Concrete Pavement Thickness Design & Slab Geometry

Tyler Speakmon, PhD
Infrastructure Solutions Engineer
CEMEX USA – Commercial Cement

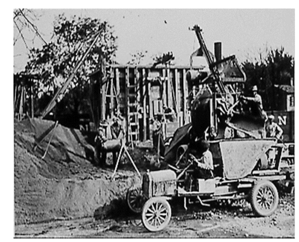
Agenda

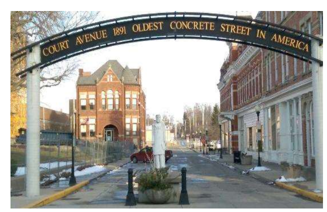
- Review of Pavement Design History & Pavement Types
- Distresses Related to Pavement/Slab Geometry
- Compare AASHTO 93 vs Pavement ME Designs
- Incorporating Slab Geometry into Design Tools
- Using Slab Geometry to Control Cracking Mechanisms
  - Thickness
  - Joint Spacing
  - Widened Lanes
- Additional Design Considerations and Jointing

In The Beginning…

Early Concrete Pavement Details

- The first concrete pavements/slabs were:
  - ≈ 6” thick… no real structural design
  - 6’ to 8’ slabs
  - No crack control joints or dowels/steel

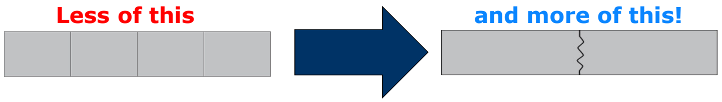




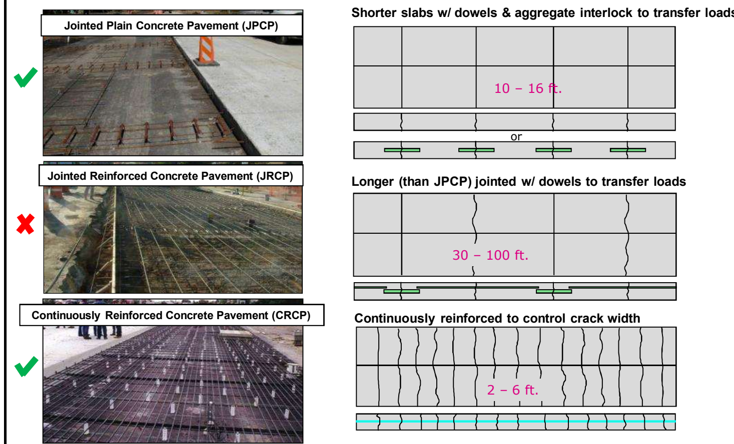
Design Challenge | Solution

- Vehicles Speeds Increased
- Loads Increased

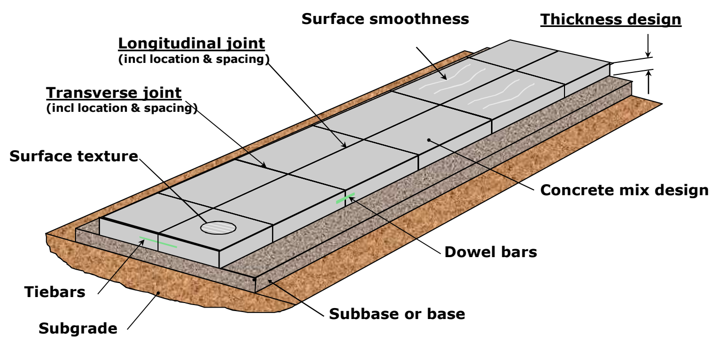
- People Noticed Joint Roughness & Wanted to Maximize Production to Minimize Cost | Minimize Construction Joints



CONCRETE PAVING SOLUTIONS USING CONVENTIONAL CONCRETE

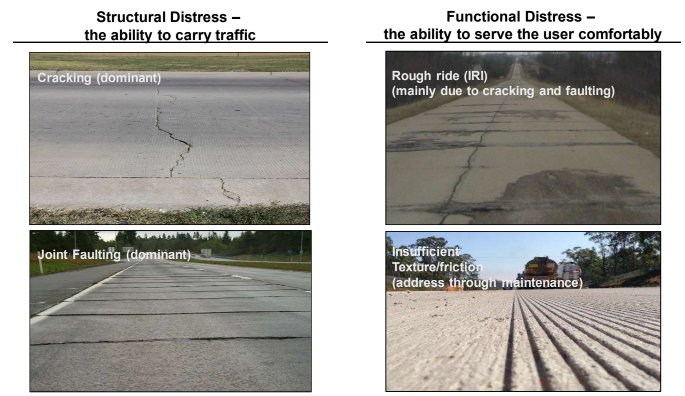


JOINTED PLAIN CONCRETE PAVEMENTS (JPCP) – Key Design Items



Design requires understanding how design features impact cost and performance
(and getting the right balance for the application)

Design also Requires an Understanding of How a Concrete Pavement Fails…



Rigid Pavement Design Tools/Methods

AASHTOWare Pavement ME (previously known as DARWin-ME and MEPDG)

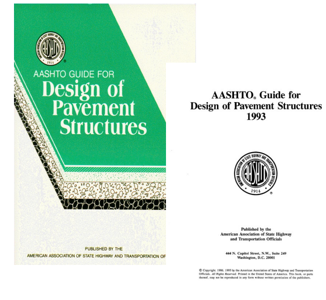
AASHTO 93 (software as ACPA WinPAS)

PavementDesigner.org

StreetPave12 Structural Design Software for Street and Road Concrete Pavements

aci 325 & 330

AASHTO 93 / WinPAS



Equivalent Single Axle Loads (ESALs)

