Role of Recycled Materials in Sustainable Roadway Construction

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Why is Sustainability Important?

- Nexus of major issues caused by rapidly growing global economy:
  - Global warming
  - Energy constraints
  - Resource availability (metals, cement, oil etc.)
- World population is 6 billion (B) → 12 B projected by 2100. US at 0.5B by 2050.
- US and EU (combined population = 0.75 B) consume most of world resources. China catching up fast.
- Remaining 5.25 B want everything we have. Not enough to go around if we do business as usual.

How Can We Make Roadway Construction More Sustainable?

1. Reduce energy consumed in construction and rehabilitation.
2. Reduce emissions emitted in construction and rehabilitation.
3. Reduce consumption of natural resources.
4. Increase service life.

How Do Recycled Materials Fit In?

1. Avoid energy and emissions associated with mining and processing construction materials. Energy has already been expended in first life of recycled material.
2. Avoid use of a natural resource (sand and gravel, limestone, oil).
3. Increase service life. Not a “linear landfill,” but better and longer lasting infrastructure.

Recycled Materials Resource Center: RMRC

- Promote the safe and wise use of recycled materials in construction of transportation infrastructure through education, technology transfer, and applied research.

- Wise … ensure that the recycled material is suitable for the highway environment and provide procedures for appropriate use.

- Safe …. ensure that material will not have an adverse impact on the environment or users.

Who is the RMRC?

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What does the RMRC do?

- Applied research and development - turn concepts into field applications.
- Continuing education/technical training on using recycled materials in roadway construction.
    - face-to-face workshops
    - webinars
- Clearinghouse for technical information (see www.recycledmaterials.org)

Applied Research

Focus on both mechanical and environmental aspects …. information *and* tools for the roadway designer, the contractor, and the environmental compliance officer.

Provide designer with methodology to use recycled materials in place of conventional materials. For example, developed method for MnDOT to design low volume roads with recycled pavement material (RPM). Validated with full-scale test sections.

Computer tools: PaLate for life cycle assessment and WiscLEACH for environmental suitability.

Two Byproducts → Useful Product

RPM + High Carbon Fly Ash

= high modulus and durable base

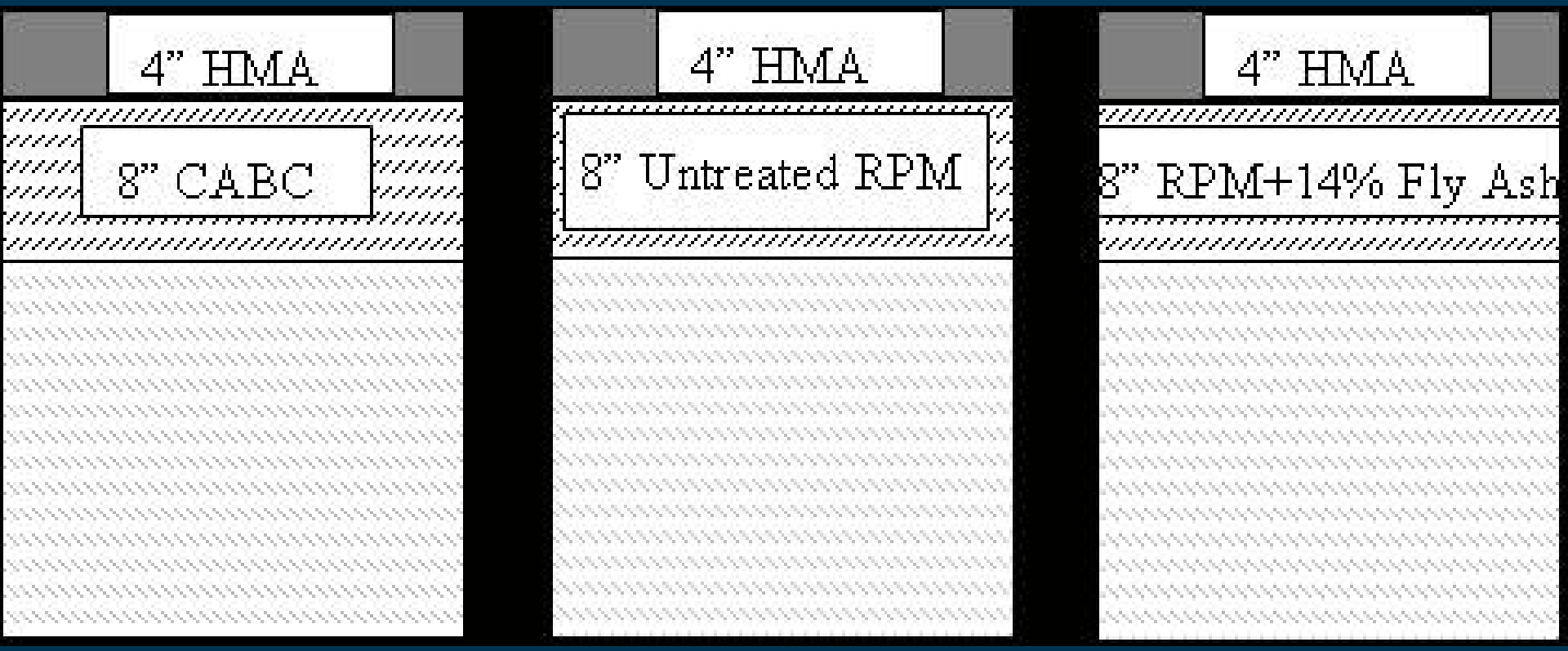
Stabilizing RPM with Off-Spec Cementitous Fly Ash at MnROAD

MnROAD is a full-scale highway test facility operated by Minnesota DOT.

