KEEPING GOOD GRAVEL ROADS GOOD

Presenter:
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GECAN
Presentation Outline

- Overview
- Roadway design
- Factors effecting roadway performance
- Measures to protect gravel roads
- Maintenance
- Rehabilitation
- Areas of concern
- Good gravel
- Dust control and stabilization
- When to pave/surface treatment
- Summary
Alberta has 140,000 km of gravel public roads largely falling under municipal jurisdiction.

Gravel roads exist to provide a means of getting to:
- agricultural products
- resources
- recreational areas and
- serve rural residents
Many of these roads will remain unpaved due to very low traffic volume and/or lack of funds.

If well constructed and maintained, a gravel road is an all-weather road:

- Compared to dirt roads (unimproved roads), gravel roads are expensive to build.
- A minimum of 50 mm of surface gravel to be considered a gravel road.
Roadway Design

- Classification (arterial, collector, local)
- Traffic volume/type
- Standards
Roadway Design

- The choice of roadway design standards are a trade off
- A savings in construction costs can be achieved with a narrow, winding low profile roadway
Roadway Design

Understanding Road Cross Section

• crowned driving surface
• shoulder
• ditch

Unfortunately, many are not constructed well initially
Roadway Design

Roads will fail at different rates based on (factors that impact maintenance cost / budget):

• Unfortunately, most gravel roads will fail when exposed to heavy hauls even when shaped properly
• This is due to weak subgrade strength and marginal gravel depths
• Seasonal/Annual change (weather, traffic)
Subgrade Modulus Variations for the Conditions Where Freeze-Thaw Occurs
Rutting caused by Deformation of the Base or Subgrade

Rutting from Weak Mixture
Spread of Wheel-Load Pressure through Pavement Structure
Ideal Cross Section and Structure of a Gravel Road
Appropriate load bearing properties suggested gravel layer thickness used by South Dakota.

<table>
<thead>
<tr>
<th>Heavy Trucks per Day</th>
<th>Subgrade Support¹</th>
<th>Minimum Gravel Thickness Mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>165 (6.5)</td>
</tr>
<tr>
<td>0 to 5</td>
<td>Medium</td>
<td>140 (5.5)</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>115 (4.5)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>215 (8.5)</td>
</tr>
<tr>
<td>5 to 10</td>
<td>Medium</td>
<td>180 (7.0)</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>140 (5.5)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>290 (11.5)</td>
</tr>
<tr>
<td>10 to 25</td>
<td>Medium</td>
<td>230 (9.0)</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>180 (7.0)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>370 (14.5)</td>
</tr>
<tr>
<td>25 to 50</td>
<td>Medium</td>
<td>290 (11.5)</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>215 (8.5)</td>
</tr>
</tbody>
</table>

Note ¹ Low Subgrade support: CBR ≤ 3% (Most common for Alberta Soils)
Medium Subgrade support: 3 < CBR ≤ 10%
High Subgrade support: CBR > 10%
Note: The root cause of this failure is not because the oil treated surface is of poor quality.
Factors Affecting Roadway Performance

- Volume of traffic (AADT)
- Axle loads
- Surface, sub surface drainage
- Freeze/Thaw cycles
- Wet/Dry cycles
- Subgrade properties
  - Resilient Modulus
  - Moisture Change
Factors Affecting Roadway Performance

• Keeping the proper shape of the roadway surface and shoulder is routine maintenance.
• The main purpose is to keep water drained and away from the roadway.
• Standing water at any place (including the ditch) is one of the major reasons for distress and failure.
Factors Affecting Roadway Performance

- Gravel roads rut more easily in wet weather
- Traffic displaces gravel form the surface to the shoulder and even the ditch during dry weather
Factors Affecting Roadway Performance

- Materials experience some permanent deformation for each load application
- Allow for some rutting
- Allow for aggregate loss
  - Traffic, erosion precipitation
- Climate and sub-grade modulus
Measures to Protect Gravel Roadway

