# Towards Harmonization of Pavement Condition Evaluation for Enhanced Pavement Management: An Ontario Case Study

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## ABSTRACT

Currently, pavement condition analysis use by Ontario municipalities utilize at least six different pavement evaluation strategies, namely, Inventory Manual Methodology (IMM), Overall Condition Index (OCI), Pavement Condition Index (PCI), Pavement Quality Index (PQI), Structural Adequacy Index (SAI), and Surface Condition Index (SCI). Also, many municipalities and consultants use modified versions of existing evaluation methodologies (adding/removing distress types or weighting criteria) to suit their individual needs. Ontario Regulation 588/17: *Asset Management Planning for Municipal Infrastructure* mandated the concept of levels of services for all asset classes. For paved roads, municipalities are required to report an average PCI value; however, the Ministry of Infrastructure used this terminology to refer to any numeric evaluation strategy.

This paper explores the need to standardize pavement condition evaluation methodology used by infrastructure owners across Ontario. This paper focuses on a review of the pavement condition evaluation methodologies being used by Ontario's municipalities, quantifying the differences, and consolidating recommendations towards pavement condition evaluation standardization. A literature review was conducted to understand the pros and cons of variability in pavement condition evaluation methods. The paper presents results from survey of infrastructure agencies in Ontario which presents trends and variabilities in pavement condition evaluation methodologies. A field pavement condition investigation was performed on four sections of municipal roads in Ontario to understand the effect of different methodologies on the outcome pavement evaluation.

## INTRODUCTION:

A few decades ago, pavement and transportation engineers realized that asset management for roadways could not be complete until you have metrics that accurately capture the state of the pavement and the road network as the Austrian-American management consultant/author Peter Drucker said, "*You can't manage what you can't measure.*" The AASHO Road Test in the 1950s resulted in breakthroughs in developing metrics for measuring pavement condition. The goal of collecting data on pavement condition is to support a wide variety of project and network-level decisions for a transportation agency. Some of the major uses of pavement condition data include:

- Baseline evaluation of current network condition
- Understanding the progression of pavement deterioration through modelling
- Projecting future pavement conditions
- Optimization of maintenance and rehabilitation budget and activities
- Allocation of resources
- Characterizing pavement performance under different conditions, designs, and materials.

Locally, the Ontario Ministry of Transportation (MTO) decision to end one of its funding programs affected how municipalities collect and evaluate their pavement condition and performance data. In 1995, MTO ended the *Conditional Grant Program* that provided partial funding for municipalities to support maintenance, rehabilitation, and reconstruction of their roadways. Without the financial incentive for municipalities to use a common standard in evaluating the condition of their roads, a proliferation of systems has sprung up since then. These evaluation methodologies have been developed by the MTO, in-house by municipalities, consulting firms and by international organizations.

Today, Ontario municipalities use at least six different evaluation strategies, namely, Inventory Manual Methodology (IMM), Overall Condition Index (OCI), Pavement Condition Index (PCI), Pavement Quality Index (PQI), Structural Adequacy Index (SAI), and Surface Condition Index (SCI). In addition, the problem is further compounded when municipalities and consultants modified the existing evaluation methodologies (adding/removing distress types or weighting criteria) to suit their individual needs. Ontario Regulation 588/17: *Asset Management Planning for Municipal Infrastructure* mandated the concept of levels of services for all asset classes. For paved roads, municipalities are required to report an average PCI value; however, the Ministry of Infrastructure used this terminology to refer to any numeric evaluation strategy.

There is a need to standardize the pavement condition evaluation methodology used by infrastructure owners across Ontario. This standardization would result in four key benefits:

1. Improved quality of the asset management plans being developed/refined;
2. Improved benchmarking capabilities allowing for municipalities to compare pavement network condition and costs;

3. More accurate allocations of funds as well as strategic funding decisions at both the provincial and municipal levels of government; and
4. The ability to establish a province-wide pavement monitoring and evaluation program and support other province-wide initiatives.

The paper/presentation focuses on a review of the pavement condition evaluation methodologies being used by Ontario's municipalities, quantifying the differences and consolidating recommendations for pavement condition evaluation standardization.

