The introduction of Pavement Surface Cracking Index (PSCI) for automatic distresses computation. Which benefits?

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Dynatest®

Outlook

- Distress rating procedures
- PCI calculation knowledge
- PSCM/PSCI calculation
- PSCI vs PCI
- Comments

Distress rating quality

A good pavement evaluation process starts always from a good distress rating.

Is easy to perform a good distress rating?

The level of subjectivity in the application of the ASTM D6433 is very high.

Ex. Definition of BLOCK CRACKING

X1.7 Description—Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 0.3 by 0.3 m (1 by 1 ft) to 3 by 3 m (10 by 10 ft).

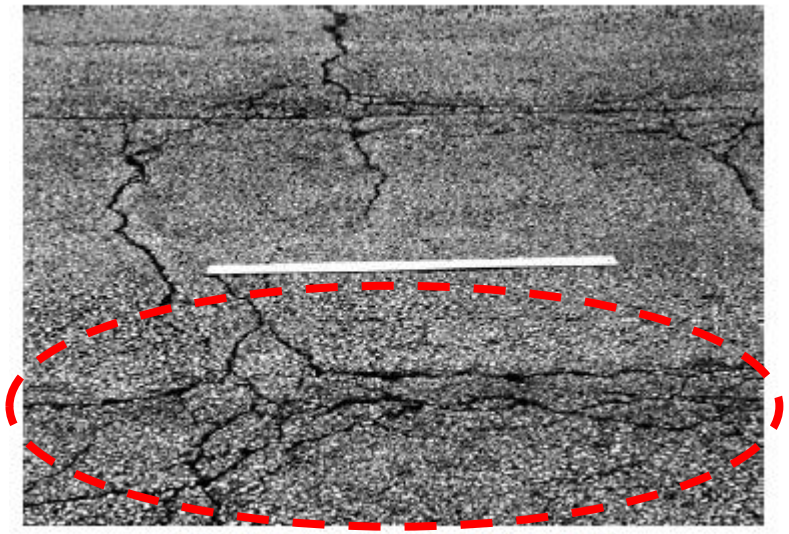


FIG. X1.7 Low-Severity Block Cracking

Distress rating quality

New technologies introduced a level of accuracy that gives us the feeling when can rate quickly and CORRECTLY all the distresses visualized on the pavement.

Have you ever looked at a distress rating algorithm?

Sometimes you can define more than 20 parameters for each single distress!!!

All these complexity is due to the fact that we try to simulate something that probably is not well codified, where the description is associated to a subjective judgment.

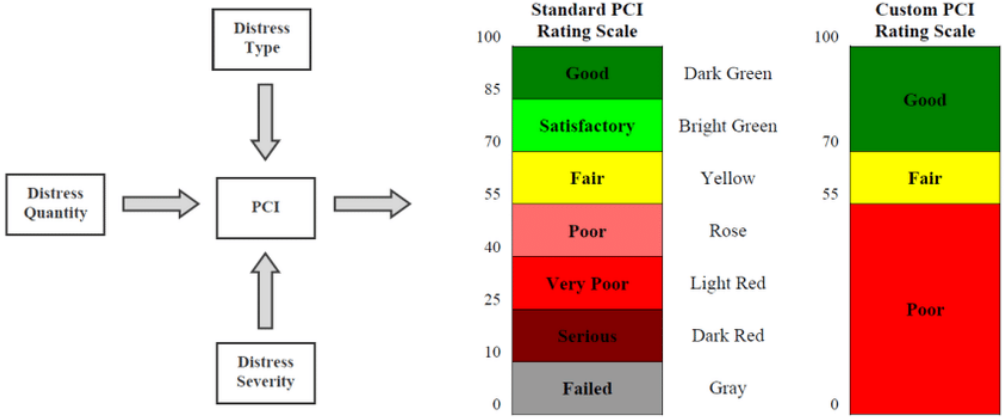
PCI (Pavement Condition Index) was developed for a manual inspection and not for an automated detection procedure.

Pavement Condition Index

Why does PCI is so popular?

Because it has been historically used and

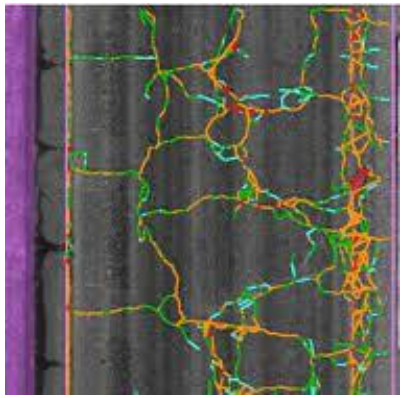
Probably because it has an easy interpretation scale.



