

## Chapter 2

### Dozers

Dozers (tracklaying crawlers or wheel tractors equipped with a blade) are perhaps the most basic and versatile items of equipment in the construction industry. Dozers are designed to provide high drawbar pull and traction effort. They are the standard equipment for land clearing, dozing, and assisting in scraper loading. They can be equipped with rear-mounted winches or rippers. Crawler tractors exert low ground-bearing pressure, which adds to their versatility. For long moves between projects or within a project, transport dozers on heavy trailers. Moving them under their own power, even at slow speeds, increases track wear and shortens the machine's operational life.

#### DESCRIPTION

2-1. A crawler dozer consists of a power plant (typically a diesel engine) mounted on an undercarriage, which rides on tracks. The tracks extend the full length of the dozer. There are two classifications of military dozers, based on weight and pounds of drawbar pull. The light class (about 16,000 pounds operating weight) includes the deployable universal combat earthmover (DEUCE) (*Figure 2-1*). The medium class includes dozers having an operating weight of 15,000 to 45,000 pounds (*Figure 2-2, page 2-2*).

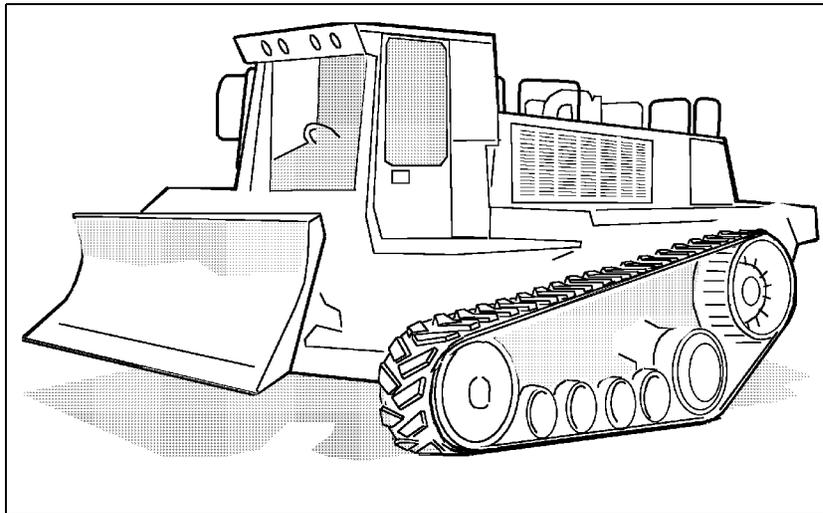


Figure 2-1. DEUCE, Light-Class Dozer

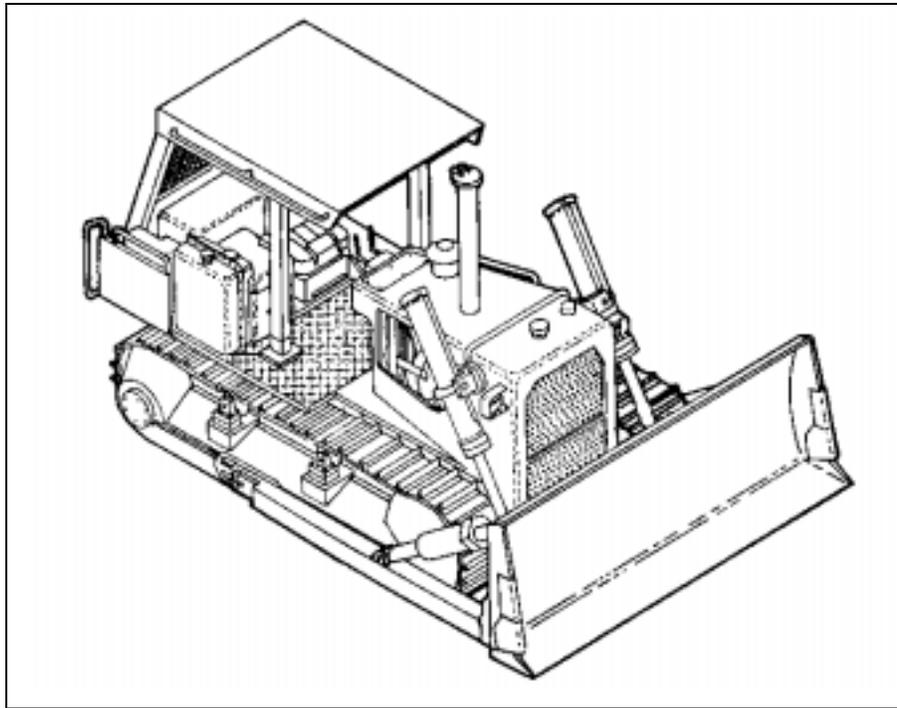


Figure 2-2. Medium-Class Dozer

## BLADES

2-2. A dozer blade consists of a moldboard with replaceable cutting edges and side bits. Either the push arms and tilt cylinders or a C-frame are used to connect the blade to the tractor. Blades vary in size and design based on specific work applications. The hardened-steel cutting edges and side bits are bolted on because they receive most of the abrasion and wear out rapidly. This allows for easy replacement. Machine designs allow either edge of the blade to be raised or lowered in the vertical plane of the blade (tilt). The top of the blade can be pitched forward or backward varying the angle of attack of the cutting edge (pitch). Blades mounted on a C-frame can be turned from the direction of travel (angling). These features are not applicable to all blades, but any two of these features may be incorporated in a single mount.

### STRAIGHT BLADE

2-3. Use straight blades for pushing material and cutting ditches. This blade is mounted in a fixed position, perpendicular to the line of travel. It can be tilted and pitched either forward or backward within a 10° arc. Tilting the blade allows concentration of dozer driving power on a limited length of the blade. Pitching the blade provides increased penetration for cutting or less penetration for back dragging.

### ANGLE BLADE

2-4. Angle blades, which are 1 to 2 feet wider than straight blades, are used most effectively to side cast material when backfilling or when making sidehill cuts. Use an angle blade for rough grading, spreading piles, or windrowing

material. It can be angled up to a maximum of 25° left or right of perpendicular to the dozer or used as a straight blade. When angled, the blade can be tilted but it cannot be pitched.

### SPECIAL-PURPOSE BLADE

2-5. There are special blades (*Figure 2-3*), such as the Rome K/G, designed for clearing brush and trees but not for earthmoving. The Rome K/G blade is permanently fixed at an angle. On one end of the blade is a stinger. This stinger consists of a vertical splitter and stiffener and a triangular-shaped horizontal part called the web. One side of the triangular web abuts the bottom of the vertical splitter, and the other side abuts the cutting edge of the blade. The abutting sides of the web are each about 2 feet in length, depending on how far the stinger protrudes from the blade. This blade is designed to cut down brush and trees at, or a few inches above, ground level rather than uprooting them. When cutting a large-diameter tree, first use the stinger to split the tree to weaken it; then, cut the tree off and push it over with the blade. Keep both the stinger and the cutting edge sharp. The operator must be well-trained to be efficient in this operation. There are other special-purpose blades not discussed in this manual which can be mounted on dozers.

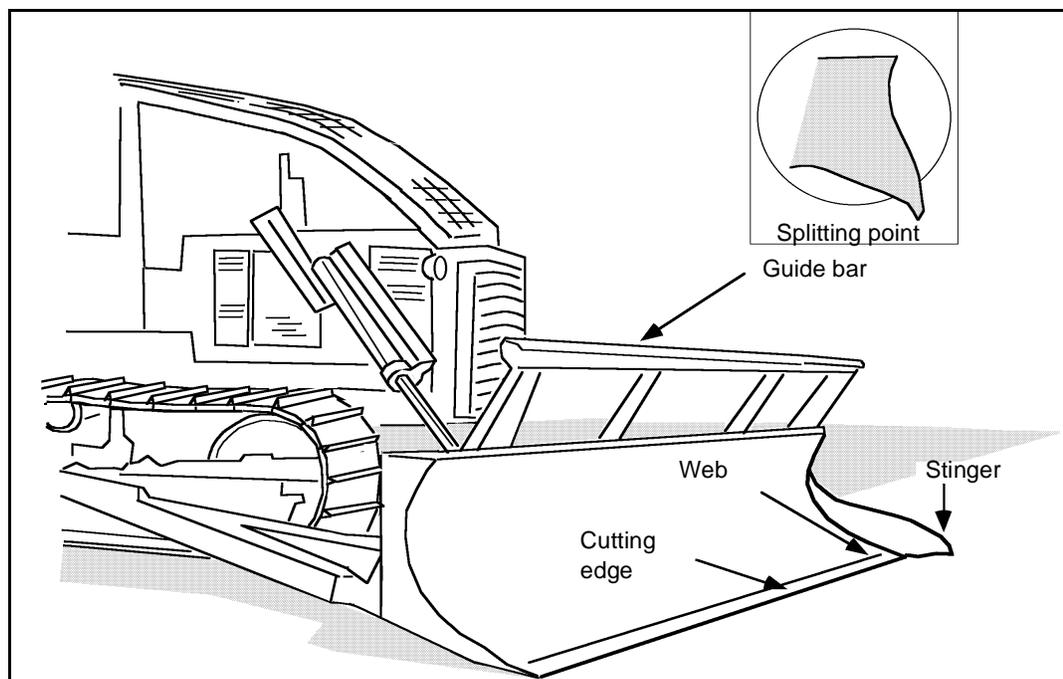


Figure 2-3. Special-Purpose Clearing Blade

### CLEARING AND GRUBBING OPERATIONS

2-6. Clearing vegetation and trees is usually necessary before moving and shaping the ground. Clearing includes removing surface boulders and other materials embedded in the ground and then disposing of the cleared material. Ensure that environmental-protection considerations are addressed before conducting clearing operations. Specifications may allow shearing of the vegetation and trees at ground level, or it may be necessary to grub (removing

