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LTPP Automated Faulting Measurement

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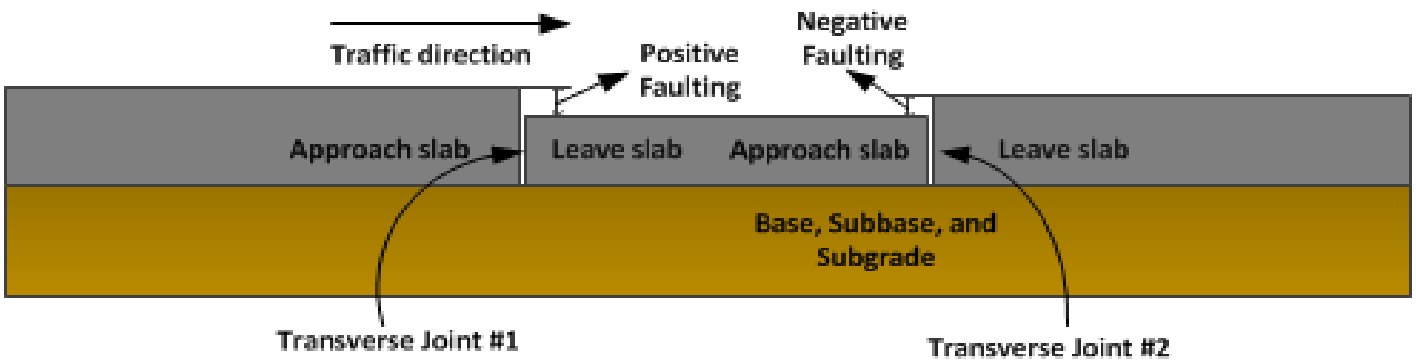
Presentation Overview

- Introduction
- Research objectives
- Profile data processing
- Analysis & comparison results
- Conclusions
- Recommendations

Introduction

- **Joint concrete pavements (JCP)**
  - Performance depends largely on Joints
  - Most JCP failures is due to problems at joints
  - Distresses from joint failure include:
    - Faulting, pumping, spalling, corner breaks, blowups and mid-panel cracking
- **Study was focused on joint faulting on jointed plain concrete pavements (JPCP)**

Faulting



- **Factors that contribute to joint faulting**
  - Slab pumping, inefficient load transfer, slab settlements, curling, warping and inadequate base support conditions
- **Key pavement performance indicator**

Faulting Cont.

- **Plays a prominent role in pavement surface roughness over time**
- **Significant joint faulting**
  - Adverse impact on pavement life-cycle costs
  - Vehicle operating costs
  - Reduces ride comfort and driver's safety

Long-Term Pavement Performance (LTPP) Program

- **Longitudinal profile data using profiler**
  - To evaluate roughness of the pavement
- **Collects joint and crack faulting data at each JCP test site using the Georgia Faultmeter (GFM)**
  - As part of the condition monitoring of the LTPP test sections
  - As rate of change in faulting values have strong correlation to rate of change in IRI values for JPCP

Joint Faulting Measurements

- **Manual faulting measurements using the Georgia Faultmeter (GFM)**
  - Time-consuming
  - Traffic control
  - Lane closure
  - Safety measures
  - Personnel cost

LTPP Profile Data using ICC Profiler

- **Automated method using a high speed inertial profiler**
  - Faster and Safer
  - No lane closure
  - No traffic control
  - Cost-effective

Research Objectives

- **Develop the LTPP automated faulting measurement (AFM) algorithm**
  - Identify JPCP transverse joints
  - Compute faulting for the detected joint locations
- **Compare the LTPP AFM with the two existing AASHTO R36 methods**
  - ProVAL AFM (method-A)
  - FDOT PaveSuite (method-B)

