Development of Strategies to Increase Recycled Asphalt Pavement Mixtures in Oregon

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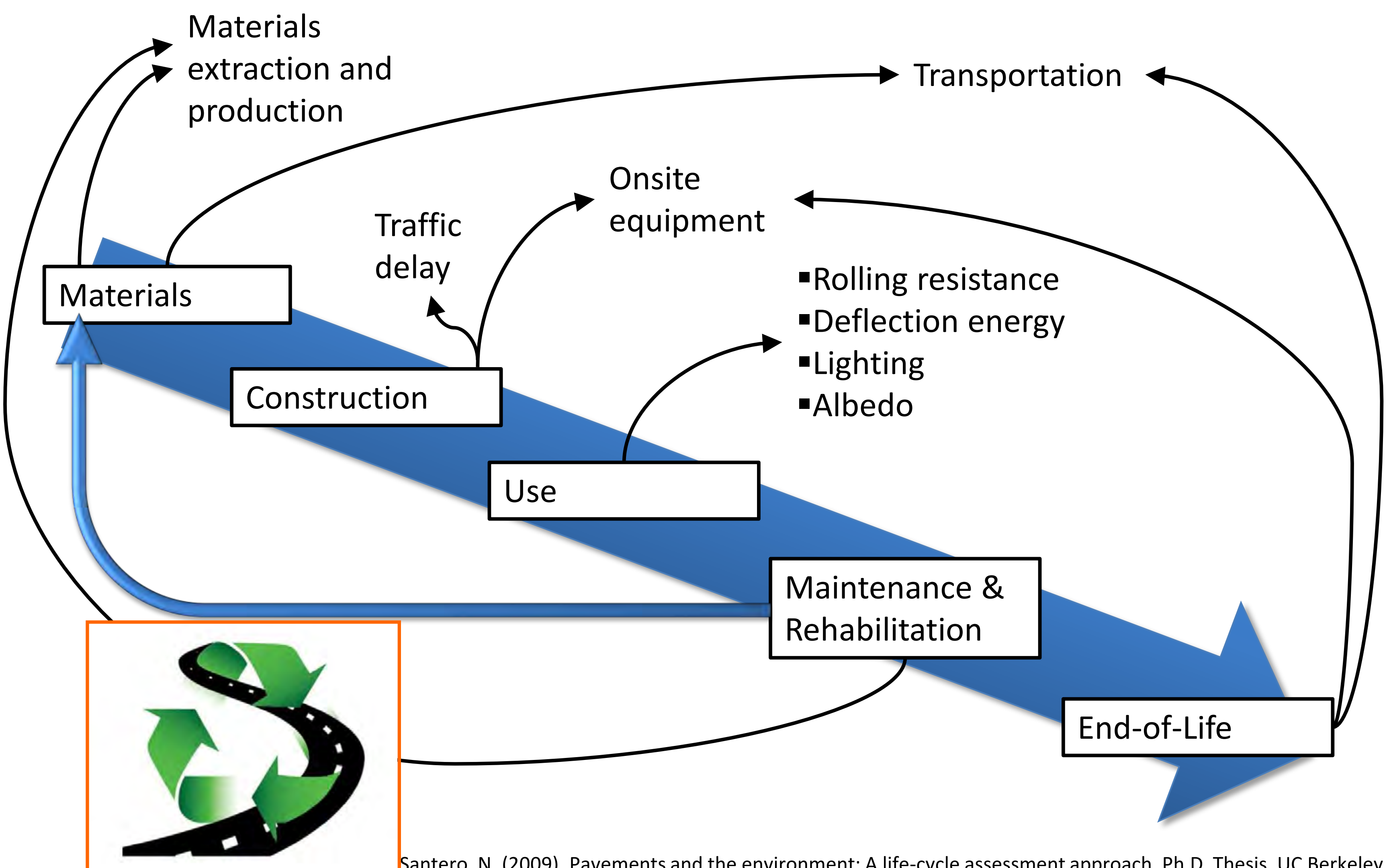
Outline

- Introduction and Literature review
- Experiment types and Objectives
  - Binder grade and binder content
  - Blending evaluation
- Impact of Roughness and Structural Response on Fuel Economy
- Summary

INTRODUCTION AND LITERATURE REVIEW



Santero, N. (2009). Pavements and the environment: A life-cycle assessment approach. Ph.D. Thesis, UC Berkeley.

INTRODUCTION AND LITERATURE REVIEW

An EPD (Environmental Product Declarations) is a third-party certified label that discloses the quantified environmental impacts of producing a product.