stumps and roots from below the ground). Project specifications will dictate the proper clearing techniques. Plan clearing operations to allow disposal of debris in one handling. It is best to travel in one direction when clearing. Changing direction tends to skin and scrape the trees instead of uprooting them or allowing a clean cut. Clearing techniques vary with the type of vegetation being cleared, the ground's soil type, and the soil's moisture condition. *Table 2-1* shows average clearing rates for normal area-clearing jobs. Increase the *Table 2-1* values by 60 percent if the project requires strip-type clearing (common in tactical land clearing). Engineers perform tactical land clearing as a combat support function intended to enhance and complement mobility, firepower, surveillance, and target acquisition.

**Table 2-1. Quick Production Estimates for Normal Area Clearing**

Equipment	Equipment (Hours Per Acre)		
	Light (12 Inches or Less*)	Medium (12 to 18 Inches*)	Heavy (18 Inches*)
Bulldozer:			
Medium tractor	2.5	5.0	10.0
Heavy tractor	1.5	3.0	8.0
Shear blade:			
Medium tractor	0.4	0.8	1.3
Heavy tractor	0.3	0.5	0.8
*Maximum tree size			
<b>NOTE: These clearing rates are average for tree counts of 50 trees per acre. Adverse conditions (slopes, rocks, soft ground) can reduce these rates significantly.</b>			

**BRUSH AND SMALL TREES**

2-7. Moving the dozer, with the blade slightly below ground level, will usually remove small trees and brush. The blade cuts, breaks off, or uproots most of the tree and bends the rest for removal on the return trip. A medium tractor with a dozer blade can clear and pile about 0.25 acres of brush or small trees per hour.

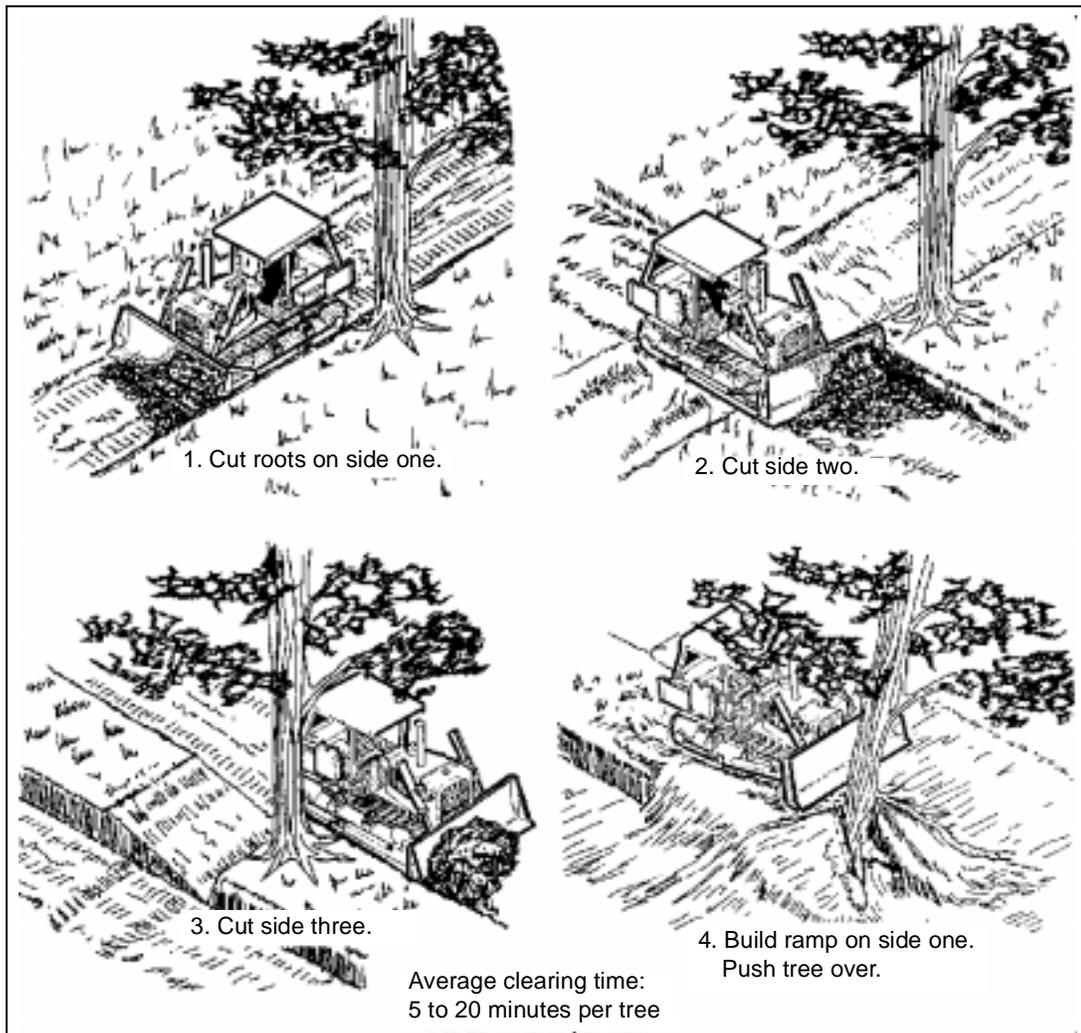
**MEDIUM TREES**

2-8. To remove a medium-size tree (7 to 12 inches in diameter), raise the blade as high as possible to gain added leverage and then push the tree over slowly. As the tree starts to fall, back the dozer quickly to avoid the rising roots. Then lower the blade and drive the dozer forward, lifting out the roots. The average time for a medium tractor with a dozer blade to clear and pile medium trees is 2 to 9 minutes per tree.

**LARGE TREES**

2-9. Removing large trees (12 to 30 inches in diameter) is much slower and more difficult than clearing brush and smaller trees. First, gently and cautiously probe the tree for dead limbs that could fall. Determine the tree's natural direction of lean, if any; this is the best direction for pushing the tree over. Then, position the blade high and center it on the tree for maximum

leverage. If possible, push the tree over the same as a medium tree. However, if the tree has a massive, deeply embedded root system, use the following method (*Figure 2-4*):



**Figure 2-4. Four Steps for Removing a Large Tree With a Massive, Deeply Embedded Root System**

**Step 1.** Start on the side opposite the proposed direction of fall, and make a cut deep enough to sever some of the large roots. Make the cut like a V-ditch, tilted downward laterally toward the roots.

**Step 2.** Cut side two.

**Step 3.** Cut side three.

**Step 4.** Build an earth ramp on the same side as the original cut to obtain greater pushing leverage. Then push the tree over and, as the tree starts to fall, reverse the dozer quickly to avoid the rising root mass. After felling the tree, fill the stump hole so that it will not collect water.

The average time for a medium tractor with a dozer blade to clear and pile large trees is 5 to 20 minutes per tree. The time required to clear and pile massive trees requiring this four-step procedure will often be more than 20 minutes each.

**NOTE: The roots on the fourth side may also need to be cut.**

## ROOTS

2-10. Mount a rake on the dozer in place of the blade to remove roots and small stumps. As the dozer moves forward, it forces the teeth of the rake below the ground's surface. The teeth will catch the belowground roots and the surface brush left from the felling operation, while the soil remains or passes through.

## SAFETY PRECAUTIONS

2-11. Never operate clearing tractors too close together. Do not follow a tree too closely when pushing it, because when it begins to fall, its stump and roots may catch under the front of the dozer. Clean out accumulated debris in the dozer's belly pan often to prevent fires in the engine compartment.

## PRODUCTION ESTIMATES

2-12. The two methods for estimating production for clearing and grubbing projects are the quick method and the tree-count method.

### Quick Method

2-13. *Table 2-1, page 2-4*, shows quick estimates for normal area clearing. Use the quick method only when a detailed reconnaissance and a tree count are not possible.

