29.9.15
Saturday

Soil Mechanics
Lec - 1
CE - 341

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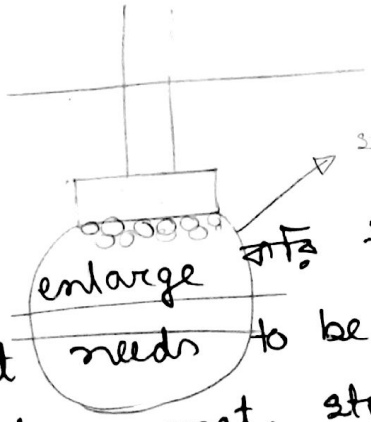
Principles of Soil Mechanics:

Excessive stress and Excessive deformation হলে failure.

Soil is a granular mass, load particle এর বড়ো, Individual না like P/A.



Base কে enlarge করি to take load. Footing loaded হলে that needs to be transmitted to base soil so granular mat. stress নিবে, এরা আবার surrounding particle এ stress distribute করবে, এ area বরাবর loading এর stress তার বেশি area এ হয় because neighbouring particle এ stress is propagated.

Smaller particle এ যখন load দিব তখন propagate stress হওয়ার voids থাকে, They are such যে particles want to go within soil. So void

এর volume change হয়। Soil এ it can be filled with air, water or gas.

Soil is a three phase system.

2. Sizes of the particles will be varying.

3. Water দিয়ে void filled থাকলে water এ pressure develop করবে, pore water pressure (maybe).

* Stress resist করা হয় strength দিয়ে।

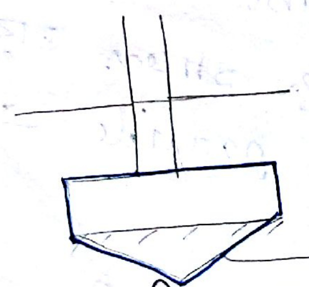
* settlement এর concept imp.

* Permiability of soil.

3 properties:

1) strength
2) settlement
3) Permeability

} Engineering characteric property of Soil



Immidiate নিচে যে soil এই area তে compacted হয়। so the whole material would be a wedge হয়। so the whole material would be a wedge. নিচে যাওয়ার try করলে soil সে stress নেবে। wedge নিচে যাওয়ার try করলে soil

← → এভাবে সরাতে চাবে

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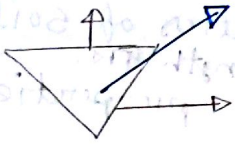
(*) soil is semi-infinite mass.

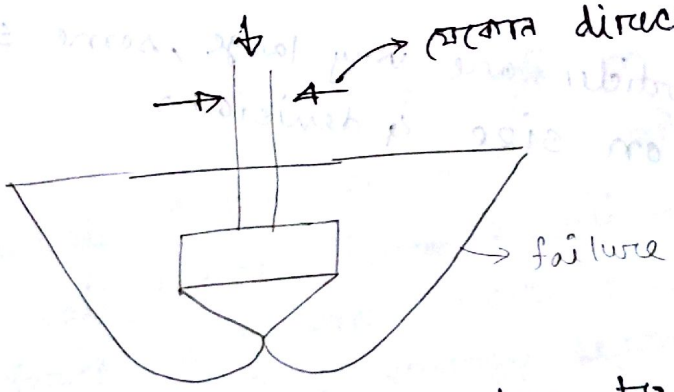
ground level ↓ infinite soil আছে, শুধু উপরে নাই।

So soil only উপরে গেলে maybe stress release করতে পারবে, so the tendency of moving a particle will move outward and then upward.



so resultant ↗ হবে,

so failure surfaces as shown at figure. ②.



Eventual failure would be due to slipage or shear. কারণ road load ই apply করে না কেন, so we use shear strength. এজন্য characteristic is defined by

1) Shear strength
2) deformation/ settlement
3) permeability

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In some cases we want ↓ permeability - like play ground.

Bank embakment → ↓ permeability.

(*)  → the whole soil collect করতে হবে এখানে foundation বানাতে, It's difficult & expensive.

(*) So we can have Index properties of soil, like grain size ইত্যাদি, এগুলো থেকে strength পাব.

These will depend on other properties of soil.

Some particles are very large, some small.

Depending on size ↓ denisions

1) Gravel
2) Sand
3) Sill
4) Clay

(*) Soil is formed from rocks, rocks from minerals, minerals from elements.

Minerals ই হচ্ছে base করে physical properties থাকে.

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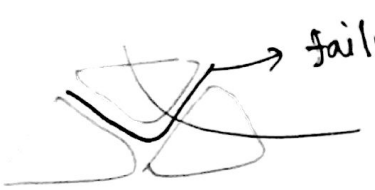
Physical Property :

1) Specific gravity : 2·60 - 2·65. এর মধ্যে heavy mineral থাকে বালার এটা কম।

* soil এ particular failure surface বলা যায় না, Even we call the failure is a plane its actually wavey. cause mineral এগুলো হবে একটা plane পাওয়া যাবে, এটা possible না,



, যত বেশি তত energy লাগবে, এর particle একটার লাগান থাকে, এর mass এর vendar wall force (for electrical charges) & body force. So আলাদা করতে bond পাওয়া হবে, This bond এর উপর energy depend করে,

(*) কোন surface এ load দিলে (normal load) there must be induced friction. frictional property না থাকলে slipage হবে, ↳ if the surface is rough.

(*) So interlocking, cohesion, friction shear stress এর জানা, So we need to learn these.

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* BOOKS:

1) Foundation Engineering
Peck, Hanson & Thornburn

2) principles of Geotechnical Eng.
B.M. Das

3) Geotechnical Engineering Soil Mechanics
Cernica

4) Craig → workout problem
fluid flow through porous media

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2.9.15

Lec-2

Intro to Soil Mechanics & Geotechnical Engg:

Aspects of geotech:-

* **Soil Mechanics:**

that concerns with the mechanics and engg of soil

* **Rock Mechanics:**

concern mechanics of rock, not bed rock cause এটা অনেক stiff.

* **Engg. Geology:**

1) Physical geology 2) Engg geology.

Fault / fold থাকলে foundation কিভাবে হবে, কোথায় place বানাব এগুলোর যে analysis ~

* **Soil Engg:**

soil mechanics এর knowledge use করে যে কাজ করব, when the foundation rests on soil

* **Rock Engg:**

Rock mechanics এর application, when foun. rests on soil

* **Foundatio Engg:**

when foundation rests on soil and rock both. So soil & rock engg এর mix

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* Geoenvironmental Engg:

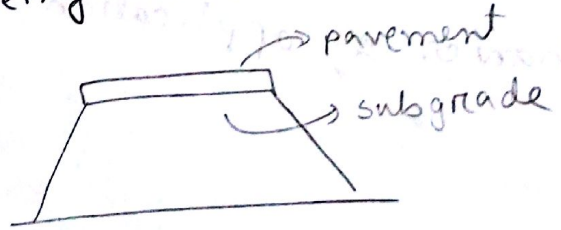
Earthquake, rain etc এর জন্য soil, rock এর change

Scope of Geotech:

- Foundation of structure
- Underground and earth retaing structure
- Embankment, excavation & dam
- Pavement
- Soil subsidence, Soil heave, frost action, soil erosion, shrinkage and swelling

There needs to be a natural maintainance of slope when we excavate. Soil এর property এর উপর slop depend করে।

Pavement thin layer, যার উপর দিয়ে traffic যায়, এটার embankment এর উপর করা হয়, Thickness depends on underlieing soil. The soil is called subgrade



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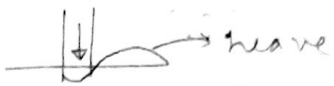
soft soil → load apply করলে 

Flow of wate ↓ soil erroded হয়, river bank erosion হয়ে সাধি depends on shrinkage & swelling.

* Inorganic soil - decomposition of rock
* organic soil - ,, of organic matter

↓problematic

inorganic rock → clay material হলো problematic.

According to size - 1) gravel
2) sand
3) silt
4) clay

clay size particle → তিনটি dimension significant (bulky)

Clay material → flaky (যে দুটো বড় dimension prominent)

clay size particle may be bulky / flaky

flaky mat ↓ problem অনেক charge carry করে, usually -ve charge.

surface are যত বেশি charge তত বেশি.

water can attract +ve & -ve. So when flaky part. comes in contact with H_2O অনেক H_2O absorb করে, so সহজে H_2O remove করা very difficult. As a reason the thickness of flaky particle increases

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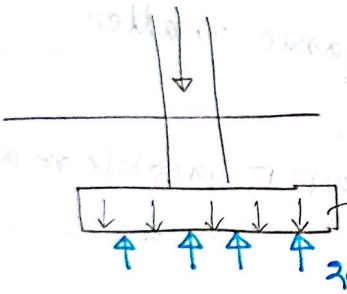
- Koolinite
- Illite
- Montmorillonite

} clay mineral

↳ এটা সবচেয়ে ছোট.



নিচে এ 3 রকম mineral থাকলে dry season এ ok. Rainy season এ এটা water absorb করবে & foundation expand করবে, so 20 KN load (suppose) উপরে যাবে,

So rainy তে উপরে & dry season এ building নিচে যাবে, This is called **shrinkage and swelling** problem

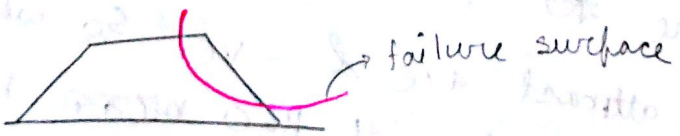
Development of Geotechnical Engg:

* History of soil mechanics:

i) Pre-classical ii) classical phase-I iii) classical phase-II

iv) Modern v) Recent

(*) Embankment এ circular slip surface এ failure হয়



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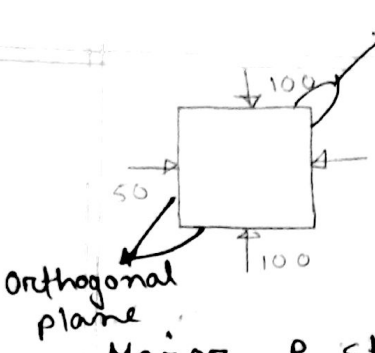
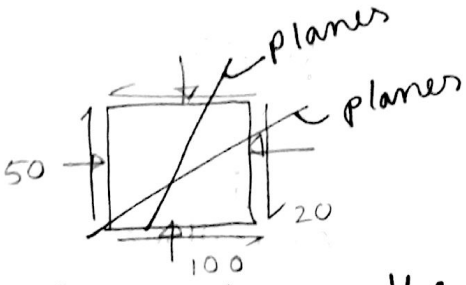


Stress element considered, the planes are orthogonal.
when only normal streeses are there we call them principal stress.

Major P. stress : বড় (σ_1)
Minor P. stress : ছোট (σ_2 or σ_3)



And shear stress ও থাকতে পারে।
Shear stress এর plane এ same হতে হবে.

Mohr said we can draw a circle if we know the stress condition of orthogonal planes.
যেকোন plane এর stresses circle এ circumfarance এ থাকবে.

* Liquid condition:
Condition of soil where the soil flows for its own weight.

* Plastic cond: যেকোন shape নেয়া যাবে without cracks

* Semi-solid cond:
it is the condition of soil that can be given any shape with cracks

* Solid cond:
No shape can be given.

এদের limit of water আছে, এর change হলে একটা থেকে আরেকটা হয়ে যাবে।

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9.9.15

Lec-3

Defⁿ of Geotech:

Soil is used by diff professionals and their definitions are diff

- Agriculture
  - ↓
  - ⇒ thin layer
  - ⇒ plant grows
- Geologist
  - formed by disintegration of rock, also ,,
  - inorganic ⇐ of organic matter
  - ↳ organic soil
  - ↓
  - Based on origin
- Geotech engineers

Defⁿ of Soil:

In our language agr. মাটি soil বলে we call it top soil. For agr is good for us not. Cause plants, organic matter এর shear strength বাড়ায়, তাই we remove top soil.

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Formation of Soil:

Disintegration of rock - weathering

- physical
- chemical
- Biological

Earth crust → rock & wethered rock

upto 20km depth → rock

Rock is formed of diff minerals

Surface of earth crust 80% sedimentary

Total volume of 90% igneous.

More than 4000 minerals. Only 8 are rock forming minerals.

Earth Crust:

1) Based on silicate composition layers
   - Crust
   - Mantel
   - —
   - —

2) Based on stiffness Mechanical layers
   - lithosphere
   - Asthenosphere
   - Mesosphere
   - Outer core
   - Inner core

Minerals can be expressed by chemical formula

Rock can't " " " " "

↓

Basic diff of rock & mineral

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We can classify rock on various criteria.

* Formation History — i) organic ii) inorganic
* grain size
  1) gravel
  2) sand
  3) silt
  4) clay (size)

*) Minerals — 1) clay soil (mineral) → changes its property with water content
2) non-clay soil

sand whenever confined is as hard as stone.

Q. Underlining footing এ sand/clay?

sand.

Monmorillonite এত fine যে 1g দিয়ে football field cover করা যাবে, so extremely water absorbent.

So its expanding / swelling soil

- Igneous Rock
- Metamorphic Rock
- Sedimentary Rock

*) Diff betw rock & mineral?

Rock → organic, made of more than 1 mineral, solid

Minerals → inorganic, solid, one mineral

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Once rock is weathered it can be transfered and then deposited. যদি running water দিয়ে deposited হয় then called alluvial soil.

Types of weathering:

Physical

Coarse grain soil formed

- Elements → mineral → rocks
- Diff volume expansion.
- Periodic temp change
- wedging action of ice
- Splitting action of plant roots
- Abrasion of wind/water

Chemical

- solution → carbonation
- Hydration - Dehydration
- Oxidation - Reduction
- Hydrolysis

fine grained soil formed

Leaching action

Biological

plant – animal

Solid NaCl water এর সংস্পর্শে আসলে soln. So consistency change হয়, so soluble সব rocks in water disintegrate

cement + water দিলে cement solid হয়। কিন্তু mineral water এর touch এ এলে disintegration হয়।

chemical composition of O_2 with mineral. $Fe + O_2 = Fe_3O_4$. So iron solid, rust granular. So এসব mineral সহজে disintegrated. Usually redish color হয়।

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water H^+ & OH^- এর দ্বারা সংঘটিত disintegration
তাকে hydrolysis.
water itself reacting is hydration

carbonation rain + CO_2 কার্বনিক এসিড, reacting with water.

Reverse procedure:

Water evaporate করলে dehydration

O_2 যুক্ত হলে reduction

Leaching action is like soln. Minerals combining agent salt. Some salts are soluble in flowing water. So salts চলে গেলে rock disintegration হয়।

Q. What are the agents of physical/chemical/Bio weathering? What is weathering?

Biological:

Soil থেকে plant সারার বানায়, rock থেকেও বানায়, plant/animal enzyme secration করে, enzyme changes rocks. Enzymes are weak acids. So action done by insects, plants হল biological.

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Factors Effecting weathering :

1) Temperature 2) Precipitation

Climate conditions control weathering

So saudi Arabia তে সেরকম weathering Bd তে হেরকম না,

* Physical weathering :

* stress release :

usually rock depth এ থাকলে এর উপর vertical soil or other এ pressure দেয় যেটা overburden pressure. Earthquake or any reason এ pressure release হলে volume expansion হবে. So disintegration হয়।

⇒ Rock formation এর 1st এ edge sharp থাকে, বড় থাকে, abrasion এর ফলে edges rounded হয়, rock ছোট হয়।

⇒ Splitting action for larger trees, Biological for small plants.

Soil Profile & Soil Horizon:

1) Whenever transporting → 1) transported soil

2) Staying at place → 2) residual soil

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residual soil & transported soil এর property different.

Residual soil is lazy soil. Transported soil চঞ্চল.

Residual এ rock disintegrate হয়, degree of weathering will depend on depth. উপরে weathering বেশি, 30m পর্যন্ত হতে পারে, Russia তে 100m ও হয় but it's exception.

* Horizon:

A → intense wethering

B → কম "

C → আরও কম "

D → আরও " "

Soil profile & Horizon same

profile → layering of transported soil → strata 1, 2, 3, etc

Horizon → layering of residual soil

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12/9/15

Saturday

Lec - 4

Soil of Bd:

Seven tracts. (morphological)

3 soiles — 1) recent alluvium 2) old alluvium 3) raised alluvium

Most soils silty material.

Modhupur: old alluvium, redish

Tista silt:

Bramhaputra Alluvium: Biggest tract

Deposits: 6 types

Geotech soil of Bd:

P.T.O.

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Chapter - 3

Soil Reposit, Type Structure & Classification

Type হল generalization
Classification more specific.

Classification:

Classification এর জন্য criteria is a must
soil এর inherent property হল cohesion.

⊛ Classification Based on Reposition:

1) organic → ,, of organic matter
2) Inorganic → disintegration of rock

Organic soil (formation time ও fine grained)

OC ≤ 5%,	O.C = 6 - 20%.	OC = 21 - 74%.	OC > 74%
inorganic soil	adjective Organic silt & organic clay (noun)		peat soil

* peat soil:

very low shear strength
High compressibility - deform করবে, settlement হবে
অনেক পানি ধরে রাখে, like sponges

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organic soil dark / black in color.

Inorganic soil:

Residual Soil : (~~Blackish~~ / Yellowish)
reddish

1) Laterite → mostly ~~fine~~ grain, ~~%~~.
2) Lateritic → mostly ~~fine~~ coarse grain soil >90%.
3) Black cotton → water contact ⇒ swells in volume
very rare, cotton চাষ হয়।

Transported soil:

1) Water ~
2) Glacier ~
3) Wind ~
4) Gravity ~

Water Transported Soil:

1) Alluvial → deposited in running water condition, নদীতে
2) Lacustrine → deposited in quite water, বিল ঝিল
very fine mat, very thin layer of soil.

3) Marine → সাগরে তৈরি হবে
4) Marl → deposit contains $CaCO_3$.
$CaCO_3$ dry হয়ে mudstone

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Glacier Transported soil:

glacier move করার সময় rock নিয়ে আসে plane land এ আসলে melting এর উপর depend করে diff.

Glacier Till → unstatified layer, Glacier Drift: sorted + unsorted হতে পারে, But only unsorted হলে till.

Boulder clay → নুড়ি ছোট & বড় deposit

Morraine → ⌒ টিলা

Drumlin → উল্টানো চামচ

Eskers → আকা বাকা রাস্তা

Erratics → large mass

Wind Transported soil:

Dunes → high quantity of sand

loess → silt, compaction ↓ হলে structure collapse করে & water এর সাথে flow হয়, এটা mud flow & collapsable soil

Tuff - volcanic ashes দিয়ে. Also called Tufa.

Problematic soil

Gravity soil:

Colluvial soil or Talus

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colluvial soils are basically unsorted soil. Cause সব size এর particle থাকে।

Alluvial এ sorted materials will be there.

So according to gradation this is uniformly graded or poorly graded.

Grain size:

1) Gravel 2) Sand 3) Silt 4) Clay

(Gravel, Sand → coarse grained; Silt, Clay → fine grained)

Basic classification of size 4টা, এরা size এর range দেখে।

ASTM → সুবিধা হল seive opening এর corresponding এ classification.

1) number of seive 2) size of seive

200 seive এর দিয়ে pass হলে hydrometer দিয়ে analysis করি।

3"–12" cobble, Boulder > 12"

AASTHO:

larger than 2mm → Gravel

ASTM এ carse sand, AASTHO এ gravel

" " medium " , " " coarse sand

USCS: Gravel, sand, fines

British:

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16.9.15
Wednesday

Lec-5

Field identification of soil:

Silt 2 Types 1) reacts with H_2O – plastic silt
2) doesn't " " " – non plastic silt

When we consider fine grain soil we consider
1) silt 2) clay 3) fine sand 4) organic soil

Feel: clay smooth feeling দিবে, sand খসখসে

wooden hammer used, cause steel use করলে particle ভেঙে যায় in dry strength test.

- 1/8" dia এর thread বানাতে গেলে গুড়া গুড়া হয়ে গেলে silt.
- particle বড় হলে void size বড়, silt এ void size বড়, so এটা দিয়ে water passes fast. so tapping এ H_2O তাড়াতাড়ি বের হবে cause ~~পরিমাণ~~ pore size বড়,

- clay minerals have affinity to cations. Field এ impurity এর water দিলে cation attach হয়ে diameter of soil particle বেড়ে যাবে, so প্রবাহের clog বাড়বে. This is called flo culation.
এজন্য ছোট particle ও তাড়াতাড়ি settle করে.

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Classification Based on Cohesive Properties:

silt & clay → charge থাকে, এদের মধ্যে attraction force cohesion.

Soil structure & fabrics:

We always work with soil mass, not a single particle. So mixture of soils থাকবে, so property change হবে.

Arrangement of particles in a soil mass is called structure.

In general structure & fabric same.

Clays soil এর ক্ষেত্রে fabric বলি.

Macro structure:

soil এ crack থাকলে (খালি চোখে visible). এর strength কম.

Micro - - - :

crack খালিচোখে দেখা যায় না.

Micro কে based এ 5 টি ভাগ.

Single grain:

void বেশি - loose structure

void ↓ - dense ,,

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2. Honeycomb:

silty soil এ, charge দিয়ে attract হয়ে ring form করে, মাঝে void.

collapsable soil honeycomb structure, void এ H_2O গেলে collapse.

3. Flaky structure:

২টি dimension. Depending on diff charge arrangement diff.

parallel – Dispersed  (easy slipage)

Bundle – Packet or Ped, এরা নিজেরা আবার flocculated

Flocculated –  (not easy slipage)

Dispersed এ failure easy, shear st. কমে। comparison with flocculated

Particle Shape:

Bulky – 3 dimension

Flaky – 2 "

little – 1 "

Angular shape desired cause interlocking হলে।

Angularity can be measured.

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sphericity :

$$S = \frac{De}{Lp}$$

roundness and shericity :

* Engineering classification of soil : (most imp)

several agencies classify করে

1) USCS 2) AASTHO

value থাকে, যে test এর value নিয়ে আমরা classification test.

- grain size test
  - larger particle (seive annalysis)
  - smaller particle (sedimentation annalysis)
    - Hydrometer
    - Pipette
- consistency test

classification এর জন্য numerical value থাকে,

Fineness modulus is the measure of coarseness.

But FM is not used in soil mechanics.

Q. what is classification test? এর ① grain size ann → coarse grain

consisty test : Fine soil এর, consistency এর condition in terms of strength. Depending on H_2O content

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strength changes.

Q. What is index ~~value~~? property?

↳ The numerical results of classification test.

Seive Designation:

Mesh always square.

Number দিয়ে বলতে linear length এ কয়টা division আছে।

Horizontal shaking দেয়, not verticle shaking.

usually for 10 mins.

cumulative % retained মানে only ঐ seive দিয়ে seiving করলে যা retain করবে in that seive.

Q. What is effective grain size? D_{10}

It is the size of the particle ~~passing~~ from which 10% is finer.

D_{30} – it is the " " " " from which 30% material is finer.

D_{50} (নয়) But for classification it's not important. হয়।

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⊛ Uniformity Co-eff : C_u

$C_u = \frac{D_{60}}{D_{10}}$, যত বেশি মুসব soil particle এর size এর মধ্যে variation বেশি,

⊛ Co-eff of curvature : Spread of the curve বুঝি,

$$C_z = \frac{D_{30}^2}{D_{60} \times D_{10}}$$

যদি প্রকৃত size এর particle থাকলে $C_u = 1$, then curve verticle. |

C_u is a measure of spread of the curve.

