

Title: Comprehensive, Full Spectrum, Road Condition Measurements – An Essential Element for Robust Road Maintenance and Rehabilitation Management

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Introduction.

The “Transport in the European Union Current Trends and Issues March 2019” states that Europe has been suffering from low levels of investment in the transport infrastructure area since the global economic crisis, which has held back modernization of the European transport system. Generally, investment in infrastructure has stopped declining, but it is still at 20% below pre-crisis levels, thus slowing economic development. This lack of funding simply eats up the road’s capital value, and the cost for eliminating backlog is high.

The less funding available for maintenance means more emphasis is put on maintenance prioritization, to maintain a well-functioning road infrastructure. Optimal prioritization requires smart thinking and smart technologies.

Seen from a financial and optimization perspective, the earlier the need for maintenance is detected, the more possibilities are available for remedial interventions. Therefore, comprehensive assessments should be conducted to confirm the presence of pavement deterioration before treatments are planned.

It is not uncommon for administrations to delay treatments on some roads where such extensive work is required. Either way, the need for comprehensive condition data is an important part of appropriate treatment selection.

What is Full Spectrum, Road Condition Measurements.

The unique capability of continuous high accuracy and high-resolution data enables infrastructure managers to pinpoint areas where the pavement structure may be subject to failure.

By collecting structural and surface condition data simultaneously, at traffic speed, is providing a more comprehensive assessment of infrastructure condition. This enables an effective and intelligent management of road infrastructure assets.

The Full Spectrum, Road Condition Measurements includes simultaneous measurements of:

- pavement strength
- cracking
- longitudinal and transverse road profile
- pavement macro texture
- road geometry
- geospatial position
- digital imaging
- asset inventory and condition

Value decisions for road administrations.

Increased knowledge of the road infrastructure condition improves the possibilities of the right activities being budgeted, planned, procured, and to be carried out effectively, in a way that is cost-effective in the long term.

The three major groups of models engaged in valuable decisions for road administrations are:

- Strategy models, - which tell from approved standards when intervention ought to be considered, and what maintenance solutions may be possible options.
- Performance models – which tell, how economical and physical parameters will perform into the future, taking deterioration and future intervention into account.
- Optimization models, - which from objective criteria single out the optimum plan of intervention from the list of possible options, that can be carried out within the budget constraints.
- The strategy models will set the limits when functional and structural criteria are exceeded, and rehabilitation options may be considered as possible solutions.
- The strategy models will rehabilitation a possible option, when either of the following criteria are exceeded.
- The cost of repair exceeds the annual depreciation of a wearing course renewal.
- The routine measurements performed by Full Spectrum, Road Condition Measurements, the road condition is below the threshold values decide by the administration.
- The structural residual lifetime is less than the standard design period.

Pavement condition

Roads are generally designed and built based on strength characteristics or bearing capacity, but generally managed according to their functional condition, as strength is difficult and expensive to measure on a routine basis. Until now, pavement condition has been largely determined using evenness, or IRI, which assumes that if a road is smooth, the pavement tends to be strong. However, experience shows that the inverse can also be true.

Having a complete dataset, incorporating information of the pavement below and above the surface, enables the road asset manager to better understand its condition. This dramatically improves decision making in managing the road network. Road agencies in North America, Europe, South Africa, China, Australia and New Zealand are now using Full Spectrum, Road Condition Measurements as a tool to collect pavement stiffness properties, at traffic speed, on a yearly basis, along with associated synchronized and simultaneous collected surface condition data.

Combining pavement structural and surface data into comprehensive, full spectrum, pavement measurements, as shown in Figure 1, enables the identification and cause of pavement failure much easier, providing a very powerful tool, in managing pavement condition and providing a solid background for robust maintenance strategies of road networks.

