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

LESSON PLAN

MILITARY ROADS

EEO/EEC-B05

WARRANT OFFICER/CHIEF COURSE

A16ACN1/A1613E1

REVISED 9/8/2014

APPROVED BY ________________________ **DATE** ____________________

(ON SLIDE 1)

INTRODUCTION **(15 MIN)**

1. **GAIN ATTENTION**: In a theater of operations during time of war or during peace time, missions such as Humanitarian/Civil Assistance projects, mobility is vital to commanders. Engineers provide and/or enhance mobility. In order to be effective and efficient, we as engineers must understand the design fundamentals of a road. Look at the variety of vehicles that we bring to the fight. The roads that we design and construct must be able to support not only the HMWWVs but also the MK48/18A1s hauling dozers as well as M1A1 tanks and other armored vehicles.

(ON SLIDE 2)

2. **OVERVIEW**: Good morning/afternoon, my name is ________________. The purpose of this period of instruction is to provide you the knowledge to identify basic requirements, design, plan, and supervise military road construction to meet specifications for vehicle type and traffic quantity.

INSTRUCTOR NOTE
Introduce the learning objectives. Have the students read all learning objectives to themselves.

(ON SLIDE 3)

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

a. **TERMINAL LEARNING OBJECTIVE**: Provided a horizontal construction mission, resources, and references, manage/supervise 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 military road characteristics per the FM 5-430-00-1/Vol I, and FM 5-34. (1310-HORZ-2002i)/(1349-HORZ-2002i)

(2) Without the aid of references, identify steps in the planning process concerning military roads per the FM 5-430-00-1/Vol I, FM 5-233, and FM 5-34. (1310-HORZ-2002j)/(1349-HORZ-2002j)

(3) Without the aid of references, identify expedient roadway surfaces per the FM 5-430-00-1/Vol I, FM 5-233, and FM 5-34. (1310-HORZ-2002k)/(1349-HORZ-2002k)

(4) Without the aid of references, identify road design process per the FM 5-430-00-1/Vol I, FM 5-233, and FM 5-34. (1310-HORZ-2002l)/(1349-HORZ-2002l)

(5) Without the aid of references, identify road maintenance procedures per the FM 5-430-00-1/Vol I, FM 5-233, and FM 5-34. (1310-HORZ-2002m)/(1349-HORZ-2002m)

(ON SLIDE 4)

4. **METHOD/MEDIA:** This period of instruction will be taught using the lecture method with aid of power point presentation, demonstration and practical application.

INSTRUCTOR NOTE
Explain Instructional Rating Forms and Safety Questionnaire to

(ON SLIDE 5)

5. **EVALUATION:**

You will be evaluated by a 28 question written exam at the time indicated on the training schedule.

(ON SLIDE 6)

6. **SAFETY/CEASE TRAINING (CT) BRIEF.**

There are no safety / cease training concerns for this period of instruction.

INSTRUCTOR NOTE
Ensure to explain Crane Shed fire and inclement weather procedures.

(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 introduction to military roads.

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(ON SLIDE 8)

BODY **(7 HOURS 25 MIN)**

1. **INTRODUCTION TO MILITARY ROADS**. **(50 Min) (ON SLIDE 9)** Mobility is one of the many broad areas in which Marine Corps engineers influence the battlefield terrain. Terrain must be evaluated and potentially modified to ensure trafficability, or the quality of terrain that permits the passage of troops or vehicles. One means of providing trafficability is by road construction. **(ON SLIDE 10)** Military road construction is categorized as either hasty or deliberate.

(ON SLIDE 11)

a. **Hasty Road Construction**.

(ON SLIDE 12)

Hasty road construction, also known as *Combat Trails,* are primitive roads that may be deliberately constructed but often have been established over time by the passage of motorized vehicles. Combat Trails are extremely expedient in nature and are intended only for short term use. The following are general characteristics of a Combat Trail.

(ON SLIDE 13)

(1) Expedient Methods: Built with extremely expedient methods and/or intended for short term use. Where there is an urgent need for a road, there may not be enough time to fully design a road and then build to that design. In these cases a path is made that will support the traffic for the short duration needed. If the road’s duration of use is extended beyond the intended timeframe then more permanent methods will need to be employed to improve the trail. We will talk about

different typs of expeidient surfaced roads a little later in the class.

(2) Indigenous Materials: *Combat Trails* are built with indigenous materials. The expedient nature of a combat trail necessitates using materials that are readily available. The fact that the combat trail is intended for a very short term usage allows the use an inferior building material.

(3) Repair of existing/damaged roads: It is often more practical to repair/rebuild an existing, but damaged, road than to build a road from the ground up. When possible, a combat trail will tie in with existing roads thereby lessening the amount of engineering effort required.

(ON SLIDE 14)

b. **Deliberate Road Construction**.

(ON SLIDE 15)

Deliberate Military, or Combat Roads, require a great deal of planning and constructon time. However, the resulting product is (should be) better quality and should hold up under heavy use with minimal maintenance. Combat roads have the following general characteristics:

(ON SLIDE 16)

(1) Combat Roads are engineered based on anticipated daily traffic. Structural and Geometric design criteria are utilized to ensure the final product is of sufficient quality to support the long term mission.

(2) Due to the more detailed nature of construction, deliberate roads are more logistically intensive, requiring more equipment on site as well as more manpower.

(ON SLIDE 17)

(3) Based on the more intensive manpower and equipment required for the deliberate road project, more time will be required to effectively plan for and execute the Combat Road.

(4) Engineered roads are built using quarry materials which are picked for their specific material properties.

(4) Deliberate combat roads will be surveyed and staked.

(ON SLIDE 18)

c. **Characteristics of a Road**. Regardless of whether they are deliberately or hastily built, all roads will have some basic characteristics in common:

(ON SLIDE 19)

(1) Traffic lane. The area that vehicles maneuver in.

(2) Traveled Way. The total combined width of traffic lanes. A traveled way width of less than 18 feet is considered "one lane."

(3) Shoulders. Used for pull-off etc.

(ON SLIDE 20)

(4) Roadbed. Includes the shoulders and traffic ways.

(5) Roadway. The entire width within the limits of earthwork construction and is measured from the outside edge of cut or fill slopes.

(6) Width of cleared area. Roadway plus a minimun of six feet.

(ON SLIDE 21)

(7) Crown. Used to aide drainage of traffic lanes.

(8) Road Courses. The courses of the road are the load carrying components.

(ON SLIDE 22, 23)

(a) Surface Course: Asphalt, concrete, expedient or indigenous materials that vehicles traffic over.

(b) Base course(s). The purpose of a base course is to distribute the induced stresses from the wheel load so that it will not exceed the strength of the underlying soil layers. Thicker base courses (including any subbase courses) provide better pressure distribution, lowering the load stesses incurred by the subgrade. Therefore, weaker subgrades require thicker base courses.

(c) Subgrades. The subgrade is the foundation that ultimately carries any load that is applied to the road and is most usually made up of indiginous materials.

(ON SLIDE 24)

d. **Military Road Construction**:

The "seven step" military road is the basis of all military road construction. The area where the military road is to be built should be cleared, grubbed and stripped by bulldozers. After the bulldozers have finished, scrapers or graders should rough grade, and smooth out the intended route for the road. Once this is done the road grader is ready to begin the process of road building.

(ON SLIDE 25)

It should be pointed out that these are general steps, more or less may be required depending on the environment. These are **NOT** seven passes of the grader, to build the road.

