DID WE GET WHAT WE WANTED? – GETTING RID OF MANUAL CONDITION SURVEYS

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ABSTRACT

For more than 25 years, RAMM surveys have been the backbone of maintenance planning on New Zealand (NZ) road networks. Using a 10% or 20% sampling method associated with a detail manual survey differs significantly with other parts of the world that opted mostly for a 100% windshield survey. During a recent NZTA research project the NZ visual survey methodology has been fully reviewed. One of the major recommendations of this report was that minimum sampling length should be increased to 20%. The report also concluded that for all the visual distress modes, cracking is by far the most important rated item. The remaining problem is that even with an increased sampling size, the variability and quality of survey outcomes are still much worse than what is required by current planning processes and trend monitoring. The reality is also that in the new performance based world of today, the repeatability and robustness of visual surveys are simply not good enough.

During 2003 NZTA has seized using visual surveys on the State Highways for all defects but cracking. All other defects are either measured or inferred from High-Speed Data (HSD) measurements. The reasoning was that cracking remained an important consideration for determining both pavement health and resurfacing needs. HSD technology at that stage relied on photo and pixel-analysis for crack detection proven to be effective on asphalt surfaces but less reliable on chip seals. Some HSD providers in NZ are starting to offer automated crack detection of chip seal surfaces on the basis of a scanning laser technology. Claims are that this technology that does not rely on light and shadows to determine crack positions seems to be adequate for the purposes of identifying cracks on NZ roads. This paper will report on comparative results between the automated crack detection and detail manual surveys undertaken on the NZ Long-Term Pavement Performance Sections. It will also compare automated measurements with normal RAMM surveys in order to justify whether this technology is ready for the implementation in NZ. Should this technology be of acceptable robustness it will greatly advance asset management and same time mitigate the need for manual surveys during a time when quality road rators are getting fewer and more costly. Ultimately, with an automated system it is believed that more repeatable and reproducible data would increase the value of outcomes from pavement management systems and performance monitoring.

INTRODUCTION

BACKGROUND

Cracking is one of the most important defects engineers monitor on bituminous surface roads. For asphalt roads cracking is an indication of layer failure since cracking is one of the design parameters of asphalt surfaces (AUSTROADS, 2012). Cracking is also important to monitor on chip sealed roads. Even though it may not indicate a failure per se, it does compromise the water proofing of the seal, letting in water that could cause significant pavement damage as a result. Authorities in New Zealand would resurface between 7 to 11% of their road network and it is estimated that at least 40% of the resurfacing would be using cracking as a primary driver for the intervention.

Knowing that cracking is important to monitor, naturally lead to authorities spending considerable amounts of money to undertake road condition measurements and visual surveys. Historically condition data was solely used for maintenance planning using a decision algorithm. Lately, the data is used for performance monitoring, benchmarking and performance modelling using systems such as dTIMS (Tapper et al, 2013).These increase use of the data has also resulted in increased demand for more robust, complete and more frequent data. This paper consider the merit of maintaining current practices of visual rating compared to using more sophisticated methods such as automated crack detection.

PROBLEM STATEMENT

For more than 25 years, RAMM surveys have been the backbone of maintenance planning on New Zealand (NZ) road networks. Using a 10% or 20% sampling method associated with a detail manual survey differs significantly with other parts of the world that opted mostly for a 100% windshield survey. During a recent NZTA research project, the NZ visual survey methodology has been fully reviewed (Tapper et al, 2013).One of the major recommendations of this report was that minimum sampling length should be increased to 20%.The report also concluded that for all the visual distress modes, cracking is by far the most important rated item. The remaining problem is that even with an increased sampling size, the variability and quality of survey outcomes are still much worse than what is required by current planning processes and trend monitoring. The reality is also that in the new performance based world of today, the repeatability and robustness of visual surveys are simply not good enough.

However, doubts over the effectiveness of automated crack detection has prevented its wider use, especially on chip seal surfaces. Experiences with earlier models have suggested that due to the macro texture, processing algorithms struggles to identify cracks effectively.

