Gravel Road Maintenance & Design

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Workshop Goals

- Share information from other sources
- Participate in thinking about how service is delivered
- Discuss different policies
- Hear what "best practices" are
- Improve service by knowledge sharing
- Renew your knowledge "what is good gravel"
- Leave the workshop today with new ideas on how you can improve gravel road maintenance

Introduction

Another important matter to consider is the dramatic change in the vehicles and equipment using low volume roads. Truck and agricultural equipment are increasing in size and horsepower. The trend is toward even larger machinery. The effect of larger and heavier vehicles on our paved roads is not well understood by the driving public. There is a definite need to build stronger bases and pavements. But the effect on gravel roads is just as serious and often is not recognized. For this reason, a section on the design of gravel roads is included. The strength of the subgrade and depth of the material needed to carry today's heavy loads must be considered. Proper drainage is also very important.
2017 New Minnesota Statue 169.869 Road Construction Special Permit

Introduction

Good gravel road maintenance or rehabilitation depends on two basic principles: proper use of a motor grader (or other grading device) and use of good surface gravel. The use of the grader to properly shape the road is obvious to almost everyone, but the quality and volume of gravel needed is not as well understood. *It seems that most gravel maintenance/rehabilitation problems are blamed on the grader operator when the actual problem is often material related.* This is particularly true when dealing with the problem of corrugation or "wash boarding." The problem is often perceived as being caused by the grader but is primarily caused by the material itself. The manual will help provide a better understanding of what makes good surface gravel.

Introduction

The final section of the manual covers innovations in the gravel road maintenance/rehabilitation industry. Change is constant in almost every aspect of this modern world and maintaining gravel roads is no exception. *There are new ways of stabilizing roads, new methods of dust control, new and different kinds of equipment available for maintenance/rehabilitation of gravel roads, and even new surface materials such as recycled asphalt being used.* Not all of these innovations may be available or practical for every local government entity, but everyone is encouraged to take an objective look at each of them. Then an informed decision can be made about changing the way gravel roads are designed and maintained within a particular jurisdiction.

Road Construction Materials Special Permit

- Minnesota Statutes 169.869
- 6 Axle Trucks to haul 90,000 lbs
- 7 Axle Trucks to haul 97,000 lbs
- Seasonal winter up to 99,000 lbs
- A road authority may issue an annual permit

- Local Road Authority shall designate haul route to be used with Special Permit
- Local Road authority may charge for the permit
- MnDot fees are $300.00 and $500.00 annually

Section 1: Gravel Road Basics

5 out of every 10 roads (50%) in United States are unpaved.

They all tend to encounter the following road management problems:

1. Drainage/Loss ofgrade line
    - Road defects such as wash boarding, potholes and ruts
    - Gravel availability
    - Erosion
    - Intrusive roadside vegetation
    - Dust control
    - Reshaping
    - Resurfacing
    - Reconstruction
    - Operator training
    - Taxpayer complaints
    - Liability (risk of lawsuits)
    - Rising costs of:
        - Gravel
        - Dust abatement products
        - Base stabilization products
        - Equipment & personnel

Background

- Gravel roads are generally maintained by performing routine blading to maintain a crowned, smooth driving surface. Surface gravel is added as needed either by "spot graveling" or placing fresh gravel on a entire section.
- Gravel roads are managed much differently from paved roads. Maintenance is needed much more often on gravel roads. Long-term planning for a paved road might be 5-20 years out; for a gravel road it would be only 1-2 years.
- Road conditions can vary greatly on gravel roads based on weather andtraffic.

Section 2: Distresses in Gravel Roads

Seven major categories of distresses in gravel roads :

1. Improper cross section
2. Inadequate roadside drainage
3. Corrugations (washboarding)
4. Dust
5. Potholes
6. Ruts (damage by usage)
7. Loose aggregate

1. Improper Cross Section

A gravel road should have a crown with enough slope from the centerline to the shoulder to drain all water from the road's surface. No crown is used on curves, because they are usually banked. The cross section is improper when the road surface is not shaped or maintained to carry water to the ditches.

