Common Sense Sustainability for Concrete Pavements

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Virginia Concrete Conference 2009

With thanks to Tom Van Dam (ApTech)

Background

- Concrete is the most commonly used building material on the planet
  - Modern civilization is built on concrete
  - The positive social impacts are immense
- Therefore, it has a relatively large environmental footprint
- Sustainability provides a way to balance the various economic, environmental, and social factors

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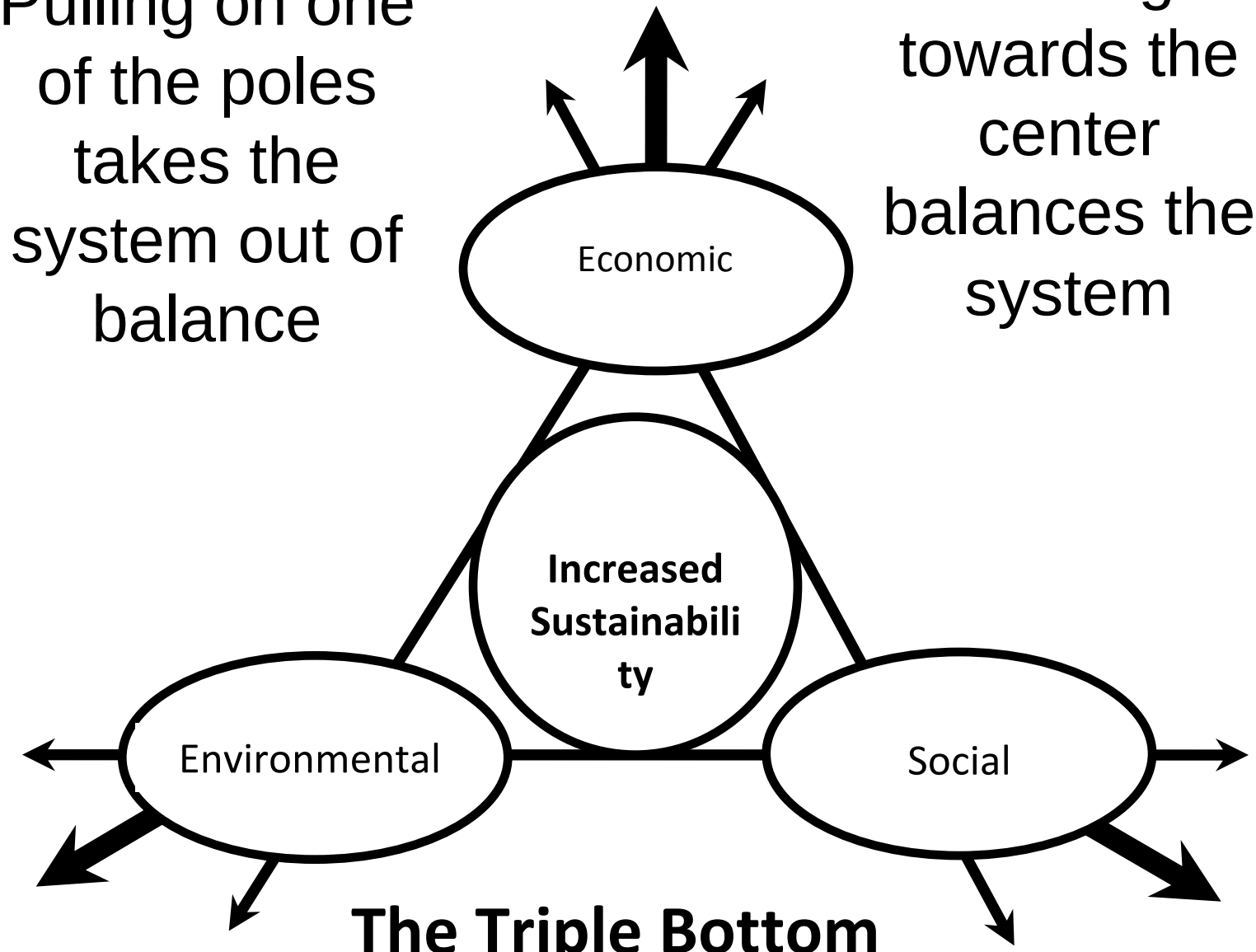
Pulling on one of the poles takes the system out of balance

Moving towards the center balances the system



The Triple Bottom Line

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What makes a Roadway More Sustainable?

