

Chapter 4

Graders

Graders are multipurpose machines used for grading, shaping, bank sloping, and ditching. They are used for mixing, spreading, side casting, leveling and crowning, general construction, and road and runway maintenance. Graders cannot perform dozer work because of the structural strength and location of its blade. However, they can move small amounts of material. They are capable of working on slopes as steep as 3:1. Graders are capable of progressively cutting ditches to a depth of 3 feet.

GRADER COMPONENTS

4-1. The components of the grader that do the work are the blade and the scarifier. The blade's position and pitch are adjustable and are determined by the type of operation being performed.

BLADE

4-2. The major component of a grader blade is a hydraulically controlled moldboard to which the cutting edges are bolted. Use the blade (*Figure 4-1, page 4-2*) to side cast material. The ends of the blade can be raised or lowered together or independently of one another.

Blade Position

4-3. The blade can be angled perpendicular to the line of travel or parallel to the direction of travel. It can also be shifted to either side or raised into a vertical position (*Figure 4-2, page 4-3*).

Blade Pitch

4-4. The blade can be pitched forward or backward (*Figure 4-3, page 4-3*). Keep the blade near the center of the pitch adjustment; this keeps the top of the moldboard directly over the cutting edge of the blade. Pitching the blade forward decreases the blade's cutting ability and increases the dragging action. The blade will tend to ride over the material rather than cut and push, and it has less chance of catching on solid obstructions. Use a forward pitch to make light, rapid cuts and to blend materials. When the blade is pitched to the rear, it cuts readily but the material tends to boil over itself.

SCARIFIER

4-5. Use a scarifier (see *Figure 4-1*) to break up material too hard for the blade to cut. A scarifier has 11 removable teeth that can be adjusted to cut a maximum depth of 12 inches. When operating in hard material, it may be necessary to remove some of the teeth from the scarifier. Do not remove more

than five teeth because the force against the remaining teeth could shear them off. When removing teeth, take the center one out first and then alternately remove the other four teeth. This balances the scarifier and distributes the load evenly. With the top of the scarifier pitched to the rear, the teeth lift and tear the material being loosened. Use this position for breaking up asphalt pavement. Adjust the pitch of the scarifier for the type of material being ripped.

ROAD AND DITCH CONSTRUCTION

4-6. Road grading, embankment finish work, and shallow-ditch construction are basic grader operations.

MARKING FOR A DITCH CUT

4-7. For better grader control and straighter ditches, make a 3- to 4-inch-deep marking cut on the first pass (*Figure 4-4, page 4-4*) at the outer edge of the bank slope (usually identified by slope stakes). The toe of the blade should be in line with the outside edge of the lead wheel. This marking cut provides a guide for subsequent operations.

