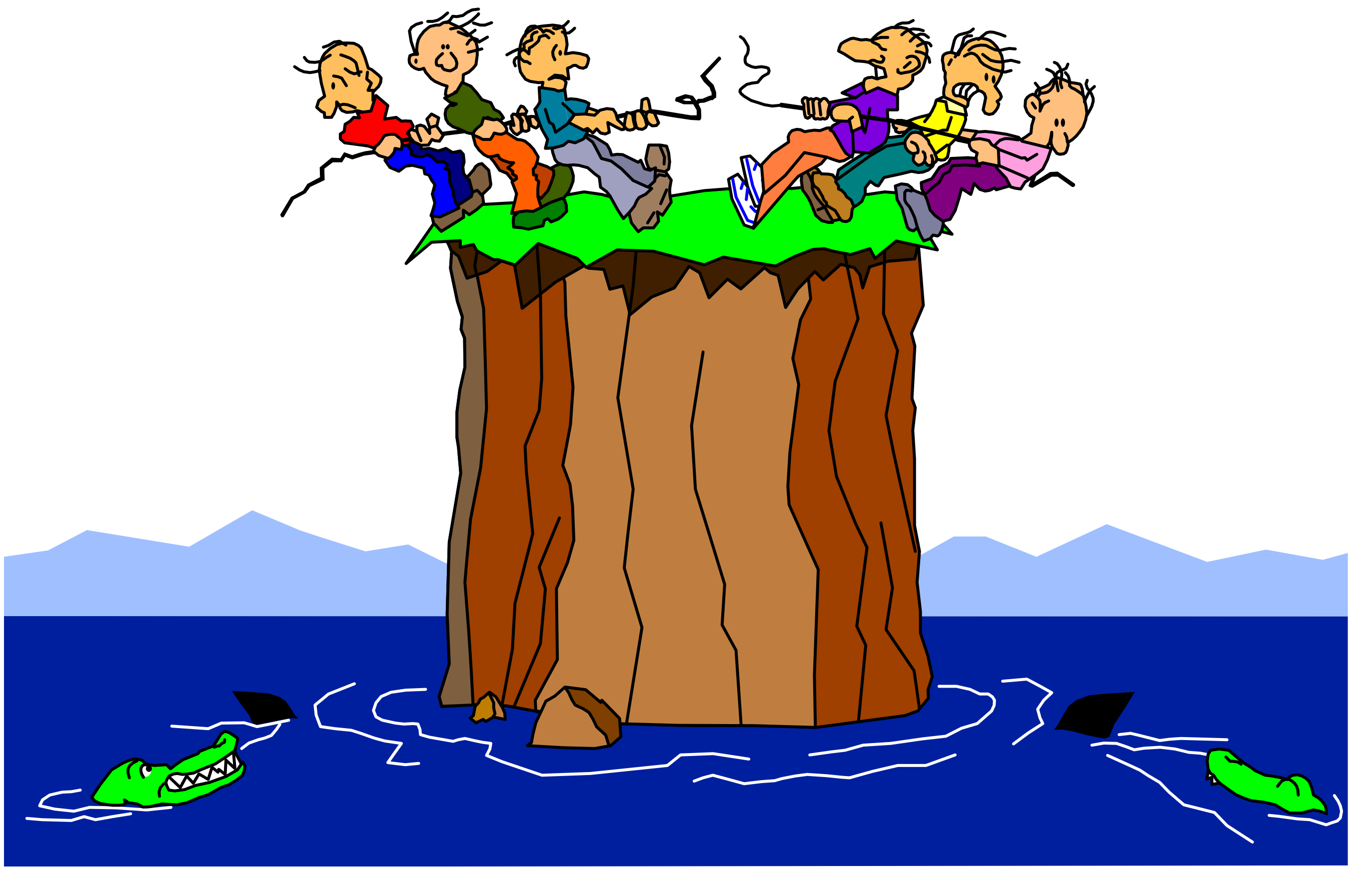
Excavation Safety



Objectives

- To provide students with:
  - **An introduction to 29 CFR 1926, Subpart P-Excavation Standard**
  - **An overview of soil mechanics**
  - **An introduction to trenching and excavation hazard recognition**

29 CFR 1926, Subpart P

- 1926.650
  - **Scope, application, and definitions applicable to this subpart**
- 1926.651
  - **General requirements**
- 1926.652
  - **Requirements for protective systems**

1926.650 Scope, Application, and Definitions

- Scope and application
- Definitions
- Competent Person

1926.650 Scope & Application, Definitions

- Accepted engineering practices
- Aluminum hydraulic shoring
- Bell-bottom pier
- Benching
- Cave-in
- Competent person
- Cross braces
- Kick-out
- Protective systems
- Ramp
- Registered professional engineer
- Sheeting
- Shield
- Shoring

1926.650 Scope & Application, Definitions

- Excavation
- Faces or sides
- Failure
- Hazardous atmospheres`
- Sloping
- Stable rock
- Structural ramp
- Trench

Definitions

- **"Excavation" means any:**
- **1. Man-made cut**
- **2. Cavity**
- **3. Trench**
- **4. Depression in an earth surface, formed by earth removal.**

Definitions

- **Confined space is a space that, by design and/or configuration has:**
- **1. Limited openings for entry and exit**
- **2. Unfavorable natural ventilation**
- **3. May contain or produce hazardous substances**
- **4. Is not intended for continuous employee occupancy.**

Definitions Cont.

- **"Trench (Trench excavation)"** means a narrow excavation (in relation to its length) made below the surface of the ground.
- 1. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m).

Definitions Cont.

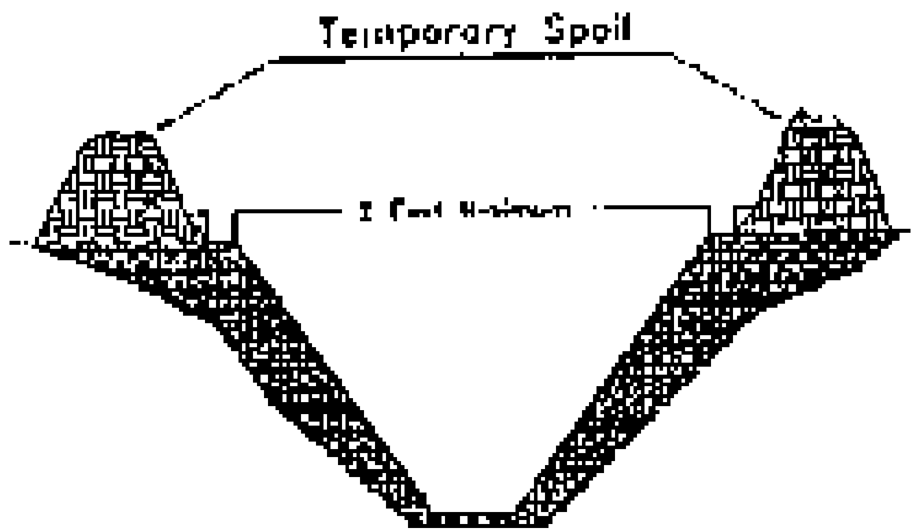
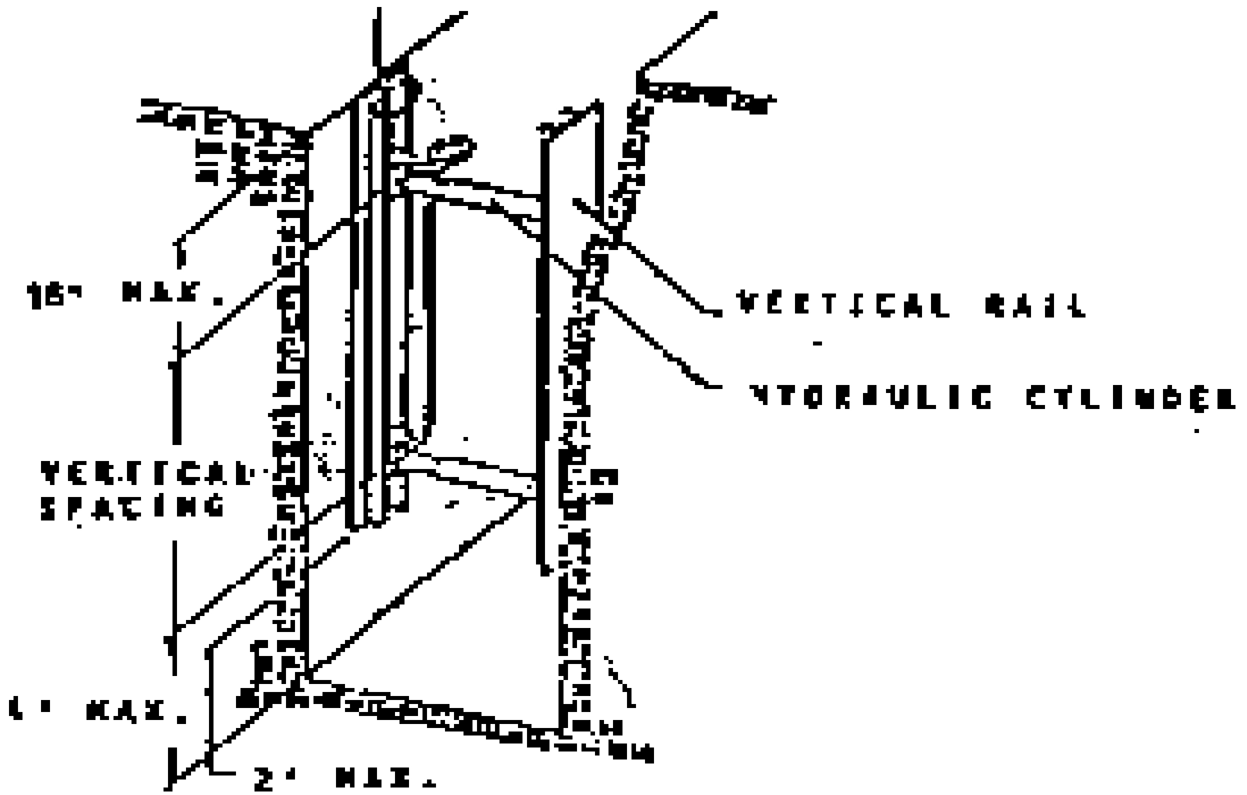


Figure 19-9. Spoil Placement.

