Design of Illinois Tollway Composite Pavements

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FHWA Tollway National Open House,

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Presentation Overview

- Starting in Composite Pavements
- Move to 2-Lift Concrete
- Design of I-90 2-Lift Concrete Pavement
- Life Cycle Cost Analysis & Type Selection

2-Lift Paving is a Forgotten Practice

Popular back in the 50's, 60's and 70's when the Tollway was originally built

2-Lift paving is in our long & recent past

1950's

2001

Developed with SHRP 2 R21 help

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Composite pavements started in 2010

- Asphalt-over-concrete composite ramps
- Strong Concrete Mix
  - 6.5 bag fly ash mix with 20 percent black rock placed
  - Compressive strengths > 3500 psi in three days
  - Flexural Strengths >650 psi in seven days

I-294 Ramp first composite pavement

- Two HMA/JPC sections of I-94 ramps north of Chicago
- Constructed 2010 using 30% RAP & 20% fly ash in PCC, high quality WMA surface layer, & saw & seal joint over doweled JPC

More Answers Needed

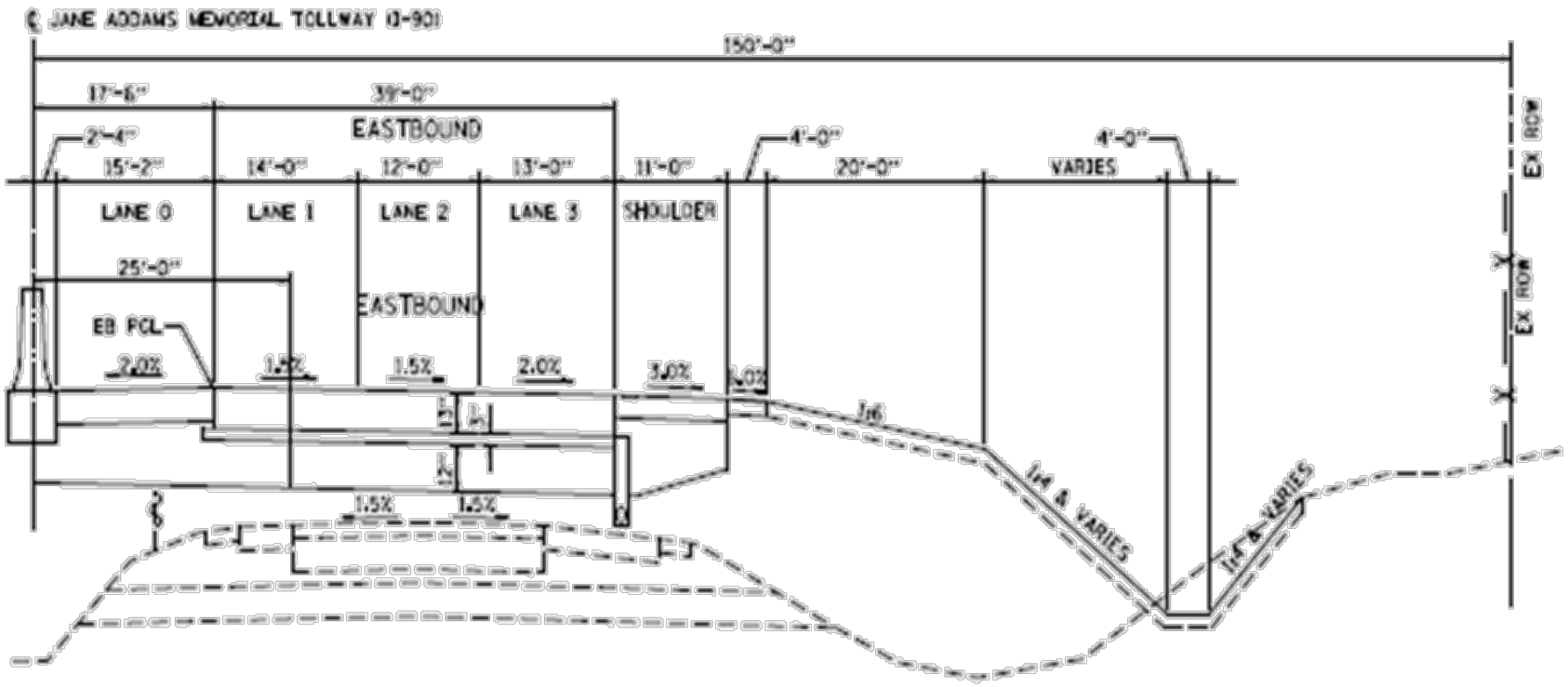
- SHRP R21 Composite Pavement Project Investigated
- Demonstrations Observed
- History of Composites Studied
- History of Black Rock Concrete Studied
- More Research Determined to be Needed

Black Rock Ternary Mixes Researched

- Fractionated Reclaimed Asphalt Pavement (FRAP) as a Coarse Aggregate Replacement in a Ternary Blended Concrete Pavement

Placed 0.7 Mile Trial Reconstruction and Widening Project on I-88 in 2012

Full Implementation Starts in 2013 for I-90 Reconstruction and Widening (62 miles)