- Primary energy (MJ)
- Global warming potential
- Ozone depletion
- Acidification potential etc.

Summary of
Environmental Product Declaration

Central Concrete

Mix 340PG9Q1

San Jose Service Area

EF V2 Gen Use P4000 3" Line 50% SCM

Performance Metrics

28-day compressive strength	4,000 psi
Slump	4.0 in

Environmental Impacts

Impact name	Unit	Impact per m3	Impact per cyd
Total primary energy consumption	MJ	2,491	1,906
Concrete water use (batch)	m3	6.66E-2	5.10E-2
Concrete water use (wash)	m3	8.56E-3	6.55E-3
Global warming potential	kg CO2-eq	271	207
Ozone depletion	kg CFC-11-eq	5.40E-6	4.14E-6
Acidification	kg SO2-eq	2.26	1.73
Eutrophication	kg N-eq	1.31E-1	1.00E-1
Photochemical ozone creation	kg O3-eq	46.6	35.7

A sample EPD for a concrete mix design by Central Concrete Supply Co.

Credit: Central Concrete Supply

National Asphalt Pavement Association (NAPA) EPD Program

http://www.asphaltpavement.org/EPD

INTRODUCTION AND LITERATURE REVIEW

- Hansen and Copeland (2014)
  - In 2014, the use of RAP/RAS on U.S. roads displaced 20M barrels of oil and 68M tons of aggregate
  - A savings of $2.8B based on binder cost of $550/ton and aggregate cost of $9.50/ton

- NCAT – Willis (2015)
  - Utilizing recycled asphalt results in a 9-26% energy savings and a 5-29% reduction in CO_2 emissions
  - A 19-42% energy savings and a 6-39% reduction in CO_2 emissions were realized when using RAP along with locally sourced materials

INTRODUCTION AND LITERATURE REVIEW

Currently 10 to 30% RAP is allowed. Higher RAP ~ Lower durability

HOW CAN WE INCREASE RAP CONTENT?

- Softer virgin binder grade (binder-grade bumping)
- Increased binder content
- Recycling agents
- Polymer and rubber modifiers
- Warm mix asphalt

INTRODUCTION AND LITERATURE REVIEW

OTHER BENEFITS OF INCREASED RAP?

- For the limited budget scenario,

More recycling = reduced construction cost

= paving more roadway sections every year

= increased road user comfort

= reduced road used costs

2 to 4% reduction in road user costs (NCHRP 720)

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Oregon State University Asphalt Materials Performance Laboratory