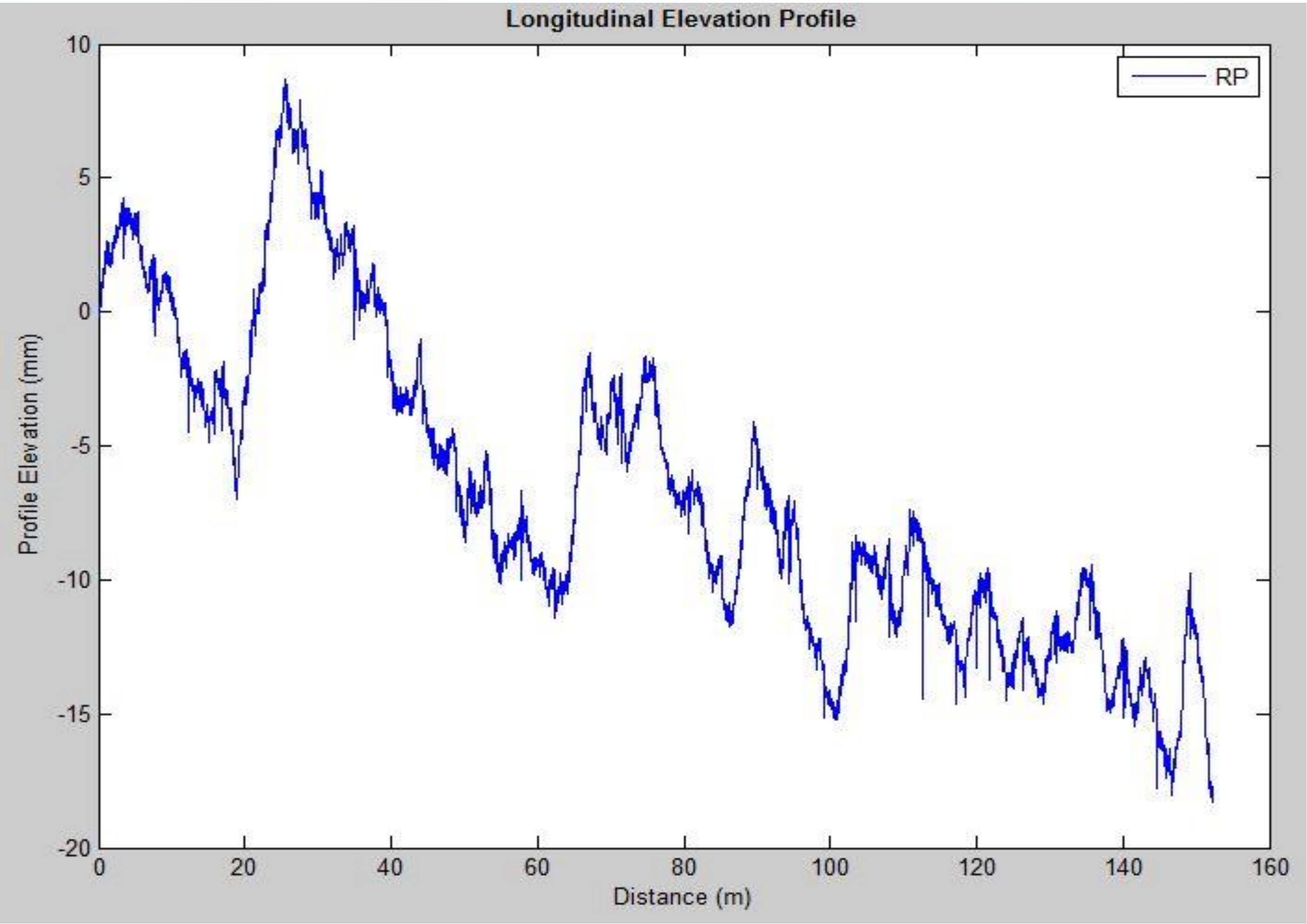
Profile Data Processing

- **Transverse joint detection challenges**
  - Varying joint spacing
  - Cracks
  - Spalled joints
  - Filled and closed joints
  - Skewed joints
  - Sampling interval
  - Profiler precision

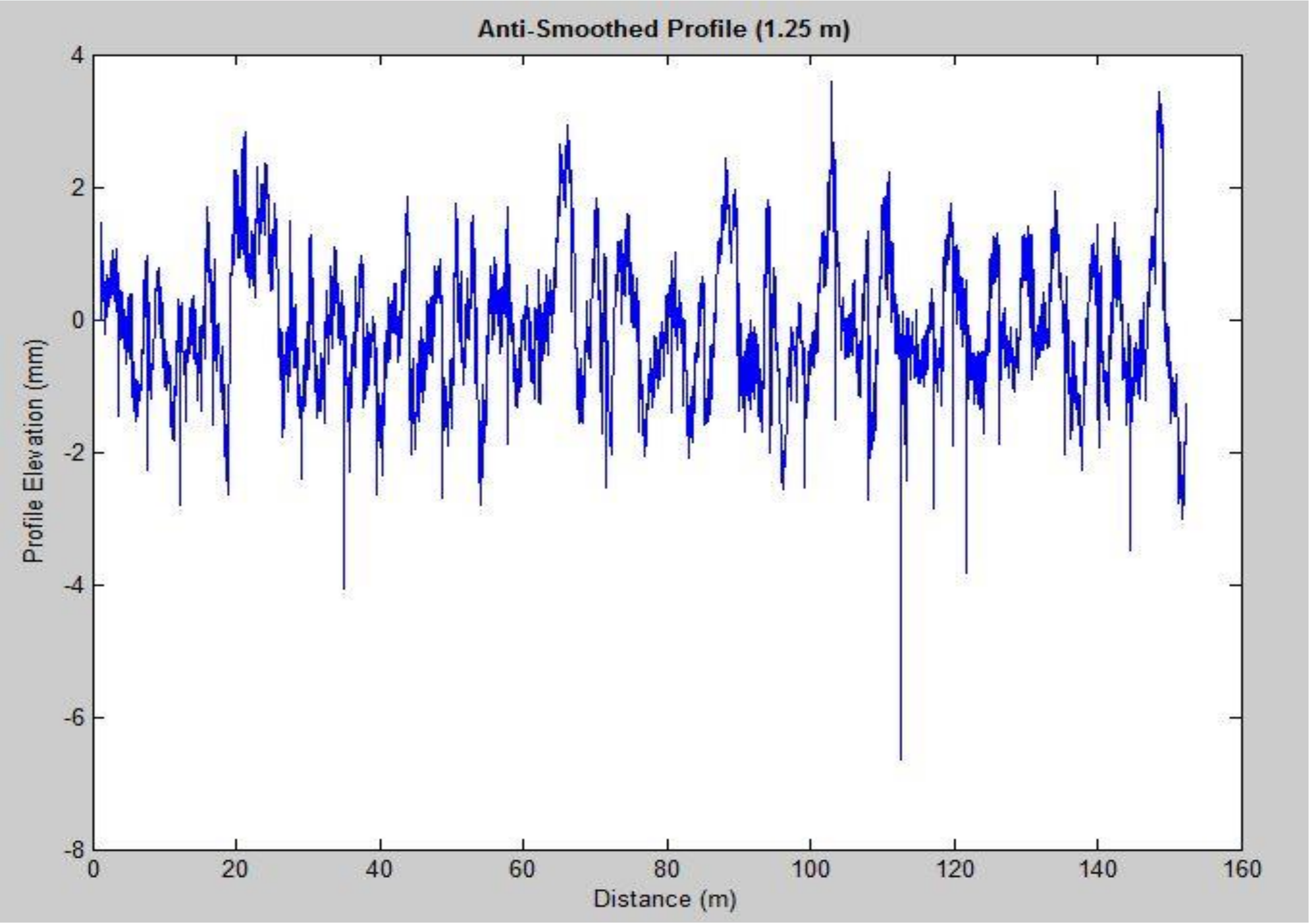
Profile Data Processing Cont.

