UNITED STATES MARINE CORPS
ENGINEER EQUIPMENT INSTRUCTION COMPANY
MARINE CORPS DETACHMENT
1706E EAST 8TH STREET
FORT LEONARD WOOD, MISSOURI 65473-8963

LESSON PLAN

SOILS

EEO/EEC-B04

WARRANT OFFICER/CHIEF COURSE

A16ACN1/A1613E1

REVISED 9/2/2014

APPROVED BY ________________________ DATE _____________________

(ON SLIDE #1)

INTRODUCTION **(10 MIN)**

1. **GAIN ATTENTION**: All construction projects, whether they are horizontal or vertical in design require a solid foundation. As an Engineer Equipment Warrant Officer or Chief, a 1310 or 1349 must be able to determine the capabilities of the soil on which the structure is to be built. A soil that is incapable of carrying the loads that will be applied will lead to failure.

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(ON SLIDE #2)

2. **OVERVIEW**: Good morning/afternoon, my name is ________________. The purpose of this lesson is to familiarize you, the student, with the classifications, testing procedures, stabilization methods, and dust abatement of soils.

INSTRUCTOR NOTE
Introduce the learning objectives.

(ON SLIDE #3)

3. **LEARNING OBJECTIVE(S)**:

INSTRUCTOR NOTE
Have students read learning objectives to themselves.

a. **TERMINAL LEARNING OBJECTIVE**:

(1) Provided a horizontal construction mission, resources, and references, manage horizontal construction project production and logistical requirements to develop project estimates in support of mission requirements. (1310-HORZ-2002/1349-HORZ-2002)

b. **ENABLING LEARNING OBJECTIVE**:

(1) Without the aid of references, identify the characteristics of soil per the FM 5-410, FM 5-34, FM 5-

430-00-1/Vol I, and Dust Abatement Handbook. (1310-HORZ-2002d/1349-HORZ-2002d)

(2) Without the aid of references, identify the objective of the Unified Soils Classification System per the FM 5-410, FM 5-434, FM 5-430-00-1/Vol I, and Dust Abatement Handbook. (1310-HORZ-2002e/1349-HORZ-2002e)

(3) Without the aid of references, identify the purpose and effect of soil compaction per the FM 5-410, FM 5-434, FM 5-430-00-1/Vol I, and Dust Abatement Handbook. (1310-HORZ-2002f/1349-HORZ-2002f)

(4) Without the aid of references, identify the soil stabilization methods per the FM 5-410, FM 5-434, FM 5-430-00-1/Vol I, and Dust Abatement Handbook. (1310-HORZ-2002g/1349-HORZ-2002g)

(5) Without the aid of references, identify dust abatement methods per the FM 5-410, FM 5-434, FM 5-430-00-1/Vol I, and Dust Abatement Handbook. (1310-HORZ-2002h/1349-HORZ-2002h)

(ON SLIDE #4)

4. **METHOD/MEDIA:** This period of instruction will be taught using the lecture method with aid of power point presentation, a soils video, instructor demonstrations, and practical applications.

INSTRUCTOR NOTE
Explain Instructional Rating Forms and Safety Questionnaire to students.

(ON SLIDE #5)

5. **EVALUATION:**
You will be evaluated by a written exam at the time indicated on the training schedule.

(ON SLIDE #6)

6. **SAFETY/CEASE TRAINING (CT) BRIEF.**
All instructors and students will use caution when walking around the equipment lot during equiment operations. Sun block should be used to avoid sunburn. Issue students bug spray if required. Encourage students

to stay hydrated as temperatures can reach 100 degrees plus during the summer months. In the event of a casualty, emergency services (911) will be called and all students will move to the classroom and await further instruction.

(ON SLIDE #7)

TRANSITION: Are there any questions over what is going to be taught, how it will be taught, or how you the student will be evaluated? The first topic we will cover is the basic understanding of what soil is, how it is formed, and what are its' engineering properties.

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BODY **(7 HOURS 35 MIN)**

(ON SLIDE #8)

1. SOIL BASICS (1 hr 30 min)

INSTRUCTOR NOTE
Introduce the following practical application (1).

PRACTICAL APPLICATION (1). (15 MIN) Break the students down into groups of 4 or 5 Marines. Send each group out to different locations around the equipment lot at Bldg. 5046 and 1150E training area to collect approximately 8 lbs. each of various soil samples.

PRACTICE: Upon return to the classroom, students will hold onto the sample as it will be used throughout the period of instruction.

PROVIDE-HELP: Check each of the soil samples to ensure student have enough material to conduct all of the various soil identification and classification tests.
1. Safety Brief: Ensure that bug repellent is available. Ensure safe proceudures are used for traffic considerations when walking on the lot and crossing the road.
2. Supervision & Guidance: Be sure to follow the step by step directions covered in your student outline along with the instructor's supervision.
3. Debrief: Are there any questions or comments concerning aquiring a soil sample? It may be necessary to get more

than one sample in order to get an accurate analysis. This sample will be used for all of the testing and identification procedures discussed throughout the class.

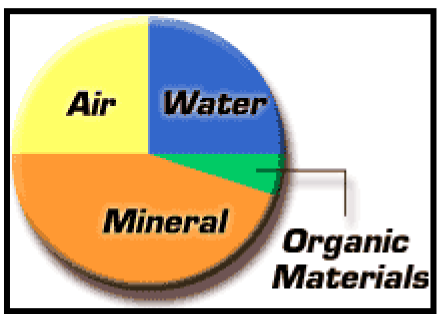
(ON SLIDE #9)

<u>TRANSITION:</u> Now that we have collected our soil samples, let's move on to learn the basics of soil engineering.

(ON SLIDE #9)

a. <u>Definition of Soil</u>: The term "soil" is defined as the entire unconsolidated material that overlies and is distinguishable from bedrock. It is composed of loosely bound mineral grains of various sizes and shapes. Due to its loose nature soil inherently contains voids of varying sizes. These voids contain air, water and organic material (see figure 1).

(ON SLIDE #10)



The Composition of Soil
Figure 1

(ON SLIDES #11,12)

b. <u>Soil Formation</u>: Soil formation is a continuous process that is still in action today. Weathering is the main process in the formation of soil. Weathering is simply the process by which rock is converted into soil. Weathering is the result of external forces that act to break larger rocks into smaller rocks. Both mechanical and chemical forces participate in the weathering process.

(ON SLIDE #13)

(1) Mechanical Weathering: Mechanical weathering is the result of physical forces, which act to decompose rock. Examples include:

(ON SLIDE #14)

- Unloading: Unloading is the fracturing of bedrock due to the removal of overlying material.

(ON SLIDE #15)

- Frost Action: Frost action occurs when moisture inside a rock freezes and expands to create pressures up to 4000 psi.

(ON SLIDE #16)

- Organism Growth: Vegetation growth can occur within joints and cracks and cause a wedging effect on rock.

(ON SLIDE #17,18)

- Abrasion: The cumulative effects of wind and water act over time to erode rocks through friction (figures 2 and 3).

(ON SLIDE #19)

(2) Chemical weathering: Chemical Weathering is the decomposition of rock through the chemical bonding of the minerals of rock with air, water, or the chemicals in the air or water. Chemical weathering includes:

(ON SLIDE #20)

- Hydration: The chemical union of a compound with water.

