When do you Convert a Gravel Road to Hard Top?

David Anderson
Asset Management Specialist

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Presentation Outline

• Considerations and Analysis
  – Financial
  – Condition, Structure and Drainage
  – Platform Width
  – Horizontal and Vertical alignment
  – Traffic
  – Less tangible benefits
  – Risk Management

• Decision Making
  – Typical priority ratings
  – Gravel Road conversion considerations
Gravel Road Overview

• Gravel roads are also a flexible pavement structure
  – As are Hot Mix Asphalt and Surface Treatment
• As with hard surfaced roads, the surface of a gravel road must also be renewed.
• Principle difference - riding/ wearing surface/pavement structure for gravel roads are one and the same.
  – Gravel wearing surface forms part of the road structure
• Diminishes/ disappears though
  – normal wear and tear,
  – grading and
  – winter control
• As the gravel deteriorates and disappears, so does its performance as a pavement structure
Financial Review Considerations

• Analyze maintenance costs
  – Gravel top road system vs hard top road system
  – Ditching, grass cutting etc are common to both (rural) so shouldn’t be included.

• Financial Analysis methods may include
  – Net Present Value over life cycle
    • Given volatility in petroleum based products, current cost over analysis period OK
  – Payback period
  – Life cycle costs

• Costing should include
  – Annual Maintenance costs/ km
  – Combined maintenance and capital comparisons for varying depths of granular
Basis for Calculations

• Basis for the calculations should include the following
  – Average Gravel Road Platform
  – Average Unit Cost of Granular A (Supplied and placed, per tonne)
  – Average Platform on LCB road
  – Average SST width
  – Average SST unit cost/m\(^2\)
  – Loose Top Surface Budget
  – Hard Top Budget

Note: Analysis from 2001 study
Sample Calculations

- Average Gravel Road Platform – 7.1m
- Average Unit Cost of Granular A - $9.50
- Average Platform on LCB road – 7.5m
- Average SST width – 5.9m (6.5m in calcs)
- Average SST unit cost/m² - $1.40
- Loose Top Surface Budget - $1,280,610
- Hard Top Budget (adjusted) - $1,174,100

Note: Analysis from 2001 study
Payback Period Analysis

(For Single Surface Treatment)

- Cost to maintain 1km of gravel road (excluding additional gravel) -
  $1,879
- Cost to SST 1 km, 6.5m wide
  $9,100

- Payback period = SST cost / 1 yr gravel maint.
  = 4.84 years

Note: Analysis from 2001 study
Net Present Value

\[ NPV = \frac{FV}{(1+r)^n} \]

NPV = Present Value
FV  = Future Value
n   = # of years
R   = rate of return
Annual Maintenance Costs ($km)$
NPV over 22 years

• Includes grading, dust control washouts, labour, machinery, and gravel resurfacing for gravel roads
• Includes SST resurfacing, labour, machinery, patching
Material Replacement and Maintenance  
*(per km)*

- Gravel annual maintenance plus 75mm resurfacing every 3 yrs (1,4,7,10,…22)
- DST first year and SST at 7 yr intervals (1,8,15,22)

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>$79,655</td>
</tr>
<tr>
<td>Surface Treatment</td>
<td>$44,661</td>
</tr>
</tbody>
</table>

*Note: Analysis from 2001 study*
Material Replacement and Maintenance
(per km)

• Gravel annual maintenance plus 50mm resurfacing every 3 yrs (1,4,7,10,…22)
• DST first year and SST at 7 yr intervals (1,8,15,22)

Gravel $61,348
Surface Treatment $44,661

Note: Analysis from 2001 study
Material Replacement and Maintenance
(per km)

- Gravel annual maintenance plus 50mm resurfacing every 5.7 yrs (1,7,13,19,…22)
- DST first year and SST at 7 yr intervals (1,8,15,22)

Gravel $44,378
Surface Treatment $44,661

*comparison to current gravel resurfacing program

Note: Analysis from 2001 study
## Analysis Summary

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Gravel</th>
<th>Surface Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>75mm @ 3 yrs</td>
<td>$79,655</td>
<td>$44,661</td>
</tr>
<tr>
<td>50mm @ 3 yrs</td>
<td>$61,348</td>
<td>$44,661</td>
</tr>
<tr>
<td>50mm @ 5.7yrs (Current Program)</td>
<td>$44,378</td>
<td>$44,661</td>
</tr>
</tbody>
</table>