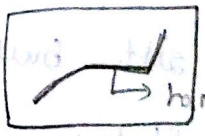
S shape curve হলে well graded soil.

co-eff of curvature থেকে C_z থেকে shape of the curve.

if $1 < C_z < 3$ then S shape.

From C_u & C_z & curve থেকে gradation বলতে পারি,

Gradation basically – well graded
poorly graded – uniformly
Gap graded



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3.10.15
Saturday

Lec-6

Grain size Annalysis:

1) seive annalysis
2) sedimentation annalysis

percent retained whole number, except #200 seive.

if more than 12% or 10% is passing #200 100gm soil নিলে then hydrometer / sedimentation annalysis (in some cases)

Sedimentation Ann:

Stokes Law → larger particle, faster settlement.

seive করব using #200, এর 50gm নিব, Then 100cc jar এ soil + H_2O নিলে 100cc হবে, thoroughly mixed.

soil এ impurity → salts ionized.

silt bulky / flaky, clay flaky.

flaky surface এ -ve, so সহজে +ve এর contact এ এসে এবারে large particle form করবে, so particle small হলেও fast settlement. So prevent by Na Hexa metaphosphet deflocculating agent.

এরাও -ve charge create করে।

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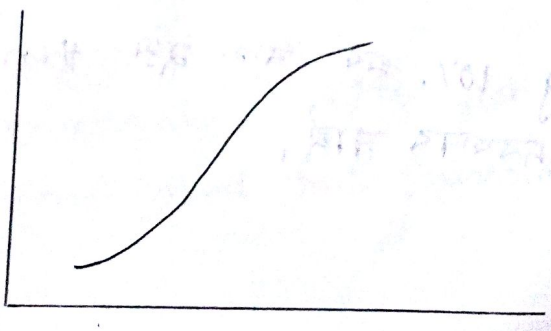
vol^m of suspension 1000 cc, After sometime density lower হবে cause particles settle হচ্ছে।
After infinite time density H_2O এর সমান।
So time বেরে reading নিবি।
Density কমলে hydrometer reading নিচে যাবে,
Solid particle দিলে S.G. determined হয়,
Intelegent hydrometer সরাসরি ~~Determined~~ কত gm soil আছে direct reading.

151H → density measured
152H → amount of soil in suspension.
usually 151H not used.

D = particle size
L = length of hydrometer
G_S = S.G. of soil
percent finer = N
V = 1000 cc
R = hydrometer reading
W = wt of soil usually 50 gm
Grain size distribution curve



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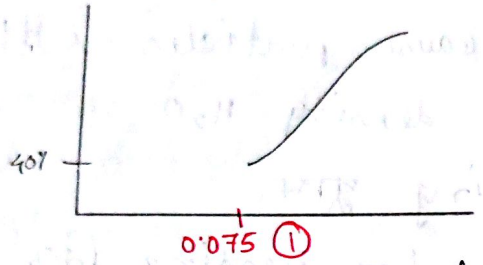
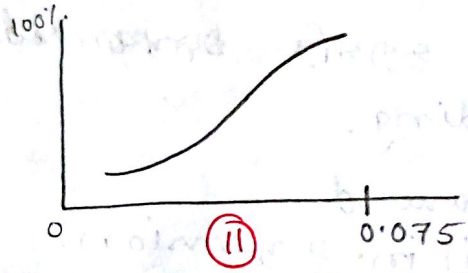
suppose 40%. passes 200 seive



So বাকিটার জন্য hydrometer max^m dia 0.075.



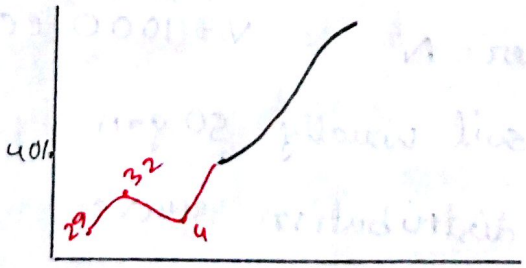
এখানে % finer
0.075 - 100
0.05 - 80
0.033 - 73

① এ যেটা 40%. , ⑪ তে সেটা 100%.

So %. finer 100 কে 40 বলতে বুঝে, ১০

% finer
0.075 - 100×0.4 = 4
0.05 - 80×0.4 = 32
0.033 - 73×0.4 = 29

So combined



যদি 200 থেকে %. passing 10%. এর কম হয় then grain size analysis এ দরকার নাই.

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Grain Size distn curve:

soil এর high shear strength, deformation less. এটা well graded soil.

* যদি soil sand হয় তাহলে $C_u > 6$ $1 < C_z < 3$, then the soil is well graded sand.
* But in case of gravel its not correct. যদি more than 50% is retained in #4, then gravel তাহলে $C_u > 4$ $C_z = 1 < C_z < 3$ then well graded gravel

2nd Classification Test: Consistency test

→ Always passing by #40 sieve

Done for fine grain soil. water bipolar.

water এর জন্য soil এ যে special property plasticity. plasticity property এটা, Bipolar না হলে plastic property হবে না.

* Limiting water containts আছে.

এর clay এর জন্য limiting H_2O diff, cause diff proportion of minerals.

So on minerals limits depend.

plastic soil not good for foundation. Shear strength বাড়ে.

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so কখনও plastic হবে না, so from limits we can conclude soil কোন না প্রকার,

Definition of limits:

① liquid limit:
ω_L = water content W_L = weight
small shear strength = 1.7 kPa

② Plastic Limit:

③ Shrinkage Limit:
smallest water content ,, saturated water content
below this volume change হবে না even if we change H_2O content.

small shear usually machine দিয়ে করা যায় না,

Liquid Limit Determination: for fine grain soil

- Casagrande's Method
- Cone Penetration method
  ↳ demarkation line of fine & medium sand

Prep of soil: Dry in air → powder → seive (#40) 0.425mm
↓
mix with water → keep for 24 hrs
↓
throughly mix

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7.10.15
Wednesday

Lec - 7

⊞ Determination of liquid Limit:

1) Casagrande's Method: (Popular in USA)

25 blow এর বড় $\frac{1}{2}$" close হলে it's in liquid limit. মাঝের soil নিয়ে water content নিব then আবার water add

No. of blow	W. content
34	51
29	59
24	63
19	71
16	73

max 35 এর কম min 15 blows.

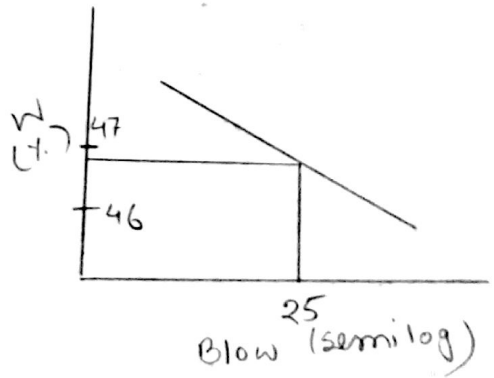
Try and error method.

25 blows ≈ $\frac{1}{2}$" closing এর জন্য w.content liquid limit.

liquid limit whole number unless it's less than 10.

water 47 এর কাছাকাছি, so it's 47.

Flow curve



2) Cone Penitration:

penitration হল ▽ এর surface এর shear strength. 20mm penitrate করলে আমরা liquid limit. suppose 12.5 mm হল, so we need to add more water.

In scale এক ঘর = 0.1 mm

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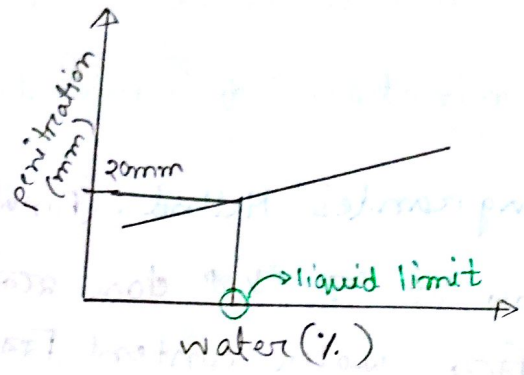
previous ⊐ X ⊐ blow

Y ⊐ w(%)

এখানে উল্টো.



Q. What is flow index?

Flow curve এর slope flow index. এটা দিয়ে strength measured

we can use one point to determine liquid limit.

1st method ⊐ যত 25 এর কাছে আসবে তত ভাল.

Then for single point method in (1).

$$w_L = w\left(\frac{n}{25}\right)^{e \to 0.1}$$

$$= 63\left(24/25\right)^{0.1} = 62.74 \approx 63$$

25 এর কাছাকাছি আসলে better result

$$w_L = 71\left(19/25\right)^{0.1} = 69$$

~~[illegible]~~

(*) cone penitration এ single point method can be used

cone penitration for ,, ,, should be ~~26 - 16~~.

26 - 16 (water content)

Plastic limit almost 100% more strength than liquid limit.

↓ folds

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⊛ Plasticity index = diff betⁿ liquid & plastic limit

(PI or I_p) = LL − PL

⊛ Liquidity Index (LI or I_L) = $\frac{\omega - PL}{LL - PL} = \frac{\omega - PL}{I_p}$ ← natural water content

⇒ If the natural water content যদি LL এর বেশি then LI = 1. (soil soft)

⇒ if " " " " " PL " " " LI = 0 (soil stiff)

⇒ LL & PL of a soil is fixed. only determiner is ω.

⇒ If a soil is dry then ω = 0. So LI can be negetive.

⇒ LI > 1 is unlikely. Cause LI এর বেশি ω থাকলে flow করবে. But soil slurry হিসেবে থাকলে it can be > 1.

⇒ consistency Index CI or I_C = $\frac{LL - \omega}{LL - PL}$

just reverse of LI.

⇒ Flow Index

⇒ Toughness Index I_T: Measure of strength of soil = $\frac{I_p}{I_F}$

⊞ Determination of shrinkage limit:

swelling soil কে classify করা হয়,

Betⁿ solid and semisolid ω content.

Sh. Limit is the saturated water content of the soil at its minimum volume during the process of drying.

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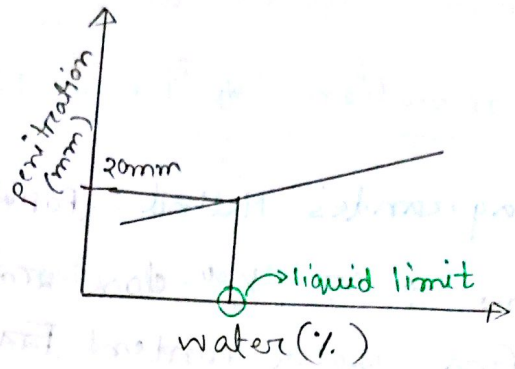
previous ⇒ X ⇒ blow

Y ⇒ w(%)

এখানে উল্টো.



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25 এর কাছাকাছি আসলে better result

$$w_L = 71\left(19/25\right)^{0.1} = 69$$

~~(1) ... ...~~

(*) cone penitration ⇒ single point method can be used

cone penitration for ,, ,, should be ~~26 - 10~~ 16.

26 - 16 (water content)

Plastic limit almost 100% more strength than liquid limit.

(almost 1 fold)

* Plasticity index = diff betⁿ liquid & plastic limit

(PI or I_P) = LL − PL

* Liquidity index (LI or I_L) = $\frac{\omega - PL}{LL - PL} = \frac{\omega - PL}{I_P}$ ← natural water content

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Determination of shrinkage limit:

swelling soil কে classify করা হয়।

Betⁿ solid and semisolid ω-content.

Sh. Limit is the saturated water content of the soil at its minimum volume during the process of drying.

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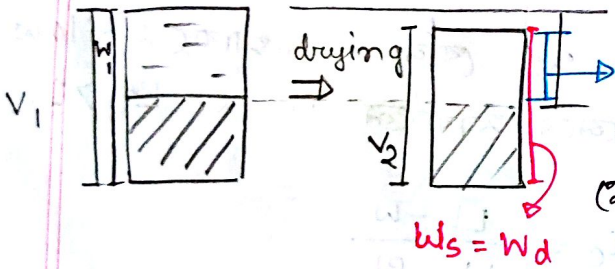
oven এ dry করলে irregular shape হবে, এই অবস্থায় (min volume এ) এ w content.

i) S.g of soil is unknown
ii) s.g " " " known

i) SG unknown:

When soil is made slurry then phase dia soil + water cause voids are filled with H_2O



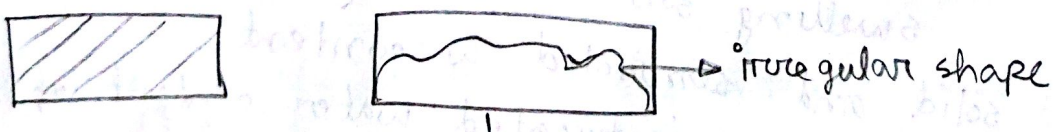
dry করলে এখানে air void. এটা min volume. এখানে air না থেকে H_2O থাকলে Shrinkage limit

$W_1 - W_d$ করলে initial water weight.

$V_1 - V_2$ এ যে water content হল সেটা water করল, This is $(V_1 - V_2)\gamma_w$

$$\text{Shrinkage limit} = \frac{(W_1 - W_d) - (V_1 - V_2)\gamma_w}{W_d}$$

(*) solid soil never changes volume.



এটার vol বের করতে mercury used.

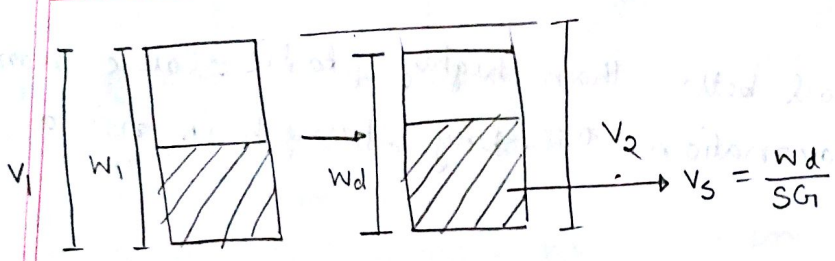
এই পাত্রে mercury নেব, whole soil shape immerse করব, যে mercury replaced হবে তাঁর $W_{Hg}/13.6$ হল volm.

10.10.15
Saturday

Lec-8

Determination of shrinkage limit:

(*) SG is known:

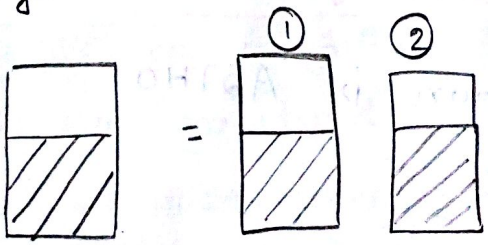


Volume of void $= \left(V_2 - \frac{W_d}{G_S}\right) \times \gamma_w$

Shrinkage limit $= \frac{\left(V_d - W_d/G_S\right)\times \gamma_w}{W_d}$

3. write derivation of shrinkage limit if Gs is known and unknown.

* S.L is 5, s.L is 10
⇓
This is a better soil. we want the volume of the soil not to change. যদি volume change বেশি হয় then void ও volume change হবে।



① যত deformation বেশি, তত shrinkage limit বেশি,
② " " কম, তত SL বেশি, তত SL যত বেশি তত ভালো soil.

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Determination of Linear Shrinkage:

Shrinkage বেশি হলে length shrinkage measured. Linear shrinkage হয় ↑ soil হয় poor. L.shrinkage বেশি হলে deformation ↑.

Non-plastic soil better than highly plastic. Cause non plastic এ deformation কম, Dry strength is not a criteria.

Relation LS, Plasticity index $\Rightarrow I_P = 2.13 L_S$

Soil H_2O এর contact এ আসলে expansive হবে কিনা see from shrinkage limit. SL ↑ হলে linear shrinkge ↓.

(*) Shrinkage potential low হলে when it comes in contact with H_2O it will expand less.

Singificance of Indices:

Q. কোন index → like flow, plasticity index ↓ / ↑ হওয়া ভাল?

Unified Soil classification system:

Another classification is ASTHO.

construction এ USCS

Road, airport ASTHO

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grain size characteristics and consistency test এর results used.

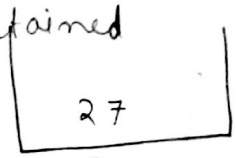
GW → well graded gravel
ML → silt of low plasticity

(*) 100g soil, #200 এ retained 52, passed 41. More than 50%. retained এ #200 ~~~~~ coarse grain. So G or S.
gravel sand

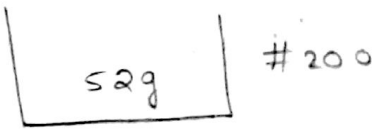
if passes 50 or more than 50 then fine grain. clay(C) or silt (M)

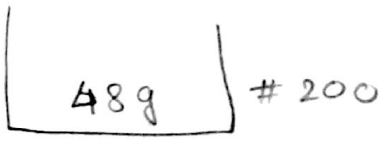
52g → seive through #4

more than 50% retained

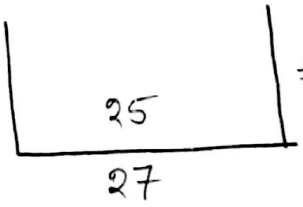


so the whole 100g will be known as gravel. So 1st letter G.





then 100g of whole soil is sand. So S.



যদি G or S এর ভিতর আরো বিভাজন sieving by #200, 3 things are considered

(1) % passing #200 seive $\leq 5\%$ → clean Gravel / clean sand
(2) % " " " " " 5-12%.
(3) % " #200 " >12%.

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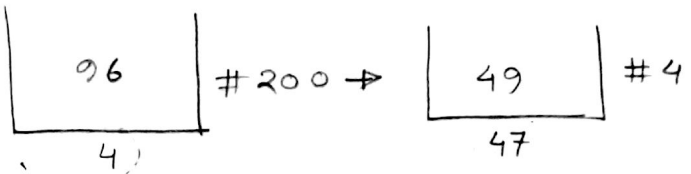
Here % passing was 48g, so it's >12%.

Again suppose



so the 1st letter is G.

% passing #200 is <5%., so we will call it clean gravel.

clean gravel / clean sand হলে then to classify it the only criteria is Gradation (grain size)

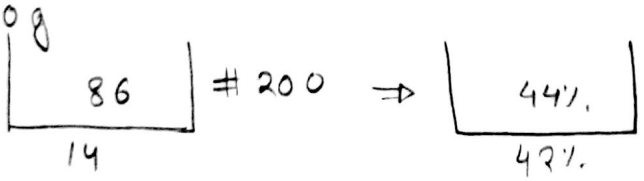
Then if $C_u > 4$ and $1 < C_z < 3$ then it's called well graded soil.

So this soil is GW.

যদি $C_u < 4$ and $1 < C_z < 3$ এটা না হয়, then GP

If $C_u \geq 6$ and $1 < C_z < 3$ then SW. otherwise SP.

(*)



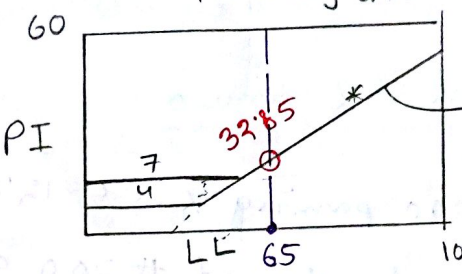
So 1st G

% passing #200 >12%, then second letter determine করতে can't use gradation. New criteria That's basically used for classifying fine grain.

plasticity chart → Liquid limit vs plastic limit

$PI = 0.73 (LL - 20)$

Plasticity chart



যদি PI = 4
and PI = 7 উপরে
if LL = 100 PI = 58 ... *

Suppose যেমন কল্পনায় PL = 36 LL = 65

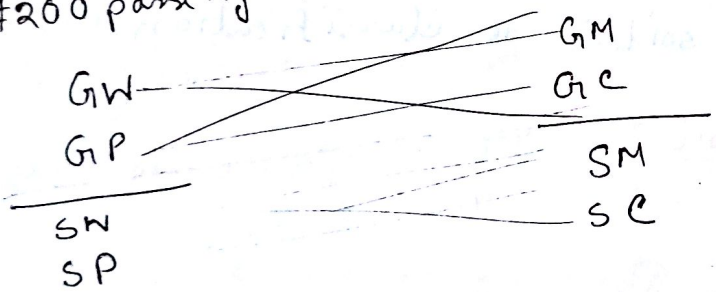
$\therefore PI = 65 - 36 = 29$, (65, 29) A এর নিচে না উপরে
↓ silt(M) ↓ clay(C)

$\therefore 0.73 (65 - 20) = 32.85$

32.85 on A Line, 29 এর নিচে, so it's silt(M)

So it's called silty gravel.

#200 passing $\leq 5\%$. # ... $\geq 12\%$.



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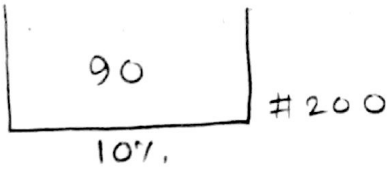
14.10.15
Wednesday

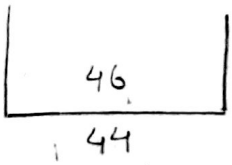
Lec - 9

USCS Continued:

#200 passing %. 5-12%. হলে ⇒

percent retained #200 90





so 1st letter G.

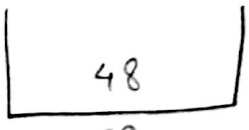
Here dual classification হবে, (Previous pg হতে combination)

well graded silty gravel
- GW - GM
- GW - GC
- GP - GM
- GP - GC

and for sand
- SW - SM
- SW - SC
- SP - SM
- SP - SC

coarse grain soil এ 16 classification.

⊛ Fine grain soil:



more than 50%. or even 50%.

so it's fine grain. < silt (M), clay (C)

Then LL = 65

PL = 36

∴ PI = 29

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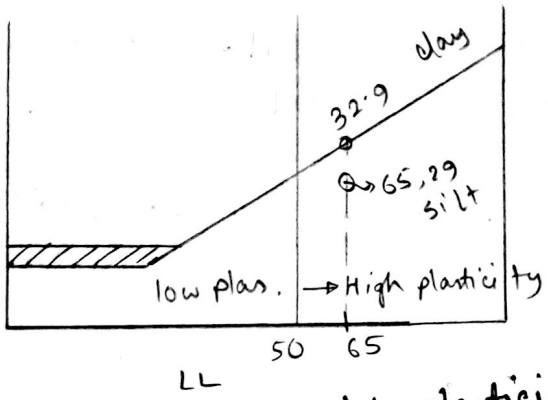
silt বা clay হলে plasticity curve এ বসবে।

Then plot (65, 29)

Again PI = 0.73(LL − 20) = 0.73(65 − 20) = 32.9

so 29 falls below 32.9, so 1st letter is silt M

Then we draw another line



LL greater than 50 হলে high plasticity.

Here LL = 65 > 50 ∴ high plasticity. ∴ MH

চারটে classification MH CH ML CL

(*) Hatched area তে কোন point পড়লে dual classification

CL-ML : silty clay of low plasticity

(+) organic soil এ determine liquid limit in 2 ways

1) dry it in air

2) dry it in oven

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oven dry করলে organic soil হলে liquid limit will be less.

Inorganic হলে air & oven dry তে same.

$\frac{LL_{oven\ dry}}{LL_{air\ dry}} < 75\%$, so we say organic soil.

এই organic soil is always fine grain soil.

Air dry LL > 50 হলে OH – organic soil of High plasticity

Air dry LL < 50 " OL – " " " low "

- organic content > 75 হলে peat soil. এজন্য we go for loss on ignition test.

soil কে air dry, then oven এ 400-500°C এ heat করলে organic matter burned out, ash residue থাকবে।

Here Ash content > 75% হয় then we call peat soil.