Medium Severity Level

- Moderate amounts of ponding water or evidence of ponding water on the road surface; or
- The road surface is bowl shaped

High Severity Level

- Large amounts of ponding water; or
- The road surface contains severe depressions

Winter Damage

- Snowplowing gravel loss
- Traffic damage
- Winter freeze and thaw cycles

2. Inadequate Roadside Drainage

Poor drainage causes water to pond. Drainage becomes a problem when ditches and culverts are not on good enough condition to direct and carry runoff water because of improper shape or maintenance

Low Severity Level

- Small amounts of ponding water or evidence of ponding water on the road surface; or
- Overgrowth or debris in the ditch

Medium Severity Level

- Moderate amounts of ponding water or evidence of ponding water on the road surface; or
- Moderate erosion of the ditches into the shoulders or roadway

High Severity Level

- Large amounts of ponding water; or
- Heavy erosion of the ditches into the shoulders or roadway

3. Corrugations

Corrugations (also known as wash boarding) 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 and loose aggregate. They usually form on hills, on curves, in areas of acceleration or deceleration, or in areas where the road is soft or potholed

Severity Levels

- Low:
  - Corrugations are less than 1 inch deep
- Medium:
  - Corrugations are between 1 and 3 inches deep
- High:
  - Corrugations are deeper than 3 inches

4. Dust

The wear and tear of traffic on gravel roads will eventually loosen the larger particles from the soil binder. As traffic passes, dust clouds create a danger to trailing or passing vehicles and cause significant environmental problems. Dust contributes to many complaints from adjacent property owners.

Low Severity Level

- Normal traffic produces a thin dust that dos not obstruct visibility

Medium Severity Level

- Normal traffic produces a moderately thick cloud that partially obstructs visibility and causes traffic to slow down

High Severity Level

- Normal traffic produces a very thick cloud that severely obstructs visibility and causes traffic to slow down significantly or stop

There are 1.6 million miles of unpaved roads in the US (53%)

1 vehicle for 1 year produces 1 ton dust per mile

Each mile with 100 cars per day = 100 tons of dust per year!

5. Potholes

Potholes are bowl-shaped depressions in the road surface. They are usually less than 3 feet in diameter. Potholes are produced when traffic wears away small pieces of the road surface at soft spots in the underlying soils. They grow faster when water collects inside the hole.

Severity Levels

Based on both the diameter and depth of the pothole according to the following table:

	Average Diameter			
Maximum Depth	< 1 foot	1-2 feet	2-3 feet	> 3 feet
½ - 2 inches	Low	Low	Medium	Medium
2-4 inches	Low	Medium	High	High
4 + inches	Medium	High	High	High

6. Ruts

A rut is a surface depression in the wheel path that is parallel to the road centerline. Ruts are caused by a permanent deformation in any of the road layers or sub grade. They result from repeated vehicle passes, especially when the road is "soft". Significant rutting can destroy a road.

Severity Levels

- Low
  - Ruts are less than 1 inch deep
- Medium
  - Ruts are between 1 and 3 inches deep
- High
  - Ruts are deeper than 3 inches

BITUMINOUS INTERSECTIONS

7. Loose Aggregate

The wear and tear of traffic on gravel roads will eventually loosen the larger aggregate particles from the soil binder. This leads to loose aggregate particles on the road surface or shoulder. Traffic moves loose aggregate away from the normal road wheel path and forms berms in the center or along the shoulder (the less traveled areas)

Severity Levels

- Low:
  - Loose aggregate on the road surface, or a berm of aggregate (less than 2 inches deep) on the shoulder or less-traveled area
- Medium:
  - Moderate aggregate berm (between 2 to 4 inches deep) on the shoulder or less- traveled area; a large amount of fine soil particles is usually found on the roadway surface
- High:
  - Large aggregate berm (greater than 4 inches deep) on the shoulder or less-traveled area

Section 3: Drainage Drainage

- Drainage: Get the water OFF of the road (crown)
- Drainage: Keep the water OUT of the road (ditch depth, smooth surface)
- Drainage: Keep the water AWAY from the road (clean ditches, adequate approach, centerline culverts).

Section 4: Adding Gravel Prepare Surface

Remove all wash boarding, potholes and restore a uniform crown

Loading from Stockpile: Blend material prior to loading to eliminate segregation in the stockpile

Hauling and Spreading

- Install warning signs according to MMUTCD
- Calculate the spread for each load
- Spread as evenly as possible
- Equalize the material by building a uniform windrow
- Spread the material from the windrow

WORK ZONE SIGNING

SAFETY!!!!!!!SAFETY!!!!!!!SAFETY!!!!!!!

