Minnesota State University – Mankato

Concrete Activities

2017 Annual Concrete Paving Workshop
Concrete Paving Association of Minnesota

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WHERE THE RESEARCH HITS THE ROAD

Overview

Concrete Canoe

PCI Big Beam Competition

Recycled Concrete Aggregate Research

Concrete Canoe

Concrete Canoe

- Competing since 2004 – Two years after the program inception
- Competed at Nationals once
- Hosted the Regional Competition once (Next time is April 2018!)

Concrete Canoe

- 600 psi compressive strength
- 130 psi flexural strength
- 19-22 feet long
- ½ inch thick
- 55 pcf density

Concrete Canoe

- We've had some nice looking canoes…

Concrete Canoe

- We've had some nice looking canoes…

Concrete Canoe

…and some ugly canoes

Concrete Canoe

…and some broken canoes

Concrete Canoe

…and some heavy canoes: 450+ lbs!

Concrete Canoe

Made some innovations: prestress!

Wireless Strain Gauge System for Analysis

Concrete Canoe

Made some innovations: SCC Mix!

Concrete Canoe

We've made the paper.

Concrete Canoe

We've made the paper – twice!

TO AND SOUTH-CENTRAL MINNESOTA

The ee Press

MONDAY 75¢

TIP HOTLINE NO. 344-6385 | 24 pages | Volume 125, No. 36

TION & WORLD, A3

PHIS NEXT
LOOD PATH

IN THE VALLEY, B1

PADDLING THE
CONCRETE CANOE

CNHI Newspaper of the Year

Concrete Canoe

Students learn about

- Concrete mix design
- Problem solving
- Fundraising
- Motivating freshmen
- Professional presentations
- Working with a strict schedule
- Working with people!

Prestressed Concrete Institute and Big Beam

Prestressed Concrete Institute – Studio Grant

- PCI awarded MSU a 4-year grant for civil engineering and construction management
- Funds scholarships, courses, field trips, convention travel, etc.
- Partnered with Wells Concrete Products

Prestressed Concrete Institute – Studio Grant

- Many trips to the US Bank Stadium site

Prestressed Concrete Institute – Studio Grant

- Many Wells Concrete plant tours

Prestressed Concrete Institute – Studio Grant

- Graduates highlighted in PCI's *Ascent* trade journal

Prestressed Concrete Institute – Studio Grant

- Big Beam Competition
- Design and build a 20-ft beam
- Must work with a precast partner
- The beam must break within a specific load range