Tuncer B. Edil, RMRC, PI

US DoE & RMRC

MnROAD Test Sections



Conventional Aggregate Base

RPM Base

RPM + Fly Ash Base

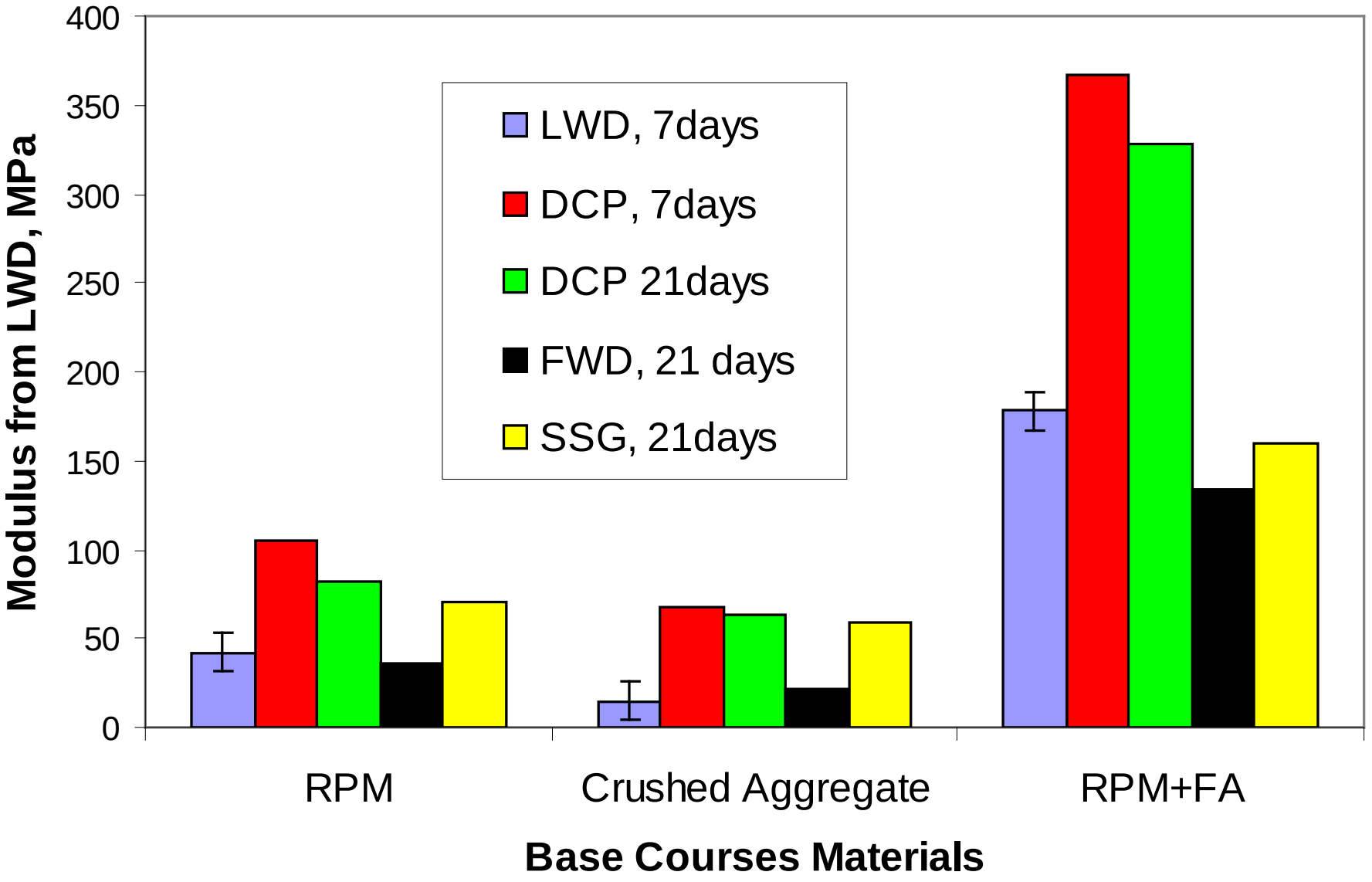
Riverside 8 Fly Ash from Xcel Energy, 14.6% LOI and 22% CaO
Non-compliant with MCPA requirements.

