IQRA NATIONAL UNIVERSITY PESHAWAR

DEPARTMENT OF CIVIL ENGINEERING

M.S TRANSPORTATION

Submitted To:

Instructor:

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Course:

Transportation Geo-Technics

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ID # 15170

M.S (T.E)

0332-2882828

Q1. Explain weathering and Erosion.

Answer:

Weathering:

All the processes that physically disrupt or chemically decompose a rock at or near the Earth's surface.

There are three types of weathering.

1. Chemical Weathering
2. Mechanical Weathering
3. Biological Weathering

Chemical Weathering

- Decomposition of rocks and minerals via *chemical reactions* at the Earth's surface
- Chemical agents: acids in rain air and rivers etc.
- More effect in soluble rocks

Some process involved in chemical weathering which are as under.

- Solution. CO_2 in soil profile making carbonic acid H_2CO_3 with percolating rain water.
- Oxidation. Oxygen with mineral forms oxides
- Reduction. Oxygen leaves mineral
- Hydration. Absorption of water, expands clays, hastens the above processes

Pic.1: Features of Karst Cave

Pic2: Sinkholes

Pic3: Disappearing Stream

Further Living organism and also Acid Rain causes of weathering.

- Living Organisms
    - Lichens that grow on rocks produce weak acids that chemically weather rock
- Acid Rain
    - Compounds from burning coal, oil and gas react chemically with water forming acids.
    - Acid rain causes very rapid chemical weathering

Mechanical Weathering

- disintegration/ disaggregation of rocks via *mechanical* processes
- Temperature, abrasion in wind, rain drops

Further causes of Mechanical Weathering are:

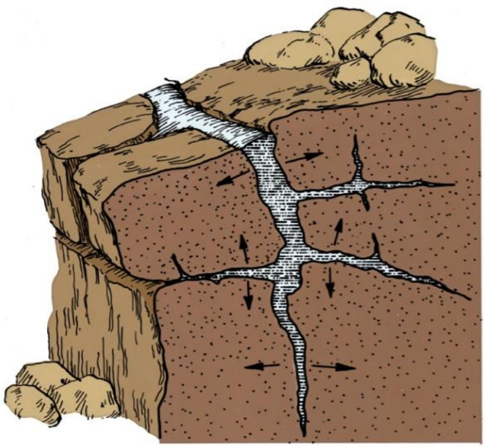
- Mechanical Unloading. Vertical expansion, erosion reduces load opening fractures
- Mechanical Loading. Impact and abrasion of wind borne particles in deserts and effect of intense rain drops
- Thermal Loading. Expansion of freezing water, high and low temperatures
- Wetting and drawing. Repeated loss & abrasion of water in certain clays
- Crystallization. Formation of crystals in fissures and pores, originally in solution
- Pneumatic Loading. Waves effect on trapped air in cliffs.

It can explain as follow:

- Unloading
    - Seen in granite intrusions
    - Joints parallel to ground open up forming 'sheets',
    - Spallings, small platy fragments fall of
    - Many open up during quarrying with sound onces relieved of stresses


- Frost Action
    - Freezing process increases volume in pores
    - Ice Wedging. Repeated freezing breaks of flakes & angular fragments (Screes)
    - Screes to Breccia deposits
- Frost Heaving
    - In areas including permafrost areas
    - Ice lenses formed at shallow depth. Up to 30 mm. Combined effect heaves up
    - Engineering problem, Water pipes above surface, higher plinth or air circulation to reduce heating effect

- Insolation (sunlight exposure)
    - Temperature variation in hot climate, flakes of outer layer of rocks split off
    - Process is exfoliation
    - Cracks may form, salts and water cause decomposition and increase weathering called insolation
    -



Biological Weathering

- Mechanical and chemical changes directly associated with animals and plants.
- Plant roots, burrowing animals, root gases increasing acidity
- Rock surface kept damp by plants, increase in solvent action.
- Vegetable Humus, aided by bacteria and fungi aerobic, organic acids are added
- Bacteria in aerobic mineral pore spaces, expanding byproducts
- Mechanical breakup of rocks hastened by wedging apart by roots.

Erosion:

Erosion is the process where **rocks** are broken down by natural forces such as wind or water. There are two main **types** of **erosion**: chemical and physical. Chemical **erosion** occurs when a **rock's** chemical composition changes, such as when iron rusts or when limestone dissolves due to carbonation where

In earth science, **erosion** is the action of surface processes (such as water flow or wind) that removes soil, rock, or dissolved material from one location on the Earth's crust, and then transports it to another location (not to be confused with weathering which involves no movement). This natural process is caused by the dynamic activity of erosive agents, that is, water, ice (glaciers), snow, air (wind), plants, animals, and humans. In accordance with these agents, erosion is sometimes divided into water erosion, glacial erosion, snow erosion, wind (aeolic) erosion, zoogenic erosion, and anthropogenic erosion. The particulate breakdown of rock or soil into clastic sediment is referred to as *physical* or *mechanical* erosion; this contrasts with *chemical* erosion, where soil or rock material is removed from an area by its dissolving into a solvent (typically water), followed by the flow away of that solution. Eroded sediment or solutes may be transported just a few millimeters, or for thousands of kilometers.

Natural rates of erosion are controlled by the action of geological weathering geomorphic drivers, such as rainfall; bedrock wear in rivers; coastal erosion by the sea and waves; glacial plucking, abrasion, and scour; areal flooding; wind abrasion; groundwater processes; and mass movement processes in steep landscapes like landslides and debris flows. The rates at which such processes act control how fast a surface is eroded. Typically, physical erosion proceeds fastest on steeply sloping surfaces, and rates may also be sensitive to some climatically-controlled properties including amounts of water supplied (e.g., by rain), storminess, wind speed, wave fetch, or atmospheric temperature (especially for some ice-related processes). Feedbacks are also possible between rates of erosion and the amount of eroded material that is already carried by, for example, a river or glacier. Processes of erosion that produce sediment or solutes from a place contrast with those of deposition, which control the arrival and emplacement of material at a new location.

While erosion is a natural process, human activities have increased by 10-40 times the rate at which erosion is occurring globally.[6] At well-known agriculture sites such as the Appalachian Mountains, intensive farming practices have caused erosion up to 100x the speed of the natural rate of erosion in the region. Excessive (or accelerated) erosion causes both "on-site" and "off-site" problems. On-site impacts include decreases in agricultural productivity and (on natural landscapes) ecological collapse, both because of loss of the nutrient-rich upper soil layers. In some cases, the eventual end result is desertification. Off-site effects include sedimentation of waterways and eutrophication of water bodies, as well as sediment-related damage to roads and houses. Water and wind erosion are the two primary causes of land degradation; combined, they are responsible for about 84% of the global extent of degraded land, making excessive erosion one of the most significant environmental problems worldwide.

Intensive agriculture, deforestation, roads, anthropogenic climate change and urban sprawl are amongst the most significant human activities in regard to their effect on stimulating erosion. However, there are many prevention and remediation practices that can curtail or limit erosion of vulnerable soils.

It concluded as follow.

- Removal of weathered material from its place of origin
- Agents are river , moving ice, wind and waves

Picture: An actively eroding rill on an intensively-framed in eastern Germany

Q2. Write a note on shear strength of soils.