Prestressed Concrete Institute – Studio Grant

- Big Beam Competition

Prestressed Concrete Institute – Studio Grant

Recycled Concrete Aggregate Research

Recycled Concrete Aggregate Research

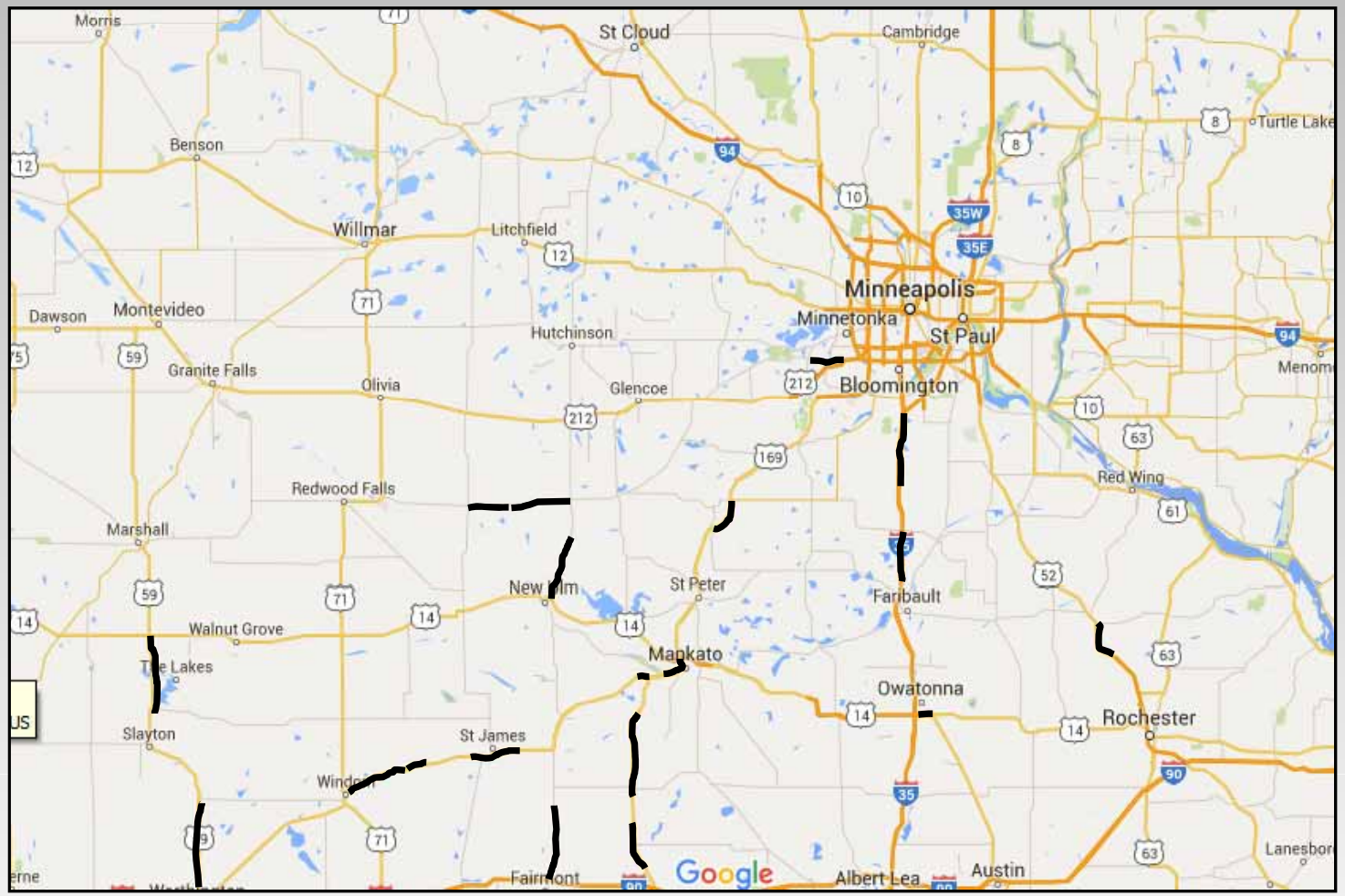
- Review of literature and test sections
- Historical data and performance review
- Properties of concrete made with RCA
- Economic Analysis
- Recommendations

Review of Literature and Test Sections

- Snyder (1994 and 2006) reviewed RCA test sections constructed in 1980s in many states
- Most performed well. Problems in poorly performing pavements were attributed to
  - High amounts of mortar (new and recycled)
  - Low slab thickness
  - Long joint spacing
- Many other reviews and test sections, but no formal comparison of performance or service life

Review of Literature and Test Sections

- Minnesota Test Sections (1980-1988)



