

Establishing a Validation Procedure for Continuous Friction Measurement Equipment (CFME) Chris Young, RPUG 2024



### **Overview**

➢CFME − How it works and why we care Motivation for Study Site Description Initial Collection Results Pre-Network Collection Results Results Analysis Thoughts at ~2700 Miles Collected



# CFME – How it works

- Continuous measurement
- ➢Tire skewed at 20°
- Dynamic Vertical Load
- Dynamic speed-controlled watering system
- Air & tire temperature monitoring
- Continuous tire pressure monitoring









### Sideways Force Coefficient

$$SFC = \frac{F_S}{F_V}$$

Sideways-force Ratio or Skid Ratio (SR) is:

SR = SFC\*100





# Why do we care about Skid Ratio and CFME?

# ➢Safety

- Nearly 5,700 people are killed and more than 544,700 people are injured in crashes on wet pavement annually."
- "...about 70% of wet pavement crashes can be prevented or minimized by improved pavement friction"

#### -FHWA

https://safety.fhwa.dot.gov/roadway\_dept/pavement\_friction/index.cfm

https://ops.fhwa.dot.gov/weather/weather\_events/rain\_flooding.htm#:~:text=Each%20year%2C%2075%20percent%20of,crashes%20on%20wet%20pavement%20annually.



# Motivation for Study

Precision and bias values are not prescribed in existing standard (AASHTO TP143)

### Solution

- Partner with IDOT to validate the CFME
- Goals
  - Quantify repeatability of our equipment
  - Produce repeatable, reliable results
  - Increase confidence in CFME



# **Description of Testing**

>ICART testing track ➢ Part 1 in October 2023  $\geq$  2 different types of tires (A&B) >3 lanes – CRCP, JPCP, Asphalt  $\geq$  5 passes on each lane per tire (A&B) Part 2 in March 2024  $\geq$ 1 type of tire ▶ 5 passes on each lane

Check repeatability on network level with selected tire



# ICART Track

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CRCP - Turf Drag	CRCP - Smooth Finis with Diamond Groovi	en L	CRCP - Turf Drag with Diamond Grooving	CRCP - Smooth Finish with Diamond Grinding	CRCP - Smooth Finish (Float Only)	CRCP - T	urf Drag
Stone Matrix Asphalt	Stone Matrix Aspha with Artificial Ruttin		Stone Matrix Asphalt	9.5 MM NMAS Dense Graded HMA	Micro surfacing - High Friction (30% Calcine Bauxite + 70% ACBF	Chip Seal with Fog Seal	9.5 MM NMAS Dense Graded HMA
JPCP - Turf Drag	JPCP - Artificial Faulti	ng E E	JPCP - Longitudinal Lining	JPCP - Random Transverse Tining		JPCP - Turf Drag	
800 ft	400 ft	*	780 ft	780 ft	400 ft	400 ft →	400 ft



https://idot.illinois.gov/news/new-test-track-to-aid-pavement-assessment-and-research.html



### **Test Description**

CRCP - Turf Drag with Diamond Grooving

CRCP - Smooth Finish with Diamond Grinding

CRCP - Smooth Finish (Float Only)

- Longitudinal Lining				P	d	Ρ.	Ra	311	ıd	o	n		ſ	n	51	<b>/</b> €	21	5	e	ir	ni	nę	50							JP	<del>СР</del>	-1	ū	ff	Эr,	аį

		Micro surfacing - High
Stone Matrix Asphalt	9.5 MM NMAS Dense Graded HMA	Friction (30% Calcine
		Bauxite + 70% ACBF

1		
780 ft	780 ft	400 ft
		•



# **Results Analysis**

Processed data at 0.001-mile interval in initial testing

Calculated r<sup>2</sup> for all combinations of runs

- Reported median r<sup>2</sup> for each pavement type
- Produced graphs for SR values at each segment
- Calculated average SR for each segment



# Trial Run Results – Tire A

#### AM Runs

Site	Pavement Type	0.001-mile Correlation	0.001-mile Correlation CORRECTED	Average SR CORRECTED
1	CRCP	86.7%	91.8%	74
2	JPCP	61.5%	75.9%	75
3	Asphalt	79.1%	87.6%	73
PM Runs				
Site	Pavement Type	0.001-mile Correlation	0.001-mile Correlation CORRECTED	Average SR CORRECTED
Site 1	Pavement Type CRCP	0.001-mile Correlation 68.7%	0.001-mile Correlation CORRECTED 90.3%	Average SR CORRECTED 74
Site 1 2	Pavement Type CRCP JPCP	0.001-mile Correlation 68.7% 52.9%	0.001-mile Correlation CORRECTED90.3%84.2%	Average SR CORRECTED 74 72



# Trial Run Results – Tire B

#### AM Runs

Site	Pavement Type	0.001-mile Correlation	0.001-mile Correlation CORRECTED	Average SR CORRECTED		
1	CRCP	63.3%	91.4%	74		
2	JPCP	80.1%	81.9%	73		
3	Asphalt	62.8%	91.7%	75		
Site	Pavement Type	0.001-mile Correlation	0.001-mile Correlation CORRECTED	Average SR CORRECTED		
Site 1	Pavement Type CRCP	0.001-mile Correlation 71.0%	0.001-mile Correlation CORRECTED 94.0%	Average SR CORRECTED 72		
Site 1 2	Pavement Type CRCP JPCP	0.001-mile Correlation 71.0% 91.6%	0.001-mile Correlation CORRECTED94.0%92.0%	Average SR CORRECTED 72 73		



# **Pre-Network Collection Results**

Site	Pavement Type	0.001-mile Correlation	0.01-mile Correlation	Average SR
1	CRCP	96.1%	97.5%	73
2	JPCP	83.2%	86.1%	70
3	Asphalt	87.4%	91.1%	74



# **SR Values - CRCP**



SR Right on CRCP Testing Track at 0.001 mi



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### **SR Values - JCPC**



Average SR - 76

>Average SR - 76

SR Right on JCPC Testing Track at .001 mi





# SR Values - Asphalt



SR Right on Asphalt Testing Track at .001 mi





# **Comments on Results**

- High repeatability on CRCP and Asphalt
- Lower repeatability on JPCP
- SR on different surface treatments
  - Clear difference between surface treatments on CRCP and Asphalt
  - No clear difference between surface treatments on JPCP



# Thoughts after 2,700 miles collected

### Formal validations in Mississippi

- ▶0.1-mi section
- >0.74 r<sup>2</sup> between most recent 5 runs
- Values are lower than ICART results
- One-off longer validation test
  - >0.74 r<sup>2</sup> between two long tests over 8 miles
- Based on these tests, we think we are getting reliable friction measurements

### Questions





Chris.Young@arrbsystems.com