• Limit Volume and Weight of Traffic during Weak Soil Conditions (Road Bans) – Spring Thaw, Wet Rainy Periods
• Wider right-of-ways – less shading from the sun to improve drying conditions
• Ensure a “Positive Crown” is maintained to create positive drainage (minimum 3% crown at all times)
Measures to Protect Gravel Roadway

• **Additional Maintenance/blading** during wet periods
• **Additional gravel structure** in order to create a “Load Carrying Crust”

Materials must meet specifications if they are to perform (or design assumptions are wrong)
Maintenance

Gravel maintenance has traditionally been “more of an art than science” and very few formal standards exist.
Maintenance

GRAVEL ROAD BASICS

Good gravel road maintenance or rehabilitation depends on two basic principles:

• The proper use of a motor grader (or other grading device) and;

• The use of “Good” surface gravel
Maintenance

Proper equipment operation
- Operating speed < 8 kph (5 mph)
- Moldboard angle 30 and 45 degrees
- Moldboard Pitch or “tilt”
Maintenance

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 well understood.**

It seems that most gravel road 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.**
Maintenance

Three basic items:

• Crowned driving surface,
• Shoulder area that slopes directly away from the edge of the driving surface, and a
• Ditch
• Gravel layer
Maintenance
Crown

- Slope of 3% to 4%
- Shouldn’t be parabolic (straight line from shoulder to Centerline)
Maintenance Shoulder

- Supports edge of traveled portion
- Safety area for vehicle recovery
- Carry water further away from road surface to ditch
- Should not be a steep drop-off or a
- Ridge that blocks drainage (high shoulder)
- High shoulders become secondary ditches
Maintenance

• More frequent maintenance than sealed roads after wet periods and when accommodating increased traffic volumes
• Wheel motion shoves materials to the outside leading to rutting, reduced water-runoff, and eventually road destruction
Maintenance

• As long as the process is interrupted early enough, simple re-grading is sufficient
• Another problem is wash-boarding

Grading removes the corrugations and reconstruction with “Good” quality gravel can help prevent them re-forming
Gravel Road Rehabilitation

Requires more than routine maintenance to correct

Secondary ditches
- shifting of material
- displaced by traffic
- winter ploughing
- erosion from heavy rains
- poor routine blading
Gravel Road Rehabilitation

Reshaping Surface and Shoulder

- Spring (minimal vegetation and moisture is present)
- Use of roller for compaction will improve surface finish (denser, stronger, smoother surface)
Gravel Road Rehabilitation

Reshaping Entire Cross Section

- Severe rutting, loss of crown, gravel loss and deep secondary ditches
- After heavy haul during wet weather
- Erosion Control
- Motorgraders, disks, pulverizer/mixers and rollers needed
Areas of Concern
Corrugations or Wash Boarding
Three primary causes:

- Driving habits of people (places were drivers tend to accelerate hard or brake aggressively)
- Lack of moisture
- Poor quality of gravel (proper blend of fractured stone, sand and plastic fines)

Wash Boarding can never be completely eliminated (Calcium Chloride)
Areas of Concern

Soft Areas

Caused by:

• Underground springs
• Poor subgrade soil
• Severe drainage problems

Produces a mud-slurry that is pumped upwards into the surface layer and aggregate sinks into the subgrade
Areas of Concern
Soft Area Remediation

- Improve lateral and/or vertical drainage
- Reduce capillary rise, capillary barrier
- Geotextiles or drainage layer as separator
- Mechanical/Chemical Stabilization
Areas of Concern

Drainage

To often maintenance teams deal with surface problems that come from weak soil conditions

Basic drainage requirements:

- Ditches (volume)
- Culverts & Bridges at the right locations & elevations to carry water away from the road
- Under-drains/sub-drains
Lack of roadside ditch

Poorly maintained ditch
“Good” Gravel?