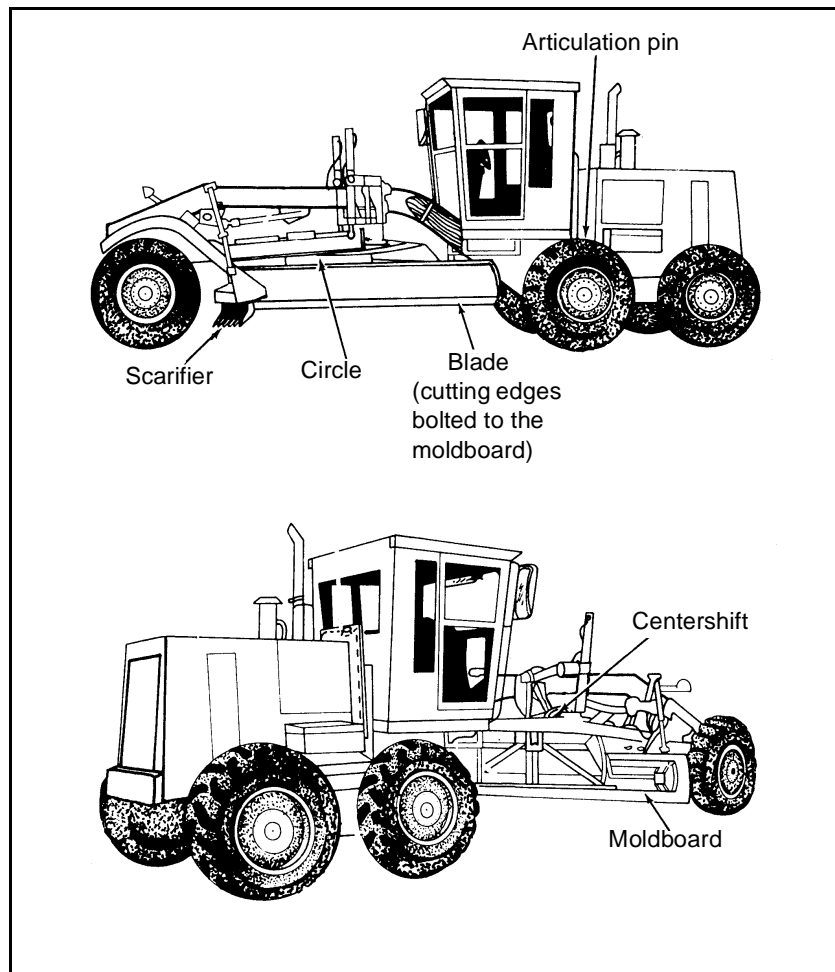


Figure 4-1. Grader

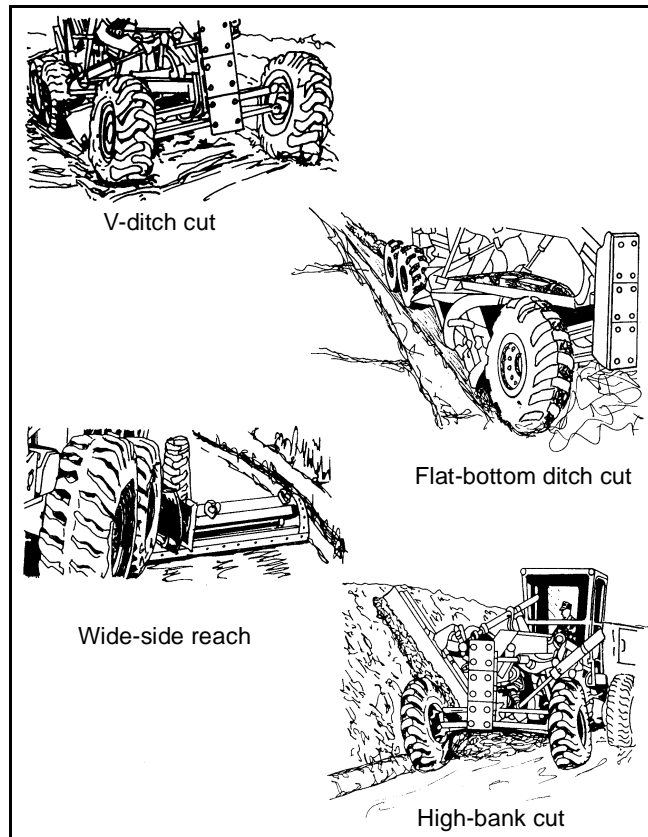


Figure 4-2. Blade Positions

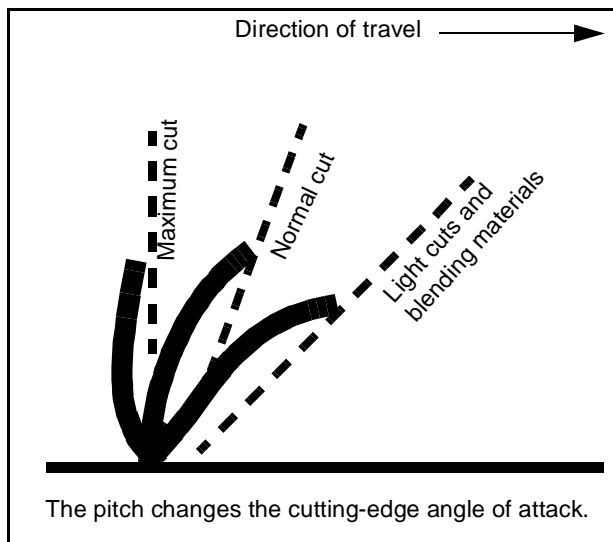


Figure 4-3. Blade Pitch

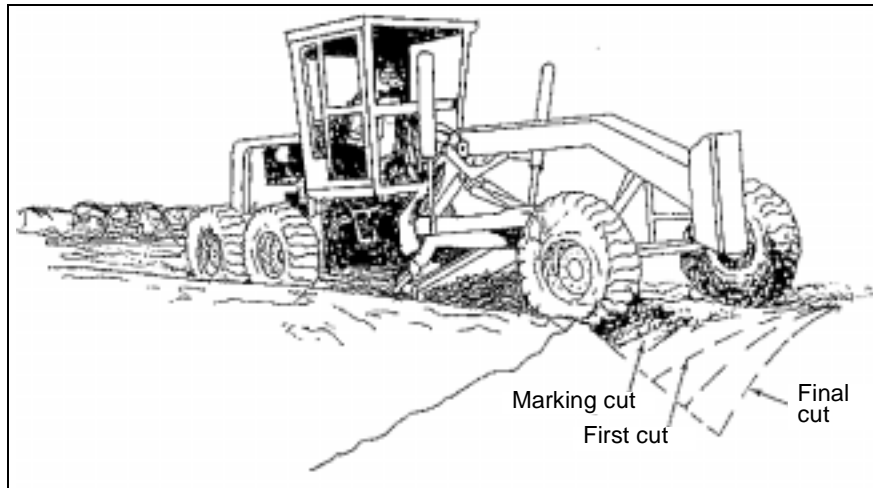


Figure 4-4. Starting a Ditch

MAKING A DITCH CUT

4-8. Make each ditch cut as deep as possible without stalling or losing control of the grader. Normally, make ditching cuts in second gear at full throttle. Start with the blade positioned so that the toe is in line with the center of the lead wheel. Bring each successive cut in from the edge of the bank slope so that the toe of the blade will be in line with the ditch bottom on the final cut. *Figure 4-5* shows the steps of the V-ditching method. The steps shown in *Figure 4-5* are for a single roadside ditch. Repeat the steps on the opposite side of the road. The machine's frame should be articulated when performing steps 4 and 7.

