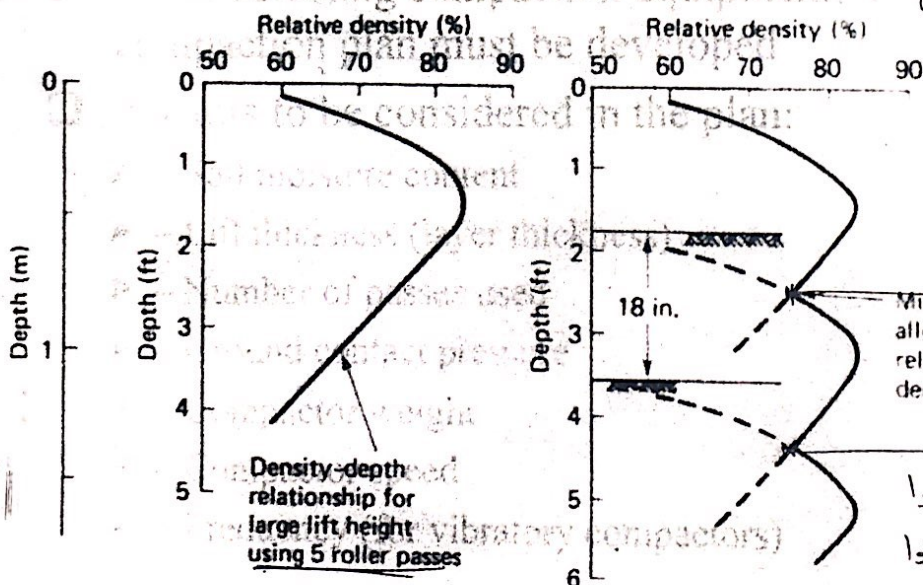
عند واحد
أعطيتي (104)
dry density

ليس حرقا
يكون ال
Number of pass
عالي حتى
نحقق ال
density المطلوبه
لأنه ممكن نجيبها
من ثاني مرة

5.2.4 Determine the Lift Height

مسافات صغيرة ← Confined space

أفضل عمق



الرسم بوضح عمق الطبقة
و نوع ال Compactor اللى لازم

Soil Stabilization and Ground Reinforcement

Holtz and Kovacs, 1981

استخدمها لهاد العمق
و كم مرة لازم أشفي فوقها

لا أفضل عمق يكون بين (10-30) م

(12)

Selection of Compaction Equipment

Objective: Obtaining the required soil density with a minimum expenditure of time and effort

لا الجدول بوضوح نوع التربة و أفضل آلة ممكنة نستخدمها والآلات المقبولة للاستخدام

Materials	Steal wheel	Pneumatic	Vibratory	Tamping foot	Grid
Rock	●	○	●	●	●
Gravel, Clean or silty	●	⊖	●	●	●
Gravel, Clay	●	⊖	⊖	●	⊖
Sand, clean or silty	○	○	●	○	⊖
Sand, clay silt	○	⊖	⊖	●	○
Clay, sandy or silty	○	●	⊖	●	○
Clay, heavy	○	●	⊖	●	○

● Recommended ⊖ Accepted ○ Not Recommended
Soil Stabilization and Ground Reinforcement

٢٣

Compaction Operation

- ❑ After selecting compaction equipment, a compaction plan must be developed
- ❑ Factors to be considered in the plan:
 - - Soil moisture content
 - - Lift thickness (layer thickness)
 - - Number of passes used
 - - Ground contact pressure
 - - Compactor weight
 - - Compactor speed
 - - Frequency (for vibratory compactors)

Soil Stabilization and Ground Reinforcement

٢٤

* بعد ما حددنا نوع الآلة اللي بدنا نشتغل عليها ، في عدة عوامل لازم نراعيها بالموقع مثل :-

- 1) Soil moisture Content
- 2) lift thickness (layer thickness)
- 3) Number of passes used
- 4) Ground contact pressure
- 5) Compactor weight
- 6) Compactor speed
- 7) Frequency (for vibratory compaction)

* هلا حكيينا عن طريق الرسومات إنه كلما زاد عدد ال (Passes) بتزيد ال (density) للموقع

لكن بعد (10 passes) بتكون الزيادة في الكثافة قليلة جدا ~ وبالتالي الكلفة بتزيد عالفاضي .



section 5.3 :- dynamic compaction :-

مبدأ ال (dynamic compaction) هي إسقاط وزن كبير اسمه (hammer) من ارتفاع معين على فترات منتظمة.

وزن ال (hammer) يتراوح بين (8-35) metric ton

والارتفاع يتراوح بين (7.5-30.5) m

المقدار ال (compaction) يعتمد على العوامل التالية:-

1] وزن ال hammer

2] الارتفاع

3] الموقع.

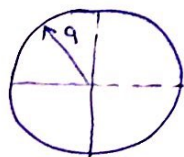
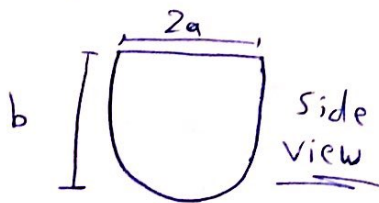
$$DI \approx \frac{1}{2} (wh)^{1/2}$$

DI : depth of influence (m)

w : mass of falling weight in metric tons

h : drop height in meters

الشكل التقريبي للتربة بعد ما تتعرض لل (Dynamic compaction) :-



* الشكل التقريبي هاد بسا عدفي بشوية حسابيات

منها قوانين

ومنها في رسمة (D-1)

عشان نمتي بالطريقة صح لازم نتبع هاي الخطوات:-

[1] نفرض إنه (DI) هي نفسها (b) اللي بالرسمة $\boxed{DI = b}$

[2] بنطلع ارتفاع ال (hamme) h

مساحة المقطع اللي بالرسمة $A \leftarrow \frac{\pi D^2}{4}$ ← القطر D

[3] بنكون العلاقة التالية $\boxed{\frac{DI}{D} = \frac{b}{D}}$

[4] بنروح على الرسمة (D-1) و بنطلع قيمة $NW_h h$ ← عدد الضربات h ← الارتفاع NW_h ← الوزن Ab ← مساحة المقطع

بعد ما صار معنا (h, A, b)

بنقدر نطلع عدد الضربات $NW_h h = Ab$

[5] بعد ما عرفنا عدد الضربات بنرجع للرسمة (D-1) و بنطلع (q) عن طريق خط $\left(\frac{q}{D}\right)$ الموجود بالرسمة بالصيغة اللي قبل

[6] آخر شي بنطلع ال (grid spacing) (S) ← من الرسمة (D-2) (S) ← أقل أو تساوي (q)

(هي المسافة بين كل منقطة ومنقطة: S)

Example i:-

Required to enhance a depth of 10m. weight of hammer is 200 kN. Determine the height of drop, No. of drop, and spacing if the hammer has radius of (2m)

Solution:-

1) $DI = b = 10 \text{ m}$

2) determine h

$$DI = \frac{1}{2} (Wh)^{1/2}$$

$$10 = \frac{1}{2} (20h)^{1/2}$$

$h = 20 \text{ m}$

3) $D \Rightarrow \text{Diameter} = 2 + 2 = 4$

$$\frac{b}{D} = \frac{10}{4} = 2.5$$

4) from figure

$$\frac{N W_h h}{A b} = 200 \text{ kN/m}^3$$

$$5) \frac{N(200)(20)}{(\pi \times 2^2)(10)} = 200$$

$N = 6.28$ use 7 drops $\rightarrow$ بنقرّب للعدد الأكبر

6) Find (a)

$$\frac{N W_h h}{A b} = 200 \Rightarrow \frac{a}{D} = 1.1$$

from figure
 $D-1$

$$a = 1.1(D) = 1.1 \times 4 = 4.4 \text{ m}$$

بناخذ أقلّ منها بس مسموح
الأكتر

7) $S_g \leq 4.4$

* section 5.4 :- Vibroflotation :-

What is the meaning of vibroflotation?