- **About LTPP profiler data**
  - ERD file format (text file)
  - 25 mm sampling interval for left and right wheelpaths and center of the lane
- **Processing steps using Matlab**
  - Import profile ERD file
  - Filter and normalize profile elevation points
    - Moving average
    - Anti-smoothing
    - Root mean square (RMS)

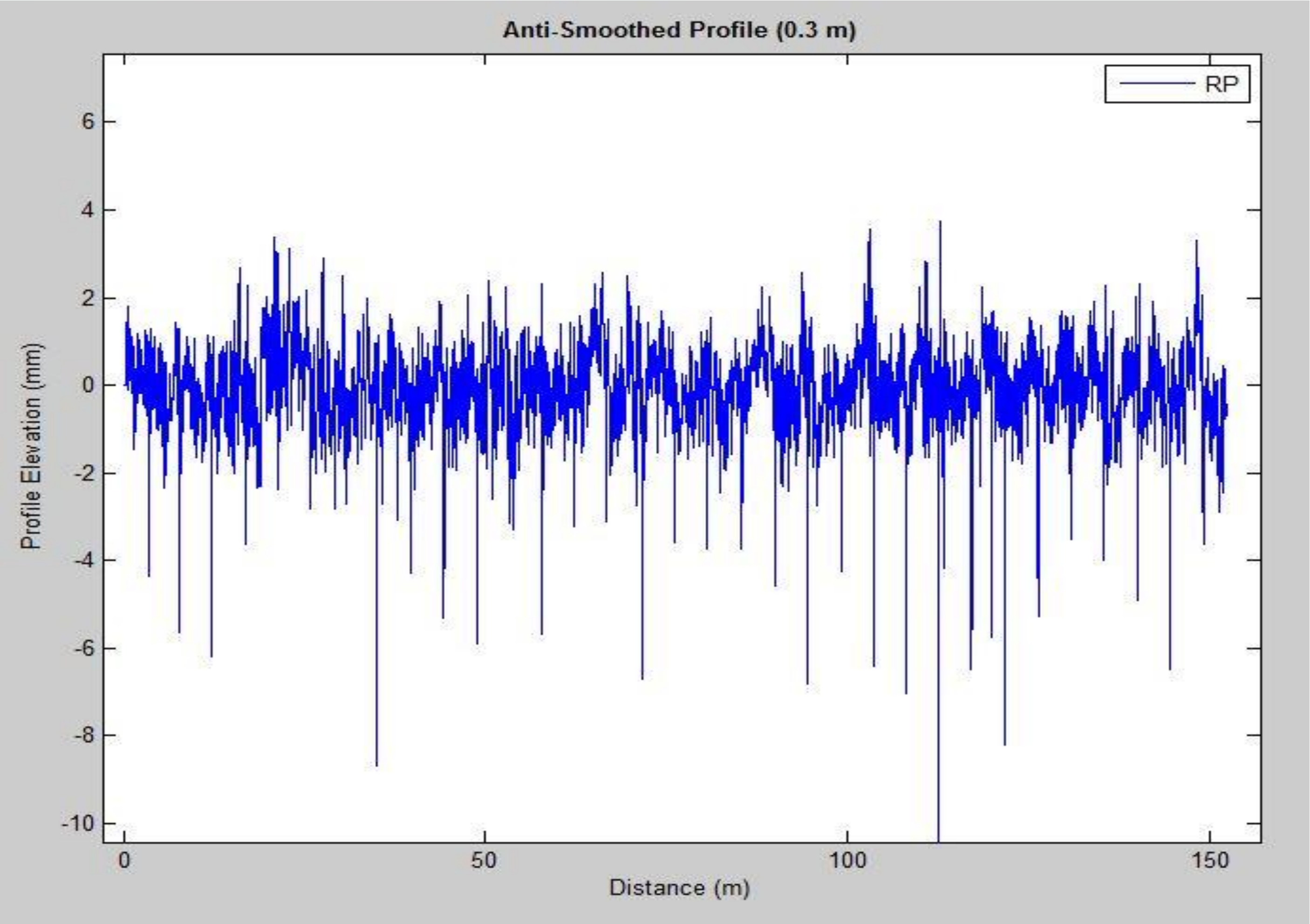
Original Elevation Profile



Anti-Smoothed Profile with 1.25 m base length

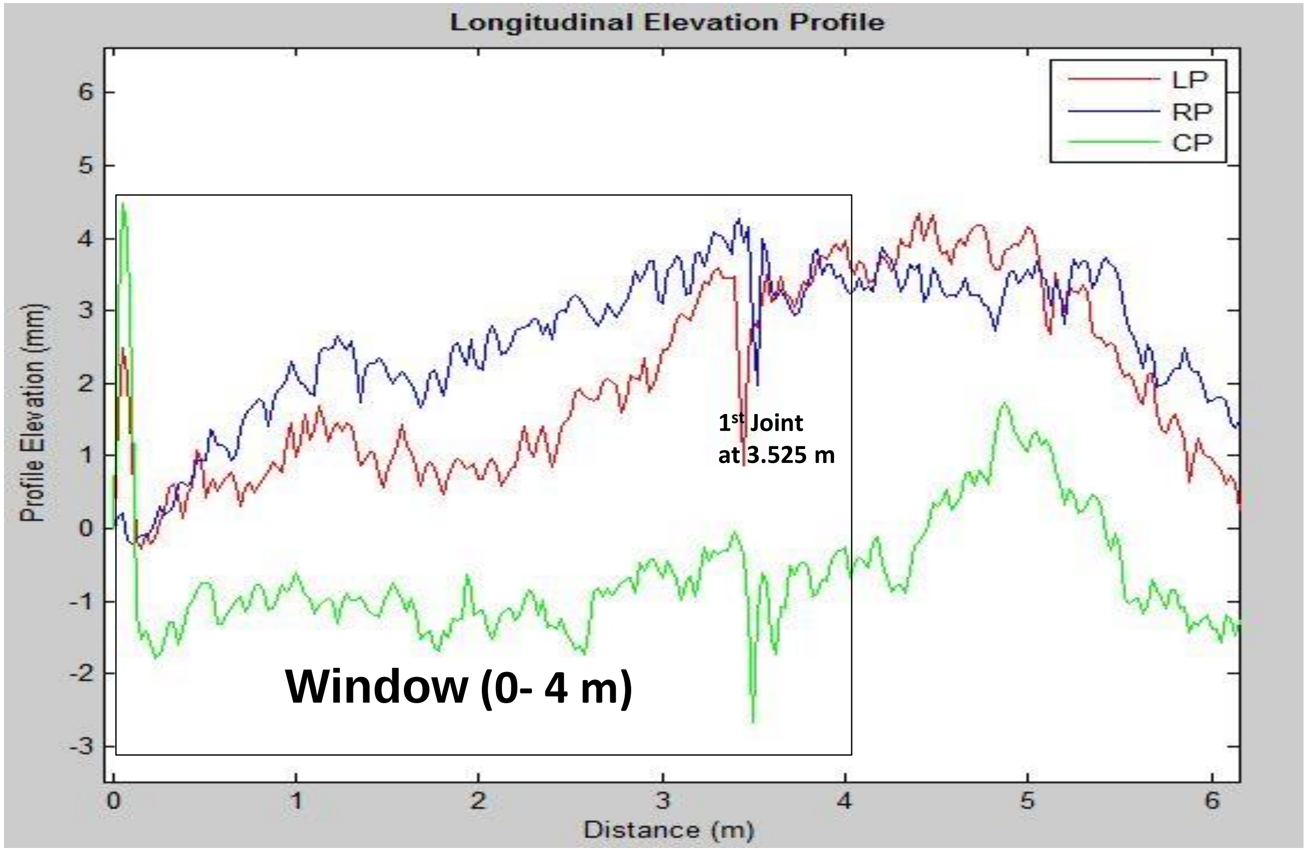


