

3D sensors for High Speed
Network Level Detection of
Raveling Conditions and Texture
Evaluation using Simulated
Digital Sand Patch
Measurements



Pavemetrics

RPUG 2011

Vision Technology for Inspection of Transportation Infrastructures

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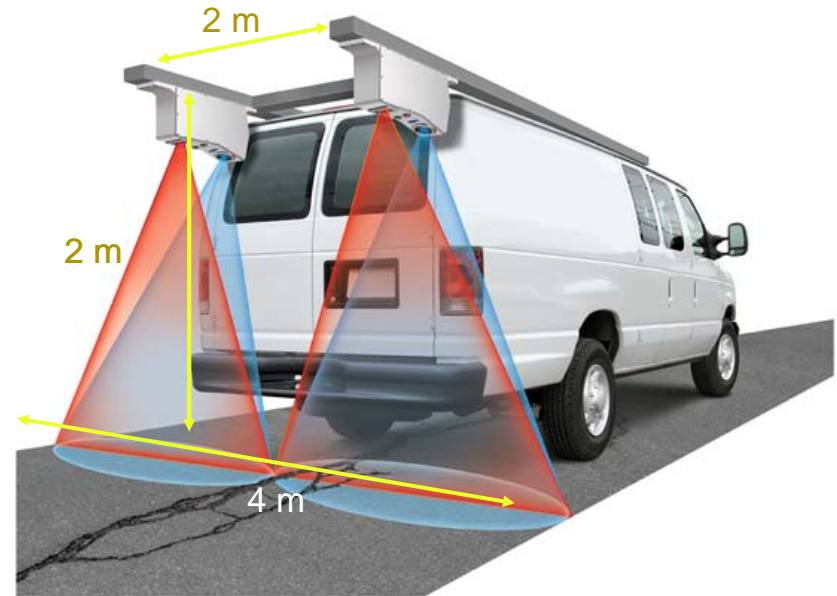
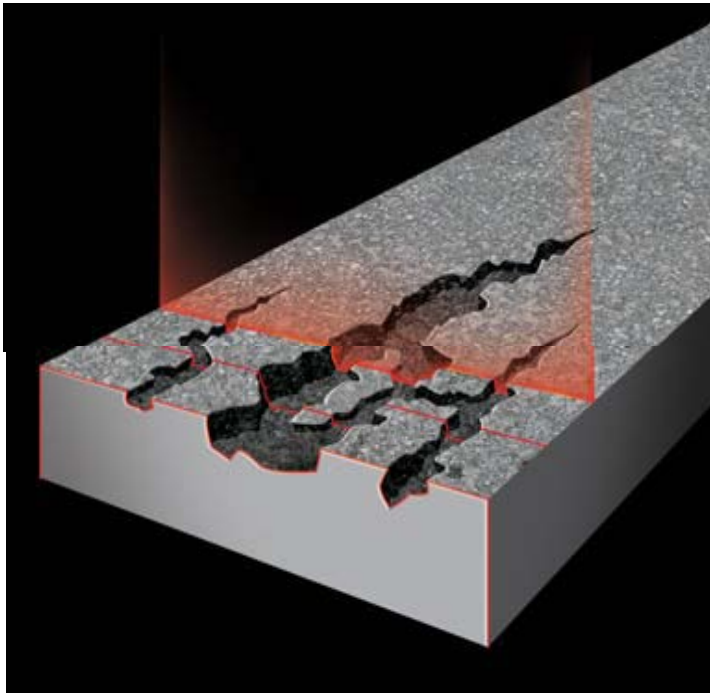
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Does Pavemetrics-INO have developed a new sensor for macro-texture measurement???

Does Pavemetrics-INO have developed a new sensor for macro-texture measurement???

NO.... New processing modules have been implemented for the LCMS (Laser CRACK Measurement System)

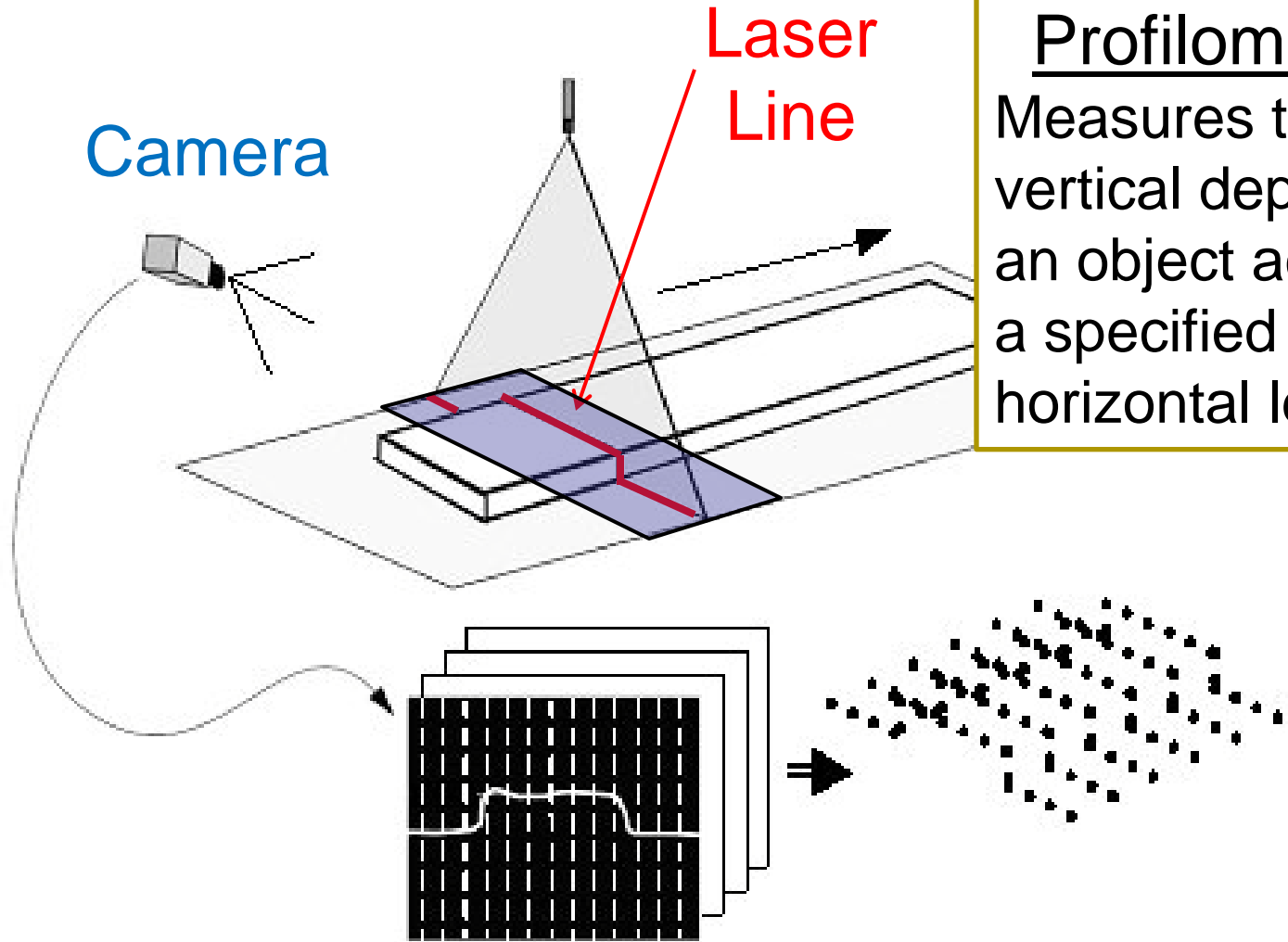


LCMS: Description and Specifications

Macro-texture: Results

Raveling: Results

Principle of Operation



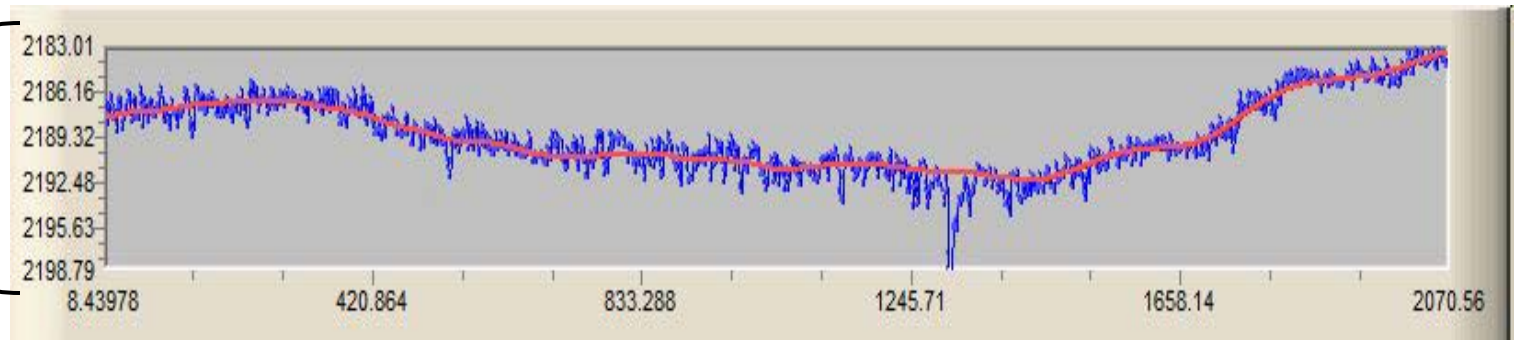
Camera

Laser Line

Profilometer:
Measures the vertical depth of an object across a specified horizontal length.

Single Road Profile (2 meter)

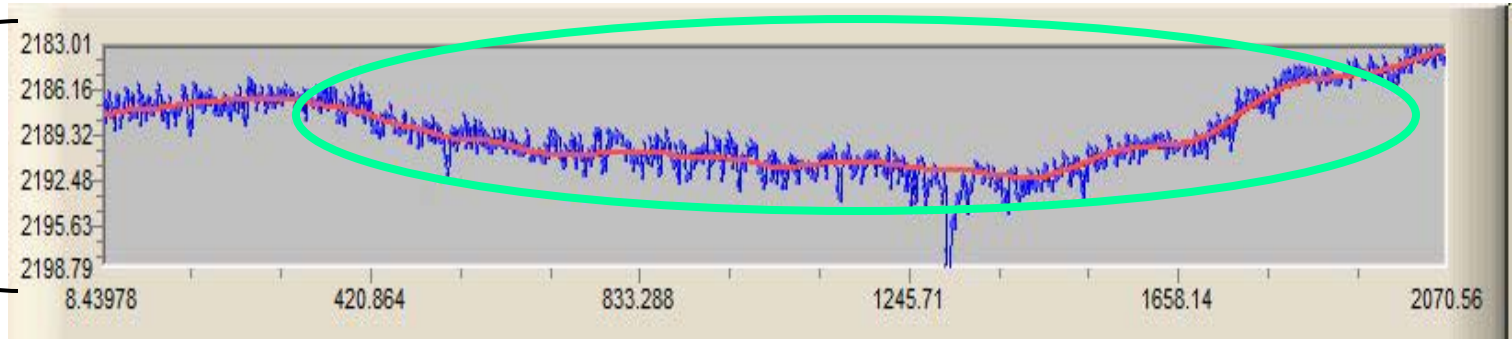
Distance
between Sensor
and ground
(in mm)



Single Road Profile (2 meter)

Rut

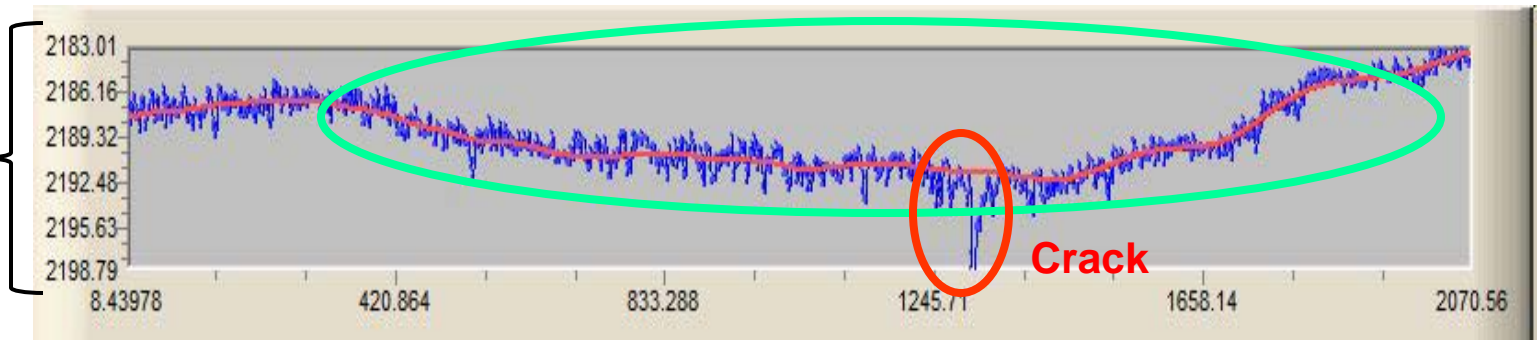
Distance
between Sensor
and ground
(in mm)



Single Road Profile (2 meter)

Rut

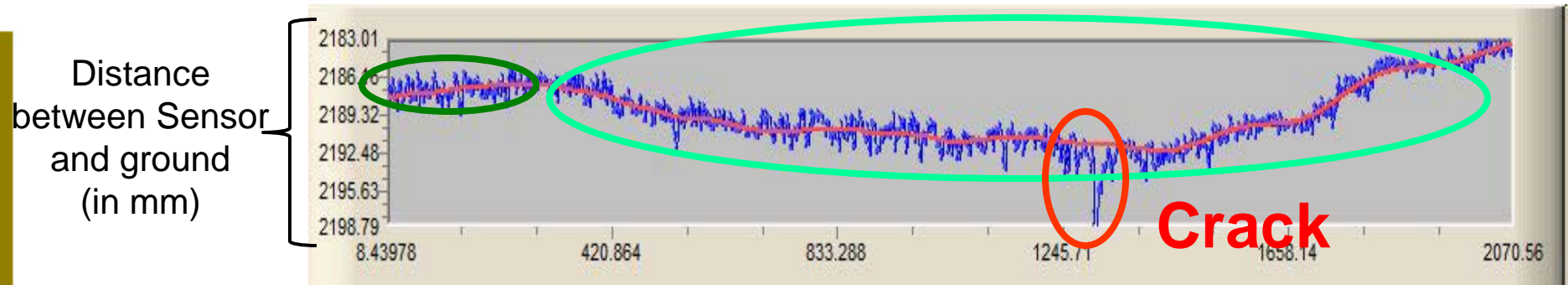
Distance
between Sensor
and ground
(in mm)



Single Road Profile (2 meter)

Macro-texture

Rut

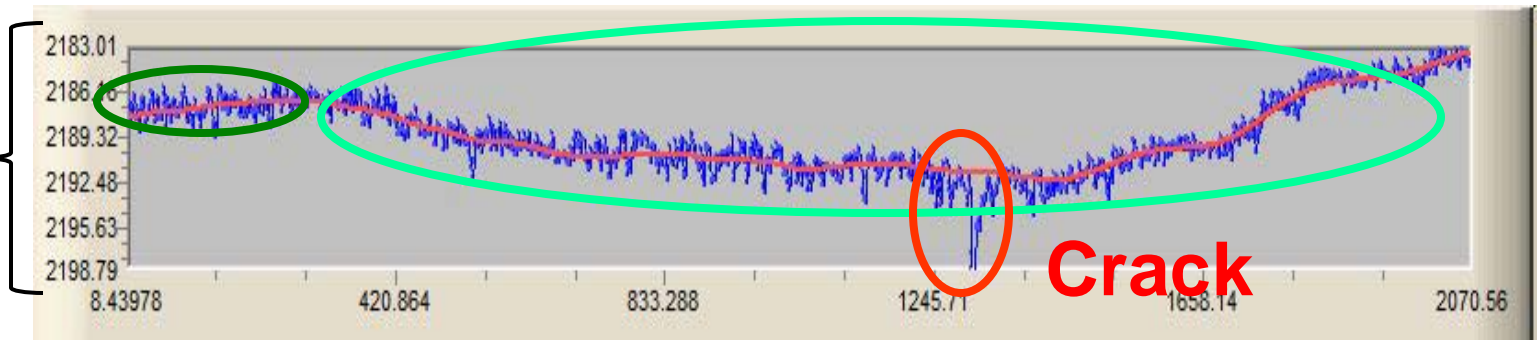


Single Road Profile (2 meter)

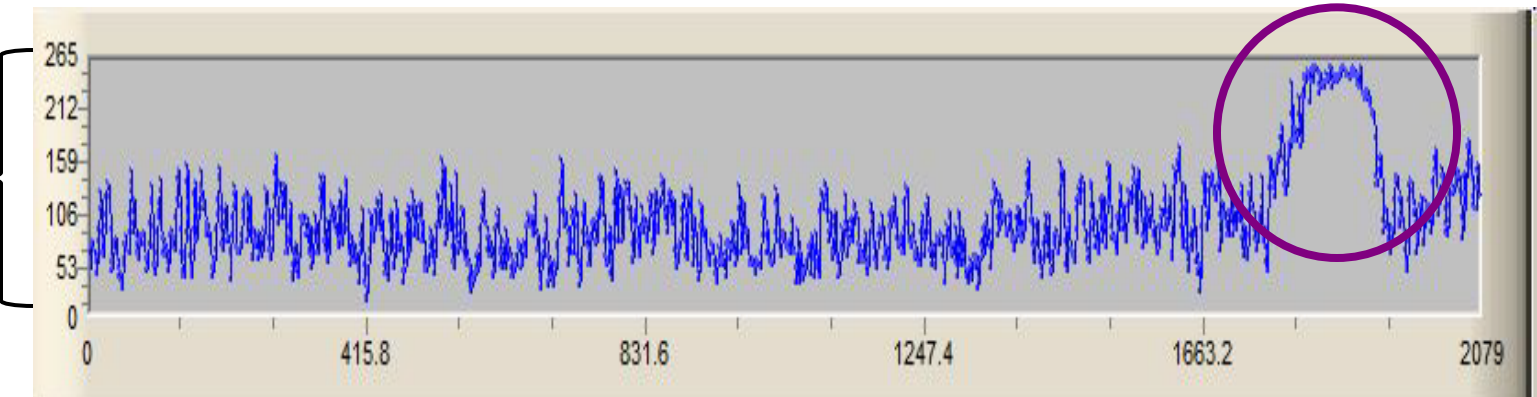
Macro-texture

Rut

Distance
between Sensor
and ground
(in mm)



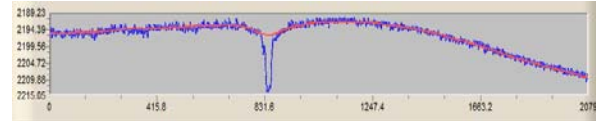
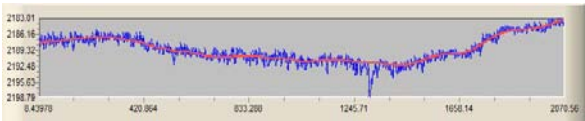
Laser intensity
(black = 0,
white = 255)



**Right Lane
Marking**

What makes a 3D sensor very good for ~~crack~~ ^{Texture} measurement?