It is a technique for in situ densification of thick layers of loose granular soil deposits. ~~It was developed in~~

→ This process involves the use of a vibroflot (called the vibrating unit)

* The device is about (2m) in length. This vibrating unit has an eccentric weight inside it and can develop a centrifugal force.

* The weight enables the unit to vibrate horizontally.

* Openings at the bottom and top of the unit are for water jets.

* The vibrating unit is attached to a follow-up pipe.

* هادا كله حكي السلايد... ما في اشي ثاني و كلها حكي عن الآلة
و عالاغلب الدكتور ما يجيب هيك حفظ
لأنه بركنز عالفهم أكثر

* سلايد (65) ← هي خطوات عمل ال (vibroflotation)
* سلايد (64) ← جدول يقارن بين أكثر من نوع من الآلات

١- (vibroflotation) يكون عندي (٣) احتمالات للمنطقة :-

□ (1) Zone (1) ← يكون المنطقة متساوية و ملائمة للـ compaction by vibroflotation

[2] Zone(2) ← Fine sand
 ← silt-size particle
 يكون صلب تماماً Compaction لكن
 بمشي حالها المنطقة

3] Zone (3) ← يتكون (gravel) و الر (compaction) فيها صعب كثير
و ممكن تؤدي إلى تكلفه - عاليه - و فشل بالمسروع
عشان هيك بنسبعتها تماماً

٤. طبقات ال (Zone) ممكن تختلف حسب نوع ال (vibroflot)

* كلما زاد قطر المنطقة ← احتجنا لطاقة المحاكاة عسان
نعمل (Compaction)

مثلاً المنطقة التي نصف قطرها $(2\text{ m}) \leftarrow$ يحتاج (23 kw)
و المنطقة التي نصف قطرها $(3\text{ m}) \leftarrow$ يحتاج (75 kw)

بـ سلايد (67) هي نفس الشرح الذي حكيته فوق

Suitability Number:-

$$S_N = 1.7 \sqrt{\frac{3}{(D_{50})^2} + \frac{1}{(D_{20})^2} + \frac{1}{(D_{10})^2}}$$

* Suitability number for rating backfill material.

* هي باختصار معدل الردم (back fill) و الرقم اللي بطلع معي
بقرانه بالجدول التالي:-

<u>Range of S_N</u>	<u>Rating as backfill</u>
0-10	excellent
10-20	Good
20-30	Fair
30-50	Poor
>50	Unsuitable

* Relative Compaction:-

$$R.C = \frac{\gamma_{d \text{ field}}}{\gamma_{d \text{ max lab}}} \times 100\%$$

* In General (R.C) required to be between (90%-100%)

هاي اجبتن سوال بالسوال كان طالب نحسب
(R.C) و بعدين نحكي اذا النسبة مقبولة او لا
وليست؟!

* Relative density:- (D_r)

$$D_r = \frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}$$

where

e = void ratio (field)

e_{max} = void ratio (when soil very loose)

e_{min} = void ratio (when soil very dense)

لا عشان انبي بناء معين لازم
التربة تخضع لاختبار معين (control test)
لل (compaction) عشان اعرف اطلع (R.C)
معينة باستخدام آلة معينة

ال (relative compaction) مهم عندي في تصميم
الطرق و أساسات الابنية

but:-

$$\gamma_d = \frac{\rho_s}{1+e} \quad ; \quad \rho_s = G_s \rho_w$$

$$e = \frac{\rho_s}{\gamma_d} - 1$$

$$D_r = \frac{\frac{1}{\gamma_{d \text{ min}}} - \frac{1}{\gamma_d}}{\frac{1}{\gamma_{d \text{ min}}} - \frac{1}{\gamma_{d \text{ max}}}}$$

$$D_r = \left(\frac{\gamma_{d \text{ field}} - \gamma_{d \text{ min}}}{\gamma_{d \text{ max}} - \gamma_{d \text{ min}}} \right) \left(\frac{\gamma_{d \text{ max}}}{\gamma_{d \text{ field}}} \right)$$

(21)

قانون
معتد في
الحل

تابع الاستيفاق

$$D_r = \left(\frac{\gamma_{d\text{field}} - \gamma_{d\text{min}}}{\gamma_{d\text{max}} - \gamma_{d\text{min}}} \right) \times \left(\frac{\gamma_{d\text{max}}}{\gamma_{d\text{field}}} \right)$$

$$\Rightarrow R.C = \frac{\gamma_{d\text{field}}}{\gamma_{d\text{max}}}$$

$$D_r = \frac{R - R_o}{1 - R_o} \times \frac{1}{R}$$

where:-

$$R_o = \frac{\gamma_{d\text{min}}}{\gamma_{d\text{max}}}$$

$$R = \frac{R_o}{1 - D_r (1 - R_o)}$$

$$R = 80\% + 0.2 D_r$$

* Optimum water content:-

$$W_{opt} = W_p - 5\% \Rightarrow \text{if } W_p \leq 15\%$$

where W_p is plastic limit

For
cohesive

$$W_{opt} = W_p - 2\% \Rightarrow \text{if } 15 < W_p \leq 32\%$$

$$W_{opt} = 6.77 - 0.43 W_L - 0.21 I_p$$

where (W_L) is liquid limit

(I_p) is plasticity index $\Rightarrow PI = LL - PL$

* For sand and gravel:-

$$\rho_{max} \text{ (kg/m}^3\text{)} = \left[4804574 G_s - 195.55 (LL)^2 + 156971 (R\#4)^{0.5} - 9527830 \right]$$

$$L_n(w_{opt}) = 1.195 \times 10^4 (LL)^2 - 1.964 G_s - 6.617 \times 10^5 (R\#4) + 7.651$$