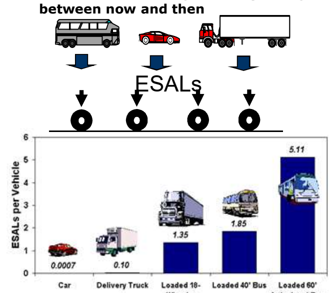
- ESAL = # of 18 kip (8,165 kg) equivalent single axles needed to cause same "response"
  - Because pavement responses are different for concrete and asphalt, ESALs are different for the same exact traffic loading… **ESAL ≠ traffic**
  - ESALs depends on thickness, among other things
- Flexible ESALs generally about 1/3 less than rigid ESALs for highway-type traffic; NEVER COMPARE RIGID & FLEXIBLE ESALs

TRAFFIC IS THE MAIN SOURCE OF DAMAGE FOR PAVEMENTS

The Magnitude of Damage Depends on Vehicle Number, Type, and Load

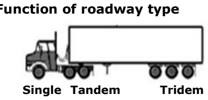
Equivalent Single Axle Loads (ESALs)

- Assumes traffic is only 18,000 lbs single axles
- Conversion of trucks to ESALs is empirical
  - Based on field test conducted 50 years ago
  - Traffic conditions significantly changed between now and then



Load Spectrum

- Consider traffic composed of axles w/ different weights
- Required inputs:
  - Number of trucks
  - Axle load spectrum
    - Function of roadway type



Axle load, kips	Axles / 1000 trucks
Single Axles	
26	0.07
24	1.6
22	2.6
20	6.63
18	16.61
16	23.88
14	47.76
12	116.76
10	142.7
8	233.6

Axle load, kips	Axles / 1000 trucks
Tandem Axles	
44	1.16
40	7.76
36	38.79
32	54.76
28	44.43
24	30.74
20	45
16	59.25
12	91.15
8	47.01

1986-93 JPCP AASHTO 93 Equation

Standard Normal Deviate · Overall Standard Deviation · **Thickness** · Change in Serviceability · Traffic

$$Log(ESAL) = Z_R * s_o + 7.35 * Log(D+1) - 0.06 + \left[\frac{Log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1+\frac{1.624*10^7}{(D+1)^{8.46}}}\right]$$

Terminal Serviceability · Modulus of Rupture · Drainage Coefficient · Load Transfer · Modulus of Elasticity · Modulus of Subgrade Reaction

$$+(4.22-0.32*p_t)*Log\left[\frac{S_c' * C_d * (D^{0.75}-1.132)}{215.63*J*\left[D^{0.75}-\frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$

WHAT DO DESIGNERS FOCUS ON?

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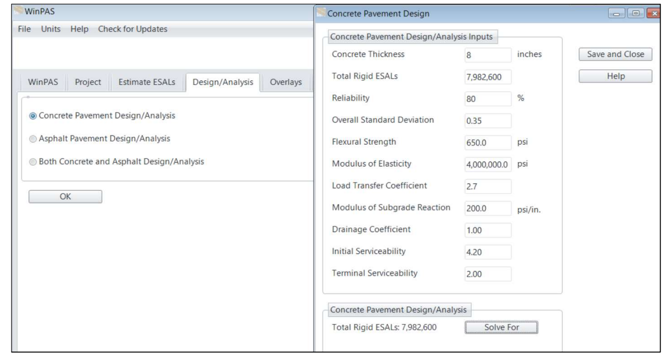
WinPAS Makes it Easy!



AASHTO 93 Slab Geometry involved => Thickness

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Concrete Pavement Design Methodologies

Outdated | THE 40 YEAR DIVIDE | *Current Design Tools*

AASHTO 93	StreetPave	PavementDesigner	OptiPave	Pavement ME
1962-1998	2005-2017	2018 - Present	2009 - 2018	2009-2018
10 inputs	12 inputs	12 inputs	≈ 50 inputs	≈ 1,000 inputs
"Performance"	Crack & Fault	Crack & Fault	Crack, Fault, IRI	Crack, Fault, IRI
Field Data	FEA + Field Data	FEA + Field Data	FEA + Field Data	FEA + Field Data

Increasing Complexity = More Accurate Models & More *Optimization*

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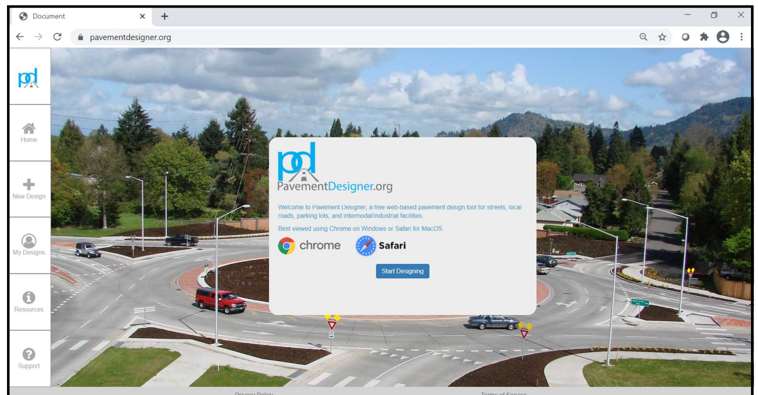

Industry Developed Methods

PavementDesigner.org

PavementDesigner.org

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PavementDesigner.org Background

A free tool designed to simplify concrete pavement design for:

- Parking lots
- Roadways (JPCP, RCC, CRCP, Overlays Unbonded & Bonded)
- Industrial / Intermodal yards (Forklifts & Specialty Equipment)

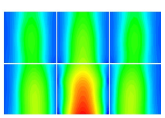
Uses More Accurate Traffic Inputs

PD.org Slab Geometry => Thickness & Joint Spacing

MEPDG / DARWin-ME / AASHTOWare Pavement ME

Pavement ME Design

- Not "perfect" & not intended to be a "final" product
- Complex and relatively costly
- Primarily for high volume roadways