**Step 1.** Determine the size of the area to clear (in acres).

$$\text{Acres to be cleared} = \frac{\text{width (feet)} \times \text{length (feet)}}{43,560 \text{ square feet per acre}}$$

**Step 2.** Determine the size and number of dozers available.

**Step 3.** Determine the maximum size of the trees to clear.

**Step 4.** Determine the time required (hours per acre) for clearing, based on dozer size and tree size (see *Table 2-1*).

**Step 5.** Determine the efficiency factor for the work. Operators require breaks, and there are always secondary delays for minor equipment repairs. Therefore, actual production time per hour is something less than 60 minutes. In the case of a well-managed job, expect 50 minutes of production time per hour.

$$\text{Efficiency factor} = \frac{\text{actual working minutes per hour}}{60\text{-minute working hour}}$$

**Step 6.** Determine the operator factor using *Table 2-2*.

**Step 7.** Determine the total time (in hours) required to complete the mission.

$$\text{Total time (hours)} = \frac{D \times A}{E \times O \times N}$$

where—

- D = time required, in hours per acre
- A = total area, in acres
- E = efficiency factor
- O = operator factor
- N = number of dozers available

**Table 2-2. Operator Factors for Track Dozers**

Operator Ability	Daylight	Night
Excellent	1.00	0.75
Average	0.75	0.56
Poor	0.60	0.45

**NOTE:** These factors assume good visibility and a 60-minute working hour efficiency.

### EXAMPLE

Determine the time required to clear an area that is 500-feet wide by 0.5 mile long. Two medium bulldozers are available for the task. The largest trees in the area are 14 inches in diameter, and the ground is fairly level. The operators are of average ability and will do all work during daylight hours. Expected efficiency is 50 minutes per hour.

**Step 1.** Total area in acres =  $\frac{\text{width (feet)} \times \text{length (feet)}}{43,560 \text{ square feet per acre}}$

$$= \frac{500 \text{ feet} \times (0.5 \text{ mile} \times 5,280 \text{ feet per mile})}{43,560} = 30.3 \text{ acres}$$

**Step 2.** Dozer size = medium  
 Number of dozers available = 2

**Step 3.** Maximum tree size = 14 inches

**Step 4.** Time required = 5 hours per acre (*Table 2-1, page 2-4*)

**Step 5.** Efficiency factor =  $\frac{50 \text{ minutes per hour}}{60\text{-minute working hour}} = 0.83$

**Step 6.** Operator factor = 0.75 (*Table 2-2*)

**Step 7.** Total time (hours) =  $\frac{5 \text{ hours per acre} \times 30.3 \text{ acres}}{0.83 \times 0.75 \times 2} = 121.6 \text{ or } 122 \text{ hours}$

### Tree-Count Method

2-14. Use this method when a detailed reconnaissance and a tree count are possible. The tree-count method allows for a better production estimate.

**Step 1.** Determine the size of the area to clear (in acres). Refer to step 1 of the quick method.

**Step 2.** Determine the size and number of dozers available.

**Step 3.** Determine the average number of each size of tree per acre. This will require a field reconnaissance.

**Step 4.** Determine the basic production factors (hours per acre) based on the dozer size and the size of the trees to clear (*Table 2-3*).

**Table 2-3. Production Factors for Felling With a Clearing Blade**

Tractor	Base Minutes Per Acre B	Tree Diameter Range				
		1-2 Feet M <sub>1</sub>	2-3 Feet M <sub>2</sub>	3-4 Feet M <sub>3</sub>	4-6 Feet M <sub>4</sub>	More Than 6 Feet F
Medium	23.48	0.5	1.7	3.6	10.2	3.3
Heavy	18.22	0.2	1.3	2.2	6.0	1.8

**NOTE:** These times are based on working on reasonably level ground with good footing and an average mix of soft and hardwoods.

**Step 5.** Determine the time required to clear one acre.

$$D = H([A \times B] + [M_1 \times N_1] + [M_2 \times N_2] + [M_3 \times N_3] + [M_4 \times N_4] + [I \times F])$$

where—

D = clearing time of one acre, in minutes

H = hardwood factor affecting total time—

H = 1.3 if hardwoods are 75 to 100 percent

H = 1 if hardwoods are 25 to 75 percent

H = 0.7 if hardwoods are 0 to 25 percent

A = tree-density and presence-of-vines factor affecting total time

A = 2 if density is more than 600 trees per acre (dense)

A = 1 if density is 400 to 600 trees per acre (medium)

A = 0.7 if density is less than 400 trees per acre (light)

A = 2 if heavy vines are present

B = base time per acre determined from dozer size, in minutes

M = time required per tree in each diameter range, in minutes

N = number of trees per acre in each diameter range, from reconnaissance

I = sum of diameter of all trees per acre greater than 6 feet in diameter at ground level (in foot increments), from reconnaissance

F = time required per foot of diameter for trees greater than 6 feet in diameter, in minutes

**NOTE:** When it is necessary to grub roots and stumps, increase the time per acre by 25 percent.

**Step 6.** Determine the total time (in hours) required to complete the mission.

$$\text{Total time (hours)} = \frac{D \times A}{N}$$

where—

D = time required to clear one acre (from step 5), in hours

A = total area

N = number of dozers

**NOTE: The tree-count method has no correction factor for efficiency or operator skill. The values in *Table 2-3* are based on normal efficiency and average operator skill.**

## SIDEHILL EXCAVATIONS

2-15. One of a dozer's more important uses is making sidehill cuts, which includes pioneering road cuts along hillsides. An angle blade is preferred for this operation because of its side-casting ability.

### CREATING A SLOPE

2-16. It is best to start the cut at the top of the hill, creating a bench several dozer lengths long. Do this by working up and down the slope perpendicular to the long direction of the project (*Figure 2-5[A], page 2-10*). Design the benches to ensure that water runs off without damaging the slope. If possible, start the bench on the uphill extreme of the cut (the highest point of the cut) and then widen and deepen the cut until the desired road profile is achieved. Be sure to start the bench far enough up the slope to allow room for both the inner slope and the roadway.

**NOTE: When working on extremely steep slopes, a winch line may be necessary to stabilize the dozer (see *paragraph 2-37*).**

2-17. Because the perpendicular passes are short, the dozer usually is not able to develop a full blade load. Therefore, after constructing the initial bench, turn the dozer and work in the long direction of the project (*Figure 2-5[B], page 2-10*). Develop a full blade load and then turn the dozer to push the material over the side. After developing the bench, use either a dozer or a scraper to complete the cut. Keep the inside (hillside) of the roadway lower than the outside. This allows the dozer to work effectively on the edge and decreases the erosion of the outer slope. Make sure to maintain the proper slope on the inside of the cut. It is very difficult to change the cut slope after construction. Maintain the proper bench slope by moving out from the inside slope on each successive cut. Determine the slope ratio from the distance moved away from the slope for each successive cut and the depth of each cut. When cutting the road's cross slope, work from the toe of the bench to the road's outside edge.

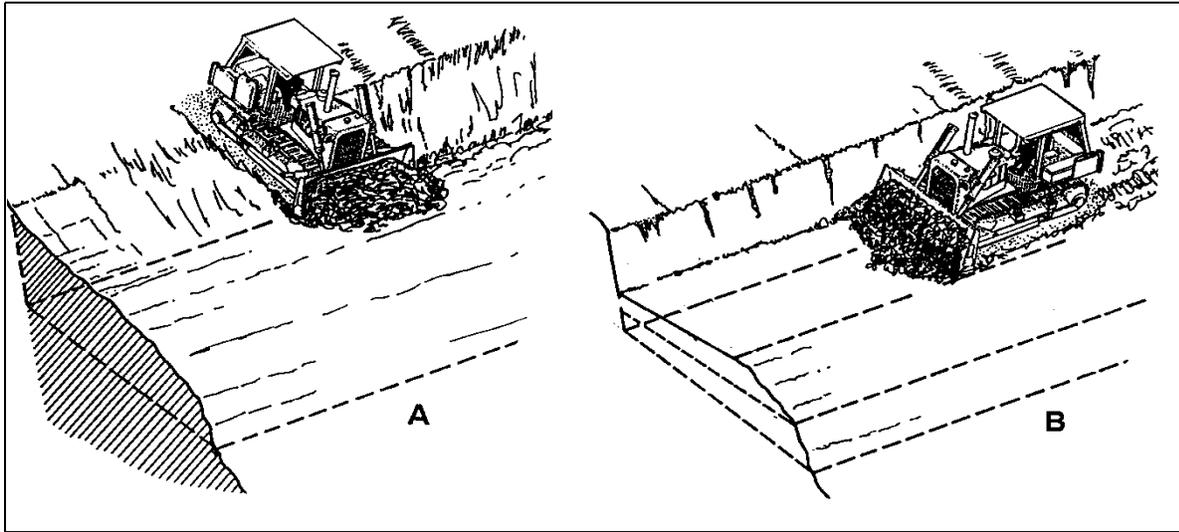


Figure 2-5. Sidehill Cut

**FINISHING A SIDE SLOPE**

2-18. There are two methods for finishing a side slope—working perpendicular to the slope and working diagonally up the slope.