*Note: Analysis from 2001 study*
Financial Conclusions

• Generally ‘hard topping’ a gravel road is cost effective management of the road system
• Unit costs of products will change the analysis
  – If significant changes occur – re-run the model
• Should not be confused with a reconstruction project
• Financial analysis is only one of the considerations in determining conversion candidates
CONDITION, STRUCTURE AND DRAINAGE
Condition, Structure, and Drainage

• There’s a direct relationship between these elements!!!
• A road in poor condition (soft spots and frost boils) likely does not have sufficient structure
• A saturated road structure will not perform
When do we convert a gravel road to a hard surface?

• It depends on a number of factors.
Hard topping a gravel road that performs poorly will result in a hard top road that performs poorly.

All gravel roads are not conversion candidates.
Ontario in the Spring!!!
Some gravel roads are not even all gravel.
• Conversion
Candidates should have a reasonable structure for the native soil conditions

A few simple test holes on a candidate section may be all that’s required to confirm existing

Table from MTO Pavement Rehabilitation and Design Manual
Not all roads have sufficient structure or adequate drainage
### Inventory Manual

### Road Structure

#### TABLE F-1 ROAD DESIGN STANDARDS

<table>
<thead>
<tr>
<th>Rural Road Standards</th>
<th>50-199 AADT</th>
<th>200-399 AADT</th>
<th>400-899 AADT</th>
<th>1000-1999 AADT</th>
<th>2000-2999 AADT</th>
<th>3000-3999 AADT</th>
<th>4000+ AADT</th>
<th>4 lanes &amp; 6L N, EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Width (m)</strong></td>
<td>8.0</td>
<td>6.0</td>
<td>6.5</td>
<td>6.5</td>
<td>7.0</td>
<td>7.0</td>
<td>7.5</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Shoulder Width (m)</strong></td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Hot Mix (mm)</strong></td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Granular A (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Southern Ontario</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Granular B (mm)</strong></td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>160</td>
<td>225</td>
</tr>
<tr>
<td><strong>Concrete Surface</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concrete (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>225</td>
</tr>
</tbody>
</table>

*Double Surface Treatment (DST) assumed to equal 15 mm of Hot Mix.

Note: Class 100 rural roads are eligible for maintenance subsidy only.

#### SEMI-URBAN ROAD STANDARDS

<table>
<thead>
<tr>
<th>Local Roads</th>
<th>Collector Roads</th>
<th>Arterials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Commind (LR)</td>
<td>Residential</td>
</tr>
<tr>
<td>Lane Width (m)</td>
<td>3.0</td>
<td>3.25</td>
</tr>
<tr>
<td>Shoulder Width (m)</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Hot Mix (mm)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Southeastern Ontario</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Granular A (mm)</strong></td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Northern Ontario</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Granular B (mm)</strong></td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td><strong>Concrete Surface</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concrete (mm)</strong></td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

#### URBAN ROAD STANDARDS

<table>
<thead>
<tr>
<th>Local Roads</th>
<th>Collector Roads</th>
<th>Arterials</th>
<th>Expressways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Commind (LR)</td>
<td>Residential</td>
<td>Commind (CR)</td>
</tr>
<tr>
<td>Through Lane Width (m)</td>
<td>3.0</td>
<td>3.25</td>
<td>3.25</td>
</tr>
<tr>
<td>Parking Lane Width (m)</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Curb Offset (each side)</td>
<td>.5</td>
<td>.5</td>
<td>.5</td>
</tr>
<tr>
<td><strong>Hot Mix (mm)</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Granular A (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Southern Ontario</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Granular B (mm)</strong></td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td><strong>Concrete Base</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concrete (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td><strong>Granular B (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Concrete Surface</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concrete (mm)</strong></td>
<td>150</td>
<td>150</td>
<td>250</td>
</tr>
</tbody>
</table>

Note: Benchmark costs will not exceed the design standards specified in the above tables.
Drainage

- Drainage is critical to performance also
- A saturated granular base will not support load
If you build in a swamp..............
OPSD 200.010 Rural Road Cross Section

NOTES:
1 Cut slope shall be 3H:1V or steeper when specified.
2 Fill slope shall be 3H:1V or flatter when specified.
3 Distance shall be 1.5m minimum when ditch is not required.