## METHODOLOGY

To achieve the goals and objectives of this research, the following methods were used:

**Literature Review:**
The aim of the literature review part of the methodology is to understand the variety of methods used in distress identification and pavement condition evaluation. The review focused on manuals authored by transportation agencies and organizations in North America.

**Agency Survey:**
This step of the methodology aims to capture the state of the practice of pavement evaluation and distress evaluation on a Municipal level in Ontario. An online survey was developed to record the types of distress manuals used, the different condition indices applied, and how Municipalities conduct such activities (in-house, contracted, automated, etc.).

**Field Application:**
To understand the differences between the main distress identification manuals in Ontario (SP-022, SP-024, and ASTM-D6433), a field survey was conducted to collect distress information using both manuals through multiple teams on several pavement sections. The collected data was used to calculate the Pavement Condition Rating (PCR), and Pavement Condition Index (PCI) to compare the variability of the different methods used in field application.

## DISCUSSION

### A – Literature Review:

### VARIETY IN CONDITION EVALUATION
The earliest attempts to capture pavement condition in a numerical metric was a simplistic approach through a group of evaluators who recorded their judgment of the quality of the ride on a standard scale. This metric was referred to as the Pavement Serviceability Rating (PSR). [1] Given the subjectivity of the PSR, more efforts were

made to develop a more objective metric that captures pavement condition with a more technical approach. The Pavement Serviceability Index (PSI) was devised to incorporate cracking, rutting, and roughness measurements. [2] Since then, numerous studies have been conducted to develop metrics and indices that accurately capture pavement condition. Such metrics became more specific as they would capture the state of the pavement in terms of its:

- Structural Capacity
- Extent of Distress Manifestation
- Serviceability, (ride quality and friction)
- Comprehensive Condition

Such advances in precise pavement condition measurements were essential in the development of the field of pavement asset management. For example, Hass et al. determined that the estimated structural capacity of pavement sections is important at the network level, as it helps decision-makers make appropriate maintenance and rehabilitation (M&R) decisions [3]

However, the continuous development of pavement condition indices created a redundancy where numerous indices measure the same pavement condition characteristics but in different scales and formulas. This variability in indices creates harmony issues between transportation agencies regarding asset management information sharing. Having local agencies use inconsistent pavement condition metrics results in considerable variability in reported levels of service for similar assets in similar geographical locations under similar loading conditions. The following paragraphs detail the different indices and methods used for capturing pavement condition.

To better grasp the numerous pavement condition metrics and to understand potential redundancy, the pavement condition metrics/indices were broken down into three categories based on the characteristic they represent, namely Distress Manifestation, Serviceability, and Structural Condition. In addition, a comprehensive pavement condition metric exists where it incorporates metrics from the mentioned categories through a mathematical equation that can graphically describe how pavements perform over time. **Table 1** summarizes the pavement condition metrics organized in categories, while **Tables 2 to 5** present more detailed insights and comparisons of each metric.

*Table 1 - Breakdown of the different indices found in the literature based on the pavement condition characteristic they represent*

| Distress Manifestation | Serviceability | Structural Condition |
|---|---|---|
| Surface Condition index | Ride Quality Rating | Structural Condition Index |
| Pavement Distress Index | Slope Variance | Structural Adequacy Index |
| Surface Distress Index | Rideability Number | |
| Distress Manifestation index | International Roughness Index | |
| Surface Rating | | |
| Distress Index | | |
| Pavement Condition Index | | |

| Comprehensive Pavement Condition |
|---|
| Pavement Quality Index<br>Pavement Condition Rating<br>Present Serviceability Index<br>Overall Condition Index |

**DISTRESS QUANTIFICATION**

Pavement condition evaluation depends heavily on identifying and quantifying the level of distress manifestation. Distress types and their levels of severity and extent are captured in a standard process known as Distress Identification or Distress Survey. **Table-6** presents a comparison of the type of distresses, and ways of measuring severity and extent between distress identification manuals for MTO (SP-024), Ontario municipalities (SP-022), Long Term Pavement Performance (LTPP), British Columbia Ministry of Transportation and Infrastructure (BCMT), and Saskatchewan Ministry of Highways and Infrastructure (SMHI).