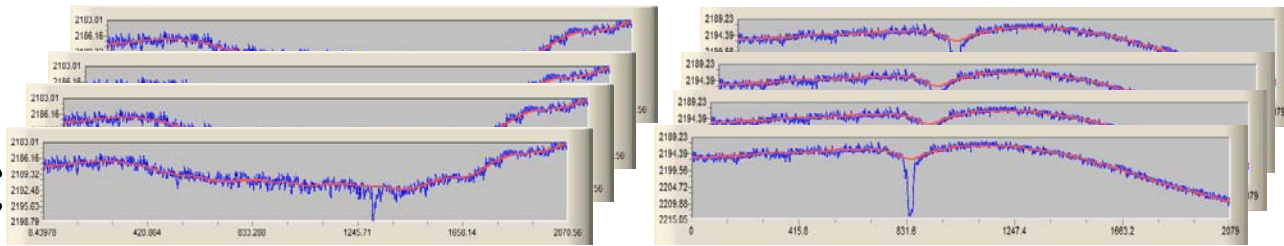
Excellent 3D Accuracy



Good Lateral Resolution

What makes a 3D sensor very good for ~~crack~~ measurement?

Texture



Excellent 3D Accuracy



High Acquisition Rate

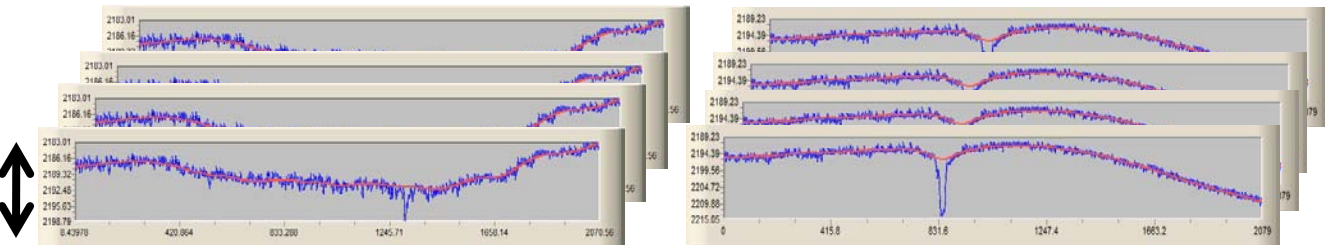


Good Lateral Resolution

What makes a 3D sensor very good for ~~crack~~ ^{Texture} measurement?

Texture

Excellent 3D Accuracy

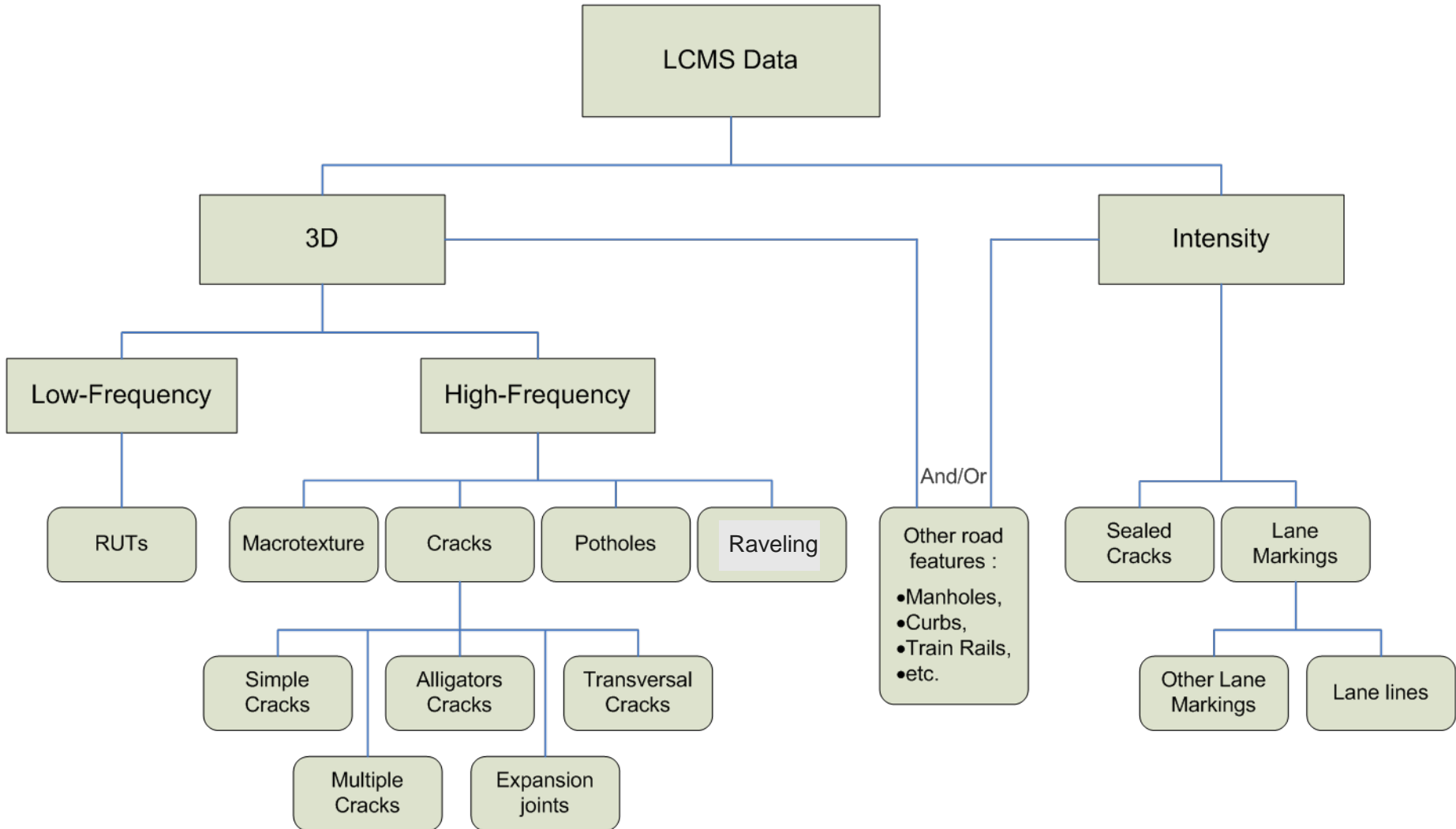


High Acquisition Rate

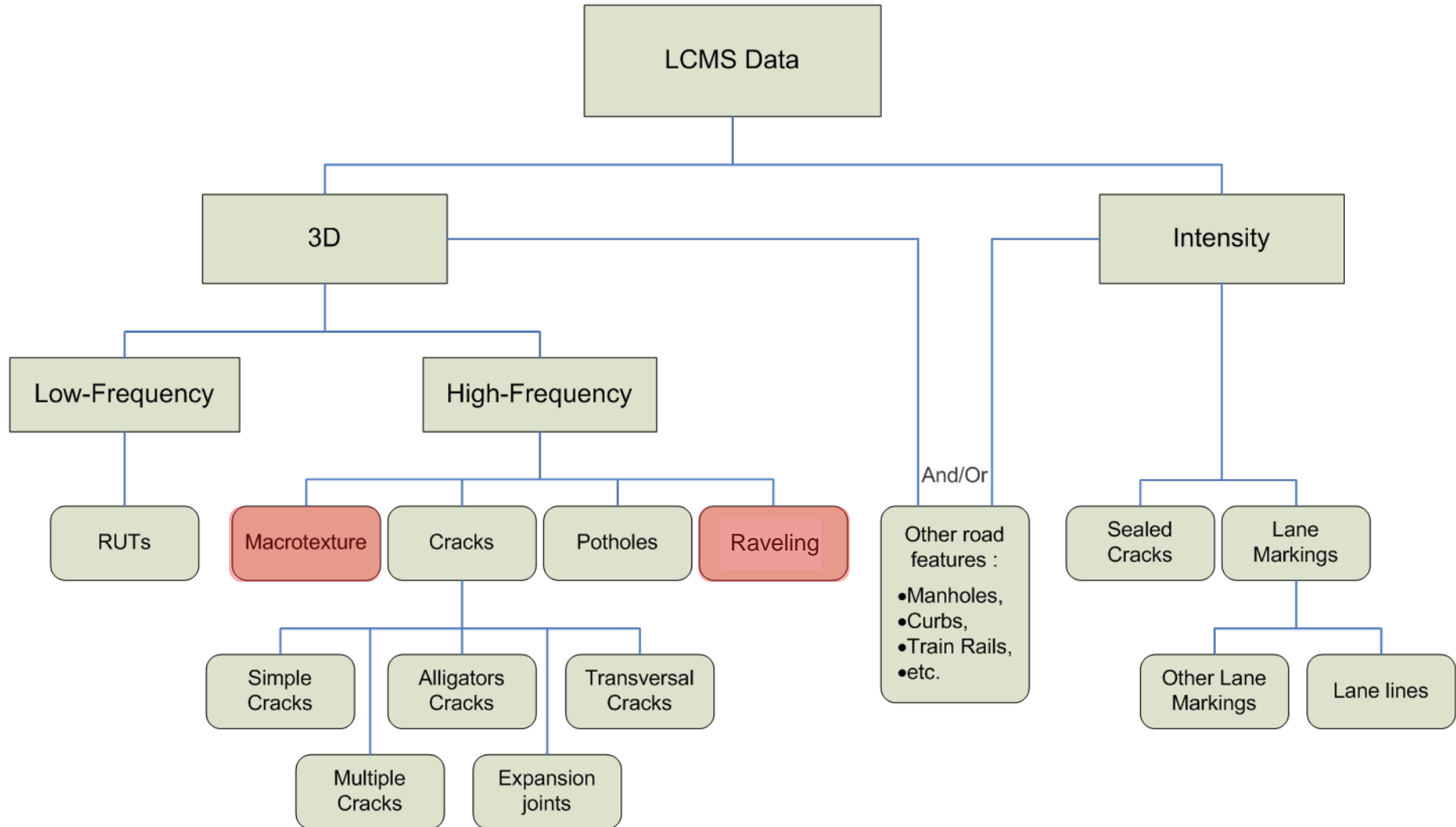
Good Lateral Resolution

LCMS Specifications	
Acquisition Rate	11 200 profiles /s
Range Accuracy	0.5mm
Lateral Resolution	1mm (FOV = 4m)

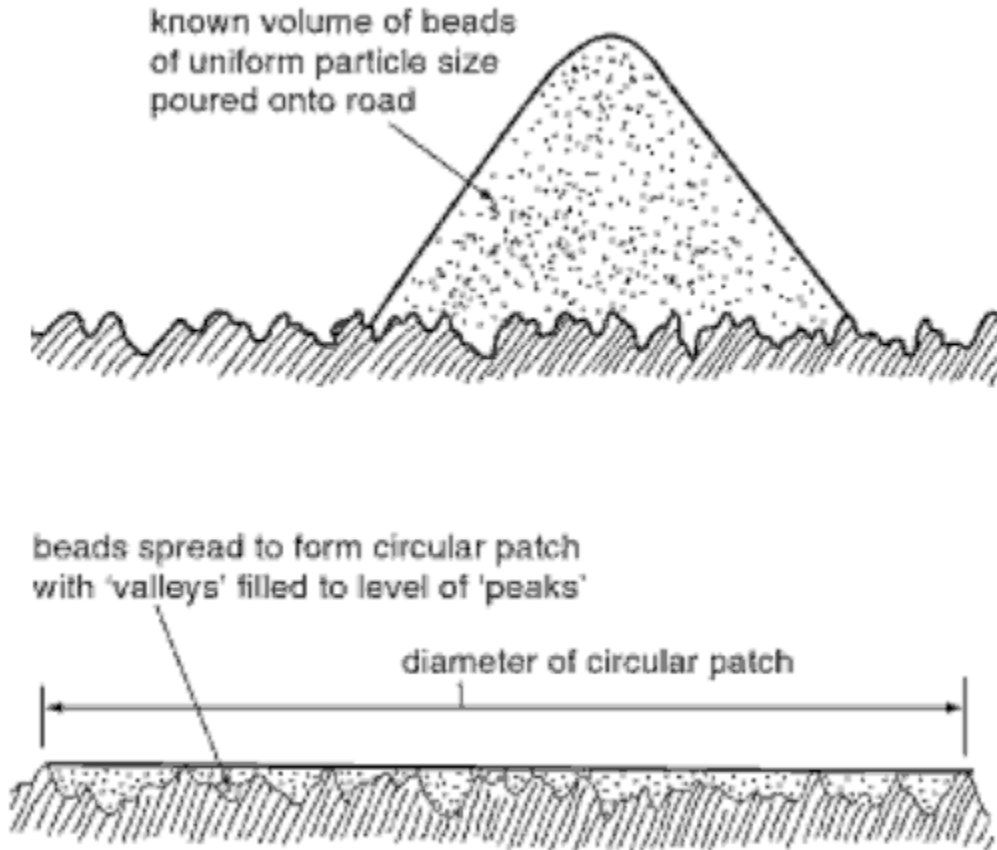
LCMS Data Processing Tree



LCMS Data Processing Tree



Macrotexture : Sand patch method (MTD) (ASTM E965)



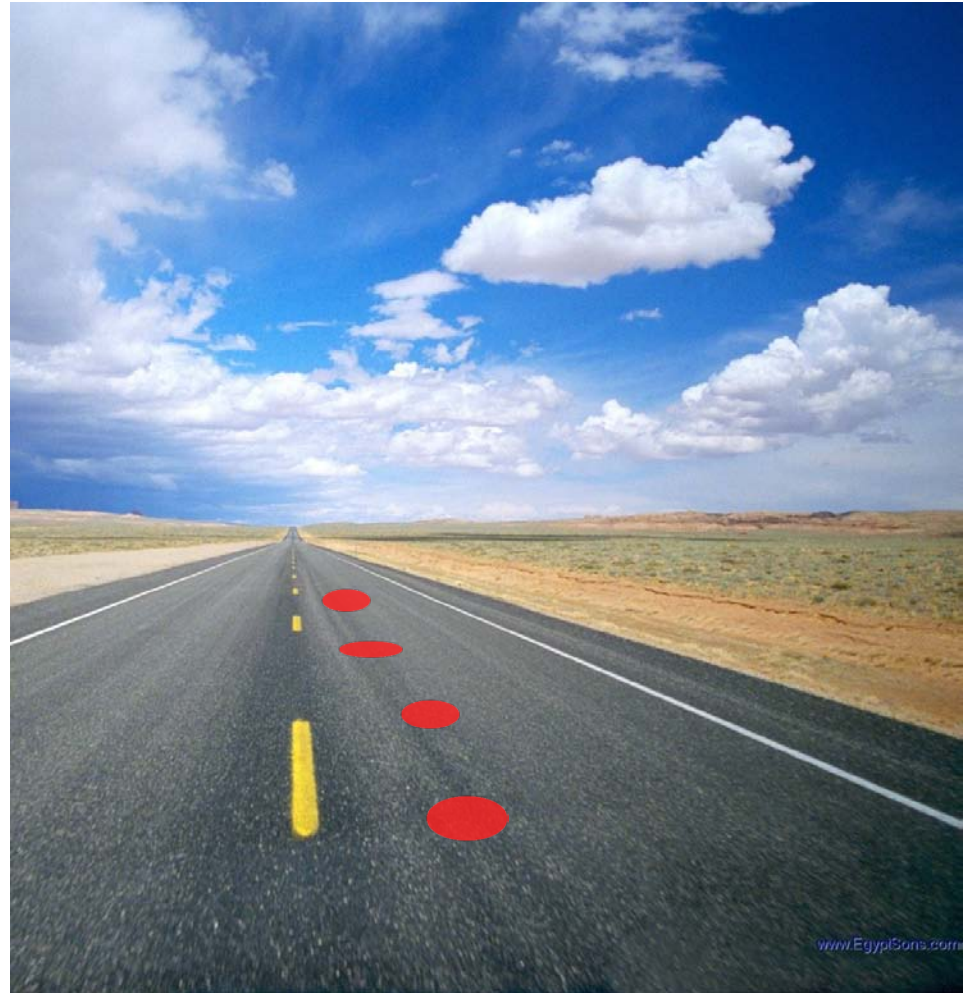
Macrotexture : Sand patch method (MTD - ASTM E965)

Pros:

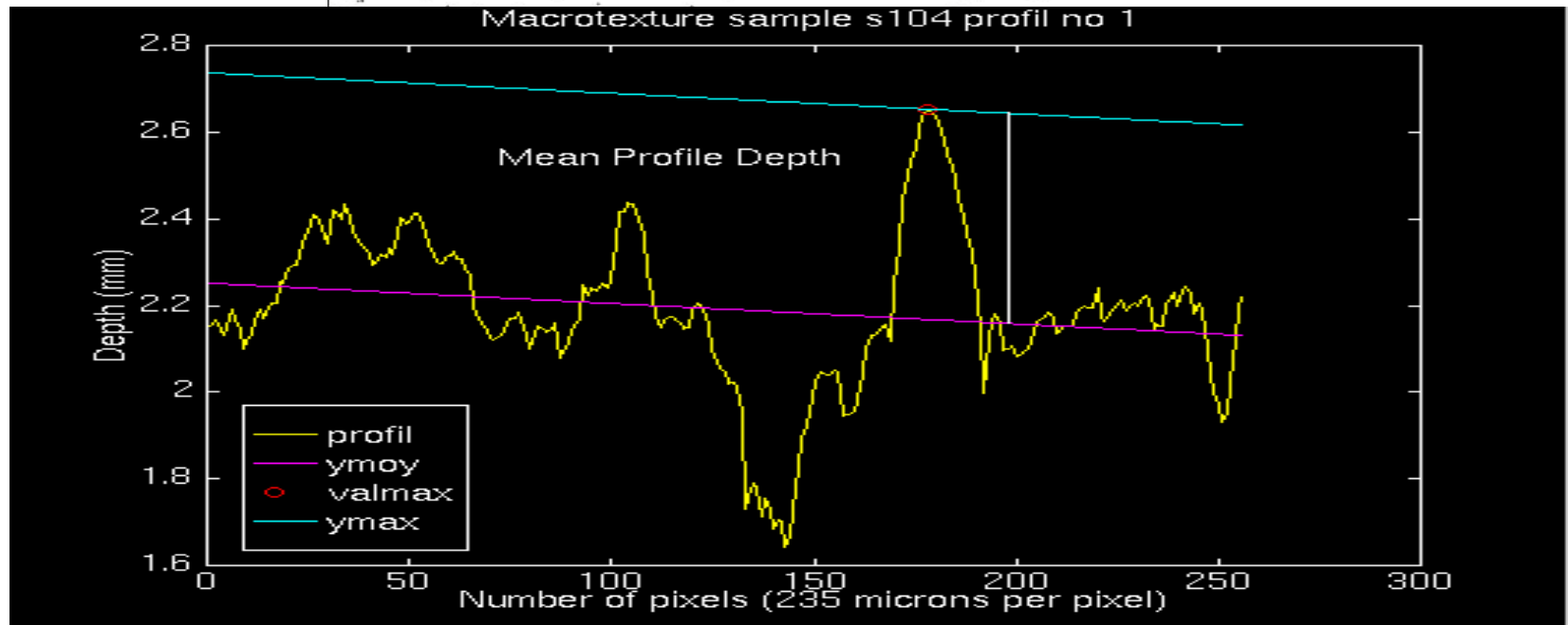
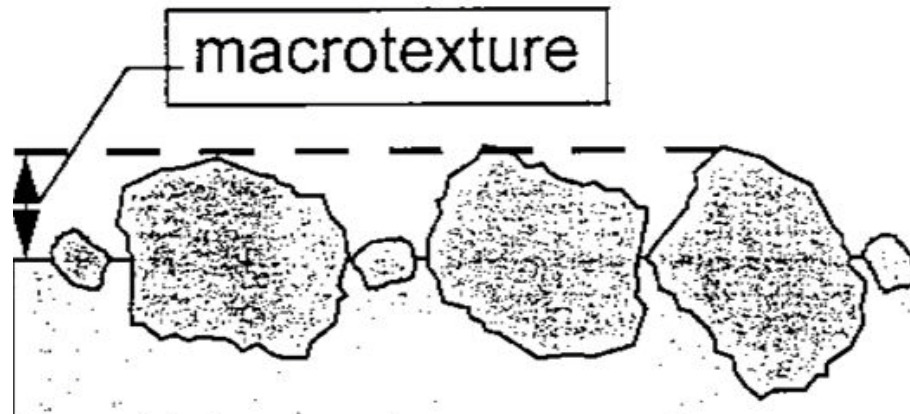
- Common and accepted practice by the community