Problem:

sample নিলাম, Grain size Analysis করলাম, Then grain size Annalysis থেকে :

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% passing # 4 = 85

% ,, # 40 = 60 ⇒ 0.425 mm

% ,, # 100 = 30 ⇒ 0.149 mm

% ,, # 200 = 10 ⇒ 0.075 mm

LL ovendry = 48 , PL = 25 , SL = 10 , LL air dry = 65

Classify the soil as per USCS.

⇒ 1st এই % passing #200, Here retained 90%, so coarse grain. coarse grain হলেই organic check করতে হবে না.

Then retained in #4 = 15 in 100 gm

But coarser soil আছে 90 gm

∴ % of coarser fraction retained in #4 = $\frac{15 \times 90}{0.9}$ gm

= 16.65 gm

this is less than 50% of 90 gm. So this is S.

#200 এর passing 10, ∴ fines 5-12%, so dual classification

Now classifications can be SW-SM
SW-SC
SP-SM
SP-SC

এগুলোর এটা, so go to grain size & plasticity

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$\therefore Cu = \frac{D_{60}}{D_{10}} = \frac{0.425}{0.075} = 5.67$

$C_z = \frac{0.149^2}{0.425 \times 0.075} = 0.69$

so $Cu \geq 6$ না & $1 < C_z < 3$ না, so not well graded.

So we know SP

PI $= 0.73(65-20) = 32.85 = 32.9$ (on A line)

Determine PI $= LL - PL = 65 - 25 = 40$

40 lies above A line. $\therefore$ the sample is clay

$\therefore$ The soil is **SP-SC**

ASSTHO classification system:

Suppose data given of previous math and

% passing # 10 = 70

ASSTHO used for pavement design,

1) Granular material
2) silt - clay material

ASSTHO এ symbol দিয়ে classified.

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A-1 to A-8, এই ৮টা classification.

একটা একটা করে একটা বাক্যের জন্য ভাল

(better) A-1 ← A-1-a, A-1-b

A-2 → A-2-4, A-2-5, A-2-6, A-2-7

A-3

A-1, A-2, A-3 → Granular material

silt-clay material → A-4 ⋮ A-7 → A-7-5, A-7-6

A-8 ⟶ reserved for organic soil

A-1 থেকে A-7 for inorganic soil.

⊛ Chart এ A-1 এর পর A-3.

A এর number যত বড় তত ভাল soil.

⊛ For classification basis

% passing #10
#40
#200

LL
PL
} এই ৩টা data judge

⊛ Given data এ previous math & chart compare

Non plastic হলে LL & PL can't be determined.

So the soil is A-2-7, (যেকোন ১টা criteria meet না করলে discard)

For A-7-5, A-7-6 আলাদা ~~notation~~ note আছে,

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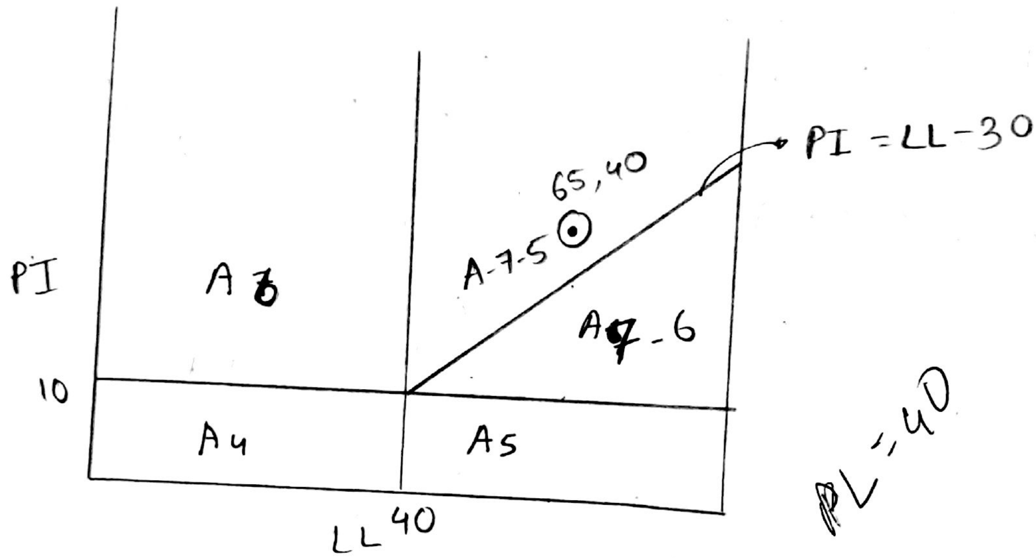
35 or less passing through # 200 is called (granular material)

যখনই দেখব granular তখন A_1, A_2, A_3

silt clay হলে plasticity chart



if silt & clay LL = 65 PI = 40

(65, 40) put করব, so 40 is above 35,

so A-7-5

PI = 65 - 30 = 35

31.10.15
Saturday

Lec - 10

Project দেখে বুঝতে হবে কোন classification.
ASSTHO is done for roads & airports.

Group Index:

$$GI = (F-35)[0.2 + 0.005(W_L - 40)] + 0.01(F-15)(I_p - 10)$$

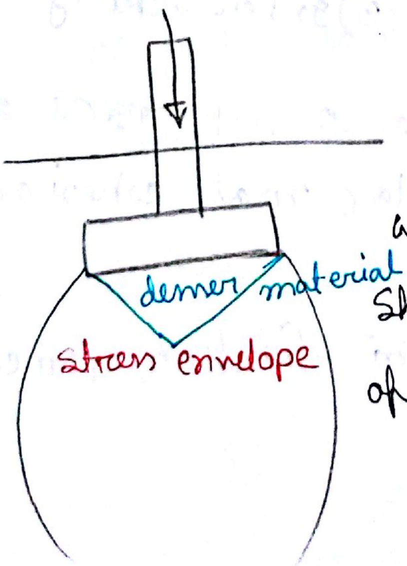
It should be round figure. It can't be negative.
For inorganic its 0 - 20 usually. But অন্য value ও হতে পারে।

GI = 0 : Best soil GI↑ worse soil
GI = 20 : worse "

A 2-6 A-2-7 বাদের অংশে GI partial use হবে। 0.01(F-15)(Ip-10)

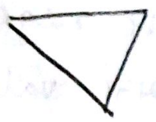
GI is stated in parenthesis. Like A-3 (10) → GI

Chapter-7

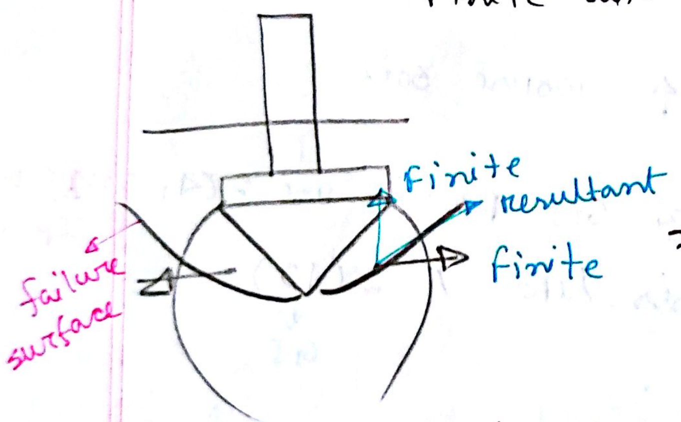


Footing is loaded, soil এ granular material থাকলে soil in contact with footing will be stressed. এই পার্টিকেলগুলো shift করবে, এভাবে propagation of stress over area হবে।

এই load certain area তে পড়লেও propagation এর জন্য area stressed to infinity. But envelop of stress এ stress significant. এখানে area different stress deliver করার জন্য soil particles load (roll) over each other, so fail করে।

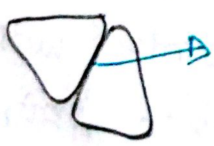


এই wedge নিচে যেতে soil কে pressure দিবে। so ⊲— —⊳ এভাবে move করবে। finite distance এ move করবে φ.



Failure surface plane বললেও actually curve. যত দেরিতে fail তত ভাল strength.

Strength criteria 3 : i) cohesion
ii) friction
3) Interlocking



এ surface এ roll করতে হলে bonding betn similar mat cohesion overcome করতে হবে।

grain smooth না হলে friction force develope করবে।

$F = \mu N = N \tan\phi$

μ → co-efficient of friction

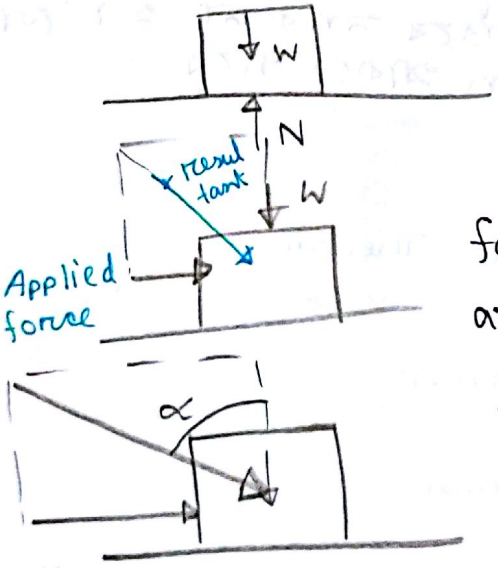
ϕ → friction Angle

roll করতে হলে distance travelled, no energy লাগবে, এর interlocking.

length of contact বেশি হলে বেশি interlocking.

friction:

N should be = W



with the increase of horizontal force so vertical এর সাথের angle ∝ increase বাড়বে.

vertical force এর সাথে resultant এর angle বাড়বে that is called angle of obliquity.

impending motion হলে angle of friction.

In case of angle of obliquity movement হবে না.

cohesion:

surface এ -ve charge. Fine grain soil হলে -ve charge এ. Nature এ H_2O. Flaky particle -ve charge carry করে.

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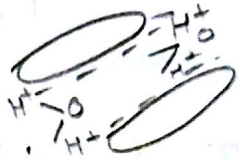
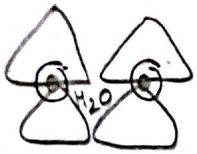
if H_2O is there



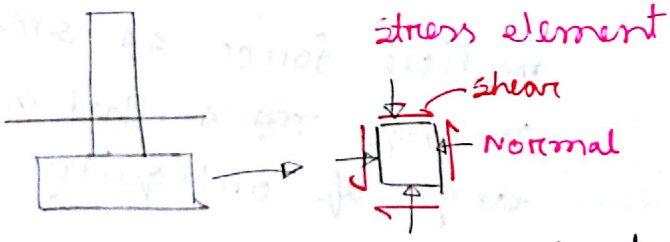
in fine grain soil cohesion is prominent.

In coarse " " " " not "



00 tremendous stress. তাদের H_2O এ তেমন stress নাই। pore pressure etc Depending on H_2O content, soil stress দিতে পারবে নাকি না এটা বোঝা যাবে, clayey soil হলে cohesion থাকতে পারে

Mohr – Coulomb failure Theory :



if we know normal & shear stresses then we can draw a circle.

According to Mohr কোন particular plane এ fail করলে failure angle তাননে ঐ plane এর N & shear stress must lie on the circumfarance of the circle.

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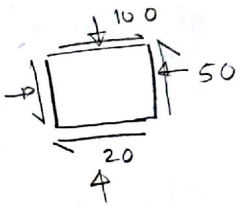
Mohr Circle Diagram:

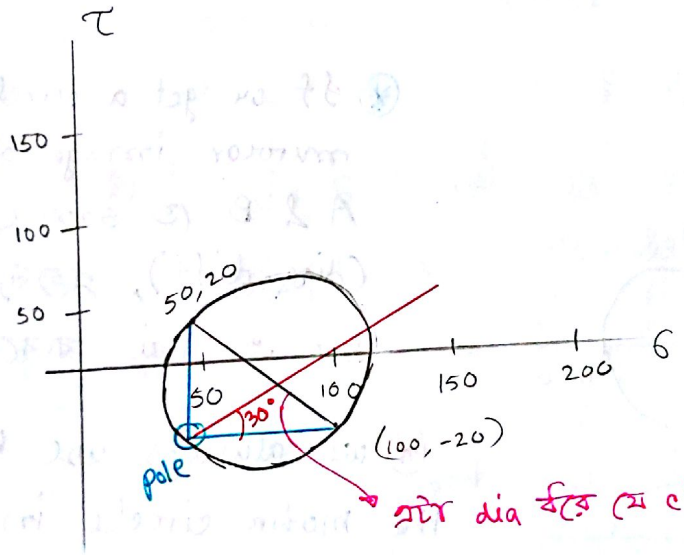
soil এ most of the load compressive. This is (+ve).

counter clockwise = (+ve)

Shear

σ, τ plane. in same scale





consider two orthogonal plane

in horizontal plane (100, -20)

↓ counter clockwise

In verticle (50, -20)

~~যার~~ dia ~~বরে~~ যে circle → pole of the Mohr Circle / ~~centre of~~ controling point

100, -20 acts on a horizontal plane, যা parallel এ line

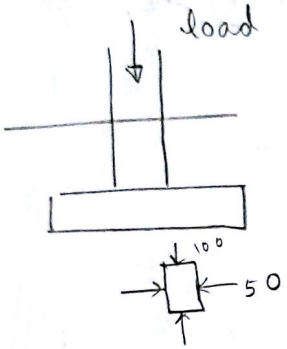
50, 20 " " a verticle plane, যা " এ line.

Intersection যে pole of Mohr circle

30° করে horizontal যা আরেক plane

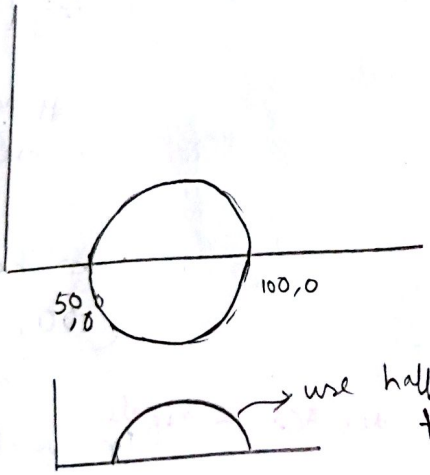
4.11.15
Wednesday

Lec - 11



soil granular হলে lateral force থাকবে on stress element

if no shear then we call it principal stress



(*) If we get a circle which is mirror image of x axis A & B তে same shear (dir. diff), কিন্তু কোন dir. এ fail করবে বলা diff.

(*) we always use half or the mohr circle in soil mecha. Cause এর point এর opposite shear ও থাকবে।

Mohr Coulumb Failure theory:

$$\tau = c + \sigma \tan\phi$$

c → intersection of y

ϕ → slope angle

c & ϕ → shear strength parameter

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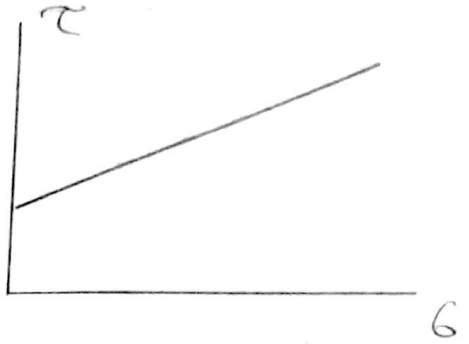
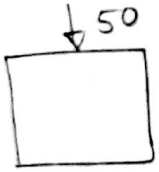
Mohr circle failure stresses on the circumferance, coulumb failure stress particular plane এ shown by st. line.



So circle satisfy করতে the st. line must be a tangent on the mohr circle.



$\tau_f = c + \sigma_f \tan\phi$

So জানা, So σ_f জানা, to determine τ_f we need to known → c & ϕ

c → apparent coherion

ϕ → apparent angle of internal friction.

Date. of shear strength parameter:

করার method, we use 4 in this course.

Direct shear:

Suppose normal 100, shear 44. particular plane a failure

Again N = 200, τ = 50

N = 300, τ = 55

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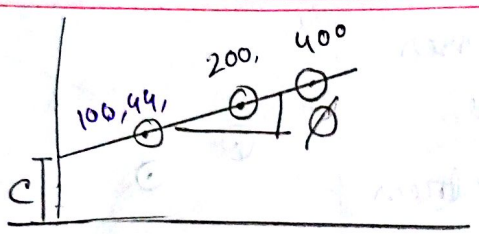
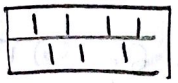
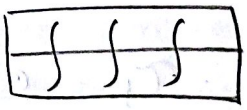


Adv → simple & quick

Disadv → particular predetermined plane ২ failure, weakest plane ২ হয়।

In case of plastic soil deformation of fiber

But shear হলে হল্ fibers এলোমেলো হলে হয় like 


এজন্য, so shear failure ⇒ false impression পাব।

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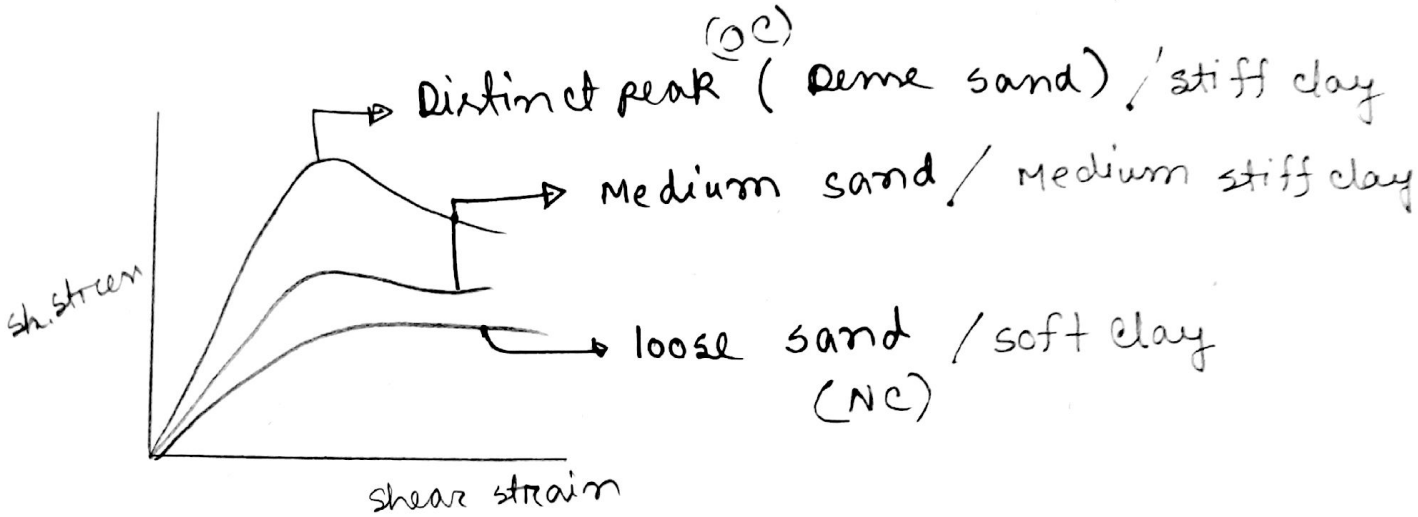
7.11.15
Saturday

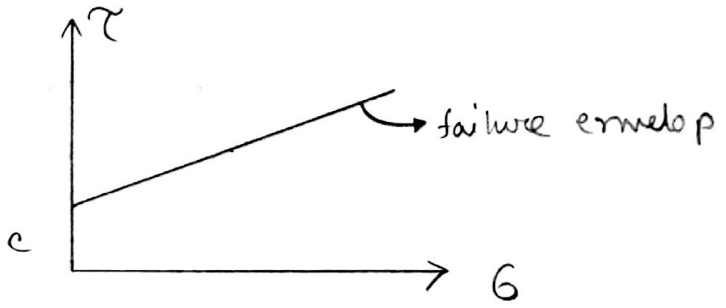
Lec - 12

continuation of last lecture:

shear gradually apply করি.

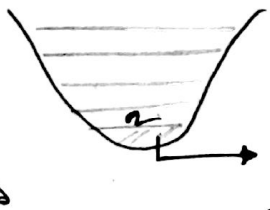


For clayey soil we use diff terms
soil এর formation এর উপর shear strength dependent



$\tau = c + \delta \tan\phi$

Alluvial soil river bed এ পাওয়া যায়.
1st এর small layer
1st এ very thin layer,
normal load বাড়ে, it was
like slurry
থাকে (2) deposit হলে densify হয়ে and normal
stress বাড়ে, so shear বাড়ে.



1st layer এ history
of stress

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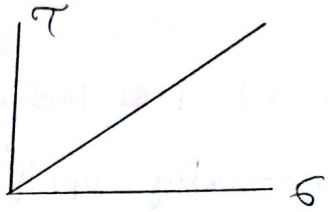
যে soil টার কোন point of time এর v. load তার জীবনের max load হলে Normally consolidated soil.

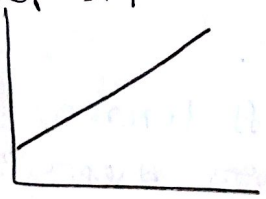


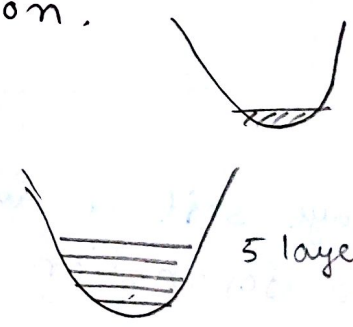
6 years এ জমা।

Geological কারণে erosion.

then single layer, এর উপর certain shear থাকবে for previous densification.

Then আবার deposit হলে





usually over consullated soil stiffer, N.C.S softer

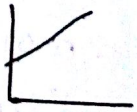
⇓

বর্তমানে যে stress তার চেয়ে বেশি stress নিতে পারত, cause এখন উপরে 4টা layer. আগে 5 টা ছিল.

Then যেকোনো একটা উপরে add হবে layer and 5th layer then - N.C. এর পরের যত additional load হলে N.C.

Normal applied loads যদি N.C. এর range এ থাকে then

if N. load over C এর range এ থাকে



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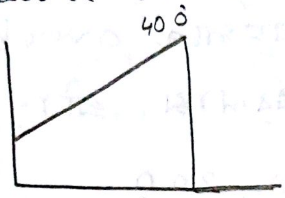
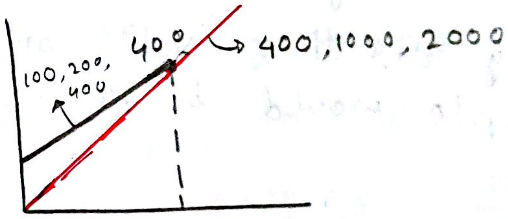
Maximum past pressure / over consolidation pressure

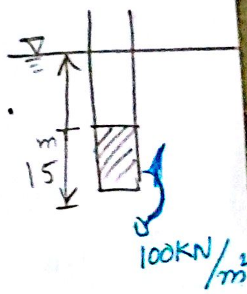
100, 200, 400 N load তার ওপরে max^m load না হলে line



400 max^m হলে
if 400, 1000, 2000 দিয়ে কাজ করি then line passes through origin:



Foundation এর নিচে soil থাকে N.C.
ওটা নিয়ে lab এ আনলে O.C cause no V. load.
so all the soil samples in lab are O.C.