$R\#4 = \% \text{ Retained on No. 4 sieve.}$

* Osman et al 2008:-

$$w_{opt} (\%) = (1.99 - 0.165 \ln E) (PI \%)$$

$$\gamma_{d-max} = L - m (w_{opt})$$

where:-

$$L = 14.34 + 1.495 (\ln E)$$

$$m = 0.19 + 0.72 (\ln E)$$

$$E = \text{ (kN.m / m}^3\text{)}$$

$$\gamma_d = \rho_g$$

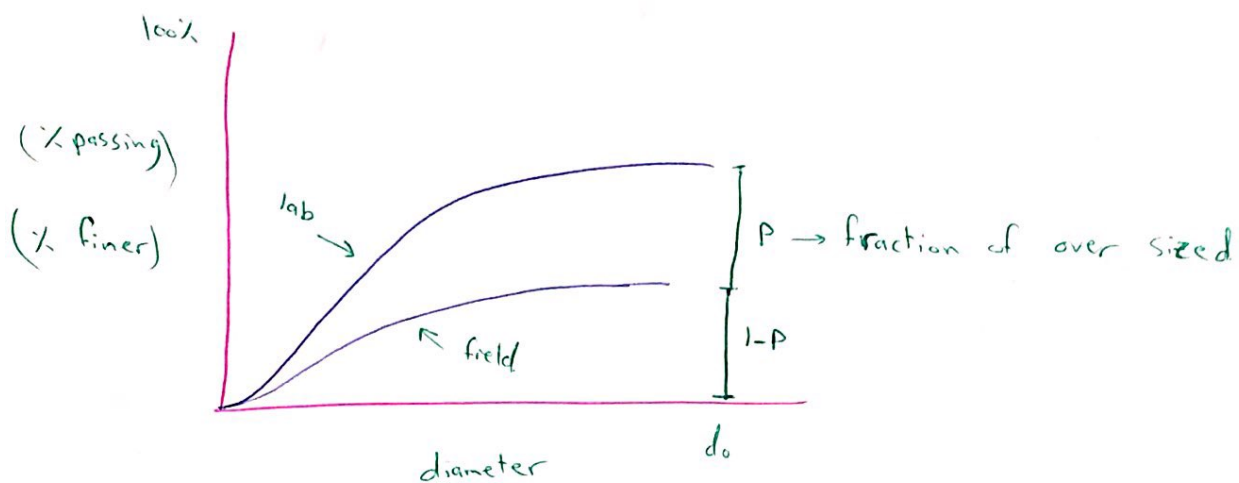
$$g = 9.81 \text{ m/s}^2$$

* Correction for over size:-

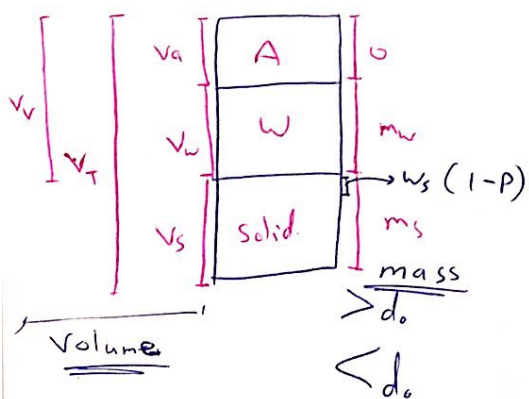
↓
the removed
from lab test

* See methods A, B, C and D in ASTM - for standard or modified Proctor test.

* Use sieve pass #4 or $3/4"$



Phase relation:-



$$w_s(1-P) + w_s P = w_s$$

* let us assume the over size has zero moisture content.

γ_s = soil solids unit weight.

* lab dry unit weight :-

$$\gamma'_d = \frac{w_s(1-p)}{V'}$$

$$w' = \frac{ww}{w_s(1-p)}$$

but:-

$$V' = \frac{w_s(1-p)}{\gamma'_d}$$

$$\gamma'_d = \frac{w_s}{\frac{w_p}{\gamma_s} + \frac{w_s(1-p)}{\gamma'_d}}$$

$$\gamma_d = \frac{1}{\frac{p}{\gamma_s} + \frac{1-p}{\gamma'_d}}$$

γ'_d → maximum dry unit weight from lab test

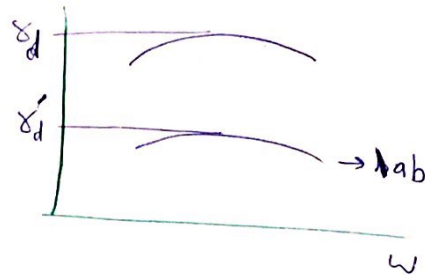
$$ww = \frac{ww}{w_r} = \frac{w'}{w_{opt}} (1-p)$$

w_{opt} in lab test

* in field :-

$$\gamma_d = \frac{w_s}{V}$$

$$= \frac{(w_s p) + w_s(1-p)}{V}$$



if the over size contain center moisture:-

$$W_{\text{field}} = W_c P + W' (1-P)$$

W_c = water content of over sized

$$\gamma_{\text{field}} = \gamma_c P + \gamma'_d (1-P)$$

$$\gamma_c = 0.9 \quad \gamma_s = 0.9 \gamma_w G_s$$

* Only valid for over sized of $\leq 30\%$.

Example :-

A sandy soil has a max. dry unit weight of 18 kN/m^3 and Dry unit weight of compaction in the field of 17.25 kN/m^3 . If the over size particles percentage is 5% and its moisture content is 1.5% more over, it is required to have ~~the~~ a field relative compaction of 95% estimate:-

- ① Relative compaction in the field
- ② is field compaction satisfactory? why?
- ③ Relative density in the field.
- ④ Min. dry unit weight in lab for this soil

Assume $G_s = 2.7$

Solution 

Solution:-

$$\text{in lab } \gamma_{\max} = 18 \text{ kN/m}^3$$

$$\gamma_{\text{field}} = 17.25 \text{ kN/m}^3$$

$$p = 5\%$$

$$w_c = 1.5\%$$

$$\gamma_{d_{\max}}^{\text{in field}} = 0.9 \gamma_s p + \gamma_d' (1-p)$$

$$\begin{aligned} \gamma_d &= 0.9 G_s \gamma_w p + \gamma_d' (1-p) \\ &= 0.9 \times 2.7 \times 9.81 \times 0.05 + 18(1-0.05) \\ &= 18.292 \text{ kN/m}^3 \end{aligned}$$

$$\text{① } R.C = R = \frac{\gamma_{d_{\text{field}}}}{\gamma_{d_{\text{lab}}}} = \frac{17.25}{18.292} \times 100 = \boxed{94.303\%}$$

② Not satisfactory since $94.303 < R - \text{Required } 95\%$.

$$\text{③ } R.C = 80\% + 0.2 D_r$$

$$D_r = \frac{94.303 - 80}{0.2} = 71.57\%$$

$$\text{④ } D_r = \frac{R - R_0}{1 - R_0} \times \frac{1}{R}$$

$$\gamma_{d_{\min}} = 15.0903 \text{ kN/m}^3$$

$$\begin{aligned} R &= 94.303\% \\ D_r &= 71.57\% \\ R_0 &= \frac{\gamma_{d_{\min}}}{\gamma_{d_{\max}}} \end{aligned}$$

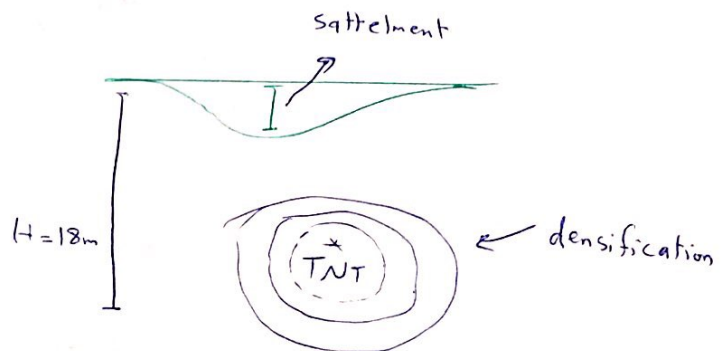
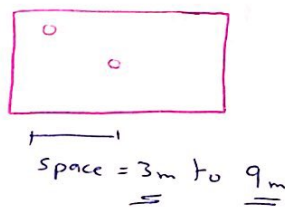
Blasting Explosion:-

Blasting :- a deep compaction technique used by detonating of buried explosions

* Soil suitable for soil with grain size similar to Flotation (Zone I) - especially loose to very loose sand, loose soil.

* procedure :-

- (1) insert hollow pipe by Jetting driven.
- (2) Place a charge of (TNT)
- (3) with draw pipe or back fill it
- (4) detonate



* لها يصير عندي تفجير بسبب (TNT) بشكل عندي فراغ
يؤدي إلى هبوط الـ (Soil) بالطبقة التي فوق.

In saturated condition $\Rightarrow$ pore water pressure increase $\Rightarrow$ ^{في حالة التغيير} $\Rightarrow$ liquification $\Delta \sigma_v' = 0 \Rightarrow$ Soil will fill up the hole

* Guid lines

[1] charge size $< \underline{1 \text{ kg}}$ up to $\underline{12 \text{ kg}}$

كمية المتفجرات

[2] Depth of buried $> \frac{1}{4}$ depth to bottom عمق التفجير

$$\underline{\frac{1}{2} H(r)} \quad \underline{\frac{3}{4} H(r)} \quad \underline{\frac{2}{3} H}$$

↓
أكثر شي
معارف
عليه

يعني العمق الذي يدي
أخط فيه المتفجرات
أقل شي لازم يكون ربع $\frac{1}{4}$
و أفضل شي $\underline{\frac{2}{3} H}$

[3] Number of coverage 1-5 per area typically 2-3 times.