Mechanistic Calculation of Responses

+

Empirical Tie to Ground

=

Pavement Performance Prediction

Sounds Easy Enough, Right?

$$Fault_m = \sum_{i=1}^{m} \Delta Fault_i$$

$$\Delta Fault_i = C_{34} * (FAULTMAX_{i-1} - Fault_{i-1})^2 * DE_i$$

$$FAULTMAX_i = FAULTMAX_0 + C_7 * \sum_{j=1}^{m} DE_j * Log(1 + C_5 * 5.0^{EROD})^{C_6}$$

$$FAULTMAX_0 = C_{12} * \delta_{curling} * \left[Log(1 + C_5 * 5.0^{EROD}) * Log\left(\frac{P_{200} * WetDays}{p_s}\right)\right]^{C_6}$$

$$\sigma_0 = \frac{E_{PCC}\Delta\varepsilon_{tot}}{2(1-\mu_{PCC})}$$

$$IRI = IRI_I + C1*CRK + C2*SPALL + C3*TFAULT + C4*SF$$

$$SCF = -1400 + 350 \cdot AIR\% \cdot (0.5 + PREFORM) + 3.4 f'c \cdot 0.4 - 0.2\,(FTCYC \cdot AGE) + 43\, h_{PCC} - 536\, WC\_Ratio$$

$$cw = Max\left(L \cdot \left(\varepsilon_{shr} + \alpha_{PCC}\Delta T_{\zeta} - \frac{c_2 f_{\sigma}}{E_{PCC}}\right) \cdot 1000 \cdot CC,\ 0.001\right)$$

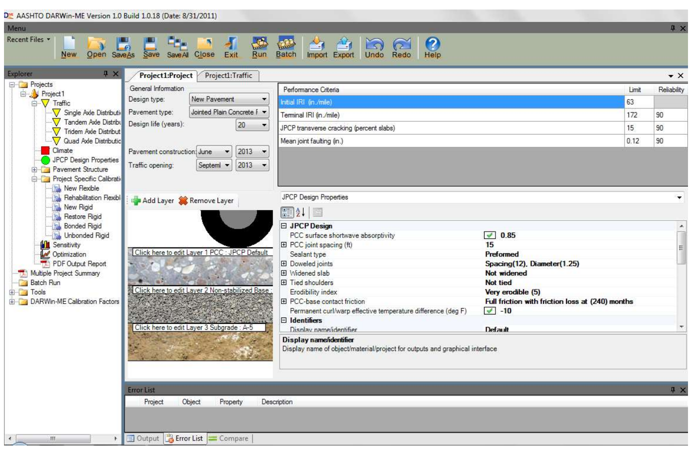
MEPDG / DARWin-ME / AASHTOWare Pavement ME

Concrete Pavement Design Options

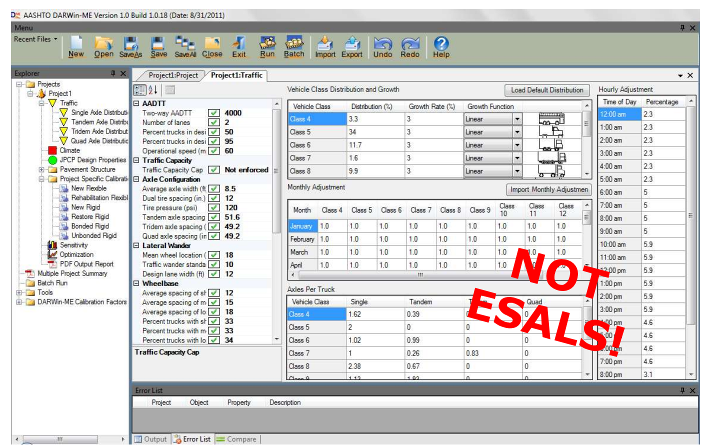
Pavement ME's Concrete Pavement Designs

- New Pavement
  - Jointed Plain Concrete Pavement (JPCP)
  - Continuously Reinforced Concrete Pavement (CRCP)
- Overlay
  - Bonded PCC over JPCP or CRCP
  - Unbonded JPCP or CRCP over JPCP or CRCP
  - JPCP over AC
  - CRCP over AC
  - SJPCP over AC
- Rehabilitation