By the time, the survey technologies is changed a lot,

can we adopt some new criteria to improve analysis quality?

Manual rating



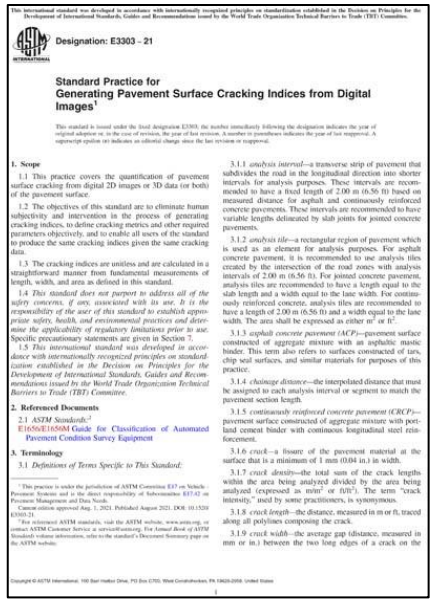
Automatic 3D/2D survey

Pavement Surface Cracking Index /1

The idea of a new parameter able to describe the pavement surface quality was initially conceived by W.D. Peterson in the “Proposal of Universal Cracking Indicator for Pavement” in 1994.

The ASTM E17 working group has worked to identify and suggested a new parameter that is more oriented to use the potentiality of the new technologies and overcomes some critical issues associated with the use of the PCI parameter

In the 2021 the ASTM released the E3303 standard, titled “*Standard Practice for Generating Pavement Surface Cracking Indices from Digital Images*”.



Designation: E3303 - 21

Standard Practice for
Generating Pavement Surface Cracking Indices from Digital Images[1]

1. Scope

1.1 This practice covers the quantification of pavement surface cracking from digital 2D images or 3D data (or both) of the pavement surface.

1.2 The objectives of this standard are to eliminate human subjectivity and intervention in the process of generating cracking indices, to define cracking metrics and other required parameters objectively, and to enable all users of the standard to produce the same cracking indices given the same cracking data.

1.3 The cracking indices are unitless and are calculated in a straightforward manner from fundamental measurements of length, width, and area as defined in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 7.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
E1656/E1656M Guide for Classification of Automated Pavement Condition Survey Equipment

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *analysis interval*—a transverse strip of pavement that subdivides the road in the longitudinal direction into shorter intervals for analysis purposes. These intervals are recommended to have a fixed length of 2.00 m (6.56 ft) based on measured distance for asphalt and continuously reinforced concrete pavements. These intervals are recommended to have variable lengths delineated by slab joints for jointed concrete pavements.

3.1.2 *analysis tile*—a rectangular region of pavement which is used as an element for analysis purposes. For asphalt concrete pavement, it is recommended to use analysis tiles created by the intersection of the road zones with analysis intervals of 2.00 m (6.56 ft). For jointed concrete pavement, analysis tiles are recommended to have a length equal to the slab length and a width equal to the lane width. For continuously reinforced concrete, analysis tiles are recommended to have a length of 2.00 m (6.56 ft) and a width equal to the lane width. The area shall be expressed as either m^2 or ft^2.

3.1.3 *asphalt concrete pavement (ACP)*—pavement surface constructed of aggregate mixture with an asphaltic mastic binder. This term also refers to surfaces constructed of tars, chip seal surfaces, and similar materials for purposes of this practice.

3.1.4 *chainage distance*—the interpolated distance that must be assigned to each analysis interval or segment to match the pavement section length.

3.1.5 *continuously reinforced concrete pavement (CRCP)*—pavement surface constructed of aggregate mixture with portland cement binder with continuous longitudinal steel reinforcement.

3.1.6 *crack*—a fissure of the pavement material at the surface that is a minimum of 1 mm (0.04 in.) in width.

3.1.7 *crack density*—the total sum of the crack lengths within the area being analyzed divided by the area being analyzed (expressed as m/m^2 or ft/ft^2). The term “crack intensity,” used by some practitioners, is synonymous.

3.1.8 *crack length*—the distance, measured in m or ft, traced along all polylines composing the crack.