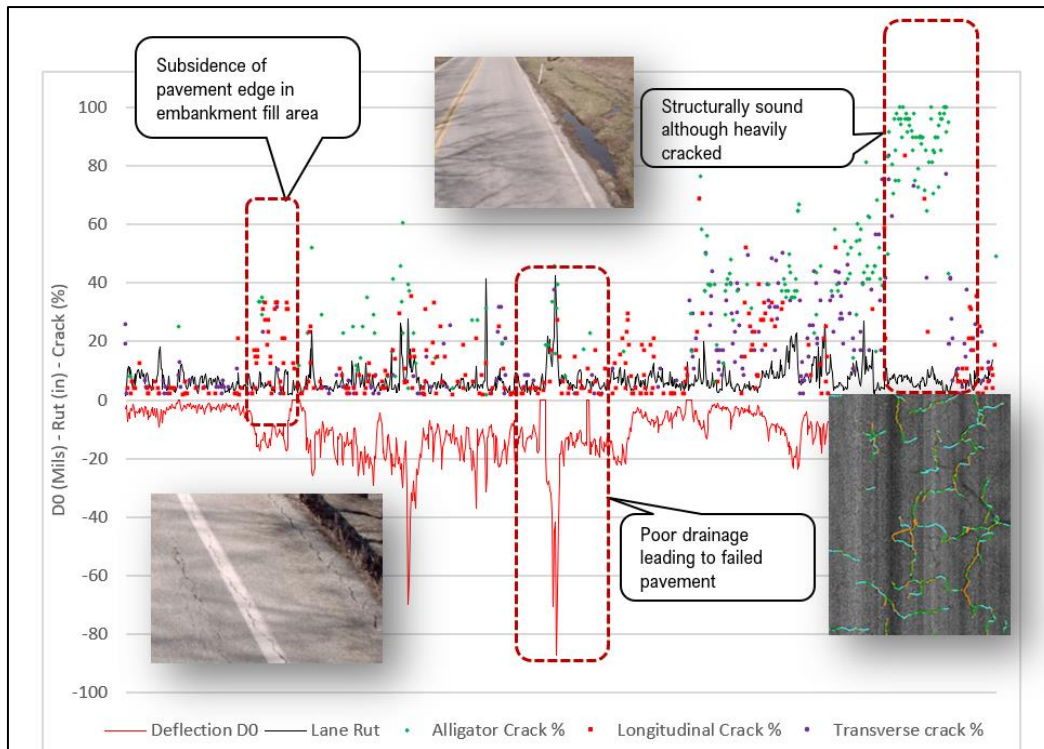


Figure 1, Comprehensive, full spectrum, pavement measurements

A proactive approach for maintenance of road assets is critical.

This will:

- Ensure a robust network and efficient cost management.
- Improved interaction between road managers and policy makers – secure funding.
- Will raise awareness of the consequences of delayed or postponed decisions (Backlog).
- Highlight the need to invest in long-term condition databases to strengthening decision making and optimizing maintenance strategies.

Today many road agencies are developing strategies to radically change pavement management. Comprehensive, full spectrum, pavement measurements, along with pavement composition, can be used to determine the properties of the road infrastructure including the pavements functional and structural condition. With the addition of traffic volume data, the remaining functional and structural life, of the pavements, until needed maintenance, can be determined. Based on the comprehensive measurements, the road network can be divided into segments with relatively homogeneous remaining life, leading to an optimization of the maintenance strategies. This enables optimized planning and decision-making going from a road network screening to a project level decision making.