Answer:

Shear Strength of Soil:

Shear strength of a **soil** is indicative of its **resistance** to erosion.

Properties which resist stresses generated by gravitational forces:

SHEAR STRENGTH has three components

1. Effective normal stress
2. Cohesion
3. Angle of internal friction

Shear Strength = Cohesion + Normal Stress x TAN (Angle Internal friction)

$$\text{Or } S = C + \sigma . (\tan . \theta)$$

Effective normal stress:

There are three conditions for normal stress:

1. Dry Soil:
   $\sigma = \sigma - 0$

2. Unsaturated wetted soil when pore water matric suctions (μ) (Soil matric suction is a primary stress state variable used to characterize unsaturated soil behavior) are negative. Effect is to INCREASE normal stress:
   $\sigma = \sigma - (-\mu)$

3. Saturated soil condition where pore water pressure (μ) is positive, acting upwards against gravity. Effect is to DECREASE normal stress:
   $\sigma = \sigma - \mu$

Cohesion:

- Cohesion: Bonding
- Rocks:
- Chemical Bonds - Cements….
- Clays:
- Electrostatic forces - Attractive forces between particles and lubrication by water.
- Apparent Cohesion:
- Produced by capillary forces and interlocking friction of particle surfaces.
- Affected by SIZE, SHAPE & MINERALOGY of particles.

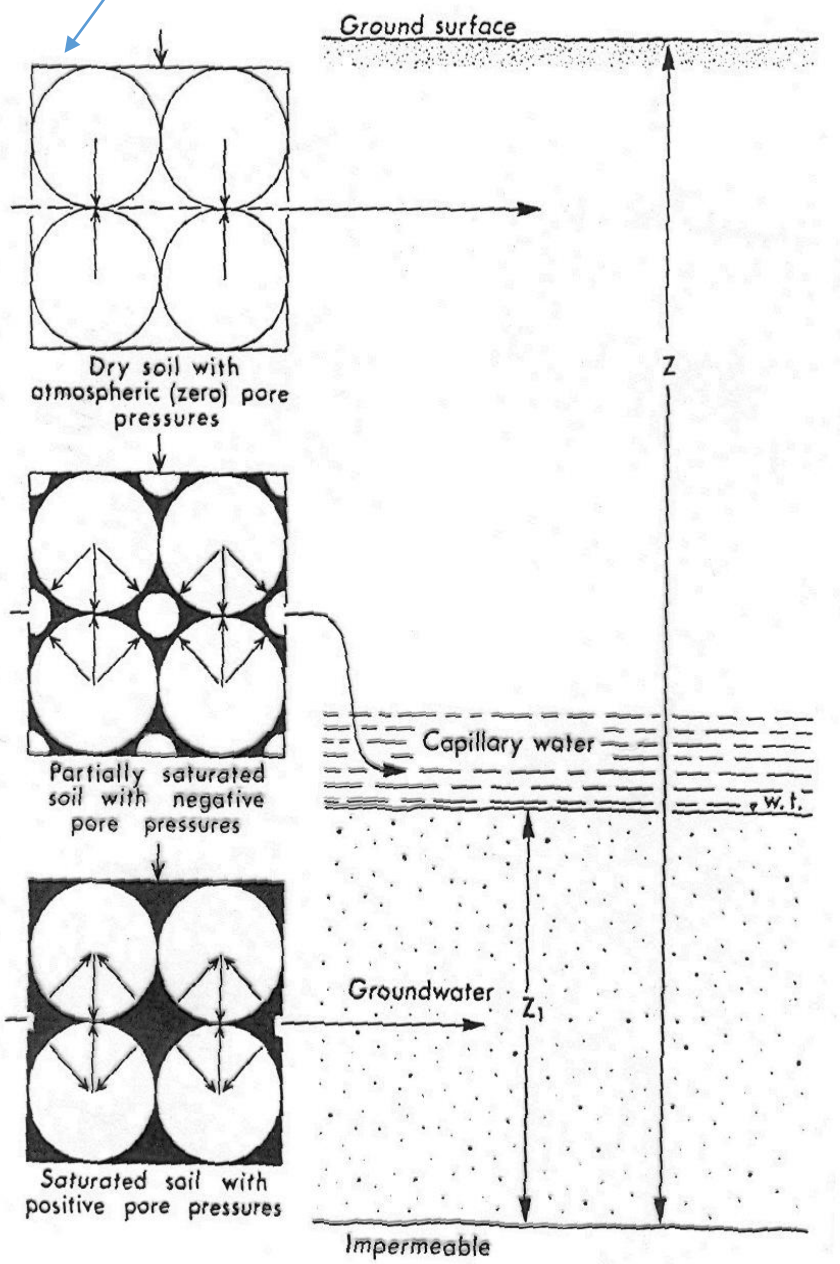
Normal Stress and apparent Cohesion: Impact of Pore Water.

Dry Soil above water table

Soil fabric supported by point contacts .

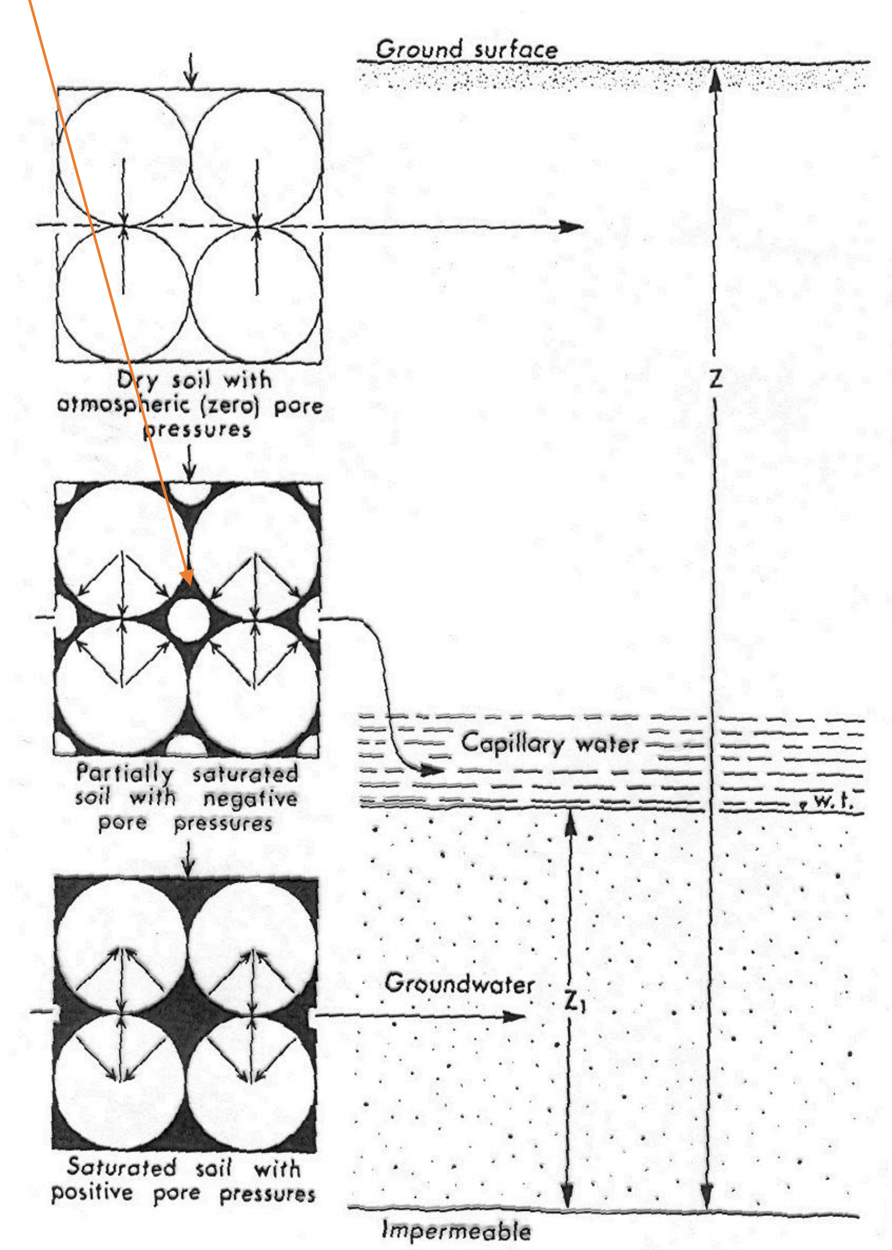
Pores air filled and pore water pressure = 0.0.