(ON SLIDE 26)

Step 1. Mark the ditch.

a. A light marking cut is made to define the ditch.
b. This cut should not be deep, and should be kept as straight as possible.

Step 2. Cut the ditch.

a. Follow the marking cut and begin cutting the V ditches.
b. Make as many passes as needed to cut ditch to required depth.

Step 3. Pull the shoulder.

a. Shoulders are typically cut 4' wide.
b. Spoils are pulled onto the road travel way.

(ON SLIDE 27)

Step 4. Mark opposite ditch.

a. The opposite ditch is marked according to road specifications.
b. This step is performed in the same manner as Step 1.

Step 5. Cut opposite ditch.

a. The opposite ditch is cut in the same manner as Step 2.
b. Ditch requirements may vary depending on the terrian.

Step 6. Pull the shoulder.

a. This shoulder is cut the same as Step 3.
b. The spoils are again rolled onto the travel way of the road surface.

(ON SLIDE 28)

Step 7. Crown the road.

a. The spoils pulled from the shoulder cuts are used to crown the road for proper drainage.
b. Several passes will most likely be required to complete this process

(ON SLIDE 29)

TRANSITION: We have just discussed a brief introduction to military roads. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

Q. What are the two types of military roads?

A. Hasty and Deliberate.

Q. What are some of the different parts of a road?

A. Traffic lane, traveled way, shoulders, roadbed, roadway, cleared area, crown, road courses.

(BREAK - 10 Min)

TRANSITION: Now that we have discussed the types of military roads and their components, we will talk about the planning involved in constructing a military road.

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(ON SLIDE 30)

2. PLANNING. (50 Min)

(ON SLIDE 31)

Once the need for a combat road or trail has been identified planning can begin. The amount of planning time will vary based on the mission and the type of road needed, whether hasty or deliberate. There are several steps involved in ensuring you are prepared and able to produce a well made finished product.

(ON SLIDE 32)

a. **Coordinate security**. Security will be needed for the site survey/site recon team(s). The local situation will dictate how much security is required.

b. **Reconaissance**. Conduct reconnaissance as soon as possible in planning phase.

(ON SLIDE 33)

Who will attend will be based on who is available and the space available for transportation. It is recommended that the site recon be conducted jointly with the Project Officer, Engineer Assistant Chief, Engineer Equipment Chief and when vertical contruction is involved the Combat Engineer Chief. While on the site survey there are many factors that need to be investigated to include but not limited to the following:

(ON SLIDE 34)

(1) Feasibility of proposed road placement. Geographic, geologic, or other conditions may pose complications that are too severe to overcome. Alternate, more suitable routes should be identified.

(2) Restrictions. Identify existing terrain restrictions such as steep slopes and or marshy areas.

(ON SLIDE 35)

(3) Identify existing roads/bridges. These may be used to help reduce the amount of work that is needed. Earthwork is the single largest work item during the construction of a road. When connecting to existing roads or bridges or when crossing existing railroads it is important to ensure proper vertical alignments.

(4) Natural and manmade obstacles. Rivers or streams will have to be crossed. The crossing means will be dependant on many factors such as the width and depth of the gap, amount of flow and current velocity. Crossing means will be discussed during later classes. Man made obstacles include homes, religious structures, cemeteries, etc.

(ON SLIDE 36)

(5) Existing Assets. Identify existing assets (water, equipment, materials). These will help to reduce the logistical burden as well as time and expense of the engineering effort.

(6) Indentify drainage concerns. The number one reason for failure of a road project is inadequate drainage. As you have already learned, drainage will have to be addressed before work begins, while work is on-going, and even after work has been completed.

(ON SLIDE 37)

(7) Potential Difficulties. Identify potential difficulties such as accessibility, availability of resources, special equipment requirements, etc.

(ON SLIDE 38)

c. **Test Soil**. It is imperative to understand what type(s) of material you have on location and what type(s) of materials you have available as borrow material in order to properly design and prepare the subgrade and base courses of your road to handle the anticipated loads.

(1) Using the Marine Corps Soils Test Set, identify the soil in accordance with the Unified Soils Classification System (USCS) and determine the California Bearing Ratio (CBR) capacity of the in situ soil.

(ON SLIDE 39)

(2) In cases where an extreme amount of engineering may be involved requiring more detailed soils analysis, soils samples should be acquired during the site survey and transported to an appropriate location to conduct the required tests.

(3) Determine suitability of indigenous soils in accordance with the design specifications.

(4) Identify borrow pits within a reasonable proximity of the job site.

(ON SLIDE 40)

d. **Select Proposed Site(s)**. Select proposed sites for the road and the logistical footprint necessary to support the engineering effort for construction. This should be done by:

(ON SLIDE 41)

(1) Utilizing terrain to your advantage (i.e. using existing infrastructure, following contours, etc).

(a) Locate portions of new roads along existing roads whenever possible.

(b) Locate the road on soil that is stable, and easily drained. Avoid the low points of valleys, swamps, marshes, or other low lying areas because this is where water will cause surface and subsurface drainage problems.

(ON SLIDE 42)

(c) Avoid constructing roads in areas that have high water tables. Locating roads through these areas will present continuing problems.

(d) Locate roads along ridges and streamlines to keep the construction of drainage structures to a minimum. The road must be kept well above the waterline when the route follows a stream to prevent flooding.

(e) Locate roads along contour lines to avoid unnecessary earthwork operations.

(ON SLIDE 43)

(f) Select locations which avoid rock work or excessive clearing and grubbing if practical.

(g) Avoid sharp curves and routes which require bridging.

(2) Utilizing best indigenous materials to eliminate the time, logistical effort and expense of hauling select materials from a far distance.

(ON SLIDE 44)

e. **Report Findings**. Report findings along with your recommendations to your higher headquarters. The appropriate reconnaissance forms should be used and supplemented with digital photos and any other source of data as can be acquired.

(ON SLIDE 45)

TRANSITION: We have just discussed some necessary considerations for planning a road. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

Q. Who are the individuals that should be present during the site reconaissance.

A. Project Officer, Engineer Assistant Chief, Engineer Equipment Chief and when vertical contruction is involved the Combat Engineer Chief.

(ON SLIDE 46)

Q. What is the single largest work item of a road construction project?

A. Earthwork

(BREAK – 10 Min)

TRANSITION: Now that we have talked about planning and conducting the site reconnaissance, let's talk about preparing for a road construction project.

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(ON SLIDE 47)

3. **PREPARE**. **(25 Min)**

(ON SLIDE 48)

Once the mission has been determined, the site selected and the design complete, preparations can begin for the construction phase.

(ON SLIDE 49)

a. **Acquire needed assets**.

(1) Establish equipment density lists (EDL's) based on required engineer effort garnered from the design and site survey results.

(2) Determine what equipment and support is available at the location through adjacent units or host nation support.

(ON SLIDE 50)

(3) Don't overlook the need for logistical support getting to and from the location. Refueling and maintenance needs will also need to be addressed here.

(4) Identify sources of Class IV materials and borrow pit loactions that will be used (if needed).

(ON SLIDE 51)

b. **Conduct Briefings**.

(1) To higher to ensure that your plan meets their expectations.

(2) To subordinates to ensure they understand what they will be doing and what is expected of them.

(ON SLIDE 52)

c. **Inspect/Maintain Equipment**.

(1) Inspect and maintain all items of equipment to ensure that they are in sound working order.

