Jointed Concrete Pavement Faulting Collection and Analysis Standards – Phase I

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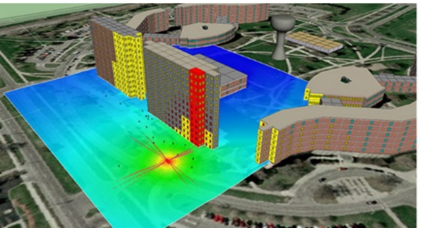



Acknowledgement

1. FHWA – Andy Mergenmeier
2. SHA Panel – Cindy Smith, David Huft, Bouzid Choubane
3. SHA Providing Information – Alabama, Florida, Kansas, Mississippi, Missouri, North Dakota, Ohio, South Dakota, Utah, and Washington
4. Vendors Providing Information – Ames Engineering Inc., Dynatest North America, Inc., International Cybernetics Corp. (ICC), Pathway Services Inc., and Pavemetrics
5. Team – ARA: Hyung Lee, Hesham Abdualla; Transtec: George Chang, David Merritt

Phase I

1. Task 1—Kickoff Meeting
2. Task 2—Literature Review and Information Gathering
    - Subtask 2.1. Literature Review and Information Gathering
    - Subtask 2.2 Development of New Definitions and Procedures
3. Task 3—Draft and Final Phase I Report and Phase II Work Plan

Phase II

4. Task 4—Pilot Projects
   - Definitions
   - Equipment
   - Certification and Verification Procedures and Protocols
   - Precision and Accuracy
   - Faulting Standards (AASHTO)
5. Task 5—Draft and Final Phase II Report

Limitations of Current Practice

1. Lack of a Standard Definition for Faulting
   - Manual Distress Survey vs. Automated [2D (Line Laser, Point Laser) vs. 3D], Transverse Location(s), Longitudinal Location(s)
2. Uncertainties Associated with Different Methods
   - Method A, Method B
3. Lack of a Standard Reporting Protocol
   - Positive fault, negative fault, averages, joint detection
4. Lack of a Certification Process for Faulting

The objective of this project (Phase I and Phase II) is to address the shortcomings of current faulting practices and establish standards that will quantify the accuracy and precision requirements for faulting data collection and analysis to meet SHA requirements.

BACKGROUND

What is faulting? ↔ What is the difference between faulting (the distress) and faulting (the measurement)?

↓ Reporting

How do agencies measure faulting? ↔ What are the current definitions, standards, and protocols for collecting and analyzing faulting data?

STRUCTURE

↓ Decision Analysis

What are the effects of faulting? How do agencies use and report faulting data? ↔ What data standards are needed based on agencies use of faulting data?

↓ Data Analysis

How do we define faulting? How should faulting be interpreted/analyzed? ↔ How can we make faulting (the measurement) consistent and a true representation of faulting (the distress)?

↓ Data Acquisition

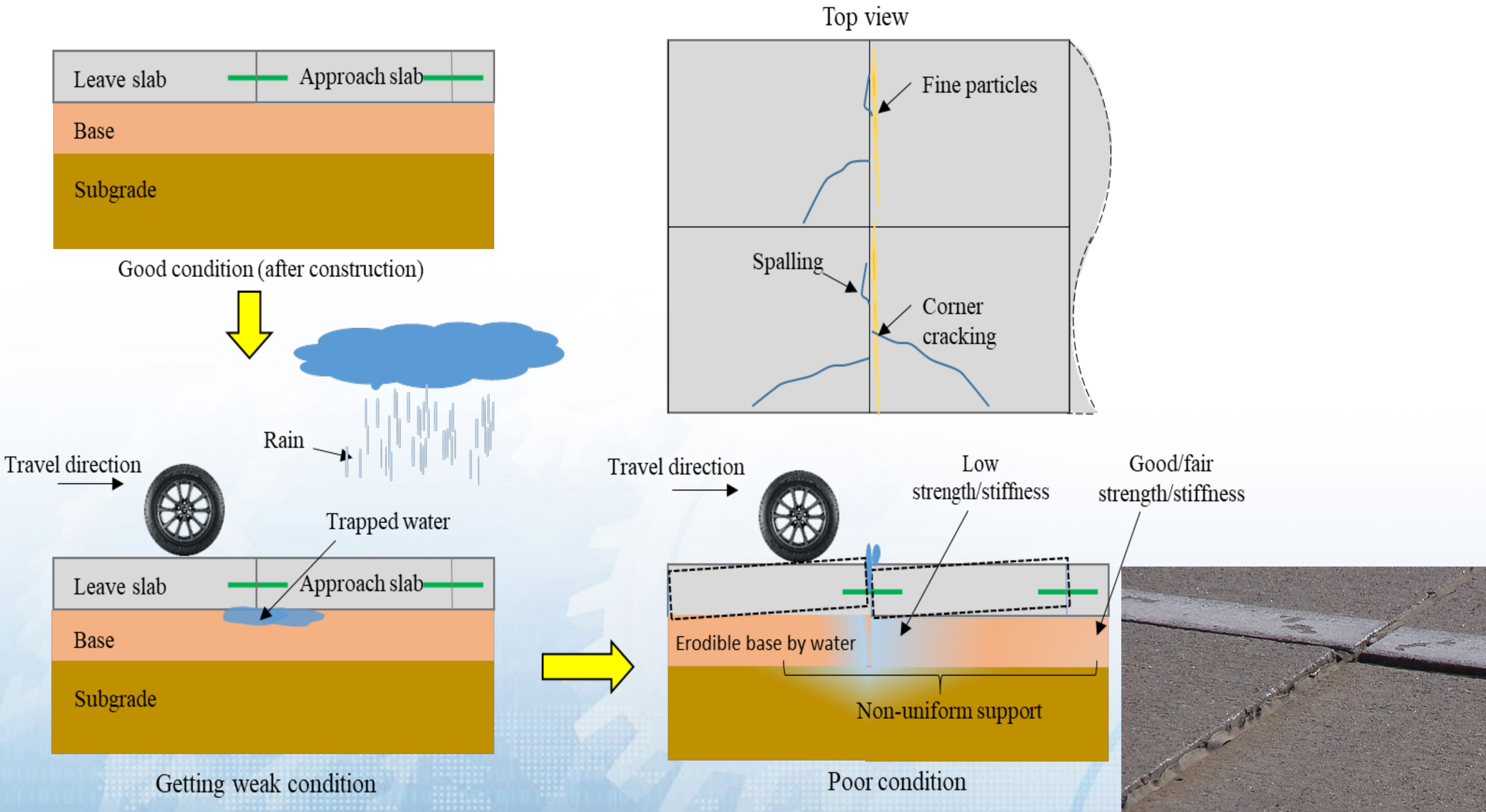
How do we collect faulting data? ↔ What equipment should be used to collect faulting data on a production basis? How do we verify the data quality?

↓ Certification

How do we certify production faulting measurements? ↔ What are the requirements for and how should measurements be evaluated to meet quality needs?

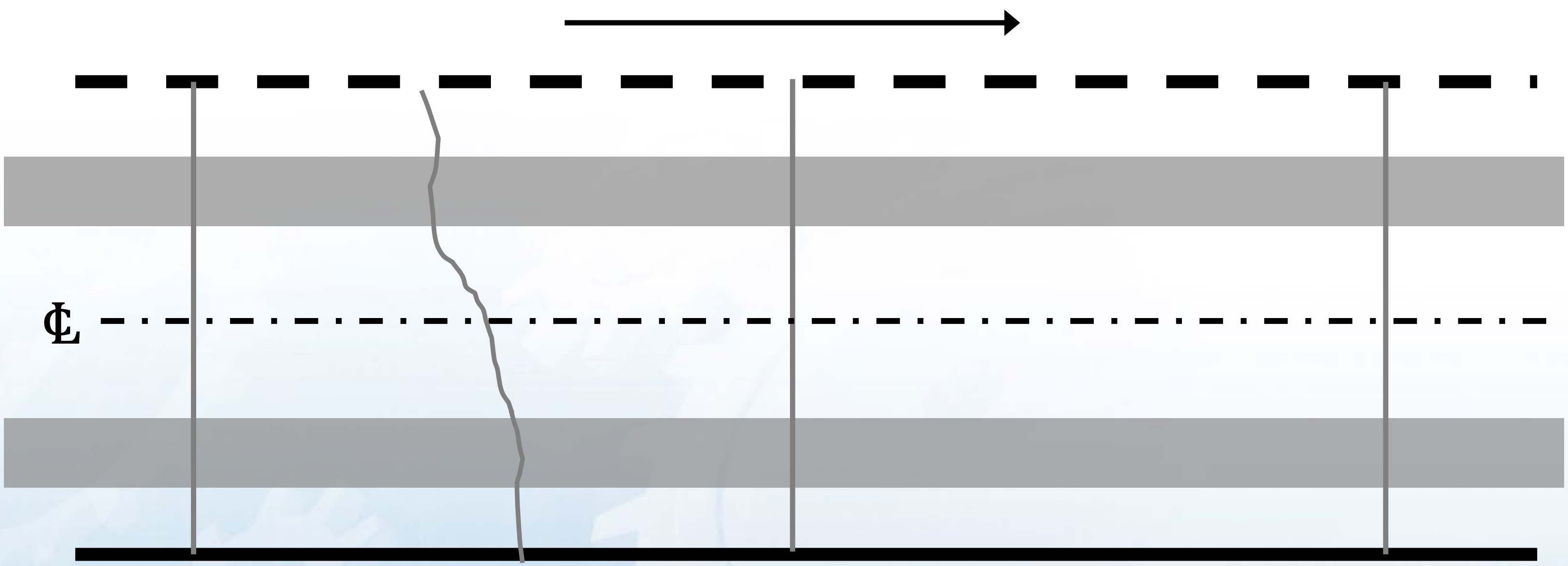
↓ Reference Test

What kind of reference test is appropriate for certification? ↔ What are the requirements for the reference tests? What artifacts are needed to certify the measurements?