* Successive charge :- are usually seperated by hours to several days

* Note :-

Care should excrsize against existing structure :-

[1] $\Delta u = \text{excess p.w.p} \rightarrow$ لازم أعرفها

[2] $\Delta h = \text{sattelment} \rightarrow$ لازم أتجنبها



Radial distance from point of explosive) $\rightarrow R$ (m)

بعد المنشأة عن مكان التفجير

$$R = \sqrt{\frac{W_{ex}}{C}}$$

(R) in meter

$W_{ex} = \text{Kg}$ (charge weight)

$C = 0.0122 \text{ mm}$ (W in Kg)

$\rightarrow$ Hopkinson's Number:-

$$N_h = \frac{W^{1/3}}{R}$$

if $N_h < 0.09$ to $N_h = 0.15$ little or no liquification

no liquification $\leftarrow$ 0.15 أو أكبر من 0.09 كانت أقل من

$$\frac{\Delta u}{\sigma'} = 1.65 + 0.65 \ln N_h$$

$\left[\frac{\Delta u}{\sigma'} = 1 \right] \rightarrow$ ~~no~~ liquification $\Rightarrow$ $N_h > 0.37$
occure

Liquifacation $\Rightarrow$ يعني انه السائل

يصير $\frac{\Delta u}{\sigma'} = 1$

Example:-

5-meter deep of sand is to be compacted by plating using 8-meter spacing bore ~~the~~ half.

it is inserted to create a p.w.p equal to 80% of ~~the~~ effective overborden.

- Estimate the TNT charge?

- How much its prevent volume compacted?

(Solution:-

$$(1) \frac{\Delta u}{\sigma'} = 1.65 + 0.65 \ln N_h$$

$$0.8 = 1.65 + 0.65 \ln N_h$$

$$N_h = 0.27$$

N_h soil
weight

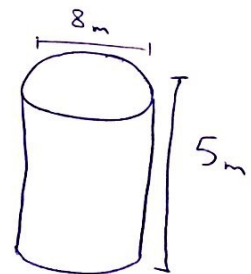
$$N_h = \frac{W^{1/3}}{R}$$

$$W = (N_h R)^3$$

$$= (0.27 \times 4)^3 = 1.2597 \text{ kg} \\ = 1.26 \text{ kg}$$

$$V = \frac{\pi}{4} D^2 H = \frac{\pi}{4} (8)^2 \times 5 = 251.3 \text{ m}^3$$

$$\frac{\text{kg}}{V} = \frac{1.2597}{251.3} = 5 \times 10^{-3} \text{ kg/m}^3$$



(31)

Example i:-

estimate the safe distance from an underground explosion of 10 kg of TNT beyond which little or No liquefaction occurs?

Solution:-

$$R = \sqrt{\frac{W_{ex}}{C}} = \sqrt{\frac{10}{0.012}} = \boxed{28.63 \text{ m}} \rightarrow \text{take this}$$

$$R = \frac{W^{1/3}}{N_h} = \frac{10^{1/3}}{0.09} = 23.94 \text{ m}$$

x دایماً بحل عالطریقین وباخذ الرعم الأكبر .

* بالنسبة لسكشن [6.6] ← الدكتور ما جاب سيرته بالمحاضرة
← بني ادرموه للاحيات

* من سلايد ((28 إلى 34)) سوفوهم انتوا برسوا

أهم القوانين في هذا الشايفر :-

$$F = \frac{\text{Weight of hammer} \times \text{Height of drop of hammer} \times \text{Number of blows per layer} \times \text{Number of layers}}{\text{Volume of mold}}$$

$$[2] \rho = \frac{M_t}{V_t}$$

$$[3] \rho_d = \frac{\rho}{1+w} = \frac{\rho_s}{1+e}$$

$$[4] \rho_d = \frac{\rho_w S}{w + \frac{\rho_w}{\rho_s} S} = \frac{\rho_w S}{w + \frac{S}{G_s}}$$

$$[5] Se = w G_s$$

$$[6] DI = \frac{1}{2} (wh)^{1/2}$$

$$[7] S_N = 1.7 \sqrt{\frac{3}{(D_{S0})^2} + \frac{1}{(D_{20})^2} + \frac{1}{(D_{10})^2}}$$

$$[8] D_r = \left(\frac{\gamma_{field} - \gamma_{dmin}}{\gamma_{dmax} - \gamma_{dmin}} \right) \times \left(\frac{\gamma_{dmax}}{\gamma_{dfield}} \right) = \left(\frac{e_{max} - e}{e_{max} - e_{min}} \right)$$

$$[9] R = \frac{R_0}{1 - D_r (1 - R_0)} = 80\% + 0.2 D_r$$

$$[10] R_0 = \frac{\gamma_{dmin}}{\gamma_{dmax}}$$

$$(11) \quad \omega_{opt} = \omega_p - 5\% \quad \text{if } \omega_p \leq 15\%$$

$$(12) \quad \omega_{opt} = \omega_p - 2\% \quad \text{if } 15\% < \omega_p \leq 32\%$$

$$(13) \quad \omega_{opt} = 6.77 - 0.43 \omega_L - 0.21 I_p$$

$$(14) \quad I_p = P_I = LL - PL$$

$$(15) \quad \rho_{max} = \left[4804574 G_s - 195.55 (LL)^2 + 156971 (R\#4)^{0.5} - 9527830 \right]^{0.5}$$

(kg/m³)

$$(16) \quad L_n(\omega_{opt}) = 1.195 \times 10^{-4} (LL)^2 - 1.964 G_s - 6.617 \times 10^{-5} (R\#4) + 7.651$$

$$(17) \quad \omega_{opt}(\%) = (1.99 - 0.165 \ln E)(PI\%)$$

$$(18) \quad \gamma_{dmax} = L - m(\omega_{opt})$$

where:

$$L = 14.34 + 1.195 (\ln E)$$

$$m = 0.19 + 0.72 (\ln E)$$

$$E = \text{energy (kJ.m/m}^3)$$

$$(20) \quad \gamma_{field} = \gamma_c P + \gamma_d' (1-P)$$

$$(21) \quad R = \sqrt{\frac{W_{ex}}{c}}$$

$$(22) \quad N_h = \frac{W^{1/3}}{R}$$

$$(23) \quad \frac{\Delta u}{\sigma'} = 1.65 + 0.65 \ln N_h$$

Precompression and Precompression with sand Drains

لا يثبت بلزمتا نحل (Precompression) للسوي ١٩

← لأن التربة - بتكون :-

- ① highly compressible
- ② normally consolidated clayey soil layers
- ③ lie at limit depth
- ④ large consolidation settlements
- ⑤ construction of large buildings, highway embankments or earth dams

→ why?!

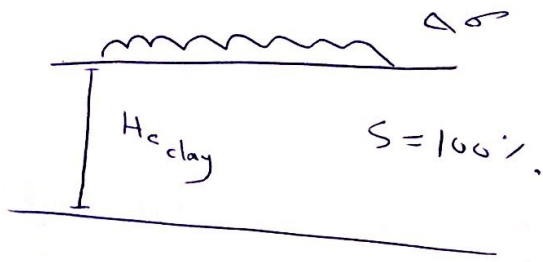
to minimize postconstruction settlement

لا يختار لما تكون التربة (fully saturated soft sand or clay) نحل (Precompression) عشاح

أزبد σ_0 (shear strength)

و أقل :- (compressibility)

Remember That:-



σ'_0 = Effective overborden pressure
or middle of clay layer (Initial)

$\sigma'_p = \sigma'_0$ = Preconsolidation prassure (maximum past pressure)

U_z = Degree of consolidation
 $= 1 - \frac{u_e}{u_0}$

درجة تسوية
التربة

سؤال
فأين
سؤال
 u_e = Excess pore water pressure at any time equal (t)
 u_i = Excess pore water pressure at $t = \text{zero}$
 $= \Delta \sigma$ at the onset of load applied.

