

#### **IRISE** Projects:

#### Customizing Rigid Pavement ME and Early Opening to Traffic Study

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# Rigid Pavement Design

- The current Pennsylvania design method for rigid pavements is outdated
  - AASHTO 93-based procedure (1960-s technology)
  - Not cost-effective: many empirical evidences of overdesign built into AASHTO 93
- Pennsylvania is considering a transition to AASHTO ME design, which requires the user:
  - to provide many inputs thus increasing possibilities of the design errors
  - to use AASHTOWare Pavement ME software with annual license fees



# Why AASHTO ME Design?



### Pavement ME JPCP Design Inputs

G	noral IDCD inputs	~	JPCP Design							
Ge	eneral JPCP inputs		PCC surface shortwave absorptivity		✓ 0.85					
		>	Doweled joints		Spacing(1	12), Diameter(1.25)				
			Erodibility index		Erosion re	esistant (3)				
		2	PCC-base contact friction		Full frictio	on with friction loss at (0) mon	iths			
	/	5	PCC joint spacing (ft)		15					
		1	Permanent curl/warp effective temperature different	ence (deg F)	✓ -10					
Sealant type					Other(Including No Sealant Liquid Silicone)					
✓ Tied shoulders			Tied shoulders		Tied with long term load transfer efficiency of 50					
			Tied shoulders		True					
			Load transfer efficiency (%)		✓ 50					
		>	Widened slab		Not wider	ned				
	•//	_	·· ·-							
✓ Do	weled joints			Spacing(12), Diameter(1.25)						
	Dowel diameter (in)	_/		✓ 1.25	Dow	el bar desian				
	Dowel spacing (in)			✓ 12		ci bai acsign				
	Is joint doweled ?	1		Irue						
		/								
~ P	CC-base contact friction			Full friction with friction loss at (0)	months	PCC-base bondir	na			
	PCC-Base full friction contact			True			-3			
	Months until friction loss			✓ 0		conditions				
	Unbonded JPCP			False						
_	* /									
✓ PC	CC joint spacing (ft)			15						
	Is joint spacing random ?			False						
	Spacing of Joint 1				lain	tengeing				
	Spacing of Joint 2				JOIN	rspacing				
	Spacing of Joint 3									
	Spacing of Joint 4									
	Joint spacing (ft)			✓ 15						
✓ Tie	ed shoulders			Tied with long term load transfer ef	ficiency of	f 50				
	Tied shoulders			True						
	Load transfer efficiency (%)			✓ 50		Shoulder type and				
✓ W	idened slab			Not widened						
	Is slab widened ?			False		lane width				
	Slab width (ft)			✓						
					. –					

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### **Pavement ME Climate Inputs**

	a 2↓ 🖻					iummary Hourly climate data	а		
r	✓ Climate State	tion				2 2↓ 🖻			
	Elevation		1240			Climate Summany			
	Climate statio	on	PITTSBL	JRGH_NARR_GRIDP	OINT,PA (	<ul> <li>Mean annual air temper</li> </ul>	ature (deg E)	51.5	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
	Latitude (dec	imals degrees)	40.35			Mean annual precipitatio	on (in)	38.2	
	Longitude (de	ecimal degrees)	-79.92	-		Ereezing index (deg E -	davs)	500.6	
	Depth of wate	er table (ft)	🖌 Annual(	(10)		Average appual number	of freeze/thaw cycles	64.7	
	✓ Identifiers					Number of wet days		200.7	
1	Approver		0 (10 (0010 )	0.00 014		<ul> <li>Monthly Temperatures</li> </ul>	idea pl       115         inp.       132         inp.       132         inp.       132         inp.       124         inp.       124		
	Date approve	d	2/12/2019 4	2:09 PM		Average temperature in	January (deg F)	27.4	
	Author		2/12/2010 2	2.00 DM		A	eu d'en	20 F	•
	County		2/12/2013 2	2.03 ГМ		Mean annual air temperat	ture (deg F)		
	Description	fobject							
	Direction of t	ravel							
	Display name	e/identifier							
	District					pennsylvania		h i r A	
	From station	(miles)				Use custom hcd folder	The The S	a man interest	
	Item Locked?	>	False			Correct for elevation at	t project location	Theready	the second secon
	Highway						Allegheny		
	Revision Nur	nber	0				National	Tioga State	
	State						Porest	Susquehannock Forest	Sol for
	To station (m	iles)				K. Jahren	and all	Elk State	The stand the stand
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	User defined	tield 3				1 million	Motha	naan Star Star Will	Wilkes Barre
Summany Hourly climate data						for	State F	orest State Forest	Miles Darre
Summary							- Cart	and a start the former	She was he have
January /1979		June /2015				Verify Weath	her		The second
Date/Hour Ter F)	mperature (deg (deg F)	Wind Speed (mph)	Sunshine (%)	Precipitation (in.)	Humidity (%	) Water Table (ft)	· monther	Bald Eagle State Forest	Hazleton
1/1/1979 12:00:00 AM 39.4	4	18	0	0	93	10	HAY I	Centra Collinga	B AN
1/1/1979 1:00:00 AM 39.7	7	19	0	0.05	93	10	2 and 2	state Conege	and the
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1/1/1979 2:00:00 PM 41.9	9	11	0	0	85	10			
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#### **Pavement ME Traffic Inputs**

