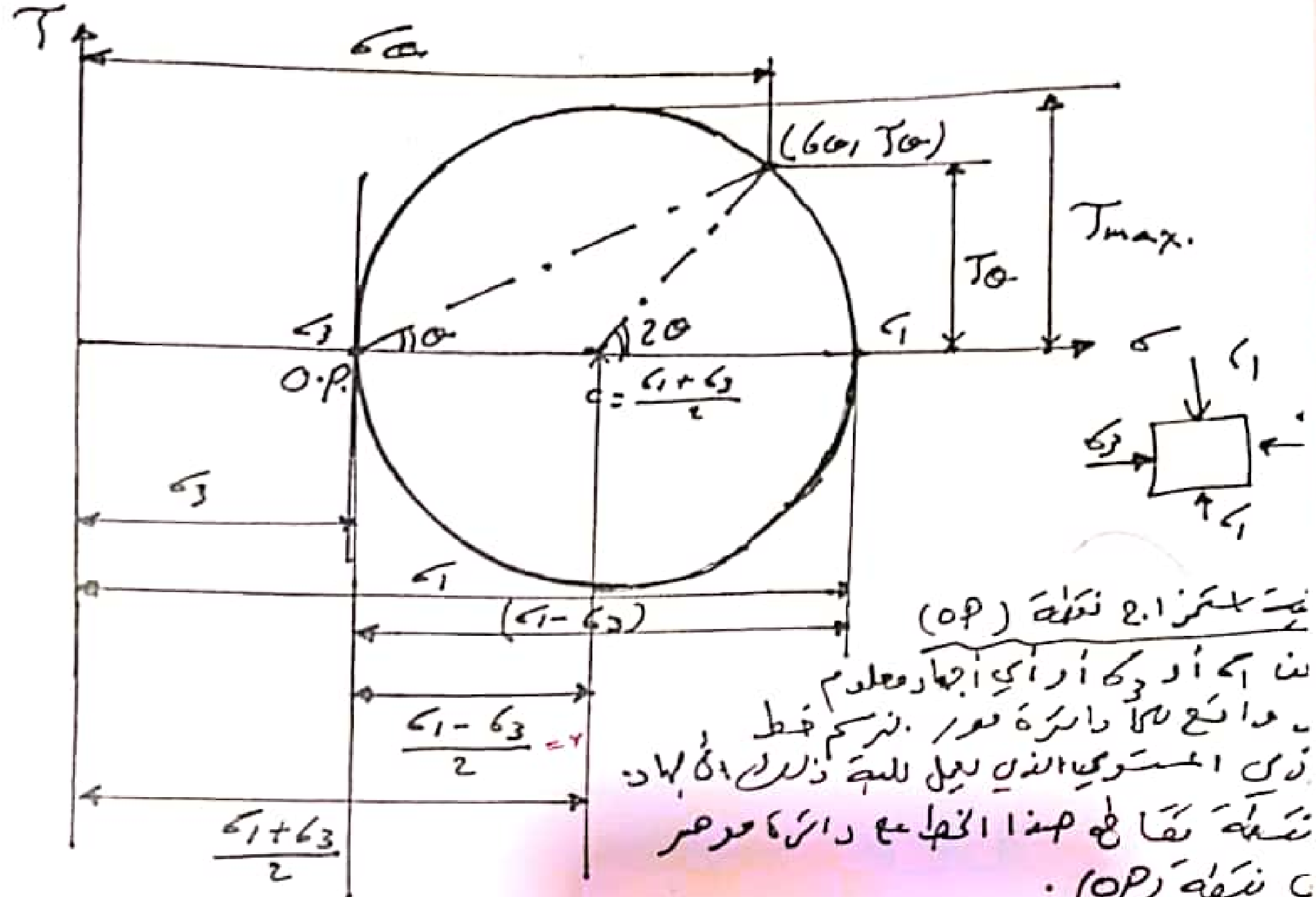
Mohr Circle:-

LEC 14
7/3/2016



يستخدم نقطة (OP)
نا σ_1 أو σ_3 أو أي إجهاد معلوم
هو التي تقع على دائرة مور. نرسم خط
يوازي المستوى الذي يعمل عليه ذلك الإجهاد
نقطة تقاطع هذا الخط مع دائرة مور هي
نقطة (OP).
من نقطة (OP) نرسم خط يوازي
الفشل أو أي مستوى
نقطة تقاطع هذا
مع دائرة مور هي
الإجهادات التي
على ذلك المستوى
مقدارا وإتجاها.

From the Graphical of Mohr circle:.

σ_1 = The major principle stresses at $\tau = 0$

σ_3 = minor principle stresses at $\tau = 0$

$\left(\frac{\sigma_1-\sigma_3}{2}\right)$ = radius of Mohr circle = τ_{max}.

$\left(\frac{\sigma_1+\sigma_3}{2}\right)$ = center of Mohr circle.

$\sigma_1 - \sigma_3$ = deviator stress = σ_d. (الإجهادات المرفوعة)

origin of plane "op":-

Is a point on Mohr circle with the following property. A l.. through "op" and any point (like A) of the Mohr circl.. will be parallel to the plane on which the stresses given by (A) act.

Dr. h...

Scanned by CamScanner

EX1:- For the element shown, find the stresses on the p
A-A by using Mhor circle.