Cons:

- Variation in results
 - Human operators
 - Local texture variation
- Static measurement
- Time consuming



Macrotexture : Mean Profile Depth (ASTM E1845-01)



Macrotexture : Mean Profile Depth (ASTM E1845-01)

Pros:

- Good correlation between MPD and MTD.
- Network survey is possible

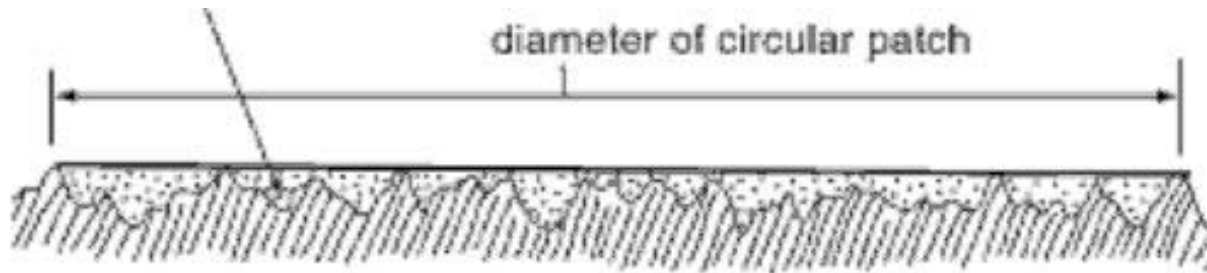
Cons:

- Variation in results
 - Human operators
 - Local texture variation



Macrotexture - LCMS Digital Sand Patch Method

RPI - Road Porosity Index = (Volume under the surface — Cracks) divided by a surface area



$$RPI = \frac{Vol_{air\ void} - Vol_{cracks}}{Area_{Total}}$$

Macrotexture - LCMS Digital Sand Patch Method

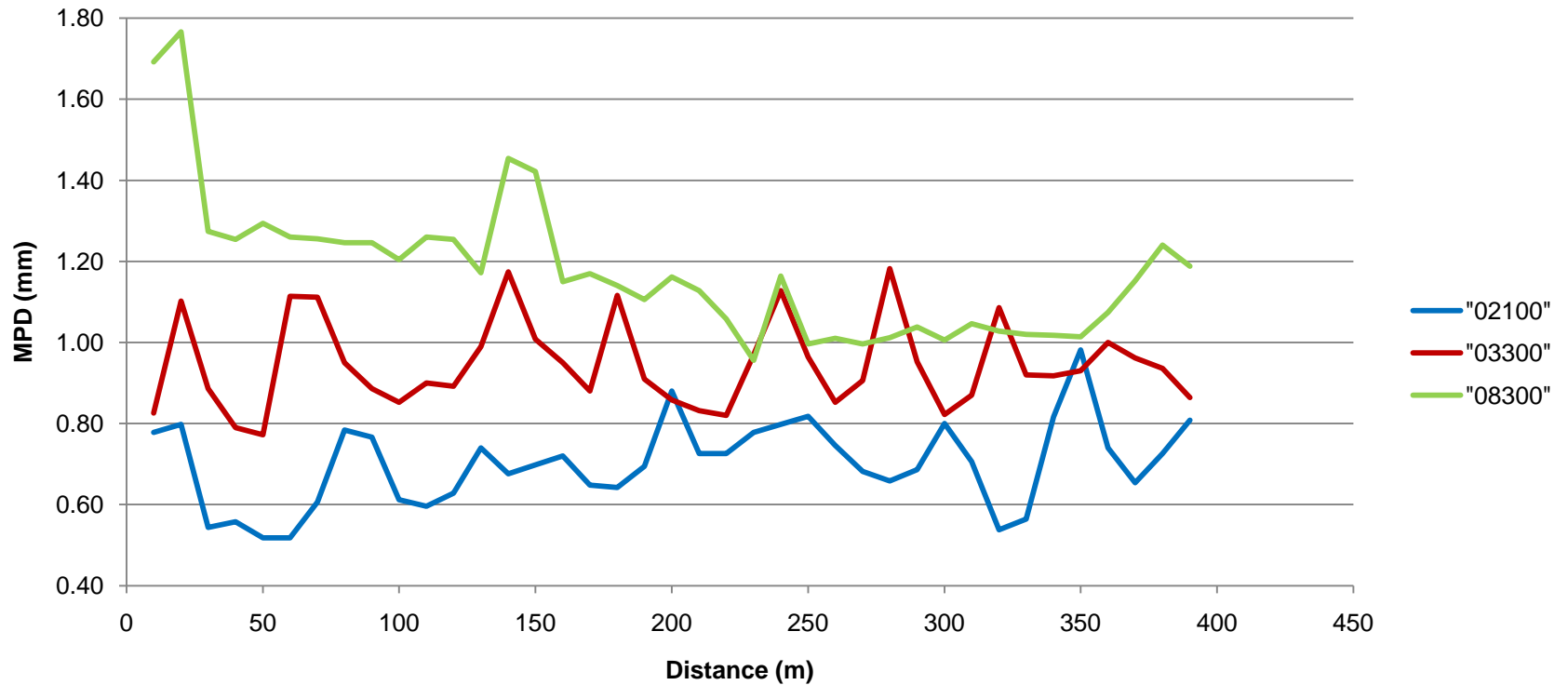
Pros:

- Network survey is possible at 100kmh
- Full lane width is measured
 - 5 AASHTO bands
- Great repeatability
 - Automatic lane marking detection



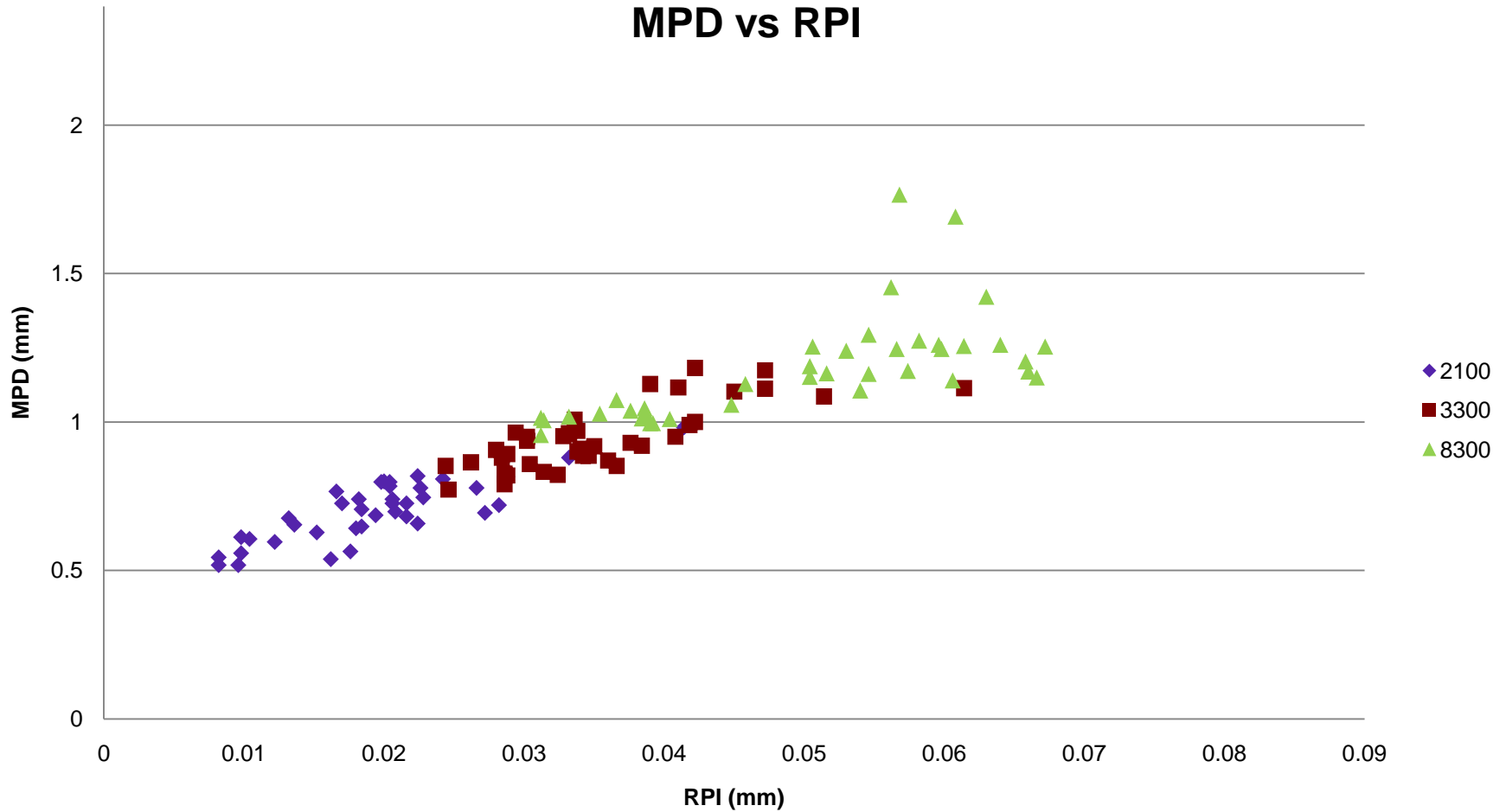
Macrotexture - Data Sets

MarkIV-MPD values - 400m test sections



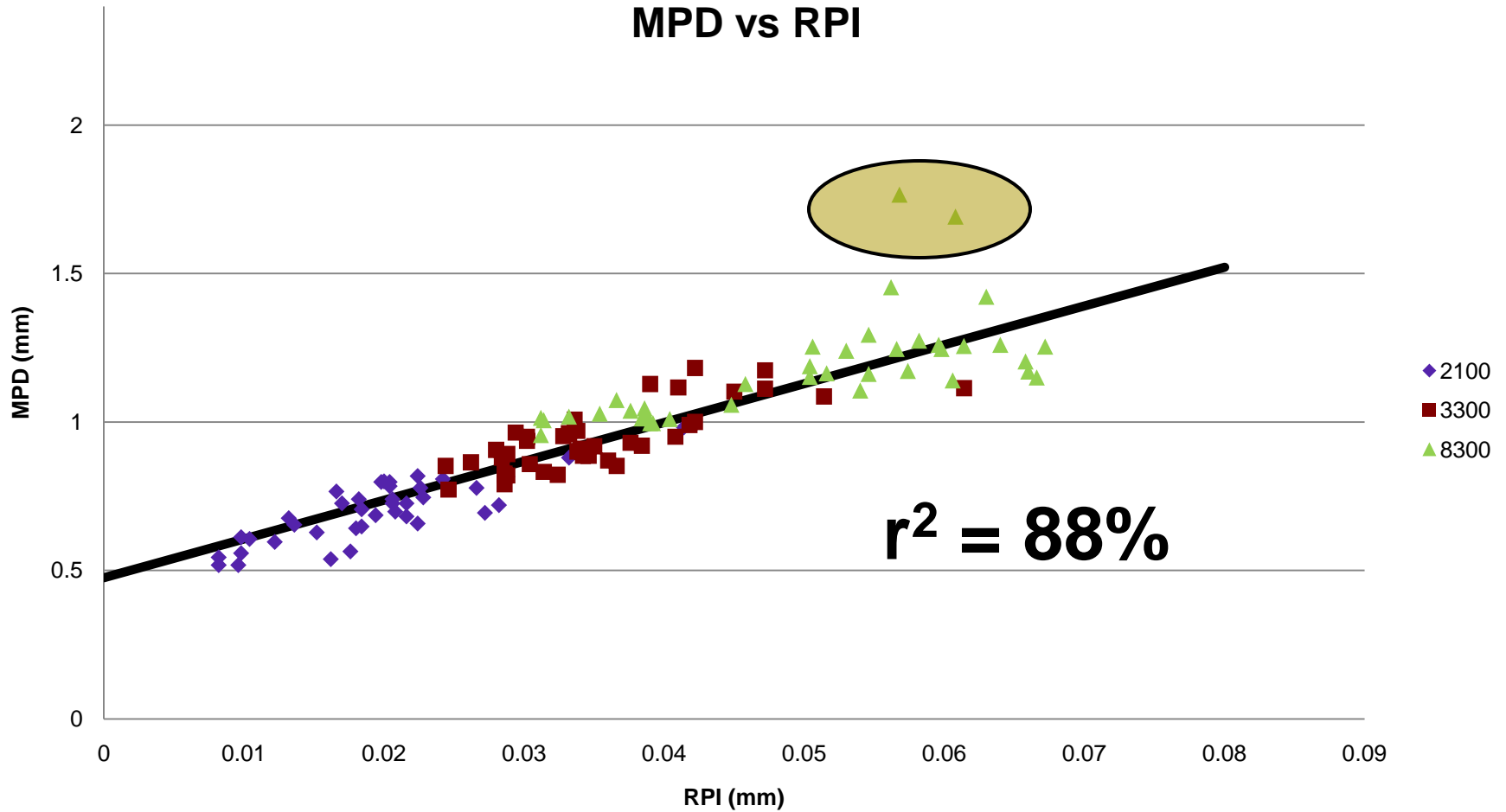
Macrotexture - Correlation between MPD and RPI

MPD vs RPI



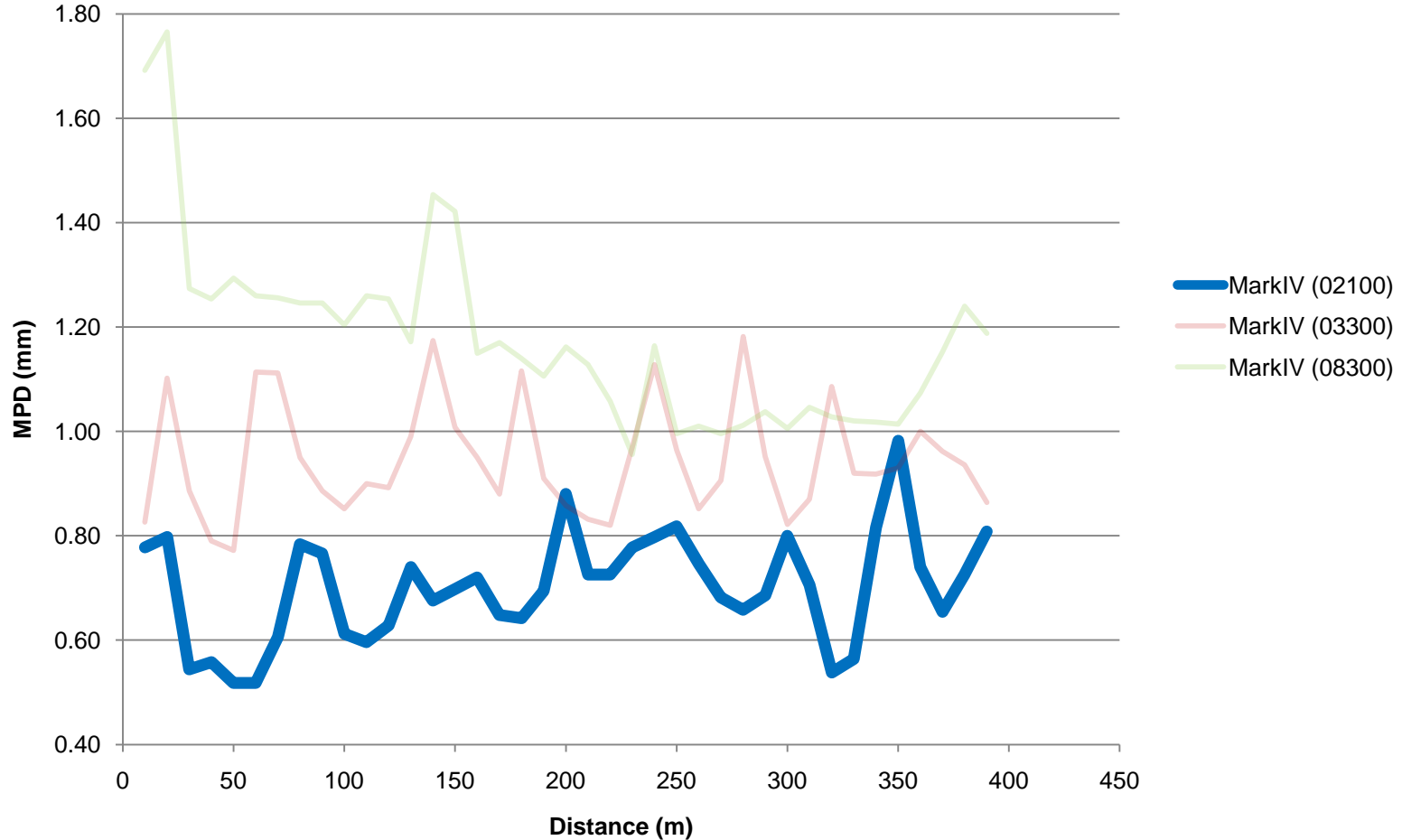
Macrotexture - Correlation between MPD and RPI