(ON SLIDE #21)

- Oxidation: The chemical union of a compound with oxygen. An example is rusting, which is the chemical reaction of oxygen, water and iron to form ferrous sulfate.

(ON SLIDE #22)

- Carbonation: The chemical process in which carbon dioxide from the air unites with various minerals to form carbonates.

(ON SLIDE #23)

c. **KSE K-2009 STS (Soil Test Set)**. The KSE K-2009, fielded in 2009, gives Marine Corps Engineers the ability to conduct field identification tests, classification tests, determine the California Bearing Ratio (CBR), and trafficability of soil. The STS is manufactured by Kessler Corps. and is currently registered in the Marine Corps Warranty Program. The warranty ending date will be based on the date received. The soils test kit is comprised of three cases: Case 1)- consist of the laboratory equipment (sieves, water bottles, mortar, pestle bags, etc...) Case 2)- consist of the Dynamic Cone Penetrometer (DCP) assembly, and Case 3)- the speedy moisture tester.

INTERIM TRANSITION: So far we have discussed soil formation, engineering properties, and introduced the KSE K-2009 Soils Test Set. Are there any questions? Let's move on to identifying the components of the K-2009 STS.

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(ON SLIDE #24,25,26,27,28,29)

INSTRUCTOR NOTE
Introduce the following demonstration (1).

DEMONSTRATION(1). **(15 MIN)** Introduce the students to the KSE D-2009 STS. An assistant may be used to pull items outof the kit and display as the instructor explains each piece.
Begin with Case 1: the lab equipment.

1) Explain and display the 32 oz. Nalgene bottles.
2) Explain and display the mortar and pestle.
3) Explain and display the spatula and spoons.
4) Explain and display the sample collection bags.
5) Explain and display the varnish brush.
6) Explain and display the ECH$_2$O moisture probe.
7) Explain and display the Digital Moisture Reader
8) Explain and display the mixing bowls.
9) Explain and display the No. 200, 40, and 4 sieves.
10) Explain and display the hand trowel.

11) Explain and display the nylon coyote material.
12) Explain and display the collapsible 5 gal. jug.
13) Explain and display the USACE Cone Penetrometer and wrenches.
14) Explain and display the Magnetic Ruler Printer.
15) Explain and display the 4000 gram scale.
16) Explain and display the sampling auger tube and wrenches.
17) Explain and display the pelican case.

Then move on to Case 2: the DCP and Magnetic ruler.

1) Explain and display the user's manual. (CD & Booklet)
2) Explain and display the upper assembly. (rod, handle, and dual mass hammer)
3) Explain and display the drive rod.
4) Explain and display the hex key allen wrench.
5) Explain and display the 3-in-1 oil.
6) Explain and display the wrenches.
7) Explain and display the 40 in vertical scale.
8) Explain and display the vertical scale foot.
9) Explain and display the vertical scale upper attch.
10) Explain and display the measuring rod.
11) Explain and display the hardened points, cone adapter, and disposable cones.

Finally, move to Case 3: Speedy Moisture Tester.

1) Explain and display the speedy moisture tester.
2) Explain and display the 20 gram cups. (gauge)
3) Explain and display the two steel balls.
4) Explain and display the scoop.
5) Explain and display the cleaning brush.
6) Explain and display the 200 gram scale.

STUDENT ROLE: Observe functions and capabilities of equipment in the kit and ask questions.

INSTRUCTOR(S) ROLE: Demonstrate the use of and reason for the equipment contained in the kit to the students.
1. Safety Brief: Do not allow the students to hold the upper rod while engaging the dual mass hammer.
2. Supervision & Guidance: Students will be encouraged to ask questions and handle the equipment.
3. Debrief: Are there any questions or comments concerning the K-2009 Soils Test Set? The STS is a mobile lab that can be taken to the field for expediant soils analysis.

INTERIM TRANSITION: We have just reviewed the contents of the KSE Soils Test Kit. Are there any questions? We will take a break and then we will discuss how to determine and classify the size of soil particles.

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(Break – 10 Min)

INTERIM TRANSITION: Are there any questions before we discuss how to determine and classify the size of soil particles.

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(ON SLIDE #30)

(1) Grain Size: The size of a soil particle can be classified in four major categories; cobbles, gravels, sands, and fines. Particle size determination, in respects to military engineering, is conducted via sieves. The STS 2009 (Soils Test Set) contains three sets of sieves ranging from a #4 sieve to a #200 sieve. If the particle will not pass through a sieve screen, it is said to be "retained on" that sieve (see table 4 and figure 5).

(ON SLIDE #31)

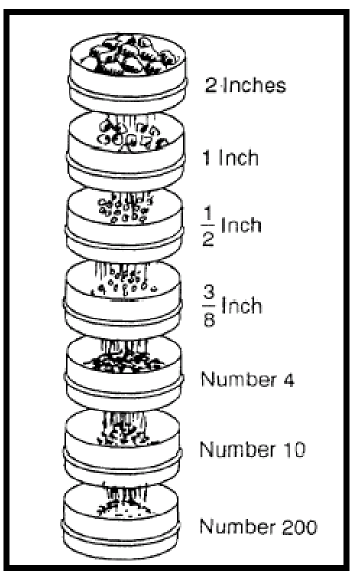

Figure 5
Dry Sieve Analysis

(ON SLIDE #32)

Size Group	Sieve Size	
	Passing	Retained On
Cobbles	No Maximum Size	3 inches
Gravels	3 inches	No. 4 (≈0.25 inches)
Sands	No. 4 (≈0.25 inches)	No. 200 (0.05 mm)
Fines (silt or clay)	No. 200 (0.05 mm)	No minimum Size
In military engineering, the maximum size of cobbles is accepted as 40 inches, based on the maximum jaw opening of a rock-crushing unit.		

Grain-Size Groups
Table 4

INTERIM TRANSITION: We have just discussed grain sizes and the soil sieves. Are there any questions? Let's move on and learn how to use the sieves to determine grain size in a practical application.

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INSTRUCTOR NOTE
Introduce the following practical application.

PRACTICAL APPLICATION (2): S **(15 MIN) ____ steps**
Step 1: With Marines in their groups, have them place coyote mat on table, pour soil sample onto coyote mat, and separate soil sample into four different samples by cutting sample in half twice.
Step 2: Remove cobbles and gravel over one inch in circumference and break up clumps of soil with wooden pestles.
Step 3: Place empty mixing bowl onto the 200 gram scale, then zero out the scale.

Step 4: Place the sample with large particles removed into mixing bowl and place bowl with sample back on the scale and record the weight on a sheet of paper. This will be considered 100% of the sample for grain size and gradation purposes.
Step 5: Place the #4 sieve in a second mixing bowl and run sample through the #4 sieve. Take the #4 sieve out of the mixing bowl and weigh sample in the mixing bowl, record data on sheet of paper with original weight.
Step 6: Divide the new sample weight by the original sample weight to find the percentage of material that ran through the #4 sieve.
Step 7: Repeat steps 3-6 with the #40 and #200 sieves, ensuring to record the data on the same sheet of paper as the original sample weight.

PRACTICE: Have each group perform the above steps to determine the percentages of particle types for the soil samples.

