VALIDATION OF FDOT AUTOMATED FAULTING METHOD

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Outline

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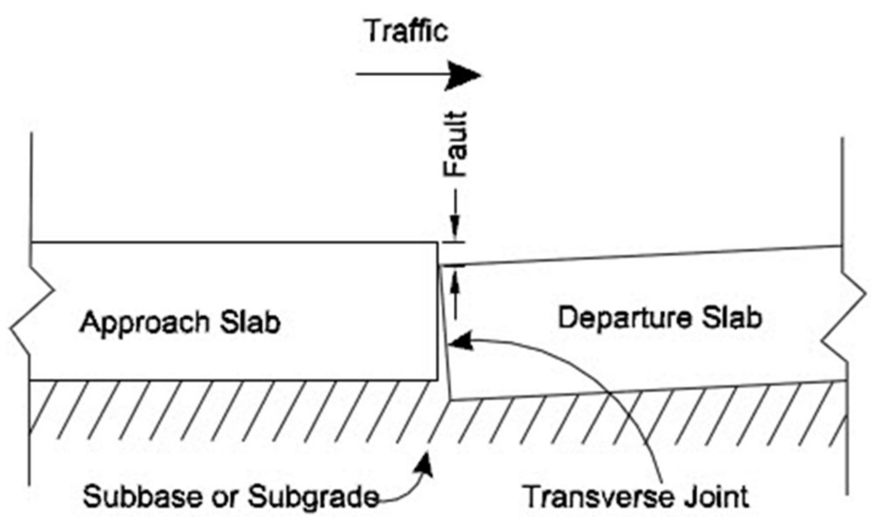
- Goal & Objectives
- Automated Faulting Program
- Test Equipment
- Data Collection
- Results
- Analysis
- Conclusion
- Recommendation

Background

What is Faulting ?

"…the difference in elevation across a transverse joint or a transverse crack .." Ref. AASHTO R-36

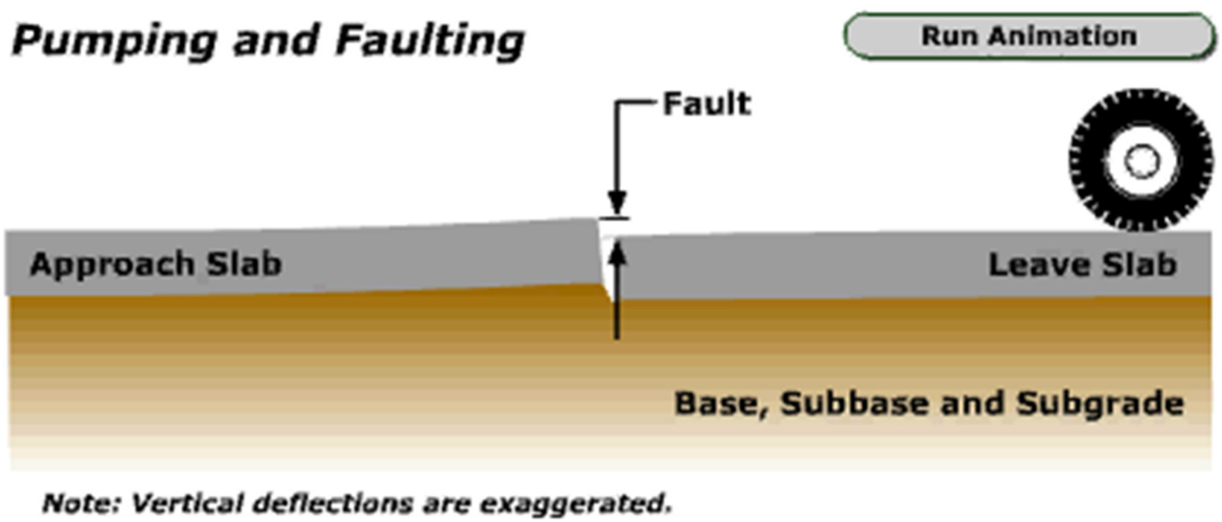


Background

Faulting is …

- a key distress in jointed concrete pavements
- an important performance indicator
- a critical factor in the life-cycle cost of a pavement