Definitions Cont.

- **2. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.**

Definitions Cont.



Definitions Cont.

- **Accepted engineering practices are procedures that are compatible with the standard practice required of a registered professional engineer.**

- **Adjacent structure stability refers to the stability of the foundation(s) of adjacent structures whose location may create surcharges, changes in soil conditions, or other disruptions that have the potential to extend into the failure of the excavation or trench.**

Definitions Cont.

- **A competent persons is one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to eliminate them.**

Definitions Cont.

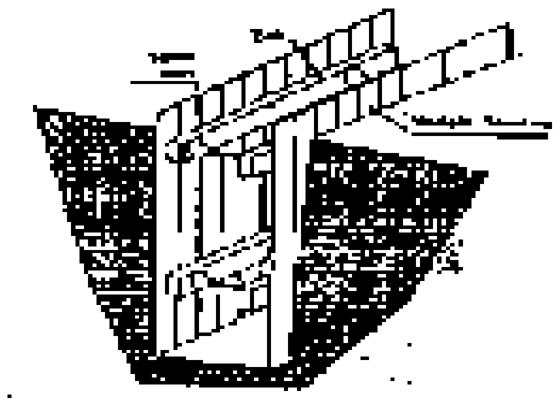
- **A competent person must have specific training in, and be knowledgeable about,**
  - **soils analysis**
  - **the use of protective systems**
  - **requirements of this standard**
    - » **Preamble page 45909**

Definitions Cont.

- **Protective systems refers to a method of protecting employees from cave-ins, material that could fall or roll from an excavation face into an excavation, and from the collapse of adjacent structures.**

- **Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.**

Definitions Cont.



[illegible] SHORES

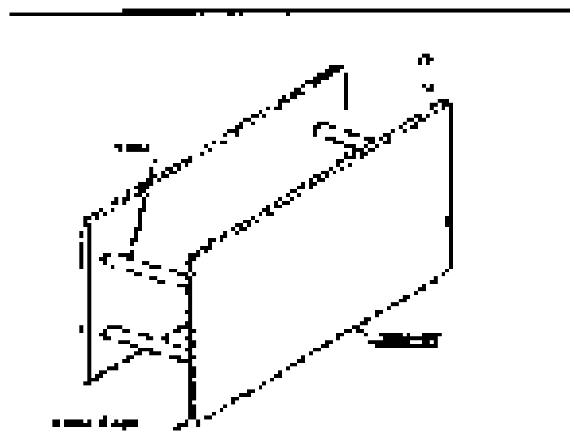
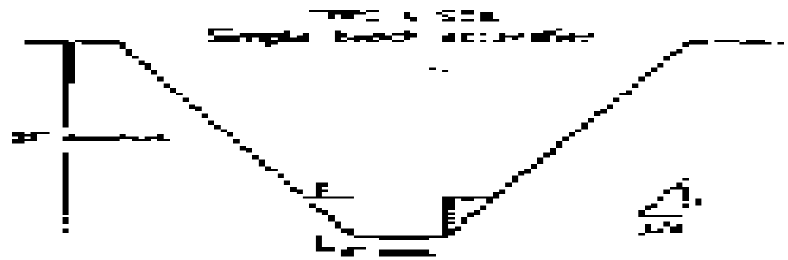


Figure [illegible] Trench Shield

Definitions Cont.



Definitions Cont.

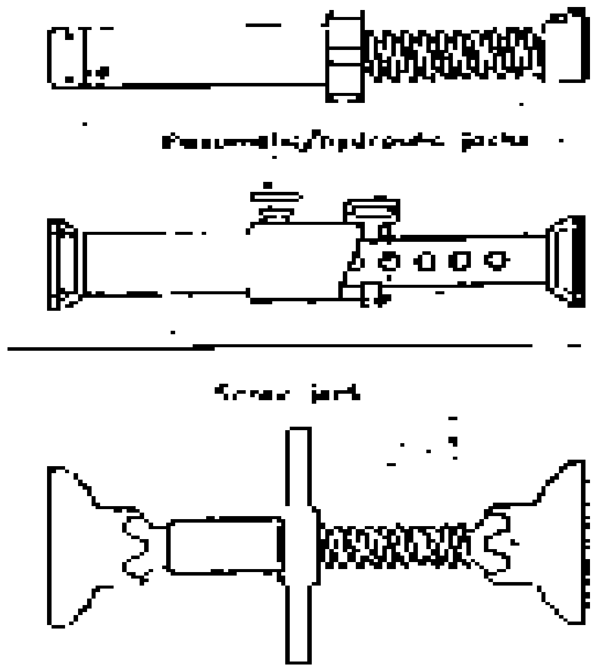


Figure [illegible]. Shoring Variations.

1926.651 - General requirements

- Surface encumbrances
- Underground installations
- Access and egress
- Exposure to vehicular traffic
- Exposure to falling loads
- Warning system for mobile equipment
- Stability of adjacent structures
- Protection of employees from loose rock or soil
- Inspections
- Fall protection
- Hazardous atmospheres
- Protection from hazards associated with water accumulation

1926.651(c)(2) Means of egress

- **Means of egress from trench excavations:**
- **1. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 mm) or more in depth.**
- **2. A means of egress should require no more than 25 feet (7.62 m) of lateral travel for any employee to reach.**

1926.651(k)-Inspections

- **Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in:**
- **1. Possible cave-ins**
- **2. Indications of failure of protective systems**
- **3. Hazardous atmospheres**
- **4. Other hazardous conditions.**

1926.651(k)-Inspections Cont.

- **An inspection shall be conducted by the competent person:**
- **1. Prior to the start of work and as needed throughout the shift.**
- **2. After every rainstorm or other hazard increasing occurrence.**
- **3. These inspections are only required when employee exposure can be reasonably anticipated.**

1926.652 - Requirements for protective systems

- Protection of employees in excavations
- Design of sloping and benching systems
- Design of support systems, shield systems, and other protective systems
- Materials and equipment
- Installation and removal

1926.652 (a)-Protection of employees in excavations

- (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:
  - (i) Excavations are made entirely in stable rock; or
  - (ii) Excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

[illegible]

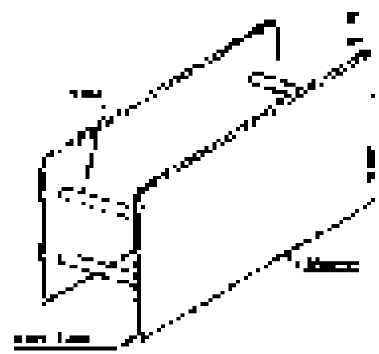


Figure [illegible] Trench Shield

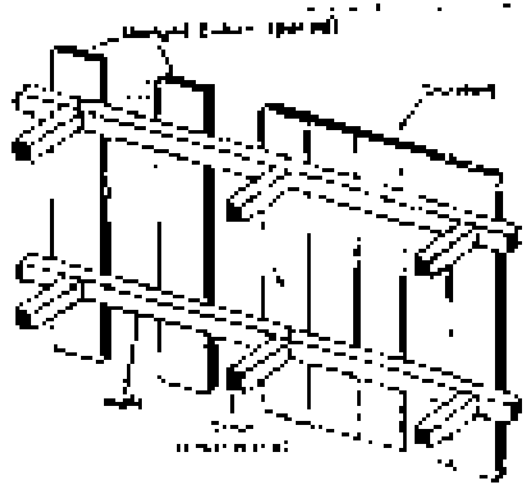


Figure [illegible] Timber Shoring

1926.652 (d)-Materials and equipment

- **(1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.**

1926.652 (d)-Materials and Equipment Cont.

- **(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use.**

1926.652 (d)-Materials and Equipment Cont.