Placement of RPM and Fly Ash

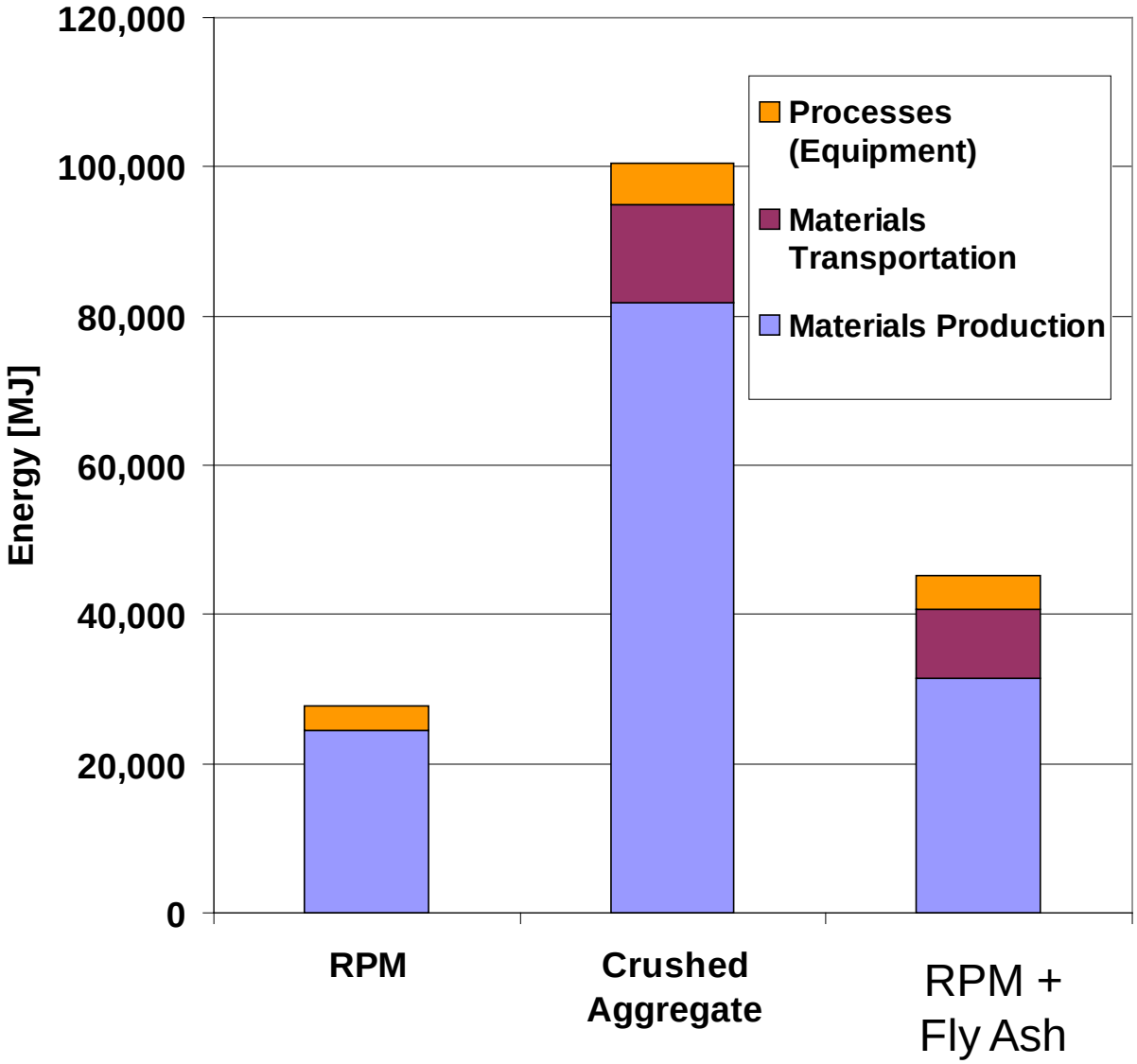
Mixing & Compaction

HMA Paving

Pavement Performance - Modulus



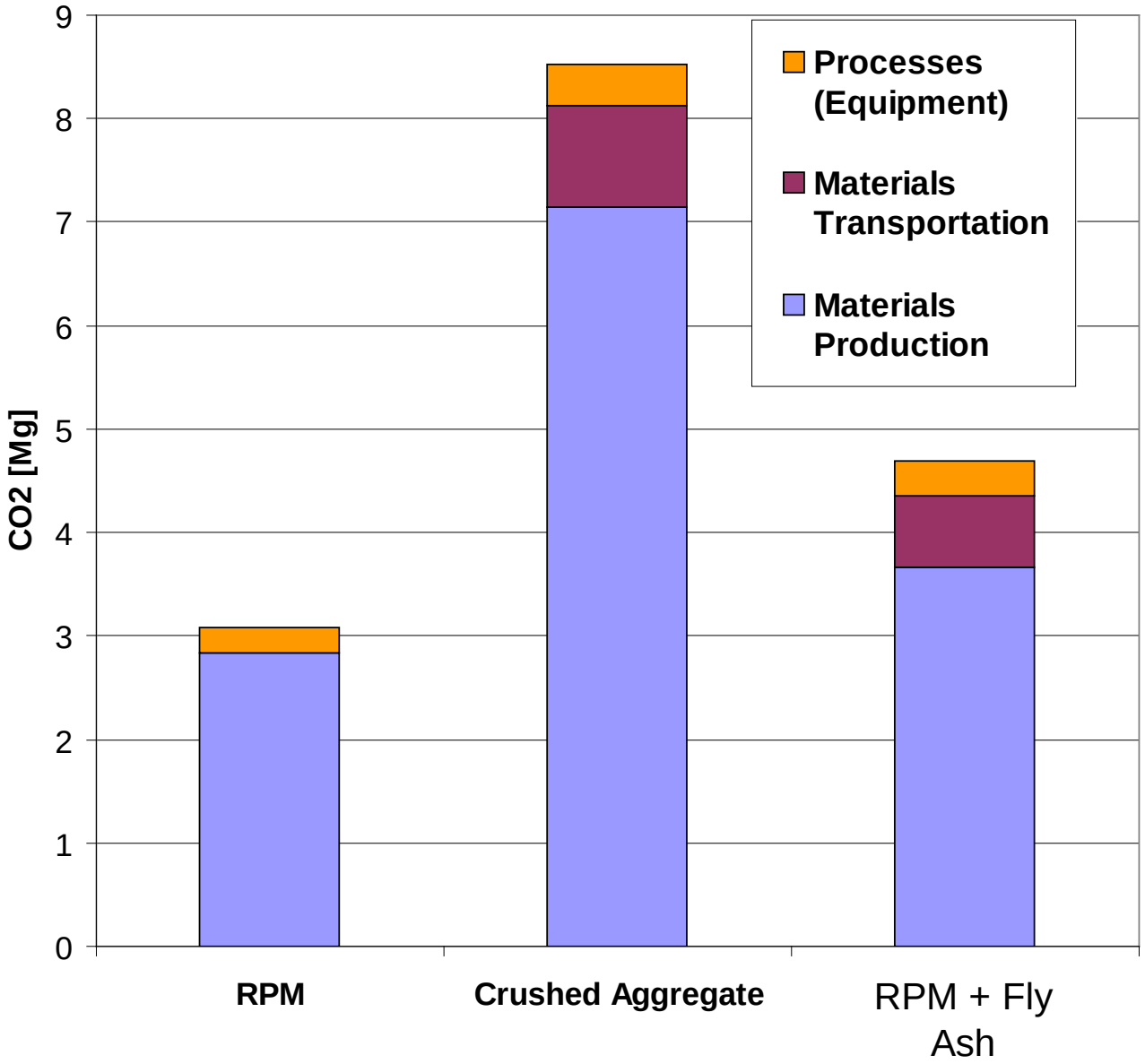
Construction Life Cycle Analysis – Energy Usage



Most energy: Conventional construction material.

Least energy: recycled pavement in place of crushed aggregate.

