KUMPULAN IKRAM SDN BHD
IKRAM ENGINEERING SERVICES
GEOTECHNICAL LABORATORY

By

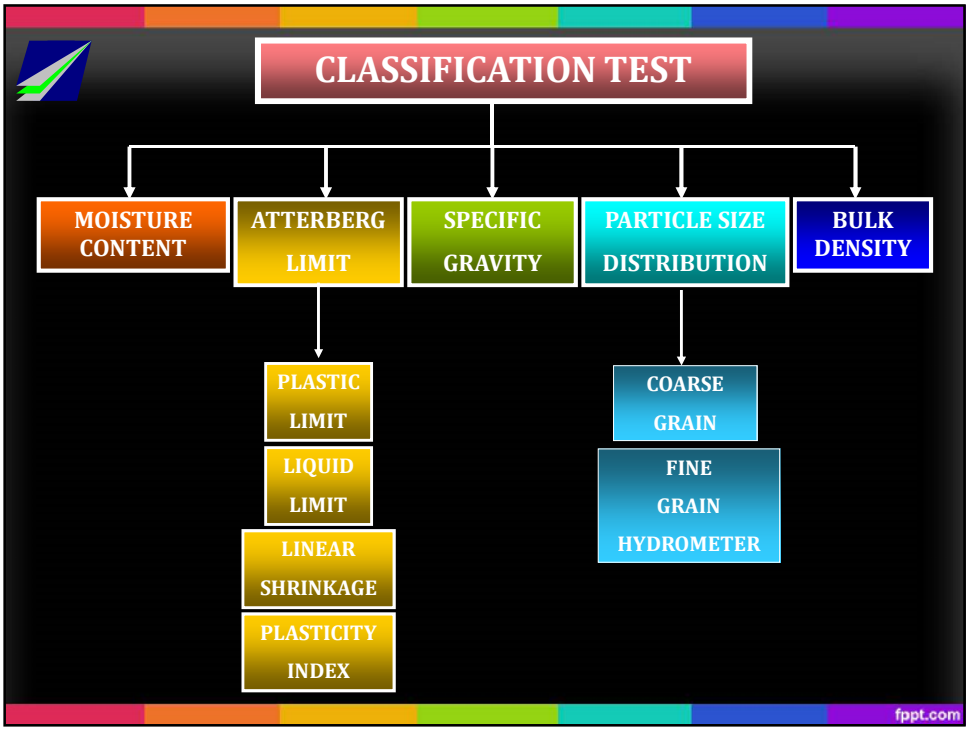
NURUL FAUZIAH BT AZIZ

INTRODUCTION TO LABORATORY TESTING (GEOTECHNICAL)

LABORATORY TEST

BS 1377
MS 1056

Part 2	CLASSIFICATION TEST
Part 3	CHEMICAL & ELECTRO CHEMICAL TEST
Part 4	COMPACTION RELATED TEST
Part 5	COMPRESSIBILITY, PERMEABILITY & DURABILITY
Part 6	CONSOLIDATION & PERMEABILITY TEST IN HYDRAULIC CELLS & PORE PRESSURE MEASUREMENT
Part 7	SHEAR STRENGTH TEST : TOTAL STRESS
Part 8	SHEAR STRENGTH TEST : TEFFECTIVE STRESS



CLASSIFICATION TESTS

	MOISTURE CONTENT *w*	UNIT WEIGHT	SPECIFIC GRAVITY SG
PURPOSE	Determine amount of water present. Provide general correlation with strength, settlement, workability and etc	Determine the unit weight of soil	Determine the specific gravity of soil grain
PROCEDURE	Oven-dry to constant dry weight. Temperature 110°C ± 5°C at 16-24 hrs.	By weighing a portion of a soil sample and dividing by its volume. The moisture content is measured at the same time to allow conversion from total to dry unit weight	Determined as the ratio of the weight of a given volume of soil solids at a given temperature to the weight of an equal volume of distilled water at the temperature, both weights being taken in air.
REMARKS	When combined with other test, provide an early indication to soil characteristics such as consolidation settlement.		SG value is necessary to compute void ratio of soil. It is used in hydrometer analysis,

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PARTICLE SIZE DISTRIBUTIONS

	COARSE GRAIN SOIL / SIEVE ANALYSIS	FINE GRAIN SOIL / HYDROMETER
PURPOSE	Determine percentage of various grain sizes. The grain size distribution is used to determine the textural classification of soils (ie gravel, sand, silty, clay etc) which in turn is useful in evaluating the engineering characteristics such as permeability, strength, swelling potential and susceptibility to frost action	Determine the percentage of finer < No 200 sieve (< 0.075mm) size, material as Clay/Silt.
PROCEDURE	Wash & prepared representative sample through a screen of sieve. The amount retained on eah sieve is collected dried & weight to determine the percentage of material passing that size.	Soil passing no.200 sieve is mixed with dispersing agent and distilled water and is placed in graduated cylinder in a state of liquid suspended. The specific gravity of the mixture is taken periodically. The relative size and percentage of fine soil are determine based on Stoke's Law for settlement of idealized spherical particles.

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ATTERBERG LIMIT

	ATTERBERG LIMIT
PURPOSE	To describe the consistency and plasticity of fine grain soils with varying degree of moisture.
PROCEDURE	For the portion of the soil passing the No. 40 sieve, the moisture content is varied to identify three stages of soil behavior in terms of consistency. These stages are known as the liquid limit (LL), plastic limit (PL) and shrinkage limit (SL) of soils. • liquid limit (LL) – defined as the water content at which 25 blows of the liquid limit machine closes a standard groove cut in the soil pat for a distance of 12.7 cm. • Plastic limit (PL) - as the water content at which a threat of soil, when rolled down to a diameter of 3 mm will crumble. • Shrinkage limit (SL) – water content below which no further soil volume change occurs with further drying.
Remarks	The Atterberg limits provide general indices of moisture content relative to the consistency and behavior of soils. The LL defines a liquid./semi-solid change, while the PL is a solids boundary. The difference is termed the plasticity index (PI=LL – PL). The liquidity index is LI=(w-PL)/PI is an indicator of stress history, LI=1 for normally consolidated (NC) soils and LI=0 for over-consolidated (OC) soils.