- **If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use.**
- **1. Such material or equipment shall be removed from service.**
- **2. Such material or equipment shall be evaluated and approved by a registered professional engineer before being returned to service.**

Worker Protection Systems

- Appendix A
  - Soil Classification
- Appendix B
  - Sloping & Benching
- Appendix C
  - Timber Shoring
- Appendix D
  - Aluminum Hydraulic Shoring

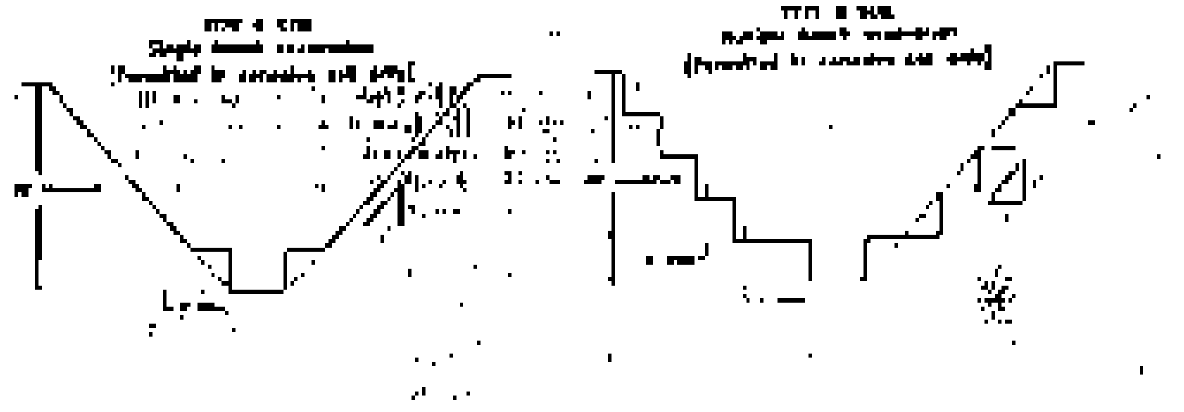


Figure 19-8. Excavations Made in Type B Soil.

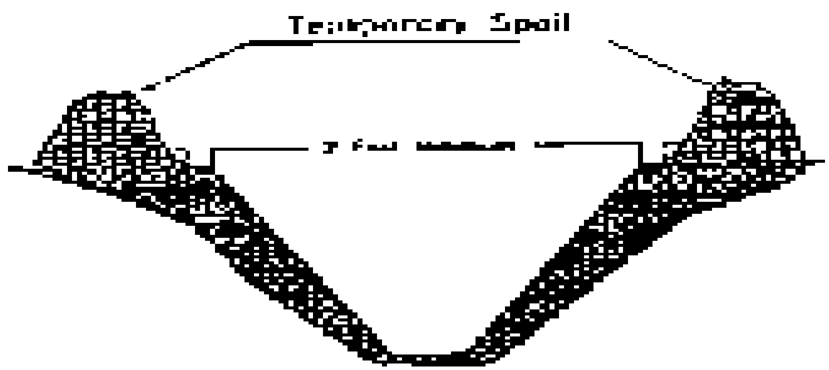
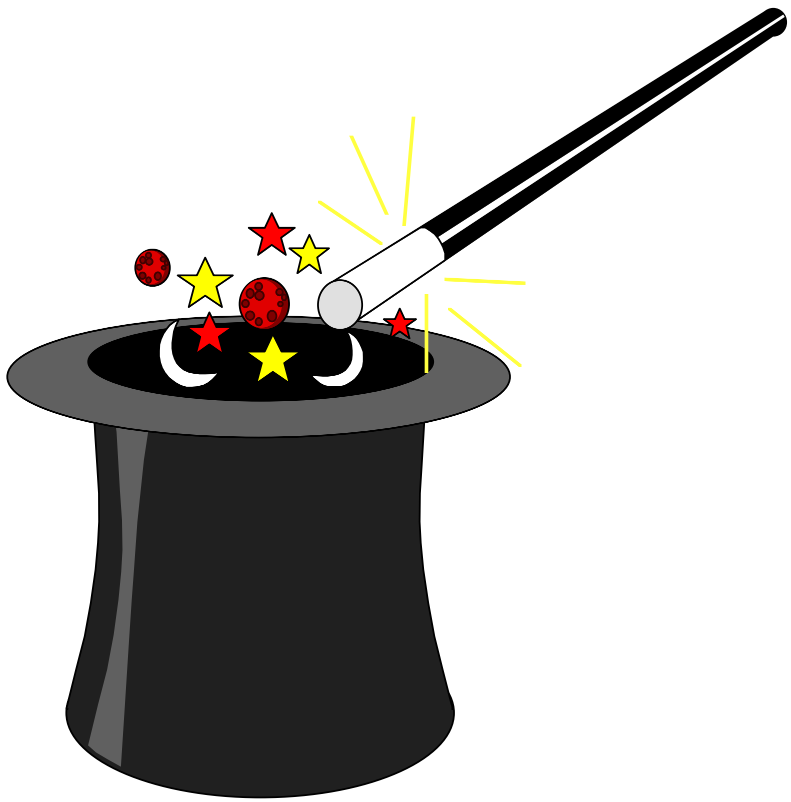


Figure 19-9 Spoil Placement.

Soil Testing



OBJECTIVES

- **Provide the student with:**
  - **A brief overview of 29 CFR 1926 Subpart P Excavation Standard**
  - **A Brief Introduction into Soil mechanics**
  - **A Brief overview of tests they can use in determining soil conditions**

Overview: Soil Mechanics

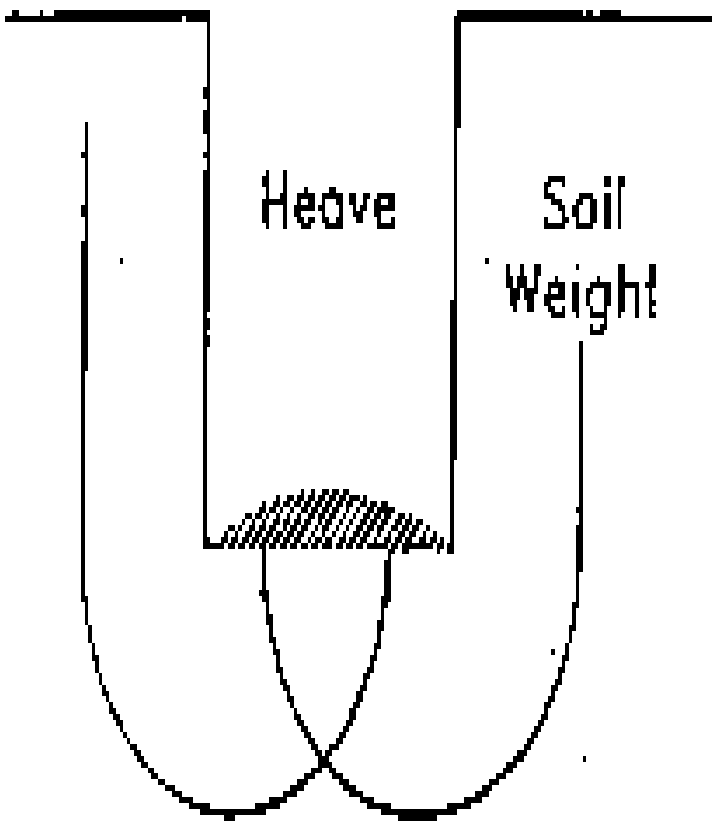
- **Soil Mechanics**
- **A number of stresses and deformities can occur in an open cut or trench.**
- **For example, increases and decreases in moisture content can adversely affect the stability of a trench or excavation.**

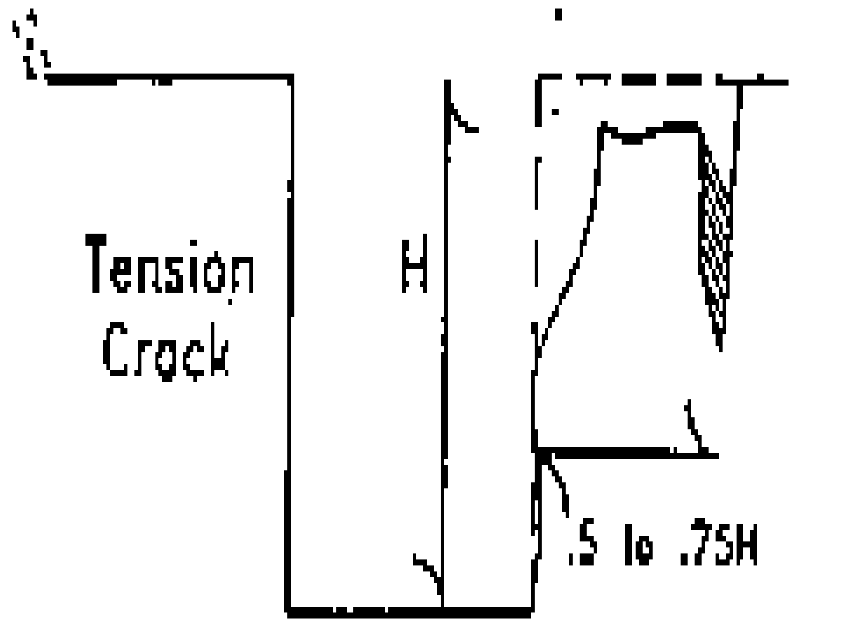
Soil Mechanics Cont.