ATPB+2A Subbase:Project ATPB+2A Subbase:Traffic														
	and Grov	vth						Load Defa	ault Distributior	1	Hourly Adjustment			
V AADTT	Vehicle Cla	55	Distrib	ution (%)	Grow	th Rate (%)	0	Frowth Function	n			~	Time of Day	Percentage
Two-way AADTT 2000	Class 4		3.3	auon ()	2	(	li	near	~	<u>p</u>			12:00 am	2.3
Number of lanes 4 Percent trucks in design dirs 50	Class 5		3/		2		1	near					1:00 am	2.3
Percent trucks in design lan V 95	Class J		11.7		-			lical	× ·	L			2:00 am	2.3
Operational speed (mph) 🗹 60			11.7										3:00 am	2.3
✓ Traffic Capacity	Class /		1.6	Annu	aı gr	owth	rate	•	~	-006	* <b>E</b>		4:00 am	23
Avia Configuration	Class 8		9.9		-				~	0	<b>0</b> -0		5:00 am	2.0
Average axle width (ft)	Class 9		36.2		2		Li	near	$\sim$				5.00 am	2.3
Tandem axle spacing (in) 🗹 51.6	Class 10		1		2		Li	near	~		-		6:00 am	5
Dual tire spacing (in) 12	Class 11		1.8		2		نا	near	~		<u> </u>		7:00 am	5
Quad axle spacing (in)	Class 12		0.2		2		Li	near	~		ľ.		8:00 am	5
Tridem axle spacing (in) 492	Maathly Adia						_			<u> </u>	101 m		9:00 am	5
✓ Lateral Wander	Monthly Adju	istment								Import Mo	onthly Adjustme	en	10:00 am	5.9
Design lane width (ft) 12	Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	^	11:00 am	5.9
Mean wheel location (in) 18	January	1 1		1	1	1	1	1	1	1	1		12:00 pm	5.9
✓ Wheelbase	February	1 1		1	1	1	1	1	1	1	1		1:00 pm	59
Average spacing of long axle 🖌 18	March	1 1		1	1	1	1	1	1	1	1		2:00 pm	5.0
Average spacing of medium 🖌 15	And	1 1		1					1		1		2.00 pm	5.5
Percent trucks with long axle 61	Apri				Mo	http://www.	Δdi	istmo	nt		1		3:00 pm	5.9
Percent trucks with short av	May	1 1		1	moi	у	Adj	<b>J</b> 31111C	•••		1		4:00 pm	4.6
Average spacing of short ax 🖌 12	June	1 1		1	Fac	tor (N	AAF)				1		5:00 pm	4.6
✓ Identifiers	July	1 1		1			,				1		6:00 pm	4.6
Approver	August	1 1		1	1	1	1	1	1	1	1		7:00 pm	4.6
Date approved 1/1/2011	September	1 1		1	1	1	1	1	1	1	1	v .	8:00 pm	3.1
		1 1			1	1	1	1	1	1			9:00 pm	3.1
County	Actes Fer Th	UCK	<b>C</b> 1		T	1				0.1		-	10:00 pm	31
Description of object Default Traffic File	Vehicle Clas	ss	Single		land	em		ridem		Quad			11:00 pm	2.1
Basic traffic	Class 4		1.62		0.39		0			0			T1.00 pm	3.1
Dasic Iranic	Class 5		2		0		0			0			lotal	100.0
configuration	Class 6		1.02		0.99		0			0				A 1º 1
coningeration	Class 7		1		0.26		0.	83		0			Hourly	Adjustmen
Highway Devicing Number 0	Class 8		2.38		0.67		0			0			Faratava	
State	Class 9		1.13		1.93		0			0			ractors	(NAF)
To station (miles)	Class 10		1 19		1.09		0	89		0				
Traffic Capacity Cap	Class 11		4.29		0.26		0.	06		0				
	Class 11		9.23		0.20		0.	00		0				
			3.52		1.14		0.	00		0		$\mathbf{v}$		
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					-									