Sol:- since $\tau = 0$ so, the stresses given is principle stres

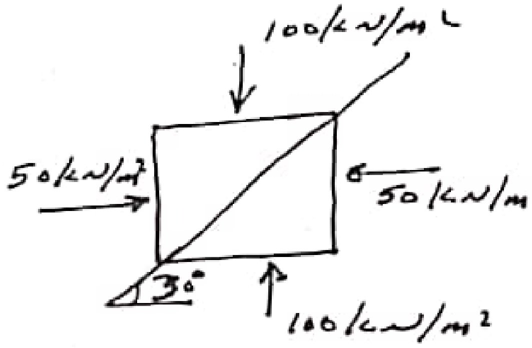
$\sigma_1 = 100\ kN/m^2$

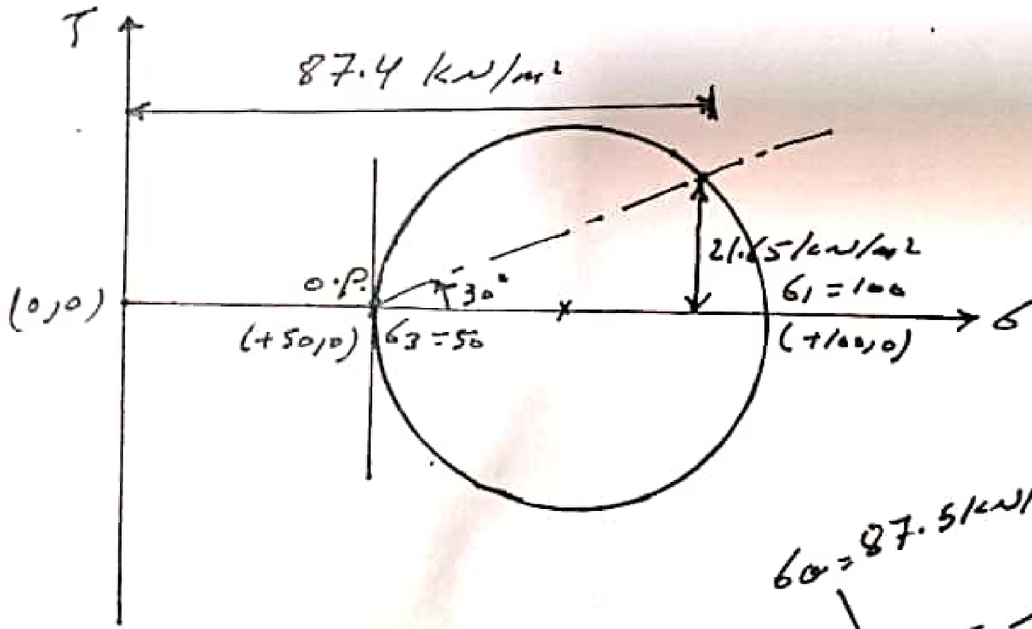
$\sigma_3 = 50\ kN/m^2$ and $\theta = 30^\circ$

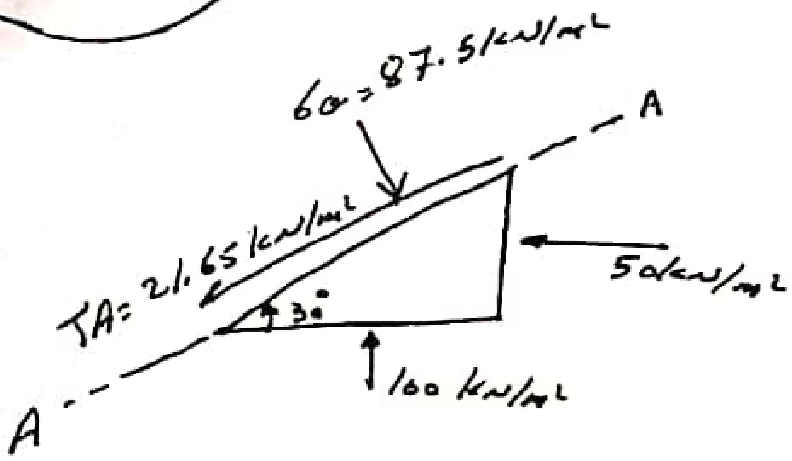
From the drawing of Mohr circle.

