

NDSU

UPPER GREAT PLAINS
TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

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2018 Motor-Grader Operator Training



2018 North Dakota LTAP Presentation. Special thanks to Nebraska and South Dakota LTAPs for providing the material.

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Disclaimer

- The material shown in this presentation is based on best practices; however, it should not supersede the regulations of your agency or insurance carrier.
- Equipment appearing in this presentation does not indicate endorsement by North Dakota LTAP

Training Objectives

- Use a “Think Safety First” attitude
- Explain benefits of effective preventative maintenance
- Share roadway issues
- Solutions/Suggestions for roadway issues
- Help you become even a better operator



**SAFETY
FIRST**

Work Hazards

- More than 95% of all accidents happen to experienced operators
- 5,190 workers were killed on the job in 2016*
 - **North Dakota – 28 total in 2016**

The Top 4 injuries that Lead to Fatalities in North Dakota

- Falls 38.7%
- Struck by Object 9.4%
- Electrocutions 8.3%
- Caught in/between 7.3%

Safety is the Prime Motive in Everything we do in Transportation And the **Biggest** Part of Your Job

- Safety for yourself
- Safety for co-workers
- Safety for the traveling public

Safety Attitude

The **First Step** is Injury Prevention

- ✓ Being Positively Alert
- ✓ Being Focused
- ✓ Being Aware of Conditions



The Operator is the Key to Safety

- **Communicate with the Public**
 - Proper signing
 - Properly flagged
 - Lights on
- **Fellow Workers**
 - Wait for clear signal from operator
- **Proper Protective Equipment**

Qualities of a Good Operator

Good Eyesight

- Depth perception, distance, and peripheral vision are needed for proper performance

Hearing

- Ability to detect and identify unusual noises

Mobility and Overall Physical Fitness

- Safely climb in and out of machine as well as maneuver around

The Operator cont.

Inexperienced Operators More Often...

- Take chances
- Fail to properly assess situations
- Damage equipment unless trained and supervised

Fatigued Experienced Operators

- Can revert back to inexperienced operators

Self Assessment

- Prepare for longer hours of work
- Operators aren't superhuman
- Share experiences with co-workers

The Operator cont.

Medicated Operators

- Discuss your medications with supervisor
- Carefully review over-the-counter medications
- Know agencies policy on alcohol use rules

Physical Problems

- Advise supervisor as they develop
- Problem areas: vision, hearing, restricted body movement

Personal Problems

- Try to leave at home
- If on-the-job issue, take a break and resolve

Seat Belts

Proper seat belt use is mandated by federal, state, and agency regulations.

Seat belts should be:

- Properly adjusted
- Fit snugly enough to restrain driver but not too tight



Every time one is in the cab with the engine running, a seat belt **MUST** be worn!

PERSONAL PROTECTIVE EQUIPMENT

- Headwear
- Hearing Protection
- Clothing
- Gloves
- Footwear



Headwear

Hard Hats:

- Prevent serious head injury from falling or ejected objects.

Eye Protection:

- Protects eyes from flying pieces of debris



Hearing Protection

May be required depending on the equipment.

Prevents tinnitus and hearing loss.



Protective Clothing

- Loose clothing in good condition with collars closed and cuffs buttoned at the wrist.
- Pants without cuffs which extend over the tops of the boots

- **DO NOT** Wear:

- Rings
- Watches
- Necklaces
- Any other loose item



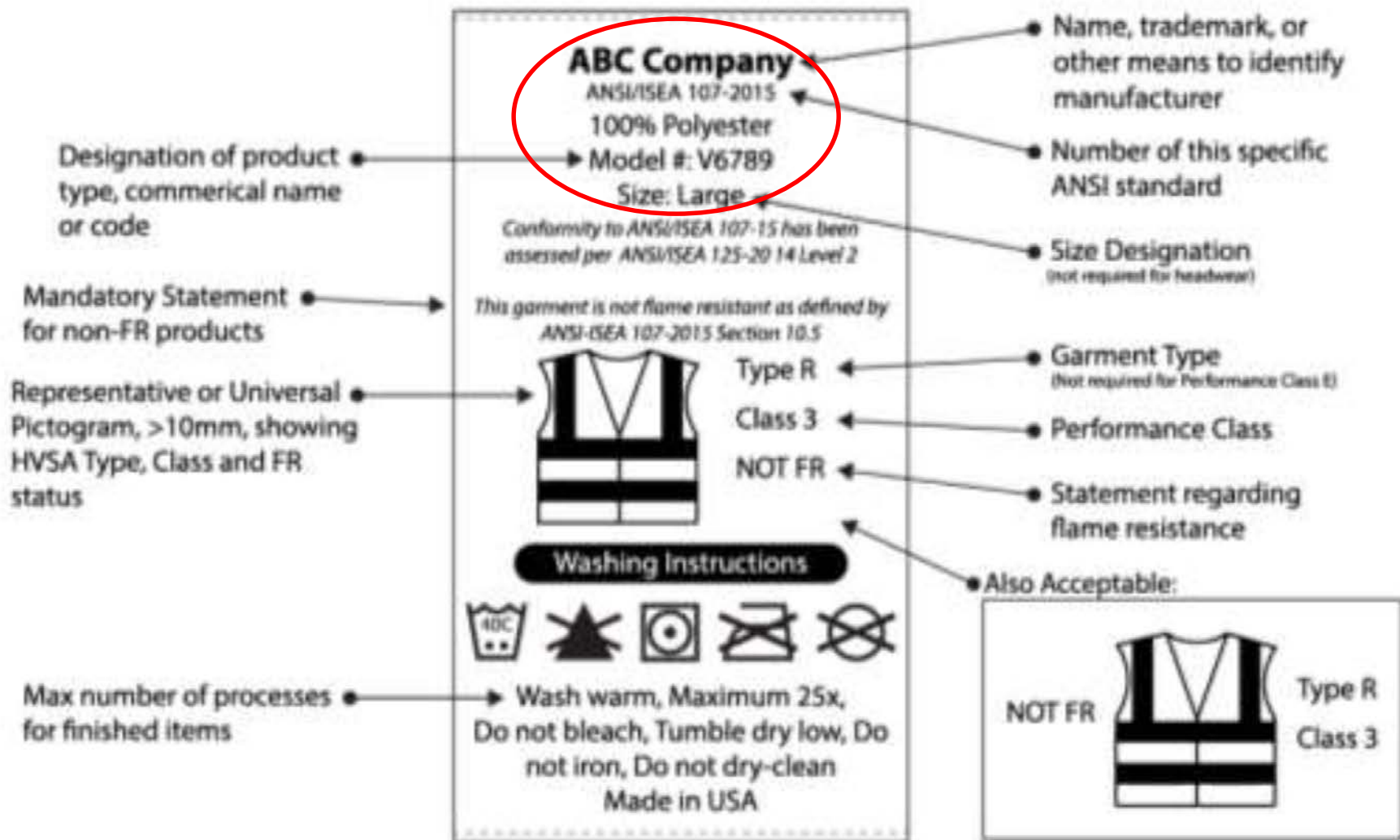
Reflective Vests

OSHA requires all workers who are at risk of injury from traffic or equipment to wear a high-visibility vest.

Others must be able to see the garment from a full 360 degrees.

Must be ANSI Approved





Gloves and Footwear

Protective Gloves:

- Prevents lacerations and burns



Steel-Toed Boots:

- Protect toes from being crushed



Proper Entry and Exit

- Face the machine at all times while entering and exiting
- Maintain three points of contact at all times!
- Keep boots as clean as possible
- Keep the steps clean to prevent slips and falls
- **DO NOT** jump out of the truck!



Hurrying to get a job done and taking shortcuts on safety can cost *lives*.

Shortcuts save minimal time and resulting accidents can be devastating.

You just simply can never predict where and when an accident might occur.

NEVER put deadlines ahead of *Safety!*



Looking Before Backing

This may sound easy, but operators in a hurry do not look before they back

Excuses for this vary from:

- "There's nothing there, I can go"
- "There is nothing in my mirror"
- "Can they hear my back horn?"

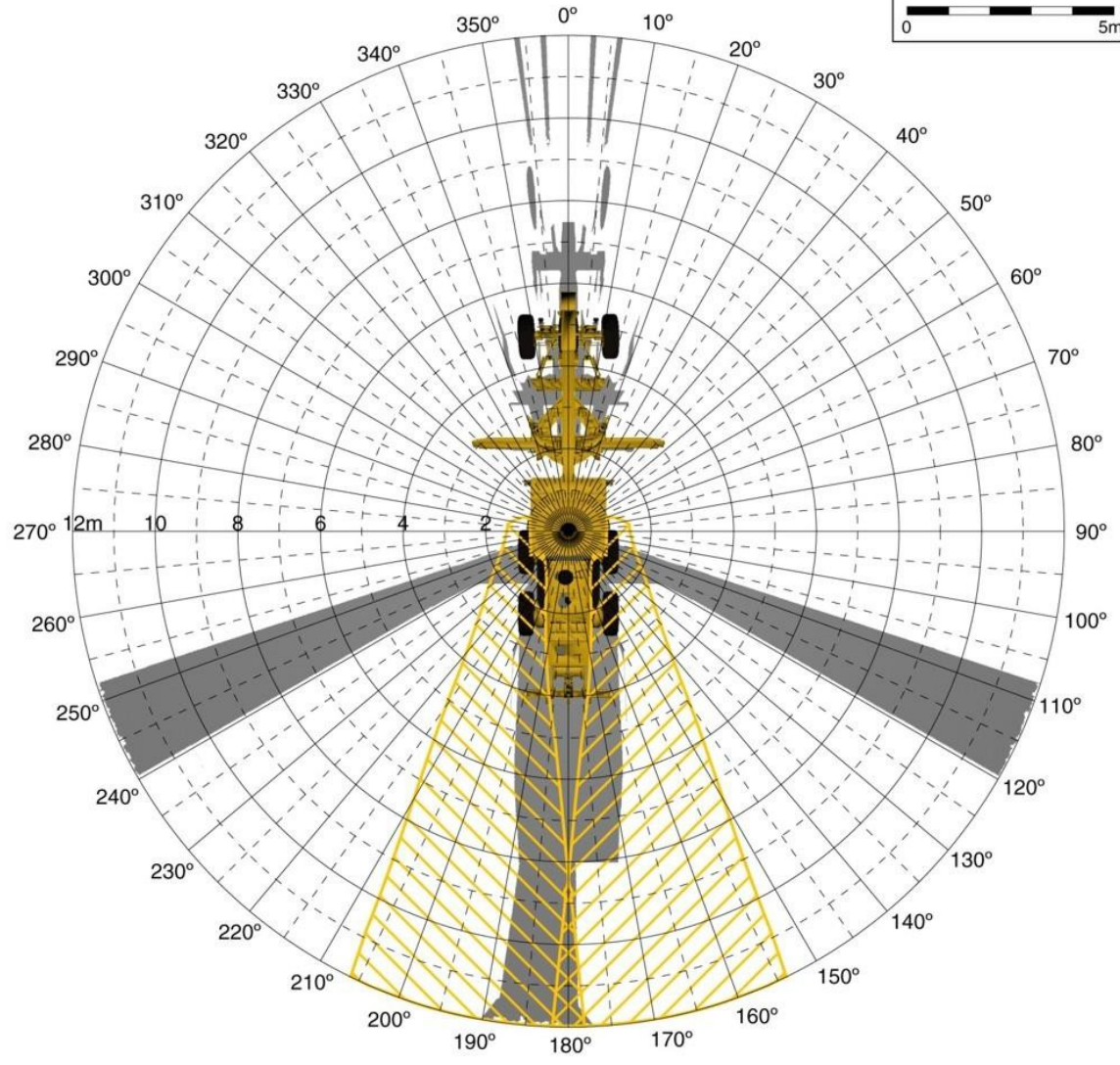
No EXCUSE IS VALID!!!

Cat 12G
1500 mm Level

Blind Area
Mirror Visibility

Scale
0 5m

Know Your Blind Spots



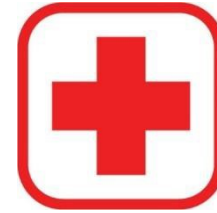
Properly Flagged Machine

Safety





FIRST AID



*A FIRST AID KIT is required by law
to be on site at ALL times!*

- First aid supplies must be adequate and should reflect the kinds of injuries that occur.
- Must be stored in an area where they are readily available for emergency access.



Equipment Preventative Maintenance – It's Your Job



Equipment Preventive Maintenance

- Reduces possibility of machine breakdown
- Saves money on repairs [labor and parts]
- Saves time [loss of production]



Equipment Preventive Maintenance

- Reduces loss of power [machines in need of maintenance may be sluggish]
- Increases operator's safety

Record Keeping

Material that provides official information or evidence or that serves as a record.

- Valuable defense proof in event of litigation and complaints
- Aids in planning upcoming work
- Aids response to questions from the public.



Record Keeping

- Could be admissible evidence in a court case
- Accountability tool for supervisors and managers
- Data for budget and resource request
- Data to support continuous improvement efforts



Clean The Machine Regularly!

- Remove any grease, oil or debris buildup to maintain a healthy machine and prevent damage
- Don't forget to clean the work area around the grader as well



Cab Inspection

Check windows and keep cab clean of excess junk.



Fire Extinguishers

There must be a mounted fire extinguisher with a current inspection date displayed within the grader.

It should be **ABC rated** and **fully charged**.



Engine Compartment Check

- Check brake fluid for leaks around master cylinder, lines and reservoir
- Check coolant system hoses for bulges, wear, cracks, leaks, and connections at the clamps

Fluid Checks

- Oil
 - Should not be dirty or gritty
- Coolant
 - Should be above the baffles and clean. Check reservoir.
- Brake Fluid
- Hydraulic Fluid
 - Should be a light gold color. Check with a sight glass

Battery Hazards

- **Sulfuric Acid** – Small amounts can cause severe contact burns to the skin.
- **Gases** – Batteries produce hydrogen and oxygen mixture continuously. Keep all ignition sources away.
- **Electricity** – Batteries are capable of producing very high discharge rates. Avoid direct shorting situations.

Battery Explosions

- Battery gas can explode. Keep sparks, flames, and other ignition sources away from the top of the battery.
- Never check battery charge by placing a metal object across the posts, use a voltmeter.
- Never charge a frozen battery; it may explode. Warm battery to 16°C (60°F).