**Working Perpendicular to the Slope**

2-19. The dozer shown in *Figure 2-6* is finishing a side slope by working perpendicular to the slope. Start the dozer at the top of the embankment and, on each pass, earth will fall to the lower side of the blade forming a windrow. On succeeding passes, pick up this windrow and use it to fill holes and other irregularities in the terrain. Be careful to prevent the blade corner from digging in too deep; this would steepen the slope beyond job specifications.

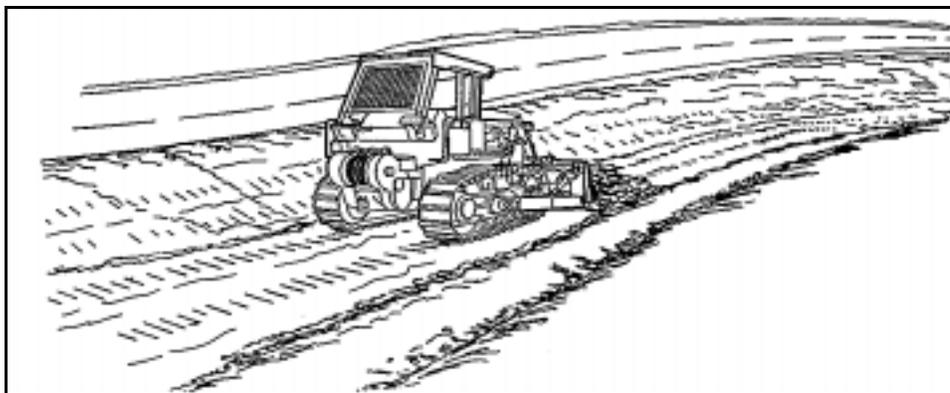


Figure 2-6. Finishing a Side Slope Working Perpendicular to the Slope

### Working Diagonally Up the Slope

2-20. The dozer shown in *Figure 2-7* is finishing the side slope by starting at the bottom and working diagonally up the slope. The windrow that forms is continually pushed to one side, which tends to fill low spots, holes, and irregularities. This is one of the few instances where a dozer works effectively pushing uphill.

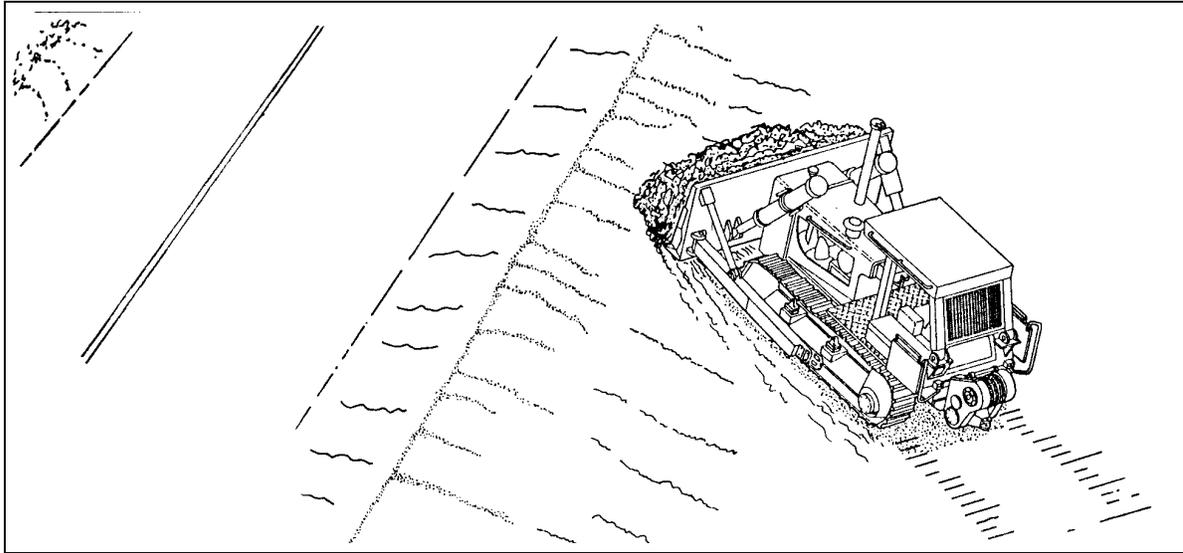


Figure 2-7. Finishing a Side Slope Working Diagonally up the Slope

### OPERATION TECHNIQUES

2-21. Dozers work best when the ground is firm and without potholes, sharp ridges, or rocks. Uneven surfaces make it difficult to keep the blade in contact with the ground. This tends to bury vegetation in hollows rather than remove it. To save time and increase output, use the following techniques when conditions permit.

#### DOZING

2-22. When straight dozing, if the blade digs in and the rear of the machine rises, raise the blade to continue an even cut. If moving a heavy load causes the travel speed to drop, shift to a lower gear and/or raise the blade slightly. When finishing or leveling, a full blade handles easier than a partially-loaded blade.

#### Side-by-Side Dozing

2-23. Side-by-side dozing will increase production 15 to 25 percent when moving material 50 to 300 feet (*Figure 2-8, page 2-12*). When the distance is less than 50 feet, the extra time needed to maneuver and position the dozers will offset the increased production.

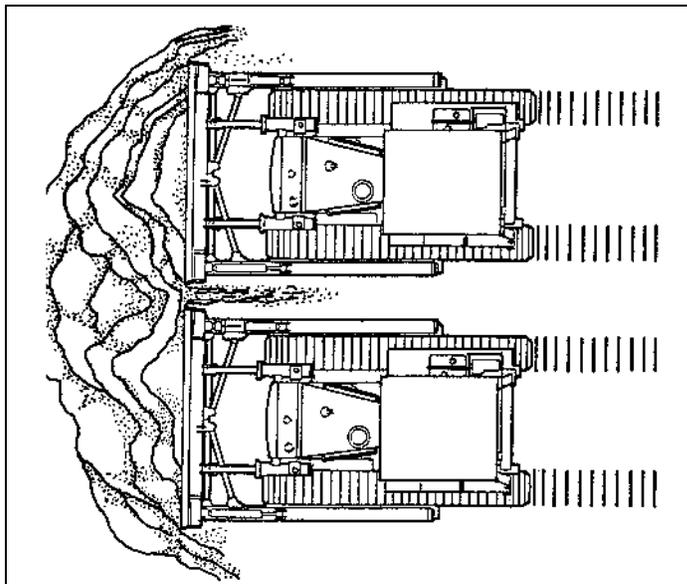


Figure 2-8. Side-by-Side Dozing

### Slot Dozing

2-24. Slot dozing uses spillage from the first few passes to build a windrow on each side of a dozer's path (*Figure 2-9*). This forms a trench, preventing blade-side spillage on subsequent passes. To increase production, align cuts parallel, leaving a narrow uncut section between slots. Then, remove the uncut section by normal dozing. When grade and soil conditions are favorable, slot dozing can increase output by as much as 20 percent.

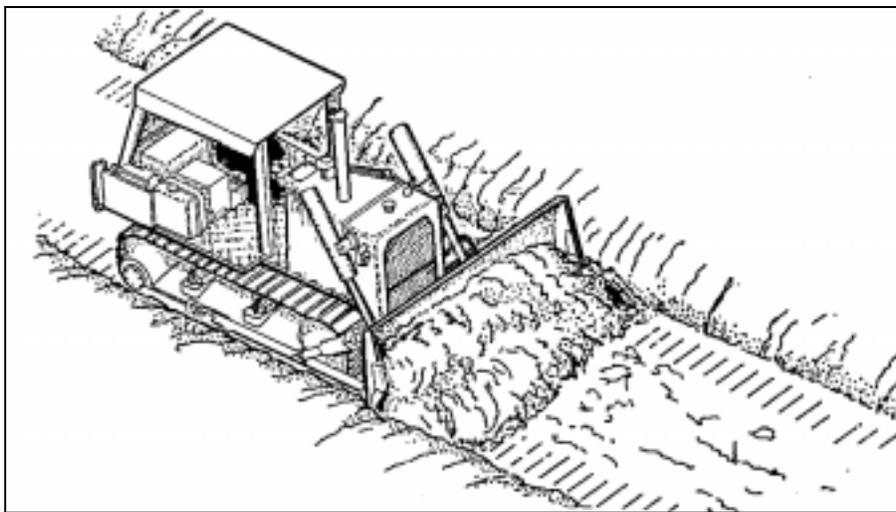


Figure 2-9. Slot Dozing

### Downhill Dozing

2-25. Pile several loads at the brink of the hill, and then push them to the bottom in one pass. When dozing downhill, travel to the bottom of the hill with each load. Use downhill dozing whenever possible since it increases production.