PROPOSED I-90 TOLLWAY

HIGH FILL SECTION

Pavement ME Design is design tool

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$
$$C_{34} = C_3 + (C_4 * FR^{0.25})$$
$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_S}\right)\right]^{C_6}$$
$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$
$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$
$$C_8 = DowelDeterioration$$

C1 - Cracking
C2 - Spalling
C3 - Faulting
C4 - Site Factor

$$\log(N) = C_1 (MR/\sigma)^{C_2}$$

$$P.O. = \frac{C_3}{1 + C_4 Damage^{C_5}}$$

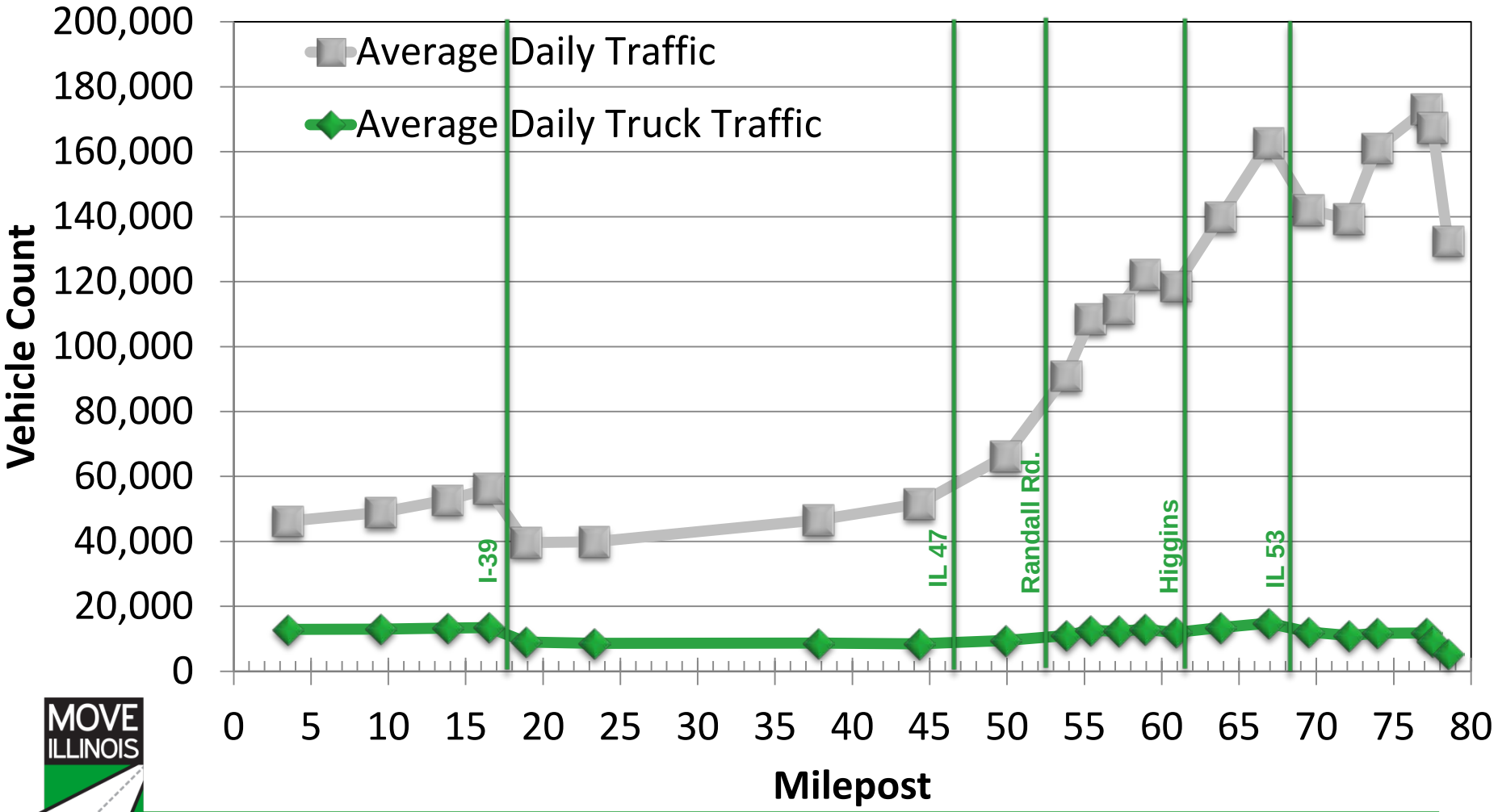
$$cw = C_6 (cw_i)$$

$$\log(N) = C1 \cdot \left(\frac{MR}{\sigma}\right)^{C2}$$

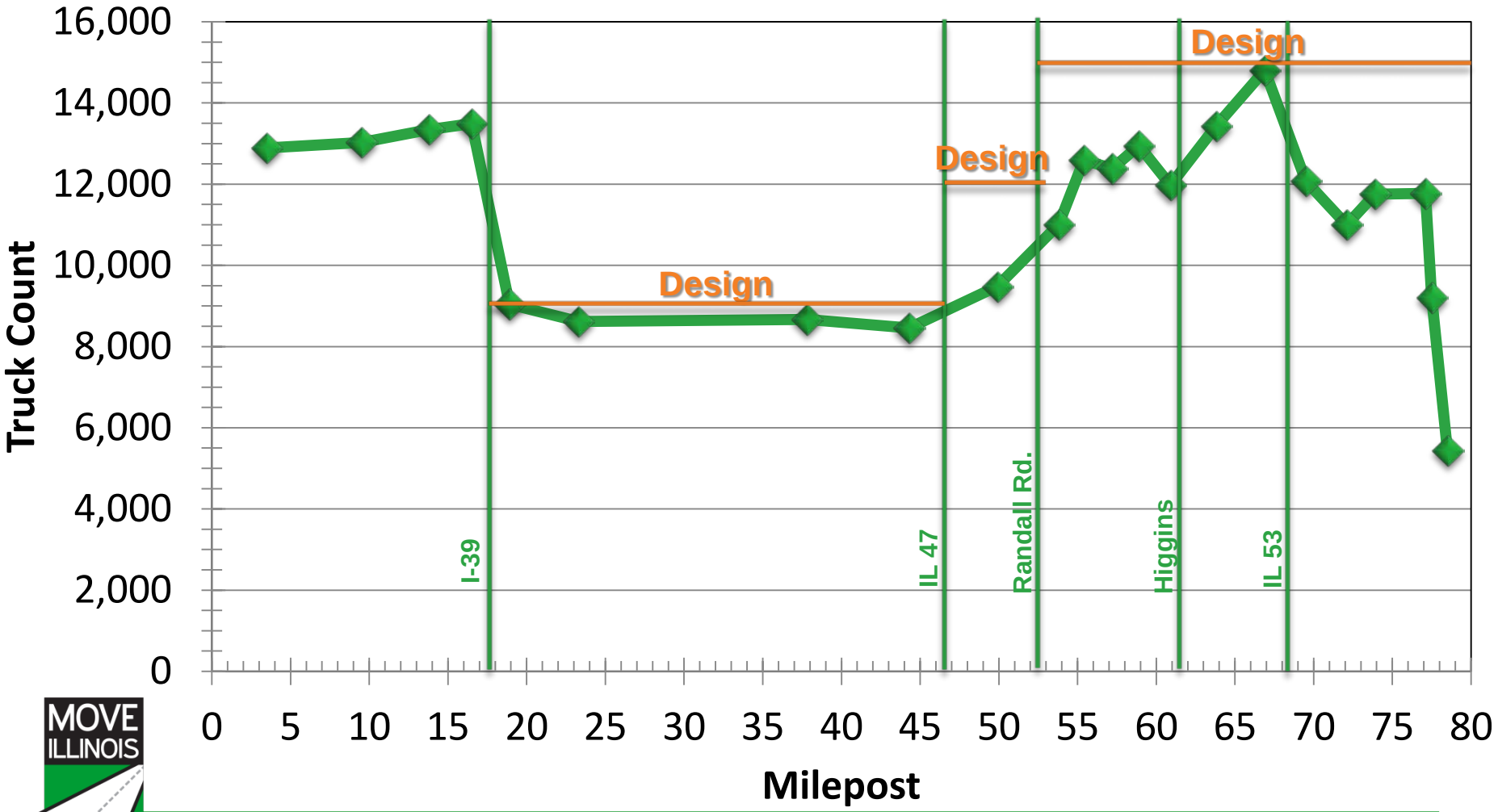
