

# Expected Performance of MnRoad Composite Pavements

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# Presentation

- Performance measures
- Initial performance results
- Prediction of future performance
  - HMA / RCA
  - EAC / RCA
  - EAC / LCA
- Summary

# Performance Measures

- HMA surface on Recycled Aggregate Concrete (RCA): Initial & over Time
  - Smoothness, IRI
  - Texture depth
  - Noise
  - Friction
  - Rutting
  - Fatigue Cracking (transverse, longitudinal)
  - Joint Reflection Cracking (HMA)
    - No treatment
    - Saw & Sealed joints cut in HMA

# Performance Measures

- Instrumentation results
  - Temperature gradations
  - Moisture gradations
  - Dynamic strains (from moving wheel loads)
  - Vibrating wire strains (temperature & moisture)

# Performance Measures

- EAC surface of RCA & Low Cost Agg.:  
Initial & over Time
  - Smoothness, IRI
  - Texture depth
  - Noise
  - Friction
  - Fatigue Cracking (transverse, longitudinal)

# Initial Results: Noise

Surface	Sound Intensity Level
HMA	???
Exposed Aggregate Concrete	101.7 dBA
Conventional Diamond Grind of EAC	100.4 dBA
Next Generation Concrete Surface (Special grinding) of EAC	98.8 dBA

# Initial Smoothness: IRI

Surface	IRI, in/mile
HMA	???
Exposed Aggregate Concrete	???
Conv. Diamond Grind of EAC	???
Improved Diamond Grind of EAC	???

# Initial Texture, inches ASTM E 965

Surface	Texture Depth, in
HMA	0.334
Exposed Aggregate Concrete	0.784
Conv. Diamond Grind of EAC	1.127
Next Generation Diamond Grind of EAC	???



# Initial Friction

Surface	Friction
HMA	0.656
Exposed Aggregate Concrete	0.615
Conv. Diamond Grind of EAC	0.720
Improved Diamond Grind of EAC	0.547

# Prediction Future Performance

- AASHTO Mechanistic-Empirical Pavement Design Guide
  - Overlay design procedure for HMA OL of JPCP & Bonded Concrete OL of JPCP
  - Use for new composite pavements?
    - Some limitations, but with proper inputs can be used.
  - Inputs for new composite pavements for 3 MnRoad sections
- Thickness designs were intended for constructability and relatively short life.

# Experimental Plan at MnROAD

1400 ft

100	100	100	100	100	100	100	100	100	100	100	100	100	100
3-in HMA (S & S joints except for a few joints)					3-in EAC Granite (first 400-ft ultra diamond grind)								
6-in PCC (15-ft joints, 1.25-in dowels driving lane, undoweled passing lane, recycled PCC)					6-in PCC (15-ft joints, 1.25-in dowels, recycled PCC)				6-in PCC (15-ft joints, 1.25-in dowels, low-cost PCC)				
8-in Class-5 Special (Granular Base)													
Clay Subgrade													

# MEPDG Inputs

- Traffic: I-94 WIM data
- Climate: Nearest weather stations
- HMA: Test data
- Concrete: EAC, RCA, LCA test data
- Subgrade: test data, backcalculation of modulus
- Design: joints, dowels, joint spacing, thickness of layers, shoulders

# MEPDG Inputs

- Traffic: I-94 WIM data
  - AADT: 29,000
  - Percent Class 4 to 13 trucks: 12
  - Percent trucks outer lane: 85%
  - Axle load distribution: Measured with WIM
  - Vehicle type classification distribution: Measured with WIM.