PROVIDE-HELP: Walk around the classroom to ensure students are conducting the soil analysis correctly. Answer questions and demonstrate as necessary.
1. **Safety Brief:** Ensure material not used stays on the coyote mat to avoid material falling on floor and becoming a slip hazard.
2. **Supervision & Guidance:** Be sure to follow the step by step directions covered in your student outline along with the instructor's supervision.
3. **Debrief:** Are there any questions or comments concerning how to use the sieves to determine grain size? The sieves also play an important role when determining the make-up of your soil sample and how much of the different types of soils contained within your sample.

INTERIM TRANSITION: We have just ran our samples through the sieves to determine the amount of different soil types in the samples. In conjunction with the practical application, we will determine the gradation of the different samples using the portion of the sample that has been seperated.

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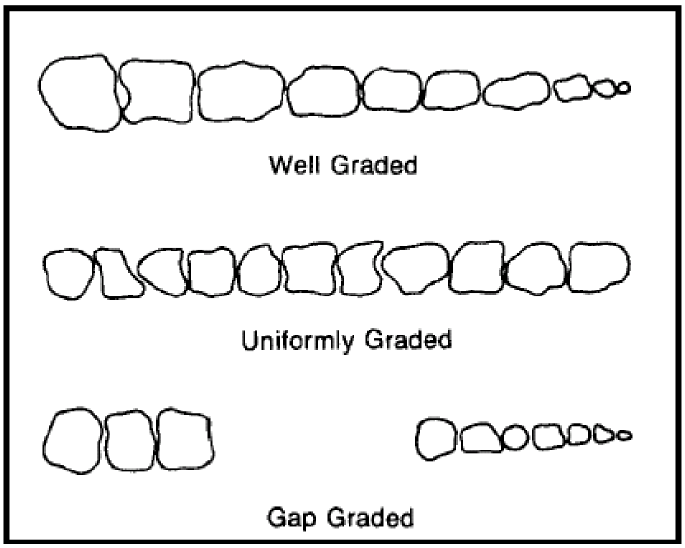
(ON SLIDE #33)

(2) Gradation: Gradation is the distribution of particle sizes within a soil and can be determined by using the sieves. A soil can be described as either well graded or poorly graded. A well-graded soil has a good representation of all particle sizes, whereas a poorly graded soil would not. Furthermore, a poorly graded soil can be broken down into uniformly and gap graded soils. A uniformly graded soil primarily contains one particle size. A gap-graded soil is missing particle sizes required to have a well-graded soil (see figure 6).

(ON SLIDE #34)



Soil Gradations
Figure 6

INTERIM TRANSITION: We have just discussed determining the gradation of your soil sample using the sieves. Are there any questions? Let's move on and determine the gradation of our sample in a practical application.

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INSTRUCTOR NOTE
Introduce the following practical application.

PRACTICAL APPLICATION (3): **(10 MIN) Determining Gradation Refer the students back to the sieve analysis and the data that they recorded. Gradation determination will fall into three catagories:**

1) Well-Graded: By refering to the data recorded, are there equal percentages of material throughout the #4, #40, and #200 sieves? If yes, the sample is "well-graded".

2) Poorly-Graded: If the data shows one sieve retains most of the material, then the sample is considered poorly graded.

3) Gap-Graded: If the majority of the sample is retained on two of the sieves with little of the sample on a third, then the material is "gap-graded".

If the majority of the material runs through the #200 sieve, then the material is largely silts and fine-clays, which makes the material undesirable for construction purposes.

PRACTICE: Have each group refer to their sieve analysis and recorded data for the determination of gradation of their samples.

PROVIDE-HELP: Instructor will observe student to ensure correct application of the data for the determination of gradation.

1. **Safety Brief:** Ensure material not used stays on the coyote mat to avoid material falling on floor and becoming a slip hazard.
2. **Supervision & Guidance:** Be sure to follow the step by step directions covered in your student outline along with the instructor's supervision.
3. **Debrief:** Are there any questions or comments on how to determine gradation or why gradation is important to know and understand for a construction project? Remember, gradation will help you determine if the soil located at your project site has a good mix of different material types or if it is dominated by one soil type that may require non-indigenous material to be trucked in to achieve the requirements for your road or airfield.

INTERIM TRANSITION: We have just ran our samples through the sieves to determine the gradation of our samples. We will now look at the variation of particle shapes.

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(ON SLIDE #35)

(3) Grain Shape: The shape of the particles influences a soil's strength and stability. Two general

shapes are normally recognized: bulky and platy. Bulky shapes include particles that are relatively equal in all three dimensions. In platy shapes, one dimension is very small compared to the other two (see figure 7).

(a) Bulky shapes: Bulky shapes are subdivided into five categories, depending on the amount of weathering that has acted on them.

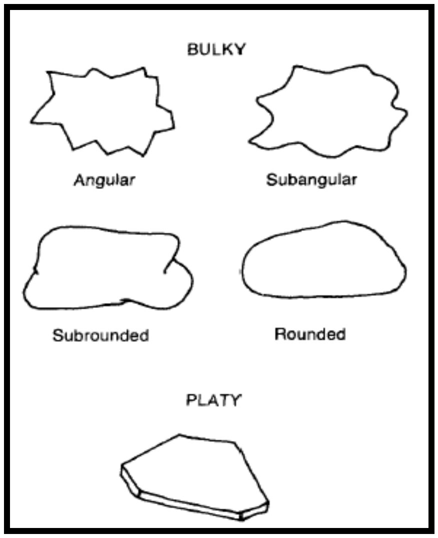
- Angular: Angular particles are particles that have recently been broken up. Jagged projections, sharp ridges and flat surfaces characterize angular particles. The interlocking ability of angular particles is most desirable for engineering purposes; however, these particles are seldom found in nature. Rock crushers are effective means of producing angular particles.

- Sub angular: Sub angular particles have been weathered until the sharper points and ridges have been worn off. These particles are still irregular in shape and are excellent for construction.

- Sub rounded: Sub rounded particles have been weathered further than sub angular particles and are adequate for construction.

- Rounded: Rounded particles have all projections removed and are smooth in texture. These particles are not desirable in construction.

(ON SLIDE #36)



Particle Shapes
Figure 7

(ON SLIDE #37)

(4) Density: The density of a soil is determined by the percent of voids (air and water) compared to the percent of soil particles. A denser soil (tightly packed) will have fewer voids than a loosely packed soil. When each particle is closely surrounded by other particles, the grain-to-grain contacts are increased thus increasing a soils ability to carry loads.

(ON SLIDE #38)

(5) Moisture: The moisture content in a soil is the most important factor affecting its engineering characteristics. The effect of water on the behavior of soil greatly varies with the type of soil. A soil that is course grained (most particles are gravel and/or sand) usually remains unchanged in the presence of moderate amounts of moisture. However, a soil that is fine-grained (most particles are fines) is much more susceptible to the shrinking and swelling effects of soil. The effects of shrinkage can be seen at the bottom of a dried lakebed. The effects of swelling can be seen on unpaved clay roads after a rainstorm.

INTERIM TRANSITION: We have just discussed the effects of moisture content in a soil. Are there any questions? Let's take a look at using the two different types of moisture measuring devices in the STS and how to use them.

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INSTRUCTOR NOTE
Introduce the following demonstration.

