BETOFLEX™ AN ALTERNATIVE PAVING MATERIAL

Sukhwinder Dhanoa, P.Eng.
Pavement Management Engineer
City of Calgary

Ted HARRISON, P.Eng.
General Manager
GECAN (Div. of CRB Inc.)
ACKNOWLEDGEMENTS

**Colas**

Jean-Martin Croteau, P.Eng.
*Technical Director*
*Colas Canada Inc.*

Simon PIANAROSA, P.Eng.
*Vice-President - Operations*
*Standard General Inc.*

Laurent BRISSAUD
*Head of Bituminous Mixes Section*
*Campus for Science and Techniques (Colas S.A.)*

Curt SLAWINSKY, C.E.T.
*Manager of Aggregate Operations and Quality Control*
*Standard General Inc.*

**City of Calgary**

Venkat Lakkavalli, P. Eng
*Senior Pavement Engineer*

Nasir ul Mulk, P. Eng
*Pavement Engineer*

Carlos Montanez, P. Eng
*Leader Contract Services*

Dean Forster, C.E.T
*Engineering Assistant*
OUTLINE

» Introduction
  • CTAA 2016, “A paving solution to minimize airport down time while providing resistance to surface deformation: Calgary Airport”.
  • CTAA 2017, “Performance-based asphalt mixture development process to optimize material durability and pavement design”.

» PART I - Project details and Issues

» PART II - Background
  • Multi-level mix-design approach
  • Rational pavement design method

» PART III - Properties
  • Mechanical properties of Betoflex®, Superpave and SMA

» Conclusions
INTRODUCTION
Calgary Airport

- Taxiway Alpha/Charlie
  - Main access to 17R-35L runway
  - Severe pavement deformation
  - Concrete substrate (Charlie)
  - Surface course replacement
Betoflex™ - Target Properties for Calgary

- **Binder - GECAN**
  - Colflex binder
    - SBS modification
    - Possibly the use of viscosity reducer
    - Formulated using MSCR test
  - Target binder - PG58E-28

- **Mixture - CST**
  - French mix-design level 2
    - Compaction: 95% of max. density
    - Rutting: ≤ 5.0% at 30,000 cycles
    - Placement: 100 mm single lift
  - Target mixture - 0/16 mm
...The road forward

- Betoflex™ 0/16 mm PG58E-28
  - Continue with modulus & fatigue
    → Modulus at 15°C, 10 Hz: ≥ 5,000 MPa
    → Fatigue $\varepsilon_{f}$, 10°C, 25 Hz: ≥ 160
  - Evaluate Betoflex™ with other MSCR developed binders
    → PG58V-31 & PG58H-34
- Betoflex™ 0/10 mm
  - Perform level 4 formulation
- Calibration work
  - North-American approach & testing procedures
  - Gyratory compactor i.e. Pine vs. PCG-3
PART I – PROJECT DETAILS AND ISSUES
CITY OF CALGARY
WHY INNOVATE?

“We must allow for innovation and creativity in our solutions to remain resilient and adaptive to changes that will inevitably come our way.”

» City of Calgary has over 15,000 lane-Km roads network

» The City’s asphalt and concrete road infrastructure is valued at $12 Billion

» Expanding network, shrinking budget
Some of the innovations which were already implemented are:

» Stone Mastic Asphalt (SMA)
» Implementation of combigrid, Geogrids, composite Geogrids, Fibreglass grid
» Reinforced Fibres in asphalt
» Use of high strength concrete reinforcement grid
» Full Depth Reclamation (FDR) and Cold in Place Recycling (CIR)
» Piloted Betoflex, rut resistance asphalt mix
Project – 36th Street NE – Memorial Dr. to 16 Ave., Calgary, Alberta

Major Road with Bus routes and LRT line; 25,000 to 40,000 vehicles/Day; Commercial zone (Malls and Businesses)
PILOT PROJECT AREA

Project – 36th Street NE at Marlborough Station

» Owner – City of Calgary
» Contractor – Standard General
» Rehab Year - 2016
PROJECT BACKGROUND

Pavement Condition:

» Bus pads - High severity rutting and shoving.

» Intersection Approach - Moderate rutting.

Design Recommendation:

» Bus pads - 225 mm PCCP (With fibre) on 150 mm of Granular Base Course.