Background



Source: Pavement Interactive – http://pavementinteractive.org

Background

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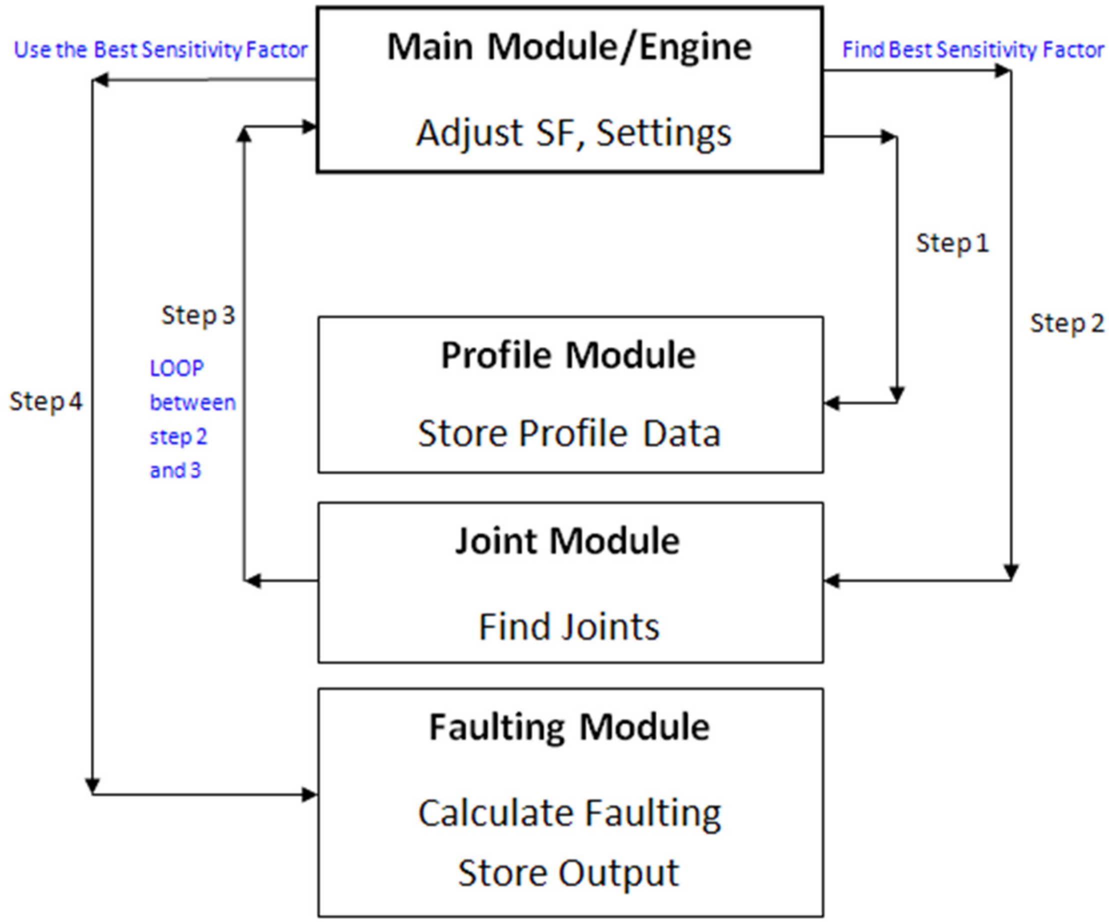
Background