OBJECTIVES OF THE RESEARCH

The main objective of this research is to establish whether laser scanning crack detection methods can effectively identify cracking on chip seal surfaces. The further objective is also to determine the effectiveness of crack detection on a larger scale compared to a visual rating that typically looks at either a 10 or 20% sample size. On the basis of the result, recommendations are made for New Zealand authorities.

AUTOMATED CRACK DETECTION TECHNIQUES

Summary of Technology

Engineers have been developing a wide range of auto crack detection devices. Some of these are summarised in Table 1

Table 1: Auto Crack-detection Devices

Crack Detection Device	Basic Principle
Area View Camera	High resolution cameras mounted on the vehicle. Manually processed or pixel analysis. This method was found to be light sensitive
Line Scan Cameras	Only a narrow line is photographed which allowed for high resolution. It was still subject to lighting issues.
3D – Laser Imaging	Laser “sweeps” across pavement and a 3 D image is stored. Can identify a number of defects.
RoadCrack (Australia)	Line scan cameras with artificial lighting.

During a study completed by the ARRB (Wix and Lesschininski, 2012) that investigated the accuracy and issues associated with the methods listed in Table 1. Accuracy and repeatability tests were undertaken for the RoadCrack and the Laser Crack Measurement System (LCMS). The results on the chip sealed road were promising with the repeatability of the two devices depicted in Table 2. The results suggest that the LCMS is far more repeatable than the RoadCrack – camera technology. This is consistent with other anecdotal experience that suggested the camera technology not being that effective on chip seals, mainly due to the algorithms that struggle to interpret the “shadow” areas as a result of the larger chips. Obviously, the laser is not affected by light, thus having the potential of working better on chip seals compared to the other methods.

Table 2: Repeatability - RoadCrack and LCMS Correlation for Repeated Runs (Wix and Lesschininski, 2012)

System	Statistics	Northbound	Southbound
RoadCrack	r^2	0.70	0.87
	Slope	0.83	0.91
	Intercept	2.8	1.4
LCMS	r^2	0.90	0.96
	Slope	0.99	0.99
	Intercept	0.2	0.5

So How does the Scanner Works?

The LCMS consist of high power scanning lasers combined with a camera that records the “laser line” on the pavement surface (Refer to Figure 1).Subsequent to this, the image is processed to yield the profile of the road as depicted in Figure 2. Note that although this paper only focuses on cracking, the same technology is also used to detect texture, roughness, cracking and rutting.

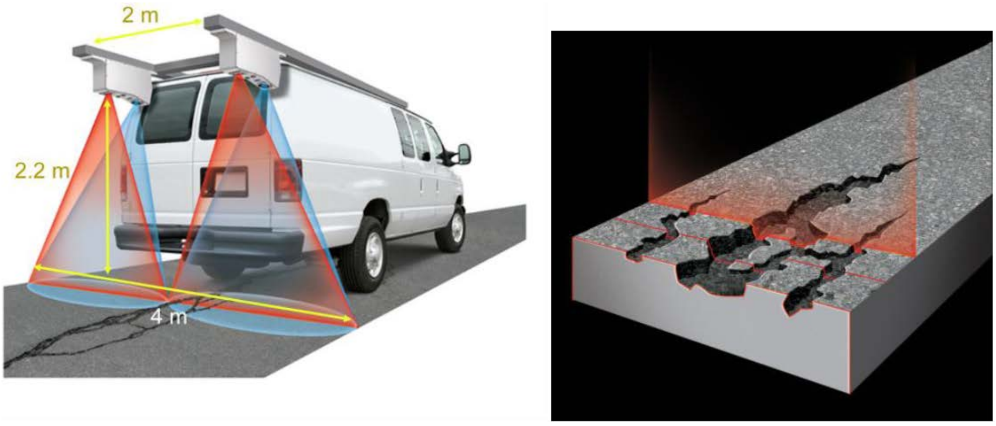

Figure 1: 3D Laser Scanning (Laurent, et. al., 2011)