- **Following are some of the more frequently identified causes of trench failure.**

- **Tension Cracks: Usually form at a horizontal distance of .5 to .75 times the depth of the trench, measured from the top of the vertical face of the trench.**

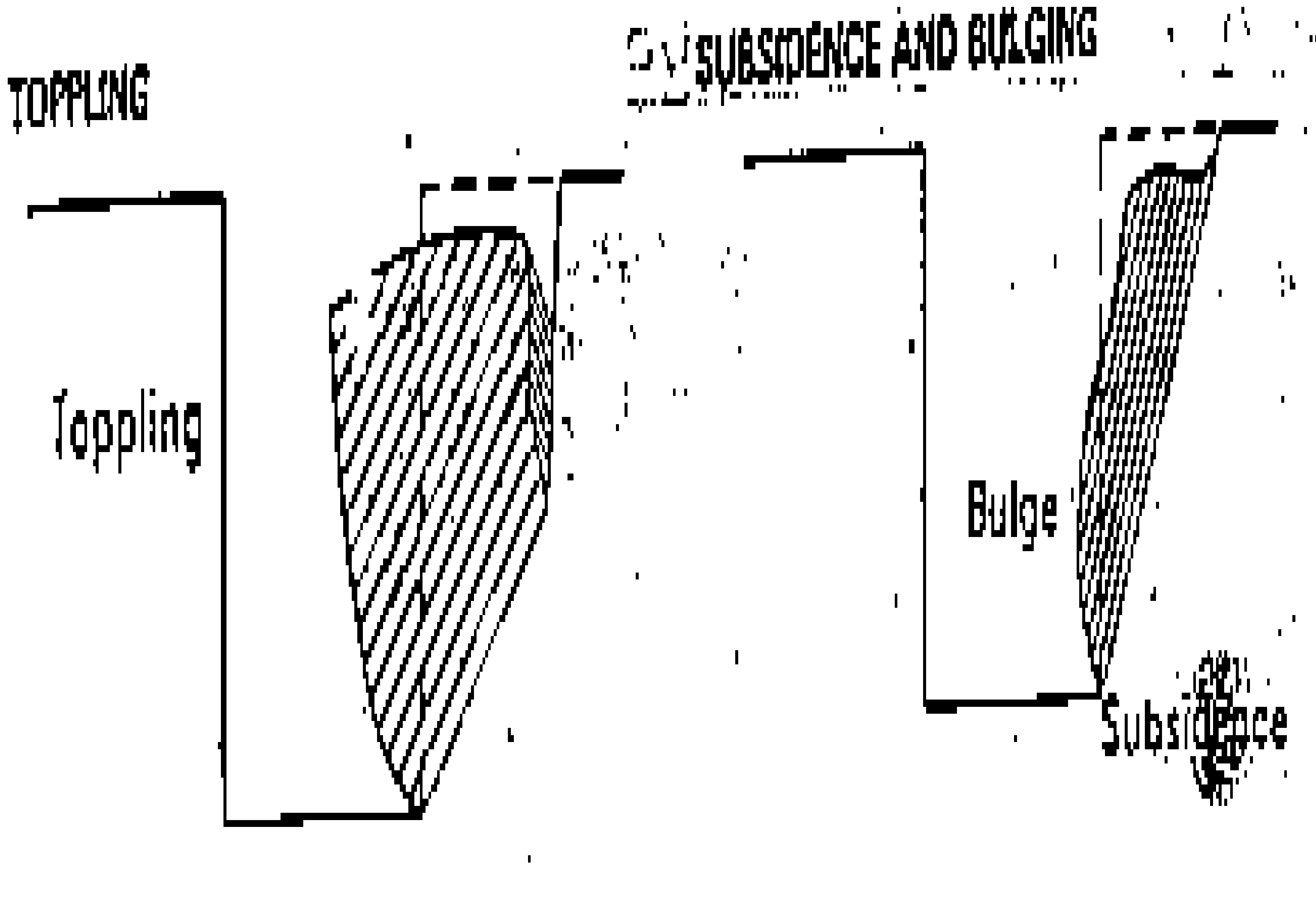
- **Sliding or Sluffing: May occur as a result of tension cracks.**


Heave
Soil
Weight


Tension
Crack
H
.5 to .75H

Soil Mechanics Cont.

- **Toppling: In addition to sliding, tension cracks can cause toppling.**
- **1. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.**



TOPPLING
Toppling
SUBSIDENCE AND BULGING
Bulge
Subsidence

Soil Mechanics Cont.

- **Subsidence and Bulging:**
- **1. An unsupported excavation can create unbalanced stress in the soil, which in turn, causes subsidence at the surface and bulging of the vertical face of the trench.**
- **2. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.**

Soil Mechanics Cont.

- **Heaving or Squeezing:**

- **Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut.**

- **Heaving and squeezing can occur even when shoring or shielding has been properly installed.**

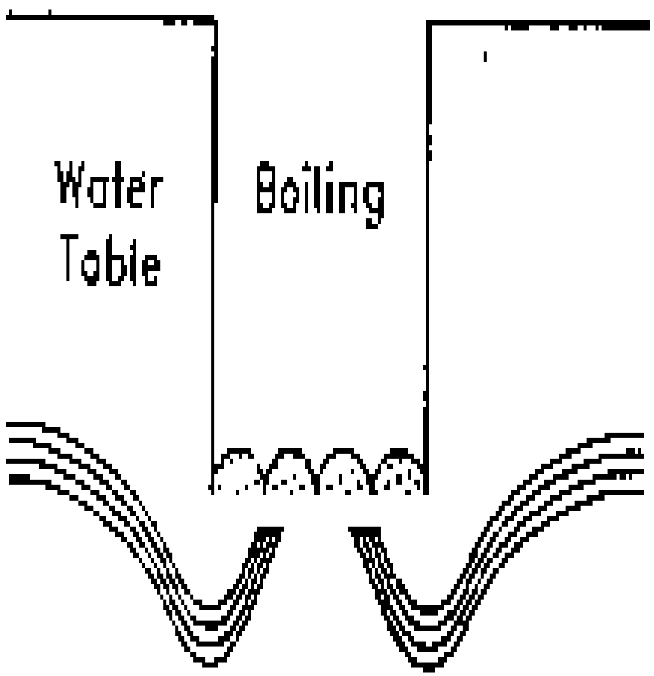
Soil Mechanics Cont.

- **Boiling is evidenced by an upward water flow into the bottom of the cut.**
- **1. A high water table is one cause of boiling.**

- **Boiling produces a "quick" condition in the bottom of the cut, and occur even when shoring or trench boxes are used.**

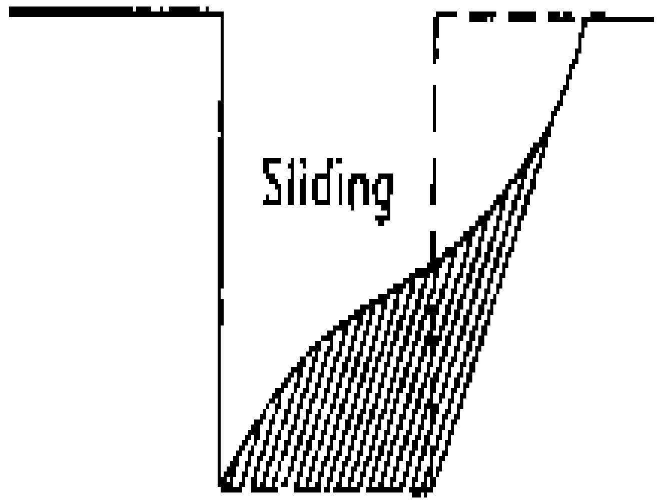
properly installed.

BOILING



SLIDING

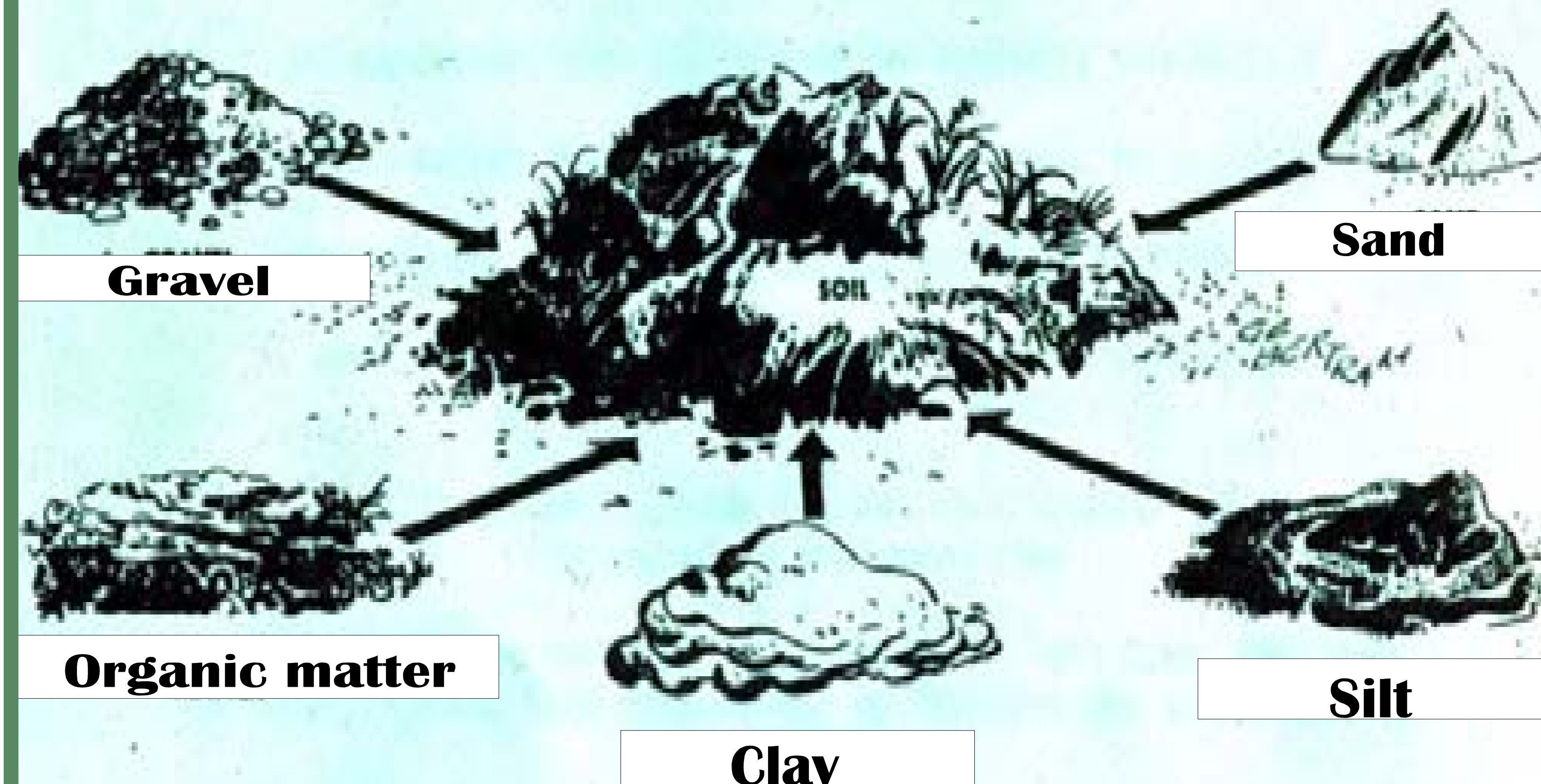
Sliding or sluffing may occur as a result of tension cracks. The illustration below illustrates sliding.