Marking the Cut

Step 1. Begin the ditch by establishing a marking cut as follows (ditching is normally done on the right-hand side of the grader):

- Ensure that the moldboard is high enough off the surface to allow unrestricted movement.
- Ensure that the blade is pitched halfway.
- Center shift until the left lift cylinder (heel) is straight up and down.
- Rotate the moldboard so that the toe is just behind the outside edge of the right front wheel (about a 45° angle to the frame).
- Side shift the blade if necessary to extend the edge of the moldboard to the outside edge of the right front wheel.
- Raise the left lift cylinder all the way.
- Lean the front wheels to the left. The grader is now in the ditching position.

Step 2. Move the grader forward. As the right front wheel passes over the starting point of the ditch, lower the toe of the moldboard. Apply enough pressure on the toe to penetrate the ground's surface about 3 to 4 inches.

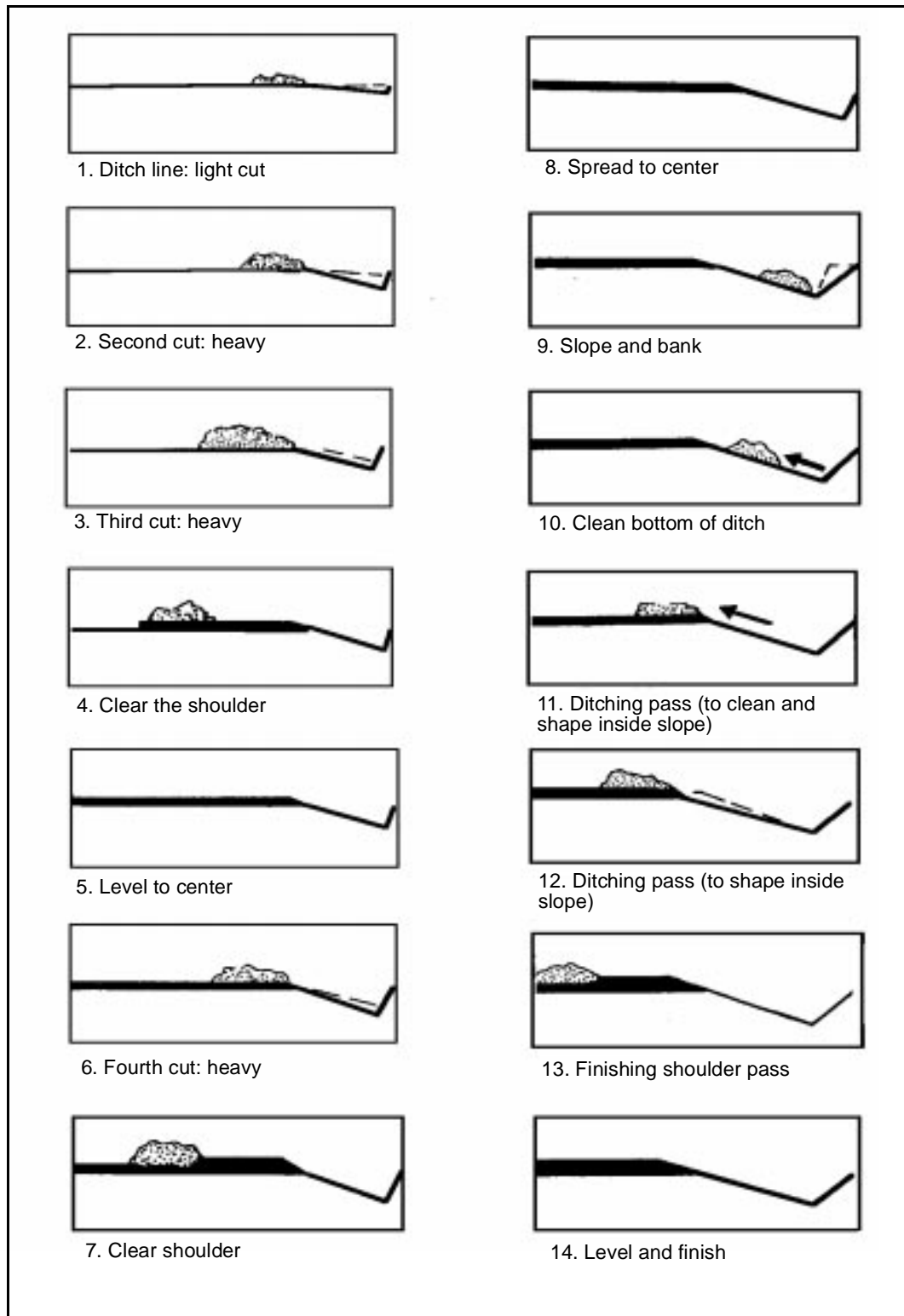


Figure 4-5. V-ditching Method

Step 3. Feather the material and raise the moldboard toe clear of the ground at the completion of the marking cut. Continue moving forward until the rear wheels pass over and off the marking cut.

NOTE: Feathering is accomplished by raising the moldboard in 1/2- to 1-inch increments while moving forward. Two or three seconds are recommended between each upward adjustment until all the material in front of the moldboard passes under it.