(2) Inspect personnel to ensure their readiness.

(3) Inspect personnel actions such as planning, design scheduling functions to ensure they are being completed correctly and in a timely manner.

(ON SLIDE 53)

d. **Organize Mission Forces**.

(1) Task organize your manpower and equipment based on tasks at hand.

(2) Determine shortfalls in the TO/TE. This may not be solely based on the earthmoving equipment. The support functions (fuel, utilities, etc) cannot be overlooked.

(ON SLIDE 54)

e. **Move to/Toward Project Site**.

(ON SLIDE 55)

TRANSITION: We have just discussed some condiserations for perparing to build a road. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

Q. What are some of the steps in preparing for a road construction project.

A. Aquire needed assets, conduct briefings, inspect/maintain equipment, organize mission forces, move to the site.

(ON SLIDE 56)

Q. During which step do you determine any shortfalls in the TO/TE?

A. Organize mission forces.

TRANSITION: Now that we know some of the planning requirements of a military road project we will move into the building process of a hasty road or combat trail.

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(ON SLIDE 57)

4. **CONSTRUCT COMBAT TRAIL**. **(50 Min)**

(ON SLIDE 58)

a. **Coordinate work-site security**. The security may fall to the engineer platoon, or there may be supplemental personnel that can fill the role of security for the project. Regardless of who is acting in the security role, it is a function that must not be overlooked. The security may be broken down in to different areas including, but not limited to the engineer equipment park (EEP) security, Job site security, Convoys to and from the port of entry (POE)/EEP/Site/Cantonment site and security at the Cantonment site itself.

(ON SLIDE 59)

b. **Delineate route**. One of the first steps in the construction phase is delineating the actual route to be constructed.

(ON SLIDE 60)

(1) When doing so, choose the route requiring least amount of effort. Since we are discussing a combat trail, we want to perform as little work as necessary.

(2) The route can be marked by any means readily available such as spray paint, E-tape, or travel wear.

(ON SLIDE 61)

c. **Clear pathway**. Remove as many obstacles from the route as you can. Large trees and rock should be cleared enough to operate. When feasible, leave enough small vegetation to serve as dust abatement.

(ON SLIDE 62)

d. **Reduce limiting grades along the route**.

(1) Cut and fill operations should be planned so that they are in close proximity and complimentary.

(2) In keeping with the hasty combat trail philosophy, keep engineer effort to a minimum.

(2) The single largest work item during the construction of a road is the earthwork operations. Balancing cut and fill volumes will decrease excessive hauling distances, and decrease the amount of work required to handle the material.

(ON SLIDE 63)

e. **Construct roadway surface**.

(1) Earthen Roads consist of native soils graded and drained to form a surface for carrying traffic.

(ON SLIDE 64)

They are designed to satisfy immediate traffic needs and provide a subgrade for surfaces of better quality. Their use is generally limited to dry weather and light traffic.

(a) For continued use, periodic maintenance by graders and drags is necessary to maintain a high crown and smooth surface for draining surface water.

(ON SLIDE 65)

Dust control must also be provided in dry climates or during dry weather.

(b) Earthen roads will likely become impassable in wet weather because of the rutting action of heavy traffic. Generally, they are used in combat areas where speed of construction is required with limited equipment and personnel.

(c) Earthen roads may be treated with admixtures to control dust and to waterproof the surface. This helps prevent softening of the surface in wet weather. Treated surfaces are most successful with silt or clay soils. There is a wide range of admixtures available to treat the road surface including bituminous materials. Ecological concerns must be addressed when using any admixture in the stabilizing process.

(ON SLIDE 66)

(2) Expedient Surfaces. There will be occasions where the trafficability of the existing soils is below that required by the mission. There are several methods that can be used to improve the trafficability in a hasty environment. Some examples are listed below.

(ON SLIDE 67)

(a) Chespaling. Chespaling is a hasty, expedient surface used either in mud or sand. It is made from small, green saplings, preferably about 1 1/2 inches in diameter and 6 1/2 feet long. They are wired together to form a 12-foot-long mat as shown in Figure 9-29. Chespaling is often rolled into bundles and carried on each wheeled vehicle. The mats are used to cross sandy terrain or to get out of mud. Some mats are constructed from dimensioned timbers wired together to resemble a picket fence. A variation slightly more effective for crossing sand is made by attaching chicken wire netting to the bottom of the mats.

(ON SLIDE 68)

(b) Corduroy-Surfaced Roads. A corduroy road is an expedient road which uses logs or small trees as the road surface (decking). This method of construction is used in extremely muddy terrain when there is a sufficient supply of natural material. There are three types of corduroy construction: standard corduroy, corduroy with stringers, and heavy corduroy.

(ON SLIDE 69,70,71)

1 Standard Corduroy. The most frequently used corduroy road, shown in Figures 9-25 and 9-26, is built of 6- to 8-inch diameter logs about 13 feet long. The logs are placed across the road surface adjacent to each other from butt to tip. Along the edges of the roadway, place 6 to 8 inch diameter logs as curbs and attach them in place with drift pins. Drive pickets about 4 feet long into the ground at regular intervals along the outside edge of the road to hold the road in place. To give this surface greater smoothness, fill the gaps between logs with brush, rubble, or twigs. Cover the whole surface with a layer of gravel or dirt. Construct side ditches and culverts as for normal roads.

2 Corduroy with Stringers. A more substantial corduroy road is made by placing log stringers, as shown in Figure 9-27, parallel to the centerline on about 3-foot centers. Lay a standard corduroy over them, securely pin the corduroy decking to the stringers, and prepare the surface as described in the preceding paragraph.

3 Heavy Corduroy. Sleepers (heavy logs 8 to 10 inches in diameter)are used for heavy corduroy roads. The sleepers must be long enough to to span the entire road. Place the sleepers at right angles to the centerline on 4-foot centers.

(ON SLIDE 72)

(c) Plank Tread Road. Use plank roads for crossing short sections of loose sand or wet, soft ground. When built with an adequate base, plank roads last for several months.

1 To construct a plank-tread road, first place sleepers 12 to 16 feet long, perpendicular to the centerline on 3- to 4- foot centers, depending on the loads to be carried and subgrade conditions. (If finished timber is not available, logs may be used as sleepers.) Then place 4- by 10-inch planks parallel to the line of traffic to form two treads about 36 inches apart. Stagger the joints to prevent forming

weak spots. If desired, 6-inch curbs may be installed on the inside of the treads.

2 Planks 3 to 4 inches thick, 8 to 12 inches wide, and at least 13 feet long are desirable for flooring, stringers, and sleepers. Rough 3- by 8-inch and 3- by 10-inch planks can be cut to order. Position stringers in regular rows parallel to the centerline, on 3-foot centers, with staggered joints. Lay floor planks across the stringers with about 1-inch gaps when seasoned lumber is used. The gaps allow for swell when the lumber absorbs moisture. Spike the planks to every stringer. Place 6-inch-deep guardrails on each side, with a 12-inch gap left between successive lengths of the guardrail for surface-water drainage. Place pickets along each side at 15-foot intervals to hold the roadway in line. Where necessary, use corduroy or other expedient cross sleepers spaced on 3- to 5-foot centers to hold the stringers in place and to gain depth for the structure.

(ON SLIDE 73,74)

(d) Landing Mat. Metal airfield landing mat panels are still the foremost expedient surface for crossing sandy terrain. Landing-mat designs fabricated from aluminum alloys can support heavier loads. They also provide smoother surfaces and have a lower weight per square foot.