### Hard-Materials Dozing

2-26. Use the dozer blade to loosen hard material when rippers are not available. Tilt the blade to force one corner into the material. Tilting is done through blade control, by driving one track onto a ridge of material bladed up for this purpose or by placing a rock or log under the track. To maximize the driving force of the blade, hook only the tilted end under the material. Break a thin layer by turning on it with a dozer. Turning causes the track grousers (cleats) to break through the top layer. With a thin layer of frozen material, it is best to break through at one point. By lifting and pushing, the blade breaks through the top frozen layer as shown in *Figure 2-10*.

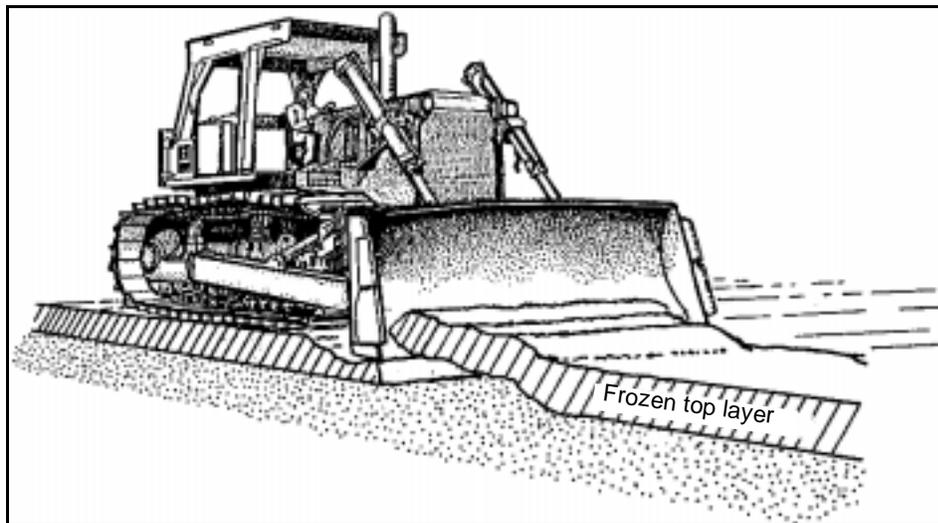


Figure 2-10. Dozing Hard Materials or Frozen Ground Layers

### Rock Dozing

2-27. Use a rake to remove small rocks. The rake lets the soil remain, or pass through, while digging the rocks from the earth. When removing large, partially buried boulders, tilt the dozer blade and dig the earth out from around three sides of the boulder. Lower the blade enough to get under the fourth side. Lift the blade as the dozer moves forward to create a lifting, rolling action of the boulder. If the dozer cannot push the boulder, lift it upward with the blade and have someone place a log or some other object under the boulder so the dozer can get another hold. The rolling action removes the boulder as the dozer moves forward. Dozer work in rocky areas increases track wear. If possible, install rock shoes or rock pads to cut down on this wear.

## Wet-Materials Dozing

2-28. Wet material is difficult to move with a dozer. Also, the wet ground may be too soft to support the weight of the dozer. If so, make each successive pass the full depth of the wet material. This will place the dozer on a firmer footing. If available, use wider tracked shoes for better flotation. When working in mud, push the mud back far enough that it will not flow back into the cut. Make provisions for recovery operations in case the dozer becomes stuck. Try to use machines equipped with a winch.

## DITCHING

2-29. Shallow ditches are best accomplished using a grader, but dozers can accomplish rough ditching. Tilt the dozer blade to cut shallow V-ditches (*Figure 2-11*). For larger ditches, push the material perpendicular to the center line of the ditch. After reaching the desired depth, push the material the length of the ditch to smooth the sides and bottom. Many times it is necessary to correct irregularities in a ditch. Attempt to remove humps or fill holes in a single pass. Use multiple passes to correct the grade.

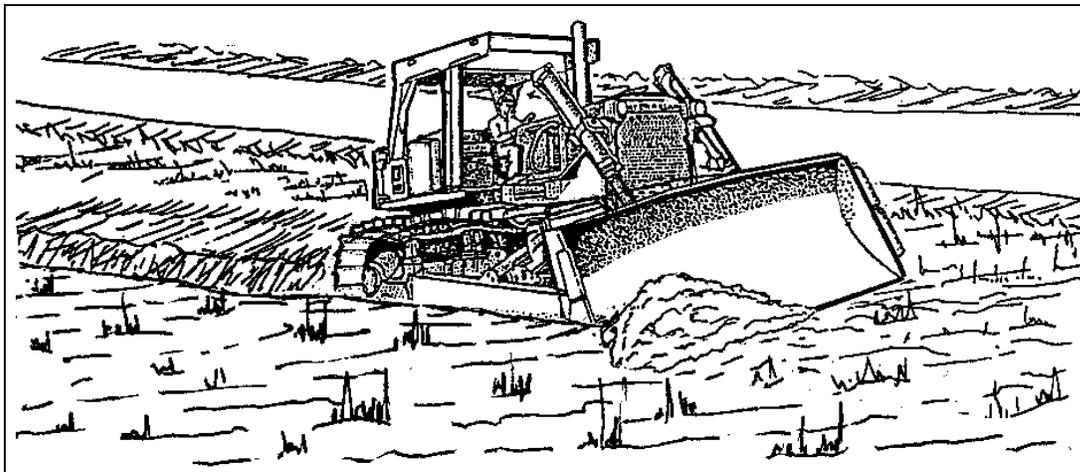


Figure 2-11. Tilt Dozer Ditching

## CONSTRUCTING A STOCKPILE

2-30. A dozer is a good machine for creating stockpiles of material that can then be easily loaded into haul units by either a loader or a hydraulic hoe excavator. Use the following steps to construct a stockpile:

**Step 1.** Push the material from the beginning of the excavation to the stockpile area on the first pass. This distance should be no more than 75 feet from the start point. Do not excavate deeper than 6 to 8 inches, while maintaining a smooth cut.

### WARNING

Before putting the machine in reverse, and while backing, the operator must be satisfied that no one will be endangered.

**Step 2.** Begin to raise the blade one dozer length from the stockpile, letting the material drift under the blade forming a ramp upon reaching the stockpile area.

#### CAUTION

Keep the dozer under control at all times. Do not put the transmission into neutral to allow the machine to coast. Select the gear range necessary before starting down the grade. Do not change gears while going downhill.

**Step 3.** Push the material on successive cuts in the same manner, working the dozer from the start point all the way around the work area while stockpiling. Overlap cuts about one-third of the blade's width to pick up windrows.

**NOTE: Do not stop the forward motion or cause the tracks to spin while pushing material.**

**Step 4.** Make successive cuts the same as in step 2, constructing the stockpile higher on each pass until it reaches the desired height.

### SPREADING A STOCKPILE

2-31. Large piles should be worked from the side, cutting material away from the stockpile, using one-third of the blade. Use the following steps to spread a stockpile:

**Step 1.** Lower the blade to the desired height while moving forward.

**Step 2.** Adjust the blade height and move the dozer into the side of the pile making the cut with only one-third of the blade.

**NOTE: When using the left side of the blade, continue working to the left. When using the right side of the blade, continue working to the right.**

**Step 3.** Cut into the stockpile. The blade should be as full as possible without stalling the dozer or spinning the tracks. Raise and lower the blade to maintain a smooth pass.

#### WARNING

When spreading materials that are higher than the midpoint of the rollover protective structure (ROPS), adjust the height of the cut to eliminate the danger from collapsing material.

**Step 4.** Spread the blade load after cutting the pile by continuing to move forward and slowly raising the blade until all material is evenly feathered.

**Step 5.** Feather the blade load and reverse the dozer. Raise the blade about 12 inches off the ground, back the dozer to the stockpile, and reposition for another cut.

Repeat the above steps until the stockpile has been leveled and spread over the designated area. **Do not** back blade to level the stockpile.

## BACKFILLING

2-32. Backfilling can be effectively accomplished by drifting material sideways with an angle blade. This allows forward motion parallel to the excavation. With a straight blade, approach the excavation at a slight angle and then, at the end of the pass, turn in toward the excavation. No part of the tracks should hang over the edge. Adjust the length of the push based on soil conditions. For example, when working in soft material or on an unstable slope, let the second bladeful push the first bladeful over the edge. Be careful to keep oversize materials out of the backfill.

## RIPPING

2-33. *Figure 2-12* shows various ripping operations. Use first gear for ripping operations. When performing one-shank ripping, always use the center shank. Use additional shanks, where practical, to increase production. When ripping for scraper loading, rip in the same direction that the scrapers are loading, whenever possible. It is usually desirable to rip as deeply as possible. However, it is sometimes better to rip the material in its natural layers even if this is less than full-shank depth. Use the ripped material on top of the unripped formation to cushion the machine and provide traction. When the final material size must be relatively small, space passes close together. Cross rip only when necessary to obtain the required breakage. Use the following steps to rip material:

**Step 1.** Position the dozer on the uphill side if operating on a slope, about half the length of the dozer from the start of the area to be ripped.