$$CRK = \frac{100}{1 + C4\ FD^{C5}}$$

C1 - Punchout
C2 - Site Factor

Total Traffic and Truck Traffic Are Different



Truck Counts Split In 3 Segments



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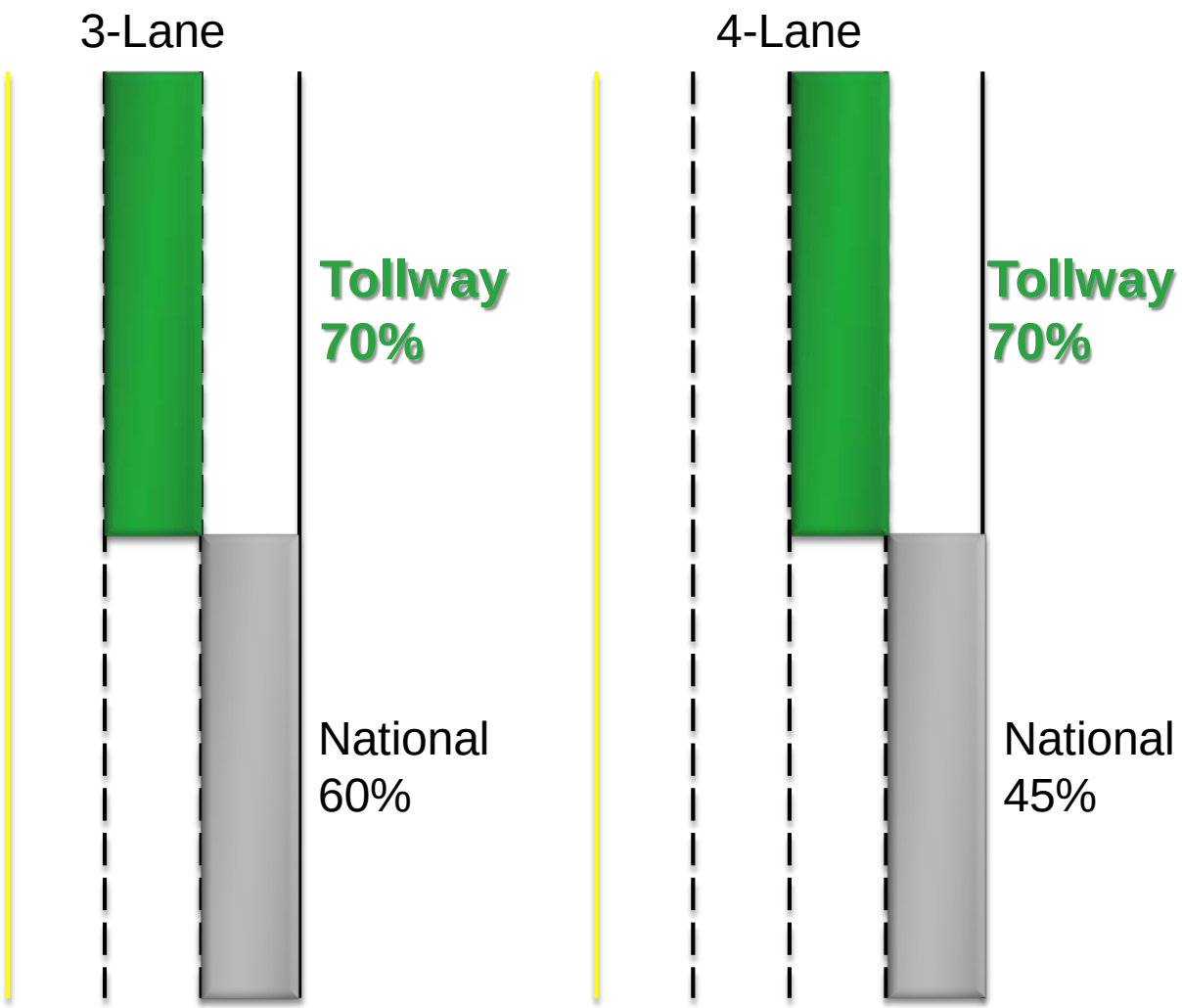
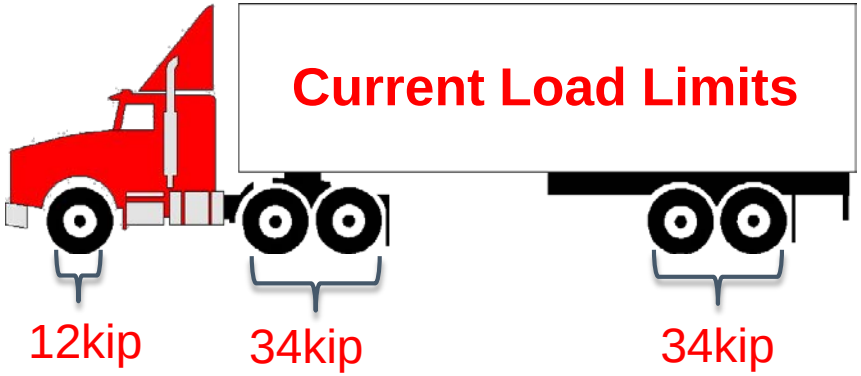
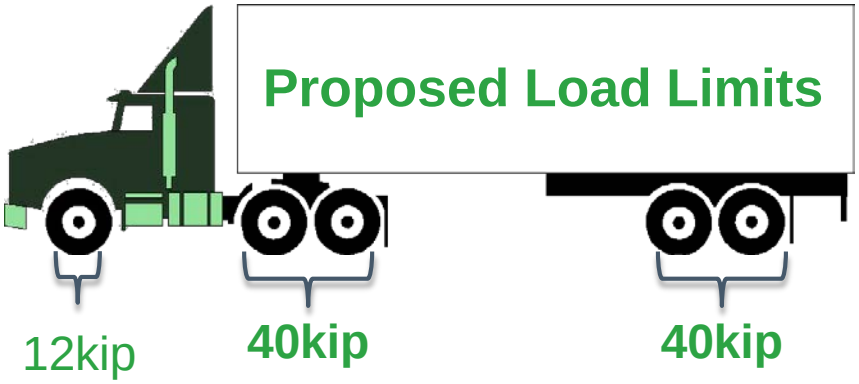
Major Traffic Inputs for Pavement Design