Performance Review

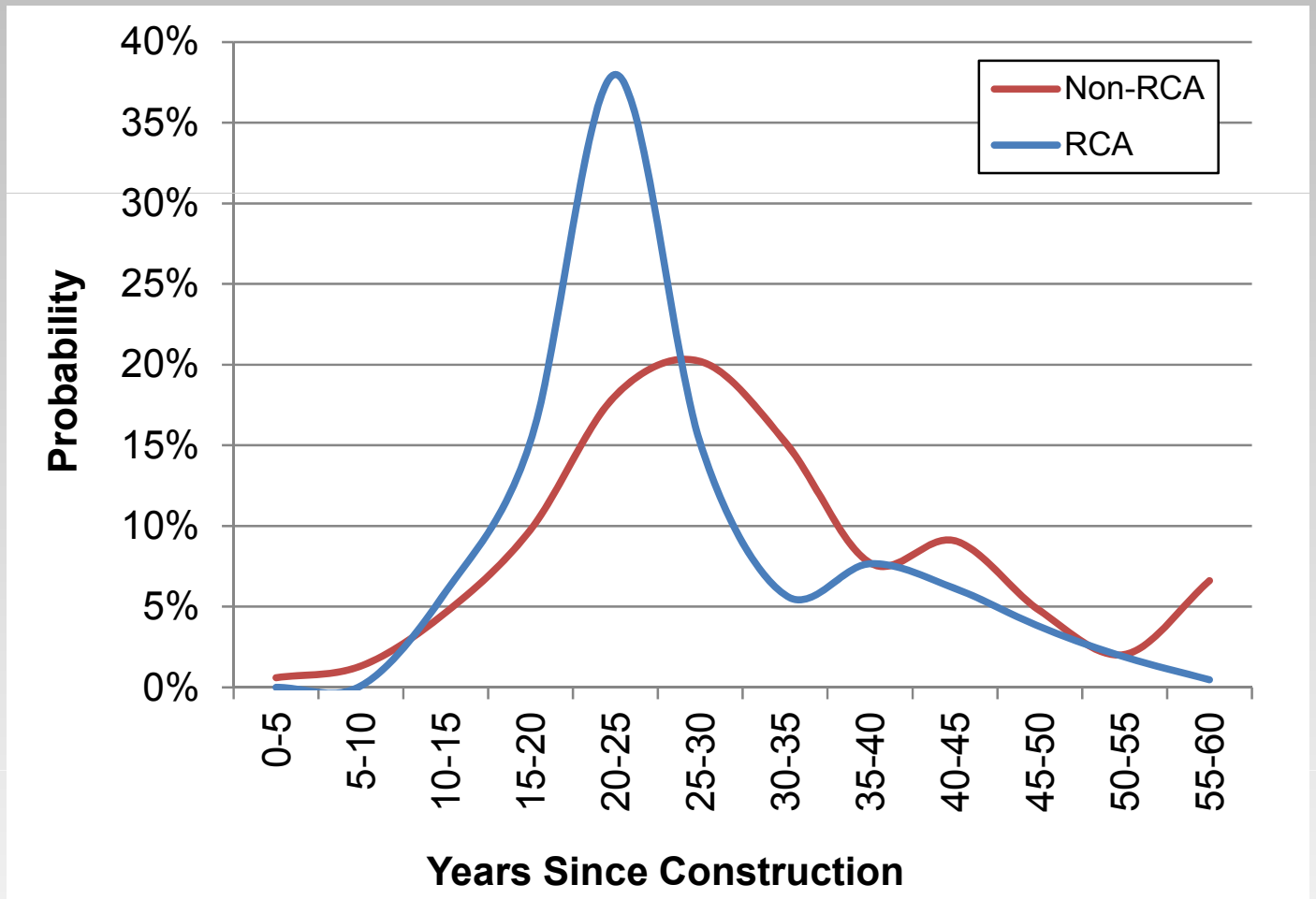
- Equivalent sample size: about 212 miles each of RCA and non-RCA pavement
- Pavement constructed about the same time frame: 1980s and early 1990s
- Similar ADT levels
- Included all 212 miles of RCA pavements, and a random selection of 212 miles of remaining non-RCA pavements

Performance Review

- Average RQI over time, RCA and non-RCA

Performance Review

- Time to Reach RQI=2.5



Performance Review

- Time to Reach RQI=2.5

	RCA	Non-RCA
Miles of Pavement	211.934	211.752
Number of observations	231	245
Minimum, yrs	8	5
Mean by miles, yrs	27	32
Standard deviation by miles, yrs	10	12

Performance Review

- Time to Recorded Maintenance

	RCA	Non-RCA
Time to 1st Repair Treatment, yrs	16	18
Time to 2nd Repair Treatment, yrs	21	23

Concrete Properties – Lab Testing

- Base Mix Design
  - 410 pcy Cement
  - 175 pcy Type C Fly Ash
  - 216 pcy Water (0.37 w/cm)
  - 1819 pcy Natural Coarse Aggregate
  - 1309 pcy Natural Fine Aggregate
  - HRWRA and AEA

