



# **3-D Laser Data Collection and Analysis of Road Surface Texture**

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# Presentation Organization

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- Introduction
- Problem Statement
- Objective
- Tests Performed
- Results and Discussions
- Conclusions



# Introduction

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- Good pavement condition is an essential prerequisite for a safer highway
- Road surface friction minimizes skidding and reduces roadway crashes
- Skid resistance highly depends on the pavement texture characteristics
- Estimation of texture characteristics could give useful information about the condition of the roadway



# Problem Statement

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- ASTM Locked Wheel Skid Trailer (LWST) is universally used for determining friction characteristics
- LWST measures pavement skid number
- Driving speed should be 40 mile/hour or 55 mile/hour
- Maintaining speed is difficult especially on some curves and ramps



# Problem Statement

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- 3-D Laser Crack Measurement System (LCMS) can be a viable alternative to LWST in some locations
- LCMS measures Mean Texture Depth (MTD) of pavements
- LCMS offered the possibility to measure pavement texture more precisely



# Objectives

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- To assess whether skid resistance on different KDOT highways can be assessed using LCMS measurements
- To find a suitable correlation between skid number and texture depth
- To replace the traditional ASTM skid trailer by LCMS for routine skid monitoring



# Test Sections

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Four KDOT (Kansas Department of Transportation) Highways were selected for investigation

- K-18 Westbound/ I-70 Westbound On-Ramp (Geary County)
- K-177 Southbound/ I-70 Westbound On-Ramp (Geary County)
- I-70 Westbound Off-Ramp/ K-177 Northbound (Geary County)
- K-87 (North of K-9, Nemaha County)



# Equipment used for Data Collection

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Pavement friction and texture data were collected using four different instruments:

- ASTM Locked Wheel Skid Trailer (LWST)
- 3-D Laser Crack Measurement System (LCMS)
- Circular Texture Meter (CTM)
- Dynamic Friction Tester (DFT)





# Locked Wheel Skid Trailer

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- Measures steady state friction force
- A locked wheel is dragged under constant load at a constant speed over a wet pavement
- Friction is determined from resulting force and reported as Skid Number (SN)
- Higher SN represents greater skid resistance

# Locked Wheel Skid Trailer

- Ribbed and Smooth tires are used for measuring friction
- Operated at near highway speed
- Can measure large sections of roadway without lane closures





# Laser Crack Measurement System

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- Use of high speed camera, custom optics and laser line projectors
- Acquire both 2-D images and high-resolution 3-D profiles of the road
- Can be operated under all types of lighting condition
- Various pavement types can be measured at survey speed
- Data analysis software analyze all collected data

# KDOT Laser Crack Measurement System

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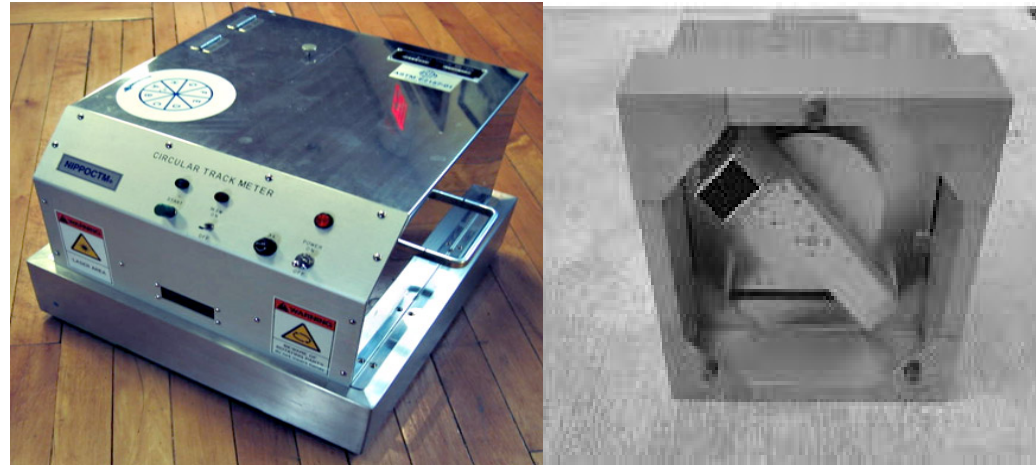




# Circular Texture Meter

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- Laser-based device for measuring Mean Profile Depth (MPD) at a static location
- There is a Charged Couple Device (CCD) laser sensor in the bottom of the instrument