DEMONSTRATION (2): (10 MIN) Take the class outside the building anywhere on the lot.
Step (1): Using one of the trowels from the STS, clear any grass or gravel from an area approximately 6 inches in diameter and use the pointed end to loosen the soil.
Step (2): Connect the ECH_2O Moisture Probe cord to the $ECHO_2O$ Moisture Monitor and push the "On/Read" button.
Step (3): Push the "Mode" button until "Pct" appears in the upper right hand corner. This is the percentage mode.
Step (4): Gently insert the probe end approximately 1-2 inches into the soil and wait for the reading. The display will show the percentage of moisture content in the soil.

STUDENT ROLE: Observe the instructor, listen, and ask questions.

INSTRUCTOR(S) ROLE: Walk the class through each of the above listed steps and demonstrate the use of the $ECHO_2$ Moisture Probe.
1. Safety Brief: Ensure that bug repellent is available. Ensure safe proceudures are used for traffic considerations when walking on the lot.
2. Supervision & Guidance: Be sure to follow the step by step directions and be prepared to answer questions.
3. Debrief: Now that you have seen first-hand how to use the $ECHO_2$ Moisture Probe, are there any questions or comments concerning the demonstration? We will now move into the practical application where each group of Marines will get an opportunity to use the equipment.

INTERIM TRANSITION: You have just seen the demonstration for the ECH_2O. Are there any questions? Now each group will get an opportunity to use the moisture probe in a practical application to determine moisture content.
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INSTRUCTOR NOTE
Introduce the following practical application.

PRACTICAL APPLICATION (4): (20 MIN) Due to the STS having only one digital moisture monitor and the simplicity of using the item, each group will get an opportunity to use the moisture monitor to get a moisture content of a given area.

PRACTICE: Each group of students will utilize the ECH_2O Soil Moisture Monitor to check the percentage of moisture in a given area using the steps from the demonstration above.

PROVIDE-HELP: The instructor will observe each group verifying the correct steps are followed and answer questions as they arise. (Ensure the students do not jam the moisture probe into the ground as it can cause the tips to break off.)
1. Safety Brief: Ensure that bug repellent is available. Ensure safe proceudures are used for traffic considerations when walking on the lot.
2. Supervision & Guidance: Ensure students follow the step by step directions covered in your student outline along with the instructor's supervision.
3. Debrief: Are there any questions or comments concerning the use of the ECH_2O Soil Moisture Monitor? The ECH_2O is an expedient method of determining moisture content and many tests may be required throughout your project site to get an accurate determination of the moisture content from the start to the finish segment of a project.

INTERIM TRANSITION: The moisture probe is one of two moisture measuring tools in the STS. We will take a break and then we will use the second method of moisture detection, the speedy moisture tester, in an instructor demonstration.
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(BREAK – 10 MIN)

INTERIM TRANSITION: Are there any more questions before the instructor demonstration.
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INSTRUCTOR NOTE
Introduce the following demonstration.

DEMONSTRATION (3): (20 MIN) Speedy Moisture Tester
Step 1: Remove one of the cups from the kit.
Step 2: Place the cup on the 200 gram scale, then zero out the scale.
Step 3: Remove the cup from the scale and put approximately 20 grams into the cup and place back on the scale.
Step 4: Remove or add material in the cup until the scale reads 20 grams (+ or - .01 grams).
Step 5: Unscrew the base of the speedy moisture cylinder and flip down the stirrup handle.
Step 6: Keeping the cylinder horizontal, place the 20 gram sample into the cylinder.
Step 7: Keeping the cylinder horizontal, place the two steel balls gently into the cylinder.
Step 8: Using the scooper that's in the kit, place two level scoops of Calcium Carbide into the cap of the moisture tester.
Step 9: Keeping the cylinder horizontal, place the cap back
onto the cylinder, swing the stirrup into position over the cap, and tighten down the top screw until secure.
Step 10: Rotate the cylinder slightly up so that the gauge is angled upward so that the sample falls into the cylinder.
Step 11: Shake the tester in a circular motion vigorously for at least 5 seconds or until all of the sample is broken up and mixed with the Calcium Carbide.
Step 12: Hold the tester horizontal for 1 to 2 minutes to allow for the chemical reaction to occur.
Step 13: Keeping the tester horizontal, bring the gauge up to eye level to take the moisture reading. Record the data.
Step 14: Carefully, with the cap notch pointed away from all personnel, release the pressure from the tester.
Step 15: Dump the contents of the tester into an empty mixing bowl to allow the chemical to become inert. Use the brush in the kit to clean the tester.

STUDENT ROLE: Follow along in the student's supplemental handout, observe the instructor, listen, and ask questions.

INSTRUCTOR(S) ROLE: Walk the class through each of the above listed steps and demonstrate the use of the Speedy Moisture Tester.

1. Safety Brief: Calcium Carbide is a controlled item, ensure disposed of correctly. Ensure the notch of the Speedy Moisture Tester in pointed away from all personnel when releasing the pressure from the cylinder. The gas that is released from the cylinder is acetylene, ensure proper ventilation when releasing the gas. (The gas smells like rotten eggs.)

2. Supervision & Guidance: Be sure to follow the step by step directions and be prepared to answer questions.

3. Debrief: Now that you've seen how to use the speedy moisture tester, are there any questions or comments? The speedy moisture tester is slightly more accurate than the ECH_2O because it is based on a larger sample portion, but is slightly less expedient in nature. Keep in mind, the ECH_2O is a newer technology than the speedy tester and is limited to testing only as deep as the probe can penetrate.

INTERIM TRANSITION: You now have an understanding of how to use the speedy moisture tester. Are there any questions? At this time, each group will get an opportunity to employ the equipment.

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INSTRUCTOR NOTE

Introduce the following practical application.

PRACTICAL APPLICATION (5): (30 MIN) Allow each group an opportunity to utilize the Speedy Moisture Tester using the samples that passed through the #40 sieve from the sieve analysis.

PRACTICE: Each group of students will utilize the Speedy Moisture Tester to check the percentage of moisture from the previously obtained and sieved samples.

PROVIDE-HELP: The instructor will observe each group verifying the correct steps are followed and answer questions as they arise. (Ensure the students take the tester outside to release the gas and follow the safety instructions mentioned in the demonstration for releasing the gas.)

1. Safety Brief: Calcium Carbide is a controlled item, ensure disposed of correctly. Ensure the notch of the Speedy Moisture Tester in pointed away from all personnel when releasing the pressure from the cylinder. The gas that is released from the cylinder is acetylene, ensure proper ventilation when releasing the gas.
2. Supervision & Guidance: Ensure students follow the step by step directions covered in your student's supplemental handout along with the instructor's supervision.
3. Debrief: You have just used the speedy moisture tester, are there any questions or comments. The speedy moisture tester is the second method of moisture detection in the STS. It can be used anywhere a sample can be taken. The only restriction for the speedy tester is that the calcium carbide additive must be available to use with the instrument.

(ON SLIDE #39)

(6) Plasticity and Cohesion: Plasticity is the ability of a wet soil to deform without cracking or breaking. Fine-grained soils (greater than 50% is smaller than 0.072mm), like clay, have a wide range of plasticity to them. Coarse-grained soils (less than 50% is smaller than 0.072mm), like clean sands and gravels, are non-plastic.

(ON SLIDE #40)

(7). Engineering Properties of Soil: The engineering characteristics of soil vary greatly depending on its physical properties. The nature of any given soil can be changed by manipulation. Vibration, for example, can change loose sand to a dense one. Therefore, the behavior of a soil is not exclusively dependant on physical properties. It is also dependant on the arrangement of particles within the soil.