$\bar{U} = U = U_{ave}$ = Average degree of consolidation
 $U_{ave} = \frac{S_t}{S_f} = \frac{S_t}{S_p}$

S_t = sattlement at time (t) → مقدار الهبوط عند زمن محدد

S_p or S_f = final sattlement (Primary consolidation sattlment)

Time factor:-

$$T_v = T = \frac{C_v b}{H_{dr}^2}$$

T = time factor

C_v = coefficient of consolidation

t = time

H_{dr} = drainage distance

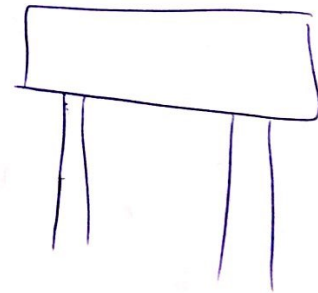
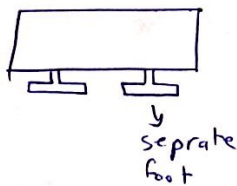
= $\frac{1}{2}$ layer if sand exist up and below layer

= layer thickness (H_c) if sand exist only above clay

Preloading:-

placement of (temporary) surcharge on soft ground ~~prior~~ prior to construction of actual structure (permanent)

Surcharge $\equiv$ fill



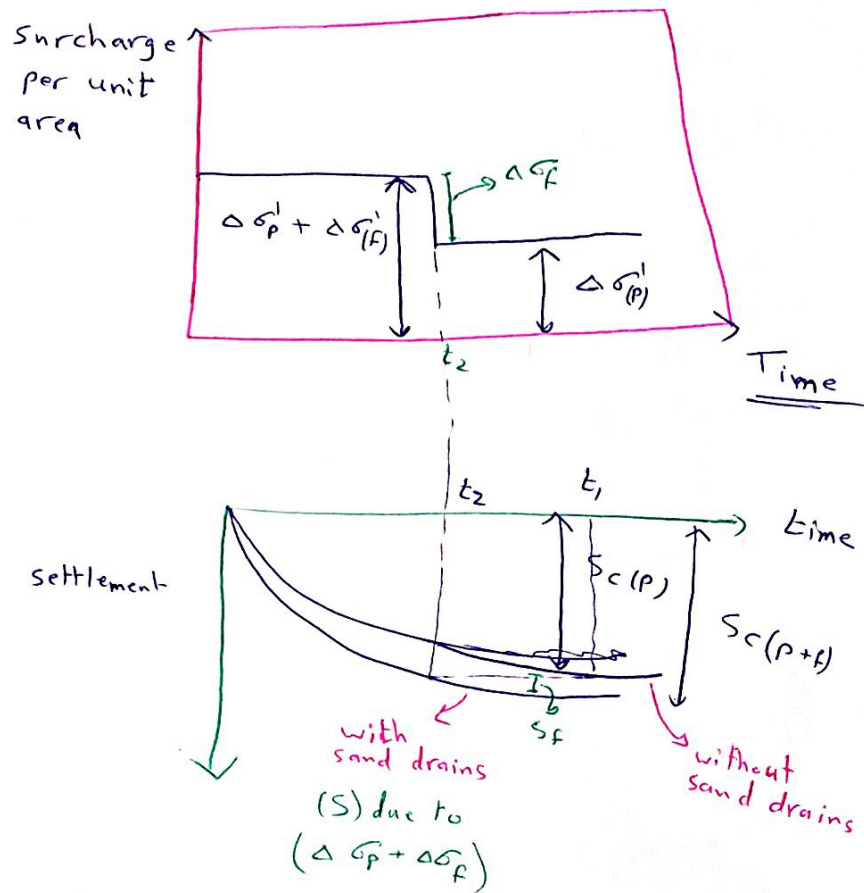
huge settlement هون بصرى عيسى

(sheet piles) لاجل

Settlement ← بخفف من ال

* طیب کرا کنا محکومین بالوقت ~~و بتدریج~~ بشو نعل ۱؟

(بجز آبار و بتبیه sand عشان یسرع Consolidation) بنسرخ ال



$\Delta \sigma'_p \Rightarrow$ permanent

$\Delta \sigma'_f \Rightarrow$ fill

$$S_p = \frac{C_c}{1+e_0} H_c \log \frac{\sigma'_0 + \Delta \sigma'_p}{\sigma'_0} \rightarrow \text{for permanent load}$$

$$S_{(p+f)} = \frac{C_c}{1+e_0} H_c \log \frac{\sigma'_0 + \Delta \sigma'_p + \Delta \sigma'_f}{\sigma'_0} \rightarrow \text{temporary and permanent load}$$

Note:- S_p will occur in a time $t_2 \ll S_{(p+f)}$
at this time t_2 remove surcharge and build $\Delta \sigma'_p$

$$S_p = \frac{C_c}{1+e_0} H_c \log \frac{\sigma'_0 + \Delta \sigma'_p}{\sigma'_0}$$

$$S_{p+f} = \frac{C_c}{1+e_0} H_c \log \frac{\sigma'_0 + \Delta \sigma'_p + \Delta \sigma'_f}{\sigma'_0}$$

قسمنا هم
على بعض

الناتج
أعطانا

degree of consolidation

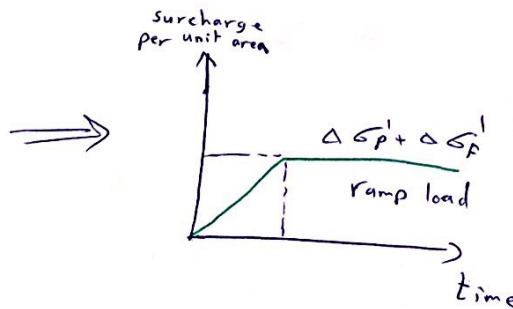
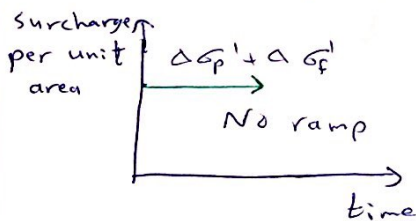
$$U_{(p+f)} = \frac{S_p}{S_{(p+f)}}$$

$$= \frac{\log \frac{\sigma'_0 + \Delta \sigma'_p}{\sigma'_0}}{\log \frac{\sigma'_0 + \Delta \sigma'_p + \Delta \sigma'_f}{\sigma'_0}}$$

$$U_{(p+f)} = \frac{\log \left(1 + \frac{\Delta \sigma'_p}{\sigma'_0} \right)}{\log \left(1 + \frac{\Delta \sigma'_p}{\sigma'_0} \left(1 + \frac{\Delta \sigma'_f}{\Delta \sigma'_p} \right) \right)}$$

See first graph, figure

* Preloading and ramp load:-



↓
إذا كان عني
المقدار ثابت
No ramp

(5)

Example :-

During the construction of highway ~~bridge~~ bridge, the average permanent load on the clay layer is expected to increase by about 115 kPa. The average effective overburden pressure at the middle of the clay layer is 210 kPa. Here, $H_c = 6\text{m}$, $C_c = 0.28$, $e_0 = 0.9$ and $C_v = 0.36 \text{ m}^2/\text{month}$. The clay is normally consolidated.