# Circular Texture Meter (CTM)

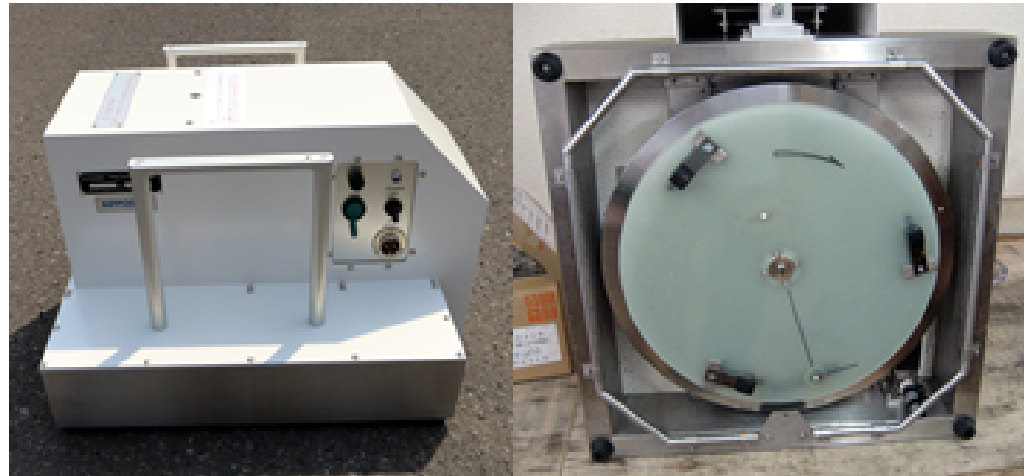
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- Measures the profile of a circle having 35.12 inch circumference
- Divides the circumference into eight segments
- Average Mean Profile Depth (MPD) is determined for each of the segments
- Reported MPD is the average of all eight segment depths

# Dynamic Friction Tester (DFT)

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- Measures frictional characteristics of roadway
- For Friction Number (FN) calculation, needs to put over the same area where CT Meter measurement was taken
- The disk at the bottom of the machine consists of 3 rubber slider





# Dynamic Friction Tester

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- During rotation, the disk measures the torque generated
- Torque is monitored and recorded at 20,40, 60 and 80 km/hr
- Both CT meter and DF tester readings are required to calculate the Friction Number



# K-18 WB to I-70 WB



# Results and Discussions

## *K-18 Westbound I-70 Westbound On Ramp (HFS placed in Sep, 2014)*

Pavement Type	3D laser MTD (mm)			Skid Number (Before HFS)		Skid Number (After HFS)		Pavement Type	3D laser MTD (mm)			
	Section	Before HFS (June 2014)	After HFS (April 2015)	Grooved Tire (Jun 2014)	Smooth Tire (Jun 2014)	Grooved Tire (Apr 2015)	Smooth Tire (Apr 2015)		Section	Before HFS (June 2014)	After HFS (April 2015)	
Asphalt	F 00001	0.8094	1.0798	40.16	33.65	78.54	71.27	Concrete	F 00019	0.6222	0.9629	
	F 00002	0.8864	1.0828						F 00020	0.6702	0.9884	
	F 00003	0.9001	1.1359						F 00021	0.5781	1.0068	
	F 00004	0.7963	1.0332						F 00022	0.6246	1.0298	
	F 00005	0.8089	1.0127						F 00023	0.7085	1.0421	
	F 00006	0.8055	0.9989						F 00024	0.7181	1.0308	
	F 00007	0.7808	1.0037						F 00025	0.7046	1.0813	
	F 00008	0.9467	1.0099						F 00026	0.6937	1.0828	
	F 00009	0.9044	0.9307						Result	Mean	0.67	1.03
	F 00010	0.8331	0.8978							SD	0.048	0.039
	F 00011	0.8458	0.9821					COV (%)		7.16	3.82	
	F 00012	0.8665	0.9793									
Result	Mean	0.85	1.01									
	SD	0.050	0.063									
	COV (%)	5.86	6.20									

# Results and Discussions

*K-18 Westbound I-70 Westbound On Ramp (HFS placed in Sep, 2014)*

Pavement Type	3-D laser MTD (mm)			ASTM Locked Wheel Skid Trailer SN			
	Section	Before HFS (June 2014)	After HFS (April 2015)	Skid Number (Before HFS)		Skid Number (After HFS)	
				Grooved Tire (Jun 2014)	Smooth Tire (Jun 2014)	Grooved Tire (Apr 2015)	Smooth Tire (Apr 2015)
Concrete	F 00018	0.6528		40.16	33.65	78.54	71.27
	F 00019	0.6222	0.9629				
	F 00020	0.6702	0.9884				
	F 00021	0.5781	1.0068				
	F 00022	0.6246	1.0298				
	F 00023	0.7085	1.0421				
	F 00024	0.7181	1.0308				
	F 00025	0.7046	1.0813				
	F 00026	0.6937	1.0828				
Result	Mean	0.66	1.03				
	SD	0.045	0.039				
	COV (%)	6.79	3.82				