A This OPSD to be read in conjunction with
B All dimensions are in metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

EARTH/SHALE GRADING
UNDIVIDED RURAL

OPSD – 200.010
Proctor Curve - effect of additional water

Increasing Density

Increasing Moisture Content

Fig. 17-7: RELATIONSHIP BETWEEN DRY DENSITY AND MOISTURE CONTENT FOR CONSTANT AMOUNT OF COMPACTION
The three most important things are drainage, drainage and drainage!!!
PLATFORM WIDTH
Platform Width

- If platform and surface width are too narrow may create a higher risk
- Inventory Manual (1991) defines minimum tolerable standards for road widths
- Hard topping a road that does not meet the minimum tolerable standard may increase risk.
- Platform width and surface width inter-related
- Minimum shoulder width is .5m
### Minimum Surface Width – Inventory Manual

**TABLE 93R - MINIMUM TOLERABLE SURFACE WIDTH - RURAL**

<table>
<thead>
<tr>
<th>EXISTING CLASS</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>4LN</th>
<th>EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROADWAY WIDTH</td>
<td>5.0</td>
<td>5.5</td>
<td>5.5</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>6.5</td>
<td>6.5</td>
<td>13.0</td>
<td>3.5/lane</td>
</tr>
</tbody>
</table>
# ITEM 84 SHOULDER WIDTH - Maximum Points 10
(RURAL AND SEMI-URBAN SECTIONS ONLY)

Point ratings for Shoulder Width will be calculated by the computer and are based on Shoulder Width (Item 40) and Existing Class (Item 33) using linear interpolation.

The Shoulder Width Point Rating Tables are shown below.

### TABLE 84R RURAL SECTIONS

<table>
<thead>
<tr>
<th>Point Rating</th>
<th>100 &amp; 200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>4LN,EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### TABLE 84S SEMI-URBAN SECTIONS

<table>
<thead>
<tr>
<th>Point Rating</th>
<th>Local Roads</th>
<th>Collector Roads</th>
<th>Arterials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential All, L/R</td>
<td>Comm/Ind LCI</td>
<td>Residential C/R</td>
</tr>
<tr>
<td>10</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Note:** The highest point rating corresponds to the design standard surface width or more; and the lowest point rating corresponds to the minimum tolerable surface width or less. Point ratings for intermediate surface widths will be determined by the computer through interpolation.
Existing Conditions - Surface Width - Item 37

Surface is only the maximum width of the class
HORIZONTAL AND VERTICAL ALIGNMENT
Horizontal and Vertical Alignments

- Most low volume rural roads have sub-standard horizontal and vertical curves
- Converting to a hard top surface is not a reconstruction project
  - Substandard curves will likely then not be dealt with
- Additional signage or reduction in speed limit will reduce the risk
TRAFFIC
Inventory Manual
Traffic Triggers

**ITEM 92 SURFACE TYPE**

The existing Surface Type (Item 35) and Minimum Tolerable Standard are determined by the computer.

**RURAL SECTIONS**

The Minimum Tolerable Standard is determined, according to the following AADT volume range (Item 57):

(a) Earth, if AADT is less than 50 (ETH).

(b) Loose Top, if AADT is 50 to 399 (G/S, PRI).

(c) Hard Top (LCB or better) if AADT is 400 or more (HFL, LCB, ICB, C/M, HCB, CON, A/C, OTH).

**CODE (Now)**

- If the Existing Condition is less than the Minimum Tolerable Standard based on the existing AADT (Item 57).

(1 - 5)

- If the Surface Type, based on the traffic forecast calculated for the 10 year forecast AADT (Item 65), is expected to be less than the Minimum Tolerable Standard within 5 years.

(6 - 10)

- If the Surface Type, based on the 10 year forecast AADT (Item 65), is expected to be less than the Minimum Tolerable Standard in the 6-10 year period.

(Adeq)

- If the Existing Condition equals or exceeds the Minimum Tolerable Standard for the 10 year study period.

