Low volume roads in Canada: design, challenges and perspectives

Jean-Pascal Bilodeau, ing., PhD – Université Laval
Papa Masseck Thiam, P.Eng., M.Sc., M.Eng., PMP – FPInnovations
Guy Doré, ing., PhD – Université Laval
What is a low volume road?
How it differs from paved roads?

• Great Importance in Canadian Economy
• Structure
  • Unpaved, surface treatment, ...
• Level of traffic and overall bearing capacity
• Design methodology, life cycle, failure mode and maintenance practices
• Seasonal frost and permafrost conditions
• Ownership

Source: Thiam, 2016 (FPInnovations)

Vehicle weight increasing

Resource Roads

Highways & interstates

Streets & rural roads

Traffic volume increasing

Source: Douglas, 2016

operationsforesthire.ca

lenouvellushebdo.com
Unpaved road network

• Canada:
  • 1.13 million two-lane equivalent lane-kilometres of public road in Canada, with 60% unpaved (0.7 M) (statcan.gc.ca)

• US case:
  • 2.3M km of roads, 35% unpaved (0.78 M) (FHWA 2015)

World bank 2008
Typical low volume road

• Layers
  • Surface treatment or else
  • Gravel wearing course
  • Granular base
  • Granular subbase
• Materials
  • Quality materials are required ... but not often used!

Groupe Forchemex
Typical low volume road - Materials

• Importance of the choice of the adequate granular materials for the base and wearing course

Légère and Thiam, 2013
Design methods

- Few methods available
  - AASHTO 1993
  - USDA-Forest Service STP
  - Critical Strain Method (CSM)
  - ME
  - Giroud and Han Method
  - Australian LVR design chart
  - Atkinson’s CBR design charts
- Importance of adequate granular base construction

Methods difficult to compare
- Method may be applicable to specific conditions
- Failure criteria may be different
- A parameter included in one method may not be in another
Mechanistic-empirical

- Recommended practice
- Combines response model and empirical transfer function
- Response model
  - e.g.: Burmister, FEM
  - Calculation stresses, strains, etc
  - Importance of quality inputs
  - Versatility
- Empirical transfer functions
  - Calibrated with empirical observations
  - Converts output of the response model to service life for a given failure criteria
  - Allows considering « real life » / « real scale » effects difficult to model

Huang 2004

Bilodeau et al. 2017

Gupta et al. (2014) — TRRL (1987)
Shell (1978) — Theyse et al. (1996)
Sahoo (2009) — This study
Austroads (2004)
Distress and damage - Dust

Causes
- Lack of fines (binder)
- Prolonged dry conditions
- Excessive winter sanding

Solutions
- Aim for fines content of 10 to 15% in the wearing course aggregate
- Plastic fines are needed
- Dust palliatives
Distress and damage - Washboard

Causes
• Lack of fines (binder)
• Acceleration zones
• Steep grades
• Trailer hop
• Air suspensions

Solutions
• Aim for fines content of 10 to 15% in the wearing course aggregate
• Plastic fines are needed
• Dust palliatives
## Distress and damage - Potholes

### Causes
- Poor drainage (crown)
- Loose wearing course material
- Accumulation of water in ruts and corrugation
- Excessive moisture

### Solutions
- Maintain crown at 4 to 6%
- Offer training for grader operators
- Slope meter in graders
Distress and damage - Rutting

Causes
• Inadequate aggregate thickness
• Poor subgrade soils
• High moisture levels
• Heavy axle loads

Solutions
- Review thickness design for desired traffic levels and axle loads
- Consider thicker aggregate layers
- Consider subgrade stabilization
- Consider subgrade/base geotextile separation/reinforcement
Distress and damage – Permafrost conditions

• Permafrost is in equilibrium with its environment
• Embankments and climate change induce perturbation in the equilibrium
• Serious consequences if thermal degradation with ice-rich permafrost occurs

Modified from L’Hérault et al., 2012
Distress and damage – Permafrost conditions

Differential settlements

Creep of frozen soils

Shoulder rotation

Solutions → Thermal stabilization and reinforcement
Example of research projects outputs

- Research projects on transportation infrastructures built on permafrost
- Benefits from using a surface sealing layer on unpaved roads
- Development of ME design method for unpaved roads
Research projects outputs

- Development of ME design method for unpaved roads (integrated in i3C-me 2.0)
Challenges

• Economical
  • Investment in capital for LVRs (LVRs seen as a liability)
  • Small Maintenance budget vs Big Network
  • Accelerated distresses due to climate change

• Granular materials
  • Problematic base
  • Poor quality materials
    • Need for better understanding, characterization and estimation

• Road life largely exceeded
Challenges - Super Heavy Loads

• Questions to be answered:
  • Permissible load without negative change to the structural behaviour?
  • Maximum number of load repetitions without rest (number of axles in SHL truck)?
  • Accumulation of permanent deformation (damage assessment)?
Challenges – Super Heavy Loads

\[
\bar{\varepsilon}_p = \frac{d\varepsilon_p}{\sum W_N - W_0} + \varepsilon_p^{ps} \frac{1 + e}{dx}
\]
Challenges – Super Heavy Loads

Field measurements – Oct. 2019
Concluding perspectives

• Design methods
  • From empirical based to ME
  • Increased test trials and sections for supporting development/validation of Canadian performance models
  • Use of HVS tests in support of performance assessment

• Technology to assess response, performance and condition

• New 5 yrs research chair upcoming
  • Support for development of remote regions and exploitation of natural resources
Thank you for your attention!

Questions and comments?