CAT® MOTOR GRADER APPLICATION GUIDE

APPLICATION GUIDE

The motor grader is one of the most versatile earthmoving machines in use today. It's weight, horsepower, wide range of attachments, and maneuverability allow it to be used in a diverse set of applications. This application guide will help you decide how to configure a grader to meet the demands of your applications. It will also illustrate key operating techniques that can help you get more work done every day. If practiced these techniques will maximize grader life and minimize operating costs.

Motor Grader Safety

No. 1 rule of motor grader operation is: ALWAYS OPERATE SAFELY!

- Wear the seat belt at all times.
- Use three points of contact when getting on or off the machine.
- Read and follow all the safety instructions in the Operating & Maintenance Manual (OMM).

You can also visit SAFETY.CAT.COM™ for a variety of resources to help you and your operators enhance job site safety.

For more detailed information on machine selection, equipment options, safety and operating techniques, consult your local Cat® dealer.

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MOTOR GRADER ANATOMY

Toe of moldboard	Leading end.
Heel of moldboard	Trailing end.
Circle turn	Allows the circle and moldboard to be rotated 360 degrees.
Circle sideshift	This cylinder allows the circle and drawbar to be moved left and right in relation to the main frame.
Moldboard sideshift	Allows the moldboard to be moved left and right in relation to the circle assembly to increase side reach, work around stationary objects, etc.
Moldboard tip	Allows the Moldboard to tip fore and aft.

Front wheel lean	Allows the front wheels to be leaned against the side draft caused by the angled moldboard.
Articulation hitch	This hitch can be steered left and right. This allows a machine to be steered much tighter than using the front tires alone. It also allows the machine to be crab steered, where the hitch and front tires are angled in opposite directions.
Linkbar	Allows the drawbar, circle and moldboard to be repositioned for additional reach.
Tandem	Connects the rear drive tires and allows them to walk over uneven surfaces, helping the machine to establish a smoother grade.

KEY MACHINE FUNCTIONS

Frame Articulation

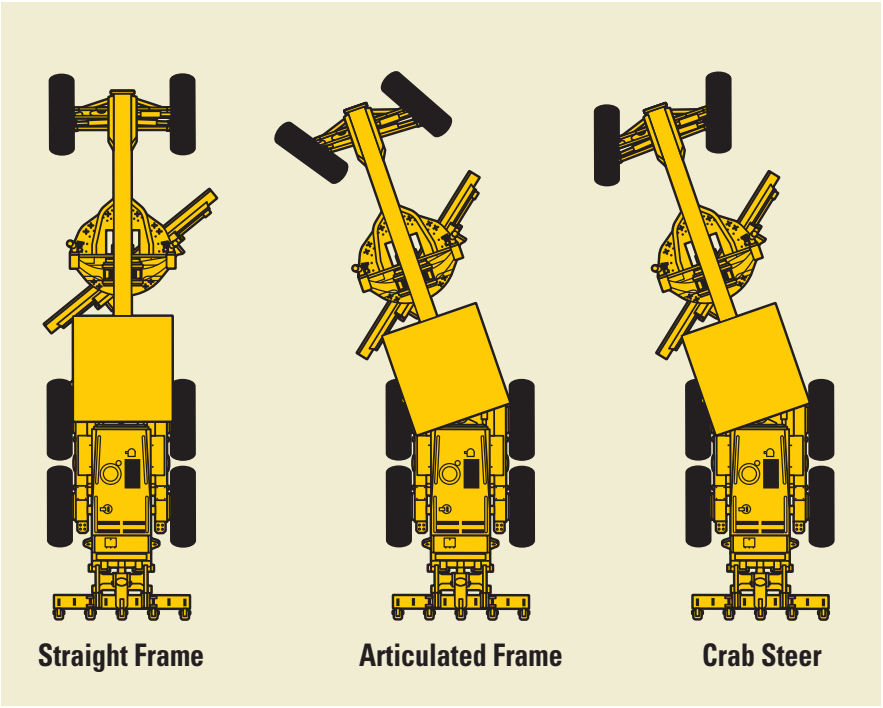
MODES OF OPERATION

Straight Frame

- Only front steering is used.
- Normally used for long straight blading passes, most finishing work, moving light to medium windrows, ditch cutting, ripping, and scarifier work.

Articulated Frame

- Use front steering and frame steering as required.
- Articulated frame gives the shortest turn radius for close quarter work, cul-de-sac or corners.
- Used to counter side draft from large windrows-blade loads, to change cutting width of the moldboard and reduce blade loads without use of the circle.
- Allows steering the leading end when reversing or in tight quarters for more control and safety.
- Auto Articulation is an option on joystick controlled machines that automatically articulates the frame in sync with the operator steering the front tires.



Crab Steer

- Front wheels and rear frame travel in the same direction.
- Increased side slope capability, allows off setting tandems away from edge fill for safety or to prevent road shoulder rutting.
- Used to level truck dumped material without running the front of the machine over a pile.
- Keeps the entire machine on a smooth surface allowing faster finishing of the area.
- Used for large windrows.
- Articulation can prevent a machine from getting stuck and helps remove it should this occur.

APPLICATIONS FOR FRAME ARTICULATION

Counteracting Side Loads

Articulation can be used to counteract side draft when you're making a heavy cutting pass. As the rear of the machine starts to slide away from the moldboard heel, articulate the back frame toward the toe to offset the side load.

Reducing Blade Loads

Articulation can be used to reduce blade loads without circling the blade under the load or where maximum circle torque has been reached. Articulate the front frame towards the direction you want to move material. This reduces the width of cut and the load.

Use articulation whenever possible to reduce wear on the circle. Rotating the circle under a heavy load accelerates wear on the pinion and circle teeth.

Machine Turnaround

The articulated unit can frequently turn around without stopping, commonly used on long or short pass work. This can mean faster cycle times and more productivity.

Work in Confined Areas

When working in confined areas or where the machine must be operated in reverse, the ability to steer the leading end of the machine gives outstanding maneuverability and allows it to be safely operated at higher reverse speeds.

Grading Around Curves

When grading around a curve, articulation is a useful tool to allow the front and rear tires to follow the same radius. This is particularly useful in cul-de-sacs and curved ditch cuts.

Freeing a Stuck Machine

Articulation can frequently prevent a machine from becoming stuck by allowing the rear end to be kept on a hard surface.

Remove a stuck machine:

1. Turn the rear frame and front wheels away from the dropoff.
2. Use articulation to duck walk (side-to-side articulation while backing up) the motor grader's way free.

Linkbar

The centershift linkbar is designed to increase moldboard positioning and reach from the centerline of the machine and to allow steeper moldboard angles. Repositioning the linkbar will increase the motor grader's productivity when ditching, backsloping and moving large windrows.