Catalysts for the study …

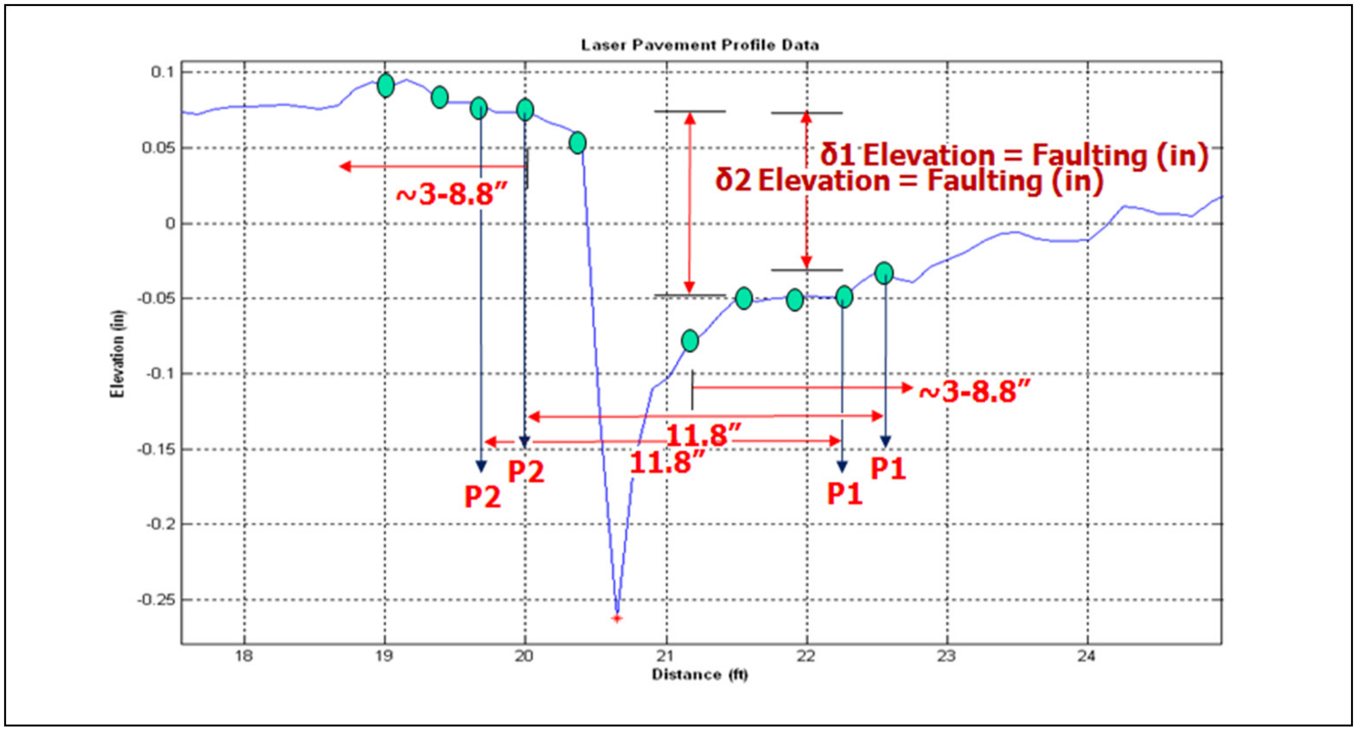
- HPMS reassessment requirements
- Need to leverage profile data
- Lack of validation information
- **Safety**