Roll-Up Warning Signs

Option: Roll-up warning signs may be used to provide advance warning signing for temporary traffic control zones.

Standard: Roll-up warning signs shall have a black legend on a reflectorized orange or reflectorized fluorescent orange background. They may be used for daytime or nighttime only when workers are present to monitor the signs. The mounting height of roll-up signs shall conform to the standards.

Guidance: A 0.3 m (1 foot) minimum height will be allowed for roll-up warning signs, but the signs should be mounted higher in order to improve their visibility.

Position of Advance Warning Signs

Guidance: Where highway conditions permit, warning signs should be placed in advance of the temporary traffic control zone at varying distances depending on roadway type, condition, and posted speeds. Where a series of two or more advance warning signs is used, the closest sign to the temporary traffic control zone should be placed approximately 30 m (100 ft) for a low-speed urban streets to 300 m (1,000 ft) or more for expressways and freeways

Support: Various conditions, such as limited sight distance or obstructions that might require a driver to reduce speed or stop, might require additional advance warning signs.

Option: As an alternative to a specific distance on advance warning signs, the word **AHEAD** may be used

Support: At temporary traffic control zones on lightly-traveled roads, all of the advance warning signs prescribed for major construction might not be needed

Option: Utility work, maintenance, or minor construction can occur within the temporary traffic control zone limits of a major construction project, and additional warning signs may be needed.
Guidance: Utility, maintenance, and minor construction signing and temporary traffic control should be coordinated with the governing road authority so that road users are not confused or misled by the temporary traffic control devices.

Road (Street) Work Ahead Sign
Guidance: The **ROAD (STREET) WORK AHEAD** sign, which serves as a general warning of obstructions or restrictions, should be located in advance of the work space or any detour, on the road where the work is taking place, and on all intersecting roadways.
Standard: The **ROAD (STREET) WORK** sign shall have the legend **ROAD (STREET) WORK, XX FT, XX MILES, or AHEAD.**

Detour and Road Closed Ahead Sign
Guidance: The **DETOUR AHEAD** sign should be used in advance of a road user detour over a different roadway or route.
Guidance: The **ROAD (STREET) CLOSED AHEAD** sign should be used in advance of the point where a highway is closed to all road users, or to all but local road users.

One Lane Road Ahead Sign
Standard: The **ONE LANE ROAD AHEAD** sign shall be used only in advance of that point where motor vehicle traffic in both directions must use a common single lane.
Guidance: If the affected one lane roadway is not visible from one end to the other, or if the traffic is such that simultaneous arrivals at both ends occur frequently, flagging procedures, stop sign or signal control should be used to control alternate traffic flows.

Traffic Control Devices for Low Volume Roads
Definition of a Low-Volume Road STANDARD:

- Rural
- Less than 400 vehicles per day
- Not a freeway, expressway or on a designated State Highway System
- Classified as a conventional or special purpose (recreational) road

Basic Applications

- Warn of conditions not normally encountered.
- Prohibit unsafe movements.
- Provide minimal destination guidance
- The application of traffic control devices on low-volume roads is based on engineering judgment or studies and the full range of devices may be used where conditions justify.

Design, Retro reflectivity, and Placement: The same as in Part 2.

Gravel Spreading Example
What is the required spread for a 10 cubic yard load in order to place 2 inches of new gravel on a 24-foot wide road?
Gravel Coverage Chart Showing Depth of Gravel in Inches
For a 24-foot road, 2.05 inches will require 800 cubic yards/mile. This is close enough- use 800 cubic yards/mile.
Gravel Spreading Chart In Feet Per Truckload
A 10 cubic yard load requires a spread length of 66 feet.

Conversion factor Cubic yards to Tons

- Multiply yards by 1.4
- 800 x 1.4 = 1,120 tons
- Tons to Cubic Yards Divide by 1.4
- This for loose volume
- Compacted volume use 1.8 conversion.

Section 5: What is Good Gravel?