MODES OF OPERATION

Center Hole

- This position is used for long straight blading passes, most finishing passes, and light to medium windrows.

First and Second Hole from Center

- This position is used for cleaning shallow ditches.
- Processing and moving large windrows.
- Used with articulation to build narrow flat bottom ditches and backfill curb radiuses.

Third Hole from Center

- This position is used for cutting ditch backslopes and high bank slopes.
- Cleaning deep ditches.
- Grading and dressing fill slopes.
- Disposing of sod and oversize rock on backslopes.
- Use with articulation to grade on steep slopes.

REPOSITIONING LINKBAR USING FLOAT

1. Shift the drawbar/circle assembly to its maximum position towards the ditch/slope to be graded.
2. Ground the moldboard by placing both lift cylinders in the float position (if equipped).
3. With the moldboard grounded, release the centershift lock pin with the toggle switch.
4. When the light on the front console is illuminated, the pin is retracted.
5. With the lift cylinders, still in the float position, move the centershift away from the ditch/slope to be graded. (Example: If the centershift was moved to the right before grounding the moldboard and pulling the pin, now move the centershift to the left.)
6. As the centershift cylinder is either retracted or extended (depending on the direction the linkage is being moved), the linkage will roll around freely moving the linkbar sideways.
7. Line up the hole using the gauge on the back-right lift-cylinder mount.
8. Insert the pin with the toggle switch. When the light on the console goes out, the pin is in.
9. Now sideshift the drawbar towards the slope angle to be cut.

ALTERNATE METHOD: REPOSITIONING LINKBAR WITHOUT FLOAT

NOTE:

Some machines are not equipped with float, or the machine may not have enough centershift stroke to reach the furthest linkbar hole. Use this alternative method for either situation.

1. Start with the same procedures as listed above to release the pin.
2. Once the pin is released take the lift cylinders out of float.
3. Simultaneously lower the right end of the blade, move the centershift to the left and raise the left end of the blade. This will allow the linkbar to move into the third hole position.

Wheel Lean

Allows the front wheels to be leaned against the side draft caused by the angled moldboard and operating on slopes. The top of the front wheels are normally leaned in the direction the material comes off the moldboard.

APPLICATIONS FOR WHEEL LEAN

- Keeping the front wheels from sliding off the desired path of travel
- To shorten turning radius
- Reduce front tires from sliding downhill on slopes
- To reduce sidewall damage to tires when making ditch cuts
- Allowing the front axle to oscillate when on slopes or in ditches
- Make slight steering corrections when finish grading
- Varying the depth of cut when using moldboard in high bank position

Drawbar, Circle and Moldboard

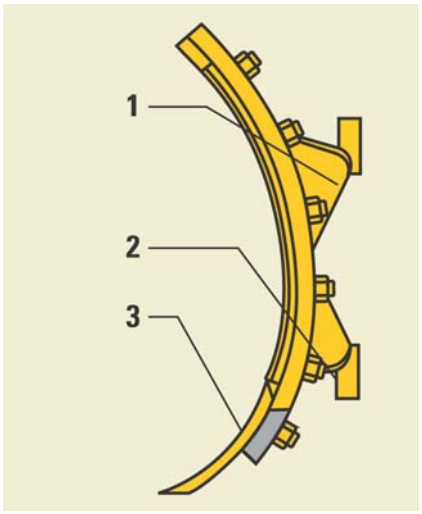
The moldboard is the primary work tool on a motor grader. The angle of the moldboard will depend on the type of work being performed. While the machine is often powerful enough to rotate a moldboard under load, this is not recommended. Rotating under heavy load will accelerate wear on the pinion drive and circle teeth. Circle teeth should be lubricated with grease at all times to prevent wear.

In rocky areas where there is a need to reduce vertical stress in the drawbar, circle and main frame, use optional blade lift accumulators. The accumulators provide a cushion for the blade lift cylinders when they impact solid objects. This will reduce maintenance and lengthen circle and drawbar component life.

An important feature in snow plowing or other high impact areas is the circle drive slip clutch. It will relieve horizontal impacts on the moldboard and circle and can reduce repair costs.

MOLDBOARD TIP

Side view of moldboard cutting edge
1. Footprint



Cross section of moldboard cutting edge
1. M Section Reinforcement
2. Slide Rails
3. Cutting Edge

This is an important feature. Tipping the moldboard to the proper angle will minimize power usage and fuel consumption. Material should roll across the moldboard. Avoid dozing material as this consumes excess fuel.

Proper Use of Moldboard Tip

- Normally start with the moldboard top edge positioned 2 inches ahead of the cutting edge.
- From this position tip forward or backward for the desired cutting, rolling, and carrying action needed for the application.
- When finish grading, adjust the moldboard tip to get the drawbar and circle parallel to the working surface. This will minimize the impact on grade when rotating the circle.
- If more penetration is needed, pitch the moldboard forward slightly to utilize the sharp edge of the cutting edge.
- When in high bank position, use moldboard tip to adjust the depth of cut. This will allow the moldboard to maintain a consistent slope angle.
- For maximum cutting-edge life, maintain a consistent moldboard angle as much as possible.
- Constantly pitching the blade forward and backward will round off the cutting edge accelerating wear and reducing penetration.

CUTTING EDGES

Cutting edge condition is very important for keeping a proper road profile and is a major expense in this application, so check their condition frequently. For long life in road maintenance, use the thickest edges that allow you to do the job. In hard material if you use excessive down pressure, the machine's front end will seem light. If penetration is a problem use thinner cutting edges, a serrated edge or a scarifier to loosen the material.

Material Types

- High Carbon (yellow Mark): Used in *low impact* applications. They are also better in high temp (high speed) situations since they are not as hard and therefore can handle higher temps.
- Through Hardened: Caterpillar uses a patented hardening technique to ensure GraderEdges are through-hardened to the optimal specifications available, ensuring longer life and industry leading impact resistance.
- Tungsten Carbide Tile: The tungsten carbide provides substantially higher life in high speed snow removal applications, while the through-hardened steel provides protection from impacts seen during demanding applications.
- Tungsten Carbide Inserts

Edge Shapes

- Curved:

  – All around best cutting edge for fuel efficiency.

- Flat:

  – Stronger, thicker cutting edges where longer wear life is desired.

- Serrated:

  – Penetrates hard surfaces better than a continuous edge, available in flat or curved.

Cutting Edge Systems

- Graderbit System:

  – In a serrated form, they do quick work of breaking into hard roads, down into pot holes and last a very long time (20-30× longer than GraderEdges™) as long as speed and impact are minimized.

- Rotating Bit System:
  – Very similar to GraderBits, but not as sensitive to blade angle since the circular bits are constantly spinning. They are very effective in road maintenance/repair applications.

