Looking to the Future of Concrete Pavements

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Outline

• Opportunities
• Challenges
• Levers we can pull
• Resources
• What next?
Opportunities

• Money!
• Infrastructure Investment and Jobs Act
Opportunities

• Sustainability
  • A focus for FHWA

• We can’t live without concrete

• Can we deliver it without killing the planet?
  • Long life
  • Recycling
  • Heat island
  • Fuel consumption
Opportunities

• Resilience
  • Flooding recovery
  • Hardening
Opportunities

• Truck traffic
  • Expected to grow >40%
Challenges

• Staffing
Challenges

• Equipment
Challenges

- Materials
  - Cement
    - PLC
  - Low carbon materials
- Fly ash
  - Alternative SCMs
  - Recycled Glass
  - Harvested fly ash
Challenges

• Materials
  • Dowels
Challenges

- Sustainability
- EPDs are coming

<table>
<thead>
<tr>
<th>Core Mandatory Impact Indicators</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>GWP kg CO₂e</td>
<td>261.19</td>
<td>426.75</td>
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<tr>
<td>ODP kg CFC11e</td>
<td>7.84E-06</td>
<td>1.11E-05</td>
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<tr>
<td>AP kg SO₂e</td>
<td>0.99</td>
<td>1.33</td>
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<tr>
<td>EP kg Ne</td>
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<td>0.55</td>
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<tr>
<td>POCP kg O₃e</td>
<td>21.38</td>
<td>28.22</td>
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<tr>
<td>ADPf MJ, NCV</td>
<td>1,522.19</td>
<td>2,229.70</td>
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<td>ADPe kg Sbe</td>
<td>2.44E-04</td>
<td>3.69E-04</td>
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<tr>
<td>FFD MJ Surplus</td>
<td>143.16</td>
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Challenges

• Opening to traffic
Challenges

• Durability
  • Buckling
  • Joints
  • Cracking
Things we can do now

• Sustainability
  • Use less concrete
  • Use less binder in the concrete
  • Use less clinker in the binder
Things we can do now

• Performance Engineered Mixtures
  • What do we want?
  • How do we know its good?
  • How do we deliver it?

• Higher chance of those bonuses
• Lower risk of failure
• Improved sustainability

<table>
<thead>
<tr>
<th></th>
<th>Workability</th>
<th>Transport</th>
<th>Strength</th>
<th>Cold weather</th>
<th>Shrinkage</th>
<th>Aggregate stability</th>
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<td>Aggregate System Type, gradation</td>
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<tr>
<td>Paste quality Air, w/cm, SCM type and dose</td>
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<tr>
<td>Paste quantity Vp/Vv</td>
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<td>✔️ ✔️</td>
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</tbody>
</table>
Things we can do now

- Overlays
Things we can do now

• Geotextile interlayer
Things we can do now

• Fibers
Things we can do now

- Recycled Concrete Aggregate
Things we can do now

• Stringless
Things we can do now

• Real Time Smoothness
Things we can do now

• Bigger Better Smarter Machines
Things we can do now

- UPV to guage saw timing
Things we need to investigate

- Additives
  - Nanomaterials
  - Graphene
Things we need to investigate

- Curing
  - What with?
  - When?
  - How much?

- How do we check?
Things we need to investigate

• Internal curing
  • Reduces cracking and warping
  • Constructability is challenging with LWFA
  • Looking at super-absorbent polymers
Things we need to investigate

- Penetrating sealants
  - Develop a protocol
  - All sealers are not the same and should not be applied equally to all concretes.
  - We recommend absorption/desorption, and saturation/desorption testing.
Things we need to investigate

- Vibration
  - Correlate vibration variables with mixture variables
  - Develop control protocols
  - Smart vibrators

(a) Mixture 1 - slump 10cm
(b) Mixture 3 - slump 2.5cm
Things we need to investigate

• Performance Engineered Mixtures 2.0
  • What happens to the concrete after it leaves the truck
    • Consolidation
    • Smoothness
    • Thickness
    • Finishing
    • Curing
    • Sawing
Research Needs

• Moisture content
• Machine control
• Achieving uniformity load to load
• Carbonation rates

• Paving in cold weather
Resources

- Bed time reading
- Workshops
- Webinars
- Experts
- Videos
So

• Change is inevitable
• Enjoy the ride
• Opportunity abounds