Soil - Composition

- **What is Soil ?**

SOIL



Soils - Types

- **Gravel**
  - larger than 2 millimeters
- **Sand**
  - Smaller than 2 millimeters but larger than 0.075 millimeters
- **Silt**
  - Smaller than 0.075 millimeters but larger than 0.002 millimeters
- **Clay**
  - Smaller than 0.002 millimeters

Determination of Soil Type

- OSHA categorizes soil and rock deposits into four types. Each type is briefly described below.

- Stable rock is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

ROCK!

Igneous
Sedimentary
Alluvial
Loess

Black Pine Mine Slide - Idaho

Determination of Soil Type

- **Type A soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot or greater.**

- **Examples of type A soils are: clay, silty clay, sandy clay, clay loam, and in some cases silty clay loam and sandy clay loam.**

Determination of Soil Type

- **No soil is type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4H to 1V or greater, or has seeping water.**

Determination of Soil Type

- **Type B soils are cohesive soils with an unconfined compressive strength greater than 0.5 tons per square foot, but less than 1.5 tons per square foot.**

- **Examples are: angular gravel, silt, silt loam, previously disturbed soils unless otherwise classified as type C soil.**

Determination of Soil Type

- **Soils that meet the unconfined compressive strength or cementation requirements of type A soils but are fissured or subject to vibration; dry unstable rock; layered systems sloping into the trench at a slope less than 4H to 1V (only if the material would be classified as a type B soil).**

Determination of Soil Type

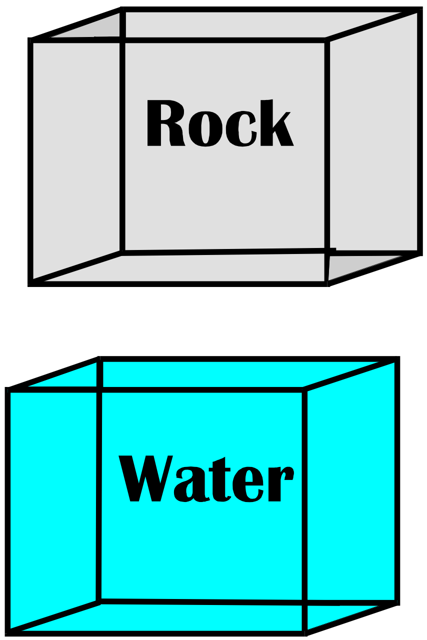
- **Type C soils are cohesive soils with an unconfined compressive strength of 0.5 tons per square foot or less and include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable.**

Determination of Soil Type

- **Type C soils also include in this classification material in a sloped, layered system where the layers dip into the excavation or have a slope of 4H to 1V or greater.**

SP=2.68

1 cubic ft.

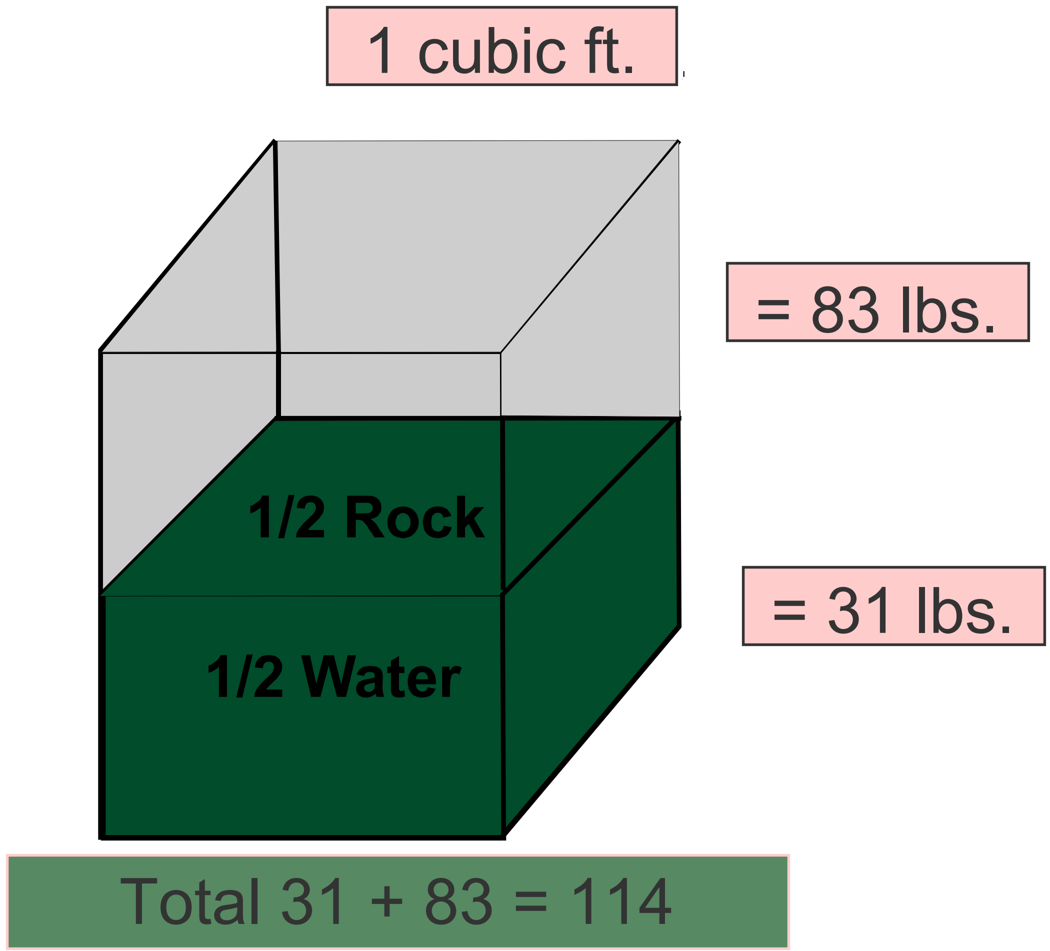


= 167 lbs.

= 62.4 lbs.

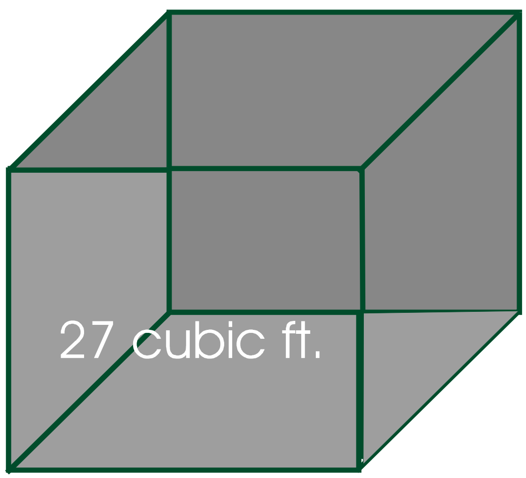
Specific Gravity
The ratio of the weight of an object, to the weight of an equal volume of water

Soils - Volume



Soils - Cubic Yard Weight

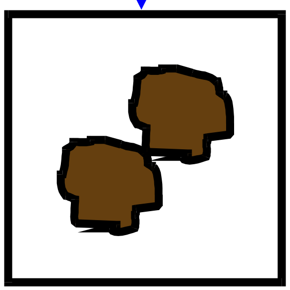
1 cubic yd.



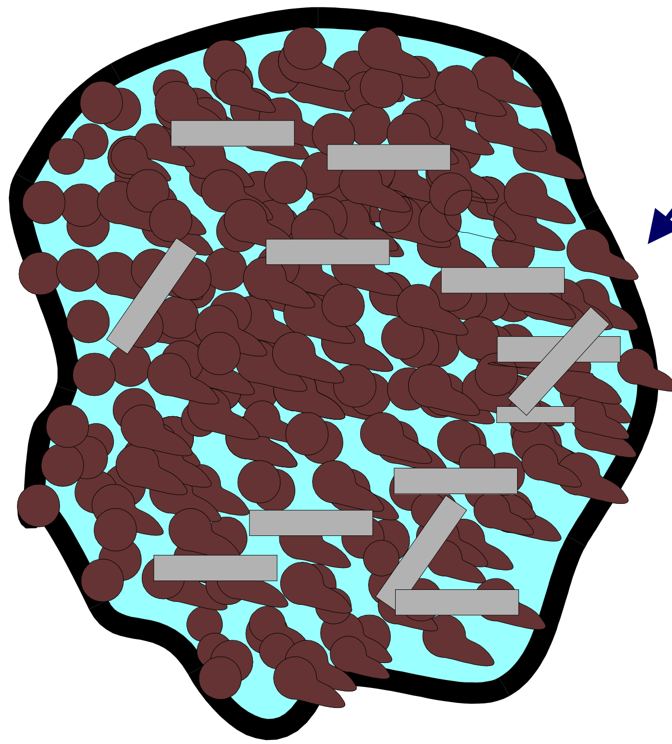
27 X 114 = 3078 lbs.