Drawbar, Circle and Moldboard *(continued)*

Other Motor Grader GET

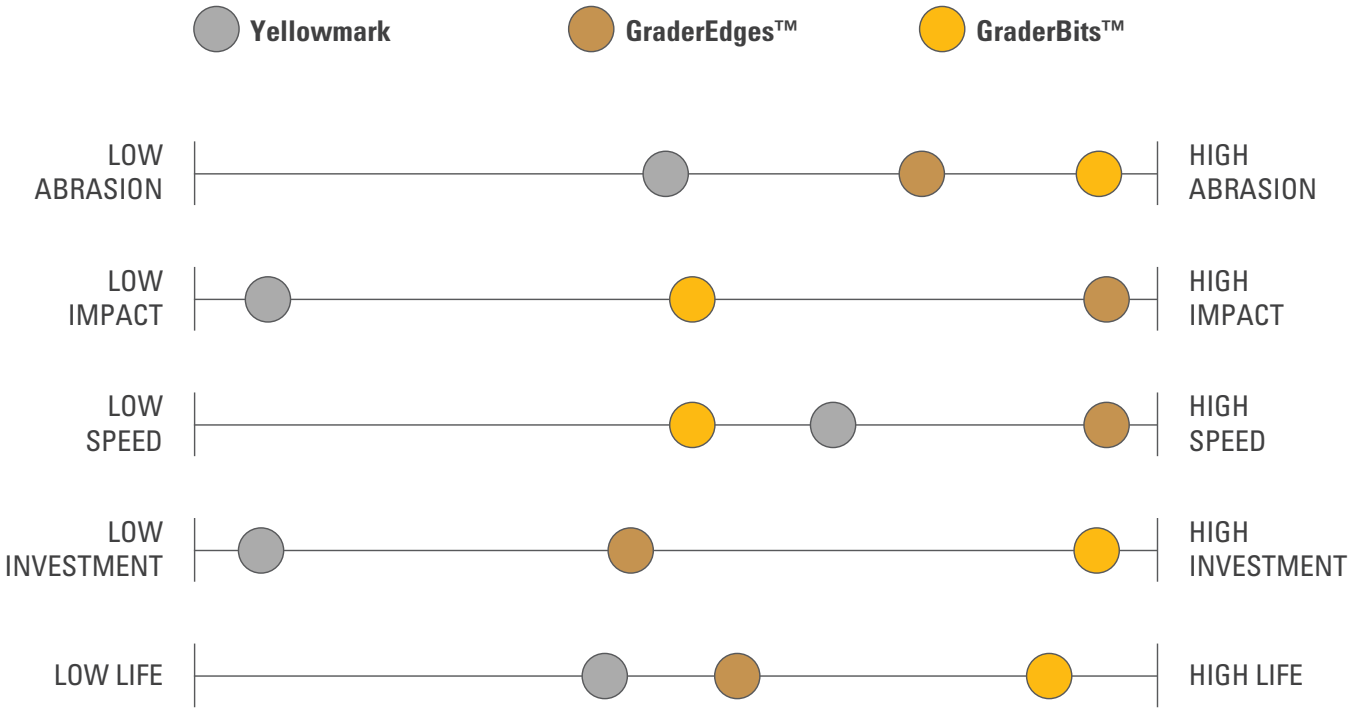
- End Bit:

  – Suggested in any situations where there is a concern with abrasive wear on the moldboard. End-bits are a must for all moldboards, OVERLAY end-bits are not a must but strongly encouraged.

- Ripper-Scarifier Tips:

  – Replaceable for long life.

Cutting Edges Available for Motor Graders



All Wheel Drive (AWD) System *(optional)*

The optional AWD system utilizes hydraulic power to turn the front wheels. The AWD option provides significantly more traction when underfoot conditions are less than ideal. This is particularly helpful in mud, loose sand, snow and working on slopes.

Tires

Motor grader performance depends heavily on selecting the right tire for the conditions that can range from dry "potato dirt" to wet shot rock. Speed, gradients, climatic conditions, operator skills, and maintenance all have a major effect on tire performance and tire life. No one tire can meet all requirements on any one machine.

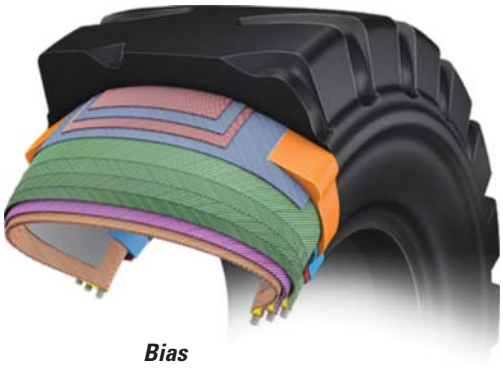
TWO MAJOR TYPES OF TIRES ARE AVAILABLE FOR MOTOR GRADERS

Bias Ply Tire

- Manufactured with multiple nylon plies.
- 1 to 4 bead bundles are used on each side.
- Plies run at an acute angle to the centerline.
- Fabric or steel breakers added under tread for reinforcement/bruise resistance.

Bias Ply Advantages:

- Better lateral stability due to multiple-ply sidewall.
- Better sidewall penetration characteristics.
- Lower cost verses comparable size radial tire.



Bias

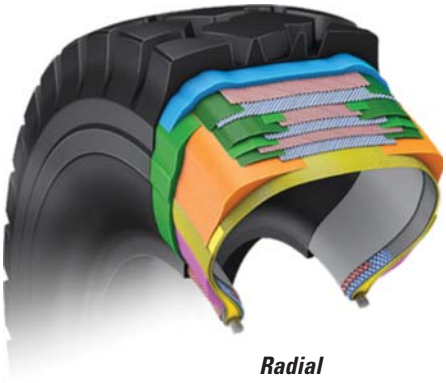
Photos provided by Bridgestone

Radial Tire

- Single ply of high-strength steel cords run at 90-degree angle to tread centerline.
- High ply turn-up around bead strengthens sidewall and improves steering response.
- 2 to 6 steel belts placed under tread.

Radial Advantages:

- More resistance to heat buildup due to flexible casing.
- Less cutting damage to tread surface.
- Impact resistance in rocky conditions due to flexibility.
- More resistance to puncture due to more steel in the tread.
- Better traction on most types of surfaces.



Radial

TIRE LOAD RATING

A tire's load capacity is critical to the performance and life of the tire. Load capacity is dependent on the tire construction and its inflation pressure. The nominal load capacity and pressure recommendations are provided by the tire manufacturer. The proper tires for a specific motor grader can be selected only after the total machine operating weight is computed. This weight should include any field-installed attachments such as snow wings and front-mounted plows. A tire whose load rating exceeds the maximum single tire load on the machine must then be chosen.