INTERIM TRANSITION: Plasticity and cohesiveness can also be determined by testing the soil sample. All of the expedient test required to determine the make up of the soil you will be using are illustrated in the USACE Field Identification Diagram. We will be conducting the field expedient tests identified on the diagram. The demonstration and practical application will be conducted jointly. Each test will lead you to another section of the chart to determine the classification of your soil sample.

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INSTRUCTOR NOTE
Introduce the following demonstration

DEMONSTRATION (4): (15 MIN) Field Identification. Using the steps in the Soil Field Identification Diagram, show the students how to identify the soil type for classification, construction properties, plasticity, and cohesion.

STUDENT ROLE: Students will observe the instructor as he/she performs the tests in the field identification diagram.

INSTRUCTOR(S) ROLE: The instructor will perform each step as it is listed in the field ID diagram to show the students how to identify soil types.
1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Students will perform each step as it is completed by the instructor. Ensure students are recording their data.
3. Debrief: Now that you've seen each test conducted to classify a soil, you will conduct each test using your sample.

INTERIM TRANSITION: Are there any questions before we go into the practical application.

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INSTRUCTOR NOTE
Introduce the following practical application.

PRACTICAL APPLICATION (6): (30 MIN) Field Identification. Using the steps in the Soil Field Identification Diagram, identify the soil type to determine classification, construction properties, plasticity, and cohesion.

PRACTICE: Each group of students will perform each of the steps in the identification diagram to determine the soils properties. Document the results of each test in order to keep track of where you are in the diagram.

PROVIDE-HELP: The instructor will observe each group verifying the correct steps are followed and answer questions as they arise.
1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Ensure students follow the step by step directions covered in your student's supplemental handout along with the instructor's supervision.
3. Debrief: We have just conducted the field identification tests to determine the classification and properties of your soil sample. Are there any questions or comments. We will keep the documented results as we will need them later in the USCS soil classification chart.

INTERIM TRANSITION: Are there any questions before we go into the concept of soils engineering.
____
____
____

(ON SLIDE #41)

d. Concepts of Soils Engineering

(ON SLIDE #42)

(1) Settlement: The magnitude of a soil's settlement depends on several factors, including:

(a) Density.

(b) Void ratio.

(c) Grain size and shape.

(d) Structure.

(e) Past loading history of the soil deposit.

(f) Magnitude and method of application of the load.

(g) Degree of confinement of the soil mass.

(ON SLIDE #43)

(2) Shear Resistance: A soil's shearing resistance under given conditions is related to its ability to withstand loads. The shearing resistance is especially important in its relationship to supporting strength, or bearing capacity, of a soil used as a base or sub grade beneath a road, runway, or other structure. The shearing resistance is also important in determining the stability of the slopes used in road or airfield embankments. Shear resistance can only be determined in a laboratory environment.

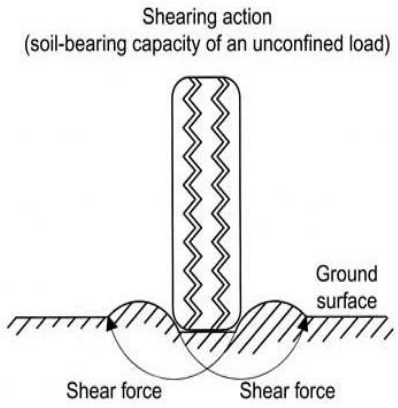
(a) California Bearing Ratio (CBR): CBR is a soils ability to support a load based on its strength, relative to a soil of known strength (crushed, compacted limestone). CBR measures the shearing resistance of a soil under carefully controlled conditions of density and moisture content.

(ON SLIDES #44)

(3) Bearing Capacity: The bearing capacity of a soil is its ability to support loads that may be applied to it by an engineering structure. It is usually expressed in terms of pounds per square foot or square inch. A soil with insufficient bearing capacity to support the loads applied to it may simply fail by shear, allowing the structure to sink or shift (see figure 9). The soils with the greatest bearing capacities display the following characteristics:

- Very Dense
- Well-graded
- Angular Particles
- Some moisture (not too much or too little)

(ON SLIDES #45)



(ON SLIDES #46)

(ON SLIDES #47)

TRANSITION: So far we have covered the formation of soil, engineering properties of soil, the K 2009 Soils Test kit and it's uses, identifying the soil type through testing procedures, and concepts of soil engineering.

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

A. What is a soil?

Soil is defined as the entire unconsolidated material that overlies and is distinguishable from bedrock

b. What are the three things that fill the voids in a soil?

A. Air, Water and/or organic material

(BREAK - 10 Min)

TRANSITION: Now that we have identified our soil type and understand its' basic properties, let's learn how to classify our samples so we can determine if it will be suitable for our construction purposes using a standardized system known as the Unified Soils Classification System.

____
____
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(ON SLIDES #48)

2. UNIFIED SOILS CLASSIFICATION SYSTEM (USCS) (25 min)

(ON SLIDES #49)

INSTRUCTOR NOTE
VIDEO "Military Soils Testing" 25 min At this time, show the soils video.

(ON SLIDES #50)

a. Soil seldom exists in nature separately as sand, gravel, or any other single component. Usually they occur as mixtures with varying proportions of particles of different sizes. Each component contributes its characeristics to the mixture. The USCS is based on those characterisics which effect the engineering properties and behaviors of a soil.

b. Soil Classification Considerations

(1) The percentages of gravel, sands, and fines.

(2) Is the soil well graded or poorly graded?

(3) The plasticity and compressibility of the soil.

(ON SLIDE #51,52)

c. USCS Soil Categories

(1) Coarse grained soils: These soils have less than or equal to 50% fines. Coarse grained soils are further

subdivided into two divisions: gravels and gravelly soils, and sands and sandy soils

(2) Fine grained soils: These soils have greater than 50% fines and are also subdivided into several divisions:

(a) Silts (0.05 to 0.005mm in size)

(b) Clays (less than 0.005mm in size)

(c) Organics

(3) Highly organinc soils (Peat): These soils have no construction value and no laboratory standards established since they are so easily identified in the field.

(ON SLIDES #53)

d. USCS Soil Groups & Symbols: The USCS assigns a letter symbol to each of its catagories (e.g. gravels = G). Additionally, a letter symbol can be assigned to describe one of its pyhsical properties (e.g. well graded = W). These symbols are combined to produce a two letter soil descriptor (e.g. GW). Table 8 lists symbols used and possible placement in a two letter soil descriptor. Table 9 lists all possible soil descriptors within the USCS.

(ON SLIDES #54)

Soil Groups	Symbol	Remarks
Gravel	G	Primary only
Sand	S	Primary only
Silt	M	Primary and secondary
Clay	C	Primary and secondary
Organic (silts or clays)	O	Primary only
Highly Organic (peat)	Pt	Stands alone
Soil Characteristics	**Symbol**	**Remarks**
Well graded	W	Secondary only
Poorly graded	P	Secondary only
Low liquid limit (less than 50)	L	Secondary only
High liquid limit (50 or greater)	H	Secondary only

Soil-Classification Symbols
Table 8

(ON SLIDES #55,56,57,58)

INSTRUCTOR NOTE
This chart is not on the power point, but the group symbols and typical name are described in the presentation.