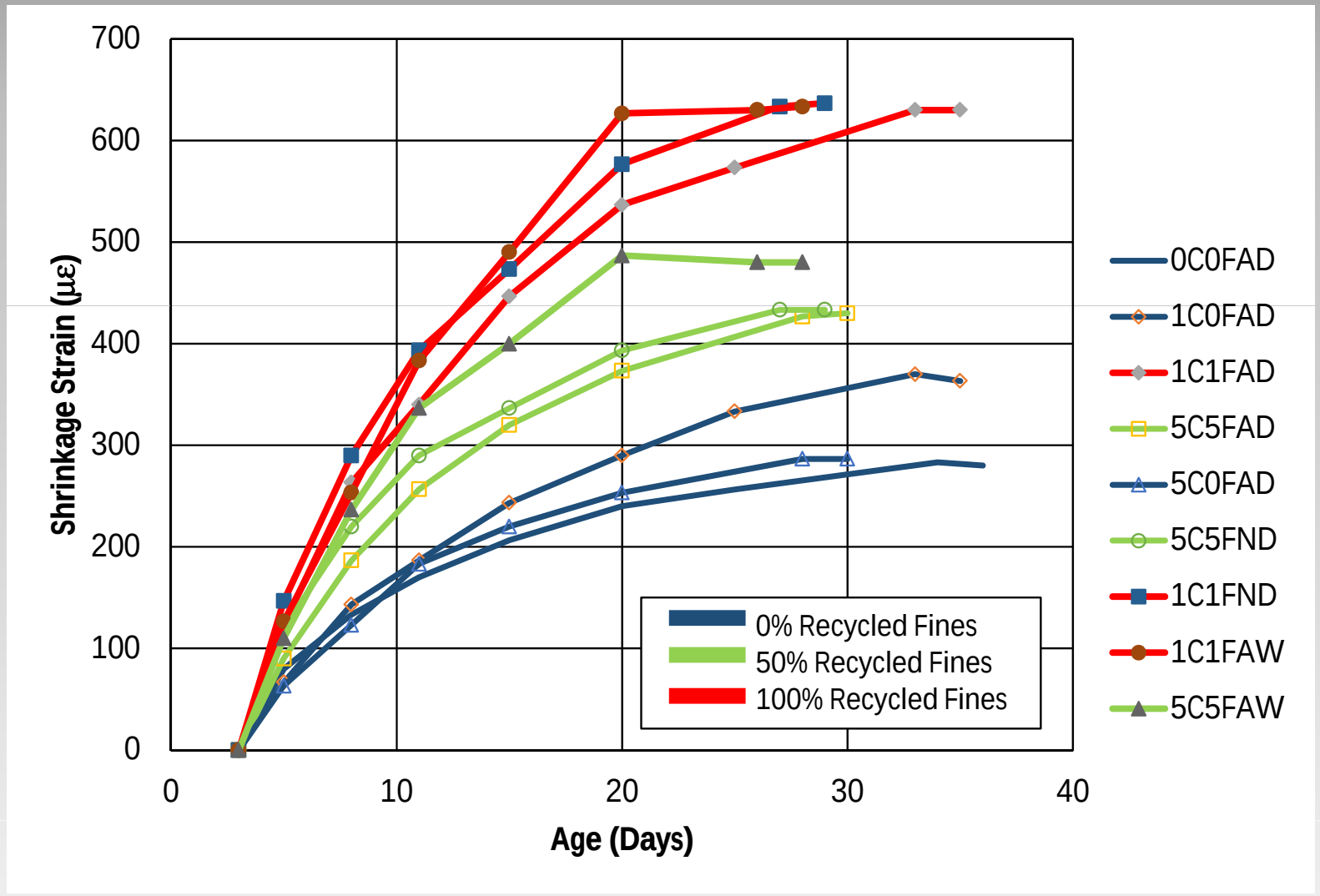
Concrete Properties

- Mix Design Variations – by Volume
  - 0% Coarse, 0% Fine RCA (Base Mix)
  - 50% Coarse, 0% Fine
  - 100% Coarse, 0% Fine
  - 50% Coarse, 50% Fine
  - 50% Coarse, 50% Fine (presoaked RCA)
  - 100% Coarse, 100% Fine
  - 100% Coarse, 100% Fine (presoaked RCA)
  - 50% Coarse, 50% Fine (No Fly Ash)
  - 100% Coarse, 100% Fine (No Fly Ash)