CAUTION:

Overloading a tire can result in poor motor grader performance and even puncture, or "blowout" of the tire.

Differential Lock

The differential lock allows the operator to lock left and right wheels together for traction in poor under foot conditions. Most models have an operator selectable switch to allow the differential lock to be disengaged for turns. Joystick control models are equipped with an automatic differential lock to automatically lock and unlock entering and exiting turns.

Models that do not have an operator selectable differential lock are equipped with a no-spin differential. This performs a similar function to a differential lock but does not require operator input.

Front Lift Group

The front lift group provides a quick coupling mechanism for front mounted blades and plows. There are other aftermarket tools like road wideners and shoulder reclaimers that also utilize this lift group. The lift group is available with manual or hydraulic attachment pins.

Rippers and Scarifiers

These attachments are used in a wide range of applications, from conditioning soils, mixing materials, loosening hard material, to ripping asphalt. The motor grader is not designed to continuously rip hard material but will do a good job if properly used.

Front Scarifier

This arrangement hooks to the front lift group and is normally used for light work. The main advantage is cost since it uses the lift group for raising and lowering. Its disadvantages include less control of direction and cut depth when ripping, due to its location ahead of the steering wheels. This location also limits visibility to the scarifier teeth and material fracture.

Mid-Mount Scarifier

Its advantages, when compared to the front mounted scarifier, are better control of cut depth, improved visibility, and ability to fracture harder material. Disadvantages are interference with blade positioning, interference with material flow along the moldboard in some applications, and problems working into corners and close to objects.

Rear Ripper/Scarifier

This arrangement allows the maximum ripping capability by placing the ripper weight on the rear drive tires. It can be used to rip into corners, along walls or close to an object. The ripper shanks are used for heavy ripping; the scarifier shanks for light work where maximum surface fracture is desired. Both sets of shanks can be stored on top of the bar when not in use.

TIPS ON USE OF RIPPER-SCARIFIER

- Use straight frame mode for maximum traction.
- Minimize articulation while ripping to avoid side loading the ripper or shanks causing possible failures.
- To maximize production, rip as deep as possible and to a uniform depth but avoid bulldozing with the ripper bar.
- Avoid excessive tire slippage.
- Use lower gears (first and second) and reduced engine RPMS to minimize damage.
- Use only the number of teeth required for material fracture. Too many teeth will prevent material penetration, bridging material between teeth and causing excessive tire slip.
- To penetrate material, lower shanks into the ground slowly while traveling in a straight line.
- Cross rip only when material fracture cannot otherwise be achieved.
- Three to five ripper shanks are used in most materials.
- With the ripper use only one shank when ripping extremely hard material; keep this shank in the center position.

CAUTION:

Damage can occur if the ripper or scarifier is not used properly.

Never use a single scarifier shank. The scarifier shank can break or the pocket can be damaged.

Do not operate ripper or scarifier with badly worn or missing tips: damage to the shank will occur.

Tires can be easily worn or cut by excessive slippage.

Do not rip or scarify in sharp turns or while using articulation – components can be damaged from side loading.

Front Blades

Straight Blade

A Straight Blade is effective for spreading piles, removing debris from road ways, pushing materials into washouts and grading in corners where it can be difficult to reach with the moldboard. It's available in widths and heights to match virtually any application and machine size. It's available in a version that bolts to the front bolster or in a hook on version that attaches to the front lift group.

Angle Blade

In addition to all the benefits of the Cat Straight Front Blade, this product features 30-degrees of left- or right-angle capability. That means increased material control during conventional dozing operations. Angle blades are available in manual or hydraulic angle versions.

CAT GRADE TECHNOLOGY

The motor grader has several different grade control technologies to match the job at hand. Below is a summary of the different technologies available and the jobs they fit best.

Cross Slope

Machine-mounted sensors calculate necessary blade slope positioning to achieve desired cross slope of the surface.

Sonic

Technology provides elevation control and can be combined with Cross Slope for full automatic blade control.

Laser

Technology provides elevation control and can be combined with Cross Slope on motor graders to control both elevation and slope of the blade for full automatic blade control.

Single Mast GPS

The system uses a 3D position from the GPS receiver in combination with information from the cross-slope sensors on the machine to automatically control elevation and cross slope.

Double Mast GPS

The dual GPS receiver configuration allows the system to automatically control blade adjustments for automatic control of elevation at both ends of the moldboard.

Universal Total Station (UTS)

The UTS receiver gets a signal from a stationary gun on the job site which provides location and elevation. This receiver is used in conjunction with the Cross Slope sensors to provide full 3D control of the moldboard with very high accuracy.

	Job Fit	Accuracy	Considerations
Cross Slope	– Road maintenance – Road shaping – Sports fields – Embankments – Road ditches	±0.2-0.4% slope	– Operator manually controlling elevation – Does not need design file
Sonic with Cross Slope	– Any construction work where there is a finished surface or string line to follow.	±3-5 mm elevation ±0.2-0.4% slope	– Does not need design file – Requires curb and gutter, string line, or previous pass for elevation reference – Operator must steer machine to maintain the Sonic sensor over the external elevation reference
Laser with Cross Slope	– Working indoors – Building pads – Sports fields	±3-5 mm elevation ±0.2-0.4% slope	– Does not need design file – Only works on planar applications: flat and single or dual sloped – Requires Laser Transmitter as off board infrastructure – Laser Transmitter requires line-of-sight to machine within 750 ft (228 m) – Range and accuracy affected by dust, fog, and wind
Single Mast GNSS with Cross Slope	– Large earth moving projects – Landfills – Rough grading roads/ highways	±20-30 mm elevation ±0.2-0.4% slope	– Requires skill and expertise to manage: 3D design data, GNSS base station setup and site calibration – Requires off board infrastructure to provide RTK correction signal – Requires a clear view of the sky (trees and tall buildings can interfere with satellite signals)
Dual Mast GNSS with Cross Slope	– Large earth moving projects – Complex designs – Steep slopes	±20-30 mm elevation	– Requires skill and expertise to manage: 3D design data, GNSS base station setup and site calibration – Requires off board infrastructure to provide RTK correction signal – Requires a clear view of the sky (trees and tall buildings can interfere with satellite signals)
Universal Total Station (UTS) with Cross Slope	– Finish grading roads/ highways – Airport construction – Complex commercial/ residential site prep designs	±2 mm elevation ±0.2-0.4% slope	– Requires skill and expertise to manage: 3D design data, Total Station setup and site calibration – Requires Total Station and 2400 MHz radio network as off board infrastructure – Total Station requires line-of-sight to machine within 750 ft (228 m) – One Total Station is required for each machine

ROAD BUILDING AND MAINTENANCE

Surface Maintenance

Maintaining gravel and dirt roads is one of the most common uses for a motor grader. Several techniques have been developed for different material types, road widths, environmental conditions, and traffic loads.