Anti-Smoothed Profile with 0.3 m base length

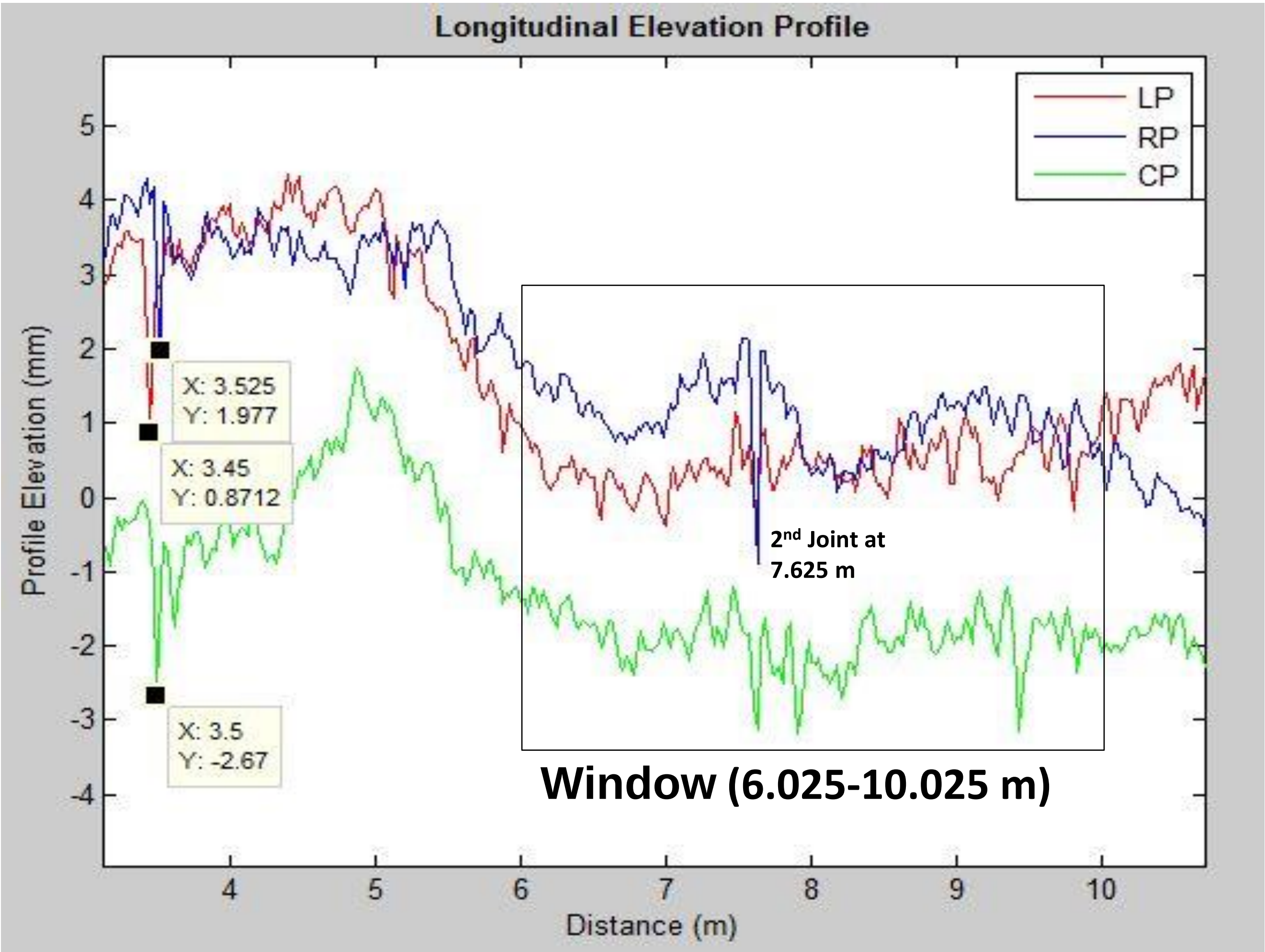


Moving Window Method using Peakdet Algorithm

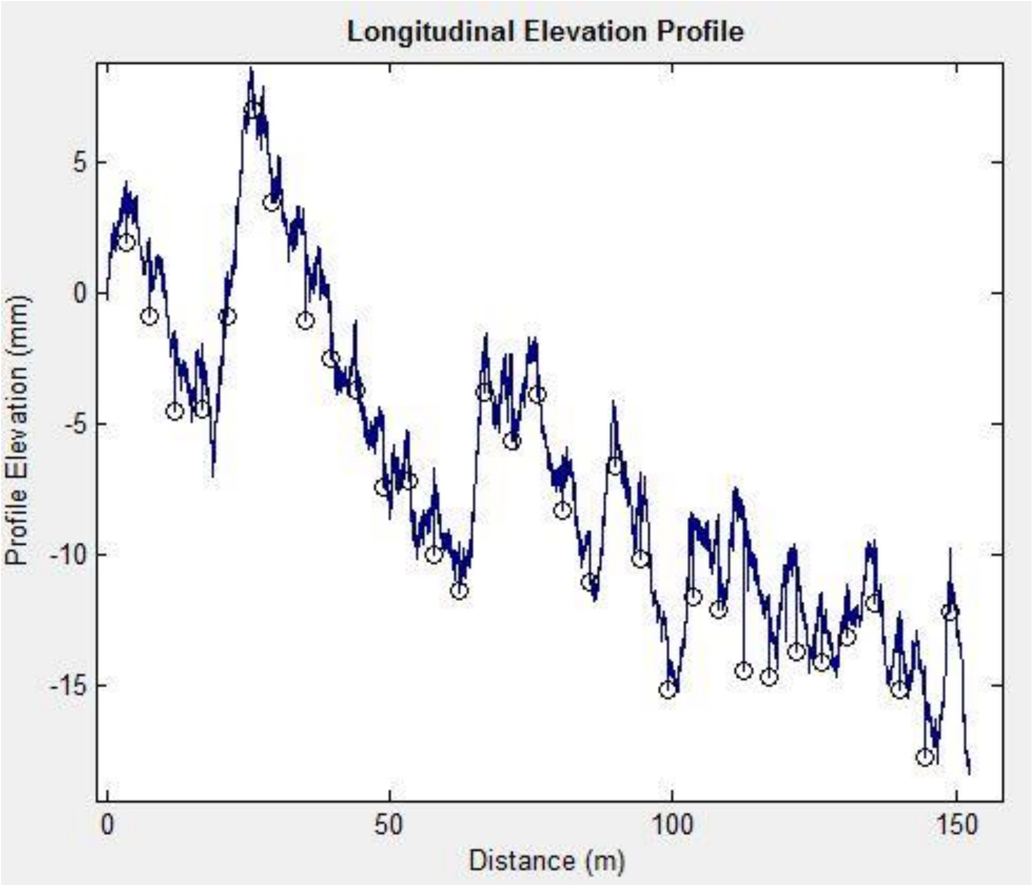
- **JPCP joint detection**



Moving Window Method using Peakdet Algorithm Cont.