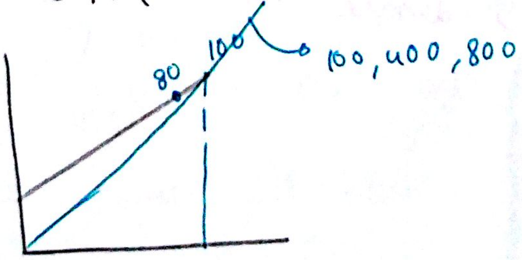


Soil এর Bulk unit wt 16 − 20 KN/m^2

Effective unit wt 16 − 9.81 = 6 KN/m^2
⇓
H_2O এর unit wt

so 15^m এ around 100 KN/m^2 Effective verticle pressure

then lab এ আনলে 20, 40, 80 load দেই then

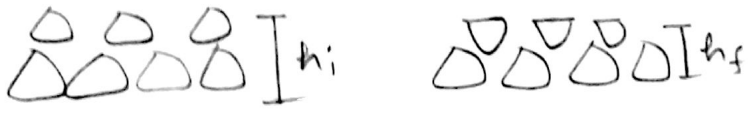


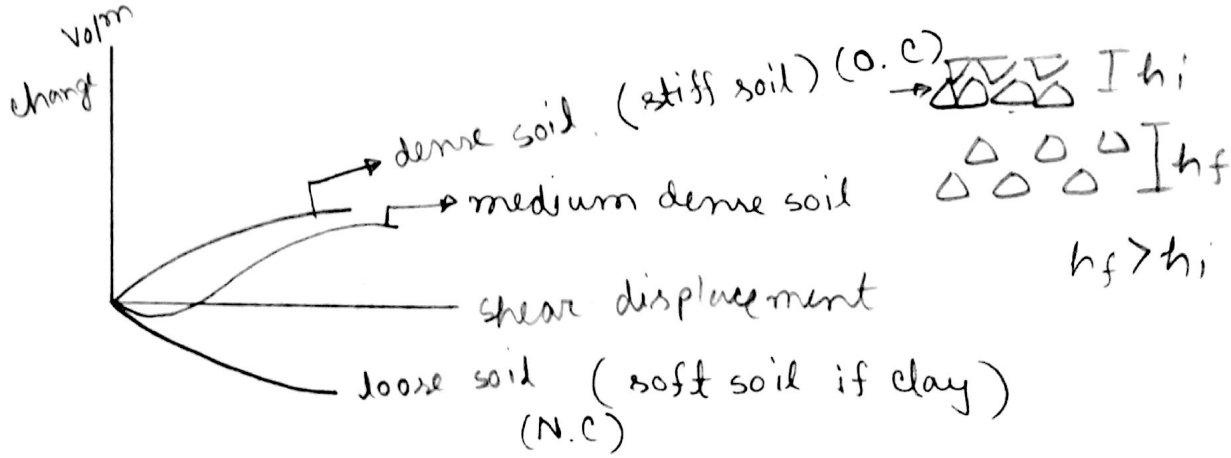
if test 100, 400, 800 load দিয়ে করি then origin দিয়ে pass

cause H_2O table উপরনামা করে।

(*) Exact pressure পাওয়া সম্ভব না, কাছাকাছি রেখে rounding করব,
testing এর সময় বর্তমান overburden pressure এর ৩০, ৫০ 100 বিবেচনা। এটার ½ & ২গুণ use করব, so 50, 50, 100, 200

soil initially loose থাকে & shear displacement apply করি then vol^m or the height of the soil sample would be reduced.





Q. Typical vol^m change shear displacement dia for N.C, O.C, loose, dense ... ?

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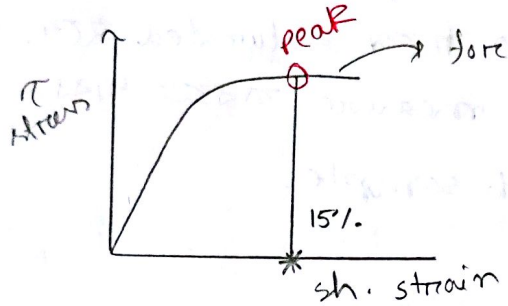
If a soil is loose / soft & district pick করতে না, so 15% strain এর reading of stress এর peak.



soil এ H_2O থাকলে softer mat & strength কমে. প্রত্যন্ত saturated করে নেই, But the prob is we can't known if it is fully saturated, so Degree of saturation থাকে না.

To overcome these disadvantages এর test.

Field এ v. load থাকে, so lateral load ও থাকবে (may be 2 side দিয়ে), But এ direct shear এ lateral load এর value জানা যায় না.

For all these do direct shear Test.

Direct Shear Test : ৩টি specimen used.

cylindrical soil sample. Dia = 38 mm L = 75 mm

Field থেকে collect করা হয় by sampler.

we want to saturate it, but তাহলে shape নষ্ট হয়ে যাবে.

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so sample তৈরি করার পর filter paper দিব trap করে rubber membrane দিয়ে fully encared, so H_2O যাবে না, But ২ পর্ব & নিচে H_2O দিলে saturated হবে, এখন থেকে degree of saturation measure করতে পারব, 3য় connection with sample.

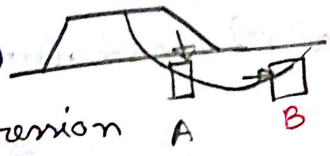
11.11.15
Wednesday

Lec-13

Direct Shear Test (continued):

২ ভাবে fail করান যায় by verticle & by horizontal load.
(⇓ Triaxial ~~direct shear~~ compression; ⇓ ~~direct shear~~ Extension)

Triaxial
- compression
- Extension (not very common)

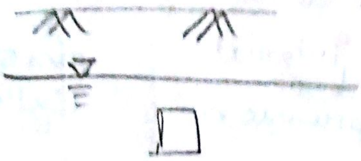


A fails in verticle load, so compression

B তে horizontally fail করান হচ্ছে though the verticle load is constant. pressure দিব তা equal (cell pressure). এটা
cell কে ভরাব, cell এ যে loading ram দিয়ে load দেব,
soil sample এ যাবে।
Here we can make the soil sample saturated.
Bottom & top এর ২টা connection কে water sample এর সাথে connect করব।
এটা হল back pressure.
সরাসরি অনেক pressure দিয়ে saturated করার try করলে crack form করবে, so balance by back pressure.

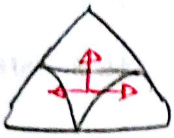
Saturated হলেই triaxial test.

construction stage } both case এ excess pore H_2O
loading " } pressure হবে।



A তে H_2O pressure হল static pore " ".

এর উপর extra load দিলে excess pore H_2O pressure হবেই concern.



এখানে extra pore H_2O p ঢুকতে দেবে, so উপরে উঠবে।

Depending on two stages

1) consolidation (in construction stage) – Consolidated

2) Drainage (in loading ") – Drained

H_2O এ যেকোন pressure develop করলে leakage হতে চাইবে, interparticular gap দিয়ে পানি ~~...~~ বের হবে so expulsion of H_2O & E.P H_2O p. decrease করবে।

Drainage ও একই as consolidation, just to diff the stages এই name.

(*) Triaxial test 3 divisions:

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1) Unconsolidated Undrained — UU Test - Quick Test — Q Test

2) Consolidated Undrained — CU Test — R Test

3) Consolidated drained — CD Test - slow Test - S test

we don't want the P. H_2O pressure to decipate.
so fast load apply করতে হবে, তাহলে UU present
so quick test

CD → Slow load apply করি যেন H_2O decipit করে

Soil sample saturation না করে construction না load
দেব cell pressure দিতে হবে।
Extra load টা দিব তবে দিবে।
If we want Q Test then top & bottom connection
close করব, so H_2O বের হতে পারবে না।

R-Test : construction করেবে slow এবং consolidated
loading fast দিলে undrained.
Undrained হলে connection of H_2O tube closed.
Drained " " " " open.

(*) cell pressure apply করে construction stage stimulate করব and তাহলে H_2O tube খোলা, তাহলে consolidated হবে।

(*) water expell হচ্ছে নাকি বুঝতে drainage tube এ burette লাগাব, তাহলে H_2O এর পরিমাণ determine করতে পারি, usually takes 2 days for total drainage according to cell pressure.

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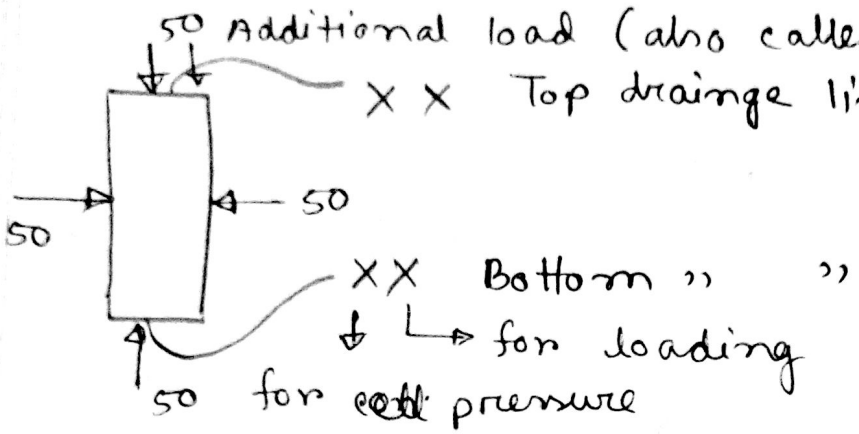
Unconsolidated Undrained Test :

All the test need 3 specimen.



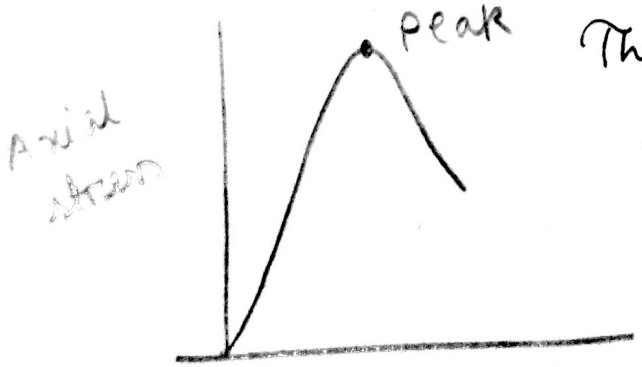
খারাপ saturated কাদা মিটে হয়, 90-95% saturated হলেই হয়, we can check if it's saturated.

Cell pressure applied 50, all around pressure same

laterally pressure দিলেও vertically ও 3 same pressure থাকবে

Saturated কাদার যত drainage হতে না দিলে pressure দিলে no Vol^m change.

Progressively additional load দেয়।



This graph is for only Additional stress

↳ measured with strain gage

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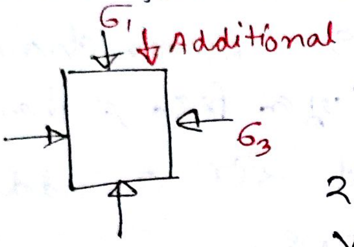
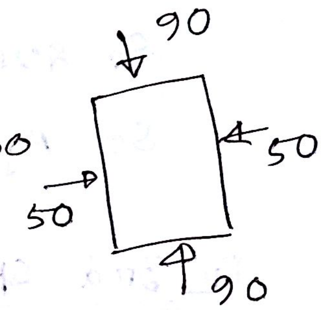
At the failure যখন load working



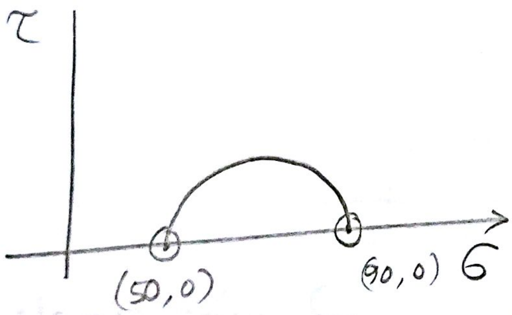
এখানে V. দিক থেকে cause করে additional চাপ লাগছে।
যখন principal stress দুটো হচ্ছে
V. দিক থেকে so σ_1
H দিক σ_3

$\sigma_1 = \sigma_3 + \Delta\sigma$

σ_3 → cell pressure; $\Delta\sigma$ → deviator stress



suppose Add. load needed 40, লাগল 50. so



So the diameter of the Mohr circle হবে 40.

$\sigma_1 = 90$

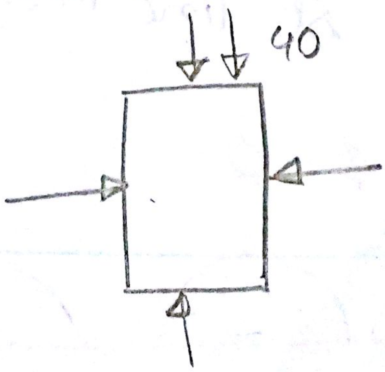
$\therefore \sigma_1 = \sigma_3 + \Delta\sigma$

$\Rightarrow 90 = 50 + \boxed{40}$

so Diameter of the mohr circle = deviator stress

2nd specimen:

Top & bottom drainage line closed



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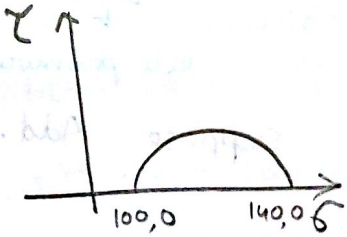
Sample ① & ② ৯ vol^m same as drainage line closed and saturated. So no change in density. [drainage line খুলে দিলে ρ change হবে]
So same density এর mat. হবে এ additional load ৯ fail করবে তাই same.

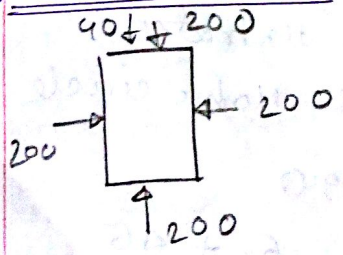
Additional load is a function of density.

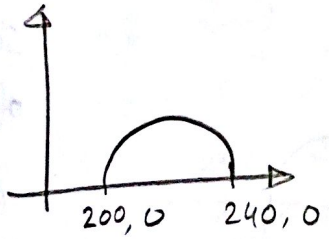
So এক্ষেত্রেও add load 40.

So Again Mohr circles dia 40.

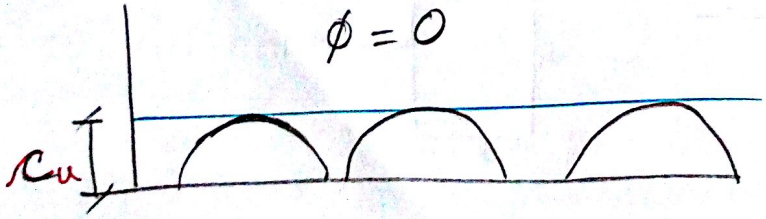


☐ 3rd specimen:





Mohr করলে failure stress এর তার circle এর circumfarance এ আসবে,
coulumb করলে st line দিয়ে represented



As we get this c পাচ্ছি for undrained condition

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in both cases we call it c_u.

So in UU Test the only parameter we get is c_u.

যদি বলি 1 week a embankment বানাব then the parameter will be c_u.

আবার অনেক time ধরে বানালে অন্য parameter.

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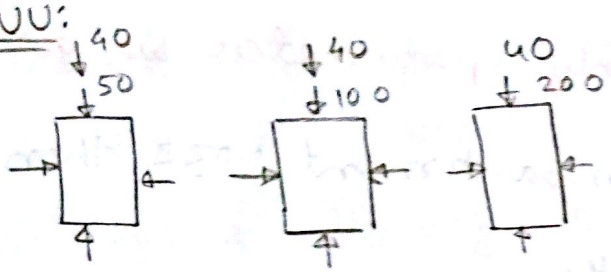
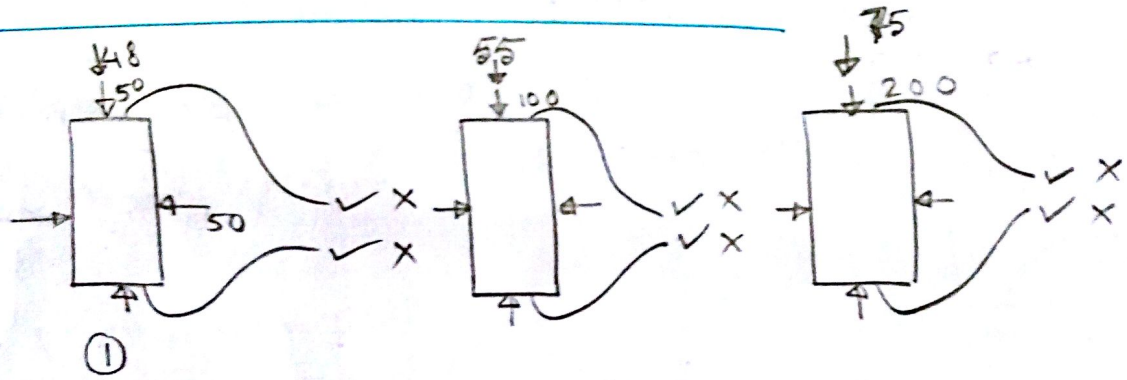
14.11.15
Saturday

Lec - 14

UU:



Consolidated Undrained Test (CU) : 5 - 15 min time লাগে।



①

consolidated undrained -- fail.

cell pressure apply করা time এ top & bottow H_2O line open.

water বের হবে, so vol^m change হবে।

Then additional load, then H_2O line closed.

(*) strength is a function of density

water expelled হওয়ায় vol^m কমে যাবে, so ρ↑, so the load needed will be higher.

(*) 100 কিপা pres করলে ρ↑ আরও বেশি than 50, so load আরও ↑ লাগবে।

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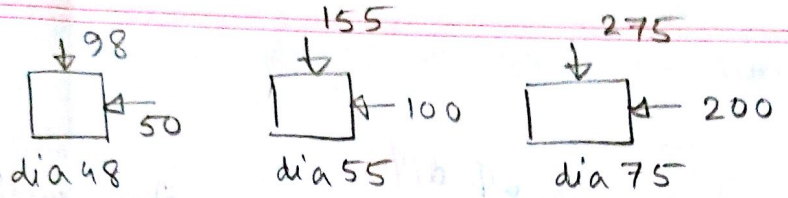
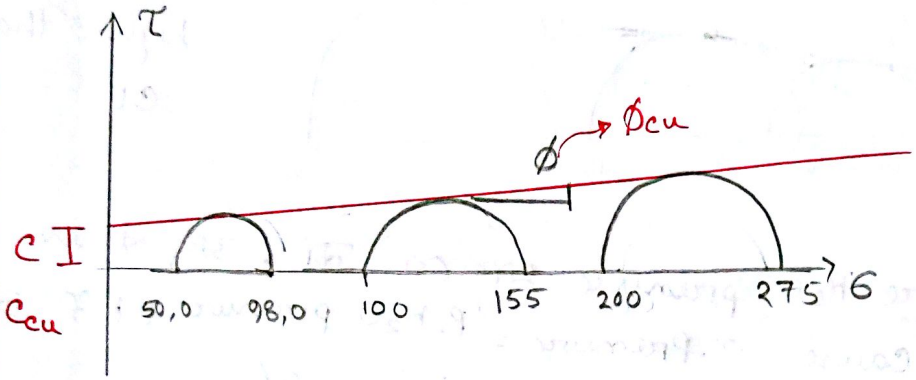
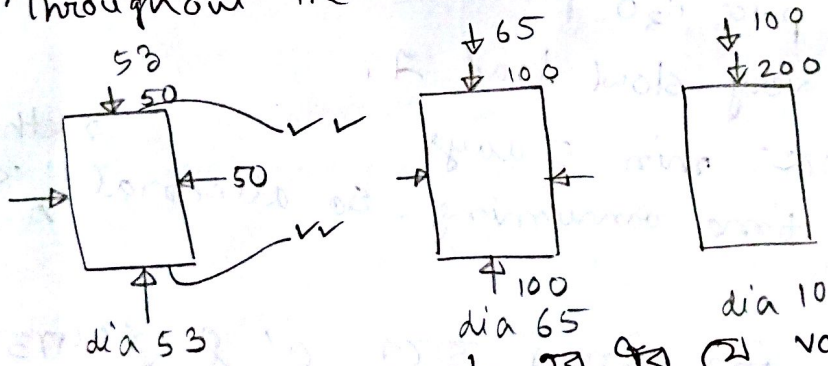




CD Test : S test :

Throughout the test H_2O line open



1st এ cell pressure apply করে কিছু volm change CU এর 1st টার্ন অবস্থান।

Now add load এ H_2O line open, তখন H_2O এ excess pore H_2O pressure develop করবে and H_2O বের হতে থাকবে and at a point fail করবে, Now failed condition এ থাকে CU এর 1st এর চেয়ে ρ ↑.

so load ↑ নিবে।

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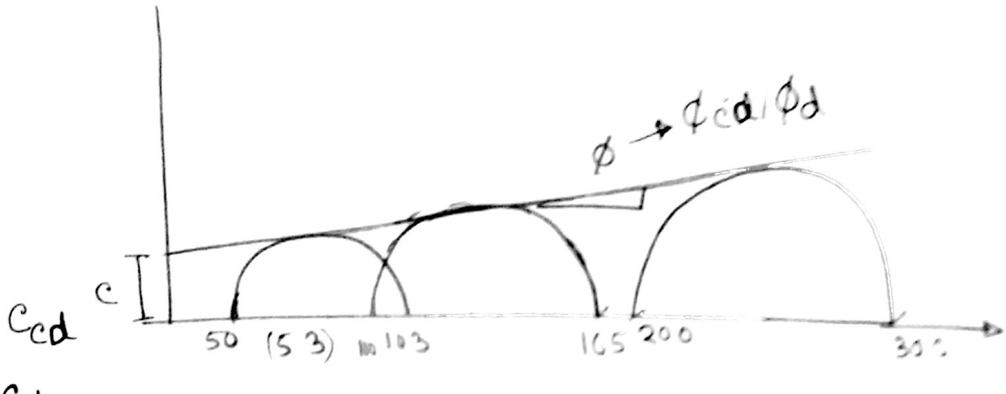

Slope will be higher than CU.

Cd

এখানে pore H_2O pressure থাকবে না, তাই stress effective. cause T. Pressure = P. H_2O pressure + Eff. stress
So we call it effective cohesion c′
" angle of friction φ′

Drained মানে pore H_2O pressure develop করবে না, so fail করাই very slow load এ।
এভাবে fail করাতে min 5 days.
so এটা অনেক time consuming. So alternate method করা যায়

(*) con. Undrained ভিন্ন উপায়ে করে c′ & φ′ পাওয়া যায়, Here 3 days সময় save করা যায়।

Bottom এ ২টা connection ছিল, এর মধ্যে ১টা বন্ধ ছিল by pressure Transducer.
CU এ deviator stress এর জন্য pore pressure হবে, এ pore pressure can be measured by pressure transducer.