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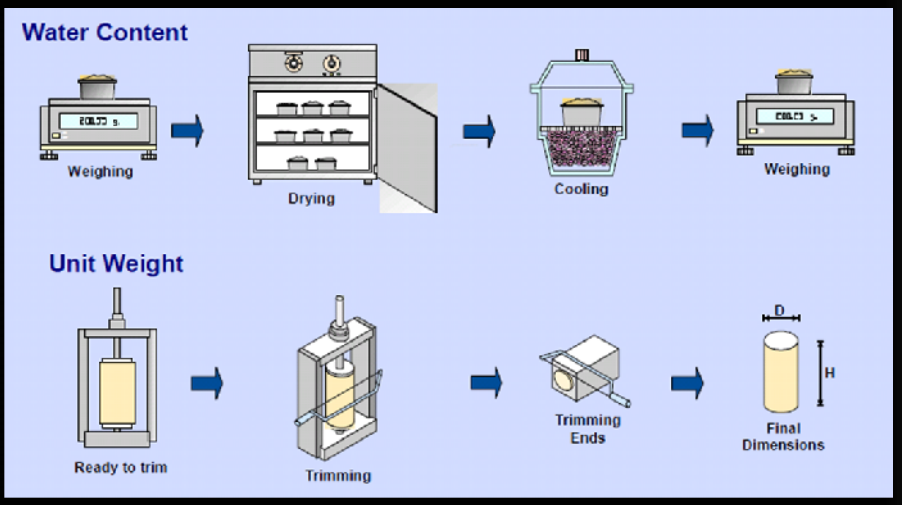
WATER CONTENT & UNIT WEIGHT



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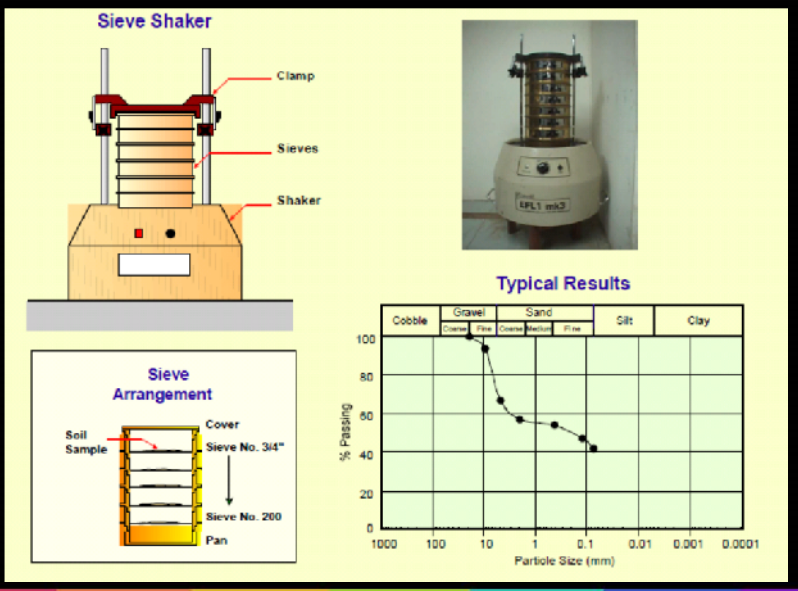
SIEVE ANALYSIS



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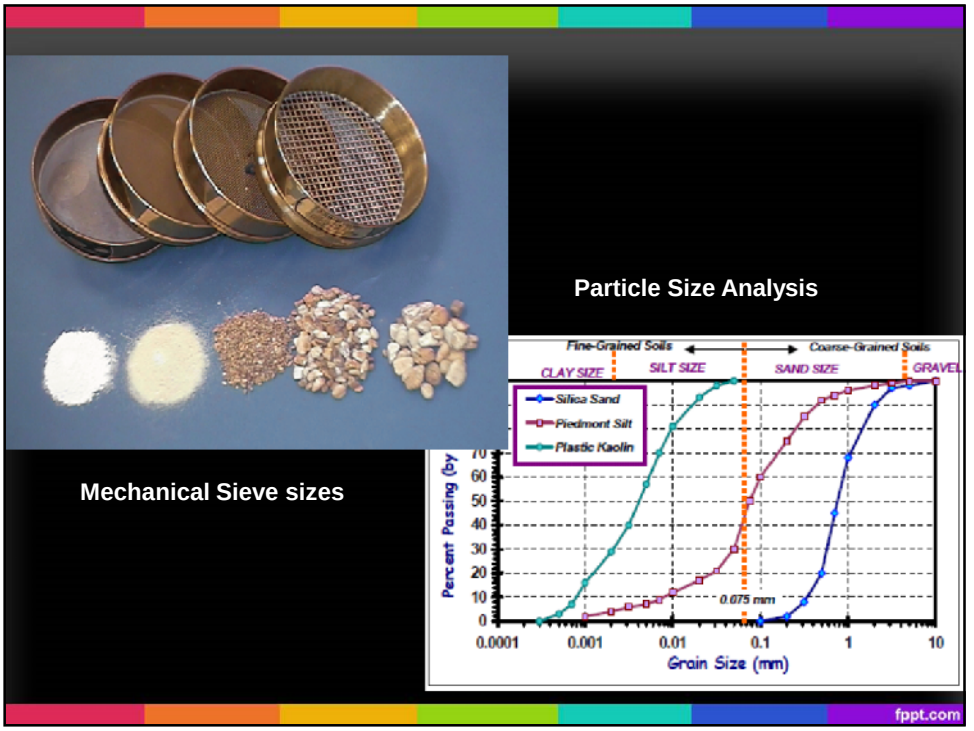
Particle Size Analysis
Mechanical Sieve sizes
Fine-Grained Soils
Coarse-Grained Soils
CLAY SIZE
SILT SIZE
SAND SIZE
GRAVEL
Silica Sand
Piedmont Silt
Plastic Kaolin
Percent Passing (by
0.075 mm
0.0001
0.001
0.01
0.1
1
10
Grain Size (mm)
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ATTERBERG LIMIT
Liquid Limit Determination
Soil Cake Before Testing
Soil Cake After Testing
Grooving Tool
Spatula
Plastic Limit Determination
20g Air Dry
Rolling
Crack
3mm
Drying
Plasticity Chart
Plasticity Index, PI (%)
Liquid Limit, LL (%)
Typical Liquid Limit Results
Water Content (%)
LL
Number of Drops (N)
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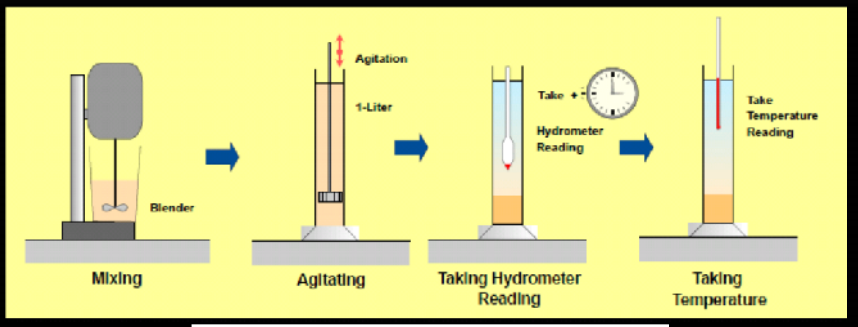
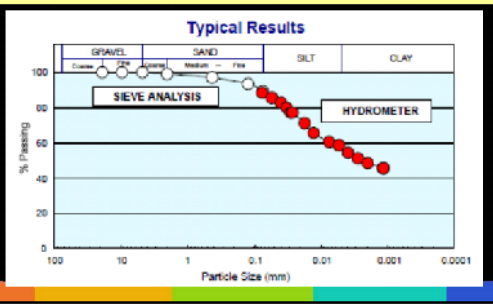
Manual Casagrande Mtd