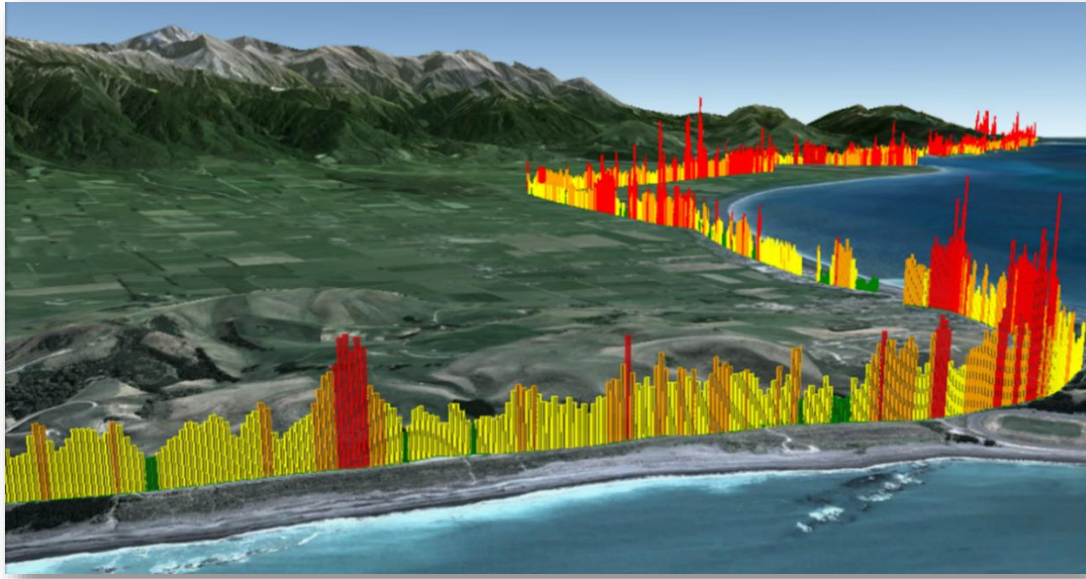


Figure 2: Spatial representation of derived condition data (red - weak pavement, green - strong pavement)

Closing the gap between network level and project level evaluations

By surveying a complete road network using Full Spectrum, Road Condition Measurements, provides the possibility to locate critical road sections where more in-depth evaluations need to be done and where the data measured are used to find the optimal maintenance and rehabilitation solution. To pinpoint those sections in a critical need for maintenance, selection criteria need to be established as a combined criterion, highlighted in figure 3.

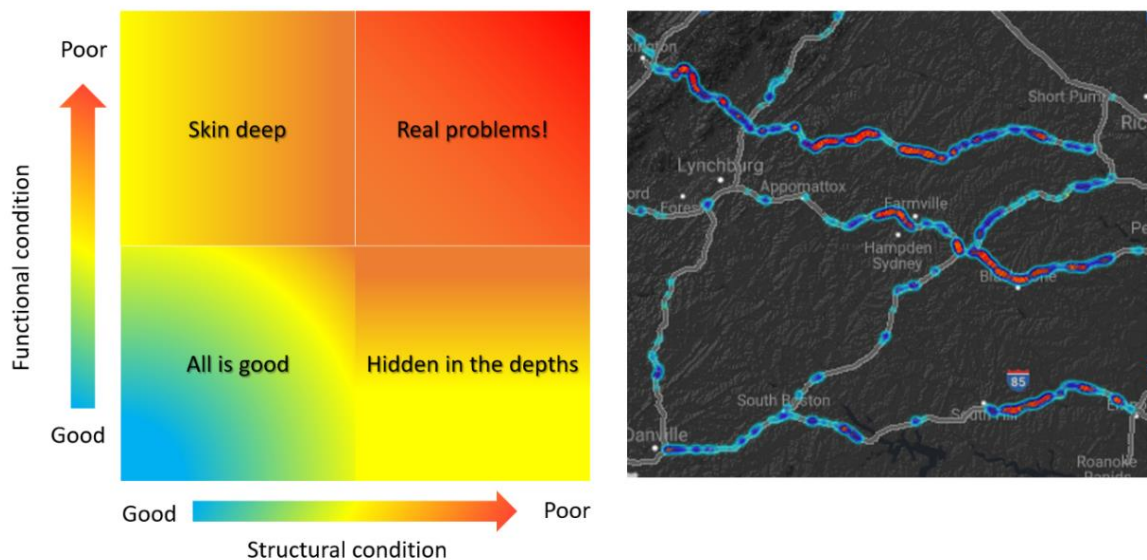


Figure 3: Pinpointing road sections for project level evaluation based on network level measurements.