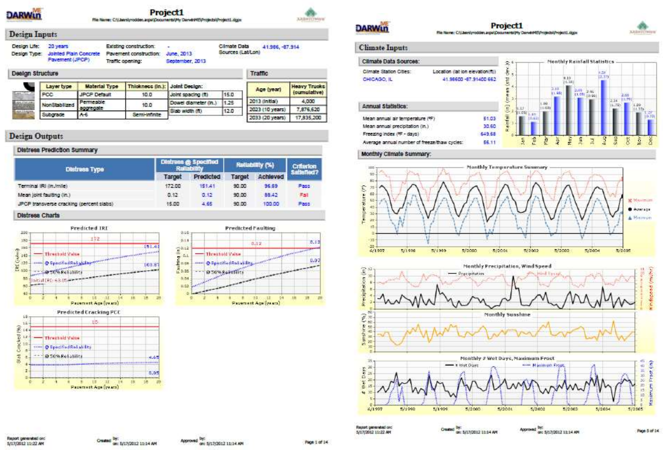
Pavement ME Inputs…



EXACT Traffic Inputs…



Pavement ME Outputs…



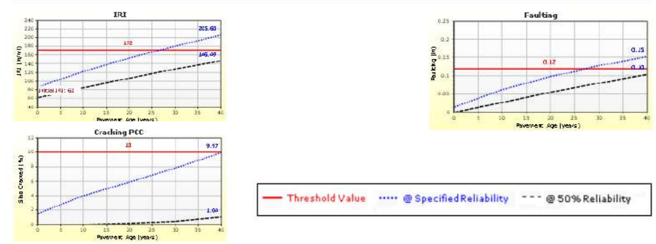
Pavement ME Performance Outputs

Design Outputs

Distress Prediction Summary

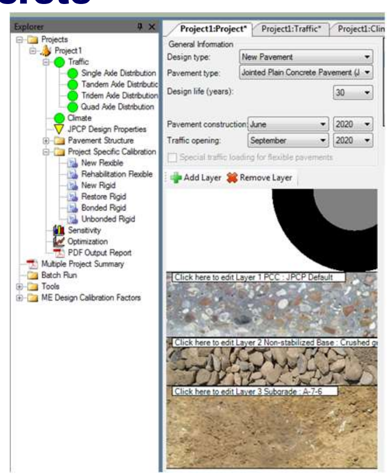
Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	205.60	90.00	70.99	Fail
Mean joint faulting (in)	0.12	0.15	90.00	66.92	Fail
JPCP transverse cracking (percent slabs)	10.00	9.97	98.00	98.03	Pass

Distress Charts

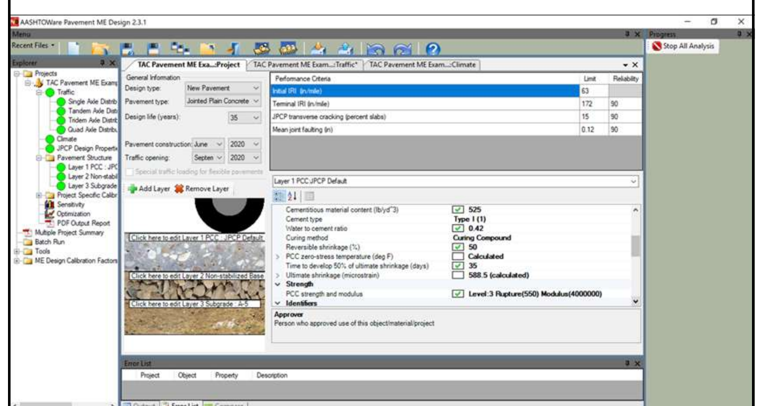


Jointed Plain Concrete Pavement (JPCP)

- JPCP Design Process
  - General Info and Performance Criteria
  - Traffic Details
  - Climate
  - Characterizing Pavement Structure
  - **JPCP Design Properties**



JPCP – Characterizing Pavement Structure



JPCP – Pavement Structure – PCC Materials

PCC	
Poisson's ratio	☑ 0.2
Thickness (in)	☑ 11
Unit weight (pcf)	☑ 150
Thermal	
PCC coefficient of thermal expansion (in/in/deg F x 10^-6)	☑ 5.5
PCC heat capacity (BTU/lb-deg F)	☑ 0.28
PCC thermal conductivity (BTU/hr-ft-deg F)	☑ 1.25
Mix	
Aggregate type	Limestone (1)
Cementitious material content (lb/yd^3)	☑ 525
Cement type	Type I (1)
Water to cement ratio	☑ 0.42
Curing method	Curing Compound
Reversible shrinkage (%)	☑ 50
PCC zero-stress temperature (deg F)	☐ Calculated
Time to develop 50% of ultimate shrinkage (days)	☑ 35
Ultimate shrinkage (microstrain)	☐ 588.5 (calculated)
Strength	
PCC strength and modulus	☑ Level:3 Rupture(550) Modulus(4000000)

Let's Break it Down

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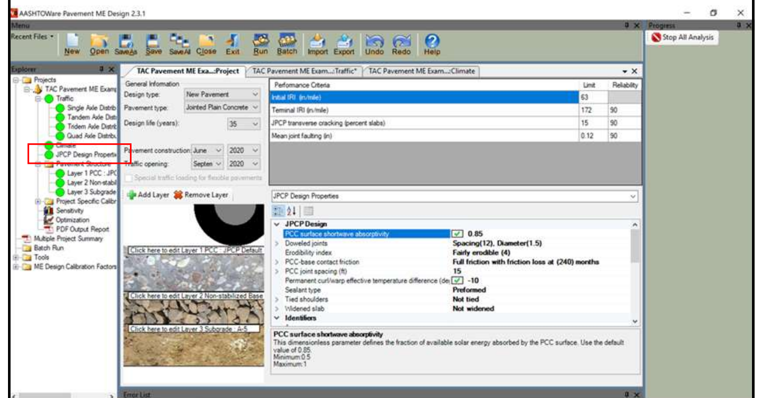
JPCP – Design Properties



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JPCP – Design Properties

JPCP Design	
PCC surface shortwave absorptivity	☑ 0.85
Doweled joints	Spacing(12), Diameter(1.5)
Erodibility index	Fairly erodible (4)
PCC-base contact friction	Full friction with friction loss at (240) months
PCC joint spacing (ft)	15
Permanent curl/warp effective temperature difference (de	☑ -10
Sealant type	Preformed
Tied shoulders	Not tied
Widened slab	Not widened

Let's Break it Down

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JPCP – Design Properties

JPCP Design	
PCC surface shortwave absorptivity	☑ 0.85
Doweled joints	Spacing(12), Diameter(1.5)

- SSA
  - 0.85 (Default and semi-constant)
- Doweled Joints
  - Typically used if thickness > 8 in
- Diameter
  - Often depends on thickness
    - 1 inch for 8 inches or less thickness
    - 1.25 inches for 8 – 10 inches thickness
    - 1.5 inches for >10 inches
- Spacing
  - 12 inches is most common