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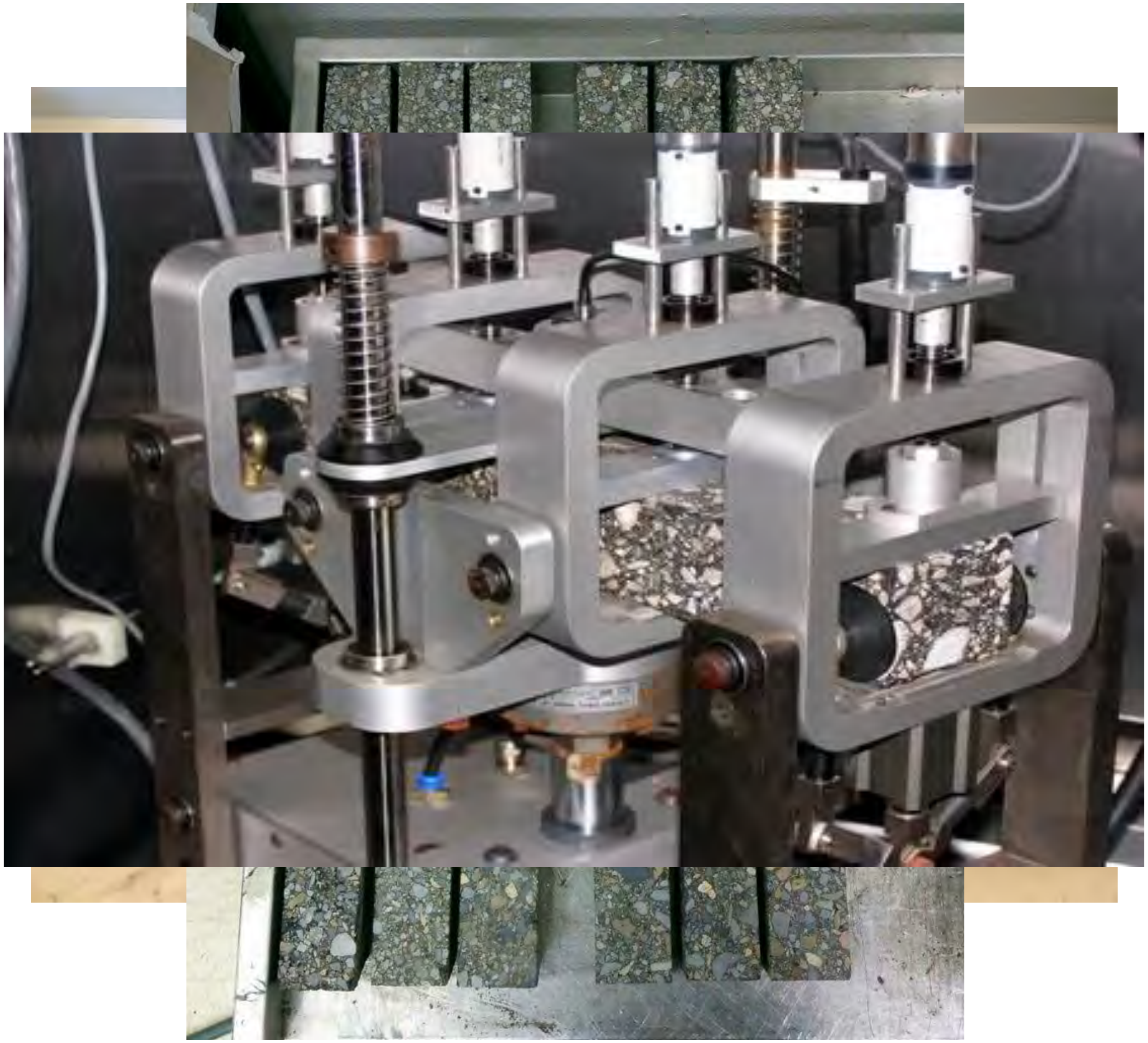
EXPERIMENTS USED IN THIS STUDY
BEAM FATIGUE TEST



EXPERIMENTS USED IN THIS STUDY