Refueling

- Most grader filler caps are equipped with a venting device and a fuel screen
- The screen serves as a fire retardant device by keeping fire out of the fuel tank
- Check when refueling to make sure the screen is in place

Refueling

- **Safe refueling checklist:**

- Refuel in designated areas with good ventilation
- Smoking and open flames are prohibited
- Lower the attachment, controls in neutral, and set the parking brake before beginning
- Don't overfill the tank
- Clean up any spills





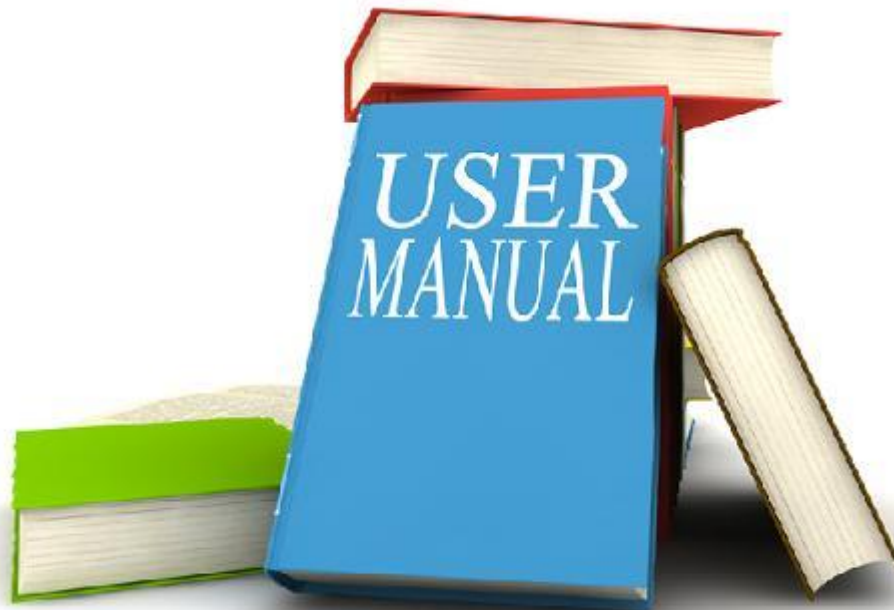
Exhaust Fumes

- Engine exhaust fumes can cause sickness or death from carbon monoxide.
- If you must operate in a building provide adequate ventilation.
- Open doors and windows to bring outside air into the area.

On the Move Inspection

- Begin by rechecking all gauges before moving to ensure everything is running normally.
- Check the free play in the transmission and for signs of slippage (forward & reverse).
- Test both the parking brake and the service brake (grader should not veer off to one side).
- Make sure backup alarm is audible

Before operating any equipment –
ALWAYS be sure to read and understand the
operator's manual specific to the machine you



What Are Your Road Issues?



Road Issues Discussion

PRINCIPLES OF A



GOOD ROAD

Principals of a Good Road

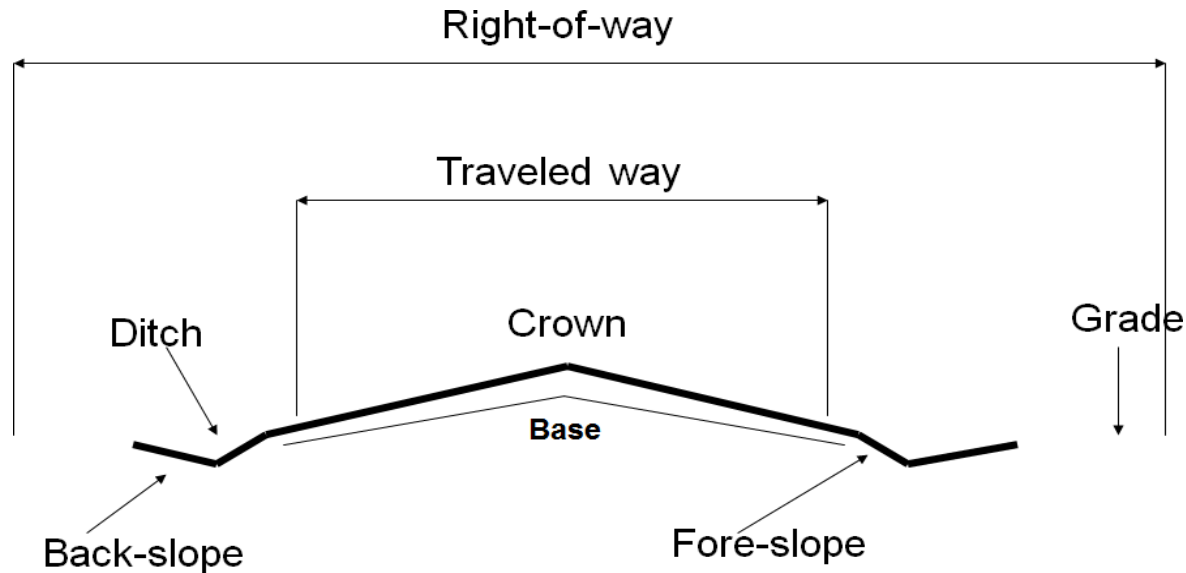
- Good Profile
 - Without it, there will not be good drainage
- Good Drainage
 - Without it, there will not be a proper profile



Cross-Section

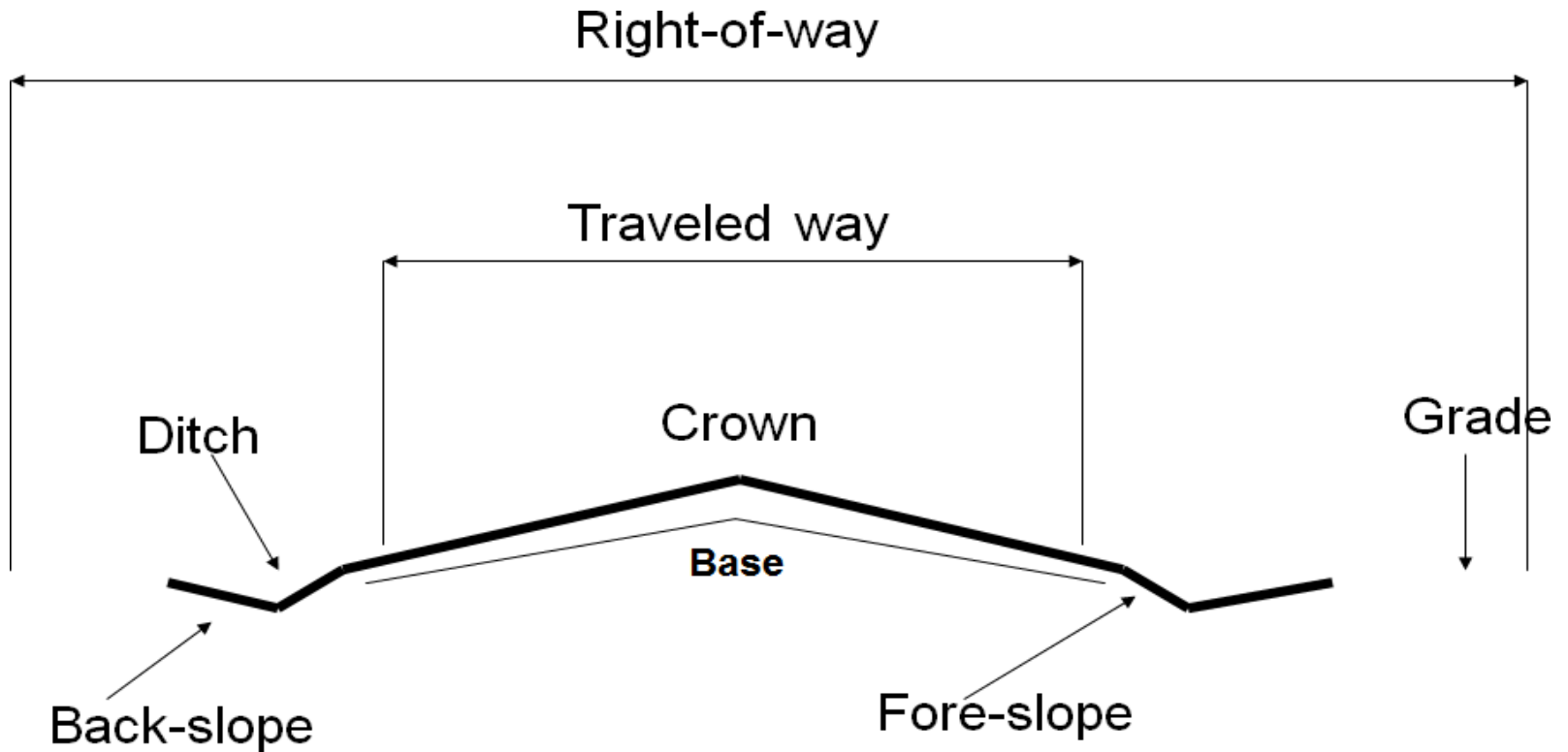
Maintaining Gravel Roads

- Understanding correct shape of the roadway cross-section is the most important knowledge an operator can possess.
- Gravel roads constantly change shape!!! Operators and supervisors have to deal with this.



Principles of a Good Road

- Good cross-section = good drainage

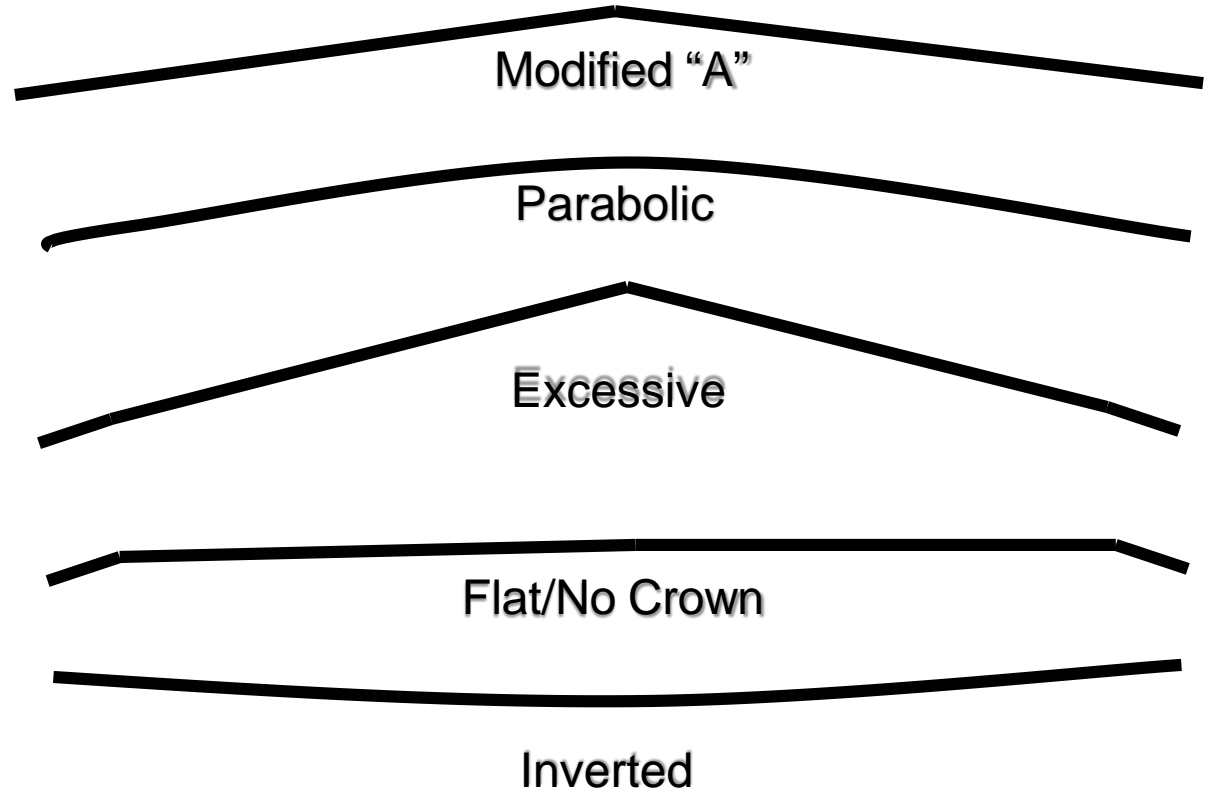


When looking at your road don't just look at the road top look at the entire cross-section. You need to get the water away from the centerline to the shoulder to the ditch and away from the road.

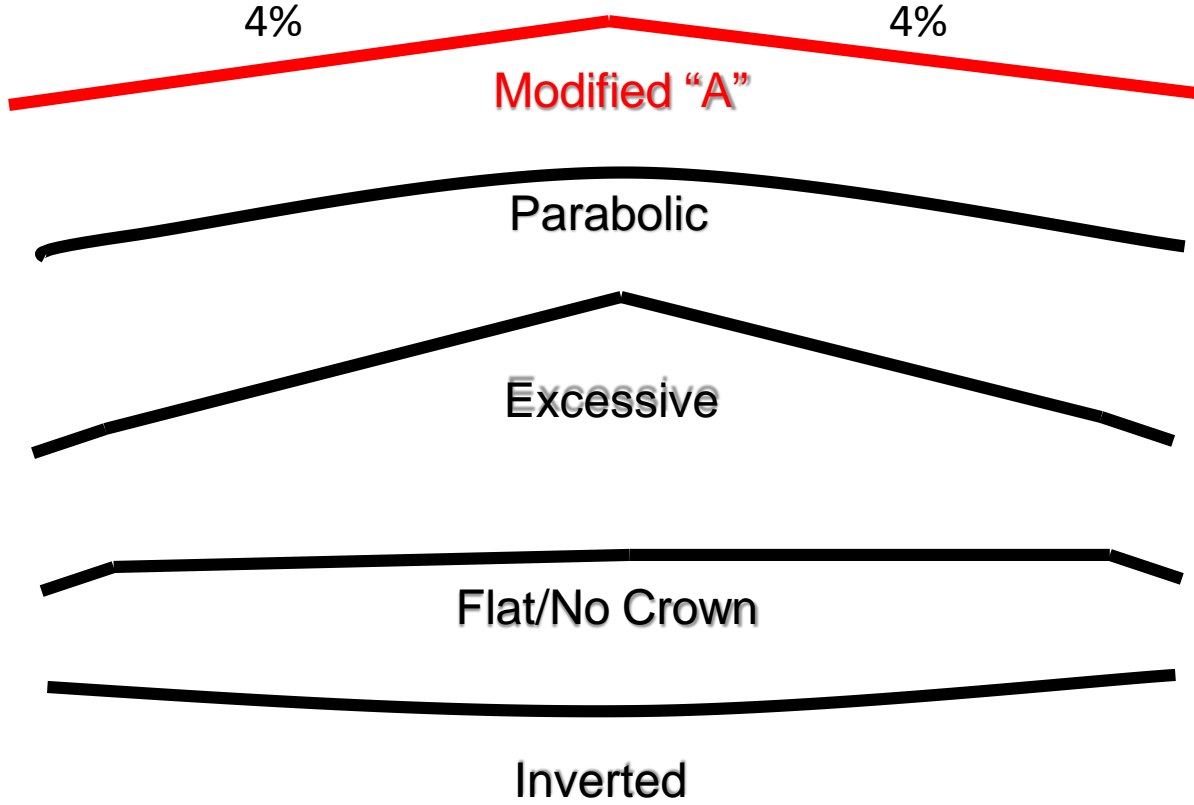
The Road and its Surroundings

- Terrain
- Cross Slope
- Clear Zone
- Drainage
- Ditches
- Bridges/Culverts
- Transitions
- Traffic Pattern Changes

Proper crown and cross slope?