The use of practices and materials in concrete pavement that provides a durable pavement over the design life of the 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.

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Sustainable Design

- It is simply good engineering
  - Using limited resources to achieve design objectives
  - Not about perfection, but about balancing competing, and often contradictory, interests
- Considers life-cycle economic, environmental and societal factors
- It's complicated – get over it

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In Addition

Sustainability:

- Is being demanded
- Appeals to a younger workforce
- Allows the industry to communicate the good that is being done
- Makes the concrete industry more competitive
- Drives innovation
- Is an important part of the stimulus package

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Common Sense Principles of Sustainability – v 1.0

1. Get smart
2. Design to serve the community
3. Choose what you use
4. Less is more
5. Minimize impact
6. Take care of what you have
7. Innovate

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No. 1: Get Smart

- Design for what you need
  - No more and no less
  - Don’t sacrifice engineering quality
- Incorporate design features that ensure that the design criteria are met
  - Holistic approach to design – it is not just thickness
- Incorporate innovative features that enhance sustainability
  - Standardized details

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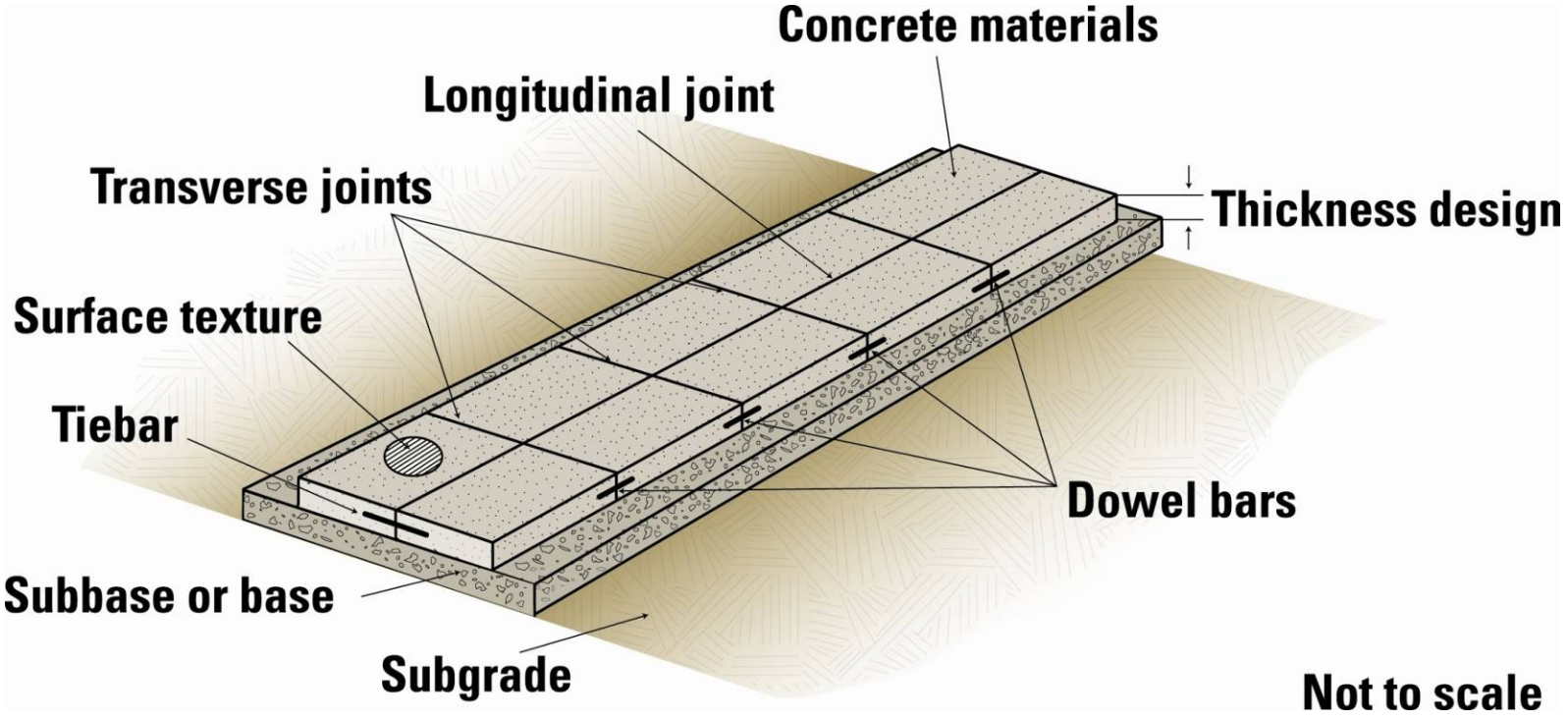
Holistic Concrete Pavement Design