DYNAMIC MODULUS AND FLOW NUMBER TESTS

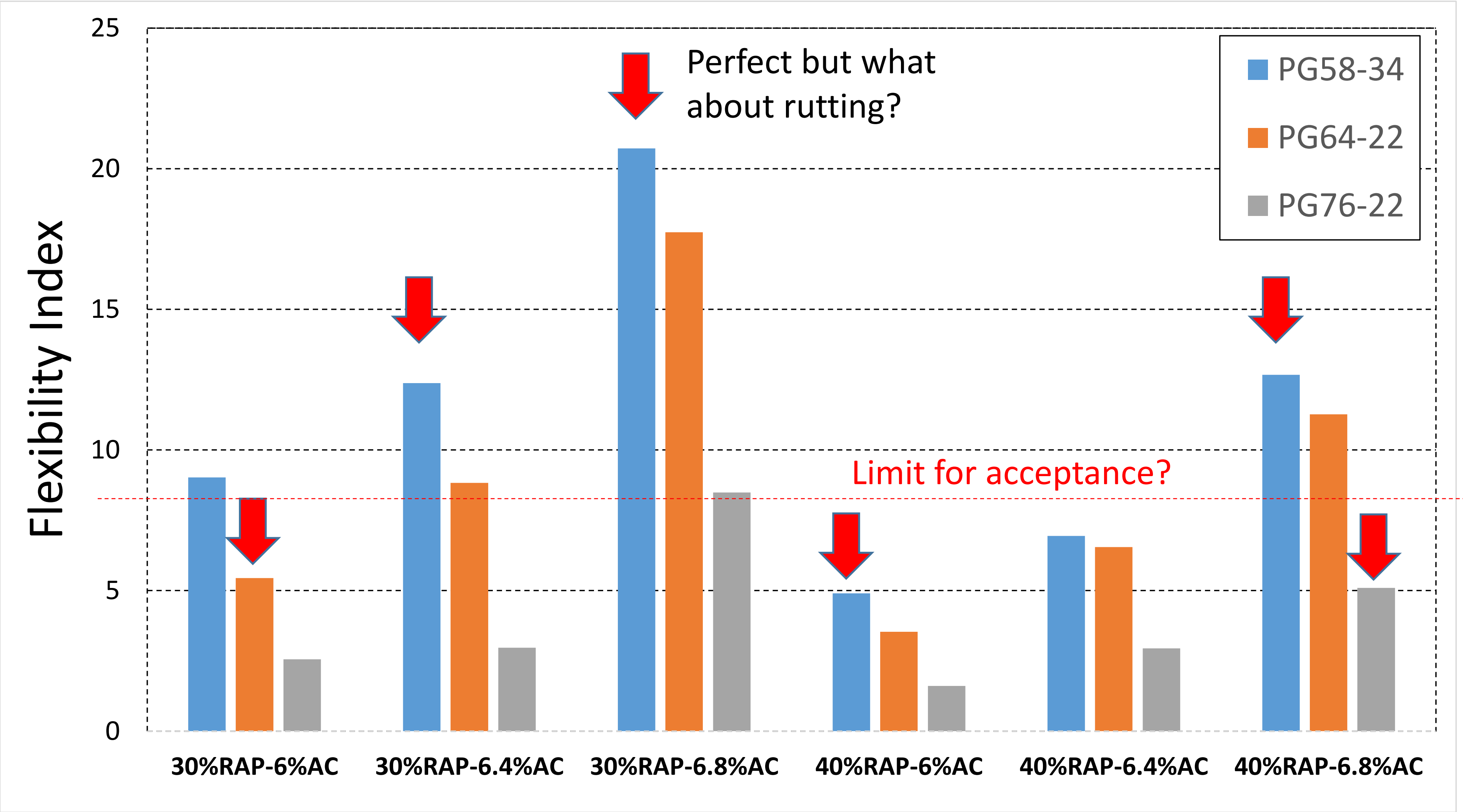
Dynamic modulus: Determine mix stiffness at different temperatures and load frequencies