3.1.9 *crack width*—the average gap (distance, measured in mm or in.) between the two long edges of a crack on the

Pavement Surface Cracking Index /2

The usage of new PSCI parameter has some clear advantages compare to the traditional PCI parameter:

- **Objectivity** the algorithm is base ONLY on quantitative mathematical base, exclusively cracks measurements are taken into account;
- **Reproducibility** based on the fact the calculation is only computational, the level of Reproducibility (and repeatability) is very high;
- **Speed** considering the reduced number of possible classification types for each distress, the elaboration speed is increased consistently;
- **Consistency** the elaboration result is a valid reference for the pavement evaluation and pavement management application;

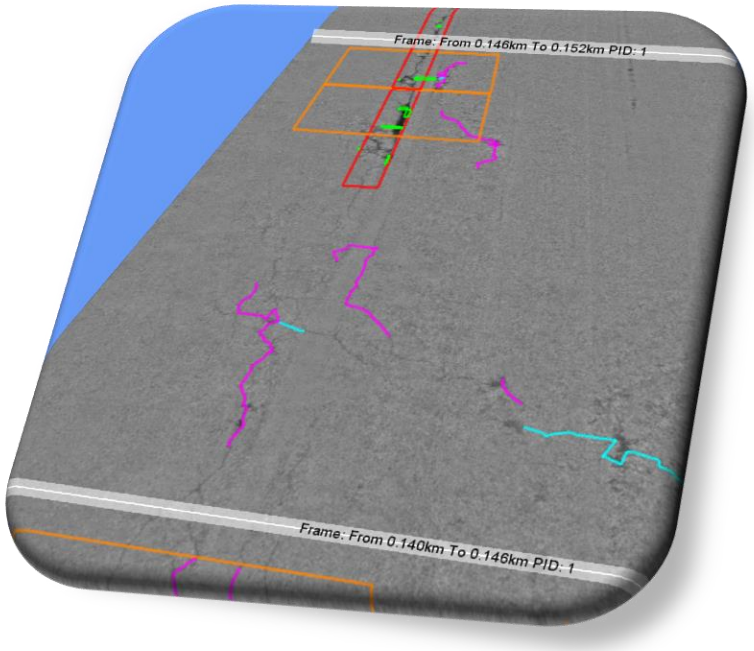
Pavement Surface Cracking Index /3

The new parameter is developed based on new technology available for pavement surface inspection and data output generated:

- Crack is defined as “a fissure of the pavement material at the surface that is a minimum of 1mm in width”.

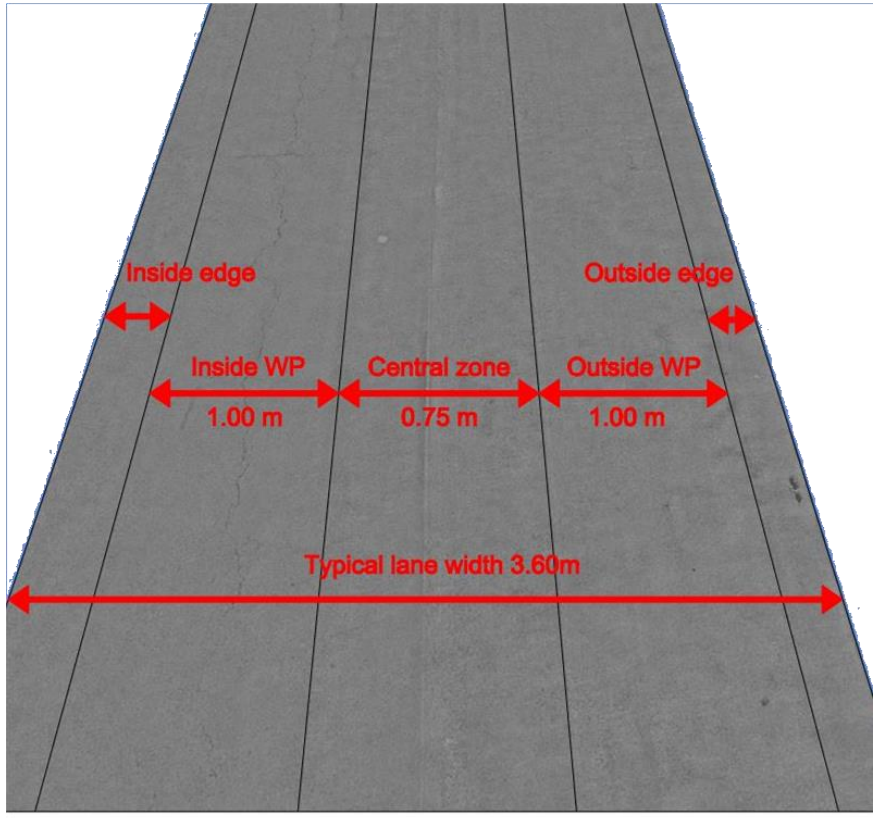
- Crack width is defined as “the average gap between two long edge of a cracks”

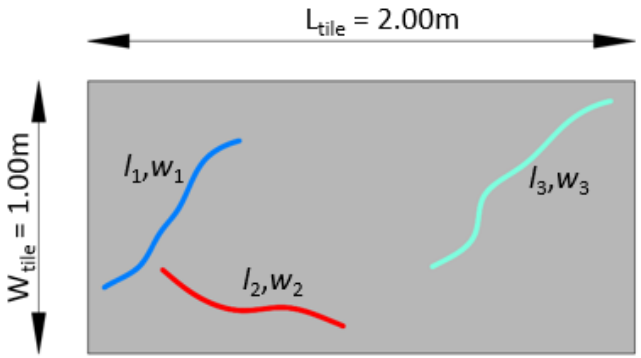
- The measured data should have a longitudinal sampling interval of 2 mm, a transverse sampling of 2 mm and a transversal coverage of 3,65 m.