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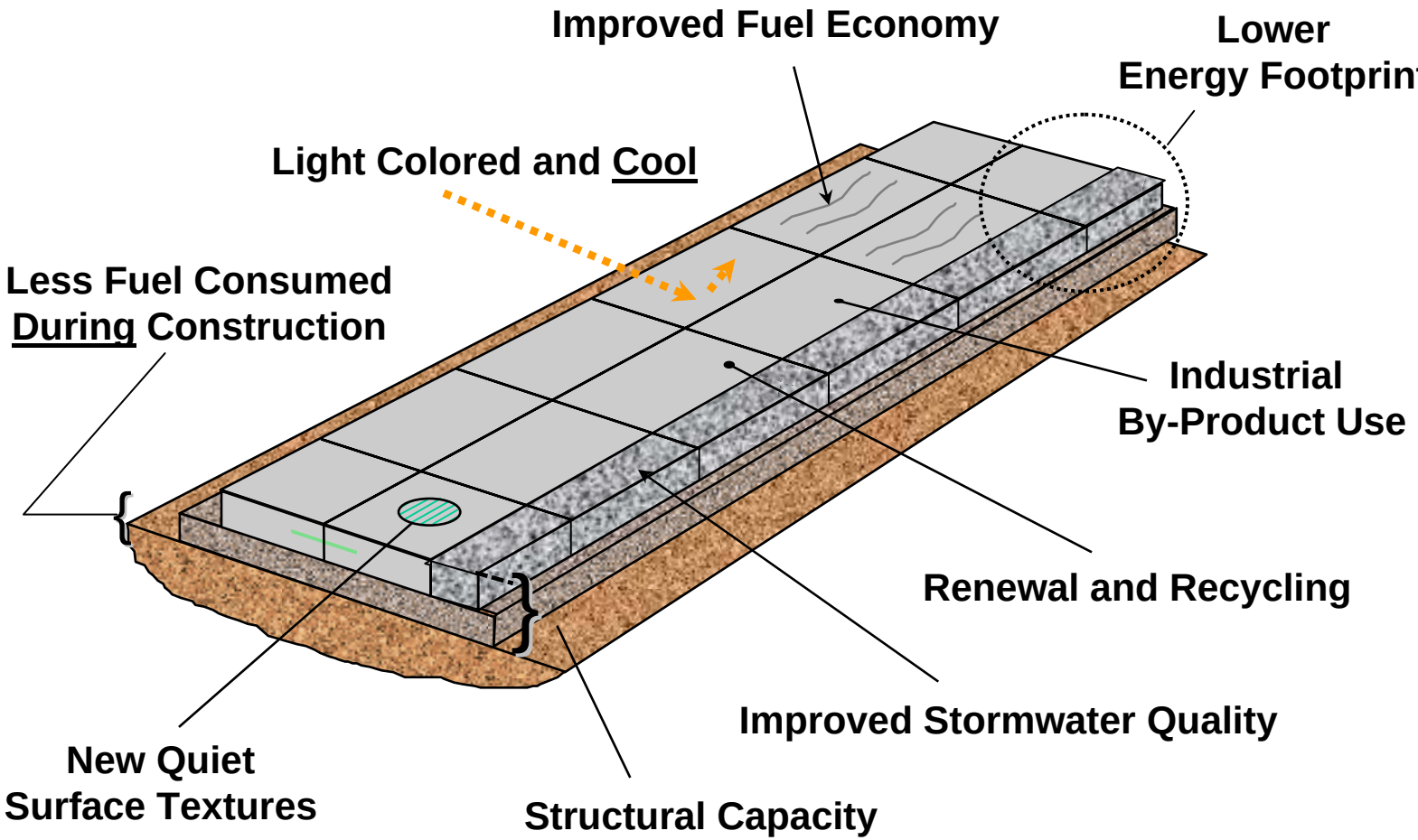
Design Beyond Longevity



