3D Measurement of the Quality of Road Markings

Kars Drenth[1,*], Jun Yew Tan[2], Marc Drenth[1] and Ong Ju Kit[2]

[1] Samwoh Innovation Centre B.V., Kranebittenbaan 21, 3045AW Rotterdam, Netherlands, kars.drenth@swic.international

[2] Samwoh Innovation Centre Pte Ltd, 51 Kranji Crescent, Singapore 728661

Abstract The assessment of the structural and functional pavement condition is nowadays a fully machine based non-destructive procedure in which equipment covers all the data input required for a modern PMS approach. A LCMS (Laser Crack Measurement System) is a high-resolution transverse profiling system based on 3D Sensors capable of real time continuous measurement of condition data in a single run. One of the images produced by a LCMS is the intensity image, which expresses the reflective properties of the pavement surface. As quality control of road marking often retro-reflectometers are used. A limitation of retro-reflectometers is that they can only measure for instance a single edge marking at any time whereas the road surface can have multiple markings. The LCMS captures the intensity of the surface over the total width of a lane and as such can measure the intensity of all road markings at any transverse location. This paper discusses the results of the correlation of the retro-reflectometer measurements with the intensity measured by the LCMS-2. This study resulted in a very promising correlation showing that the LCMS-2 collected data is very useful in rating the quality of road markings and predicting the need for maintenance.

Keywords: LCMS-2, 3D-images, markings, intensity, retroreflectivity

1 Introduction

The assessment of the structural and functional pavement condition is nowadays a fully machine based non-destructive procedure in which equipment covers all the data input required for a modern PMS approach. A LCMS (Laser Crack Measurement System) is a high-resolution transverse profiling system based on 3D Sensors using custom optics and a laser line allowing the system to operate not only during daytime but at night as well. The LCMS Sensors are capable of real time continuous measurement of condition data regarding cracking, rutting, roughness, macro-texture, ravelling, potholes, pavement marking and road geometry in a single run. The LCMS-2 is the latest

upgrade of this technology having an improved vertical and horizontal resolution resulting in higher quality and reliable output.
One of the images produced by the LCMS-2 is the intensity image, which expresses the reflective properties of the pavement surface. The reflective quality of a road marking tells something about its visibility under different light conditions and is a safety related characteristic. As quality control of road marking often retro-reflectometers are used. A limitation of retroreflectometers is that they can only measure for instance a single edge marking at any time whereas the road surface can have multiple markings like the centreline, arrows and other type of markings in transverse direction. The LCMS-2 captures the intensity of the surface over the total width of a lane and as such can measure the intensity of all road markings at any transverse location.

2 Road Marking Rating and Testing Approach

There are international and local standards related to the materials to be used for road marking, its performance and the way it has to be applied. The performance-orientated standard for Singapore (Singapore Standard, 2013) is rating the field measurement of the coefficient of retro-reflected luminance characteristics during day-and nighttime (Q_D and R_L mcd/m^2/lx) using a portable device complying with ASTM E1710 (ASTM E1710-18). The minimum value of the field measurement of Q_D respectively R_L (dry condition) of thermoplastic material shall be ≥180/≥300 mcd/m^2/lx for a white marking and ≥160/≥160 mcd/m^2/lx for a yellow marking. The minimum value for R_L after 5 month of installation of thermoplastic material shall have a level of respectively ≥150/≥50 mcd/m^2/lx in dry condition. The degree of wear (wear index) is based on a visual assessment and should after 5 month be ≤20 based on a specified procedure using a reference chart shown in Fig. 1.

Condition	Wear Index	% of marking faded
	20	< 5
	25	25
	35	50
	43	60
	63	75
	82	90

Fig. 1 Wear index reference chart

In the Netherlands a visual quality catalogue (CROW, 2018) is used for rating all elements of the public space from A+ (no damage) to D (maintenance required). Fig. 2 shows this rating related to road marking as well as a percentage of area to meet the rating level referenced to a NEN Standard (NEN-EN 1436:2018) based on the performance of the marking and test methods.

Fig. 2 Visibility rating of road markings

The listed references specify the measurement of the retroreflection of markings by means of a portable instrument as well as visual rating. The background of this research is to make the rating of markings part of the automated rating already in place for the condition of the pavement wearing course.
The reflective characteristic of a pavement surface is sampled by the LCMS, called 'intensity'. This intensity shows a clear difference between markings and the non-marked pavement surface, for all the marking within the transverse profile of the width of a lane. Fig. 3 shows the Survey Vehicle with LCMS-2 equipment.

Fig. 3 LCMS-2 Survey Vehicle with two sensors

The portable instrument used for collecting the retro-reflection of different quality of markings is the Delta LTL-XL as shown in Fig. 4.