Automated Faulting Program



Automated Faulting Program

TRB Publication 10-1868, 2010



Goal and Objectives

Validate automated faulting method

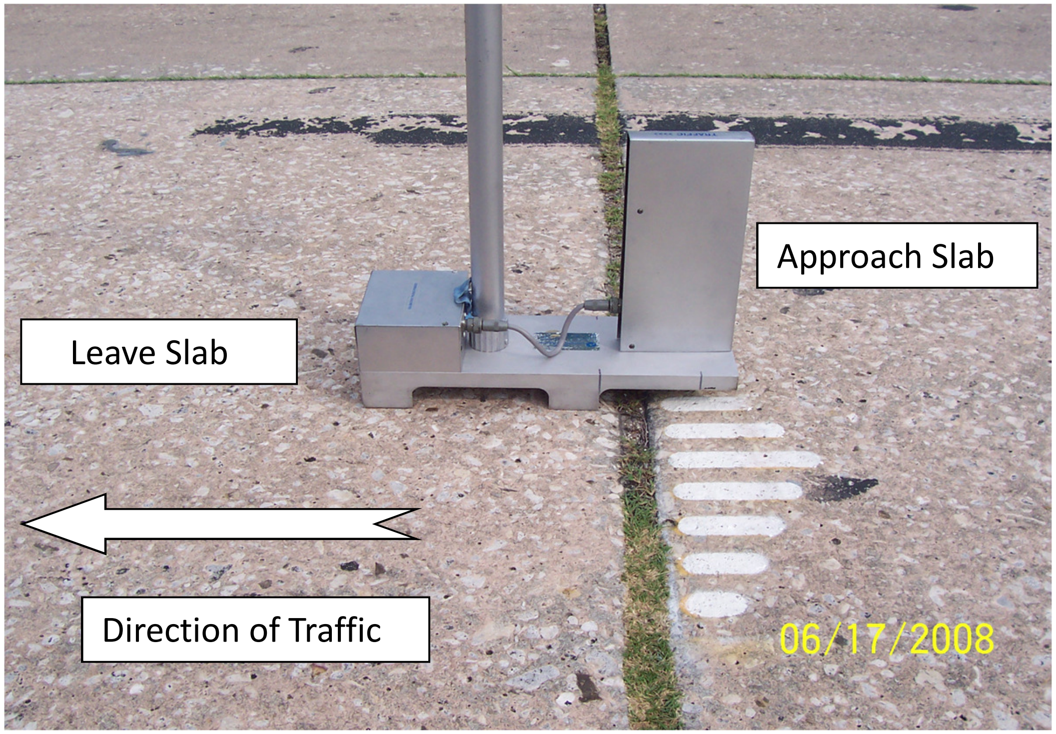
- Phase 1 – Faulting simulation
- Phase 2 – Field validation

Automated faulting precision

- Repeatability
- Accuracy
- Reproducibility

Test Equipment

Georgia Faultmeter



Test Equipment

Five High Speed Profilers (HSP)

Test Equipment

IRI Filtered Cross Correlation

HSP	Interval (in)	Left	Right
29748	0.8	93	94
30330	0.7	92	96
30781	0.9	62	84
29863	0.8	94	97
30392	0.7	97	97

Test Equipment

Faulting Simulation Device

Software

- Automated Faulting Program – Major Steps
  - Remove user-defined exclusions from collected data
  - Set default sensitivity factor (SF)
  - Find valleys (negative slopes) and peaks (positive slopes) meeting minimum SF
  - Calculate distance between consecutive peak and valley
  - Distance has to be less than 2.5 inch to consider the couple as joint
  - Calculate faulting based on AASHTO R36-04 criteria
  - Check if the calculated faulting is more than 1/64th inch (FDOT PCS spec) → YES → temporary save location of the joint

This is a test page!

- Automated Faulting Program – Major Steps
  - Repeat previous steps for all the points in the given profile
  - Check distance between consecutive joints to be more than 14.8 in → NO → keep one with deeper fault
  - Count number of joints
  - Repeat all previous steps for different SF
  - Keep SF which has largest number of found joints meeting all previous described criteria
  - Recalculate joint location and fault magnitude for the chosen SF
  - Save results

Data Collection

Phase 1: Simulated Faulting

- “controlled” conditions (eliminates effects of pavement texture and vehicle wander)
- Asses HSIP’s ability to collect accurate and repeatable elevation data in a dynamic mode
- Middle laser was used to collect elevation data
- Average of left and right accelerometer readings was used to correct middle laser sensor height data

