PAVEMENT MANAGEMENT AND CLASSIFICATION FOR LOW VOLUME ROADS

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OVERVIEW

- Introduction
- LVR Classification
- Principles of Low Volume Road Design
  - Geometric Considerations
  - Selection of Surface Type
- Gravel Surfaces
- Management of Gravel Surfaces
- TBS Surfaces
- Management of TBS Surfaces
- Summary and Conclusions
TAC Initiatives

- LVR Chapter in new Pavement Management Guide
- Project underway for new LVR chapter in the Geometric Design Guide
- Soils and Material standing committee considering a proposal for structural design of Low Volume Roads
Definition of LVR

- Roadex: 1000 vpd
- Saskatchewan: 500 vpd
- TAC 1986: 400 vpd
- AASHTO: 400 vpd
Why 400 vpd

- 400 vpd is the approximate value at which the reduced frequency of crashes makes designs normally applied on higher volume roads less cost effective
- 400 vpd is the approximate value at which many agencies consider conventional pavement structures
Inventory

- There are over 900,000 km of two-lane roads in Canada
- Approximately 65% are gravel surfaced
- Remainder consist of BSTs, plant and road mixed cold-laid Bituminous Surfaces, a few chemically stabilized surfaces and some hot-mix pavements
For Design and Pavement Management purposes:
- 7 Rural Classifications
- 3 Urban Classifications
Low Volume Road Classes

- Rural
  - Northern Highways
  - Major Access Roads
  - Minor Access Roads
  - Rural Agricultural Access Roads
  - Recreational and Scenic Roads
  - Resource Roads
  - Commercial/Industrial Access Road

- Urban
  - Major Access Streets
  - Residential Streets
  - Commercial/Industrial Access
Northern Highways

- Long distances with few attractions resulting in the need for high speed all-weather roads
- Traffic generally passenger vehicles and supply trucks
- Intermittent use by Mining and Forestry resources to get to market
Major Access Roads

- Service to neighbouring properties and connecting services to higher traffic facilities
- Saskatchewan Grid Roads
Minor Access Roads

- Give Access to adjacent property
- Typically short and sometimes are cul-de-sac
Rural Agricultural Access Roads

- Farm to market access
- Over 400,000 kms in Alberta, Saskatchewan, Manitoba alone
- Provide access to fields and farming operations often carrying combines, tractors and other oversize equipment.
Recreational and Scenic Roads

- Access to parks, cottages, rural historic attractions
- Tend to have limited truck traffic
- Tend to emphasize the “park experience” to the traveller
Resource Roads

- Used primarily in mining, forestry and energy developments
- May be used by off-highway vehicles
- Often become recreational roads in a later reincarnation and may not have a suitable design or surface for their new vocation
Rural Commercial Access Roads

- Provide access to elevators, processing plants, etc
- Tend to be short
- Have more heavy truck traffic than minor access roads which they otherwise resemble
Urban Major Street Access

- Provide access to adjacent properties and provide through and connection service to local roads or higher volume facilities
- Tend to have buried utilities
Urban Residential Streets

- Provide service to single and multiple unit residences
- Passenger vehicles are predominate traffic with occasional garbage, fire, delivery trucks and buses
Urban Commercial/Industrial Access

- Provide access to factories or other commercial activities
- Tend to be short
- Carry more truck traffic than residential streets which they resemble
Principles of Low Volume Road Design

- Encounters between vehicles are low, meaning that opportunities for crashes and multiple vehicle collisions are rare
- Local nature means that most motorists are familiar with its design features
- Geometric features that may surprise an unfamiliar driver are anticipated
- Design guidelines can be less stringent
RLU-design speed

Design speed should represent operating conditions

Little difference in horizontal and vertical alignment criteria between low and high volume roads

Roadway width, side and back slope standards, however can be substantially less

Wide shoulders seldom required

Minimum Shoulder width a function of pavement support.
Selection of Surface Type

- Gravel, BST and cold and hot mixed pavements are most common
- Life cycle costing should be used to select surface type
- Costs include construction and rehabilitation costs
- Benefits include savings in maintenance and user costs. User time costs can be significant
- May be adjusted for scarce gravel resources, heavy commercial vehicles, impact on nearby residents and long distance travel
Gravel LVRs
Types of Gravel Surfacing