Step 4. Straighten the front wheels and steer the grader to the right (about a 45° angle to the ditch).

Step 5. Back the grader along the outside edge of the windrow.

Step 6. Reposition the grader at the start point.

Step 7. Lean the front wheels to the left.

Establishing the Depth of the Ditch

Step 1. Place the grader in forward motion and apply as much downward pressure to the toe of the blade that the grader will handle.

Step 2. Continue along the ditch line until the grader has reached the finishing point, and then follow the exit procedures previously discussed under marking the cut.

NOTE: When making ditch cuts, windrows form between the heel of the blade and the left rear wheel. Move or level these windrows when either the ditch is at the planned depth or the windrow becomes higher than the road clearance of the grader. This material will form the shoulder of the road.

Establishing the Shoulder of the Ditch

4-9. This task is accomplished by placing the grader in the wide-side reach position.

Step 1. Adjust the moldboard as follows:

- Rotate the moldboard to a 90° angle (perpendicular) with the frame (straight across) and adjust the height of the blade to about 4 to 6 inches above the surface.
- Center shift the blade all the way to the right.
- Readjust the height of the blade to about 2 inches above the surface.
- Side shift the blade all the way to the right.
- Lean the front wheels to the left.
- Circle the moldboard counterclockwise until the toe is about 12 to 15 inches from the outside edge of the front right wheel.

NOTE: Do not adjust the moldboard height, especially the left lift cylinder.

Step 2. Move the grader forward and maintain a position and course so that the toe of the moldboard passes directly over the center of the ditch.

Step 3. Apply enough downward pressure to skim the material from the shoulder; do not cut the shoulder.

Step 4. Continue forward as the grader passes the finishing point of the ditch until all the material in front of the moldboard passes under it or is windrowed off the heel.

Step 5. Continue forward until enough space is available to position the grader to back up and straddle the windrow.

NOTE: Place the grader in the right-hand general grade position and the moldboard will be positioned to execute the next maneuver. Do not back the grader in the wide-side reach position.

Step 6. Ensure that the front wheels are straight up and down before backing the grader.

Step 7. Back the grader to the starting point of the project and, after stopping, lean the wheels to the left.

Step 8. Lower the toe and heel of the moldboard to the surface.

Step 9. Raise the heel about 2 to 3 inches and ensure that the toe is just touching the surface. With the heel raised about 3 inches, the loose material from the ditch should pass under and off the heel of the moldboard.

Step 10. Move the grader forward. Maintain a straight course by keeping the grader centered on the windrow.

Step 11. Skim the shoulder of the road with the toe and spread the windrow to form the surface of the road.

Step 12. Ensure that the material is feathered at the end of the pass before stopping the grader.

Step 13. Straighten the front wheels and raise both lift cylinders all the way.

Step 14. Reposition the grader at the finishing end of the project. The grader should be positioned to establish a V-ditch (going the opposite direction) on the other side of the project area.

NOTE: Sometimes ditch cuts produce more material than is needed for the roadbed and shoulders. Use this excess material as fill at other locations throughout the project. Blade the excess material into a windrow and haul it to the appropriate location.

CREATING A BANK SLOPE

4-10. Sloping the bank on a road cut prevents slope-sloughing failures. It also prevents excessive erosion of the bank, which could fill the roadside ditch. Initially, cast the material cut from the outer slope into the bottom of the ditch and remove it later. *Figure 4-6, page 4-8, shows a grader sloping a high-bank cut.*

CLEANING A DITCH

4-11. To remove unwanted material that was pushed into the ditch during the bank slope operation, place the blade in the same position as used for the ditching cuts. This casts the material onto the shoulder.

FINISHING A SHOULDER

4-12. Move the windrow (formed by cleaning the ditch) onto the road at the same time the shoulder is being finished to the desired slope.

FINISHING A CROWN OR A CROSS SLOPE

4-13. The final operation is to spread all the material brought from the ditch onto the roadway. Use this material to bring the roadway to the desired crown or a cross slope.