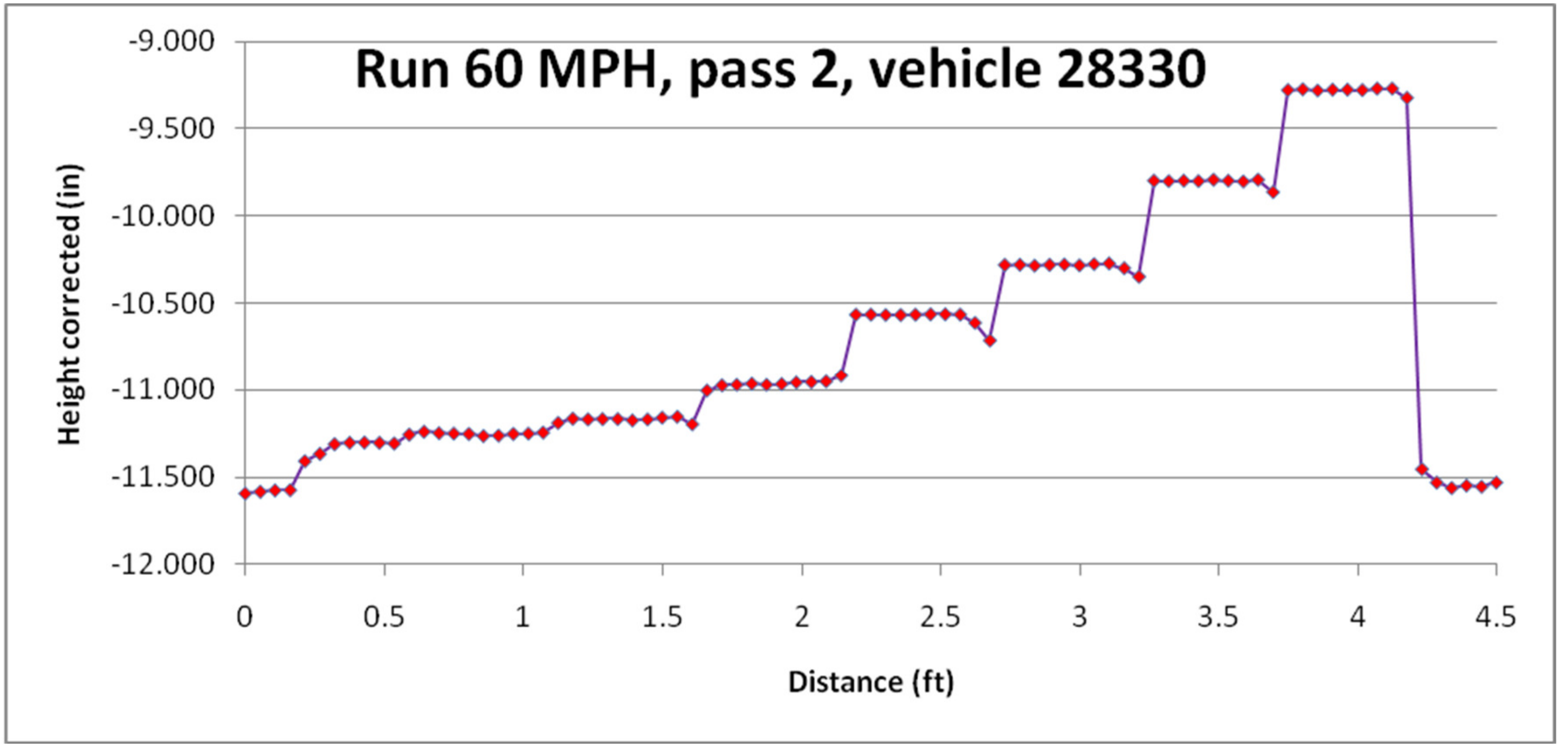
Data Collection

Phase 1- Simulated Faulting

- 5 HSP
  - 0.68 to 0.91inch interval
- Faulting simulation device (reference)
  - 13, 11.89, 10.07, 7.00, 5.05, 2.01, 0.91 (mm)
- 6 speeds
  - 20,30,40,50, 60, and 70 mph
- 3 replicate runs per speed