No apparent cohesion due to soil moisture tension.



Moist Soil

Particles have apparent cohesion due to capillary forces and are under suction due to matric suction effects.



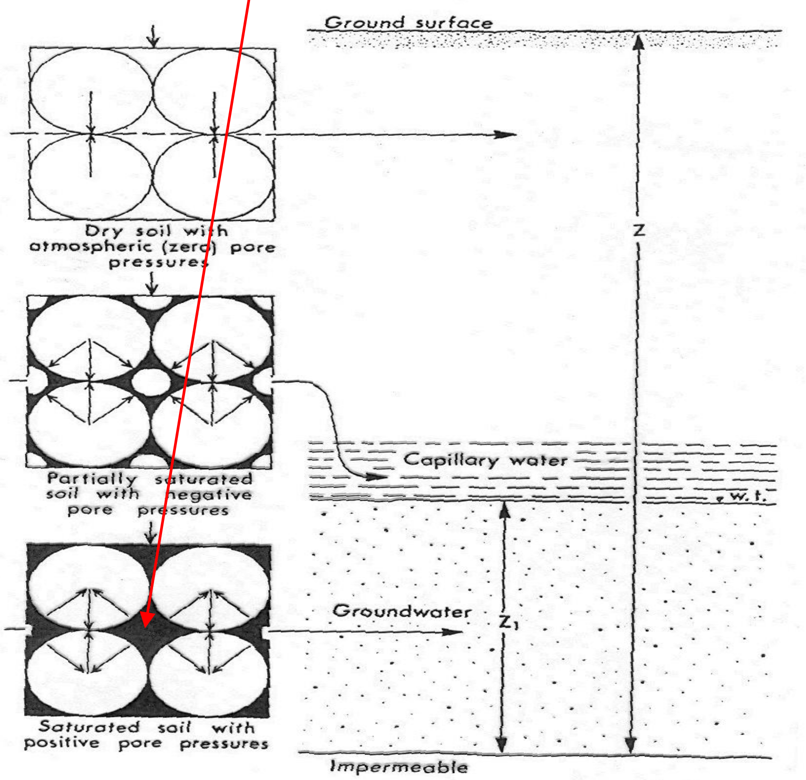
Saturated soil

• Soil apparent cohesion lost as no capillary forces or matric suction.

Part of the NORMAL STRESS of overburden taken by the pore water rather than soil fabric.

(Buoyancy/upthrust) & positive pore water pressures.

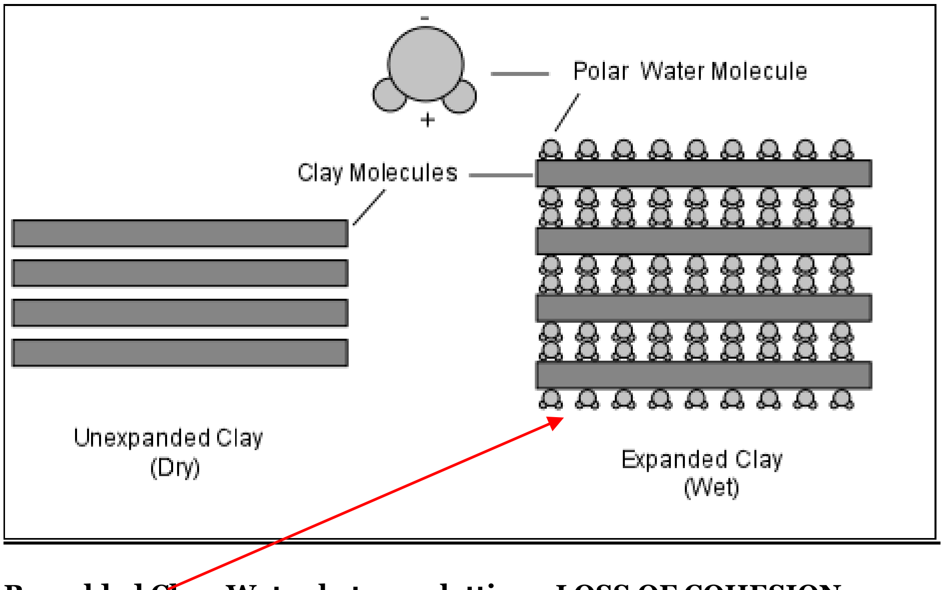
DECREASE IN SOIL STRENGTH



Cohesion effects

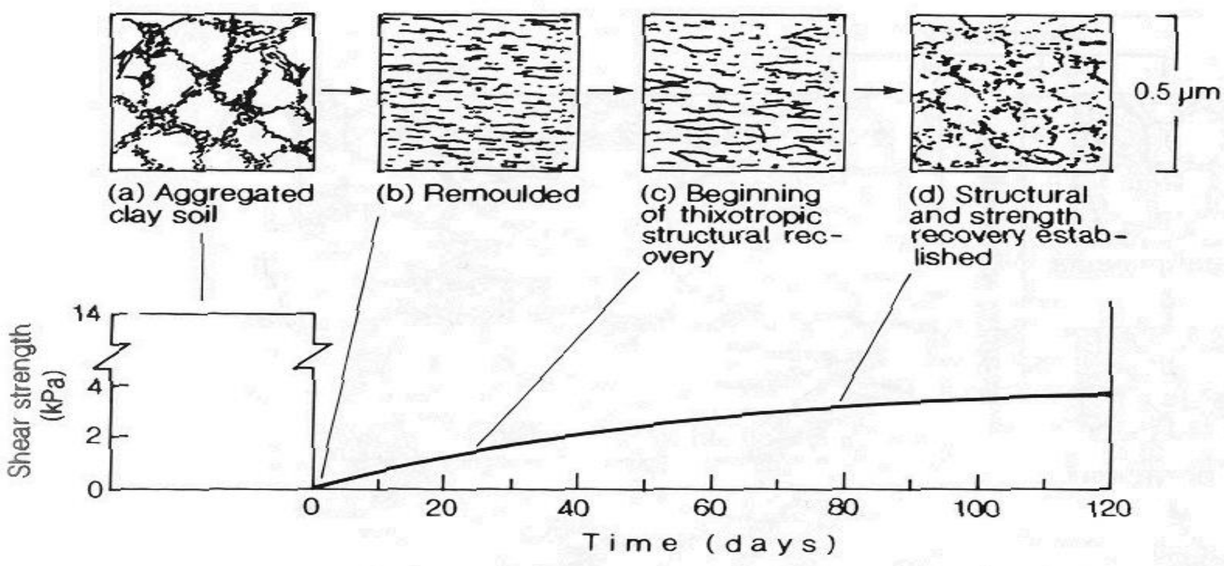
1. Loss of strength under shear:

◦Marine Clays. Highly structured clay fabric.
◦Subjected to shear – strength may be reduced to 1/1000th original value. These are QUICK clays.