$\sigma_\theta = 87.4\ kN/m^2$

$\tau_\theta = 21.65\ kN/m^2$







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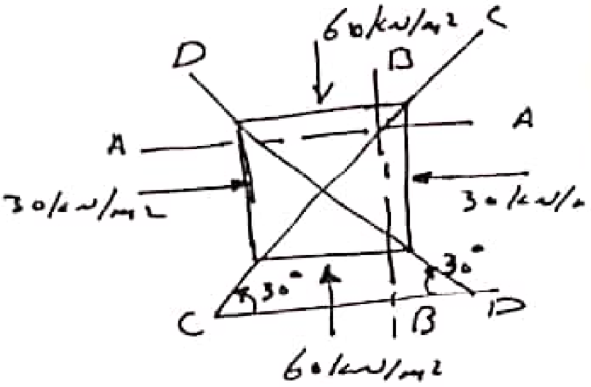
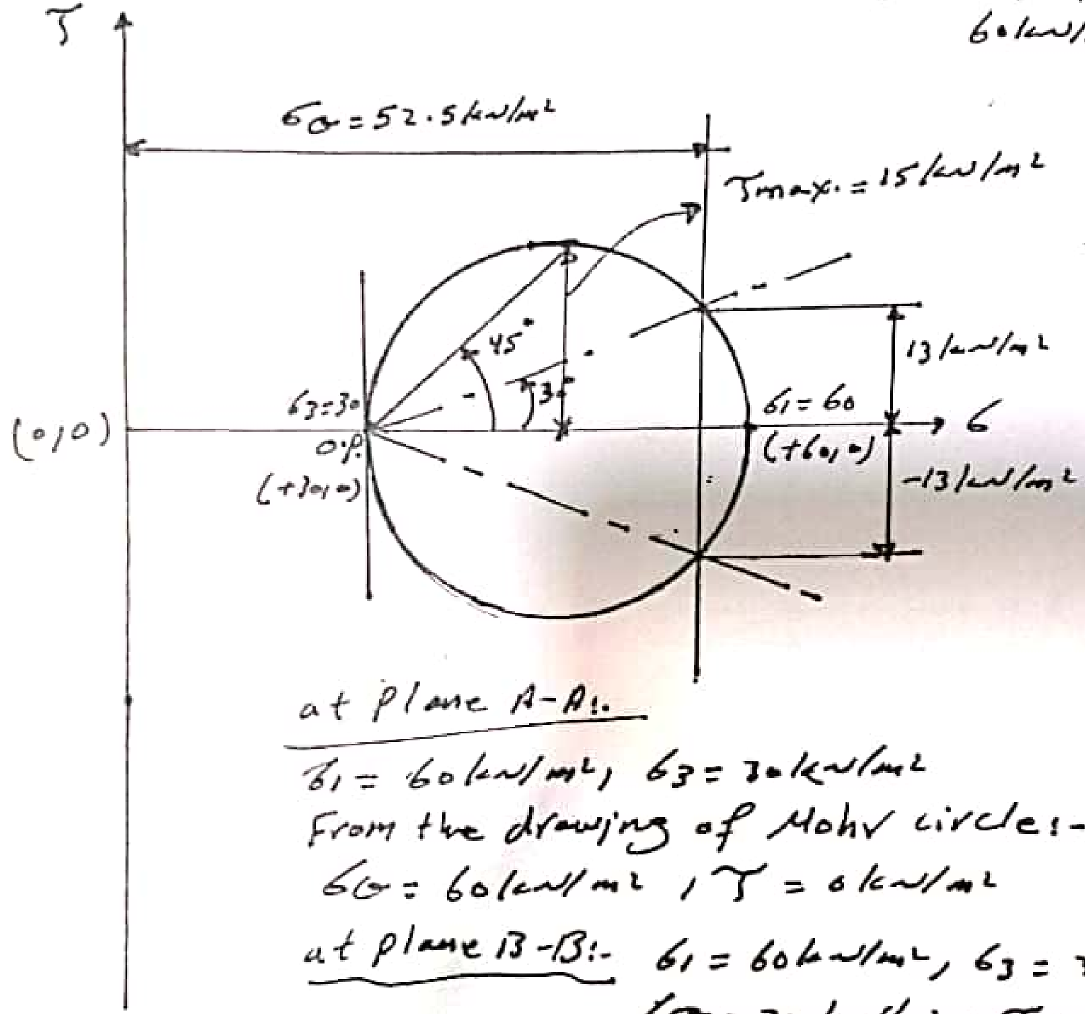
Ex2:- For the element shown, find the stresses on the planes A-A, B-B, C-C, D-D



sol:-

since $\tau = 0$ so the stresses given is principle stresses at all planes



at plane A-A:-

$\sigma_1 = 60\ kN/m^2$, $\sigma_3 = 30\ kN/m^2$

From the drawing of Mohr circle:-

$\sigma_\theta = 60\ kN/m^2$, $\tau = 0\ kN/m^2$

at plane B-B:- $\sigma_1 = 60\ kN/m^2$, $\sigma_3 = 30\ kN/m^2$

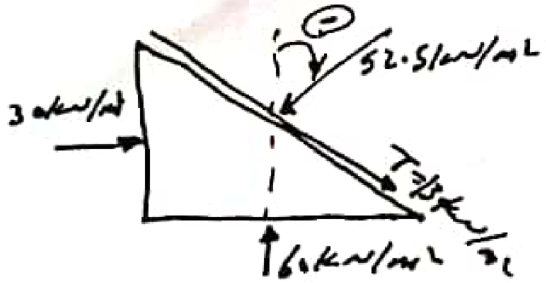
$\sigma_\theta = 30\ kN/m^2$, $\tau = 0\ kN/m^2$

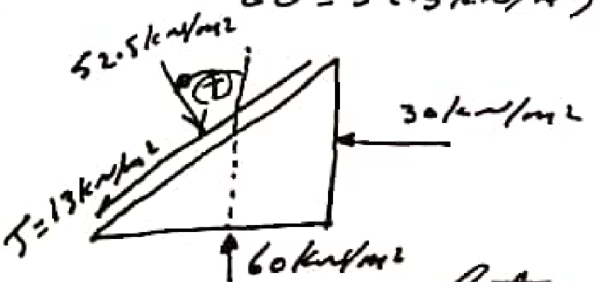
at plane C-C:- $\sigma_1 = 60\ kN/m^2$, $\sigma_3 = 30\ kN/m^2$

$\sigma_\theta = 52.5\ kN/m^2$, $\tau = 13\ kN/m^2$

at plane D-D:- $\sigma_1 = 60\ kN/m^2$, $\sigma_3 = 30\ kN/m^2$

$\sigma_\theta = 52.5\ kN/m^2$, $\tau = -13\ kN/m^2$





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$u = u_s + u_{e_0}$ $(u_{e_0} = \Delta\sigma)$, $\Delta\sigma = \Delta\bar{\sigma} + \Delta u$

In this stage: $\Delta u = u_{e_0} = \Delta\sigma$ —— $\Delta\bar{\sigma} = \text{Zero}$.