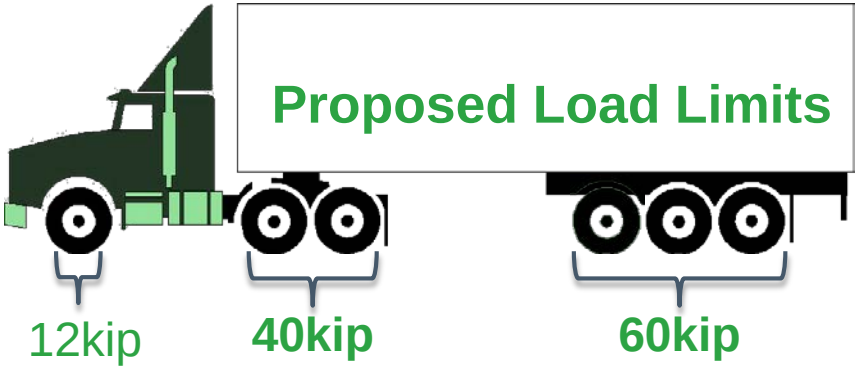
- Lane Distribution
- Traffic Volume
- Load Spectra



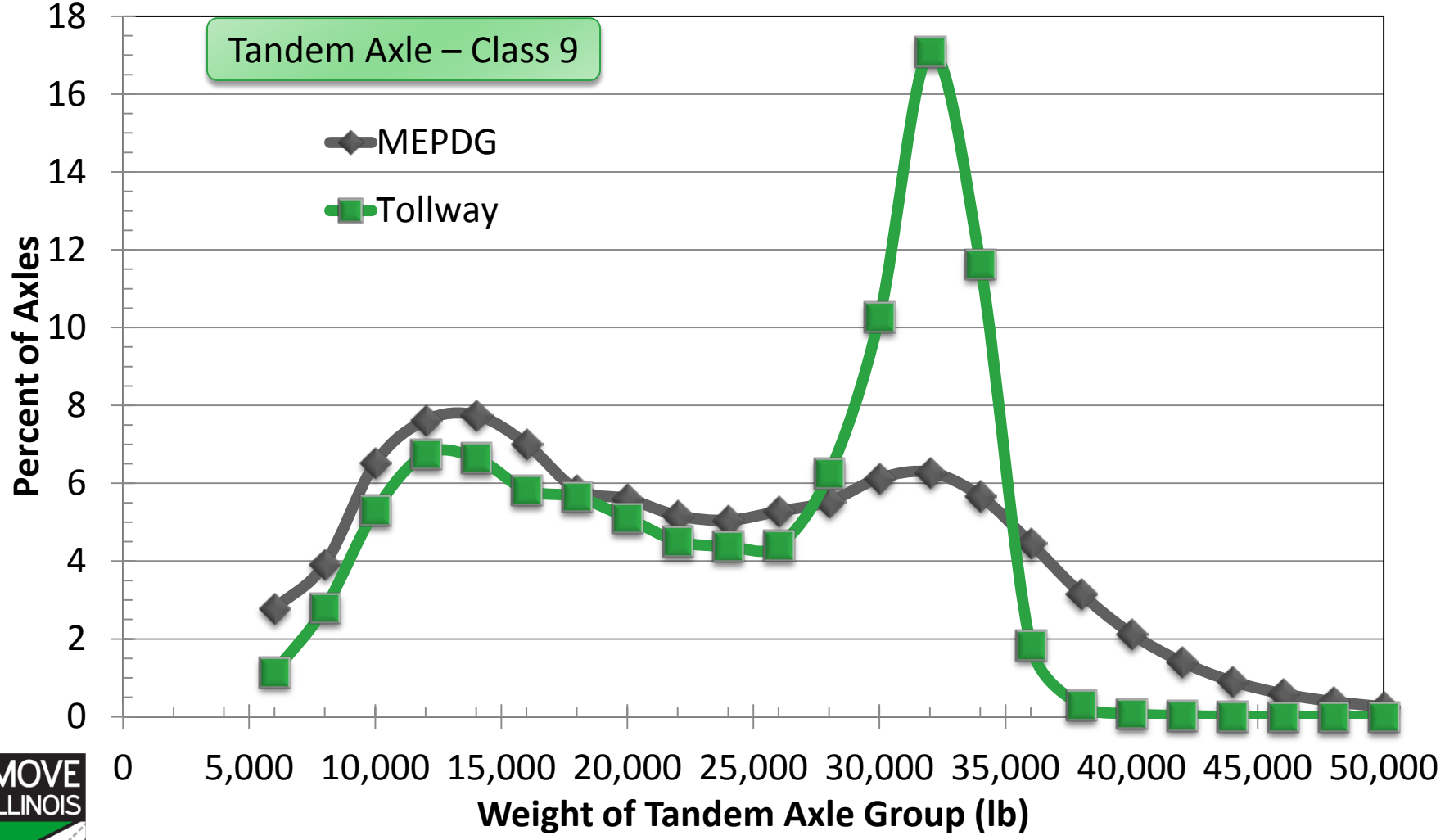
Design Trucks – Load Distributions







Tollway Axle Weight Distribution Does Not Follow National Data



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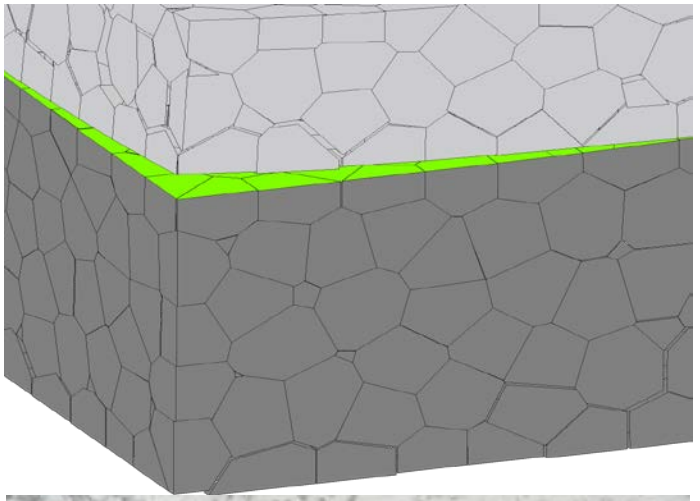
Understanding bonding is key

- Latice Model (PCC/PCC Debonding)
  - R-21 work coupled lattice models with finite element models
  - Analysis concluded wet on wet paving had only very low chance if any to debond, matching field surveys & bond testing.



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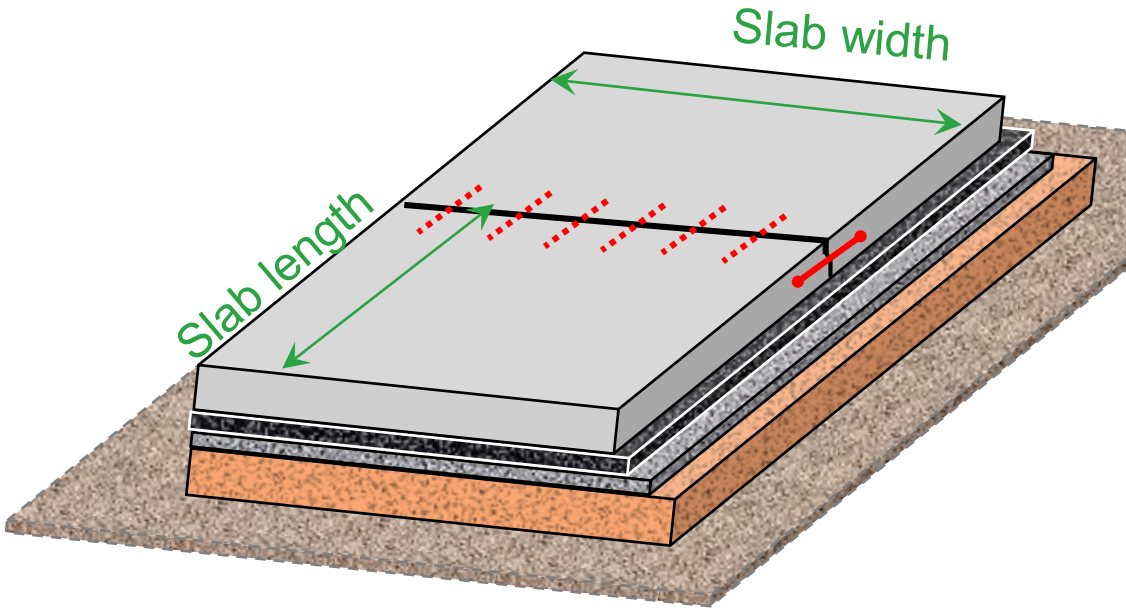