What we want from a GravelSurface:

- Never Washboards
- Is not greasy when wet
- Is not dusty when dry
- Never potholes
- Never has loose rocks on the surface
- Never ruts in the wheel tracks

What we get from a Gravel Source: none of the above Why? COSTS

What is Good Gravel?

- Good gravel has a blend of aggregate sizes that fit together
- It stays in place
- Has enough binder to form a crust and shed water
- Doesn't rut when it is wet
- Doesn't dust when it is dry

Every road agency must balance the amount of funds available for gravel surface, how much gravel material is needed, and the cost of available gravel material

Gravel Costs

1. Royalty
    a. .50 to $1.50 per cubic yard
2. Processing – crushing, screening, etc.
    a. $1.55 to $3.25 per cubic yard
3. Stockpiling or storage
    a. .35 per cubic yard
4. Loading and Trucking
    a. .35 per cubic yard - .20 to .35 per cubic yard – mile
5. Other – testing, permits, restoration, etc. Varies

Rule #1: When it comes to Gravel, you get what you pay for!

Gravel Economics

What goes into gravel costs

Gravel Costs per Cubic Yard	
Royalty:	1.00
Crushing:	3.00
Loading:	.25
Trucking:	.35 per CY/mile
Total	4.25 cy est.

Commercial pits could be higher

1. Assume the average haul distance from the pit to your road is 15 miles…

The cost for crushed material on the road:

Royalty:	1.00
Crushing	3.00
Loading:	.25
Trucking:	$5.25 (15 mi. x $.35)
Base Cost:	$ 9.50/cy est.

If screened material is used the value could 1/3 less

= $6.50 approx. (33% less) in cost but a much less valued material for surface material!

If your budget is $20,000, then you can haul:

Screened: 3,076 CY

Crushed: 2105 CY [971 CY less than screened material]

Screened material should still be tested to see size of rock, stone, sand and binder

Rule of thumb for relative value of gravel surfacing:

- Crushed: 1.0 Best
- Screened: .67 Lesser Value
- Pit-Run: .50 or less if size is under 1"

If we applied these values to our example:

3,076 CY Screened (.67) is equivalent to 2,060 CY Crushed

2,105CY Crushed (1.0) is equivalent to 2,105 CY

Therefore, in this example, crushed gravel would be the best value for the budget for a quality road surface material.

Reasons Why Crushed Gravel is Better than Screened or Pit-Run

- More uniform size of aggregate.
- You loose more aggregate when blading screened or pit-run gravel. Thus, the gravel will not stay on the road as long.
- With screened gravel and especially pit-run, the top size material will be much higher and the spread may be shorter, or the aggregate will be lost.
- Crushed gravel should compact better and form a more stable crust that will resist loss of aggregate.

Recipe for Gravel

Gravel is not just a bunch of rocks

- Gravel is a uniform mixture of stones, sand, and clay that, when compacted with adequate moisture, will form a hard crust on the road.

Basic Recipe:

25 %	medium stones, 3/8" to ¾"
20 %	smaller stones, less than 3/8"
35 %	coarse to medium sand
20 %	very fine sand to clay

- The shape of the stones and sand particles is also very important. Sharp, angular particles will compact better and stay on the road longer than rounded, smooth particles.

- This is also why crushing of the pit-run gravel dramatically improves the quality. This assumes that you have enough rocks in the raw gravel to begin with. At least 10% crushing is recommended. Sometimes, rock must be hauled in and added to the crusher to meet specifications.
- Having too many stones is usually not a problem unless you need to stop at the bottom of a hill at a tee intersection with a major trunkhighway!
- Having too much sand and not enough binder (clay) is also a problem. Sandy gravel will not set up (crust), will washboard easily, and will leave a lot of loose aggregate (float) on the road surface. Slow rains will soak through the gravel, saturate the road sub grade, and make the road soft.
- Too much binder (clay) makes the road surface will make it sloppy and slippery when it rains. The driving public will not appreciate these sloppy roads and will let you know about it one way or another! (8-15%)
- The good news is that gravel with too much binder is like concrete when it's dry. You feel like putting a yellow stripe down the middle because the road is so smooth. However, this type of road can also get very dusty, which is not appreciated by neighboring residents. This problem will eventually solve itself when all of your binder blows away over time.
- Use a higher percentage of binder on gravel over sandy soils and a lower percentage over clay soils.