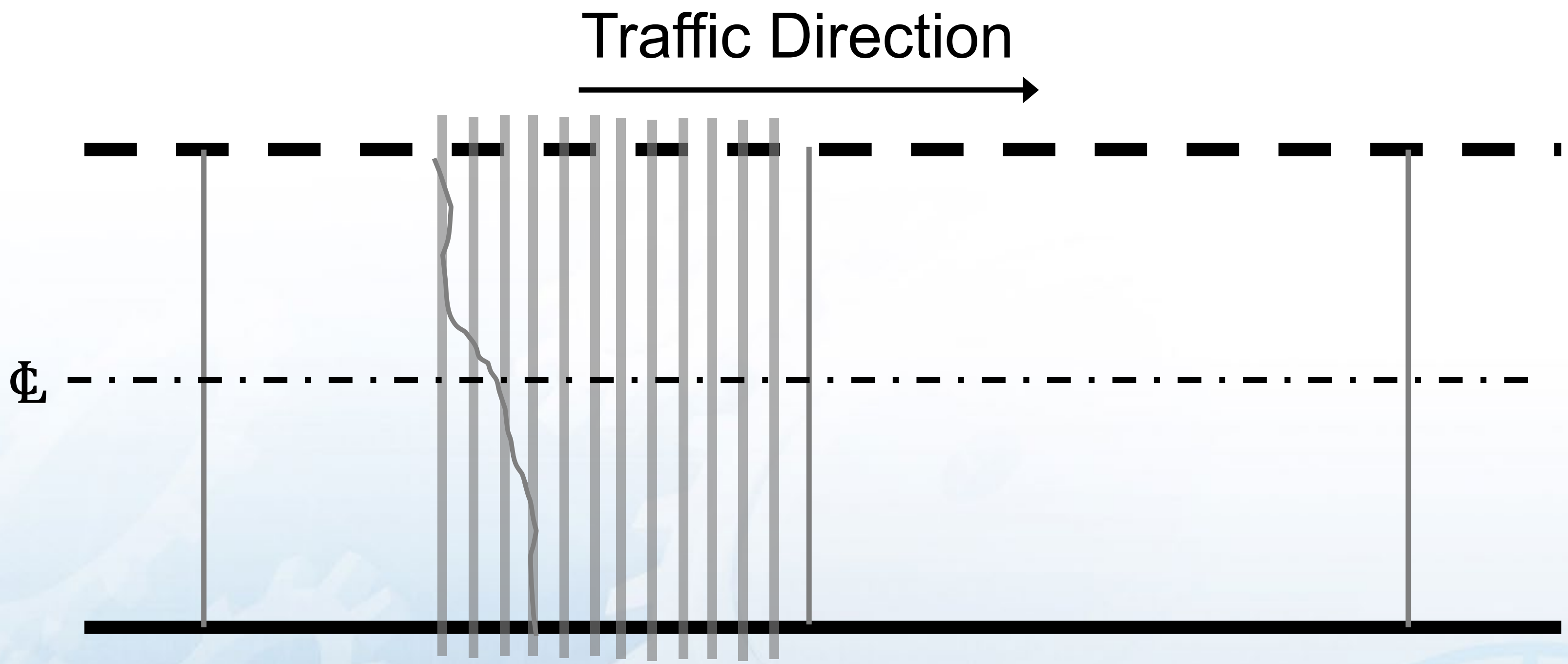

Leave slab
Approach slab
Base
Subgrade
Good condition (after construction)
Top view
Fine particles
Spalling
Corner cracking
Rain
Travel direction
Trapped water
Leave slab
Approach slab
Base
Subgrade
Getting weak condition
Travel direction
Low strength/stiffness
Good/fair strength/stiffness
Erodible base by water
Non-uniform support
Poor condition

Faulting (the measurement) is a clearly-defined quantification of faulting (the distress) and requires definitions, procedures, and protocols for measuring (including verifying and certifying), analyzing, and reporting.