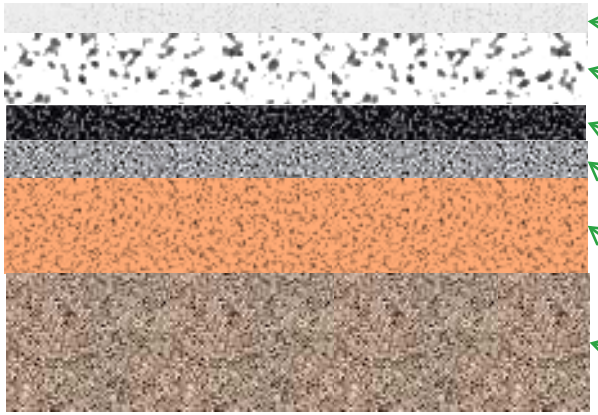
SHRP2 STRATEGIC HIGHWAY RESEARCH PROGRAM

I-90 Concrete Pavement Design Details

- 15’ Slab length
- 1’ Widened slab
- Doweled Joints (1 ½”)





Process for Pavement Type Selection

Agency-based pavement-type selection

Identification of feasible alternatives

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Development of pavement life cycle strategies

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Life cycle cost analysis

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Evaluation of economic and noneconomic factors

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Agency-based selection of preferred pavement type