**Step 2.** Place the transmission shift lever in forward, first gear.

**Step 3.** Lower the rippers to the ripping depth as the dozer begins to cross the area to be ripped.

### WARNING

Maintain a straight line while ripping. Turning the dozer with the rippers in the ground will cause damage to the dozer.

**Step 4.** Raise the rippers out of the ground and then stop at the end of the pass.

**Step 5.** Place the transmission in reverse and back the dozer to the start point.

**Step 6.** Position the dozer to overlap the previous ripping pass.

Repeat steps 1 through 6 until the area is completely ripped.

## Packed Soil, Hardpan, Shale, and Cemented Gravel

2-34. Three-shank ripping works well in these materials. Use as many shanks as possible to break material to the desired size.

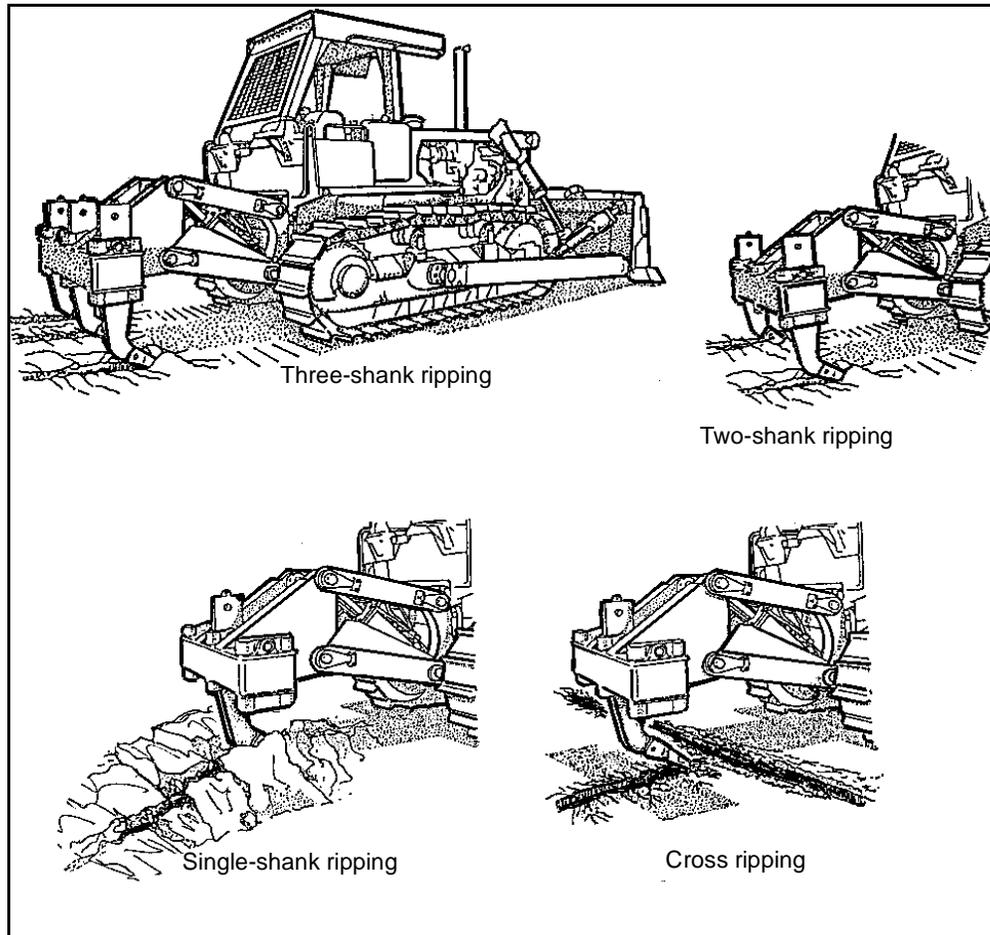


Figure 2-12. Ripping Operations

### Rock with Fractures, Faults, and Planes of Weakness

2-35. Use two shanks for ripping where rocks break out in small pieces and the machine can handle the job easily. Use only the center shank if the machine begins to stall or the tracks spin.

- **Asphalt.** Raise the ripper shank to lift out and break the material.
- **Concrete.** Use one-shank ripping to sever reinforcing rods or wire mesh effectively.

### Solid Rock, Granite, and Hard-to-Rip Material

2-36. Use one shank in hard-to-rip material or material that tends to break out in large slabs or pieces.

### WINCHING

2-37. Winching is hoisting or hauling with a winch, using a cable. When winching, make sure personnel are clear of the cable. Cables can break and cause severe injury. Exercise caution with suspended loads. If the engine revolutions (speed) are too low, the weight of the load may exceed the engine

capacity causing the load to drop, even though the winch is in the reel-in position.

#### **CAUTION**

Always keep the winch cable in a straight line behind the machine. For safety and maximum service life of the winch component, decelerate the engine before moving the winch control lever. After shifting, control the cable speed by varying the engine speed. Winch loads at low engine speed with the machine stationary. When moving away from a load, operate the machine in low gear to prevent overspeeding of winch components. Do not operate the winch for extended durations.

### **DOZER PRODUCTION ESTIMATES**

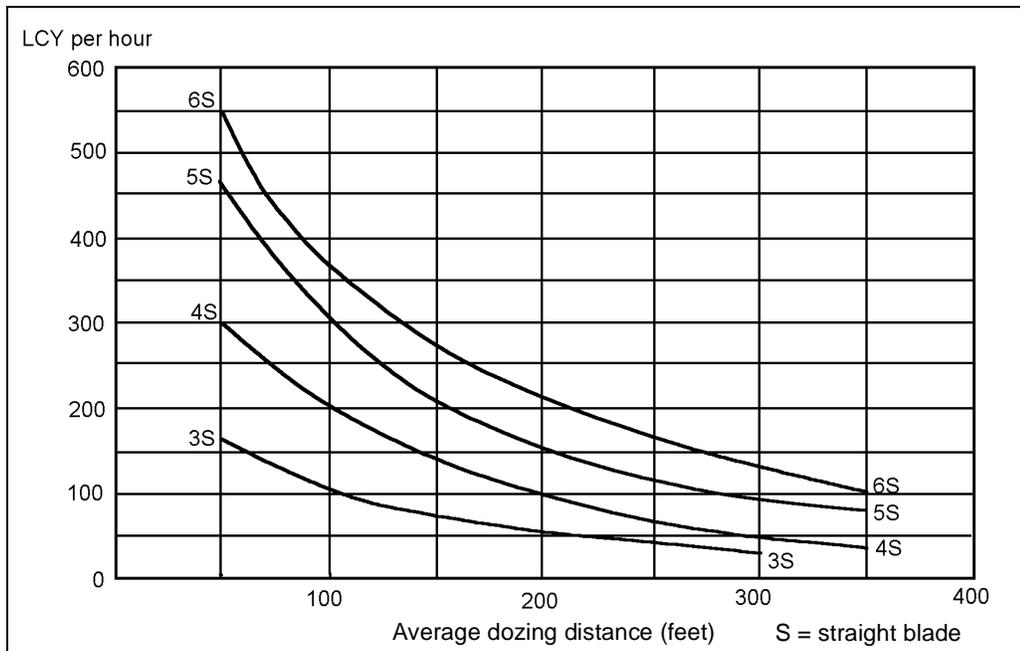
2-38. Dozer production curves give maximum-production values (in LCY per hour) for straight and universal blades based on the following conditions:

- A 60-minute working hour (100 percent efficiency).
- Power-shift machines with 0.05-minute fixed times are being used.
- The dozer cuts 50 feet, then drifts the blade load to dump over a high wall.
- The soil density is 2,300 pounds per LCY.
- The coefficient of traction equals 0.5 or better for crawler machines and 0.4 or better for wheel machines.
- Hydraulic-controlled blades are being used.