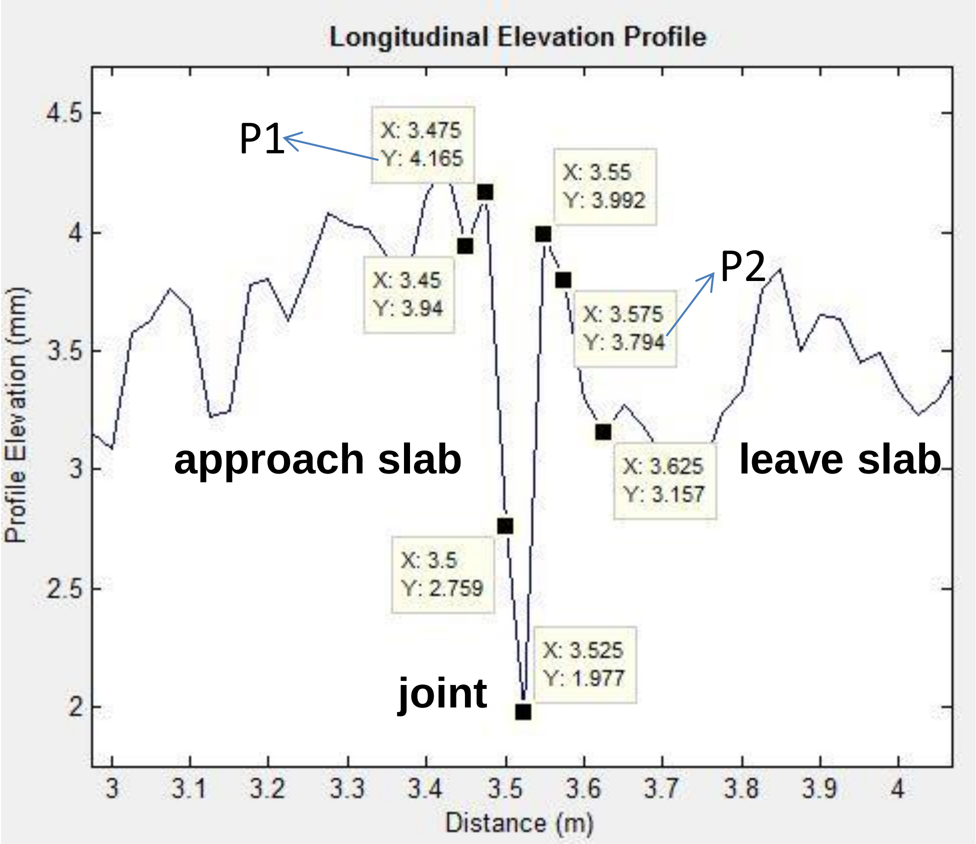
Moving Window Method using Peakdet Algorithm Cont.



Profile Data Processing Cont.

- **Compute joint faulting**
  - LTPP slope method
  - AASHTO R36 (method-A)

Joint Faulting (LTPP Slope Method)

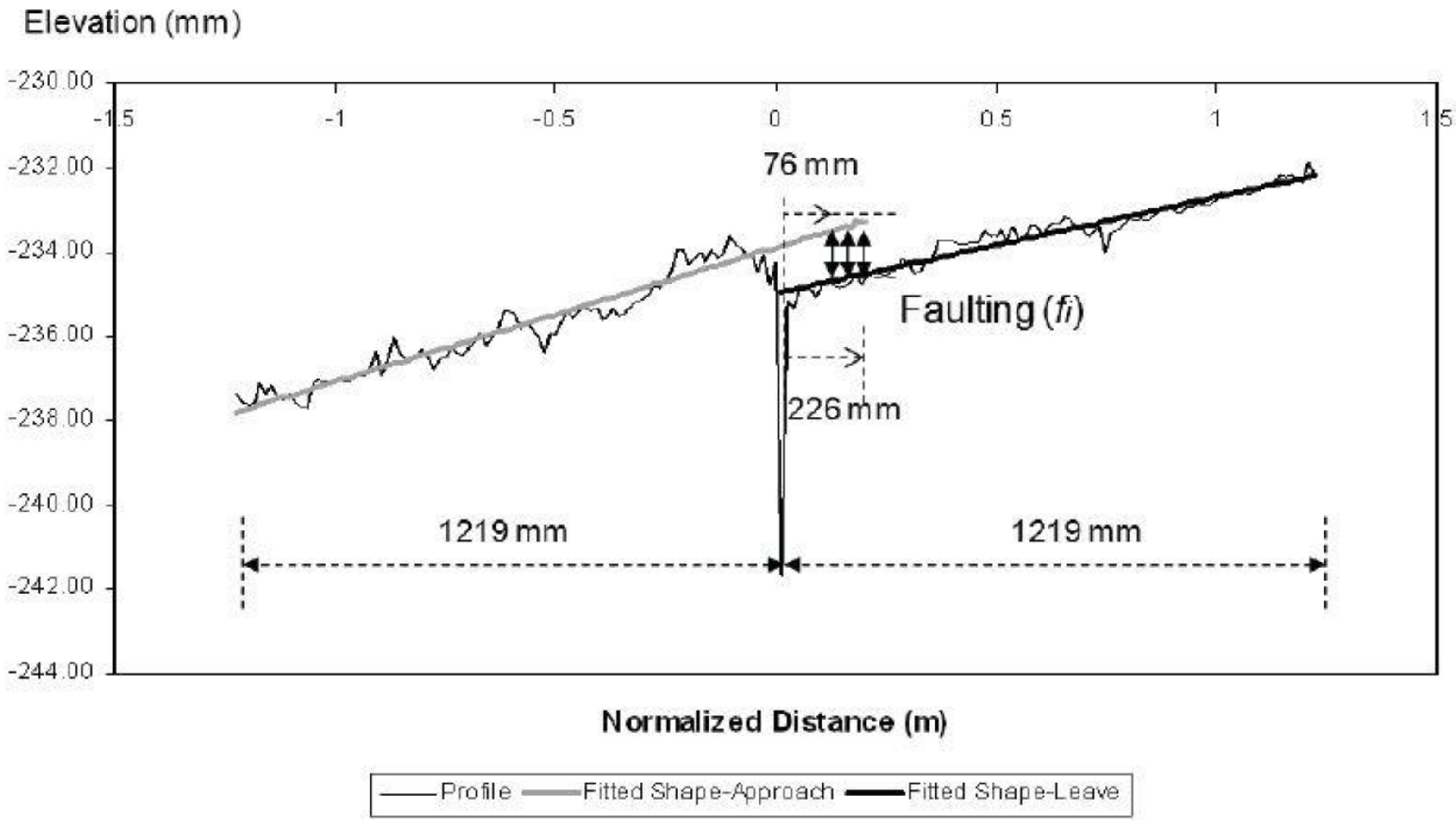


Approach Slab			
y2	1.977	2.759	4.165
y1	2.759	4.165	3.94
x2	3.525	3.5	3.475
x1	3.5	3.475	3.45
Abs. Slope	31.28	56.24	9