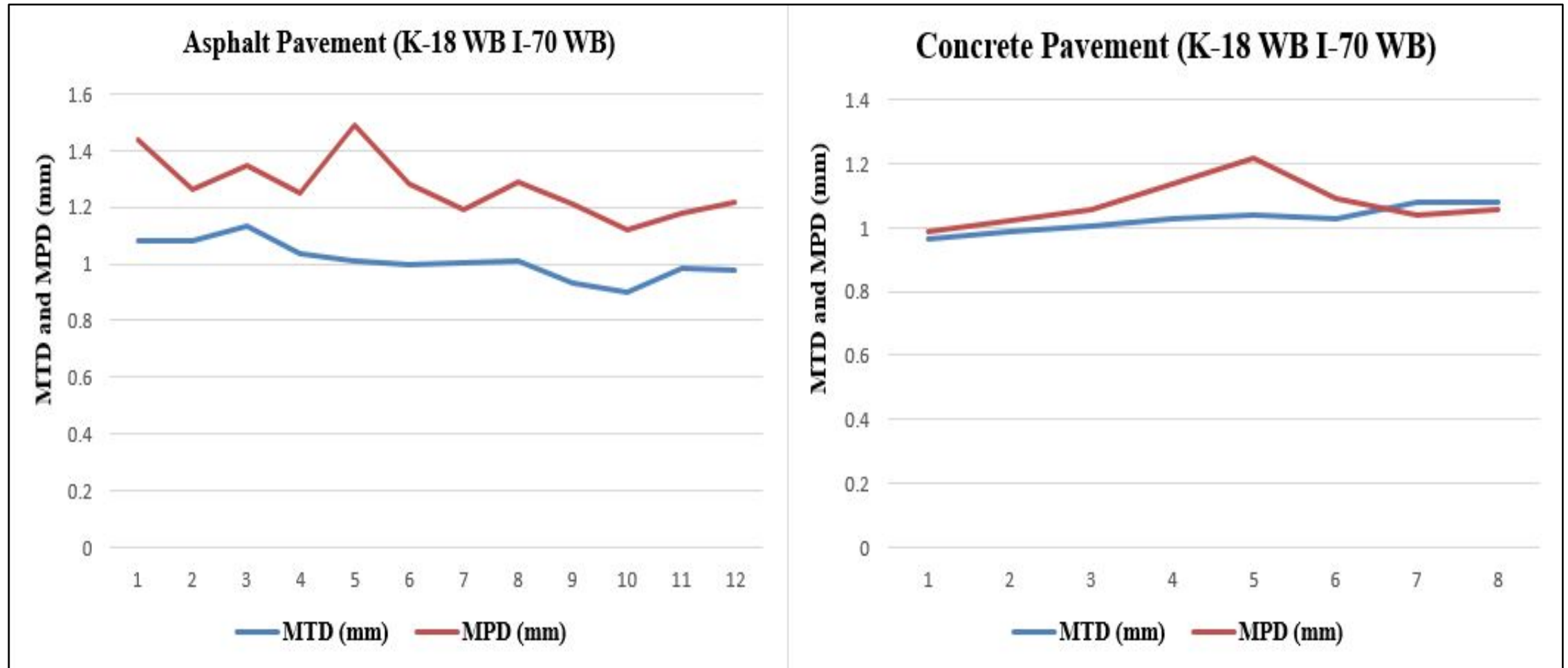
# Results and Discussions

*K-18 Westbound I-70 Westbound On Ramp (HFS placed in Sep, 2014)*

Pavement Type	Section	CTM MPD (mm)	Pavement Type	Section	CTM MPD (mm)
	(20 ft c/c)	After HFS (April 2015)		(20 ft c/c)	After HFS (April 2015)
Asphalt	1	1.44	Concrete	1	0.99
	2	1.26		2	0.92
	3	1.35		3	1.06
	4	1.25		4	1.29
	5	1.49		5	1.22
	6	1.28		6	1.09
	7	1.19		7	1.04
	8	1.29		8	1.01
	9	1.21		9	1.22
	10	1.12			
	11	1.18			
Result	Mean	1.29	Mean	1.09	
	SD	0.076	SD	0.117	
	COV (%)	5.91	COV (%)	10.67	