MPD vs RPI



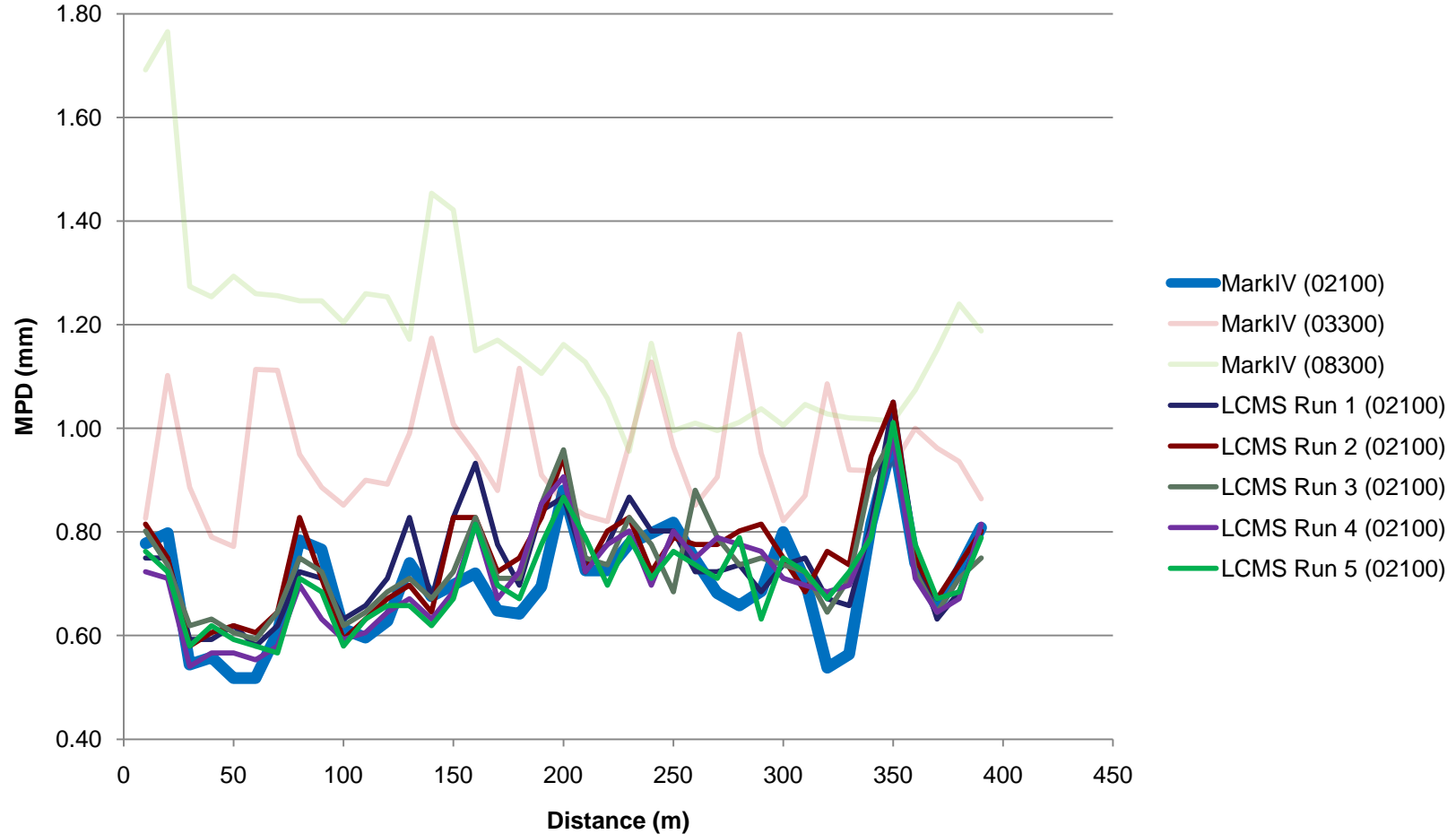
Macrotexture - Results for Section 02100

02100 - MarkIV and LCMS



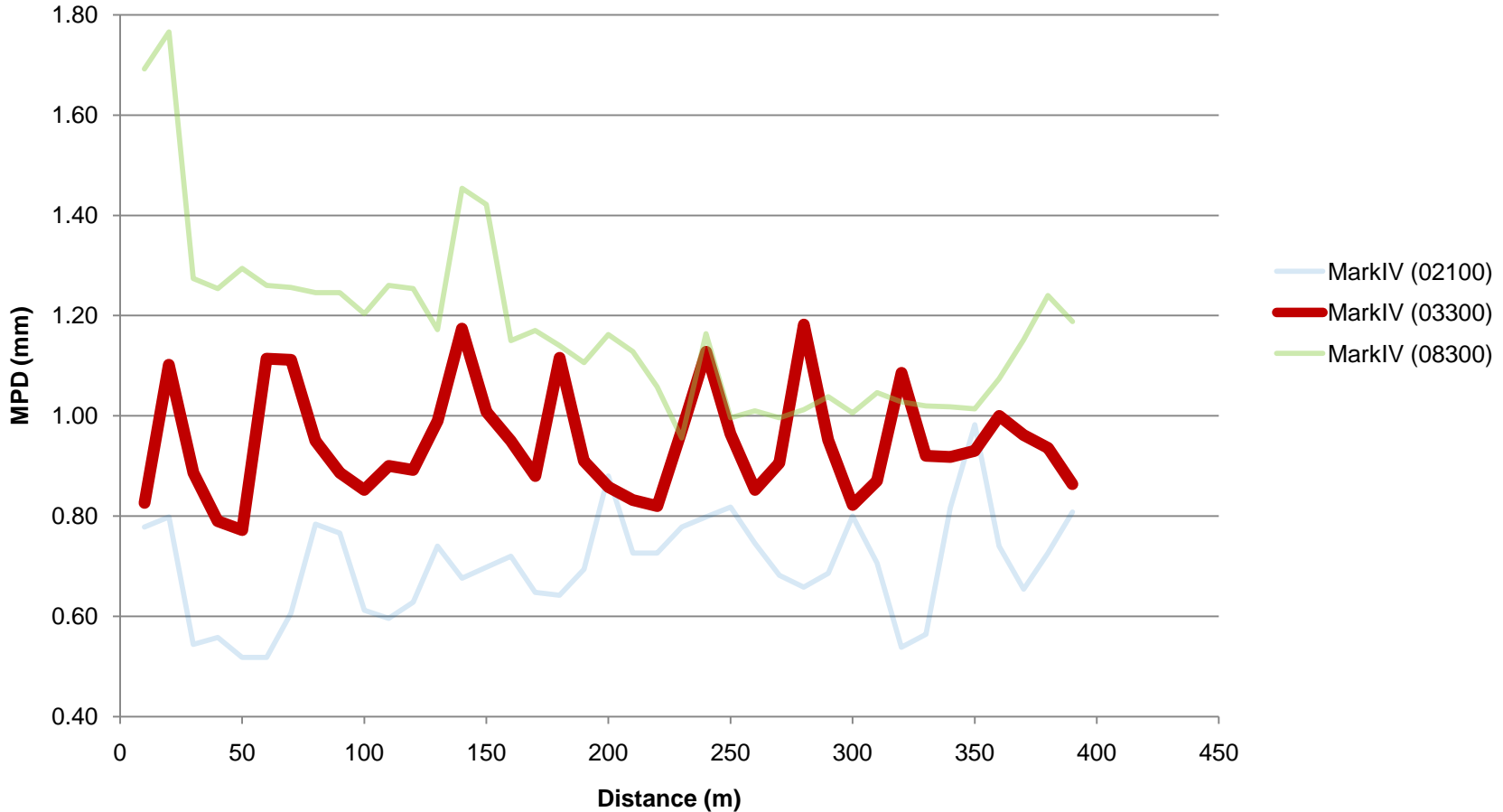
Macrotexture - Results for Section 02100

02100 - MarkIV and LCMS



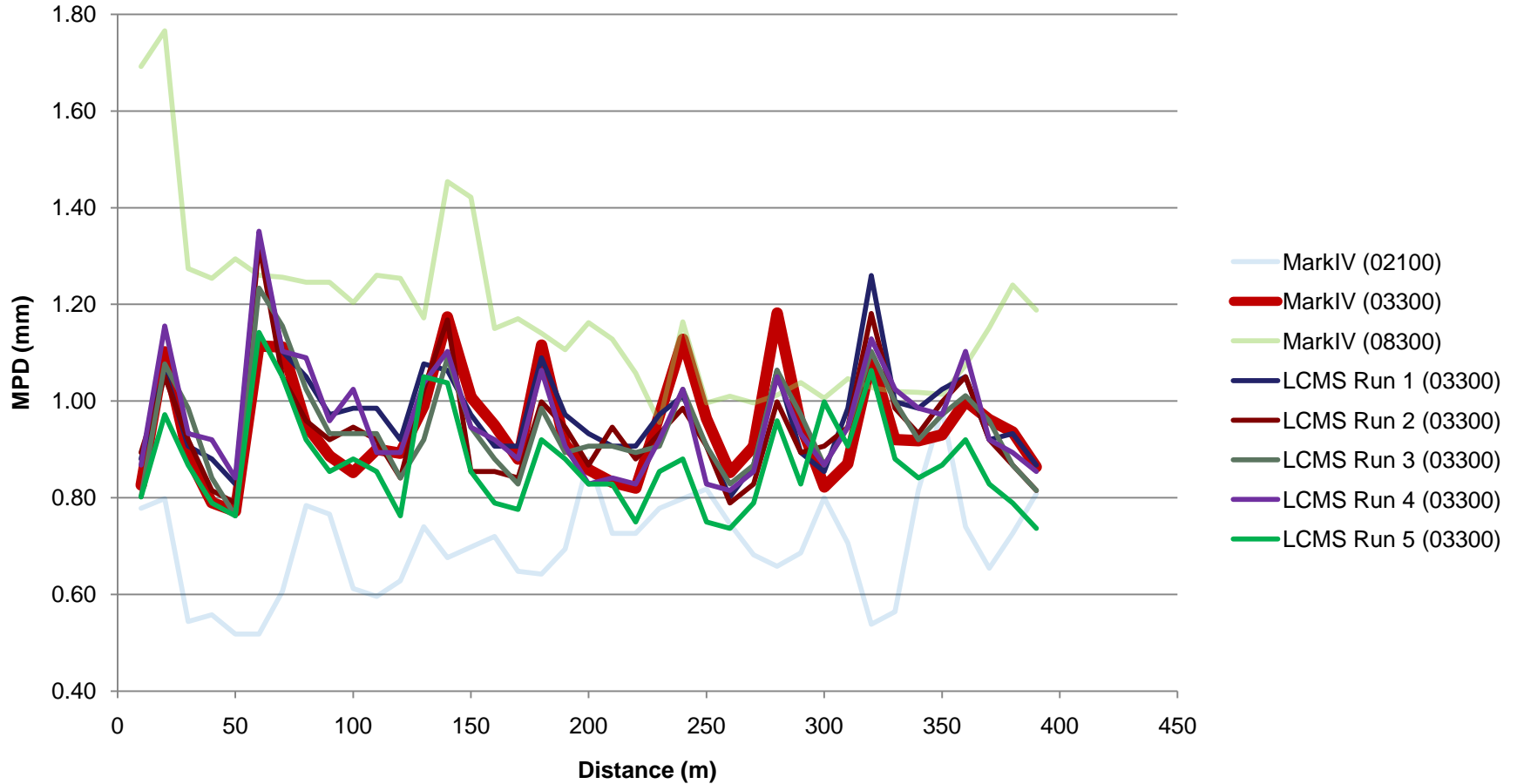
Macrotexture - Results for Section 03300

03300 - MarkIV and LCMS



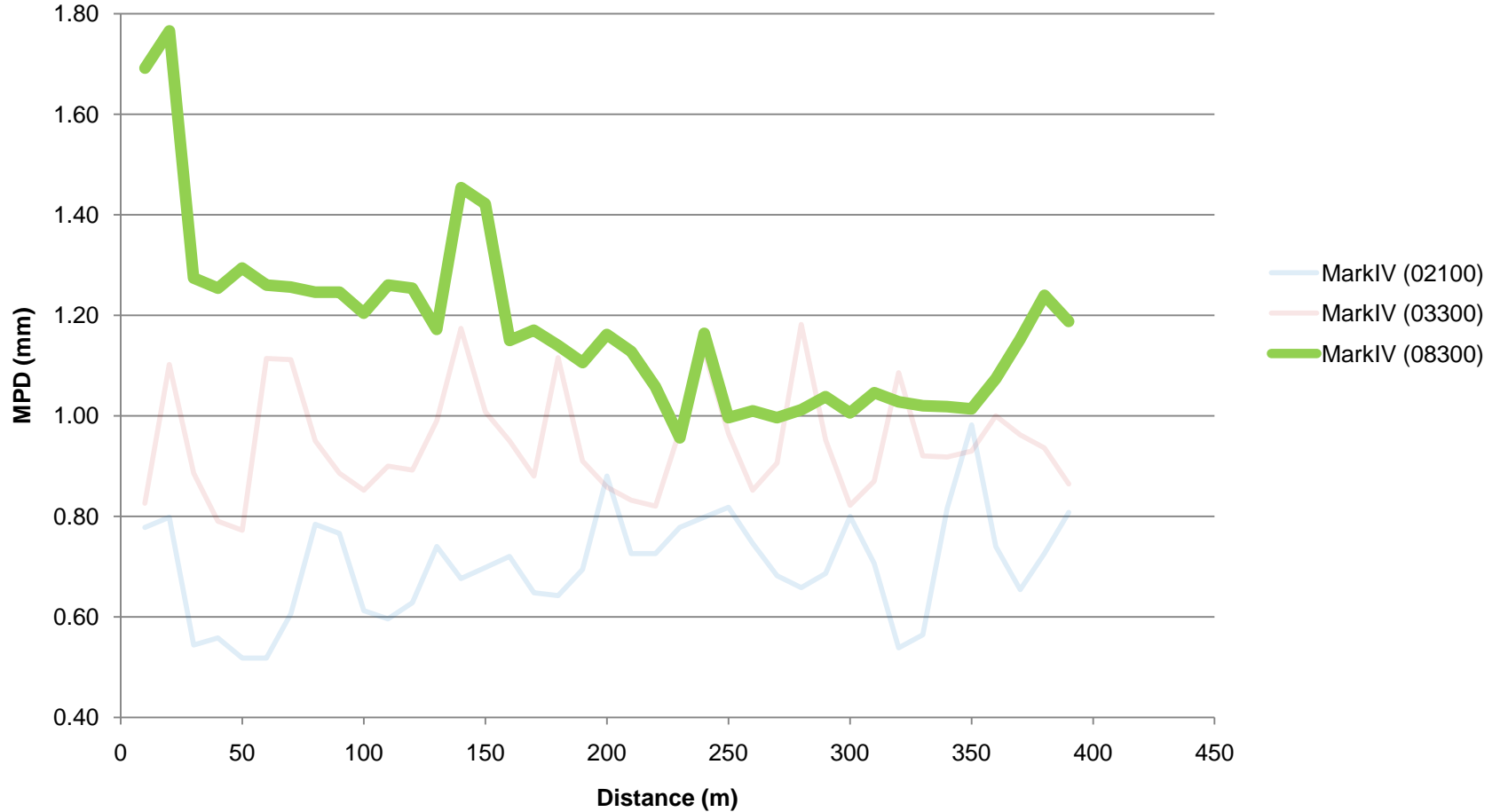
Macrotexture - Results for Section 03300

03300 - MarkIV and LCMS



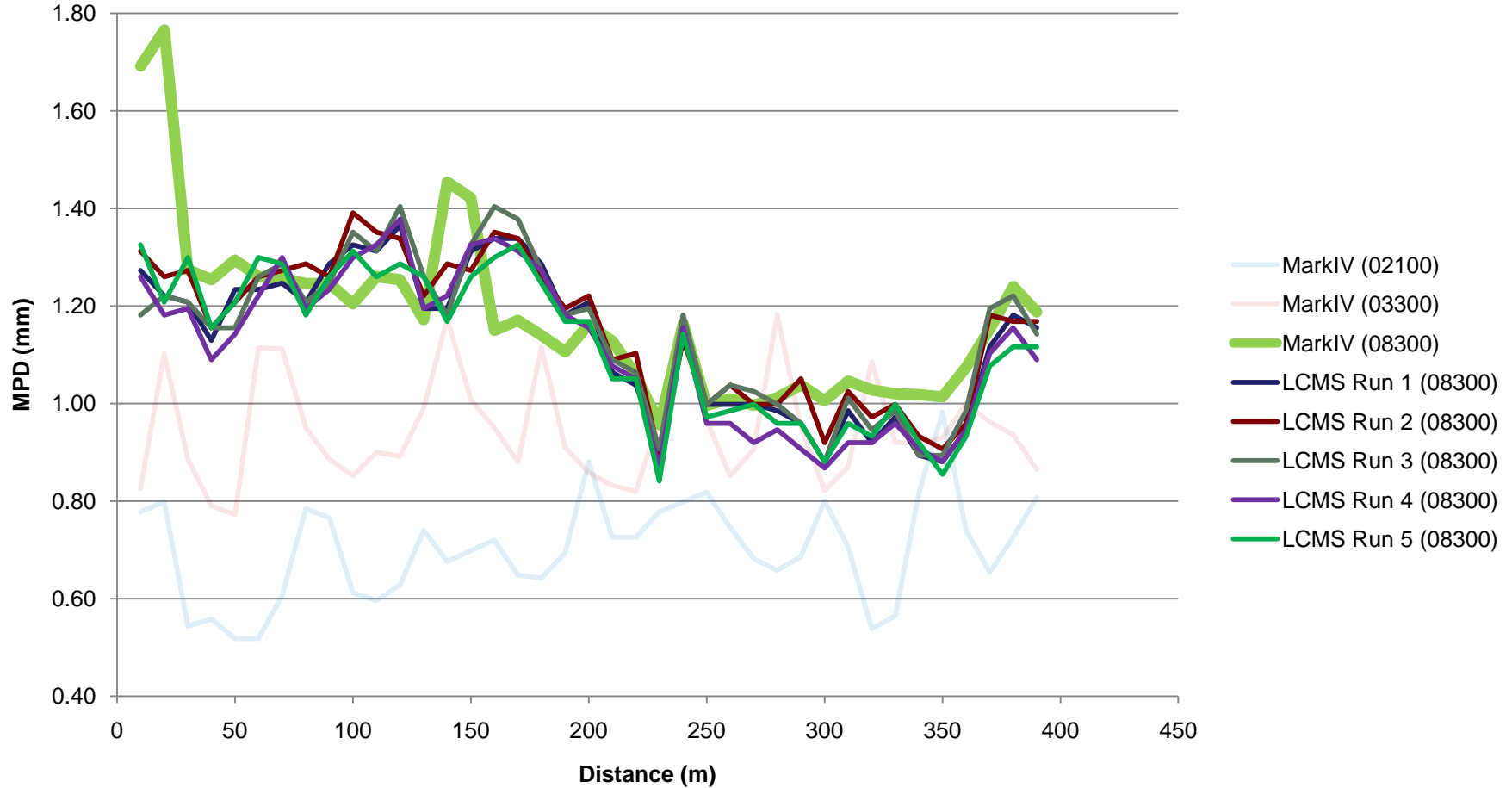
Macrotexture - Results for Section 08300