1 Place the mat so that its long axis is perpendicular to the flow of traffic. If a width greater than the effective length of one plank is required, use half sections to stagger the joints. A second layer of the steel mat, laid as a tread way over the initial layer, increases its effectiveness.

2 If MO-MAT (a reinforced plastic material) is available, it may be used as a roadway surface for vehicular traffic.

(ON SLIDE 75)

(e) Chain link Fence or other metal mesh can be stretched across sandy or other weak areas for added traction and bearing capacity. The addition of burlap or other similar materials underneath the burlap will aid in confining the sand.

(ON SLIDE 76)

(f) Sand Grid involves the confinement and compaction of sand or sandy soils in interconnected cellular elements called grids to produce a load-distributing base layer. Uses of the grid include road and airfield pavements, airfield crater repair, erosion control, field fortifications, and expedient dike repair.

(ON SLIDE 77)

TRANSITION: We have just discussed condiserations for perparing to build a combat trail. Are there any questions?

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

Q. What is an example of roadway surface for a combat trail?

A. Earthen and expedient surfaced roadway.

Q. What are some examples of expedient surfaced roadways?

A. Chespaling, corduroy, landing mat, chain link, sand grid.

(BREAK – 10 Min)

TRANSITION: Now that we know the basics of constructing a combat trail, let's move onto a combat road.

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(ON SLIDE 78)

5. **CONSTRUCT COMBAT ROAD**. **(2 Hr 20 Min)**

(ON SLIDE 79)

a. Combat Road. Combat roads are deliberate roads that require a great deal of planning and construction time. Combat roads are engineered based on anticipated traffic. Combat roads also use the best material available for the roadway surface and are surveyed and staked prior to contruction.

(ON SLIDE 80)

b. Clear pathway. Just as with a combat trail remove obstacles from the route. Large trees and rock should be cleared enough to operate. When feasible, leave enough small vegetation to serve as dust abatement.

(ON SLIDE 81)

c. Survey and stake route. Alignment stakes indicate the horizontal alignment of the road and establish subgrade and finish grade elevations, which guide equipment operators during earth moving operations. Different types of alignment stakes are:

(ON SLIDE 82)

(1) Centerline Stakes: These stakes establish the location of the road centerline (CL). They are normally set at 100 foot station intervals starting at the beginning of the project (BOP), and proceeding to the end of the project (EOP). They are marked with station values on the front.

(ON SLIDE 83)

(2) Grade Stakes: These stakes guide grading operations during the establishment of the vertical alignment (subgrade and finish grade) for a road. They will indicate the amount of earth that must be cut or filled at each station.

(ON SLIDE 84)

(3) Slope Stakes: These stakes establish the earth moving limits left and right of the centerline. They are placed at the left and right limits of the road construction. They identify the top of cut on the back slope of a ditch or the toe of fill on an embankment and are marked with station values and slope ratios.

(ON SLIDE 85)

(4) Offset Stakes: Are placed as references to the location of the slope stakes. Offset stakes are used as a backup for surveyors to reestablish critical alignment stakes that may have been disturbed.

(ON SLIDE 86)

d. Construct roadway surface. Road way surfaces will vary depending on the type of soil available for use on a project. The following are examples of roadway surfaces.

(ON SLIDE 87)

(1) Stabilized Soils Roads. Bituminous, stabilized soil mixtures and soil-cement are used as road surfaces to carry light traffic in expedient situations for relatively brief periods. Mechanically stabilized soil mixtures are widely used as surfaces for military roads under favorable conditions.

(a) For the bearing surface soils with a Maximum Sized Aggregate (MSA) of 1” to 1½” are the preferred materials since the larger soil particles will work to the surface.

(b) Fine particles (10% to 25%) are desirable for the bearing surface as they are more resistant to the abrasive effects of traffic and the penetration of precipitation which is damaging to the road.

(ON SLIDE 88)

(2) Sand-Clay Roads. One type of mechanically stabilized soil surface is called a sand-clay road. It consists of a natural or artificial mixture of sand and clay that is graded and drained to form a road surface. The addition of fine gravel (1” to 1½”) will usually add stability.

(a) Sand-Clay roads will carry light traffic reasonably well and heavy traffic except under bad weather conditions.

(b) Maintenance is required in the way of dust control, blading, and dragging.

(c) Sand-Clay mixtures generally are considered unacceptable as a base course.

(ON SLIDE 89)

(3) Gravel Roads. Gravel roads consist of a compacted layer of gravelly soil having a Maximum Sized Aggregate (MSA) of no more than 1” and approximately 30% retained on the number 4 sieve.

(a) Angular materials are best used for this application. River stone will generally require additives to serve as a binder.

(b) Like other non-paved surfaces, gravel surfaced roads require considerable maintanance such as dust control, blading, and draging.

(ON SLIDE 90)

e. Road Design. Road design is based on two criteria: Geometric and Structural.

(ON SLIDE 91)

(1) Geometric Design.

(ON SLIDE 92)

For safe and speedy traffic movement, the geometric design requirement for given road classes must be met. The following procedures are followed to determine the geometric design and are completed by a 1361 Engineer Assistant with the assistance from the project officer and engineer equipment chief.

(ON SLIDE 93)

(a) Draw the proposed centerline on the topographic survey.

(b) Plot the centerline on plan-and-profile sketch.

(c) Calculate grades, the degree of curvature of horizontal curves, and curve lengths of vertical curves.

(ON SLIDE 94,95)

(d) Compare the values of step 3 with the military road specifications stated in Table 9-1 of the FM 5-430-00-1 (enclosure 1).

(ON SLIDE 96)

(e) Adjust the centerline, if possible, to reduce any calculated grades and limit horizontal and vertical curves that exceed the specifications.

(f) Plot new tangents (straight sections of road) on the plan and profile in those locations where horizontal and vertical curves exceed the military road specifications.

(g) Design horizontal and vertical curves for all tangent intersections.

(ON SLIDE 97)

(h) Plot newly designed curves on the plan and profile.

(i) Develop a mass diagram for the project. Balance the cuts and fills and optimize ruling grade and earthwork volumes.

(j) Design super elevations (curve banking) and widening for all horizontal curves.

(ON SLIDE 98)

(k) Draw typical cross sections.

(l) Design the required drainage structures and bridges.

(ON SLIDE 99)

(m) Table 9-1 of the FM 5-430-00-1 (enclosure 1), shows four possible road types. They are based on expected traffic volumes and show the values for the design control elements for each road class. Of these four types of road construction, types A and B are permanent construction while C and D are considered temporary. We as Marines are capabible of constructing road types C and D.

(ON SLIDE 100)

<u>1</u> Class "A" roads are four lanes or more, each with a paved travel way width of at least 12 feet. Class "A" roads generally have a surface of asphalt, concrete, or similar continuous material. Shoulders will be a minimum of 10 feet and of a dustless construction (paved). Class A roads are designed for speeds up to 60 MPH.

(ON SLIDE 101)

2 Class “B” roads will be at least two paved lanes with a minimum of 12 feet of travel way width each. There should be a minimum of 10 feet of stabilized shoulders. Class B roads are designed for speeds up to 60 MPH.