Even though there are numerous distress indices and numerous ways of calculating them, the distress identification process is generally similar across different manuals where it depends on recording the severity levels and extent/density of distresses based on standardized thresholds. Differences exist in the scale of the levels of severity, and the method for quantifying the extent of the distresses between transportation agencies. The following notes can be drawn from examining the comparison in **Table-7:**

- Numerical scale for the level of severity for the same distresses is different from one manual to another
- MTO and BCMT use a defined density scale for each distress, while the LTPP manual and SMHI use the exact value of how much of the pavement section is distressed as the measure of distress density
- Identical distresses are referred to using different terminologies in different manuals, for example Bleeding / Flushing, Raveling / Loss of Aggregates / Pickouts, and Random Cracking / Miscellaneous Cracking / Map Cracking.
- SP-022 manual identifies and measures the greatest number of pavement distresses (18 distresses), while the SMHI identifies the least number of pavement distresses (seven distresses).

*Table 2 - Summary of indices measuring the distress manifestation in pavements*

| Index Name | Agency | Equation and Comments | Scale Range |
|---|---|---|---|
| Pavement Condition Index (PCI) | City of Toronto | • Uses mathematical curves that represent each surface distress and severity to obtain values for deduct values (CDV)<br>• Developed by U.S Army Corps of Engineers [4]<br>• Standardized by ASTM [5] | 0 – 100 |
| Pavement Condition Rating (PCR) | ODOT | Uses deduct values based on severity, density, and distress weight [6]<br>$PCR = 100 - \sum_{I=1}^{n} Deduct_i$ | 0 – 100 |
| Present Serviceability Rating (PSR) | MnDOT | • Originally developed by AASHTO in 1960 and takes into account: smoothness, rutting, cracking & patching [7]<br>• MnDOT uses PSR as per the below equation [8]<br>$PSR = 5.6972 - 2.104\sqrt{IRI}$ | 0 – 5 |
| Distress Index (DI) | MDOT | $DI = \frac{\sum DP}{L}$<br>It is the sum of weighted distress points normalized by the section length [9] | 0 – ∞ |
| Surface Condition Index (SCI) | SMHI | • Saskatchewan Ministry of Highways and Infrastructure developed SCI as the metric for pavement condition [10]<br>• The SCI is the highest of either the density of the pickouts along the section or the sum of weighted cracking measurements (single and block cracking)<br>• The ministry uses automated distress collection systems<br>$SCI = \max(SCI_{pickouts}, SCI_{single} + SCI_{block})$ | 0 – 100 |
| Pavement Distress Index (PDI) | NY Thruway Authority | $PDI = \frac{100(\sum_{d=A}^{H} W_{id} - \sum_{d=A}^{H} W_{fd})}{\sum_{d=A}^{H} W_{id}}$<br>It is a modified version of the PCI that was originally developed by the U.S Army Corps of Engineers. [11] | 0 – 100 |
| Distress Manifestation Index (DMI) | MTO | • Original equation was developed by Phang et. al [12]<br>• The original equation was modified by MTO where the term **DMI<sub>max</sub>** and the integer **10** were added to the equation as constraints to limit the outcome to a range of 0 to 10 [13]<br>$DMI = 10 * [\frac{DMI_{max} - \sum_{k=1}^{k=14}(\boldsymbol{S}_k + \boldsymbol{D}_k) * W_k}{DMI_{max}}]$ | 0 – 10 |
| Surface Rating | MnDOT | Uses the sum of weighted distresses (Total Weighted Distresses) as an initial parameter to find the Surface Rating value from a standard table [8] | 1 – 4 |