- **Traffic Gravel**
  - Function of gravel is to provide an all weather surface
  - Adds little structural strength
  - Range from 400 to 800 t/km in western Canada to 2500 to 3000 t/km in eastern Canada

- **Structural Gravel**
  - Provides structural strength based on truck traffic, subgrade strength, freeze-thaw cycles and spring restrictions
  - Designs based on experience, pavement structural designs, bearing capacity
Gravel Quality

- Surfacing Gravel should be 20 mm max size with a high % of fractured faces
- Pit run or larger crushed material commonly used under 100-150 of 20 mm crushed gravel
- Uniform or gap graded gravels tend to washboard and pothole
- High percentage of fines (15 to 20%) provides a tight surface that requires little maintenance during dry weather
- During wet weather, it becomes soft, ruts and becomes slippery
- This high % of fines increases the frost susceptibility and is a structurally weak layer
Surface Drainage

- Gravel roads are pervious and water percolates downwards weakening underlying layers
- Crown on gravel roads is often increased to 4%
- Improperly maintained gravel roads often have shoulders higher than the travelled lanes
Stabilized Materials

- Stabilization of Gravel Driving Surface Materials
- Stabilization to Improve Structural Capacity
# Surface Stabilization (Dust Palliatives)

<table>
<thead>
<tr>
<th>Type of Treatment or remediation</th>
<th>Action or Stabilization Mechanism</th>
<th>Materials and Techniques used</th>
<th>Typical Concentrations, Depth of Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salts</td>
<td>Deliquescent or by hydrosopic chemical reaction</td>
<td>Calcium Chloride</td>
<td>Solution concentration minimum 36% by weight brine CaCl₂; applied at a controlled rate varying from 1.21 to 1.31 l/m². Flake concentration minimum 77% by weight CaCl₂; blade-mixed at rate of 0.82 to 1.03 kg/m².</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magnesium Chloride</td>
<td>Solution concentration 28% by weight brine MgCl₂: applied at a controlled rate varying from 1.81 to 2.26 l/m².</td>
</tr>
<tr>
<td>Organic</td>
<td>Chemical reaction resulting in cohesive effect</td>
<td>Lignin Sulfonate</td>
<td>Undiluted solution 48% by weight total solid lignin concentration applied at a rate of 2.26 l/m², blade mixed into top 25 mm of the wearing course.</td>
</tr>
<tr>
<td>Emulsion</td>
<td>Binding effect increases particle cohesion</td>
<td>Asphalt emulsion</td>
<td>One or more applications of sprayed asphalt followed by a layer of aggregate, Typical total thickness 25 mm or less.</td>
</tr>
</tbody>
</table>
Stabilization to Improve Structural Capacity

- Traditional Stabilizers
  - Lime for fine grained soils rich in silica and alumina
  - Fly Ash with an activating agent for fine grained soils
  - Cement and Bituminous products for marginal granular soils
  - Calcium Chloride and Lignosulfates at greater (3 to 5 times) than used for dust control
## Non-traditional Stabilizers

<table>
<thead>
<tr>
<th>Stabilization Additive</th>
<th>Proposed Primary Stabilization Mechanism</th>
<th>Soil Compatibility</th>
<th>Strength Improvement</th>
<th>Volume Stability</th>
<th>Waterproofing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic</td>
<td>Cationic exchange and flocculation</td>
<td>Fine-grained soils</td>
<td>Low-medium</td>
<td>Low-medium</td>
<td>Low-medium</td>
</tr>
<tr>
<td>Enzymes</td>
<td>Organic molecule encapsulation</td>
<td>Fine-grained soils</td>
<td>Low</td>
<td>Low-medium</td>
<td>Low</td>
</tr>
<tr>
<td>Lignosulfonates</td>
<td>Physical bonding/cementation</td>
<td>Granular soils</td>
<td>Medium</td>
<td>Low-medium</td>
<td>Low-medium</td>
</tr>
<tr>
<td>Salts</td>
<td>Hygroscopy/cation exchange and</td>
<td>All</td>
<td>Low-medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>flocculation/crystallization and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum resins</td>
<td>Physical bonding/cementation</td>
<td>Granular soils</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Polymers</td>
<td>Physical bonding/cementation</td>
<td>Granular soils</td>
<td>Medium-high</td>
<td>Medium</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Tree resins</td>
<td>Physical bonding/cementation</td>
<td>Granular soils</td>
<td>Medium-high</td>
<td>Medium</td>
<td>Medium-high</td>
</tr>
</tbody>
</table>
Management Systems for Gravel Roads