Major Divisions			**Group Symbols**	**Typical Name**
Coarse grained soils (grater than 50% of material is retained on No. 200 sieve)	**Gravels** (more than half of the coarse grained material is retained on No.4 sieve)	(For visual classification a 1/4" sieve may be used as equivalent to the No. 4 sieve)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
			GM	Silty gravels or gravel-sand-silt mixtures
			GC	Clayey gravels or gravel-sand-clay mixtures
	Sands (more than half of the coarse grained material is smaller than No.4 sieve)		SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly-sand mixtures, little or no fines
			SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine grained soils (less than 50% of material is retained on No. 200 sieve)	**Silts and clays** (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low or medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and clays (liquid limit greater than 50)		MH	Inorganic silts, micaccous or diatomaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly organic soils			Pt	Peat and other highly organic soils

USCS Soil Types
Table 9

e. <u>Other Soil Terms</u>: In addition the Unified Soils Classification System, several other systems are used by various federal agencies and commercial companies. Some of the different terms that may be heard from time to time are listed below:

(1) Loam: Refers to a soil containing a high amount of organics. For example, a soil can be refered to as gravelly loam or even clayey loam.

(ON SLIDE #59)

TRANSISTION: We have just discussed classifying our soil in order to identify if our construction requirements can be met using the samples that we've tested. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

Q. What is the objective of soil classification?

A. The principle objective of any soil classification system is to predict the engineering properties and behavior of soil.

Q. What does GM stand for?

A. Gravel with some silt

(BREAK – 10 Min)

TRANSISTION: Now we will see if the soil identified from our samples can meet compaction requirements in order to achieve the required CBR.
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(ON SLIDE #60)

3. SOIL COMPACTION (50 min)

(ON SLIDE #61)

a. Purpose of Compaction: Soil compaction is one of the most critical components in the construction of roads, airfields, embankments, and foundations. The durability and stability of a structure are related to the achievement of proper soil compaction. Structural failure of roads and airfields and the damage caused by foundations settlement can often be traced back to the failure to achieve proper soil compaction.

(ON SLIDE #62)

b. Effects of Compaction: Certain advantages resulting from soil compaction have made it a standard procedure in the construction of earth structures, such as embankments, sub grades, and bases for road and airfield pavements. Principal soil properties affected by compaction include:

(1) Settlement: The reduction of settlement is the principle advantage resulting from compaction. This is true because compaction and consolidation both bring about a closer arrangement of soil particles.

(2) Shearing resistance: Increasing density by compaction usually increases shearing resistance. Large-scale experiments have indicated that the unconfined compressive strength of clayey sand could be doubled by compaction.

(3) Movement of water: When soil particles are forced together by compaction, both the number and size of voids within a soil are decreased. The change in voids has an obvious effect on the movement of water through soil.

(4) Volume change: Volume change is generally not of greater concern in relation to compaction, except with clay soils. For these soils, the greater the density, the greater the potential volumes change due to swelling.

(ON SLIDE #63)

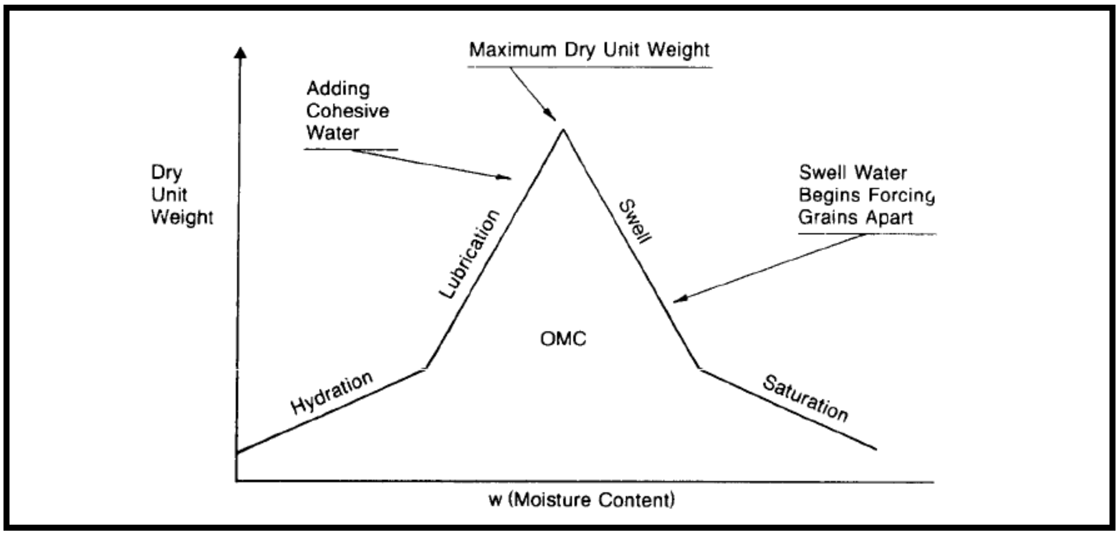
c. Compaction Design Considerations: The degree of compaction that may be achieved in a particular soil depends on the soils physical and chemical properties; however, certain common factors influence compaction in all soils:

(ON SLIDE #64)

(1) Moisture Content: The moisture content of a soil has a great bearing on a soils ability to densify. For every soil there is an Optimum Moisture Content (OMC). OMC is simply that percentage of water to particles, at which a soil will achieve maximum density under a given compactive effort. For each soil, a Maximum Dry Density (MDD) develops at the Optimum Moisture Content (OMC) for the

compactive effort used (see figures 10 and 11). When MDD is obtained within a soil, the soil particles become so closely packed that most air is expelled. For most soils (except cohesionless sand), when the moisture content is less than optimum, the soil becomes more difficult to compact. Beyond OMC, most soils are not as dense because the water interferes with the close packing of soil particles.

(ON SLIDE #65)



Effect of Water on Soil Density
Figure 10

(ON SLIDE #66)

(2) Compaction Characteristics of Various Soils: The nature of soil itself has a great effect on its response to a given compactive effort. Light weight soils may have maximum densities under a given compactive effort as low as 60 pcf. The same compactive effort applied to clay may yield maximum densities from 90 to 100 pcf, while a well graded soil may be as high as 135 pcf.

(ON SLIDE #67)

d. Selection of Materials: Soils generally come from cut sections of the road or airfield concerned, providing the material is suitable. Tables 13, 14, and 15 list the properties of different soils and their value as construction materials.