Conduct flow number experiment at high temperatures to determine rutting resistance

Objectives
RAP content, Binder grade, and binder content

- Identify the effects of binder-grade bumping and higher binder content on RAP/RAS performance
- Determine the impact of these alternatives on increasing RAP/RAS contents
- Evaluate the effect of blending on mixture performance
- Evaluate the cost and benefits of using binder-grade bumping and higher binder content to increase RAP/RAS.

Initial Test Results – SCB – Flexibility Index



BLENDING EVALUATION

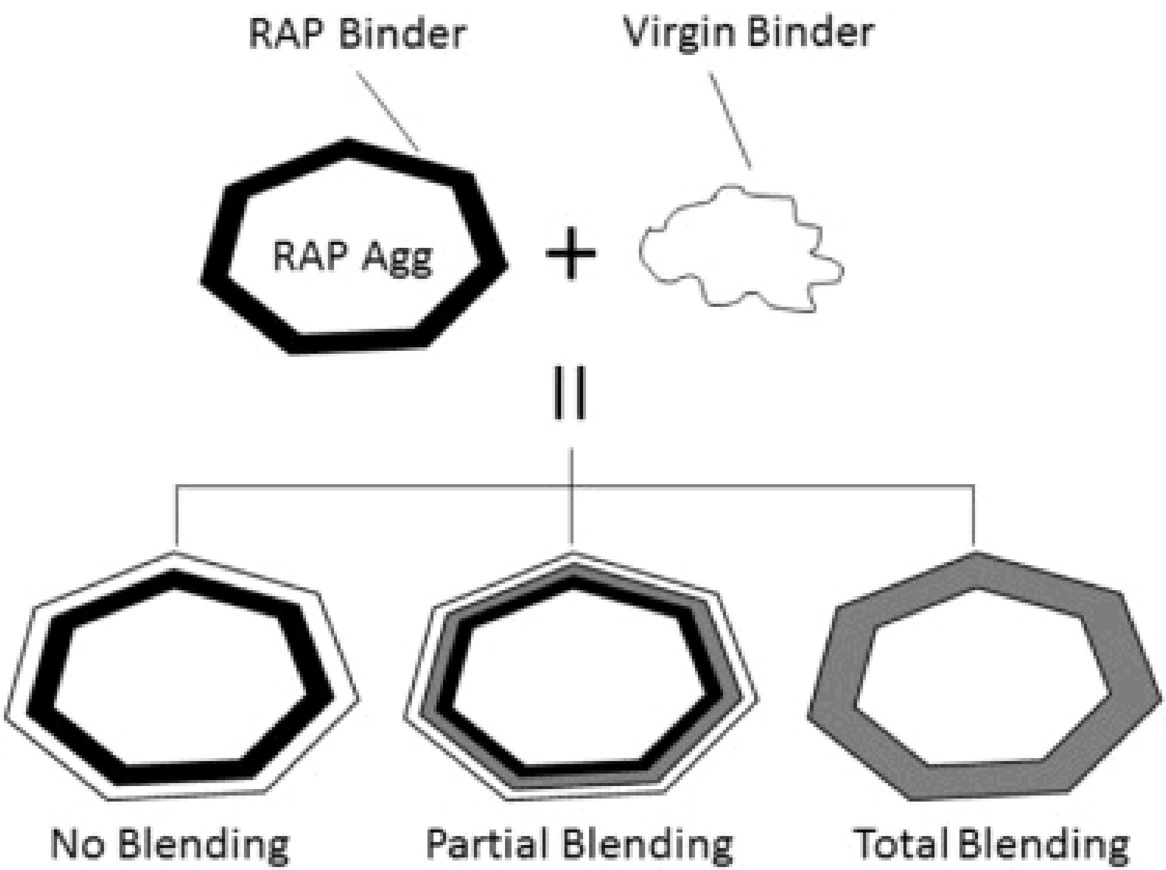


Image: Zhao et al. (2016) Materials and Design

Blending evaluation

Binder extraction

Binder recovery

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IMPACT OF ROUGHNESS AND STRUCTURAL RESPONSE ON FUEL ECONOMY

- Analyze how pavement structure affects vehicle fuel economy and GHG emissions through the pavement deflection and roughness.
- **Phase I:** Work with modelers from OSU, MIT, and MSU to obtain the modeling results.
- **Phase II:** Field experiments in California and verify the modeling results. Develop a database for fuel economy evaluation
- Funded by Caltrans.