# Results and Discussions

*K-18 Westbound I-70 Westbound On Ramp (HFS placed in Sep, 2014)*





# K-177 SB to I-70 WB Ramp



# Results and Discussions

*K-177 Southbound and I-70 Westbound On- Ramp (HFS placed in Sep, 2014)*

Pavement Type	3-D laser MTD (mm)			Skid Number (Before HFS)		Skid Number (After HFS)		Pavement Type	3-D laser MTD (mm)		
	Section	Before HFS (June 2014)	After HFS (April 2015)	Grooved Tire (Jun 2014)	Smooth Tire (Jun 2014)	Grooved Tire (Apr 2015)	Smooth Tire (Apr 2015)		Section	Before HFS (June 2014)	After HFS (April 2015)
Asphalt	F 00001	1.1169	1.0828	43.39	32.4	82.02	65.12	Concrete	F 00012	0.8534	1.0359
	F 00002	1.1296	0.9117						F 00013	0.8716	1.1763
	F 00003	1.0925	0.8994						F 00014	0.6294	1.0993
	F 00004	1.1945	0.8759						F 00015	0.6414	1.0191
	F 00005	1.1639	0.8909						F 00016	0.6043	
	F 00006	1.0878	0.8757						F 00017	0.5566	
	F 00007	1.1635	0.8478						F 00018	0.4638	
	F 00008	1.1164	0.9094						<b>Mean</b>	<b>0.66</b>	<b>1.08</b>
	F 00009	1.08	0.9483						<b>SD</b>	<b>0.139</b>	<b>0.062</b>
	F 00010	1.1245	0.9163						<b>COV (%)</b>	<b>21.1</b>	<b>5.71</b>
	F 00011	1.0134	0.9803								
Result	<b>Mean</b>	<b>1.12</b>	<b>0.92</b>								
	<b>SD</b>	<b>0.047</b>	<b>0.061</b>								
	<b>COV (%)</b>	<b>4.2</b>	<b>6.66</b>								

# Results and Discussions

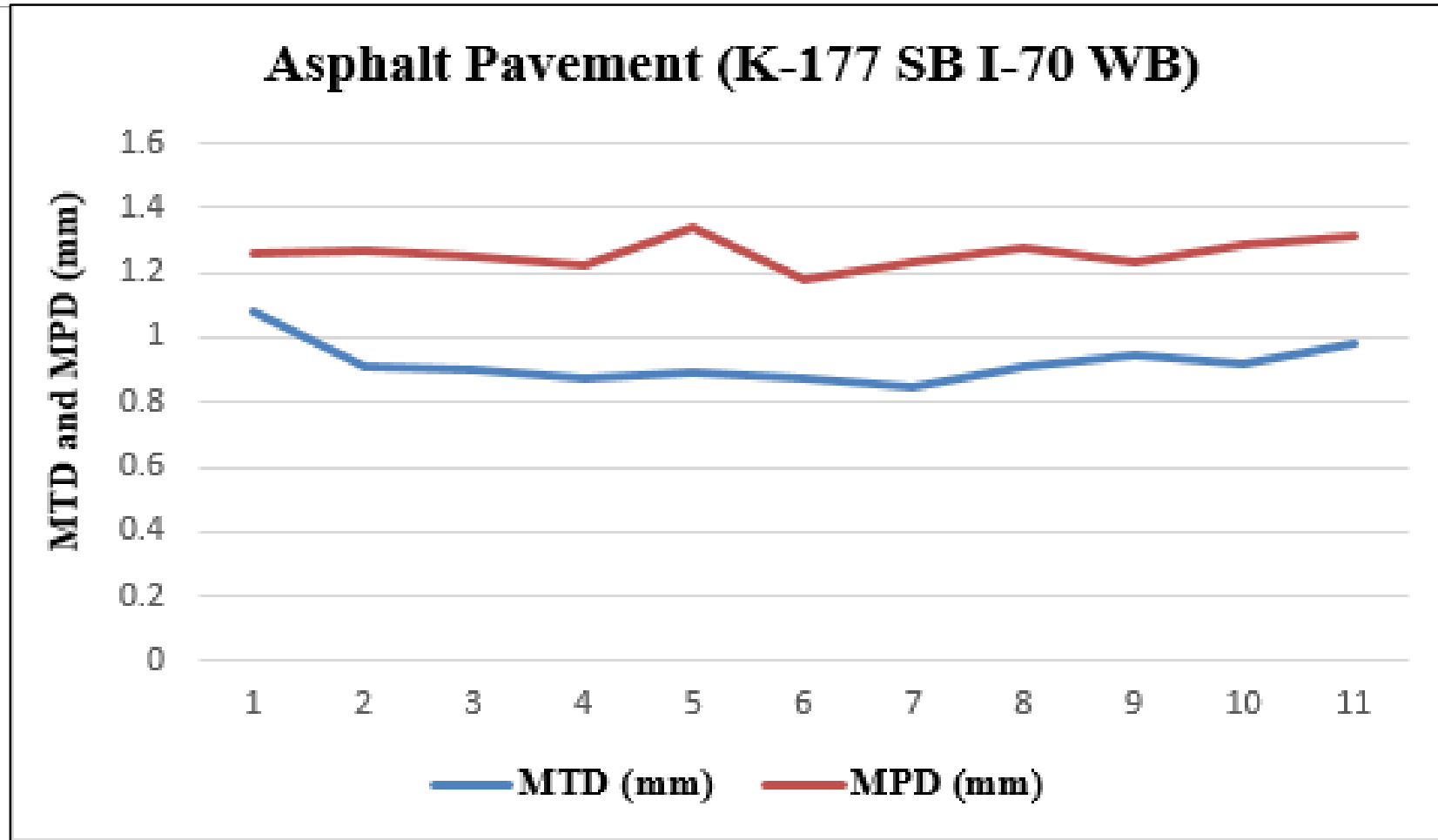
*K-177 Southbound and I-70 Westbound On- Ramp (HFS placed in Sep, 2014)*