(ON SLIDE 102)

3 Class “C” roads will consist of two lanes at least 10 feet wide and are considered an improved road, constructed with a natural or aggregate surface, and they may have berms, ditches, or culverts. Regular maintenance allows passage by standard passenger and commercial vehicles such as cars, light trucks, and some heavy trucks. Seasonal conditions and lack of snow removal may render these roads impassable. Shoulders will be constructed of compacted sod at least 6 feet wide. Class C roads are designed for speeds up to 40 MPH.

(ON SLIDE 103)

4 Class “D” roads are primitive, one-lane roads. While some Class D roads may have been deliberately constructed, others were not constructed but have been established over time by the passage of motorized vehicles. These roads are generally referred to as “combat trails”. The condition of these roads varies from sometimes passable by a passenger car to only suitable for high-clearance four wheel-drive vehicles. Seasonal conditions or wet weather may render these roads impassable at any time.

INTERIM TRANSITION: Are there any questions on what we have covered? If not take a ten minute break.

(BREAK – 10 Min)

INTERIM TRANSITION: Are there any more questions before we move on.

(ON SLIDE 104)

(n) The Average Daily Traffic (ADT) and the Design Hourly Volume (DHV) are the two most critical factors that we must consider as we design our roads.   The first step in the design of a road is to estimate the daily or hourly number of vehicles in a military organization.

(ON SLIDE 105)

Where this cannot be done, the number of vehicles organic to the units that will use the road, multiplied by a factor of two, is suggested as a reasonable estimate. This conservatively assumes that each vehicle uses the road twice (one round-trip) per day.

(o) If either anticipated DHV or ADT is known and the sight distance restriction can be estimated from preliminary plans, the necessary road type can be determined from Figure 9-3. If ADT or DHV and the road type desired are known, sight-distance-restriction requirements can be determined from Figure 9-3.

(ON SLIDE 106)

(p) A range of possible DHV values is given for each road classification in Table 9-1. The actual DHV for a road is a function of the sight-distance-restriction factor, which also has an allowable range for each type of road. The DHV varies directly with a change in the sight-distance-restriction factor. Figure 9-3 shows this straight-line relationship. After the sight-distance-restriction factor is determined from the design plans of an assumed road class, the actual DHV is determined to ensure that the capacity is adequate.

(ON SLIDE 107)

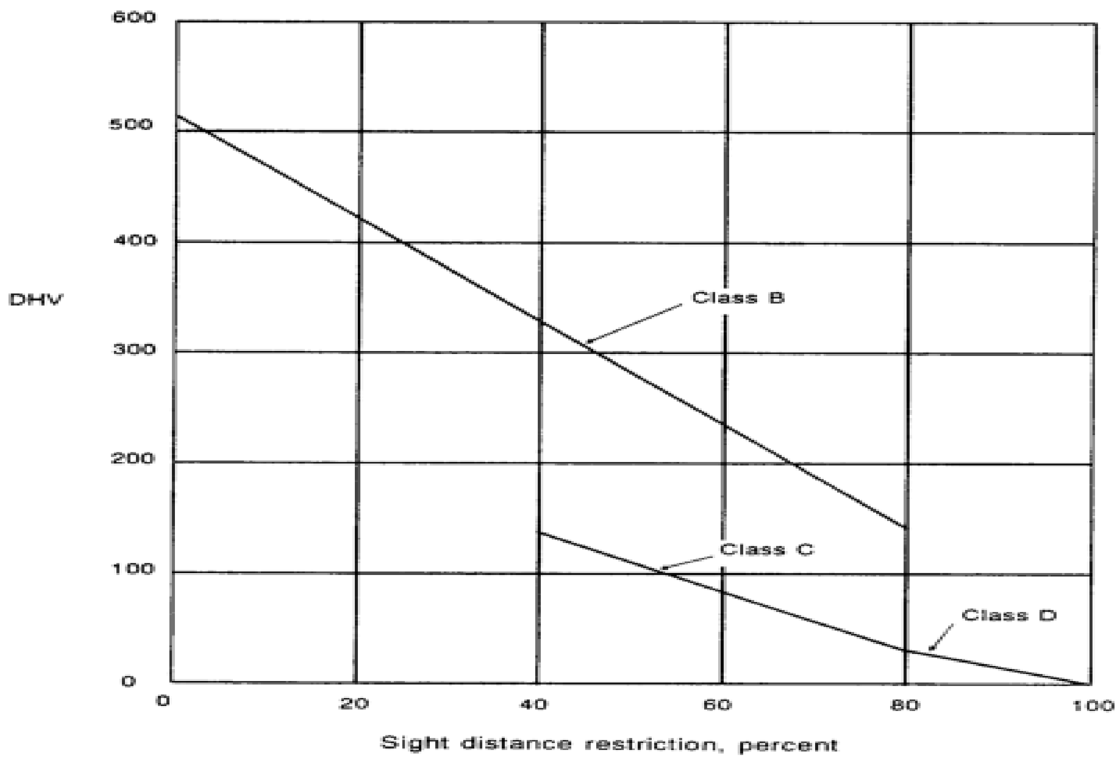

Figure 9-3. Interpolation of DHV for selection of road class (not to scale)

(ON SLIDE 108)

Example:
A road is to be designed for a military organization having approximately 250 vehicles.

ADT = 250 x 2 = 500 and DHV = 0.15 x 500 = 75

The 0.15 factor clusters the traffic into rush hours.

Solution:
The calculated DHV of 75 could be met by a class C road. Therefore, assuming a class C road is used, plan-and-profile designs could be drawn and a sight-restriction factor can be determined from the design. From Figure 9-3, a sight-distance-restriction factor of 62 percent is determined (based on a class C road and a DHV of 75). Using Figure 9-3, the maximum sight-distance-restriction factor for a class C road is 80 percent. This provides a DHV for a class C road of only 30. Since the sight-distance-restriction factor for the example (62 percent) is less than the maximum of 80, this meets the initial requirement of the DHV being greater than or equal to 75. Therefore, the class C road assumption is adequate.

(ON SLIDE 109)

(2) Structural Design.

(ON SLIDE 110)

The Structural Design criteria deals with the actual composition of the road components (those outlined above). Military roads such as those that would be built by Marine Engineers will normally be designed as un-surfaced, or aggregate surfaced systems.

(ON SLIDE 111)

The design procedure for each type first involves assigning a class designation (A-G) to the road based upon the number of vehicle passes per day. A design category (I - VII) is then assigned to the traffic based upon the composition of the traffic. A design index (1-10) is determined from the design category and road class. This design index is used to determine either the CBR strength requirements of the unsurfaced roads or the thickness of the aggregate surface.

(ON SLIDE 112)

(a) Classes of Roads. Selection of the proper class depends upon the traffic intensity and is determined from Table 9-8 of FM 5-430-00-1. A rule of thumb is used to determine the number of vehicles per day, also known as the Average Daily Traffic (ADT) when the actual traffic volume is unknown. Simply take the number of vehicles owned/used by the using unit(s) and multiply by two.

(ON SLIDE 113)

Road Class	**Vehicles/Day**
"A"	↑ 10,000
"B"	8,400-10,000

"C"	6,300-8,400
"D"	2,100-6,300
"E"	210-2,100
"F"	70-210
"G"	↓ 70

(ON SLIDE 114)

EXAMPLE: A UNIT HAS THE FOLLOWING T/E.