Included are some tips to get the most from your machinery investment.

- For productivity keep the moldboard angle as square to the frame as possible.
- If material starts to flow around the leading end of the moldboard, increase the blade angle.
- Keep machine travel speed as high as possible for maximum productivity but low enough to prevent machine bounce.
- The cutting width of a pass will depend on the length of the moldboard and the moldboard angle used. This chart shows the width of coverage for different length moldboards and several blade angles.

Moldboard Length, m (ft)	Effective Length, m (ft) 30-degree blade angle	Effective Length, m (ft) 45-degree blade angle
3.658 (12)	3.17(10.4)	2.59 (8.5)
4.267 (14)	3.70 (12.1)	3.02 (9.9)
4.877 (16)	4.22 (13.9)	3.45 (11.3)
7.315 (24)	6.33 (20.8)	5.17 (17.0)

For other blade lengths and carry angles:
Effective Moldboard Length = Moldboard Length × COS (blade angle)

- Three passes are normally required to maintain a 28-foot (8.5-meter) wide road (24-foot [7.3-meter] wide traffic lanes with 2-foot [0.6-meter] shoulders).
  - Pass 1 – Pull material from side of road to the center.
  - Pass 2 – Pull material from other side of road to the center and deposit past the peak of the crown.
  - Pass 3 – Spread the material from the center toward the edge of the road.

NOTE:
Alternate directions each time the road is maintained to keep material balanced on each side of the road.

CAUTION:
Do not straddle the center of the road while grading. This will cause the center of the road to become flat and potholes will form.

- Four passes may be required during heavier cuts. After both sides of the road have been graded to the middle, make separate passes pulling approximately half of the windrow from the center to each edge of the road.
- In this application, on wider roads, blade extensions are frequently used on one or both ends of the moldboard to increase pass width and reduce the number of machine passes required. These extensions are of lighter construction than the parent moldboard.
- Typical gravel roads should have a cross slope of 3-5%. Any less and water will not drain properly. Any more and water will drain too fast washing the fines from your gravel.

Road Surface Washboarding

Washboarding occurs mostly at areas where vehicles brake or accelerate and areas with deep and/or poor gradation of base material. It is highly undesirable from the standpoint of safety, vehicle ride and the effect on vehicle longevity. To remove corrugations, cut to their full depth using a scarifier or a serrated cutting edge. Then regrade the area with moist material that will compact, not loose dry material as it will reform quickly in areas of high vehicle traffic. 5-10 degrees of articulation can help the front tires walk over the corrugations and minimize machine bounce.

Potholes

Cut to the depth of all major potholes. Do not fill these holes with loose dry material because traffic will quickly displace the loose material and the holes will reform.

Ditch Building

Ditches and shoulders are critical components of a road system, particularly in areas of high rain fall. Ditches carry water away from road surfaces preventing them from getting soft. When ditches are not present or maintained, road surfaces often deteriorate quickly.

COMMON DITCH BUILDING STEPS

Step 1: Marking Pass

- Cut just deep enough to mark the intended line (4 to 6 inches deep or 10.2 to 15.2 centimeters deep).
- This pass should be made in first or second gear.
- Lock the differential when marking straight ditches.
- Keep as close to the intended flow line as possible.
- Some slight ditch line corrections can be made on succeeding passes.

Step 2: Cutting Passes

- Place the front wheel into the marking ditch.
- Cut deeper with the toe of the moldboard directly behind front tire in the ditch.
- Side shift the circle away from the ditch to obtain a steep moldboard angle.
- Make the cutting pass holding the desired ditch slope and flow line.
- After several cutting passes, the shoulder windrow must be moved to the road center.
- Alternate between cutting passes and moving material toward the centerline (step 3) as needed.

CAUTION:

On straight sections of road use Straight Frame Mode for deep ditch cutting passes to avoid possible:

- Tire Sidewall Damage – With articulation on straight sections, the front or rear tire can be forced against the ditch backslope, possibly causing sidewall damage if rocks or other objects get trapped. In corners, articulation can prevent the rear tandem tires from tracking on the backslope.
- Loss of Air Pressure or Damage to the Rim – Using articulation on straight sections can force material between the tire bead and rim, causing loss of air pressure in the tire. Have tire pressure at the proper level before starting any ditching work. Extended periods of deep ditching will require higher air pressure and/or tubes in the tires.

Step 3: Shoulder Cleanup Pass

- As the ditch becomes deeper, material tends to roll under the tandem tires.
- When this occurs, the windrow must be moved off the road shoulder toward the road center line.
- Articulation and linkbar can be used for heavier blade loads and to keep material from falling back into the ditch.

Repeat Steps 2 and 3 until desired ditch depth

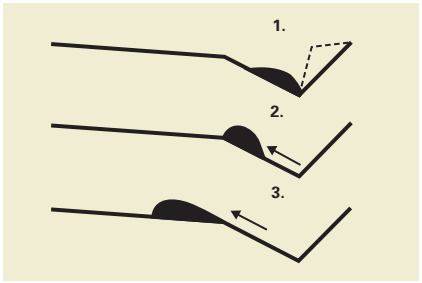
Step 4: Ditch Backslope

- Start with a smooth shoulder – a rough surface will be magnified at the moldboard's toe.
- To backslope, move the linkbar to its maximum position toward the slope.
- Tip the moldboard to near the center of its tip range.
- Adjust tip to after starting to control the depth of cut.

CAUTION:

Tipping the moldboard to the rear may result in rear blade support and blade beams contacting the bank and preventing the cutting edges from reaching the material.

- Place the machine in the ditch with the heel of the moldboard near the outer edge of the rear tire.
- Adjust the toe of the moldboard to obtain the desired slope.
- Start with the front wheels vertical.
- Lean wheels can be used to vary cut depth over the entire moldboard length without affecting the set slope.



- Material from the backslope will be deposited inside the rear tandem tires.
- Move this material out of the ditch using a very steep blade angle and the Vee ditch position, being careful not to gorge the backslope or contact the front tire.

CAUTION:

When backsloping, extensions must be installed on the toe to obtain the heel clearance required. Using it on the leading end in tough or rocky material may damage the extension.

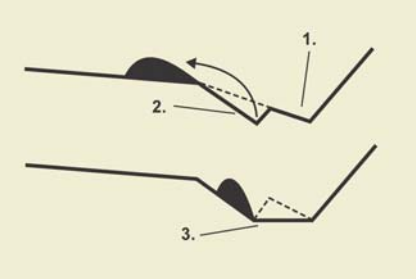
Repeat Steps 2 and 3 to clean material from ditch

Step 5: Finish Shoulder Pass

Use a finish shoulder cut when a precise shoulder line is required or in dry material to prevent material from spilling back into the ditch.