Symbol	Shear Strength	Compressibility	Workability as a Construction Material	Permeability when Compacted
GW	Excellent	Negligible	Excellent	Pervious
GP	Good	Negligible	Good	Very Pervious
GM	Good to Fair	Negligible	Good	Semi-impervious to Impervious
GC	Good	Very Low	Good	Impervious
SW	Excellent	Negligible	Excellent	Pervious
SP	Good	Very Low	Fair	Pervious
SM	Good to Fair	Low	Fair	Semi-impervious to Impervious
SC	Good to Fair	Low	Good	Impervious
ML	Fair	Medium to High	Good to Fair	Semi-impervious to Impervious
CL	Poor	Medium	Good to Fair	Impervious
OL	Poor	Medium	Fair	Semi-impervious to Impervious
MH	Fair to Poor	High	Poor	Semi-impervious to Impervious
CH	Poor	High to Very High	Poor	Impervious
OH	Poor	High	Poor	Impervious
PT	NOT SUITABLE FOR CONSTRUCTION			

Soil Characteristics
Table 13

Symbol	Subgrade Value	Sub-base Value	Base Value	Drainage Characteristics
GW	Excellent	Excellent	Good	Excellent
GP	Good to Excellent	Good	Fair to Good	Excellent
GM	Good to Excellent	Good	Fair to Good	Fair to Poor
GC	Good	Fair	Poor to Not suitable	Poor to Not suitable
SW	Good	Fair to Good	Poor	Excellent
SP	Fair to Good	Fair	Poor to Excellent	Not suitable
SM	Fair to Good	Fair to Good	Poor	Fair to Poor
SC	Poor to Fair	Poor	Not suitable	Poor to Impervious
ML	Poor to Fair	Not suitable	Not suitable	Poor to Fair
CL	Poor to Fair	Not suitable	Not suitable	Practically Impervious
OL	Poor	Not suitable	Not suitable	Poor
MH	Poor to Fair	Not suitable	Not suitable	Poor to Fair
CH	Poor to Fair	Not suitable	Not suitable	Practically Impervious
OH	Poor to Very Poor	Not suitable	Not suitable	Practically Impervious
PT	Not suitable	Not suitable	Not suitable	Poor to Fair

Soil Values for Roads and Airfields
Table 14

Symbol	Compaction	Permeability	Compressibility	Stability
GW	Good	High	Very Slight	Very Stable
GP	Good	High	Very Slight	Moderately Stable
GM	Good	Medium	Slight	Moderately Stable
GC	Good	Low	Slight	Fairly Stable
SW	Good	High	Fair	Very Stable
SP	Good	High	Very Slight	Moderately Stable
SM	Good	Medium	Slight	Fairly Stable
SC	Good	Low	Slight	Fairly Stable
ML	Poor to Good	Low to Medium	Medium	Poor Stability

CL	Fair to Good	Low	Medium	Stable
OL	Poor to Fair	Low to Medium	Medium to High	Not Suitable
MH	Very Poor to Poor	Low to Medium	Very High	Poor Stability
CH	Poor to Fair	Low	High	Fairly Stable
OH	Very Poor to Poor	Very Low	Poor to Good	Not Suitable
PT	NOT SUITABLE FOR CONSTRUCTION			

Soil Values for Embankments
Table 15

(ON SLIDE #68)

TRANSISTION: We have just discussed the purpose, effects, and design considerations for applying compaction in order to reduce settlement, improve drainage, and increase shearing resistance of the materials within our construction project. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

A. What does OMC stand for?

Optimum Moisture Content.

b. What is the most critical component in horizonatal construction?

Compaction

(BREAK 10 – Min)

TRANSISTION: Compaction, although effective, is not the only method that can be used to improve the quality of a road or airfield. There are methods used to increase the life and sustainability of your horizontal construction project. Our next topic of discussion, soil stabilization, can be used in conjunction with or instead of compaction to achieve a stronger, more durable road or airfield.

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(ON SLIDE #69)

4. <u>SOIL STABILIZATION</u> (50 min)

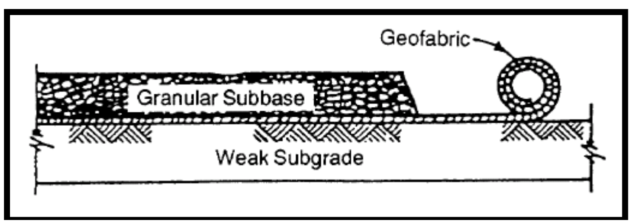
(ON SLIDE #70,71)

Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Typical soil properties affected by stabilization are texture, gradation, or plasticity. Stabilization can also be used to cement soil particles together. Soil stabilization is used when the available soil does not meet the minimum design requirements.

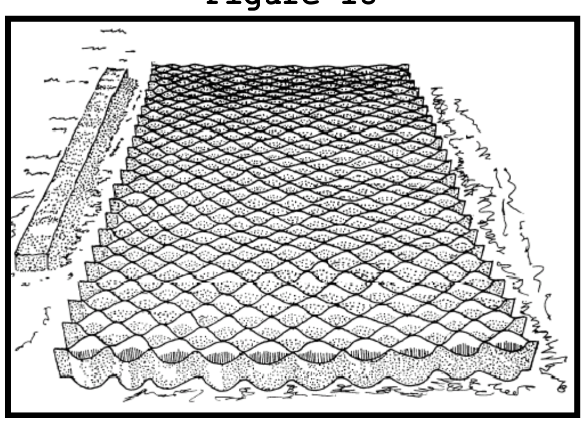
(ON SLIDE #72)

a. <u>Geotextile Stabilization</u>: Geotextiles serve three primary functions with regards to soils stabilization: reinforcement, separation, and drainage (see figures 17 and 18). Types of geotextiles include, among others, sand grid, sand fibers, and geo-fabrics. The goal of geo-textiles is to eliminate pumping.

(ON SLIDE #73)

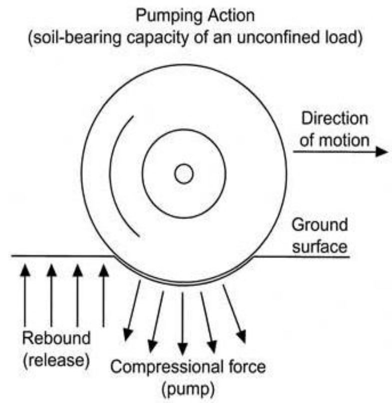


Separating a Weak Sub-Grade From a Granular Sub-Base
Figure 18



Sand Grid
Figure 19

(ON SLIDE #74)



(ON SLIDE #75)

b. Mechanical Stabilization: Mechanical stabilization is the most widely used method of stabilization. It invloves the mixing or blending of two soils of different gradations to obtain a material meeting required specification. Normally, compaction will follow the blending process; however, **compaction is not considered a form of mechanical stabilization.** The process of blending followed by compaction the most efficient type of soil stabilization.

(ON SLIDE #76)

c. Chemical Stabilization: Chemical stabilization is process of stabilization by adding granular material or chemical admixtures to the soil. Chemical admixtures are often used to stabilize soils when mechanical methods of stabilization are inadequate and replacing an undesirable soil with a desirable soil is not possible or is too costly. Common chemical stabilization techniques are:

(ON SLIDE #77)

(1) Portland Cement: Portland cement can be used to either modify or improve to quality of soil or to transform the soil into a cemented mass with increased strength and durability. Cement is effective on a wide range of materials. For coarse-grained soils, the percent passing the No. 4 sieve should be greater than 45%. Table 20 lists the estimated cement requirements for various soil types.

(ON SLIDE #78)

Soil Classification	**Initial Estimated Cement Requirement, Percent Dry Weight**

GW,SW	5
GP,SW-SM,SW-SC	6
GW-GM,GW-GC	6
GM,SM,GC,SC,SP-SM,SP-SC,GP-GM,GP-GC,SM-SC,GM-GC	7
SP,CL,ML,ML-CL	10
MH-OH	11
CH	10
*Table extracted from FM 5-410, page 9-15.	

Estimated Cement Requirements for Various Soil Types
Table 20

(ON SLIDE #79,80)

(2) Lime: Lime reacts with medium grained, moderately fine grained and fine grained soils to produce decreased plasticity, increased workability and strength, and reduced swell. Lime is not normally used with SW, SP, GW, and GP soils because of the low amount of fines. When lime is used the reaction that takes place causes a significant change in the plasticity of a soil, thus increasing strength and reducing swell of the soil.