Cross-Section



Cross-Section



- Crown should be at or near $\frac{1}{2}$ inch per foot [4 %]
 - 4% Gravel 2% Asphalt
- Example: 24 ft. roadway should have 6 in. of crown
- Crown should be straight like a roof
- Eliminates flat areas in travel way
 - Which allow water to remain on road surface and cause potholes and other problems

Principles of a Good Road

Straight Blades
Straight Blades
Straight Blades



Straight blades are very important in shaping a road to achieve the **modified A shape**

Principles of a Good Road



Cupped blades one of biggest issues in road maintenance

Dry maintenance on a road with improper crown caused cupped blades

Cross-Section

Proper Profile

- Modified A
- Target 4%
- Straight blades



Cross-Section

Proper Profile

- Roof top
- Keep edge

Straight Blades!!!

Picture on bottom was taken after about ten days when road was bladed on top picture.

Road receives about 200 adt and had gotten approximately 6 inches of rain over 7 days.



P
r
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b
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R
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a
d



Parabolic crown has a **flat circular contour**, **drains poorly** and gravel tends to get displaced from center of road.

Water tends to run along the roads center and **weaken the road** in the process.

Parabolic crowning develops during blading because of motor grader moldboards that have edges that are worn or cupped in the middle.

Cross-Section



Actually an inverted crown

Doesn't allow water to run off the road but actually channels it towards the center and holds it in the traveled way.

When you have higher shoulders than the road you don't have a road you have a canal.

Cross-Section



Flat crown

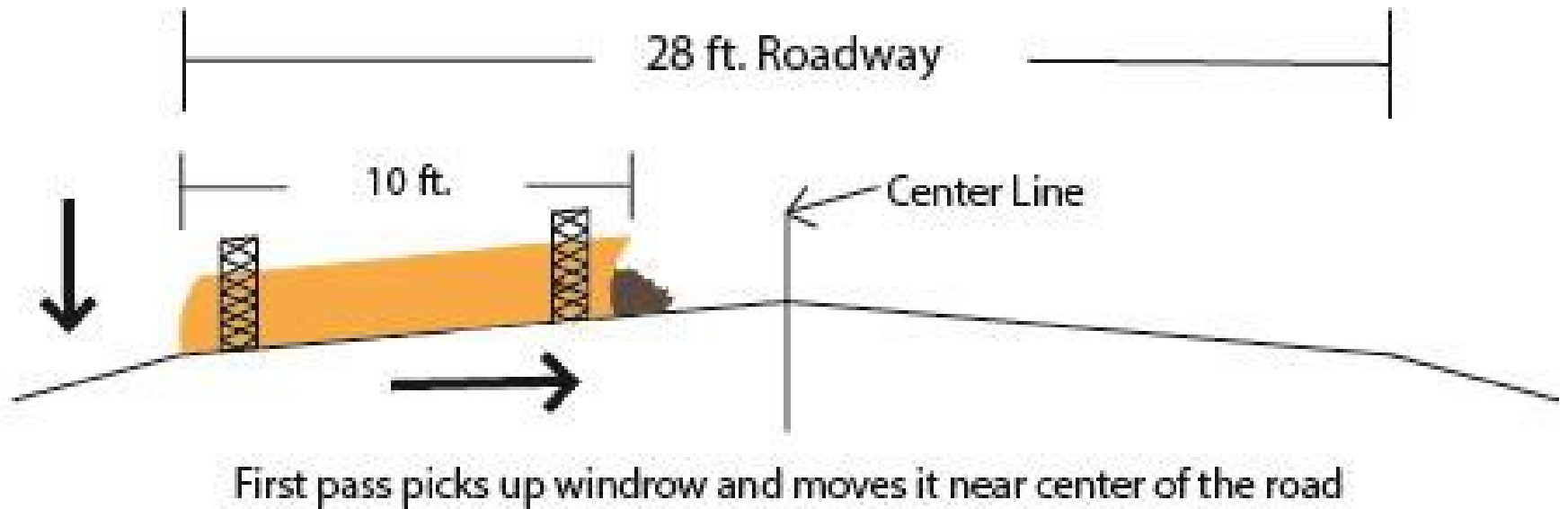
Really has no crown at all, it allows for little or no drainage

Maintaining Gravel Roads

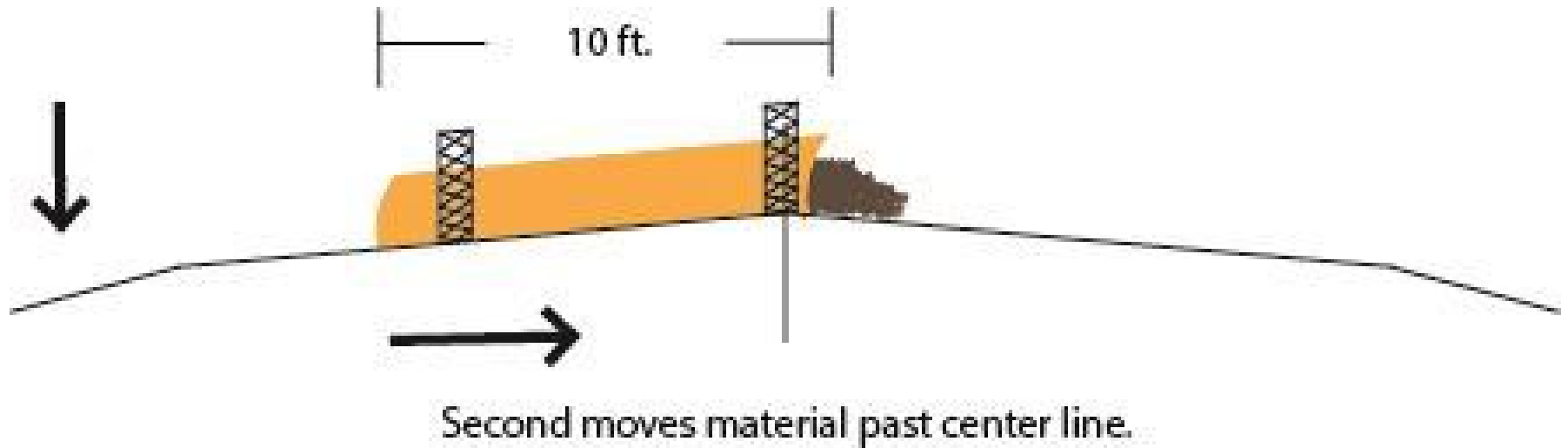
Important things to understand about the use of the motor grader:



- Moldboard Angle
- Moldboard Pitch
- Motor Grader Stability
- Operating Speed
- Articulation
- Windrows



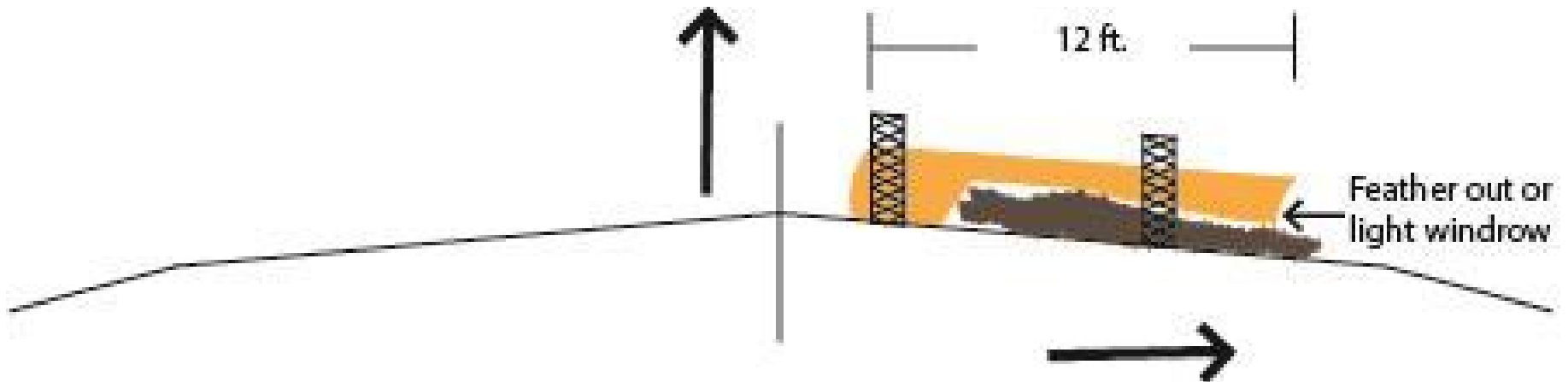
Pass 1 – from the right shoulder to the lane up the slope of the crown.



Second moves material past center line.

Second pass takes the material across the ridge of the crown.

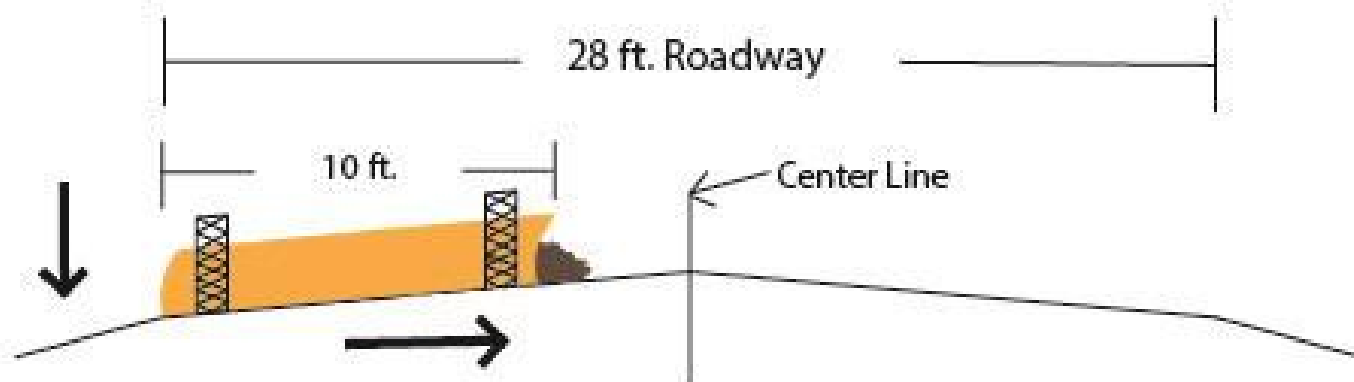
When carrying windrow across the centerline will actually have a gap under the heel of the blade that is over the center of the road be careful not to cut center out of the road.



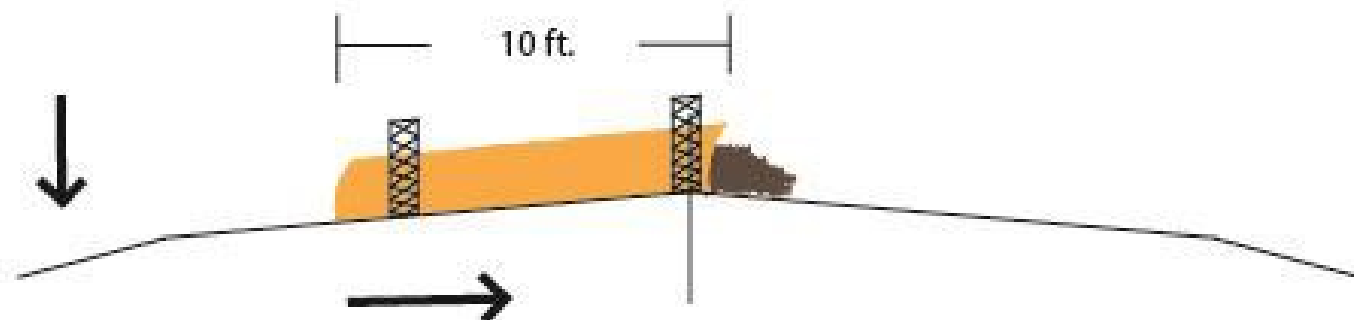
Third pass brings windrow to opposite shoulder.
Gives 24 ft. of smooth driving surface.

Lastly you move the material to the opposite shoulder while shaping to ideal crown slope. Notice the gap underneath the toe of the machine on this pass instead of the heel.

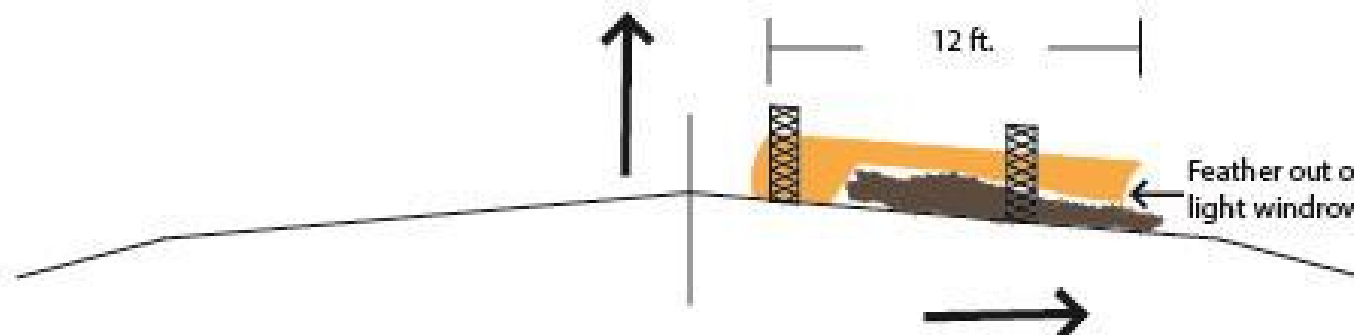
It is like cutting a modified X be careful not to cut centerline



First pass picks up windrow and moves it near center of the road



Second moves material past center line.



Third pass brings windrow to opposite shoulder.
Gives 24 ft. of smooth driving surface.

Setting Machine

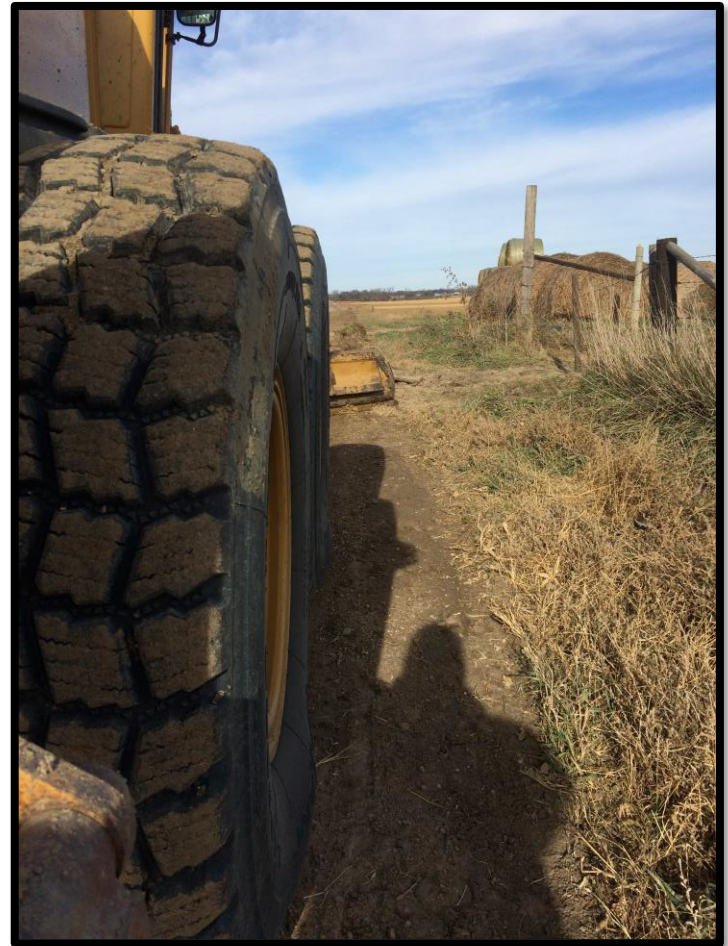
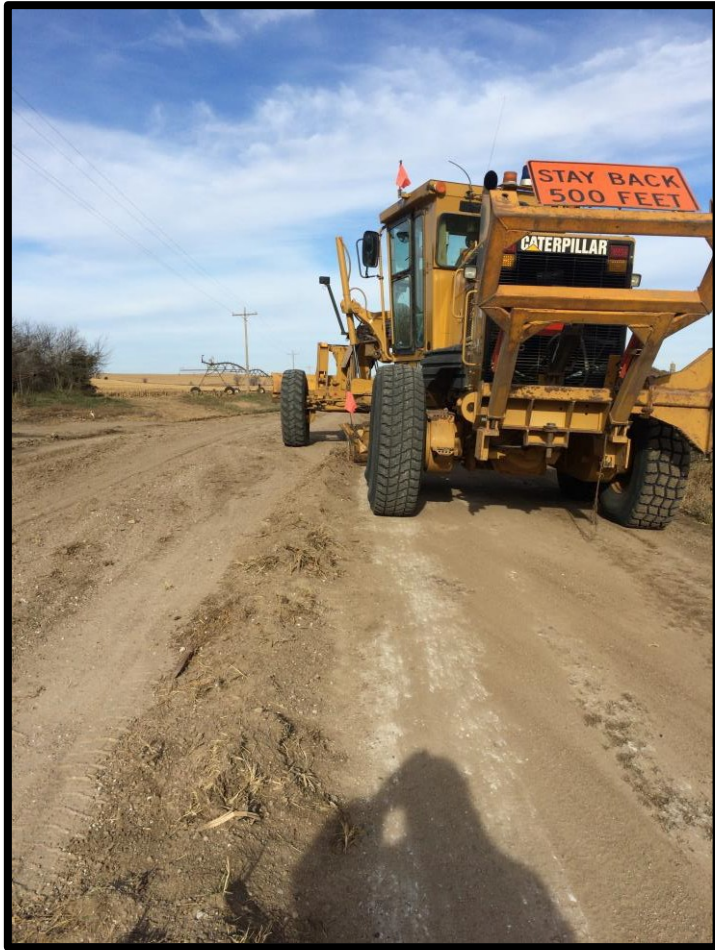
Articulation

- True cross slope
- Wider compaction area
- Shoulder compaction
- Lay material on edge
- What is taken away must be put back

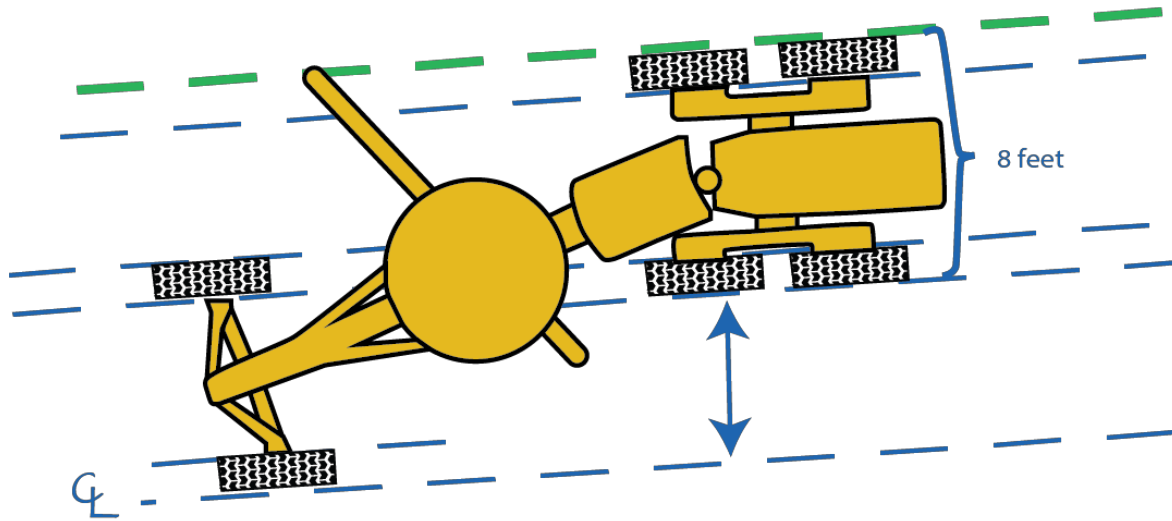


First Pass

Moldboard Set Up



First Pass



Aerial view of machine, notice how rear tandems ride the shoulder for compaction and the front wheel is on the centerline.

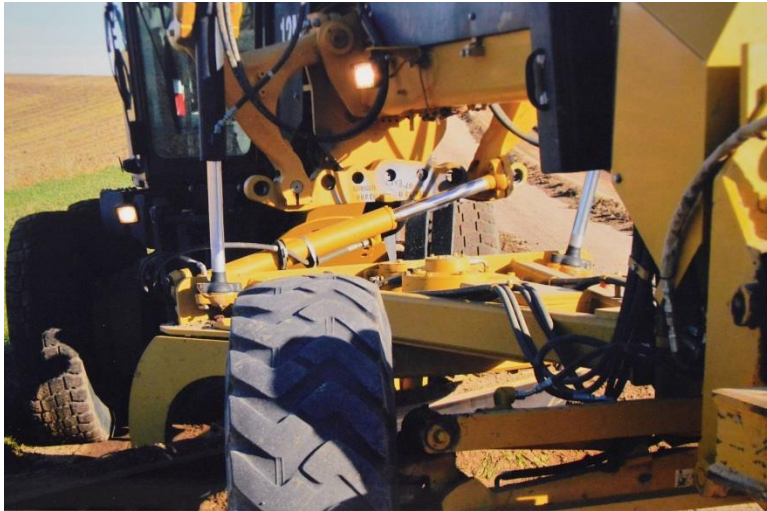
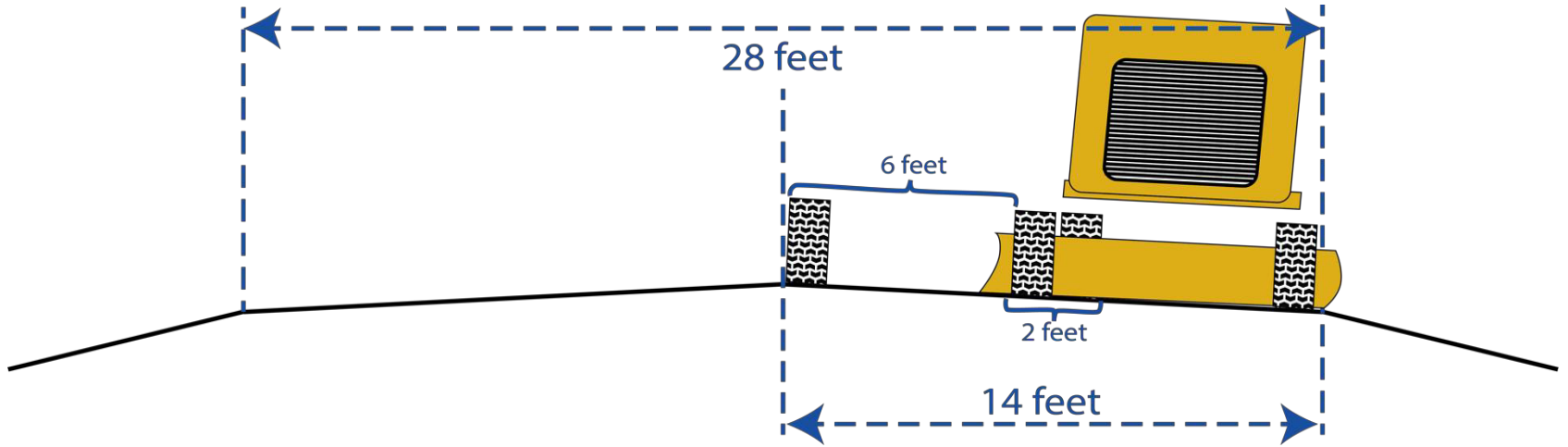
Articulation

Articulate so right front wheel is riding inside the left set of tandems.



Articulation

First Pass



Notice how the front tire sits right inside the tandems

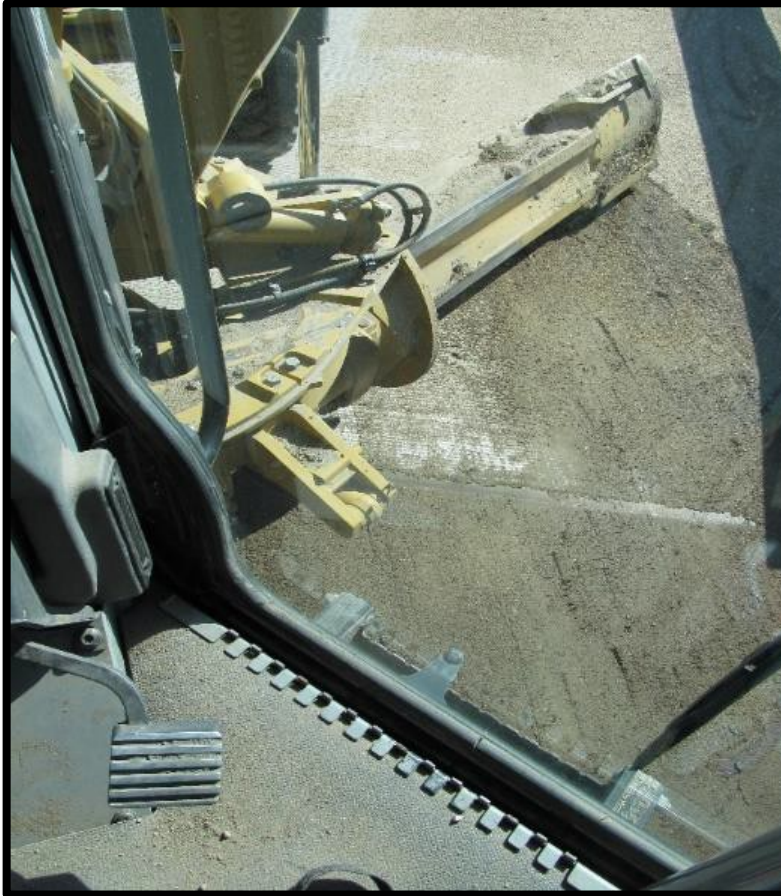
Operator's View When Articulated

First Pass

- Increased visibility
- Go straight
- Moldboard pitched to create rolling action
- Angled to prevent material loss

Articulation

- Maneuver around objects
- Maintain straight path



First Pass

Be aware of dead weight on bridges!



First Pass

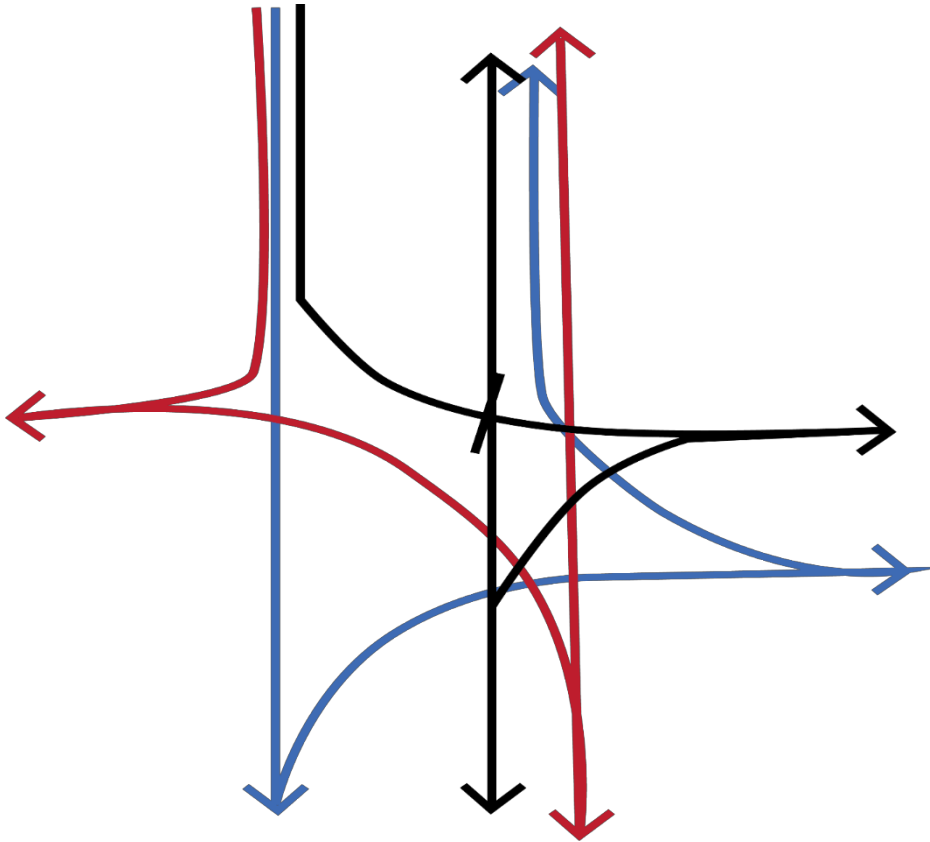
Beware of Dead Weight





What do you see here?

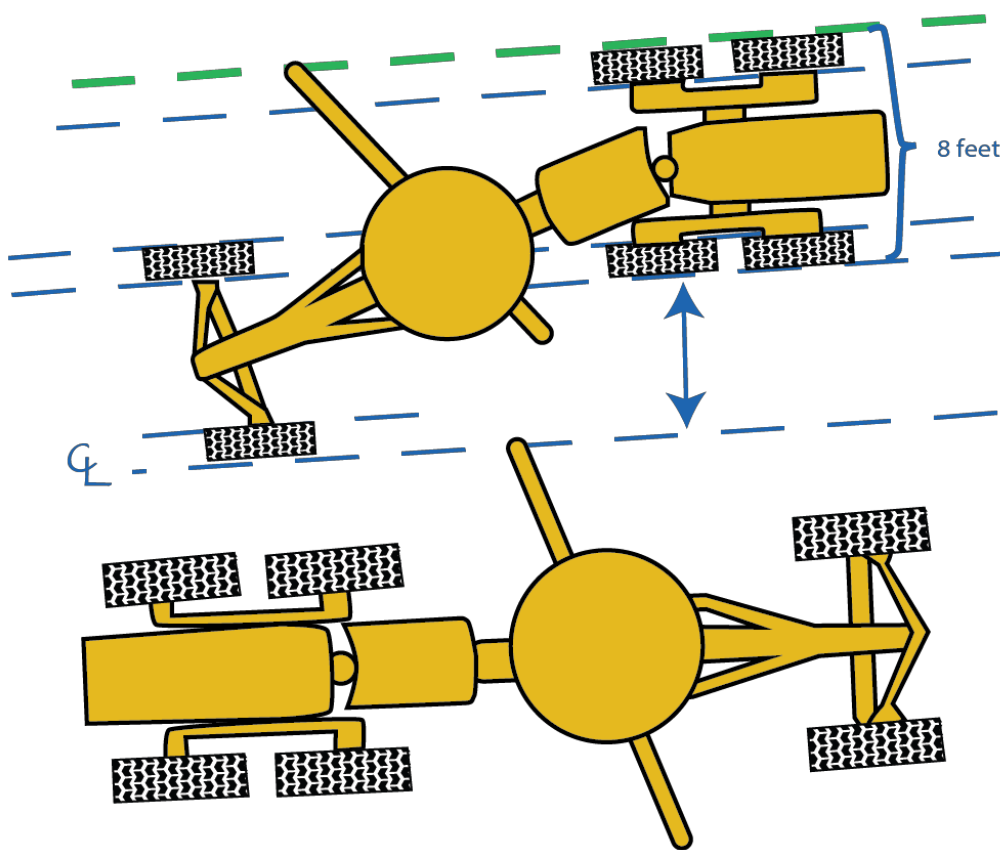
Intersections



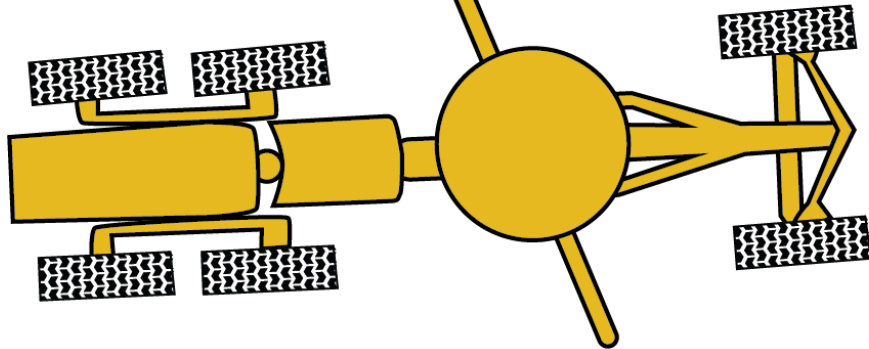
First Pass



First Pass



Second Pass



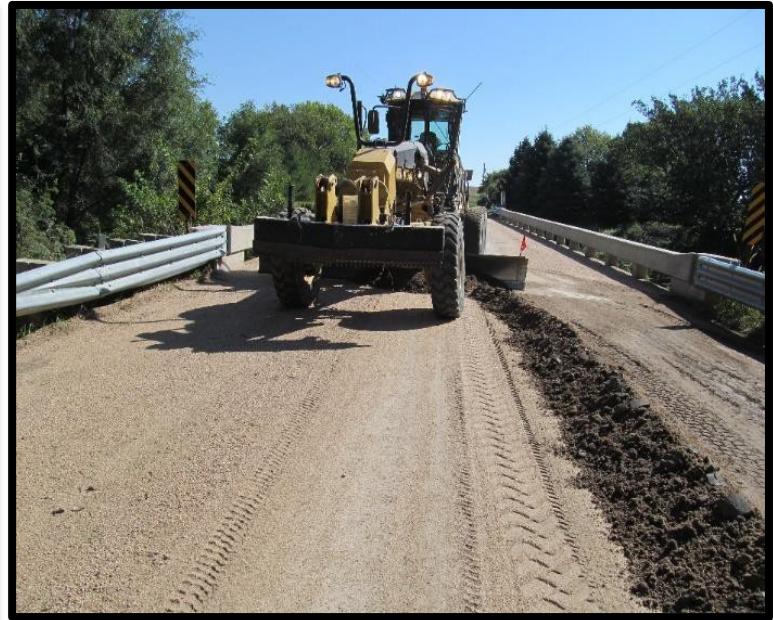
On this intersection the operator fans the material back when starting second pass to keep intersection flat as there is also a bridge that goes across this intersection basically you are square blading the material back which keeps intersection flat and material from piling up and builds up road before intersection if humped.

You do the same thing at **bridges** to keep a smooth transition to bridge remember bridges typically carry a 2% and your road should carry 4% you need to adjust for this transition try to carry this transition for a 100ft from bridge deck.

Second Pass

Techniques

- Pick up material and fan it to even out the windrow.
- Fill-in low spots, particularly on intersections.
- Remove excess material from bridges and creating smooth transition to roadway.



Vegetation



- Deadhead
- Light vegetation:
 - Pick up material
 - Shave vegetation
 - Fan to center
- Heavy vegetation:
 - Just like 1st pass



Second Pass

Advantages

- Increases ability
 - Stay on slope
 - Carry load
 - Better stability
- Turn in small area increasing productivity
- Place engine frame squarely behind load
 - Providing better leverage
 - Handle heavier loads
 - Counteract side thrust

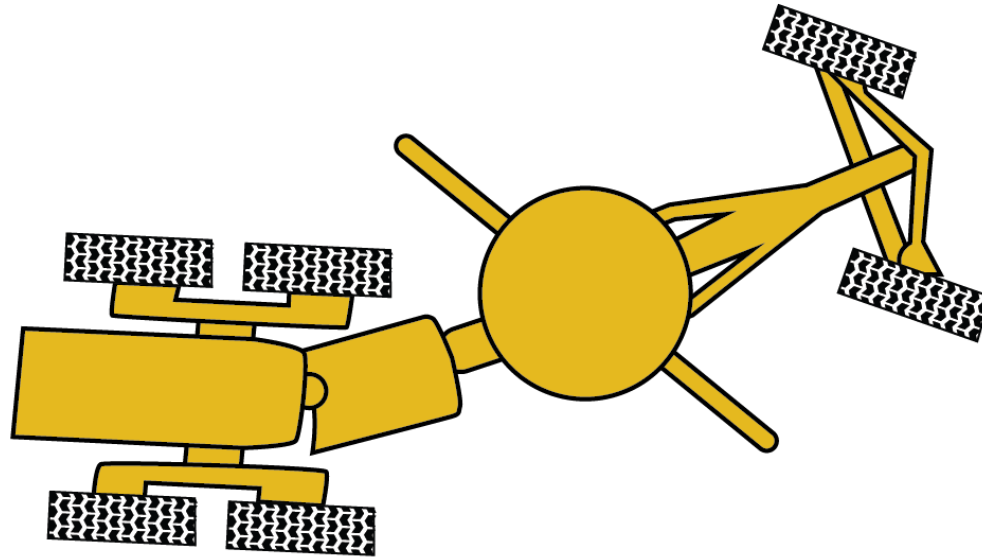
Articulation

Advantages

- Increased blade reach
- Easier steering in reverse
- Maneuverability when stuck
- Place tandems on good traction

Where are other uses for articulation?

Articulation



Blade Pitch

Moldboard Pitch or Tilt: the angle the moldboard is tipped forward or backward

- Rearward for more aggressive cutting
- Forward for light blading or dragging action



Blade Angle

Moldboard Angle:

- Should be between 30-45°
- Not losing material off the toe is a good indicator of proper angle
- Angle should not mimic corrugations



Blade Pitch and Angle

Improper Angle and Pitch:

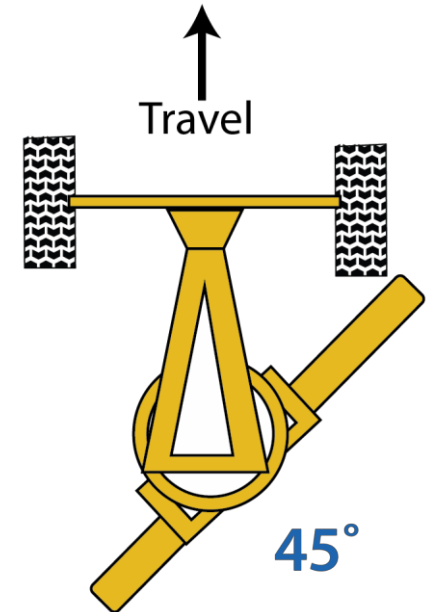
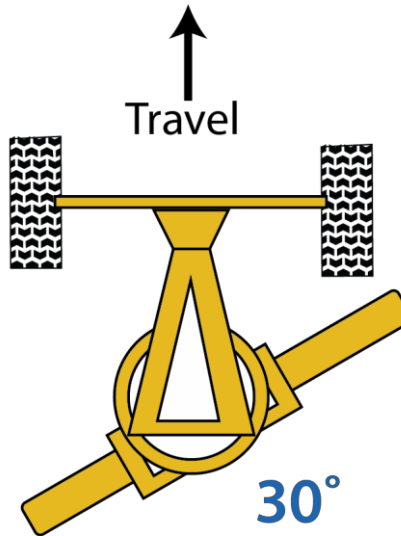
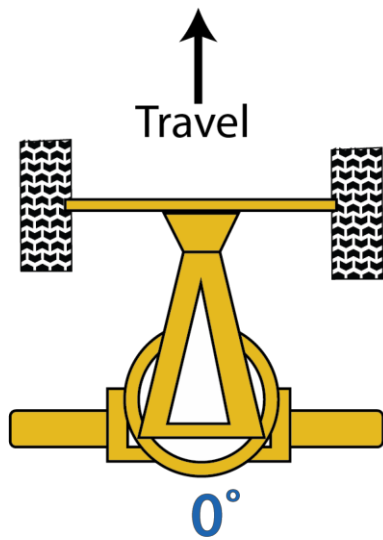
- Creates a big loss of aggregate from the toe of the moldboard
 - Overworks the machine
 - Reduces fuel efficiency
 - Leads to unnecessary wear on machine and operator
- Pitch and angle will vary for different operations performed
 - Pitch and angle varies with types of material, moisture content, etc.



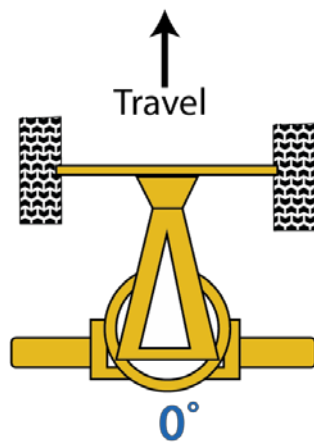
**Which pitch is
correct for
maintenance
blading?**



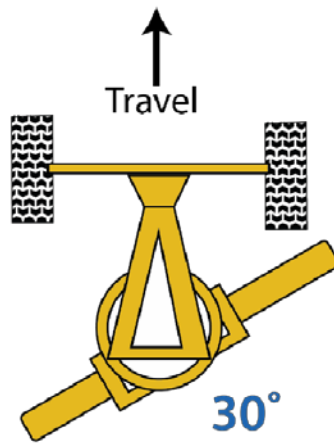
Blade Angles for Road Maintenance



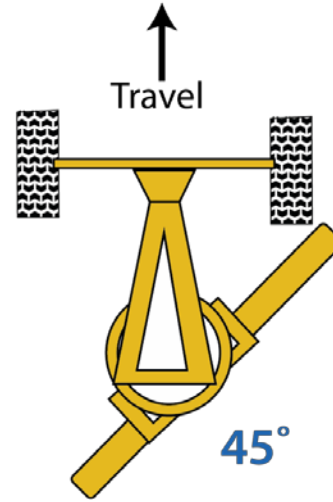
Which blade angle is recommended for travel down the roadway?



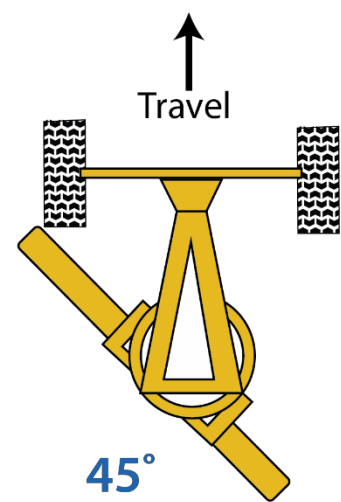
A.



B.



C.



D.

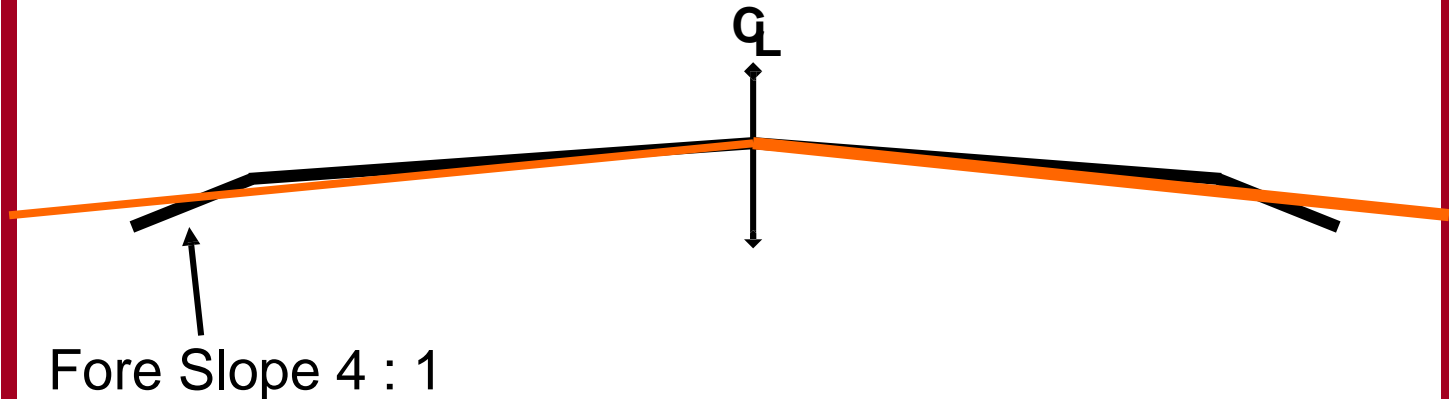
Redefining Your Road

- A look at fore slope
- Retrieving material
- Dust



Frequently Asked Questions

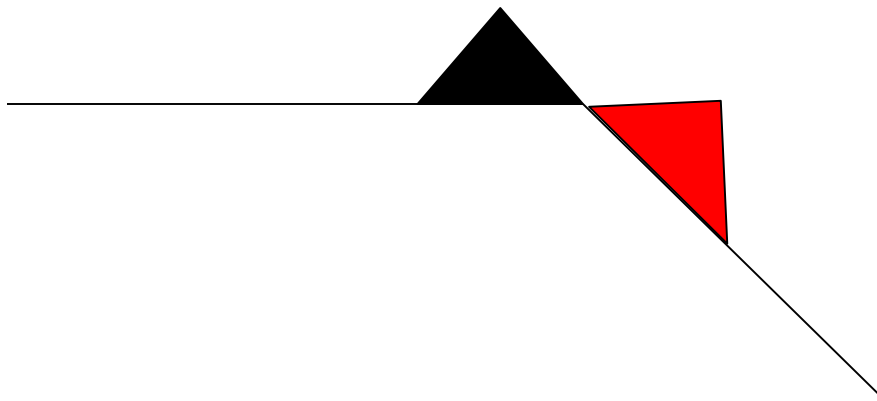
Why are his roads getting so wide?



1 inch cut will widen road 2 inches per side

What is taken away has to be put back

Pinching in



Dust: An Important Piece of the Puzzle

- Dust is a very important component of a gravel road.
- It is the binder that holds the coarser material together the same way cement holds stone and sand together in concrete.
- Big clouds of dust are an indicator of deterioration.



Retrieving Material

Marking Cut?

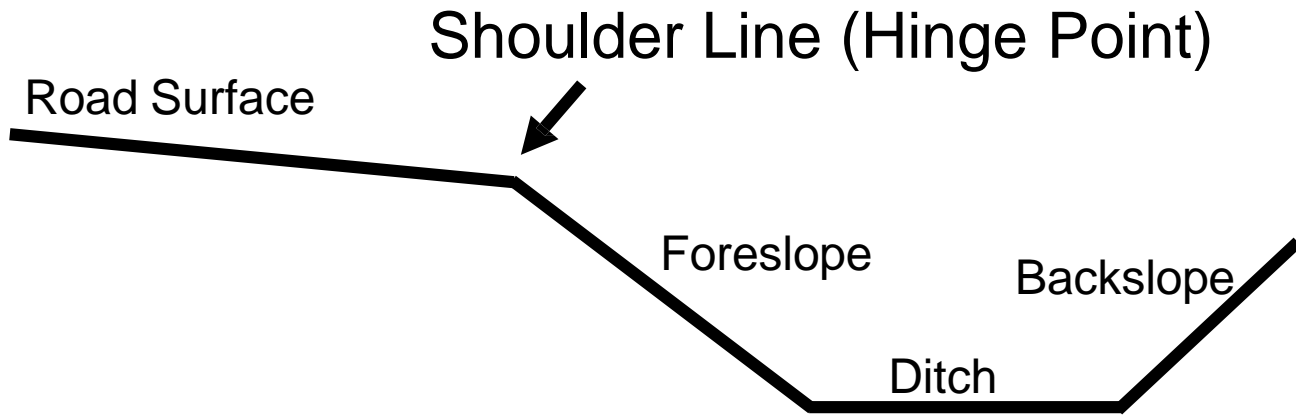


Retrieving Material

Marking Cut?



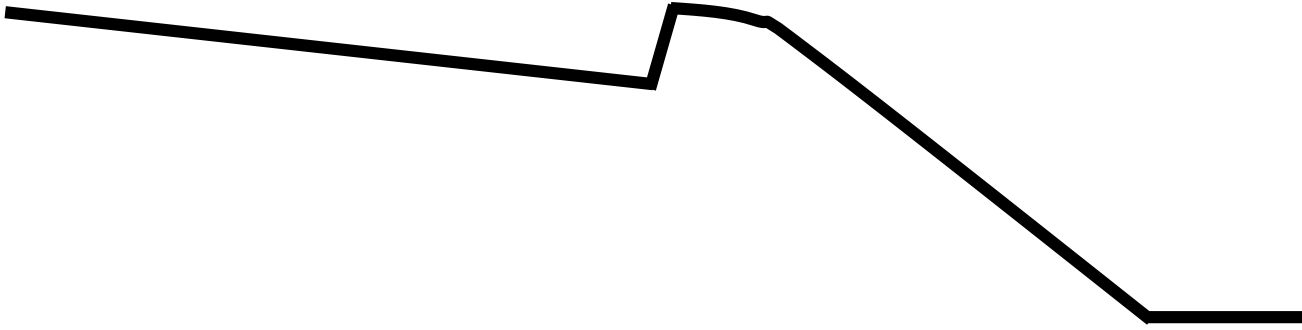
Retrieving Material



Does your shoulder line look like this??

or this →

Retrieving Material



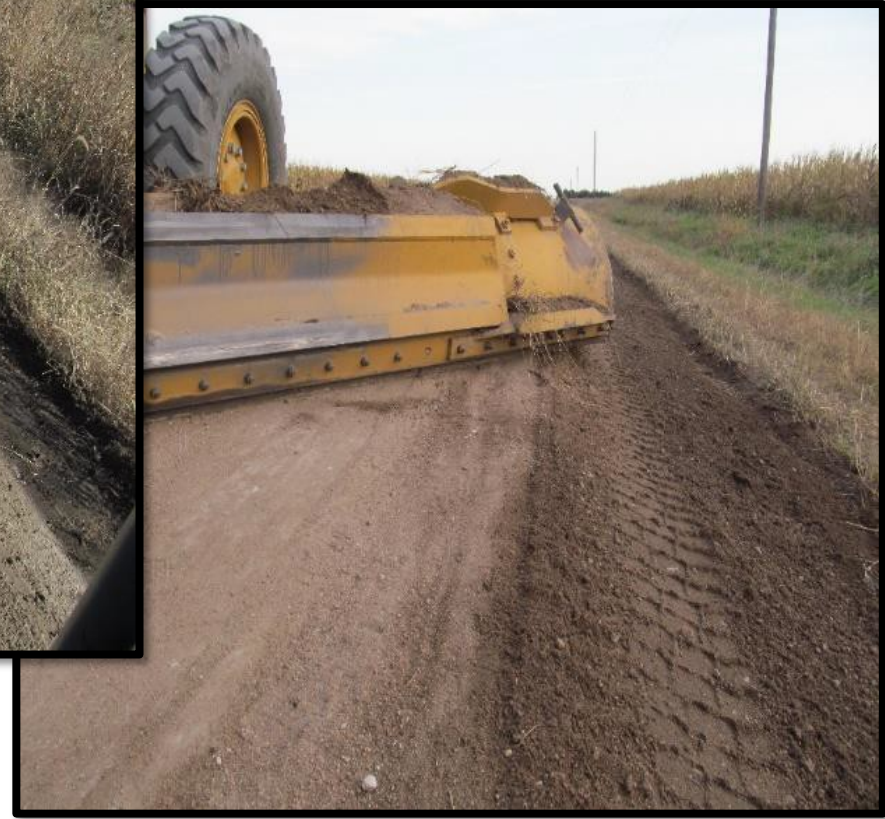
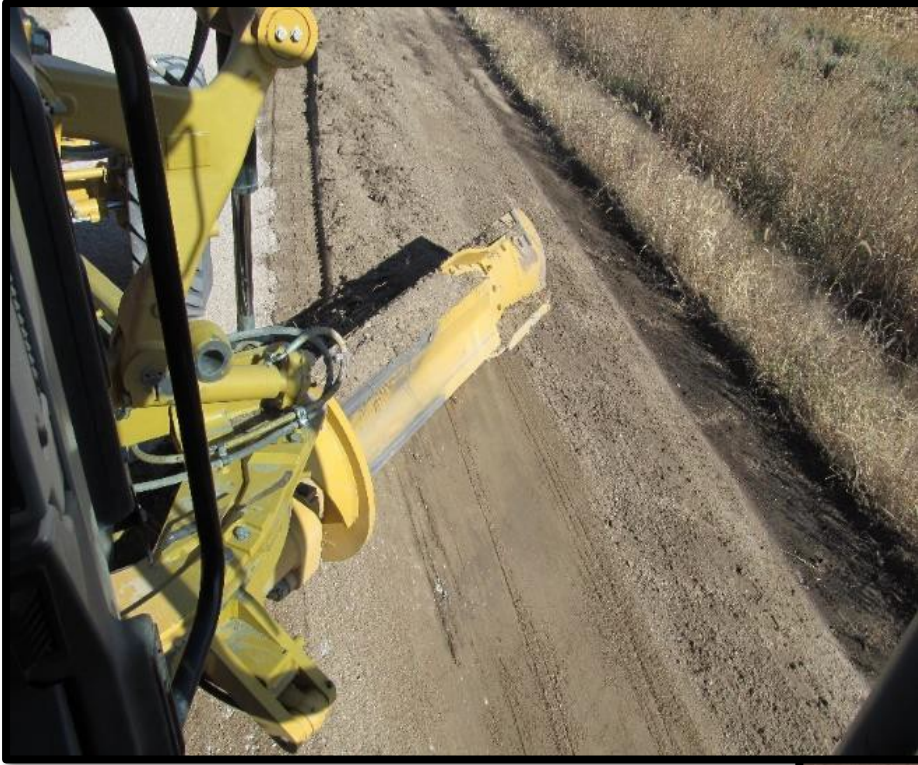
A serious problem that obstructs drainage from the roadway to the ditch.

Fore Slope

- The fore slope should be as gentle as possible to provide a safe exit in case of emergency.
- And, it should provide good drainage and easy maintenance.
- Right of way, soil conditions, elevation, and type of road are factors in determining your fore slope.

Retrieving Material

- Defined edge
- No lip



Retrieving Material



- Smooth transition
- Limit Material



Retrieving Material



Retrieving Material



Retrieving Material



Finished

- Established edge
- No lip
- Good drainage
- Recoverable fore slope
- Cures soft spots
- Reduces weed growth



Retrieving Material



Retrieving Material



One of the Biggest Challenges in Road Maintenance

Crown



How do we fix this?

Crown



Straight Blades

Crown

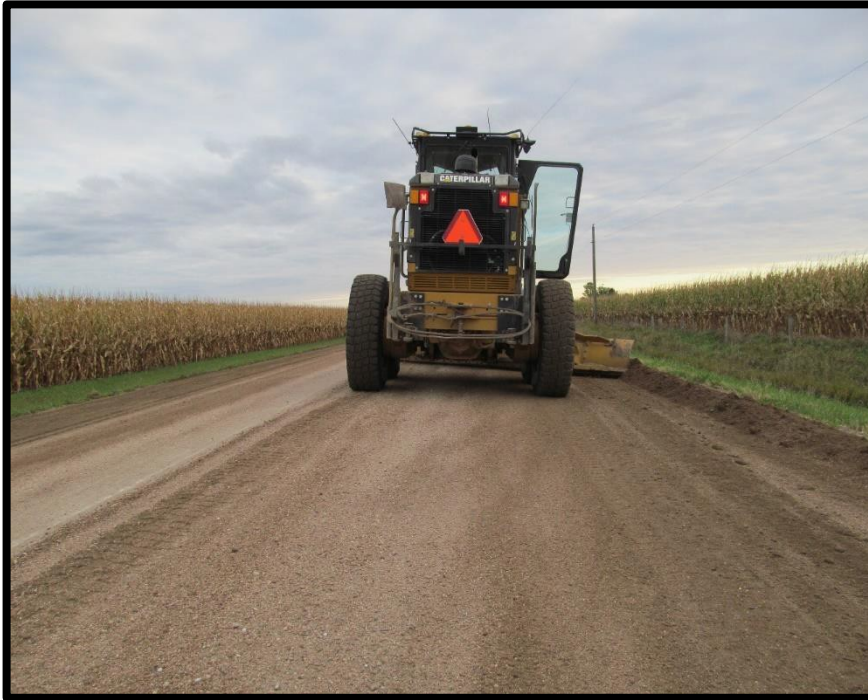


- Retrieve material from edge
- Fan to center



Crown

Good



Excessive



Good or Excessive ?



**Public road should retain crown and
driveway should match the edge**



Simple Fix For Driveways and Intersections



Cut through humped intersections or driveways and smooth lip out on succeeding passes





Shaping the corner leaving the material to work the crown



The return trip on the other side



Flattening the immediate approach to the intersection to match.

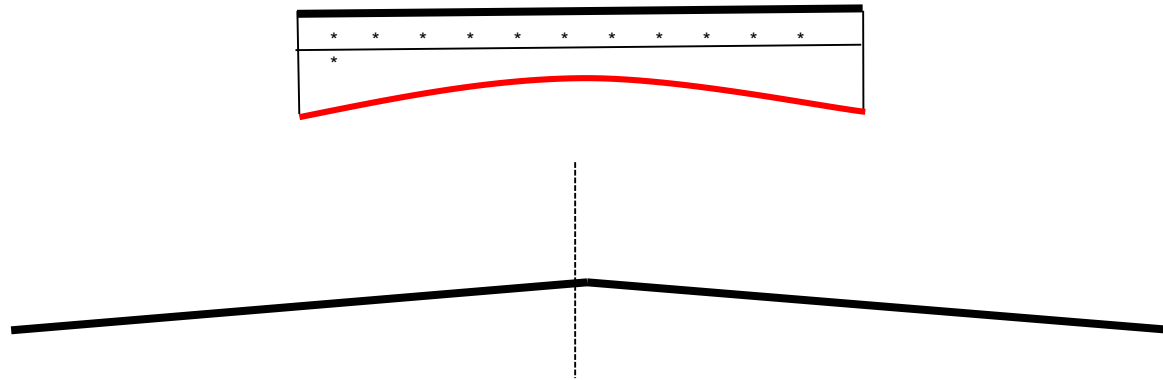


All done – moving on! This technique works well on both humped intersections and driveways.

Proper Operating Speed

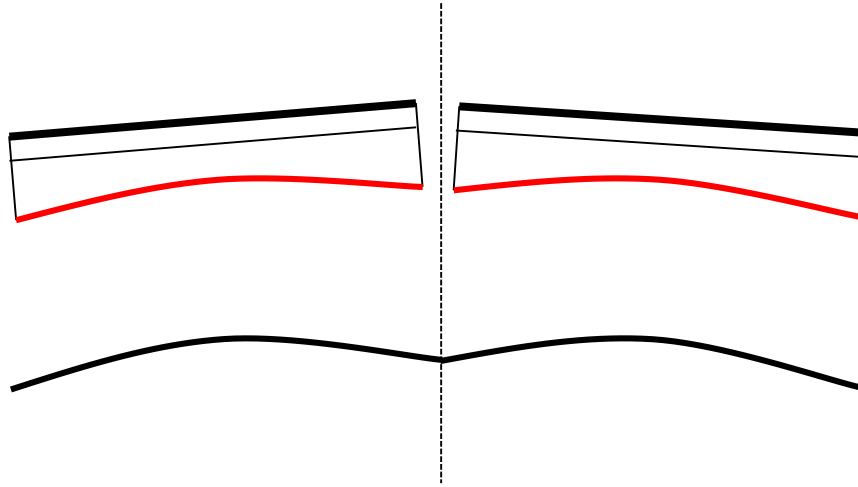
- Operate at a speed that is safe for public, fellow workers, and yourself
- Comparable with operators abilities!!!
- Advancements in machinery and technology
- Task at hand
- Road conditions [wet, dry]
- Weather [wind]

Cupped Blades and how they relate to:



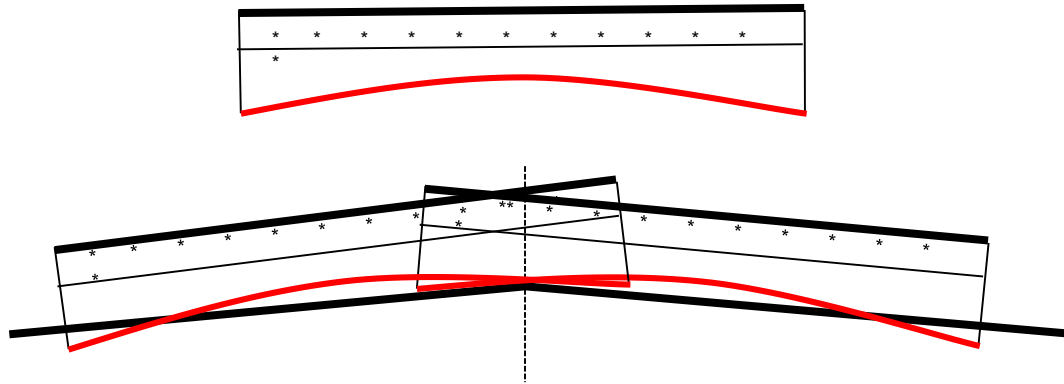
- Quarter crown
- Humped intersections and driveways
- Secondary ditches
- Overall deterioration of road

Two Pass

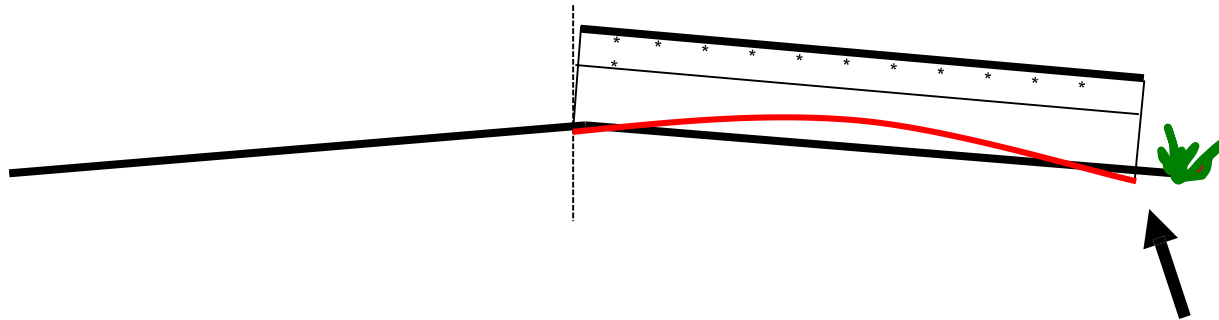


Even if your policy is a two pass policy the bits must not be cupped or you get this with water retainage in the center.

Two Pass in Reality



Cupped Blades and How They Relate to Secondary Ditches







Maintaining Gravel Roads



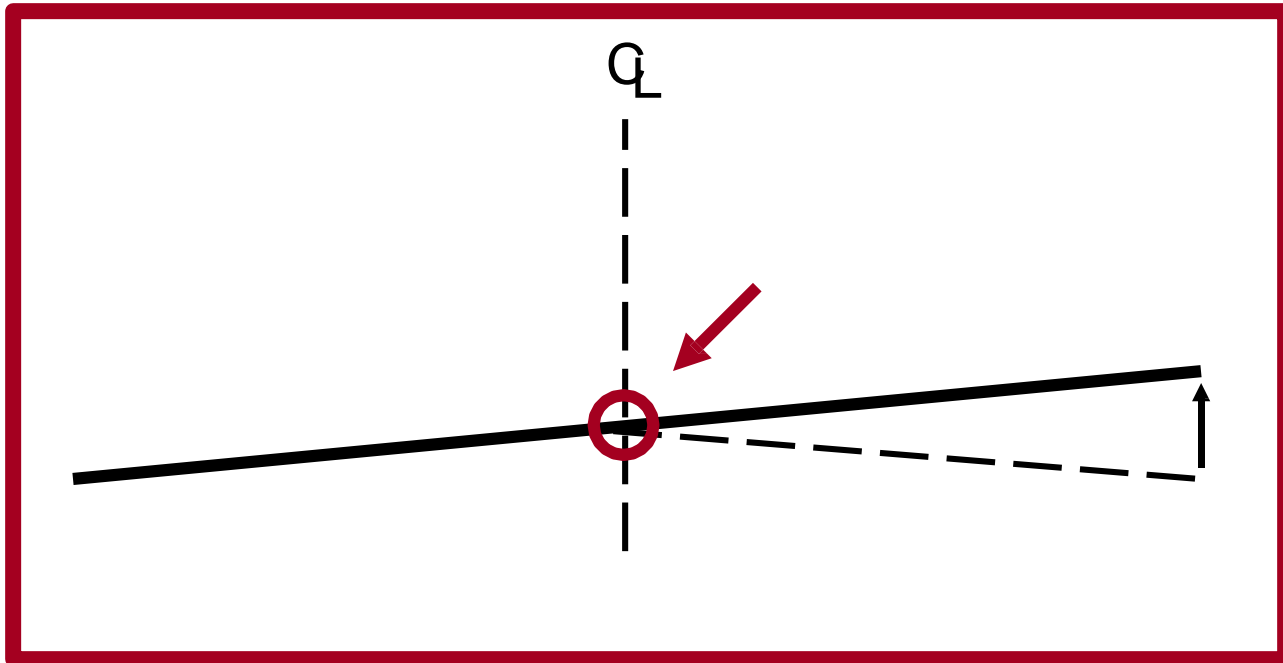
Carbide Cutting Edges
can solve many issues
in maintaining roads.



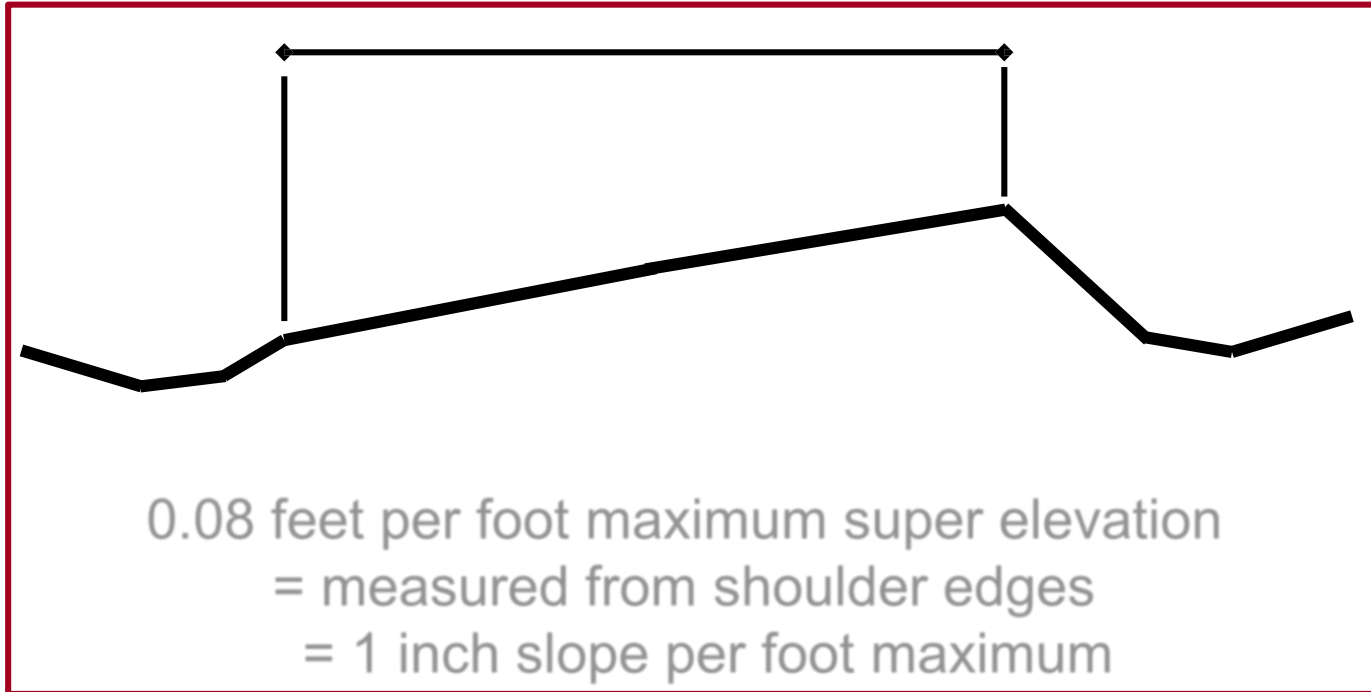
Good Blades ?

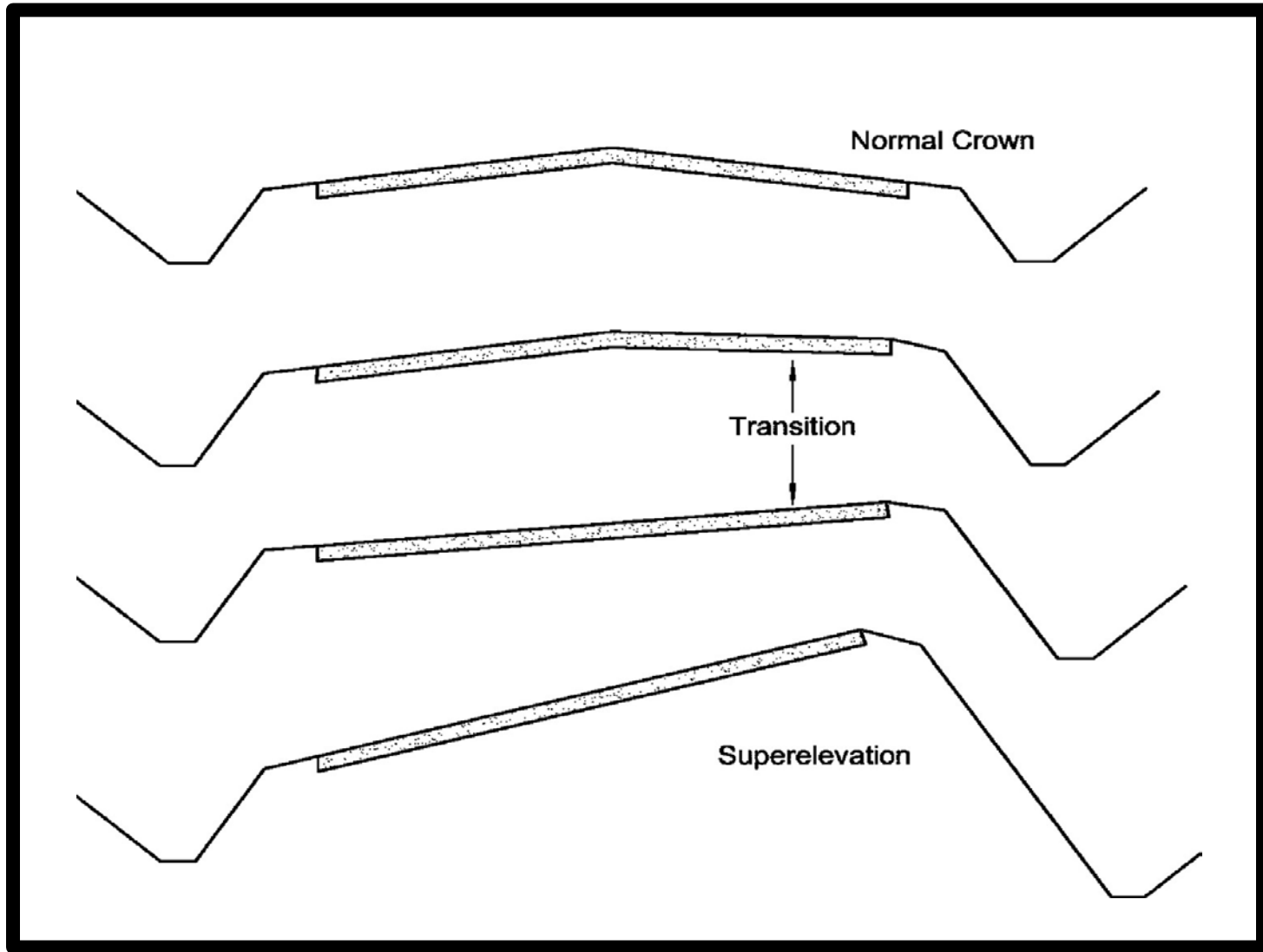


Super Elevation



Super Elevation

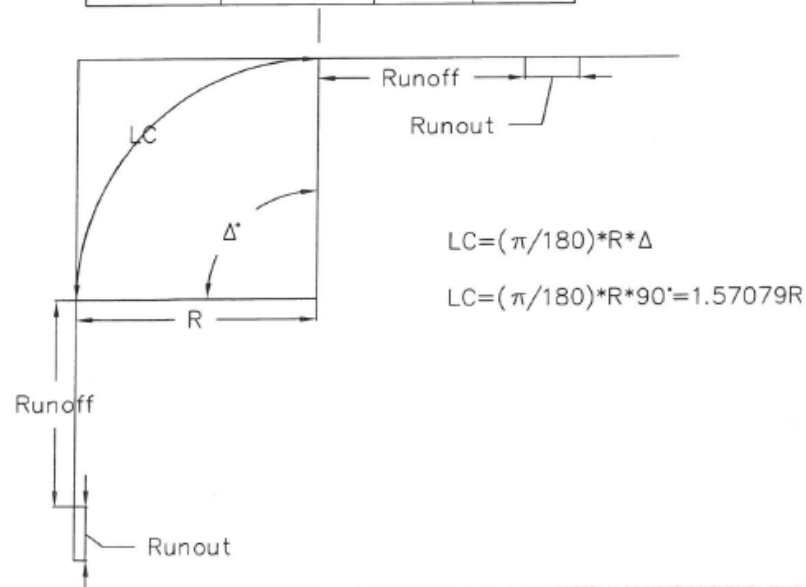




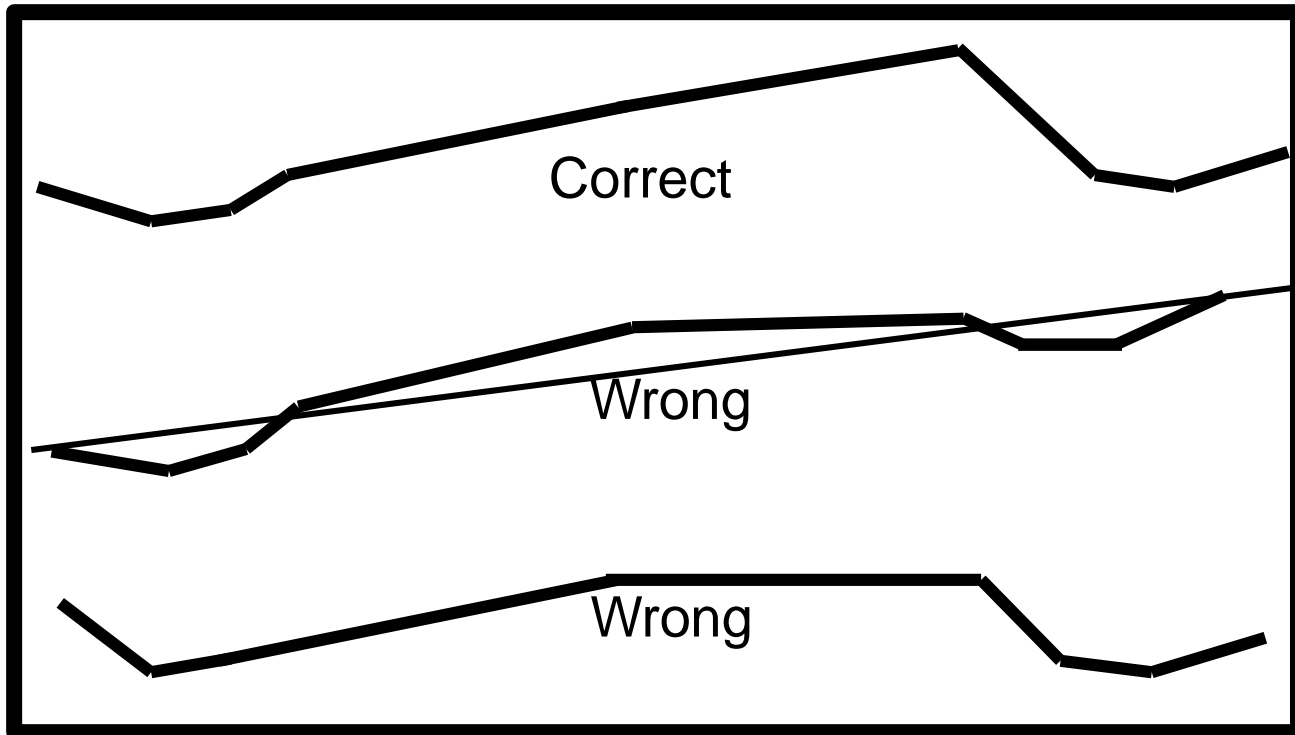
Here is a graphic that demonstrates the transition of a road as it goes into a curve and super elevates the high (outside) side

Superelevation @45mph			
$f \approx 0.150$ $\Delta = 90^\circ$ 2% crown	8%	10%	12%
Length of Curve (LC)	730	668	621
Radius (R)	465	425	395
Runoff	178	222	226
Runout	44	44	44

Superelevation @55mph			
$f \approx 0.140$ $\Delta = 90^\circ$ 2% crown	8%	10%	12%
Length of Curve (LC)	1194	1092	1006
Radius (R)	760	695	640
Runoff	204	256	307
Runout	51	51	51



Super Elevation



This



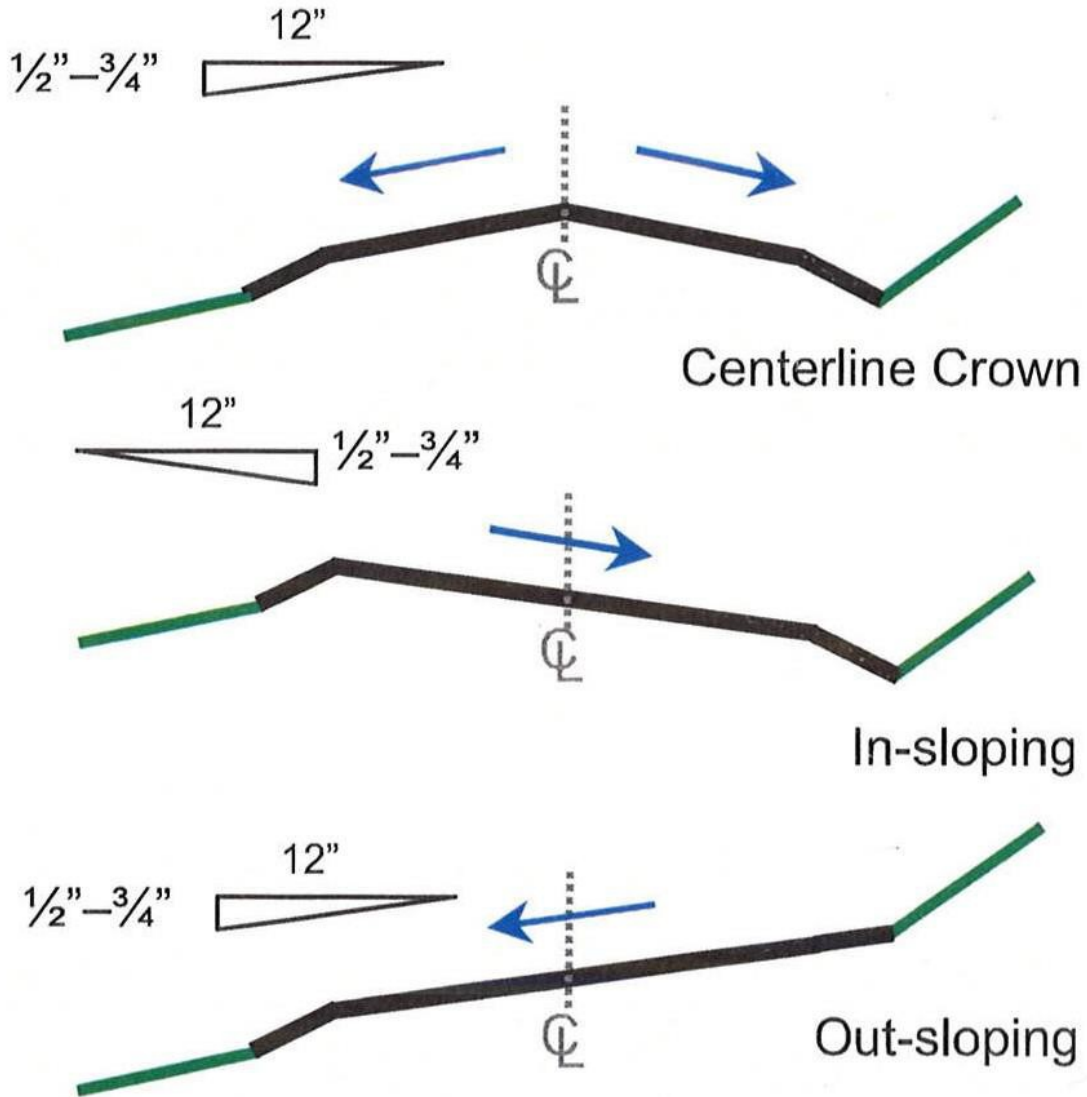
Not this



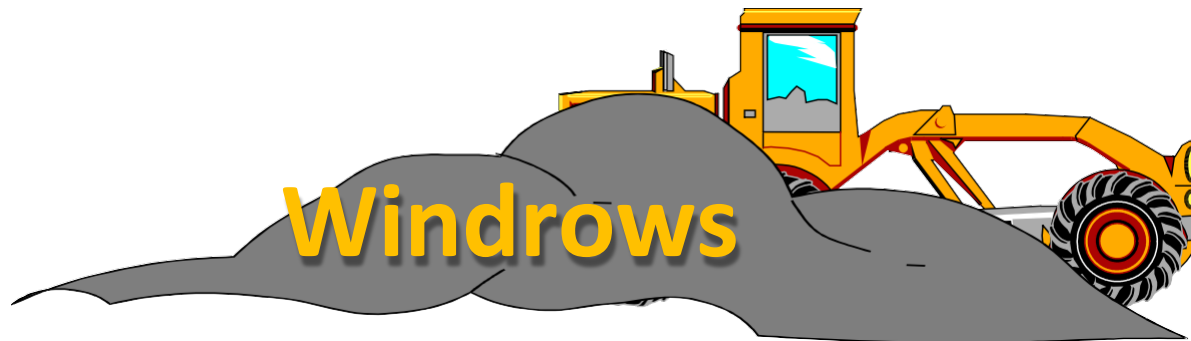
Picture to the right is what you want to try and achieve

Picture to the left is more common to what we see there is actually about a 6 foot drop on the shoulder, the operator has funneled all of the traffic to the inside land.

Types of Crown



Figures not drawn to scale.



**Not recommended in
North Dakota**

Disadvantages

- Weep holes need cut
- Too much material
- Narrows roadway
- Impedes drainage
- Hazard to motorists
- Softens shoulder

A crown gauge
made by SLOPE METER, INC[®]



A slope meter
made by SLOPE METER, INC[®]



ATTACHMENTS:

Principles and
Products for Doing
More Work
More Efficiently



PHOTO: BOBCAT





Using a cutting bit on the front quick couple attachment of your motor grader simplifies the need to change out molboard bits.



To get to the bottom of those rumble bars and potholes, you need scarifying teeth. A front or rear attachment is there when you need them.

Also a useful tool when grading if soil is dry and hard helps to break soil up in ditch makes it easier to cut especially when grading with carbide blades and can also be used as a depth gauge when grading

Another way of compacting material







A retriever or shoulder disc will improve your shoulder maintenance as it grinds up the grasses and mixes the dirt and recovered gravel into a usable material but will still need to be retrieved with motorgrader and placed on the road.



Magnet



When approaching particular maintenance situations ask yourself ?

- Is this proper time to perform this maintenance procedure ?
- Is it too wet or too dry ?
- Do I need additional equipment or only motor grader ?
- Will I need aggregate hauled in or material hauled away ?
- Can I accomplish this in a day or will it take longer?



More Questions to Ask

- Should the road be barricaded or closed ?
- Should the utility company be notified ?
- Should I do this or are there more important areas that need attention ?
- Should I notify my supervisor prior to maintenance ?



Remember Nothing Worthwhile Comes Easy

- You need to know
 - Your equipment
 - Proper operating procedures
 - The law
 - Agency policies
- To be a good operator you must expend a lot of time and effort



- No matter how much you know today you will need to know more in the future
- Keep an open mind and be willing to try new ideas
- How well you do your job is entirely up to you !!



YOU ARE THE KEY

NDLTAP Resources Page

NORTH DAKOTA LOCAL
TECHNICAL ASSISTANCE
PROGRAM

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Resources

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Events

Training Calendar

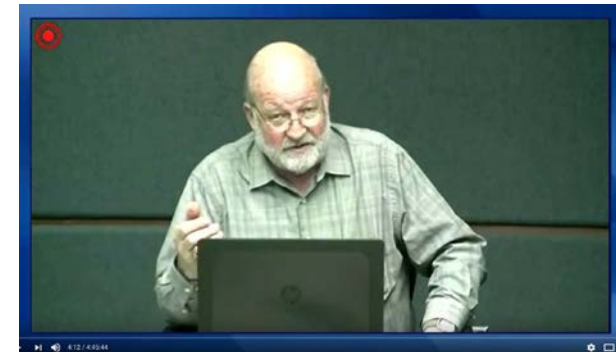
Upcoming Events

NDLTAP

Gravel/Motor Grader

Roadway design, gravel quality and motor grader operation are key factors for maintaining gravel roadways. NDLTAP's Gravel/Motor Grader Resource section is a one-stop shop for gravel roadway information, providing gravel roadway training and technology ranging from resource publications to hands-on motor grader field training.

- [Aggregate Roads Dust Control](#) (PDF, 849K)
- [Dust Suppressant](#) (PDF, 1363K)
- [Quality Gravel's Secret Ingredient is Clay](#)
- [Gravel Roads Manual](#) (PDF, 18278K)
- [Montana 2000 Gravel Manual](#) (PDF, 4900K)
- [Motor-Grader Maintenance Presentation](#) (PDF, 3549K)
- [Slope Meter](#) (PDF, 2024K)
- [Gravel Road Presentations - NDLTAP Staff](#)
 - [Sargent County Township Meeting](#)
 - [ASHE - Central Dakota Section](#)
- [Montana Gravel Road Video - Flathead County](#) (MACRS/Montana LTAP production)
- [Gravel Road Maintenance: Meeting the Challenge](#) (video) (AMK Production Services)
- [Answers to Common Questions About Gravel Roads](#) (video) (Local Road Research Board)
- [A Day in the Life of a Blade Operator](#) (PDF, 110K)
- [Gravel Reclaimer](#) (PDF, 844K)
- [Grader Mount Sod Mulcher](#) (PDF, 764K)
- [Gravel Roads Maintenance Recorded Video Conference Session - Ken Skorseth, SDLTAP](#)
 - [Course Description](#) (PDF, 296K)
- [GT II Spreader](#)
 - [GT2 in Action](#) (video)
- [Local Road Surface Selection Tool](#)
- [12H Grader Pulling Ditch](#) (video)
- [Smoothing and Reshaping the Traveled Way](#) (video)
- [Unpaved Road Chemical Treatment Selection Tool](#)
- [Guidelines for the Selection, Specification and Application of Chemical Dust Control and Stabilization Treatments on Unpaved Roads](#) (PDF, 29038K)
- [Unpaved Road Dust Management: A Successful Practitioner's Handbook](#) (PDF, 5897K)
- [OXY Study - Calcium Chloride vs Magnesium Chloride](#) (PDF, 251K)



NDSU

UPPER GREAT PLAINS
TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

Questions???

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