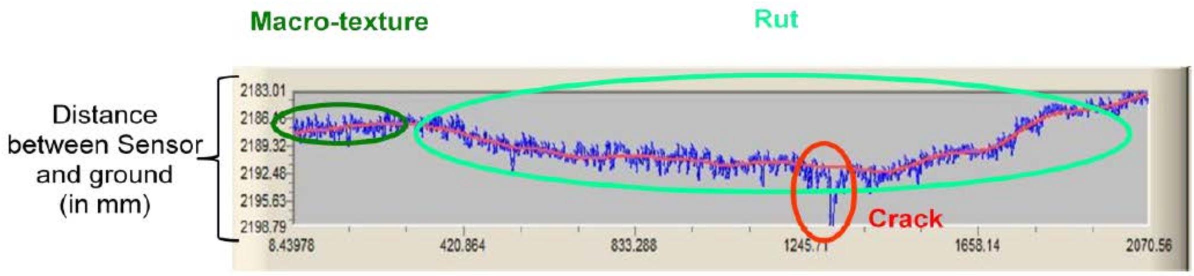

Figure 2: Measurements from the LCMS (Laurent, et. al., 2011)

An output from the system yield identified crack pattern images as illustrated in Figure 3. Note that the crack severity is also recorded as a function of the crack width. Suppliers claim this system being able to detect cracking to a width of 0.5 mm.

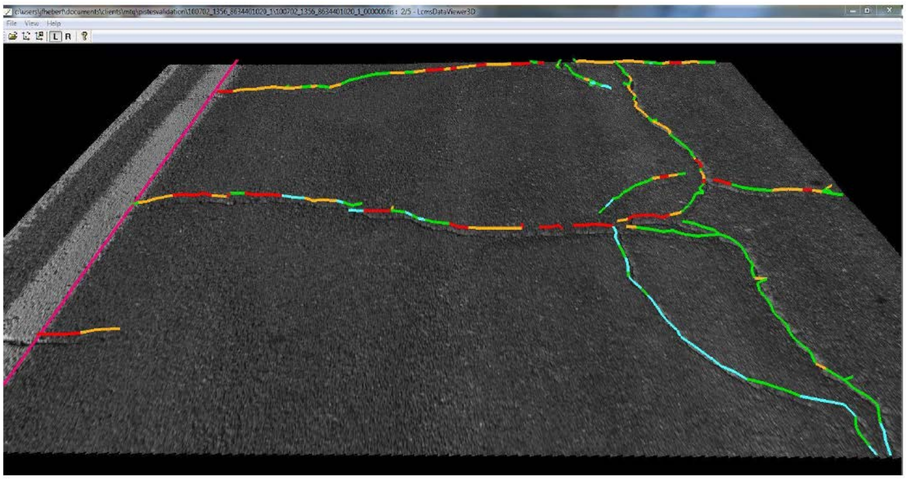

Figure 3: Crack Severity Analysis (Laurent, et. al., 2011)

OUTCOMES FROM THE NEW ZEALAND CRACK DETECTION STUDY ON CHIP SEALS

METHODOLOGY

The New Zealand study aimed at establishing whether the LCMS process yield robust crack detection suitable for adoption by NZ authorities. As part of the process questioning the value of this system compared to a 10% sample size visual assessment process. In order to answer these questions two data items were used:

1. In order to assess the measurement accuracy, LCMS measurements were taken on ten of the New Zealand Long-term Pavement Performance Sites (LTPP).This results in 60 data points for comparative purposes. The sample also covered a variety of chip surface types ranging from void fill to one, and two coat surfaces;
2. Secondly two road lengths from the Dunedin network were surveyed and crack data from the LCMS was compared to RAMM survey data taken on a 10% sample size. A total of 39 rating lengths have been compared.

The NZ-LTPP collects visual distress data according to specification discussed in Henning et al. (2004). Cracks are assessed for each 50-m subsection of the LTPP site by recording the severity (narrow or wide), the length of the crack (to an accuracy of 10cm) and also the Geospatial coordinates of the crack location.

The Dunedin visual crack data was taken from the RAMM surveys conducted by an experience RAMM surveyor.