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Adapted from Wathne, ACPA

No. 2: Design to Serve the Community

- Listen to the communities being affected
  - The “community” includes both the human community and natural community
- Design to address the specific needs of the community
  - Now and for the life of the pavemen`t

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No. 3: Choose What You Use

- Recycle – zero-waste
- Local first – minimize transportation
- Select the materials to use – don't let the materials select themselves
  - Understand what is available
  - Import only what you need

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Recycling and Reuse

- Concrete is 100% recyclable
- Recycled concrete aggregate (RCA) can be used in:
  - new concrete
  - subbases
  - granular fill
  - two-lift (FHWA)

- On-site recycling reduces time, energy, pollution, and makes money

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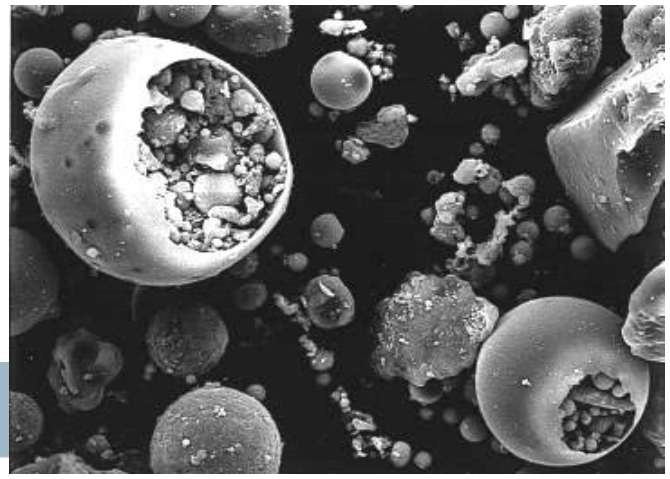
Waste or Resource?

- Cement and concrete industries consumed 20.59 million metric tons of coal combustion products in 2005 (ACAA)
- Slag cement utilization in 2006 was 3.62 million metric tons (SCA)
- Rice Husk Ash



From J.C. Roumain, Holcim (USA), Inc.

No. 4: Less is More

- All things equal, less material means less impact
- Using less portland cement can improve sustainability
  - Blended (ASTM C595) and performance specified (ASTM C1157) cements
  - Supplementary cementitious materials (SCMs – fly ash, slag, etc.)
  - Aggregate grading
  - Optimized mixture design

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Why Does Cement Matter?

- Annual portland cement production for <u>use</u> in the U.S. results in approximately:
  - 110 MMT CO_2 and consumes 550 QBTU of embodied energy
  - Domestic cement production is responsible for approximately 1.5% of U.S. total CO_2
- Portland cement is responsible for approximately 90% of the CO_2 and 85% of the embodied energy **in concrete**

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The Cement Industry...

- Has increased the efficiency of their clinkering process, significantly reducing the CO_2 to cement ratio
- Offers blended (ASTM C595) and performance specified (ASTM C1157) cements
- About half of CO_2 production is from decomposition of carbonate
- New cements are emerging that may sequester CO_2