Cone Penetrometer Mtd

HYDROMETER TEST



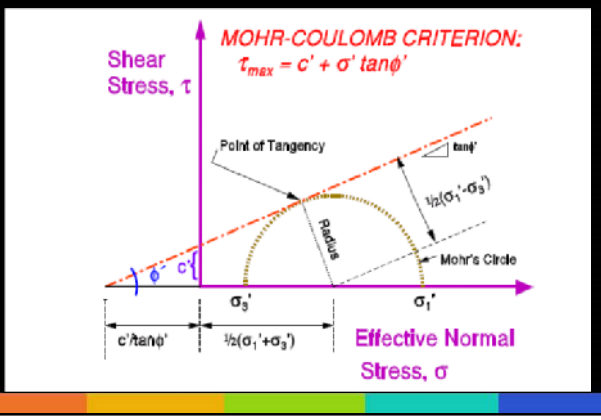


SAMPLE PREPARATION

STRENGTH TEST

STRENGTH TEST

- Commonly used – shallow, deep foundation, excavation earth retaining structures, fill and slopes.
- Total & effective stress analysis



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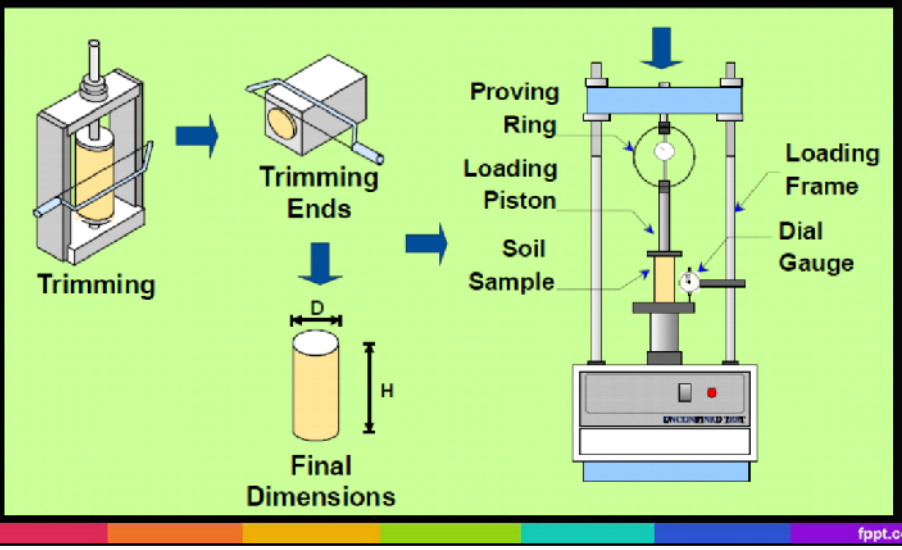
Unconfined Compression



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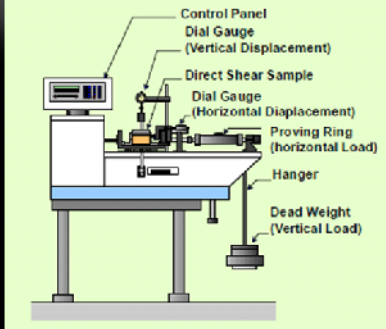
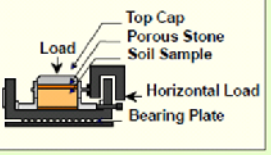
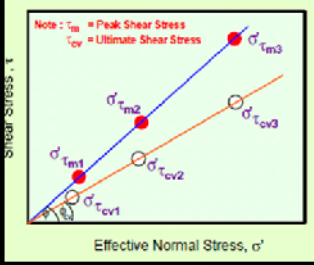
SHEAR BOX TEST



Direct Shear Sample



Results of Direct Shear Test



Typical Values of ϕ and ϕ_{cv} for Granular Soils

Type of Soil	ϕ, Deg	ϕ_{cv}, Deg
Sand : round grains		
Loose	28 to 30	
Medium	30 to 35	26 to 30
Dense	35 to 38	
Sand : angular grains		
Loose	30 to 35	
Medium	35 to 40	30 to 35
Dense	40 to 45	
Sandy Gravel	34 to 48	33 to 36

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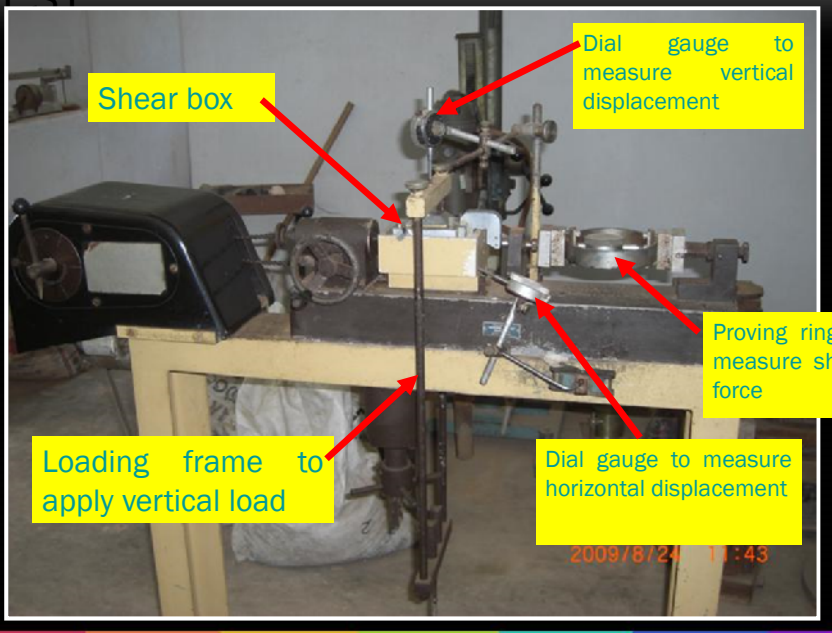
DIRECT SHEAR TEST



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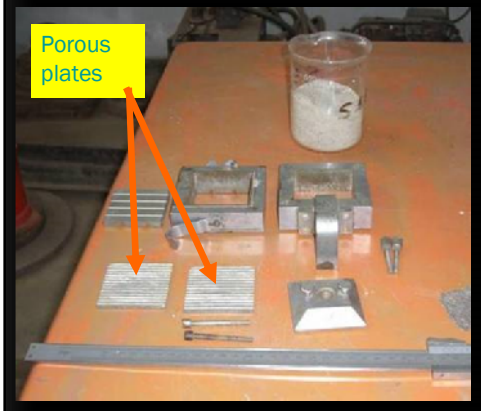
Procedure:

1) Check the inner dimension of the soil container.
2) Put the parts of the soil container together.
3) Calculate the volume of the container. Weigh the container.
4) Place the soil in smooth layers (approximately 10 mm thick). If a dense sample is desired tamp the soil.
5) Weigh the soil container, the difference of these two is the weight of the soil. Calculate the density of the soil.
6) Make the surface of the soil plane.
7) Put the upper grating on stone and loading block on top of soil.