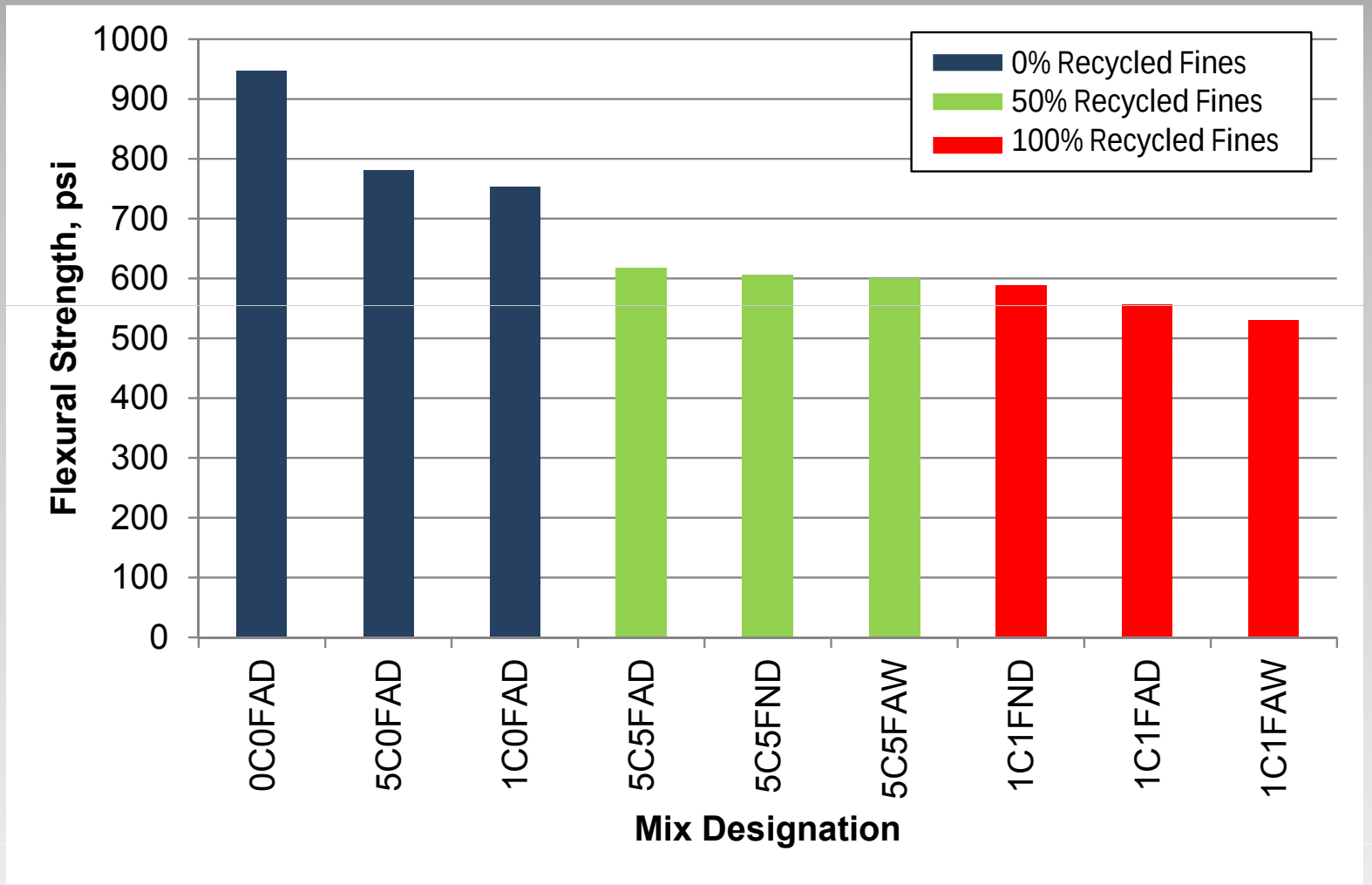
Concrete Properties

- Properties
  - Workability (Box Test)
  - Compressive Strength
  - Flexural Strength
  - Drying Shrinkage
  - Thermal Coefficient
  - Resistivity