For both the comparisons, data from only a single run from the LCMS was used as this most closely simulated the actual data collection regime on networks. Also, the repeatability of the LCMS measurements was not investigated as part of this study as the ARRB study indicated an excellent repeatability for this device (Wix and Lesschininski, 2012).

CURRENT ACCURACY OBTAINED FROM RAMM SURVEYS

The study undertaken by Tapper et. al. (2013) assessed current processes for visual data collection with the aim of improving the accuracy and repeatability of the surveys. The RAMM surveys are based on a detail assessment (visual assessment on foot) for a 10, 20 or 100% sample size of the network. For a 10% sample, 50-m rating length of 500m rating sections is assessed with the assessor recording the length of wheel-paths affected by cracking. Practices elsewhere in the world undertake larger sample size to less accuracy. For example, South Africa undertakes a wind-screen survey at 30km and for a road sections estimates the degree and extend of cracking to a five point scale (Taper et al., 2013). According to the maintenance requirement in NZ, it is important to identify even narrow cracks, thus resulting in the RAMM assessment process opting to do more detail assessment on a sampling basis.

As part of the NZTA research a number of aspects regarding the rating method have been investigated. Some of these were:

- The accuracy of the rating method – for this test a RAMM rating was performed on some LTPP section and the outcome of this comparison is illustrated in Figure 4. The figure shows a direct comparison of the 50m subsection crack percentage as rated according to the LTPP and RAMM rating method;

- The sampling method used for the RAMM survey has also been investigated. The recommendation from this work is moving to a 20% minimum sampling process. It was noted in an earlier study that a considerable number of authorities still undertake a 10% sample (Refer to Figure 5); and,
- Quality assurance practices were also reviewed for both during the training and actual surveys. Recommendations from this resulted in much increased acceptance criteria for the training. Also, an over-lapping survey process is recommended for councils to ensure a better quality of rating on their networks.

Of particular concern was the result obtained and depicted in Figure 4. The figure shows an over-all under-estimation of cracks that were surveyed according to the RAMM rating method. Also, there are a number of cracks observed by one method and not by the other. This result signals that visual rating methods are not as repeatable or as accurate as we would have hoped for.

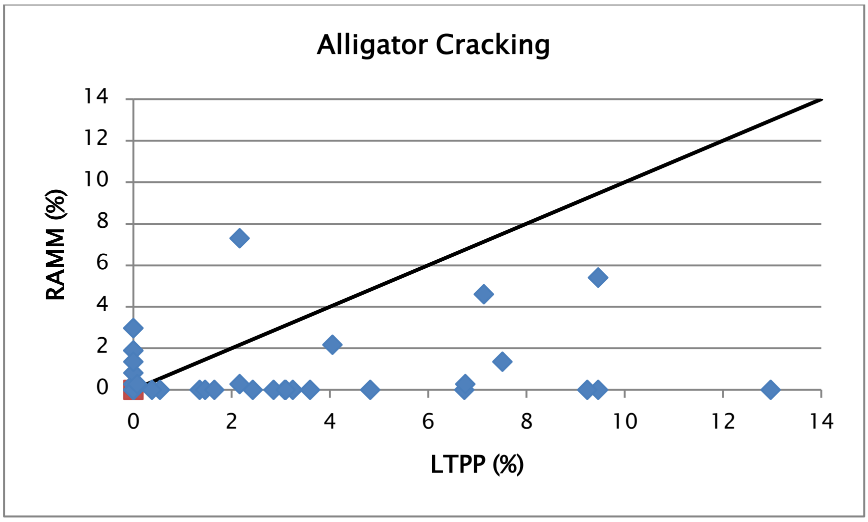

Figure 4: Comparing RAMM Rating Surveys to LTPP Manual Surveys (Tapper et. al., 2013)