- Larger top-sized stone and small percentage of clay or fine material does not form a crust to keep material bond together
- High percentage of sand sized particles remains loose and unstable
- Gravel road needs well graded aggregate with sufficient fine material that has a plastic or “binder” characteristic
Good Gravel?

- Good gradation (Stone, sand and fines)
- Stone for strength
- Sand to fill voids between stone
- Good plastic fines to bind material together (PI-NP-8)
- Proper volume of gravel to carry loads
- Proper handling to avoid segregation

This mixture forms a crust to shed water
### Coarse & Fine Grain Soils

#### COARSE GRAINED SOILS

<table>
<thead>
<tr>
<th>Boulder</th>
<th>Cobble</th>
<th>Gravel</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 mm</td>
<td>75 mm</td>
<td>20 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
<td>Medium</td>
</tr>
</tbody>
</table>

#### FINE GRAINED SOILS

<table>
<thead>
<tr>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>Coarse</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Fine</td>
<td>Fine</td>
</tr>
</tbody>
</table>

| 80 µm   | 20 µm   | 6 µm   | 2 µm  | 0.6 µm | 0.2 µm |

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**APWA**

*Alberta Public Works Association*

**GECAN**

*Division of Canadian Road Builders Inc.*
Atterberg Limits

relationship of atterberg limits to states of soil

- Liquid State
- Plastic State
- Semi-Solid State
- Powder State

- Liquid Limit
- Plasticity Index
- Plastic Limit
- Shrinkage Limit

Increasing Moisture

Figure 4.2

Alberta Public Works Association

GECAN - Division of Canadamidio Enterprises Inc.
<table>
<thead>
<tr>
<th>ESTIMATED DRY STRENGTH</th>
<th>EQUIVALENT PLASTICITY INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RANGE</td>
</tr>
<tr>
<td>friable (F)</td>
<td>0</td>
</tr>
<tr>
<td>low (L)</td>
<td>0.5-1.5</td>
</tr>
<tr>
<td>medium (M)</td>
<td>1.0-2.0</td>
</tr>
<tr>
<td>high (H)</td>
<td>1.5-2.5</td>
</tr>
</tbody>
</table>
Road restored by reshaping and small amount of surface gravel added

Wet Season, Heavy Haul
Wash Boarding as a result of excessive grader speed

Wash Boarding lack of moisture and poor quality gravel
Dust Control and Stabilization

- Amount varies depending on climate and quality and type of aggregate
- Virtually all methods require annual treatment
- Reduces material loss (Whip OFF) and
- Reduces blade maintenance
Dust Control and Stabilization

- Chlorides
- Resins
- Liquid asphalt
- Commercial Binders
When to Pave (Surface Treatment)

The primary purpose is to protect the subgrade

• 400 to 500 AADT
• 25 Trucks per Day
• As loads get heavier the pavement thickness is increased
When to Pave (Surface Treatment)

Benefits of gravel over light pavement structure

• Capital cost
• Maintenance cost
• More forgiving of external forces (easier to repair if failed by overloads)
Gravel vs. Oil

Gravel – failure
Failures on a gravel road are more forgiving (can wait)!

Oil Road – failure
Cross-section of a Roman road showing the layering technique and outer ditches.

1) At the bottom of the trench, the Romans put a big layer of stones.
2) Broken stones, pebbles, cement and sand to make a firm base.
3) Cement mixed with broken tiles
4) Paving stones formed the surface of the road. These were cut so they fitted together tightly.
5) Kerb stones at the sides held in the paving stones and made a channel for the water to run away.
Wet ground covered by causeways, or timber embankments
SUMMARY

• Proper Shape and Cross Section
• **Good** Gravel (Quality and Volume)
• Proper use of motor grader
  • (operating speed, angle, pitch and stability)
• Proper Maintenance/Rehabilitation at the proper time provide the best service possible from gravel roads
Pavement Surface Evaluation and Rating

Gravel Roads

Manual

Transportation Information Center
University of Wisconsin-Madison
•QUESTIONS ?
CAUTION
WATER ON ROAD
DURING
RAIN