# MEPDG Inputs

- **Climate: Nearest weather stations**

**3.3 miles ST CLOUD, MN - ST CLOUD REGIONAL AIRPORT Lat. 45.32 Lon. -94.03 Ele. 1024 Months: 116 (M1)**

**43.5 miles MINNEAPOLIS, MN - CRYSTAL AIRPORT Lat. 45.04 Lon. -93.21 Ele. 872 Months: 101 (C)**

**52.8 miles MINNEAPOLIS, MN - FLYING CLOUD AIRPORT Lat. 44.5 Lon. -93.28 Ele. 922 Months: 100 (C)**

**56.6 miles MINNEAPOLIS, MN - MINPLIS-ST PAUL INTL ARPT Lat. 44.53 Lon. -93.14 Ele. 874 Months: 116 (C)**

**60.5 miles ST PAUL, MN - ST PAUL DWTWN HOLMAN FD AP Lat. 44.56 Lon. -93.03 Ele. 711 Months: 116 (M6)**

**62.5 miles BRAINERD, MN - BRAINERD LAKES RGNL ARPT Lat. 46.24 Lon. -94.08 Ele. 1225 Months: 116 (C)**

# MEPDG Inputs

- HMA materials data
  - PG Grade: 64-34
  - Percent asphalt:
  - Percent inplace air voids:
  - Density:

# MEPDG Inputs

- Concrete: EAC, RCA, LCA test data

Test	EAC	RCA	LCC
Flexural Strength, psi	854 psi	677	548
Modulus of Elasticity, psi	4.9 M psi	4.9 M psi	5.1 M psi
Coef. Expansion	5.6/F	5.8/F	5.4/F
Poisson's Ratio	0.23	0.25	0.23

# MEPDG Inputs

- **Subgrade:** FWD tested on top of slab & backcalculation of subgrade modulus (dynamic k-value, kd)
- Mean backcalculated k-value = 140 psi/in.
- Corresponding Input **Mr = 14,000 psi** at optimum density and water content gives k-value output of about 140 psi/in.

# MEPDG Inputs

- **Design:**
  - Joint spacing: 15-ft
  - Dowels:
    - Driving lane: 1.25-in diameter, 12-in spacing
    - Passing lane: No dowels
  - Layer thickness:
    - HMA: 3-in
    - EAC: 3-in
    - RCA and LCA: 6-in
    - Shoulders: HMA
    - Untreated aggregate base: 8-in

# HMA/RCA Predictions

- MEPDG outputs:
  - Slab fatigue transverse cracking
  - Rutting of HMA
  - IRI
- Other potential distress
  - Transverse saw and seal joints