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pore pressure all around. so horizontaly 3 reduced হবে,

Suppose CU এ 1st এ P.P = 5

(Eff. stress)

$\sigma_1 = \sigma_3 + \Delta\sigma$

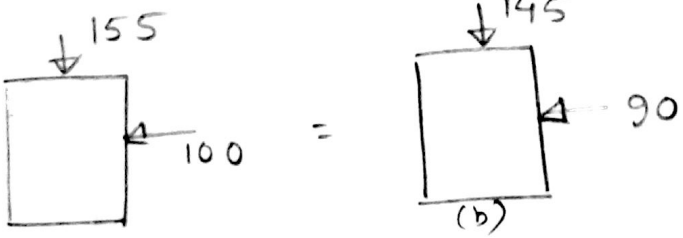
$\Rightarrow \Delta\sigma = \sigma_1 - \sigma_3$

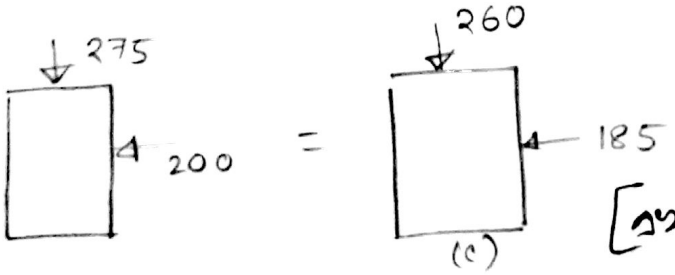
$= 93 - 45$

$= 48$

2nd টায় dia same but it will go to left by 5 ⟶

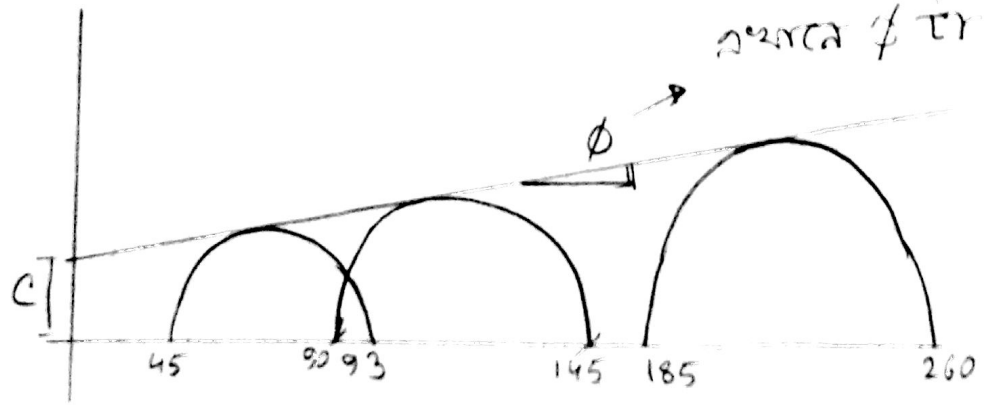
vol^m কম হলে pore এর size ছোট, তাতে compress করবি, so 2nd টায় PP 4. Let it be 10





[Eff stress = T.S − P.P]

[এখানে PP = 15 হলে এটা]



এখানে ϕ এর মান বাড়ে

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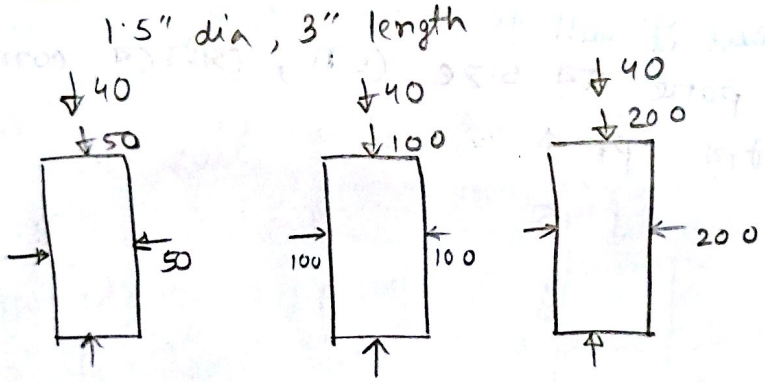
C ↑ or ↓ যেকোনটা একটা হতে পারে depending on the 1st circle. অন্যগুলোর dia আগের মত just shifts to left by 5, 10, 15

✱ CU test with pore pressure measurement.
written as $\overline{CU}$ or CU Bar

Unconfined Compression Test:



UU এর অসুবিধা always 40 লাগছে, 0 দিলেও 40 ই আসবে, so এত বারবেলার দরকার ছিল না. But 3 বার load দেই saturation আসতে.

I) If we are sure that the soil is saturated then এটা বারার দরকার নাই,

II) আবার H_2O line বন্ধ রেখে বললাম water can't expell out → এই ,, ,, না করে যদি অনেক fast fail করাই তাহলেও H_2O can't expell out.

so Unconfined com. এর যে condition/assumption

1) soil must be cohesive
2) soil ,, saturated

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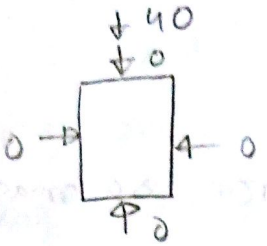
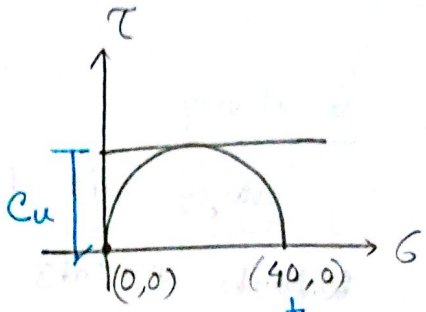
এই test এ cell pressure zero



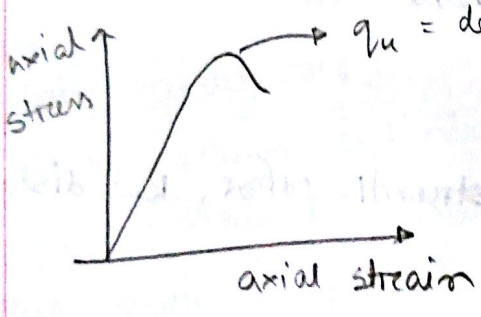
(40, 0) in H. plane

(0, 0) in V. plane



যত cell pressure এ নেই dia 40 and line Horizontal হবে, so এটা circle দিয়েই আঁকি,

$\therefore Cu = \frac{q_u}{2}$



Q. Shear strain parameter by unconfined com. test is $\frac{q_u}{2}$?

(*) যতই বলি same value আর but slight diff আসবে, suppose $q_{u_1}, q_{u_2}, q_{u_3}$, avg নিয়া যাবে না, judgement apply করতে হবে যে কোন এবং কোনটা নিব, যদি $q_{u_1}, q_{u_2}, q_{u_3}$ কাছাকাছি হয় then we can take an average.

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18.11.15
Wednesday

Lec-15

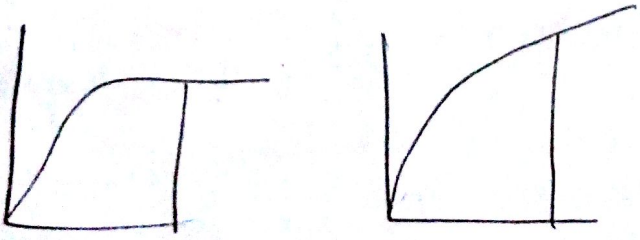
Sensitivity:

clayey soil flaky, electric charge আছে, so magnetic. Disturb করলেও same orientation এ থাকে।
যদি soil disturbed হলে strength কি পরিমান change হবে.
if $S < 2$ then ok, >2 হলে diff consideration.
excavation এর time এ movement অনেক হলে problem & then consider sensitivity

Quick clay → undisturbed হলে strenth বেশি, But disturb হলেই settle করবে.
clayey soil magnetic হওয়ায় time allow করলে strength gain করে.
এজন্য no time delay. Remold করার আগে আগে test.

Q. What is Thixotropy?
Regaining strength for reorientation of particle.

* যদি peak না থাকে / increases then 15%. strain এর stress



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Condition of unconfined consolidation test:

soil must be clay

soil must be saturated

clay হতে হবে যেন নিজে stand করতে পারে.

যদি visually soil sample এ crack থাকে then go for UU test.

Vain Shear Test:

It can be done both for field and lab.

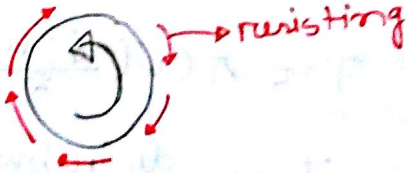
vain inserted করে rotate করলে fails in 3 planes.

Top, bottom, cylindrical.

1st এ resist করবে, so applied torque measure.

We know applied torque = resisting torque

Section of cylindrical surface



⇒ Clay soil, undrained (as very quick loading)

for undrained con. $\phi = 0$ then $\tau = c + \sigma \tan\phi$

$\therefore \tau = C_u$

↓ force per area

If dia d, height H

$\therefore$ Area = $\pi DH \cdot C_u$ (force on surface)

$\therefore$ Moment = $\pi DH \cdot D/2 \cdot C_u$ (resisting moment of the surface)

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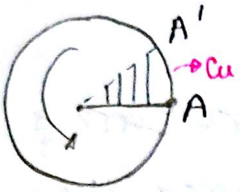
* Resistance at surface and top, bottom edge এ

Resisting moment at edge :



centre এ displacement 0

যে particular moment এ fail there will be max^m displacement. So point A will go to A'

so AA' এর জন্য failure.

ধরব triangular distribution নাও হতে পারে, we never know the dis. of strength on the surface.

(*) rod এর area বাদ নেই

(*) distribution এর উপর a depends

for △ $a = 1/2$

for paraboll a =

$$T = \pi C_u\left(\frac{d^2h}{2} + \frac{ad^3}{4}\right)$$

uniform distribution হলে $a = 2/3$

$$\therefore T = \pi C_u\left(\frac{d^2h}{2} + \frac{2}{3}\,d^3/4\right)$$

$$= \pi C_u\left(d^2h/2 + d^3/6\right)$$

Mostly $h = 2d$

$$= \pi C_u\left(\frac{d^2 \times 2d}{2} + d^3/6\right)$$

$$= \frac{7\pi C_u d^3}{6}$$

$$\therefore C_u = 6T/7\pi d^3$$

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Applied torque জানলেই Cu জানা যাবে.

Exam এ derivation, integration করে $T = \pi C_u \left(\frac{d^2 h}{2} + \frac{a d^3}{4}\right)$ এটা derive করতে হবে। [See from book]

Pore H_2O pressure:

no derivation needed.

$\Delta u = u_3 + u_1$

$= B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$

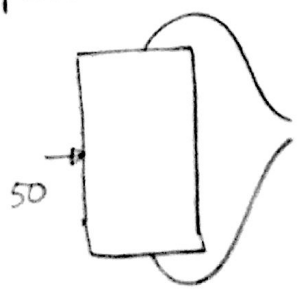
2 ভাবে p.w.p develops → 1) when apply cell pressure
2) when apply additional load

σ_3 = change in lateral pressure

যদি we apply both the cell pressure and additional load at same time then $\Delta u = \ldots$ σ_1 is change in add. load at a small time

B parameter = depends on degree of saturation of sample

A parameter = " consolidation of sample



cell pressure 50 change to 60

the p.wp = 30 p.w.p = 35

$\therefore B = \frac{35-30}{60-50} = 5/10 = 0.3$

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saturated করলাম, cell p. ↑, the increase in p.w.p. if B is from .9 to .95 then it is considered saturated practically. (প্রকৃতি theoretically saturated)

Fully saturated হলে p.w.p = 1.

⇒ p.w.p can be negetive: Highly O.C হলে highly dense হলে p.w.p decreases with application of cell pressure.

dense হলে volm ↓, so void ↓, so water আগে ছোট জায়গায় ছিল, volm ↑ করায় ওই H_2O র বেশি জায়গা নিয়ে গেলবে, so p.w. pressure will decreare.

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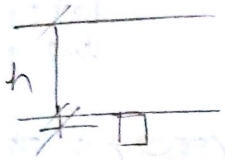
21.11.15
saturday

Lec-16

LATERAL EARTH PRESSURE

Earth pressure 2 types

1) V. pressure — for overburden, easy to determine



$h \times \gamma_{soil}$

2) Lateral E.P : $K \times \gamma h$
↳ co-eff of lateral earth pressure.

Automatically induced in soil.

Depends on: 1) Physical characteristic of soil
2) Deformation " of structure.

Soil 2 types : cohesive, cohesionless

1) So from phy. characteristic of soil — cohesionless soil / cohesive soil

if 2 parameters exist then c-ϕ soil.
of friction

2) Def. of str — i) No deformation
ii) lateral expansion (Active Earth pressure)
↓ lateral stress max^m ↑ due to shear
so failure condition taken
iii)

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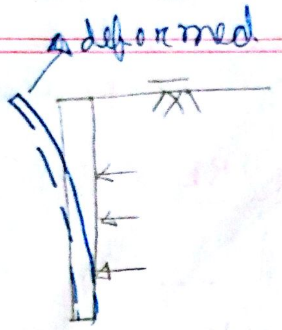
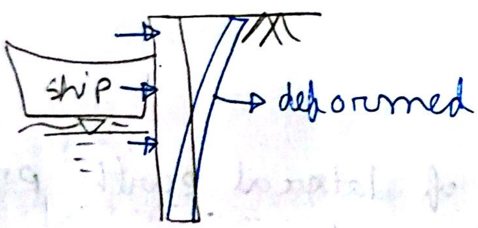


so soil side এ ধাক্কা দিবে and নিচেও যাবে।

This is lateral expansion, movement of soil outword & down

iii) Lateral contraction: (Passive earth Pressure) (Min^m lateral EP) due to shear

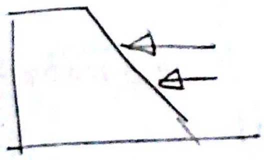
movement of soil inward & upward



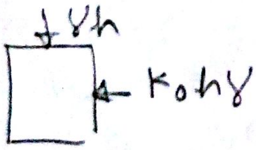
ship ভিড়লে ভেতরে ধাক্কা দিবে on retaining structure.

(*) In case of no deformation of structure, we call it earth p. at rest.

no deformation when the structure is massive



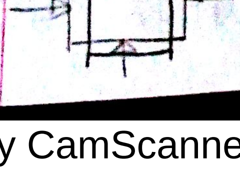
1) No Deformation:



K_0 = co-eff of earth p. at rest

2) if $K\gamma h$ reduced so the soil expands and fails at max^m shear.

K_a = co-eff of act. E.P



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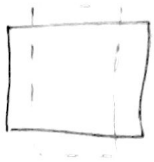
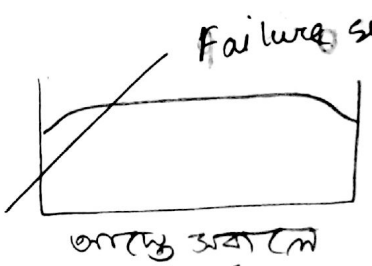
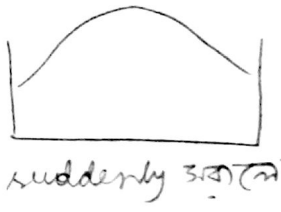
3) fails due to lateral contraction. ↑ KYh, so contract করে fail করবে,
so K_p = co-eff of passive E.P

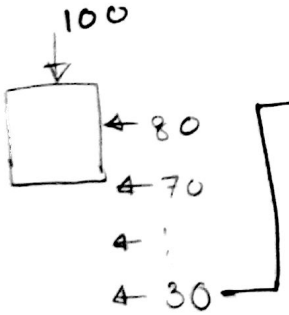


9. Defn K_o, K_p, K_a.
The ratio of Lateral E.P to V at this condition is co-eff of ~ . $K_o = \frac{K_o \gamma h}{\gamma h}$

A.E.P:
* To reduce L.E.P we can move the support apart

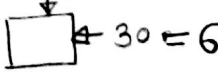




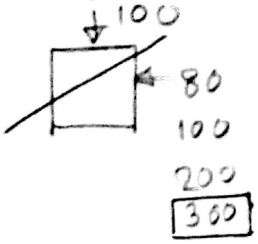


→ suppose 30 করলে failure surface develop করবে, 20, 10, 0 হলে ,, ,, থাকবে.
so max^m shear at which failure 30

∴ A.E.P = 30 ∴ $K_a = \frac{30}{100} = \boxed{63/6_1}$

At failure condition 

P.E.P:
lateral contraction ↑ fail করলে ↑ L.P.



300 ↑ L.P নিলে failure surface.
400, 500, 600 নিলেও ,, ,, থাকবে,
so the min^m shear = 300

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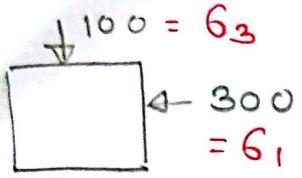
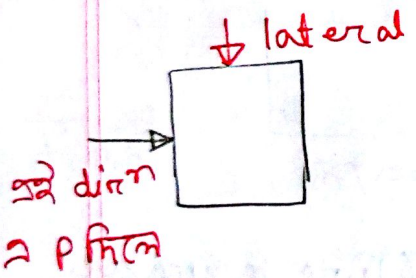
$\therefore P.E.P = 300$

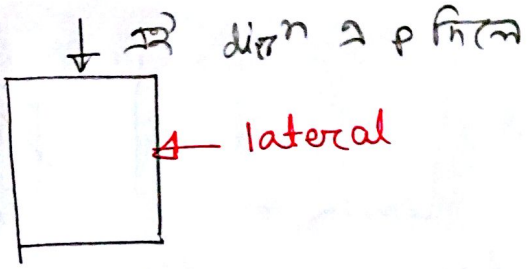
$\therefore K_p = \frac{300}{100} = 3.00 = \frac{G_1}{G_3}$



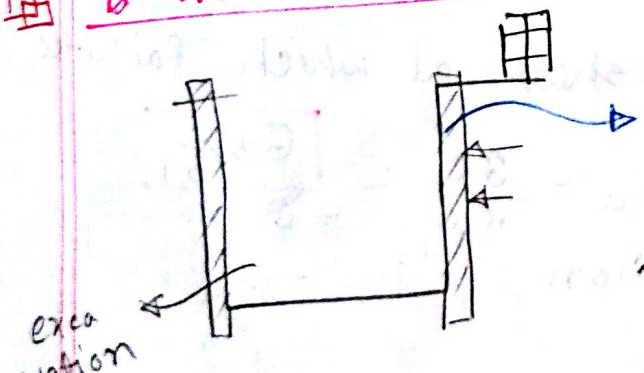
(*) Practically V. load doesn't change that much. so we are only considering lateral load.

$K_a < K_0 < K_p$





E.P at rest :

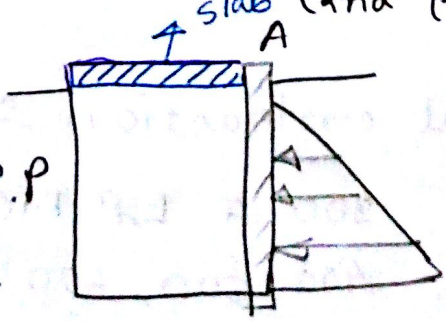


stiffness বাড়ালে moves away, so A.E.P still থাকবে E.P @ R.

so if the p is

so this will be A.E.P

cause A point free.



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যে moment এ slab বানানোর, A আটকে গেল, so E.P @ rest.

যদি A.E.P এ fail না করে অন্যান্য strutting/bracing দেয়া হয়, Then consider E.P @ Rest.

Bracing না দিলে consider A.E.P.

We don't want deformation, so want E.P @ R.

E.P @ Rest :

$\sigma_h = \sigma_3 = K_0 \sigma_v = K_0 \gamma h$ $\quad \because \sigma_v = \gamma h$

↳ vertical p.

$K_0 = \frac{\sigma_h}{\sigma_v}$

$\Rightarrow \sigma_h =$

Lateral strain $\epsilon_h = \frac{1}{E[\sigma_h - \mu(\sigma_v + \sigma_h)]}$

↓ poisons ratio

We won't allow deformation $\therefore \epsilon_h = 0$

$\sigma_h - \mu\sigma_v - \sigma_h\mu = 0$

$\Rightarrow \sigma_h(1-\mu) = \mu\sigma_v$

$\therefore \sigma_h = \frac{\mu}{1-\mu}\sigma_v$ and $\sigma_h = K_0\sigma_v$

$\therefore$ From these two $K_0 = \frac{\mu}{1-\mu}$

determination of μ is very difficult, so try to avoid it.

So we use emphirical relations.

1) ~~cohesionless~~ ~~normally consolidated~~ soil এ ϕ জানলে (sandy)

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for flat Ground surface

Jaky's formula : $K_0 = 1 - \sin\phi'$

∴ ϕ determined in drained condition. (for sandy and NC)

K_0 for over C $= (1 - \sin\phi) \cdot OCR$ → over consolidation ratio

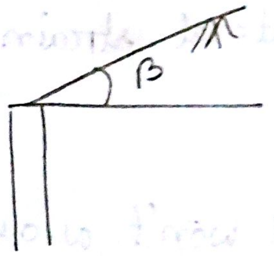
(*) If we determine LL, PL and PI : For clayey

$K_0 = 0.19 + 0.233 \log(I_P)$ (NC)

$K_{0(OC)} = K_0 \sqrt{OCR}$ (OC)

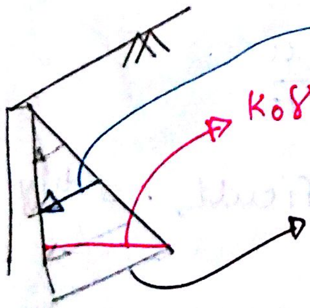
(*) If inclined soil then P ↑ [illegible]

??: $(1 + 0.5 \tan\beta)^2 K_{0(OC)} = \sqrt{OCR} \cdot K_0$



(*) L.E.P. always works parallel to earth surface

??:



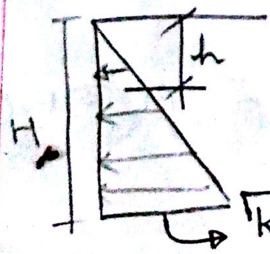
total thrust → ∴ $P_0 = \frac{1}{2} K_0 \gamma H^2 \cos\beta (1 + 0.5 \tan\beta)^2$

$K_0 \gamma H \cos\beta (1 + 0.5 \tan\beta)^2$

$K_0 \gamma H (1 + 0.5 \tan\beta)^2$

[Find hor. component of thrust → $\times \cos\beta$]

$\gamma = 16\ KN/m^3$ $h = 5m$



$K_0 = \gamma h$

∴ Total thrust [illegible] force so unit [KN]

force?? pressure maybe

$K_0 \gamma H = KN/m^2$

$\therefore$ Total thrust per unit width $= \frac{1}{2} K_o \gamma H \times H$ (KN/m² × m)

$= \frac{1}{2} K_o \gamma H^2$ KN/m

Lec -17

25.11.15
Wednesday

Earth P. Theory:

1) Rankine's theory
2) Coulombs theory

} For A & P E.P } for cohesionless and cohesive soil

And under the heading of horizontal and inclined ground surface

water Table
soil stratification
load

} Graphical method
Culmann method
2)

A.E.P

Cohesionless soil:

Rankein's theory:

→ infinite soil
homoganeous
Ground surface horizontal/inclined

most important: soil and retaining wall is contact surface vertical & smooth

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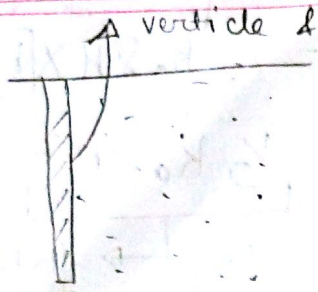
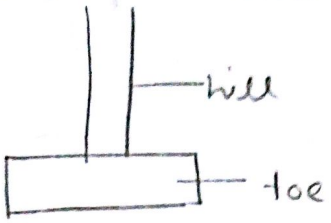
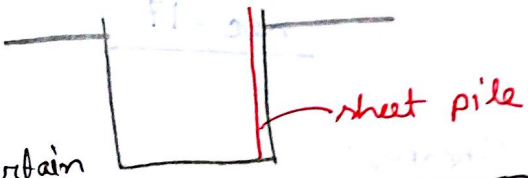
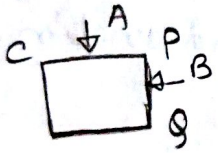




basement কাজে retaining wall design করা যায় না, তখন sheet pile / pile.