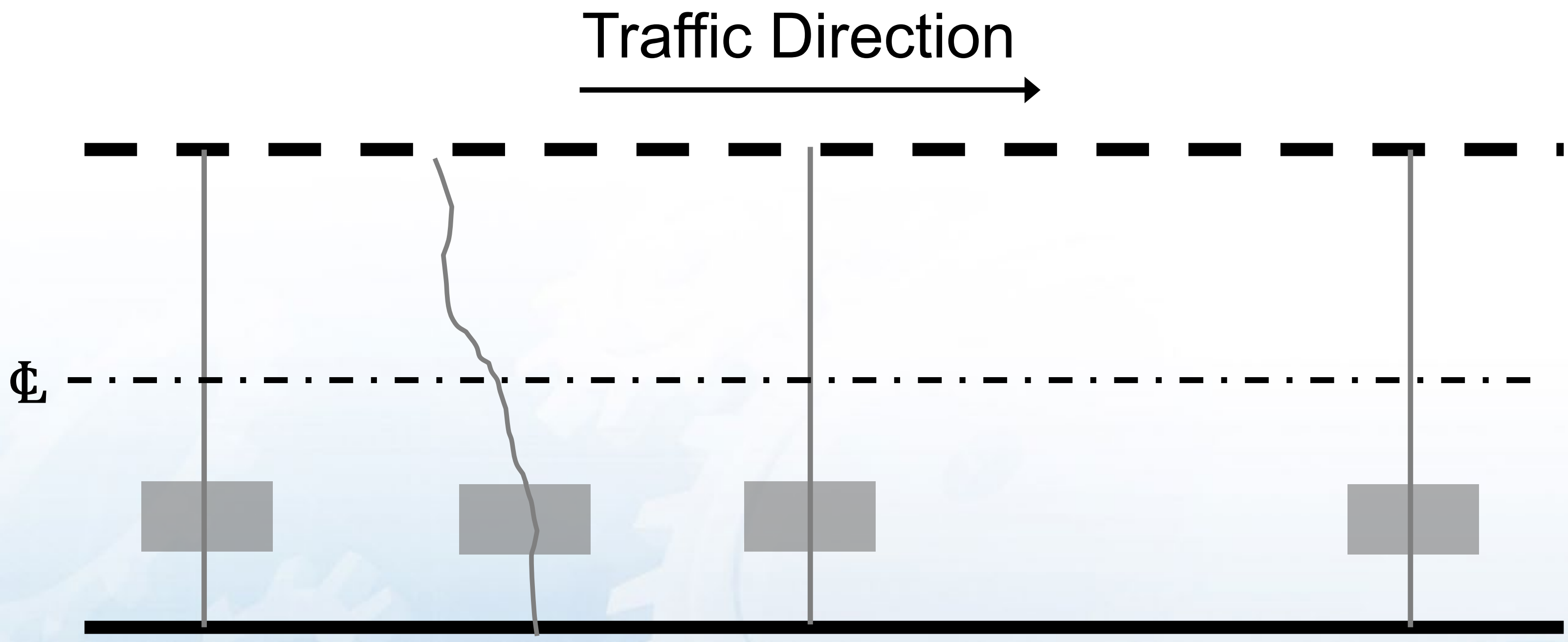
Traffic Direction



IRI Measurement

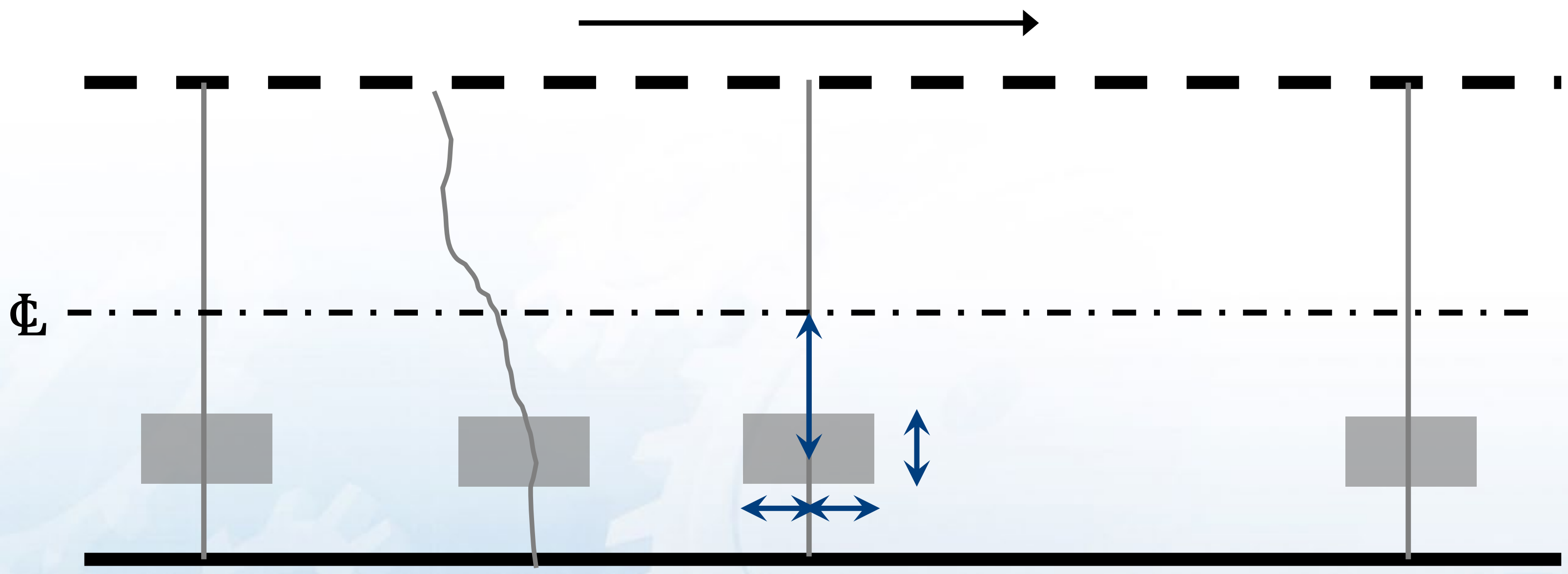


Transverse Profile Measurement



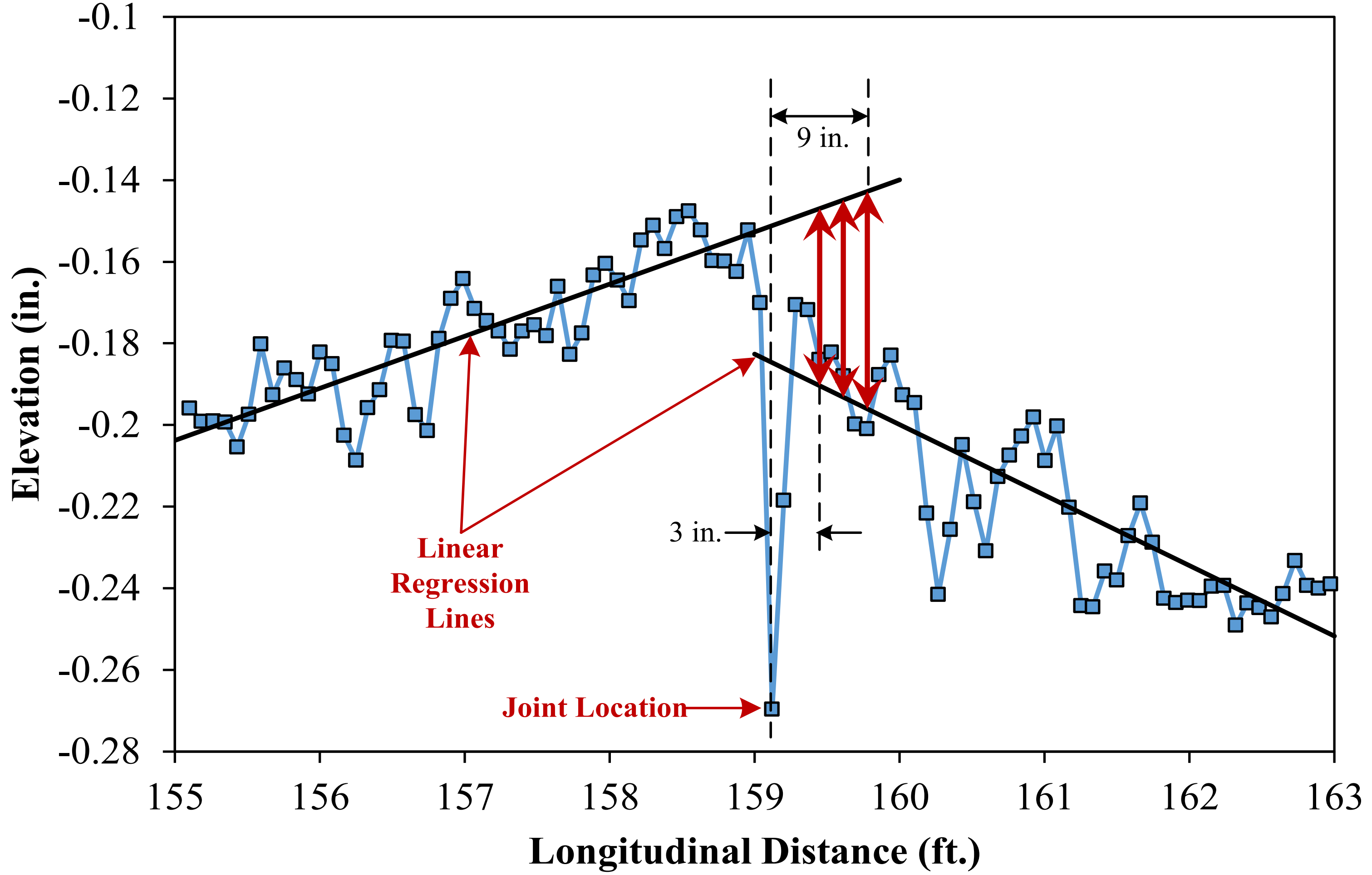
Faulting Measurement

Traffic Direction



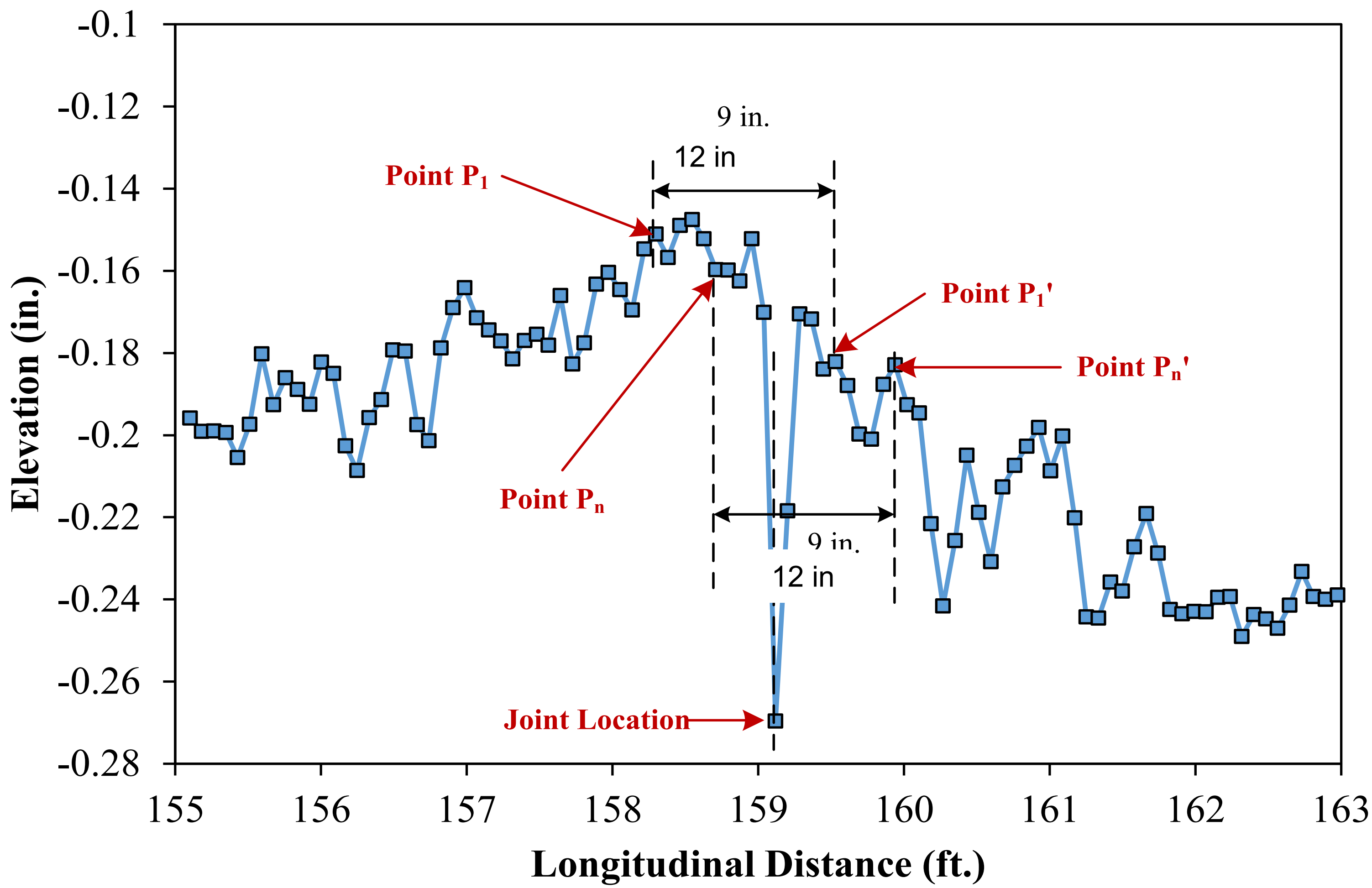
Faulting Measurement

We are really interested in Z measurement…
but which X and Y location(s) should we use?
What impact does it have? How do we account for local texture?