Remolded Clay: Water between lattices: LOSS OF COHESION

2. Thixotropic behaviour: Strength lost on disturbance. Disturbed soils with high water content may rapidly become weak and fail. When they come to rest they REGAIN STRENGTH.



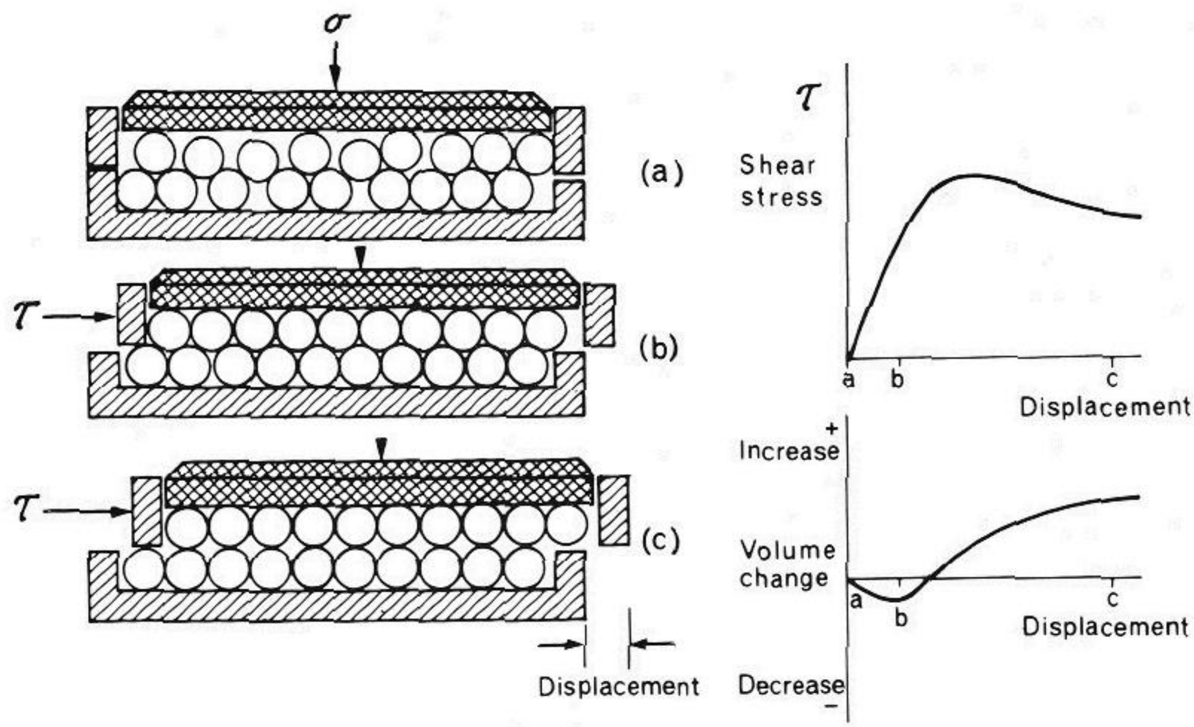
3. Addition of water to REMOULDED clay rich soils: reduces strength as electrostatic bonds are weakened by separation of particles.

4. Clays in slurry & mudflow: lose strength due to disruption of aggregate structure & increase water content.

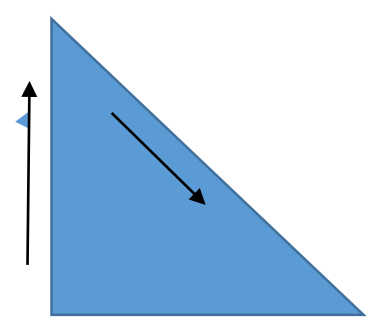
Angle of Internal Friction:

Friction:

- Strength of rocks/soils part controlled by frictional resistance between mineral particles in contact. Interlocking friction and planar friction.
- Friction strength proportional to NORMAL STRESS holding grains in contact.
- Contact points due to size, shape & resistance to crushing of grains.
- Poor sorting increases contacts & interlocking friction.



The angle at which the particle begins slide down the surface.



Frictional contact is broken.

Soils & rock friction angles controlled by:

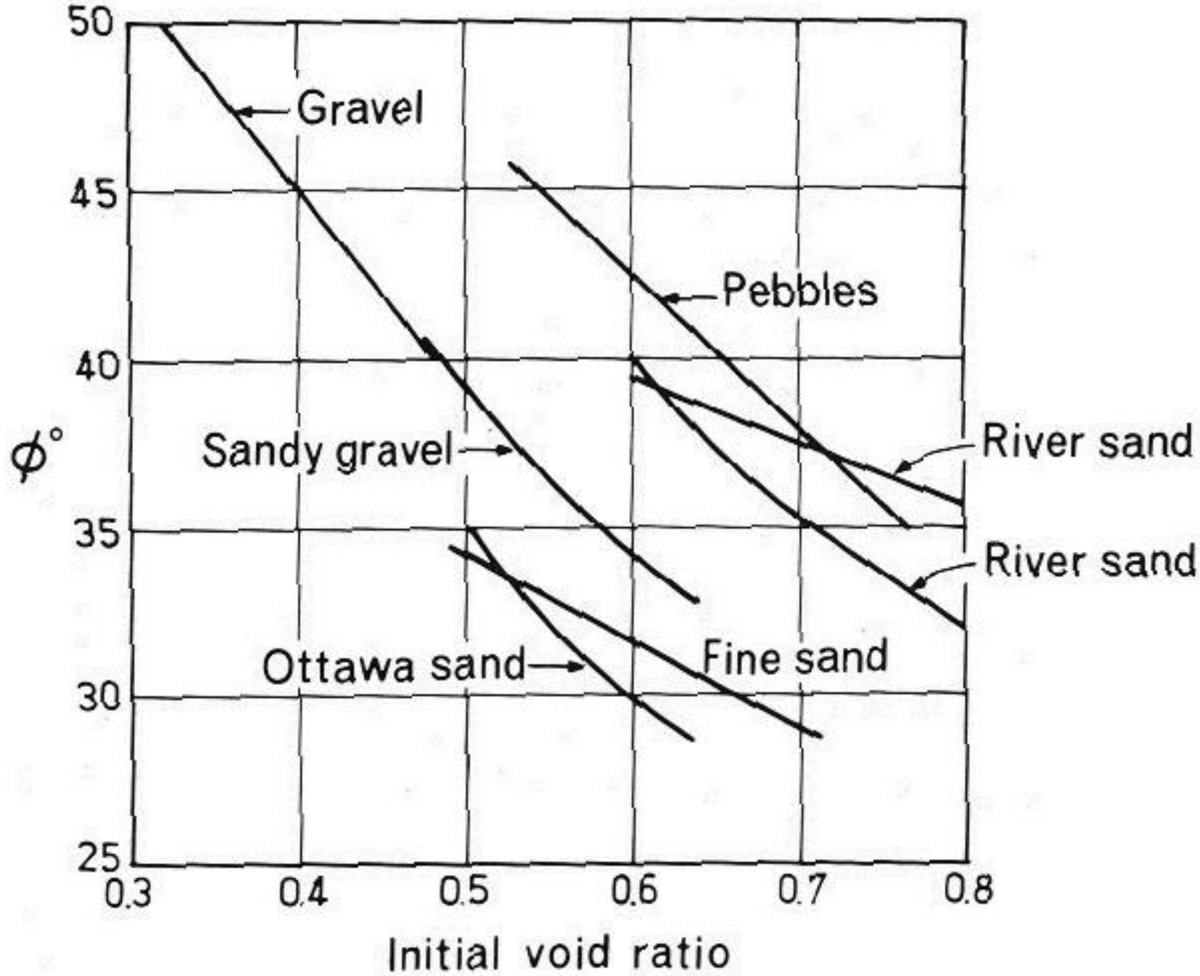
1. Volume of voids

2. Particle size distribution

3. Particle shape.

Friction angle decreases with PLASTICITY & WATER CONTENT.

Effect of void ratio on angle of internal friction for non-cohesive materials.



Q3. What is meant effective size D10. Also explain Atterberg limits and consistency indices.

Answer:

Effective Size D10:

D10 is called as **effective** particle **size**. This **means** that 10% percent of the particles are finer and 90% of the particles are coarser than **D10**. This is the **size** at 10% finer by weight.
Effective Size, D10, can be correlated with the hydraulic conductivity (describing the permeability of soils).

Shape and Size of particle has an important role in Engineering. On the basis of shape, Size and texture one can find type and gradation of soil whether it's poorly graded or well graded. Furthermore coefficient of uniformity and coefficient of curvature can also be found with grain /size of soil.
For Example:
For Well Graded:

D_{10} = 0.02 mm (Effective Size)
D_{30} = 0.6mm
D_{60} = 9mm

Coefficient of Uniformity

$C_u = D_{60}/D_{10} = 9/0.02 = 450$

Coefficient of Curvature

$C_c = (D_{30})^2/(D_{10})(D_{60}) = (0.6)^2/(0.02)(9) = 2$

Criteria:

Well Graded Soil

$1 < C_c < 3$ and $C_u \geq 4$

For Gravel

$1 < C_c < 3$ and $C_u \geq 6$

For Sand

Atterberg Limits and Consistency Indices:

Consistency limits an Indices
General
Property of soil manifested by resistance to flow. Cohesive and not inter granular. Affected by moisture contents of soil.

Consistency Limits.

Atterberg's six stages of soil consistency range

Liquid limit

Sticky limit

Cohesive limit

Plastic limit

Shrinkage limit

The presence of water in fine-grained soils can significantly affect associated engineering behavior, so we need a reference index to clarify

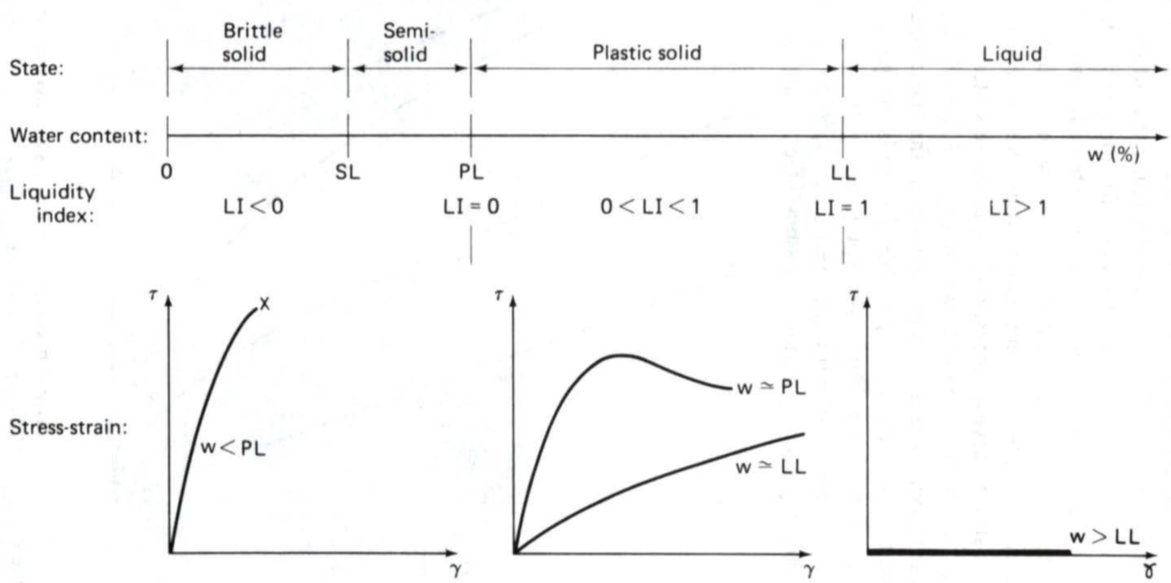


Fig. 2.6 Water content continuum showing the various states of a soil as well as the generalized stress-strain response.

Fluid Soil (Water Mixture)

Liquid State	**Liquid Limit, LL**
Plastic State	**Plastic Limit, PL**
Semi Solid State	**Shrinkage Limit, SL**
Solid State	

Dry Soil

Casagrande Method
(ASTM D4318-95a)

Professor Casagrande standardized the test and developed the liquid limit device.

Cone Penetrometer Method
(BS 1377: Part 2: 1990:4.3)

This method is developed by the Transport and Road Research Laboratory, UK.