DIRECT SHEAR TEST

Direct shear test is most suitable for consolidated drained tests specially on granular soils (e.g.: sand) or stiff clays

Preparation of a sand specimen



Components of the shear box

Preparation of a sand specimen

DIRECT SHEAR TEST

Preparation of a sand specimen

Leveling the top surface of specimen

Pressure plate

Specimen preparation completed

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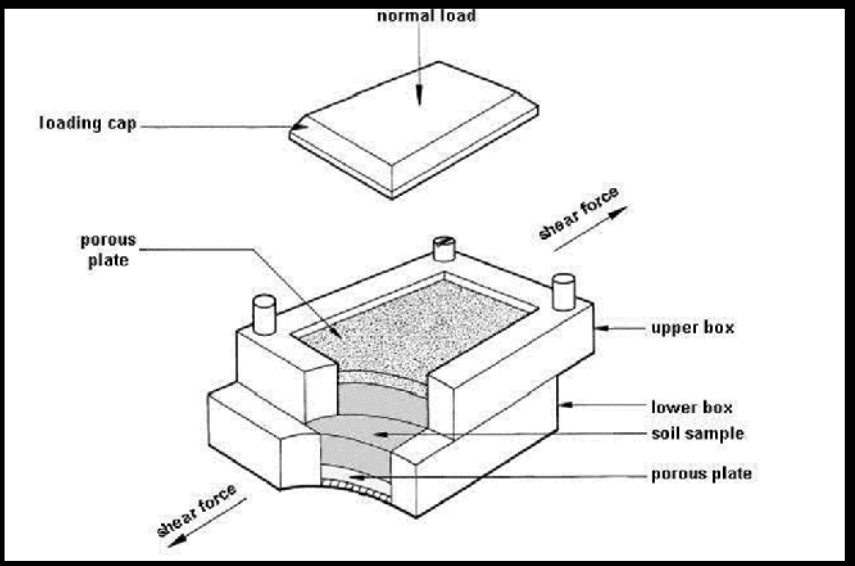

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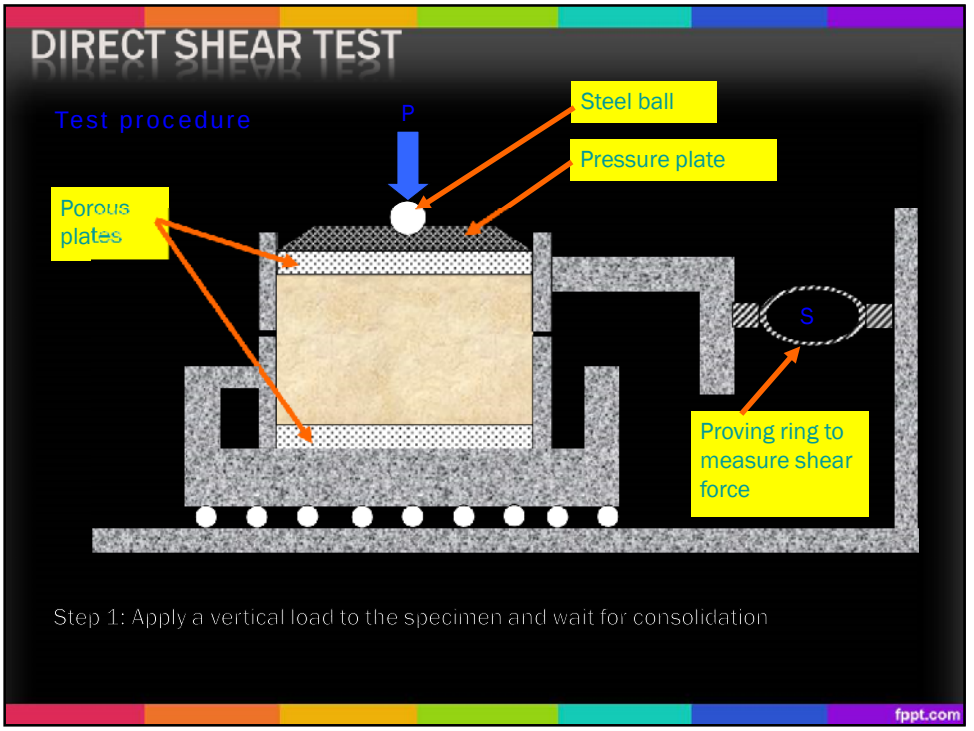
DIRECT SHEAR TEST
Test procedure
P
Steel ball
Pressure plate
Porous plates
S
Proving ring to measure shear force
Step 1: Apply a vertical load to the specimen and wait for consolidation
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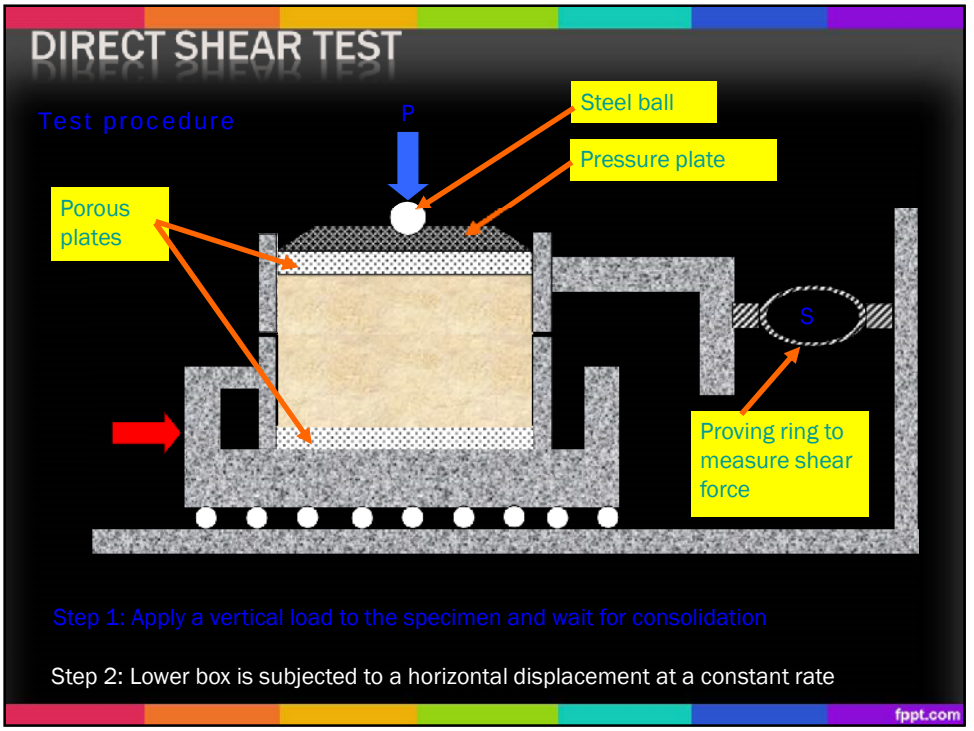
DIRECT SHEAR TEST
Test procedure
P
Steel ball
Pressure plate
Porous plates
S
Proving ring to measure shear force
Step 1: Apply a vertical load to the specimen and wait for consolidation
Step 2: Lower box is subjected to a horizontal displacement at a constant rate
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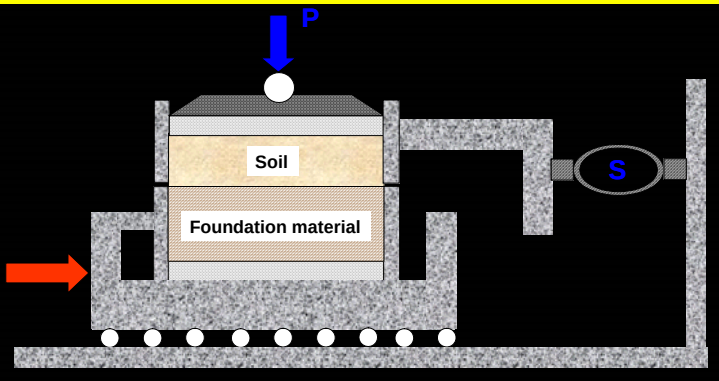
Procedure:

8) Measure the thickness of soil specimen.
9) Apply the desired normal load.
10) Remove the shear pin.
11) Attach the dial gauge which measures the change of volume.
12) Record the initial reading of the dial gauge and calibration values.
13) Before proceeding to test check all adjustments to see that there is no connection between two parts except sand/soil.
14) Start the motor. Take the reading of the shear force and record the reading.
15) Take volume change readings till failure.
16) Add 5 kg normal stress 0.5 kg/cm2 and continue the experiment till failure
17) Record carefully all the readings. Set the dial gauges zero, before starting the experiment

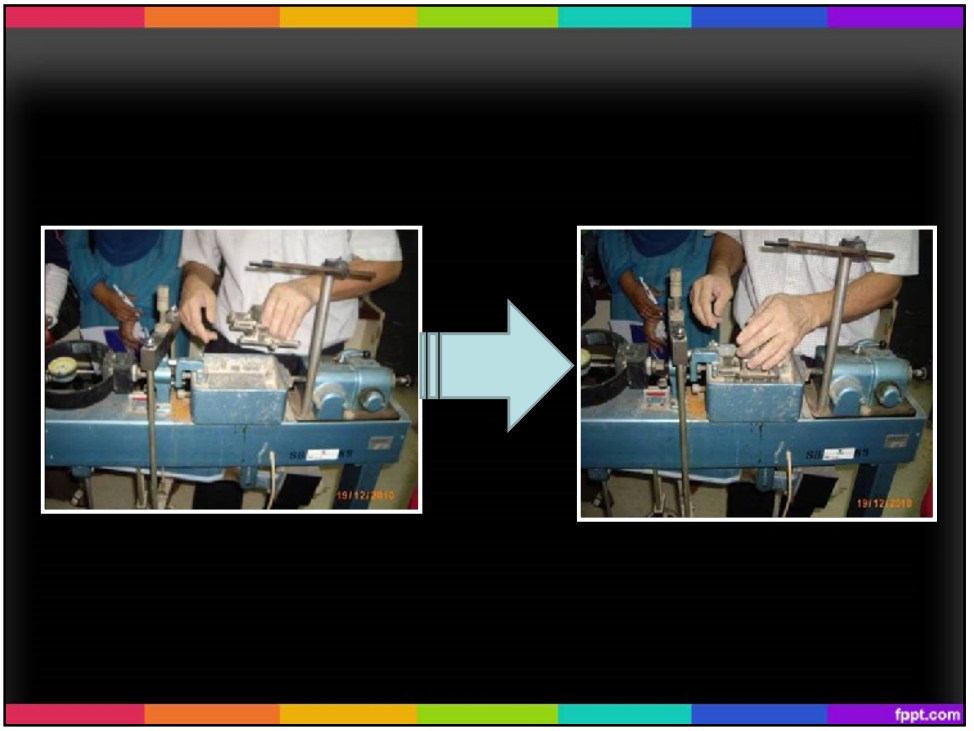
Interface tests on direct shear apparatus

In many foundation design problems and retaining wall problems, it is required to determine the angle of internal friction between soil and the structural material (concrete, steel or wood)



$$\tau_f = c_a + \sigma' \tan\delta$$

Where,
c_a = adhesion,
δ = angle of internal friction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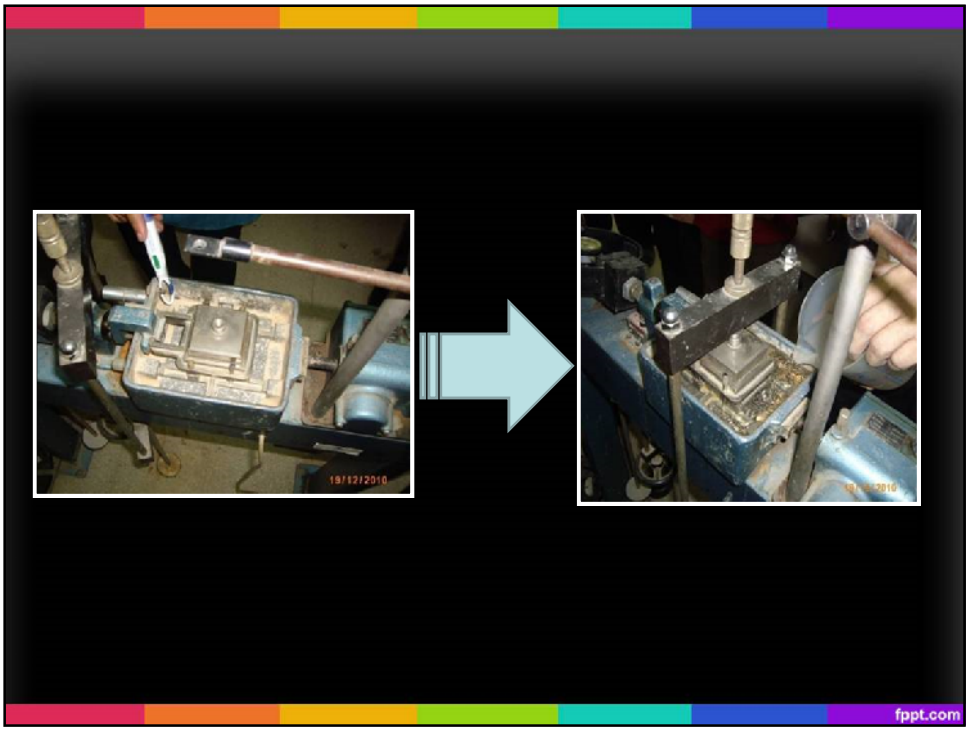
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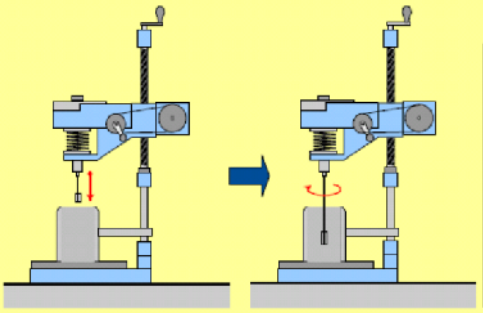
LABORATORY VANE