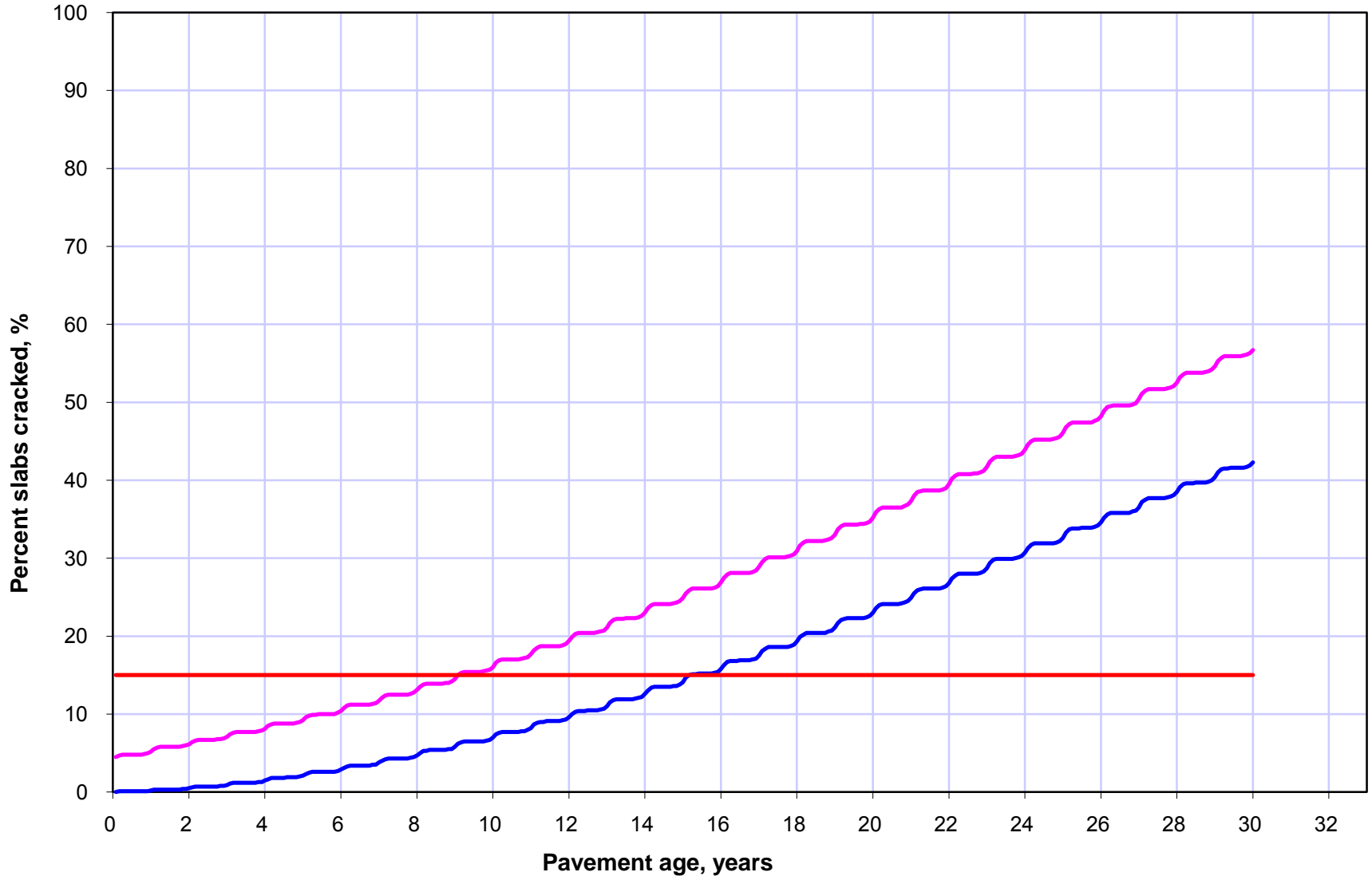
# 3-in HMA / 6-in RCA Section



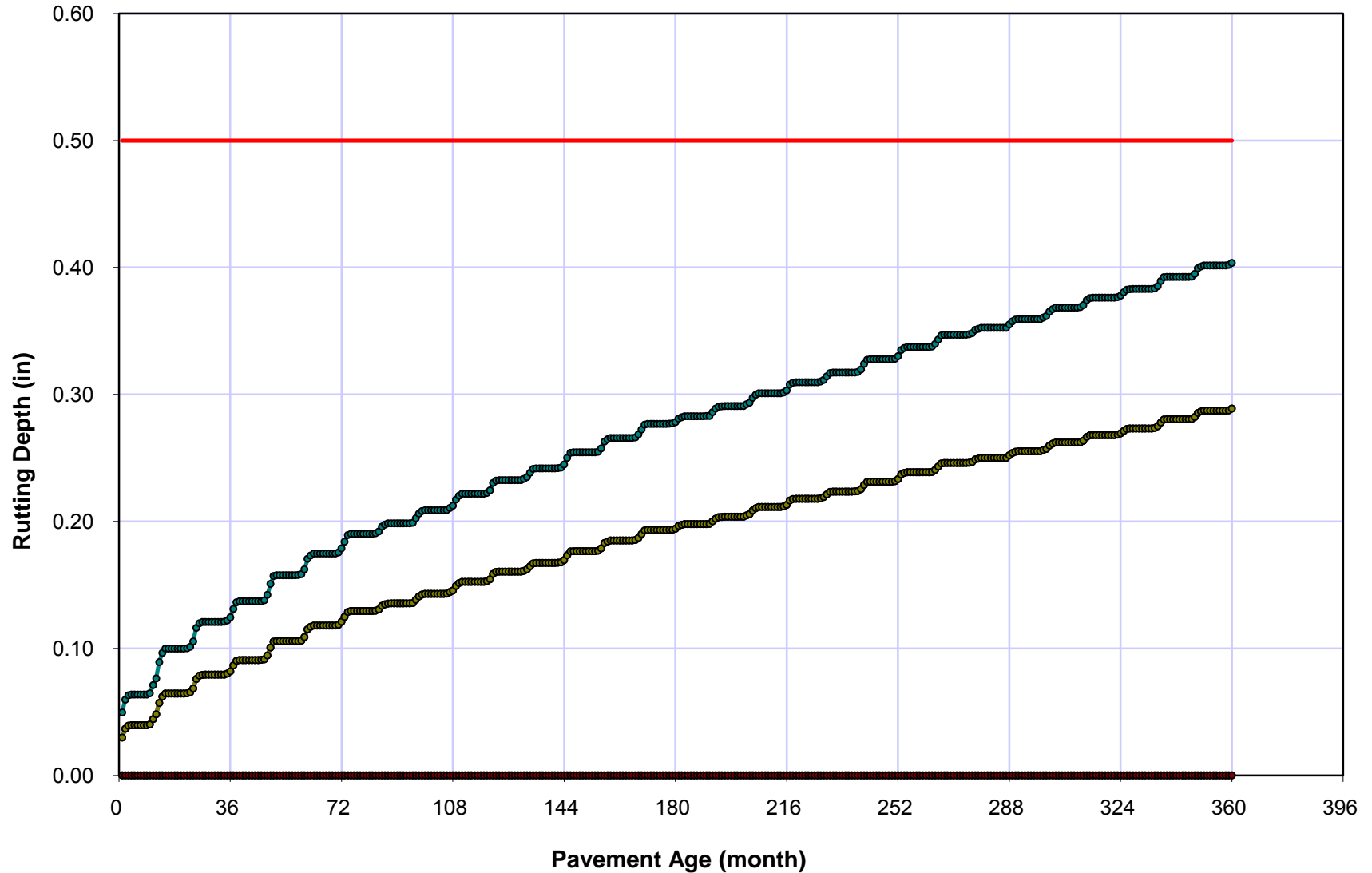
# Saw & Seal Transverse Joints



# Slab Cracking, 3-in HMA / 6-in RCA



# Rutting, 3-in HMA / 6-in RCA



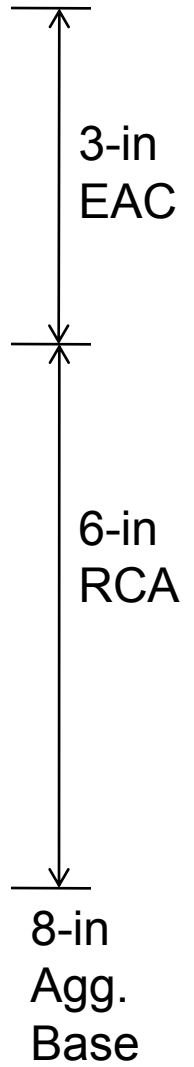
# MEPDG Prediction HMA / RCA

<b>Age / Trucks</b>	<b>% Slab Cracking</b>	<b>Rutting, in</b>	<b>Smoothness IRI, in /mile</b>
0	0	0	63
5 years 3 million	2.1	0.11	101
10 years 6 million	7.0	0.16	108
15 years 10 million	14.1	0.19	115

# EAC/RCA Predictions

- MEPDG outputs:
  - Slab fatigue transverse cracking
  - Transverse joint faulting
  - IRI