Sources of Good Gravel

- Most county highway departments let bids for gravel crushing, either for maintenance gravel or for road construction. Counties also have the necessary testing equipment and trained personnel to monitor the crushing operation to insure quality.
- A township or city may be able to work with the county highway department to piggy-back their gravel needs and requirements with the county contracts.
- You must talk with your county engineers and discuss how to best combine your gravel needs with the county.
- You can have your own separate stockpile in a pit and even modify your specifications to fit your needs. Even if your pit is in a separate location, you may save on mobilization costs, testing costs, etc. By including your gravel needs with the county's needs, this makes the size of the overall contract larger and more attractive to contractors and they may give a better cost/CY
- To reduce the initial capital investment in a pile of gravel, you might make arrangements with the county to just buy what you need each year from their pit. Of course, you should give them some advance notice and let them know approximately what your annual needs are.
- Crushing is usually not cost effective unless the pile is 10,000 cubic yards or more. The bigger the pile, the cheaper the price per cubic yard.

New Sources of Gravel

Take the time to do some research in your area for potential gravel sources.

- Hire someone with a small backhoe to dig test holes in potentialareas.
- When you find a source, try to buy the land or enter into a long-term lease with the owner.
- Again, if you're nice, the county may test the raw gravel for you to let you know if it would make good crushed gravel.
- Having your own source will pay off in the long run.

Recycled Materials

- More and more areas are recycling concrete and asphalt materials. These can be crushed or pulverized and made into good gravel or added to "sweeten" poor quality raw gravel.
- Recycled glass can be added during the crushing process and will actually improve the gravel while recycling a product.

- Asphalt shingles are also increasingly being used as an additive in gravel road mixtures, 25-50% mix does work well

Gradation Exercise

In this exercise, we will:

- Define what a gravel gradation is
- Understand how a gradation can help us to determine if we have "good" gravel or not
- Learn to read a sieve analysis

To Do List (when you get back to the office/shop)

1. Inventory: find out how well your gravel sources are doing
2. Investigate: check out sources and costs of crushed gravel
3. Review: look at the gravel's typical gradations
4. Organize: cooperative purchasing and/or processing of gravel materials between your county, area cities, and townships
5. Develop: a re-graveling program and budget
6. Develop: policies to "save" the gravel
7. Locate: new gravel sources

Section 6: Turning a Poor Gravel Road into a Good One

7 Crucial Factors to building and Maintaining a Great Gravel Road Understand Your Needs

- Before construction or rebuilding begins, it is necessary to understand the needs and uses of the area where the road is located
- Type of Traffic, heavy industrial, farming or residential

BUILD ON A STRONG FOUNDATION

- A strong foundation is essential in any construction project.
- Ideally you will building your road on a strong, deep subgrade.
- There are times, however wet soils and weak soils where we need to sub cut and use select backfill materials and engineering fabric.

Choose the Right Materials

- The best materials for a project are typically determined by the location of the project.
- Depending on the areas available resources ideal aggregate will very, but all should drain well. It is important to select the proper gravel for its respective use as either surface or base material.

Build from the Bottom Up

- This may seem straightforward concept, but it's worth the extra attention. In the same way choosing the right materials is crucial, the order in which they are applied, and how can, be the difference between a great cost effective gravel road and a weak one that needs constant expensive repairs.

Again Drainage, Drainage, Drainage

- In many ways, all the most important steps of gravel road maintenance and construction are related to drainage.
- Roads that allow water to properly drain off the surface and out of the roadbed soils are much easier to maintain and therefore less costly.

Apply Proper Palliatives [Stabilizing Agents]

- Once the road is near completion we can look at stabilizing it with material to help bind are aggregates together, serving both a strengthening and protecting agent.

- This added agent will help to strengthen for the ever increasing equipment, in both size and horsepower, resulting in increased tire pressures and grater damage.
- We are seeing more and more economical base stabilization being used state wide in Minnesota
- Dust control can add a benefit also.

Maintenance

- Whether accomplished through regular grading or soil stabilization, keeping a regular and thorough maintenance schedule will ensure the road performs well. Correct technique is essential and best left to the experienced grader operator as an untrained operator with improper grader use can damage the road.
- Materials will periodically need to be recovered and/or replaced in thin and worn out places.