200 HMMWV
40 MTVR DUMP
10 MTVR 7TON
250 x 2 = 500 CLASS "E" ROAD

(ON SLIDE 115)

(b) Traffic Composition. The design index is based on typical magnitudes and compositions of traffic reduced to equivalents in terms of repetitions of an 18,000-pound, single-axle, dual-wheel load. For designs involving pneumatic-tired vehicles, and tracked vehicles and forklifts not exceeding 40,000 and 10,000 lbs respectively are classified into three groups, as follows:

(ON SLIDE 116)

- Group 1. Passenger cars and panel/pickup trucks.
- Group 2. Two-axle trucks (excluding cars & pickup trucks).
- Group 3. Three, four, and five-axle trucks.

(ON SLIDE 117)

INSTRUCTOR NOTE
HAVE STUDENTS WRITE DOWN THE INFORMATION ON SLIDE 117 FOR USE THROUGHOUT THE REST OF THE CLASS

1 Where tracked vehicles or forklift trucks are involved in the traffic composition, the following three considerations apply:

- Tracked vehicles not exceeding 15,000 lb and forklift trucks not exceeding 6,000 lb are treated as two-axle trucks (Group 2 vehicles) in determining the design index.

- Tracked vehicles exceeding 15,000 pounds but not 40,000 pounds and forklift trucks exceeding 6,000 pounds but not 10,000 pounds are treated as three-axle trucks (Group 3 vehicles) in determining the design index.

- Traffic composed of tracked vehicles exceeding 40,000 pounds and forklift trucks exceeding 10,000 pounds has been divided into the three categories shown in Table 9-11.

(ON SLIDE 118)

2 Traffic composition will then be grouped into the following categories (summarized for easy reference in Table 9-9):

Traffic Category	**% of Vehicles by Group**		
	Group 1	Group 2	Group 3
Category	≥ 99	≤ 1	

(ON SLIDE 119)

I			
Category II	≥ 90	≤ 10	
Category III	≥ 84	≤ 15	≤ 1
Category IV	≥ 65	≤ 25	≤ 10
Category IVA	Any Amount	> 25	> 10

- Category I. Traffic composed primarily of passenger cars and panel and pickup trucks (Group 1 vehicles) but containing not more than 1 percent two-axle trucks (Group 2 vehicles).

- Category II. Traffic composed primarily of passenger cars and panel and pickup trucks (Group 1 vehicles), and containing as much as 10 percent two-axle trucks (Group 2 vehicles). No trucks having three or more axles (Group 3 vehicles) are permitted in this category.

- Category III. Traffic containing as much as 15 percent Group 2 but with not more than 1 percent of the total traffic composed of trucks having three or more axles (Group 3 vehicles).

- Category IV. Traffic containing as much as 25 percent Group 2 but with not more than 10 percent of the total traffic composed of trucks having three or more axles (Group 3 vehicles).

• Category IVA. Traffic containing more than 25 percent Group 2 or more than 10 percent trucks having three or more axles (Group 3 vehicles).

(ON SLIDE 120)

EXAMPLE: A UNIT HAS THE FOLLOWING T/E.

200 HMMWV	**80% GROUP 2**
40 MTVR DUMP	**20% GROUP 3**
10 MTVR 7TON	
250	

BASED ON % OF GROUP 3 VEHICLES THE TRAFFIC CATEGORY IS CAT IVA

(ON SLIDE 121)

(c) Design Index. The design of roads will be based on a design index representing all traffic expected to use the road during its life. The design index to be used, if designing a road for the usual pneumatic-tired vehicles, will be selected from Table 9-10 based on the road class (A to G) and category (I to IVA).

(ON SLIDE 122)

CLASS	CATEGORY				
	I	II	III	IV	IVA
A	2	3	4	5	6
B	2	2	4	5	6
C	2	2	4	5	6
D	1	2	3	4	5
E	1	2	3	4	5
F	1	1	2	3	4
G	1	1	1	2	2

(ON SLIDE 123)

EXAMPLE:

ROAD CLASS "E"
TRAFFIC CAT IVA
DESIGN INDEX = 5

(ON SLIDE 124)

1 The life assumed for design is less than or equal to 5 years. For a design life of more than 5 years, the design indexes in Tables 9-10 and 9-12 must be increased by one. Design indexes below 3 need not be increased.

(ON SLIDE 125)

2 Regardless of the design class selected for hardstands, special consideration should be given to the design of approach roads, exit roads, and other heavy-traffic areas. Failure or poor performance in these channelized traffic areas often has greater impact than localized failure on the hardstand itself.

(ON SLIDE 126)

f. Unsurfaced Roads. An un-surfaced road is one in which the in place natural soil or borrow soil is used as the road surface. Typically, the construction effort required includes only clearing and grubbing followed by scarifying, grading, and compacting. Designing un-surfaced roads consists of the following steps:

(ON SLIDE 127)

(1) Estimate the number of passes of each type of vehicle expected to use a road on a daily basis.

(2) Select the proper road class based upon the traffic intensity from Table 9-8.

(3) Determine the traffic category based upon the traffic composition criteria shown in Table 9-9.

(4) Determine the design index from Table 9-10 or Table 9-12.

(ON SLIDE 128)

(5) Read the soil-surface strength required to support the design index from Figure 9-50.

(6) Check whether the design (compacted) CBR value of in-place soil exceeds the CBR value required. If the in-place design CBR value is less than the CBR required, the engineer must decide whether to decrease the design life or improve the in-place soil to meet the CBR required by one of the following methods: soil stabilization, soil treatment, or placing aggregate.

(7) Determine the required un-surfaced-soil thickness. Given the required CBR from step 6 and the design index from step 4, the required un-surfaced-soil thickness or depth of compaction can be obtained from Figure 9-51, page 9-62.

(ON SLIDE 129)

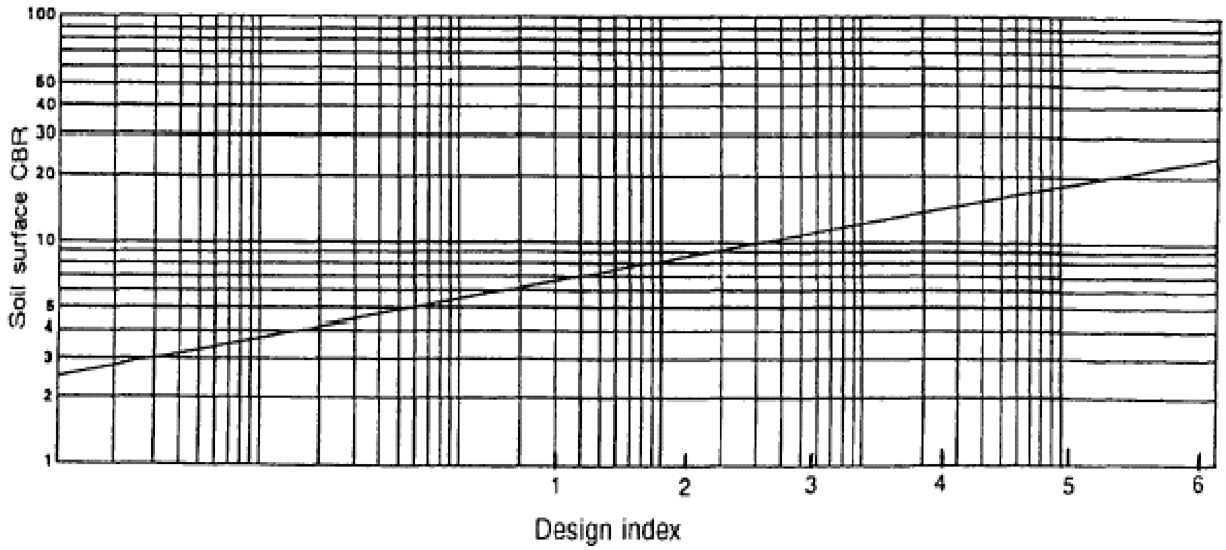

Figure 9-50. Unsurfaced-soil strength requirements

(ON SLIDE 130)