# 3-in EAC / 6-in RCA



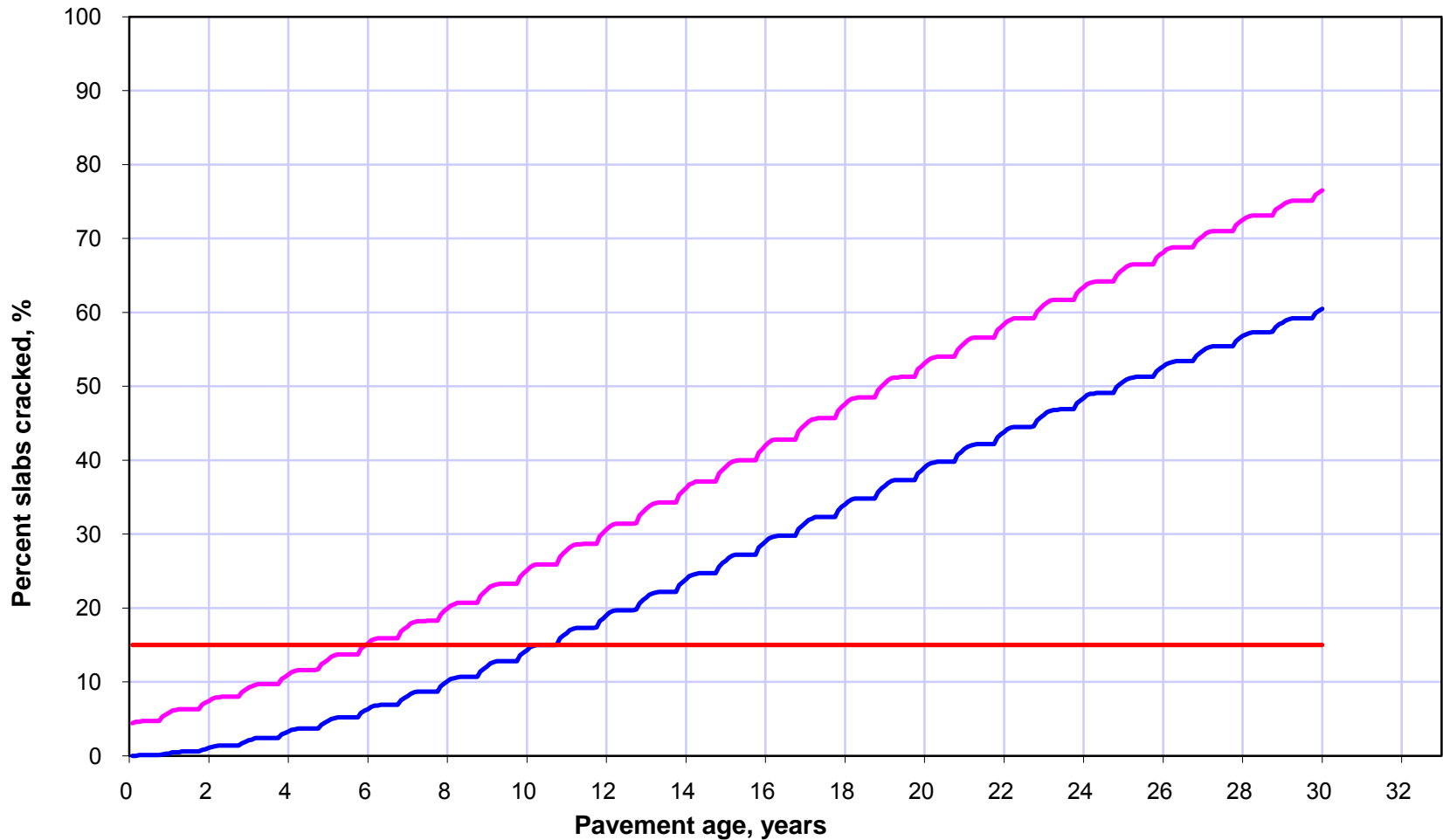
# 3-in EAC / 6-in RCA



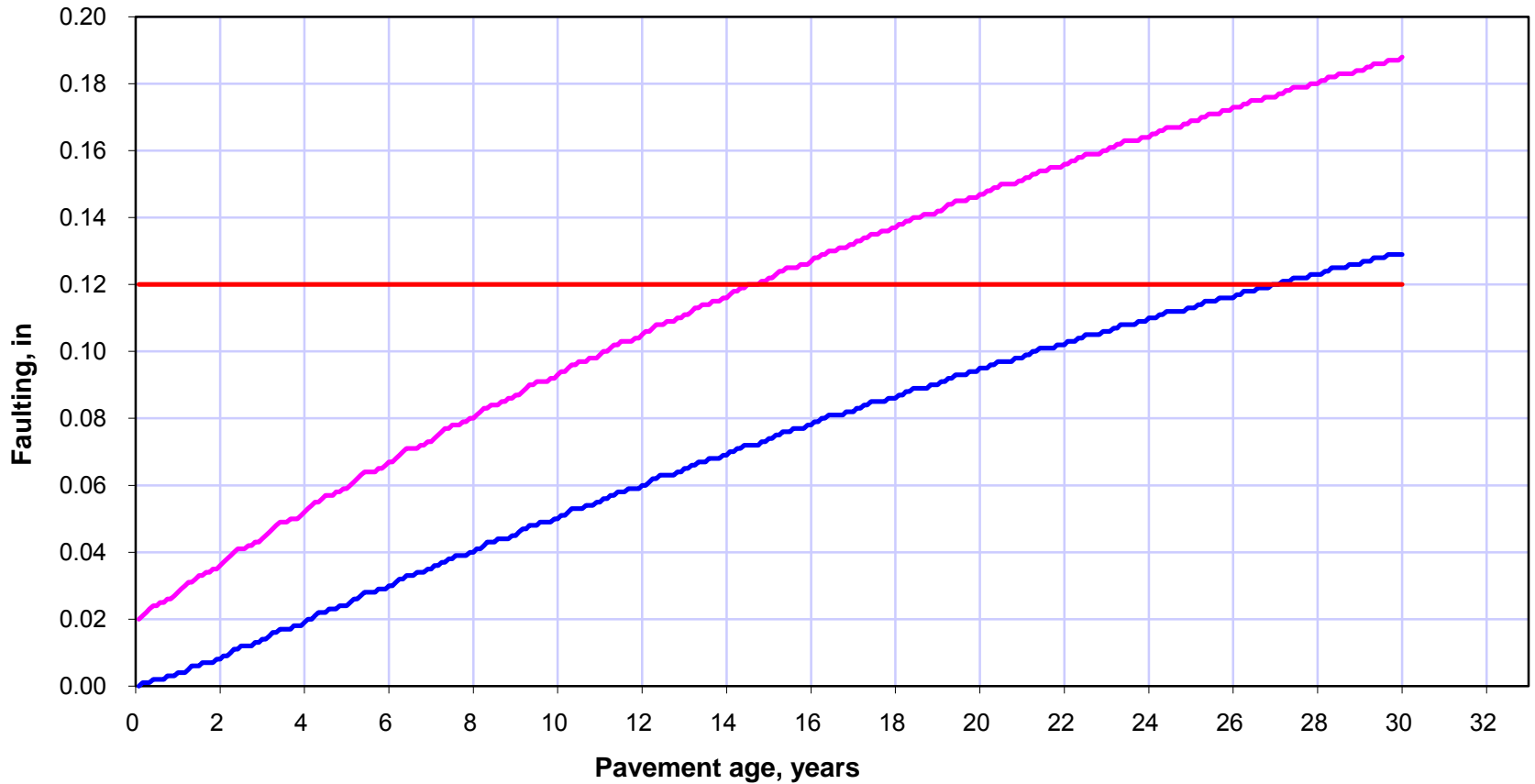
# 3-in EAC / 6-in LCC



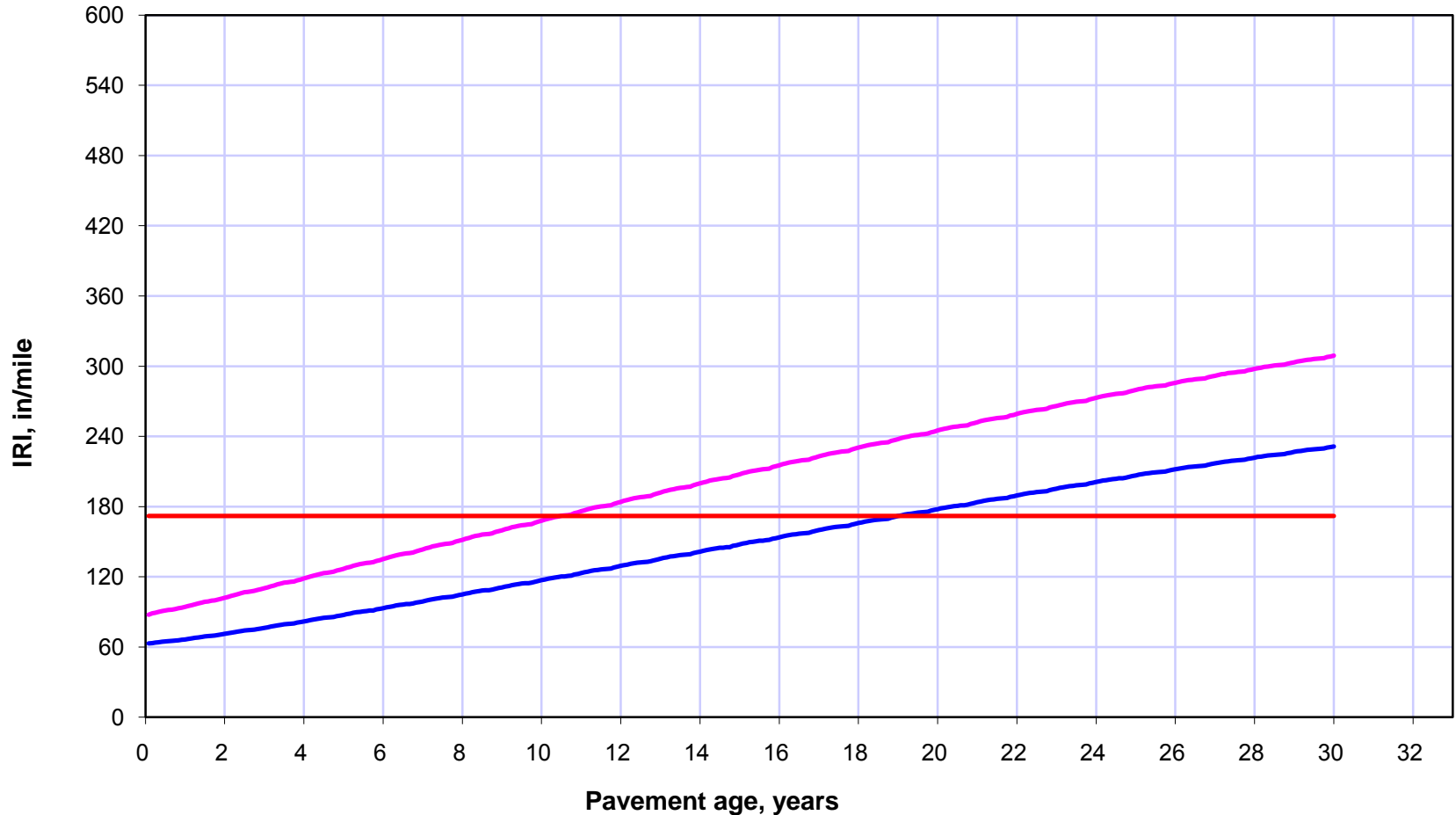
# Slab Cracking, 3-in EAC / 6-in RCA



# Joint Faulting, 3-in EAC / 6-in RCA



# IRI, 3-in EAC / 6-in RCA



# MEPDG Prediction EAC / RCA

<b>Age / Trucks</b>	<b>% Slab Cracking</b>	<b>Joint Faulting, in</b>	<b>Smoothness IRI, in /mile</b>
0	0	0	63
5 years 3 million	4.7	0.02	87
10 years 6 million	14.3	0.05	117
15 years 10 million	26.0	0.07	148