Pavement Surface Cracking Metric /1

The analysis is performed at “tile” level, defined as an area identified inside a homogeneous part of the pavement, where all the cracks are identified and counted.



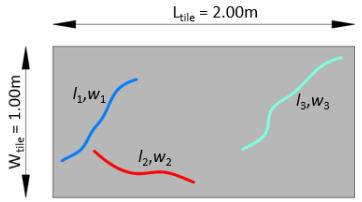


In the transversal pavement of lane (usually 3.65m wide) are identify 5 zones, two wheel paths (1.00m), a central zone (0.75m) and two outern zones. The tile area is identified inside in a unique zone.

Pavement Surface Cracking Metric /2

The first step of the process is to calculate the “Pavement Surface Cracking Metric” (PSCM).

$$PSCM = 100 \cdot \frac{\sum_i^n l_i \cdot w_i}{A}$$



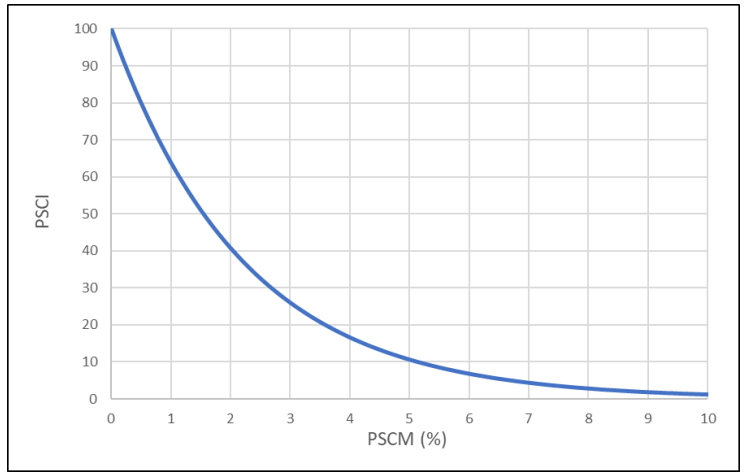
The calculation idea is reported to evaluate the percentage area of pavement covered by cracks, different from the PCI calculation where the length of cracks associated to the severity level are assumed to evaluate the surface quality.

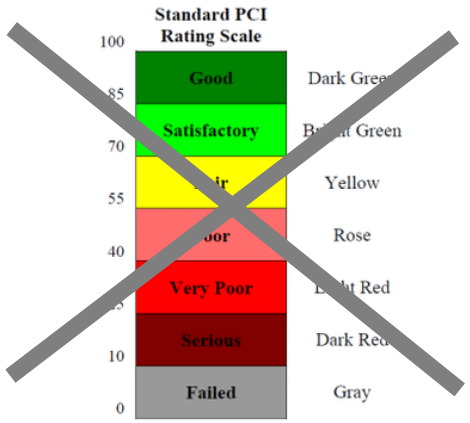
$$PSCM = \frac{1}{A_{section}} \sum_j^n A_j \cdot PSCM_j$$

All the single tile PSCM values can be evaluate at section level.

Pavement Surface Cracking Index

The Pavement Surface Cracking Index (PSCI), that represent a numerical dimensionless rating of the pavement cracking condition, between 0 (worst condition) and 100 (best condition).