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JPCP – Design Properties

Erodibility index	Fairly erodible (4)
PCC-base contact friction	Full friction with friction loss at (240) months
PCC joint spacing (ft)	15

- Erodibility
- Base Friction
- **Joint Spacing**

- Depends on soil conditions
- Good defaults
- Typical range = 12 – 20 ft

JPCP – Design Properties

Permanent curl/warp effective temperature difference (de	-10
Sealant type	Preformed
Tied shoulders	Not tied
Widened slab	Not widened

- Curl/Warp Temp.
- Sealant Type
- Tied Shoulder
- **Widened Slab**

- -10ºF (Good default)
- Preformed or Other (none, liquid, silicone)
- Project dependent
- Project dependent

Pavement ME Slab Geometry Inputs include Thickness, Joint Spacing, Lane Width

Summary of Unique JPCP Critical Inputs

- Performance Criteria
  - IRI, Cracking, Faulting
- **Thickness**
- **Joint Spacing**
- **Lane Width**
- **Shoulder Type**
- **Dowel Design**

- PCC Strength
- PCC Modulus
- Coef. of Thermal Exp.
- Curing Method
- Base Erodibility
- Mix Design (Cement type, w/cm, etc.)

BOLD *=> Inputs Related to Slab Geometry*

SHORT JOINT SPACING IMPROVES JPCP PERFORMANCE

Reduces Shrinkage Force

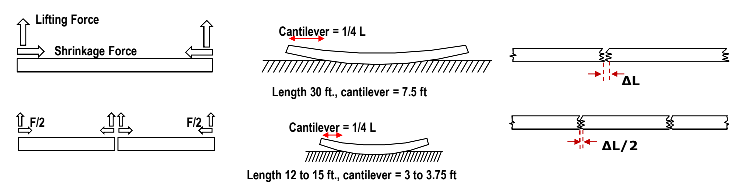
- Curling & warping is due to the differential drying and thermal shrinkage at the slab surface
- Shorter slabs have less length, which means reduced curling

Reduces Environmental Stress

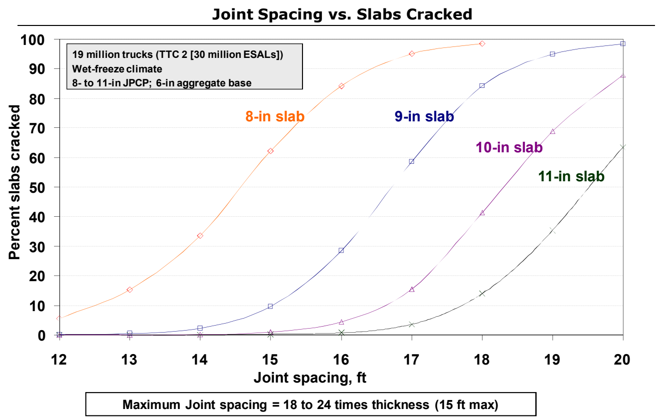
- ~1/4 of slab length is cantilever
- Reducing unsupported length reduces the bending stress
- Reducing length reduces uplift and improves smoothness

Improves Load Transfer

- Shorter slabs have smaller joint/crack opening
- Agg. Interlock stronger for tighter cracks
- High load transfer results in less stress in concrete

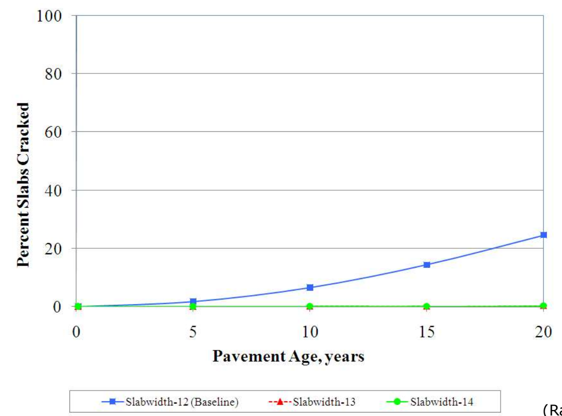


SHORT JOINT SPACING REDUCES SLAB CRACKING



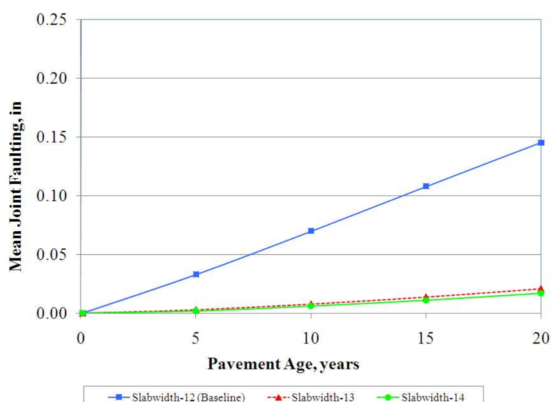
Graph Developed by Tommy E. Nantung
INDOT Office of Research and Development

Engineering Solutions – Widened Slab Example



(Rao, 2018)

Engineering Solutions – Widened Slab Example



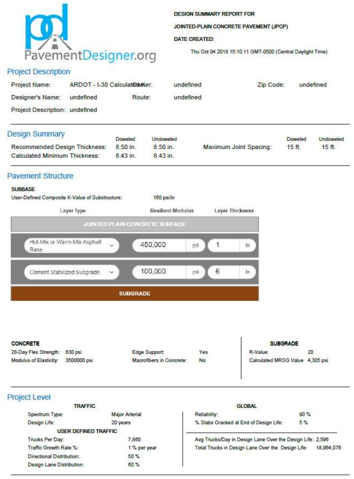
(Rao, 2018)