And (it's very short stage).

<u>stage (2):-</u>

Drainage stage:- as water flows out of soil forced the hydraulic gradient caused by increase in P.w.P. The excess in (P.w.P.) (u_e) will gradually decreased. The effective stress will increased simultaneously and the soil volume will decreased due to Particles movement clo together.

Here, at any time this stage $u = u_s + u_e$, $(0 < u_e < u_{e_0})$ and $\Delta\sigma > \Delta\bar{\sigma} > 0$, $\Delta\sigma = \Delta\bar{\sigma} + \Delta u$ $(\Delta u = u_e)$.

this stage is very long stage.

the Process of gradual reduction of excess Pore wate Pressure with time is called (dissipation of excess P.

<u>stage (3)</u> :-

Drained condition:- the of soil when the excess pore wa pressure has been dissipated completely $(u_e = 0)$.

in this case $\Delta\sigma = \Delta\bar{\sigma}$

this condition lasts forever provided that no change in total stress or location of ground water table take pla this Process is called (consolidation in soil) when soi particles movement occurs in one direction only it's called (one dimensioned consolidation)..

$\Delta\sigma$	Δu	$\Delta\bar{\sigma}$	Time
10	10	0	t_0
10	8	2	$t_1 > 0$
10	6	4	$t_2 > t_1$
After many times	⋮	⋮	⋮
10	0	10	$t = \infty$

$\sigma = \bar{\sigma} + u \longrightarrow \Delta\sigma = \Delta\bar{\sigma} + \Delta u$

when the total stress (σ) on saturated soil is chan (increased) by a certain value $\Delta\sigma$. The soil will pas three distinguished stages.

① befor (σ) is changed, the pore water pressure at point is equal to the static pressure (u_s) which is gove by the location of ground water table ($u = u_s$).

② after loading (application of $\Delta\sigma$), the p.w.p will no m be equal to the static value. There ($u = u_s + u_e$).

u_e = excess pore water pressure is the increase in p.w above the static value.

stage (1):-

At the instant of total stress increase (at time = t_0) all change in total stress will be carried by water as an increase in pressure above the static value. this mean that at this time ($u_e = \Delta\sigma = u_{e_0}$ = intial excess pore wat pressure).

in this stage soil is said to be in the undrained conditio

undrained condition:- the condition of saturated so when a stress increment ($\Delta\sigma$) is carried completely by water as an increase in pressure called initial excess pore water pressure (u_{e_0}) (no dissipation of water pressu has take place)

Response of Effective stress to change in Total stress:

suppose a surface surcharge ($q = \Delta\sigma$) is placed on the surface of laterally confined soil. (q) is infinity extend surface load applied instantaneously (the time durati for load increase = Zero).

⊗ Before loading (initially $u = u_s$).

⊗ immediately after loading at time $= t_o$ soil partic try to move closer together. But the water filling the voids resist this movement as result. the pressure water will increase above the static pressure (u_s) the increase in P.W.P. above the static value called excess pore water pressure (u_e).

At time $= t_o$ the excess in pore water pressure is at this time called (initial excess) (P.W.P (u_{e_o})). ($u_{e_o} = \Delta\sigma = q$) hence $\Delta\bar{\sigma} = 0$.

As time proceeds — water escapes out of soil po. — pressure in water decrease — soil particles now can move close together — interparticles forces increa — effective stresses increase.

⊗ Before loading ($u = u_s$)

at time $= t_o$ $\quad u = u_s + u_{e_o} = u_s + \Delta\sigma \quad$ so, ($u_{e_o} = \Delta$

$$u = u_s + u_e \quad (0 < u_e < u_{e_o}).$$

⊗ after long time the excess P.w.P will become Zero and so the P.w.P will be equal to the static pressure again $u = u_s$ (after very long time). At this time water movement stops and particles movement stop too and the increase in total stress ($\Delta\sigma$) will be carri by the mineral skelton entirely, as an increase in effec stress ($\Delta\bar{\sigma}$).

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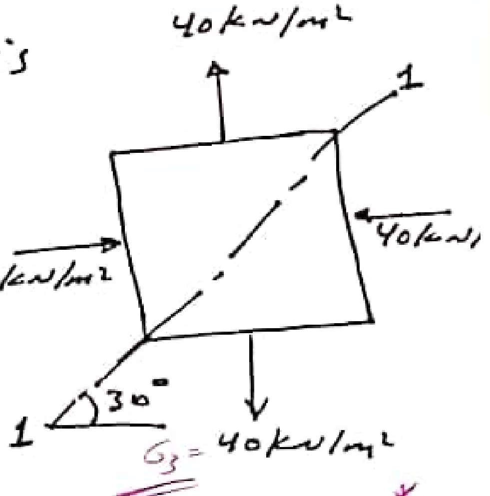
Ex3:- For the element shown, find the normal and shear stresses on the plane 1-1 ?

