

Life-Cycle Analysis: A Powerful Tool for Improving the Sustainability of Concrete Pavements



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Outline of Presentation

- Why should we care about concrete pavement sustainability?
- A tale of three scenarios: how can two-lift construction result in “sustainable” alternatives?
- What is life-cycle analysis (LCA)?
- What does LCA tells us about the scenarios considered for two-lift construction?

What is Sustainability?



UNITED NATIONS
PLANET EARTH - SOL SYSTEM

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

[WCED 1987]

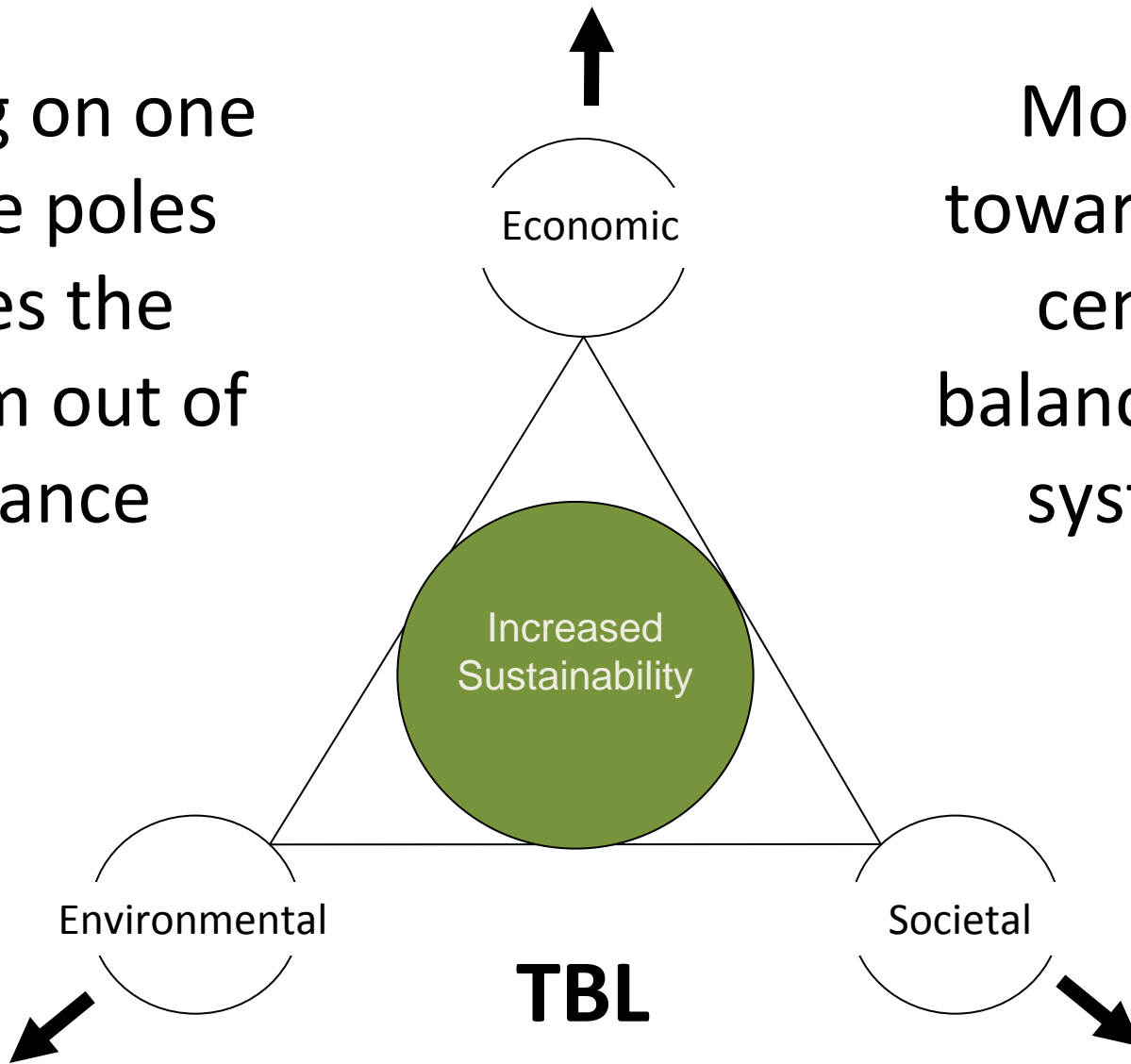
Sustainable Infrastructure



The Triple Bottom Line (TBL)

- Economic
- Environmental
- Societal

Pulling on one
of the poles
takes the
system out of
balance



Moving
towards the
center
balances the
system

Simply Put...