<u>Liquid Limit Definition</u>

- The water content at which a groove cut in a soil paste will close upon 25 repeated drops of a brass cup with a rubber base
- Prepare paste of soil finer than # 40 sieve
- Place Soil in Cup
- Cut groove in soil paste with standard grooving tool
- Rotate cam and count number of blows of cup required to close groove by 1/2”

<u>LL Test Procedure</u>

- Perform on 3 to 4 specimens that bracket 25 blows to close groove
- Obtain water content for each test
- Plot water content versus number of blows on semi-log paper
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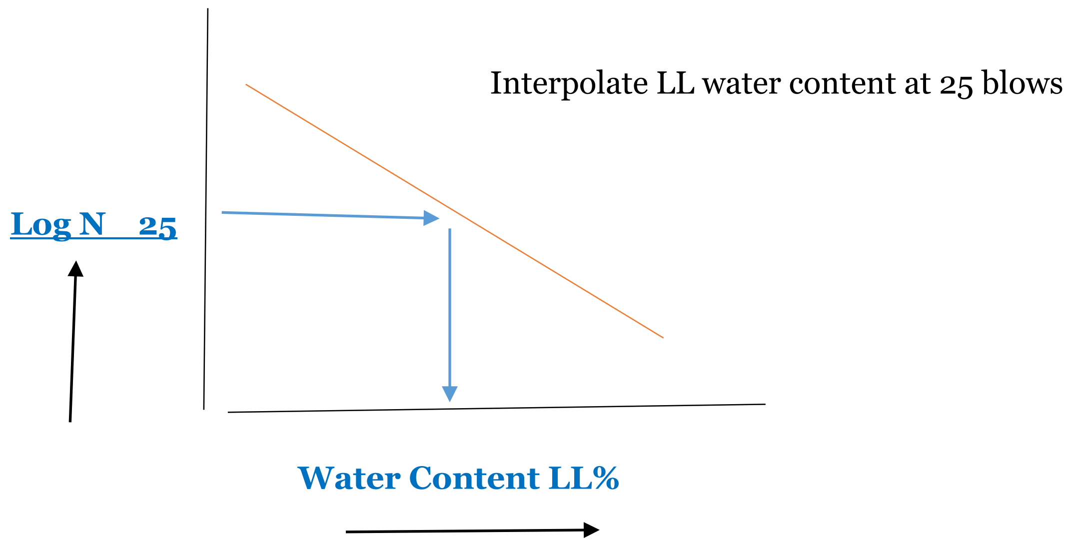


Q4. Explain compaction in soils. Also write note on moisture density relationship and its effect in compaction of soils

Answer:

Compaction:

- In most instances in civil engineering and/or construction practice, whenever soils are imported or excavated and re-applied, they are *compacted*.
- Defined as artificial increase ie densification by mechanical means.
- The terms compaction and consolidation may sound as though they describe the same thing, but in reality they do not.

There is different between Compaction and Consolidation.
Compaction means the removal of porosity.
Where Consolidation means he removal of water-filled porosity.

Principles of Compaction

Compaction of soils is achieved by reducing the volume of voids. It is assumed that the compaction process does not decrease the volume of the solids or soil grains·

The degree of compaction of a soil is measured by the dry density/ unit weight of the skeleton.
The dry unit weight correlates with the degree of packing of the soil grains.

$$\rho_d = \rho_s / (1+e)$$

The more compacted a soil is:
The smaller its void ratio (e) will be.
The higher its dry density will be.

Compaction mainly for:

1. **Increased Shear Strength**
   This means that larger loads can be applied to compacted soils since they are typically stronger.
2. **Reduced Permeability**
   This inhibits soils' ability to absorb water, and therefore reduces the tendency to expand/shrink and potentially liquefy
3. **Reduced Compressibility**
   This also means that larger loads can be applied to compacted soils since they will produce smaller settlements.
4. **Control Swelling & Shrinking**
5. **Reduce Liquefaction Potential**

Moisture Density Relationship

mc definite relationship with dry density.

$$\rho_d = \rho_t / (1+\omega)$$

Specific soil, specific value with specific compactive effort.

Determine compaction curve.

Determine structural capacity of soil for estimation of design parameters.

Establish compaction specifications for adequate quality control.

The Standard Proctor Test

R.R. Proctor in the early 1930's was building dams for the old Bureau of Waterworks and Supply in Los Angeles, and he developed the principles of compaction in a series of articles in Engineering News-Record.

General

- Air or oven dry, break aggregations
- Passing 2”, 30% or < retained 3/4”, above 2” discarded, 2” material replaced with ¾”passing retained on #4
- 5 and 13 lbf specimen for 4 and 6” moulds.
- Oversize correction, More than 5% coarser than specified

Procedures and Results

Several samples of the same soil, but at different water contents, are compacted according to the compaction test specifications.

The total or wet density and the actual water content of each compacted sample are measured.

Plot the dry densities ρd versus water contents w for each compacted sample. The curve is called as a *compaction curve*.

Each data point on the curve represents a single compaction test, and usually four or five individual compaction tests are required to completely determine the compaction curve.

At least two specimens wet and two specimens dry of optimum, and water contents varying by about 2%.

Optimum water content is typically slightly less than the plastic limit (ASTM suggestion).

Typical values of maximum dry density are around 1.6 to 2.0 Mg/m3 with the maximum range from about 1.3 to 2.4 Mg/m3. Typical optimum water contents are between 10% and 20%, with an outside maximum range of about 5% to 40%.

Below wopt (dry side of optimum): As the water content increases, the particles develop larger and larger water films around them, which tend to “lubricate” the particles and make them easier to be moved about and reoriented into a denser configuration. At wopt:
The density is at the maximum, and it does not increase any further. Above wopt (wet side of optimum): Water starts to replace soil particles in the mold, and since ρw << ρs the dry density starts to decrease.

Water Role in Compaction Process

- A little bit of water facilitates compaction
- too much water inhibits compaction.

Effect on compaction of soil:

Increasing engineering properties by compaction. MD relationship difficult in certain cases.

Go for test fill in the field. Which plant, passes, lift thickness.

Density correction to oversize fraction.

Replacement over size technique, not good?

Degradation of certain soils. More in lab so difficult to achieve results

Gap gradation.

Same method for aggregate bases and sub bases.

Uses

To establish specifications for adequate quality control.

To assist providing desired structural capacity.

To assess seasonal variation in engineering properties of soil.

A greater compactive effort produces a greater CBR for the dry of optimum. However, the CBR is actually less for the wet of optimum for the higher compaction energies (overcompaction).

Q.5: Write note on geo physical testing.

Answer:

GEOPHYSICAL TESTING

- Geophysical Exploration consists of making indirect measurements
- from the earth's surface or in borehole
- to obtain subsurface information.
- Requirement of Geotechnical Investigations Grouping of the Subsurface strata with similar Geotechnical Properties
- Strength
- Stiffness
- Geophysical Exploration helps in
- *Rapid location and correlation of geological features* Stratigraphy
- Lithology
- Discontinuities
- Ground Water
- *In-situ measurement of* Modulli and Densities

General Techniques

◦Seismic
◦Electrical
◦Sonic
◦Magnetic
◦Radar
◦Gravity

SEISMIC TECHNIQUES

PRINCIPLE difference in stiffness of different soil/rock layers

PROCEDURE An elastic wave is generated in the ground by Impactive force (Falling Weight or Hammer Blow)
Explosive Charge

Resulting Ground motion is measured using vibration detectors (geophones)

Time elapsed will help to evaluate different *Wave Velocities* in different layers

Wave Types

Longitudinal Waves (P waves)

Transverse or Shear Waves (S waves)

Rayleigh Waves

Love Waves

Methods **Refraction**

Reflection

Cross-Hole

Down-Hole

Reflection: standard in oil exploration (deep)

Refraction: for shallow features like depth to bedrock or thickness of the unconsolidated material,

Also used in deciphering the internal structure of the earth (very deep, need a strong source of vibration like an earthquake)

Wave/ ray behavior similar to light

Surface wave: considered noise

Body waves: P (compressional) and S (shear)