The need for comprehensive measurements

Internationally, several hundred thousand kilometres of such data are being collected annually, using technology for continuous traffic speed collection of structural and functional condition. As this capability begins to gain interest the cases investigating the use and impact of comprehensive assessment to address both network and project level needs help to examine the potential of such data. Using these case studies, explore the overall impact such comprehensive assessments have on the optimization (and application) of agency pavement funds.

In the following 4 case studies are presented to highlight the need for using comprehensive measurements of road conditions.

- 1.) A section of pavement appears deficient from the surface AND is also determined to be structurally deficient.
- 2.) A section of pavement appears acceptable from the surface BUT is determined to be structurally deficient.
- 3.) A section of pavement appears deficient from the surface BUT is determined to be structurally adequate.
- 4.) A section of pavement appears acceptable from the surface AND an Agency can confirm it is also structurally adequate.

Each of these cases is discussed further in the following sections with examples provided for more detailed examination. Where available, financial implications will be provided for each of the scenarios to help recognize the potential value comprehensive assessments on optimizing fund allocation.

Case 1

For most, the common belief is that structural issues will manifest themselves in surface deterioration, eventually (see Figure 4). While this may typically be true, it is not always the case and therefore structural assessments should be conducted to confirm the presence of structural deterioration before treatments are planned for such extensive deterioration. It is not uncommon for some agencies to delay treatments on some roads when such extensive work is required. Either way, the need for confirmation is an important part of appropriate treatment selection.

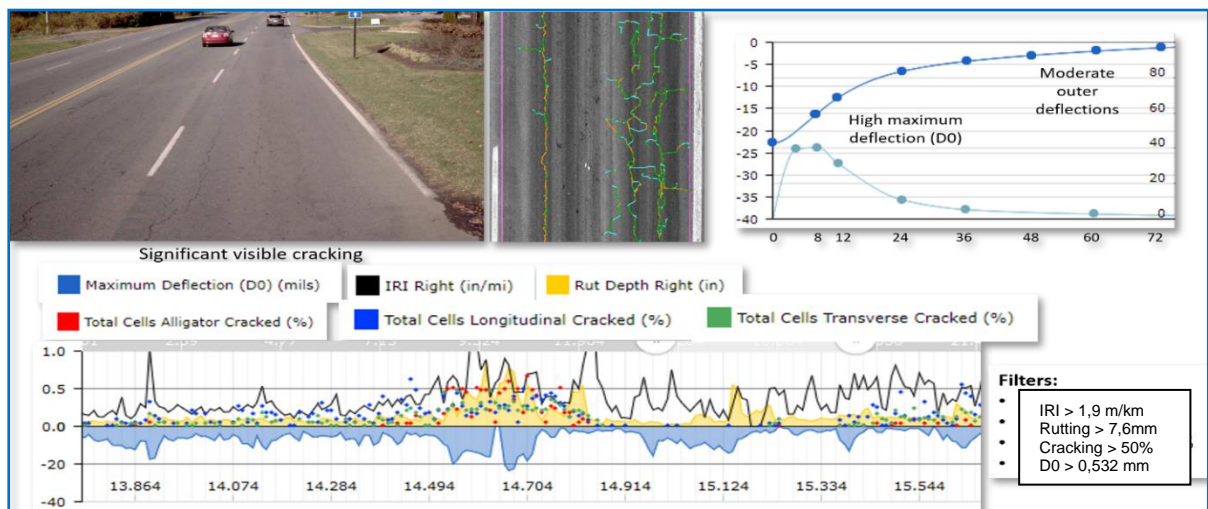


Figure 4 – Structural and Surface Issues (Case 1)

When the surface is heavily deteriorated, but no further assessment is conducted:

- a.) If the Agency elects to delay treatment because of the perceived deterioration, the surface may continue to decline, and could ultimately cause structural deterioration (by allowing water to infiltrate the pavement). This will likely lead to accelerated deterioration, regardless of whether structural issues existed or not.

- b.) If the Agency elects to plan an extensive treatment (based on the surface deterioration) this could result in unnecessary expenditures.