- Use the same method as above but shift the circle 8 to 12 inches (20.3 to 30.5 centimeters) toward the ditch.
- Use a steep blade angle and extend the toe of the moldboard well beyond the windrow and very close to the front tire.
- Tip the blade slightly forward.
- Place the windrow between the tandem tires.
- It may be useful to place tandem tires in the bottom of the ditch for a steeper moldboard angle.

Step 6: Flat Bottom Ditch (If Required)



1. Original Vee Ditch
2. Second Vee Ditch
3. Flat Bottom Ditch

Flat bottom ditches are useful in areas where a standard V-ditch does not provide enough capacity for the water that needs to be moved away from the road. Use this process to expand a standard V-ditch into a flat bottom ditch.

- Cut a Vee ditch to desired depth with a flatter than normal road shoulder slope.
- Rough finish the ditch and backslope.

Ditch Building *(continued)*

- Place the motor grader into the original Vee ditch and use the backslope to keep the front tires from sliding off the desired line.
- Place the centershift linkbar one hole off center away from the ditch.
- Place the moldboard toe inside the front tire to the desired flat bottom width and cut a second Vee ditch nearly the same depth as the first.
- Cut the desired road shoulder slope angle and place the material onto the road shoulder.
- Move the windrow to the road center and smooth the shoulder to make a uniform surface.
- Move the centershift linkbar two holes toward the ditch.
- Articulate the machine into a crab mode position.
- Place the tandems into the original Vee ditch. Position one front tire in the secondary ditch and the other one on the ditch slope.
- The toe of the moldboard should be near the bottom of the backslope.
- The heel should be between the tandems at the desired ditch bottom width and at the base of the ditch slope.
- Tip the moldboard further forward than normal.
- Cut out the center ridge between the two Vees, placing the cut-out material onto the road shoulder slope.
- Move the cut material onto the shoulder using the normal ditch cut position.

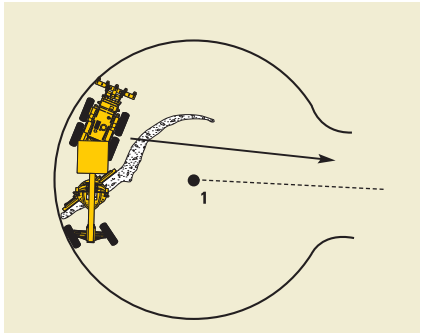
Ditch Cleaning

Often ditches can fill up with silt and become less effective. A motor grader is a fantastic tool to clean ditches and return them to their original shape. When ditch bottoms fill with silt, they often become too muddy to support the weight of a motor grader.

Here are some tips to reach into ditches and get them cleaned out.

- Move the linkbar to the furthest hole toward the ditch.
- Circle sideshift toward the ditch.
- Use the lift cylinders to place the blade at the desired slope.
- Rotate the blade to pull material out of the ditch and place it between the rear tires.
- Side shift the blade to place the toe at or near the desired flow line of the ditch.
- Keep your tandem drive tires on the road surface for traction and stability.
- If more reach is needed, articulate the front tires toward the ditch and place the nearest front tire in the flow line of the ditch.

Cul-De-Sac Grading



To finish grade or clear a cul-de-sac is simple work for the articulated motor grader. Use this process to grade a cul-de-sac:

- Keep the rear wheels on a smooth surface.
- Move the moldboard to near a 30-degree angle.
- Center the drawbar under the frame.
- Extend the moldboard to near three-fourths of its travel towards the heel end.
- Lean the wheels near the center of its travel.
- As the motor grader nears the cul-de-sac entrance, articulate the rear frame toward the toe of the moldboard.
- Use moldboard sideshift to maintain the moldboard near the curb.
- With the moldboard at the corner, steer the front wheels in the proper direction.
- Use circle rotation, sideshift and wheel lean to keep the moldboard tow positioned against the curb or back of the cut.
- When the front of the tandems is beyond the corner, articulate the rear frame away from the curb or back of the cut.
- Be careful not to articulate too fast and scuff the finished surface.
- Turn the front wheels in the proper direction, use circle, sideshift and wheel lean to keep the moldboard toe position to the curb or back of the cut.
- Continue to articulate to follow the cul-de-sac radius.
- After the curb pass has been widened by second pass, back onto the finished surface and move any excess material out of the cul-de-sac.

Remember: the centerline crown extends all the way to the center of the cul-de-sac. Do not straddle the crown or grade perpendicular to it at the entrance of the cul-de-sac.

BACKFILLING CURBS IN CUL-DE-SAC

Backfilling cul-de-sacs is often done with other machines. This can be done with a motor grader eliminating the need for support equipment. Follow these steps:

- To fill areas, shift the drawbar two holes toward the heel and near its maximum position.
- Carry a full blade load near the heel of the moldboard as you near the Vee of the curb.
- Slow the machine. Use the inching pedal to slowly move the machine as required.
- Use circle rotation and moldboard sideshift to place material into the corners.
- When backfilling curbs in a cul-de-sac, use articulation and offset the machine's rear away from the curb.
- Place the lighter front wheel close enough to compact the material next to the curb.
- Be very careful not to move the curb out of position while backfilling material.

Material Spreading

Trunk Dumps

A motor grader is frequently used to level fill or material for the travel surface that has been dumped by trucks. Belly dump trucks or trucks than can tail gate spread can speed up material placement. When these trucks are not available, use this technique to get the most productivity from your motor grader:

- Use crab mode to place the machines tractive effort behind the area of maximum load.
- Driving over loose material wastes engine power.
- Crab mode keeps the front wheels on a smooth surface for faster finishing and better directional control.
- The up-and-down motion of the mainframe when driving over piles affects your ability to smooth the surface. It can also shorten frame and axle life.
- Articulate the back frame toward the heel of the moldboard 15 to 18 degrees.
- Shift the drawbar, circle and moldboard toward the piles with the moldboard at a 30 to 40-degree blade angle.
- Cut out a windrow the machine can handle and spread it over the surface.
- Work the material in both directions or material may be moved beyond the intended limit.
- Keep the differential locked to prevent tire spin.
- Where material must be moved straight ahead, keep the blade nearly square to the main frame but shifted toward the piles.
- Place the drawbar circle near its center position.

Windrows and Material Mixing

Frequently a motor grader is used to spread windrowed material dumped by bottom dumps or to mix material. Use crab mode to improve productivity in this application.