08300 - MarkIV and LCMS



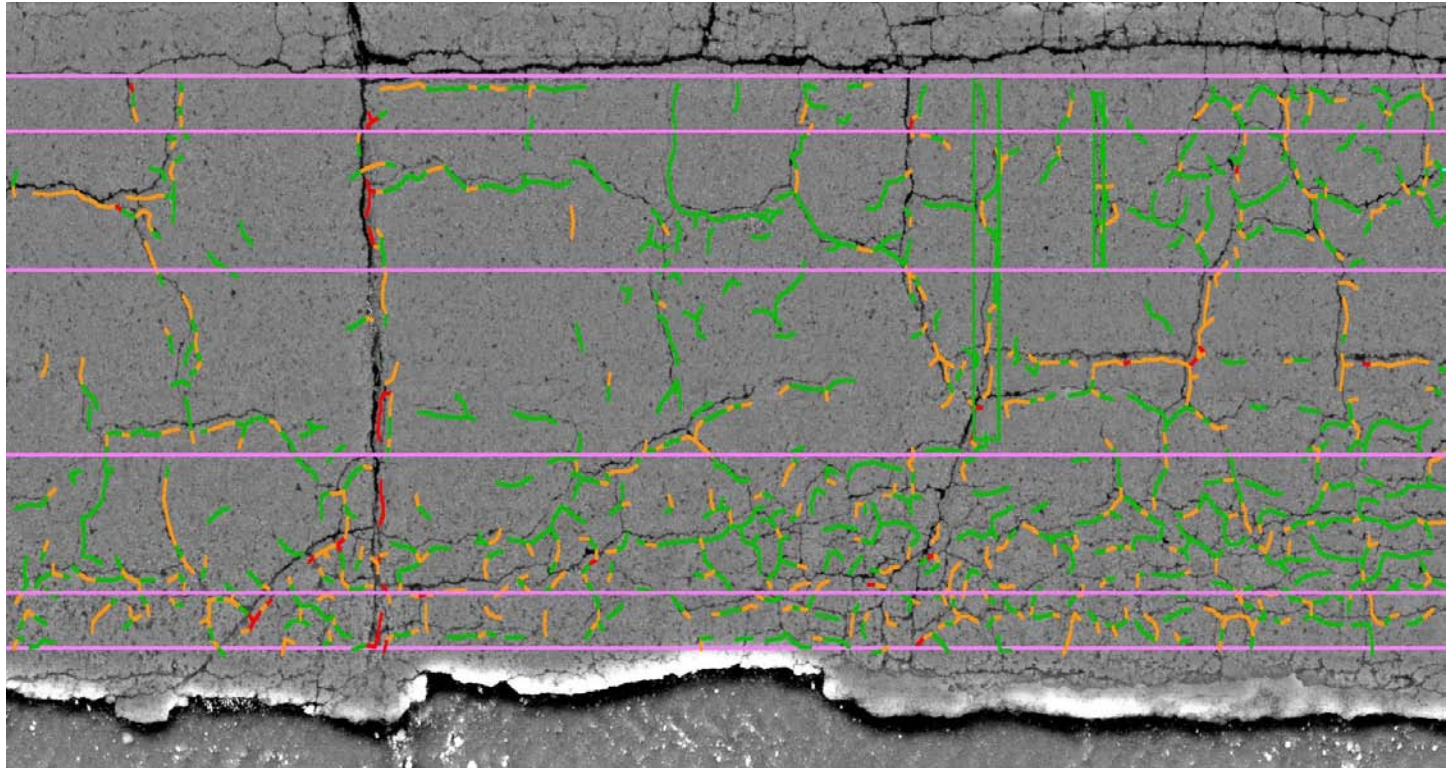
Macrotexture - Results for Section 08300

08300 - MarkIV and LCMS



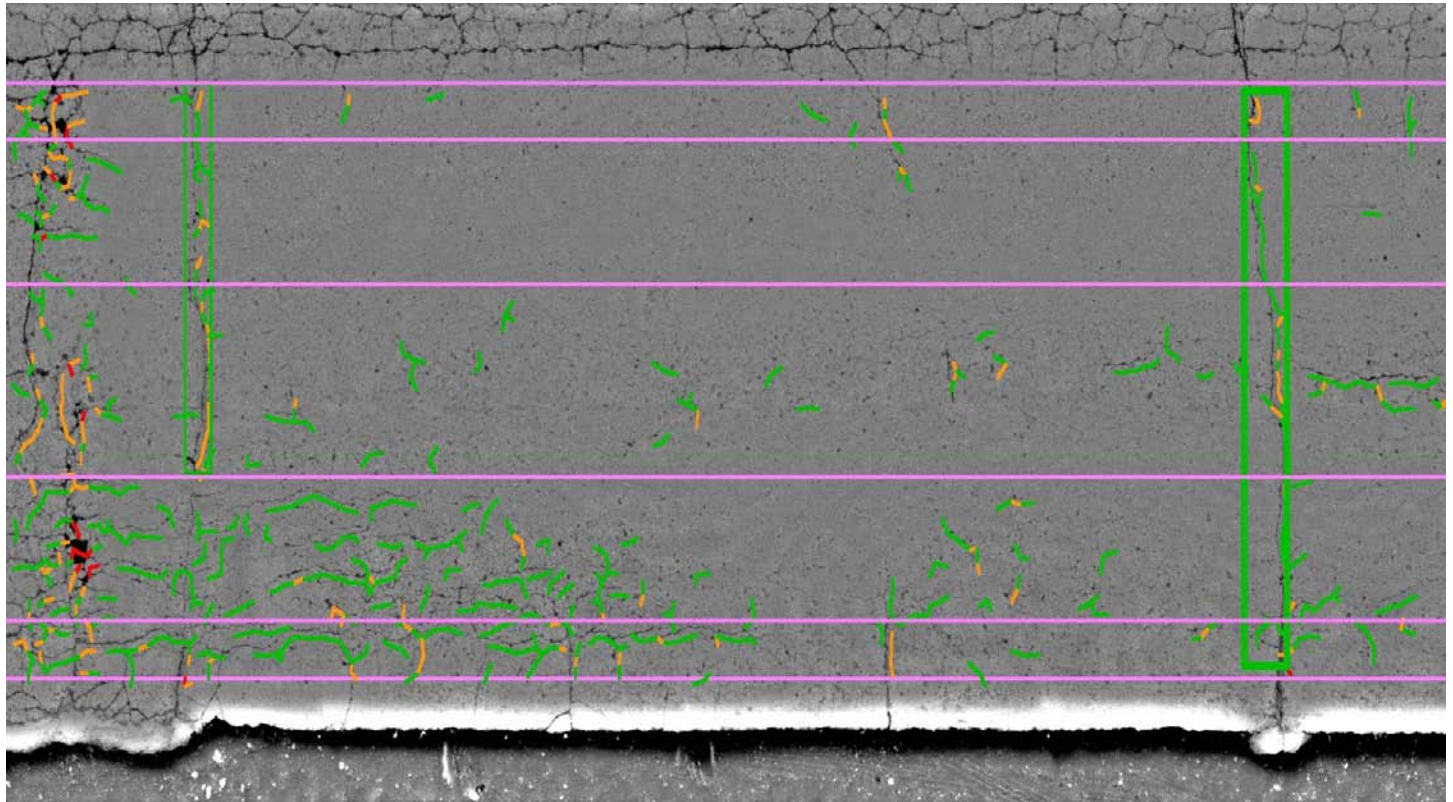
Macrotexture – Results for Section 08300

Right wheel path
(10-20m)

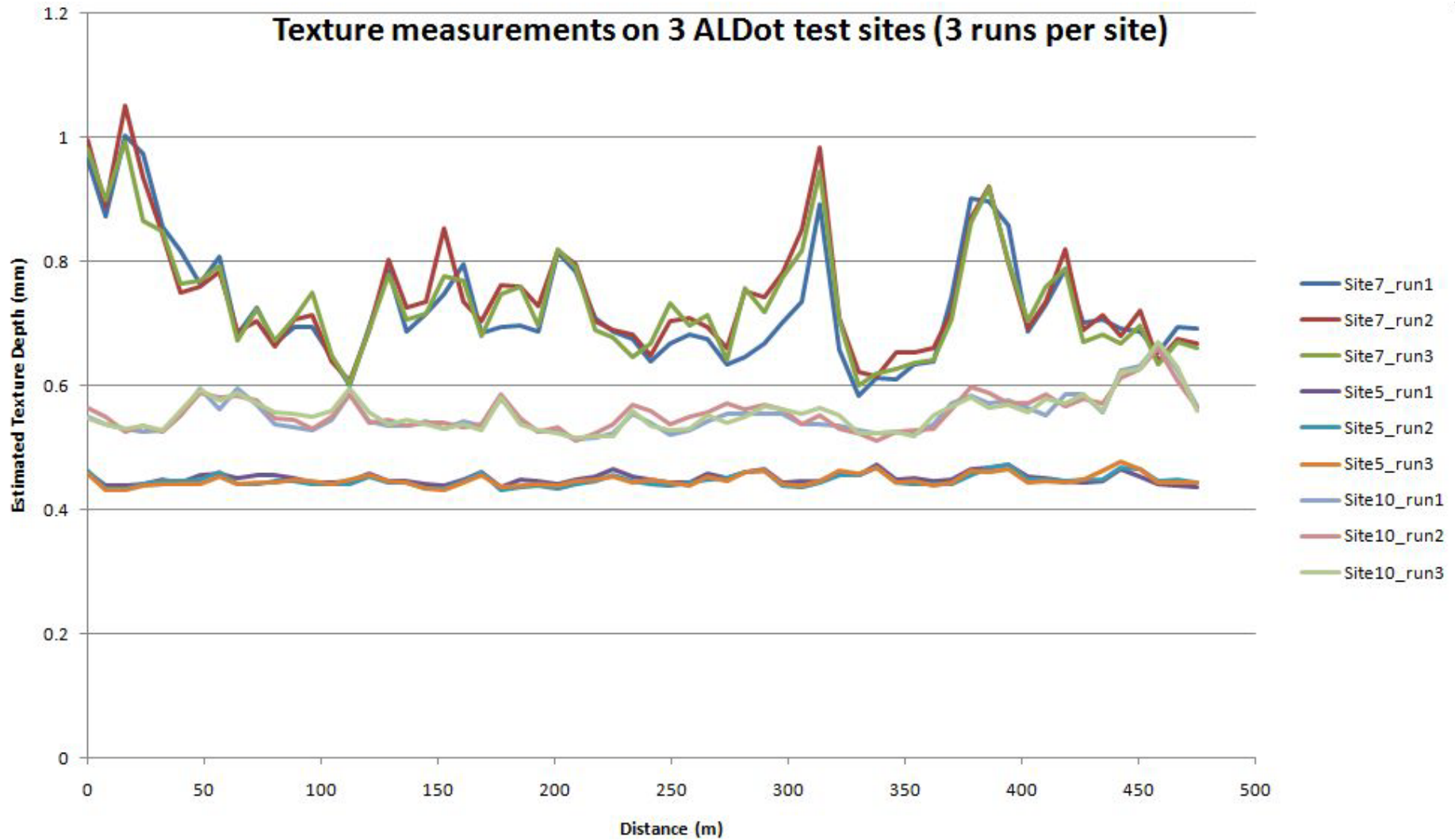


Macrotexture - Results for Section 08300

Right wheel path
(20-30m)



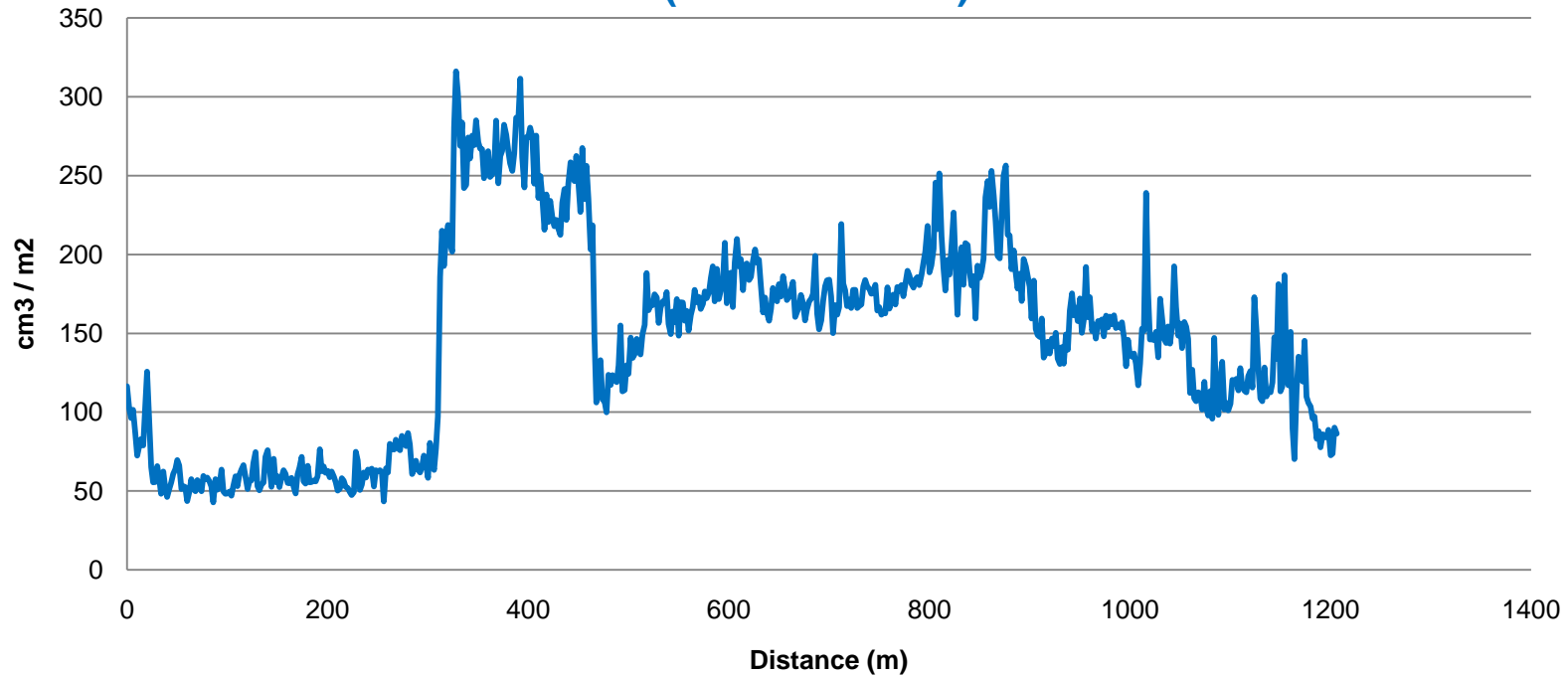
Repeatability – RPI measurement



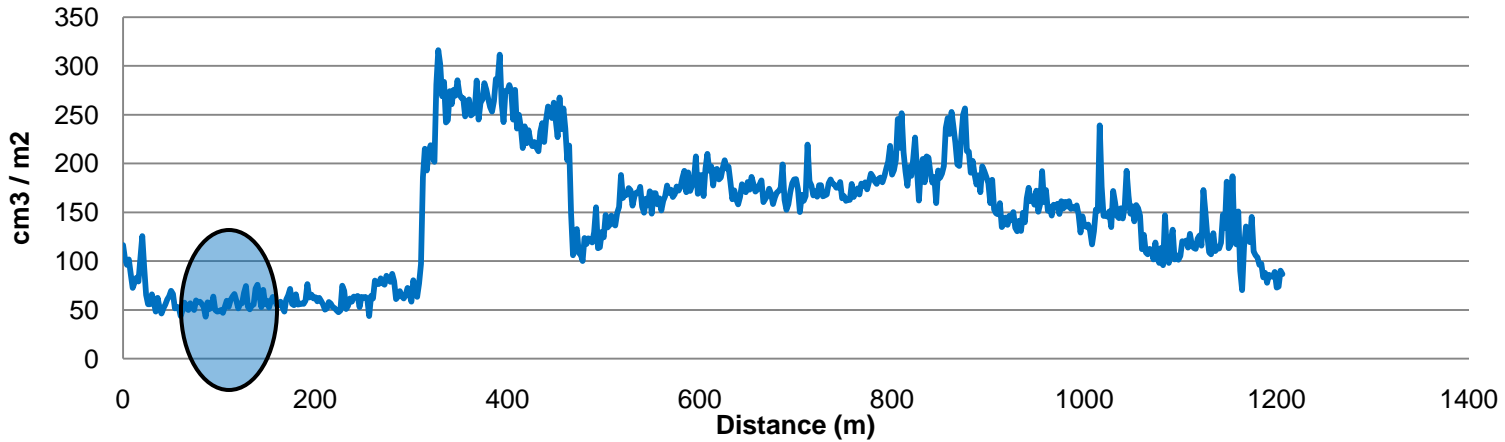
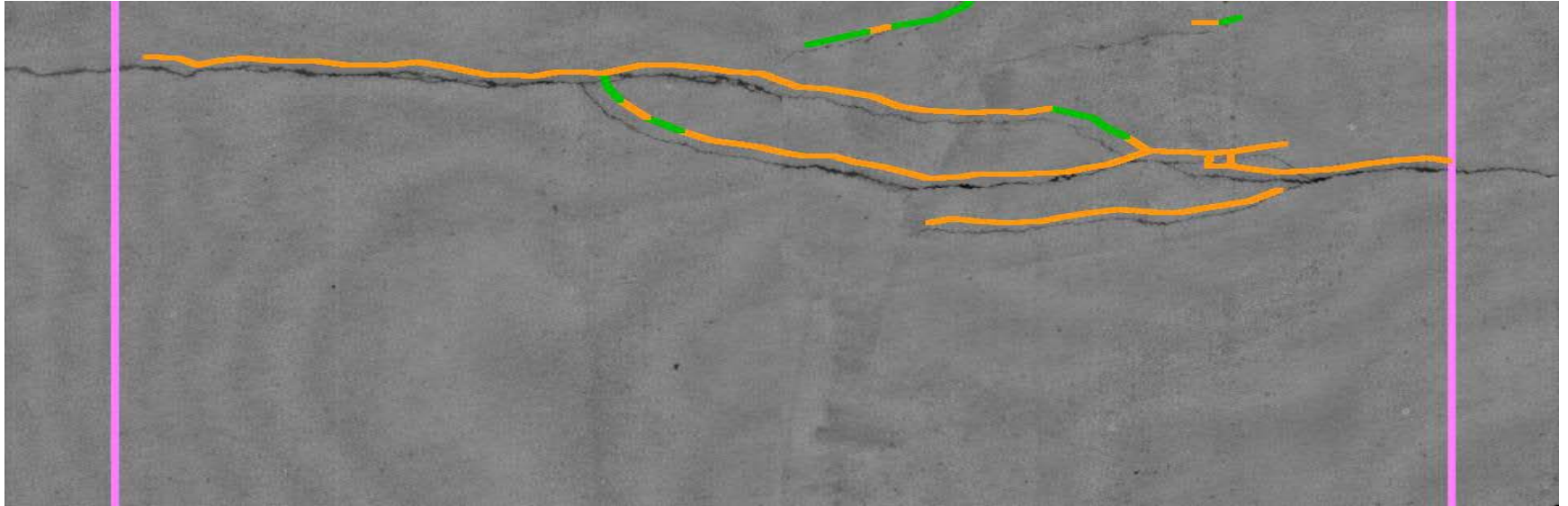
RPI – Road Test (Québec)

- This test section is interesting because it involves different types of pavement surfaces: Smooth, Very rough and Rough.