Detect joint: Downward Spike, Step, Curled Edge
4 ft linear regression, average elevation 3-9 in departure slab

AASHTO R36 Method A



Sensitivity Factor / Slope interative to identify joints
3 to 9 in from joint only, paired difference

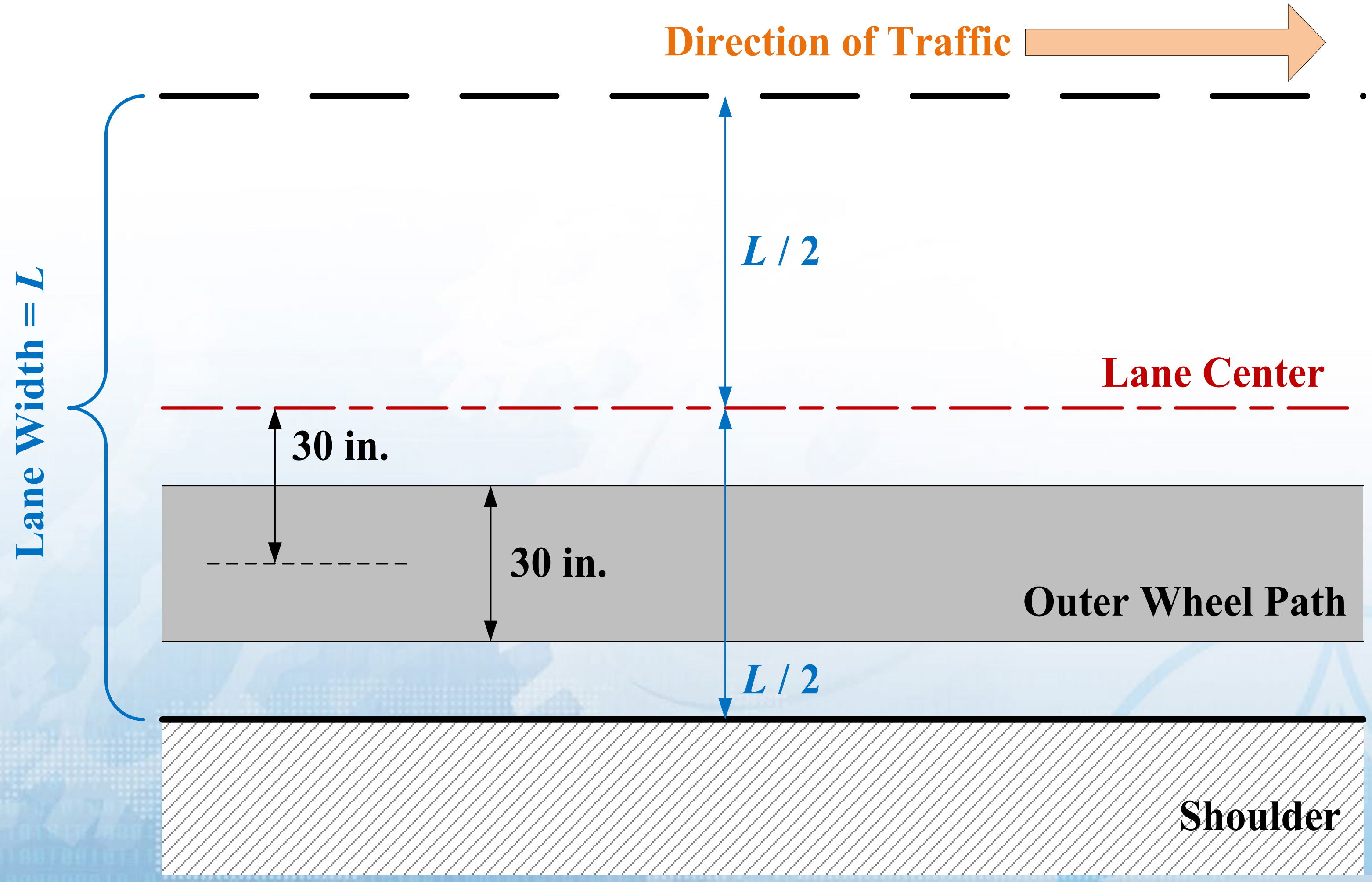
AASHTO R36 Method B

Faulting Definition: Option 1

Faulting is defined as the difference in average elevations across a transverse joint, measured within the outer wheelpath, in accordance with the following items.

- The outer wheelpath for faulting is defined as the area within 15 in. to 45 in. from the lane center (i.e., center of wheelpath is 30 in. from the lane center and the width of wheelpath is 30 in.), regardless of the lane width.

Proposed Definition: Option 1

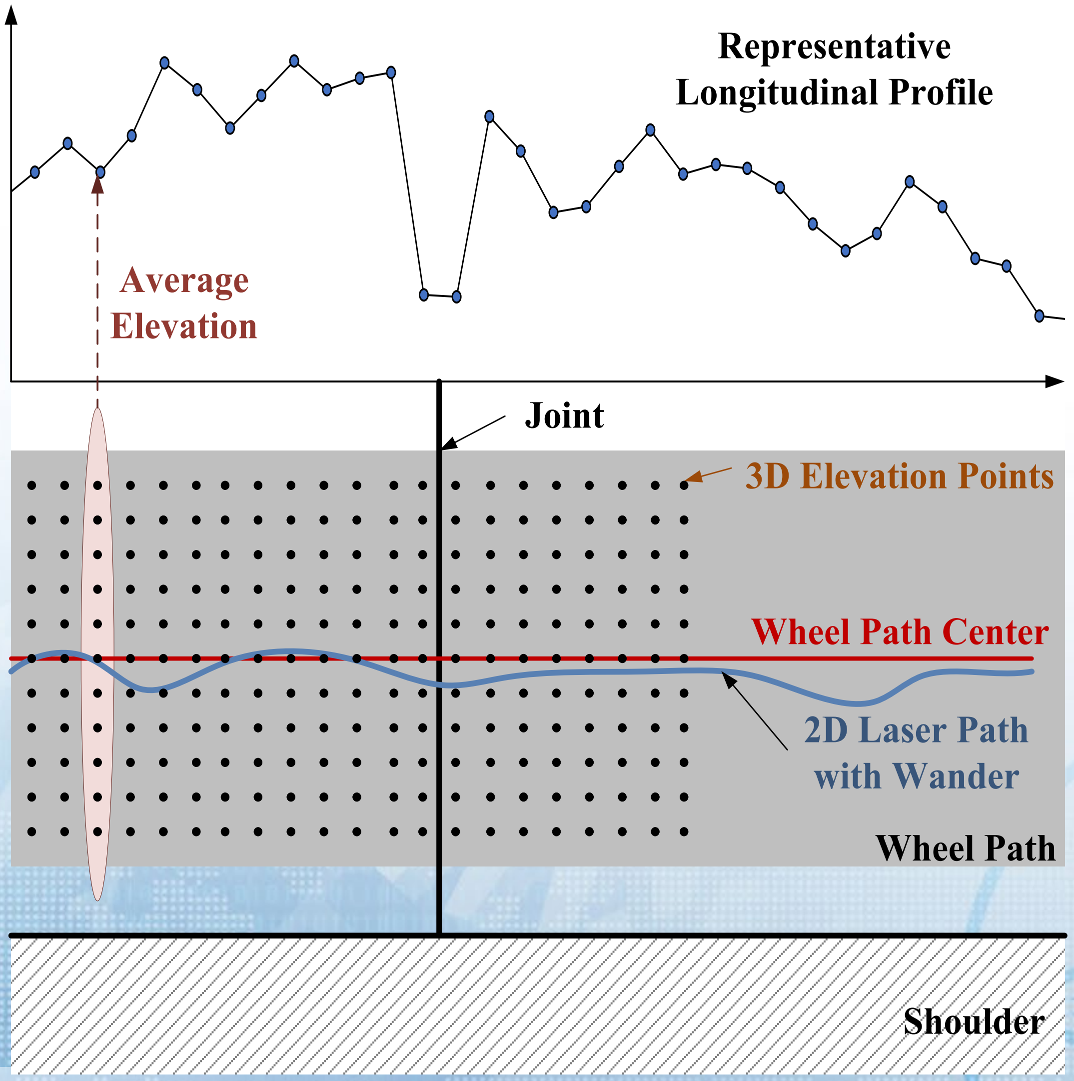


Faulting Definition: Option 1

Faulting is defined as the difference in average elevations across a transverse joint, measured within the outer wheelpath, in accordance with the following items.

- Faulting is calculated from a "**Representative Longitudinal Profile**" of the outer wheelpath.