Engineering Solutions – Widened Slab Example

- Widening the slab reduces longitudinal edge midpanel stresses but this could increase stresses in other locations not considered in Pavement ME
- With 14 ft wide slab there is a much higher risk of longitudinal cracking due to increased stresses at interior transverse joint edge locations

(Rao, 2018)

Highway Design Problem



DESIGN SUMMARY REPORT FOR

JOINTED-PLAIN CONCRETE PAVEMENT (JPCP)

DATE CREATED:

Thu Oct 04 2018 15:10:11 GMT-0500 (Central Daylight Time)

PavementDesigner.org

Project Description

Project Name: ARDOT - I-30 Calculator Owner: undefined Zip Code: undefined

Designer's Name: undefined Route: undefined

Project Description: undefined

Design Summary

	Doweled	Undoweled		Doweled	Undoweled
Recommended Design Thickness:	8.50 in.	8.50 in.	Maximum Joint Spacing:	15 ft.	15 ft.
Calculated Minimum Thickness:	8.43 in.	8.43 in.			

Pavement Structure

SUBBASE

User-Defined Composite K-Value of Substructure: 160 psi/in

Layer Type	Resilient Modulus	Layer Thickness
JOINTED PLAIN CONCRETE SURFACE		
Hot-Mix or Warm-Mix Asphalt Base	450,000 psi	1 in
Cement Stabilized Subgrade	100,000 psi	6 in
SUBGRADE		

CONCRETE

28-Day Flex Strength: 630 psi

Modulus of Elasticity: 3500000 psi

Edge Support: Yes

Macrofibers in Concrete: No

SUBGRADE

R-Value: 20

Calculated MRSG Value: 4,305 psi

Project Level

TRAFFIC

Spectrum Type: Major Arterial

Design Life: 20 years

USER DEFINED TRAFFIC

Trucks Per Day: 7,860

Traffic Growth Rate %: 1 % per year

Directional Distribution: 50 %

Design Lane Distribution: 60 %

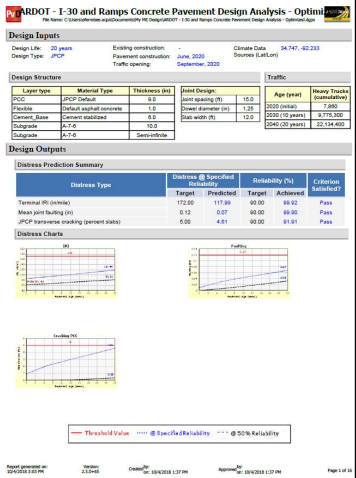
GLOBAL

Reliability: 90 %

% Slabs Cracked at End of Design Life: 5 %

Avg Trucks/Day in Design Lane Over the Design Life: 2,596

Total Trucks in Design Lane Over the Design Life: 18,964,076



ARDOT - I-30 and Ramps Concrete Pavement Design Analysis - Optimi

File Name: C:\Users\eferrebee.acpa\Documents\My ME Design\ARDOT - I-30 and Ramps Concrete Pavement Design Analysis - Optimized.dgpx

Design Inputs

Design Life: 20 years

Design Type: JPCP

Existing construction: -

Pavement construction: June, 2020

Traffic opening: September, 2020

Climate Data Sources (Lat/Lon): 34.747, -92.233

Design Structure

Layer type	Material Type	Thickness (in)
PCC	JPCP Default	9.0
Flexible	Default asphalt concrete	1.0
Cement_Base	Cement stabilized	6.0
Subgrade	A-7-6	10.0
Subgrade	A-7-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	12.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2020 (initial)	7,860
2030 (10 years)	9,775,300
2040 (20 years)	22,134,400

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	117.99	90.00	99.92	Pass
Mean joint faulting (in)	0.12	0.07	90.00	99.90	Pass
JPCP transverse cracking (percent slabs)	5.00	4.61	90.00	91.91	Pass

Distress Charts

IRI

Faulting

Cracking PCC

Threshold Value @ Specified Reliability @ 50% Reliability

Report generated on: 10/4/2018 3:03 PM Version: 2.3.0+65 Created by: on: 10/4/2018 1:37 PM Approved by: on: 10/4/2018 1:37 PM Page 1 of 16

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Additional Design Considerations Related to Slab Geometry

- Dowels
  - Dowel Spacing
  - Dowel Bar Diameter
- Edge Support
- Tie Shoulders
- Jointing Layouts

- …CRCP Design Properties

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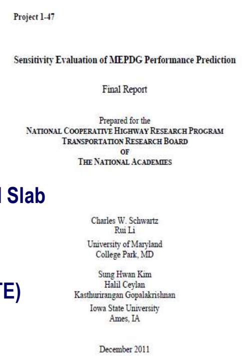
Top 10 ME Design Most Sensitive

1. **Concrete Flexural Strength at 28-Days**
2. Concrete Thickness
3. **Surface Shortwave Absorptivity (SSA)**
4. **Joint Spacing**
5. **Concrete Modulus of Elasticity at 28-Days**
6. **Design Lane Width with a 14 ft (4.3 m) Widened Slab**
7. **Edge Support via Widened Slab**
8. **Concrete Thermal Conductivity**
9. **Concrete Coefficient of Thermal Expansion (CTE)**
10. **Concrete Unit Weight**



Project 1-47

Sensitivity Evaluation of MEPDG Performance Prediction

Final Report

Prepared for the
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSPORTATION RESEARCH BOARD
OF
THE NATIONAL ACADEMIES

Charles W. Schwartz
Rui Li
University of Maryland
College Park, MD

Sung Hwan Kim
Halil Ceylan
Kasthurirangan Gopalakrishnan
Iowa State University
Ames, IA

December 2011

http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP01-47_FR.pdf

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Engineering Solutions - Faulting