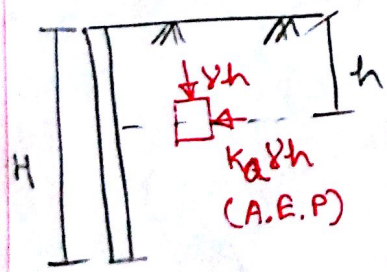


wall smooth করতে certain বাড়তি করতে হয়, plastic দিয়ে casting করলে smooth.

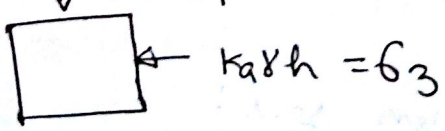
4। 

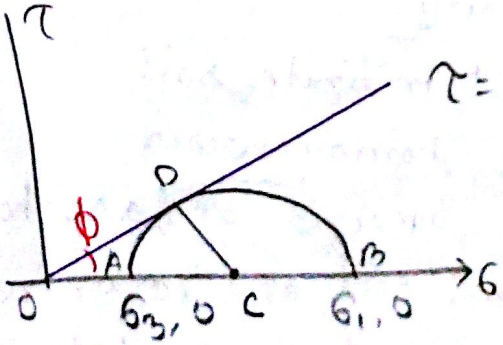
stress element এর stress A parallel to PQ
stress at B parallel to PC

Let's assume that active earth pressure prevails



$K_a\gamma h < \gamma h$





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cohesionless soil $\therefore \tau = \cancel{c}^{0} + \sigma \tan\phi$

$\therefore \tau = \sigma \tan\phi$ (failure envelop passing through origin)

$$K_a = \frac{\sigma_3}{\sigma_1} = \frac{OA}{OB} = \frac{OC - AC}{OC + BC}$$

$$= \frac{OC - CD}{OC + CD}$$

$$= \frac{OC/OC - CD/OC}{OC/OC + CD/OC} = \frac{1 - CD/OC}{1 + CD/OC} \quad (CD/OC \to \sin\phi)$$

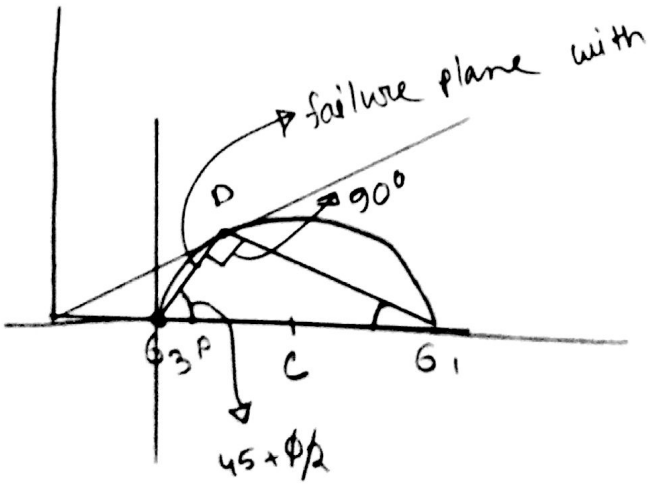
$$\therefore K_a = \frac{1 - \sin\phi}{1 + \sin\phi} = \tan^2(45° - \phi/2)$$

(*) Angles must be in degrees.

(*) **Orientation of failure plane:**

σ_1 working horizontal so —

σ_3 " vertical plane so |



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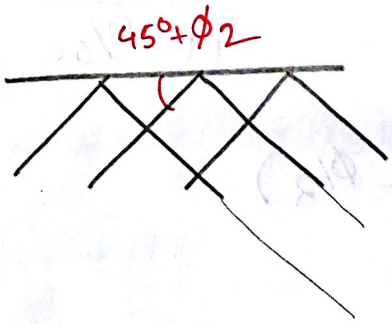
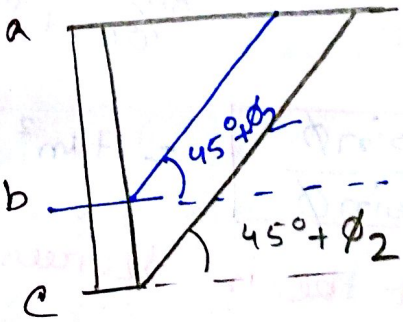
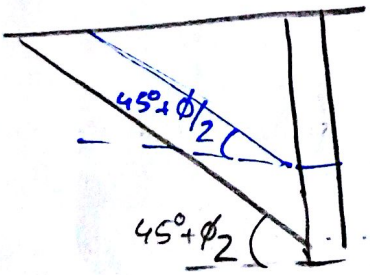
slope maintain করি cause always fails at $45° + \phi/2$

Depending on height of retaining wall failure ori. $45° + \phi/2$

Q. Draw ori. of failure plane for A.E.P







ab height হলে blue failure orientation.

ac height ,, নিচেরটা

so 2 রকমের হতে পারে failure depending position of soil.

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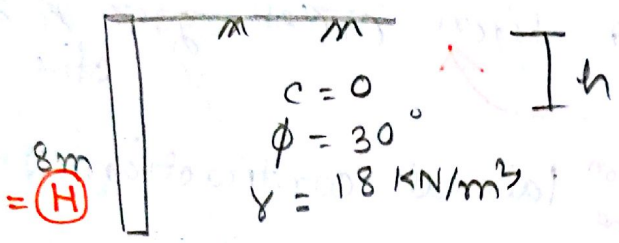
Problem:

Ac. Thrust = ?
↓
force

Active E. Pressure বলে লাগে



St-1:

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30^\circ}{1+\sin 30^\circ} = 0.333$$

St-2:

Active E.P P_a at any depth h $P_{a(h)} = K_a \gamma h$

$= 0.333 \times 18 \times h$

$= 6h$

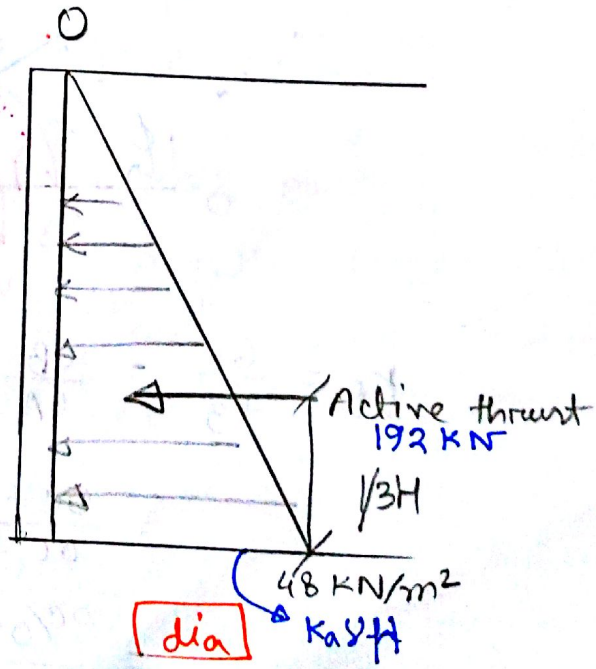
$\therefore P_{a(h)} = 6h$ (st. line eqn)

Step-3:

$P_{a(0)} = 6 \times 0 = 0$

$P_{a(8)} = 6 \times 8 = 48$ KN/m² ।

↓
it is pressure



* Area ? তখন unit length consider

$P_a = 1/2 \times 48 \times 8 = 192$ KN.
(Thrust)

$P_a = 1/2\ K_a \gamma H \times H$
$= 1/2\ K_a \gamma H^2$

} dia. এটা না দিলে বলা যায় if diagram not wanted

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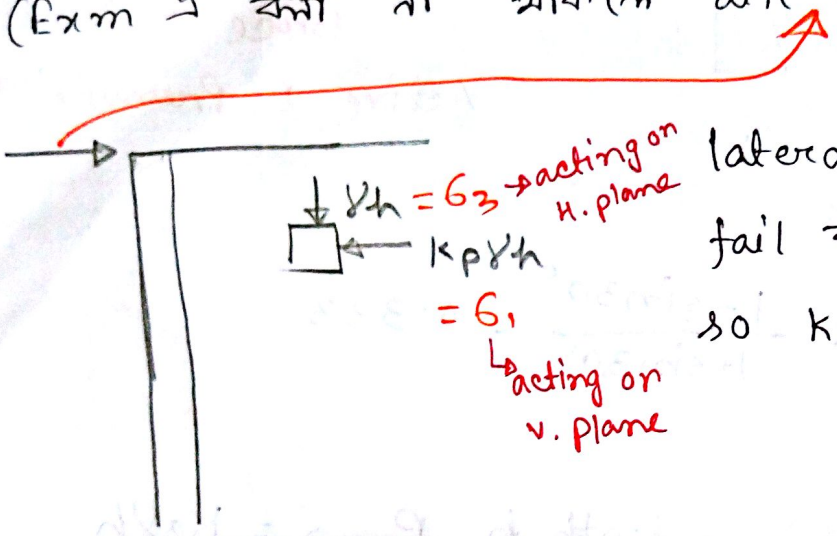
Pic-2: Passive

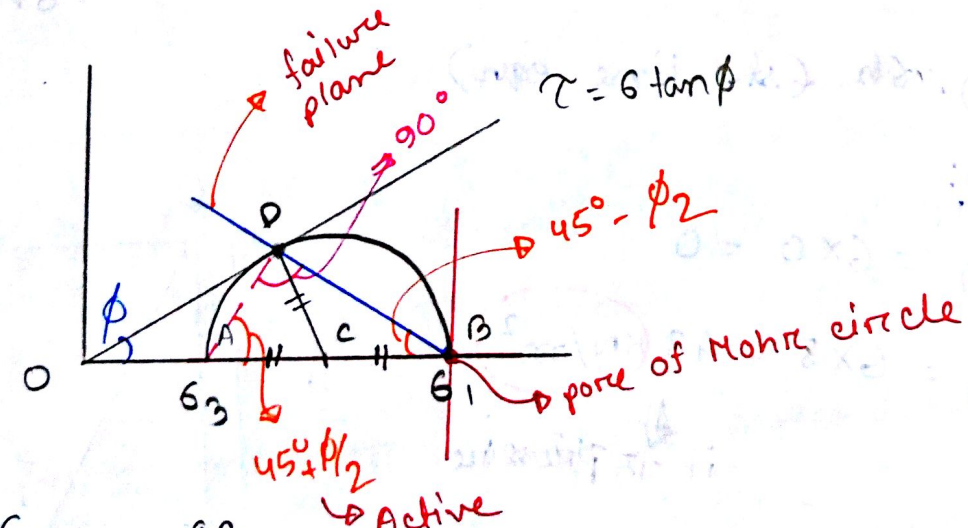
(Exm → বলা না থাকলে direction দেখে বুঝবে Active না Passive)



lateral contraction এ fail করতে হবে।

so $K_p \gamma h > \gamma h$

soil element very close to retaining wall, wall টি smooth, so downward movement এ no friction



$$K_p = \frac{\sigma_1}{\sigma_3} = \frac{OB}{OA}$$

$$= \frac{OC + BC}{OC - AC} = \frac{OC + CD}{OC - CD}$$

$$= \frac{OC/OC + CD/OC}{OC/OC - CD/OC} = \frac{1 + \sin\phi}{1 - \sin\phi} = \frac{1}{K_a}$$

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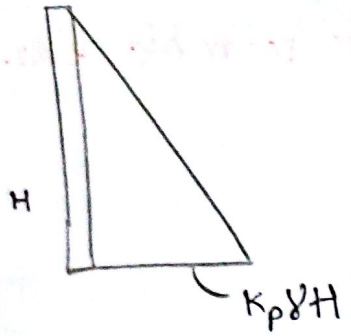
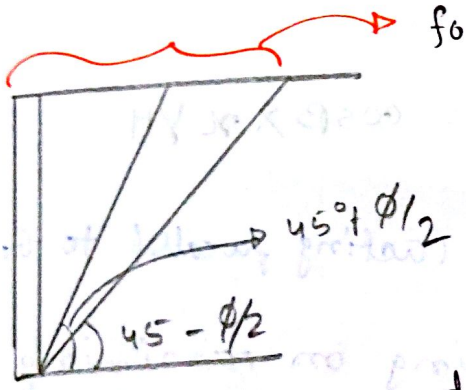
Total Thrust for P.E.P

$$P_p = \frac{1}{2} K_p \gamma H^2$$



Draw orientation of failure plane for P.E.P?

passive এ fail করতে movement এ লাগবে,

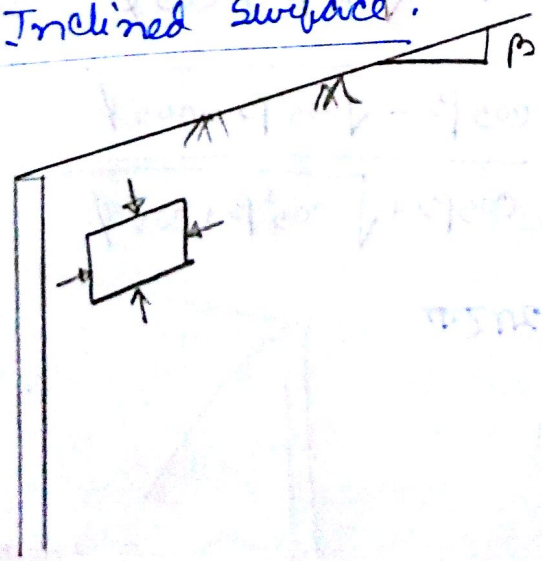


for passive, so passive এ fail করতে distance বেশি

cause failure in passive এ $45°-\phi/2$ এ fail করবে, এর achieve করতে অনেক deformation লাগবে,

Q. কাদামাটি movement & why?

A.E.P → Inclined surface:



সেক্ষেত্রে earth p. parallel to ground surface, so rombick element ছিড়ে করবে,

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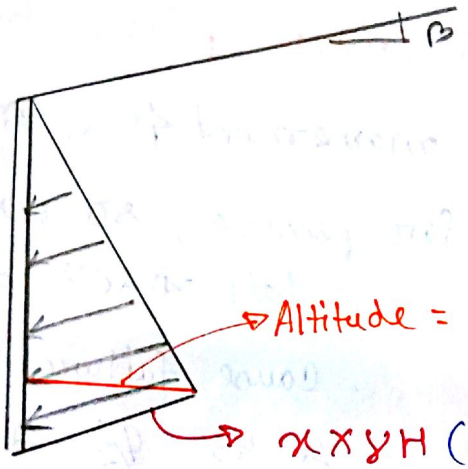
$$k_a = \left(\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta + \cos^2\phi}} \right)$$ [For rombic element]

Pressure Distribution Dia:

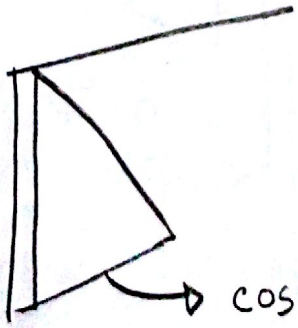


Total active thrust coming on retaining wall

$$P_a = \frac{1}{2} \cos\beta \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta + \cos^2\phi}} \gamma H . H$$

$$= \frac{1}{2} \gamma H^2 \cos\beta \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta + \cos^2\phi}}$$

(*) in most cases বলা আছে



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$P_a = 1/2\ K_a \gamma H^2$

Pressure dis. diagram ला must use γ as K_a.

Thrust ला सरकातोर can be used.

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28.11.15
Saturday

Lec - 18

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

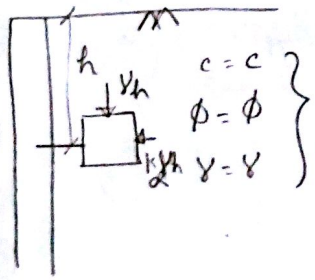
$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$

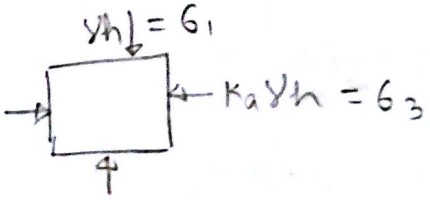
$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$$

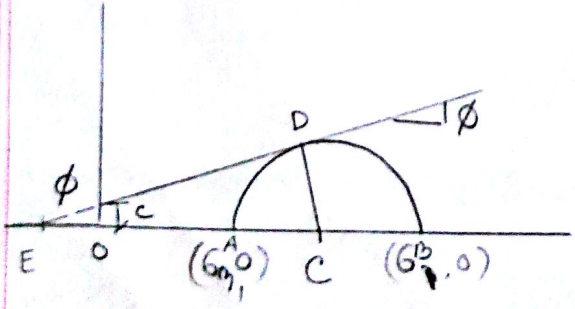
$$K_p = \frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta + \cos^2\phi}}$$

If a soil has cohesion & friction both :- $c\phi$ soil

Active condition:







$$\sin\phi = \frac{CD}{EC}$$

$$= \frac{CD}{EO + OC}$$

$$= \frac{\frac{\sigma_1 - \sigma_3}{2}}{c\cot\phi + \frac{\sigma_1 + \sigma_3}{2}}$$ → diameter

$$= \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3 + 2c\cot\phi}$$

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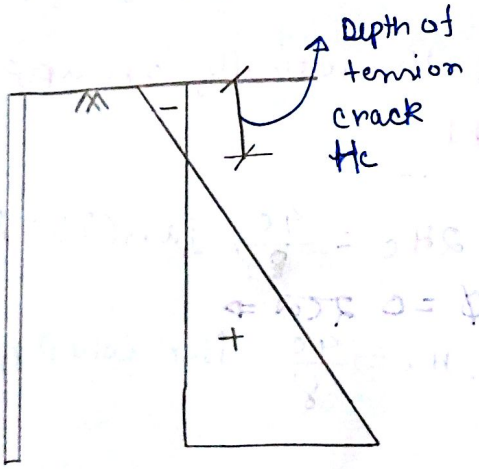
$$\therefore \sigma_3 = \left(\frac{1-\sin\phi}{1+\sin\phi}\right)\sigma_1 - \frac{2c\cos\phi}{1+\sin\phi} \rightarrow \text{simplify} = \sqrt{K_a}$$

$$= \left(\frac{1-\sin\phi}{1+\sin\phi}\right)\sigma_1 - 2c\sqrt{\frac{1-\sin\phi}{1+\sin\phi}}$$

$$\boxed{\sigma_3 = K_a \gamma h - 2c\sqrt{K_a}}$$ Active E.P for $c\phi$ soil



$h = 0$ হলে $\sigma_3 = -2c\sqrt{K_a}$

Pressure (−) মানে tension, soil can't take much tension

Tension নিতে না পারলে crack.

At H_c lateral pressure zero.

$\therefore \sigma_3 = 0$

$\therefore 0 = K_a \gamma H_c - 2c\sqrt{K_a}$

$\Rightarrow H_c = \frac{2c\sqrt{K_a}}{\gamma K_a}$

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

$= \frac{2c}{\gamma} \frac{1}{\sqrt{\tan^2(45-\phi/2)}}$

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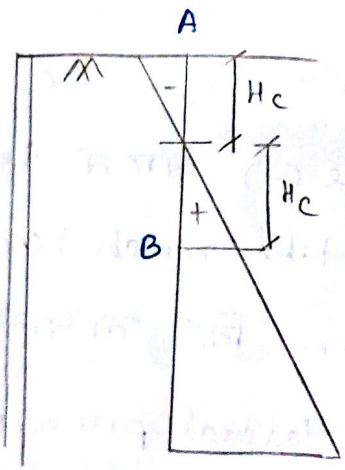
$= \frac{2c}{\gamma} \cot(45 - \phi/2)$

$= \frac{2c}{\gamma} \tan(45 + \phi/2)$ [Prove for a $c\phi$ soil the depth of tension crack . . .]

for purely cohesive soil $\phi = 0$

$\therefore H_c = \frac{2c}{\gamma}$ [Prove for cohesive soil]



AB তে total thrust zero.

Called theoretically unsupported height

$H_u = 2H_c = \frac{4c}{8\gamma} \tan(45 + \phi/2)$

$\phi = 0$ হলে $\Rightarrow$

$\therefore H_u = \frac{4c}{\gamma}$ (for cohesive soil)

$c = 20\ KN/m^2$

$\gamma = 16\ KN/m^3$

$\therefore H_u = \frac{4 \times 20}{16} = 5m$, so theoretically এতটুকুতে cohesion আছে & excavation এ support লাগবে না,

For Passive E.P:

$$P_p = K_p \gamma h + 2c\sqrt{K_p} = G_1$$

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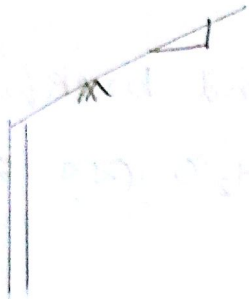
C-Φ soil with sloping surface:

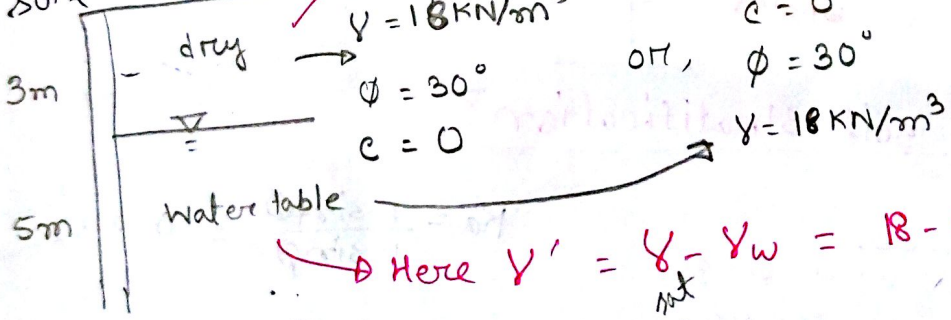


graphical method used,
But formula আছে, don't need to memorize.