Proposed Definition: Option 1

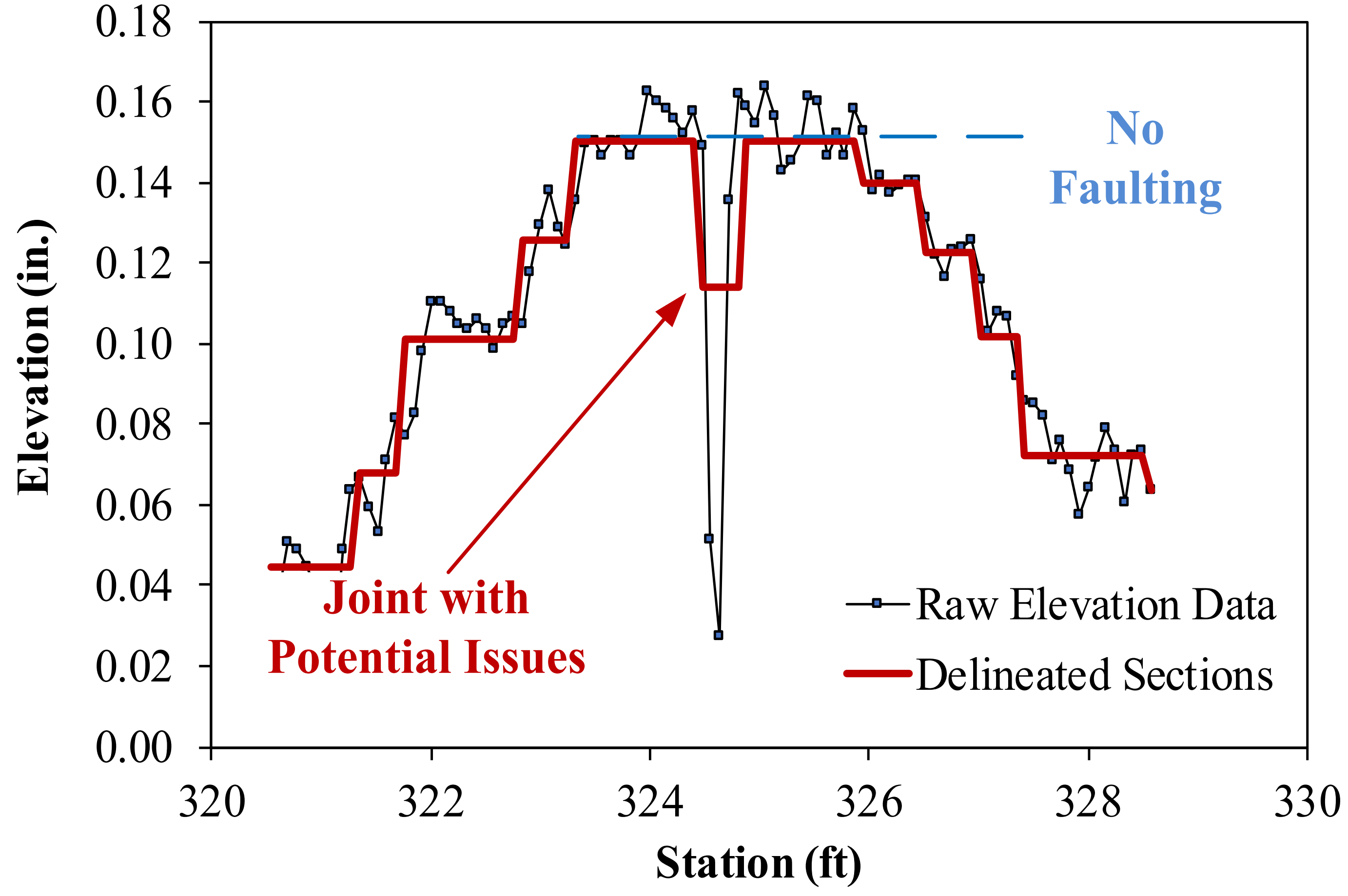


Faulting Definition: Option 1

Faulting is defined as the difference in average elevations across a transverse joint, measured within the outer wheelpath, in accordance with the following items.

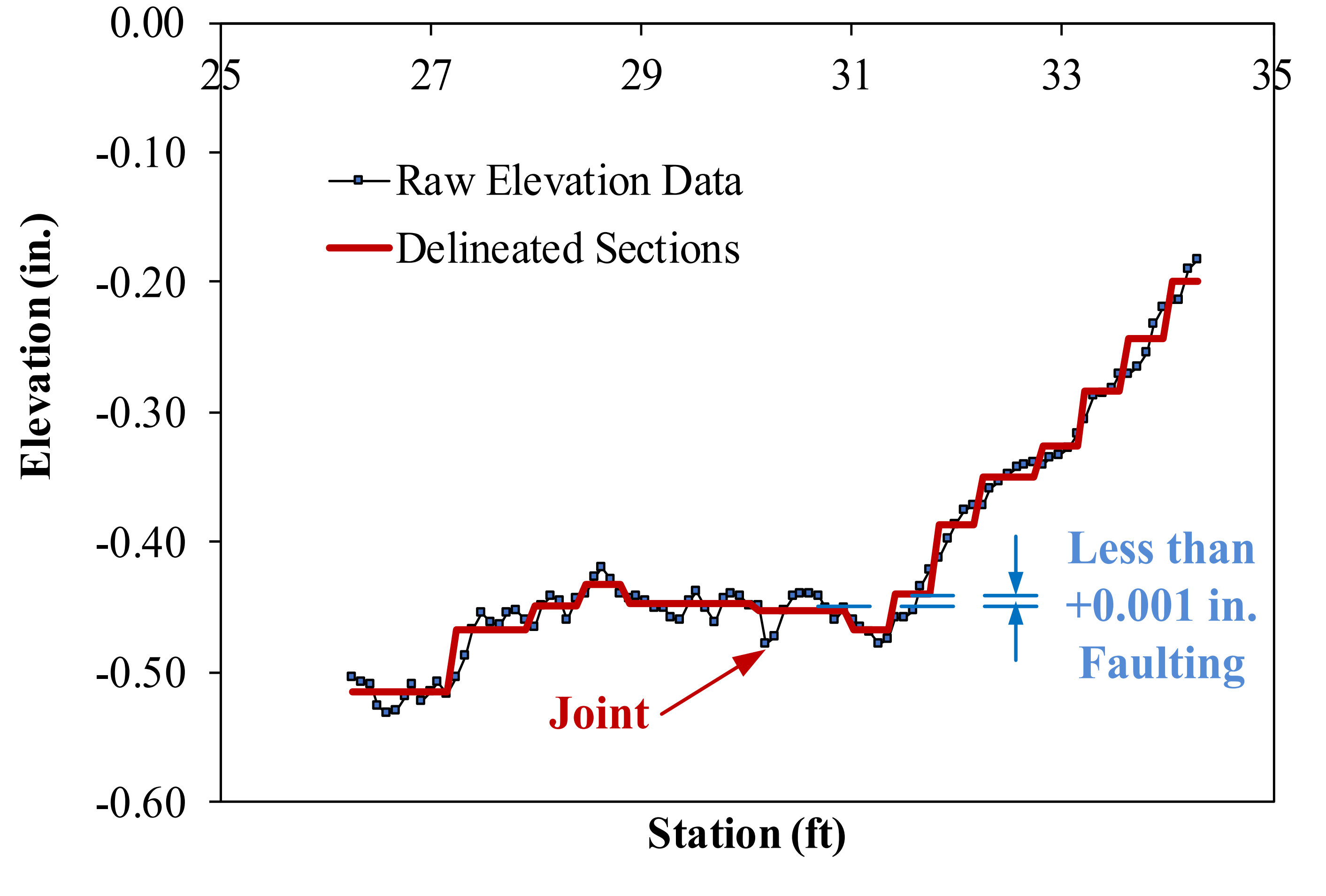
- From the representative longitudinal profile, the average elevations before and after the joint are calculated using an Enhanced Cumulative Difference Approach (ECDA).
- The minimum longitudinal distance for calculating the average elevations before and after the joint is 5 in.
- Potential effect of spalling and/or wide joint opening detected by the ECDA algorithm is to be excluded from faulting calculation.

Proposed Definition: Option 1



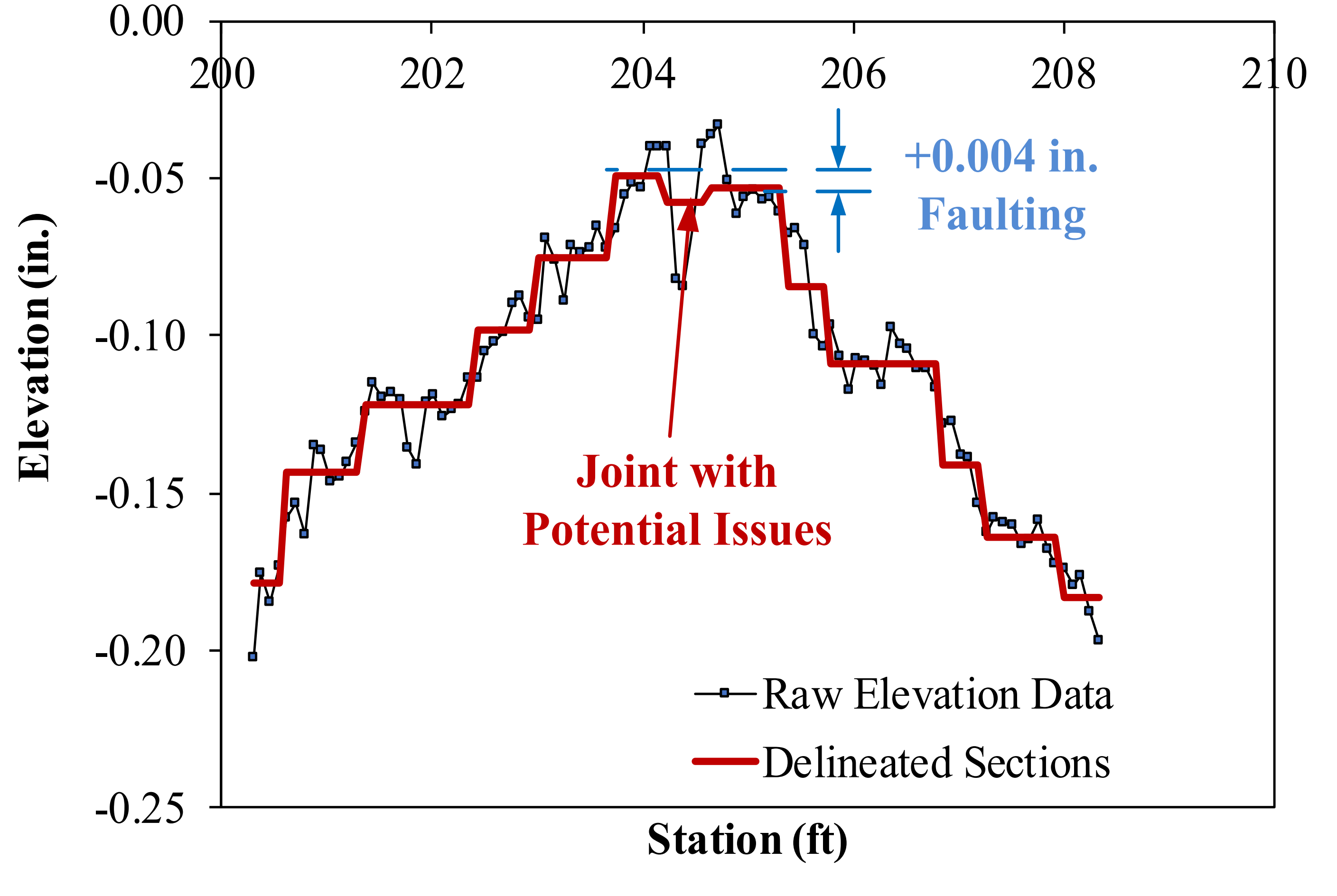
LTPP Section 04-0215. Joint at Station 324.6 ft.