Construction Life Cycle Analysis – GHGs

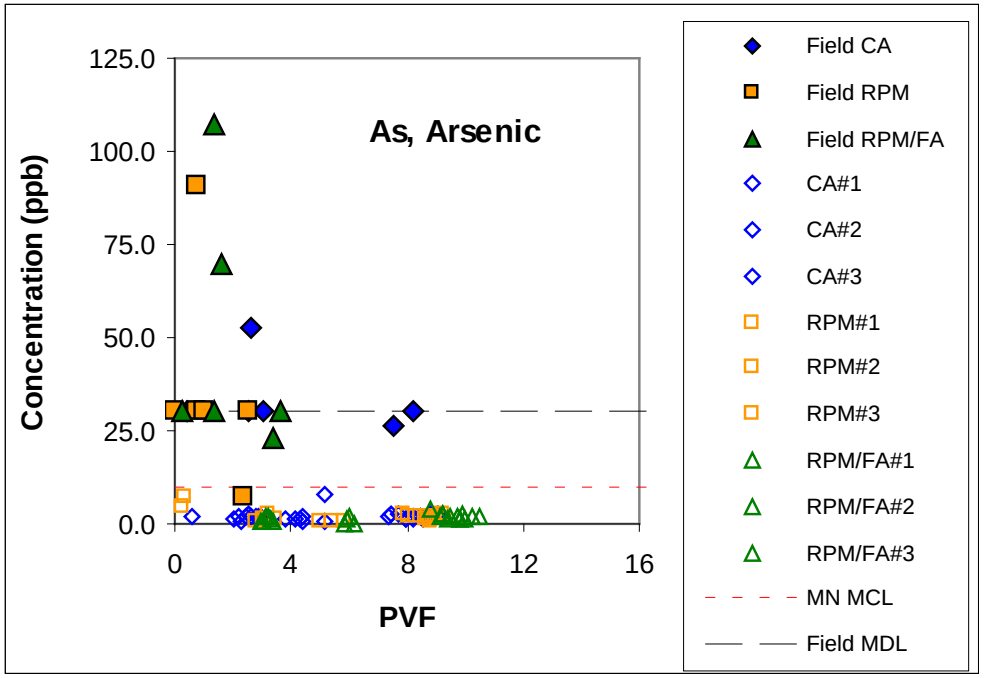


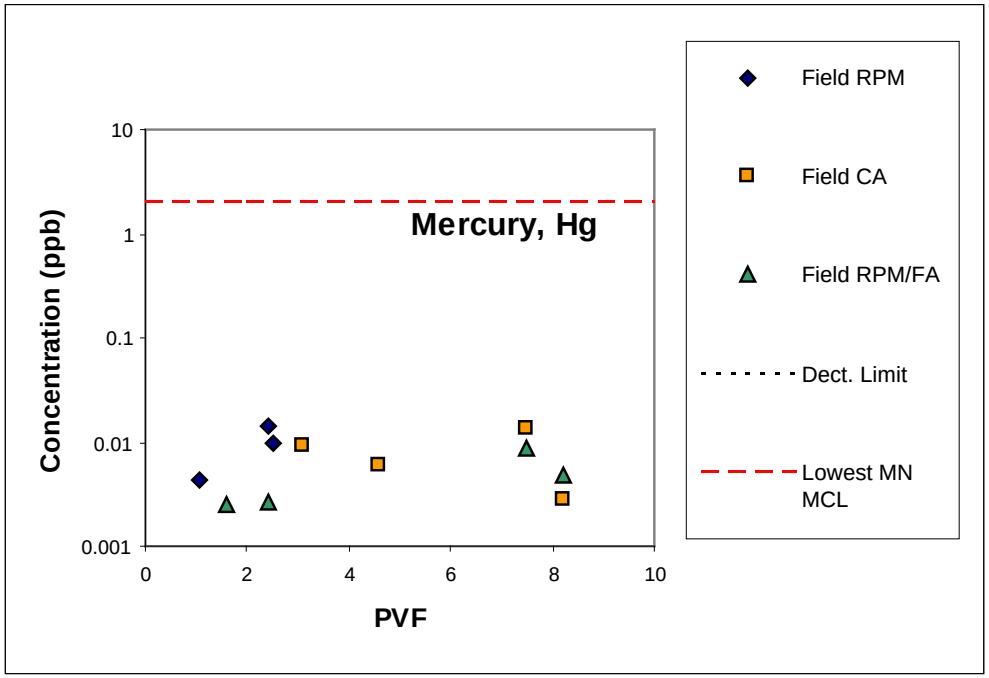
Most emissions: Conventional construction material

Least emissions: recycled pavement in place of crushed aggregate

Do recycled materials affect our environment adversely compared to conventional materials?


Geomembrane installation
Sump welding
Drainage layer installation
Collection tank installation