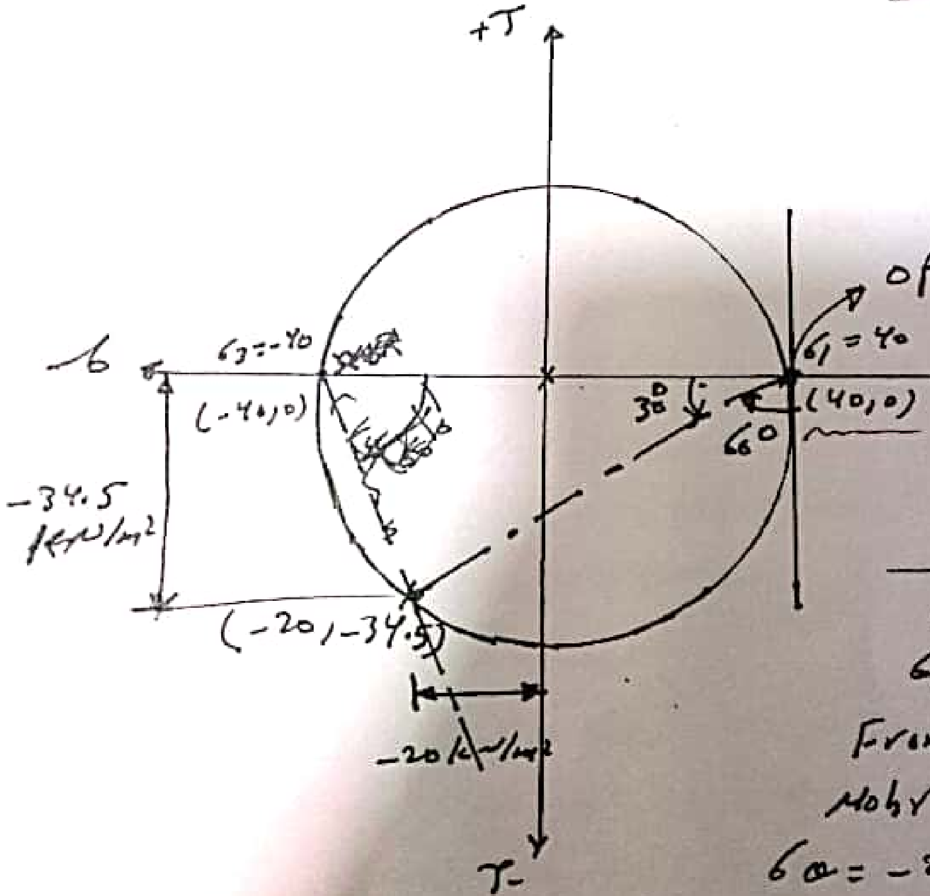


sol:- Since $\tau = 0$ so the stresses given is principle stresses

$\sigma_1 = 40\ kN/m^2$

$\sigma_3 = -40\ kN/m^2$

$\theta = -60°$



at Plane 1-1

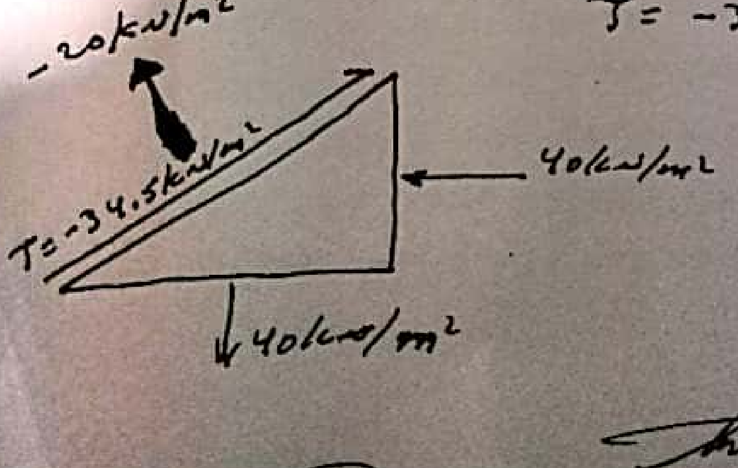
$\sigma_1 = 40\ kN/m^2$

$\sigma_3 = -40\ kN/m^2$

From the drawing of Mohr circle:-

$\sigma_\theta = -20\ kN/m^2$

$\tau = -34.5\ kN/m^2$



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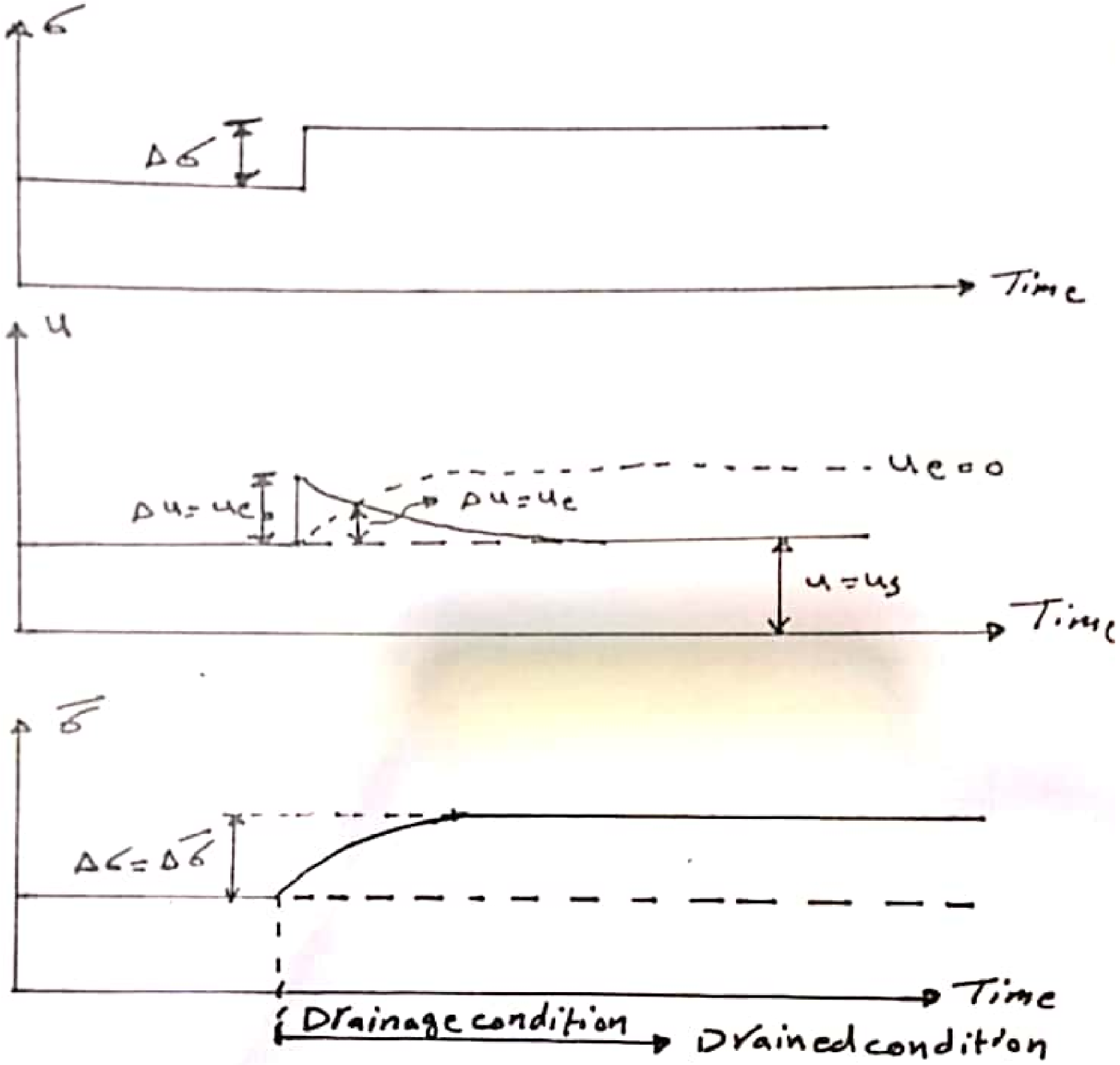
Consolidation :-

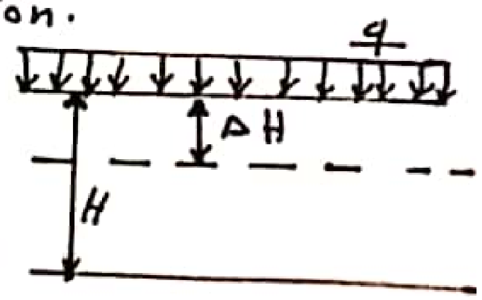
The Process of gradual squeezing of water out of accompanied by reduction in soil volume and increase of effective stress under an increase in total stress.