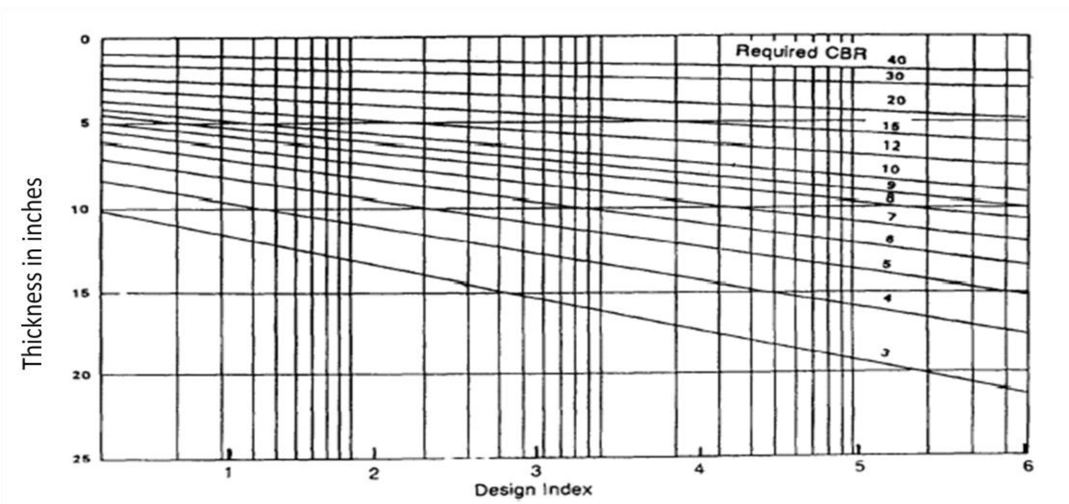

Figure 9-51. Unsurfaced-soil thickness requirements

(ON SLIDE 131)

Example (Un-surfaced Road Design):

To illustrate the procedure for determining soil-surface strength requirements, assume that an un-surfaced road is to be used one year. The road will be subjected to the following average daily traffic:

200 HMMWV

40 MTVR DUMP
10 MTVR 7TON

Solution:

1. Determine the average daily traffic (given).

2. Select road class E from Table 9-8, based upon 250*2 = 500 vehicles per day.

3. Select traffic category IVA, based upon the percentage of Group 3 vehicles.

4. The design index is 5 from Table 9-10.

5. The soil-surface strength requirement for a design index of 5 is 19 CBR.

6. Check to ensure the design CBR value of the in-place soil exceeds the 19 CBR required. If not, consider using either soil stabilization or an aggregate road.

7. Determine the required un-surfaced-soil thickness from Figure 9-51. Given a design index of 5 and a required CBR of 19, the required thickness from Figure 9-51 is 4 inches.

INTERIM TRANSITION: Are there any questions? If not take a break and then we will go into the demonstration.

(BREAK – 10 Min)

INTERIM TRANSITION: Are there any more questions before the demonstration.

(ON SLIDE 132)

INSTRUCTOR NOTE
Introduce the following demonstration.

DEMONSTRATION. **(30 Min)**
1. Safety Brief: This is a classroom exercise. There are no safety concerns covering this practical application.

2. Supervision & Guidance: Ensure students are following along with the demonstration. Show students how to use all of the charts and graphs properly.
3. Debrief: Are there any questions or comments concerning determining the structural design of a un-surfaced road. Accurate estimations of a road and what vehicles that it will be able to support will build confidence in your leaders when asked to perform structural design of a road.

Determine the design requirements for an unsurfaced road that will be required to support the following T/E for a 10 month period.

- (50) Passenger cars/pickups
- (100) HMMWV
- (5) MRAP, Cougar 4x4
- (10) MTVR, Dump
- (3) LVSR

ADT: 336 Road Class: "E" % Group 1: 30%

Group 2: 63% % Group 3: 8% Category: IVA

Design Index: 5 CBR Rqr: 19 Thickness: 4"

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

(ON SLIDE 133)

INSTRUCTOR NOTE

Introduce the following practical application.

PRACTICAL APPLICATION. (30 Min) The following four practical applications will be completed individually, and should take approximately 30 minutes. Each practical application should be debriefed prior to moving on to the next PA. The practical application is located at the end of the student handout. It will be labled enclosure (1).

PRACTICE: Using the information contained in the student outline, answer the questions provided in the practical applications.

PROVIDE-HELP: Assist students while they do the practical application. If any questions arise answer them and make sure the entire class understands.

1. Safety Brief: This is a classroom exercise. There are no safety concerns covering this practical application.

2. Supervision and Guidance: During the PA, the instructor must be present to assist any students that may need help. Allow students to take breaks as needed.

3. Debrief: Allow students the opportunity to ask questions during and after the practical applications. Ensure all students thoroughly understand the information contained in the PA’s before moving on.

INTERIM TRANSITION: Are there any questions before we talk about aggregate surfaced roads.

(ON SLIDE 134)

g. Aggregate Surfaced Roads.

(ON SLIDE 135)

The design of aggregate-surfaced roads is similar to the design of un-surfaced roads. However, in aggregate-surfaced roads, layers of high-quality material are placed on the natural subgrade to improve its strength.

(ON SLIDE 136)

(1) Materials: Materials used in aggregate roads must meet the requirements as stated in Chapter 5 of the FM 5-430-00-1 (capable of obtaining a CBR of 50 or better, with a MSA of < 3”).

Table 9-15. Assigned CBR ratings for base-course materials - aggregate-surfaced road

Number	Type	Design CBR
1	Graded crushed aggregate	100
2	Water-bound macadam	100
3	Dry-bound macadam	100
4	Lime rock	80
5	Stabilized aggregate	80
6	Soil cement	80
7	Sand shell or shell	80

NOTE: It is recommended that stabilized-aggregate base-course material not be used for tire pressures in excess of 100 psi.

(2) The materials should have greater strength than the sub-grade and should be placed so that the higher-quality material is placed on top of the lower quality material.

(ON SLIDE 137)

(3) Thickness: requirements for aggregate surfaced roads are determined from figure 9-52, enclosure 2, for a given soil strength and design index. The minimum thickness will be four inches.

(4) Depth of Compaction: Compact the sub-grade to the depth specified in table 9-16 for cohesive soils and 9-17 for cohesion less soils.

