Environmental benefits of two-lift pavement

A quantitative perspective based on life cycle assessment (LCA)

Joep Meijer
President of theRightenvironment

In collaboration with the CP Tech Center
Topics

1. What is LCA?
2. Our experience
3. Two-lift case
4. What’s next
Life cycle assessment (LCA)

LCA is a powerful tool for assessing the environmental performance of products, services or scenarios. It is based on material and energy flows for processes and materials that together form a life cycle.
Life cycle assessment (LCA)

We use world-leading software and databases and apply ISO standards

- ISO 14041 Goal and Scope Definition
- ISO 14042 Inventory Analysis
- ISO 14043 Interpretation
- ISO 14044 Guidelines and principles
- ISO 14025 Type III environmental declarations
Goal and Scope

Functional unit: what is to be assessed in terms of:
- Amount
- Unit
- Functions
- Requirements
- Geographical considerations
- Timeframe
Inventory

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Impact Assessment

A range of impact categories

- global warming
- depletion of non-renewables
- depletion of the ozone layer
- acidification
- eutrophication
- summersmog
- aquatic ecotoxicity
- terrestrial ecotoxicity
- human toxicity
- energy
- non-hazardous waste
- hazardous waste
- …
# Impact Assessment

<table>
<thead>
<tr>
<th>Inputs and outputs</th>
<th>Environmental effects</th>
<th>Environmental indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Abiotic depletion</td>
<td>Embodied energy</td>
</tr>
<tr>
<td>Energy</td>
<td>Global Warming</td>
<td>Eco-indicator</td>
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<tr>
<td>Emissions</td>
<td>Ozone layer depletion</td>
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<tr>
<td>Waste</td>
<td>Smog</td>
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<tr>
<td></td>
<td>Acidification</td>
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</tbody>
</table>

Classification: Weighing
## Impact Assessment

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<td>1 kWh of electricity</td>
<td>Global Warming</td>
<td></td>
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</table>

### Use of equivalency factors

*From carbon dioxide and methane to global warming*

1 kg carbon dioxide = 1 kg GWP-equivalents  
1 kg methane = 24 kg GWP-equivalents  

Total = 25 kg GWP-equivalents  
*Source: IPCC*
Impact Assessment
The result is an Environmental profile

Example
Interpretation

Major contributions give options for improvements
Our experience

Over 10 years of consulting with CEMBUREAU, EFCA, BIBM, ERMCO, UEPG, HOLCIM, HEIDELBERG, ENCI, CBR, ITALCEMENTI, ready mixed, prefab drafting national standards for EPD, EU funded research project such as EcoServe, Carbon footprinting, Sustainability frameworks, databases, tools to educate the industry, language development. Consulting for European DOTs on green purchasing, environmental road design selection, tool development, standardization, feasibility of recycling scenarios, thermal concrete recycling, local secondary resources, comparisons, labeling, benchmarking, ....

Over 10 years of consulting with CEMBUREAU, EFCA, BIBM, ERMCO, UEPG, HOLCIM, HEIDELBERG, ENCI, CBR, ITALCEMENTI, ready mixed, prefab
Two-lift Kansas

Comparison of:
1. Traditional
2. Two-lift
3. Optimized two-lift

Together with Tom Van Dam, APTech
Gary Fick, Trinity Construction Management
Peter Taylor, CP Tech Center
Two-lift Kansas

Functional unit

The material acquisition and construction of 1 km of a two lane highway with a total width of 7.4 m according to KDOT requirements in Kansas
Two-lift Kansas

Traditional

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System boundaries

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Two-lift Kansas

Key differences

1. Traditional
   • Primary aggregate from OK for PCC
   • Portland cement

2. Two-lift (same plus)
   • CTB secondary aggregates on-site crusher
   • Part fly ash in CTB and top lift

3. Optimized two-lift (same plus)
   • CTB and bottom lift on-site crusher
   • Fly ash in bottom lift
Two-lift Kansas

Limitations

• Average European data for materials, processes, allocation parameters
• “just” material acquisition and construction

➡️ Look for relative differences not numbers
Comparison

1. Traditional
2. Two-lift
3. Optimized
Sensitivity analysis

All primary aggregates local

Comparing Option 1 - Traditional s.s. KS, 1p Option 2 - SLR Kansas case s.s. KS, and 1p Option 3 - SLR recycled aggregate s.s. KS, Method WLCGE005-426008 adopted by BRON 0209 V2.04
Sensitivity analysis

All recycling off-site
Sensitivity analysis

All recycling off-site and local primary aggregates
Conclusions

- Two-lift shows great potential
- Reducing clinker content is a sound strategy
- Recycling pays off
- Optimizing logistics matters
- With equal distances for primary and secondary aggregates, handling proves to be discriminating
LCA related lessons

- Always look at more than 1 indicator (trade-offs)
- Do not forget we did not look at all life cycle stages (trade-offs)
- Always look for sensitivity analyses to test the robustness of certain parameters or assumptions
Next steps

Gain experience, learn the language
• Develop a framework
• Expand on current efforts to make a concrete and cement US database
• Feed with primary data
• Perform case studies
• Make this “just” part of design

 ➔ Making informed decisions on a quantitative basis
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Back-up slides
Traditional

[Diagram showing environmental impacts of different options, with bars representing various impacts such as abiotic depletion, global warming, ozone layer depletion, etc.]

Option 1: PCC (340mm)
Option 1: CTB (150mm)
Single lift paver and spreader

Analyzing 1 p 'Option 1 - Traditional' Method: VLECA2005-EN/EN/06: adapted by INTRON 0308 V2.04 / World, 2003 / characterization

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Optimized

Analyzing Option 1: 2Lift recycled aggregate
Method: YLCA2006-NEH8006: adapted by INTRON 0309 V2.04
World, 2000 / characterization

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Normalization

Comparing 1 p 'Option 1 - Traditional', 1 p 'Option 2 - 2Lift Kansas case' and 1 p 'Option 3 - 2Lift recycled aggregate'. Method: VLCA2005-NEN8006: adapted by INTRON 0306 V2.04 / World, 2000 / normal