When the surface is heavily deteriorated, and further assessment is conducted:

- c.) An Agency can spend significant resources, to quantify the extent of the deterioration.
- d.) An Agency can conduct some forensic analysis, and potentially not fully document the extent of the deterioration.

Case 2

Not surprisingly, continuous structural capacity assessment, can reveal isolated/discrete portions of highways that may appear acceptable from the surface, but (for a multitude of potential reasons) are not able to provide the same structural support as adjacent portions of the same highway (see Figure 5).

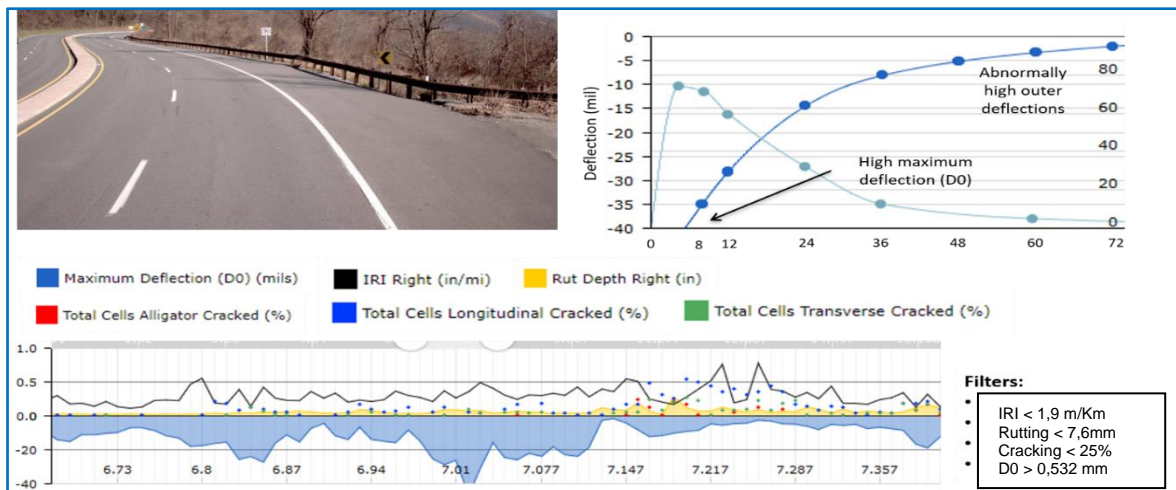


Figure 5 – Surface Appears Acceptable, Despite Lack of Structural Support (Case 2)

When left undetected:

- a) Isolated recurring maintenance issues will create frustration for years to come.
- b) Larger areas of structurally deficient pavement will ultimately lead to changes in treatment forecasts, which can prove very costly and embarrassing.

As an example, improperly constructed pavements can experience early structural problems that may not be as obvious from the surface (see Figure 6).