Fig. 4 Delta LTL-XL portable retroreflectometer

3 Retroreflectometer Data

Twenty (20) retroreflecometer measurements were collected at four (4) different roads having different marking rating qualities, white as well as yellow. The retroreflectometer is factory calibrated valid till 13-09-2020 and the supplied calibration unit was used each day measurements were taken. The locations where the measurements were taken were marked for easy reference with the LCMS-2. Fig. 5 shows a representative collection of the selected locations for rating the marking.

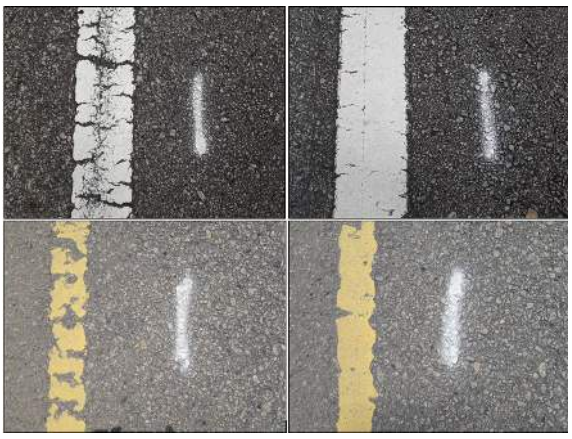

Fig. 5 Selection of different levels of wear

For the comparison of the reflective quality of a marking measured with the Delta LTL-XL and the LCMS-2 the daytime visibility Q_D was used as characteristic. Fig. 6 shows a measurement with the Delta LTL-XL and the result shown real-time.

Fig. 6 Retroreflectometer result shown real-time

All the sampled retroreflectometer results for the 4 different roads and different color of the marking are listed in Table 1. The % of marking faded is based on a visual rating of the test locations in accordance with Fig. 1.

Table 1 Retroreflectometer results

Road	Test	Q_D	Marking	% Marking Faded
Perahu Road	1	184	white	5-25
	2	138	white	25-50
	3	87	white	60-75
	4	187	white	5-25
Lim Chu Kang Road	5	139	yellow	25-50
	6	128	yellow	50-60
	7	134	yellow	50
	8	104	yellow	75-90
Woodlands Street	9	224	white	<5
	10	189	white	<5
	11	204	white	<5
	12	177	white	<5
	13	255	white	<5
	14	226	white	<5
	15	220	yellow	<5
	16	191	yellow	<5
Rosewood Drive	17	189	white	5-25
	18	188	white	<5
	19	104	white	60-75
	20	112	white	60-75

4 LCMS-2 Data

In addition to the Intensity image produced by the LCMS there is as well a 3D image. This continuously sampled 3D image is showing all the condition details of a pavement surface, including the wear of all markings present within a traffic lane or the width (4 meter) of the surveyed area. Fig. 7 shows some 3D examples of rated locations.

Fig. 7 Selection of 3D LCMS-2 images

The sampled LCMS-2 results for the 4 different roads and different color of the marking are listed in Table 2. The visibility is rated based on the visual condition rating of the test locations in accordance with Fig. 2.

Table 2 LCMS-2 results

Road	Test	Intensity	Marking	Visibility
Perahu Road	1	174	white	A
	2	157	white	B
	3	117	white	D
	4	170	white	A
Lim Chu Kang Road	5	138	yellow	B
	6	138	yellow	C
	7	132	yellow	B
	8	117	yellow	D
Woodlands Street	9	217	white	A+
	10	212	white	A+
	11	222	white	A+
	12	169	white	A+
	13	200	white	A+
	14	194	white	A+
	15	214	yellow	A+
	16	203	yellow	A+
Rosewood Drive	17	173	white	A
	18	174	white	A+
	19[1]	120	white	B
	20[1]	130	white	C

5 Retroreflectometer vs LCMS-2 Comparison

The LCMS automatically detects any marking independent of its transverse location or lateral wander and calculates automatically the intensity. This intensity can be calculated over a to be specified file length of 2 till 10m, although it is foreseen to make this possible over a length of minimal 250mm. In this comparison the LCMS-2 file length was 5m. The retroreflectometer testing is measured over a length of 185mm but repetitive measurements can be taken to cover a larger length by moving it forward including the calculation of the average of the number of preset tests (forward movements). The Delta LTL-XL results have been compared with those of the LCMS-2 as shown in Fig. 8. The computed R^2 of 0.8491 shows a very good polynomial (and linear of 0.8351) correlation when taking into account the relative difference in procedure and the (slightly) larger area of the LCMS-2 results. The results will depend on the type of marking as well but this first trial is very promising.