Pavement Type	Section (20 ft c/c)	CTM MPD (mm)		DFT ( $\mu$ )		FN	
		After HFS	(April 2015)	After HFS	(April 2015)	After HFS	(April 2015)
Asphalt	1		1.26				
	2		1.27				
	3		1.25				
	4		1.22				
	5		1.34				
	6		1.18				
	7		1.23				
	8		1.28				
	9		1.23				
	10		1.29		0.86		54.4
	11		1.31		0.86		54.6
	12		1.26		0.79		50.3
	13		1.39		0.91		58
	14		1.49		0.9		58.5
Result	<b>Mean</b>		<b>1.29</b>		<b>0.86</b>		<b>55.16</b>
	<b>SD</b>		<b>0.076</b>		<b>0.042</b>		<b>2.957</b>
	<b>COV (%)</b>		<b>5.91</b>		<b>4.89</b>		<b>5.36</b>



# Results and Discussions

*K-177 Southbound and I-70 Westbound On- Ramp (HFS placed in Sep, 2014)*



# I-70WB to K-1777 NB Ramp

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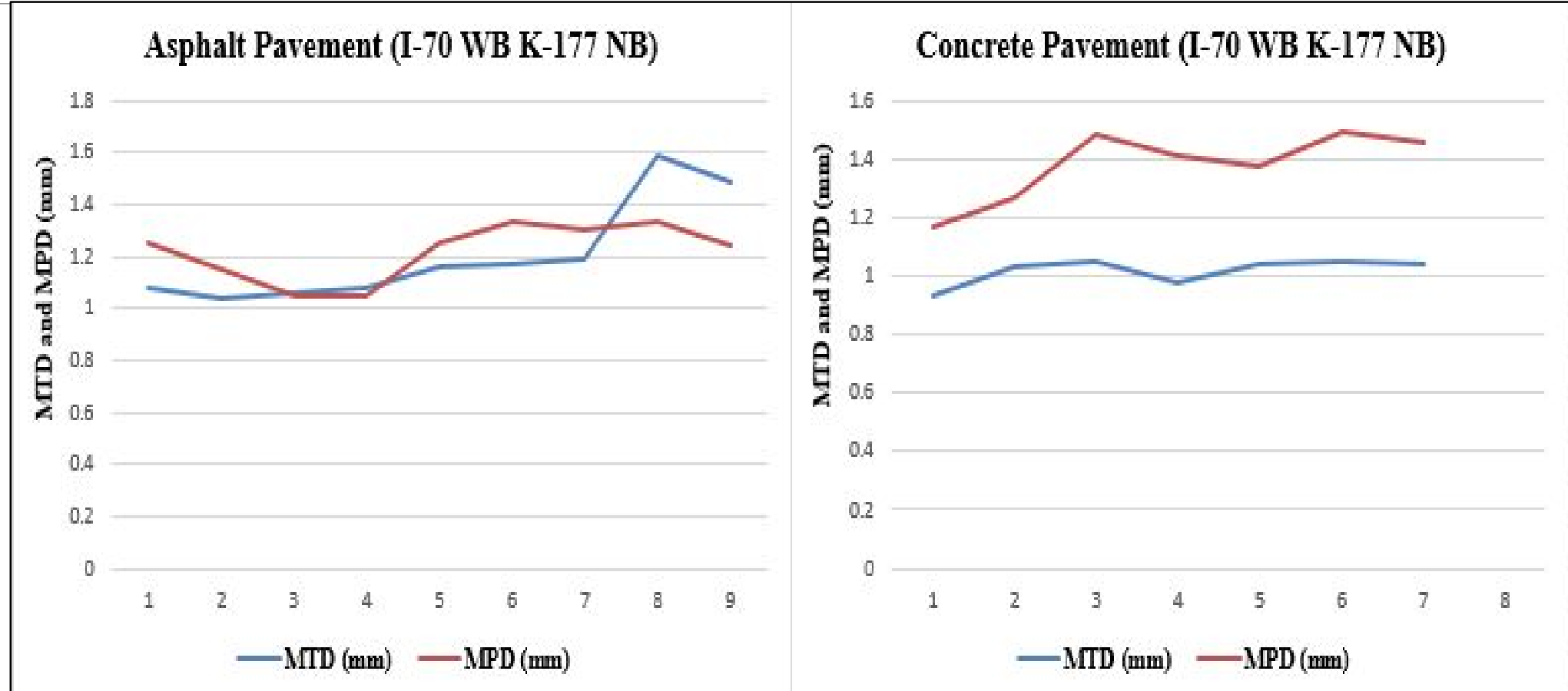
# Results and Discussions