Determine :-

- 1) The total primary consolidation settlement of the bridge without precompression.
- 2) The surcharge, needed to eliminate the entire primary consolidation settlement in nine months by precompression.

$$1) S_p = \frac{C_c H_c}{1 + e_0} \log \left(\frac{\sigma'_0 + \Delta \sigma_p}{\sigma'_0} \right)$$

$$= \frac{0.28 (6)}{1 + 0.9} \log \left(\frac{210 + 115}{210} \right)$$

$$= 0.1677 \text{ m} \rightarrow$$

بالنسبة لبناء جسر
الرقم كثير كبير
و لازم أقلله .

$$2) T_v = \frac{C_v t^2}{H_{dr}^2} = \frac{\left(0.36 \frac{\text{m}^2}{\text{month}} \right) (9)^2}{\left(\frac{6}{2} \right)^2} = 0.36$$

$$T_v = 0.36 \rightarrow \text{Fig (2)} \Rightarrow U = 0.4$$

⑥

$$\frac{\Delta \sigma_p'}{\sigma_s'} = \frac{115}{210} = 0.548 \approx 0.55$$

From figure:-

$$\frac{\Delta \sigma_f}{\Delta \sigma_p} = 2.5 \Rightarrow \Delta \sigma_f = 2.5 \times 115 = 287.5 \text{ kPa}$$

let us assume $\gamma_{fill} = 20 \text{ kN/m}^3$

$$\Delta \sigma_{fill} = 287.5 = \gamma_{fill} H_{fill}$$

$$H_{fill} = 14.3525 \text{ m}$$

بحتاج آنزل
(14 م) عثمان

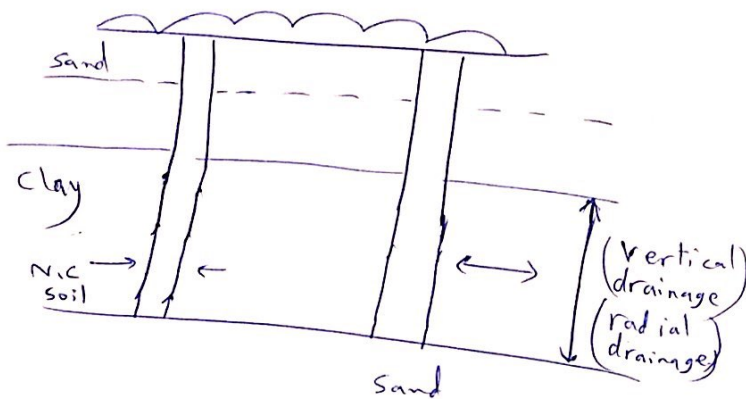
Settlement من اخلص

احتاجت هاي الطريقة (9) مشهور والوقت هاد كثير

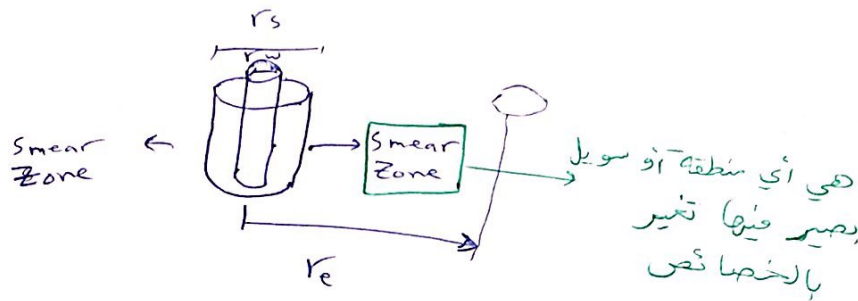
كبير عثمان هين بنلجا لد

Sand Drains

Sand drains and Preloading :-



fill $\equiv$ surcharge



average degree of consolidation due to drainage in both directions
(i.e : vertical Radial)

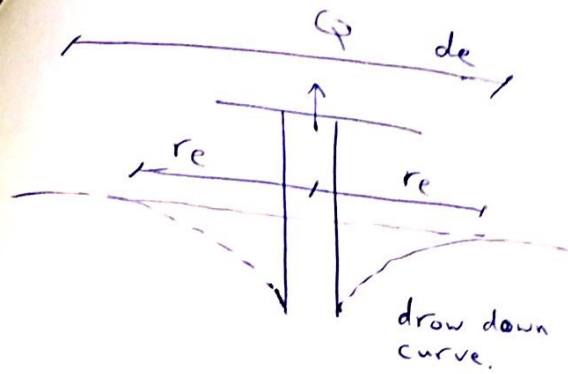
$$U_{v,r} = 1 - (1 - U_r) (1 - U_v)$$

U_r : Radial degree of consolidation (avg)

U_v : vertical degree of consolidation (avg)

$r_e = \frac{d_e}{2}$ = radius of effective zone of drainage

- The surcharge will increase the pore water pressure in the clay.
- The excess pore water pressure in the clay will be dissipated by drainage - both vertically and radially to the sand drains thereby accelerating settlement of the clay layer.



* r_w = radius of sand drains

* $U_r = 1 - e^{-\frac{8\pi r}{m}}$

* $m = \frac{n^2}{n^2 - s^2} \ln\left(\frac{n}{s}\right) - \frac{3}{4} + \frac{s^2}{4n^2} + \frac{k_h}{k_s} \left(\frac{n^2 - s^2}{n^2} \right) \ln s$

* $n = \frac{r_e}{r_w} = \frac{d_e/2}{r_w}$

* $s = \frac{r_s}{r_w}$

k_h = Hydraulic gradient of clay in horizontal direction

k_s = Horizontal Hydraulic gradient smear zone

T_v = non dimensionless time factor for radial drainage

$$= \frac{C_{vr} t_2}{d_e^2}$$

C_{vr} = coefficient of consolidation in radial direction of drainage

$$C_{vr} = \frac{k_h}{\left[\frac{\Delta e}{\Delta \sigma' (1 + e_{av})} \right] \gamma_w}$$

if NO - Smear zone (Ideal case):-

$r_s = r_w$

$k_h = k_s$

and

$$m = \left(\frac{n^2}{n^2 - 1} \right) \ln(n) - \frac{3n^2 - 1}{4n^2}$$

$s = 1$

(9)

Avg Degree of consolidation (vertical) :-



$$T_v = \frac{\pi}{4} \left[\frac{U_v \%}{100\%} \right]^2 \quad \text{for } (U_v = 0 \text{ to } 60\%)$$

$$T_v = 1.781 - 0.933 \log[100 - U_v \%] \quad \text{for } (U_v > 60\%)$$

U_v = average degree of consolidation due to vertical drainage

$$T_v = \frac{C_v t^2}{H^2}$$

C_v = Coefficient of consolidation for vertical drainage.

for the case of ramp loading, the variation of U_v with T_r can be expressed as :-

$$\left. \begin{aligned} T_v \leq T_c & \quad U_v = \frac{T_v}{T_c} \left\{ 1 - \frac{2}{T_v} \sum \frac{1}{m^4} [1 - \exp(-m^2 T_v)] \right\} \\ T_v \geq T_c & \quad U_v = 1 - \frac{2}{T_c} \sum \frac{1}{m^4} [e^{-m^2 T_c} - 1] e^{-m^2 T_v} \end{aligned} \right\}$$

$$M = \frac{\pi}{2} (2m' + 1)$$

$$m' = 0, 1, 2, \dots$$

$$T_c = \frac{C_v t_c}{H^2}$$

زسحل
طريقة تدخل
المعطيات
والمعادلة زي ما هي
على الآلة الحاسبة

other wise

$$U_v = \sqrt{\frac{4 T_v}{\pi}} \quad 0 < T_v \leq 0.197$$

$$U_v = 1 - \frac{8}{\pi^2} e^{-\frac{\pi^2 T_v}{4}}$$

if the surcharge is applied in the form of a ramp and there is no smear :-

$$U_r = \frac{T_r - \frac{1}{A} (1 - e^{-A T_v})}{T_{rc}} \quad \text{for } (T_r \leq T_{rc})$$

$$U_r = 1 - \frac{1}{A T_{rc}} (e^{A T_{rc}} - 1) e^{-A T_r} \quad \text{for } (T_r \geq T_{rc})$$