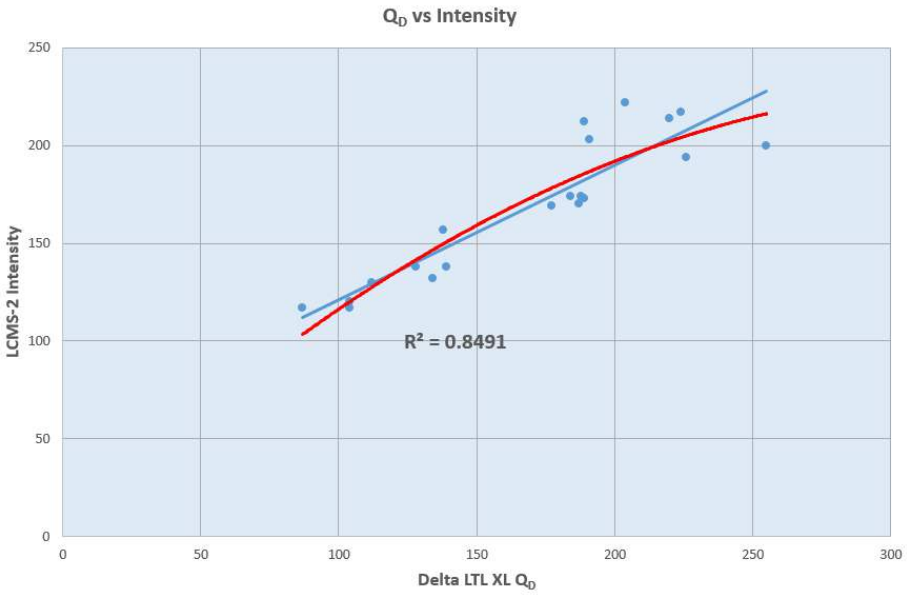

Fig. 8 Correlation of Q_D vs Intensity

During the analysis of the LCMS-2 data the intensity results can already being visualized by moving the mouse pointer over any marking present within a lane. Fig. 9 gives some examples of the intensity of typical markings like arrows, pedestrian crossings etc.

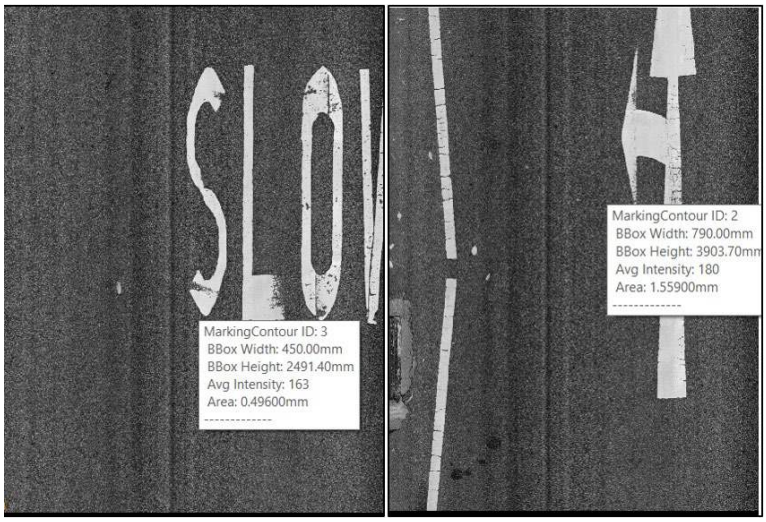

Fig. 9 LCMS Intensity measurement of any marking feature within a lane

6 Conclusions

A LCMS (Laser Crack Measurement System) is a high-resolution transverse profiling system based on 3D Sensors capable of real time continuous measurement of condition data in a single run. One of the images produced by a LCMS is the intensity image, which expresses the reflective properties of the pavement surface. The LCMS captures the intensity of the surface over the total width of a lane and as such can measure the intensity of all road markings at any transverse location. The following conclusions can be drawn:

This study resulted in a very promising correlation between the Intensity of the LCMS-2 and Q_D of a manual retroreflectometer.

A LCMS survey delivers a continuous image of all markings present within a lane allowing a visual rating according to present international procedures.

The LCMS images allowing for linking a visual quality of the wear to an automated analyzed intensity in a way that the subjectivity of a human rating can be eliminated.

The availability of past LCMS data allows to qualify the performances between different marking materials.

A survey of the quality of the functional condition of the surface of a pavement can include the collection of marking data at no extra cost and is far more efficient than any other way of collecting the level of wear of markings automatically or by use of handheld equipment.

This study resulted in a very promising correlation showing that the LCMS-2 collected data is very useful in rating the quality of road markings and predicting the need for maintenance.

References

Singapore Standard (2013). Specification for hot-applied thermoplastic road marking materials – Materials, performance and application. *Singapore Standard SS 589 : 2013.*

ASTM E1710-18. Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer.

CROW Publication 380 (2018). Kwailiteitscatalogus openbare ruimte 2018 – Standaardkwaliteitsniveaus voor onderhoud (in Dutch).

NEN-EN 1436:2018. Road marking materials – Road marking performance for road users and test methods.