- Objectives
  - Guidance for local maintenance personnel
  - Identification of Short Term projects that are beyond capability of local forces
  - Establish Priorities for major rehabilitation needs
  - Prediction Models to forecast long term funding needs
Management Systems for Gravel Roads

- Three Systems in use in Canada
  - Ministry of Transportation of Ontario
  - U.S. Army Corps of Engineers
  - Government of Yukon Gravel Airports
## Gravel Distresses

<table>
<thead>
<tr>
<th>Distress</th>
<th>Weighting Value ($w_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors Independent of Rate Timing</strong></td>
<td></td>
</tr>
<tr>
<td>Gravel Supply</td>
<td>3</td>
</tr>
<tr>
<td>Cross Section</td>
<td>3</td>
</tr>
<tr>
<td>Subgrade Failures</td>
<td>3</td>
</tr>
<tr>
<td>Settlements/Distortions</td>
<td>3</td>
</tr>
<tr>
<td>Roadside Drainage</td>
<td>2</td>
</tr>
<tr>
<td>Maintainability</td>
<td>3</td>
</tr>
<tr>
<td><strong>Factors Dependent on Time of Rating</strong></td>
<td></td>
</tr>
<tr>
<td>Rutting</td>
<td>2</td>
</tr>
<tr>
<td>Potholes</td>
<td>1</td>
</tr>
<tr>
<td>Washboard</td>
<td>1</td>
</tr>
<tr>
<td>Surface Drainage</td>
<td>2</td>
</tr>
<tr>
<td>Loose Gravel</td>
<td>1</td>
</tr>
<tr>
<td>Slipperiness</td>
<td>1</td>
</tr>
<tr>
<td>Dust</td>
<td>1</td>
</tr>
<tr>
<td>Patching</td>
<td>1</td>
</tr>
</tbody>
</table>
Local Maintenance
- Can be corrected with locally available equipment

Rehabilitation Projects
- Drainage improvements
- Gravel Resurfacing

Reconstruction
- Reconstruction due to a lack of structural strength
Long Term Analyses

- General Condition Rating PCR – from the MTO system
- Unsurfaced Road Condition Index URCI – from US Corps of Engineers system
- Gravel Condition Index GCI from the Yukon system
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 – 100</td>
<td>The roadway is well shaped with well defined shoulders. There are no surface distress manifestations, and there is no more than a slight classification for dust and loose gravel. There are no frost heaves or soft spots and there is good drainage for surface runoff.</td>
</tr>
<tr>
<td>60 – 79</td>
<td>The roadway surface is well shaped. There are some distress manifestations in the slight to moderate category, such as loose gravel, dust and potholes. There may be a few soft spots in the spring. There is good drainage for surface runoff.</td>
</tr>
<tr>
<td>40 – 59</td>
<td>A mixture of properly shaped roadway surface and improperly shaped areas. Shoulder distress manifestations such as surface drainage are in the slight to moderate class, as are various surface distress manifestations, including washboards and potholes. There may be localized soft spots. Increased routine maintenance is required and spot gravel application may be necessary.</td>
</tr>
<tr>
<td>20 – 39</td>
<td>The majority of the roadway is improperly shaped. Surface drainage is impeded. There are some localized breakup areas and various distress manifestations, such as washboards, potholes or distortions, are in the severe or very severe classification. Maintenance with the addition of gravel is necessary. Some portions may need rehabilitation.</td>
</tr>
<tr>
<td>0 – 19</td>
<td>A flat or reverse crown characterizes the surface or there are severe roadway distresses such as washboards, loose gravel and potholes. Water is trapped along the edge of the travelled lane. There is little or no gravel. Rehabilitation is necessary.</td>
</tr>
</tbody>
</table>
Calculate Deduct Values for each distress

q is the number of deduct values greater than 5
GCI Calculations

- \[ \text{GDMI} = \sum_{i=1}^{n} w_i (s_i + e_i) \]

Where: GDMI = Gravel Distress Manifestation Index. GDMI is an overall characteristic describing surface condition in terms of distress manifestations.
- \( w_i \) = weighting value representing the relative weight of each distress manifestation.
- \( s_i \) = severity of a distress manifestation expressed on a scale from 0-4.
- \( e_i \) = extent of a distress manifestation expressed on a scale from 0-4.
- \( n \) = the total number of distress types.