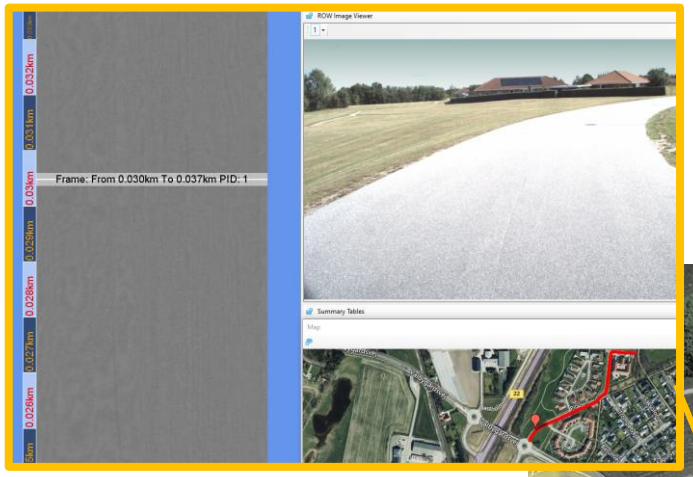


$$PSCI = 100 \cdot e^{-0.45 \cdot PSCM}$$

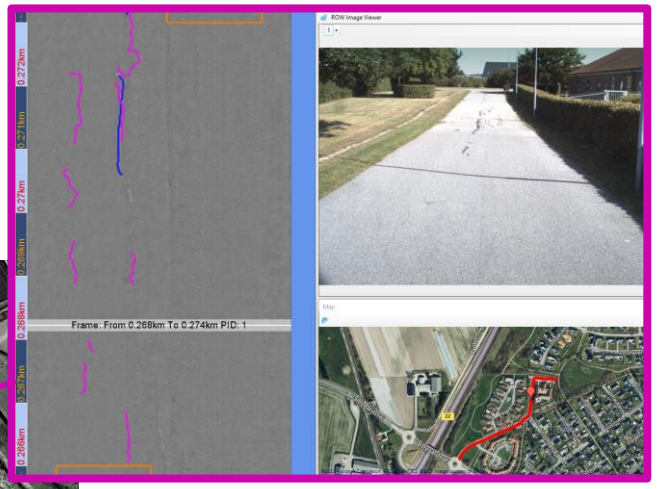
No interpretation scale is included in the ASTM standard.

Survey site

Survey carried out on a rod with presence of multiple surface conditions.



NO CRACKS



LOW CRACKS

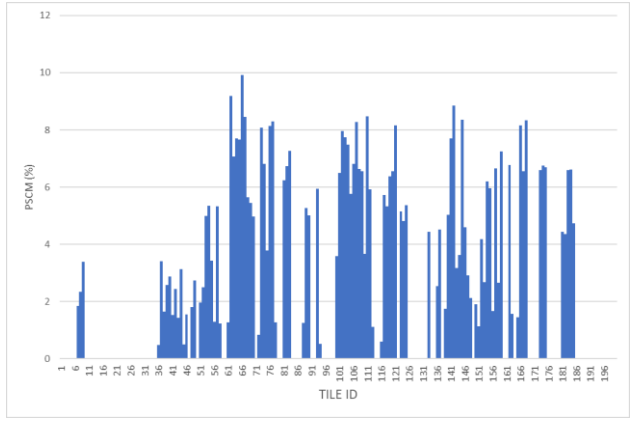
HIGH CRACKS

Road length equal to 400m

Repeatability level

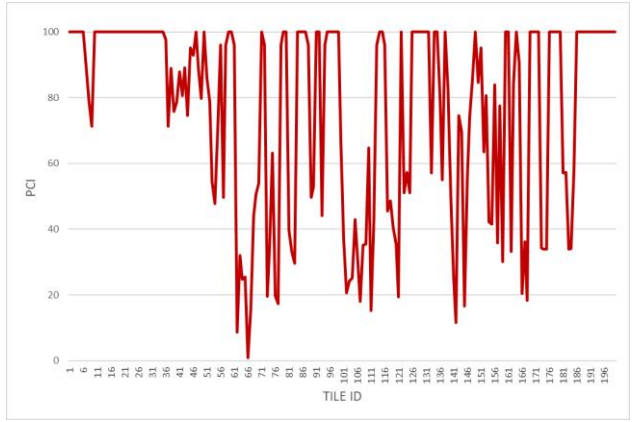
Several survey has been repeated to verify the repeatability of the PSCM parameter