*I-70 Westbound and K-177 Northbound Off- Ramp (HFS placed in Sep, 2014)*

Pavement Type	Section (20 ft c/c)	CTM MPD (mm)	DFT ( $\mu$ )	FN	Pavement Type	Section (20 ft c/c)	CTM MPD (mm)
		After HFS (April 2015)	After HFS (April 2015)	After HFS (April 2015)			After HFS (April 2015)
Asphalt	1	1.35			Concrete	1	1.43
	2	1.25				2	1.17
	3	1.15				3	1.48
	4	1.05				4	1.41
	5	1.05				5	1.27
	6	1.25				6	1.49
	7	1.33				7	1.46
	8	1.3	0.84	53.4		8	1.4
	9	1.33	0.81	52		9	1.32
	10	1.24	0.79	50.1		10	1.58
Result	<b>Mean</b>	<b>1.23</b>	<b>0.81</b>	<b>51.83</b>	Result	<b>Mean</b>	<b>1.40</b>
	<b>SD</b>	<b>0.106</b>	<b>0.021</b>	<b>1.352</b>		<b>SD</b>	<b>0.113</b>
	<b>COV (%)</b>	<b>8.58</b>	<b>2.53</b>	<b>2.61</b>		<b>COV (%)</b>	<b>8.07</b>

# Results and Discussions

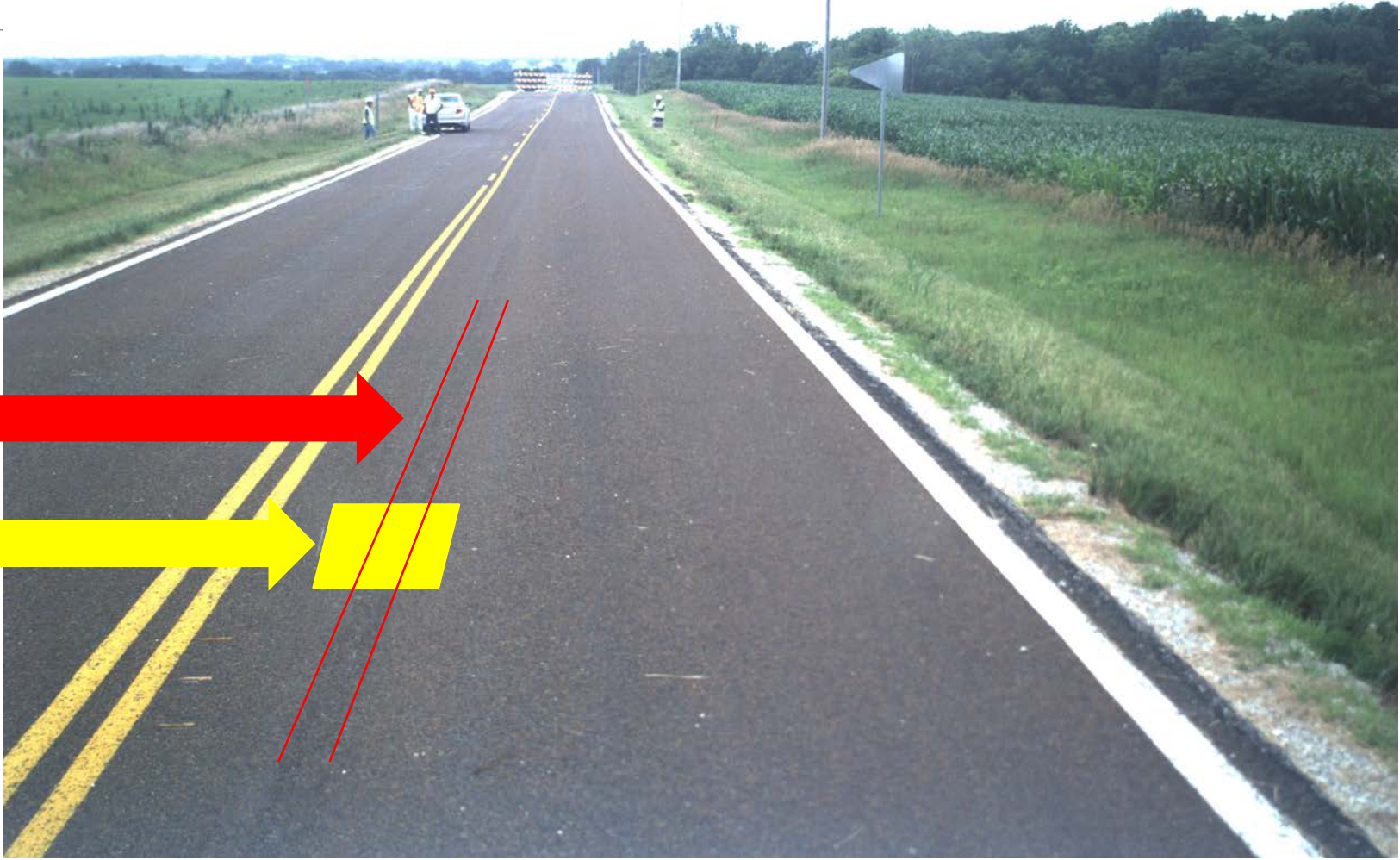
*I-70 Westbound and K-177 Northbound Off- Ramp (HFS placed in Sep, 2014)*