(10)

$$T_{rc} = \frac{C_v t_c}{d_e^2}$$

$$A = \frac{2}{m}$$

$$m = \left(\frac{n^2}{n^2 - 1} \right) \ln(n) - \frac{3n^2 - 1}{4n^2}$$

Example:-

Redo last example but:-

determine the surcharge required to estimate the entire primary consolidation settlement ~~at~~ within 9 month if we use a fine sand drains with precompression

if $r_w = 0.1 \text{ m}$, $d_e = 3 \text{ m}$

and let $C_v = C_{vr} = C_r = 0.36 \text{ m}^2/\text{month}$
assume No smear Zone

Solution:-

vertical:-

$$T_v = 0.36 > 0.197$$

حساباً من حل المثال السابق

$$U_v = 1 - \frac{8}{\pi^2} e^{-\frac{\pi^2 T_v}{4}}$$

$$= 1 - \frac{8}{\pi^2} e^{-\frac{\pi^2 (0.36)}{4}}$$

$$= 0.667$$

$$n = \frac{r_e}{r_w} = \frac{(d_e/2)}{r_w} = \frac{3/2}{0.1} = \underline{\underline{15}}$$

$$T_r = \frac{C_{vr} t_2}{d_e^2} = \frac{0.36 (9)}{3^2} = 0.36$$

$$U_r = 1 - e^{-2 T_r / m}$$

$$m = \left(\frac{n^2}{n^2 - 1} \right) \ln(n) - \frac{3n^2 - 1}{4n^2}$$

$$= \frac{15^2}{15^2 - 1} \ln(15) - \frac{3(15)^2 - 1}{4 \times (15)^2} = 1.971$$

$$U_r = 1 - e^{-\frac{2(0.36)}{1.971}}$$

$$= 0.76799 \equiv 77\%$$

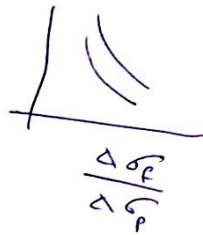
⑪

$$\begin{aligned}
 U_{v,r} &= 1 - (1 - U_r)(1 - U_v) \\
 &= 1 - (1 - 0.667)(1 - 0.76799) \\
 &= 0.9227 \approx 0.923
 \end{aligned}$$

fig $\left(\frac{\Delta \sigma_p}{\sigma'_1} = 0.548 \right)$

$$U_{v,r} = 0.923 \quad \leftarrow \quad \frac{\Delta \sigma_f}{\Delta \sigma_p} = 0.12$$

$$\begin{aligned}
 \Delta \sigma_f &= 0.12 \times 115 \\
 &= 13.8 \text{ kPa}
 \end{aligned}$$

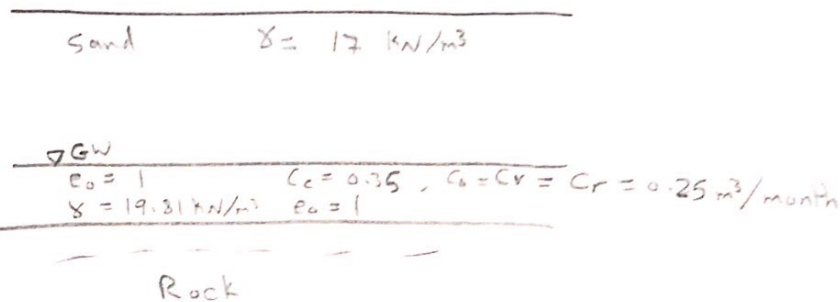


Sand Drains and Precompression

- * The use of sand drains is another way to accelerate the consolidation settlement of soft, normally consolidated clay layers and achieve Precompression before the construction of a desired foundation
- * Sand drains are constructed by drilling holes through the clay layer(s) in the field at regular intervals
- * The holes are then backfilled with sand. This can be achieved by several means, such as:
 - 1) rotary drilling and then backfilling with sand
 - 2) drilling by continuous-flight auger with a hollow stem and backfilling with sand (through the hollow stem)
 - 3) driving hollow steel piles. The soil inside the pile is then jetted out. After which backfilling with sand is done.
- * After backfilling the drill holes with sand, a surcharge is applied at the ground surface.

Example:-

A (2m) Fill layer with $\gamma_{fill} = 18 \text{ kN/m}^3$ was placed above NC clay layer to eliminate the primary Consolidation settlement with a sand drains of 15cm in radius. The total settlement was within (6) months. Determine the spacing of sand drains if the permanent load is 100 kPa.



Solution:-

$$\Delta \sigma_f = \gamma_{fill} H_{fill}$$

$$= (18)(2) = 36 \text{ kPa}$$

$$\sigma'_0 = \sum \gamma' z = (17 \times 4) + (4 \times 19.81 - 9.81)$$

$$= 108 \text{ kPa}$$

$$\frac{\Delta \sigma'_f}{\Delta \sigma'_p} = \frac{36}{100} = 0.36$$

$$\frac{\Delta \sigma'_p}{\Delta \sigma'_0} = \frac{100}{108} = 0.926$$

From figure

$$U_v = 83\%$$

$$(0.197) U_v$$

$$U_{v,r} = 1 - (1 - U_v)(1 - U_r)$$

$$0.83 = 1 - (1 - U_v)(1 - U_r)$$

$$0.83 = 1 - (1 - 0.1727)(1 - U_r)$$

$$U_r = 0.2054 \approx 0.21$$

$$T_v = \frac{C_v t_2}{H^2} = \frac{0.25 \times 6}{8^2} = 0.0234$$

$$U_v = \sqrt{\frac{4T}{\pi}} = \sqrt{\frac{4 \times 0.0234}{\pi}} = 0.1727$$

$$U_r = 1 - e^{-\frac{8T_r}{m}} \Rightarrow \frac{T_r}{m} = 0.2946$$

$$T_r = \frac{C_v t^2}{d_e^2} = \frac{C_v t^2}{(2r_e)^2} = \frac{0.25 \times 6}{4(r_e)^2} = \frac{0.375}{r_e^2}$$

* let us assume that No smear zone:-

$$m = \frac{n^2}{n^2 - 1} \ln(n) - \frac{3n^2 - 1}{4n^2}$$

$$\frac{12.724}{r_e^2} = \frac{\left(\frac{r_e}{0.15}\right)^2}{\left(\frac{r_e}{0.15}\right)^2 - 1} \ln\left(\frac{r_e}{0.15}\right) - \frac{3 \times \left(\frac{r_e}{0.15}\right)^2 - 1}{\left(\frac{r_e}{0.15}\right)^2}$$

$$\boxed{\begin{aligned} r_e &= 2.48 \text{ m} \\ d_e &= 4.96 \text{ m} \end{aligned}}$$

(Prefabricated vertical Drains)

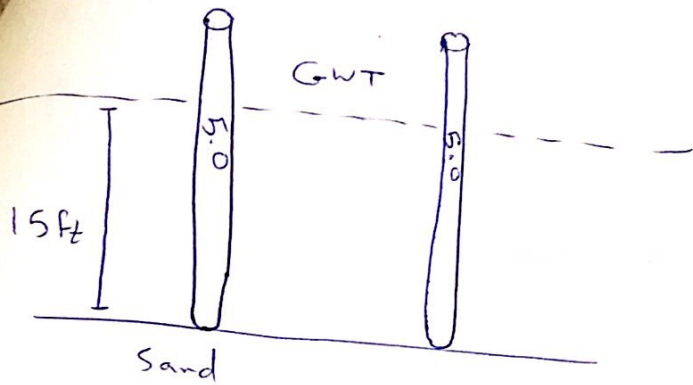
* أكثر المشاكل التي ينبغي منها لما تكون التربة (sand)، أنها
يمكن تحوي على (smear zone)

الحل لهذه المشكلة! أنه نستعمل (Prefabricated vertical drains) يكون على شكل

Square triangle



Example :-



$$C_l = 0.31$$

$$e_0 = 1.1$$

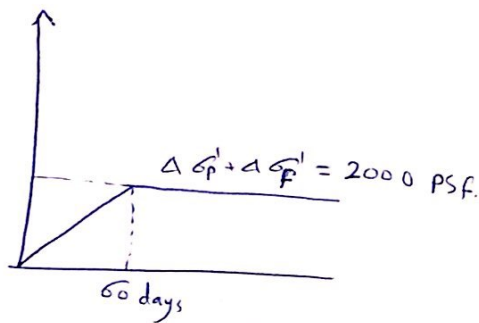
$$\sigma'_0 = 1000 \text{ PSF}$$

$$C_v = 0.115 \text{ ft}^2/\text{day}$$

for sand drains

$$m_w = 0.3'$$

$$C_v = C_{vr}$$



① Determine the degree of consolidation 30 days after beginning of the surcharge application.