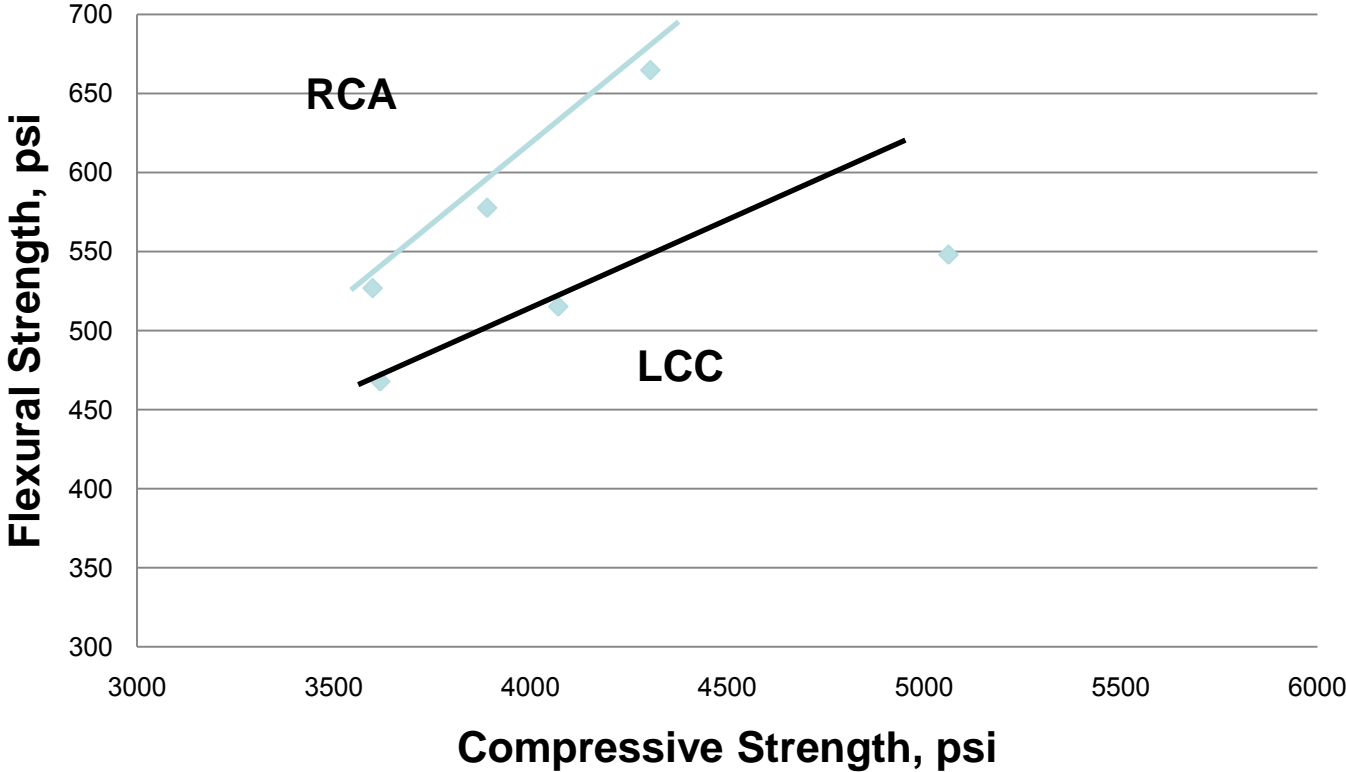
# EAC / LCA Predictions

- MEPDG outputs:
  - Slab fatigue transverse cracking
  - Transverse joint faulting
  - IRI

# Comparison RCA & LCC

Property	Recycled Aggregate Concrete, RCA	Low Cost Concrete, LCC
Cement, pounds	360	240
Flyash, pounds	240	360
Compressive Strength, psi	4300	5062
Flexural Strength, psi	665	548
Modulus Elasticity, psi	4.8 million	5.1 million
Coefficient of Thermal Expansion, per degree F	5.8	5.4

# Flexural Vs Compressive Strength



# MEPDG Prediction EAC / LCC

<b>Age / Trucks</b>	<b>% Slab Cracking</b>	<b>Joint Faulting, in</b>	<b>Smoothness IRI, in /mile</b>
0 years 0 million	0	0	63
5 years 3 million	68	0.02	136
10 years 6 million	88	0.04	171
15 years 10 million	94	0.06	194

# What If?

30-year Design: 23 million Trucks

- 3-in HMA / 8-in RCA
  - No structural fatigue cracking
  - HMA would need replacement at 10 to 15 years.
- 3-in EAC / 8-in RCA
  - No structural fatigue cracking
  - EAC should perform with no problems: good friction, no significant wear.
  - Diamond grinding should perform with no problems: good friction, low noise.

# 30-year Design: 23 million Trucks

- 3-in EAC / 9-in LCC
  - No structural fatigue cracking
  - EAC should perform with no problems: good friction, no significant wear.
  - Diamond grinding should perform with no problems: good friction, low noise.

# Summary

- Construction quality of each section appears to be good.
- Material properties as expected.
- Initial performance measures reasonable.
- Future performance predictions show longer than expected life for HMA/RCA and EAC/RCA and less for EAC/LCC.
- Actual monitoring over time will provide proof of concept.