Basic Elements

The three most important factors in a good gravel road are: Drainage! Drainage! Drainage!

1. Drainage: adequate crown on road surface
2. Drainage: eliminate standing water in ditches
3. Drainage: adequate approach and centerline culverts

* The idea is to eliminate as much of the subsurface moisture as possible. Too much subsurface moisture is our enemy and has "killed" many a gravel road. It is the cause of frost heaves, soft roadbeds, and frost boils.

Top Ten List for Designing a Good Gravel Road

10. Use an 18" minimum size for centerline culverts
9. Install as few centerline culverts as possible
8. Use a 15" minimum size for culverts on approaches
7. Take control of the utilities install on the South and East right-of-way lines if possible, have permit process
6. Keep steep downgrades away from intersections
5. Make sure you have enough gravel (4" to 12") to adequately handle traffic loads
4. Make sure you have 2-foot minimum separation from the natural ground
3. Make it easy to maintain ditch bottom and inslope
2. Make sure your ditches and culverts drain adequately
1. KEEP PROPER CROWN and DRAINAGE

Structure and Standards

- The Local Road Research Board has developed a guide for Low Volume Aggregate Surfaced Roads (Publication No. 92-01).
- The guide helps you decide how thick your gravel base should be to adequately handle the traffic you expect on a given roadway. Thickness is based on the soil type, traffic counts, and type of gravel base available.

Gravel Thickness Example

How much surface and base gravel is required for a newly constructed road which has a clay loam sub grade with a soil factor of 100 and two-way traffic of 150 vehicles per day?

Class 1 Surface = 4 inches

Class 5 Base = 4 inches

Or, if using screen (but not crushed) Class 3 material instead of Class 5 Base = 5 inches

Or, if using pit-run material instead of Class 5 Base = 8

- It's important to understand the difference between an ideal situation and reality.

The charts show the ideal thickness of gravel; the reality is that most agencies can't afford to put down this much gravel. So, when your roads fail in the Spring, you will know why.

Rule #2: More gravel is no substitute for a poor sub grade or poor drainage

FROST BOILS

MAJOR CAUSES

- Frost Damage or cold weather related road distress caused by;
    1. Expansion and heaving of the underlying subgrade materials as they freeze.
    2. Subsequent saturation and weakening of their load carrying capacity as the road thaws out.
- Generally, most frost damage areas can be defined by three categories;
    1. Subgrades with variable compositions of different soils in the subgrade and their capability of drainage of excess moisture and with the presence of ground water.
    2. Subgrades very close to groundwater. Groundwater is the most critical component of heaving frost susceptible soils when they freeze.
    3. Subgrades in low areas occur when surface drainage and ground water accumulate. Typical areas would be in wetlands areas, swales, ravines and flood plains.
- EVALUATING PROSPECTIVE REPAIR
    1. Improve subgrade uniformity.
    2. Reducing or limiting the impact of subgrade moisture.
- SOLUTIONS
    1. Address the causes not the symptoms, evaluate using the available onsite materials and local materials.
    2. Materials, from the evaluation onsite materials maybe used aggregate or the addition of new materials, such as sized rock, pit run materials to help solve the problem.
- REPAIR METHODS

  NO repair will be universal, as each site will be unique, each so each repair will be unique and decide which repair hopefully works the best!
    1. Scarification and compaction of 6 – 12'" to blend the materials dry and compact area.
    2. Remove material to a depth of 12 – 24" mix material, dry replace and compact. May require addition of select materials.
    3. Remove poor soils replace with select good materials excavate to 12 – 24". Compact new materials to get density. New materials can be granular borrow and CL- 5 aggregate are examples of good materials.
    4. Pay close attention to drainage to get and keep moisture out of the area.
    5. Construction materials can and should be used to aid in strength and load bearing capacity. Engineering fabrics, drain tile and grid materials work very well.
    6. Excavation transition or the taper from the cut on each end should be a min. of 5:1 with max. at 20:1 taper.
    7. Conclusion, improve subgrade uniformity, limit moisture and strengthen the problem area and replace gravel surface

Geotextiles

- If drainage can't be improved, then consider using an engineering fabric and capping it with a minimum of 6" of gravel, preferably 8 to 12".
- Use a Mn/DOT Type V geotextile and have your supplier sew two 12' to 14' pieces together so that it covers the roadway. This should cost about .50 to .70 per sq. yard or about $10,000 a mile plus the cost of gravel.
- This is expensive! That's why you should try to drain the water first.