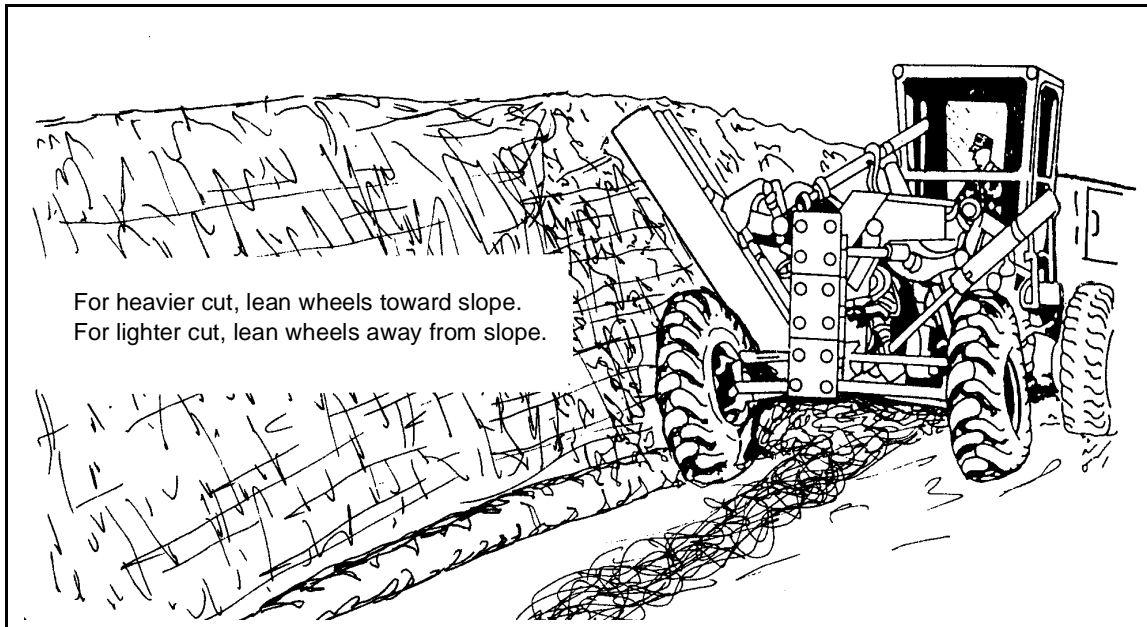


Figure 4-6. Sloping a High Bank

EARTH- AND GRAVEL-ROAD MAINTENANCE

LEVELING AND MAINTAINING SURFACES

4-14. Ordinarily, level and maintain a surface by working the material across the road or runway from one side to the other. However, to maintain a satisfactory surface in dry weather, work traffic-eroded material from the edges and shoulders of the road toward the center. Traffic or wind can cause loss of binder material, so be cautious when disturbing dry road surfaces. The surface is easier to work if it is damp; therefore, after a rain is a good time to perform surface maintenance. A water truck may be necessary to dampen dry material.

Step 1. Rotate the moldboard so that the toe is on the right side of the grader at about a 50° to 60° angle to the frame.

Step 2. Ensure that the blade is pitched halfway.

Step 3. Center shift the blade until the left lift cylinder is straight up and down.

Step 4. Lean the front wheels to the left.

Step 5. Lower the moldboard until the toe and heel slightly touch the ground.

Step 6. Place the grader in motion and, as the moldboard crosses the project start line, apply enough downward pressure on both the heel and the toe to penetrate the surface on a level plain about 1/2 inch.

Step 7. Maintain a straight course, adjusting the moldboard slightly to carry the material the length of the project.

Step 8. Feather the material at the end of the pass.

Step 9. Stop the grader and straighten the front wheels after the material is feathered to a smooth termination.

Step 10. Raise both lift cylinders all the way.

Step 11. Position the grader to straddle the windrow just made, and back the grader to the starting point while ensuring the windrow is between the wheels (do not drive on top of the windrow).

Step 12. Stop the grader just outside of the project boundary line.

Repeat this process until the entire area is leveled.

SMOOTHING PITTED SURFACES

4-15. When binder is present and moisture content is appropriate, rough or badly-pitted surfaces may be cut smooth. The cut surface material is then respread over the smooth base. Again, the best time to reshape earth and gravel roads is after a rain. Dry roads should be moistened by using a water distributor. This ensures that the material will have sufficient moisture content to recompact readily.

CORRECTING CORRUGATED ROADS

4-16. When correcting corrugated roads, be careful not to make the situation worse. Deep cuts on a washboard surface will set up blade chatter, which emphasizes rather than corrects corrugations. Badly-corrugated surfaces may require scarifying. With proper moisture content, level the surface by cutting across the corrugations. Alternate the blade angle so that the cutting edge will not follow the rough surface. Cut the surface to the bottom of the corrugations, and then reshape the surface by spreading the windrows in an even layer across the road. After reshaping the road, the traffic will compact it. However, rolling the surface after shaping will give better and longer-lasting results.

SCARIFYING ROADS OR AREAS

Step 1. Position the grader outside the working area.

Step 2. Ensure that the moldboard is high enough off the ground to allow unrestricted movement.

Step 3. Rotate the moldboard so that it is perpendicular with the frame, and adjust the height to 12 inches off the surface (level).

Step 4. Center shift the blade until the lift cylinders are centered on the grader.

Step 5. Pitch the blade halfway.

Step 6. Ensure that the front wheels are vertical.

Step 7. Move the grader forward.

Step 8. Lower the scarifier as it crosses the starting point and penetrate the surface.

Step 9. Scarify the entire length of the area to a minimum depth of about 6 inches.

Step 10. Raise the scarifier at the finish point.

Step 11. Exit the project area and stop the grader.

Step 12. Rotate the moldboard to a 50° angle, and adjust the center shift to straighten the heel cylinder.

Step 13. Return to the starting point, and reposition the grader for a second scarifying pass.

SNOW REMOVAL

4-17. Graders remove snow in much the same way as snowplows. Be sure to raise the blade 0.5 to 1 inch when removing snow from uneven pavements or portable runway surfaces. Improper adjustment can damage the grader and gouge the surface.

ASPHALT MIXING

4-18. Asphalt can be mixed in place or mixed with imported aggregate. *Chapter 12* provides additional information on asphalt mixing.