Average soil

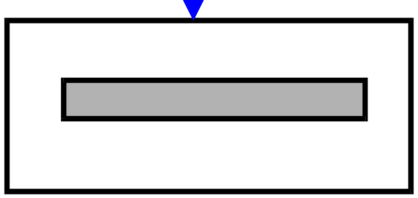
Physical characteristics of sand and silt



Soil Sample

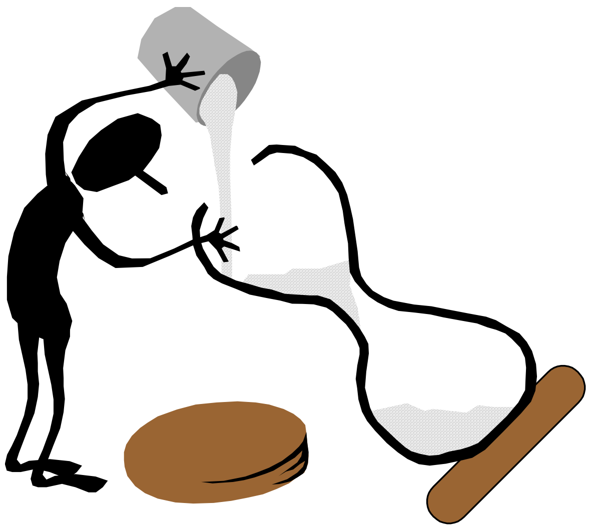


Physical characteristics of clay



Field Tests

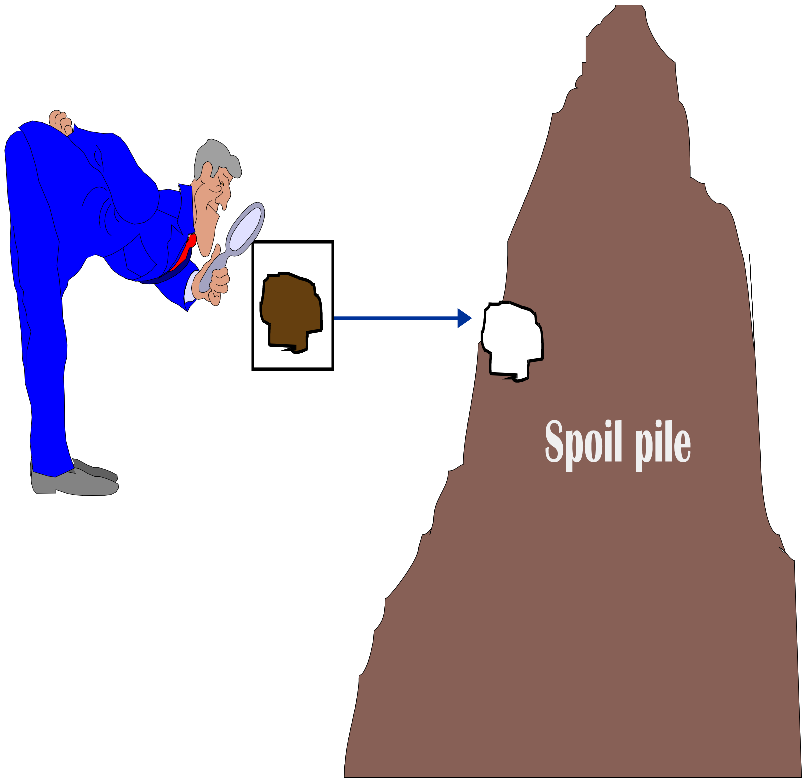
- Documenting field tests
- Sedimentation
- Ribbon
- Torvane
- Pocket Penetrometer
- Thumb imprint



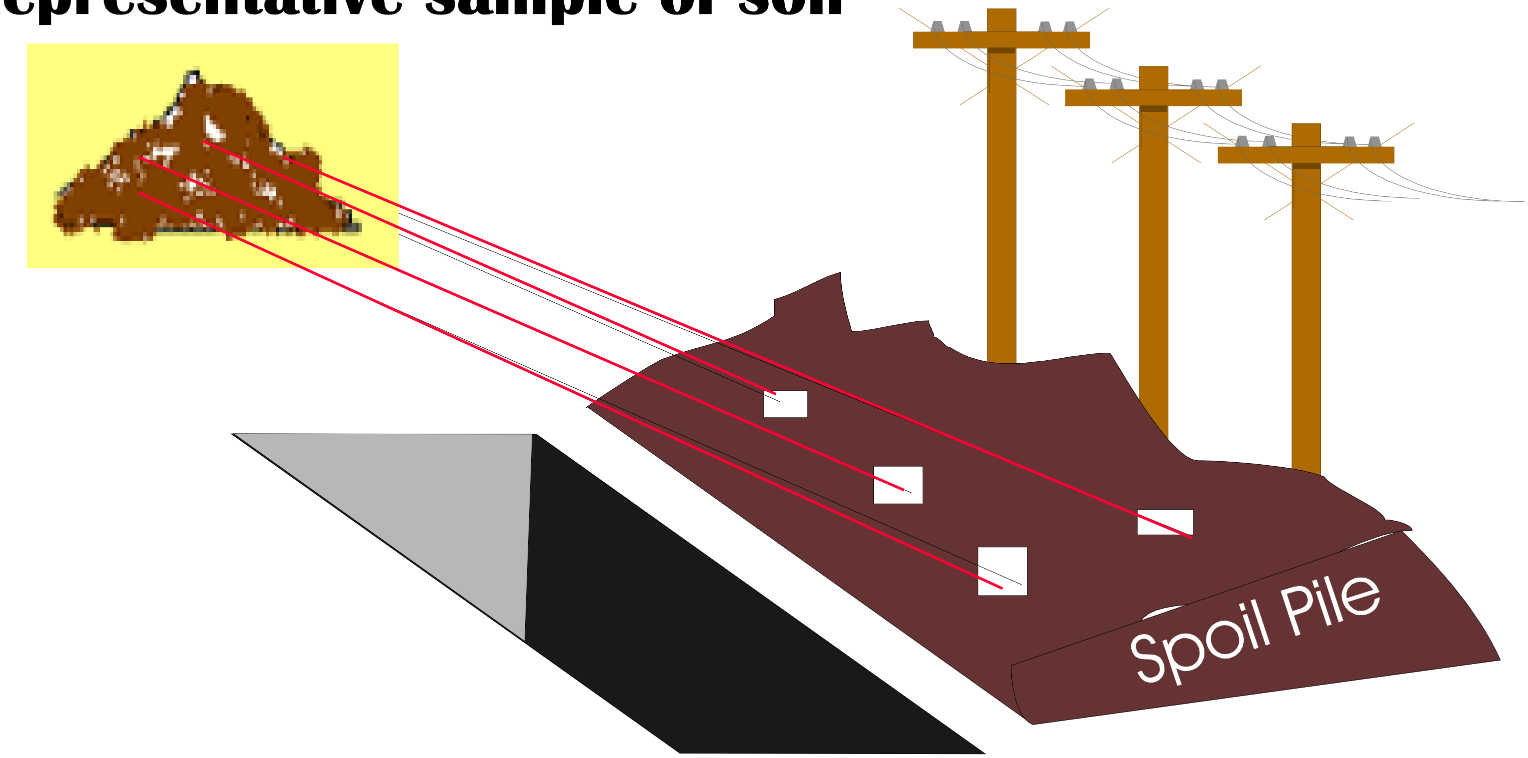
Documenting Field Tests

Documenting Field Test (continued)

- **All Tests**
  - Representative sample
  - Spoil pile
  - Inside the trench
  - Diagram
  - Site map
  - Record reading
  - Soil rating