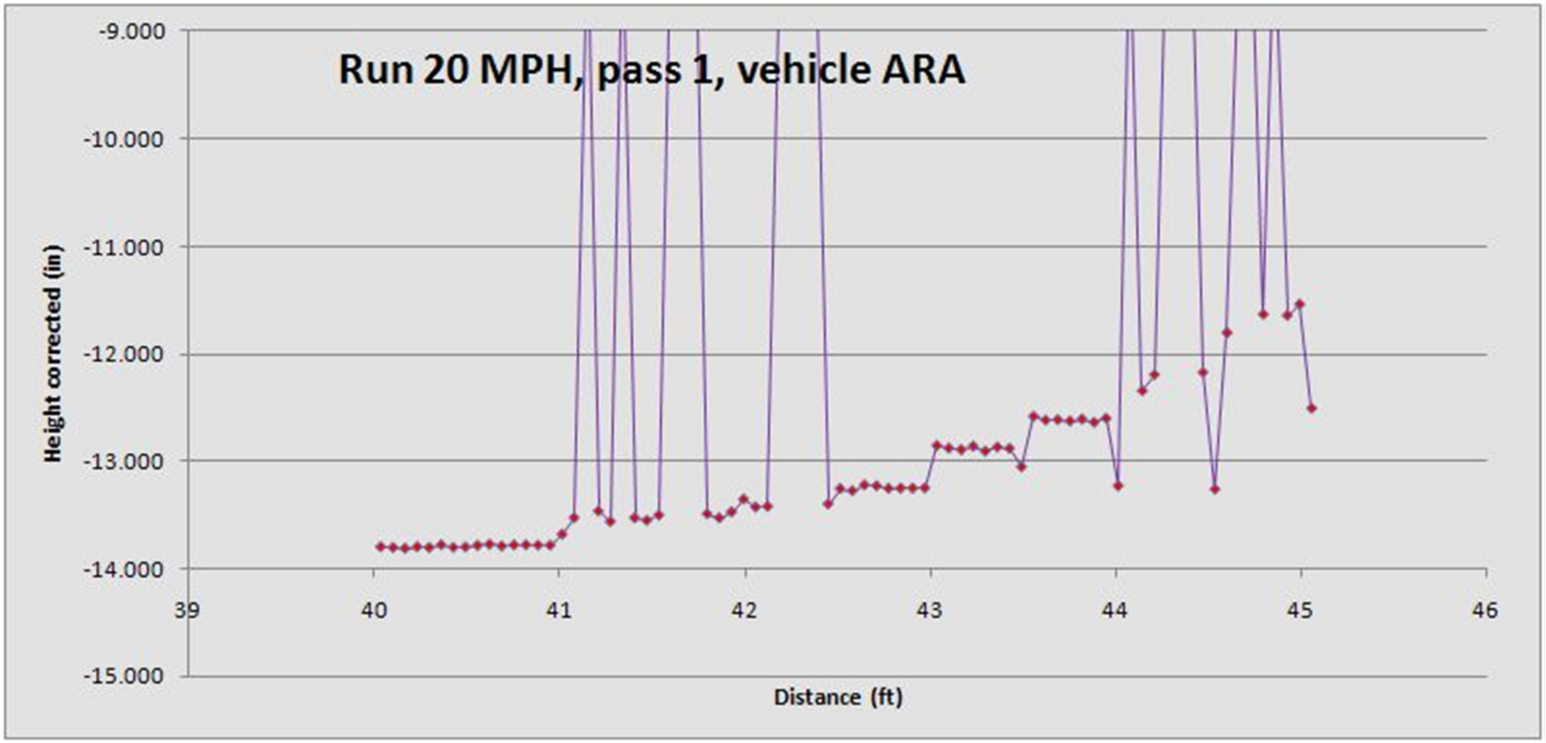
Data Collection

Phase 1- Simulated Faulting



Data Collection

Phase 1- Simulated Faulting (defective sensor)