MIXED-IN-PLACE ASPHALT

4-19. For mixed-in-place asphalt, spread the asphalt directly on the road surface, either before or after scarifying the surface. After applying the asphalt, mix it with the surface soil by scarifying and/or windrowing with the blade.

IMPORTED AGGREGATE

4-20. When using imported aggregate for a pavement—

Step 1. Shape the existing base and prepare it by blading, rolling, and curing as necessary.

Step 2. Dump the aggregate mix and blade it into uniform windrows. If the aggregate is too wet, blade the windrows to allow evaporation of the excess moisture.

Step 3. Flatten the windrow and apply the asphalt.

Step 4. Mix the asphalt with the aggregate using the grader. Move the windrow from side to side across the road by making successive passes with the blade. Several graders can operate, one behind another (tandem), on the same windrow. If rain moistens the mixture, continue mixing until dry.

Step 5. Blade the material back into a windrow after mixing and before spreading.

LARGE-AREA MIXTURES

4-21. Set stakes to mark the edges of the spread width for each windrow. When spreading mixtures over large areas, drive blue-top hubs (blue tops) to indicate final pavement elevation. The blue tops are usually placed in a grid pattern 20 feet apart. Remove the blue tops before rolling the pavement. Usually, one pass of the grader will flatten the windrow after which it can be spread to each side in increments. This produces a layer of uniform thickness with proper lateral and longitudinal slopes. A skilled grader operator is essential at this phase.

OPERATION TECHNIQUES AND TIPS

4-22. Graders can be used for spreading, leveling, side casting, and planing materials. Different procedures are required to achieve a desired result.

SPREADING AND LEVELING

4-23. Use a grader to spread windrows of loose material (*Figure 4-7*). If there is space to work around the sides of the windrows, extend the blade well to the side and reduce the windrow, using a series of side cuts. Spread the windrows as much as possible. The power and traction of the grader will limit the load to be pushed. Graders have less power and traction than dozers, but graders move the load faster. Although the grader blade is low, it is more concave than the dozer blade. This gives increased rolling action to the load so that a large quantity can be pushed without spilling over the top. Leveling large windrows may require two or more sidecuts with a grader (*Figure 4-8*).