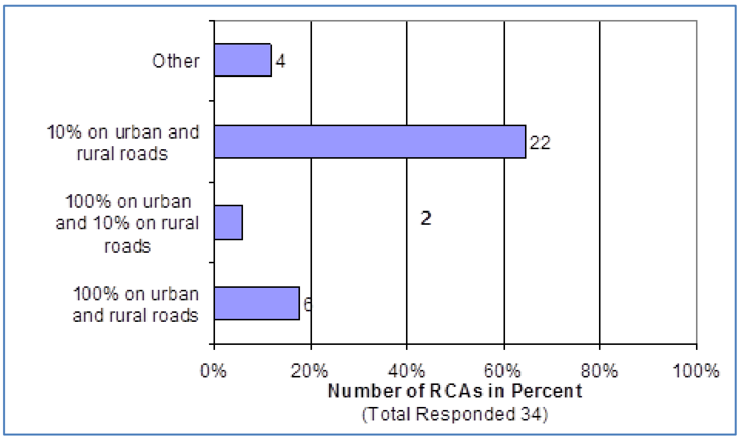

Figure 5: An indication of the Number of Councils doing a 10% Sampling Rating (Pradhan, 2009)

Accuracy Obtained from LCMS

Exactly the same comparison, described in the previous section, was undertaken between the LCMS and the LTPP survey data. The results from this comparison are presented in Figure 6. The figure shows a trend-line that resulted to be very close to the line of equality (1.05) with a strong correlation with a R^2 of 0.73. Much of the variation between the two techniques could be explained by the accuracy of the LTPP surveys that measures cracks to an accuracy of 10cm, while the LCMS would measure to millimetre accuracy.

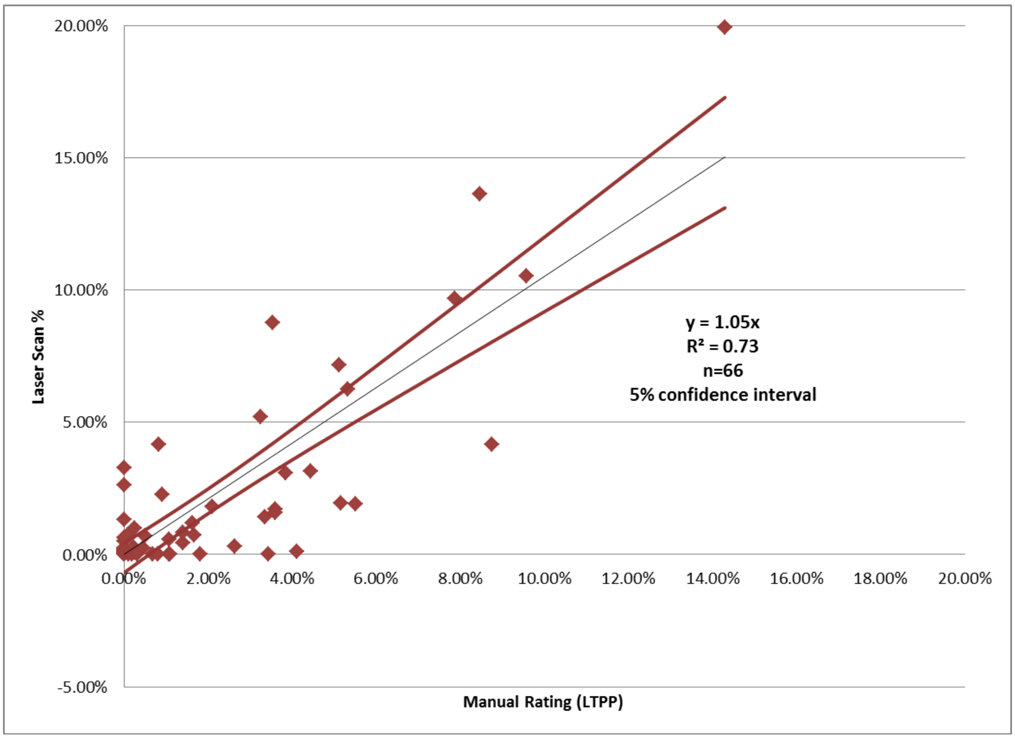

Figure 6: Comparing LCMS Readings with LTPP Survey Data

The 5% confidence level is also indicated and it can be observed that it is relatively close to the trend line. Note that there is more than 2/3 of the data point coinciding on zero. This is a particularly good outcome as it confirms that the LCMS does not “invent” cracks where there is none.

