Impacts of Pavement Preservation and Recycled Materials on Sustainability

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Agenda

• Focused on flexible pavements’ life cycle
• High-RAP HMA
• In-place recycling
• Pavement preservation
• All with sustainability in mind
Sustainability – Pavement Preservation

Programs and activities employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet road user expectations.

A safe, efficient and environmentally friendly pavement which meets the needs of present-day users without compromising those of future generations.
Sustainability and pavement preservation

• Pavement preservation and recycling are inherently about sustainability
• Environmental – use of resources, reduction in emissions and energy
• Economical – savings over the life cycle, savings for the tax payer
• Social – longer cycle times before major rehab enhances the value to the motorists
Life cycle of a pavement

Design → Materials processing → Construction → Operations → Preservation and Rehabilitation → Reconstruction and recycling

From Nov. 14, 2012 meeting by the FHWA Sustainable Pavements Program Project Team
Design

Life cycle of a pavement

- Perpetual pavement design
- MEPDG

Design → Materials processing → Construction → Operations → Preservation and Rehabilitation → Reconstruction and recycling → Design
Design

- Perpetual pavement concept – long life provides societal benefits and conserves natural resources
- Should ensure at least the top layers are recyclable
- Opportunities for use of high RAP in high modulus layer

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- MEPDG – Identify stresses in the pavement structure (load or non-load) and relate them to performance
Materials and materials processing

Life cycle of a pavement

Design → Materials processing → Construction → Operations → Preservation and Rehabilitation → Reconstruction and recycling

- Mix designs
- Warm mix
- RAP management
- Looking beyond processing and construction

National Pavement Preservation Conference 2016
Materials and processing

• Balanced mix design / performance-related tests
  – With high RAP contents, performance-based mix designs are increasingly important
  • RAP, RAS, rejuvenators, polymer, GTR
  – Some characterization in binder testing (ΔTc)

Rutting

Cracking...
Materials and processing

- Performance-based mix design
  - Dynamic modulus
  - Fatigue cracking
  - Thermal cracking

- Relate material characterization to pavement behavior
Life cycle of a pavement

Design → Materials and processing → Construction → Operations → Preservation and Rehabilitation → Reconstruction and recycling

Large gap!
Construction

Life cycle of a pavement

- Smoothness
- In-place recycling

Design → Materials processing → Reconstruction and recycling

Construction → Preservation and Rehabilitation → Operations
Construction

• Importance of building and maintaining a smooth road – “driveability”
• The smoother the road, the more comfort to the driver and the lower the fuel consumption
• In-place recycling has the potential to reduce reconstruction time
• Pavement preservation keeps good roads good
Operations

Life cycle of a pavement

- Traffic during the life of the road is responsible for most of the energy use and GHG
During the life of the road structure, road construction impact is negligible compared to traffic.

From Francois Chaignon, Colas SA
Preservation and rehabilitation

Life cycle of a pavement

- Design
- Materials processing
- Construction
- Operations
- Preservation and rehabilitation
- Reconstruction and recycling

- Pavement preservation
- Extended life
- Energy and emissions
Pavement preservation

• Employs a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations
  – Minor rehabilitation
  – Preventive maintenance
  – Routine maintenance
Preservation and rehabilitation

• Life extensions of preservation treatments on flexible pavements determined in a study of five states (Cost Benefits of Pavement Preservation, Gary Hicks, Jan. 2010 CCSA presentation)
  – Chip seals: 4 to 8 years
  – Slurry seals: 3 to 7 years
  – Micro surfacing: 3 to 8 years
  – Crack sealing: 0 to 4 years
  – Thinlay: 7 to 11 years (NCHRP Synthesis 464)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>GHG Emissions, kg/m²</th>
<th>Energy, MJ/m²</th>
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</thead>
<tbody>
<tr>
<td>Double chip seal</td>
<td></td>
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<tr>
<td>Micro surfacing</td>
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<tr>
<td>Thin wearing course</td>
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*From Etienne le Bouteiller, Colas SA - Asphalt Emulsions for Sustainable Pavements, Compendium of Papers from the First International Conference on Pavement Preservation*
Preservation and rehabilitation

- Double chip seal
- Micro surfacing
- Thin wearing course

Energy, MJ/m²/yr
GHG emissions, kg/m²/yr

Calculated from previous two slides and double chip seal of 7, micro surfacing of 6, and thin HMA of 9 years.
Reconstruction and recycling

Life cycle of a pavement

- Reconstruction and recycling
  - Design
  - Materials processing
  - Construction
    - High RAP HMA
    - In-place recycling
    - Cold central plant recycling
    - Full depth reclamation
  - Operations
  - Preservation and rehabilitation
Recycling

• High RAP hot mix
• Hot in-place recycling
• Cold in-place recycling
• Cold central-plant recycling
• Full depth reclamation
Recycling – high RAP HMA

• 25 percent or higher RAP content
  – Interest in going much higher
• Preserves resources – aggregate, asphalt
• Growing RAP piles in the U.S.
• NAPA Best Practices for RAP and RAS Management, Black and Green - Sustainability
• NCHRP Report 752 – Mix design...
• Several efficient rejuvenators in the market
Recycling – high RAP HMA

GHG emissions in equivalent CO2 (kg/m²)

25% RAP WMA

25% RAP HMA

Virgin HMA

From Francois Chaignon, Colas SA, Pavement Preservation: What About Energy and GHG
Recycling – hot in-place recycling

- Hot in-place recycling (HIR) is an on-site, in-place, pavement rehabilitation method that consists of heating, scarifying, softening, mixing, placing and re-compacting the existing bituminous pavement.
  - Surface recycling
  - Repaving
  - Remixing
Recycling – CIR and CCPR

Cold recycling consists of recycling and cold mixing RAP, with the resulting mix opened to traffic before being compacted.