PSCM

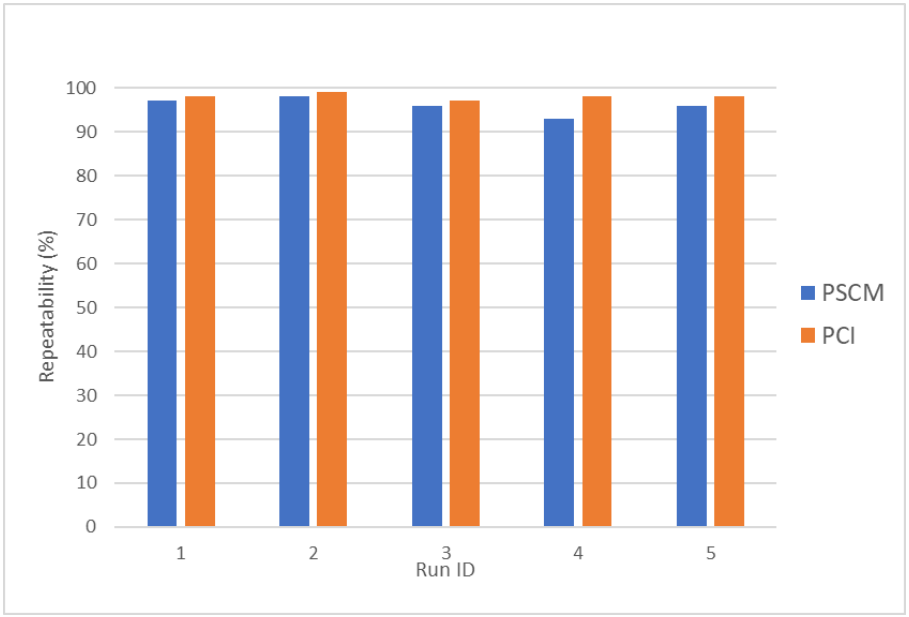


Run 0

PCI



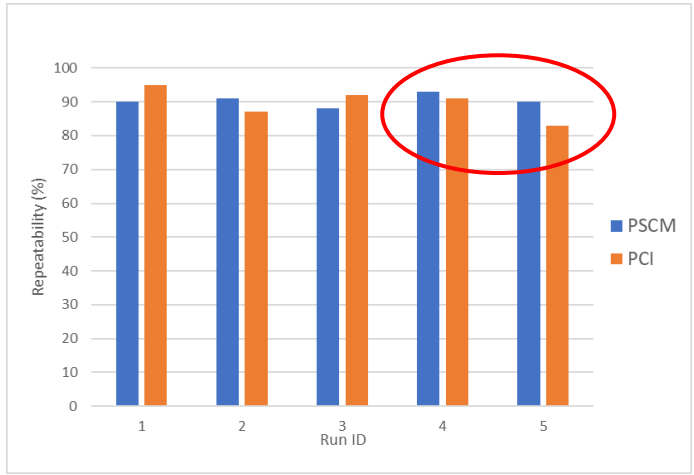
Section with presence of low-density linear cracks



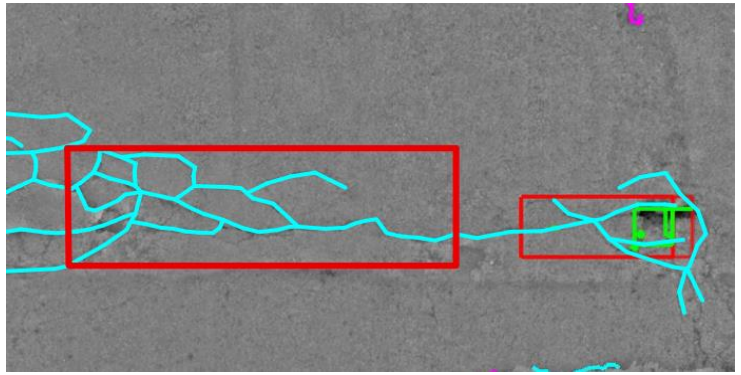
Repeatability level

Several survey has been repeated to verify the repeatability of the PSCM parameter

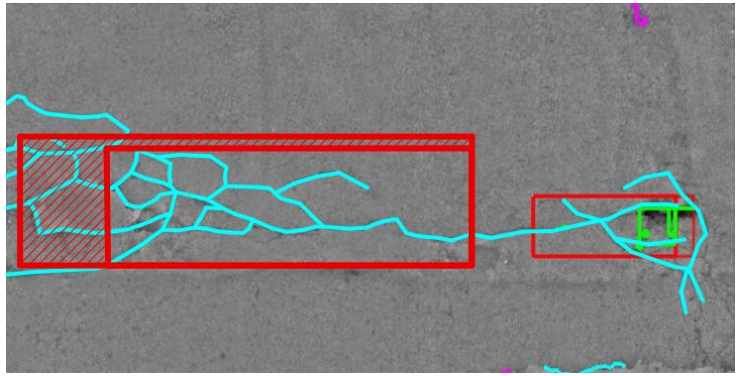
Section with presence of alligator cracks



Run 4



Run 5



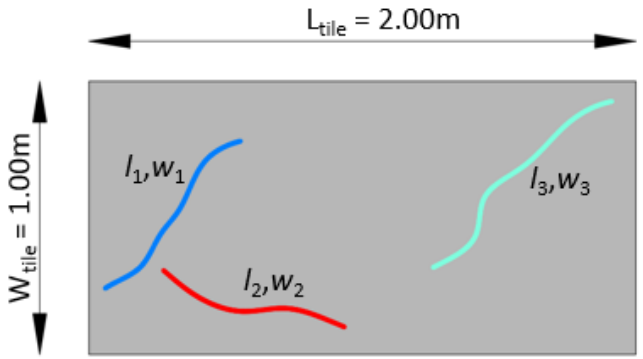
PSCM additional counting /1

The ASTM E3303 define some options in the PSCM calculation to take into account not only the cracks as linear elements, but also