- Tip the top of the moldboard approximately 4 to 5 inches (10.2 to 12.7 centimeters) ahead of the cutting edge.
- Angle the blade approximately 30 to 45 degrees to the mainframe.
- Change the moldboard angle and tip to match material type and moisture.
- Material should roll across the moldboard without flowing up into the circle.
- Increased blade angle will be required with wet material; less with dry material.
- Articulate the back frame toward the heel of the moldboard 18 to 20 degrees.
- On very large windrows, do not attempt to move the entire windrow in one pass.
- Take only the amount of material that can be handled without excessive engine lugging or tire slip.
- Ground speed is very important for good rolling/mixing of material and to control wheel slip.
- The best gear speeds for mixing materials are third and fourth (4 to 6 mph [6 to 10 km/h]).
- Keep ground speed below your machine's bounce point or a rippled surface will result.

Cutting Slopes

2.5:1 AND STEEPER (COMMONLY REFERRED TO AS "HIGH BANK")

When cutting a high bank from a flat surface:

- Before starting the slope work, smooth the base where the machine will be traveling so the base is as uniform and hard as possible.
- Position your machine at the slope base.
- Move the linkbar to the farthest position toward the slope to cut.
- The slope will normally be cut with the machine in straight frame mode.
- Tilt the top of the wheels toward the slope being cut to help hold the machine against the slope.
- Position the moldboard heel near the outer edge of the rear tire.
- Adjust the toe to obtain the desired slope.
- Tip the blade forward approximately one-half its travel range to position the cutting edges to the material.
- Make your final adjustment to meet the material needs after you start the pass.
- The machine should be operated in 1st-2nd gear at low RPM for maximum control.
- Bank height should not be allowed to exceed 6 to 8 feet (1.8 to 2.4 meters) before it is dressed

For higher slopes that cannot be reached from a flat surface:

- Use frame articulation to place one or both front tires on the slope.
- Place the rear tires at the slope's base.
- Lean front wheels down slope or the front axle oscillation limit may be reached.
- Place the windrowed material inside the tandem tires closest to the slope.

When cutting high bank slopes from a ditch:

- The application is similar to cutting a ditch backslope except for the height of the cut.
- Follow the ditch backslope instructions for setting up the machine for this application.

BANK SLOPE: MACHINE ON THE SLOPE OF 2.5:1 OR SHALLOWER

Using frame articulation allows the machine to be operated on steeper slopes with safety. Here are some tips for this application:

- Use low ground speeds for maximum control of the machine.
- Use the accelerator, not the hand throttle or throttle lock.
- In an emergency, releasing the accelerator will result in immediate reduction in engine RPMS and ground speed.
- Keep the differential locked while working on slopes.
- On steeper slopes shift the drawbar uphill toward the toe of the moldboard.
- Articulate the rear frame placing the heavy engine frame down slope for more stability.
- Deposit the windrow between the tandem tires and keep the upper tandem tires above this windrow to reduce sliding.
- Start at the top of the slope.
- Cast the windrow material outside the rear tandem tires to help prevent the rear tires from sliding.
- On subsequent passes, place the uphill front tire above the windrow with the frame in articulated mode.
- Continue this mode until all material is at the slope base, then return to straight frame to clean up the windrow.

SNOW PLOWING

CAUTION:

Safety must be your Number One objective. Work in the direction of traffic when possible. Blowing snow and other conditions may cause restricted visibility. In snow plowing applications, machines are frequently equipped with bulky attachments on the front, side and rear. They also tend to work in heavily trafficked areas that may require frequent changes of direction.

Normal operating speeds are in the 5 to 20 mph range. The moldboard should be tipped well forward to prevent damage to the machine and road surface. This allows the cutting edge to ride over rather than try to cut minor obstructions, and may prevent operator injury, cutting edge breakage or machine damage. Objects can be hidden under the snow so wear your seat belt to prevent possible operator injury or machine damage.

Use the seat belt at all times, especially in high speed operations such as snow plowing. A circle slip clutch can also reduce the effect felt by the operator and the machine when a hidden object is hit at these higher speeds.

Snow plowing techniques and the type of plowing equipment mounted on the motor grader vary greatly in different areas of the country due to:

- Terrain
- Type of snow and its moisture content
- Depth of snowfall normally expected
- Normal wind velocity that can cause extremely tight drifting
- Length of time after the snowfall before plowing was started
- How much melting has occurred
- Amount of dirt mixed with snow
- Available traction

Moldboard Plowing

The motor grader's standard moldboard is the most commonly used attachment for snow plowing. It is used in areas where snow depths are low, the terrain is relatively flat, and where excessive drifting does not occur. The standard moldboard can also be used to "wing" snow by repositioning the linkbar.

Blade float prevents damage to uneven surfaces but requires a hard surface such as asphalt or frozen ground to prevent gouging the surface. It also allows the blade to follow a varying surface using only the weight of the drawbar, circle and moldboard. In areas with loose gravel on the road surface, using blade float may windrow the gravel onto the road shoulder and is not recommended.

Snow Wings

The snow wing is a common snowplowing tool. It is an extra moldboard that normally mounts to the machine's right side. It can be used alone or in conjunction with the motor grader moldboard or front plow to move snow off the road or other surface. It provides a wider cleared area per machine pass. The moldboard is frequently used to cut the material and feed it onto the wing. The wing curvature is designed to lift the material and throw it off the plowed surface.

MAST TYPE SNOW WING

Especially effective at clearing and throwing deeply drifted snow. The snow wing is designed to displace material far back from the road to facilitate continued snow displacement.

MASTLESS SNOW WING

Designed to provide maximum visibility in high- or low-speed snow clearing applications, the Cat mastless snow wings excel at clearing and benching drifted snow, especially on shoulders, and ramps up to a 40-degree bench height.

WING APPLICATIONS AND TIPS ON USE

Ground Level Winging

When possible, use a ground speed high enough to move the snow completely off the road without leaving a windrow. Windrows will trap blowing snow and cause drifting.

- Lower the wing horizontal to the travel surface.
- A small amount of free movement is built into the mast slide to allow the toe to ride over uneven surfaces.
- Do not use down pressure unless it is needed to cut the material; it could lead to rapid cutting-edge wear or damage to the road surface.
- The ground speed needed to move snow off the roadway will vary with snow type and many other factors.
- Generally winging speeds fall in the 10 to 20 mph (16 to 32 km/h) range.
- When using the moldboard-wing combination, it is desirable to have similar angles on both units for good material flow.
- To accomplish this:
  1. Shift the drawbar toward the wing as far as it will go.
  2. Use articulation to place the front wheels approximately 12 to 24 inches (30.5 to 61 centimeters) toward the wing.
  3. Use crab mode to resist sliding.
  4. Shift the centershift lock pin right two holes with the drawbar fully shifted toward the wing.

CAUTION:
When using steep moldboard angles contact between the moldboard sideshift cylinder rod, wing mast, the moldboard heel and leading end of the wing can occur, causing damage. Tipping the blade forward approximately three-fourths of its maximum travel helps reduce the problem.