Time required to accomplish any percent of consolidation Process depends on the following factors:-

① Time increases with increasing the volume of water which mu be expelled out of soil during consolidation.

$t \propto$ volume of water



volume of water $= m * \Delta\sigma * H$

where: m = soil compressibility

$\Delta\sigma$ = change (increase in total stress).

H = thickness of consolidated layer.

$t \propto m * \Delta\sigma * H$.

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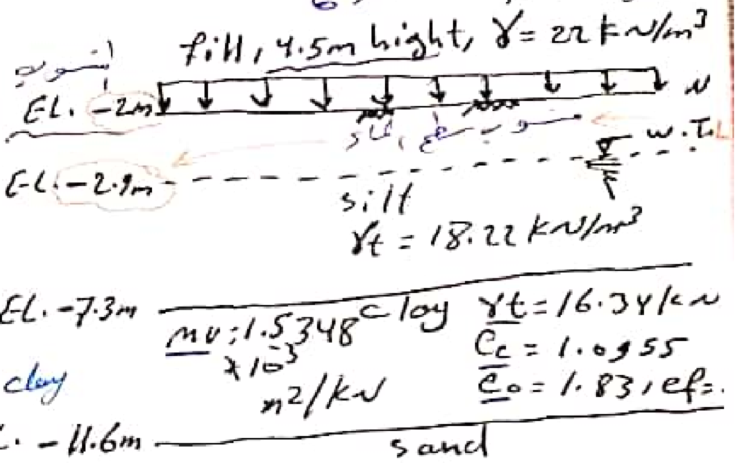
Example:- For soil profile shown in figure, Calculation the final consolidation in clay layer.