- Use of drain tile in drainage problem areas can be very beneficial at a reasonable cost.

Spring Road Restrictions

- Roads are weakest during the Spring thaw when soils are saturated and the roadbed hasn't "settled down". Only the crust of gravel surfacing separates the wheels from the muck. If heavy wheel loads break this crust, your road will start to fall apart. That's why it's important to post your roads for weight restrictions to protect this crust and your investment.
- Research is currently being conducted at the Mn/ROAD facility near Monticello, MN on restrictions for gravel roads (2001).
- Gravel roads will take longer to thaw out and will have less strength than asphalt roads. Think about leaving your gravel roads posted for a longer period or, set up a truck route on certain gravel roads in order to save the rest of your system.

Equipment

Advertise for quotes based on hourly rates for different types of equipment such as backhoes, dozers, and scrapers, along with an idea of how much work there is to be done. If you're not happy with the job or the process that they're making, end the contract and find someone else.

Establishing a Road Management Program

1. Develop some basic standards:
    a. Road dimensions
    b. Levels of service
    c. Criteria for ranking
2. Inventory your roads, assess their condition, and identify problem areas
3. Select the most appropriate treatment to improve each problem area
4. Estimate the cost of each repair using generalized costs
5. Prioritize improvements based on:
    a. Immediate improvement to serviceability
    b. Available funding
    c. Work that can be done with your own crews and equipment
6. Establish priorities and create a 3-5 year program
    a. Make sure to include preventive maintenance items such as ditch and culvert cleanout, fix ruts and potholes, etc.
7. Seek approval for an increase in annual funding to accomplish the program
8. Update your program annually and keep your decision makers informed on the progress being made

- It's sometimes hard for the public to understand the need for expensive re-grading or ditching when you could just put a little more gravel on the road. It's like painting a house with a moisture problem and rotten wood; each Spring the new paint just peels off. Unless you fix the underlying problem, you will never maintain a good surface.
- Road improvements are sometimes like a leaky roof. When it's dry and the weather is good, you forget you have a problem. It's always less expensive to fix a problem during nice, dry conditions than during spring thaw when the road fails and irate citizens are breathing down your neck! You end up spending more money for a temporary solution than it would have cost to do it right the first time.

To Do List (when you get back to the office/shop)

1. Develop: a policy on basic design standards for improvement and levels of service.

2. Coordinate: with adjacent townships, counties or cities to provide similar levels of design and service, based on use. Ask for help on this.
3. Inventory: your roads and develop a prioritized list of improvements with estimated costs. Think about truck routes.
4. Develop: criteria to rank improvements.
5. Establish: a capital improvements budget.

BASE STABILIZATION

- Gravel Road Stabilizations
- DVD on Base Stabilization

Section 7: Dust Control

Gravel surface can provide good, economical roads for low traffic volumes. The dust they produce, however, causes air pollution, slows plant growth, and damages the material structure of the gravel. Although paving is the only permanent solution to dust problems, using effective controls can significantly reduce dust and can cut required maintenance.

- Unpaved roads are the largest source of particulate air pollution in the country. According to the Environmental Protection Agency, unpaved roads produce almost 5 times as much particulate matter as construction activities and wind erosion (the next 2 largest sources) combined.
- A single vehicle traveling a gravel road once a day for a year will produce one ton of dust per mile! This translates to losing 100 tons of fine particles a year for each mile of road with an average of 100 vehicles per day.
- When these fines are lost as dust, it damages the gravel surface and exposes the larger aggregate pieces. These are then scattered by vehicles or washed away. The unstable road surface becomes rough, developing potholes and wash boarding. These depressions hold water which infiltrates and damages the base.
- The eroded materials or dust collects in ditches and drainage systems which increases maintenance and reduces their water collection ability during storms.

Dust Control Agents

When selecting materials for dust control consider these basic requirements:

- Environmentally compatible
- Easily applied with common road maintenance equipment
- Workable and responsive to future grading
- Not degrading to ride quality
- Relatively harmless to vehicles
- Poses little hazard or inconvenience to applicators and adjacent residents
- Cost competitive
- Effective at controlling dust!