Torsion Spring for Laboratory Vane

Soil Stiffness	Suggested Spring No.	Max. Shear Stress (kN/m^2)
Very Soft	4(Weakest)	20
Soft	3	40
Soft to Medium	2	60
Medium Stiff to Stiff	1(Stiffest)	90

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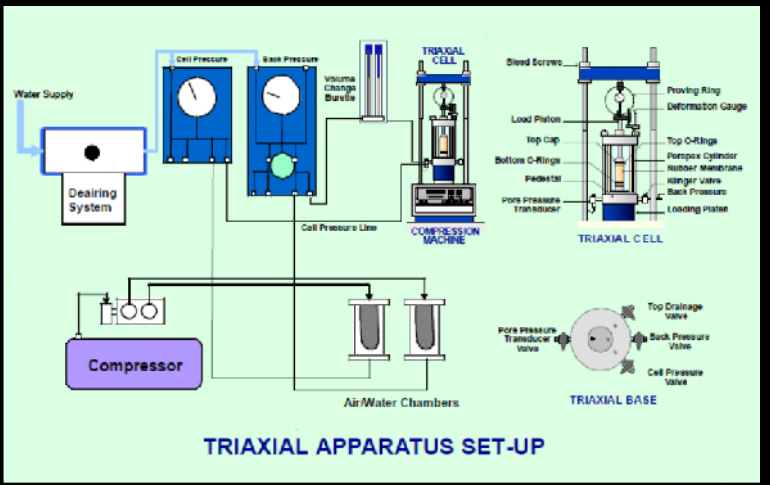
TRIAXIAL TEST



TRIAXIAL APPARATUS SET-UP

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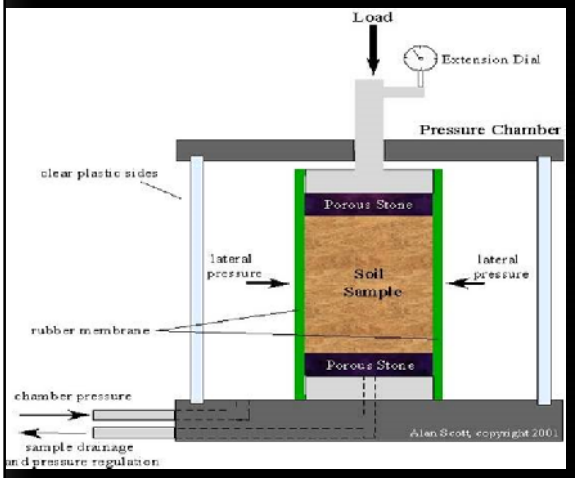
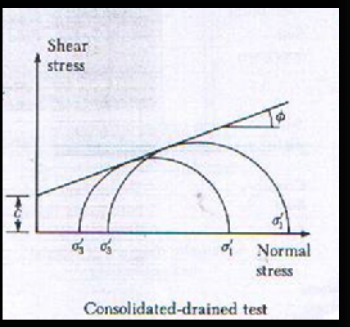
TRIAXIAL TEST





Shear Strength = c' + σ' tanΦ

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TRIAXIAL TEST

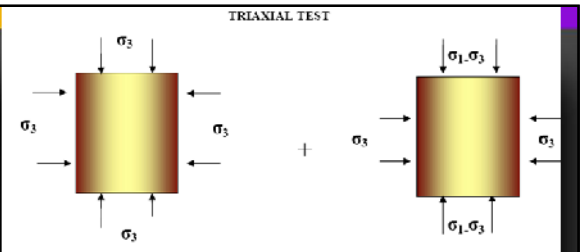


Figure 4.5 Triaxial Tests, Step I and Step II

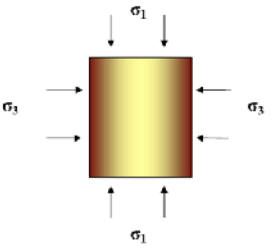
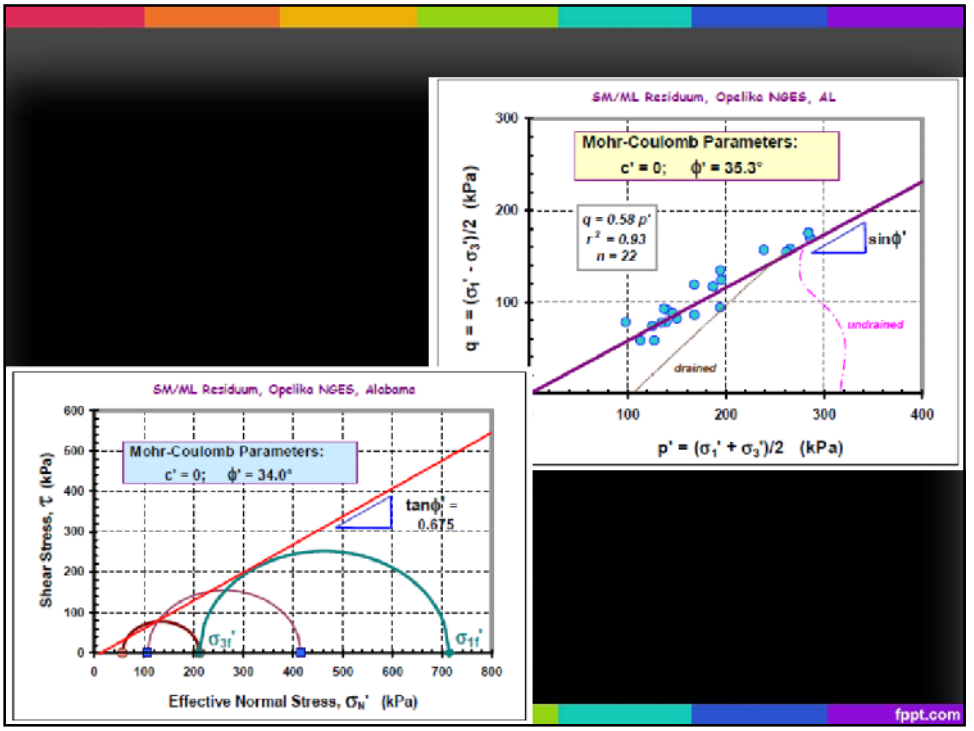


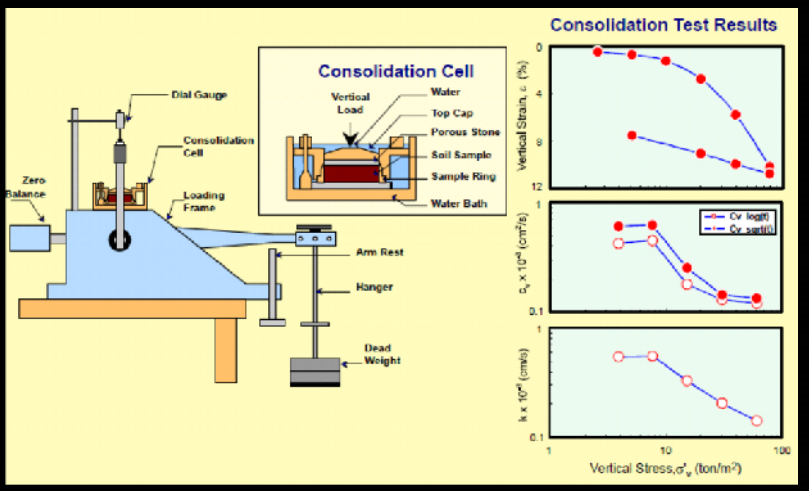
Fig 4.6 Triaxial Test-Final Step

The test may be one of the following types.