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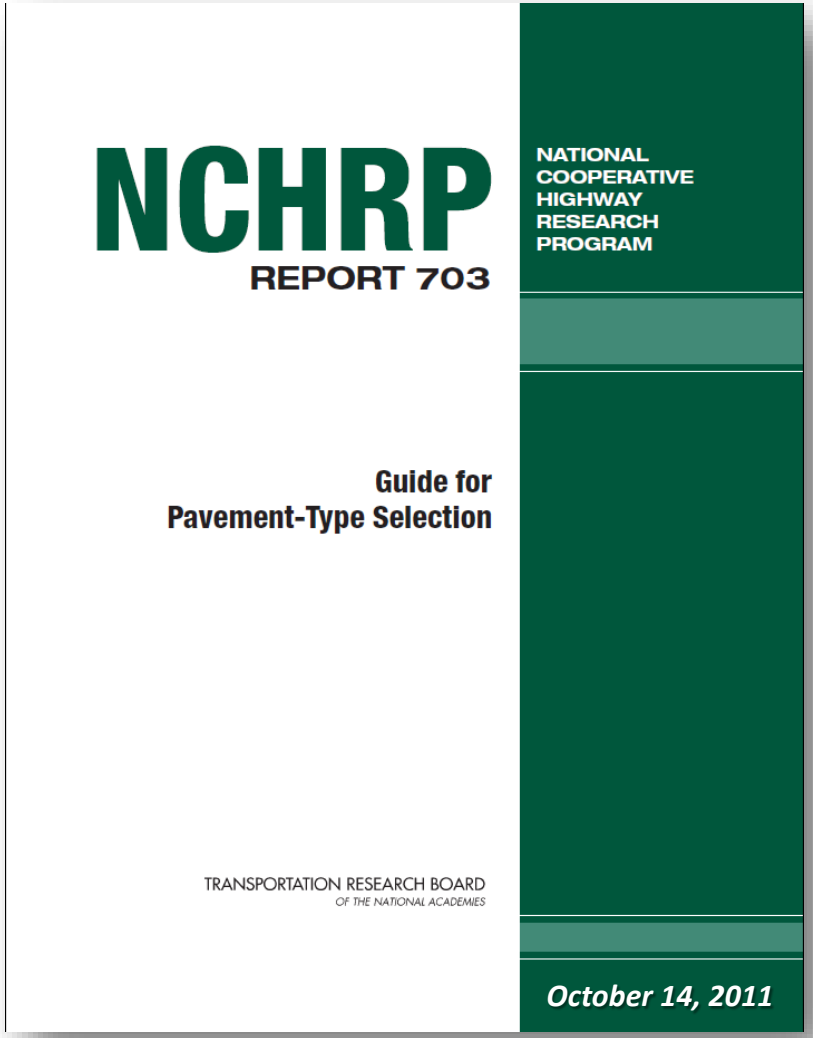
Design-bid-build preferred pavement type



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Designs & Life Cycle Strategies

- Designs for current & future traffic
- Pavement Types Evaluated

Jointed Concrete
Continuously Reinforced Concrete
Full Depth Asphalt
Asphalt over CRCP
Asphalt over Jointed Concrete

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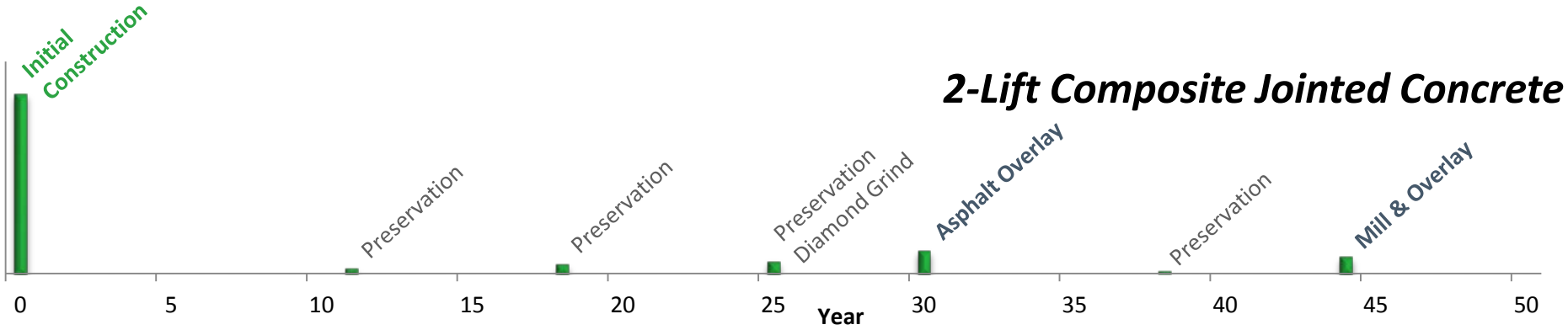