Proposed Definition: Option 1



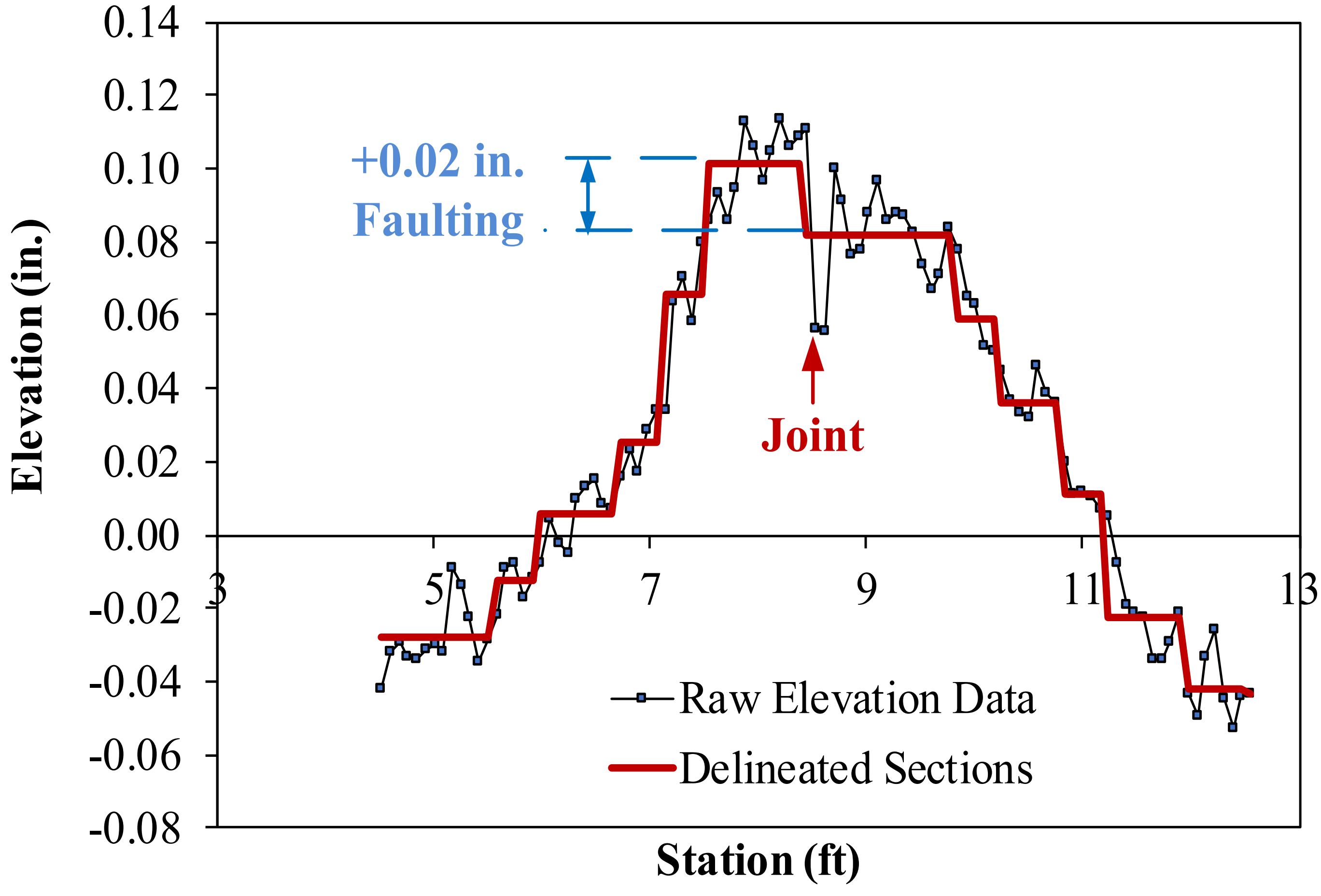
LTPP Section 27-4040. Joint at Station 30.3 ft.

Proposed Definition: Option 1



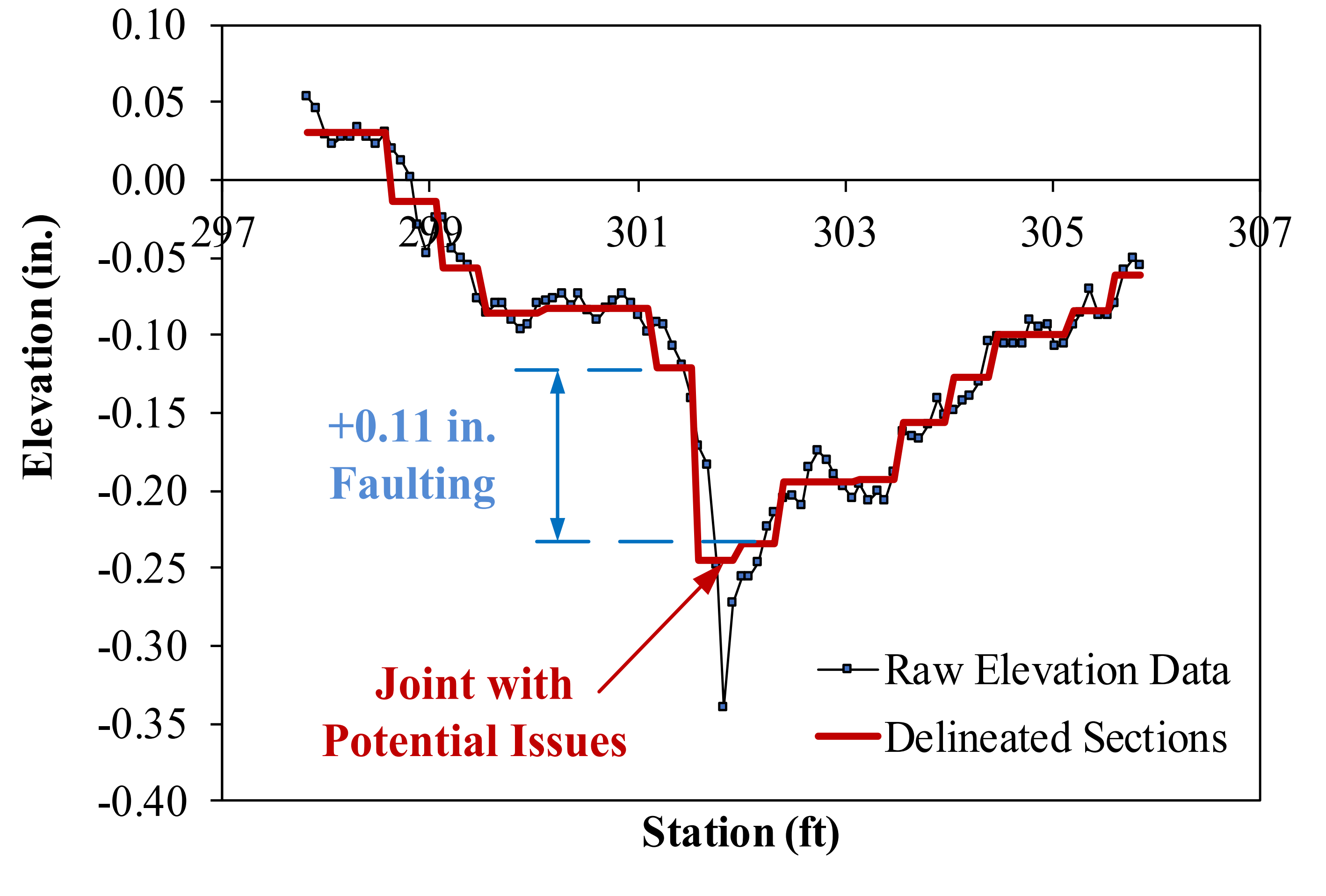
LTPP Section 04-0215. Joint at Station 204.3 ft.