K-87



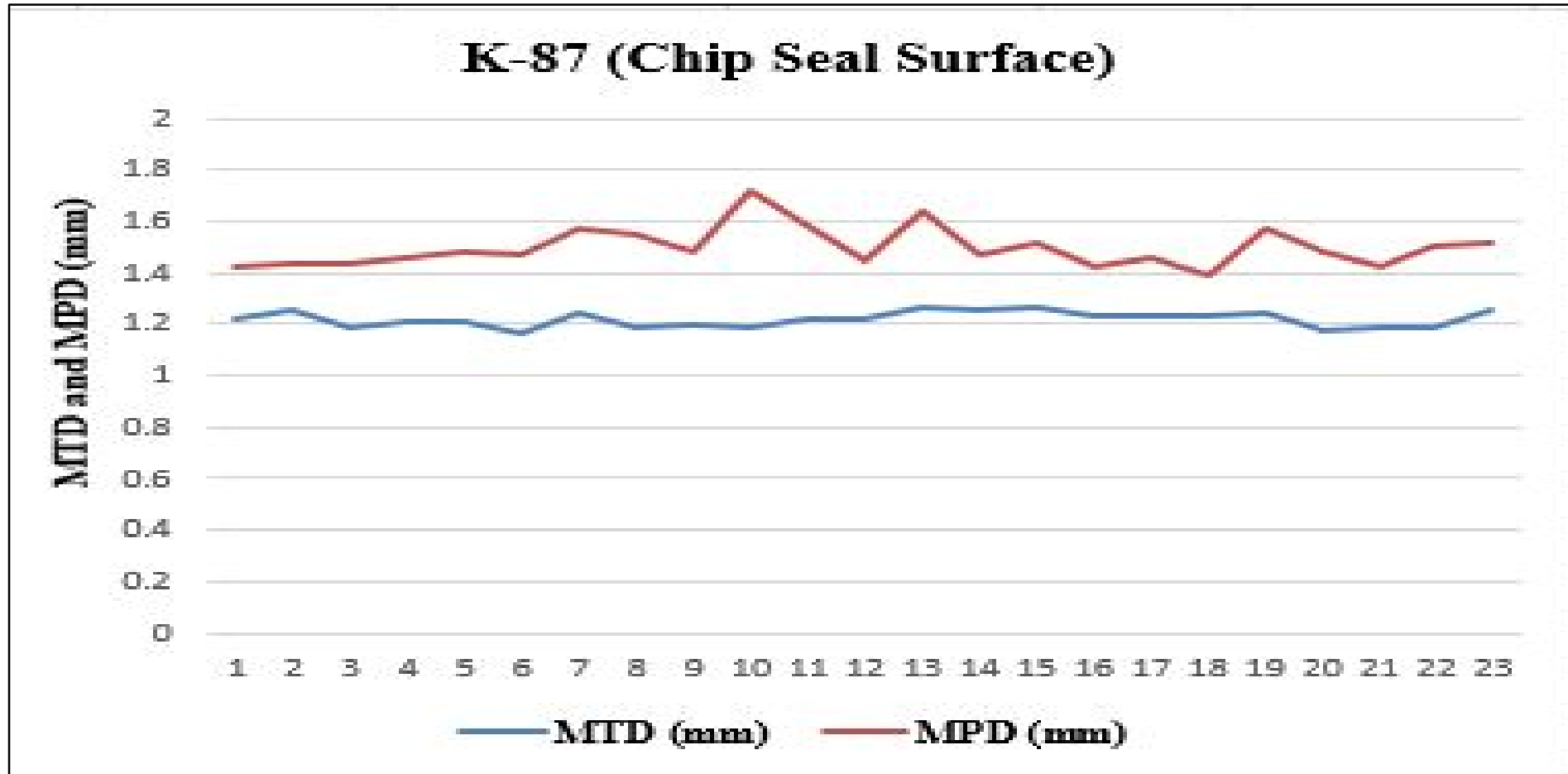
# Results and Discussions

*K-87 (With Chip Seal surface)*

Surface Type	Section	3D laser MTD (mm) (Jul 2015)	Skid Number		Section (25 ft c/c)	CTM MPD (mm) (Jul 2015)	DFT ( $\mu$ ) (Jul 2015)	FN (Jul 2015)
			Grooved Tire (Jul 2015)	Smooth Tire (Jul 2015)				
Chip Seal	F00001	1.226	68.37	58.5	1	1.56	0.69	47
	F00002	1.252			2	1.43		
	F00003	1.182			3	1.44	0.69	46
	F00004	1.206			4	1.46		
	F00005	1.211			5	1.48	0.73	49
	F00006	1.167			6	1.47		
	F00007	1.238			7	1.57		
	F00013	1.267			13	1.64		
	F00014	1.25			14	1.47		
	F00015	1.264			15	1.52		
	F00016	1.237			16	1.42	0.71	47
	F00017	1.236			17	1.46		
	F00018	1.236			18	1.39	0.76	50
	F00019	1.243			19	1.57		
F00020	1.17	20	1.48	0.79	52			
Result	Mean	1.22	68.37	58.5	Mean	1.5	0.73	48.5
	SD	0.031	5.354	0.4	SD	0.076	0.037	2.062
	COV (%)	2.5	7.83	0.68	COV (%)	5.06	5.04	4.25

