

#### EVALUATING PAVEMENT MACROTEXTURE USING 3D LASER TECHNOLOGY AND ITS CORRELATION WITH SKID RESISTANCE

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#### **PRESENTATION OUTLINE**



- INTRODUCTION
- FIELD TESTING
- RESULTS AND DISCUSSIONS
- CONCLUSIONS







#### INTRODUCTION



- A FORENSIC INVESTIGATION RELATED TO INCREASED WET WEATHER ACCIDENTS WAS CONDUCTED.
- THE ROAD OF INTEREST INCLUDED A 7-MILE SECTION OF INTERSTATE WITH 2/3 LANES PER DIRECTION. PAVEMENT STRUCTURE COMPRISED OF COMPOSITE PAVEMENT.
- ACCIDENTS OCCURRED MORE FREQUENTLY AFTER RESURFACING THE CONCRETE PAVEMENT WITH A SPECIALIZED ASPHALT CONCRETE MIXTURE: 1 IN. HIGH-PERFORMANCE THIN OVERLAY (HPTO).
- ANOTHER AREA WITH HPTO THAT WAS PREVIOUSLY CONSTRUCTED AND WITHOUT WET WEATHER INCIDENTS WAS EVALUATED FOR COMPARISON.
- AID WAS TASKED TO INVESTIGATE THE ROOT CAUSE OF THE PROBLEM AND RECOMMEND CORRECTIVE ACTIONS.





#### INTRODUCTION



- THE FORENSIC INVESTIGATION INCLUDED:
- DATA COLLECTION WITH A LASER CRACK MEASUREMENT SYSTEM (LCMS) AND HIGH-DEFINITION (HD) RIGHT-OF-WAY (ROW) CAMERAS ATTACHED TO AID'S TESTING VEHICLE TRAVELING AT POSTED SPEEDS.
- DATA WAS ANALYZED TO CHARACTERIZE PAVEMENT SURFACE TEXTURE (MACROTEXTURE), MEASURE THE RUT DEPTH AND INTERNATIONAL ROUGHNESS INDEX (IRI).
- PAVEMENT SURFACE TEXTURE MEASUREMENT USING THE SAND PATCH TEST.
- EXTRACTING PAVEMENT CORES FOR HPTO EVALUATION (AIR VOIDS, GRADATION).
- GEOMETRIC PROPERTIES WERE ALSO ASSESSED: CROSS-SLOPE AND LONGITUDINAL SLOPE, USED TO IDENTIFY ELEVATION-RELATED DRAINAGE ISSUES.





#### FIELD TESTING

ROAD INVESTIGATED:

- INTERSTATE ROAD
- AROUND 7-MILE SECTION
- 2 OR 3 LANES, BOTH DIRECTIONS
- PAVEMENT TYPE: COMPOSITE PAVEMENT (HMA OVER PCC)
- THREE SECTIONS:
  - OLD HPTO SECTION (2019), 2 MILES
  - HPTO CONTROL SECTION (2022), 1.5 MILES
  - HPTO FLUSHED SECTION (2022), 4 MILES





#### FIELD TESTING

- AID'S INTEGRATED TESTING VEHICLE (ITV),
  - LASER CRACK MEASUREMENT SYSTEM
  - 3 HD CAMERAS
  - GROUND PENETRATING RADAR (GPR)
  - GPS
- SAND PATCH TEST



• SKID TESTING LOCKED-WHEEL TESTER (LWT) (DONE BY OTHERS)

















• SKID TESTING RESULTS

AREAS WITH LOW MTD VALUES SHOWED LOW SKID NUMBER AS WELL

MP	SN40	Туре
62 21	10.2	HPTO 2022
05.51	45.5	Construction
62.4	10.2	HPTO 2022
05.4	40.5	Construction
62.51	17	HPTO 2022
05.51	47	Construction
63.6	47.8	HPTO 2022
05.0	47.0	Construction
63 71	47.9	HPTO 2022
03.71	47.5	Construction
63.81	37.1	HPTO 2022
05.01	57.1	Construction
62.04	46.8	HPTO 2022
03.94	40.0	Construction
64	33.0	HPTO 2022
04 55.		Construction
64.11	35.6	HPTO 2022
04.11	33.0	Construction

Pavement

NB L2





#### • MTD VALUES FROM LASER CRACK MEASUREMENT SYSTEM



Table 1. Average MTD values by section, lane, and wheel path.