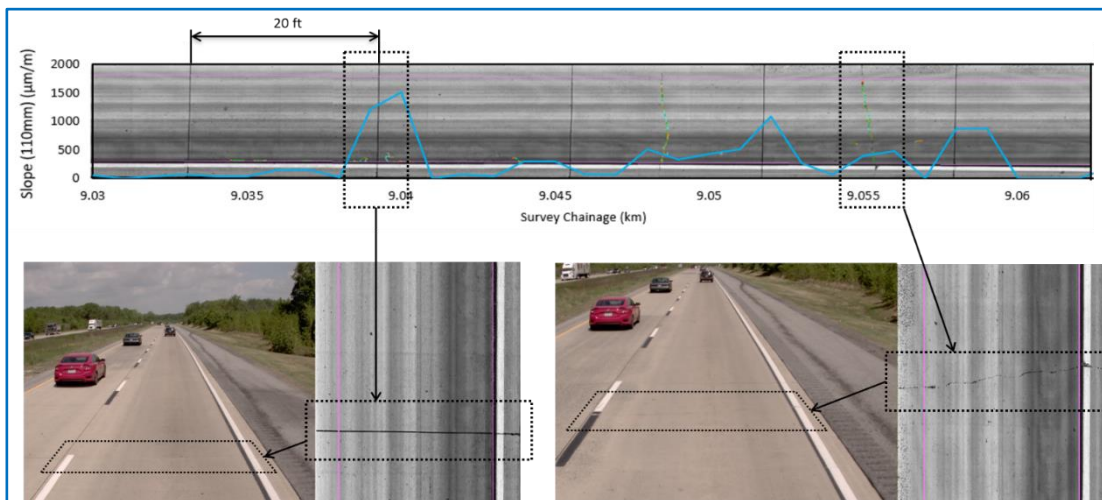


Figure 6 – Structural Issues Can Provide Early Indication of Future Problems

When detected early:

- c) Agencies can proactively conduct spot repairs in advance of treatments, to improve treatment performance and required thicknesses.
- d) Agencies may proactively alter treatment forecasts and strategies to mitigate more extensive areas of structural concern, that currently are not visible from the surface.

For some pavement types (like composite pavements), it is helpful to be aware of underlying condition to properly plan for treatment needs (see Figure 7).

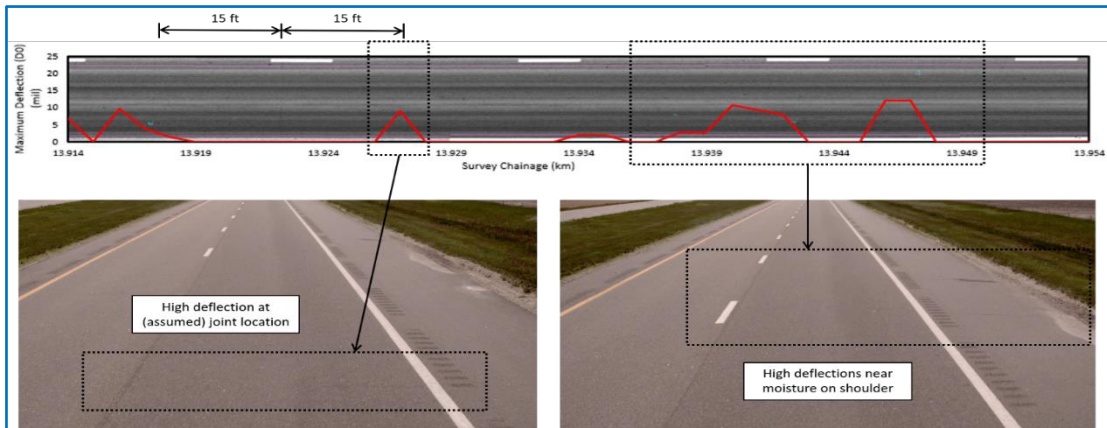


Figure 7 – Comprehensive Assessment Is Helpful for Properly Planning Treatment Needs

Case 3

Observations have also been made of sections of pavement that exhibit extensive surface deterioration, that would traditionally lead one to believe that extensive repairs are required.

Without the corresponding structural assessment:

- a.) An Agency may elect to delay treatment because of the perceived deterioration. The surface may continue to decline and could ultimately cause structural deterioration (by allowing water to infiltrate the pavement). This will likely lead to accelerated deterioration, regardless of whether structural issues existed or not.
- b.) If the Agency elects to plan an extensive treatment (based on the surface deterioration) this could result in unnecessary expenditures.

When the surface is heavily deteriorated, and further assessment reveals no structural deterioration (see Figure 8):

- c.) An Agency can remove and replace the problem surface layer and avoid more extensive unnecessary costly repair.
- d.) An Agency can use saved resources to investigate true cause(s) of surface anomalies.