» Intersection Approach – 110 mm M&I (50 bottom lift + 60 top lift); SP 12.5 NMS Fine Graded; PG 70-31.
The concrete Pad design was as follows:

Option 1

225mm Concrete
150mm GBC

The proposed Betoflex option was as follows:

Option 2

60mm Betoflex
60mm Betoflex
80mm Betoflex
Output of LCCA:
» Concrete: Initial cost - $62,475 and NPV - $ 62,475
» Betoflex: Initial cost - $33,915 and NPV - $ 53,877

Other Benefits:
» Traffic Disruption: 1 day (Betoflex) Vs 12 days (Concrete)
» Environmental – Less emission due to minimum traffic disruption
» Pedestrian Safety – minimum disruption to public (major bus stop & LRT Station)
CONSTRUCTION - METHODOLOGY

1 lift of 60 mm Betoflex

2 lifts of 60 mm Betoflex

3 lifts of (60 + 60 + 80) mm Betoflex
OBSERVATION - POST CONSTRUCTION

- Zone A – Left Turning Lane – <3 mm of rutting
- **Zone B** – 2 Through Lanes – no rutting
- **Zone C** – South End – Signs of rutting – 3-5 mm
  North End – Severe Rutting - <15 mm.
» Placed all 3 lifts of asphalt in one night shift – Traffic Constraint

» Rutting on the Betoflex was attributed by early opening to heavy traffic prior to allowing the asphalt to cool down sufficiently
PERFORMANCE – AFTER 1 YEAR

Before paving

Bus pad – high severe rutting & shoving

1 year after paving

Bus pad North end – rutting > 15 mm.

Through Lanes – moderate to high severity rutting

Through Lanes – no rutting
PERFORMANCE – AFTER 1 YEAR

Before paving

Left Turning Lane – moderate rutting

1 Year after paving

Left Turning Lane – <10 mm of rutting
REMEDIATION WORK

» A 60 mm Betoflex surface layer was proposed to address the rutting identified in left turn lane and bus pad area

» The affected areas were milled and 60 mm Betoflex was placed in a single lift

» It was ensured that surface has cooled sufficiently prior to opening to traffic
OBSERVATION – POST REMEDIATION WORK

Before – Remediation 2017

Bus pad North end – rutting > 15 mm.

After – Remediation 2017

Bus pad – no rutting
OBSERVATION – POST REMEDIATION WORK

Before – Remediation 2017

Left Turning Lane – <10 mm of rutting

After – Remediation 2017

Left Turning Lane – no rutting
LESSONS LEARNED

What did we do well?

• Evaluate options based on LCCA
• Pilot – Pilot before selecting any new potential product for any project
• Documentation – Inspection, Monitoring (measurement, photos)

What could we improve?

• Construction practices – Follow the basics, if construction practices are not followed, even the best material will not perform
• Planning and scheduling

Mistakes to avoid

• Do not open to traffic early
• Enough time for the mats to cool off prior to placing subsequent layers
• Respect weather conditions
MOVING AHEAD

Monitoring
- Continue to monitor the performance over a period of 3 to 5 years
- Documentation – Field observation with measurement and photos

Evaluation
- Based on monitoring results, evaluate with other materials used on the same project (SuperPave & Concrete)
PART II - BACKGROUND
BACKGROUND – Performance-Based Mix-Design System

» Commonalities for bituminous paving materials mix-design
  • In-service performance
    • Climate
    • Traffic
  • Production, placement & compaction consideration
  • Location with the pavement structure
    • Base vs. surface

» Mix-design approaches maybe:
  • Recipe only,
  • Recipe + empirical, or
  • Recipe + empirical + fundamental
BACKGROUND – Performance-Based Mix-Design System

Multi-level French approach

- Gradation & binder (Level 0)
- Workability & water resistance (Level 1)
  - Rutting resistance
- Modulus (Level 2)
  - Fatigue resistance
- Level 3 + Level 4

Recipe approach

- Empirical approach for mixture durability
- Level 1 + Level 2
  - Fundamental approach for mechanistic pavement design

Level 0

Level 1

Level 2

Level 3

Level 4
BACKGROUND – Performance-Based Mix-Design System

» Level 1 - Compaction and water resistance + “Level 0”
  • *PCG-III vs. Superpave gyratory compactor*