Section ID	Milenet	Lane 1		Lane 2		Lane 3		Lane 4		Average
Section ID	whiepost	LWP	RWP	LWP	RWP	LWP	RWP	LWP	RWP	(mm)
Northbound Direction										
2019 HPTO Section	58.5-60.5	0.518	0.521	0.499	0.473	0.492	0.481	N/A	N/A	0.497
2022 HPTO Control Section	60.5-62.0	0.453	0.464	0.434	0.440	N/A	N/A	N/A	N/A	0.445
2022 HPTO Section	62.0-63.8	0.469	0.483	0.451	0.452	N/A	N/A	N/A	N/A	0.460
2022 HPTO Flushed Section	63.8-67.5	0.449	0.462	0.439	0.447	N/A	N/A	N/A	N/A	0.449

Southbound Direction										
2019 HPTO Section	58.5-60.5	0.543	0.528	0.512	0.481	0.500	0.486	N/A	N/A	0.508
2022 HPTO Control Section	60.5-62.0	0.456	0.469	0.441	0.455	N/A	N/A	N/A	N/A	0.455
2022 HPTO Section	62.0-63.8	0.440	0.458	0.459	0.458	0.435	0.457	N/A	N/A	0.451
2022 HPTO Flushed Section	63.8-67.0	0.452	0.470	0.440	0.448	0.420	0.438	N/A	N/A	0.445
2022 HPTO Flushed Section	67.0-67.5	0.487	0.490	0.475	0.487	0.459	0.480	0.448	0.467	0.474

IN GENERAL, MTD WAS SIMILAR FOR ALL 2022 SECTIONS AND HIGHER FOR THE 2019 SECTIONS







• MTD VALUES FROM SAND PATCH TEST



Figure 12. Sand Patch Test Results for the NB direction.

Figure 13. Sand Patch Test Results for the SB direction.

SIMILARLY, MTD HIGHER FOR THE 2019 SECTIONS. MORE VARIABILITY ON THE 2022 DATA.







• MTD VALUES FROM SAND PATCH TEST

#### Table 4. Summary of average MTD values.

Section	MileDeet	Direction	MTD in V	VP (mm)	MTD in NWP (mm)		
Section	willePost	Direction	Average	MTD in WP (mm)         M           verage         COV, %         Av           0.442         3.9         0           0.451         10.3         0           0.360         16.2         0           0.354         19.7         0	Average	COV, %	
2010 HDTO Section	59 5 60 5	NB	0.442	3.9	0.446	11.5	
2019 HPTO Section	56.5-60.5	SB	0.451	10.3	0.458	15.1	
2022 HDTO Control Section	60 5 62 0	NB	0.360	16.2	0.374	12.9	
2022 HPTO CONTO Section	00.5-02.0	SB	0.354	19.7	0.364	23.0	
2022 HDTO Elushed Section	63 9 67 5	NB	0.336	21.5	0.364	14.9	
2022 HFTO Flushed Section	03.0-07.5	SB	0.369	20.6	0.374	21.1	

SIMILARLY, MTD HIGHER FOR THE 2019 SECTIONS. MORE VARIABILITY ON THE 2022 DATA.







- MTD COMPARISON BETWEEN LCMS AND SAND PATCH TEST
- MTD VALUES CALCULATED FROM THE LCMS DATA WERE CONSISTENTLY HIGHER THAN THE SAND PATCH DATA.
- FOR REFERENCE PURPOSES, SOME AGENCIES
   OUTSIDE THE UNITED STATES RECOMMEND
   SAND PATCH TEST MTD VALUES GREATER
   THAN 0.45 MM





• CROSS-SLOPE AND SLOPE RESULTS FORM LCMS

MAJORITY OF THE CROSS-SLOPE MEASUREMENTS WERE ABOVE THE MINIMUM RECOMMENDED VALUE OF 1.5% ON BOTH NB AND SB DIRECTIONS

AREAS WITH POSSIBLE WATER ACCUMULATION DURING RAIN EVENTS, DUE TO INSUFFICIENT LONGITUDINAL SLOPE. SUCH AREAS INCLUDE MP's 60.7, 65.8, AND 67.2