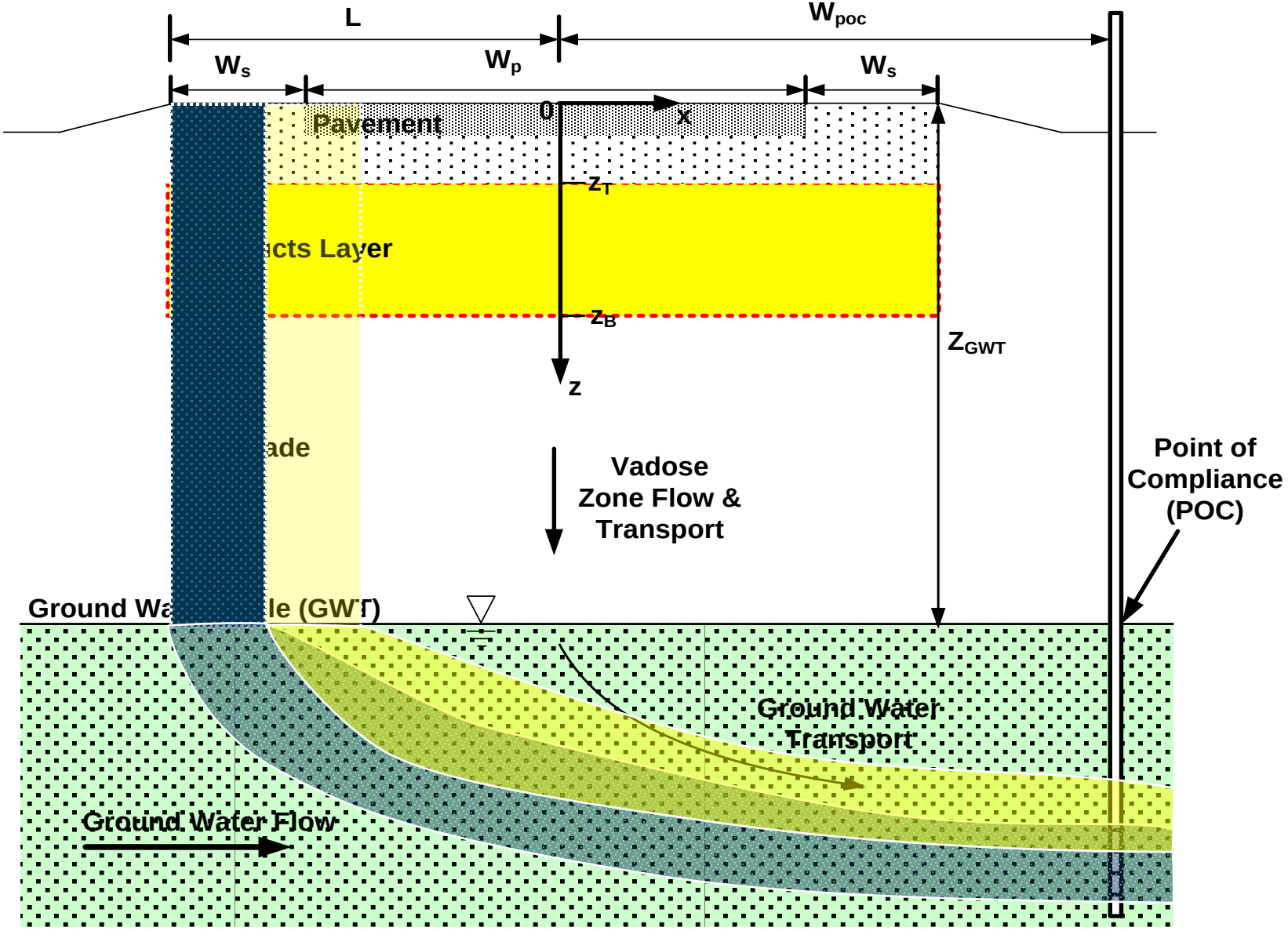




Environmental Data

- Lysimeter data and lab columns on RPM & Fly Ash for As.
- As MCL: 10 ppb
- Hg MCL: 2 ppb in MN
- Hg is well below MCL and lower for fly ash stabilized materials.

WiscLEACH Model

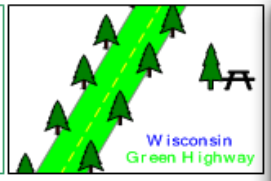


BE²ST Highway Sustainability Rating System

Building Environmentally and Economically
Sustainable Transportation-Infrastructure-Highways
(BE²ST-in-Highways™)

RMRC

THE UNIVERSITY of WISCONSIN MADISON



Introduction

1. Welcome to Building Environmentally and Economically Sustainable Transportation-Infrastructure -Highways.
2. This system has been developed to support decision makers and planners in choosing and developing better strategies for sustainable highway constructions.

Rating Procedure

1. Set up the reference design
   The reference design is a design with a conventional design concept in which no sustainable ideas have been included.
2. Set up an alternative design which is a candidate for Green Highway certification
3. Calculate the service lives of two competing highway designs using a prediction model
   For this rating system the M-EPDG model will be used.
4. set up a rehabilitation strategy based on predicted IRI
5. Conduct a Life Cycle Assessment using PaLATE
6. Conduct a Life Cycle Cost Analysis using RealCost
7. Conduct a traffic noise analysis with TNM-Look
8. Conduct an analysis of stormwater management
9. Calcuate a score for the project using the Rating Summary sheet
10. Determine a weighting option to be used
    For the board members' weighting, calculate a priority number for each criterion(Sheet .4)

BEST IN HIGHWAY

Project Information and Weighting Methods

Project Overview | Weighting Options

Service Life Estimation

Service Life

Performance Indicators

Life Cycle Assessment | Life Cycle Cost Analysis

Traffic Noise | Stormwater Management

Recycling Ratio

Security Warning Automatic update of links has been disabled Options...

Title | Rating summary | M-EPDG | Weighting | PaLATE | LCCA | Traffic Noise | Stormwater | Sheet1

Ready 70%

BE²ST Highway Sustainability Rating System

- Life cycle analysis (LCA) to assess variety of sustainability metrics (energy, GHG emissions, water use, hazardous waste generation, etc.) – PALATE model.
- Life cycle cost analysis (LCCA) – evaluate life cycle cost of design alternatives.
- Quantitative and auditable metrics – provide perception & financial incentives for owners and contractors to incorporate sustainability principles in designs.

Sustainable Use of Recycled Asphalt in Construction

Which use is more sustainable:

- Reintroduction into hot mix asphalt? (federal policy).
- Use as granular base?