#### **Axle spectrum distribution**

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### MnPAVE RIGID

The PAVE Rigid 3.0									
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Project Information	Traffic		100	n	<b>a</b> v	0			
Rigid (Concrete)	HCADT 2000			M	20				
Design Life 35 years	Growth Rate 1.0 %		MnDOT Rigid P	•					
Project Number Letting Date	Number of Lanes (two-way) 2	•	Version 3.0, May 2019						
2/17/2020 ~	Axle Loads MnDOT Averag	of							
Route	Joint Spacing 15 🔻 ft.		Transportation						
Reference Post (RP)	Widened Outer Lane								
to	Tied PCC Shoulder								
District	Structure								
4 🔻	Thickne	ess							
	Material in								
Designer	PCC 8.6								
	Class 5 ~ 4.0	-							
Soils Engineer	Select Granular 12.0	)							
	Subgrade								
Notes									
Ready									

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# Sensitivity Analysis

More than 100 Pavement ME runs for Pennsylvania conditions:

- Climate
- Traffic
- Design features
- Material properties



### **Climate Stations**



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# Effect of Climate Inputs





## **Recommended Climate Regions**



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#### Effect of Base Thickness



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# PittRIGID-ME Design Inputs

- Design reliability
- Two-way AADTT: 0-20,000
- Compound growth rate: 0-10%
- Traffic Patterns:
  - Urban Principal Arterial-Interstate
  - Rural Principal Arterial-Interstate
  - Minor Arterials, Collectors, and Recreational
- Number of lanes: 2, 4, 6, or 8



# PittRIGID-ME Design Inputs (cont.)

- Concrete modulus of rupture and coefficient of thermal expansion
- Shoulder type
- Concrete slab width
- Base type

Other parameters: defaults recommended by ARA, Inc. for Pennsylvania conditions (ARA 2015)



	ck volume ESALS	
🗹 Design	Project name:	Performance models coefficients
Climate region	Region 1: Erie County	rembor deradics
Design life, years	20	
Cracking reliability, %	90 Faulting reliability, % 90	
Two-way AADTT year 1	1000 Compound growth, % 3	
Number of lanes (two-way)	2 Traffic pattern Urban Principal Arterial-Interstate	•
Joint spacing, ft	12 -	
Slab Width	Conventional width (12 ft)	
Shoulder type	Tied PCC -	
Modulus of rupture, psi	631 COTE, 10 <sup>-6</sup> 1/ <sup>0</sup> F 4.5	
Base type	Aggregate	

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# **Comparison of Cracking Predictions**



### **Comparison of Faulting Predictions**



260 million ESALs





# Conclusions

- PittRigid-ME is not intended to replace Pavement ME, but to supplement it
- PittRigid-ME is a simple MEPDG-based design and analysis tool for Pennsylvania concrete pavements
- PittRigid-ME:
  - Matches Pavement ME for the selected sets of inputs
  - Can be expanded for other design inputs
  - Can be updated after local calibration or for improved performance prediction models



#### Early Opening of Concrete Pavements to Traffic



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# The Problem

- Current traffic-opening criteria
  - empirical
  - overly conservative (Crovetti and Khazanovich, 2005)
  - causing unnecessary construction delays and cost
- Concrete strength measurements
  - indirect (based on strength of cast aside beams or cylinders)
  - expensive



"Do not open a new pavement slab to general public traffic or operate paving or other heavy equipment on it for 7 days, or until the concrete has reached a minimum flexural strength meeting the requirements of Table 2301-18, or minimum compressive strength of 3,000 psi; whichever occurs first."

Table 2301-18 Minimum Strength Requirements for Opening Pavements to Construction and to General Public Traffic							
Slab Thickness, in	Flexural Strength, psi						
≤7.0	500						
7.5	480						
8.0	460						
8.5	440						
9.0	390						
≥ 9.5	350						

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### MnROAD Study



#### Loading 2 hours after paving





## MnROAD Study

Loading 3-11 hours after paving



Van Deusen et al, 2018



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# **Project Tasks**

- Task A: Literature review
- Task B: Laboratory and field testing
- Task C: Develop mechanistic-empirical model
- Task D: Conduct traffic simulation
- Task E: Final Report



## **Mechanistic-Empirical Model**



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# **Potential Project Benefits**

- Reduction of construction time and cost
- Reduction of traffic congestion and user cost



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