كثافة التربة المستعملة في الدفن   الارتفاع



Sol:-

① $S_{ef} = \frac{\Delta e}{1+e_o} * H = \frac{e_o - e_f}{1+e_o} * H$

$S_{ef} = \frac{1.83 - 1.4}{1+1.4} * (11.6 - 7.3) = 0.653m$

$S_{ef} = m_v * \Delta\bar{\sigma} * H$ الكثافة * الارتفاع

$\Delta\bar{\sigma} = \Delta\sigma = q = h_{fill} * \gamma_{fill}$

$= 22 * 4.5 = 99\ kN/m^2$

لان بعد مرور زمن معين

$S_{ef} = 1.5348 * 10^{-3} * 99 * (11.6 - 7.3)$

$= 0.653\ m$

$S_{ef} = \frac{C_c}{1+e_o} * H * \log \frac{\Delta\bar{\sigma} + \bar{\sigma}_{vo}}{\bar{\sigma}_{vo}}$

$\bar{\sigma}_{vo} = \sigma_v - u$ at the middle of the clay layer befor fill applicat

$\sigma_v = (7.3 - 2) * 18.22 + \left(\frac{11.6 - 7.3}{2}\right) * 16.34 = 131.7\ kN/m^2.$

$u = \left[(7.3 - 2.9) + \left(\frac{11.6 - 7.3}{2}\right)\right] * 10 = 65.54\ kN/m^2.$

$\bar{\sigma}_{vo} = 131.7 - 65.54 = 66.14\ kN/m^2.$

$S_{ef} = \frac{1.0955}{1 + 1.83} * (11.6 - 7.3) * \log \frac{66.14 + 99}{66.14} = 0.653m$

⑧ Degree of consolidation (U_z%):-

Is the ratio of the amount of the dissipated excess pore water pressure (any pressure in water above the static por pressure), to initial excess pore water pressure, for an element of soil located at depth (Z) below the top surf of the clay layer at a specific time.

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where:

S_{cf} = final consolidation settlement. هبوط الانضمام النهائي

e_o = intial void ration

Δe = change in void ratio $= e_o - e_f$

e_f = final void ratio.

H = thickness of compressed clayey soil.

m_v = coefficient of volume compressibility for the stress rav

$\Delta \bar{\sigma}$ = change in effective stress between initial and final conditions.

$\Delta \bar{\sigma} = \bar{\sigma}_{vf} - \bar{\sigma}_{vo}$.

C_c = compression index. مؤشر الانضغاطية

C_r = reloading index. مؤشر ازالة الاحمال

$\bar{\sigma}_{vo}$ = inital effective stress.

$\bar{\sigma}_{vm}$ = maximum pre-consolidation stress.

* The degree of consolidation can be represented by the following terms. (درجة الانضمام)

1- in terms of void ratio:- $u_z\% = \frac{e_o - e_t}{e_o - e_f} * 100\%$. بالبداية = 0 ، بالنهاية = 100%

where:- e_o, e_f = intial and final void ratio respectively.

e_t = void ratio at the time in question. نسبة الفجوات بالوقت المحدد

2- in term of effective stress:- $u_z\% = \frac{\bar{\sigma}_{vt} - \bar{\sigma}_{vo}}{\bar{\sigma}_{vf} - \bar{\sigma}_{vo}} * 100\%$

where: $\bar{\sigma}_{vf}$, $\bar{\sigma}_{vo}$ = final and intial effective stress respectively.

$\bar{\sigma}_{vt}$ = effective stress at the time in question.

3- in term of excess pore water pressure:- $u_z\% = \frac{u_i - u_e}{u_i} * 100\%$

or $u_z\% = 1 - \frac{u_e}{u_i}$, u_i = initial excess p.w.p. $= \Delta \bar{\sigma}$

u_e = excess p.w.p. at time in question.

الهبوط عند وقت محدد

* settlement After a specific Time (S_{ct}):- لا ناخذ بداية تسليط الاحمال، لانه لا يتحمل الاحمال.

$S_{ct} = u_{ave.} * S_{cf}$ → درجة الانضمام المعدلة

$u_{ave.}$ = (average degree of consolidation) = the degree of consolid for layer (average) irrespective of the depth (z).

$T_v = \frac{\pi}{4} * u_{ave.}^2$, T_v = time factor $\frac{C_v * t}{d^2}$, C_v = coefficient of consolidation. t = time in question.

d = whole thickness of clay layer.

(سمك طبقة الطين كلها)

2016

1) Normally and over consolidated soils :-

لتاريخ الاجهادات بالاعماق

soil types according to stress history :- يحدث فقط بالترب الطينية

A- Normally Consolidated soil (N.C.C.) :- existing

تربة لم يتم الانضغاط الزيادة والاجهادات الفعالة الحالية اجهادها وتعرضت لها في وقت لاحق او الماضي

soil is designated by N.C.C. represent the soil at which the exi(sting) effective vertical stress is the largest stress experienced by the at the present time and in the past, thus :-

For N.C.C. ——— $\bar{\sigma}_{vm} = \bar{\sigma}_{vo}$

initial effective stress ($\bar{\sigma}_{vo}$) = existing or present time vertica(l) effective stress.

maximum pre- consolidation stress ($\bar{\sigma}_{vm}$) = the maximum eff(ective) stress which has ever been subjected to the soil specimen and completely consolidated under its effect. أكبر او أقصى اجهاد فعال تعرضت له عينة التربة وصار بها انضغام كامل تحت تأثيره

B- over consolidated soil (O.C.C.) :-

تربة حالة الانضغام

soil is designated by (O.C.C.) refer to the soil experience(d) a stress in past larger than the existing vertical stress actin(g) at the present time. التربة متعرضة في الماضي أكبر من الاجهاد الحالي