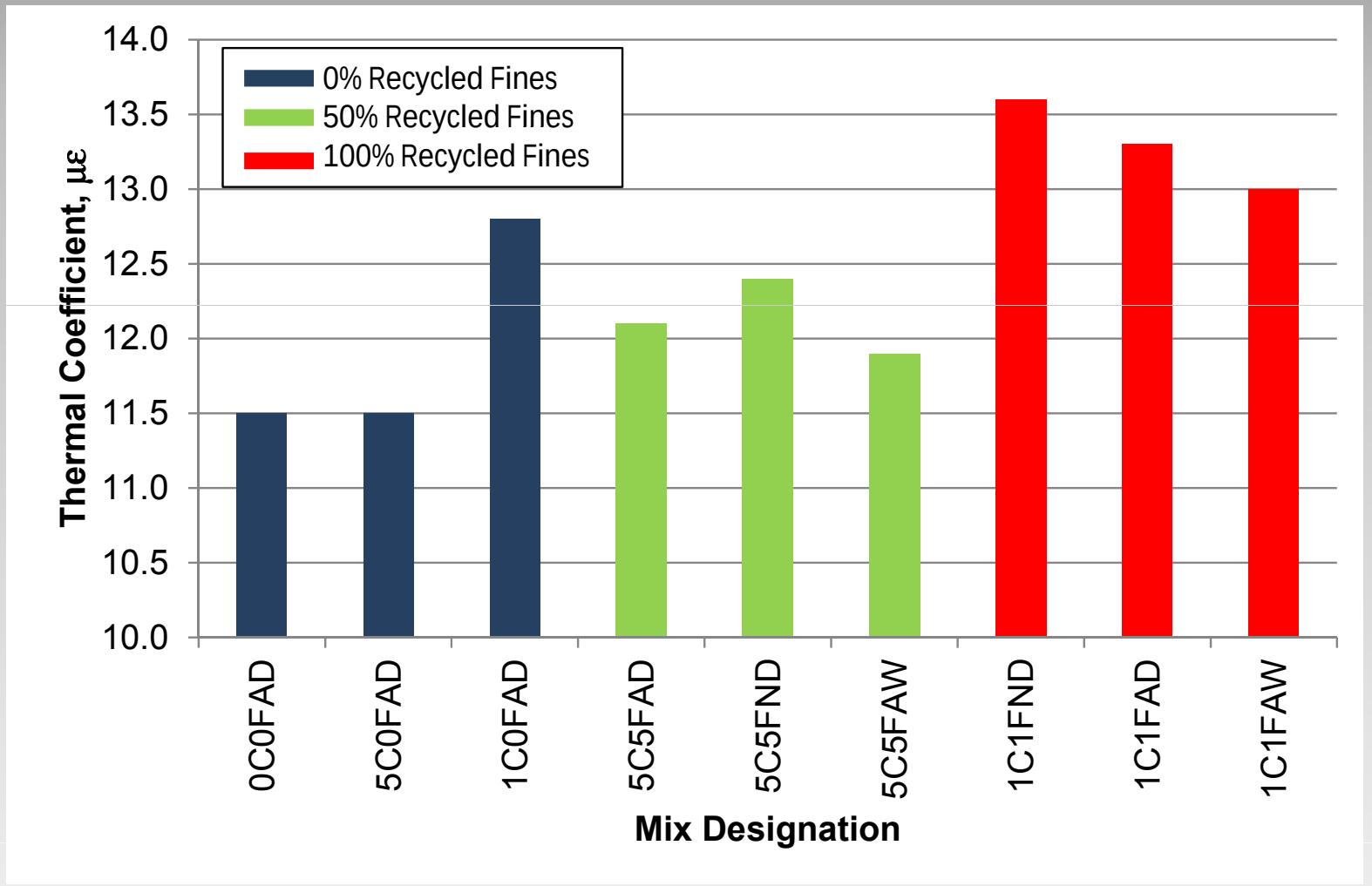
Concrete Properties – Shrinkage



Concrete Properties – Flexural Strength



Concrete Properties – Thermal Coefficient



Economic Analysis / LCCA

- An extensive economic analysis was conducted
  - Different recycle replacement rates, w/cm, construction methods
  - Found that utilizing RCA can be cost-effective with appropriate precautions. The net value can be positive, along with less tangible benefits of using sustainable materials.

Conclusions

- Recycled fines seemed to be detrimental to all measured properties. This confirms results of other studies.
- More cement can make up for lower strength, but costs more up front
- More recycled aggregate can decrease up front costs, and the net benefits can be positive

Conclusions

- Other considerations
  - Stockpile management costs (multiple stockpiles for RCA and virgin aggregates)
  - Accounting standards for additional, unused aggregates owned by producers or contractors
  - Alternative beneficial uses (base layer, subgrade stabilization, shoulders, etc.). Perhaps this can be offset by replacing more expensive aggregates in the concrete

Recommendations

- Recycled Concrete Aggregate may be used in concrete
- Should consider all costs and benefits, and alternate uses
- LAR specification on RCA for concrete (AASHTO MP 16 suggests 50% loss)
- Trial batches should be conducted

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