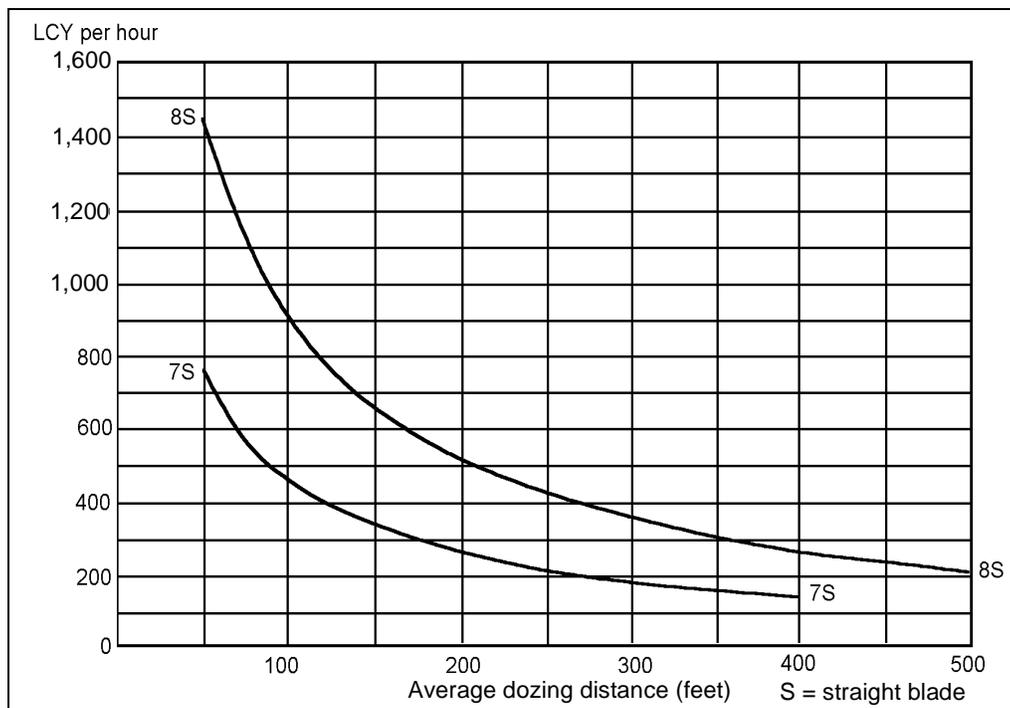
2-39. Use the following steps to estimate dozer production:

**Step 1.** Determine the maximum production. Determine the estimated maximum production from either *Figure 2-13* or *2-14*, based on the type of dozer being used. Find the dozing distance on the bottom horizontal scale in the proper figure. Read up vertically until intersecting the production curve for the dozer being considered then read the vertical scale on the left to determine the maximum production in LCY per hour.

- Use *Figure 2-13* to determine the estimated maximum production for D3 through D6 tractors with straight blades. The DEUCE has the same production capability as the D5.
- Use *Figure 2-14* to determine the estimated maximum production for D7 or D8 tractors with universal or straight blades.

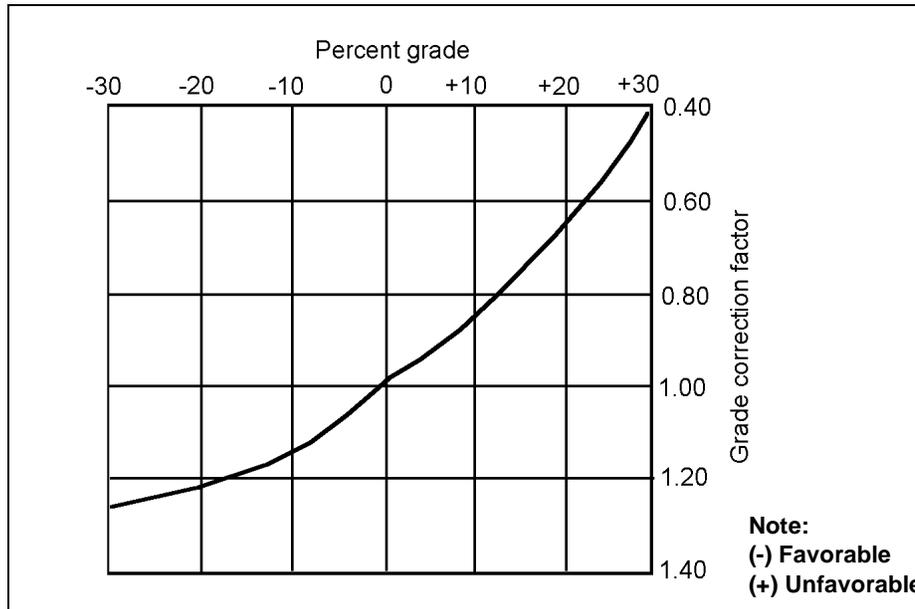


**Figure 2-13. Estimated Maximum Production for D3 Through D6 Tractors With Straight Blades**



**Figure 2-14. Estimated Maximum Production for D7 or D8 Tractors With Universal or Straight Blades**

**Step 2.** Determine the grade correction factor—(-) favorable or (+) unfavorable. Find the percent grade on the top horizontal scale of *Figure 2-15*. Read down vertically and intersect the grade correction curve, then read to the right horizontally and locate the grade correction factor on the vertical scale.



**Figure 2-15. Dozer-Production Grade Correction Factors**

**Step 3.** Determine the material-weight correction factor. If the actual unit weight of the material to be pushed is not available from soil investigations, use the average values found in *Table 1-2, page 1-4*. Divide 2,300 pounds per LCY by the material’s LCY weight to find the correction factor. Soil density of 2,300 pounds per LCY is a constant that was assumed in determining the maximum production.

$$\text{Material-weight correction factor} = \frac{2,300 \text{ pounds per LCY (standard material unit weight)}}{\text{actual material LCY weight}}$$

where—

2,300 = standard material unit weight per LCY

**Step 4.** Determine the material-type correction factor. Dozer blades are designed to cut material and give it a rolling effect in front of the blade. This results in a production factor of 1. *Table 2-4* gives the correction factors to account for how different materials behave in front of the blade.

**Table 2-4. Material-Type Correction Factors**

Material State	Factor for Crawler Tractors
Loose, stockpile	1.2
Hard to cut; frozen, with tilt cylinder	0.8
Hard to cut; frozen, without tilt cylinder	0.7
Hard to drift; dead (dry, noncohesive) material or very sticky material	0.8
Rock (ripped or blasted)	0.6 to 0.8

**Step 5.** Determine the operator correction factor (see *Table 2-2, page 2-7*).

**Step 6.** Determine the operating-technique correction factor from *Table 2-5*.

**Table 2-5. Operating-Technique Correction Factors**

Operating Technique	Factor for Crawler Tractors
Slot dozing	1.2
Side-by-side dozing	1.15 to 1.25

**Step 7.** Determine the efficiency factor. In the case of a well-managed job, expect 50 minutes of production time per hour.

$$\text{Efficiency factor} = \frac{\text{actual working minutes per hour}}{60\text{-minute working hour}}$$

**Step 8.** Determine dozer production.

$$\text{Production (LCY per hour)} = \text{maximum production} \times \text{the product of the correction factors}$$

**Step 9.** Determine the material conversion factor, if required. To find the total time (step 10) and the total number of dozers required to complete a mission within a given time (step 11), adjust the volume of material that is being moved and the equipment production rate per hour so that they both represent the same material state. Refer to material and production states as LCY, BCY, and CCY. If necessary to convert, use *Table 1-1, page 1-4*, to find the material conversion factor. Multiply the conversion factor by the production per hour to find the production per hour in a different state.

**NOTE: This conversion will not change the dozer production effort.**

**EXAMPLE**

Determine the average hourly production (in CCY) of a straight-blade D7 (with tilt cylinder) moving hard-packed clay an average distance of 200 feet, down a 10 percent grade, using slot dozing. Estimated material weight is 2,500 pounds per LCY. The operator is of average ability and will work during daylight hours. Expected efficiency is 50 minutes per hour.

**Step 1.** Uncorrected maximum production = 300 LCY per hour (*Figure 2-14, page 2-19*)

**Step 2.** Grade correction factor = 1.15 (*Figure 2-15, page 2-20*)

**Step 3.** Material-weight correction factor

$$= \frac{2,300 \text{ pounds per LCY (standard material unit weight)}}{2,500 \text{ pounds per LCY (actual material unit weight)}} = 0.92$$

**Step 4.** Material-type correction factor (a hard-to-cut material) = 0.8 (*Table 2-4, page 2-21*)

**Step 5.** Operator correction factor = 0.75 (*Table 2-2, page 2-7*)

**Step 6.** Operating-technique correction factor = 1.2 (*Table 2-5, page 2-21*)

**Step 7.** Efficiency factor =  $\frac{50 \text{ working minutes per hour}}{60\text{-minute working hour}} = 0.83$

**Step 8.** Dozer production

$$= 300 \text{ LCY per hour} \times 1.15 \times 0.92 \times 0.8 \times 0.75 \times 1.2 \times 0.83 = 190 \text{ LCY per hour per dozer}$$

**Step 9.** Material conversion factor = 0.63

Dozer production in CCY = 0.63 × 190 LCY per hour = 120 CCY per hour

**Step 10.** Determine the total time required in hours.

$$\text{Total time (hours)} = \frac{Q}{P \times N}$$

where—

- Q = quantity of material to be moved
- P = hourly production rate per dozer
- N = number of dozers

**EXAMPLE**

Determine the total time required to move 3,000 CCY of hard-packed clay, using one D7 dozer with a production rate of 120 CCY per hour.

$$\frac{3,000 \text{ CCY}}{120 \text{ CCY per hour} \times 1 \text{ dozer}} = 25 \text{ hours}$$

**Step 11.** Determine the total number of dozers required to complete the mission within a given time.

$$\text{Total number of dozers} = \frac{Q}{P \times T}$$

where—

Q = quantity of material to be moved

P = hourly production rate per dozer

T = maximum allowable duration, in hours

### EXAMPLE

Determine how many D7 dozers (with a production rate of 120 CCY per hour) would be needed to move 3,000 CCY of clay in seven hours.

$$\frac{3,000 \text{ CCY}}{120 \text{ CCY per hour} \times 7 \text{ hours}} = 3.6 \text{ D7 dozers (round up to 4 dozers)}$$

## RIPPING PRODUCTION ESTIMATES

2-40. The best method to estimate ripping production is by working a test section and recording the time required and the production achieved. However, the opportunity to conduct such investigations is often nonexistent and, therefore, estimates are usually based on historical production charts. Ripping applications will increase the machine's maintenance requirements by 30 to 40 percent.