(1) Unconsolidated – Undrained (UU) test, quick test.
(2) Consolidated – Undrained (CU) test.
(3) Consolidated – Drained (CD) test, slow test.



CONSOLIDATION TEST



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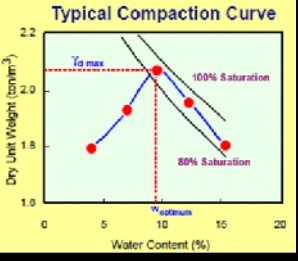
COMPACTION TEST -MANUAL

Table 1 Type of Energy Input

Energy	Standard		Modified	
Mold Size	4" ø	6" ø	4" ø	6" ø
Hammer Weight	2.5 kg	2.5 kg	4.5 kg	4.5 kg
Hammer Height	30 cm	30 cm	45 cm	45 cm
No. of Layer	3	3	5	5
No. of Blow/Layer	25	56	25	56



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COMPACTION TEST MACHINE

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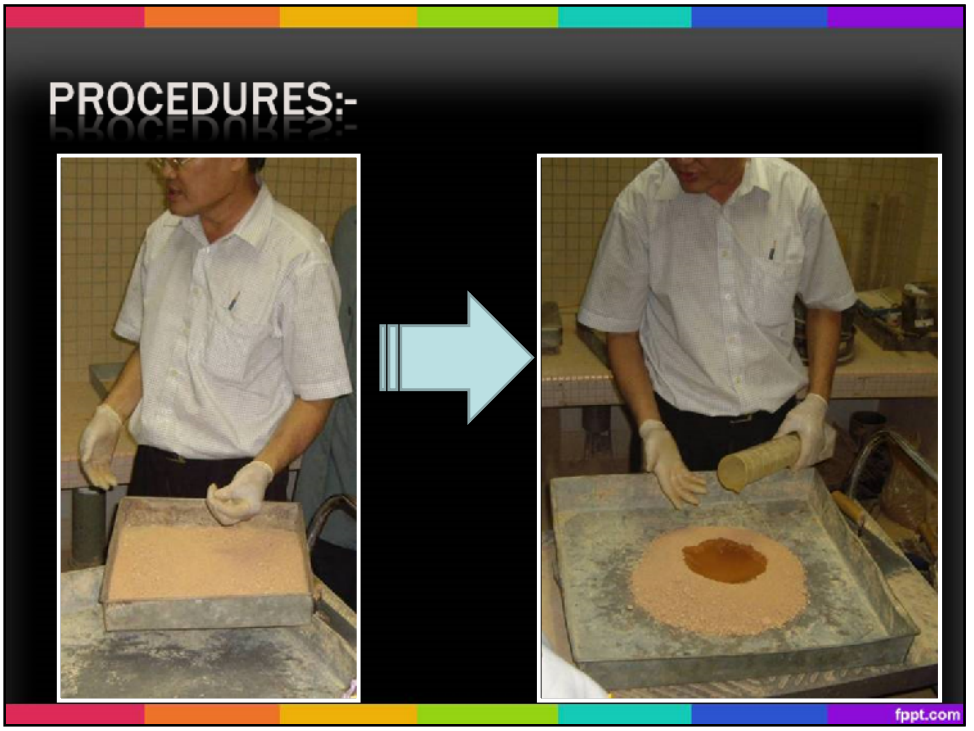
PROCEDURES:-
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PROCEDURES:-
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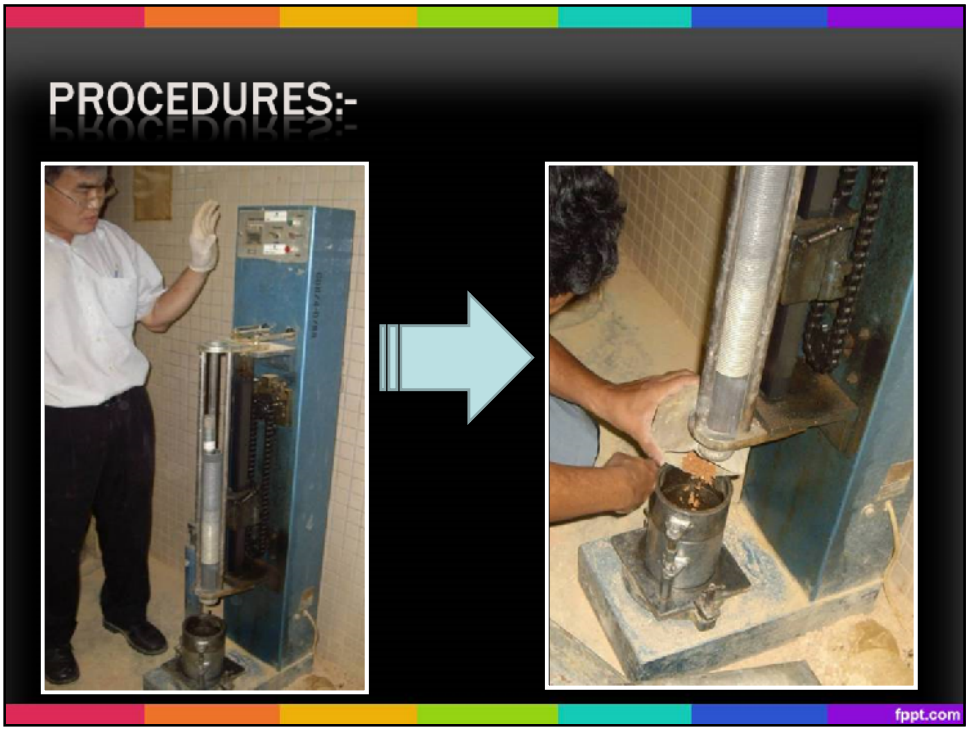
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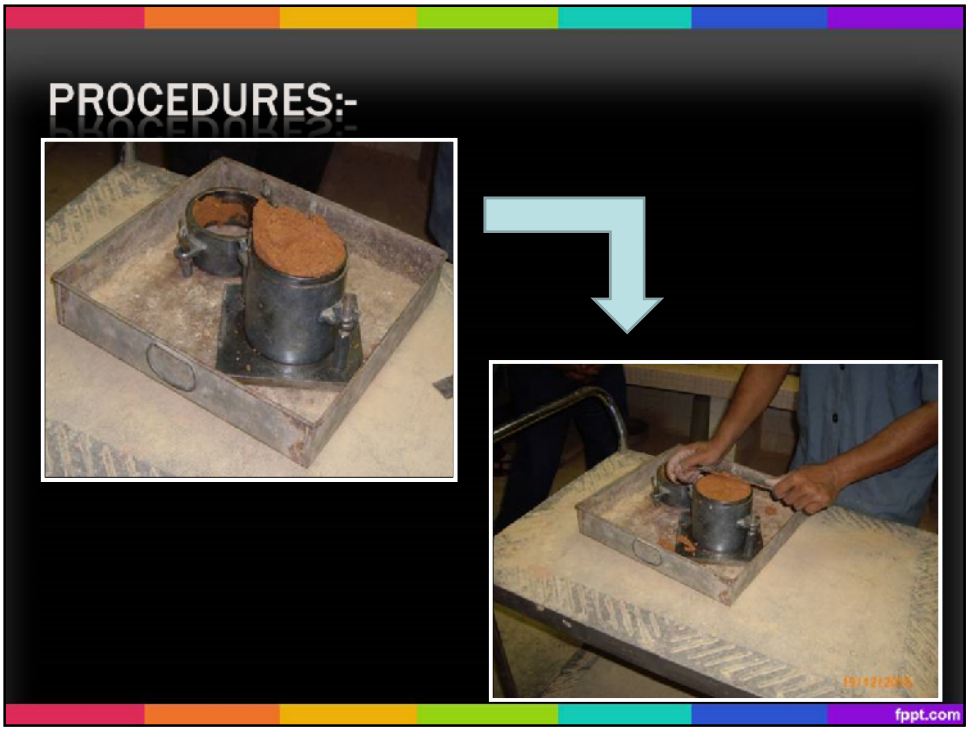
PROCEDURES:-
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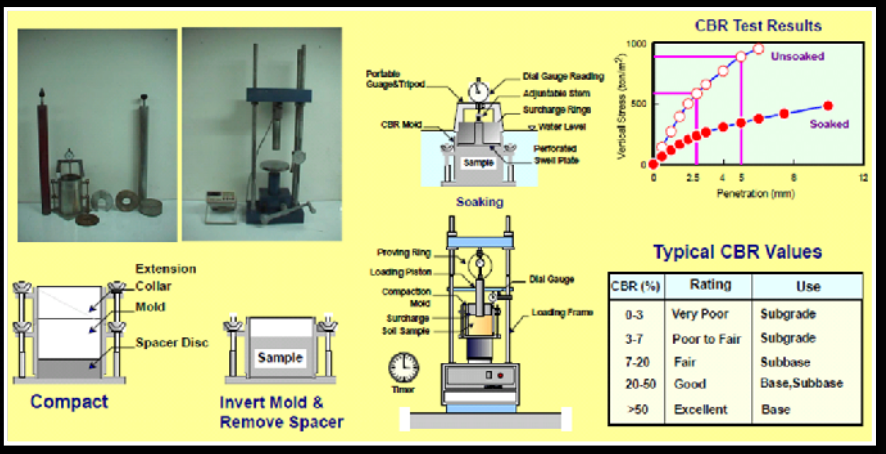
PROCEDURES:-