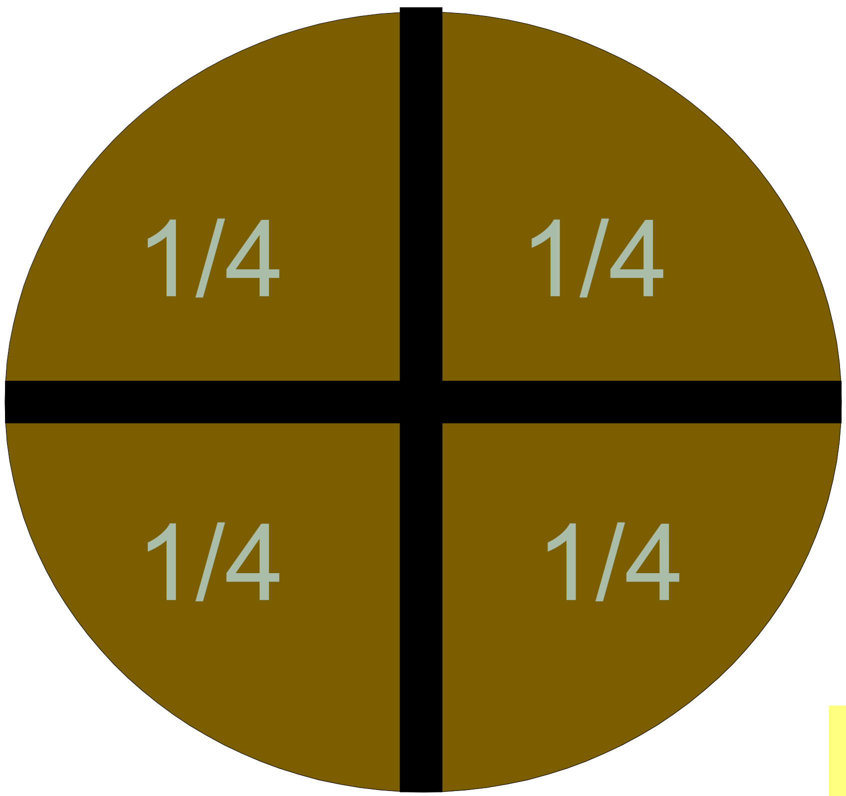


Representative sample of soil

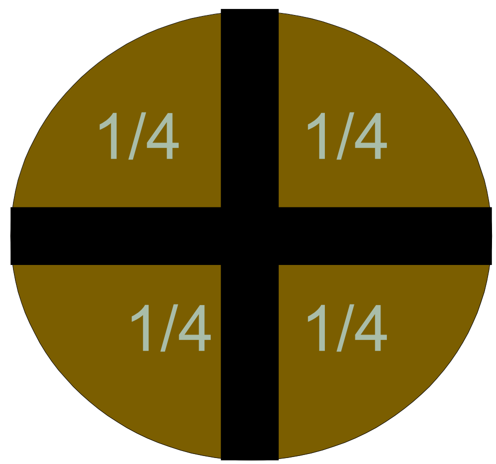


Soil sample

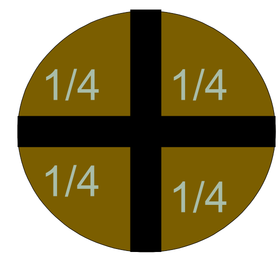
- •Ribbon test
- •Wet shaking
- •Sedimentation Test



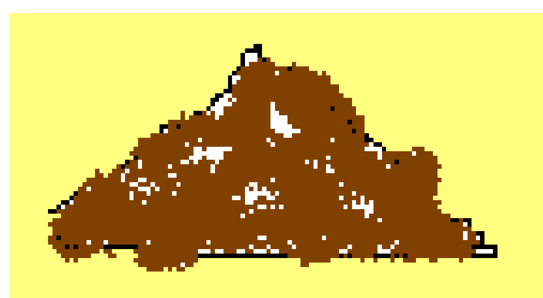
Mix it - Quarter it



Mix it - Quarter it

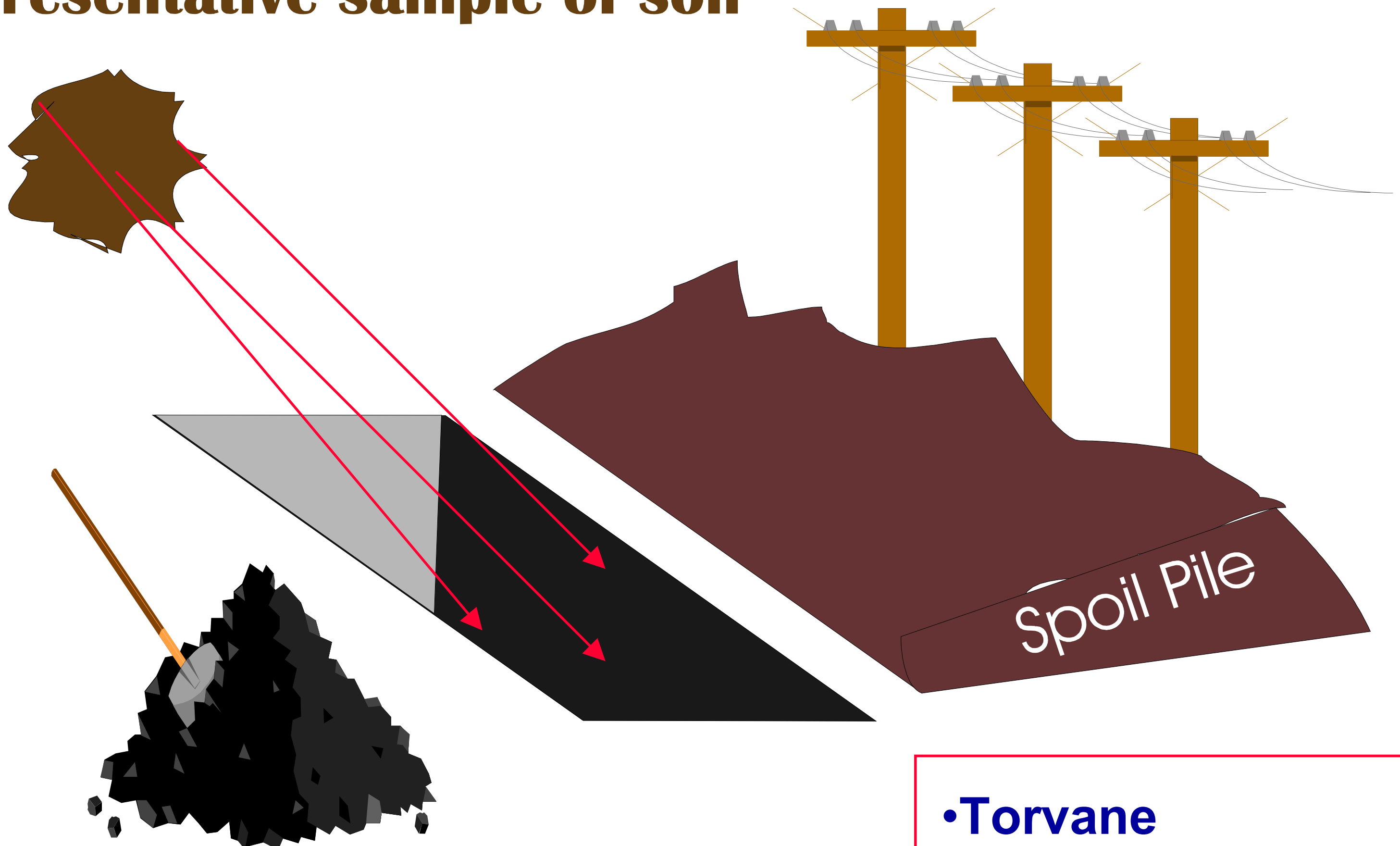


Mix it - Quarter it



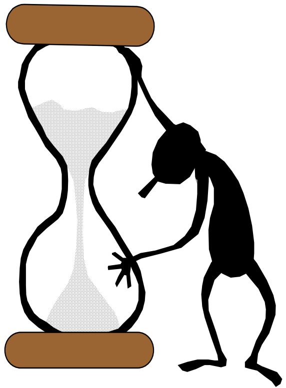
Documenting Field Test (continued)

Representative sample of soil



- •Torvane
- •Pocket penetrometer
- •Thumb imprint

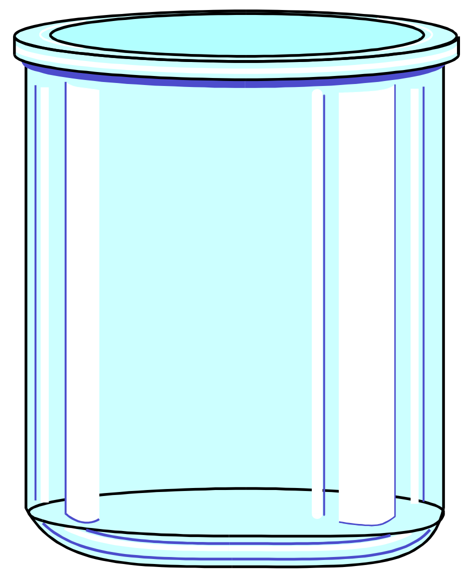
Test # 1 - Field Sedimentation Test



- Determines sand content
- Used only on sandy soils
- Sample taken from the spoil pile
- Representative of soil in the excavation