ROAD DIGITAL TERRAIN MODEL (DTM) FROM LCMS-LTDM



INLETS APPEAR TO BE LOCATED APPROPRIATELY,
BASED ON THE PROFILE. HOWEVER, THE NEARZERO SLOPES IN THIS SECTION MAY RESULT IN
SLOW-MOVING SURFACE RUNOFF AND CAUSE
WATER PONDING DURING HIGH-INTENSITY RAIN
EVENTS, CONTRIBUTING TO WET WEATHER
ACCIDENTS IN THIS AREA







SADULE UP!

• RUTTING FORM LCMS-LTDM





#### Southbound

Northbound

LANES 2/3 SHOWED HIGHER RUTTING, PARTICULARLY IN THE SB DIRECTION







- RUTTING FORM LCMS-LTDM
- HIGHER RUTTING (0.10-0.25 IN.) WAS OBSERVED IN LANES 2 AND 3 THAN IN LANE 1 (< 0.10 IN.),
- IT SHOULD BE NOTED THAT EVEN THOUGH THE
  AVERAGE VALUES ARE LESS THAN 0.25 IN.,
  LARGER VALUES OF RUTTING WERE OBSERVED IN
  A FEW LOCATIONS IN THE "2022 HPTO FLUSHED
  SECTION" IN THE NB DIRECTION, ESPECIALLY IN
  THE VICINITY OF MP 64.0.

Table 2. Summary of average Rut Depth values.
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		Lane 1		Lane 2		Lane 3		Lane 4		Overall	
Section ID	Milepost	Ave. in.	cov, %	Ave. in.	cov, %	Ave. in.	cov, %	Ave. in.	cov, %	Ave. in.	соv, %
Northbound Direction											
2019 HPTO Section	58.5-60.5	0.08	46%	0.09	37%	0.08	34%	N/A	N/A	0.09	40%
2022 HPTO Control Section	60.5-62.0	0.1	31%	0.12	40%	N/A	N/A	N/A	N/A	0.11	39%
2022 HPTO Section	62.0-63.8	0.08	20%	0.12	43%	N/A	N/A	N/A	N/A	0.10	44%
2022 HPTO Flushed Section	<b>63.8-67.5</b>	0.09	37%	0.11	46%	0.07	42%	N/A	N/A	0.10	45%
		Southb	ound Di	rection							
2019 HPTO Section	58.5-60.5	0.08	81%	0.14	48%	0.1	35%	N/A	N/A	0.11	<mark>62%</mark>
2022 HPTO Control Section	60.5-62.0	0.07	35%	0.18	31%	N/A	N/A	N/A	N/A	0.12	57%
2022 HPTO Section	62.0-63.8	0.06	18%	0.12	58%	0.19	32%	N/A	N/A	0.10	67%
2022 HPTO Flushed Section	63.8-67.0	0.07	45%	0.11	55%	0.18	31%	N/A	N/A	0.10	58%
2023 HPTO Flushed Section	67.0-67.5	0.07	12%	0.07	9%	0.07	13%	0.09	39%	0.07	27%





## CONCLUSIONS



- MTD FROM LCMS CAN BE OBTAINED AT POSTED SPEED
- AREAS WITH LOW SKID NUMBER SHOWED LOW MTD FROM LCMS AS WELL
- RESULTS DID SHOW A GOOD CORRELATION BETWEEN MTD FROM LCMS AND SAND PATCH. HOWEVER, MTD FROM LCMS WAS HIGHER THAN THE SAND PATCH
- CROSS-SLOPE AND SLOPE AND ROAD DIGITAL TERRAIN MODEL (DTM) FROM LCMS CAN HELP UNDERSTANDING THE ROAD GEOMETRY AND ITS EFFECTS ON ROAD SAFETY
- IT WAS RECOMMENDED TO REPLACE THE HPTO IN SOME AREAS (0.7-MILE SEGMENT, AROUND MP 64) WITH MIX A MORE RESISTANT AGAINST RUTTING AND LOSS OF TEXTURE







#### **THANK YOU!**