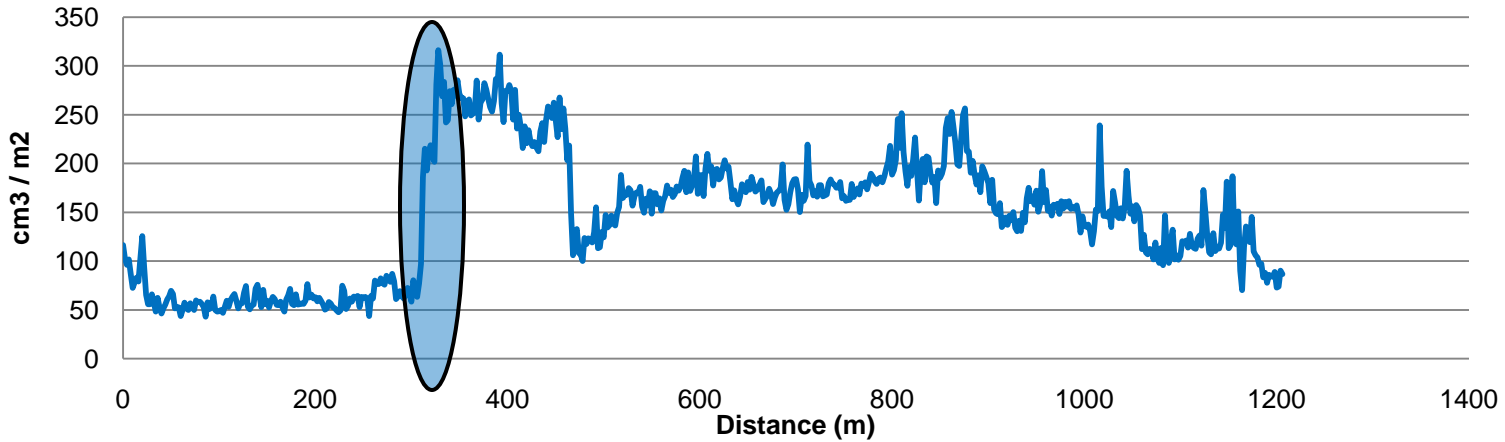
RPI measurements (10 m sections) between 0m and 1200m

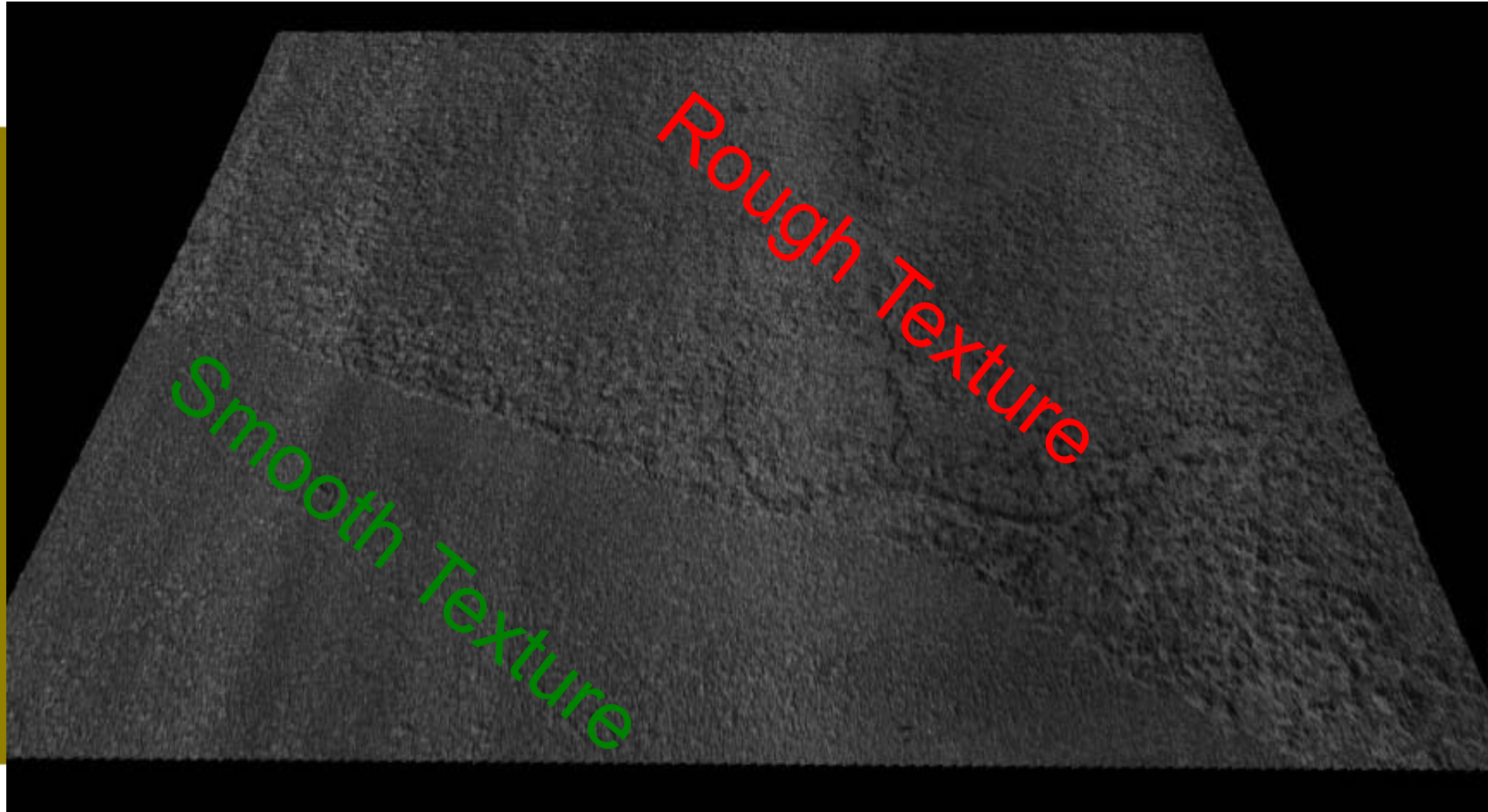


Smooth texture

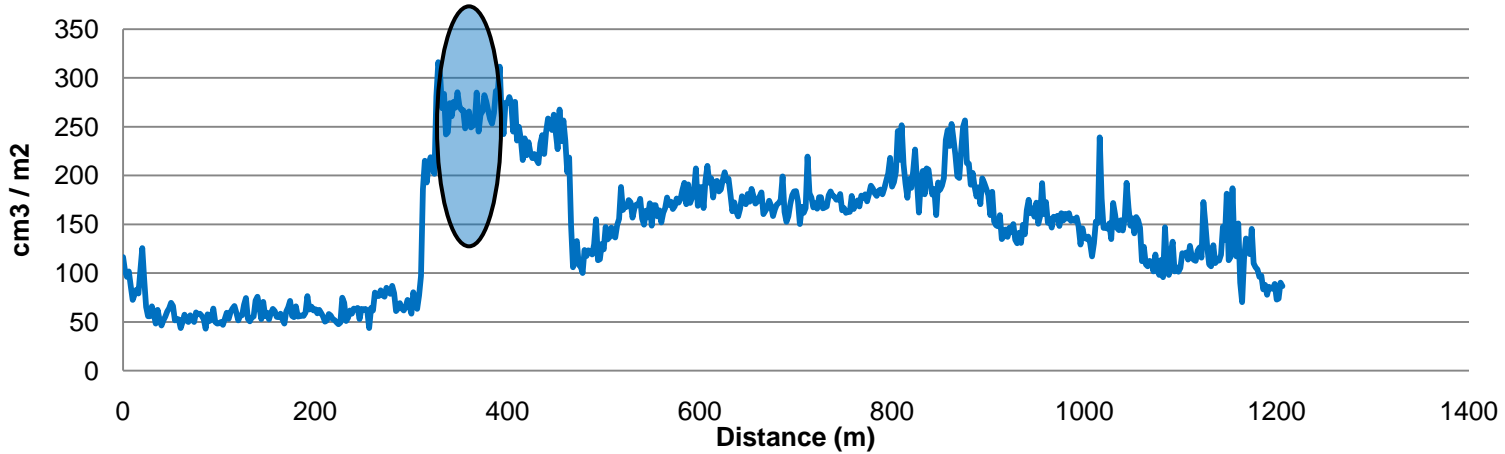
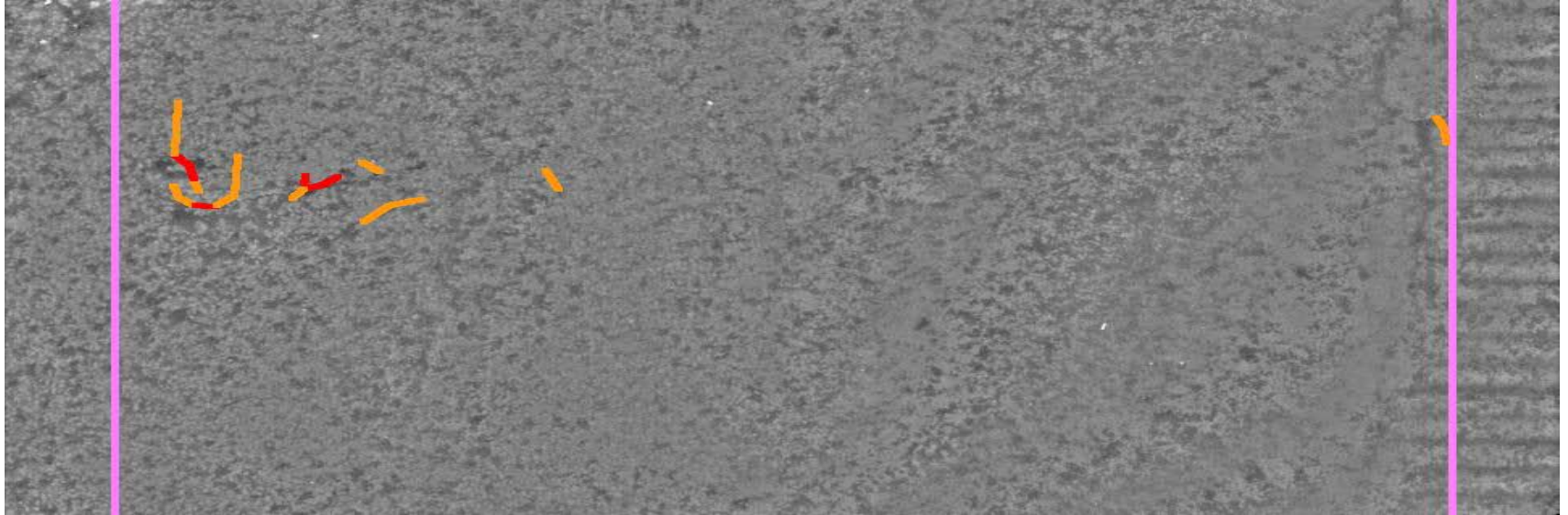


Smooth to Very Rough

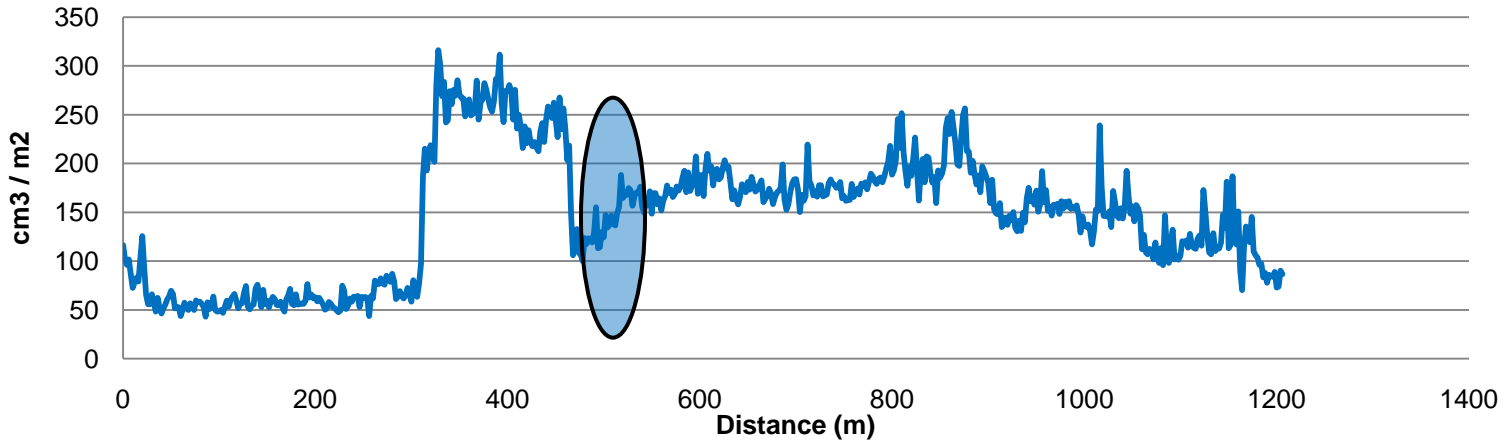
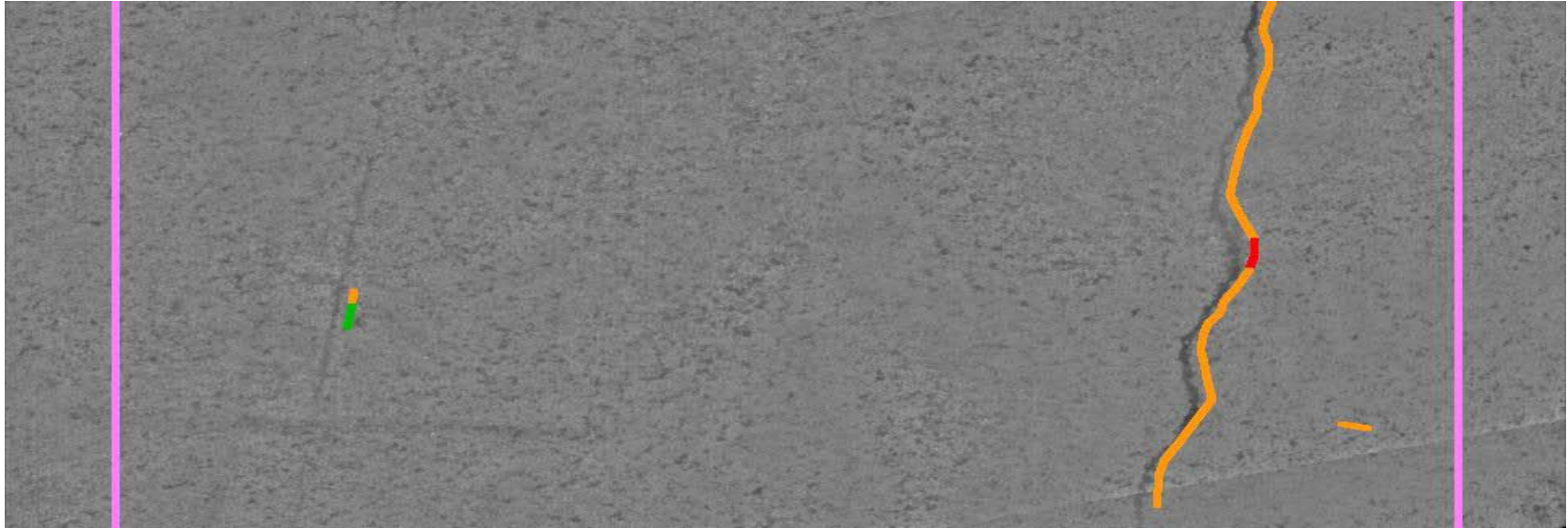




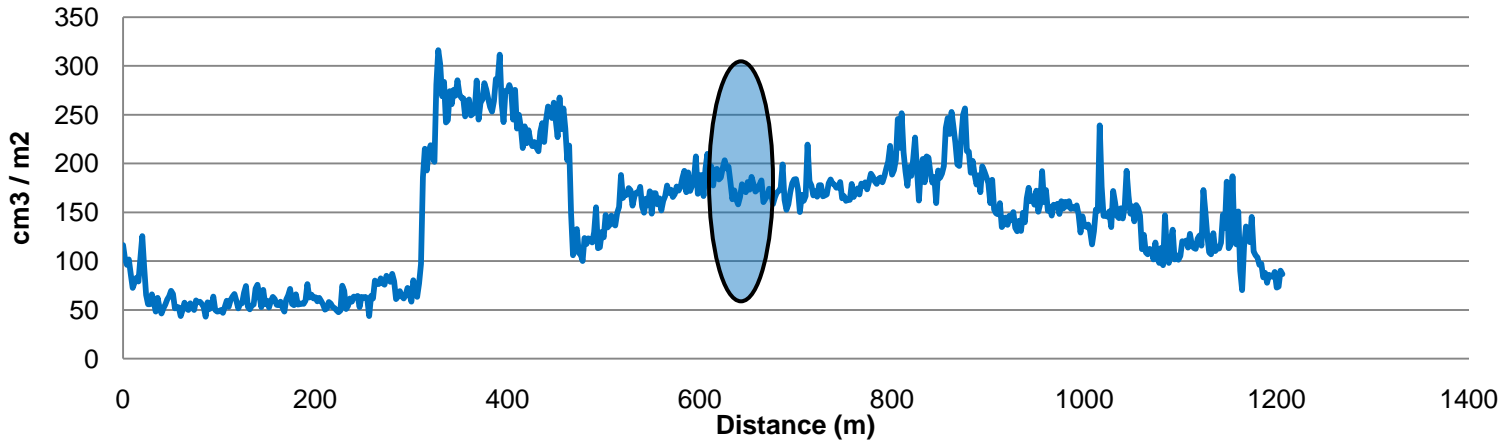
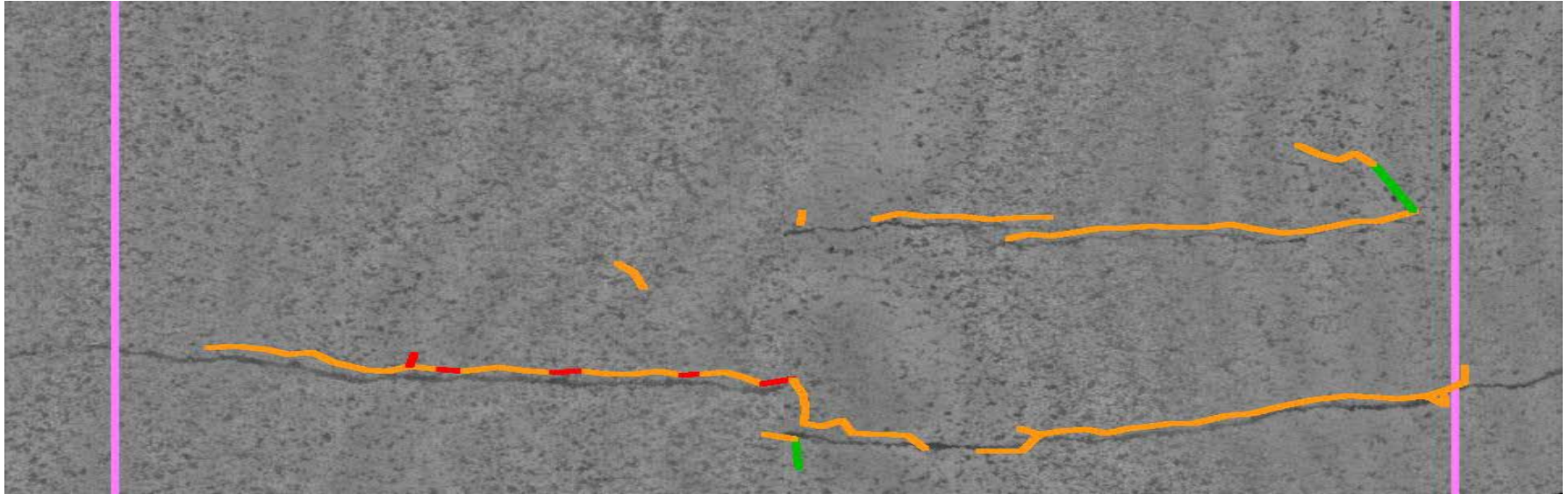
Very rough texture