<table>
<thead>
<tr>
<th></th>
<th>PCG-III</th>
<th>Superpave</th>
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</thead>
<tbody>
<tr>
<td>Internal angle</td>
<td>0.86°</td>
<td>1.16°</td>
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<tr>
<td>Sample height</td>
<td>150 mm</td>
<td>115 mm</td>
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<tr>
<td>Typical gyrations</td>
<td>40, 60 &amp; 80</td>
<td>75, 100 &amp; 125</td>
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</tbody>
</table>
BACKGROUND – Performance-Based Mix-Design System

» Level 2 – Rutting resistance + “Level 1”
  • Wheel tracking device – French style
BACKGROUND – Performance-Based Mix-Design System

- Level 3 – Stiffness modulus + “Level 2”
BACKGROUND – *Performance-Based Mix-Design System*

» Level 4 – Fatigue resistance + “Level 3”

- *Wohler fatigue*
BACKGROUND – “Rational” Pavement Design Method

» Donald Burmister work
The method is based on:
  • *Mechanistic model, and*
  • *Laboratory fundamental testing*

Two criteria for design:

- **Vertical compressive strain** $\varepsilon_z < \text{Allowable limits: permanent deformation}$
- **Horizontal tensile strain** $\varepsilon_t < \text{Allowable limits: fatigue cracking}$
BACKGROUND – “Rational” Pavement Design Method

» Field calibrated as well as IFSTTAR test track
PART III – PROPERTIES
Properties

» Performance-related/based mixture evaluation
  • Focus on durability and mechanical properties

» Betoflex®
  • Multi-stage process

» Comparaison of Betoflex®, Superpave & SMA
  • Different mechanical properties → workability and compaction level
# PRACTICAL APPLICATIONS – Betoflex®, Superpave & SMA

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Target voids <em>(Level 1)</em> (%</th>
<th>Rutting <em>(Level 2)</em> (%)</th>
<th>Modulus <em>(Level 3)</em> 10°C-10Hz (MPa)</th>
<th>Fatigue <em>(Level 4)</em> (µdef)</th>
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<tbody>
<tr>
<td>Betoflex E 0/16 mm</td>
<td>5.0</td>
<td>3.2</td>
<td>7256</td>
<td>204</td>
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<td>Betoflex V 0/16 mm</td>
<td>5.0</td>
<td>4.1</td>
<td>7578</td>
<td>165</td>
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<td>Betoflex H 0/16 mm</td>
<td>5.0</td>
<td>8.1</td>
<td>5507</td>
<td>230</td>
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<tr>
<td>Betoflex E 0/10 mm</td>
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<td>3.9</td>
<td>7323</td>
<td>200 <em>(Estimated)</em></td>
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<td>Betoflex V 0/10 mm</td>
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<td>6.4</td>
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<td>5639</td>
<td>219</td>
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<td>SP-20 (PG 64-34)</td>
<td>8.0</td>
<td>Failed</td>
<td>3201</td>
<td>206</td>
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<tr>
<td>SP-12.5 (PG 70-31)</td>
<td>7.0</td>
<td>7.1</td>
<td>5107 <em>(Estimated)</em></td>
<td>141</td>
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<td>SMA 10 (PG 70-31)</td>
<td>6.0</td>
<td>8.6</td>
<td>5466</td>
<td>172</td>
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</table>
PRACTICAL APPLICATIONS – Betoflex®, Superpave & SMA

**Diagram Description:**
- **Modulus (10°C-10Hz (MPa))** on the x-axis.
- **Fatigue resistance (µdef)** on the y-axis.
- Points representing different materials:
  - SP-20
  - Betoflex H
  - SMA-10
  - SP-12.5
  - Betoflex E
  - Betoflex V
CONCLUSIONS
CONCLUSIONS

» Performance-related/based mixture evaluation
  • *Focus on durability and mechanical properties*

» Betoflex®
  • *Multi-stage process*

» Comparaison of Betoflex® & Superpave
  • *Different mechanical properties → workability and compaction level*

» Comparative pavement design assessment
  • *ALIZE-LCPC possible in Canada → matches AT pavement designs*

» Value engineering
  • *ALIZE-LCPC → optimization of pavement structure*
Sukhwinder DHANOA, P.Eng.
Pavement Management Engineer
City of Calgary

Calgary, AB
CANADA

Dir. Line: 403-268-4383
Sukhwinder.Dhanoa@Calgary.ca

Ted HARRISON, P.Eng.
General Manager
GECAN
26120 Acheson Road
Acheson, AB T7X 6B3
CANADA

Dir. Line: 780 960-6475
Mob.: 587 986-9760
ted.harrison@gecan.ca
www.gecan.ca