Proposed Definition: Option 1



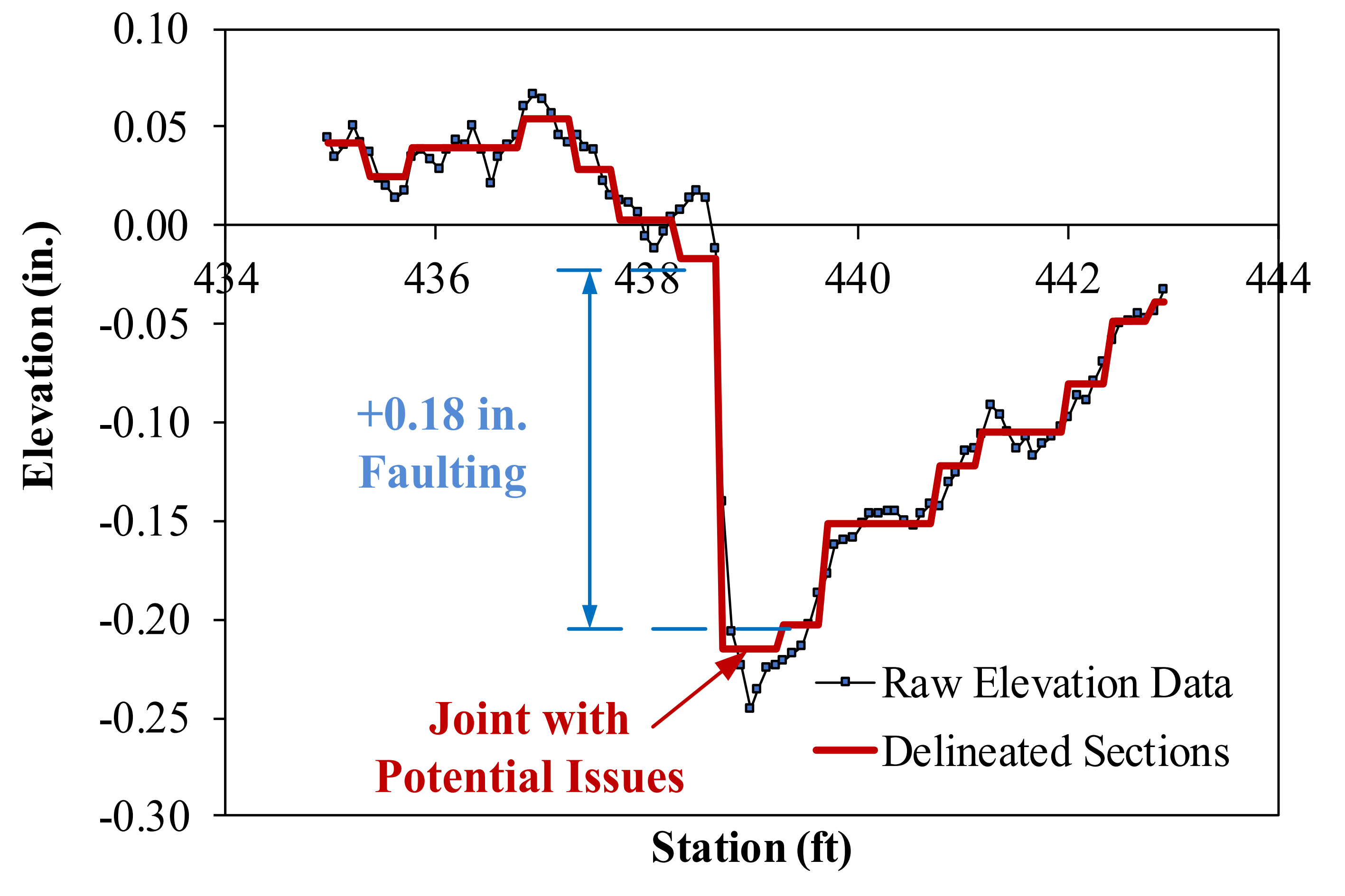
LTPP Section 04-0215. Joint at Station 8.5 ft.

Proposed Definition: Option 1



LTPP Section 27-4040. Joint at Station 301.8 ft.

Proposed Definition: Option 1



LTPP Section 27-4040. Joint at Station 439.0 ft.

Faulting Definition: Option 2

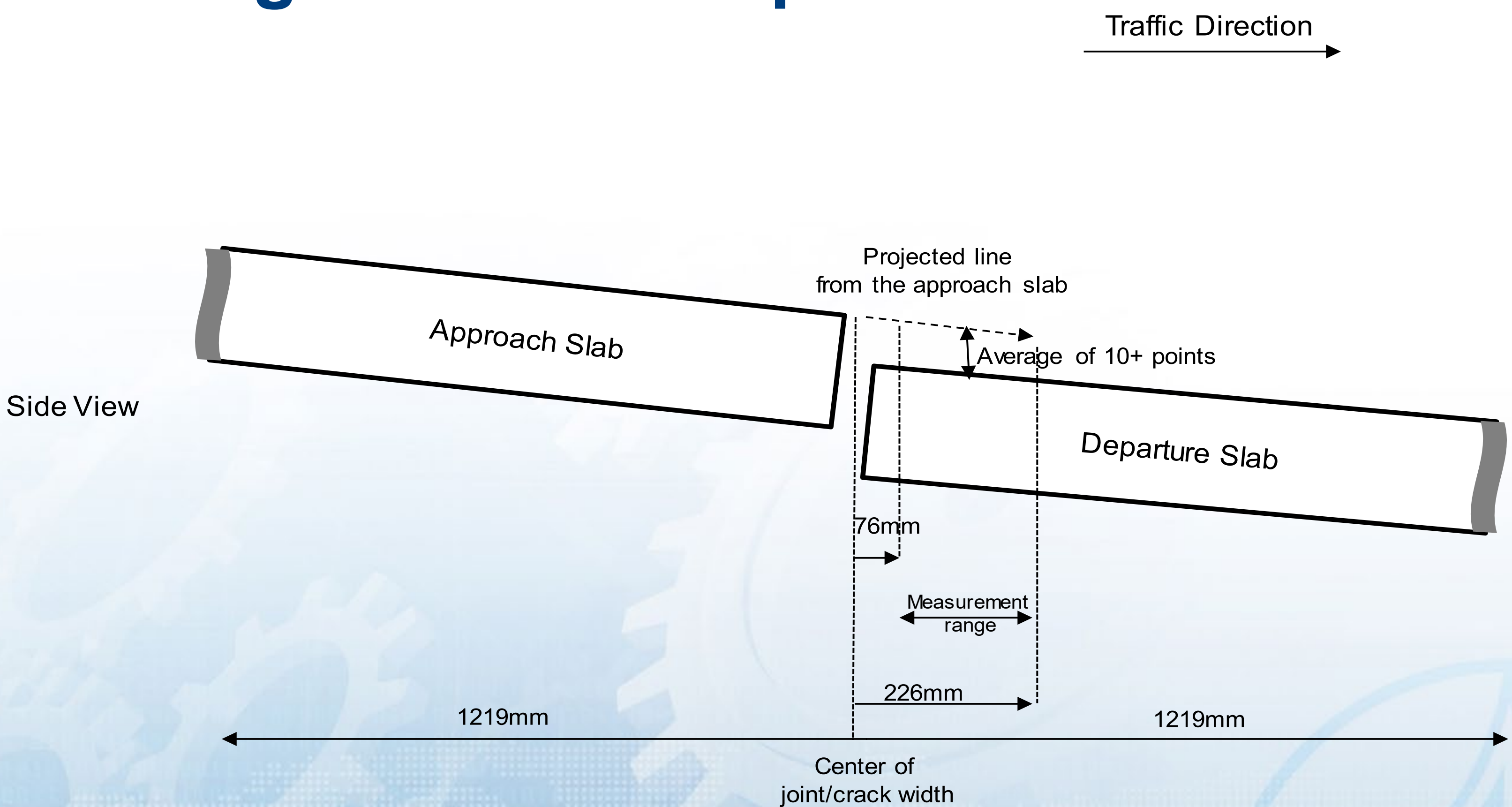
Faulting is defined as the difference in average elevations across a transverse joint, measured within the outer wheelpath, in accordance with the following items.

- Option 2 is a simplified version of Option 1.
- Rather than use ECDA, from the representative longitudinal profile, the average elevations before and after the joint are calculated using all elevations between the joint and X in. from the joint.
- The minimum longitudinal distance for calculating the average elevations before and after the joint is 5 in.
- The vendor or equipment manufacturer will be responsible to demonstrate ability to remove elevations corresponding to spalls and wide joint openings, which shall excluded from faulting calculation.