- Cluster cracks (mainly associated to alligator cracks)
- Potholes
- Sealed cracks
- Repairs

A tile can be considered to be affected by fatigue cracking when

$$\sum_{i=1}^{N} l_i > (L_{tile} + W_{tile})$$



$$L > 2{,}5L_{tile}$$

PSCPM and PSCRM parameter

The PSCM, that represents the percentage of pavement open fissures due to the cracking, can be implemented with additional parameters.

- Including Potholes

The associated parameter is called “Pavement Surface Cracking and Potholes Metric” (PSCPM), considering the potholes an open part of the pavement, calculated as

$$PSCPM = PSCM + \frac{A_{Potholes}}{A_{section}}$$

- Including Repairs and Sealed cracks

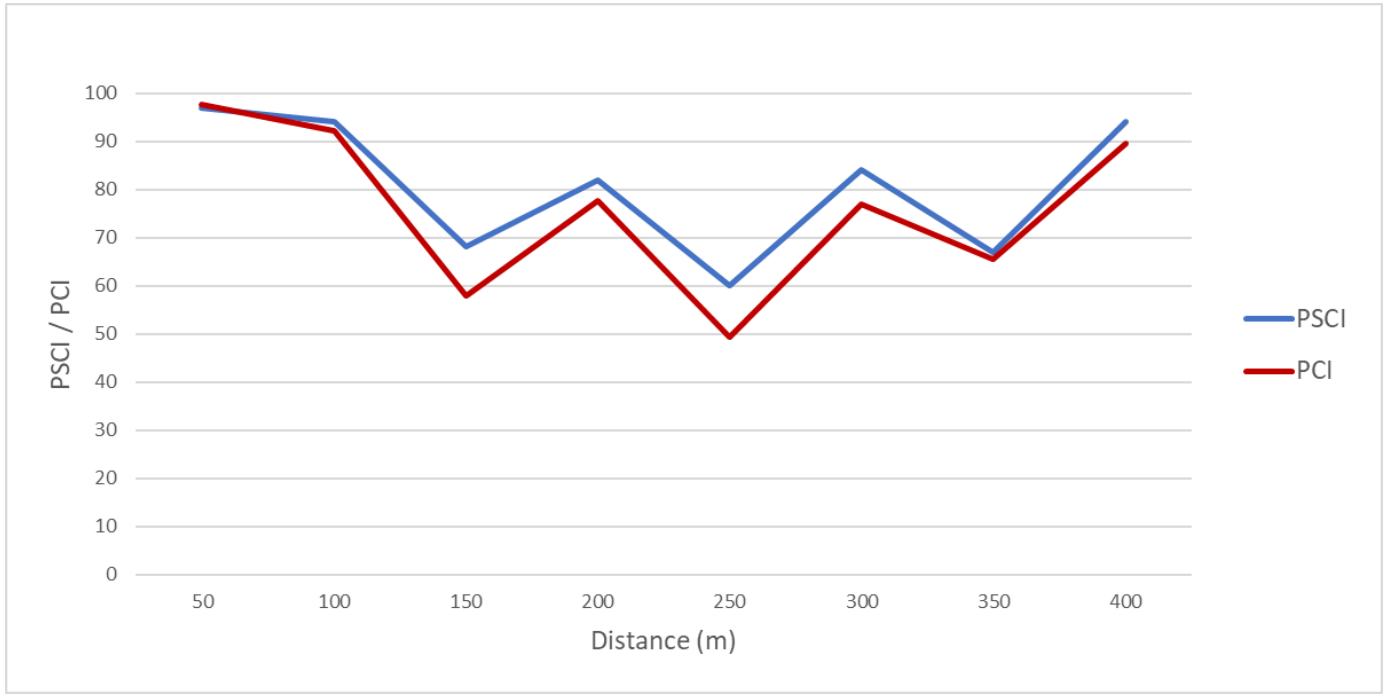
The associated parameter is called “Pavement Surface Cracking and Repairs Metric” (PSCPM), calculated as

$$PSCPM = PSCM + \frac{(0.1 \cdot A_{pat} + L_{sc} \cdot w_{sc})}{A_{section}}$$

Compared to the potholes the patching area has an influence 10% less than a potholes and the for the sealed cracks width assumed a constant value equal to 3mm.

PSCI vs PCI /1

A comparison has been performed in order to evaluate the trend of the two parameters along the test section, assuming the calculation algorithm m is quite different.