### QUICK METHOD

2-41. A quick method to determine an approximate production rate is to time several passes of a ripper over a measured distance. The timed duration should include the turnaround time at the end of the pass. Determine an average cycle time from the timed cycles. Determine the quantity (volume) from the measured length multiplied by the width of the ripped area and the depth of penetration. If measurements are in feet, divide the number of feet by 27 to convert cubic feet to cubic yards.

$$\text{Volume BCY} = \frac{\text{length (feet)} \times \text{width (feet)} \times \text{penetration depth (feet)}}{27}$$

where—

27 = factor used to convert cubic feet to cubic yards

2-42. Experience has shown that the production rate calculated by this quick method is about 20 percent higher than an accurately cross-sectioned study. Therefore, the formula for estimating ripping production is—

$$\text{Ripping production (BCY per hour)} = \frac{V}{T \times 1.2}$$

where—

V = measured volume in BCY

T = average time in hours

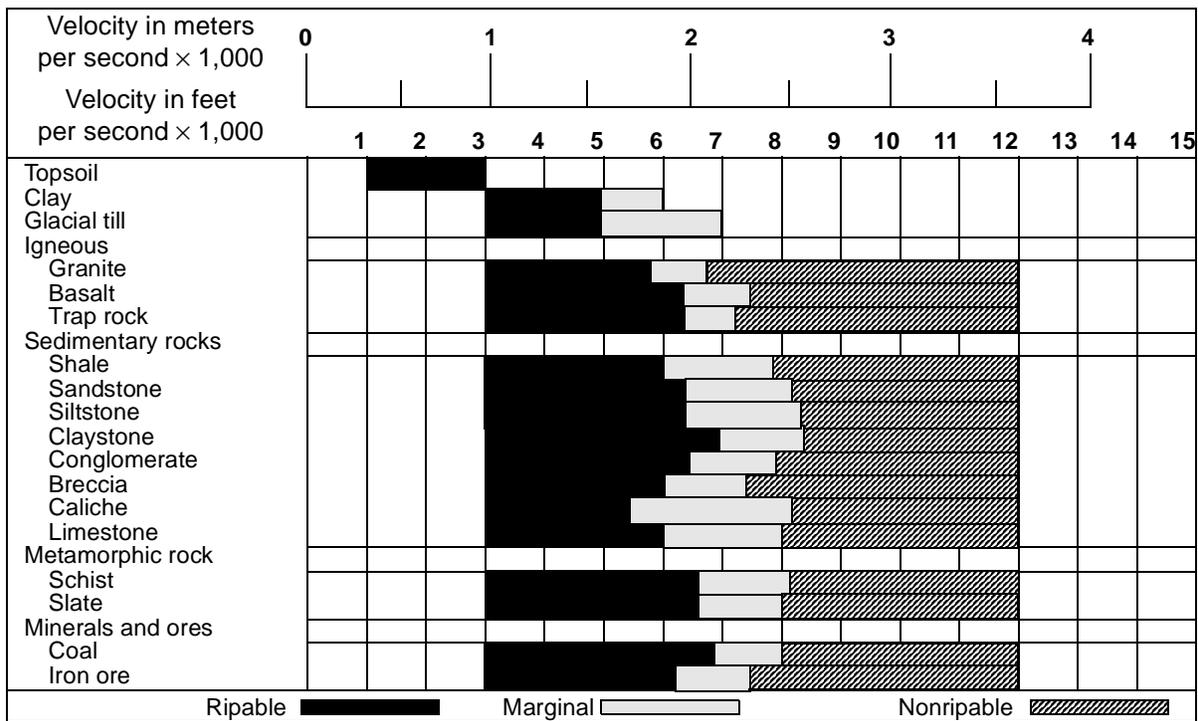
1.2 = method correction factor

**SEISMIC-VELOCITY METHOD**

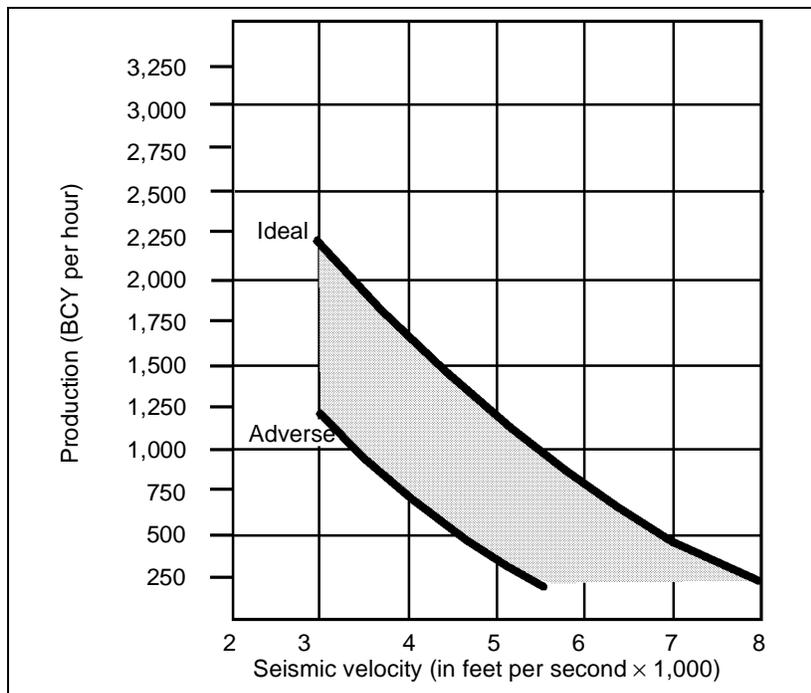
2-43. Most ripping-production charts are based on the relationship between the ripability and the seismic-wave velocity response of a material. The *Figure 2-16* ripping performance chart, which is for a 300-horsepower dozer, allows the estimator to make a determination of the machine's performance capability based on seismic velocity and general rock classifications. After establishing a seismic velocity, estimate production from the production chart in *Figure 2-17*. This chart provides a band of production rates representing ideal-to-adverse rock conditions based on the following assumptions:

- The efficiency factor is 100 percent (60-minute working hour).
- The power-shift machines used have single-shank rippers.
- The machine rips full-time, no dozing.
- The upper limit of the band reflects ripping under ideal conditions only. If conditions such as thick laminations, vertical laminations, or other rock structural conditions exist which would adversely affect production, use the lower limit.

2-44. Regardless of the seismic velocity, tooth penetration is the key to ripping success. This is particularly true for homogeneous materials such as mudstone, clay stone, and fine-grained caliches.



**Figure 2-16. Ripping Performance for a 300-Horsepower Dozer With a Single- or Multishank Ripper**



**Figure 2-17. Estimated Ripping Production for a 300-Horsepower Dozer With a Single-Shank Ripper**

$$\text{Production (BCY per hour per dozer)} = P \times E$$

where—

P = maximum production for a 300-horsepower dozer (*Figure 2-17*)

E = efficiency factor

**NOTE:** Before referring to *Figure 2-17* for determining a probable production rate, refer to *Figure 2-16* to verify the ripability with the equipment available.

### EXAMPLE

Determine how many 300-horsepower dozers are needed to rip 9,000 BCY of limestone having a seismic velocity of 4,000 feet per second in 7 hours. The limestone is bedded in thin laminated layers. Efficiency will be a 45-minute working hour.

Maximum production for ideal conditions (thin layers) is 1,700 BCY per hour (*Figure 2-17*).

**Efficiency-adjusted production**

$$= 1,700 \text{ BCY per hour} \times \frac{45}{60}$$

$$= 1,275 \text{ BCY per hour}$$

$$\frac{9,000 \text{ BCY}}{1,275 \text{ BCY per hour} \times 7 \text{ hours}} = 1,300\text{-horsepower dozer}$$

## **SAFETY PRECAUTIONS**

2-45. Listed below are some specific safety precautions for dozer operators:

- Never carry personnel on the tractor drawbar.
- Never turn around on steep slopes; back up or down instead.
- Keep the machine in low gear when towing a heavy load downhill.
- Always lower the blades when the machine is parked.
- Ensure that only one person is on the machine while it is in operation. However, in some training situations it is necessary to have two people on a dozer while it is in operation.