Highway 401
Perpetual Pavement

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Outline

- What are perpetual pavements?
- Design of the pavement structures
- Instrumentation of the project
- Construction details to date
“A Perpetual Pavement is a hot mix asphalt pavement designed to last 50 years or more without major structural rehabilitation or reconstruction”

– Newcomb (NAPA)
Design Concept

- Thin asphalt pavements may crack and rut under repeated loading of heavy traffic.
- In thicker asphalt pavements, the potential for fatigue cracking is reduced and pavement distresses (cracking and rutting) occur only in the near surface layers.
- When surface distresses reach an unacceptable level, the surface course is removed and replaced.
- Periodically renewing the driving surface keeps the pavement serviceability high throughout the life of the pavement while reducing the inconvenience for the driving public.
The multi-layer design consists of:

- a renewable rut resistant surface layer
- a strong, rut-resistant intermediate layer
- a flexible, fatigue-resistant bottom layer
Project Location

WOODSTOCK

COUNTY OF OXFORD

TOWNSHIP OF BLANDFORD-BLENHEIM

COUNTY ROAD 4
COUNTY ROAD 3
COUNTY ROAD 2
COUNTY ROAD 22
C.P.R.

HIGHWAY 401
OXFORD ROAD 2
C.N.R.

15.3 km
Pavement Design

• Pavement designs (conventional and perpetual) were developed by West Regional Geotechnical and MERO

• Pavement design was carried out using AASHTO 93 (conventional) 20 year design, PerRoad 3.2 for the Perpetual Pavement design, and AASHTO 93 using a 50 year design as a comparison to PerRoad
Conventional Pavement Design  Hwy 401 – Using AASHTO 93

<table>
<thead>
<tr>
<th>Location</th>
<th>Woodstock</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>48,000</td>
</tr>
<tr>
<td>% Truck Traffic</td>
<td>30%</td>
</tr>
<tr>
<td>Design ESALs (millions)</td>
<td>97.5 (20 years)</td>
</tr>
<tr>
<td>Design Life</td>
<td>20 Years</td>
</tr>
<tr>
<td>HMA Thickness (mm)</td>
<td>40mm SP12.5 FC2</td>
</tr>
<tr>
<td></td>
<td>50mm SP19.0</td>
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<tr>
<td></td>
<td>60mm SP19.0</td>
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<tr>
<td></td>
<td>60mm SP19.0</td>
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<tr>
<td></td>
<td>90mm SP25.0</td>
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<tr>
<td>Total HMA Thickness</td>
<td>300 mm</td>
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<tr>
<td>Total Granular Base (mm)</td>
<td>750 mm</td>
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Perpetual Pavement Design

• PerRoad 3.2 was used for the Perpetual Pavement design
• PerRoad is a mechanistic perpetual pavement design tool developed by NCAT’s Dr. David H. Timm
• Perform two level of analysis:
  – Nominal design values (ie, average stiffness or tire loads)
  – Reliability analysis and predicts the amount of risk associated with a particular design
• Pavements are designed for the traffic loading they will experience – typically in a 50 year lifetime
  – This is the lifetime without structural overlay, not the total lifetime
• PerRoad and PerRoadXPress were both developed by Dr. David Timm (NCAT, Auburn University)
  – PerRoad is a detailed tool for experienced pavement engineers and requires detailed input
  – PerRoadXPress is based on PerRoad but the inputs have been reduced and so has the calculation time
PerRoad Outputs

• Thickness design output:
  – Deterministic analysis
    • Using nominal design values
  – Reliability analysis
    • Probabilistic and predicts the amount of risk associated with a particular design

• Cost Analysis:
  – Based on the design thickness and materials in the pavement structure
Perpetual Pavement Design

• The design was carried out using axle load spectra for Hwy 401 in the vicinity of this project, as well as historical weather information, and the design parameters (soil type etc) from the original pavement design report.

• The design thickness required to achieve 90% reliability was:
  – 420 mm hot mix
  – 200 granular A
  – 550 granular B
50 year AASHTO Design

• A design comparison was carried out using a 50 year AASHTO design (400,000,000 ESALs) for this project.