Benching

Benching is used when ditches are full, and more storage area must be found for additional snow. This occurs in areas that normally receive high amounts of snowfall or in areas of drifting. Benching is accomplished by raising the wing approximately one-half the bank height (or whatever depth the machine can handle). It is usually done in straight frame mode with the wing placed near horizontal position. The grader is driven along the base of the slope to cut a notch into the bank to make room for additional snow storage.

This type of operation may require the optional hydraulic strut group for adequate support of the wing heel if the bank height exceeds 5 to 6 feet (1.5 to 1.8 meters) and to prevent the strut from cutting away the edge of bank, pulling the material back onto the road surface.

Tapered Bank

The purpose of this operation is the same as benching: to create more storage in areas of high annual snowfall, where ditches are full and where drifting is a problem. Place the wing toe at ground level with the heel set to discharge the snow uphill onto the bank top. This operation may also require the optional rear support group to provide adequate support to the wing heel.

Winging Down Slope

This application is used to move snow down a slope or ditch and place it as far as possible from the road travel surface. This reduces the chance of moisture from melting snow softening or damaging the road surface.

- Place the wing toe at the road shoulder height and lower the heel to match the slope.
- Deposit material well away from the travel surface.
- **Use slower ground speeds in the application.**
- Use crab mode, use articulation and place the front wheels 24 to 30 inches (61 to 76.2 centimeters) from the shoulder.
- Place the tandems at the shoulder line.
- This mode reduces front end sliding and helps prevent the machine from getting stuck, should the rear slide toward the ditch.

Wing angles are adjustable by the rear strut from approximately 30 to 45 degrees. With the articulated machine, use the 30-degree wing angle and use articulation to counteract the side draft on the machine but also reduce wing cutting width.

Front Plows

V-PLOW

This is designed high and in a V-shape to cast material to both sides. The V-shape centers the load on the machine for better material penetration and front-end control. It is used mainly to open deep snow or drifts and can be used alone or in conjunction with the wing and motor grader moldboard.

TIPS ON USE OF A V-PLOW

- V-plows are designed to dig into and lift packed snow.
- **To prevent damage to the lift group do not hit a snow bank at high speed with the plow raised.**
- In deep drifts keep the frame straight on the first pass and hit the drift on the deep side with the plow close to the ground.
- Move the snow toward the low side of the drift.
- Work downhill when possible for maximum efficiency.
- Penetrate the drift as far as power and traction allow.
- Use caution as the V-plow can become stuck in the drift.
- After penetrating the drift as far as possible, use one-half of the V-plow to widen the path before attempting further penetration.
- Snow sliding off the banks can trap the plow and front wheels, causing problems when you attempt to reverse.
- Normally in 3- to 4-foot (0.9- to 1.2-meter) drifts moving one side is sufficient.
- On deeper drifts use the V-plow to move back both sides of the cut before making the next cutting pass.
- When using one-half of the V-plow, offset frame articulation approximately 10 degrees to reduce front end sliding and to keep the tandems on a previously cleared path.
- After the first pass through the drift, use one half of the V-plow to move snow off the road surface. Then use the motor grader's moldboard and wing to finish the clearing process.
- Should the V-plow become stuck in a drift, use wheel lean and articulation in a side-to-side motion to help free it.

USING SKID SHOES

- Skid shoes are used to keep plows from digging into road surfaces and to limit cutting edge wear.
- On hard surface roads, set the plow skid shoe up so its cutting edge is close to the pavement to remove as much snow as possible.
- On paved or frozen roads, the plow control can be placed in float and allowed to ride on the skids if desired.
- In other areas it is advisable to remove most of the plow's weight to reduce skid shoe resistance.
- On gravel roads set the skids down to maintain cutting edge height at 1 to 2 inches (2.5 to 5.1 centimeters) off the surface.

ONE WAY PLOW

This unit mounts on the motor grader like the V-plow but is lighter duty and intended for lower snow depths. It has a fixed angle to the main frame near 30 degrees. Its angle and direction of material flow cannot be changed.

HYDRAULIC ANGLE FRONT BLADE

Perfect for use in snow applications, these blades provide 30-degrees of angle capability to the left and right. This is particularly useful in areas where snow needs to be plowed in different directions like mountainous areas. Versions are also available with cutting edges that trip to prevent road and plow damage.

HYDRAULIC U/V-PLOW:

The most versatile blade available, it has the capabilities of operating as a Straight Blade, Angle Blade, U-Blade or V-Plow. Used extensively for snow removal, it uses auxiliary hydraulics to enable operator-controlled blade changes between all four configurations.

Other Snow Removal Tips

TIRE CHAINS

Tire chains are frequently required because of the limited traction normally available in winter operations. Several different types of chains are available, each designed for specific conditions. Tire chains are normally used on rear drive tires but are used on front tires of both AWD and standard motor graders for traction and to reduce front end sliding.

COMMENTS ON TIRE CHAIN USE

- Keep a set with the machine. Most are placed on the wing rear support where they are easy to reach.
- Plan ahead. Chains are heavy to lift and hard to install, especially on the tire near the wing.
- Avoid excessive tire spinning when chains are installed. This can cause expensive chain damage as well as damage to the road or work surface.
- Check chains often during the operation and keep them tight by proper adjustment and use of bungee cords when possible.
- Loose floppy chains may come off when traveling or cause damage to the machine.
- Repair broken cross links as quickly as possible since a loose cross link can cause extensive and expensive damage to the machine.
- Keep chain repair pliers and repair links in the machine.
- Do not travel for long distances on hard surface roads with chains installed. This increases operating cost because of rapid chain and tire tread wear.
- Chains normally restrict machine travel speed to 6 to 8 mph (10 to 13 km/h) on any hard-frozen surface.
- Attempting to travel faster than this will result in rapid tire chain wear, machine loping and in some cases vibration that can loosen or damage machine components.

SNOW TIRES

Snow specific tires are available for motor graders from several manufacturers. These provide superior traction in snow and ice. Traditionally tire chains have been used to increase traction in snow and ice. Chains must be removed at high ground speeds and require maintenance. Snow tires often provide most, or all of the traction needed and can be operated at all ground speeds.

Due to the lug pattern and size, front fenders are recommended with snow tires. Snow tires can grab gravel pieces between their lugs and throw them at the cab windshield causing damage. Fenders can prevent this.

FENDERS

Front and rear fenders are available for most models. Fenders will reduce the water and salt spray when operating in winter. Rear fenders may need to be removed when using tire chains to prevent interference.

For more complete information on Cat products, dealer services, and industry solutions, visit us on the web at **www.cat.com**

Materials and specifications are subject to change without notice. Featured machines in photos may include additional equipment.
See your Cat dealer for available options.

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