(ON SLIDE #81,82)

(3) Fly Ash: Fly ash is a fine grained pozzolanic material that consists mainly of silicon and aluminum compounds that react chemically with lime and water at ordinary temperatures forming a strong slow-hardening cement capable of obtaining high compression strengths. Fly ash is a by-product of coal-fired, electric power-generation facilities and is not always available.

(ON SLIDE #83)

(4) Lime-Cement-Fly Ash (LCF): If materials are available, a Lime-Cement-Fly Ash mixture can be utilized to improve the engineering properties of a soil. When expedient construction is required, use an initial mix proportion of 1 percent cement, 4% lime, 16% Fly-Ash, and 79% soil.

(ON SLIDE #84,85)

(5) Bituminous: Most bituminous soil stabilization is performed using asphalt cement, cutback asphalt and

asphalt emulsions. Soils stabilized effectively with bituminous materials usually contain less than 30% passing the #200 sieve and have a PI < 10.

(ON SLIDE #86)

<u>TRANSISTION</u>: We have just discussed stabilization of soils through mechanical and chemical means. Are there any questions?
Here are some questions for you.

<u>OPPORTUNITY FOR QUESTIONS:</u>

1. **<u>QUESTIONS FROM THE CLASS</u>**

2. **<u>QUESTIONS TO THE CLASS:</u>**

   A. What is soil stabilization?

   The alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties.

   b. How much portland cement is required to stabilize a clay of high plasticity?

   10%

(BREAK - 10 Min)

<u>TRANSISTION</u>: Now that we have discussed proper soil stabilization, we will cover some of the techniques for dust abatement.
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(ON SLIDE #87)

5. <u>DUST ABATEMENT</u> (45 min)

(ON SLIDE #88,89,90)

The term “dust” can be defined simply as particles of soil that have become airborne. As a general rule, dust consists mainly of soil particles finer than 0.05 mm (passing No. 200 sieve). Dust may occur naturally from the force of the wind or by physical abrasion from foot or vehicle traffic. Generally, dust is a problem with sandy soils of greater than 10% fines. Soils with 60% to 90% coarse sand and 10% to 40% fines have proven in the past to be the most difficult to work with when attempting to prevent dust problems. Soils with finer sands and large percentages of fines experience the best results when treated with dust abatement products.

(ON SLIDE #91,92)

a. <u>Factors Influencing Dust Production</u> Several factors influence a soils ability to produce dust:

(1) Soil texture and structure.

(2) Soil moisture content.

(3) Presence of salts or organic matter in soil.

(4) Smoothness of the ground surface.

(5) Vegetation cover.

(6) Wind velocity and direction.

(7) Humidity.

(ON SLIDE #93)

b. <u>Dust Control Methods</u>: Four general dust control methods commonly in use are:

(1) <u>Agronomic</u>: This method consists of establishing or extending vegetative cover, mulch, shelterbelts, and rough-tillage. It includes such items as seeding, springing, sodding, topsoiling, fertilizing, mulching, and disking. Agronomic methods are not normally used for traffic areas.

(ON SLIDE #94)

(2) <u>Surface Penetrate</u>: In the surface penetration method, the dust palliative (a liquid), is applied directly on the soil surface by spraying or sprinkling and allowed to penetrate the surface on its own accord. Dust palliatives that penetrate the soil surface include bitumen, resins, salts, and water.

(ON SLIDE #95)

(3) Admix: In the admix method; the dust palliative is blended with the soil to produce a uniform mixture. This method takes more time, effort, and equipment than the surface penetrates method.

(ON SLIDE #96)

(4) Surface Blanket: This method includes the use of aggregates, prefabricated membranes and mesh, bituminous surface treatments, polyvinyl acetates, and polypropylene-asphalt membranes to create a surface blanket for dust control.

(ON SLIDE #97)

c. Common Dust Control Products: The following is a partial list of dust abatement products and the pertinent information associated with each product. Any subjective conclusions about their performance are based on Marine Corps testing and operation use of the products.

(1) EK-35: EK-35 is a product that is difficult to apply and requires a water pump to apply correctly. It works best during the first forty-eight hours after application.

(2) EnviroKleen: This is a product that is easily applied, does not breakup over time, and requires no water for application.

(3) Tar: Tar, while effective in dust abatement, is not an environmentally sound solution to dust abatement

(4) Mobi-Matting: This matting works well in coarse sands; however, most fines are too small to be contained by the matting. One benefit is the easily distinguishable colors on the matting.

(5) PAM: PAM is a polyacrylate polymer with a high atomic weight, which attaches itself to fines to prevent dust. It is reported to be both non-toxic and environmentally safe. PAM comes in three forms: dry granular powder, aqueous concentrations, and emulsified concentrations. The granular form is easy to store and transport.

(6) Tri-PAM: Scientist working in conjunction with the MCCDC developed Tri-PAM as an alternative to other

commercially available products. It is an on-site mixture of PAM, superabsorbant, and aluminum chlorohydrate. It has been tested in 29 Palms and Iraq.

(ON SLIDE #98)

TRANSISTION: We have just covered causes of dust and control methods for dust abatement. Are there any questions? Here are some questions for you.

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

A. What causes dust?

Abrasion from wind, vehicle or foot traffic.

b. What are the four dust control methods?

Agronomic, Surface Penetrate, Admix, and Surface Blanket

Summary **(5 MIN)**

During this period of instruction we have covered the basics of soils including formation and concepts of engineering, the KSE Soils Test Kit, the various tests that can be conducted to identify and classify soil types, the United Soils Classification System, compaction capabilities, stabilization using chemical and mechanical means, and dust causes and abatement methods. What you have learned during this period of instruction will aide you in the planning and design of your next horizontal construction project.

(BREAK – 10 Min)

INSTRUCTOR NOTE
Ensure to collect all IRF's and safety questionnaires handed out.

STUDENT REFRENCES:

FM 4-430	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations *	Oct 99
FM 4-472	Materials Testing *	Jul 01
FM 5-410	Military Soils Engineering *	Dec 92
FM 5-434	Earthmoving Operations *	Jun 00
TM 5-818-7	Foundations in Expansive Soils **	Sep 83
TM 5-818-8	Engineering Use of Geotextiles **	Jul 95
TM 5-822-14	Soil Stabilization for Pavements **	Oct 94
TM 5-830-3	Dust Control for Roads, Airfields, and Adjacent Roads **	Sep 87

* Can be found at *http://155.217.58.58/atdls.htm*
** Can be found at *http://www.usace.army.mil/publications*

1. Appropriate Technical Manuals

2. MCRP 3-17.7A Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations - Road Design

3. MCRP 3-17.7B Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations - Airfield and Heliport Design

4. MCRP 3-17.7F Project Management

5. MCRP 3-17.7G Military Soils Engineering

6. MCRP 3-17.7I Earthmoving Operations

7. MCRP 3-17A Engineering Field Data

8. MCRP 4-11.8A Marine Corps Field Feeding Program

9. MCRP 4-11A, Vol 1 CSS Field Reference Guide

10. MCWP 3-17 Engineering Operations

11. MCWP 5-1 Marine Corps Planning Process (MCPP)

12. TM 3-34.55 Construction Surveying