Effect of water table on A. & P earth pressure:

Active E.P is only for soil.

soil uniform → Here $\gamma = 18\ KN/m^2$



* যেখানে সমস্যা γ_{sat} ও বলতে পারে।

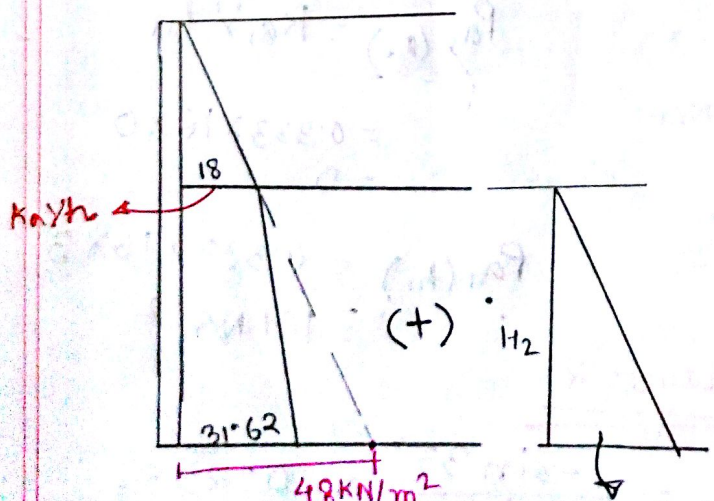
Here $\gamma' = \gamma_{sat} - \gamma_w = 18 - 9.8$

$K_a\gamma h = 0.333 \times 18 \times 3 = 18\ KN/m^2$

$0.333 \times 18 \times 3 + 0.333 \times (18 - 9.81) \times 3$

(for H_2O, submerged unit wt)

$= 31.62\ KN/m^2$



H_2O না থাকলে, $K_a\gamma H$

$= 0.333 \times 18 \times 8$

$= 48\ KN/m^2$

if whole was filled with H_2O then $P = \gamma_w H_2$

$= 9.81 \times 5 = 49.2$

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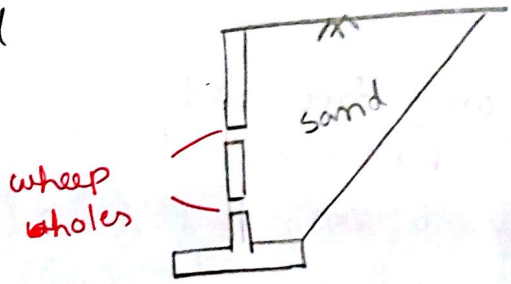
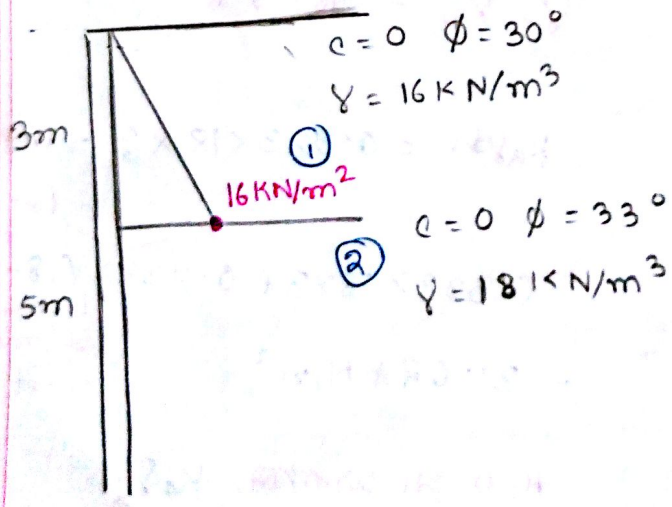
∴ water আবদ্ধ pressure develop করবে, it's not good.

এজন্য retaining wall এ holes, and backfill material sand / coarse soil. যেন H_2O বের হতে পারে clay থাকলে হবে না,

মাটির পর্যন্ত earth pre. থাকবে $45+\phi/2$ or $45-\phi/2$ মাটির backfill



Effect of soil stratification:



$$Ka = \frac{1-\sin\phi}{1+\sin\phi} = 0.333$$

Layer ①:

$$P_{a_1(h_1)} = K_{a_1} \gamma_1 h_1$$

$$= 0.333 \times 16 \times 0$$

$$= 0$$

$$P_{a_1(h_1)} = 0.333 \times 16 \times 3$$

$$\therefore = 16 \text{ KN/m}^2$$

2) Layer 2

$$K_{a_2} = \frac{1-\sin 33^\circ}{1+\sin 33^\circ} = 0.295$$

এখানে soil uniform না

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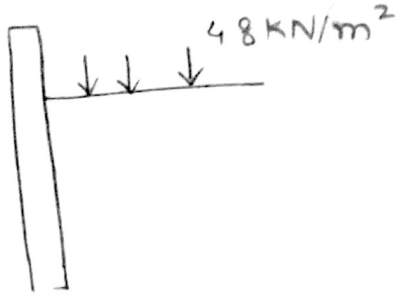
3m এ যে soil আছে তার জন্য verticle pressure

$= \gamma \times 3 = 48 \text{ KN/m}^2$ (with $\gamma = 16$, $48 = q$), এটাকে further replace করতে চাই।

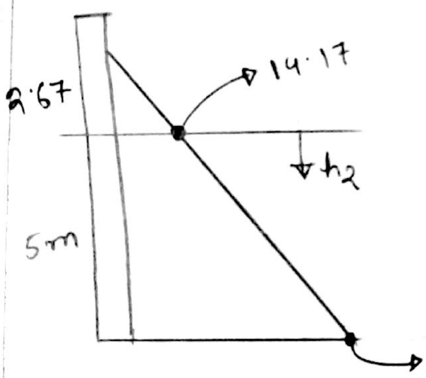


যদি 48 KN/m² এর জায়গায় layer 2 এর soil থাকত then কতটা height লাগবে of soil of layer 2.

$\therefore 48 = \gamma_2 H \Rightarrow \frac{48}{18} = 2.67$

$\therefore$ Equivalent height,

$H_e = q/\gamma_2$



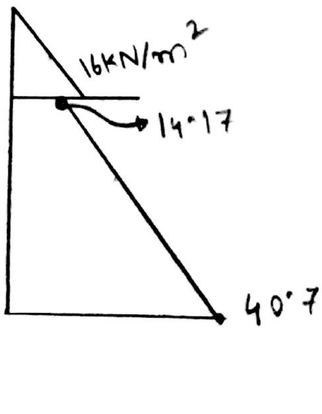
$Ka_2 \times \gamma_2 \times (5 + 2.67) = 0.295 \times 18 \times 7.67$
$= 40.7$

$Pa_2(h_2) = Ka_2 \gamma_2 (H_e + h_2)$

If $h_2 = 0$ $\therefore Pa_2(0) = Ka_2 \times \gamma_2 \times H_e$

$= 0.295 \times 18 \times 2.67$

$= 14.17 \text{ KN/m}^2 \rightarrow$ for layer ②



এখানে break হয় because of change of angle of friction.

φ ② তে বাড়ে so ভেতরে break.

φ ② তে কমলে break বাইরে

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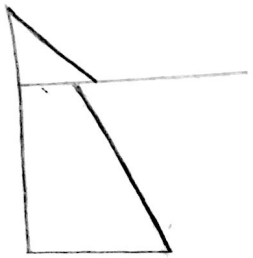
slope of the lines depend on γ ↑ হলে slope flat.

γ ↓ " " stiff.

Q. Exam ১ যদি $\gamma_1 > \gamma_2$ and $\phi_1 < \phi_2$ then pressure distribution এরকম.

① Slope flat ① break inside



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2.11.12
Wednesday

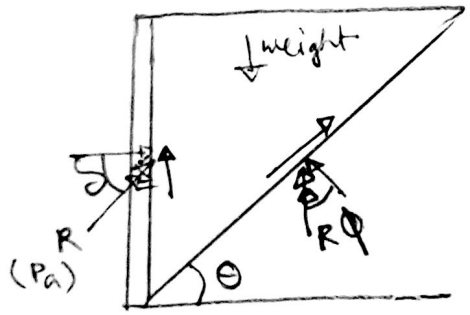
Lec 19

Coulomb's Method:

1) Soil homogenous & isotropic

2) Coulomb considering the equillibrium of failure wage.
(Rankin's said the equilli of a soil element)
Coulomb says failure always in a wedge.
Wedge is rigid body.

3) Wall vertical & smooth না হলেও হবে



pressure acting normal to surface. (→)
A.E.P ২ wedge wants to go down. = surface smooth না, so friction ~~হবে না~~ (up) (↑)

3 forces acting:

1) W (weight) 2) Pa 3) Reaction (R)

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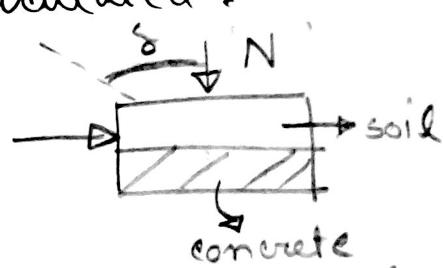
$$\frac{P_a}{\alpha} = R/\beta = \frac{W}{\gamma}$$

soil and soil এ friction হয়ে fail হলে angle of friction (ϕ)

soil & concrete এ ,, ,, fail হলে ,, ,, wall ,, (δ)

angle of wall friction can be calculated.

না দেয়া থাকলে 2/3 of ϕ.



এখানে fail করালে δ.

$$\frac{P_a}{\sin a} = \frac{W}{\sin c}$$

$$\therefore P_a = W \frac{\sin a}{\sin c}$$

W জানতে area of wedge or failure angle জানতে হবে, But failure angle জানি না,

P_a max^m হতে হলে P_a এর value depends on __

retaining wall and G.L fixed, so W depends on θ.

$\therefore P_a$ কে θ এর respect এ diffrentiate,

$\frac{\partial P_a}{\partial \theta} = 0$ করলে θ এর value পাব,

then W ??

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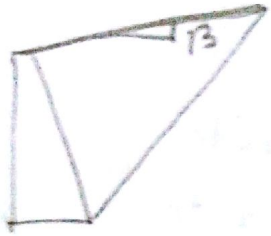
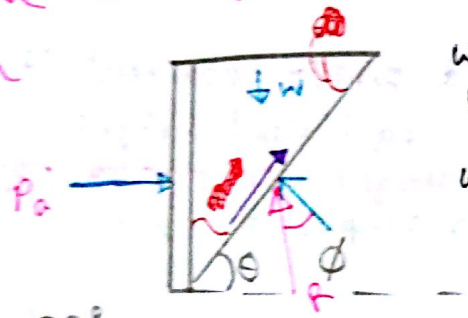
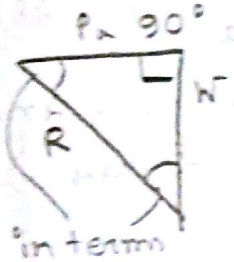


K_a
K_p
} Exam এ দিয়ে দিবে.

Derive an eqn for A.E.P using coulomb's theory when



wall smooth & verticle, soil surface horizontal.
wall is smooth, so friction হবে না



$$\frac{P_a}{\sin\phi} = \frac{W}{\sin\theta}$$

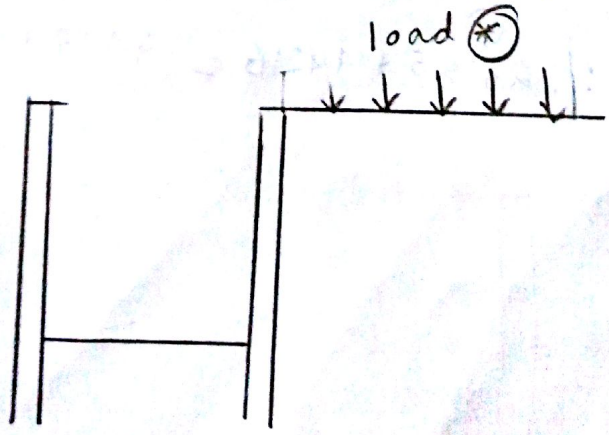
$\frac{\partial P_a}{\partial \theta} = 0$ হলে θ র value পাব.

then P_a.

[B.M. Das Introduction to soil mechanics এ আছে]

⊛ Coulomb's এ wall smooth না হলেও হবে, but rankine's এ wall must be smooth

L.E.P ~~on~~ on a rigid wall due to surcharge load on the surface backfill



load ⊛ সাধারণত পাবে for various reason. Called surcharge load

diff types of loading (PDf)

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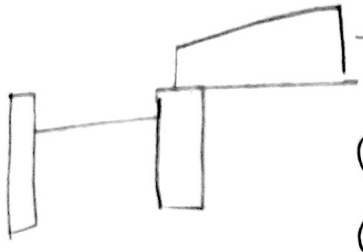


* Triangular load finite
* Sloping " infinite

Uniform load: uniform load হলে convert it to equivalent height.

But eqn Height এর কারণে হয়।

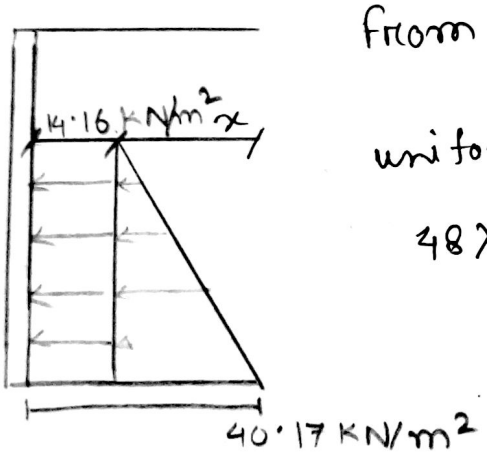
From example of previous class

uniformly distributed load $48\ KN/m^2$.

$48 \times Ka = 48 \times 0.295$ (for 2nd layer)

$= 14.16.$

so এটা throughout

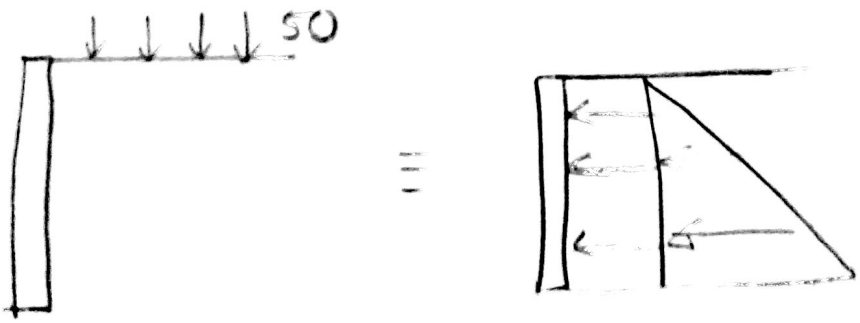


so 14.16 হচ্ছে for structure. Triangular variation for soil.

x এ only soil, so only A.E.P no surcharge

$\therefore Ka \times \gamma_2 \times 5 = 0.295 \times 18 \times 5 = 26.55$

$\therefore 26.55 + 14.16 = 40.71\ KN/m^2$



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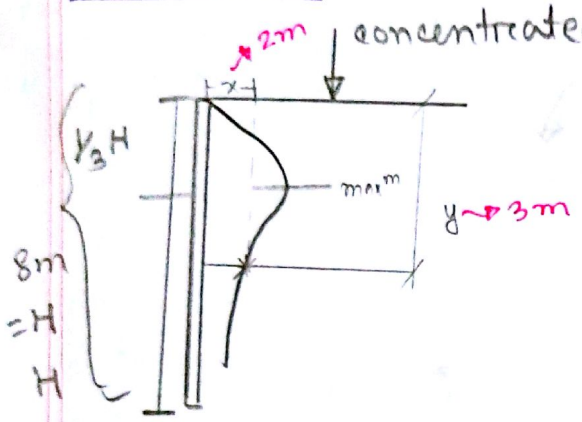
Point load :



As considering wall rigid so ওপরে soil এ A.F.P at rest.
& concentrated load.
1/3 H এ max^m pressure.

⊛ Exam এ only concentrated load এর জন্য বের করতে বলতে পারে তখন no soil considered → সেভাবে করতে হবে.

কোনো particular point এ pressure জানতে চাই (x, y)

$x = mH$ $\quad \therefore m = 2/8 = 0.25$

$y = nH$ $\quad n = 3/8 = 0.375$

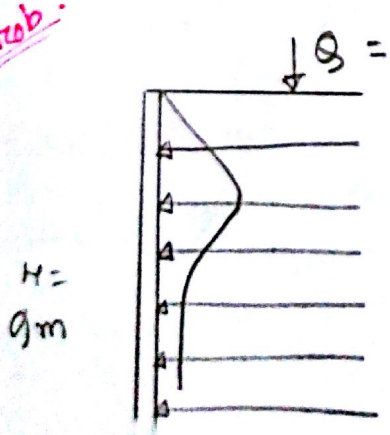
⊛ Distn will happen at a perpendicular distance (যেখানে load দিচ্ছি তার ⊥ distance এ stress পাই)

correction এ $\frac{m^2n^2}{(m^2+n^2)^3}$

$m > 0.4 \approx$ eqn (PDf) (I) (I) এ $m = 0.4$ বসালে (II)

$m \leq 0.4 =$ eqn (PDf) (II)

Prob:



9m কে uniformly ভাগ, But not less than 6

$\therefore 9/6 = 1.5$

Step 1: $m = 2/9 = 0.22$

$\therefore m < 0.4$

$\therefore P_A = \frac{0.28Q}{H^2} \cdot \frac{n^2}{(0.16+n^2)^3}$

$= \frac{0.28 \times 100}{9^2} \times \frac{n^2}{(0.16+n^2)^3}$

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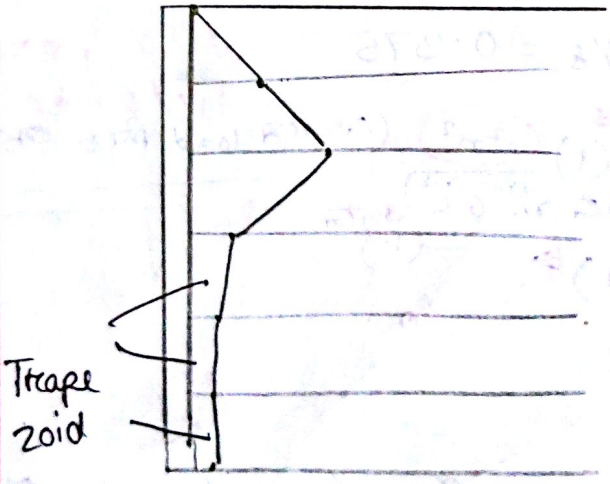
$$= \frac{0.346n^2}{(0.16+n^2)^3}$$

Depth	$n = y/H$	$P_h =$
0	0	0
1.5	0.167	1.45
3	0.33	1.93
4.5	5	1.26
6	0.667	0.7
7.5	0.833	0.39
9	1	0.22



Total area 2[2] total Thrust acting on the wall.

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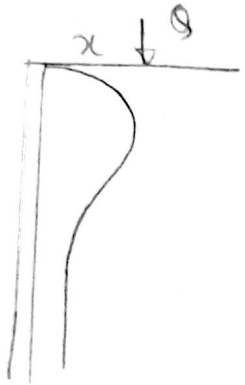
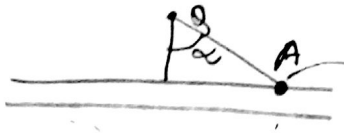
Lec - 20

12.12.15
Saturday

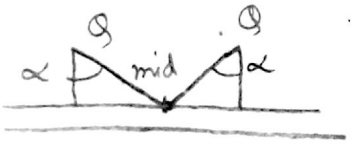


Plan of retaining wall



then প্রতি co-ordinate কে $\cos^2\alpha(1+\alpha)$ দিয়ে multiply করতে হবে
not sure

thrust বের করতে বললে total টাকেও $\cos^2(1+\alpha)$ দিয়ে multiply.



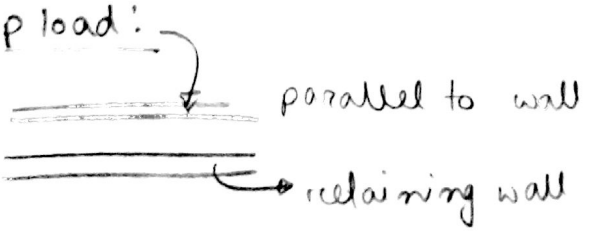
mid point এ বললে যে কোন প্রকার জন্য $\cos^2(1+\alpha)$ দিয়ে মুল করে ২ দিয়ে মুল

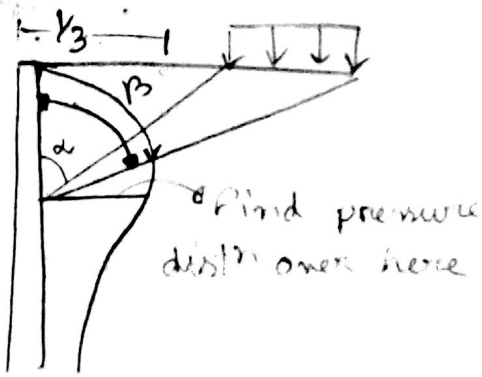
Line load:

For $m > 0.4$ $\quad p_n = \frac{4q}{\pi} \frac{m^2 n}{(m^2+n^2)^2}$

$m = 0.4 \Rightarrow$ ...

Strip load:





For all loads strip, ramp, Δ max^m dist^n at 1/3

β & α in radian.

* Exam এ point & line এর জন্য formula দিয়ে সমাধান করা।

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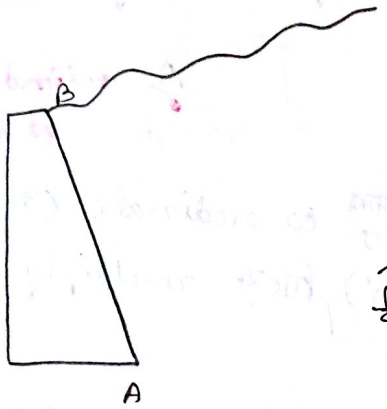
Calman's

Coulomb's Graphical Method: (consider active & cohesionless soil)

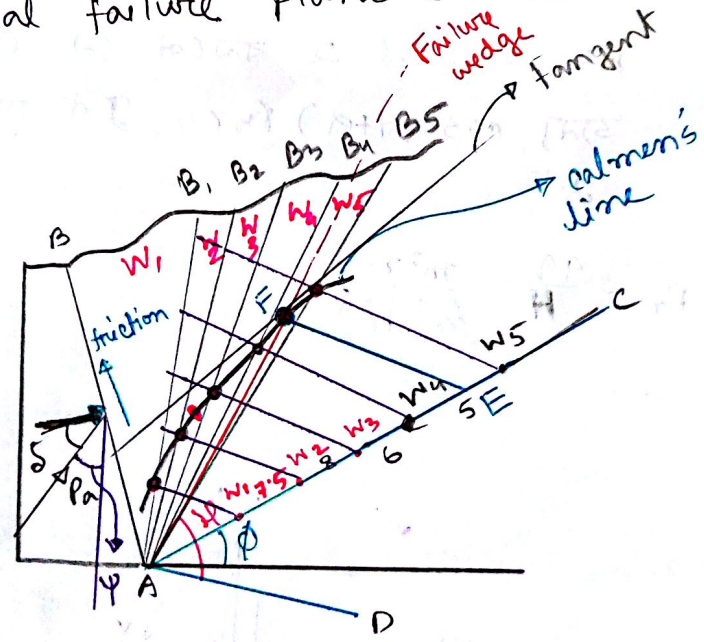
cohesionless soil নিলাম (Graphical method when surcharge load not smooth ~~~)



এভাবে failure surface $45^\circ + \phi/2$ এর আগে যাবে line, পরে যাবে line ধরব।

This is a theory extention of coulomb's (wedge) theory.

several failure plane consider করব,



$c = 0$
$\phi = \phi$
$\gamma = \gamma$

Backfill বল wall এর ওপর পাশের soil.

From A in the direction of backfill draw a line of ϕ angle

BAB1 ত্রি fail করলে (rankein's মতে) it will move down & friction up.