Rough texture



Rough texture



Raveling Index (RI)

“Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. Ravelling ranges from loss of fines to loss of some coarse aggregate and ultimately to a very rough and pitted surface with obvious loss of aggregate”

(Source: Distress Identification Guide, US Dept of Transportation, Federal Highway Administration, Publication No. FHWA-RC-05-001, August 2005)



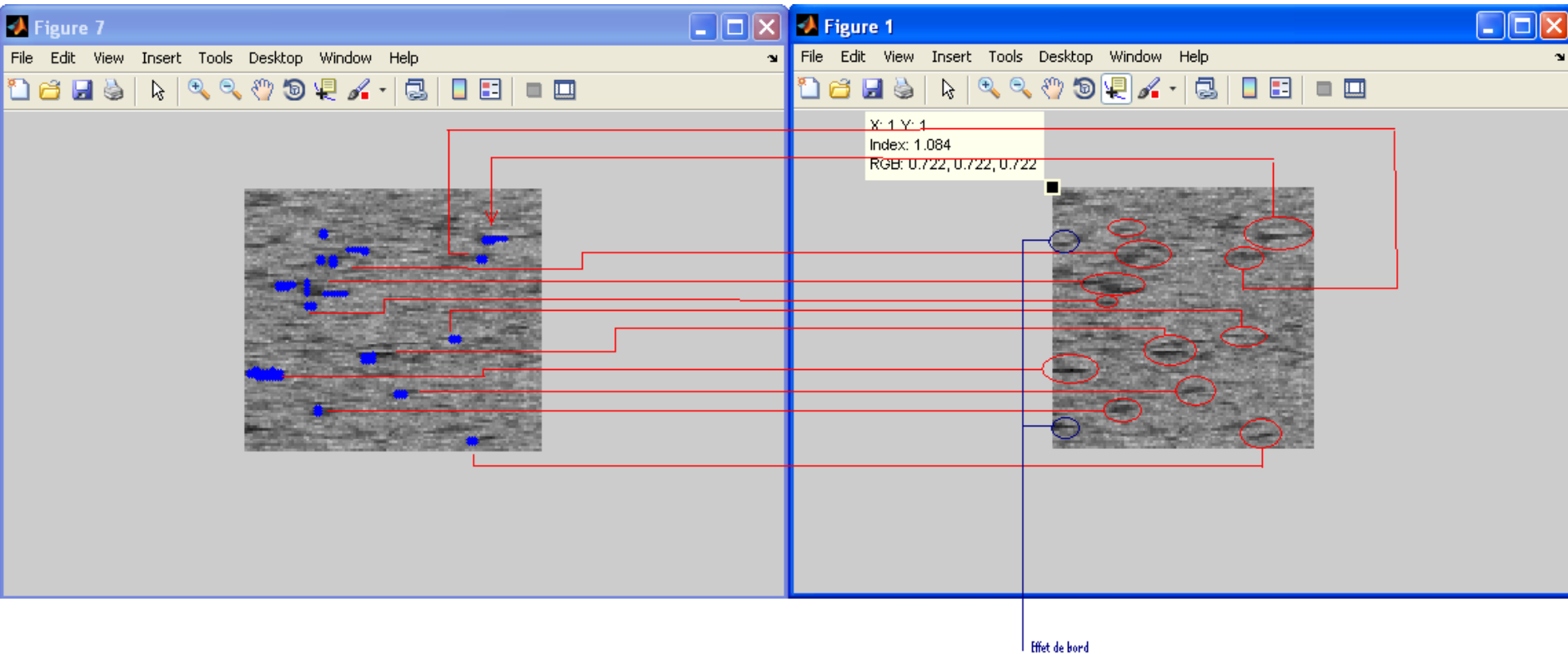
Raveling Index (RI)

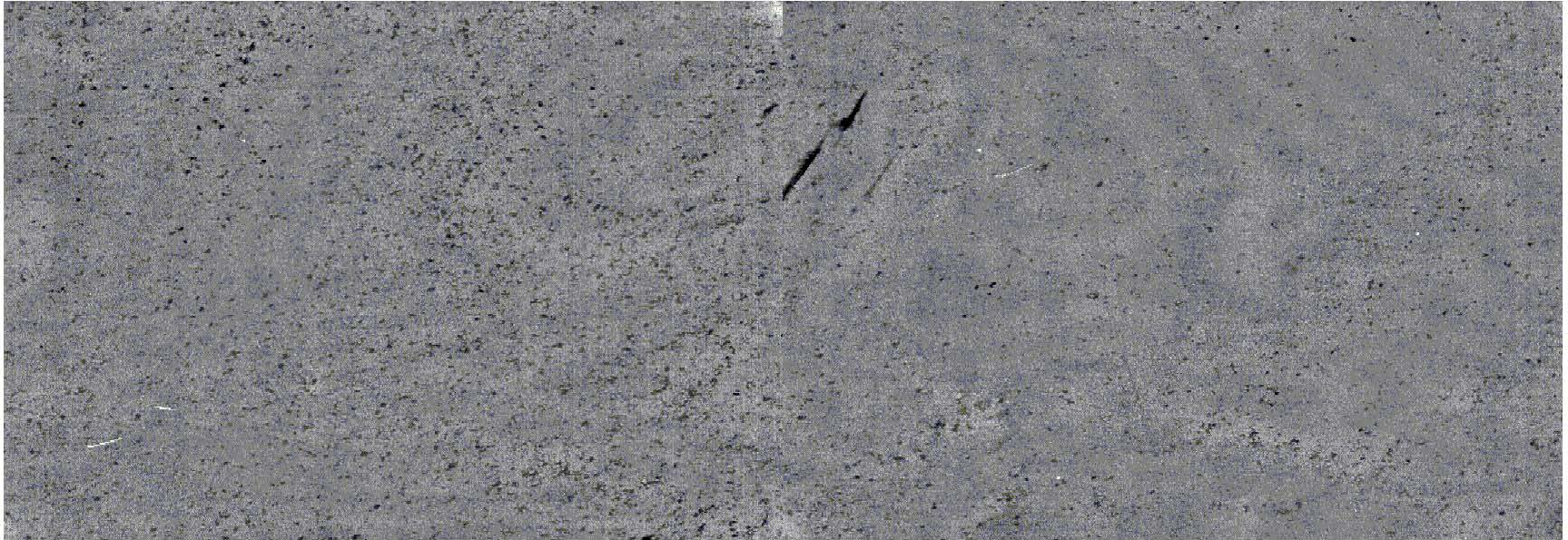
- Raveling spots (loss of aggregate) are identified from the 3D range images.
- The volume of the missing aggregate spots are measured per surface area.