- Sustainability not only considers initial and life-cycle economic factors, but also environmental and societal impacts and benefits
 - It is simply good engineering
 - As with all engineering, it entails working with limited resources to achieve design objectives
 - As such, it is not about perfection, but instead about balancing competing, and often contradictory, interests

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

The Kansas Two-Lift

- Mainline pavement consists of two, 3.7-m wide travel lanes, with 4.6-m transverse joint spacing
 - Paved in one pass, tied at longitudinal joint, and dowelled transverse joints
- A 150-mm thick cement-treated base on existing subbase
- Total concrete pavement thickness of 340-mm











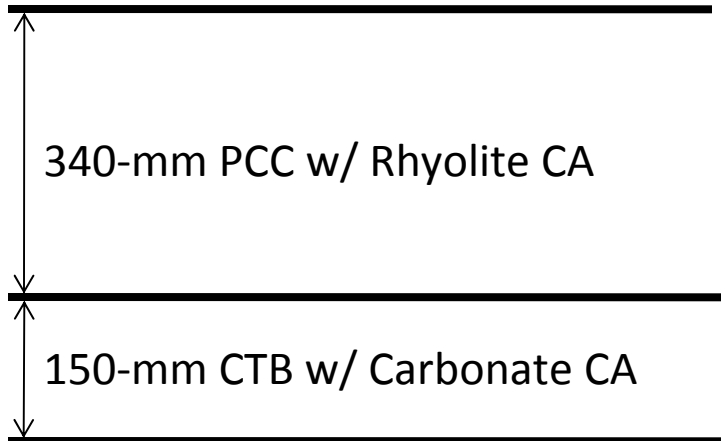


Three Alternatives

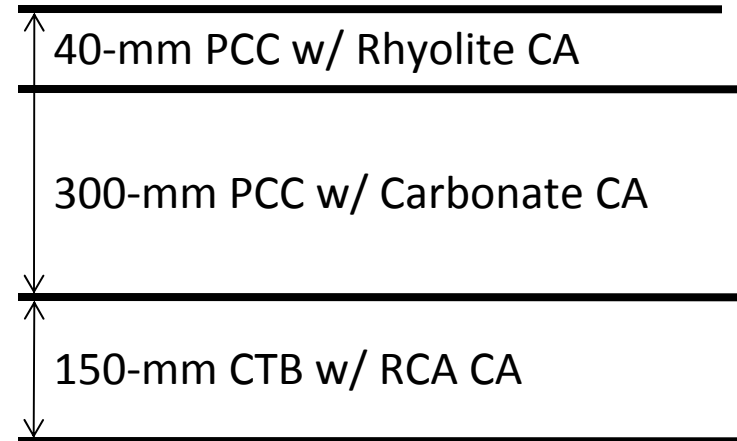
- Alternative 1: Conventional w/ same wearing surface
 - 340-mm thick PCC surface made with imported, wear resistant rhyolite aggregate
 - 150-mm thick CTB made with local carbonate aggregate
- Alternative 2: As-built two-lift
 - 40-mm thick wearing course made with rhyolite aggregate
 - 300-mm thick bottom lift made with local carbonate aggregate
 - 150-mm CTB made with recycled concrete
- Alternative 3: Two-lift with added features
 - Same as above except bottom lift uses recycled concrete coarse aggregate, reduced cementitious content, and 20% Class F fly ash

The Three Alternatives

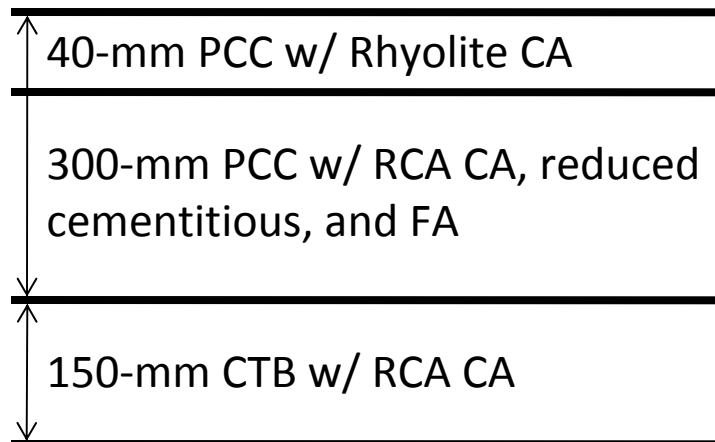
Alternative 1



Alternative 2



Alternative 3



Assumptions

- The following are constants, so were not considered in the LCA
 - Performance is assumed identical, so anticipated maintenance and rehabilitation was not considered
 - The same shoulders are used throughout so they were not considered
 - The same subbase was used throughout so it was not considered
 - The same joint design is used throughout, so joint details were not considered
- All these things can be considered in an LCA

In Summary

- Sustainability is NOT just an environmental initiative, but instead is an approach to balance economic, environmental, and social benefits and impacts
- Concrete pavements have a lot of advantages when sustainability is considered, and more are emerging every day
- Two-lift construction is one approach to enhance the overall sustainability of concrete pavement

Questions?

Here's Joep!