For (O.C.C.) —— $\bar{\sigma}_{vm} > \bar{\sigma}_{vo}$ الاجهاد

over consolidation ratio (O.C.R.) :- نسبة الانضغام العليا

Is defined as, $O.C.R. = \frac{\bar{\sigma}_{vm}}{\bar{\sigma}_{vo}}$ → تحدد نوع التربة ما عنده.

if (O.C.R.) = 1 ---- $\bar{\sigma}_{vm} = \bar{\sigma}_{vo}$ --- then the soil is N.C.C.

if (O.C.R.) > 1 —— $\bar{\sigma}_{vm} > \bar{\sigma}_{vo}$ —— then the soil is O.C.C. مطول الانضغام

2) Consolidation Settlement :-

To calculate the final consolidation settlement (i.e. at $t = \infty$), we ca(n) use one of the following correlation :-

1- $S_{cf} = \frac{\Delta e}{1+e_o} * H$ settlement — تغير الفراغات — سمك الطبقة

2- $S_{cf} = m_v * \Delta\bar{\sigma} * H$ → على اي نوعية من التربة يطبق

3- For N.C.C., $S_{cf} = \frac{C_c}{1+e_o} * H * \log \frac{\Delta\bar{\sigma} + \bar{\sigma}_{vo}}{\bar{\sigma}_{vo}}$

4- For O.C.C., check :

a- if $\Delta\bar{\sigma} + \bar{\sigma}_{vo} \leq \bar{\sigma}_{vm}$ then :

$S_{cf} = \frac{C_r}{1+e_o} * H * \log \frac{\Delta\bar{\sigma} + \bar{\sigma}_{vo}}{\bar{\sigma}_{vo}}$

b- if $\Delta\bar{\sigma} + \bar{\sigma}_{vo} > \bar{\sigma}_{vm}$, then :

$S_{cf} = \frac{C_r}{1+e_o} * H * \log \frac{\bar{\sigma}_{vm}}{\bar{\sigma}_{vo}} + \frac{C_c}{1+e_o} * H * \log \frac{\Delta\bar{\sigma} + \bar{\sigma}_{vo}}{\bar{\sigma}_{vm}}$

2- Time decrease with increasing the rate by which water is expe[lled]

$$t \propto \frac{1}{\text{velocity of water}}$$

$$\text{velocity} = ki = k * \frac{\Delta\sigma}{H}$$

where: $\Delta\sigma = u_{e_0}$ = initial excess in pore water pres.

$$t \propto \frac{m * \Delta\sigma * H}{k * \frac{\Delta\sigma}{H}}$$

$$t \propto \frac{m * \cancel{\Delta\sigma} * H}{k * \frac{\cancel{\Delta\sigma}}{H}} \qquad \therefore t \propto \frac{m H^2}{k}$$

The time required to accomplish any percent of consolidation process is called (hydro dynamic time lag). This time is:

1- increase with increasing soil compressibility.

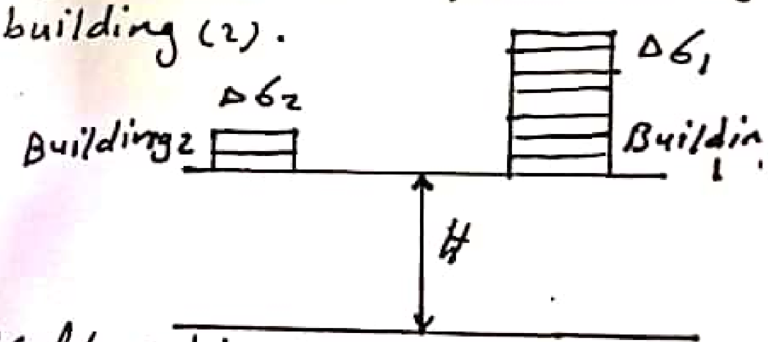
2- increase very rapidly with the increasing the thickness o[f] layer (H).

3- decreases with increasing soil permeability.

4- independent of magnitude of the change in total stress (Δ[σ])

Time required to complete consolidation (to complete settlement) is the same for both buildings. 1-ten story 2-two

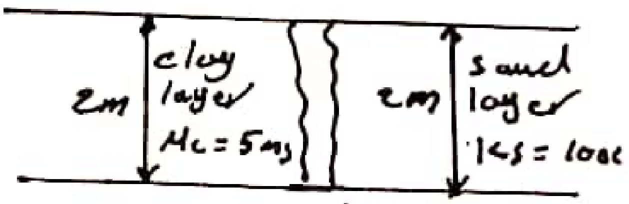
But the volume change of soil (settlement) is much hig[her] for building (1) than for building (2).



Ex:- if three months are required to achieve same consolidation sand layer. what is time required to get the same consolidatio[n] percent in the clay layer?

Sol:-

$$\frac{t_c}{t_s} = \frac{\left(\frac{mH^2}{k}\right)_c}{\left(\frac{mH^2}{k}\right)_s}$$



$$\frac{t_c}{t_s} = \left(\frac{m}{k}\right)_c * \left(\frac{k}{m}\right)_s$$

$$\frac{t_c}{t_s} = \frac{5 m_s}{k_c} * \frac{1000 k_c}{m_s} = 5000$$

$$t_c = 5000\, t_s = \frac{5000 * 3}{12} = 1250 \text{ years.}$$