Some of the outliers in Figure 6 were investigated a bit a more detail. Visual observations from the images and video taken on these sites have revealed the following:

- Whangarei site WHG3 shows the LCMS cracking to be higher than LTPP rating- On inspection this section appears to have some surface mechanical damage which the LCMS is picking up and interpreted as cracks. There is also a patch which the LCMS is picking up cracking along the edge, some of which appears to be the patch edge and not a crack
- WHG5 suggest the LCMS cracking to be lower than LTPP rating - It appears that sand / fine soil / dirt has filled these cracks, so there is no 3D information that allows our algorithm to detect these defects.

Therefore, it is accepted that the LCMS technology will be improving in the future in terms of its accuracy and repeatability, yet one always have to be mindful of some variation during the measurements which cannot be completely avoided or removed.

On the basis of this result alone it can be recommended, with confidence, that the LCMS provides significantly more accurate and repeatable crack results compared to any visual observations are able to provide. The next section discusses the full implication on network level.

THE DIFFERENCE IN USING THE LCMS FOR NETWORK SURVEYS

The methodology section describes the basis of comparison between the LCMS survey on the network and the RAMM 10% sampled survey. As per practice it is assumed that 10% sample (50m) is representative of the rating section (500m). This is compared to the LCMS survey for the entire 500m length. Figure 7 illustrates the outcome from the survey. Also indicated are the line of equality (y=x) and the number of sections where zero cracks were observed during the RAMM surveys. These cracks were mainly missed due to it falling outside of the rating length .This was a significant observation since further interrogation of the data has indicated that 23 of 39 sites fall in this category (more than 60%). Therefore more than 60% of the cracks were missed as it fell outside of the rating lengths . Where the cracks were observed there was some correlation between the two methods.

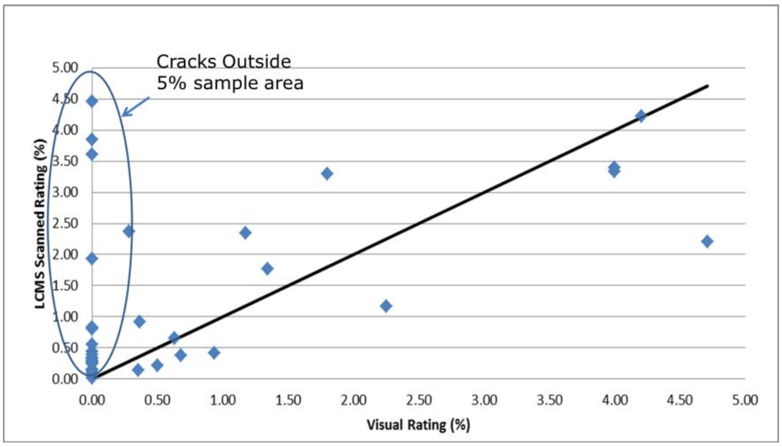

Figure 7: Comparing 100% LCMS Surveys to 10% Sampling RAMM Surveys

CONCLUSIONS AND RECOMMENDATIONS

This research has commpared the survey accuracy of the laser scanning automated crack detection (LCMS) to acurate LTPP survey data and to RAMM survey data on a network length. These comparison were ultimately assessed on the basis of earlier findings of inaccuracies identified with the RAMM surveys (Tapper et. al., 2013)

The outcomme of the research suggested the following:

- There was a strong correlation between the LCMS and the LTPP cracking data;

- The comparison with RAMM network survey data suggested that more than 60% of crack lengths are missed according to the 10% smapling length used for the RAMM surveys.

On the basis of this research, it is recommended that authorities in New Zealand should give strong consideration of using the automated crack detection. It also illustrated that the accuracy of the RAMM survey data nulifies its value for any trend monitoring and or performance specifications. It is simply not accurate enough.

It is further recommended to build onto the findings of this research and also tests the LCMS accuracy and repeatability for other visual defects.

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