Comparison of Alternatives using BE²ST in Highways

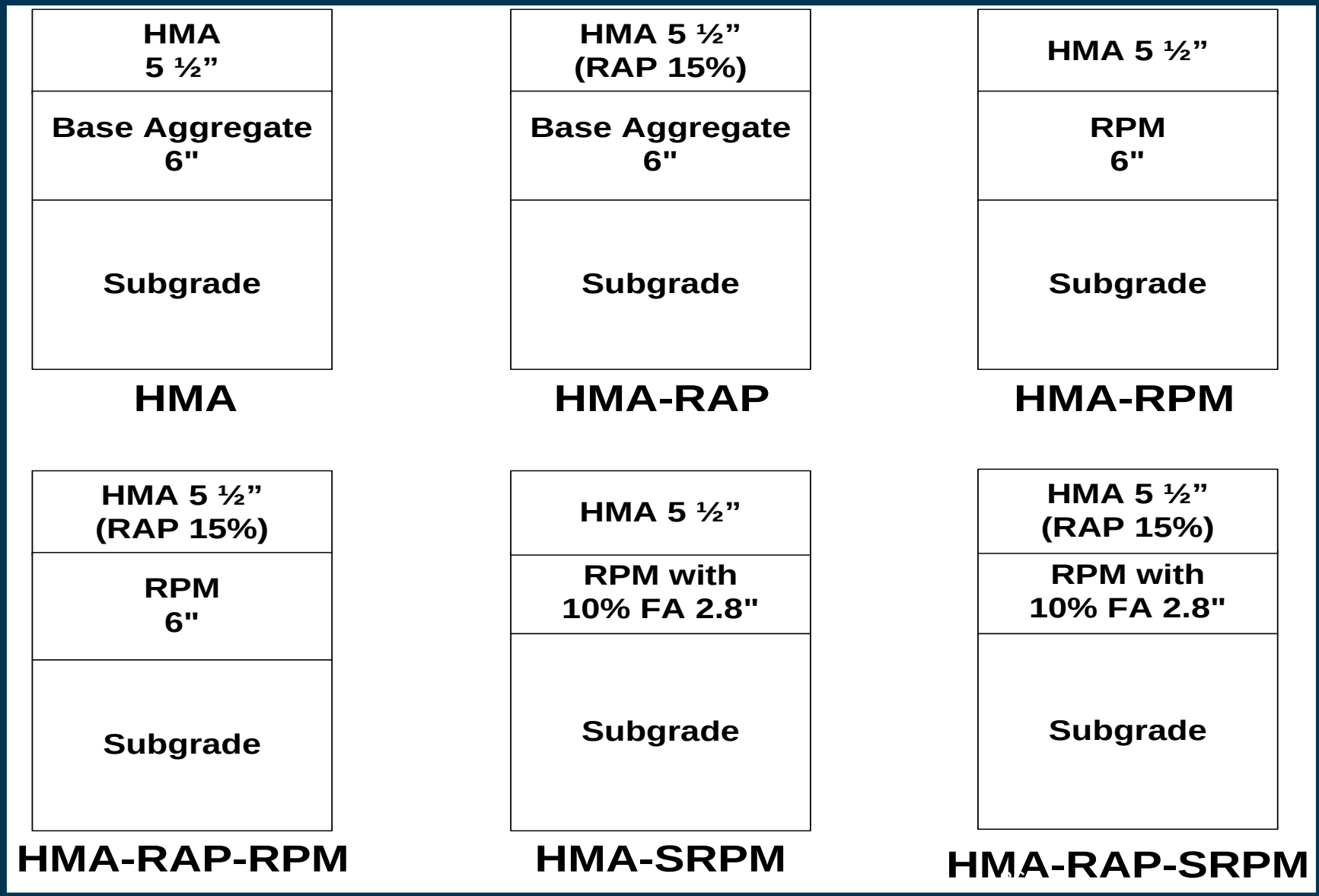
- HMA = hot mix asphalt

- RAP – reintroducing reclaimed asphalt into new hot mix asphalt

- RPM – using reclaimed asphalt as granular base

- SPRM – using reclaimed asphalt + binder (fly ash) as granular base.

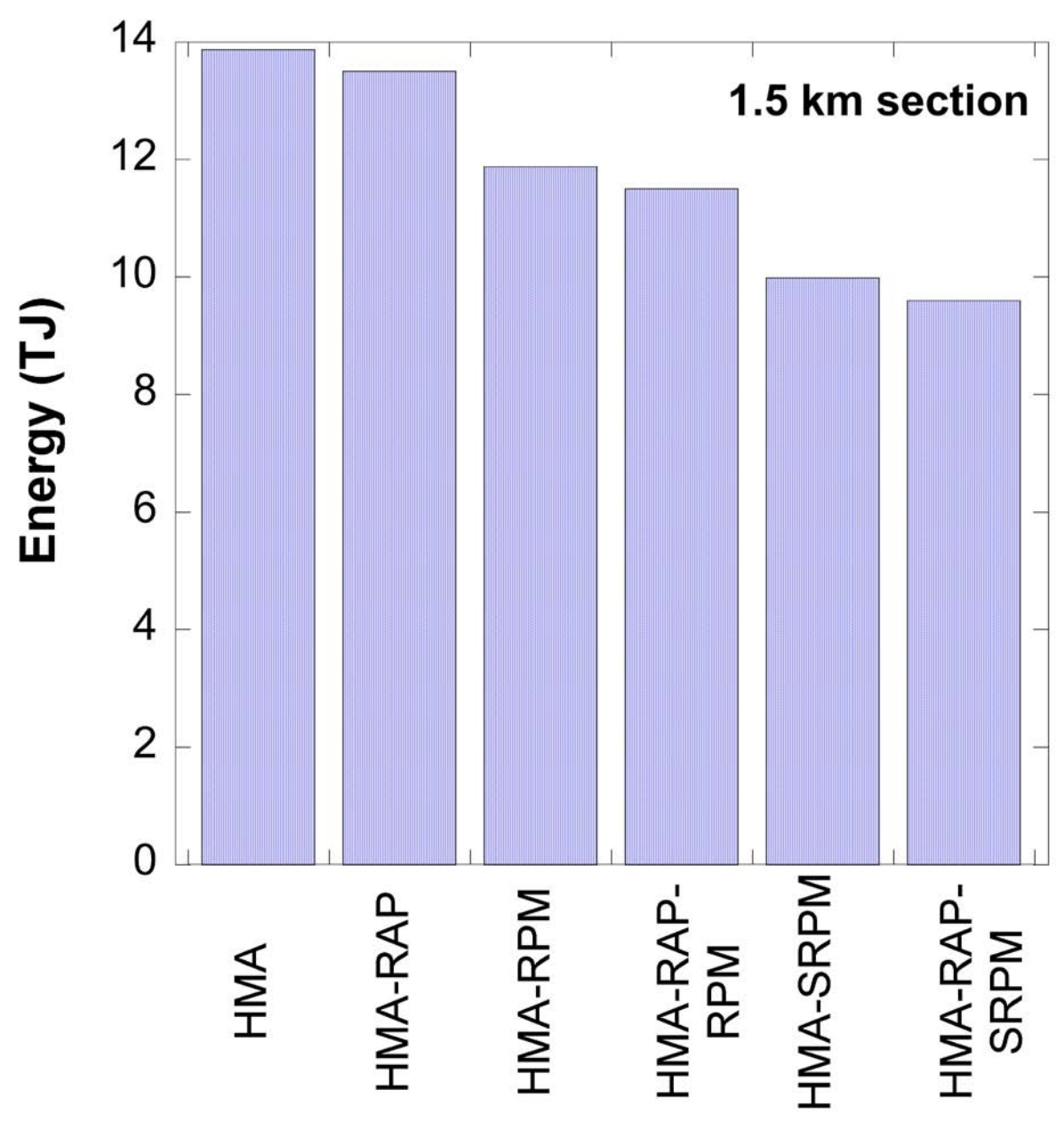
Comparison of Alternatives using BE²ST in Highways