② Consolidation settlement at that time due to the surcharge.

Solution:-

$$T_c = \frac{C_v t_c}{H^2}$$

$$= \frac{(0.115)(60)}{\left(\frac{15}{2}\right)^2} = 0.123$$

$$T_v = \frac{C_v (t_2) \rightarrow \text{time required}}{H^2}$$

$$= \frac{(0.115)(30)}{\left(\frac{15}{2}\right)^2} = 0.0615$$

Using figure T_c and T_v :

$$U_v = 0.05$$

$$n = \frac{de}{2r_w} = \frac{rc}{r_w} = \frac{612}{0.3} = 10$$

$$T_{rc} = \frac{C_{vr} t_c}{d_e^2} = \frac{0.115 (60)}{6^2} = 0.192$$

$$T_r = \frac{C_{vr} t_2}{d_e^2} = \frac{0.115 \times 30}{6^2} = 0.096$$

$$\boxed{T_{rc} > T_r} \rightarrow \text{Then:}$$

$$U_r = \frac{T_r - \frac{1}{A} [1 - e^{-AT_r}]}{T_{rc}}$$

$$m = \left(\frac{n^2}{n^2 - 1} \right) - \left(\ln(n) \frac{3n^2 - 1}{4n^2} \right) = 1.572$$

$$A = \frac{2}{m} = \frac{2}{1.572} = 1.267$$

$$U_r = \frac{0.096 - \frac{1}{1.267} [1 - e^{-1.267 \times 0.096}]}{0.192} = 3\%$$

$$U_{vr} = (1 - 0.05 (1 - 0.03)) = 0.075$$

$$S_t = U_{vr}(SP)$$

$$\begin{aligned} SP &= \frac{C_c}{1 + e_u} H \log \frac{\sigma'_0 - \sigma'_p}{\sigma'_1} \\ &= \frac{0.3 \times 15}{1 + 1.1} \times \log \frac{2000 + 1000}{1000} = 1.056 \end{aligned}$$

$$S_t = 0.078 \times 1.056 = 0.082 \times 12 = 0.99'$$

(16)

Prefabricated vertical drains (PVDs), also referred to as ~~wick~~ wick or strip drains, were originally developed as a substitute for the commonly used sand drains

* drain manufactured from synthetic polymers

- polypropylene
- high-density polyethylene

* PVDs are normally manufactured with a corrugated or channelled synthetic core enclosed by geotextile

مسائل (3, 4, 5, 6, 7) فيهم شوية حتى - سوفهم

خطوات الحل لهذه الطريقة :-

① إيجاد قيمة (t_2) عن طريق (T_v) و إيجاد $(U_{v,r})$

قانون آخر

$$U_r = 1 - \exp\left(\left(\frac{-8c_v t}{d_w^2}\right)\left(\frac{d_w^2}{d_{eq}^2}\right)\right) \leftarrow U_r = 1 - \frac{1 - U_{v,r}}{1 - U_v}$$

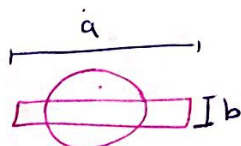
$$= 1 - \exp\left(\frac{-8T_v}{\alpha^2}\right)$$

$$d_e = 2re$$

② إيجاد (U_v) عند (t_2)

③ إيجاد d_w (effective radius)

$$d_w = \frac{2(a+b)}{\pi}$$



(٦) إيجاد $(T_r')_1$

$$(T_r')_1 = \frac{T_r'}{\alpha'} = \ln\left(\frac{1-U_r}{2}\right)$$

(٧) إيجاد T_r'

$$T_r' = \frac{\alpha'}{2} \ln(1-U_r)$$

or

$$T_r' = \frac{C_{rr} t}{d^2 w}$$

(٨) إيجاد α'

$$\alpha' = \frac{T_r'}{(T_r')_1}$$

(or)

$$\alpha' = n^2 m$$

$$= \frac{n^4}{n^2 - s^2} \ln\left(\frac{n}{s}\right) - \left(\frac{3n^2 - s^2}{4}\right) + \frac{k_h}{k_s} (n^2 - s^2) \ln s$$

$$n = \frac{de}{dw}$$

$$de = 2re$$

(٩) إيجاد قيمة $\left[\frac{de}{dw} = (n)\right]$ ← ممكن نطلعها من الرسومات البيانية بوجود α'

(١٠) إيجاد قيمة $de = n dw$

(٩) $d = \frac{de}{1.128}$ ← للمربع

(١٠) $d = \frac{de}{1.05}$ ← للمثلث

(١٨)

الجدول والرسمة إذا كانوا موجودين راح يسهلوا الحل كثير

Example :-

$$\text{Let } \Delta \sigma_p' = 115 \text{ kPa}$$

$$\Delta \sigma_{fill}' = 115 \text{ kPa}$$

$$\sigma_o' = 230 \text{ kPa}$$

$$H_c = G_m \text{ two way}$$

$$C_c = 0.22$$

$$C_v = 0.36 \text{ m}^2/\text{month}$$

assume in triangular pattern

$$\text{Let } \frac{k_h}{k_s} = 5 \quad \text{and } S = 2$$

$$t_2 = 9 \text{ months}$$

Solution :-

$$T_v = \frac{C_v t_2}{H_{dr}^2} = \frac{0.36 \times 9}{3^2} = 0.36$$

$$\frac{\Delta \sigma_p'}{\sigma_o'} = \frac{115}{230} = 0.5$$

$$\Delta \sigma_f' = \frac{115}{115} = 1$$

$$U = U_{v,r} = 0.62$$

$$\text{from } T_u \rightarrow U = 0.4$$

$$U_r = 1 - \frac{1 - U_{v,r}}{1 - U_v} = 1 - \left(\frac{1 - 0.62}{1 - 0.4} \right) = 0.36\%$$

$$d_w = \frac{2(a+b)}{\pi} = \frac{2(100+5)}{\pi} = 66.84 \text{ mm}$$

$$(T_r')_1 = - \frac{\ln(1 - U_r)}{8} = 0.05 \times 16$$

$$(T_r)' = \frac{C_v r^2}{d_w^2} = \frac{0.36 \times 9}{(66.84 \times 10^{-3})^2} = 725.22$$

$$\alpha' = \frac{T_r'}{(T_r')_1} = \frac{725.22}{0.05716} = 12687.54$$

(19)

Figure α' , n and (T_r) vs U_r

$$n = 52 \quad de = ndw \\ = 52 \times 66.84 \times 10^{-3} = 3.47 \text{ m}$$

$$d = \frac{de}{1.05} = \frac{3.47}{1.05} = 3.3 \text{ m} = 10'$$