SU dist. (m)	PSCI	PCI	Diff. %
50	97	98	-1%
100	94	92	2%
150	68	58	18%
200	82	78	6%
250	60	49	22%
300	84	77	9%
350	67	65	2%
400	94	90	5%

PSCI vs PCI /2

The main reason associated to the difference in value:

- Missing distress counted in the PSCI value (ex. rutting, raveling, block cracking, et)
- Different distress weight method
- Different zone definition in lane subdivision

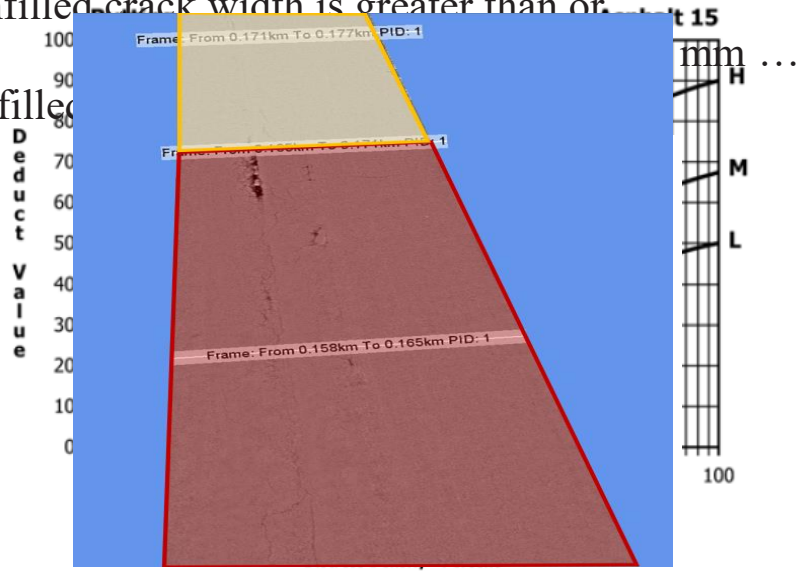
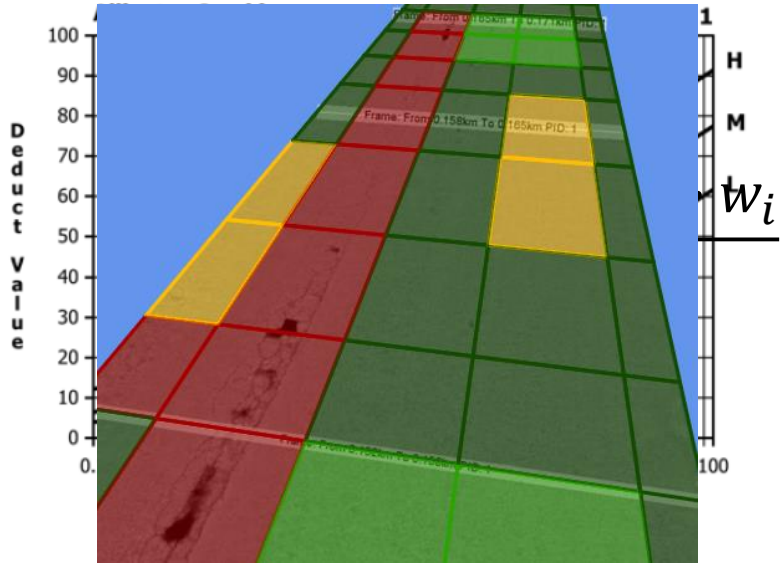


FIG. X3.15 Longitudinal/Transverse Cracking (Metric Units)

PCI



PSCI

In the PCI calculation rutting has similar impact to the Alligator cracks

Conclusion /1

The new parameters PSCM and PSCI represent new way to evaluate the pavement surface quality, introducing a new calculation method that shows positive points:

- The algorithm is purely quantitative and this match better with new 2D/3D technology;
- The subjectivity of distress interpretation is eliminated;
- The calculation can be performed for pre-defined and homogeneous zone of the lane;
- The PSCI can be associated to a quality pavement evaluation criteria;
- The algorithm (should) assure an higher level of repeatability on multi year inspection.

Conclusion /2

The results are strongly dependent from the technology used for the survey.

The minimum resolution requested is 2mm x 2mm.

Limiting the distress identification to only cracks, the elaboration time is much faster, a very important point for the network level survey.

The algorithm developed only on quantitative base excludes from the calculation a big number of distresses today accounted in the PCI calculation and RITENUTI fundamental points in the pavement evaluation.

Agency and Administration needs to define an interpretation PSCI scale since it is not reported.

Thanks for your attention

Any questions??