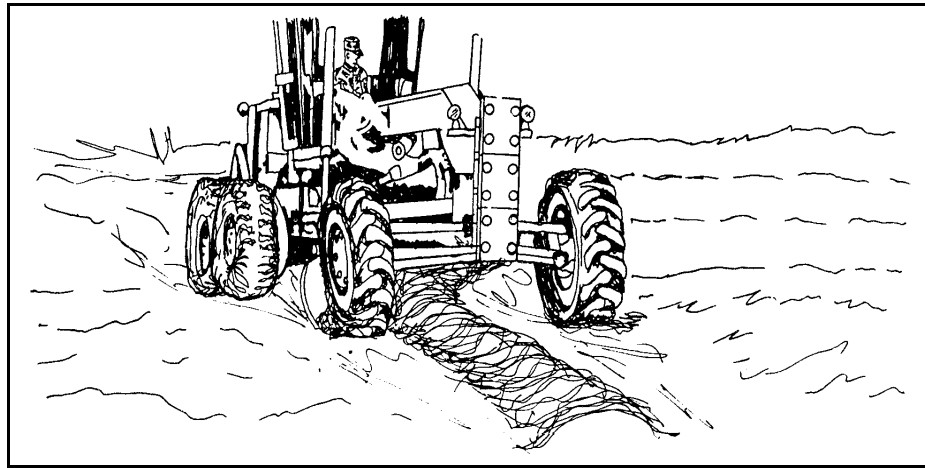


Figure 4-7. Spreading Windrowed Material

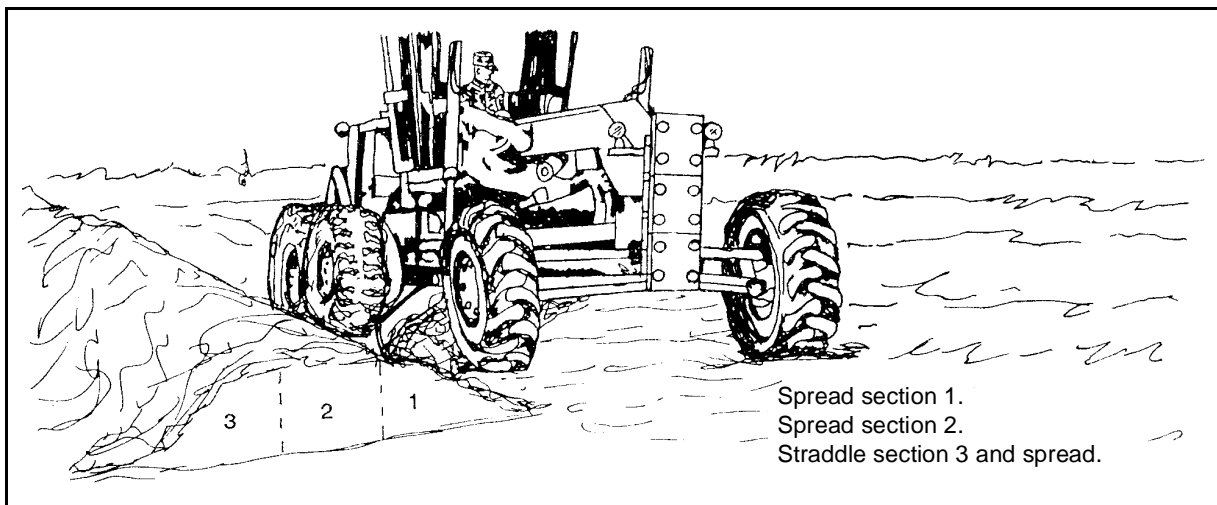


Figure 4-8. Leveling Large Windrows

SIDE CASTING

4-24. Set the blade at an angle so that the load being pushed will drift off the trailing end (*Figure 4-9*). Rolling action caused by the blade curve assists this side movement. As the blade is angled more sharply, the speed of the side drift increases (which does not carry the material as far forward) and deeper cuts can be made. To shape and maintain most roads, set the blade at a 25° to 30° angle. Decrease the angle for spreading windrows; increase the angle for hard cuts and ditching.

NOTE: A blade that is angled straight across (perpendicular to the direction of movement) is at 0°.

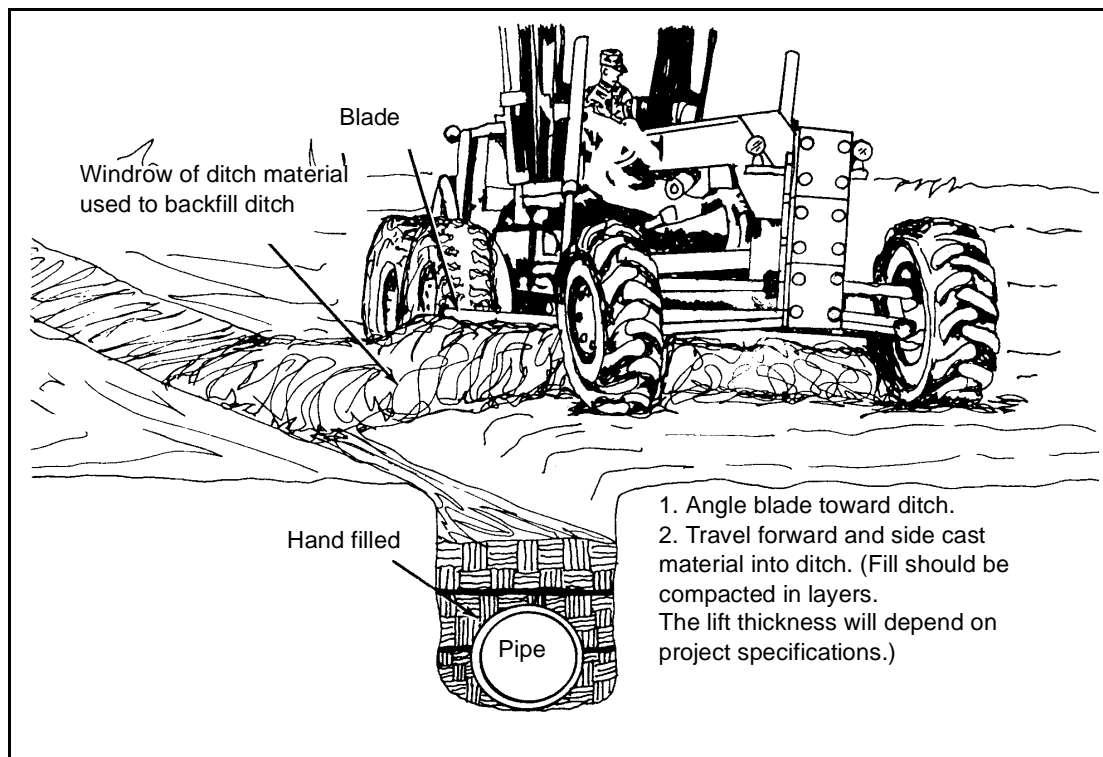


Figure 4-9. Backfilling a Ditch by Side Casting

PLANING

4-25. Set the blade at an angle to plane off irregular surfaces; use that material to fill the hollows. Cut enough material to always keep some in front of the blade. Move the loosened material forward and sideward to distribute it evenly. On the next pass, pick up the windrow that was left at the trailing edge of the blade. On the final pass, make a lighter cut and lift the trailing edge of the blade enough to allow the surplus material to go under rather than around the end. This will avoid leaving a ridge. Do not pile windrows in front of the rear wheels because it will adversely affect traction and grader control.

WORKING SPEEDS

4-26. Always operate the grader as fast as the operator’s skill and the road conditions permit. Operate at full throttle in each gear. Use a lower gear if less speed is required, rather than operate at less than full throttle. *Table 4-1* lists the proper gear ranges for various grader operations under normal conditions. *Table 4-2* lists the road speeds for the Army’s 130G grader.