(ON SLIDE 138)

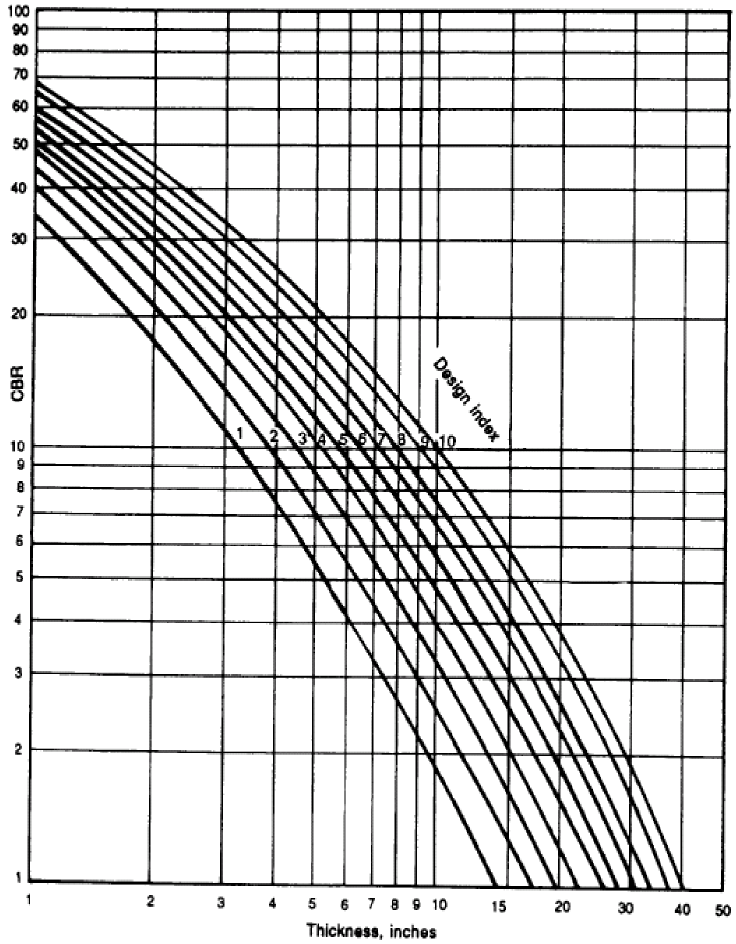

Figure 9-52. Design curves for aggregate-surfaced roads.

(ON SLIDE 139)

Table 9-16. Required depth of subgrade compaction for roads, cohesionless soils

Percent Compaction	Depth of Compaction (In Inches) for Indicated Design Index									
	1	2	3	4	5	6	7	8	9	10
95-100[1]	7	8	10	11	12	14	15	17	19	21
90-95[2]	10	12	14	16	18	20	22	24	28	30

[1]Normally used.
[2]Use if on-site test strip results show the 95-100 range is not attainable.

Table 9-17. Required depth of subgrade compaction for roads, cohesive soils (PI>5)

Percent Compaction	Depth of Compaction (In Inches) for Indicated Design Index									
	1	2	3	4	5	6	7	8	9	10
90-95[1]	6	7	8	9	10	11	12	13	15	17
95-100[2]	6	6	6	6	7	7	8	9	10	11

[1]Normally used.
[2]Use if on-site test strip results show these ranges are attainable, and shear failure is unlikely..

Example (Aggregate surfaced Road Design): Determine the design requirements for an aggregate surfaced road that will be required to support the following T/E for a minimum 3 years. The in-place CBR is 15 and the soil has been identified as non-cohesive:

- (5) SUV's
- (10) HMMWV's
- (40) Up Armored HMMWV's
- (3) LVS's

Average Daily Traffic = 5+10+40+3=58, 58*2= 116 ADT =116

Road Class = F

Traffic Composition
Group 1 = 10 9%
Group 2 = 100 86%
Group 3 = 6 5%

Traffic Category = IVA

Design Index = __4__

Aggregate Thickness = __4___

Required Depth of Compaction = __11__

(ON SLIDE 140)

TRANSISTION: We have just covered military combat roads, to include road design for both soil and aggregate surfaced roads. At this time do I have any questions.

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

Q. What is the design index for a class D, category III unsurfaced road?

A. Design Index = 3.

Q. What are the two criteria road design is based on?

A. Geometric and structual design.

(BREAK – 10 Min)

TRANSITION: Now that we know the proper steps in constructing a military road lets discuss road maintenance.

____
____
____

(ON SLIDE 141)

6. **ROAD MAINTENANCE**: **(30 Min)**

(ON SLIDE 142)

Just as with your T/O weapon, in order for the road network to continue serving in a combat effective manner it must be maintained with regularity and repaired as needed.

a. Inspect the road on a regular basis. This inspection should include not only the roadway surface but also the shoulders and drainage structures.

(ON SLIDE 143)

(1) Damage. Damage can result from failed drainage, or from acts of war.

(ON SLIDE 144)

(2) Wear. Normal traffic flow can have a detrimental effect on a road surface. Excessive traffic, overloaded vehicles, and tracked vehicles all will have a hugely adverse affect on the roadway surfaces.

(ON SLIDE 145,146)

b. Shape. The road surface should be dressed with a crown to allow for proper drainage. The shoulder of the road should have more slope than the road to facilitate water runoff. The shoulder not only acts as an emergency trafficable area, it also serves as a buffer; aiding in preventing the base course and traveled way area from becoming saturated.

(ON SLIDE 147)

c. Provide Drainage.

(1) Ditches. Ditches are used to drain water away from and move it alongside a construction project to a point where it can safely be diverted. Ditches may be temporary, used only during the construction phase, or permanent, meant to last the life of the finished project.

(ON SLIDE 148)

(a) Intercept Ditches are dug at the top of a slope to intercept water, preventing it from flowing down a slope to the roadway or project area. This water is diverted to a larger ditch/culvert system or a natural waterway.

(ON SLIDE 149,150)

(b) Road Sides. V-ditches should be dug along the roadways. The recommended slope along the road is a 3:1 which provides a gentle transition from the road shoulder.

(ON SLIDE 151)

(c) Relief Ditches. Relief ditches move water from a main ditch away from the project/road into drainage fields or existing streams preventing ditches from overflowing and causing damage.

(ON SLIDE 152,153)

(2) Culverts. Culverts are used to pass water under the project and/or finished road either as a means of relief ditches or as a natural hydraulic flow. We must ensure that the culvert provides enough area of waterway while not exceeding the maximum allowable culvert diameter for the culvert location. Today culverts are commercially manufactured with many different types of materials and can be purchased in varying diameters and lengths. Culverts can still be built on site when the need arises.

(ON SLIDE 154,155)

d. Surface. Just as with the hasty road (combat trail) there are different types of surfaces that may be used such as earthen roads, stabilized soils roads, sand/clay roads, and gravel (aggregate) surfaced roads.

(1) Drag boxes will help to even out the road surface by knocking down the high spots and filling in the low spots. Drag boxes are easy to construct from readily available materials.

(2) Stabilize as required using any available materials.

(3) A compactive effort must be applied during the maintenance process.

(ON SLIDE 156)

<u>TRANSISTION</u>: We have just covered maintenance options for military roads. At this time are there any questions?

<u>OPPORTUNITY FOR QUESTIONS:</u>

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

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

Q. What are some of the factors that cause road damage?

A. Excessive vehicles, Overloaded vehicles and tracked vehicles.

Q. What are some different types of ditches?

A. Intercept ditches, roadside ditches, relief ditches.

(ON SLIDE 157)

<u>Summary</u> **(10 MIN)**

Today we have talked about military roads, aka combat roads and trails. We discussed planning considerations, preparations for road projects, how to construct hasty (Combat Trails) and deliberate (Combat Roads) military roads and how to maintain and repair roads. Now that you have mastered this material, I am more than confident that you are able to plan and execute a road project.

(10 min Break)

<u>REFERENCES</u>:

FM 5-34 Engineer Field Data

FM 5-335 Drainage
FM 5-430-00-1 Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations