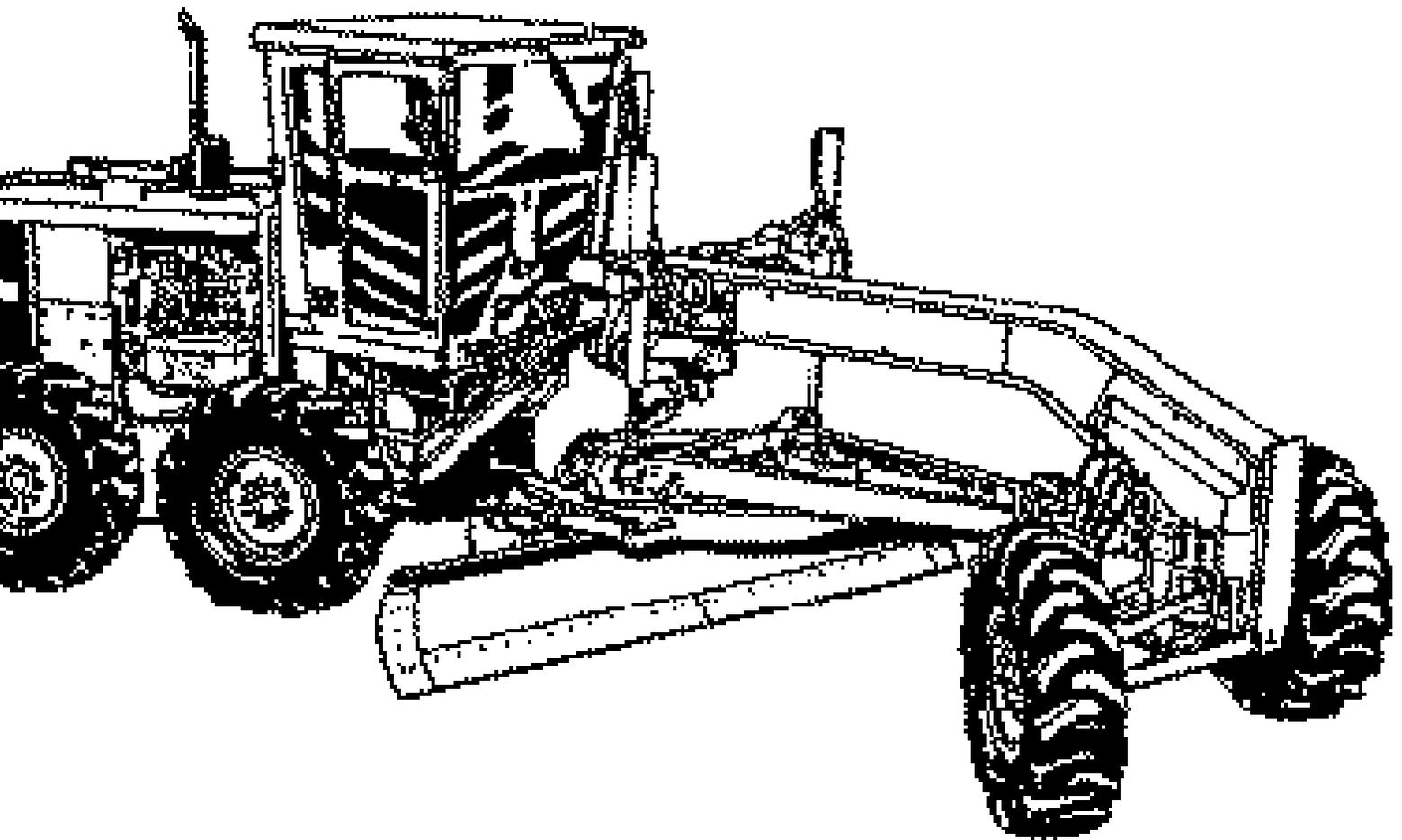


# Motor Grader Operator's Training Manual



**Michigan's  
Local Technical  
Assistance Program**

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**Motor Grader Training Manual**  
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## Preface and Acknowledgements

This notebook was prepared for use in workshops being presented at various locations throughout Michigan as part of a program developed by the Michigan Local Technical Assistance Program (**LTAP**). Materials in this notebook have been adapted from material generously provided by the Nebraska Technology Transfer Center, and the Maine Local Roads Center.

The workshops are intended for county, city, and township employees who are responsible for maintaining gravel roads and require a working knowledge of gravel road characteristics, basic maintenance procedures, and grader operator skills.

### **Workshop Instructor**

Jeffrey Shook, Genesee CRC retired

### **Disclaimer**

The contents of this notebook do not necessarily reflect any official views or policies, and use or reference to specific products or equipment does not imply endorsement of these products by any university, local, state, or federal agencies. This notebook does not constitute a standard, specification, or regulation.

## Motor Grader Rated #1 – Most Useful and Versatile

### County Engineers

What do you call a county engineer with a motor grader? A highway department. This is an old joke, but it's true; the versatile motor grader was the number one choice among the 10 most important pieces of equipment used by county highway departments, according to results of a survey conducted by Better Roads' editors.

Nearly 88% of the surveyed county engineers and equipment operations managers called the grader their most important piece of equipment. Trucks were not far behind.

The county highway department equipment top 10, as chosen by those who specify and buy the machines are:

1. Motor grader.
2. Dump truck.
3. Pickup truck.
4. A tie between mowers and surveying equipment.
5. A tie between snowplow and loader.
6. Spreader/salter.
7. Water truck.
8. A tie between excavators and portable barricades.
9. Bulldozer.
10. Pothole patcher.

### Maintaining Roads

Bannock County, Idaho engineer Terry Bailey chose the motor grader as his top equipment pick, explaining, "We maintain 250-plus miles of gravel roads and do snow removal. This equipment does duty all seasons."

While often the motor grader is converted for winter road maintenance in more northerly areas, Gary Adkins, county engineer in Lexington, South Carolina, also chose the motor grader, explaining, "We grade over 800 miles of unpaved road. We grade daily, weather permitting, with the bulk of our road maintenance activity motor grading."

Adkins says his department has 20 motor graders in its road fleet, with Caterpillar being the mainstay of the department, although other manufacturers' equipment – John Deer, Champion, and Galion – are also listed in his inventory. Brian Faust in Fulton, Missouri, explains that motor graders are the only way to maintain the roads in his county. "We have 800 miles of gravel roads," Faust explains, and his stable of 10 graders – a Cat 135H, 8 John Deere 670 Bs, and a Fiat F675 – does the bulk of the work keeping roads in shape.

North Dakota engineer Jon Mill says, "Roadway maintenance is a large part of our assignment, and the motor grader addresses many maintenance functions. It offers versatility, can blade gravel, lay patching mix, plow snow, mix material, and do finish grade work."

Road construction was the main reason listed by Donald Brandon, Chambers County, Texas Highway Department engineer, for his choice of motor grader as the number one piece of equipment. Construction and maintenance of some 150 miles of gravel roads prompted Brandon to list compactor and dump truck as numbers two and three, respectively, to go along with the grader to meet his construction needs.

Overall, 33% of those responding to the survey picked the motor grader as their first equipment choice.

"County Engineers." *Better Roads* (July 1997) : 16.

## Parts of a Road

A road is composed of three major elements (see Figure 1):

- The surface
- The base and/or subbase layer(s)
- The subgrade

The **surface** or 'wearing surface' may be asphalt, concrete, gravel, or other material. It must provide a good riding surface as well as wear resistance, skid resistance, and waterproofing.

The **base** and/or **subbase** layers provide the strength to carry heavy loads and support for the pavement surface. This material consists of compacted gravel, sand, crushed rock, or a combination of these. A minimum compacted thickness should be 18 inches for local roads.

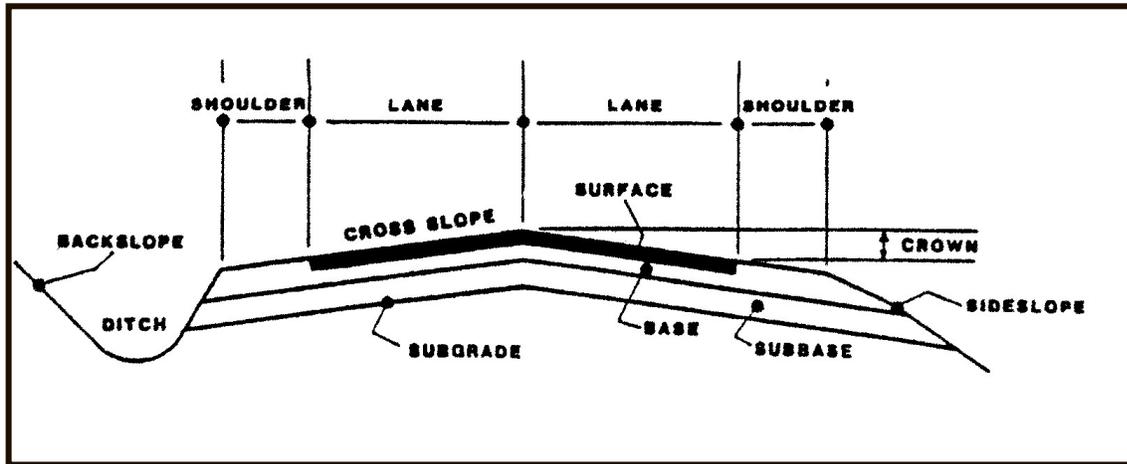
The third element is the **subgrade**. This could be fill material if an embankment is being built to a height more than 2 to 3 feet high, or it could be the existing natural soil in cut sections. It is the subgrade which ultimately carries the traffic loads.

Before construction of a road, the top 12 to 24 inches of existing ground is usually prepared by removing large boulders, stumps, bushes, and other objectionable materials.

The main function of the pavement surface and the subbase materials is to support a wheel load and to spread and transfer that load to the subgrade. The ultimate load on the natural subgrade surface should be small enough to be easily supported by the subgrade.

## Proper Cross-Section

To maintain good drainage, a road needs proper cross-section:



**Without** proper drainage, no roadway can survive. **With** proper drainage, you can maintain a stable base and keep a proper cross-section. And with a proper cross-section, the roadway, shoulder, inslope, ditch, and backslope will drain properly and your roads will be in better condition and easier to maintain under all weather conditions. Practice good maintenance habits and your time will be well spent.

Overall, this information will help you better understand your role as a gravel road maintainer and sharpen your skills so that you can do the best job possible in maintaining your local gravel road system!

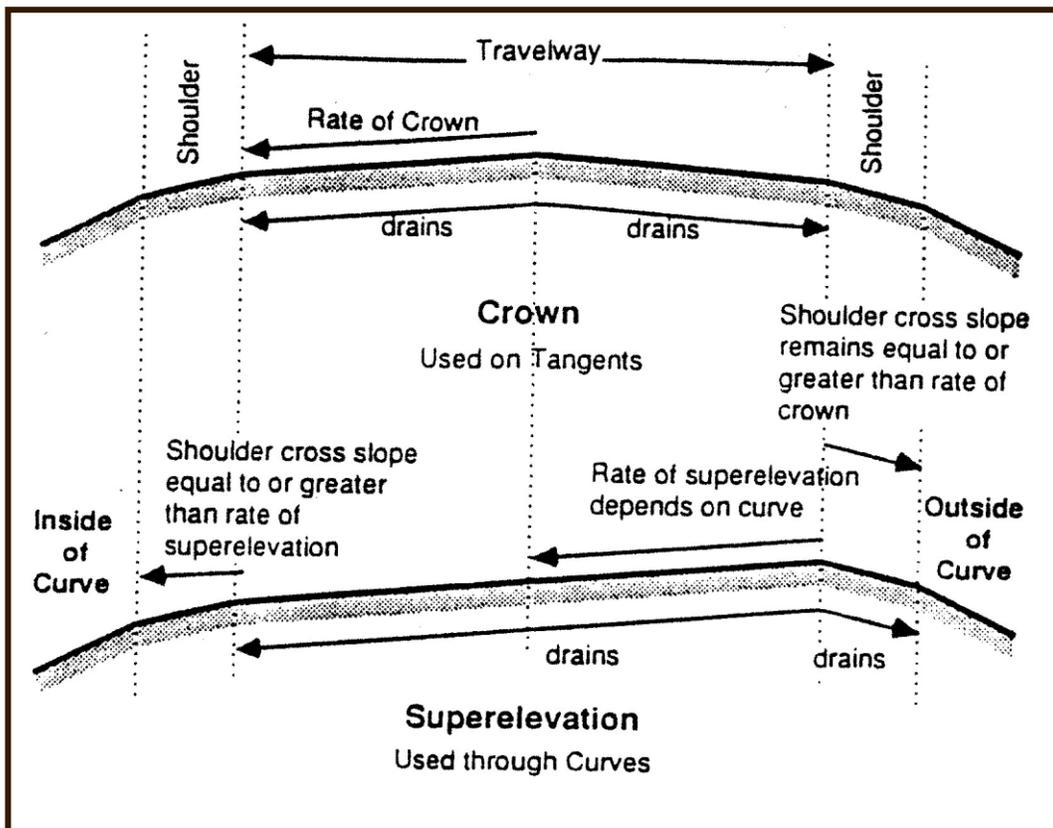
## Roadway Cross-Section Elements

Other cross-section elements of a typical road are also illustrated in Figure 1. The road surface should be ***crowned*** or sloped so that water will drain to the left and right towards the ditch. The slope should be  $\frac{1}{4}$  inch per foot of paved road width and  $\frac{1}{2}$  to  $\frac{3}{4}$  inch per foot of gravel road width.

Paved	Gravel
$\frac{1}{4}$ " per foot	$\frac{1}{2}$ " per foot

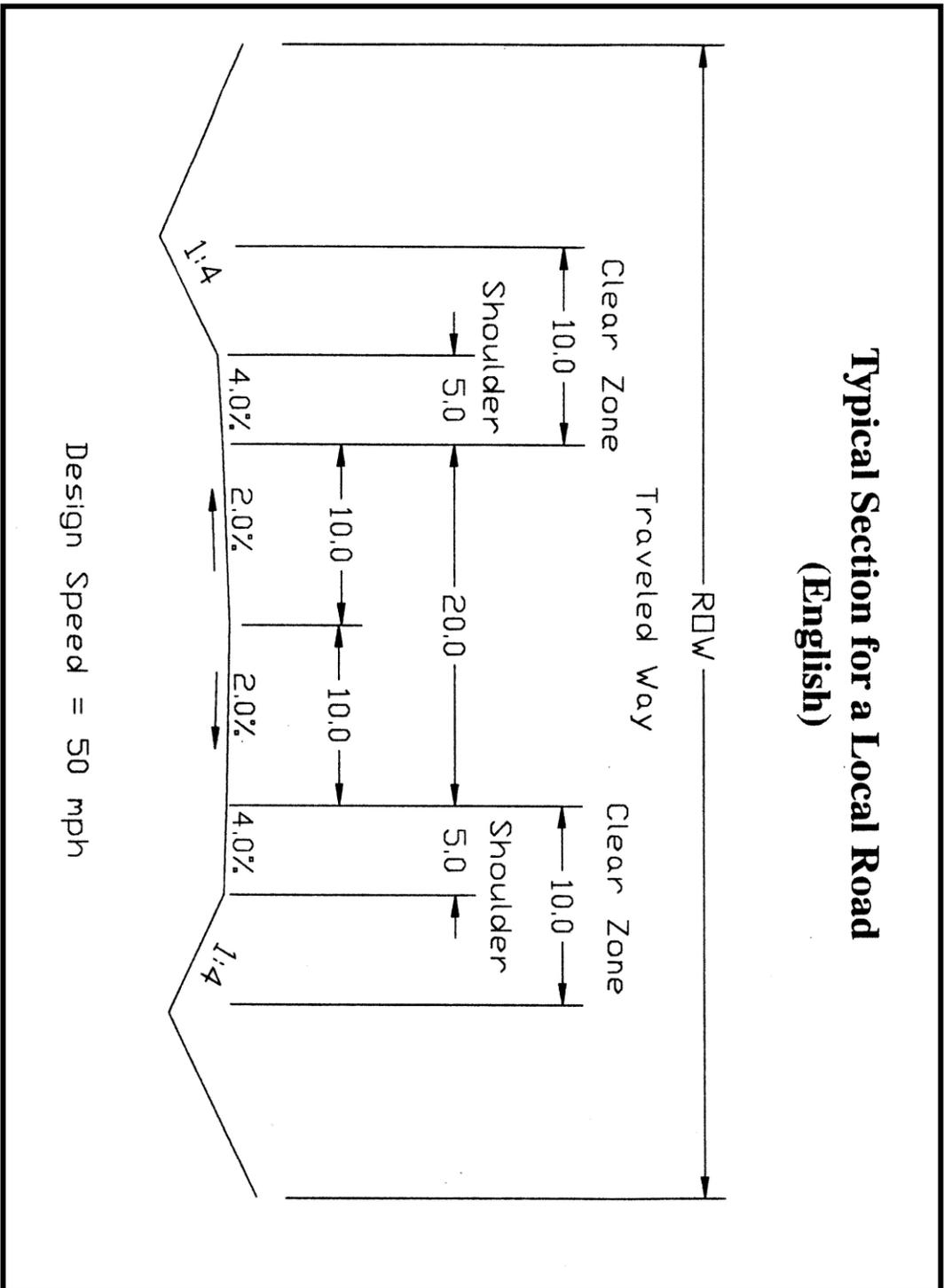
***Potholes in gravel surface roads can be directly related to road crown.*** Those roads with no crown will experience the most severe pothole problems, and those with a cross slope of  $\frac{1}{2}$  inch per foot or more should have very few pothole maintenance problems.

As you maintain your roads, you should be aware of what the town's standard dimensions are for different types of roads. If a road does not meet the standard, you can gradually bring it back to standard as you work on it. If it gets completely out of hand, an expensive re-grading or rebuilding job might be necessary. Not only that, but there are potential legal problems that can develop if roads standards are neglected and a serious accident results.

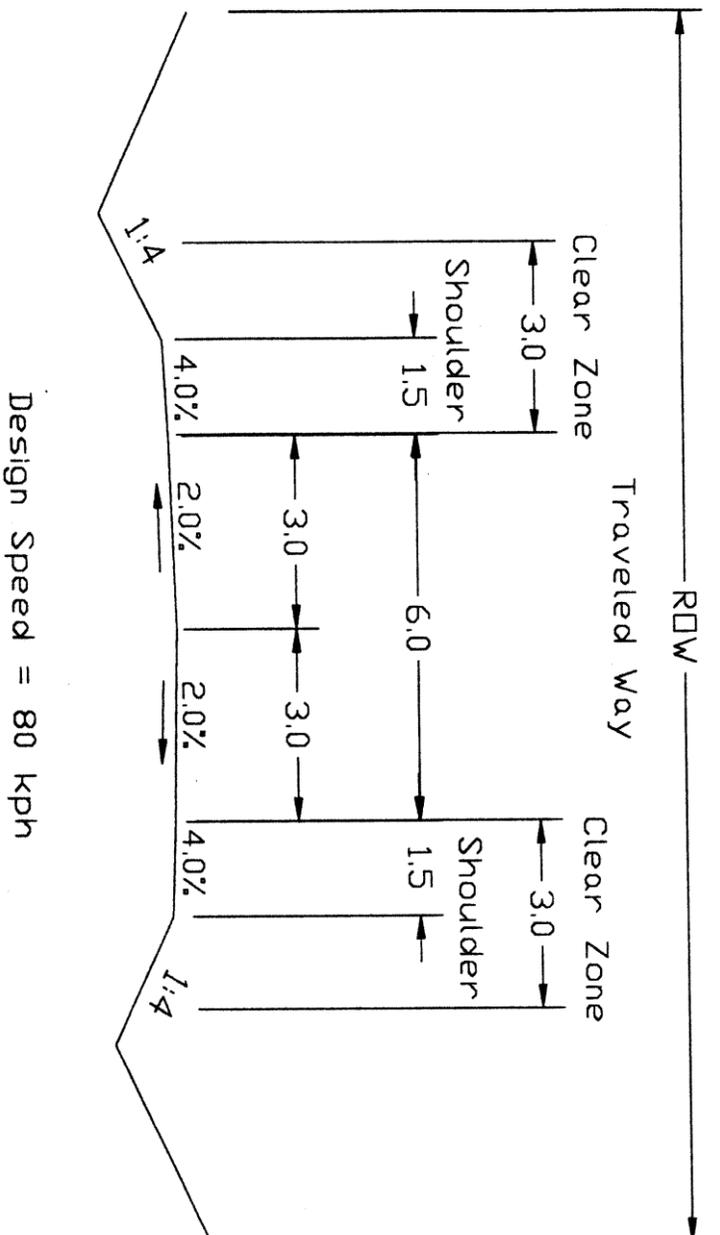


(Figure 2)

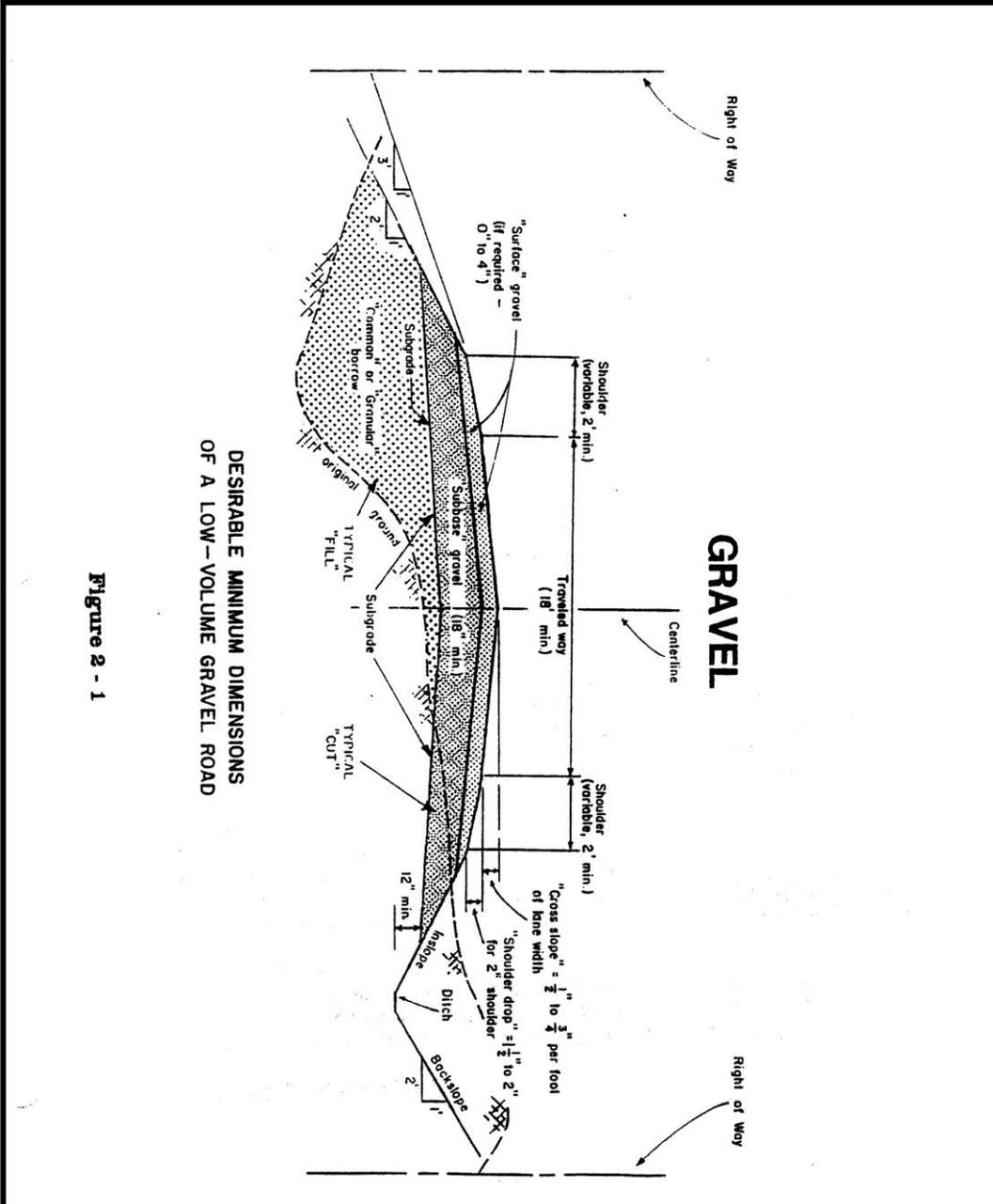
# Typical Section for a Local Road (English)



# Typical Section for a Local Road (metric)



Design Speed = 80 kph



DESIRABLE MINIMUM DIMENSIONS  
OF A LOW-VOLUME GRAVEL ROAD

Figure 2 - 1

## Five Factors Which Affect a Road's Life

Moisture	This can enter a road from surface cracks, the underlying water table, and the surrounding soil. The effects of water can be devastating, especially in Maine, when water freezes and heaves the roads each winter and spring.
Traffic	Road damage depends on the number of vehicles using the road, but even more on the weight of vehicles. A few heavily loaded wheels do far more damage than many light ones. For example, it takes 500,000 axles carrying one ton each (passenger car) to produce the same damage as eleven axles carrying 16 tons each.
Subgrade	Since the road depends on the natural ground for support, the quality of the surface can create large differences in pavement performance.
Construction Quality	Factors such as the moisture condition during construction, the lack of proper soil compaction, and the quality of paving materials can seriously affect road performance.
Maintenance.	The life of a road depends on what, when, and how maintenance is performed.

## On the Road

The Newsletter for State Highway Superintendents

Spring 1992

### Liquid Calcium Chloride Keeps Roads in Houlton, Maine “Golden”

Ralph Cleale, public works superintendent for Houlton, Maine, might never have tried liquid calcium chloride to control dust on his town’s unpaved roads had it not been for the “Golden Road.”

The town of Houlton sits on the border with New Brunswick, Canada, close to Maine’s prime timber territory. Most everyone in the state is familiar with the central logging truck artery called the “Golden Road,” which links an impressive network of unpaved roads built by local paper mills in the mid-1970s. With a great deal of money invested in their roads, the paper companies tried new methods and materials to build and maintain them, including liquid calcium chloride.



Traffic on the roads is not limited just to trucks. Mr. Cleale traveled some of them on trips to his hunting camp and noticed a lack of dust and their overall good condition in spite of the heavy truck traffic. Curiosity led him to investigate how the roads stayed in such good shape. He learned that liquid calcium chloride was a key part of the maintenance strategy. Since he had also heard about the material through magazine articles and advertisements, he was eager to try it.

“Complaints from Houlton residents about the dust from town roads in dry months were constant,” says Mr. Cleale. “We’d found no reliable way to control the dust.”

In 1988, he tested liquid calcium chloride on about one mile of a particularly rutted and dusty roadway, spreading 4,000 gallons. The results were as expected. “The calcium chloride performed just as the advertisements said it would,” says Mr. Cleale. “Over the next two years, we tripled the amount applied. It not only totally eliminated the complaints and reduced the loss of fines, it also kept the roads compact. They stay together so well that we’ve reduced grading by 70 percent.”

With less grading, Mr. Cleale finds he is able to devote much less effort to maintaining the roads. He uses the manpower that had been assigned to grading his formerly dusty roads in other important summer maintenance tasks.

The town’s road crew developed a regular procedure in laying the solution down. The roads are first lightly graded to loosen their surfaces, with the crew occasionally adding gravel to fill in low areas.

“Prepping the roads is a bit of a juggling act,” says Mr. Cleale. “We finish grading just before we order the spray truck to apply the material. We’ve learned to time this just right so traffic and rain won’t compact the surfaces.”

Loosening the surface allows liquid calcium chloride to penetrate better, improving the ability of the fines and aggregates to bind together. This binding action stabilizes the unpaved road, keeping it dense and compact.

After the roads are prepared, W.H. Shurtleff, Inc., South Portland, Maine, is called in. Using a distributor truck with a rear-mounted spray bar, a 35 percent liquid calcium chloride solution is applied. The truck makes two eight-foot passes on the 18-to2-foot-wide roads, spraying approximately 2,800 gallons per mile. The liquid calcium chloride is manufactured by General Chemical Corporation, Parsippany, New Jersey.

Mr. Cleale concentrates his annual treatment on high traffic areas and in front of houses, spreading a total of 12,000 gallons. To ensure that the calcium chloride solution is efficiently applied, he recommends using a distance measuring device to accurately calculate the application rate.

"It's important not only to control how much is applied, but to target where to apply it," Mr. Cleale explains. "Applicators don't know our roads, so we guide the truck driver to the correct spots. This way, we're assured that we have treated the intended sections and have obtained optimum coverage."

Through Mr. Cleale's observation of the "Golden Road," applying liquid calcium chloride to Houlton's unpaved roads is now the golden rule.

"Liquid Calcium Chloride Keeps Roads in  
Houlton, Maine 'Golden.'" On the Road  
(Spring 1992)

# Fighting Pot Holes and Dust

By Jim L. Hennen, SD LTAP Western Satellite Coordinator

Many communities in South Dakota have a number of gravel surfaced streets and are fighting an ongoing battle against potholes and dust. Faced with this problem on Canal Street in the city of Custer, Street Supervisor, Corbin Herman, contracted Alan Sarver of Z&S Dust Control, Inc. of Rapid City for some help. The two men decided to treat a five-block section of Canal Street with a proprietary product from Pennzoil being marketed under the brand name PennzSuppress D.\*

It was felt that this would provide a good opportunity to evaluate the effectiveness of the product as a soil stabilizer as well as a dust suppressant. The treatment was applied in mid-July of this year and the street condition was observed approximately three and a half months later.

The operation involved blading the entire length of the section as well as a short section coming onto Canal Street from the north. This short section was to receive the same blading and rolling passes as the longer five-block section but without any of the product being placed on it. This provided a good comparison between a treated and untreated section over which the same traffic volume and traffic type would be passing.



**The untreated section pictured at the top has developed potholes. The treated section in the bottom picture shows no sign of potholes and is in much better condition.**

After blading, the product was shot at a rate of one quarter gallon per square yard, using the same distributor as normally used to apply magnesium chloride dust suppressant. Forty-five minutes later a second application was shot. Following the forty-five minute waiting period for this second application to absorb into the surface, a self-propelled rubber tire roller was used to compact the treated surface. Corbin indicated that when they rolled the surfaces (treated and untreated), the treated surface glazed up very nicely. When the product was first applied there were thousands of tiny bubbles rising to the surface as the material penetrated the surface. With the second application the bubbles were still evident but with less activity than with the first shot. Due to limited funds, Corbin elected not to apply the recommended third application before rolling. The two applications, twenty-four feet wide over the five blocks, cost approximately \$1650 for the product alone.

The effectiveness of the product as a stabilizer for the gravel surfacing was very good and Corbin indicated he was very pleased at how well the five blocks have remained very tight with no potholes

showing up in the entire length. The short, untreated section has numerous potholes. The difference in the surface conditions between the sections can be seen in the accompanying photographs.

The effectiveness with respect to dust control was not what had been hoped for. Both Corbin and Alan indicated that had the third application been given, as the manufacturer recommends, its effectiveness as a dust suppressant would have received a more favorable evaluation.

Z&S Dust Control, Inc. did return to the job site some time later and shot an application of magnesium chloride to mitigate the dust problem that the treatment did not adequately provide.

\* The use of product brand names in this newsletter article does not constitute any endorsement of those products by the SD LTAP Center.

Hennen, Jim L.  
"Fighting Potholes and Dust."  
The Connection p. 6.

## Calcium Chloride for Dust Control

### Are There Environmental Concerns?

A popular method of controlling dust on many of Michigan's gravel roads is by using calcium chloride. It is available through several different suppliers in the state, in either flake, pellet, or liquid form. Typically, a road will be treated one to three times per year to help keep the surface hard-packed and dust-free under traffic.

A common concern around Michigan is whether this 'salt' can create a significant environmental hazard to groundwater, nearby wells, lakes, or vegetation. In one sentence, studies have found that because the amount of calcium chloride required for dust control and stabilization is relatively small and it is applied relatively infrequently, little potential for significant damage exists. This is unlike sodium chloride (winter road salt) which is used in relatively large quantities for de-icing Michigan roads.

The Center has two studies available which discuss this subject.

Here are the highlights from each study:

- I. "An Environmental Review of Calcium Chloride in Road Dust Control and Stabilization Applications." Dow Chemical Company (June 1981).

The widespread use of calcium chloride for dust control and stabilization of unpaved roads provides economic, personal safety and environmental benefits while presenting little potential for harm to the environment. The evidence to support this conclusion can be summarized as follows:

- The amount of calcium chloride applied for dust control and stabilization is relatively small.
- Only a small percentage of the calcium chloride applied for dust control and stabilization moves from the roadway to roadside areas.
- Little potential exists for damage to roadside vegetation due to lack of calcium chloride movement and the minor effect of calcium chloride on soils and vegetation.
- The potential for damage to animal life is small due to the lack of movement from application areas and the low toxicity of calcium chloride.
- Because migration is limited, surface water contamination is unlikely.
- Ground water contamination from leaching is unlikely, except in unusual cases.

- II. School of Public Health. An Evaluation of Dust Suppressants: Calcium Chloride and Lignosulfonates University of Minnesota (June, 1982).

Calcium is present in nearly all waters and is more abundant than any of the other alkaline-earth metals. The addition of calcium for dust suppressant most likely would be insignificant when compared to the amount already present in the environment.

The use of calcium chloride as a dust suppressant will elicit the same types of environmental problems (chloride pollution of water systems) as it does when used as a road de-icer. However, because these effects are directly related to the rate and method of application of the salt, the environmental effects following its use as a dust suppressant should be considerably less than those observed from its use as a road de-icer.

Due to its low systemic toxicity from oral administration, calcium chloride use as a dust suppressant poses little internal hazard in animals and humans.

Toxicity to vegetation, especially in and around the area of application, should be expected from the use of calcium chloride. This toxicity may be in the form of direct effects on the plant life or they may arise indirectly via soil disturbances (alkalinity, low water availability, low sodium availability, and poor aeration).

## Environmental Facts About Calcium Chloride

Growing concern for the environment means that we need to closely examine the materials used in de-icing and other road maintenance. Calcium chloride works well not only for de-icing but also for dust control/base stabilization and full depth reclamation, says Bill Massa of General Chemical Corporation. As its acceptance has grown, so have questions about how this substance works and how it impacts water quality and vegetation. This article answers questions road officials most frequently ask about calcium chloride.

### **How does calcium chloride work when mixed with aggregate?**

Clays and other soft particles have a large negative surface charge. They act like magnets and repel each other. When water coats the particles, Massa says, it insulates them and reduces the force pushing them apart. Water also has a natural surface tension that acts to bind particles together.

A dry road is less cohesive than a wet one and loses fines more readily under the pounding of passing cars and trucks. A commonly used rule of thumb is that one car traveling over a mile of untreated dirt road will throw off a ton of gravel per year. Roads that retain water last longer. Calcium chloride helps keep water in roads in two ways.

First, as calcium chloride penetrates a road surface, it reduces the negative charge on the particles. This decreases the repelling force between particles and the thickness of the water coating. A thinner coating allows particles to move closer together.

And second, the surface tension of a calcium chloride solution is far greater than that of plain water. The higher surface tension and the thinner film coating the particles substantially increase the attraction between soil particles. As the binding ability of the road fines increase, so does road stability. Calcium chloride in reclaimed aggregate and base soils produces a material well suited for use as a road base or wearable surface for an unpaved road.

### **Does calcium chloride migrate once it is added to soil?**

Calcium chloride tends to stay where it is placed. Studies indicate that calcium chloride migration is minimal and that total migration is low. Samples from a road in Maine found that the majority of calcium chloride per square yard remained in the road base after 24 years. A recent study in Ontario, Canada, conducted by Trow Geotechnical Ltd., indicated excellent migration of calcium chloride. Ninety-two percent of the material was present 8 months after application.

### **What type of calcium chloride migration is most likely to occur?**

Most migration occurs vertically in soil, depending upon rainfall, evaporation, temperature, and humidity. As rain soaks into soil, it carries calcium chloride downward. Evaporation of water from the road surface has the opposite effect due to capillary action. Although calcium chloride rises and falls with weather conditions, little is lost from the road. Calcium chloride generally stays in place in road stabilization and dust control work.

One study showed that higher water tables carried calcium chloride from the road. With this in mind, calcium chloride should not be placed in roads where drainage is poor.

### **How large a contribution are de-icers to water pollution?**

A study on dust suppressants prepared for the Environment Ontario Waste Management Branch of the municipal government of Toronto found no adverse effects on water or plants from the use of calcium chloride as a dust suppressant, Massa says. The effect of salt on ground water is believed to be minimal, but difficult to assess because of the many sources of chlorides.

More than 4 million tons of salt, both sodium chloride and calcium chloride, are carried in rain and snow each year. Sewage treatment and industry also contribute to chloride levels.

### **What effect does calcium chloride have on a reservoir?**

Studies in Maine and Wisconsin by the Highway Research Board in Washington, D.C., examined the effect of de-icing chemicals on highways. These confirmed that chloride concentrations in rivers and streams are well within acceptable limits, Massa says. The great water volume they contain dilutes chloride concentration to acceptable levels. Many states have instituted reduced salt zones in the vicinity of reservoirs. Calcium chloride is frequently used in these areas due to its performance and tendency not to migrate.

Water pollution from de-icers is primarily limited to shallow wells near roads and small ponds and streams that get direct runoff from roadways. A study conducted in Maine found chloride concentration related directly to distance from a road.

### **What about calcium chloride in drinking water?**

The American Medical Association rate for sodium chloride in drinking water is 250 mg/liter. The limit for calcium chloride is the same. It is interesting to note that the 250 mg level was set by the Public Health Service based on the taste rather than health.

### **Is chloride harmful in drinking water?**

Humans have drunk water containing as much as 2000 mg of chloride without adverse effects, Massa says. People can taste sodium chloride and calcium chloride in concentration from 70 to 900 mg and 15 to 350 mg, respectively.

### **How does calcium chloride affect vegetation?**

As with water sources, the effect of salts on roadside vegetation is related to distance. Trees along highways de-iced with salts are less vigorous than along unsalted highways. Salt injury is more apparent near the road and on the side receiving salt-laden runoff.

Plant biologists are not exactly sure how salt injures plants. Nor do they know the amount and exposure needed to harm them or what are the symptoms of salt-caused injury. Most blame plant damage on ion accumulation that enters through the roots. Salt spray may also damage plant tissue.

Different trees are affected differently. A study of sugar maples showed that trees within 30 feet of highway were moderately to severely affected. Those more than 30 feet away were almost always healthy. It was also found that calcium was less toxic than sodium chloride to roadside vegetation, Massa reports.

Salt may be falsely blamed for plant injury from gasoline and diesel engine emissions. The Environmental Health Service reports that gases such as ozone, nitrogen dioxide, ethylene, and chlorine account for the most widespread injury to plant life, destroying plant chlorophyll, disrupting photosynthesis, and reducing the plant's food production.

### **What can I do?**

Many factors determine how road salt affects plants. These include the amount of salt applied, how soon plowing occurs after application, soil quality and drainage, slope, how much snow melt runs off before the ground thaws, and the type of trees present. The type of salt also is important. Experiments show that sodium chloride is at least five to ten times more toxic to elm and white pine than calcium chloride, Massa says.

Design plantings to minimize the effect of de-icing salts. Place the most salt-tolerant and persistent turf species adjacent to the road and plant deciduous and evergreen trees as far from the roadway as possible. Plant trees sensitive to salt, such as maples, hemlock, birch, and some pines 30 or more feet from a highway.

Where snowplow and vehicular splash is present, select the most spray-tolerant species. Also, do not plant salt-sensitive trees and plants on slopes below the roadway. And, finally, place shallow diversion ditches between the road and woody plantings.

## The Relative Salt-Tolerance of Trees and Ornamentals

### What should I do to best use salt?

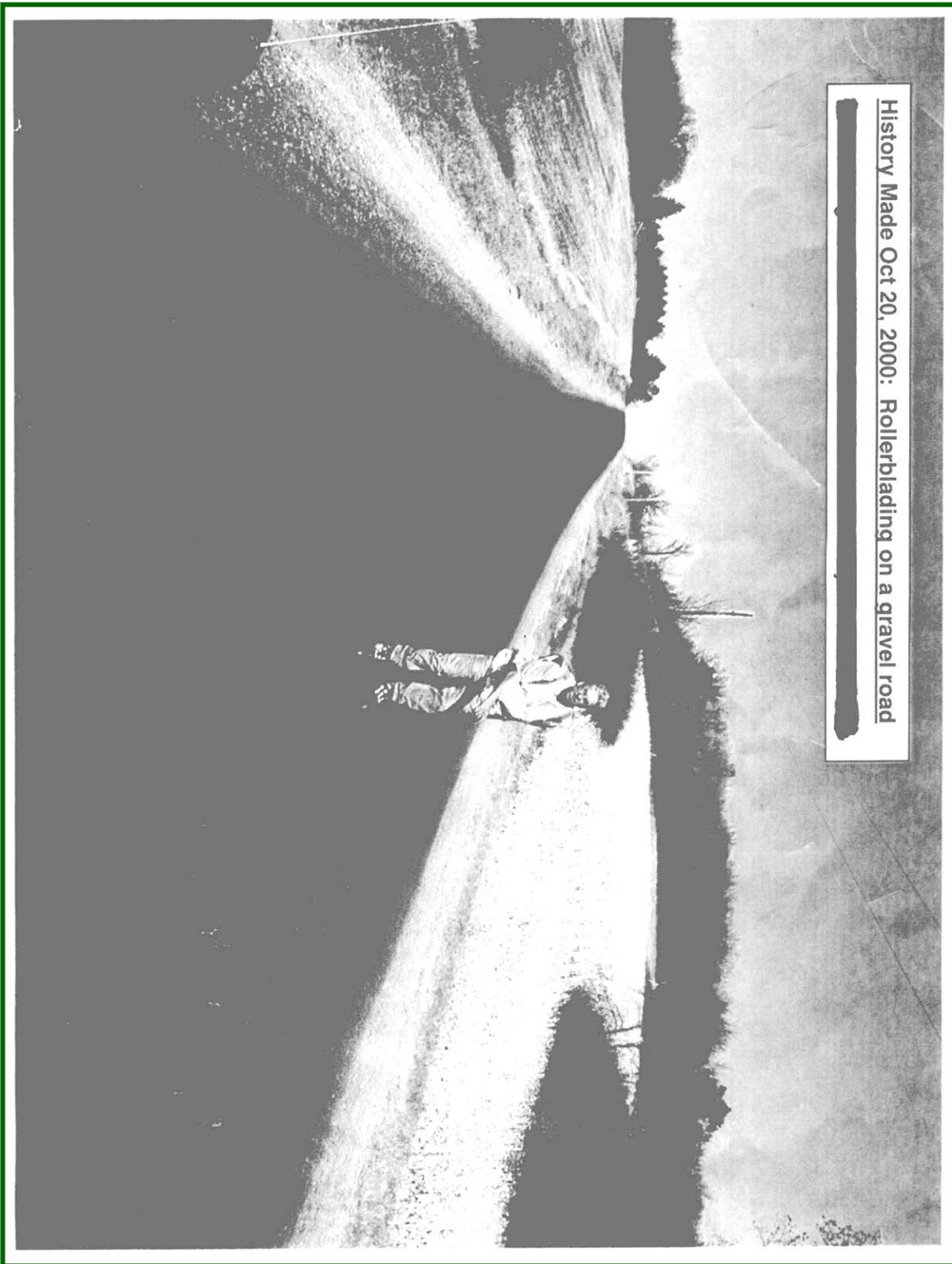
There are some ways to limit salt-caused pollution or vegetation damage. One is to use de-icers that cause less environmental damage than salt, or materials that reduce the amount of salt used. For example, calcium chloride melts more ice in less time than sodium chloride, especially at lower temperatures, according to Massa. Also, it goes into solution more rapidly than sodium chloride, so less is wasted during plowing. Both of these benefits mean that less salt is needed to maintain bare pavement, which minimizes salt-caused pollution and damage to plants.

Another strategy is to pre-wet sodium chloride with liquid calcium chloride, which increases salt efficiency, improves the application pattern, and reduces salt loss and the frequency of salt application.

Low salt tolerance (0-2,000-ppm chloride)	Moderate salt tolerance (2,000-5,000-ppm chloride)	Good salt tolerance (5,000-6,000-ppm chloride)
Filbert	Birch	Mulberry
Compact boxwood	Aspen	Apricot
Sugar maple	Cottonwood	White oak
Red maple	Hard maple	Red oak
Lombardy poplar	Beech	Hawthorne
Speckled alder	White spruce	Tamarix
Sycamore maple	Balsam fir	Squaw bush
Larch	Douglas fir	Russian olive
Black alder	Blue spruce	Scotch elm
Italian poplar	Texas pivot	White poplar
European beech	Xylosma	Osier willow
European hornbeam	Pittosporum	Honey locust
Rose	Pyracantha	Black locust
Pineapple guava	European black currant	Gray poplar
Viburnum	Siberian crab	Silver poplar
Arctic blue willow	Boxelder maple	English oak
Spirea	Japanese honeysuckle	White acacia
Multiflora rose	Green ash	Bottlebrush
Winged euonymus	Ponderosa pine	Oleander
Barberry	Golden willow	Common matrimony vine
Little leaf linden	Lantana	
Black walnut	Spreading juniper	
	Arbor vitae	
	Silver buffalo berry	

**Source: *Facts You Should Know About Effects of Deicing Salt on the Environment*, a review of a recent publication by the National Cooperative Highway Research Program, published as a supplement to the *Reporter* of the American Public Works Association. Reprinted by the Salt Institute.**

"Environmental Facts About Calcium Chloride."  
Better Roads (June 1991) : 26+.



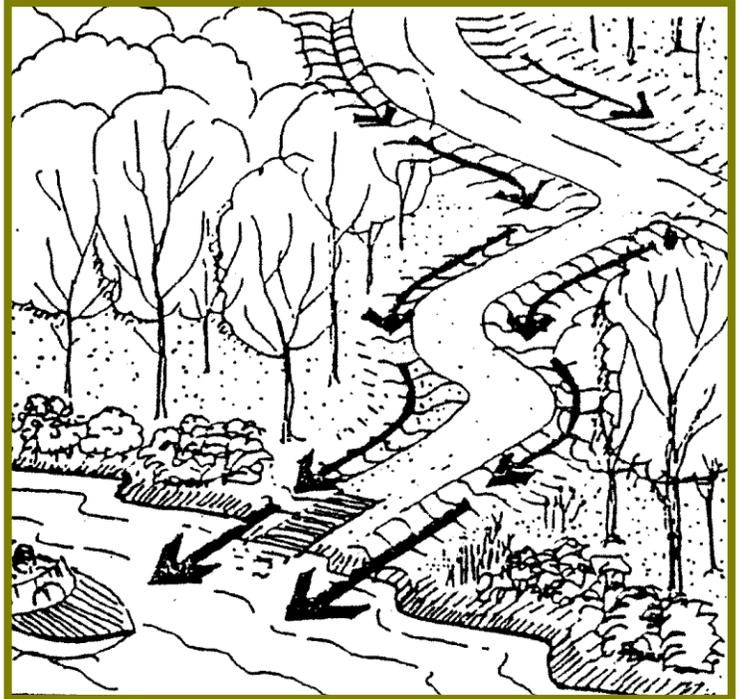
History Made Oct 20, 2000: Rollerblading on a gravel road

## Erosion Control

### *Why is everybody so concerned about it these days?*

Simply put, soil erosion and accelerated runoff can cause serious problems, such as:

1. Clogged road ditches and culverts that require more frequent cleaning and digging out.
2. Eroded ditches and banks that often reduce the life of recent road improvements.
3. Pollution of water and land by sediment.
4. Reduced private property values and angry landowners.
5. Damage claims and lawsuits.
6. Government regulatory pressure.



Minnesota is a beautiful place to live. The relative rural nature of our state is appealing to both native Minnesotans and out-of-staters. A pond, lake, or stream that is visibly polluted by runoff laden with sediment seriously detracts from the beauty. The impact of erosion can significantly impact swimming, fishing, and other recreational activities. Because this type of pollution is becoming more of a problem, recently, more stringent erosion control laws have been passed, and others are currently being developed to protect our fragile environment.

As a local road official or worker, **you** have the ability to reduce the amount of soil erosion that takes place along your town roads. In doing so, you are helping yourself because you may not have to clean out ditches or unplug culverts nearly as often as you do now.

## Erosion Control: Six Major Principles

- **Keep disturbed areas small.**
  - As you increase the amount of disturbed earth, you increase the likelihood of soil erosion.
- **Stabilize disturbed areas.**
  - Several methods and various erosion control products are available to local agencies. Contact the Michigan DEQ, Soil and Sedimentation Division at (517) 335-3178 for more information.
- **Keep water velocities low.**
  - Slow it down! Removing grass, weeds, topsoil, etc. increases both the amount and speed of runoff. Try to keep shallow slopes, short lengths of drainage runs, and some vegetative cover to prevent the water from picking up speed.
- **Protect disturbed areas from storm water runoff.**
  - Use channel diversions, ditch checks, etc. to prevent water from entering and running over disturbed areas.
- **Keep sediment within work boundaries.**
  - Retain sediment by: (1) filtering water as it flows, and (2) detaining 'dirty' runoff for a period so that the soil particles settle out.
- **Follow up and inspect recent work.**
  - This is vital to your efforts. At the end of the day, check that your erosion control practices are working properly. Make sure that filter materials are not clogged or washed out, sediment 'ponds' aren't filled, or channels have not formed under the controls.

## Drainage

Waterways or ditches are intended to carry water away from its source. They are not meant to store water. If you have standing water too near the roadway, there is a good chance it will work its way under the road, damaging both the surface and the base.

Being aware of the following items will help you keep your roads in good shape:

- Inspect drainage areas.
- Check culvert inlets and outlets for debris.
- Check for piping (voids) around outside of culverts.
- Document locations and inspection data.
- Keep ditches free of vegetation.
- If possible, keep ditch bottom at least one foot lower than the bottom of the road gravel base.
- Maintain road profile at about ½ inch of slope per foot of width measured from the centerline to the shoulder.
- Keep the shoulder smooth for good transmission of water from roadway to ditch.
- Maintain proper road profile for better driving and reduced maintenance.
- Eliminate **double ditches** or **edge dams** along shoulders.
- Poor drainage can be the **number one** cause of base failures. Without proper drainage it is very difficult to maintain a proper profile on your road.
- Heavy traffic has a pumping action on roadway bases. This works water upward towards surface of road and makes road soft and unmanageable.
- Check profile of ditches regularly. A dirty, unmanaged drainage system is trouble!

***Good drainage is the key to maintaining a good driving surface and a proper profile. Water has to be kept AWAY from the roadway, not just off of it.***

## Culvert Maintenance

Any drainage system is doomed to failure if it is not properly maintained. These failures can range from scoured stream banks or stream bottoms, to such large failures as road washouts and damaged property adjacent to the stream.

Maintenance should include periodic inspection to see that:

- The inside of the pipe is free from obstruction.
- Both the inlet and outlet ends are as originally installed.
- Embankment soils are free of erosion.
- The **endwalls** or **riprap** are in place.
- There is no misalignment or joint failure of the pipe.
- The culvert materials are not corroded or deteriorated.
- There are no pavement cracks or settling on the surface above the culvert.

Misalignment and joint failure can show up as soft spots in relatively shallow fills and **pipng** on the outside of the discharge end of the culvert pipe.

Remove large brush, weed growth, and any other materials from the upstream end of the culvert. These materials prevent the reduction of flow by getting lodged in or blocking the pipe. Repair culvert ends and correct erosion problems.

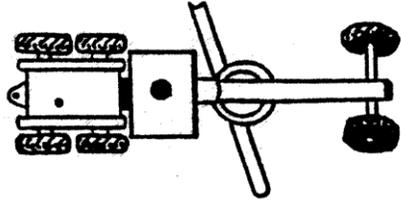
## Road Graders

- Preventive Maintenance
- Inspections
- Safety Procedures
- Grader Operation

## Grader Types

### Rigid Frame

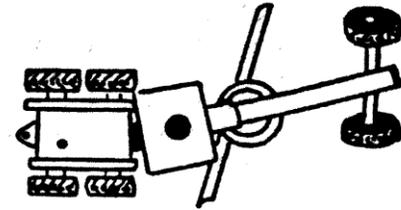
It requires space for turning and requires maximum shift to clean ditches unless the grader can get into ditch. It is best kept on a stable work platform. Use caution near road edges. It is good for smooth blading.



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### Articulated Frame

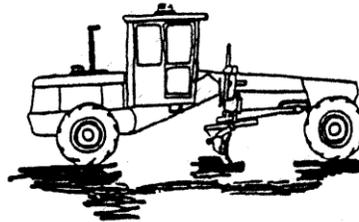
It can be turned and maneuvered in tighter spaces. frame allows offsetting the drive wheels away from and ditches. Offsetting puts the most machine and mass directly behind the load on the moldboard keeping side-shift to a minimum to reduce strain on circle. When properly used it is a good choice for heaviest work and work near edges; use the articulation or it is just a higher priced rigid frame grader.



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### Single Rear-Axle Four-Wheel Drive

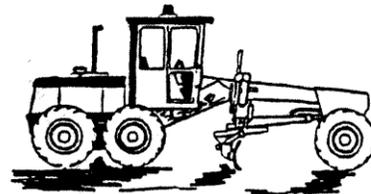
It is used for tighter areas or road alignments. It to be too light for heavy mixing work. Its finish grading capabilities are limited to low speeds even tires matched for circumference. All wheel drive it good control in slick conditions.



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### Tandem Rear Drive

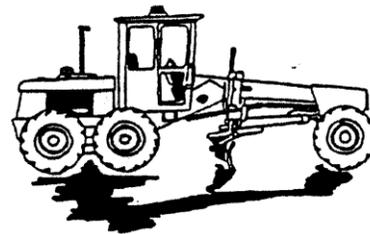
This places all the engine weight on the tandem drivers for good traction. Medium to heavy moldboard loadings can be handled in reprocessing. It has good production capability for quality finish grading when all the tires' circumferences are matched; otherwise, it may and leave chatter marks.



'jump'

### Tandem Rear, on-Demand Front-Wheel Drive

In all-wheel drive it can handle heavier loads than tandems alone. It has good control in slick conditions. Finish quality grading is usually done without front-wheel drive, so the same quality and constraints apply.



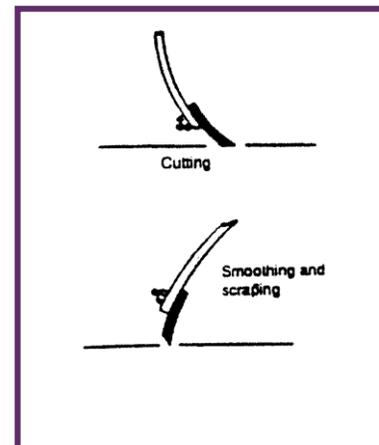
## Grader Operation

Maintaining the surface of the road requires that the operator use a combination of skills, abilities, knowledge, techniques and attitudes that are acquired over a period of time. All operators need to constantly work at improving in all of these areas. Practice new methods and ideas that will sharpen your skills and abilities. Learn all you can about your job, your equipment and what is expected of you when you are out on the road. Finally, work on developing the kind of positive attitude that says to the public, "I care about what I'm doing and I'm doing the very best job I know how to do." You are doing things differently now than you did the day you were hired. That means that you have learned from the experiences of others as well as from your own efforts to find a better way of getting the job done. Keep on learning.

Here are some pointers on the actual operation of your motor grader. Keep these things in mind as you work on your roads and your work will be easier. Neither you nor your machine will show the wear and tear at the end of the day if you follow these tips. You'll do a better job and the public will notice it as their roads improve as a result of your work.

### Blade Pitch and Angle

1. It is very important to use the proper blade and pitch settings.
2. Improper blade angle can create a big loss of aggregate from toe of the moldboard. (See Chapter 10, '**How to Figure the Cost of Lost Gravel**').
3. Improper blade angle and pitch will:
  - a. Overwork machine and cause it to burn excessive amounts of fuel.
  - b. Thrust the machine sideways.
  - c. Cause unnecessary wear on both the machine and the operator.
4. For maintenance work, the top of the moldboard should be pitched forward. Pitch varies with types of material, moisture content, etc.
5. The pitch and angle will vary for different operations performed during the day.
6. With **proper** pitch and angle, material will roll and have a packing action.
7. With **improper** pitch and angle, material will ball up and cause both the machine and operator to work harder than necessary.



### **Articulation**

1. Use articulation when possible.
2. Harden shoulders by running front wheels on the shoulder and rear wheels towards the center of road. This packs the shoulder.
3. Articulate machine for maneuvering.
4. While winging back snow, machine can be held from sliding sideways. Ditching and sloping is made easier with articulation.
5. Articulate machine when cleaning wet ditches.
6. Check your operator's manual for tips on various maneuvers you can make with the machine by articulating.

### **Grader Speed**

1. The slower you go, the smother the road.
2. Going faster than 3 mph causes the grader to bounce and the blade to move up and down. This eventually leads to a **washboard** gravel surface.

### **Blade Types**

1. Standard Straight Edge or Carbide Tooth
2. Proper pitch for carbide tooth blade.
3. Proper angle for carbide tooth blade.

### Tip for Better Grading

- Shape and smooth so that water runs **off** and **away** from the road.
- Slow down!
- Take your time.
- Use the correct pitch and angle of the blade for different operations.
- Undercut potholes – don't just fill them in.
- Treat grading as a rainy day job – a light rain or moist road softens the material. Too much rain, though, can create a mucky mess.
- Maintain your machine daily.
- Practice all the time.
- Consider using some form of dust and erosion control.

**Motor Grader**

**Daily Inspection Check**

**Vehicle #** \_\_\_\_\_ **Date** \_\_\_\_\_ **PM Location** \_\_\_\_\_

**# Hours** \_\_\_\_\_ **Type of Service** \_\_\_\_\_

Service	OK	Repair	Follow Up
Complete Visual Inspection			
Check Engine Oil			
Check Transmission and Hydraulic Level			
Check Coolant Level			
Check Hydraulic Fluid Level			
Check Tension and Wear – All Belts			
Check Gear Box for Leaks			
Check All Instruments and Gauges			
Check Brake Fluid			
Check Operation of Lights, Brakes, Back Up Alarms, and Accessories			
Check Engine Air Filter Pre-Cleaner			
Drain Water and Sediment from Fuel Filter and Sump			
Inspect Battery Cables and Terminals			
Lube All Grease Fittings			
Check Tires for Wear and Damage			
Record Tire Pressure			
Check Cutting Edge and Bolts for Wear			

Performed by \_\_\_\_\_

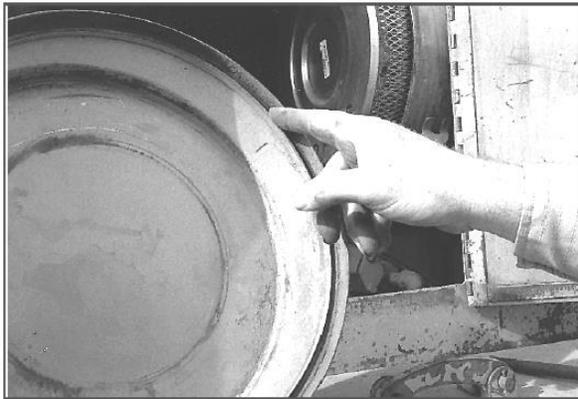
## Pre-start, Walk-Around Inspection for Motor Graders

The following pages present a walk-around inspection for motor graders adapted from Nebraska's Motor Grader Operator Workshop. Special thanks go out to Nebraska's T2 staff, Al Hauser, Bill Bowmaster, and Don Neary for making this project possible.

One of the most important aspects of motor grader operation is the pre-start inspection. Insuring that your grader is in proper operating condition not only preserves a financial investment made by your agency but also prevents against costly breakdowns out on the road and keeps you, the operator, in a safe work environment.

### Special considerations for winter operations:

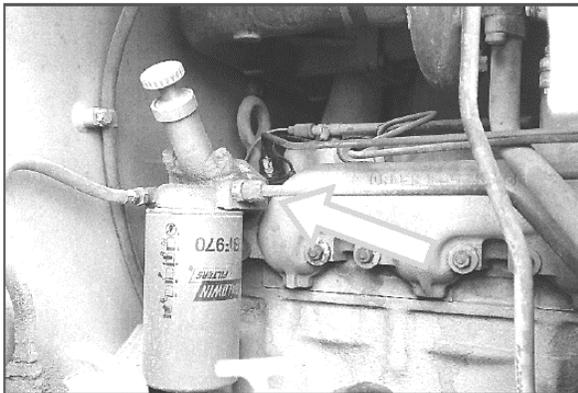
- Check engine block heaters and pre-heaters before cold weather sets in.
- Know what type of engine you are running before using starting fluids.
- Never use starting fluid on engines with glow plugs.
- Review cold-weather starting procedures in the operator's manual.
- Understand the proper way to jump the batteries in the event that this is necessary.



When servicing the air filter, check the gasket and the inner filter. If the gasket is damaged, unfiltered air can make its way through the system and into the engine.



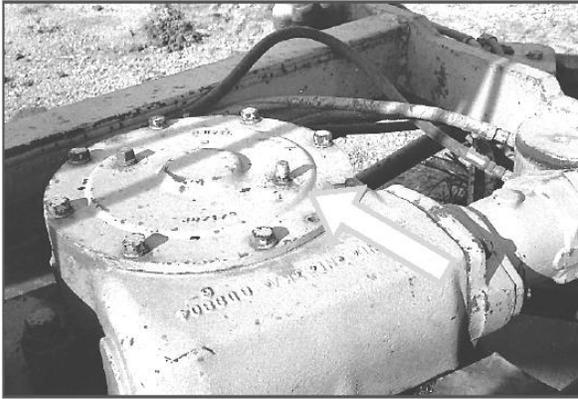
Do **NOT** bang the air filter against a tire or other object. Doing so will distort the shape of the filter, degrading the seal to the intake. If the filter is dirty, replace it!



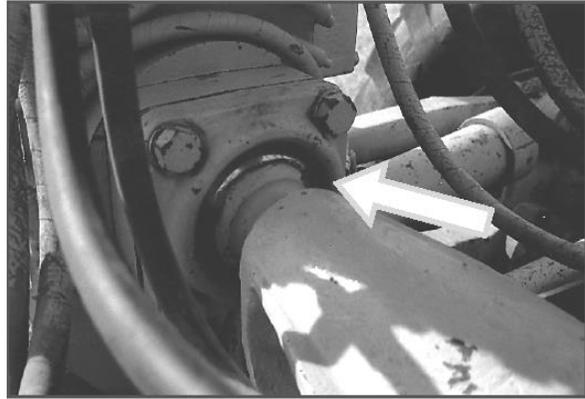
Check for leaks around the fuel filter, and all fittings and fuel lines leading to the engine. An accumulation of moist dirt is an indication of a leak.



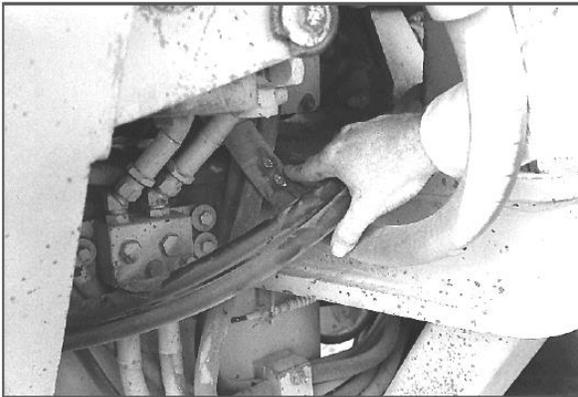
At the air compressor, check for leaks in the air system. Examine the compressor unit and all fittings and air lines. An accumulation of moist dirt is an indication of a leak.



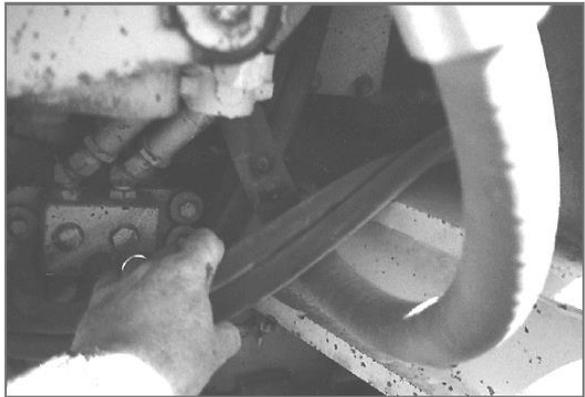
Keep the cover of the circle turn gear clean. This will allow the breather to function properly.



Check clearance of the drawbar ball and socket. Look for excessive free-play. Adjust if necessary.



Hoses should be checked daily. Hydraulic hose failure is a major cause of motor grader breakdown.



Check for hoses that touch other hoses. Hose contact causes abrasion that will eventually lead to failure.



Loose hoses are a breakdown waiting to happen. Hydraulic hoses that have been added to the machine must be of the proper pressure rating and secured to the frame with clamps or brackets.



Hoses that have been replaced must be the proper length and secured in the same way as the originals.



Mismatched tires cause internal wear on the drive chains and differential. Using mismatched tires does **not** save money.



Check all lug nuts. Because of the vibration experienced during grading operations, lug nuts can become loose.



Check the condition of the tires. A sliced tire that fails while out on the road incurs downtime that neither you nor your agency can afford.



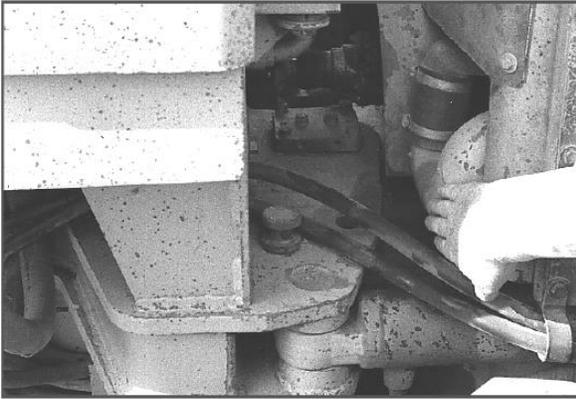
Check the spindles for excessive wear and play.



Check the condition of the blade slide. Keep the shims adjusted according to the manufacturer's specifications.



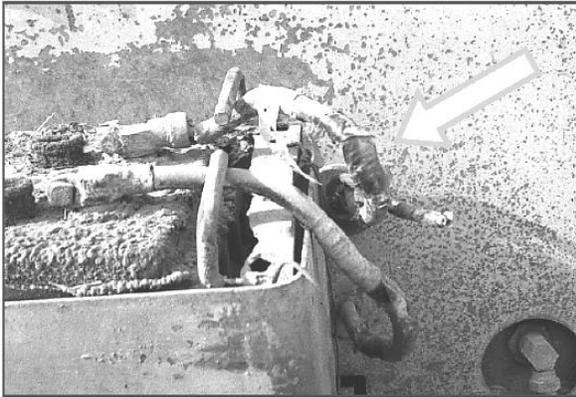
Accumulated debris will cause excessive wear on the shims. Keep the blade slide area clean.



Keep the articulation area free of dirt, ice, and snow. Accumulated debris can knock off the water pump elbow, or damage the hood, cowling, or hoses when the machine is articulated.



Be sure to replace the safety guard if you remove it to grease the drive shaft. The guard is there to protect you and your co-workers from injury.



Battery cables that are in poor condition cannot carry the current needed to start the engine and are an electrical hazard. Replace immediately.



Keep the top of the batteries clean. Accumulated dirt attracts moisture, and this mixture can drain the battery's charge.



Keep the areas around all vent caps clean.

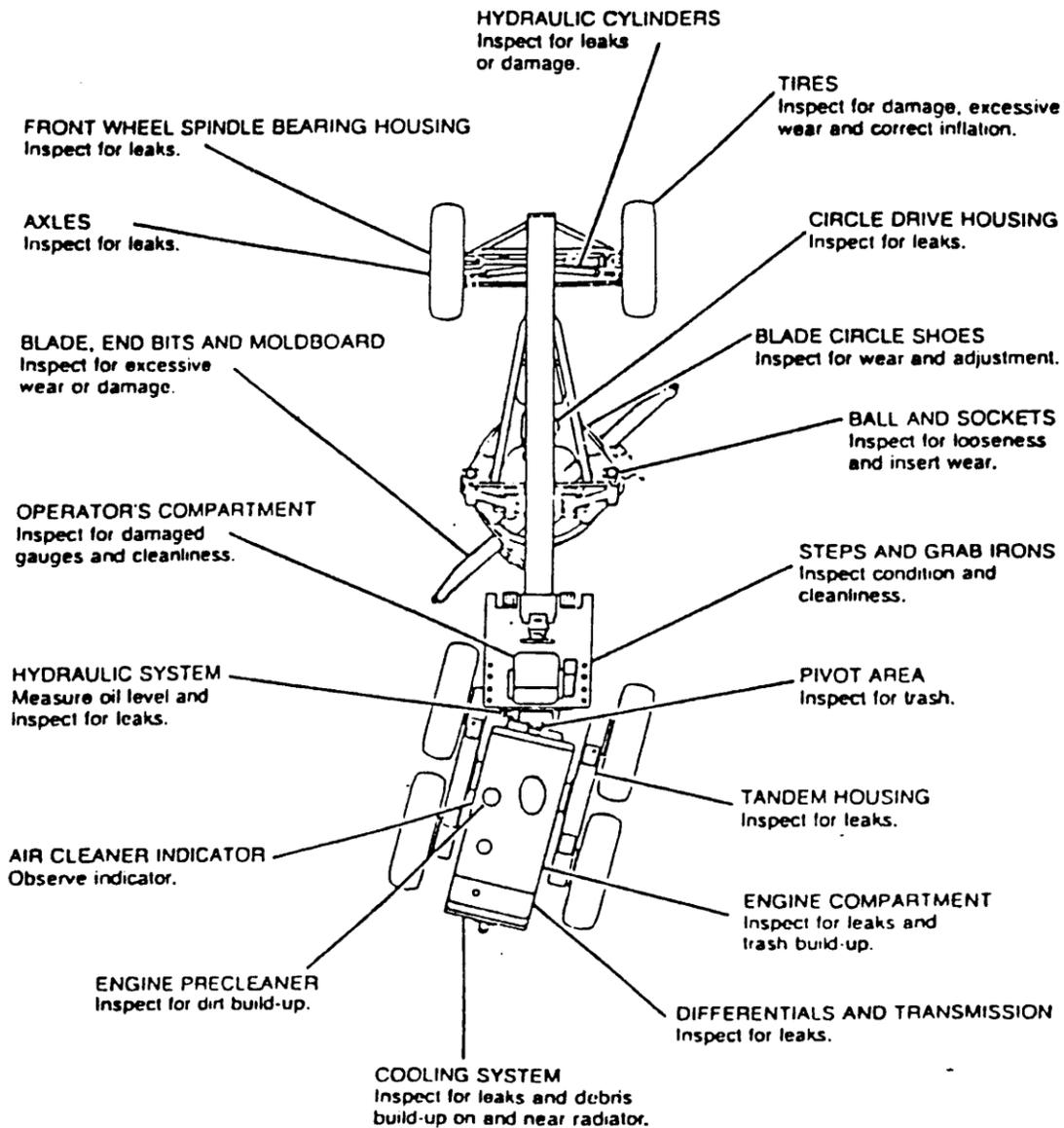


Prevent dirt from accumulating around the control valves. Valves in the condition shown above cannot operate properly. A clean machine reflects operator pride!

"Pre-Start, Walk-Around Inspection for Motor Graders."  
The Bridge Fact Sheet (January/March 1995) 1-4.

## Walk-Around Inspection

For maintenance and operator personnel safety, and maximum service life of the machine, make a thorough walk-around inspection when performing lubrication and maintenance work. Inspect under and around the machine for such items as loose or missing bolts, trash build-up, cut or gouged tires, oil, fuel, or coolant leaks, and condition of blade.



Records should be kept in a convenient place for recording and verification. The location of records varies with the use of equipment and owner's policies. Records may be kept with the machine or in the service area.

### **Pre-service**

The key to preventive maintenance is a pre-service walk-around inspection or check that should be performed each day before a machine is used. This inspection will identify potential problems that can cause a breakdown. For example, a machine that is low on oil may develop engine damage if the problem is not detected and corrected before putting the machine in service.

All operators should also inspect their machines at the end of the day and should be alert for problems that might develop during operations.

### **Walk-Around Inspection**

1. Start at same location every time so that you don't miss anything.
2. Check all hoses for wear, loose connections, leaks and loose mounting brackets.
3. Check windows, doors, wipers, lights, and direction signals where applicable.
4. Check rear tandems for poor alignment and leaks.
5. Check all fluid levels as recommended by manufacturer.
6. Inspect frame for cracks.
7. Check steering system.
8. Check brakes.
9. Make sure all warning devices are in place and that flasher lights are clean and working.
10. Clean out machine and wash windows. Take pride in your equipment.
11. After machine has been thoroughly checked, start engine and let warm up for at least 2 minutes in warm weather and 5 minutes or longer in cold weather.

## Grader Preventive Maintenance

Equipment supervisors and operators want their equipment to work properly all day, every day. Of course, this is not possible because machines will break down unexpectedly. However, breakdowns can be minimized by initiating a preventive maintenance program.

Increased use of specialized equipment with the addition of new components increases the possibility of breakdowns. These machines have increased horsepower, greater load capacity, and are subjected to more stress and shock than ever before. Now components such as torque converters, power shift transmissions, power brakes, power steering, air conditioning, and greater speed and capacity have increased the maintenance workload on supervisors and maintenance personnel.

Failure of any of the components may cause an expensive shutdown. A machine that is down for repair is costly not only in parts and labor, but also in loss of production time. It seems as if breakdowns usually occur when the workload is the greatest and work time is limited.

Preventive maintenance of equipment is essential and not difficult. The leading cause of premature equipment failure is **putting things off**. Certain steps should be taken on a regular basis to prevent expensive failures later on. Good preventive maintenance practices should become a habit and should be performed on a regular basis.

### Benefits of a Good Maintenance Program

A good preventive maintenance program not only reduces the possibility of a machine breakdown, but also:

1. Saves money on costs of repairs (labor and parts).
2. Saves time (loss of production).
3. Reduces inconvenience to the traveling public.
4. Reduces loss of power (machines in need of maintenance may be sluggish).
5. Increases operator's safety.

One of the primary reasons for properly maintaining equipment is safety. Operator safety and the safety of others is dependent on properly maintained equipment. A good preventive maintenance program will enable you to operate your equipment efficiently and safely.

#### **Setting up the Preventive Maintenance Program**

Every owner or operator of machinery should establish a good preventive maintenance program. Certain components on most machines need to be inspected, lubricated, and/or replaced at specific time intervals.

Instructions for preventive maintenance are usually in the operator's manual of each machine.

Time intervals are determined by hours of operation or by mileage. If a machine has a large percentage of idling time and/or stop-and-go driving, preventive maintenance is usually based on hours. An hour meter can be attached to a machine if it does not already have one. This automatically records the hours of operation. Machines may also be inspected daily, weekly, monthly, or annually. Examples of time intervals are 5 hours (twice daily), 10 hours (daily), 50 hours (weekly), 100 hour, 250 hours, 500 hours, etc. The time intervals for most machines have been established by the Society of Automotive Engineers (**SAE**) and adopted by most machine manufacturers.

Each time an inspection is made, all preceding inspections should also be completed. Machines removed from service for the 500 hour inspection should also receive the 250 hour, 100 hour, and 50 hour inspection. Time must be allowed for each inspection and service in order for a preventive maintenance program to be effective.

An important procedure that can help reduce the possibility of costly breakdowns is to establish an **oil sampling program**. Some equipment manufacturers and/or dealers, and some oil suppliers have oil analysis programs available. **If your town is not presently using such a service it might be worthwhile to look into.** Oil analysis involves taking samples of oil from the engine, transmission, and gear boxes, and sending them to a laboratory for analysis. This is a very worthwhile service to have when you consider the cost of major component repairs. An oil sampling program can be established when a new machine is purchased or when an older machine is overhauled. One should even consider including an analysis service when writing the specifications for new machines.

#### **Preventive Maintenance Records**

Accurate, up-to-date, preventive maintenance records are essential. It is recommended that there be a chart for each machine that describes each inspection or service that is to be done, and the corresponding time intervals. The chart should also have a record of the date each inspection or service was actually completed.

**Equipment that needs maintenance is inefficient. A vehicle needing a tune-up may use 10 gallons more fuel per day than one that is in good condition. Ten gallons of fuel, per day, per machine, can cost an agency far more than the cost of routine maintenance.**

**Motor Grader  
Preventive Maintenance Check List**

Vehicle # \_\_\_\_\_ Date \_\_\_\_\_ PM Location \_\_\_\_\_ # Hours \_\_\_\_\_

<b>150 Hour Service (90 Days)</b>	<b>OK</b>	<b>Repair</b>	<b>Follow Up</b>
Change Engine Oil and Filter			
Check Air Filter Elements – (replace if necessary)			
Check Exhaust System			
Check Air Inlet System for Leaks			
Check Wiring for Chafing, Loose Connections, etc.			
Check Battery Electrolyte Level			
Check Front End			
Check and Tighten Wheel Studs			
Check Drive Axle Oil			
Check Oil Level in Tandem Drives			
Check Parking Brake Adjustment			
Check Oil Level In Circle Drive Gear Box			
<b>300 Hour Service</b>	<b>OK</b>	<b>Repair</b>	<b>Follow Up</b>
Change Fuel Filter			
Change Hydraulic Filter and Clean Magnets			
Change Transmission Filter			
Visually Inspect Engine Mounts			
Take Oil Sample			
Check and Adjust Brake Pedal Linkage			
Steam Clean Radiator			
<b>1000 Hour Service</b>	<b>OK</b>	<b>Repair</b>	<b>Follow Up</b>
Steam Clean Engine			
Check and Adjust Engine Speeds			
Check and Adjust Valve Clearance			
Clean and Repack Front Wheel Bearings			
Clean Hydraulic Tank Breather Filter			
Check Pivot Pins and Bushings			
Road Test Prior to Releasing to Using Agency			

Performed by \_\_\_\_\_

## Radiator-Cooling System

1. Check radiator daily for damage, leaks, loose mounting.
2. Keep fluid at recommended level determined by equipment manufacturer.
3. Check fluid level when cold. Consult instruction manual for removal when engine is hot. Use extreme caution!
4. Blow dust and debris out with compressed air daily. Keep clean.
5. Clean and flush every fall prior to adding new anti-freeze.
6. Never run anti-freeze longer than recommended by its manufacturer and be sure to use the proper type.
7. 50 percent anti-freeze and 50 percent water is a good mix. ***Too much anti-freeze will raise, and not lower, the freezing point of the mix.*** When adding fluid, use 50-50 mix.
8. Replace hoses as recommended by manufacturer. Normally, hoses will not last over four year.
9. Tighten all loose hoses.
10. Check water pump daily.
11. Check fan belts for wear and proper tension daily.
12. Check head gasket for seep and leaks.
13. Check heater core for leaks.
14. Use additives only when recommended by manufacturer of machine.

## Tire Maintenance

1. Check tire pressure regularly, at least weekly.
2. Maintain the pressure recommended by manufacturer.
3. Always check and inflate tires when they are cold.
4. Never 'bleed' air pressure from warm or hot tires.
5. If tire becomes low while operating, increase pressure to match the other tires.
6. Always use liquid tire gauge when checking pressure in tires with liquid ballast.
7. Inspect tires for abnormal wear, cuts, tears, nails, broken belts, separations, etc.
8. Match and pair tires. Keep tire diameters within 3/8 inch of each other if possible. Mismatched tires (different sizes) will affect work performance and can cause serious damage to equipment.
9. Buy tires with proper load capacity and lug design.
10. Tire pressure may be increased when a wing plow, sloper, v-plow one-way plow, snow blower, rotary mower, ripper, or other heavy accessories are mounted on the side, front, or

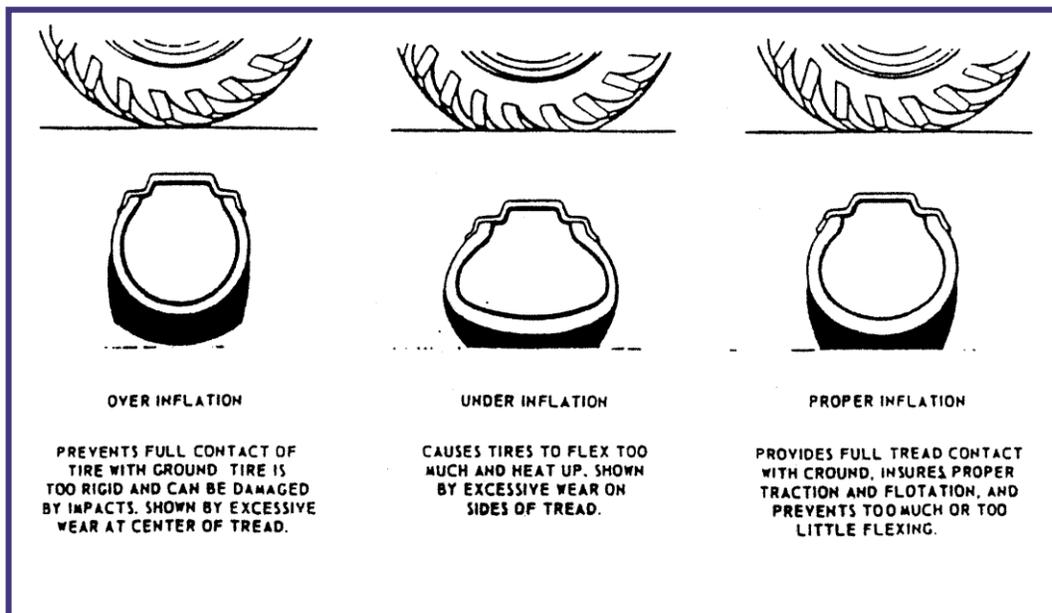
rear of the machine. **Important: Don't use excessive pressure or under-inflate tires.**

Consult tire dealer for proper pressure.

11. Use proper rim width. Consult manual.
12. Avoid sharp objects.
13. Buy good quality tires that are round.
14. Always put tire in safety cage when inflating. If tire is on machine, stand to side of tire while adding air.
15. Inspect locking ring.
16. Always have tire running in right direction. Non-pulling tires normally run in opposite direction as pulling tires.

## Tire Wear

Uneven tire wear is usually caused by a mechanical problem such as improper balancing of wheels, front-end misalignment, broken springs, etc. Tire problems that are mechanically caused can only be cured by correcting the mechanical problem. The list of causes and effects on tire life is very long. Tires that are well maintained will give long, hard service.



## **Safety Procedures**

The safety of the equipment operator is of prime concern to everyone. This unit includes helpful guidelines for the operator.

It is the operator's responsibility to know all specific requirements, precautions, and work area hazards connected with his/her job. An understanding should be reached between the operator and supervisor to ensure safe operating performance.

Remember that on any job the operator is the key to safety. Good safety practices not only protect the operator, but also the other workers. Practice safe operation. Be alert to possible hazards before they cause trouble. Perform the following procedures:

### **Be Prepared**

1. Know the safety rules for the job.
2. Check with the supervisor if appropriate, for specific instructions and safety equipment requirements.
3. Be aware of the many safety and warning devices that exist. They indicate possible hazards to expect.
4. Learn the traffic rules at each work site. Know the hand signals and who will be responsible for giving them.
5. Know the equipment. Read the manual to learn its operating characteristics, capabilities, and limitations. Be familiar with control and safety devices.
6. Know the work area. Check weight limitations, types of surfaces, and clearances.

### **Check Equipment Regularly**

1. Inspect the machine according to the operator's manual.
2. Clean windshields and windows.
3. Remove oil and grease from the equipment's walkways.
4. Remove or fasten any loose item.

### **Clear the Area**

1. Walk around the machine to make sure there is no one near the equipment.
2. Warn all people nearby that the equipment is to be started.

### **Practice Start-up Safety**

1. Check to ensure all controls are in neutral.
2. Start equipment only from operator's seat.
3. Be certain brake is set.

### **Test Machine Before Operating**

1. Test brakes for proper operation.
2. Check transmission through all gear ranges.
3. Operate all equipment controls through a complete cycle.

### **Work Safely**

1. Do not carry riders.
2. Do not let anyone ride in a pivot area.
3. Look, then look again, before backing up.
4. Move vehicle slowly in congested areas.
5. Give loaded vehicles the right-of-way.
6. Stay away from edges.
7. Use care on slopes.
8. Keep equipment under control at all times.
9. Watch for overhead dangers.
10. Report defective equipment.
11. Keep your mind on your job and stay alert.
12. Use lights after dark.
13. Select a safe parking area.
14. Shut equipment down according to the operator's manual.
15. Be sure equipment is safe to leave.

### **Perform Maintenance with Care**

1. Keep area clean.
2. Tag controls when servicing.
3. Remove pressure caps carefully.
4. Watch out for hot fluids.
5. Watch for exhaust gases.
6. Keep hands clear of moving parts.

### **Wear Appropriate Safety Equipment**

1. Reflective vest.
2. Proper footwear.
3. Hardhat.
4. Keep loose clothing away from moving parts.

## Safety Tips and Safe Operation

### Seat Belts

Seat belts are required by law. Heavy equipment operators sometimes have a false sense of security and neglect to use the safety belts. We need to let go of the illusion of well being, and recognize the possible danger when we neglect to follow safety procedures.

### Clean Windows

Many times, the insides of windows are overlooked; this can create mirror reflection and blind spots.

### Slow Moving Vehicle Signs

These are required by law; you can be ticketed for using faded or otherwise illegible signs.

### Three-Point Stance (Entering and Exiting Grader)

Most injuries occur when operator exits forward and doesn't keep a three-point stance.

Although government agencies aren't required to have daily inspection sheets, the same standard for police checks exist. ***Keep all checklist items safe!***

Flags on moldboards, strobe lights, and strobe light color are a matter of local policy.

Always remember – **You, as the operator of any given piece of equipment, are responsible, and may be held legally liable, for unsafe use or maintenance of the equipment.**

## Maintaining Gravel Roads

### Introduction

Anyone who is responsible for the proper maintenance of a gravel road has two main objectives:

1. To maintain roads and ditches in the proper shape and surface condition in order to insure a good driving surface, good drainage, and low maintenance costs.

**and**

2. To take care of the grading equipment in a way that makes the most efficient and economical use of its capabilities.

**Your job is a very important one.** Generally, the highway maintenance budget is a large share of the town's budget. Operators can either make or break a maintenance program. With proper application of your skills as a grader operator you can make your road system one everyone can be proud of. When the taxpayers are happy with your roads, they are more likely to support the operation of the highway department. You are road commissioners or town officials, and the public will appreciate your efforts.

**For those of you who are the managers, administrators, or overseers** of an operator or two, or a private contractor, this program will alert you to the fundamental concepts of proper gravel road maintenance. Knowledge of these concepts allows you to be aware of the desired end-product, and to experience the good feeling that comes from knowing that the town got its money's worth.

**For those of you who already have grader operating experience**, it is not the purpose of this training program to completely change the way you operate your machine. However, many operators taught themselves how to run a grader and learned the hard way, by doing the actual work. If this is the case, here is your chance to improve on the skills you have developed by getting a little professional advice and some really useful operating tips. This guidance should help make you even more valuable as a top-notch grader operator.

**For those trainees who are relatively new** to running a grader, this training program offers you a one-in-a-million chance to get some sound, professional instruction. We will help you learn the basic skills needed in order to develop into a knowledgeable, qualified operator. A grader is a complex machine and good professional instruction is necessary if you hope to be able to use your own talents to their fullest.

**For all road maintenance people**, the experienced and inexperienced, this program is designed both to refresh your memory and provide some new information about gravel roads themselves. We will stress the importance of good drainage and emphasize the need for well-crowned gravel roads and shoulders, clear ditches, and properly installed culverts. In addition, we want to help you improve the techniques for achieving these goals through better grader operation.

Remember, you need to know your equipment, your roads, proper operating procedures, the law, and the policies of your agency. To be a good operator, you must expend a lot of time and effort. No matter how much you know today, you'll need to know more in the future. So keep an open mind and be willing to try new ideas that come along.

We realize that what is discussed in this course can be achieved by many different methods and procedures. However, the end product should be the same – having a road with the proper cross-section, a good riding surface, a good base, and good drainage. This will produce an excellent roadway – one that shows the traveling public that the roads are being maintained by knowledgeable, skilled personnel.

The three most important  
elements in maintaining a  
good road are:

**Drainage**  
**Drainage**  
**Drainage**

## **Two Common Mistakes Cause Most Grading Problems**

1. Trying to get too much done in too short a time. Often the operator runs his blade too straight across, goes too fast, and tries to move too much material in one pass.
2. Tilting the moldboard in the wrong direction. For maintenance work, the moldboard needs to be tilted forward so that the material rolls and packs. If the moldboard is tilted back instead of forward, the blade will cut rather than scrape.

### **Conclusion**

***You, the grader operator, are the key to good roads in your local agency.***

You have the roads, the equipment, and the knowledge, to understand the importance of good gravel road shape and dimensions; you have the operating tips and techniques with which to further develop your skills and abilities.

**How good your roads are is almost entirely up to you.**

**How well you do your job is entirely up to you!**

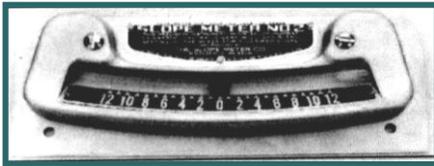
## Slope Meters

Slope Meters are a very inexpensive add-on to the motor grader that allow operators to see exactly what they are doing at all times. I include information on two available meters of which I am aware. As a matter of 'FACT,' the most widely used is the Slope Meter Company model. It has been around longer, and durability and accuracy are well proven.

When the Slope Meter is used on a daily maintenance basis, it is usually mounted in the cab, but sometimes it is mounted on the main beam. For fine grade work, it is typically mounted on the moldboard for true readings of the blade.

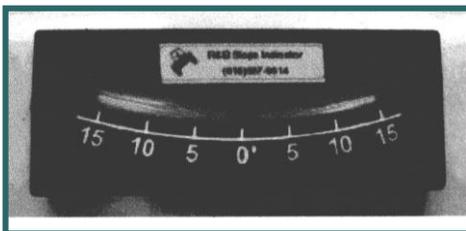
Factors that will change readings are tire lean, articulation, and change in tire pressure.

**Slope Meter Inc.**  
1317 Rice Creek Rd.  
Minneapolis, Minn. 55432



**Slope-Meter No. 2 NS** . . . . . (Call for price)  
Slope-Meter No. 2 NS has a larger Indicator tube and larger numerical scale for easier reading with a quick glance. It is desirable for applications where the Slope-Meter is mounted at some distance from the operator. It is largely used for the same purposes and on the same type of equipment as Slope-Meter No. 2.

**R & B Manufacturing**  
4948 NW High Dr.  
Riverside, MO 64150



OEM and Quantity Discounts Available!  
Model #15 Degree Indicator  
Standard Model (#15a)

## Tires

The latest in tire innovation are tires that many grader operators look at initially and say something like '**You must be kidding.**' This is because of the old idea that heavy equipment tires have to have '**big, grabbing**' treads.

The new tires I am referring to are all designated as some sort of '**SNOW**' name. Bridgestone, Michelin, and Goodyear all have variations of these tires on the market, and all are equally as good.

The tread pattern is unlike any you have seen, unless you've already seen these. They look very much like all weather tread tires for your car or pickup. Many agencies in the winter areas are extremely happy with the traction and less need for tire chains. Many agencies say they only use chains approximately 20% as often as in the past.

Other advantages are that tread life reports range from 40% up to 200% longer than standard tires. It is easy to understand this because with these tires, you have much more rubber on the road at all times. Many operators also say the ride is much better, which again is reasonable, since consistent tread is on the road surface to create a smoother ride.

Contact your local tire dealers for more info. Always remember, many companies selling products will give a pretty good allowance toward existing tires if you want to try newer styles.

Models by brand name:

- Bridgestone (G2 VSW)
- Michelin (XSNOPLUS M or S)
- Goodyear (AS-3A, G-3T)



**New style heavy equipment tires that resemble all season radials.**

## Carbide Bit Blades

Carbide bit blades are one of the most effective and efficient add-ons available to grader operators at this time. With this blade, you have a system that will give you the best results with the least work, less wear and tear on your machine, and lower fuel consumption.

After scraping for a short period of time, standard flat blades get what is referred to as **banana** curve. The carbide bit blade eliminates this problem because the cutting edge of this blade is not a flat surface, but rather a series of **teeth** that cut, break and mix the roadbed material. Your road is maintained much more consistently and has a better surface to bond back to after scraping.

Another major advantage to this system is that with a flat blade, you create a **quarter round** profile on your road. This blade eliminates that because you always have a flat cutting surface working the roadbed. You also have a better balance of **finer** and **aggregates**, due to the cutting and mixing action of these blades.

In many instances, you will have to make fewer passes to get your roads in better shape than you typically would with a standard flat blade. The dynamics of this blade create less resistance while scraping, and therefore allow you to go a bit faster and also save fuel.

The **cutting** and **breaking** abilities of these blades in extremely hard conditions or rocky areas also lessens wear and tear on equipment. While cutting and breaking larger stones that are embedded in your roadbed, you will also be making aggregate and fines to help keep your road stable and bound together better.

Initial cost of these systems is high, but as will be shown, the long-term payoff far outweighs the initial investment. Savings come in fuel, less wear and tear, less labor, and changing blades less often. The most significant advantage is years and years of use of one set of carbide bit blades, versus many, many changes of standard blades.

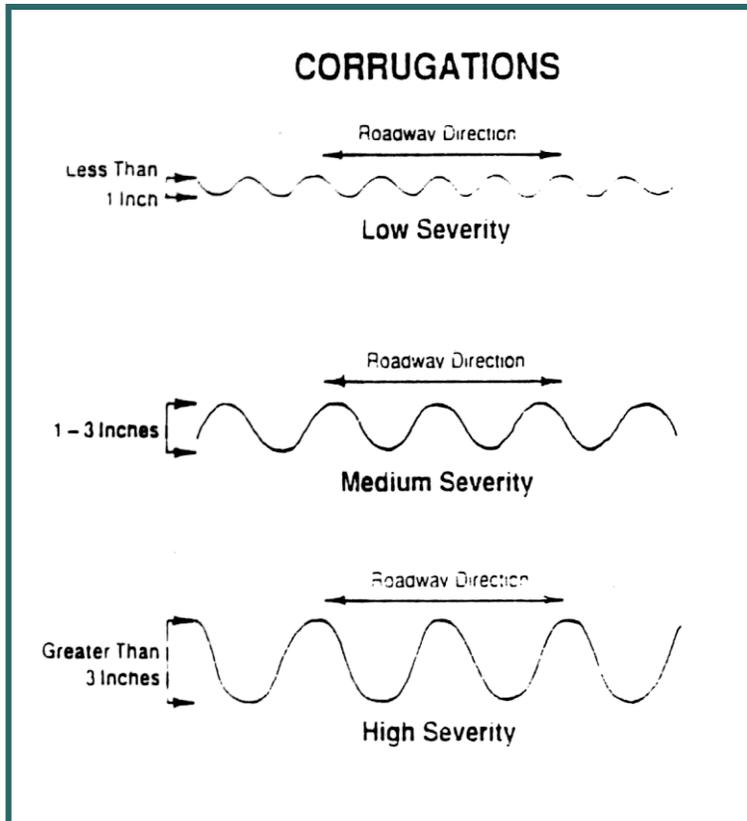
Over 90% of the agencies at which I've instructed, that use this typed of blade, use either the Pacal or Sandvik blades. From my own experience and that of others, it is because of the quality and durability of these blades. I present this information from my own personal experience, only to suggest that these are the most widely accepted and most widely used blades.

(As you will notice, information on Caterpillar blades is not included here, by their own choice.)

<b>Comparison of Carbide Bit Grader Blade Systems</b>					
	<b>Pacal</b>	<b>Sandvik</b>	<b>Kennametal</b>	<b>Caterpillar</b>	<b>Deere Stinger</b>
<b>Rotating Bits</b>	Yes	Yes	Yes	No	Yes
<b>Full Moldboard Cast Angle</b>	Yes	Yes	Yes	No	Yes
<b>Moldboard Back Angle</b>	70°	70°	90°	90°	90°
<b>Warranty</b>	Yes	Yes	Limited	Yes	Limited
<b>Back Drag Capabilities</b>	Yes	Yes	Poor	Poor	Poor
<b>Heat Treated Adapters</b>	Yes	Yes	No	Yes	No
<b># Bits Per Foot (Std)</b>	8	8	6	5	6
<b>Adapter Construction (Std)</b>	1-Pc. Extruded	1-Pc. Extruded	Welded Bit Holders	Single Piece Casting	Welded Bit Holders

## Washboards

Washboards, also known as corrugations, are closely spaced ridges and valleys (ripples) at fairly regular intervals. The ridges are perpendicular to the traffic direction. This type of distress is usually caused by traffic volume/speed and loose aggregate. These ridges usually form on hills, on curves, in areas of acceleration or deceleration, or in areas where the road is soft or potholed. Removal of the washboard corrugations and relaying the gravel material can only be effectively accomplished during the spring and fall when soil moisture conditions are adequate. Without proper moisture conditions, washboarding will rapidly reappear, increasing the cost of maintenance. Washboard corrugations can be a serious problem, both during the summer and winter months.



It is extremely important not to break the surface crust when removing the washboards. The most effective means of removing the washboard corrugations and loose material is to use a normal straight cutting edge on a motor grader and to **sweep** the loose aggregate off with the blade. The use of carbide tip points on the blade tends to break up the aggregate and leaves loose material. The removal of the loose material is important. If it is not removed, the road surface crust may break loose and the washboard corrugations will reform. Loose material on the road will enhance the dust problem and the binder material is lost.

The removal of the washboard corrugations and loose aggregate is effective as long as the surface material has at least 7% fines (minus 200 sieve). The fines work as a binder for the crust and facilitate a smooth road surface. Past experience has demonstrated that hard vehicle braking on the road

where the washboards have been removed has resulted in black tire skid marks on the road surface.

## Eliminating Berm

The most important thing to remember about 'berm' is this: ***IF YOU DON'T CREATE THEM, YOU WON'T HAVE A BIG PROBLEM LATER!***

There are a few ways to deal with berm, depending on the circumstances. If you are dealing with average, or reasonable berm, sometimes you can cut it all into the road, break it up and mix it in at one time, if the material is not too full of debris or dirt and sand. If you have some of these problems, the best bet is to work a little in each time you scrape, and let it mix in gradually so as not to contaminate your existing material.

If you have large berm, it is going to take time, unless you are able to cut, load, and haul away, or have an area to cut it to behind the ditch line. Cutting a little each time you go out will help in many ways. Berm that hasn't been touched for a long time has a hard surface that doesn't let water soak into it, which keeps your road wet longer. A wet road is not good, so by cutting a little away, you open that area for water to begin soaking off the road. Work at it a bit at a time, and eventually it will be worked into the existing roadbed.

***Turnpiking*** is an old method that is not recommended at all. This consists of using your blade and cutting a trench in the roadbed, then cutting the berm material into it. After cutting the berm into the trench, the material cut up from the road is rolled back over it to cover it. This is a huge problem, because you have now put vegetation under there that will rot and hold moisture and keep your road soft.

In the case of large berm, many operators think it necessary to cut them down to the level of the existing road, but if you start cutting from the top down, the berm will blend in with the rest easier, without having to go as deep as you may think.

To break up the sods and materials you've brought into the road, place your blade at half the depth of the material. If the clumps are 10 inches high, set your blade 5 inches off the ground, with the blade set at 45 degrees, moldboard rolled all the way back, going as fast as you can safely. The blade cuts into the material, flings it back into the blade, breaking it some, then curls it back onto the roadbed and breaks it more. This may be repeated a few times depending on the type of material and wetness of your material.

## How to Figure the Cost of Lost Gravel Or Grab Your Coffee Can

**Question:** How would you like to save over \$6,000 per motor grader operator per year?

**Answer:** Train your operators to properly pick up windrows of gravel.

Some do-it-yourself coffee-can research by the Nebraska Technology Transfer Center's Ed Wootton led to this conclusion.

As he watched motor grader operators at work, Ed wondered about the cost of the gravel lost off the toe of moldboards, as windrows were picked up.

So he measured one foot in the ditch and put all the spilled gravel he found in that area in a coffee can. When he weighed the can he found he had two pounds of gravel (which he says is a very minimal loss – often it is much more).

At that rate, the gravel loss is 21,120 pounds in one mile (includes both sides). If an operator grades 3 miles in a day, he loses about 32 tons (which is about 18 cubic yards). At \$7.00 per cubic yard, the dollar loss is \$126 per day.

If the operator works 53 days per season (grading 40 miles of gravel road four times per season), the total dollar amount of lost gravel is about \$6,700, nearly five months of salary for an average town grader operator.

"The main cause of this loss," Ed says, "is improper blade angle."

"We know there are other factors in the loss, such as wind, water loss, and heavy traffic," says Ed, "but the chief cause is improper procedure."

The spilled gravel is partially retrievable by pulling up the slopes, but that is time-consuming and costly, and 'you don't get it all.'

Here is Ed's formula, if you want to measure your own losses:

1. Weigh gravel collected from one foot of ditch = 2 pounds per foot.
2. Multiply x 5,280 (feet per mile) x two sides = \_\_\_\_\_ pounds per mile.
3. Multiply x number of miles, per day, per machine = \_\_\_\_\_ pounds per day.
4. Multiply x number of days worked per year = \_\_\_\_\_ pounds per year.
5. Divide by 3,500 pounds per cubic yard (to get number of cubic yards) = \_\_\_\_\_ cubic yards per year.
6. Multiply number of cubic yards per year x cost per cubic yard of gravel = \_\_\_\_\_ dollars per year for LOST GRAVEL.

## Two Closing Thoughts

1. There's an old saying that goes like this:

If you're not part of the solution, you're part of the problem!!

***Which do you choose to be?***

2. An old-timer who taught me a lot always reminded me that the most important thing at the end of each day was to answer this simple question:

***If someone else did a job like that in front of YOUR home, would you be happy with it?***

**Thank You!**