The most common dust control agents are chlorides, asphalt products, and lignin.

Chlorides

- Calcium chloride and magnesium chloride are the two most commonly used dust control agents (75% to 80% of the time)
- These hygroscopic (water-attracting) agents increase the moisture content of the surface by attracting moisture from the environment. This helps form a crust and hold the road fines into the aggregate material.

- These inorganic chemicals are environmentally safe and fairly economical. While their performance depends on temperature, relative humidity, and traffic, the effectiveness generally lasts 6 to 12 months. Sugar beet extract and cheese whey have also been used for dust control.

Calcium Chloride

- Is corrosive to vehicles and application equipment
- Can create a slippery surface when applied
- Is easily leached away because it is soluble in water

Precaution: when dissolving solid calcium chloride to make your own liquid, be very careful of the tremendous heat that is generated.

Magnesium Chloride

- Has many of the same advantages and disadvantages of calcium chloride
- It is more sensitive to temperature, requiring temps > 70 degrees F and relative humidity > than 32% to be effective.
- Tends to create a harder surface than calcium chloride but you need 18% to 20% more material to produce comparable results.

Lignin Sulfate

- Waste product from wood pulp digestion processes
- Not as available as in the past due to other recycling methods by paper plants
- Untreated material is very acidic, foul-smelling, and clings to vehicles
- Dried, processes lignin sulfate does not have the above listed problems but costs much more than the untreated material
- Does not negatively affect ground or surface water when established guidelines are followed
- To produce a hard surface, the material must be worked into the top 1 or 2 inches of the aggregate
- Is diluted by heavy rains and becomes slippery when wet

Other Materials and Treatments

- Products like lime, fly ash, Portland cement, and bio enzymes, are cements that work by permanently gluing together finely divided soil particles through chemical reaction.
- Stabilizers work by entering into the natural electro-chemical reactions between soil particles. Ammonium chloride, sulfonated naphthalene, and some enzymes have been used as clay stabilizers. Bentonite, a naturally occurring clay, has been used to stabilize limestone roads in Iowa.

Section 8: Equipment Innovations

The motor grader is the basic and pre-eminent piece of equipment necessary for gravel road maintenance. However, there are a number of pieces of equipment that can improve the operation.

While some may be too costly for one unit of government to purchase, sharing the cost with another agency or leasing from a local contractor or vendor may be an option.

- Windrow pulverizes
- Carbide-tipped bits and cutting edges
- Shouldering disks
- Grader-mounted dozer blade
- Grader-mounted roller

When to Pave a Gravel Road

1. After developing a Road Management Program
2. When the Local Agency is Committed to Excellence
3. When Traffic Demands It
4. After Standards Have Been Adopted
5. After Considering Safety and Design
6. After the Base and Drainage Are Improved
7. After Determining the Costs of Road Preparation
8. After Comparing Pavement Life and Maintenance Costs
9. After Comparing User Costs
10. After Weighing Public Opinion

Summary

The first and most basic thing to understand in road maintenance is proper shape of the cross section. The road surface must have enough crown to drain water to the shoulder, but not excessive crown, which makes the road hard to travel safely. Then, the shoulder area must not be higher than the edge of the traveled portion of the road. A high shoulder prevents water from draining to the ditch and therefore needs to be eliminated. Finally, a ditch must be established and maintained to drain water away from the roadside. Culverts and bridges at the right location and elevation are essential for carrying water under and away from the road.

Once the correct shape is established on a roadway and drainage matters are taken care of, attention must be given to obtaining and properly placing good gravel. It is very important to understand the makeup of good gravel. Simply stated, it is a proper blend of stone, sand and fine-sized particles. Materials vary greatly from region to region, but it is wise to use the best material available. Gravel must also be handled properly. Avoiding segregation while processing and handling material is important to maintain the quality of gravel. Calculating the volume of material and allowing for shrinkage from compaction is also needed to get the desired depth of surfacing on the road.

When proper shape is established and good surface gravel is placed, many gravel road maintenance problems simply go away and road users are provided the best service possible from gravel roads.

Thank you!

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