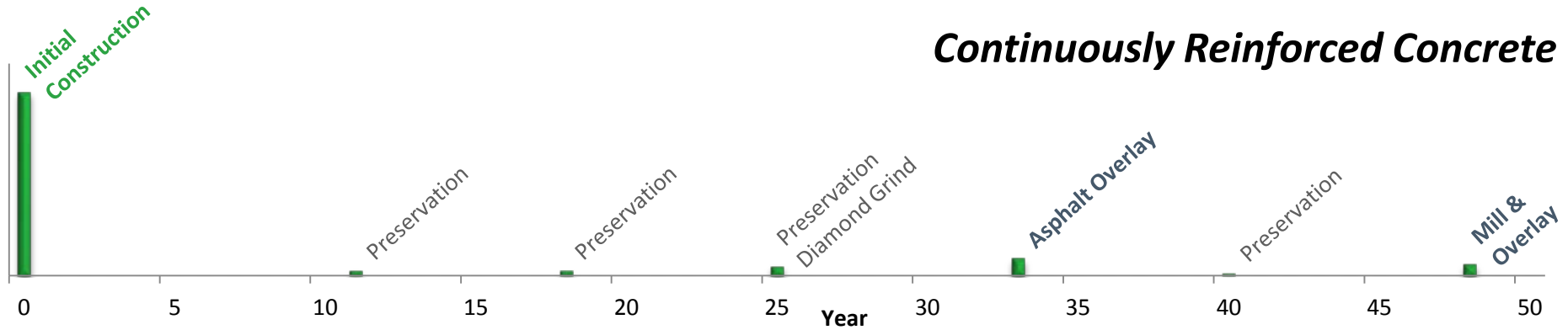

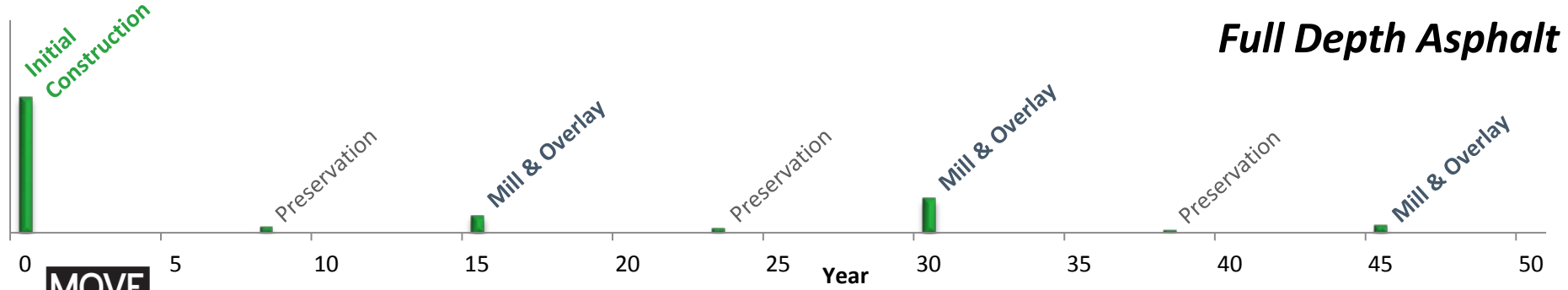

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Corridor Life Cycle Cost Analysis

Net Present Value of 50-year Cost of Ownership for the Corridor ($ Millions)

	West Rockford – IL-47	Center IL-47 to Randall	East Randall to O'Hare
2-Lift Composite Jointed Concrete			
Continuously Reinforced Concrete			
Full Depth Asphalt			
Composite Asphalt/Jointed Concrete			
Composite Asphalt/Cont. Reinforced			

Lowest — Lowest life cycle cost pavement type by section

10% — Life cycle cost within 10% of the low value is generally considered equal and is within the expected variability of costs used in the analysis

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Pavement Type Selection Grade Card

Combines Economic and Noneconomic Factors

	Guide Factors	Tollway Factors	Factor Weight
Economic	Initial cost	***Initial Construction Cost***	***40%***
Economic	Rehabilitation cost Maintenance Cost	***Capital Preservation Cost***	***40%***
Economic	Conservation of materials/energy Sustainability	***"Green" - Recycling Factor***	***10%***
Economic	Traffic during construction Availability of local materials Stimulation of competition	***Constructability / Schedule Factor***	***10%***
Noneconomic	Maintenance capability	Preference to keep Maintenance yards consistent	
Noneconomic	Subgrade soils Future needs Experimental features Safety Continuity of adjacent sections Continuity of adjacent lanes Roadway geometrics	No difference between alternatives	
Noneconomic	Noise issues Local preference	Not considered	

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Pavement Type Selection Report Card

	West Rockford – IL-47	Center IL-47 to Randall	East Randall to O'Hare
2-Lift Composite Jointed Concrete	3.16 B	3.21 B	3.02 B
Continuously Reinforced Concrete	3.00 B	3.00 B	2.99 B-
Full Depth Asphalt	3.02 B	3.03 B	2.83 B-
Composite Asphalt/Jointed Concrete	2.43 C+	2.42 C+	2.38 C+
Composite Asphalt/Cont. Reinforced	2.34 C+	2.36 C+	2.34 C+

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The Illinois Tollway

DRIVING THE FUTURE

THANK YOU