- Improve Mechanical LT
  - Increase Dowel Size
  - Decrease Dowel Spacing
- Decrease Joint Spacing
- Increase Width of Lanes
- Reduce Underlying Layer Erosion
  - Increase Erodibility Index
  - Decrease Joint Spacing
- Reduce Thickness
  - Only if Cracking is Passing

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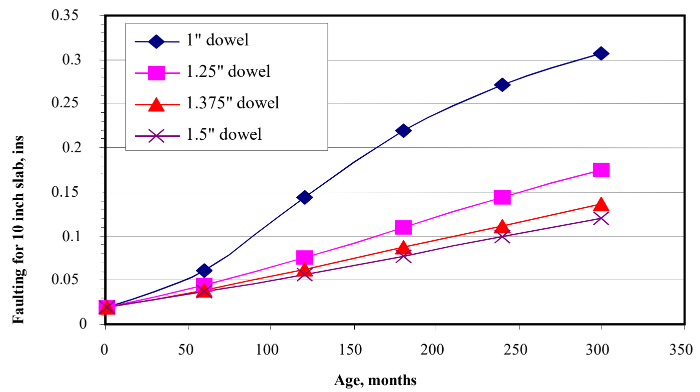
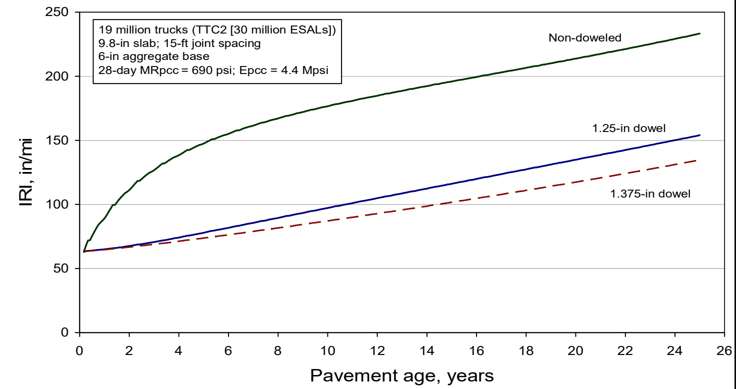
Sensitivity of JPCP Faulting to Dowel Diameter



Sensitivity of JPCP IRI Sensitivity to Dowels



Sounds Easy Enough, Right?

$$Fault_m = \sum_{i=1}^{m} \Delta Fault_i$$

$$\Delta Fault_i = C_{34} * (FAULTMAX_{i-1} - Fault_{i-1})^2 * DE_i$$

$$FAULTMAX_i = FAULTMAX_0 + C_7 * \sum_{j=1}^{m} DE_j * Log(1 + C_5 * 5.0^{EROD})^{C_6}$$

$$FAULTMAX_0 = C_{12} * \delta_{curling} * \left[Log(1 + C_5 * 5.0^{EROD}) * Log\left(\frac{P_{200} * WetDays}{p_s}\right) \right]^{C_6}$$

$$\sigma_0 = \frac{E_{PCC} \Delta \varepsilon_{tot}}{2(1 - \mu_{PCC})}$$

$$IRI = IRI_I + C1*CRK + C2*SPALL + C3*TFAULT + C4*SF$$

$$SCF = -1400 + 350 \cdot AIR\% \cdot (0.5 + PREFORM) + 3.4 f'c \cdot 0.4 - 0.2\,(FTCYC \cdot AGE) + 43\, h_{PCC} - 536\, WC\_Ratio$$

$$cw = Max\left(L \cdot \left(\varepsilon_{shr} + \alpha_{PCC} \Delta T_{\zeta} - \frac{c_2 f_{\sigma}}{E_{PCC}} \right) \cdot 1000 \cdot CC,\ 0.001 \right)$$

Continuously Reinforced Concrete Pavement (CRCP)

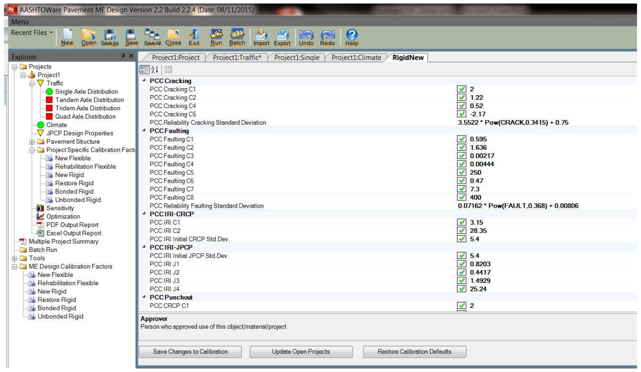
- Resources: Check out crcpavement.org for more!

Rasmussen et al. (2011) Roesler & Hiller (2013) Roesler et al. (2016)

CRCP Design Properties Related to Slab Geometry

- **Lane Width**
- Crack Spacing (Dependent on Steel Design & Base Friction)
- Steel Design
  - % Steel
  - Bar Diameter
  - Bar Depth
- Base Friction Coefficient
- Shoulder Type

Pavement ME Allows Agencies To Develop And Use Local Calibration Coefficients



You can save your local calibration coefficients as default or restore the national as default at one click

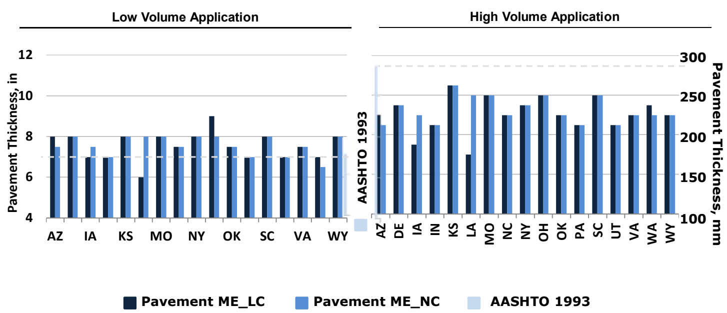
Local Calibration Examples

- Indiana DOT:
  - Changed JPCP IRI J3 from 1.4929 to 1.05 because it was too sensitive to it
- Ohio DOT:
  - Changed JPCP IRI calibrations

Calibration Coefficient	Default (national)	Ohio
PCC IRI J1	0.8203	0.82
PCC IRI J2	0.4417	3.7
PCC IRI J3	1.4929	1.711
PCC IRI J4	25.24	5.703
PCC IRI JPCP Standard Deviation	5.4	5.4

- Many states at this point are working on or have completed local calibrations.