Data Collection

Phase 2- Field Validation

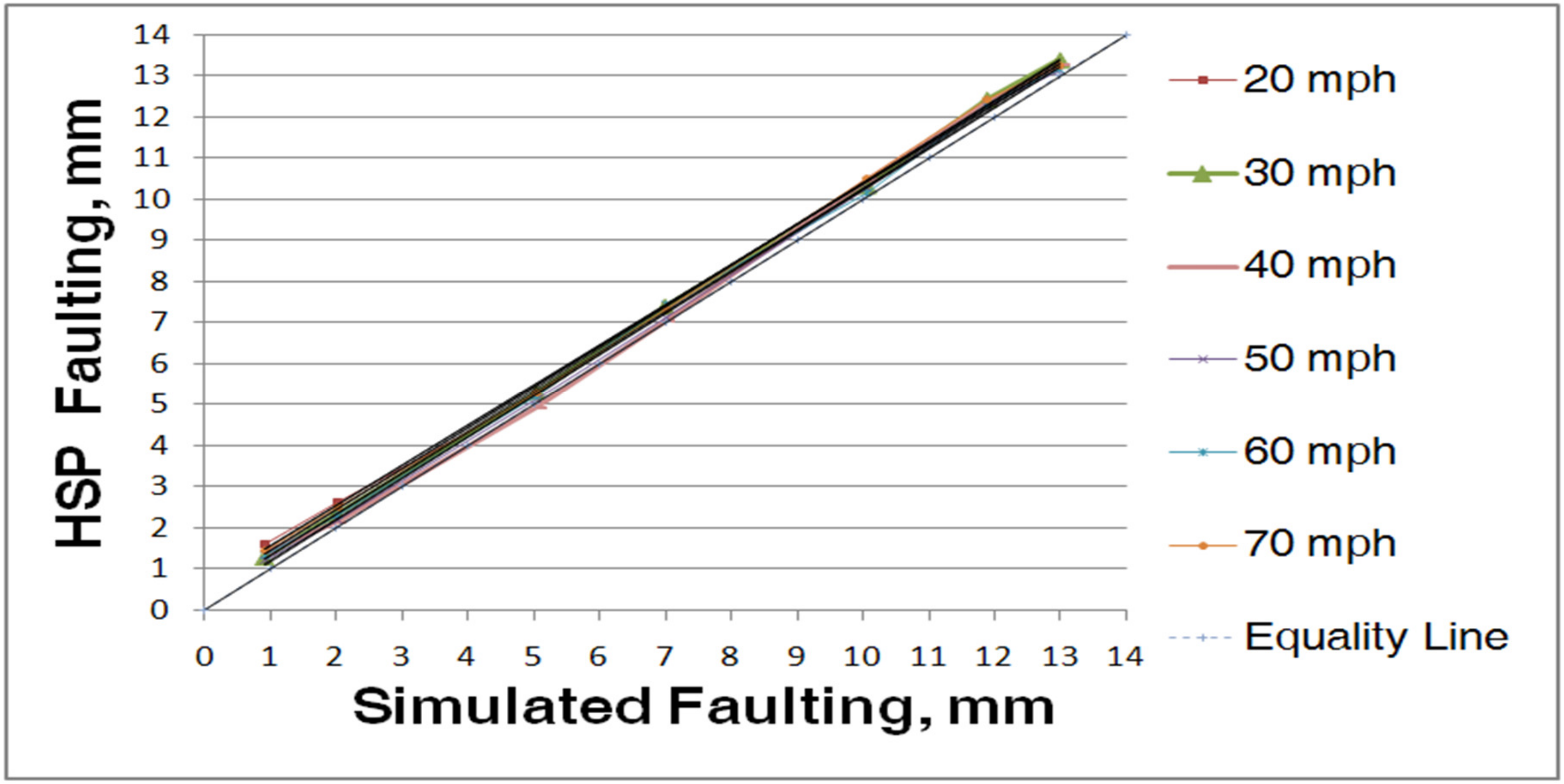
- SR-331 (Waldo Road)
  - PCP, 20 ft slabs, burlap drag texture,50 joints
- 5 HSP
  - 0.68” to 0.91” sampling interval
  - 3 runs @ 40 MPH
  - Right laser/accelerometer
- Georgia Faultmeter (reference)
  - 9 readings across right wheelpath