$$RI = V_{ravelling} / A_{Total}$$

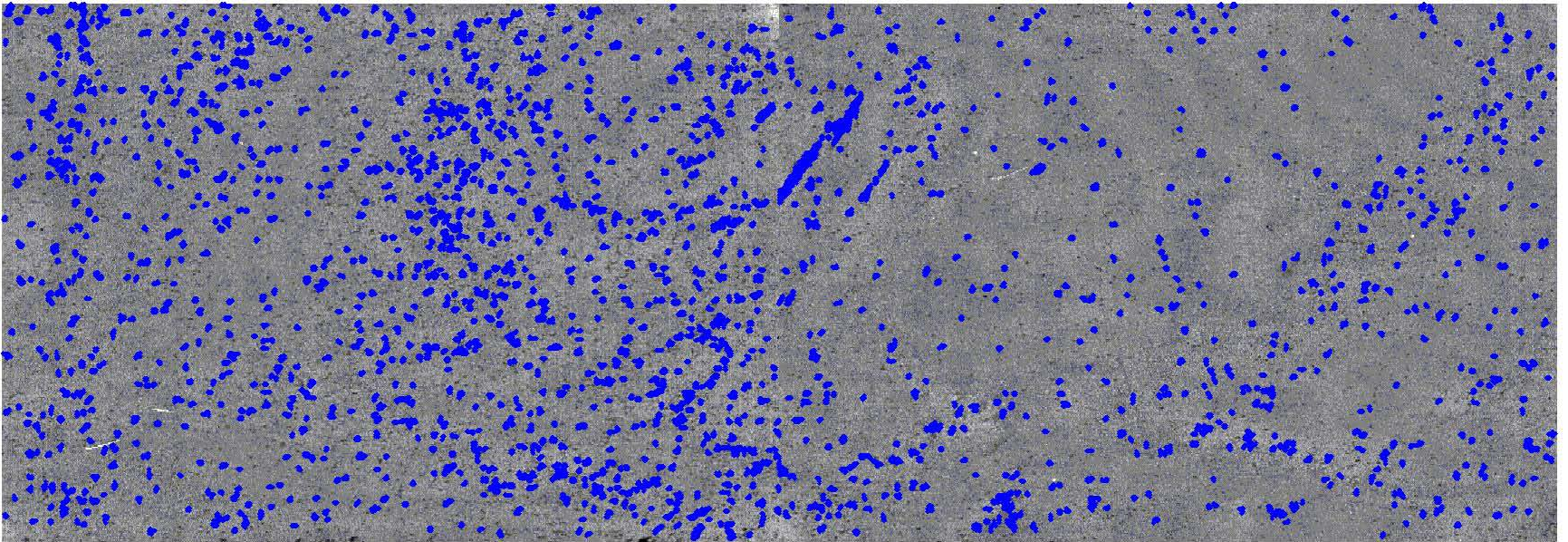


Aggregate loss detection

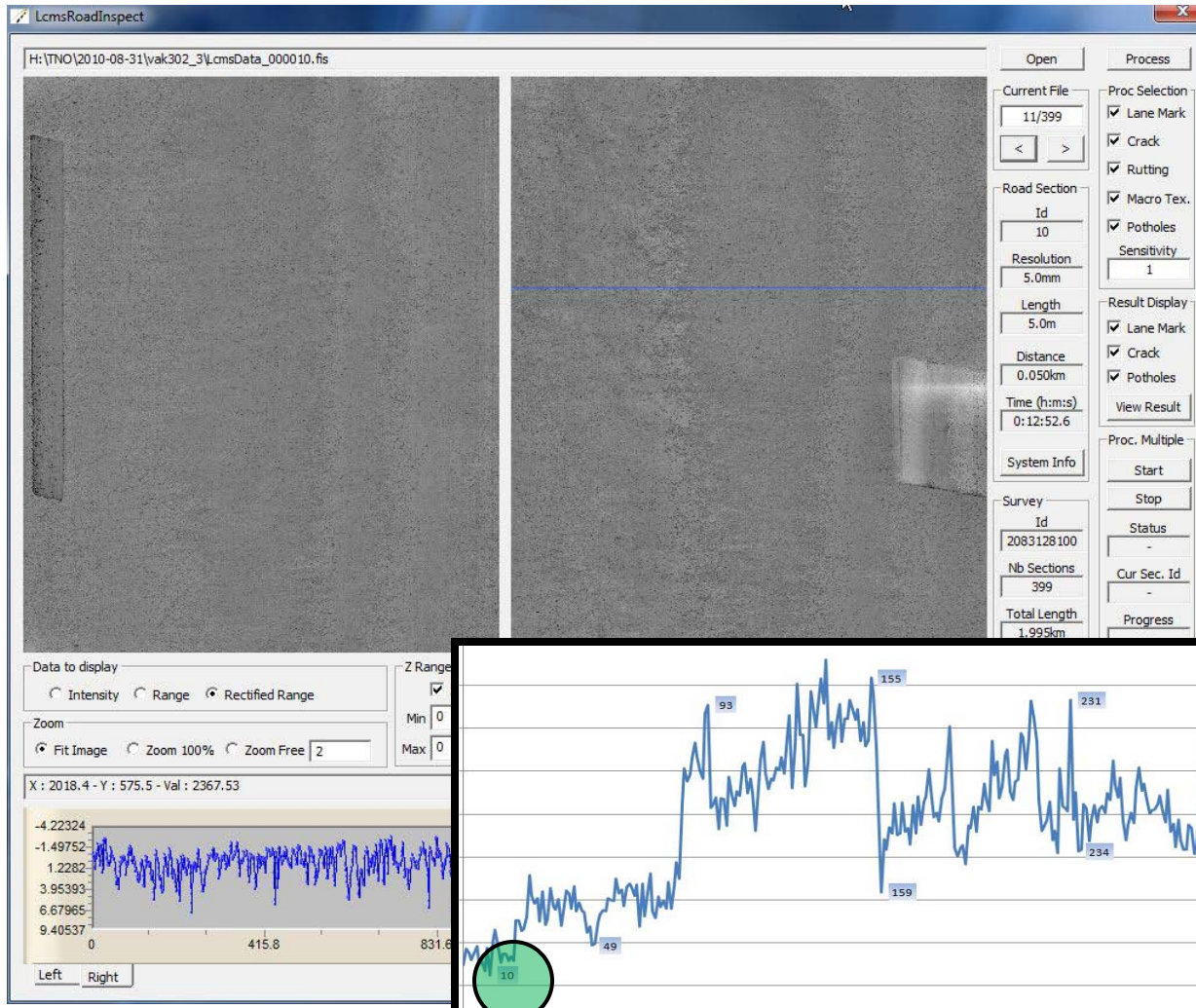




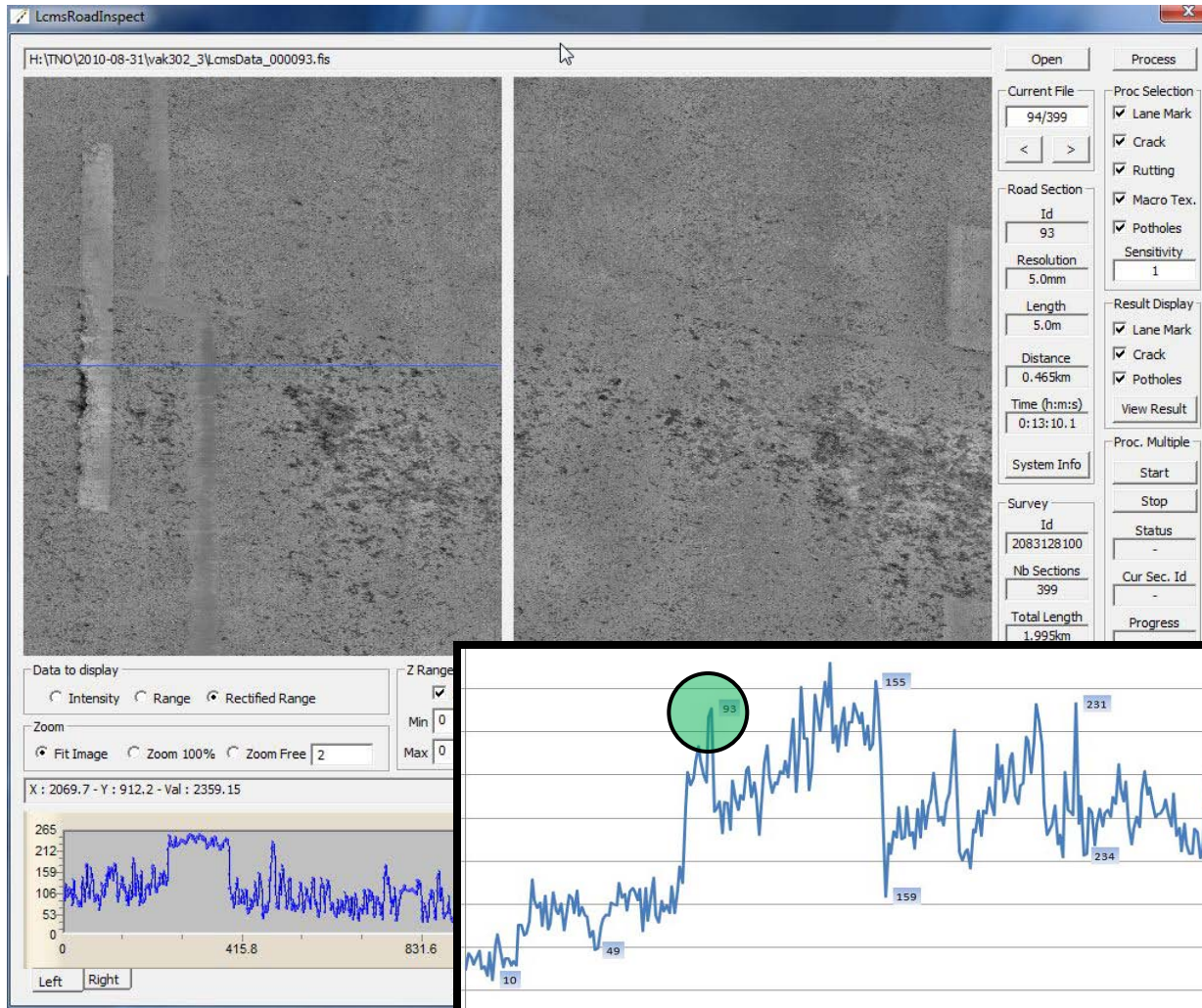
Aggregate loss detection



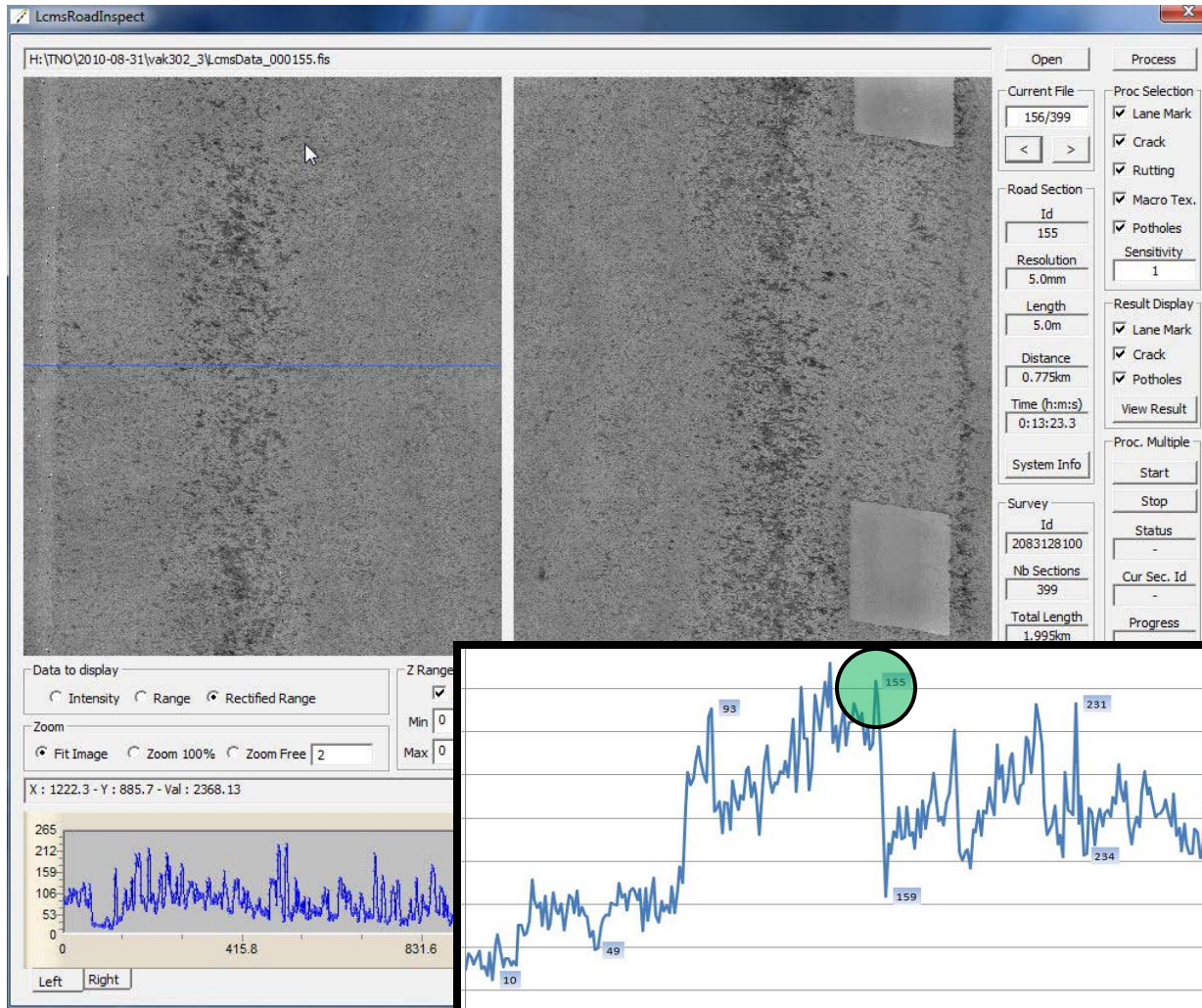
RI - Road test - Porous Asphalt in the Netherlands



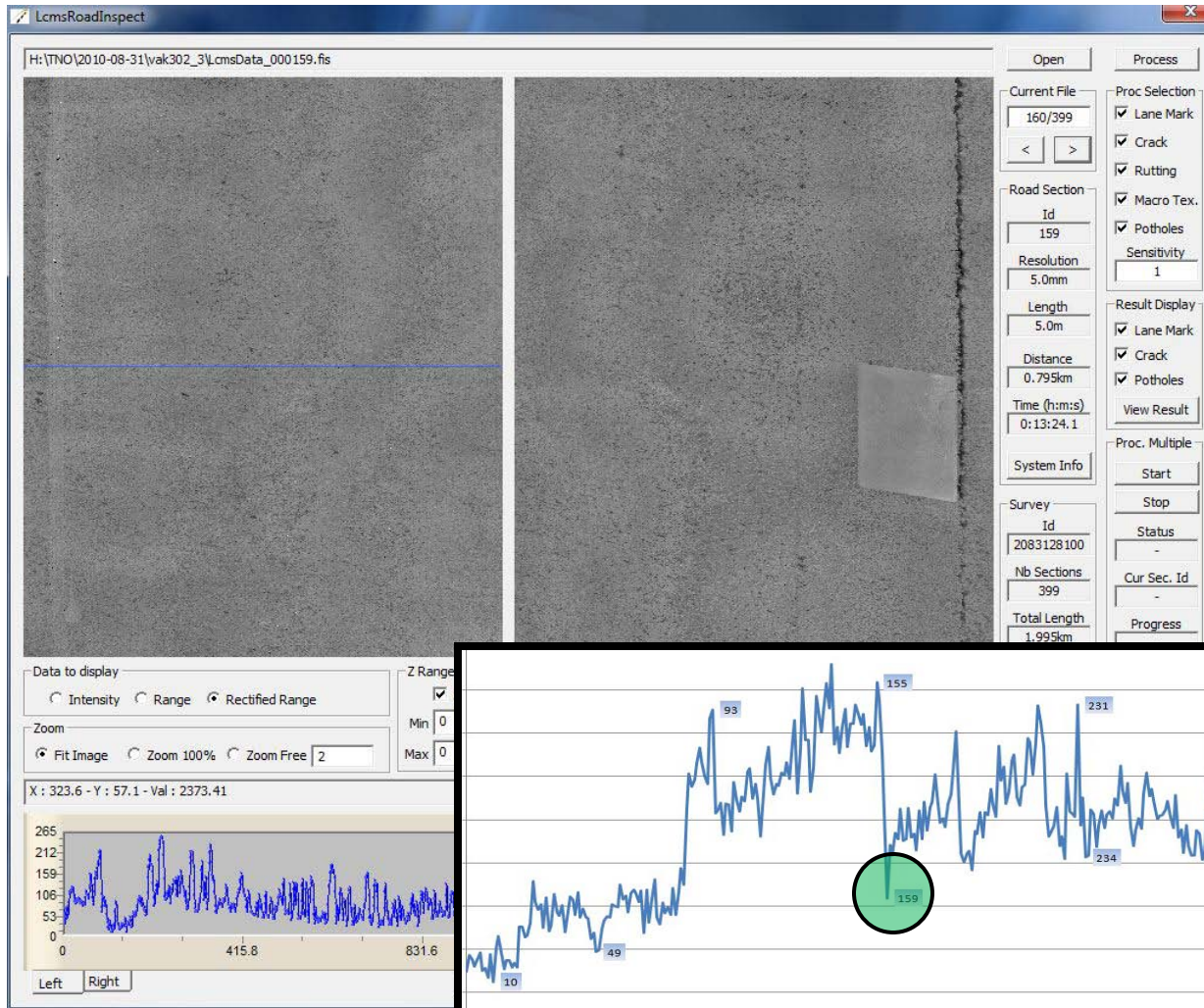
Road Section #93 : Transition between Ravelling and new pavement (Range)



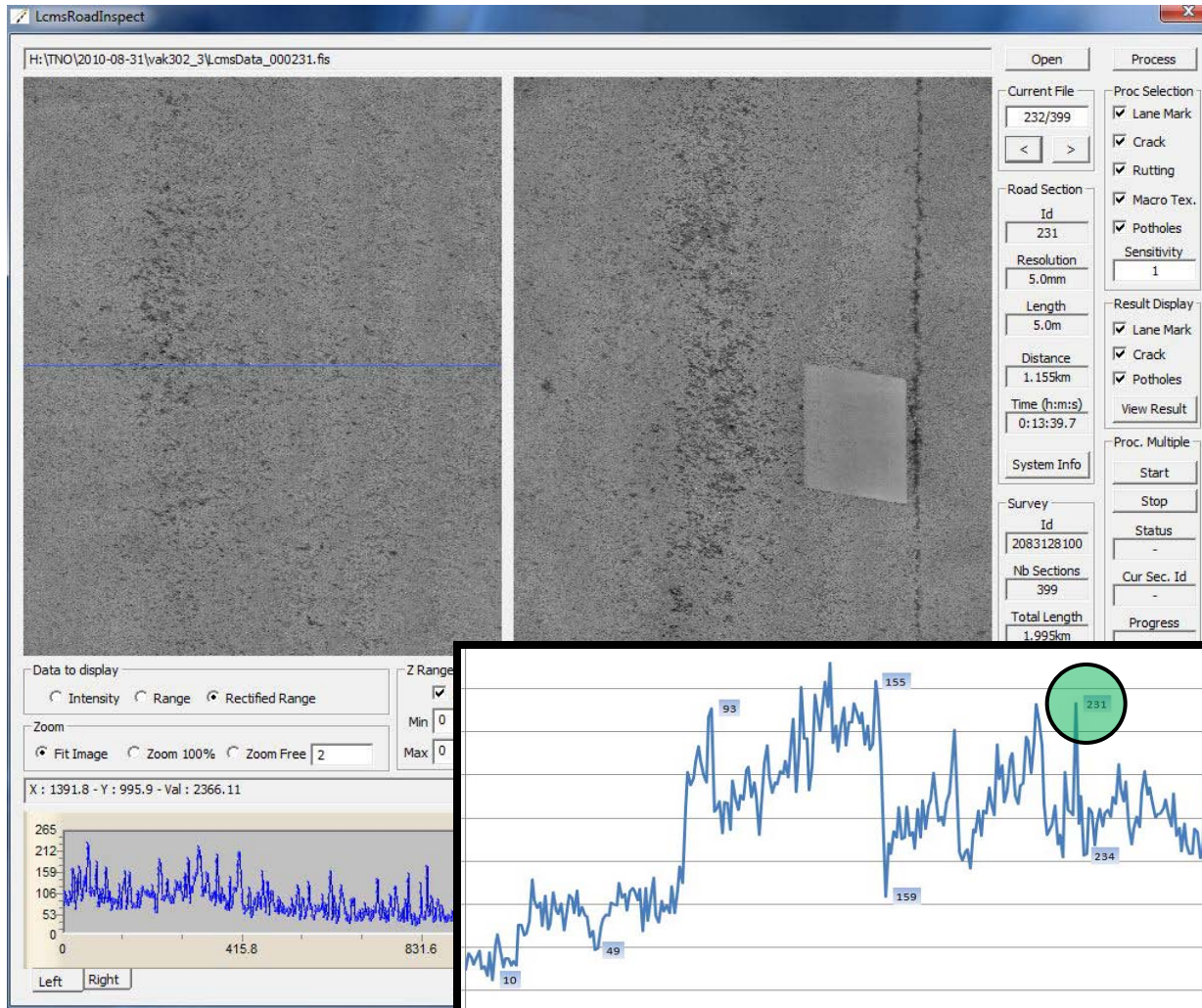
Road Section #155 : Raveling patch



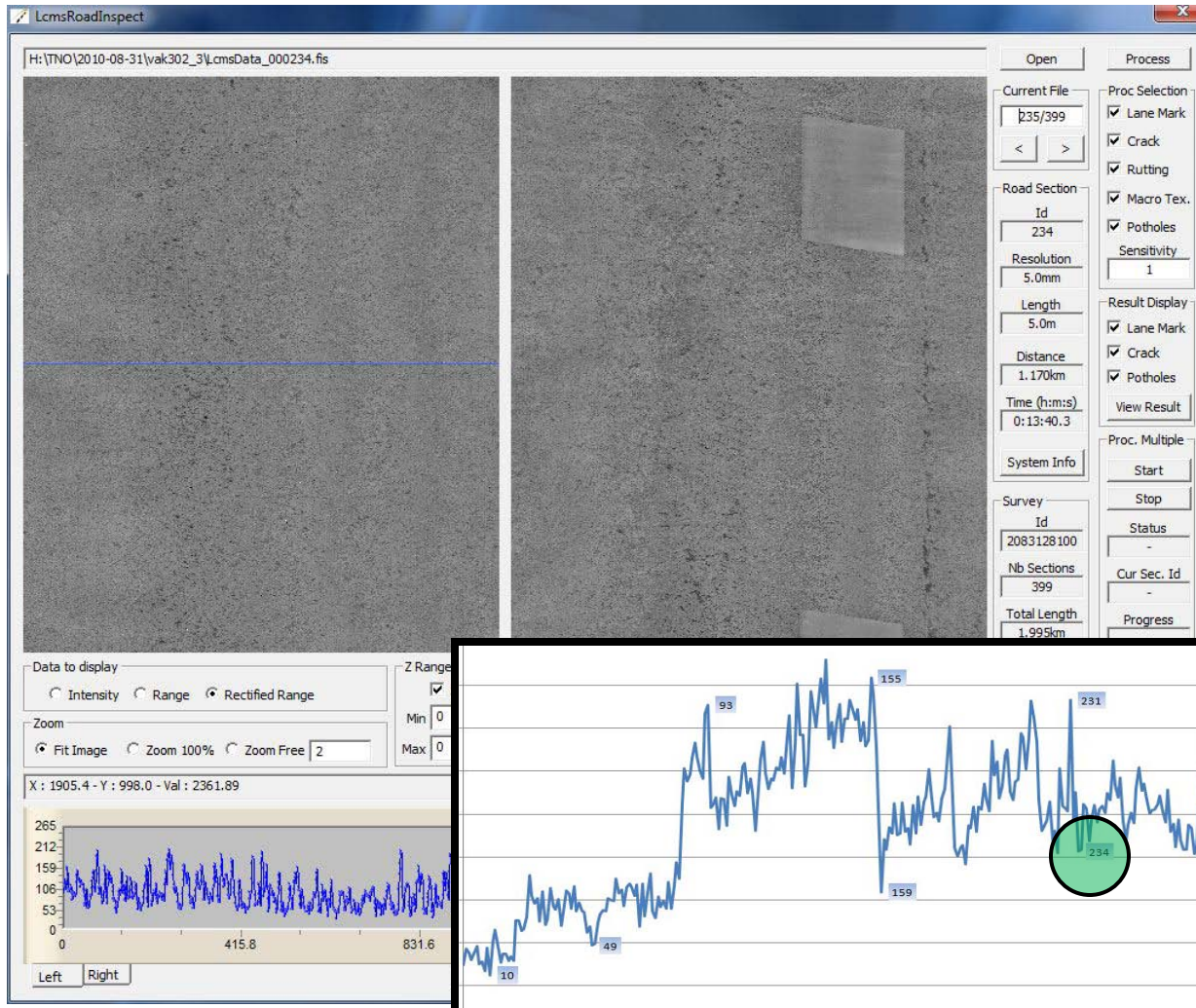
Road Section #159 : Smooth texture



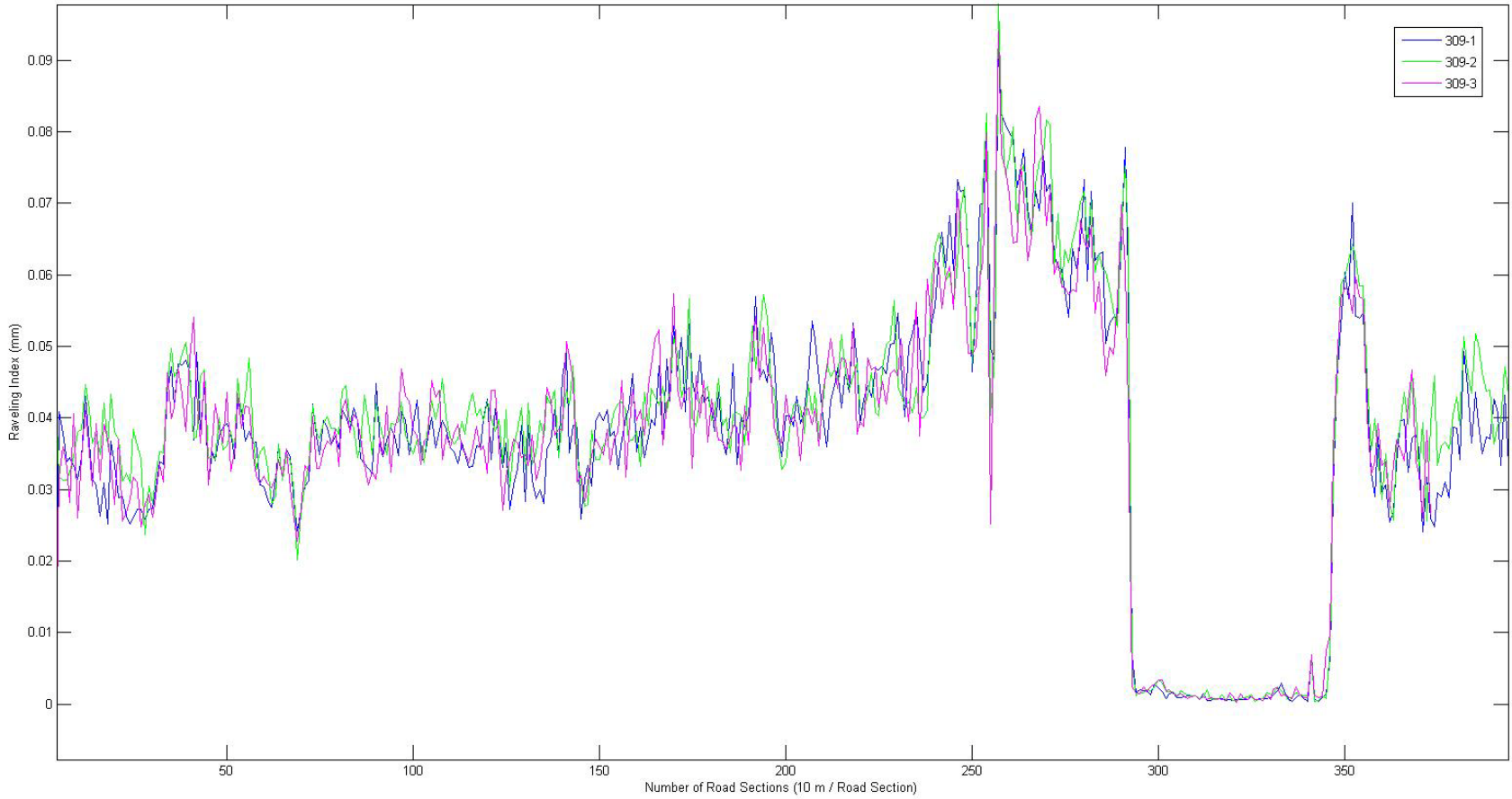
Road Section #231 : Raveling patch



Road Section #234 : Rough Texture without Raveling



Ravelling Index - Repeatability (Porous asphalt Netherlands)



- 1.Repeatable RPI measurements on several runs**
- 2.High correlation coefficient between MPD and RPI**

Future works

- Testing on different types of pavement**
- Comparison with other method (sand patch, CTMeter, etc...)**