Local Calibration Result In ½-In Or Less Difference In Required Thickness Vs. National Calibration



However, using Pavement ME result in ~2-3 in thinner JPCPs when compared to the AASHTO 93 guide.

(Mu, 2017)

Simpler ME Option: Design Tables

			Collector		Minor Arterial					
			Average Annual Daily Truck Traffic (AADTT) - 25 Year Pavement D[illegible]							
			250	500	1,000	1,500	2,500	[illegible]	[illegible]	[illegible]
Subgrade Strength	30 MPa (CBR=3)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 [illegible] 200 m[illegible]	[illegible]	[illegible]
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm SP 12.5 FC1 90 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 110 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm [illegible] 120 [illegible] 150 m[illegible] 600 m[illegible]	[illegible]	[illegible]
	40 MPa (CBR=4)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 [illegible] 200 m[illegible]	[illegible]	[illegible]
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm [illegible] 120 [illegible] 150 m[illegible] 450 m[illegible]	[illegible]	[illegible]
	50 MPa (CBR=5)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 [illegible] 200 m[illegible]	[illegible]	[illegible]
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 110 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm SP 12.5 FC1 130 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC2 140 mm SP 19 150 mm Granular A 500 mm Granular B
Concrete Slab and Joint Properties			No dowels Slab length = 4 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m 0.5 m Widened outside slab or integral curb *	

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Conclusions:

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- Slab Geometry is KEY to Optimizing Pavement Designs
- Thickness is not the ONLY Slab Geometry that Improves Performance
- Shorter Joint Spacings & Widened Lanes Improve Pavement Performance
- Improvements in Design Tools, such as Pavement ME, have allowed Designers to Utilize all aspects of Slab Geometry to Yield more Economical and Better Performing Concrete Pavements

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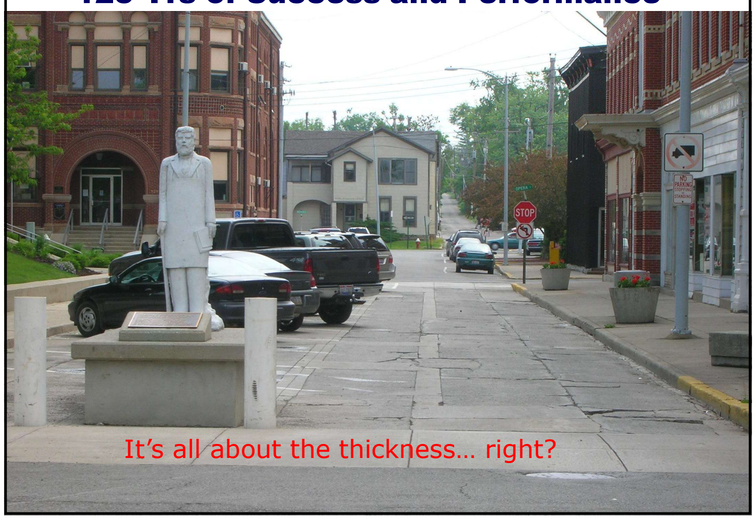
125 Yrs of Success and Performance



Acknowledgements & References

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- Mu, Feng 2017. *Establish Pavement ME Design Inputs for New Jointed Plain Concrete Pavements*, Presentation to TAC Pavement ME User Group Meeting, 4-21-2017.
- Rao, Shreenath 2018. Pavement ME Design – 3M Edition – Myths, Misuses, & Misconceptions, Presentation to 2018 CO/WY ACPA Meeting, 3-22-2018.
- Donahue, John & Jason Bloomberg 2018. *AASHTO Pavement ME Design Web Application JPCP Module*, Presentation to MO/KS ACPA's 38th Annual PCCP Conference, 2-20-2018.

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Resources

- NCHRP 1-37 MEPDG Home: http://onlinepubs.trb.org/onlinepubs/archive/mepdg/guide.htm
- Recorded Webinars: https://www.fhwa.dot.gov/pavement/dgit/aashtoware.pdf
- North American Usergroup Summary Page: http://www.pooledfund.org/Details/Study/549
- ME Design Help: http://www.me-design.com/MEDesign/data/HTML%20Help/US/index.html?design_inputs_1.htm
- Application Library: http://apps.acpa.org/

Resources

- Some States with Pavement ME User Guides
  - Michigan: https://www.michigan.gov/documents/mdot/MDOT_Mechanistic_Empirical_Pavement_Design_User_Guide_483676_7.pdf
  - Colorado: https://www.codot.gov/business/designsupport/matgeo/manuals/pdm/2017-m-e-pavement-design-manual/chapter-1.pdf
  - Indiana: http://www.in.gov/indot/design_manual/files/Ch304_2013.pdf
  - Arizona: https://apps.azdot.gov/ADOTLibrary/publications/project_reports/PDF/AZ606.pdf
  - Virginia: http://www.virginiadot.org/VDOT/Business/asset_upload_file108_3638.pdf
  - Utah: https://www.udot.utah.gov/main/uconowner.gf?n=20339215312776663

Q&A / Discussion

Thank you !