Linking PEM and Sustainability

August 16, 2022

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Outline

- Why Sustainability?
- Why Concrete?
- Why PEM?
- Putting them all together

SUSTAINABILITY...?

ECONOMIC
- Economic growth and resilience
- Affordability
- Energy security
- Product efficiency
- Outputs of cement products

Water quality and (dis)service

Greenhouse gas emissions

Source: EPA

CONTEXT
CONCRETE SUSTAINABILITY...

What are the levers?

- There's embodied... and then there's use phase emissions.
  - ~90% of embodied CO2 is from cement production.

- Use phase emissions...

Specific levers to reduce embodied CO2...

1) Consume less concrete for new structures:
   - Be efficient with our pavement designs
2) Consume less cement in concrete mixtures:
   - Optimizing our concrete paving mixtures
3) Consume less clinker for making cements:
   - Embrace lower carbon cements

Come a long way already... will continue to improve!
1) Consuming Less Concrete: Being efficient with our pavement designs!

- Use the best available design tools
  - Pavement ME Design
- Specify Long-life
  - Low hanging fruit (double life \(\rightarrow\) almost halve \(\text{CO}_2\))
  - Quality construction!
- Concrete Overlays
  - Capitalize on equity already in pavement
  - Long-life and low-carbon design solution
  - EDC6 TOPS recognizes this opportunity

2) Consuming Less Cement in Concrete Mixtures: Optimizing our Concrete Pavement Mixtures

<table>
<thead>
<tr>
<th>Optimized Aggregate Gradations</th>
<th>Durable Matrix</th>
<th>Recycled Materials</th>
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<tr>
<td>Cementitious</td>
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<td>501</td>
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<tr>
<td>w/cm</td>
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<tr>
<td>% SCM 1</td>
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</table>

3) Consume less clinker for making cement: Embrace Lower Carbon Cements

- Specify and adopt Portland Limestone Cements (PLC)
  - Reduce \(\text{CO}_2\) footprint by \(-10\%\)
  - Same concrete performance characteristics
  - Better particle packing & nucleation sites
- Consider alternative low carbon cements
  - Geopolymer Concrete
  - Alternative Pozzolanic Materials (ground glass, rice husks, etc) MnROAD test cells.

Strategies to lower the embodied footprint

- These strategies can be combined
  - Efficient long-life designs, with optimized concrete mixtures, using lower carbon cements.
  - This is about ENGINEERING our designs, constituents and mixtures
  - We can reduce the \(\text{CO}_2\) footprint of our paving mixtures drastically...!
Strategies BEYOND the embodied footprint

How do we reduce use phase impacts?
- Can we address the big kahuna (84%)?
- Reduced fuel consumption via "Pavement Vehicle Interaction"
  - Smoother = lower fuel consumption
  - Stiffer = lower fuel consumption
- Fewer closures (longer life)
- Resilience
- Albedo impacts
- Carbonation

Why PEM?
- A program to develop a better specification for concrete mixtures
  - Understand what makes concrete “good”
  - Specify the critical properties and test for them
  - Prepare the mixtures to meet those specifications
- Ask for what is needed, and no more

What is Good concrete?
- Sustainable
- Easily constructible
- Long lasting
- Low maintenance
- Cost effective
- Serves its purpose

How do we know it is good?
- Set the recipe
- Watch the process
- Poke it occasionally
- Wait and see when it dies
- Trust me…
- Or measure things
  - But what things?
Require the things that matter

- Transport properties (everywhere)
- Aggregate stability (everywhere)
- Strength (everywhere)
- Cold weather resistance (cold locations)
- Shrinkage (dry locations)
- Workability (everywhere)

Workability

- Not too wet
- Not too dry
- Prequalification

Aggregate Stability

- If aggregates expand = damage
  - Alkali silica reaction
  - D-Cracking
- Follow published guidance
- Prequalification

Transport properties (permeability)

- Keep water out = longer life
- Resistivity
- Control with paste quality
- Prequalification
- QC
- Acceptance
### Cold Weather
- Freeze-thaw
- Saturation
- Entrained air
- De-icing salts
- Sufficient SCM
- Prequalification
- QC
- Acceptance

### Shrinkage
- Influences cracking risk
- Controls warping
- Takes time
- Paste content (read the batch sheet)

### Strength
- Strong enough to carry loads
  - Cylinders
  - Beams
  - Maturity
- Prequalification
- QC
- Acceptance

### Achieving design goals?
- AASHTO R101 avoids micromanaging proportions
- Tools are available to help contractors optimize mixtures

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<table>
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<th>Aggregate System</th>
<th>Workability</th>
<th>Transport</th>
<th>Strength</th>
<th>Cold Weather</th>
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Tying it all together

- Concrete that delivers what is needed
  - Long life
  - Minimum impact
  - At time of construction
    - Increased SCMs, reduced cement
  - In the use phase
    - Reduced fuel usage

- What about cost?
  - Reduced

Equals Sustainability

In Summary

<table>
<thead>
<tr>
<th>Measurable</th>
<th>Phase</th>
<th>Impact</th>
<th>Who</th>
<th>Side effect</th>
<th>Cost</th>
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What has changed?

- Agencies are:
  - Dropping minimum cement contents
  - Using tests that better measure potential performance
  - Able to adopt sustainable practices with confidence

- Contractors are:
  - Reducing construction impacts
  - Reducing embodied carbon
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Where next?

- Keep encouraging the community to adopt change
- Keep working on:
  - Alternative materials
  - Developing the tools to quantify concrete in the field
    - Improve uniformity
    - Understand vibration
    - Measure bleeding in the field

So

- Some things we can change now
  - Make better concrete
  - Make better pavements
- Others will take time
  - Sequestration

The Difficult We Do Immediately. The Impossible Takes a Little Longer

Charles Alexandre de Calonne, 1794

National Concrete Pavement Technology Center

Iowa State University Institute for Transportation