**SEMI-URBAN and URBAN SECTIONS**

**CODE (Adeq)**

- If the existing surface type is one of LCB, ICB, C/M, HCB, CON, A/C or OTH.

**Now**

- For all semi-urban sections with a surface type of ETH, G/S, PRI, HFL
Traffic

- IM sets 400 aadt as upper limit for traffic count on a gravel surface road
- Other agencies have determined that more cost effective to have a hard top road with traffic over 100aadt
- Will depend on material costs and availability
LESS TANGIBLE BENEFITS
Less Tangible Benefits

• Winter Maintenance
• Summer Maintenance
• Reductions in administrative time on complaints
• Increased flexibility in service delivery
Comparison of Winter Control Maintenance Activities

<table>
<thead>
<tr>
<th>Gravel</th>
<th>Surface Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plow with a grader or a combination unit</td>
<td>Plow, Sand/Salt with a combination unit</td>
</tr>
<tr>
<td>Ice Blade with a grader as required</td>
<td></td>
</tr>
<tr>
<td>Spot sand /salt</td>
<td></td>
</tr>
<tr>
<td>Grader Plowing Speed 8km/hr</td>
<td>Truck Plowing Speed 40km/hr</td>
</tr>
</tbody>
</table>
## Comparison of Summer Maintenance Activities
**Gravel vs SST**

<table>
<thead>
<tr>
<th>Gravel</th>
<th>Surface Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular addition of aggregate</td>
<td>Regular application of additional surface treatment</td>
</tr>
<tr>
<td>Dust Control</td>
<td>Pothole repair</td>
</tr>
<tr>
<td>Re-grading to remove potholes</td>
<td></td>
</tr>
<tr>
<td>Washout repair</td>
<td></td>
</tr>
</tbody>
</table>
RISK MANAGEMENT
Risk Management and Mitigation

• Improving a road involves risk
• If improvements don’t address some/all of the issues, exposure/liability may increase
• Substandard horizontal and vertical curves
  – If not corrected – increase signage
  – Reduce posted speed limit
• Substandard width
  – Review signage
  – Widen to minimum tolerable standard
DECISION MAKING / PRIORITIZATION
Decision Making Matrix Potential

- **Financial**
  - Hard top maintenance budget typically less per km than gravel
- **Financial**
  - Less usage of non renewable resources
- **Financial**
  - Reduced equipment requirements over time
  - Approx 75km of gravel requires 1 grader
- **Once Financial analysis completed for municipality based on site specific unit costs = and its viable** - project selection is next task
Priority Selection

• Traditional selection mechanisms may not work
  – Condition the same or similar
  – Traffic counts the same or similar

\[
\text{Priority Rating} = 0.2 \ (100 - \text{C.R.}) \times (\text{AADT} + 40)^{1/4}
\]
Decision Making Matrix Potential

• Select projects from those potential candidates that meet the minimum tolerable requirements
  – Platform/surface width
  – Drainage
  – Structure
  – traffic
Selection Criteria

• Isolated Gravel Road Sections
  – Deadheading time
• Sections that ‘connect’ other hard top sections
  – Hard top continuity
• Reasonable structure and drainage
Implementation Strategy

- Integration into existing Programs
- Existing Gravel Program and Existing Surface Treatment Program
- Place additional aggregate
- Double Surface Treat

**NOT TO BE CONFUSED WITH A RECONSTRUCTION PROJECT!!!**
Benefits

- Customer satisfaction!!!
- Reduced maintenance costs for road surface and winter control
- Reduced complaints
Gravel Roads Decision Flow Chart

- Gravel roads typically have a low traffic volume; Class 200 or Class 300 roads; <400 AADT
- The minimum tolerable standard shoulder width for Class 200 and 300 roads is 0.5m.
- The recommended surface width for Class 200 and 300 roads is 6m
- 6m surface width and 0.5m shoulder would require a minimum 7m platform
- For Class 200 and 300 roads in southern Ontario, the minimum granular base should be 150mm Granular A over 300mm Granular B
Thank You
Questions...
• David Anderson, CET
  Asset Management Specialist
  D 519-585-7476  C 647-449-4768  F 519-579-7945
  email – dave.anderson@stantec.com

Stantec Consulting Ltd.
49 Frederick St.
Kitchener ON  N2H 6M7