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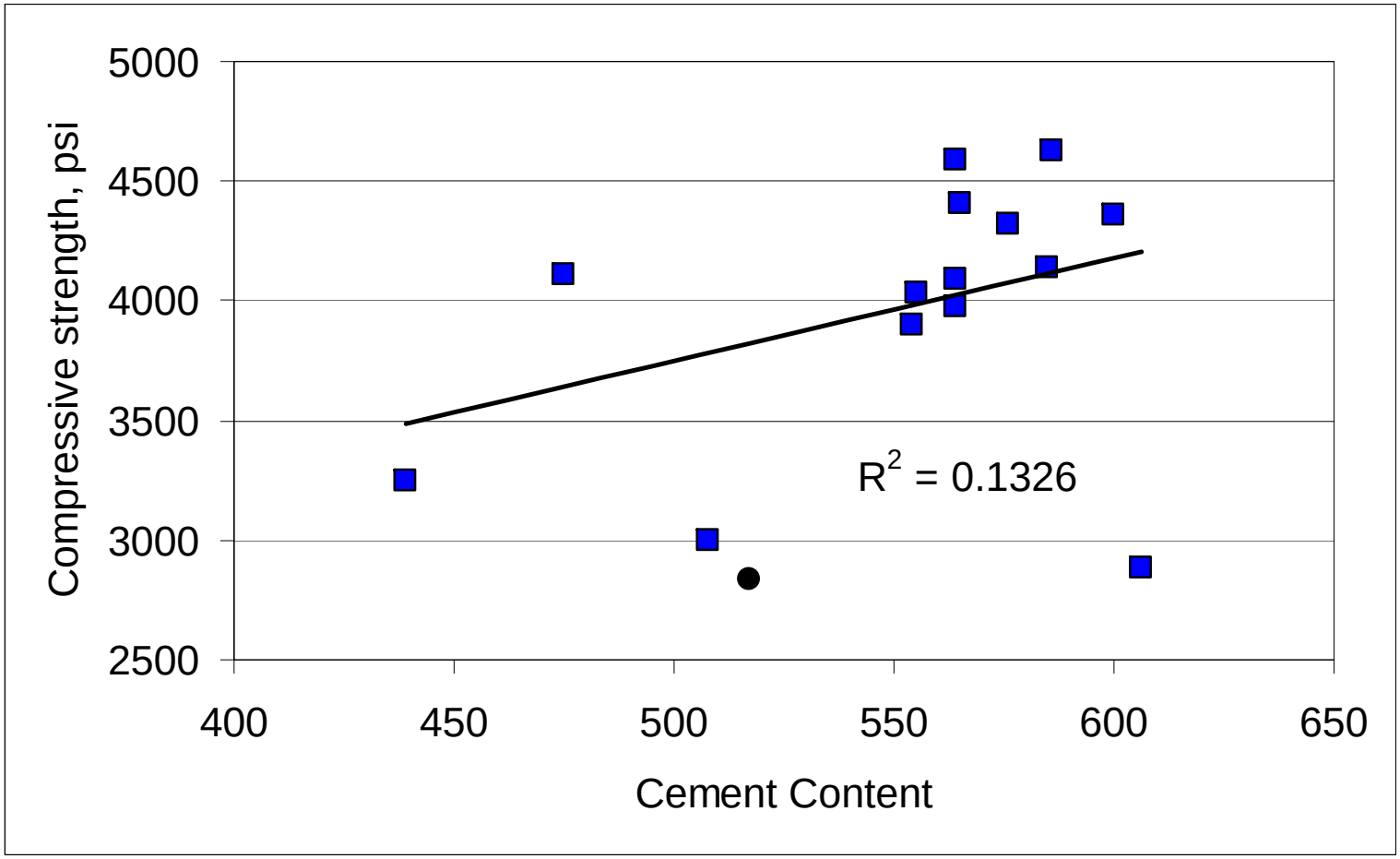
Why specify cement content?