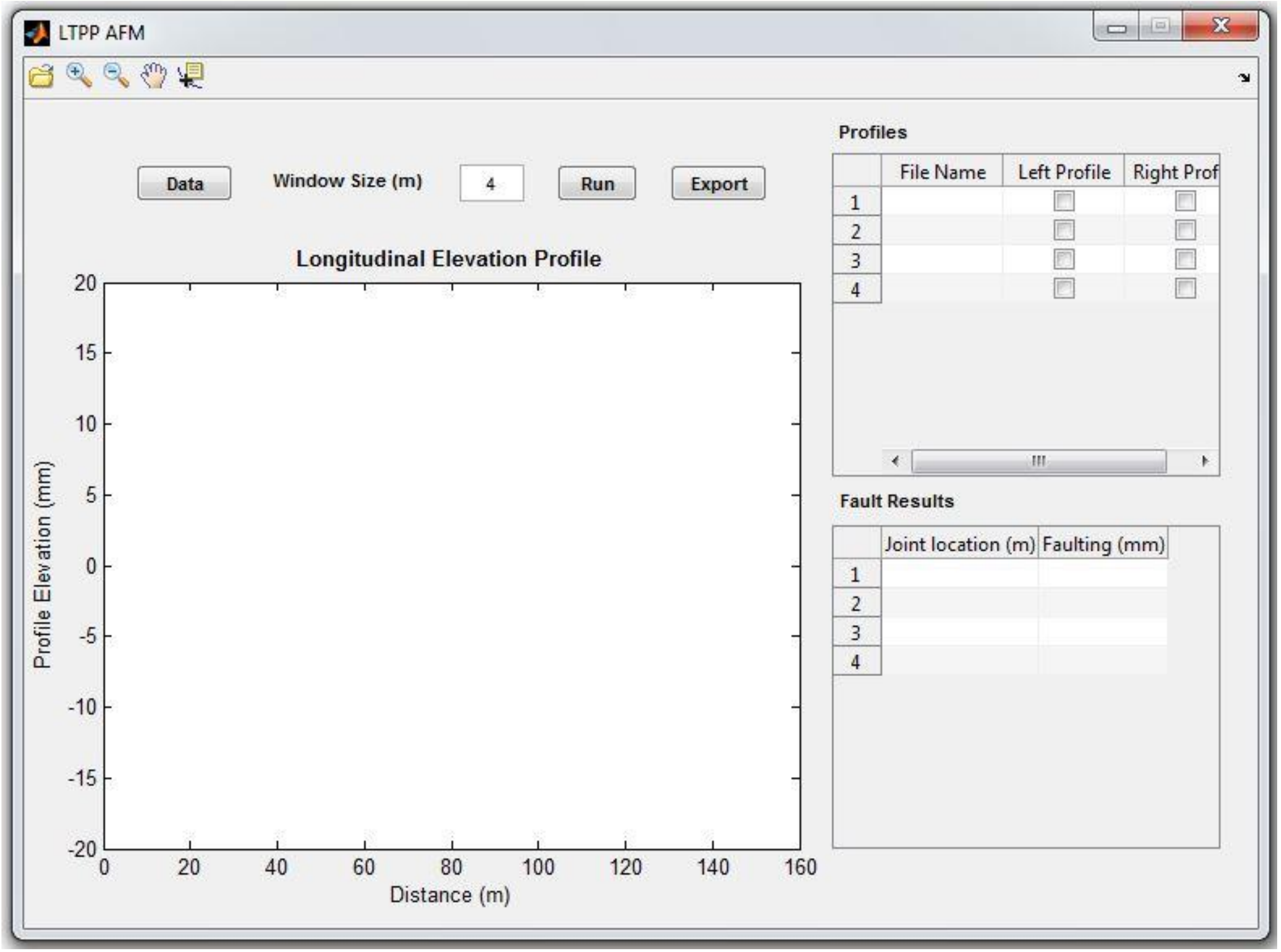
Leave Slab		
y2	3.992	3.794
y1	1.997	3.992
x2	3.55	3.575
x1	3.525	3.55
Abs. Slope	79.8	7.92

P1=4.165 mm
P2=3.794 mm
Faulting = P1- P2
= 0.371 mm

Joint Faulting (AASHTO R36 Method-A)



LTPP AFM Graphical User Interface (GUI)



Analysis & Comparison Results

- **LTPP Data**
  - Six LTPP test sections (500 ft)
  - Five repeat runs by LTPP ICC profiler (25 mm)
  - Average of three GFM measurements per joint
- **FDOT Data**
  - One Florida DOT test section (1000 ft)
  - One profile run by FDOT HSIP (20.7 mm)
  - Manual joint faulting measurements collected using FDOT Faultmeter
- **Study comparison (right wheelpath profile)**
  - ProVAL AFM (AASHTO R36 Method-A) Vs. LTPP AFM
  - FDOT PaveSuite (AASHTO R36 Method-B) Vs. LTPP AFM