The GCI is an overall rating of the gravel section on a scale of 0 to 100. The higher the GCI, the better the condition of the gravel road. The GCI is calculated using the following formula:

- \[ \text{GCI} = (100 \times ((0.1 \times \text{RideScore})^{0.5}) \times ((192-\text{GDMI})/192) \times 0.924) + 8.856 \]
TBS Low Volume Roads
TBS Classes

- **Class 1.** TBS applied directly to unimproved subgrades. These are short-lived structures where a TBS is the most economical form of dust control. Truck volumes are generally low.

- **Class 2.** TBS applied on top of 75-150 mm of crushed gravel. These are light-duty pavements serving moderate traffic volumes with few trucks and provide an improved level of service over Class 1 TBS.

- **Class 3.** Stage Construction. Initially, full depths of base and subbase are placed with a TBS surface instead of asphalt concrete. Service volumes (AADT) range between 300 and 700 vehicles per day. When traffic volumes warrant and budgets permit, the TBS is replaced or overlaid with asphalt concrete.
Thin Bituminous Surfaces

- Road Mixed Surfaces
- Cold-Mixed Cold-Laid Bituminous Pavements
- Bituminous Surface Treatments
Management Systems for TBS Roads

- Two+ Systems in use in Canada
  - Ministry of Transportation of Ontario
  - Government of Yukon/PWGSC System
  - Existing (adaptation) of Pavement Management Systems
# Distresses of Thin Bituminous Surfaces

<table>
<thead>
<tr>
<th>Distress</th>
<th>Weighting Value ($w_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Distresses</td>
<td></td>
</tr>
<tr>
<td>Ravelling</td>
<td>1.0</td>
</tr>
<tr>
<td>Bleeding</td>
<td>1.0</td>
</tr>
<tr>
<td>Shoulder Disintegration</td>
<td>0.5</td>
</tr>
<tr>
<td>Potholes</td>
<td>1.3</td>
</tr>
<tr>
<td>Deep Seated Distresses</td>
<td></td>
</tr>
<tr>
<td>Rutting</td>
<td>1.0</td>
</tr>
<tr>
<td>Subgrade Failures</td>
<td>1.5</td>
</tr>
<tr>
<td>Cracking</td>
<td>0.5</td>
</tr>
<tr>
<td>Distortions</td>
<td>1.2</td>
</tr>
<tr>
<td>Construction/Maintenance</td>
<td></td>
</tr>
<tr>
<td>Patching</td>
<td>1.0</td>
</tr>
<tr>
<td>Corrugations</td>
<td>0.4</td>
</tr>
<tr>
<td>Streaking</td>
<td>0.3</td>
</tr>
<tr>
<td>Joints</td>
<td>0.3</td>
</tr>
</tbody>
</table>
DMI = \sum_{i=1}^{n} (w_i)(s_i)

Where: DMI = Distress Manifestation Index. DMI is an overall characteristic describing BST surface condition in terms of distress manifestations.

w_i = Weighting value representing the relative weight of each distress manifestation. Those distresses that are considered more serious are given larger weighting values (w_i).

s_i = Severity and extent of distress manifestations expressed on a scale from 0 to 10.

n = 12, the number of distress types.

The Bituminous Condition Index (BCI) is calculated from the DMI and ride score:

BCI = \frac{10(DMI + \text{Ride Score})}{2} = \frac{5(DMI + \text{Ride Score})}{10}

The BCI is an overall rating of the BST section. The higher the BCI, the better the condition of the TSB.
BCI = 48

PCI = 40
Low Volume Roads make up the majority of roads in Canada and the serve a wide variety of functions.

The main types of surfaces on low volume roads are gravel, stabilized Gravels, cold-mixed-cold-laid pavements, BSTs and hot mix pavements.

Surface type should be based on life cycle costs.

Management Systems exist for gravel and TBS surfaces.

Geometric design and structural guidelines for low volume roads are currently being worked on by TAC.