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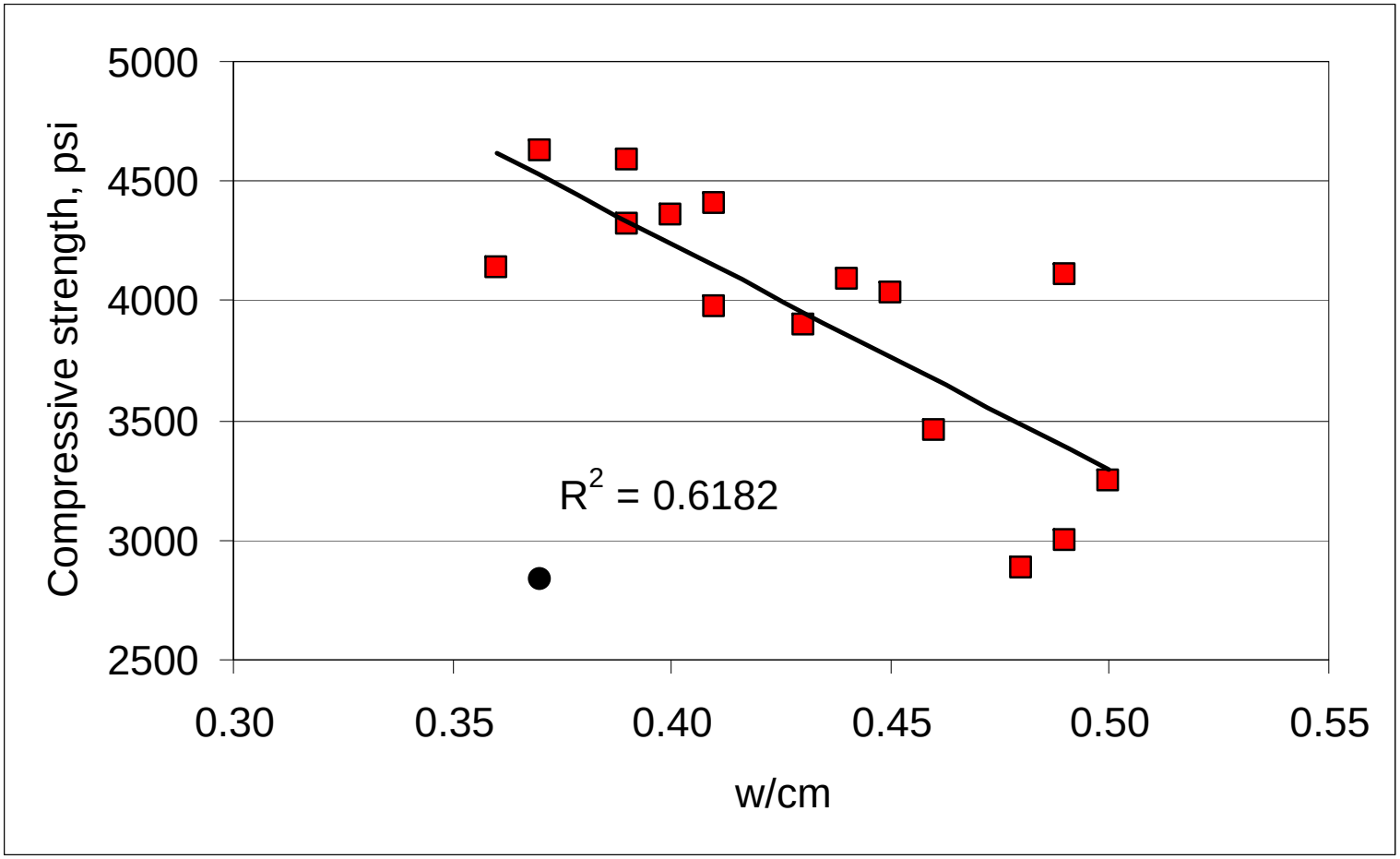
Why specify cement content?



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No. 5: Minimize Impact

- Noise – Construction and traffic
- Safety
  - Splash and spray
  - Lighting
- Delays – During construction and rehabilitation
- Emissions
  - Green house gases
  - Pollution
  - Particulates

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No. 5: Minimize Impact

- Energy efficiency –
  - Construction
  - Operation
  - Lighting
- Urban heat island effect

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Phases of a Pavement's Life

- Design
- Construction
- Operation
- Rehabilitation
- Recycling, Removal

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Factors Affecting Sustainability Design

Cut and fill

Design life

Construction method

Drainage

Thickness

Life cycle Cost

Materials selection

Capacity

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Factors Affecting Sustainability Construction

CO_2

Virgin materials

Dust

VOC's

Delay time

Energy

Noise pollution

Life cycle Cost

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Factors Affecting Sustainability Operation

Maintenance

Capacity

Water runoff

Noise pollution

Reflectivity

Heat island

Safety

Friction to vehicles

Longevity

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Factors Affecting Sustainability Repair/Rehabilitation/Removal

Removal = waste disposal

Repair/ Rebuild = similar issues to construction

Recycling in base

Recycling in concrete

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No. 6: Take Care of What you Have

- Use the equity already in the existing pavement
- Longevity is a hallmark of sustainable practice
- Well timed maintenance and rehabilitation is essential
- Design to maintain
  - For high volume roadways, accommodate future diamond grinding to extend pavement life

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No. 7: Innovate

- Identify problems/opportunities, generate solutions, implement, and reiterate
- Learn from mistakes
- Good specifications
- Evaluate emerging technologies and adopt those with demonstrated promise
- Educate and challenge yourself and your workforce