- Cold in-place recycling (CIR) is the on-site recycling process to a depth of 2 to 5 inches, using a train of equipment, an additive or combination of additives, generating a 100% RAP mix, with the resulting mix opened to traffic before being overlaid.

- Cold central plant recycling (CCPR) uses the same materials as CIR, with the recycling taking place at a central location using a stationary cold mix plant.
Recycling – CIR and CCPR

- **Sustainability of FSB Processes** by Charles W. Schwartz, University of Maryland, 2015 PPRA Fall Meeting (Niagara Falls, Ontario)
  - CIR with foamed asphalt compared to HMA structure (CIR replacing HMA base)
  - CCPR with foamed asphalt compared to HMA structure (CCPR replacing HMA base)
Recycling – CIR and CCPR

Emission Intensity Adjusted by Structure

Structural layer coefficient

Foamed Stab. Base (FSB-CIR/CCPR): 0.32
HMA base (19mm): 0.40

HMA Pavement

FSB Pavement

Schwartz, University of Maryland
Lower density nearly compensates for extra thickness.

_Schwartz, University of Maryland_
Univ. MD CIR/CCPR conclusions

- Cold-recycled FSB provides substantial GHG reductions vs. HMA. On a per ton basis:
  - 43% reduction for CCPR
  - 83% reduction for CIR

- For fair comparison, must factor in differences in density, structural characteristics:
  - AASHTO 93: 25% more FSB thickness vs. HMA
  - FSB 130 pcf vs. HMA 160 pcf
  - GHG reductions on an adjusted per ton basis:
    - 42% reduction for CCPR
    - 80% reduction for CIR

Schwartz, University of Maryland
CIR case study (2007)

- County road n° RD 911 (Southwest France)
- 31,500 sq.m

- Basic design
  - Milling existing pavement 7 cm depth (i.e. 160 kg/sq.m of milled materials)
  - Laying a 4 cm AC binder course (i.e. 90 kg/sq.m)
  - Laying a 6 cm AC wearing course (i.e., 140 kg/sq.m)

- Alternative design
  - in place recycling of the existing pavement 7 cm depth
  - Laying a 4cm AC wearing course

Étienne le Bouteiller, Colas SA, IRC - PIARC International Seminar, New Deli, 2011
CIR case study

- Green house gas emissions (kg/sq.m)
Recycling – CIR
Washington State DOT

How can data like this be used to integrate pavement management systems with selection of the best-valued treatment?

Data courtesy of Jeff Uhlmeyer
Recycling – full depth reclamation

• Full depth reclamation is a technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended, resulting in a stabilized base course; can further stabilize with cement, fly ash, foamed asphalt, emulsified asphalt
Recycling or reconstruction

- Case study – Washington Ave., Las Vegas, NV
- TRB Paper 08-2343
- FDR with emulsified asphalt considered instead of reconstruction
- FDR had a cost savings of 30 percent
- Construction time reduced: 120 to 40 days
- 3000 fewer loads of materials were trucked on and off the project with FDR
Gaps

Focusing on RAP, preservation products, and recycling

• Balanced mix design with high-RAP content
  – Progress being made on binder properties needed to reduce durability issues with high RAP (and RAS), with or without rejuvenators
  – More progress is needed, with studies underway, on mix conditioning to simulate plant at field aging
  – More progress is needed, with studies underway, on mixture testing that predicts field performance
Gaps
Focusing on RAP, preservation products, and recycling

• Mix design and pavement design
  – There is no or little integration of mix design and pavement design, leading to over-design and wasted resources.
  – **INTEGRATION OF STRUCTURAL AND HMA MIXTURE DESIGN: WHY HASN'T TIDS BEEN DONE?** Von Quintus and Hall, 2009 Annual TRB Meeting, Committees AFD60 & AFK50
Gaps

Focusing on RAP, preservation products, and recycling

• Pavement preservation
  – Adoption of specifications by agencies with a regular program of preservation construction projects is still needed in some areas
  – Integration into pavement management systems
Gaps
Focusing on RAP, preservation products, and recycling

- **In-place recycling**
  - Adoption of specs by agencies with a regular program of projects is needed in many areas
  - Avoid specs that piece together information from several sources but don’t mesh (“good intentions”)
  - Lack of experienced contractors in some areas; expensive equipment. A continuing program will encourage investment.
Gaps

Focusing on RAP, preservation products, and recycling

• In-place recycling
  – Some research is needed on best QC practices and acceptance criteria
  – Non-use of these products due to lack of education and turf protection
Conclusions

• Sustainability and preservation / recycling are complimentary
• Better integration of and improvements in the steps of the pavement life cycle will result in sustainability improvements
• High-RAP content mixes save on the use of new aggregate and asphalt and have lower GHG emissions
Conclusions

• Preservation products extend the life of pavements, and emulsion-based products have a better carbon footprint
• In-place recycling has cost and time advantages with lower GHG emissions and energy use, but it is under-utilized
Thank you

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