• Resulted in the following pavement structure:
  – 390 mm hot mix
  – 200 mm granular base
  – 550 mm new granular sub-base
### Perpetual Pavement – Hwy 401

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<td>50mm SP19.0</td>
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<td>60mm SP19.0</td>
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<td></td>
<td>70mm SP19.0</td>
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<tr>
<td></td>
<td>100mm SP25.0</td>
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<tr>
<td></td>
<td>100mm SP25.0 (RBM)*</td>
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<tr>
<td>Total HMA Thickness</td>
<td>420 mm</td>
</tr>
<tr>
<td>Total Granular Base (mm)</td>
<td>750 mm</td>
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Rich Bottom Mix (RBM)

- A flexible, fatigue resistant hot mix asphalt with an increased amount of asphalt cement that is placed as the bottom HMA layer in a perpetual pavement.
- Increased asphalt cement and reduced air voids in base course improve flexibility and minimize bottom-up cracking.
- To evaluate the benefits of the RBM:
  - one PP section will have 100 mm RBM as the HMA base course
  - the other PP section will have the same pavement structure, but with a conventional SP 25 mm HMA base course in place of RBM.
• MTO developed a specification for the Rich Bottom Mix.
• The RBM will be a modified SuperPave 25 mm mix
  – The AC content increased by 10% (or by 0.4% more AC, whichever is higher).
  – This will reduce the air-void content from 4% to approximately 3% air voids.
Pavement Instrumentation

• MTO and Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo have partnered in a research project to assess the performance of this perpetual pavement project.
• Ontario Hot Mix Producers Association (OHMPA), and National Research Council have also contributed to funding this research.
• Data will be gathered and analyzed to assess the behavior of the conventional and perpetual pavements.
There are 3 sections in this contract that will be equipped with instrumentation (Perpetual Pavement, Perpetual Pavement with RBM, and convention pavement sections).

Instrumentation consists of Temperature Probes, Asphalt Strain Gauges, Moisture Probes, and Earth Pressure Cells.

Weigh-in-motion sensors are also located at one of the instrumentation locations.
Sensors

- Moisture Probe
- Earth Pressure Cell
- Data Logger
- Asphalt Strain Gauge
- Earth Pressure Cell
- Temperature Probe
Construction

• Construction began Summer 2008.
• 385 Working Days in contract
• The project will take 3 years to complete.
• Cost $105 million.
• There are two 2 km sections at either end of this project that will be constructed with a perpetual pavement design, located at approximately:
  - 11+000 to 13+000 and
  - 16+300 to 18+300
Quantities

- Tack Coat – 2,017,803 m²
- SP12.5 Cat C – 20,261 t
- SP12.5FC2 Cat E – 38,118 t
- SP19.0 Cat E – 241,479 t
- SP25.0 Cat E – 88,017 t
- RBM Cat E – 14,744 t
- 402,619 t Total HMA
Quantities

- Earth Excavation - 694,441 m³
- Earth Fill – 121,133 m³
- SSM – 29,565 t
- Granular A – 624,589 t
- Granular B2 – 30,762 t
- Granular B3 - 568,906 t
- 1,253,822 t Total Material Moved
Accomplishments to Date

- Placed 800,000 t of 1,200,000 t
- Placed 150,000 t of 400,000 t
- 16,000 m of sewers
- 385 structures
- 85 out of 385 working days complete with almost 50% of project billed
Accomplishments

• On one of the busiest days last fall, there were 18 backhoes including 8 sewer crews
• 65 triaxels
• Asphalt crews paving 24 hours a day
• Consumed 12,000 liters of fuel per day for 4 months
The Challenges – Production

- Logistical issues when producing large quantities of Superpave mixes along with day-to-day Marshall mixes
- In the past most of the MTO paving has been done at night – negate the need to switch mixes
- Paving day and night (2,000 + tonnes a shift) while continuing to supply other 2 crews/outside sales
- Plant mix timings critical for preventing excessive amount of “wasting” while switching mixes
Summary
– Advantages of Perpetual Pavement

• Durable, long lasting flexible pavement
• Less rutting
• Less fatigue cracking
• Smoother pavement
• No major reconstruction required for 50 years
  – Work can be carried out at low traffic times
  – Minimize disruption to travelling public
Thank you