SPEED
STRICTLY
ENFORCED
SCHOOL ZONE
15 MPH
WHEN FLASHING


2
06/17/2008

Results

Phase 1 - Simulated Faulting



Results

Phase 1 - Simulated Faulting

Speed (mph)	Slope (mm)	Intercept (mm)	R^2
20	0.978	0.568	0.999
30	1.007	0.299	0.999
40	1.010	0.153	0.998
50	1.008	0.196	0.999
60	0.989	0.354	0.999
70	0.991	0.459	0.999

Results

Phase 1 - Simulated Faulting

- Accuracy
  - maximum bias between HSP and simulated faulting device
- Repeatability
  - maximum range within a HSP

Results

Phase 1 - Simulated Faulting

Accuracy (mm)	Repeatability (mm)
0.60	0.65

Results

Phase 2 – Faulting Field Validation

- Accuracy
  - maximum bias between HSP and Georgia Faultmeter
- Repeatability
  - maximum range within a HSP
- Reproducibility
  - maximum range among all HSPs

Results

Phase 2 – Joint Detection

- True Positives
  - existing joints detected
- True Negatives
  - existing joints not detected
- False Positives
  - non-existing joints falsely detected

Results

$$\text{Joint Detection Rate (\%)} = \frac{(\#\ \text{True Positives})\ \times 100}{(\#\ \text{True Positives} + \#\ \text{True Negatives})}$$

Results

Phase 2 – True Positives

29748	29863	30330	30781	30392
41	42	40	37	47
82%	84%	80%	74%	94%

Results

Phase 2 – True Negatives

29748	29863	30330	30781	30392
9	8	10	13	3
18%	16%	20%	26%	6%

Results

Phase 2 – False Positives

29748	29863	30330	30781	30392
9	8	8	7	16
18%	16%	16%	14%	32%

Results

Phase 2 - Automated Faulting

"Precision" (mm)		
Accuracy	Repeatability	Reproducibility
1.2	1.1	0.5

Analysis

Phase 1- Simulated faulting

- Speed gradient had an upward bias at all speeds.
- Simulated faulting accuracy estimated at 0.6 mm.
- Simulated faulting repeatability estimated at 0.65mm.

Analysis

Phase 2 Field validation

- Positive joint detection was 80 to 90%
- Automated faulting accuracy was 1.2 mm.
- Automated faulting repeatability was 1.1 mm.
- Automated faulting reproducibility was 0.5 mm.

Conclusions

- The simulated faulting device is an effective tool to test an inertial profiler system's ability to make accurate height measurements in dynamic mode.

- The FDOT Automated Faulting Method provides a safe, fast, accurate, and cost effective method faulting measurement method.

Recommendations

Additional validations work…

- Range of joint widths
- Different joint and slab conditions
- Range of slab lengths and geometry
- Various profile filters

Recommendations

Improve the algorithm by …

- Enhancing positive joint detection
- Reducing false positives, and
- Increasing program efficiency

Mississippi Data – True Positives

Caroll	Hinds	Itawamba	Leflore	Washington	Oktibeha
160	17	26	55	10	31
74%	100%	96%	98%	56%	91%


102610 2 8 I 55 N 1.240 46.6 2008/02/18


105140 3 76 US 61 N 20.196 48.1 2008/03/12

Thank you!