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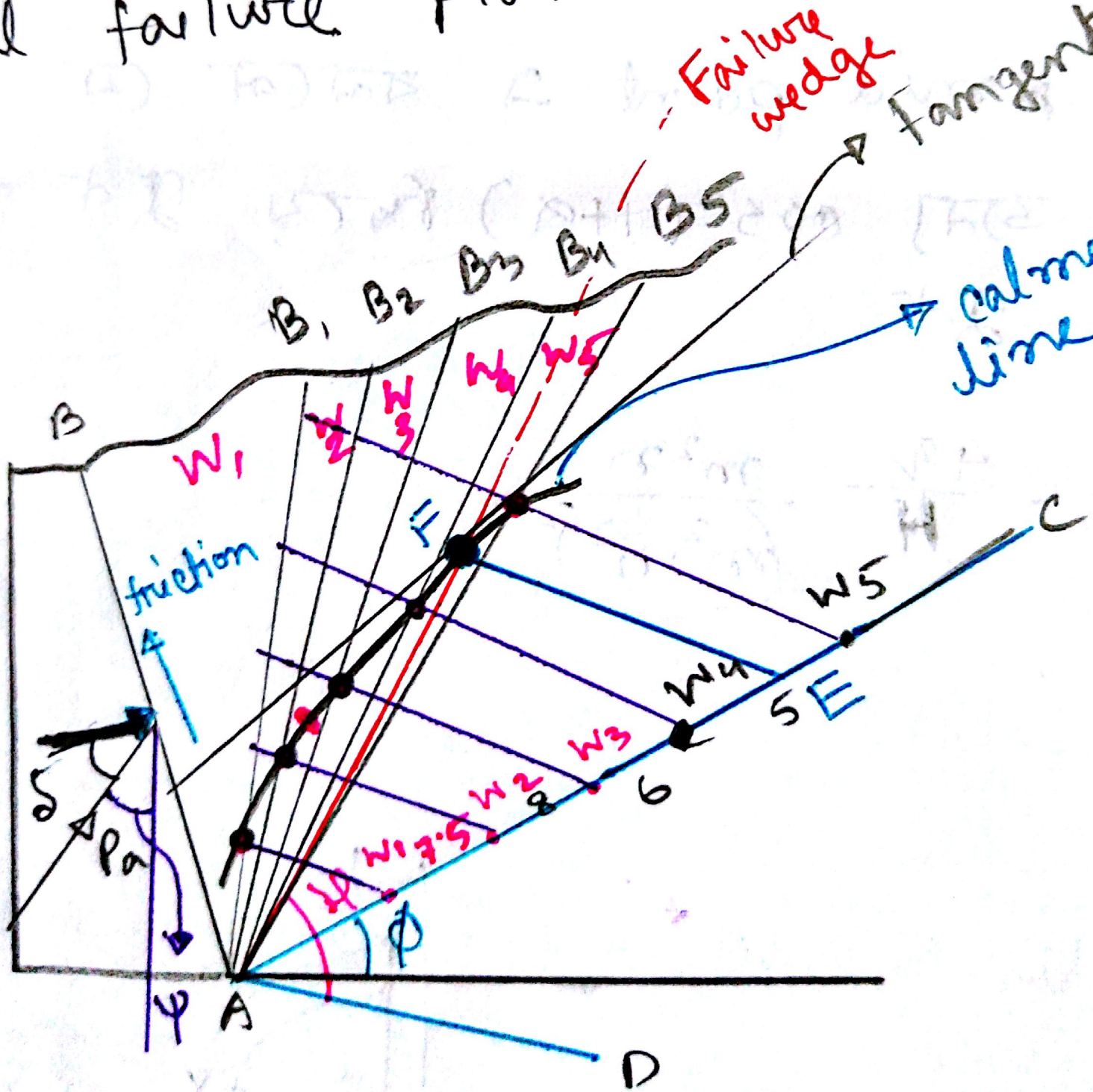
ধরব।

A

is a theory extention of coul

al failure plane consider করব



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Reaction & friction এর resultant A.E.P (P_a).

P_a & reaction এর angle δ. angle of wall friction.

এটা থেকে verticle line P_a এর মধ্যে Ψ.

$\Psi > \phi$,

again A থেকে in opposite dirn of Backfill draw a line with angle Ψ,

BAB_1 কয়টা division cover করে, per division কত scale বললাম সেটা হিসাব করব, সেটা থেকে area, অতএব ⊥ unit width ধরব, so volm & then multiply by γ, so find weight

suppose $W_1 = 1000$ KN, wt of ABB_1

go to weight scale, suppose 100 KN = 1 cm

$\therefore$ 1000 KN = 10 cm

W_2 = wt of AB_1B_2 = 750

W_3 = 800

W_4 = 600

W_5 = 500

from W_1, W_2, W_3, W_4, W_5 draw parallel to line AD

AD is called reference line.

এই lines failure surface গুলোকে যে point এ ছেদ করে সেটা দিয়ে smooth curve. এরা calmen's lines.

draw a tangent from max^m curvature,
" parallel to AC.

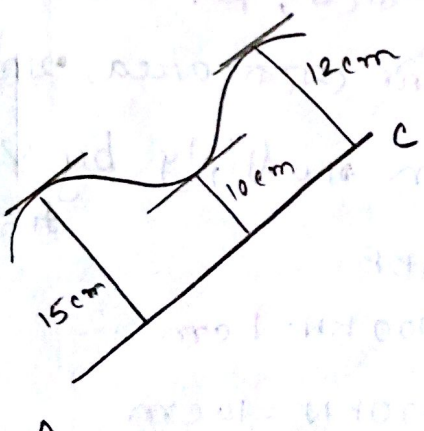
Tangent point F.

F থেকে || to AD, যাহা AC কে E তে cut.

FE = 12 cm মাপলাম

scale ছিল 100 kN = 1 cm

$\therefore$ 12 cm = 12 × 100 = 1200 kN (এটা pressure, thrust না)



এভাবে failure
15 cm নয় তবে, cause active earth pressure এর definition হল max^m pressure এ fail করবে.

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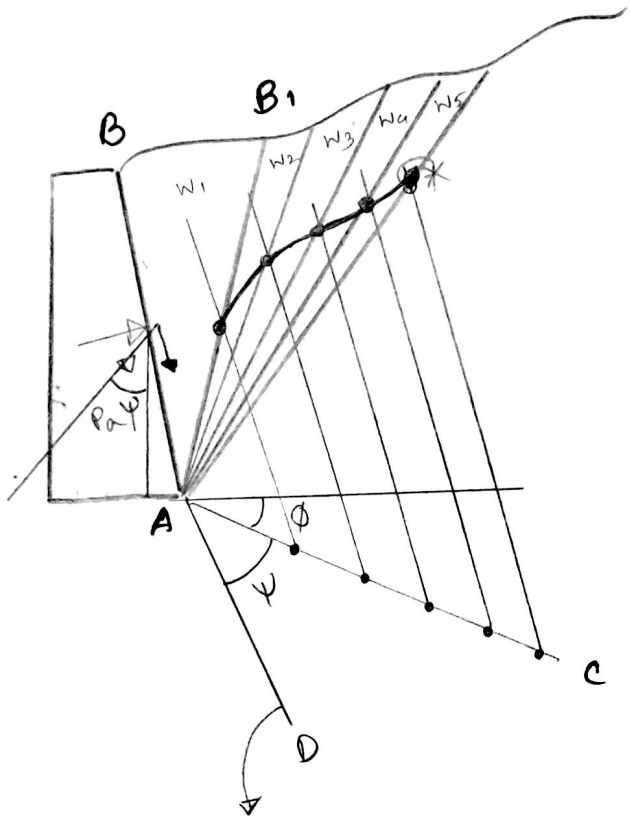
15.12.15
Tuesday

Lec 21

Passive Earth Pressure:

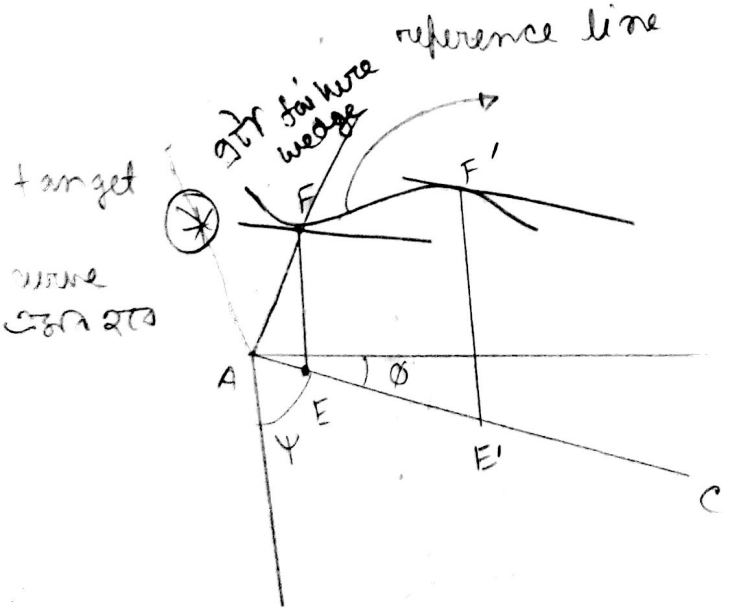


$c = 0$
$\phi = \emptyset$
$\gamma = \gamma$

Draw a line in opposite direction of Backfill //

inward & upward movement

Ψ angle of max. pressure and verticle



FF = 12 cm → ব্যর্থতার তল
F'E' = 15 cm failure

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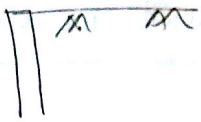
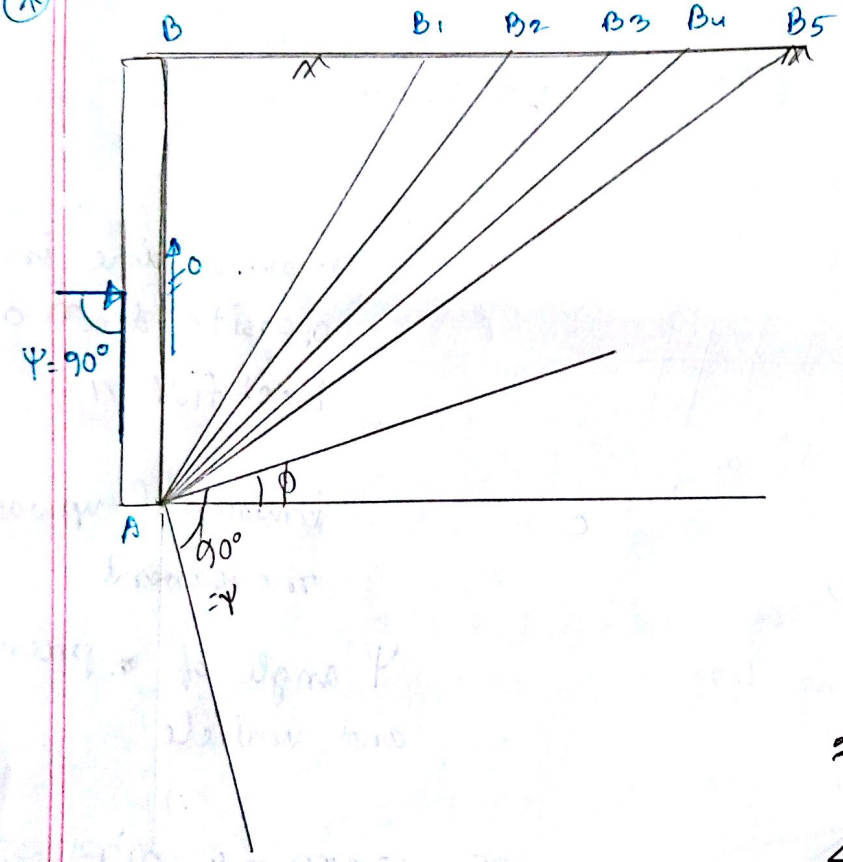
smooth & verticle wall, Ground plane.

[You indicate the failure wedge]
Solve in caimen's method



Prob prev. year (smooth wall)



we assume active pressure

Let $BB_1 = 4'$

$BA = 10'$

scale ২ আবার নাও

But right angle Δ

$\therefore$ Area $= \frac{1}{2} \times 10 \times 4$

so graph থেকে count করা দরকার নাই।

Δ area $= 20\ m^2$

$20 \times \gamma = 320\ KN$

$\downarrow$

16

Let's assume $B_1B_2 = B_2B_3 = B_3B_4 = B_4B_5 = 4$

so এর W same হবে, এটা trick.

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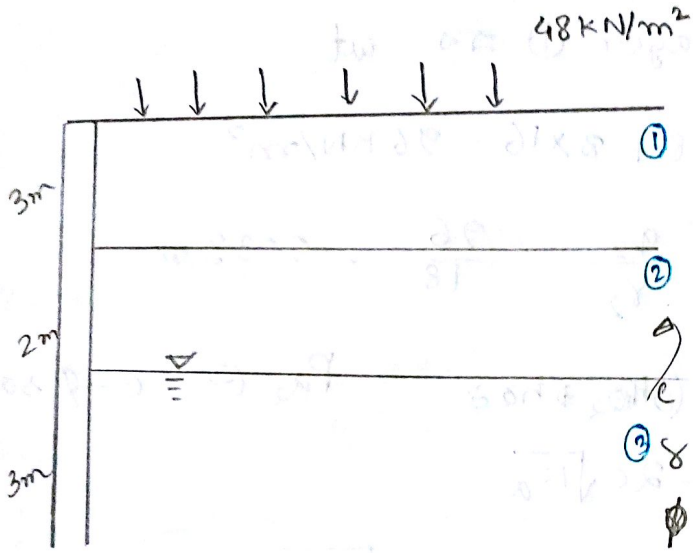


→ this is saturated cause W.T. এর নিচে saturated

Layer 1: Always see if there is surcharge

$P_{a_1}(h_1) = K_{a_1} \gamma_1 h_1$ → surcharge থাকলে h_1 এর $h + h_e$ দিয়ে বলতে হবে

Equivalent height $= \frac{q}{\gamma_1} = \frac{48}{16} = 3m$

$P_{a_1}(h_1) = K_{a_1} \gamma_1 (H_e + h_1)$

$\therefore K_{a_1} = \frac{1 - \sin 30}{1 + \sin 30} = 0.333$

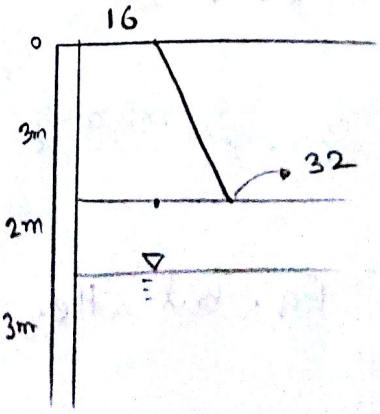
$\therefore P_{a_1}(h_1) = 0.333 \times 16 \times (3 + h_1)$

$= 5.33 \times (3 + h_1)$

$h_1 = 0 \Rightarrow P_{a_1} = 16$

$h_1 = 3 \Rightarrow P_{a_1}(3) = 31.98$

$= 32 \text{ KN/m}^2$



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④ Any F.P problem see if any surcharge

Layer 2: 48 + Layer ① ⇒ wt

surcharge $q_2 = 48 + 3 \times 16 = 96\ KN/m^2$

Eqv height $He_2 = \frac{q_2}{\gamma_2} = \frac{96}{18} = 5.33\ m$

$Pa_2(h_2) =$ ~~$K_{a_2} \gamma_2 (He_2 + h_2)$~~ Pa_2 @ c-ϕ soil

$K_a \gamma h - 2c\sqrt{K_a}$

$Pa_2(h_2) = K_{a_2} \gamma_2 (h_2 + He) - 2c\sqrt{K_{a_2}}$

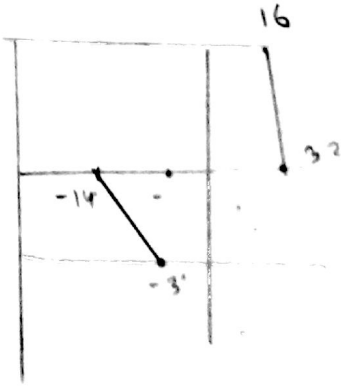
$K_{a_2} = \frac{1-\sin 32}{1+\sin 32} = 0.31$

$Pa_2(h_2) = 0.31 \times 18 (h_2 + 5.33) - 2 \times 40 \sqrt{0.31}$

$= 5.58 (5.33 + h_2) - 44.54$

$Pa_2(0) = -14.8\ KN/m^2$

$Pa_2(2) =$ ~~-14.8~~ $-3.6\ KN/m^2$



3 : surcharge $q_3 = 48 + 3 \times 16 + 2 \times 18$

$= 132\ KN/m^2$

Eq. Wt $He_3 = \frac{q_3}{\gamma_3} = \frac{132}{(18 - 9.81)} = 16.11\ m$

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⊛ identify layer কয়টা depending on soil type

⊛ then surcharge ⊛ then eqn height

$$Pa_3(h_3) = Ka_3 \gamma_3 h_3 - 2c\sqrt{Ka_3}$$

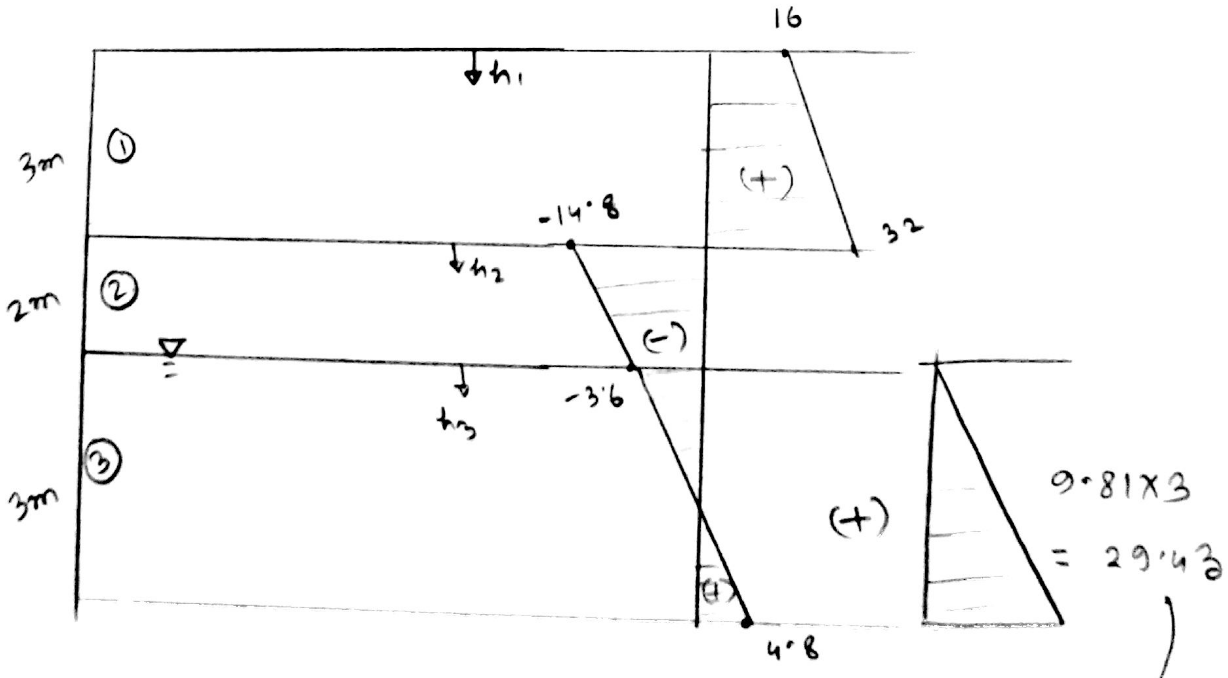
$$Ka_3 = 0.31$$

$$Pa_3(h_3) = 0.31 \times (18 - 9.81)(h_3 + 16.1) - 2 \times 40\sqrt{0.31}$$

$$= 2.54(h_3 + 16.1) - 44.54$$

$Pa_3(0) = -3.64$ (same in layer ② & ③ cause break 2টা for ϕ or γ, 2টার same, so no change)

$Pa_3(3) = 4.8$



Calculate the active thrust → ক্ষেত্র

calculate the total thrust → ক্ষেত্র + H_2O pressure △

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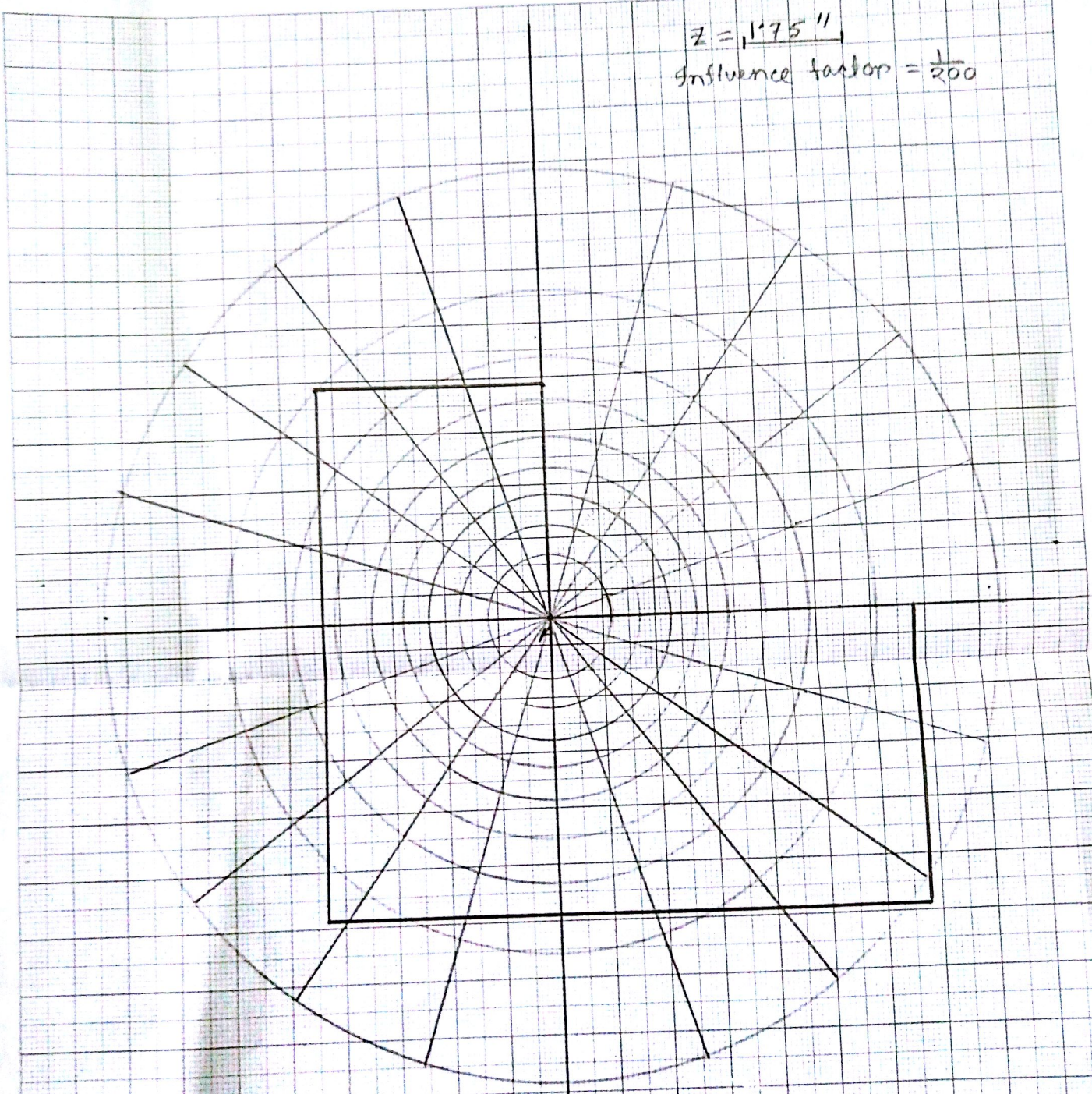
Roll No.....

$z = 1.175''$

Influence factor $= \frac{1}{200}$



$\sigma_z' = \frac{1}{200} \times 110 \times 9$

plotting wrong cause I took the wrong scale, but procedure ঠিক আছে।

NP 20 cm x 25 cm

MICRO

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