Table 4-1. Proper Gear Ranges for Grader Operations

Operation	Gear
Maintenance	Second to third
Spreading	Third to fourth
Mixing	Fourth to sixth
Ditching	First to second
Bank sloping	First
Snow removal	Fifth to sixth
Finishing	Second to fourth

Table 4-2. Road Speeds for the Army’s 130G Grader

Model	Road Speed: mph at Rated rpm							
	Forward Gears						Reverse Gears	
	First	Second	Third	Fourth	Fifth	Sixth	Low	High
130G	2.3	3.7	5.9	9.7	15.5	24.5	Same as forward	

BLADE SETTING AND GRADER SPEED

4-27. Each job requires a specific blade setting and grader speed for optimum production. Deviations from these settings and speeds will cause machine inefficiency.

TURNING

4-28. When making a number of passes over a short distance (less than 1,000 feet), backing the grader to the starting point is normally more efficient than turning it around and continuing the work from the far end. Never make turns on a newly-laid bituminous road or runway surface.

NUMBER OF PASSES

4-29. Grader efficiency is directly proportional to the number of passes made. Operator skill, coupled with planning, is most important in eliminating unnecessary passes. For example, if four passes will complete a job, every additional pass increases the time and cost of the job.

TIRE INFLATION

4-30. Keep the tires properly inflated to get the best results. Overinflated tires result in less contact between the tires and the road surface, causing a loss of traction. Air-pressure differences in the rear tires cause tire slippage and grader bucking. The operator's manual gives the correct tire inflation pressure.

WET AND MUDDY CONDITIONS

4-31. Wet and muddy conditions cause poor traction, which may decrease grader efficiency. However, in spite of reduced efficiency, the grader is the best machine to use under these conditions. One example of this would be casting surface mud to the side on a haul road.

HAUL-ROAD MAINTENANCE

4-32. Keep haul roads in good condition. This will increase the efficiency of scrapers or dump trucks on large earthmoving operations. Graders are the best machines for maintaining haul roads. The most efficient method of road maintenance is to use enough graders to complete one side of a road with one pass of each grader (tandem operation). In this method, maintenance of one side of the road is completed while the other side is open to traffic.

TANDEM OPERATIONS

4-33. Using graders in tandem expedites such operations as leveling, mixing, spreading, and haul-road maintenance.

PRODUCTION ESTIMATES

4-34. Use the following formula to prepare estimates of the total time (in hours or minutes) required to complete a grader operation.

$$\text{Total time} = \frac{P \times D}{S \times E}$$

where—

P = number of passes required

D = distance traveled in each pass, in miles or feet

S = speed of grader, in mph or fpm (multiply mph by 88 to convert to fpm)

E = efficiency factor

- **Number of passes.** Estimate the number of passes (based on the project requirements) before construction begins.
- **Distance traveled.** Determine the required travel distance per pass before construction begins.
- **Speed of the grader.** Speed is the most difficult factor in the formula to estimate accurately. As work progresses, conditions may require that speed estimates be increased or decreased. Compute the work output for each rate of speed used in an operation. The speed depends largely on the skill of the operator and the material type.
- **Efficiency factor.** For grader operations the efficiency factor is usually no better than 60 percent.

EXAMPLE

Time estimate based on the number of miles of construction.

Maintenance of a 5-mile gravel road requires cleaning the ditches and leveling and reshaping the road. Use a CAT 130G grader and a 0.6 efficiency factor. Cleaning the ditches requires two passes in first gear, leveling the road requires two passes in second gear, and final shaping of the road requires three passes in fourth gear.

Speeds (from Table 4-2, page 4-13):

First gear = 2.3 mph

Second gear = 3.7 mph

Fourth gear = 9.7 mph

$$\text{Total time} = \frac{2 \times 5}{2.3 \times 0.6} + \frac{2 \times 5}{3.7 \times 0.6} + \frac{3 \times 5}{9.7 \times 0.6} = 7.3 + 4.5 + 2.6 = 14.4 \text{ hours}$$

EXAMPLE

Time estimate based on the number of feet of construction.

A 1,500-foot gravel road requires leveling and reshaping. Use a CAT 130G grader with a 0.6 efficiency factor. The work requires two passes in second gear and three passes in third gear.

Speeds (from Table 4-2):

Second gear = 3.7 mph

Third gear = 5.9 mph

$$\text{Total time} = \frac{2 \times 1,500}{(88 \times 3.7) \times 0.6} + \frac{3 \times 1,500}{(88 \times 5.9) \times 0.6} = 15.4 + 14.4 = 29.8 \text{ minutes}$$

SAFETY

4-35. Listed below are specific safety rules for grader operators:

- Always display a red flag or a flashing light on a staff at least 6 feet above the left rear wheel when operating a grader slowly on a highway or roadway.
- Never allow other personnel to ride on the blade or rear of the grader.
- Always engage the clutch gently, especially when going uphill or pulling out of a ditch.
- Always reduce speed before making a turn or applying the brakes.
- Always keep the grader in low gear when going down steep slopes.
- Always take extra care when working on hillsides to drive slowly and to be observant of holes or ditches.
- Never use graders to pull stumps or other heavy loads.
- Always keep the blade angled well under the machine when it is not in use.
- Never allow more than one person on a grader while it is in operation. If it has a buddy seat, ensure that no more than two people are on the machine while it is in operation.