UC Davis
Lead University
John Harvey Lead PI

UCPRC UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

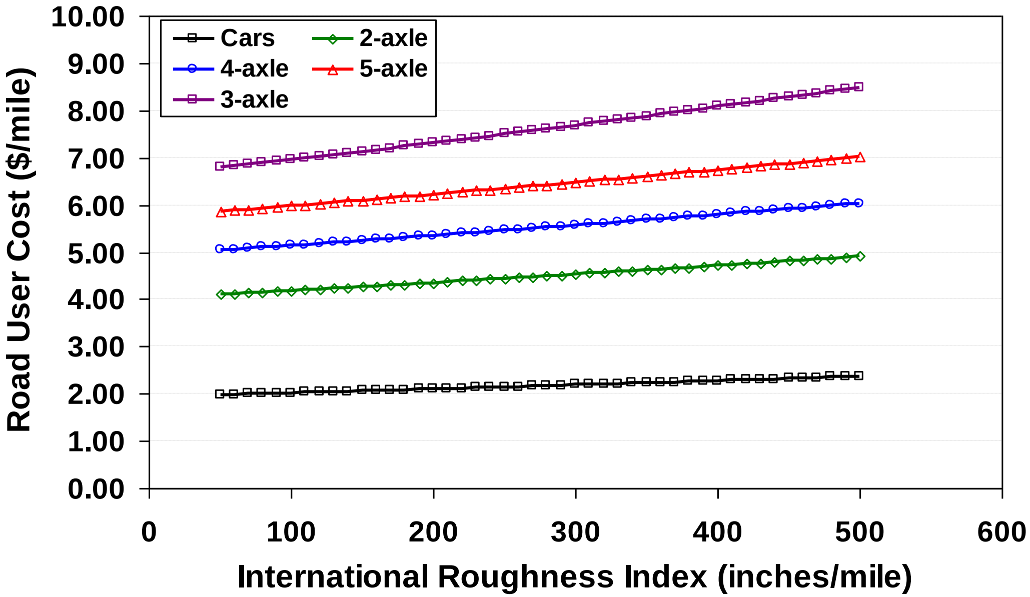
OSU Oregon State UNIVERSITY

MIT

MICHIGAN STATE

Caltrans CALIFORNIA DEPARTMENT OF TRANSPORTATION

IMPACT OF ROUGHNESS AND STRUCTURAL RESPONSE ON FUEL ECONOMY



costs used are from World Bank HDM4

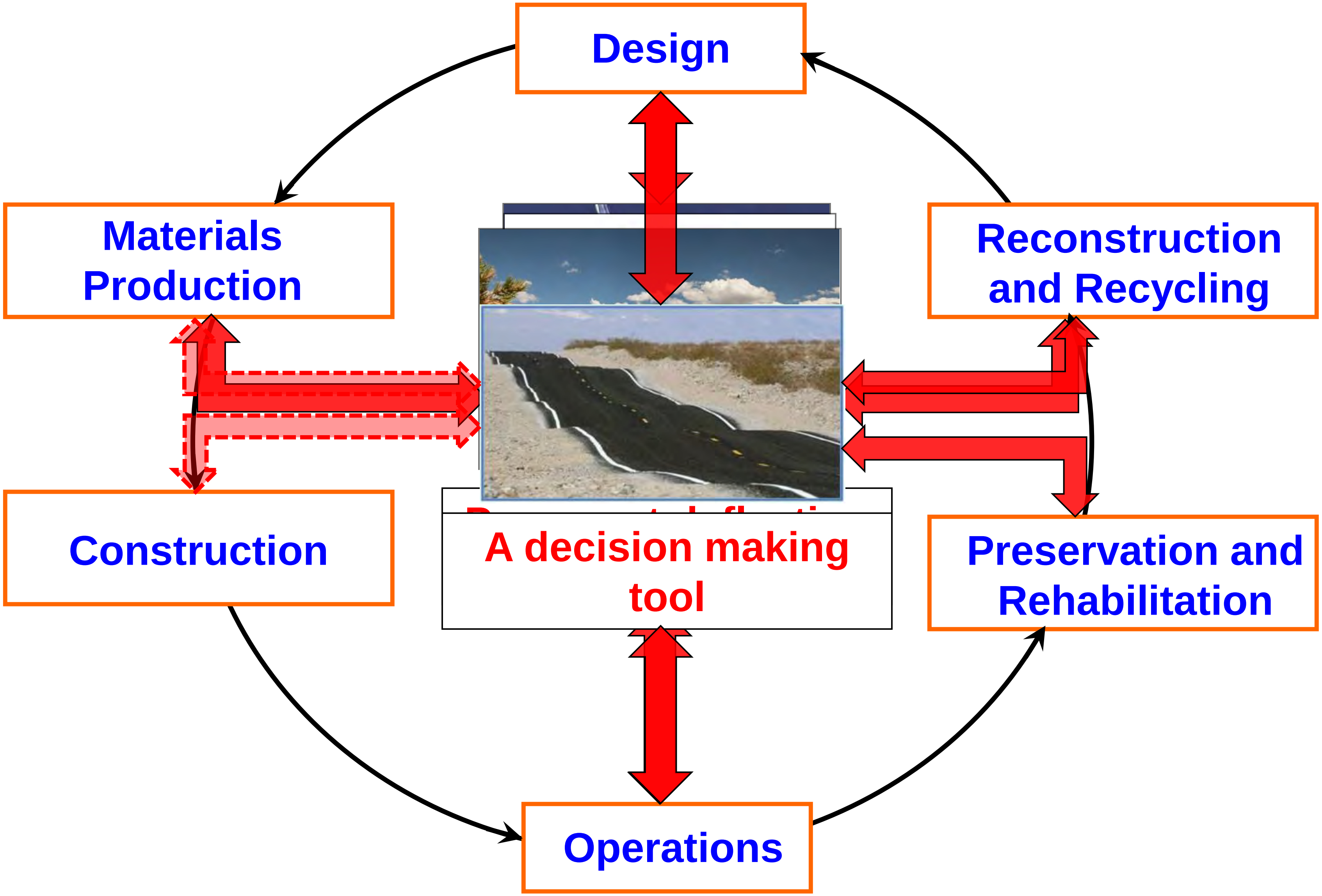
Road	Length (miles)	Traffic (AADT)	Percent trucks (%)	Roughness (in/mile)	Condition
1	1	12,000	25%	130	65
2	1	40,000	25%	100	78

Target IRI = 60 in/mile

Road 1: Annual user cost benefit = (12,000 x 0.25 x 1 x 365 x ***0.243***) + (12,000 x 0.75 x 1 x 365 x ***0.056***)
= **450,000$/mile**

Road 2: Annual user cost benefit = (40,000 x 0.25 x 1 x 365 x ***0.138***) + (40,000 x 0.75 x 1 x 365 x ***0.032***)
= **854,000$/mile**

LIFE CYCLE ASSESSMENT
MORE FUEL EFFICIENT PAVEMENTS



SUMMARY

- Sample preparation and testing will be completed soon
- Performance modeling and cost analysis will follow
- Development of a decision making tool to quantify benefits of RAP – Pactrans research project

GO BEAVS!

Q & A

Thank you!

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Oregon Department of Transportation

OSU Oregon State UNIVERSITY

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