Two-Lift Concrete Pavement Construction

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ABSTRACT

While two-lift concrete paving construction is common in other parts of the world, its use in the United States has been limited. With renewed emphasis on making our transportation system more sustainable, an overview of the two-lift paving technology will be given, along with its application in the United States and benefits derived from this application.

This presentation is part of the Sustainable Concrete Pavement Technologies session.

Key words: recycling—sustainability—two-lift concrete paving
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Why Bother?

- Lower cost system below
- Improved system above
- Changing demands on mixture
- Improved life cycle cost
- Improved environmental impact
Sustainability

The use of practices and materials in concrete pavement that provides a durable pavement, and that

- minimizes the use of energy and non-renewable resources
- while generating a minimum of pollutants
- in the most cost effective manner possible
- while maximizing the benefits to society.
Two-lift Concrete Paving

US Experience
• Concept is not new
  ➢ Used on initial interstate construction
  ➢ MI - 1993
  ➢ KS - 1998
  ➢ FL - 2001

European Experience
• Common practice in many countries
Main application: heavy duty motorways

Designed for 30 years and little maintenance
Usually 40+ years old when reconstructed
European Roadbuilding:

- Impact of US experience, equipment, and technology.
- Densely populated countries.
- Environmental aspects are of great influence
  - Noise
  - Pollution
  - Congestion
  - Natural Resources
  - Landfill
## Concrete Pavements

<table>
<thead>
<tr>
<th>Pavement</th>
<th>in. (cm)</th>
<th>base</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPCP</td>
<td>9.8/10.2 (25/26)</td>
<td>CSB+HMA</td>
<td>all</td>
</tr>
<tr>
<td>JPCP</td>
<td>10.6 (27)</td>
<td>CSB+geotextile</td>
<td>Germany</td>
</tr>
<tr>
<td>JPCP</td>
<td>11.8 (30)</td>
<td>Crushed stone</td>
<td>Germany</td>
</tr>
<tr>
<td>CRCP</td>
<td>9.0 (23)</td>
<td>CSB+HMA</td>
<td>Belgium</td>
</tr>
<tr>
<td>CRCP</td>
<td>9.8 (25) *</td>
<td>CSB+HMA</td>
<td>NL, UK</td>
</tr>
</tbody>
</table>

*plus 2 in. (5 cm) porous asphalt (Netherlands), or 1.4 in. (3.5 cm) SMA (UK)*
JPCP in two lifts

Bottom: gravel or recycled aggregate
Top: high quality virgin aggregate
Wirtgen pavers

New motorway A5 Vienna – Brno, 2008
Paving width 41 ft. (12.5 m) wide, 0.5 mi. (800 m) per day
Recycle concrete!

- Old concrete:
  - Strength 10,000 to 15,000 (70-100 N/mm²) compressive → As good as many natural aggregates

- RCA bonds well with new cement stone
  - Strength higher and better than with many virgin aggregates.

- RCA is high value
  - Should be used for concrete and not wasted for subbases.
Recycling of concrete

• Processing needs care.
• Same requirements for RCA as for virgin aggregate.
• RCA should be used in a wet condition.

• Hundreds of miles of highway recycled into concrete since 1990.
• Excellent performance; lower E and higher $w_{ads}$ not harmful.
Recycling concept for all existing materials:

old

crushed material
(max. 10 % asphalt)

4 cm

22 cm

8 cm

tar-bound

new

4 cm exposed aggregate concrete MA 8

21 cm recycling concrete MA 32

5 cm bit. subbase

25 cm cement-bound material
Concrete surfaces

- Broom and burlap drag: light or slow traffic.
- Exposed aggregate: heavily-trafficked roads (for durability of noise-reduction and friction)
- EAC first used in Belgium (7/8 in., 22 mm)
- Used since 1990 in Austria (5/16 in., 8 mm)
- Used again since 2001 in Belgium (7/8 in. with surplus 5/16 in.)
- Now also used in Germany (5/16 in., 8 mm).
EAS 8 mm after 11 Years’ Service

- Single-sized aggregate 4/8 mm
  Particles very close to each other
  (gap grading 1/4, sand 0/1)
- No loss of stones, even in the wheel path
Why Use Two-Lift Kansas Experience

Two lift construction of I-70 in 2008
- Quality surface aggregate
- Enhance Safety
- Reduce Noise
- Provide Economical Pavement
- Promote Recycling
Scope of Project

- Construct 24’ pavement with 6’ inside and 10’ outside shoulders.
- Use non “D”-cracking aggregate in surface
- Stiff bottom layer
- Construct several surface textures for noise reduction, improve friction, and reduce splash and spray.
- Form centerline plastic joint
Top & Bottom Lift
Exposed Aggregate - KANSAS
Accomplished Objectives

- Two-lift is possible and practical
- Economic pavement sections can be realized
- Exposed aggregate surface is possible and practical
- Many choices for surface texture; their use may be condition dependent.
What is Sustainability?

“Meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs”

[WCED 1987]
What Makes a Concrete Pavement More Sustainable?

• More economic
  – Lower initial cost
  – Lower maintenance and rehabilitation costs
  – Longer life
• More environmental
  – Less energy consumed
  – Less pollution generated
• More societal benefits
  – Safer
  – Quieter
  – Versatile
Some Specifics...

- Economics
  - Maximize use of lower-priced, locally available materials without sacrificing performance
    - e.g. increased aggregate volume/reduced paste, recycled content, marginal aggregates, supplementary cementitious materials (SCMs), etc.
  - Improved design that reduces costs
    - Better understanding of performance, enhanced features
  - Decreased construction costs
  - Improved maintenance and rehabilitation strategies
    - e.g. diamond grinding, in-place recycling, etc.
Some Specifics...(Continued)

• Environmental
  – Reduce the use of portland cement
    • Optimized grading, use of SCMs, etc.
  – Reduce construction impacts
  – Reduced impact during operation
    • e.g. heat island effect, increased vehicle fuel efficiency, reduced urban lighting needs, treat air pollution, etc.
  – Reduced run-off
  – Reduced waste
    • Recycling, waste fuels, waste raw materials
Some Specifics...(Continued)

- Social
  - Reduce noise
  - More livable communities
    - Colored and patterned concrete, integrated urban environment, reduced heat, etc.
  - Increase safety
    - Lighting, skid resistance, etc.
  - Less disruption due to construction
  - Locally made product
The Good News...

- We are currently in the process of becoming “good”
  - Many efforts are afoot to improve the sustainability of concrete pavements including the new CP Roadmap Sustainability Track
  - We need strategies (tools) to assess where we are and to help us get to where we need to be
- The next step is to become even better
  - LCA helps us work toward
How Can Two-Lift Construction Help?

- Two-lift construction can maximize the use of locally available materials coupled with improved performance and longevity
  - The lower lift can be made with materials that might not perform well as a surface
  - The top lift can be designed to withstand the harsh environmental and loading conditions at the pavement surface
The Bottom Lift

- Generally thick, typically being 80 to 90 percent of the total pavement thickness
- Generally optimized to have a lower cement content while making maximum use of locally available materials
  - Recycled concrete and/or recycled asphalt pavement
  - Softer aggregates with poor wearing resistance
  - High SCM content and/or low total cementitious content
    - Scaling is not an issue for this layer
The Top Lift

- Optimized to be durable, wear resistant, and quiet
  - Uses high quality, durable, wear resistant aggregate
    - In some locales, must be imported
  - Aggregate type and sizing can be optimized to reduce noise if used as exposed aggregate surface
  - Often higher cement content is required since smaller maximum aggregate size is used
  - Must be resistant to scaling and deicer damage