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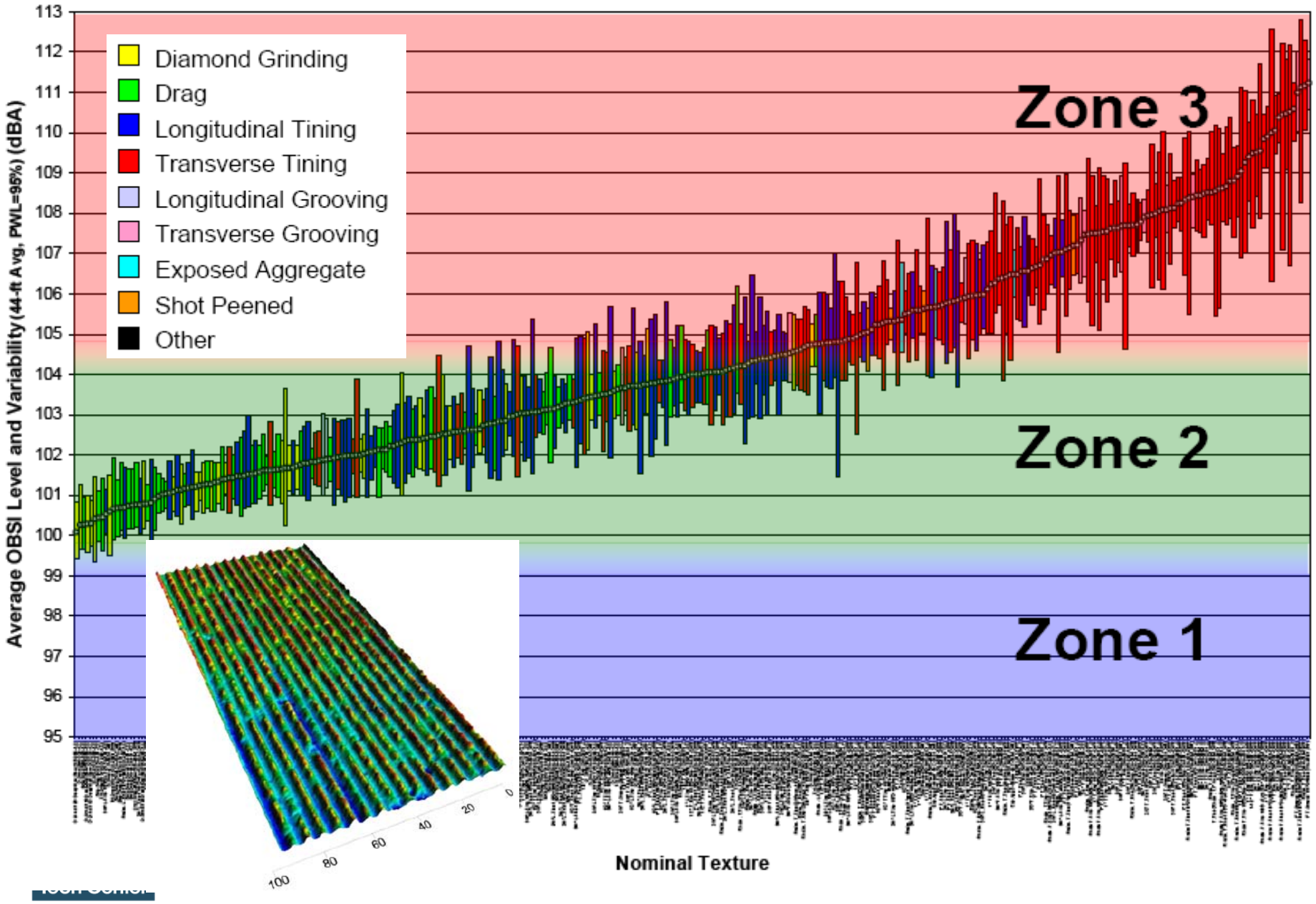

From Rasmussen et al.
www.sufacecharacteristics.com

Innovative construction approaches

- 2-lift
- Ternary
- Recycle
- …

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Quantification

- Rating systems
  - Green Roads, GreenLITES
  - LEED
- Life cycle inventory (LCI)/life cycle assessment (LCA)
  - The future is now (ISO 14000)
  - Need to establish regional data and usable software tools

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Concrete Pavement Road Map Sustainability Track Activities

- A Briefing Document
- A “Best Practices” training manual
- An International Conference – Sept 2010
- Demonstration projects

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In Closing, We Must…

- Educate
- Get tools into the hands of practitioners as soon as possible
  - Expect these tools to evolve from some type of checklist/rating system to full life cycle assessment
- Conduct research to fill the gaps in knowledge

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