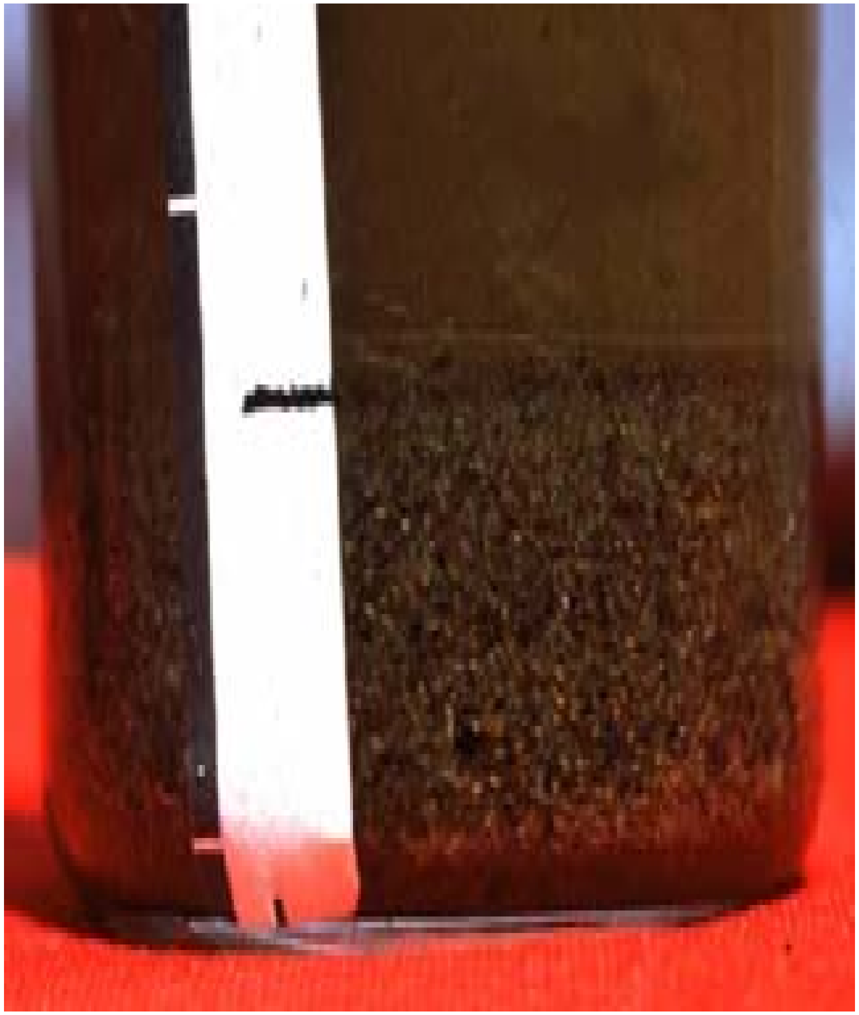
Field Sedimentation Test (Continued)

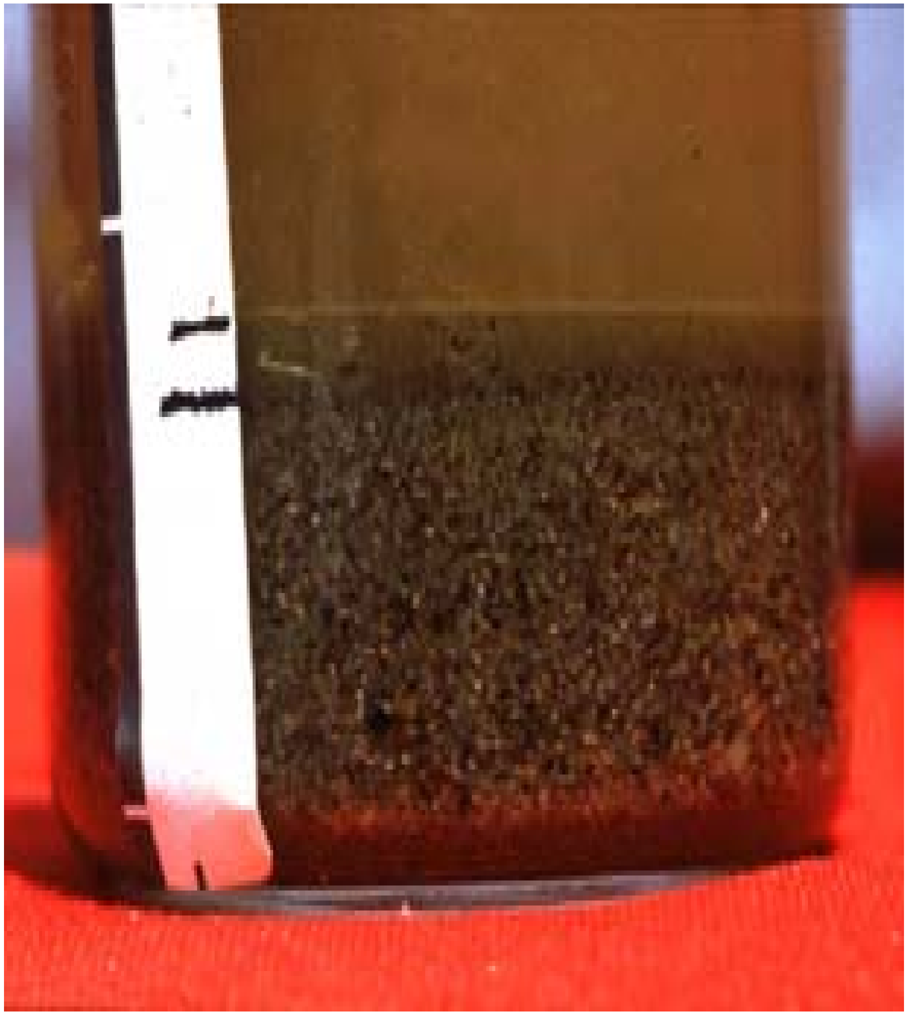
- Fill glass jar
- 5 inches of water on top of soil
- 1 1/2 inches of soil
- Flat bottom container - at least 7 inches high



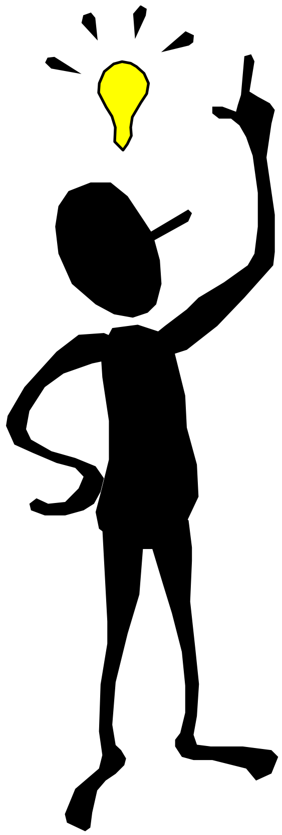
Field Sedimentation Test (Continued)

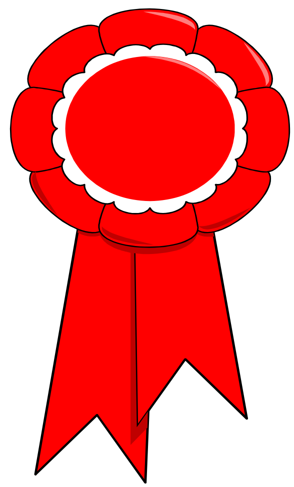
- Place lid on jar and shake
  - Set jar down
  - Rotate slightly
  - Larger particles settle out immediately
  - Wait 30 seconds
  - Mark jar
  - Silt after several minutes
  - Fine clays in an hour
  - Make second mark





Test # 2 - The Ribbon Test





The Ribbon Test

- **Run only on that part of the soil which passes # 40 sieve**
- **Test shows clay material**
- **Run on disturbed soil**
- **Representative sample from spoil pile**

The Ribbon Test (continued)

- Mix soil + water to make into plastic mass
- Roll mass into cylindrical shape 1/2 to 3/4 inch diameter
- Lay across palm of hand
- Press between thumb and second joint of index finger

The Ribbon Test (continued

- Pass through thumb
- Squeeze until it takes the shape of a 1/8 to 1/4 inch thick strip
- Allow to hang freely from hand

The Ribbon Test (continued)

- Clay loam will barely ribbon and break easily
- Clay = relatively long ribbon 6 to 8 inches or more
- More clay = longer and stronger ribbon
- Silt has tendency to produce short ribbon with broken appearance

Penciling

Test # 3 Torvane Shear Test

Torvane Shear

- **Designed to be used on saturated cohesive clay soil**
- **Vanes are inserted into soil**
- **Twist and shear soil at base and around circumference of vanes**

Torvane Shear Test (continued)

- Select fresh clod or block of undisturbed soil from spoil pile
- Cut a smooth surface on the clod
- Insert vanes of device into the soil
- Retract vanes to show foot imprint
- Set indicator at zero
- Hold device firmly against soil and twist in clockwise manner until soil fails in shear

Consistency Term	Shear Strength, psf	Unconfined Compressive Strength, psf	Soil Type
very soft	<250	<500	Type C
soft	250- 500	500-1000	
medium	500-1000	1000-2000	Type B
stiff	1000-1500	2000-3000	
stiff	1500-2000	3000-4000	
very stiff	2000-4000	4000-8000	Type A
hard	>4000	>8000	

Test # 4 - Pocket Penetrometer

Pocket Penetrometer

- **Read the unconfined compressive strength at bottom of the red slip ring**
- **The reading may be 2.0 tons per square foot shear strength**
- **Which indicate the boundary between stiff and very stiff**

Pocket Penetrometer Test

- Device is designed to work on saturated clay soil
- Measures unconfined compressive strength of soil
- Twice the value of shear strength of same soil
- Note machine ring about a quarter of an inch

Pocket Penetrometer (Continued)

- Push red ring on the barrel all the way toward the handle
- Push shaft into the soil up to the red ring
- Hold barrel so as to not to interfere with the spring inside the barrel
- NOTE slip ring moved on the barrel as barrel was pushed back into the handle

Consistency Term	Shear Strength, psf	Unconfined Compressive Strength, psf	Soil Type
very soft	<250	<500	Type C
soft	250- 500	500-1000	
medium	500-1000	1000-2000	Type B
stiff	1000-1500	2000-3000	
stiff	1500-2000	3000-4000	
very stiff	2000-4000	4000-8000	Type A
hard	>4000	>8000	

Hazard Recognition Slides