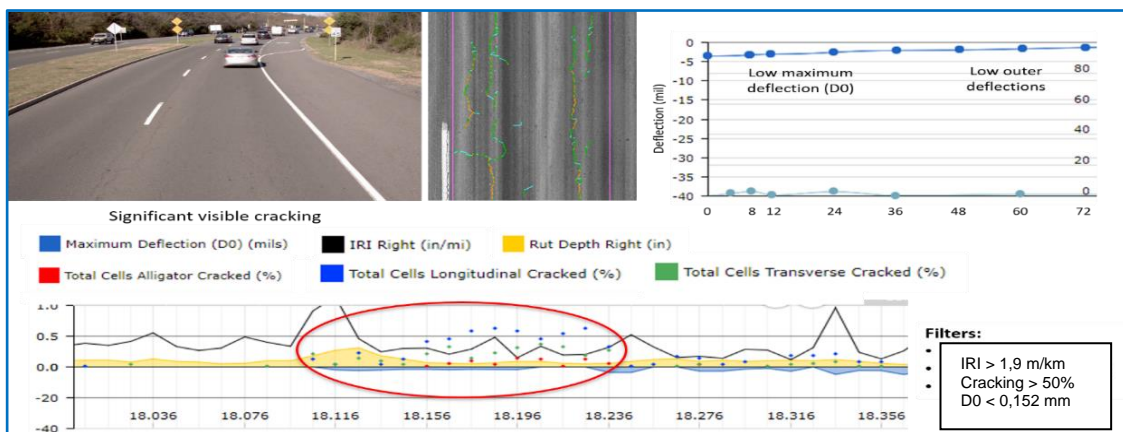


Figure 8 – Extensive Surface Deterioration, But Structurally Sufficient (Case 3)

Case 4

When sections of pavement appear to have limited surface deterioration, it is beneficial to be able to confirm that these sections truly require no work for the foreseeable future.

Without the corresponding structural assessment:

- a.) An Agency may program work based solely on the pavements age or unsupported performance expectations. This can lead to misappropriation of funds, regardless of whether structural issues existed or not.
- b.) If the Agency elects to plan treatment this could result in unnecessary expenditures.

When structural assessments can be readily conducted:

- c.) An Agency can project performance expectations and accurately plan for future needs.
- d.) An Agency can use saved resources to address projects of greater need.

Of greatest importance, is the recognition that regardless which case applies, continuous data provides a more detailed assessment within a project. Rather than assigning some "average" condition for treatment selection and design, discrete sections can be identified with greater confidence and accuracy. This ability offers the potential for isolating and treating areas of greater need. These project level decisions can now be made with 'network level' data. Such work can be performed in advance of larger rehabilitation projects to produce a more 'homogeneous' structure for more cost-effective designs. Potentially, isolated repairs of this nature may even be performed (on their own) to proactively "buy some time" before additional work is needed.

Conclusion

The challenges of assessing pavement structural capacity have historically led to a perceptible gap between network level and project level pavement management. The increasingly apparent limitations of traditional methods of assessment (safety considerations, user delays, and relatively high testing costs) are necessitating exploration of new solutions. Continuous structural capacity testing (at traffic speeds) has been used extensively in other parts of the world. The focus, however, has largely been on network level applications, until recently. With the integration of technology for continuous traffic speed collection of structural and functional condition (as one operation), project level applications are becoming more prevalent. The overall impact is still to be determined, but as seen from the limited examples cited above, many are eager to explore the possibilities.

Closing this gap between network level and project level evaluations is generating:

- 1.) More comprehensive pavement assessments, with greater value and applicability of the data collected.
- 2.) The ability to better optimize network performance and
- 3.) Improve the efficiency and effectiveness of project specific treatment needs.

As observed in the cases above, the ability to conduct more comprehensive assessments is capable of significantly impacting the optimization (and application) of Agency pavement funds.

The above examples clearly show that regardless which case applies, continuous data provides for a more detailed assessment within a project. Rather than assigning some "average" condition for treatment selection and design, discrete sections can be identified with greater confidence and accuracy. This ability offers the potential for isolating and treating areas of greater need. These project level decisions can now be made with 'network level' data. Such work can be performed in advance of larger rehabilitation projects to produce a more 'homogeneous' structure for more cost-effective designs. Potentially, isolated repairs additional work is needed.