Engineering Characteristics of Alternatives

Design	Mr of Base Layer (MPa)	Base Layer Coefficient	Service Life (yr)	No. of Rehabilitations for 50-yr Period
HMA	206	0.14	13	3
HMA-RAP				
HMA-RPM	249	0.14	14	3
HMA-RAP-RPM				
HMA-SRPM	846	0.30	18	2
HMA-RAP-SPRM				

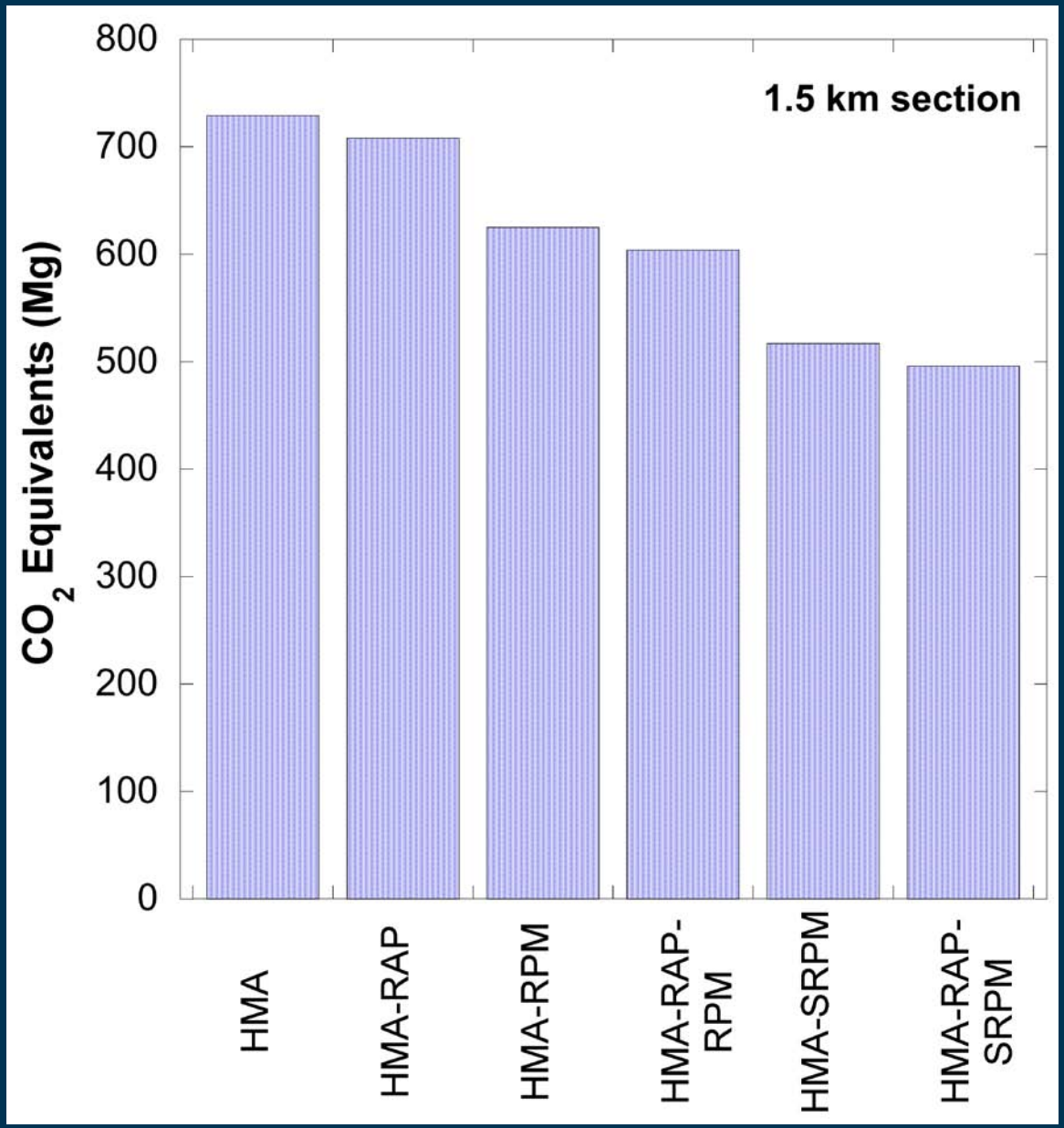
Life Cycle Energy Consumption



Most energy: reintroducing reclaimed asphalt into HMA (federal policy).

Least energy: using stabilize reclaimed asphalt in base.