Velocity depends on the density of the layers; increases with increasing density

Incident, reflected, and refracted rays

Ray gets deflected away from the normal (lighter to a denser medium)

Critical angle: refracted wave travels along the interface

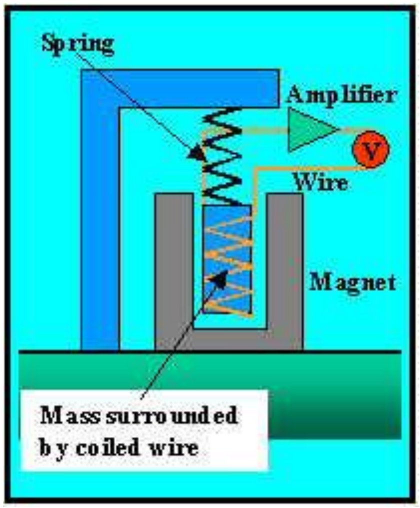
Energy source: vibration created by a hammer blow or explosive in a drill hole

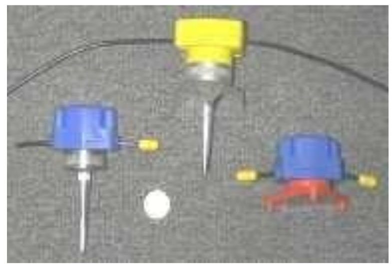
Wave propagation: spherical waves in a homogeneous medium, wave fronts

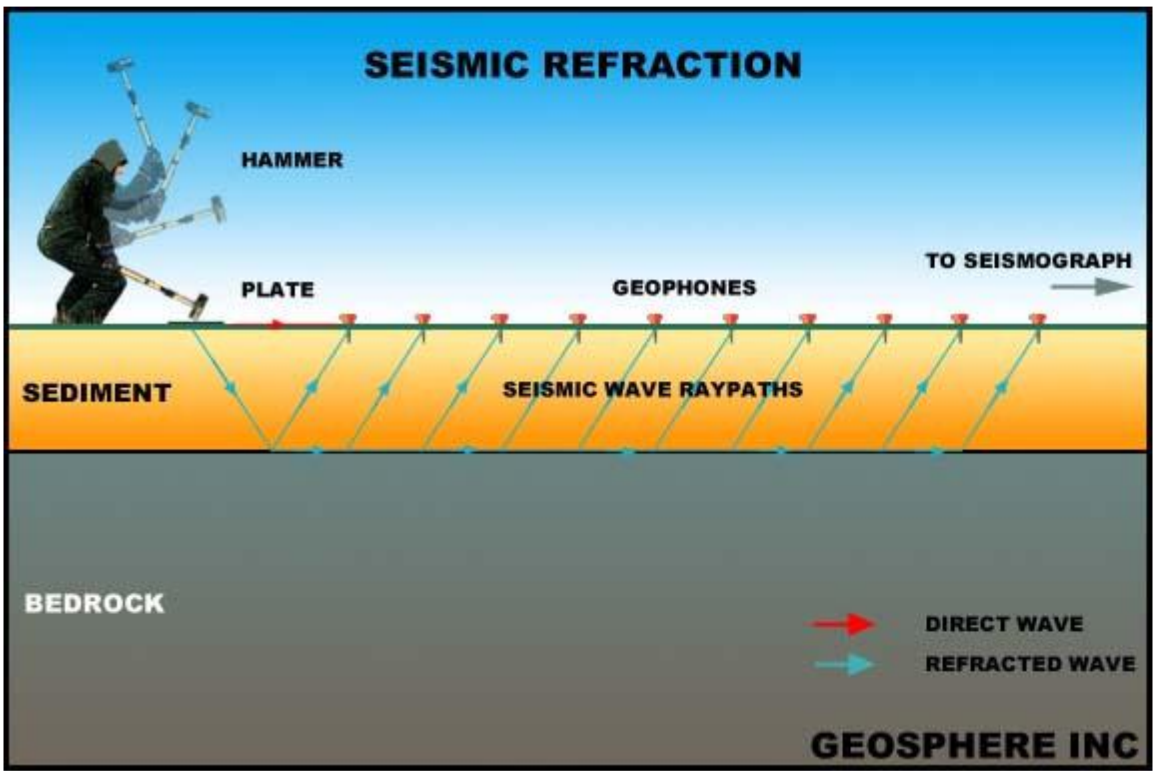
Rays: perpendicular to wave fronts, shown on diagrams

Geophone: device that detects vibrations

Seismograph: device that records the arrival times


Spring
Amplifier
V
Wire
Magnet
Mass surrounded by coiled wire




SEISMIC REFRACTION
HAMMER
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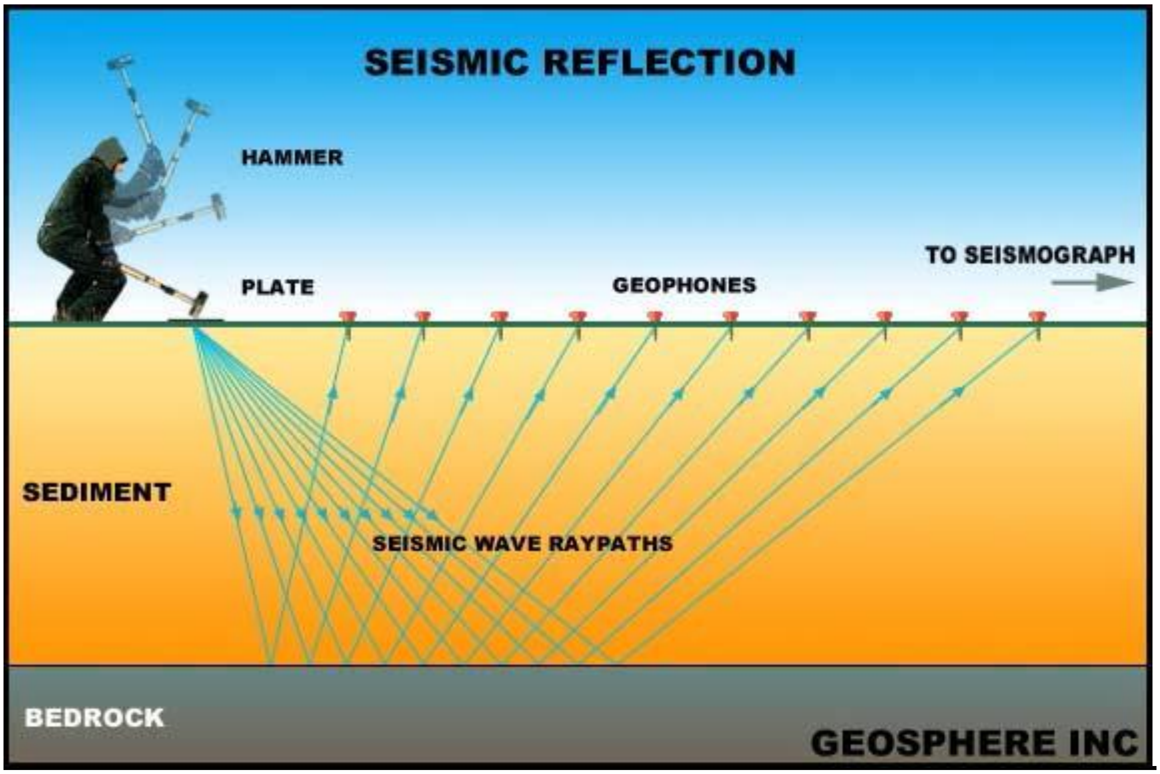