Joint Detection Results using LTPP Profiler Data

State Code	SHRP ID	Survey Date	Total # Trans. Joints	ERD File 1 TP	ERD File 1 FP	ERD File 2 TP	ERD File 2 FP	ERD File 3 TP	ERD File 3 FP	ERD File 4 TP	ERD File 4 FP	ERD File 5 TP	ERD File 5 FP	Avg. True Positives Detected	Joint Detection Rate (%)
LTPP AFM Joint Detection Results Using LTPP Profiler Data															
13	3019	11/27/2007	25	25	0	25	0	25	0	25	0	25	0	25	100.0%
31	3018	12/18/2003	32	32	0	32	0	32	0	32	0	32	0	32	100.0%
36	4018	4/13/2010	8	8	0	8	1	7	1	7	1	8	1	7.6	95.0%
37	201	9/19/2002	33	32	0	33	0	33	0	33	0	33	0	32.8	99.4%
42	1606	10/15/2003	10	9	2	10	0	10	0	10	1	9	1	9.6	96.0%
49	3011	10/9/2007	34	34	0	34	0	34	0	34	0	34	0	34	100.0%
ProVAL AFM Joint Detection Results Using LTPP Profiler Data															
13	3019	11/27/2007	25	22	1	21	1	23	0	22	1	23	0	22.2	88.8%
31	3018	12/18/2003	32	28	0	29	0	29	0	29	0	30	0	29	90.6%
36	4018	4/13/2010	8	7	5	4	7	3	10	7	6	6	5	5.4	67.5%
37	201	9/19/2002	33	31	0	31	0	30	0	31	0	30	0	30.6	92.7%
42	1606	10/15/2003	10	6	5	6	4	6	7	5	9	6	8	5.8	58.0%
49	3011	10/9/2007	34	34	0	33	1	34	0	34	0	34	0	33.8	99.4%

TP = True positive, FP = False positive

Joint Detection Results using FDOT HSIP

AFM Method	Total # Trans. Joints	FDOT HSIP Profiler		Joint detection rate (%)
		TP	FP	
FDOT AFM	50	48	8	96%
LTPP AFM		48	0	96%

TP = True positive, FP = False positive

- Joint detection rate of 96% was found for both FDOT PaveSuite and LTPP AFM

LTPP AFM Faulting Results (Slope Method) Using LTPP Profiler Data					
State Code	SHRP ID	Survey Date	GFM Avg. Section Faulting (mm)	Avg. Section Faulting for All Five Runs (mm)	Avg. Section |Bias| for All Five Runs (mm)
13	3019	11/27/2007	0.84	0.56	0.80
31	3018	12/18/2003	4.41	3.28	3.72
36	4018	4/13/2010	1.75	-3.05	5.07
37	201	9/19/2002	0.15	0.37	0.44
42	1606	10/15/2003	3.30	0.39	2.98
49	3011	10/9/2007	3.32	3.48	0.95
ProVAL AFM Faulting Results Using LTPP Profiler Data					
13	3019	11/27/2007	0.84	1.13	0.99
31	3018	12/18/2003	4.41	5.04	0.88
36	4018	4/13/2010	1.75	-6.58	8.75
37	201	9/19/2002	0.15	1.08	1.02
42	1606	10/15/2003	3.30	1.35	2.46
49	3011	10/9/2007	3.32	4.71	1.46
LTPP AFM Faulting Results (AASHTO Method-A) Using LTPP Profiler Data					
13	3019	11/27/2007	0.84	-0.56	1.86
36	4018	4/13/2010	1.75	-12.06	13.81
37	201	9/19/2002	0.15	1.66	1.59
42	1606	10/15/2003	3.30	-0.38	3.68

Joint Faulting Results using FDOT HSIP Data

Method	GFM Avg. Section Faulting (mm)	Avg. Section Faulting (mm)	Avg. Section |Bias| (mm)
FDOT AFM	1.81	1.69	1.05
LTPP AFM (Slope Method)		1.62	1.14

Conclusions

- **The developed LTPP AFM is reliable in detecting JPCP transverse joints**
  - The LTPP AFM joint detection rate ranged from 95% to 100% for LTPP profiler data
  - The ProVAL AFM joint detection rate ranged from 58% to 99.4% for LTPP profiler data
  - For FDOT HSIP data both the FDOT PaveSuite and the LTPP AFM have a joint detection rate of 96%

Conclusions Cont.

- **Fault measurements using LTPP profiler data**
  - The average difference between faulting estimated by the
    - ProVAL AFM and the GFM ranged from 0.88 to 8.75 mm
    - LTPP AFM (slope method) and the GFM ranged from 0.44 to 5.07 mm
    - LTPP AFM (AASHTO method) and the GFM ranged from 1.59 to 13.81 mm

Conclusions Cont.

- **Fault measurements using FDOT HSIP data**
  - The average difference between faulting estimated by the
    - FDOT PaveSuite and the FDOT FM was 1.05 mm
    - LTPP AFM (slope method) and the FDOT FM was 1.14 mm
- **FDOT HSIP and faulting data were collected**
  - on the same wheelpath
  - at the same time of the day
  - under same temperature conditions

Recommendations

- **Better AFM results could be generated if the manual GFM measurements and the LTPP profile data are collected**
  - on the same wheelpaths
  - at the same time of the day
  - under the same temperature conditions
- **Further research is needed for robust joint fault computation methods to accurately measure joint faulting using profiler data**

Questions