Faulting Definition: Option 3

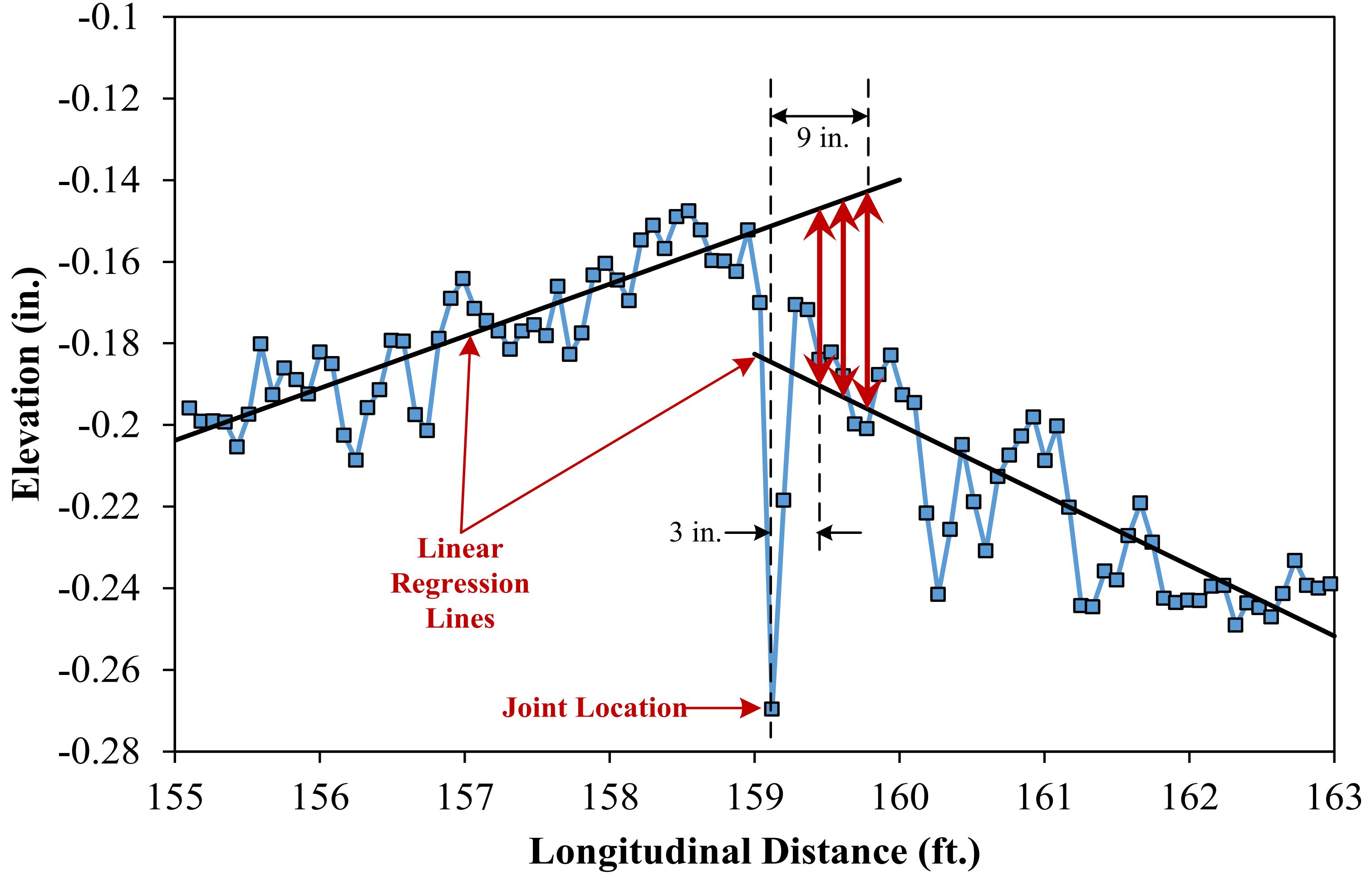
Faulting is defined as the difference in elevations of projected/existing planes of approach slab and departure slab surfaces across a transverse joint or crack along the outside wheelpath. The representative longitudinal profile shall be used for this projection. Faulting shall be measured as a mean value of the differences of the above mentioned metrics between 0 in. to 9 in. offset from the center of a joint/crack in the traffic direction with a minimum of 10 equally-spaced projected elevation points.

Faulting Definition: Option 3



Measurement of Positive Fault with Down Grade

*Not to scale



Detect joint: Downward Spike, Step, Curled Edge
4 ft linear regression, average elevation 3-9 in departure slab

AASHTO R36 Method A

Curling Artifact

Discussion Items

Transverse Location: Wheel path width

- LTPP asphalt pavement: 30 in. wide and centered 35 in. from lane longitudinal centerline.
- LTPP manual faulting measurement: 12 and 30 in. from edge/lane stripe.
- HPMS manual asphalt pavement: 39 in. wide and centered 35 in. from lane longitudinal centerline.

Transverse Location: Wheel path (inner/outer)

- Both
- Outer Only

Discussion Items

Transverse Location: Defining Centerline / Reference Edge

- 3D can do off edge or lane stripe
- 2D HSIP may not and may need a retrofit to detect edge or lane stripe

Faulting Measurement: Equipment / Data Resolution

- 3D Laser / Camera
- 2D HSIP (Account for texture effects)
- ~~Manual~~

Reporting

Basic Information

- Section identification
- Date and time of data collection
- Operator(s)
- Device(s)
- Total length of the data collection section

AFM Method Used for Analysis

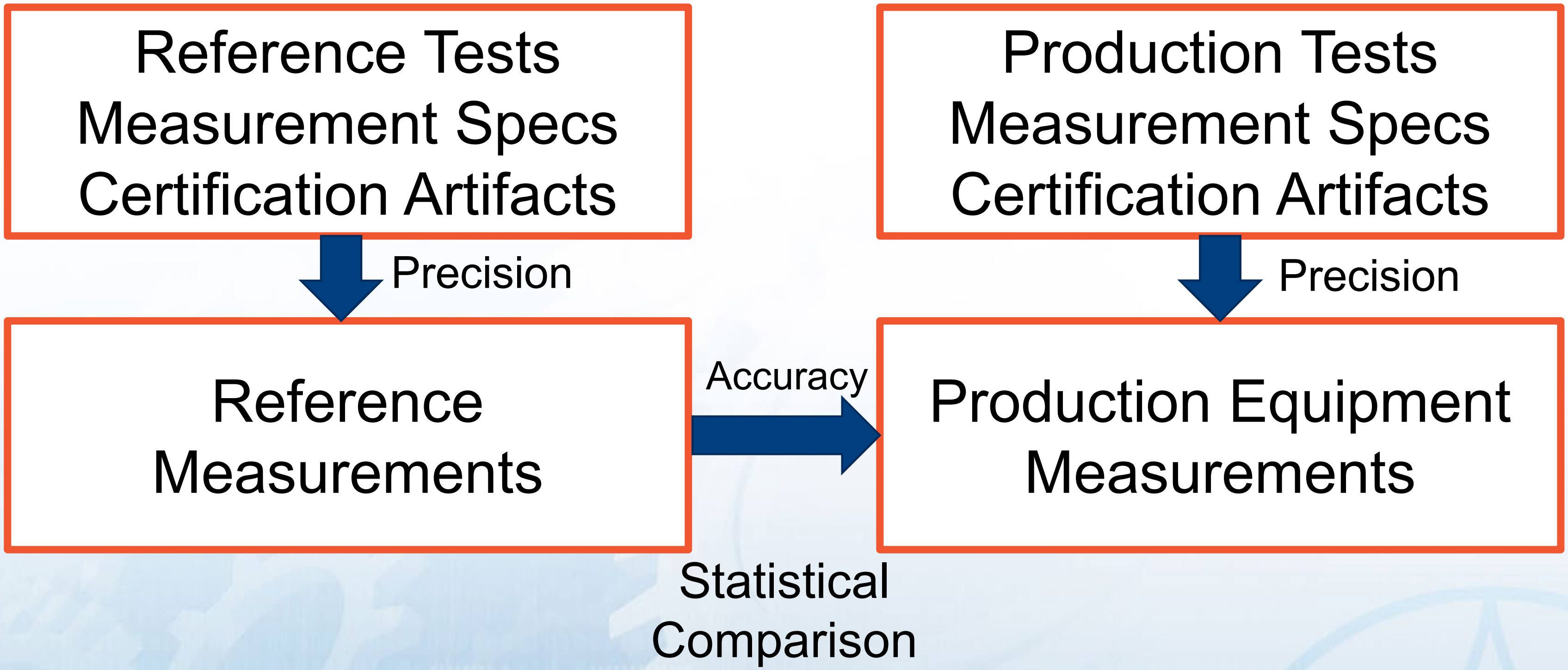
- Method for joint detection (if we go with the multiple option approach)
- Method for faulting calculation (if we go with the multiple option approach)
- Other inputs needed for joint detection or fault calculation (e.g., User inputted typical slab length, lane width, etc.)

Reporting

AFM Results

- Joint/transverse crack locations
- Positive and negative faulting at all transverse joints and transverse cracks
- Maximum value of positive and negative faulting for joints
- Maximum value of positive and negative faulting for transverse cracks
- Separate averages of positive and negative faulting for all joints in the test section
- Separate averages of positive and negative faulting for all transverse cracks in the test section
- Overall average faulting for all joints in the test section
- Overall average faulting for all transverse cracks in the test section
- Overall average of absolute faulting for all joints in the test section
- Overall average of absolute faulting for all cracks in the test section
- Total number of detected joints
- Total number of detected transverse cracks

Certification



Certification

Consistent with Transverse Profile Project

- Build upon relevant standards developed under TPP
- Method for computing faulting using longitudinal profile
- Detailed specifications not included for equipment or software used to make the calculations
- Any approach that can be adequately validated to meet the functionality is considered acceptable
- Goal is to achieve a significant level of standardization for consistent faulting computation

Certification

Consistent with Transverse Profile Project

- Range of conditions to be measured (texture, fault magnitude, joint damage, transverse crack)
- Assess x, y, z data quality (elevation)
  - Artifacts to simulate faulting
- Assess fault algorithm
  - Statistical comparison with reference measurement
- Assess Joint Detection Rate (JDR)
  - Need to meet minimum JDR

Certification

Consistent with Transverse Profile Project

- 3D Systems: Body Motion Cancelation, Drift Mitigation, Dynamic Performance, Static Performance
  - Review closely to assess application to faulting
- Reference Tests Using Artifacts

Phase II Pilot Projects

- Development, refinement, and validation of the proposed definitions and methods to quantify faulting at each joint/transverse crack, and
- Development and refinement of certification and verification tests and standards.

Thank You

- Comments / Feedback
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