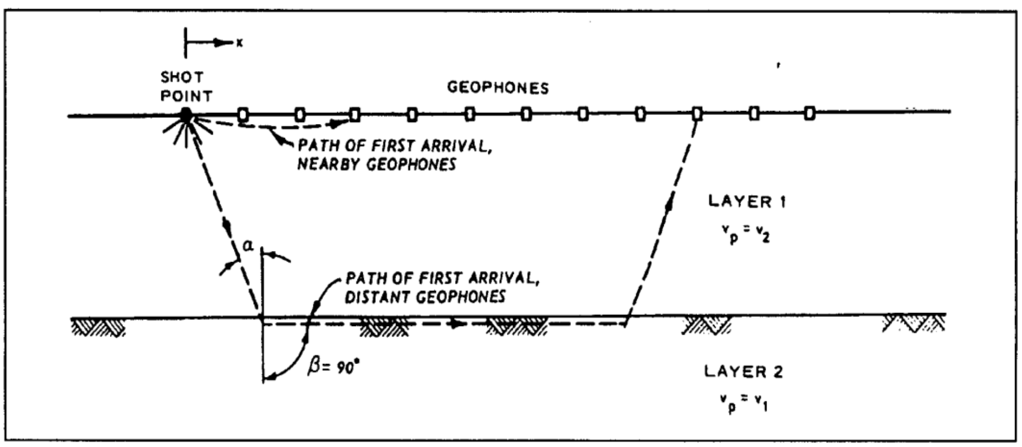

Figure 3-1. Schematic of seismic refraction survey

Table 4-1
Applications of Selected Geophysical and Other Methods for Determination of Engineering Parameters[1]

Method	Basic Measurement	Application	Advantages	Limitations
		Surface		
Refraction seismic	Travel time of compressional waves through subsurface layers	Velocity determination of compression wave through subsurface. Depths to contrasting interfaces and geologic correlation of horizontal layers	Rapid, accurate, and relatively economical technique. Interpretation theory generally straightforward and equipment readily available	Incapable of detecting material of lower velocity underlying higher velocity. Thin stratum sometimes not detectable. Interpretation is not unique
Reflection seismic	Travel time of compressional waves reflected from subsurface layers	Mapping of selected reflector horizons. Depth determinations, fault detection, discontinuities, and other anomalous features	Rapid, thorough coverage of given site area. Data displays highly effective	Even with recent advances in high-resolution, seismic technology applicable to civil works projects is limited in area of resolution
		Borehole		
Uphole/downhole (seismic)	Vertical travel time of compressional and/or shear waves	Velocity determination of vertical P- and/or S-waves. Identification of low-velocity zones	Rapid technique useful to define low-velocity strata. Interpretation straightforward	Care must be exercised to prevent undesirable influence of grouting or casing

(Sheet 2 of 5)

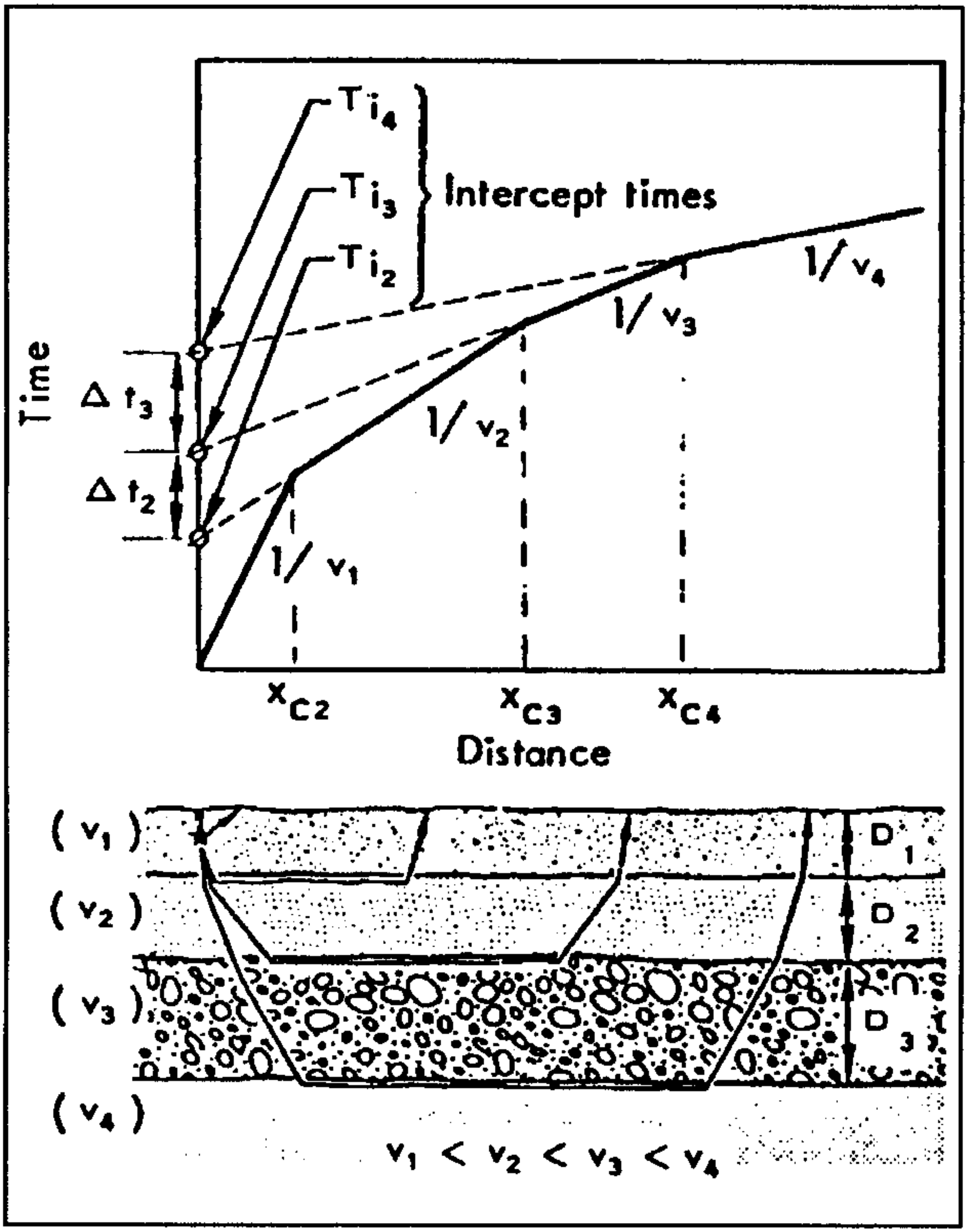

Figure 3-6. Schematic of multiple-layer case and corresponding time-distance curve (Redpath 1973)

LIMITATION

In case of Saturated Media ?

Waves will pass through water (1500 m/s) and not through the soil structure