# Results and Discussions

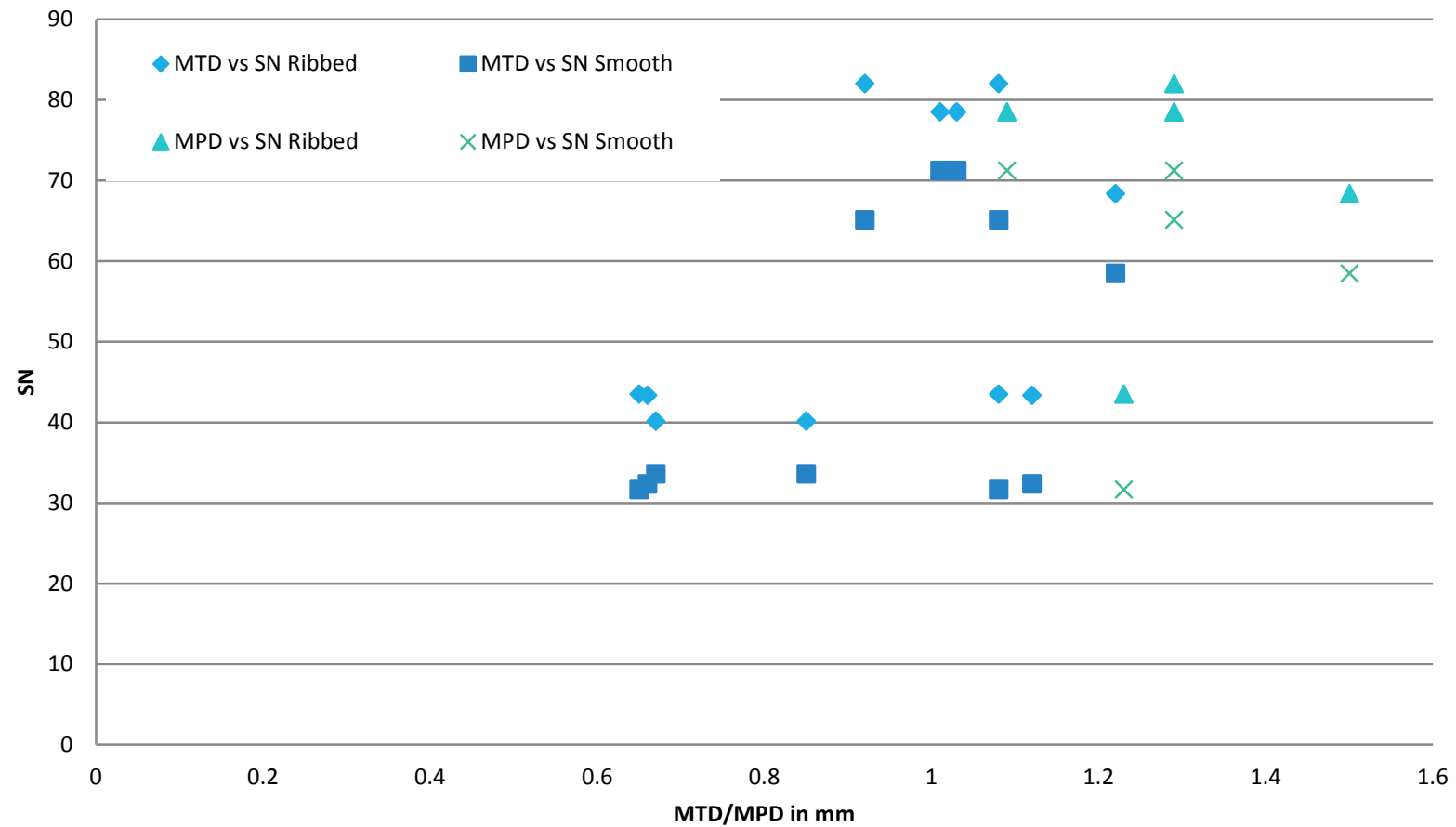
*K-87 (With Chip Seal surface)*





# Results and Discussions

## *Relationship between Skid Number and Texture Depth*





# Conclusions

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- We are still evaluating using the LCMS data (MTDs) to determine if surface friction (based on texture) is adequate.
- We continue to compare texture depth and  $\mu$  values to the SNs and MTDs that we are already collecting.
- We will still collect locked wheel skid data and LCMS (MTDs) while we learn if/how we can be more efficient in our collection.
- More roadway surface characteristics need to be analyzed to develop a valid correlation between MTD and SN