PROCEDURES:-

CBR TEST



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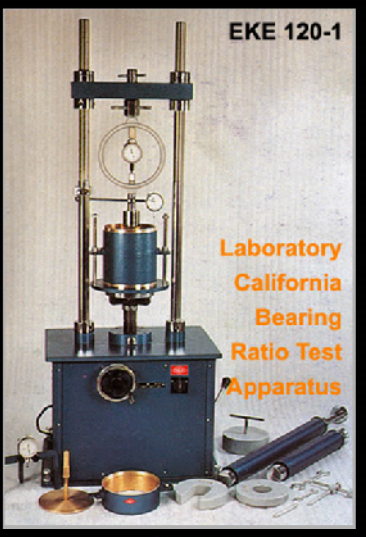
CBR TEST (cont'd)

- **Apparatus used:**

i. Mould
ii. Steel Cutting collar
iii. Spacer Disc
iv. Surcharge weight
v. Dial gauges
vi. Penetration Plunger
vii. Loading Machine



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CBR TEST (cont'd)

- **CBR test procedure:**

1) Normally about 7 kg must be compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows.
2) Weigh of empty mould
3) Add water to the first specimen (compact it in five layer by giving 10 blows per layer)
4) After compaction, remove the collar and level the surface.
5) Take sample for determination of moisture content.
6) Weight of mould + compacted specimen.
7) Place the mold in the soaking tank for four days (ignore this step in case of unsoaked CBR.

CBR TEST (cont'd)

- **CBR Test procedure:**

8) Take other samples and apply different blows and repeat the whole process.
9) After four days, measure the swell reading and find %age swell.
10) Remove the mould from the tank and allow water to drain.
11) Then place the specimen under the penetration piston and place surcharge load of 10lb.
12) Apply the load and note the penetration load values.
13) Draw the graphs between the penetration (in) and penetration load (in) and find the value of CBR.
14) Draw the graph between the %age CBR and Dry Density, and find CBR at required degree of compaction.

CBR TEST (cont'd)

- **Uses and significance of California Bearing Ratio Test:**

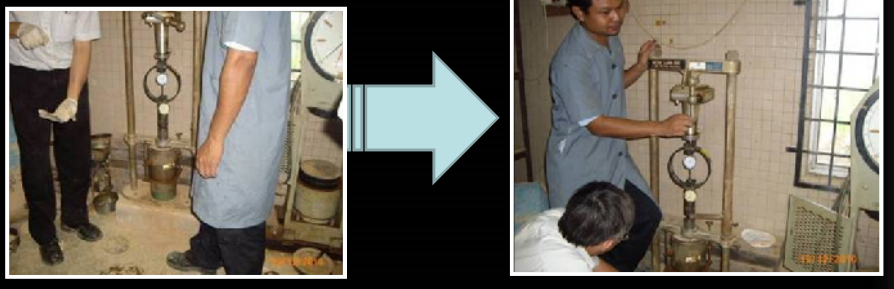
❖The CBR test is one of the most commonly used methods to evaluate the strength of a sub grade soil, sub base, and base course material for design of thickness for highways and airfield pavement.

CBR TEST (cont'd)

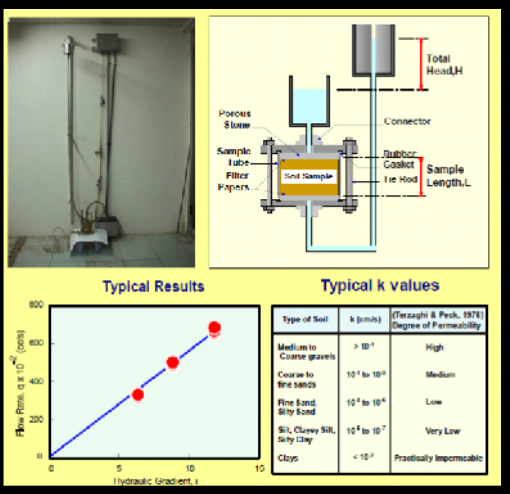
Type of soil	CBR range
Clay	1-3
Sandy clay	4-7
Well graded sand	15-40
Well graded sandy gravel	20-60

PROCEDURE:-

PROCEDURE:-



CONSTANT HEAD PERMEABILITY TEST



CONSTANT HEAD PERMEABILITY – TRIAXIAL TEST