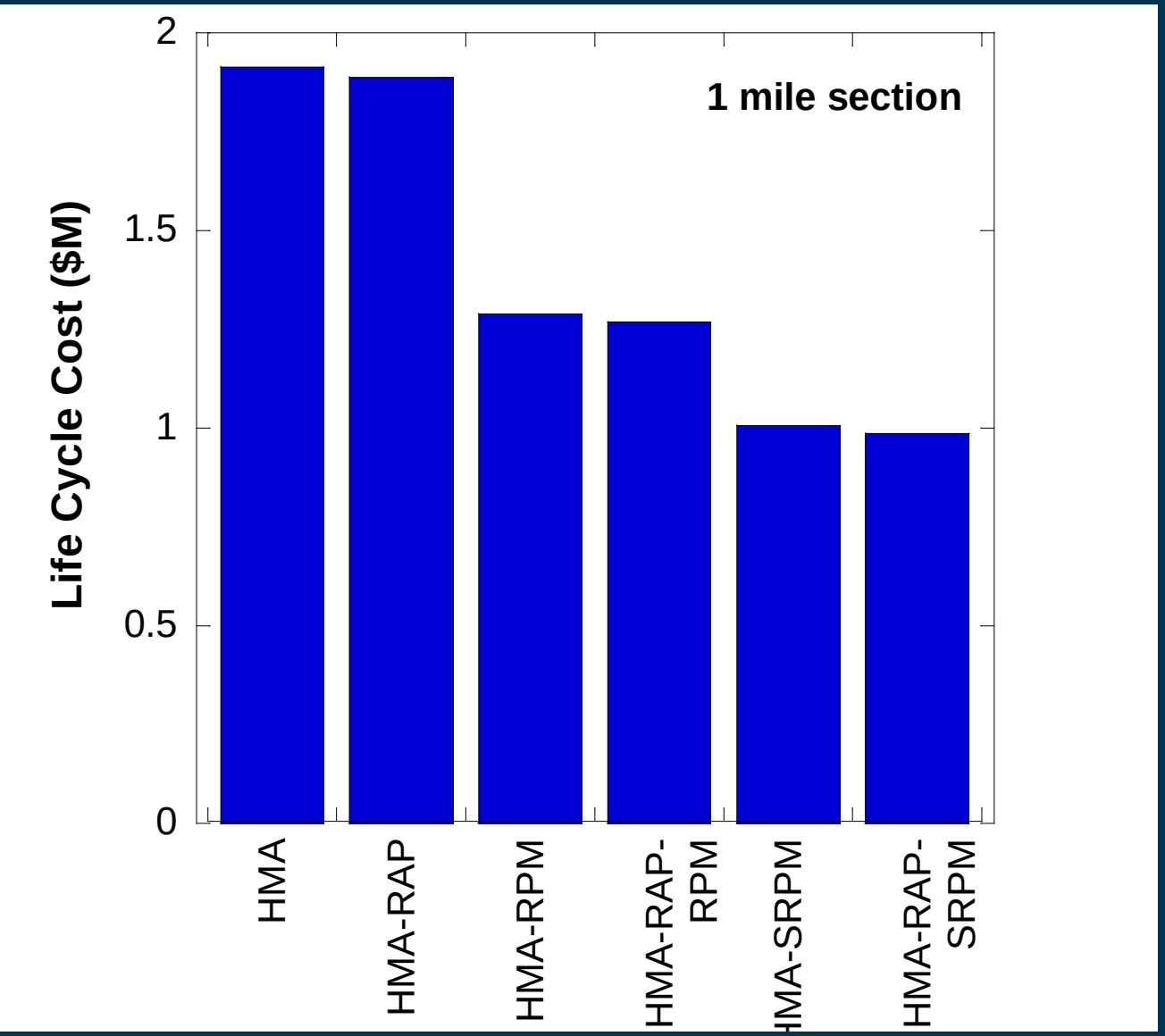
GHG Emissions



Most emissions: reintroducing reclaimed asphalt into HMA (federal policy).

Least emissions: using stabilized reclaimed asphalt in base & HMA.

Life Cycle Cost



Least expensive: using stabilized reclaimed asphalt (SRPM) in base.

Most expensive: reclaimed asphalt in hot mix asphalt (HMA)

Industry Wide Analysis: Coal Combustion Products as Construction Materials

- Coal combustion products: fly ash, bottom ash, flue gas desulphurization (FGD) gypsum
- Construction applications: concrete (fly ash), geotechnical (fly ash, bottom ash), wall board (FGD).
- Considered benefits by offsetting conventional materials and eliminating disposal.

Industry Wide Analysis: Coal Combustion Products as Construction Materials

Metric	Annual Savings	Equivalent to
Energy (trillion Btu)	159	• Annual energy use for 1.7 million households
Water (billion gal)	32	• 31% of domestic water withdrawals of CA
CO_2e (million ton)	11	• Removal of 1.9 million passenger cars per year from roadways
Financial (US $B)	5.1-9.7	• Annual full-time salary ($39.5k/yr) of 130,000–240,000 average Americans

Some Take Home Messages

- Benefits of recycled materials: energy, emissions, resource consumption, cost.
- Create longer lasting infrastructure.
- Perception & reality are different: conduct quantitative analysis to assess alternatives for recycled materials.
- Multitude of sustainability metrics: selecting and prioritizing metrics will become a more important issue.

www.recycledmaterials.org

Recycled Materials Resource Center :: ERG :: UNH

http://www.recycledmaterials.org/

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Recycled Materials Resource Center

The Recycled Materials Resource Center is a federal-university partnership that serves as a research and outreach facility for the highway community, and a catalyst for beneficial use of recycled materials.

About Us | Tools | Research | Outreach | Resources | Partners | Advisory Board

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Federal Highway Administration

University of New Hampshire

University of Wisconsin - Madison

What's New

The latest **RMRC Quarterly Newsletter** is now on-line. Check it out **here>>**

A draft Final Report for Project 60, **Quantifying the Benefits of Using CCPs in Sustainable Construction,** is now available **here>>**

Environmental Issues of Recycling Tear-Off Roofing Shingles Webinar
On October 7, NAPA, WasteCap Resource Solutions, CMRA, and Wisconsin DNR produced a webinar entitled, **Environmental Issues of Recycling Tear-Off Roofing Shingles**. The webinar was attended by 125 participants from around the continent and lasted for almost two hours. A broad range of environmental and other regulatory issues were discussed, including case study highlights from Minnesota and Wisconsin. A PDF of the handouts can be found **here>>**

CALL FOR PAPERS
International Symposium on Testing and Specification of Recycled Materials for Sustainable Geotechnical

RMRC in the News

Green roads: Highways of the future?
Article about the problems we face with the planet's fast-growing road systems. **More>>**
US Infrastructure, 09.10.09

Features

User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction
The User Guidelines have recently been updated with new materials and new evaluation guidance. Check it out **here>>**

PaLATE
This computer-based life-cycle cost analysis (LCCA) tool uses environmental parameters to assist decision-makers in evaluating the use of recycled materials. Download now **here>>**

RMRC Foundry Sand Webinar
The RMRC sponsored a series of 6 webinars on the use of foundry sands in transportation and infrastructure applications in the fall of 2008. To view the streamed presentations, click ***here>>***

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