*Table 3 - Summary of indices measuring the serviceability of pavements*

| Index Name | Developed by | Comments | Range |
|---|---|---|---|
| Ride Quality Rating (RQR) | AASHTO | • Reflection of the ride comfort "seat of the pants feeling"<br>• Recorded by a group of evaluators riding at constant speed<br>• Subjective measure of roughness<br>• Developed at the AASHO Road Test | 0 – 10 |
| Rideability Number (RN) | NCHRP | • A conversion of the longitudinal profiles' measures into subjective measures of rideability from public's perspective<br>• Reason for development is to separate distress metrics from ride quality in pavement condition assessment | 0 – 5 |
| International Roughness Index (IRI) | World Bank | • Simulates the suspension reaction of a standard car along the measured road<br>• Many agencies use equations to convert IRI into their own ride quality metrics<br>• Requires advanced calibrated instruments | 0 – ∞ |

*Table 4 - Summary of indices measuring the structural condition of pavements*

| Index Name | Agency | Comments | Range |
|---|---|---|---|
| Structural Condition Index (SCI) | TxDOT | • It is calculated by dividing the effective structural number ($SN_{eff}$) by the required SN ($SN_{req}$) for 20 years<br>• Requires measurements with Falling Weight Deflectometer (FWD) | 0 - 1 |
| Structural Adequacy Index (SAI) | MnDOT | • Developed by Asphalt Institute<br>• Represents a percentage of the remaining structural capacity of the pavement<br>• Based on the Representative Rebound Deflection (RRD) value which is the deflection performance of an entire section (mean + 2std dev.)<br>• RRD is compared to Design Rebound Deflection (DRD) which is a function of the anticipated ESALs in the remaining pavement life | 0 – 100 |

*Table 5 - Summary of indices measuring the comprehensive condition of pavement*

| Index Name | Agency | Equation & Comments | Range | Function of |
|---|---|---|---|---|
| Pavement Quality Index (PQI) | MnDOT | $PQI = \sqrt{SR * PSR}$ | 0 – 4.5 | • Surface Roughness<br>• Surface Distresses |
| Pavement Condition Rating (PCR) | BCMT | $PCR = PDI^{0.5} * RCI^{0.5}$ | 0 – 10 | • Surface Roughness<br>• Surface Distresses |
| | MTO | $PCR = 13.75 + 9DMI - 7.5e^{\frac{(8.5-RCI)}{3.02}}$<br>Also refered to as Pavement Condition Index in some literature | 0 – 10 | • Surface Roughness<br>• Surface Distresses |
| Present Serviceability Index (PSI) | AASHTO | $PSI = 5.03 - 1.91\log(1+\overline{SV}) - 0.01\sqrt{C+P} - 1.38(\overline{RD})^2$ | 0 – 100 | • Surface Roughness<br>• Surface Distresses |

*Table 6 - Comparison of the Ride Condition Rating in SP-022 and SP-024*

| Condition Description | Classification of Ride Quality | Ride Condition Rating (RCR) | |
|---|---|---|---|
| | | **SP-022** | **SP-024** |
| A very smooth ride | Excellent | 8-10 | 9-10 |
| A smooth ride with just a few bumps or depressions | Good | 6-8 | 7-9 |
| A comfortable ride with intermittent bumps or depressions | Fair | 4-6 | 5-7 |
| An uncomfortable ride with frequent to extensive bumps or depressions. Cannot maintain the posted speed at lower end of the scale | Poor | 2-4 | 2-5 |
| A very uncomfortable ride with constant jarring bumps and depressions. Cannot maintain the posted speed and must steer constantly to avoid bumps and depressions | Very Poor | 0-2 | 0-2 |

*Table 7 - Comparison of Types of Distresses Measured by Different Distress Identification Manuals*

| **Distress Manifestations** | | **Distress Identification Manuals** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **SMHT** | **BCMT** | **LTPP** | **SP-022** | **SP-024** | **ASTM** |
| Surface Defects | Bleeding (Flushing) | | X | X | X | X | X |
| | Polished Aggregates | | | X | | | X |
| | Raveling (Loss of Coarse Aggregates) (Pickouts) | X | X | | X | X | X |
| | Potholes | | X | X | X | | X |
| | Pavement Edge Breaks | | | | X | | |
| | Weathering | | | | | | X |
| | Manholes and Catchbasins | | | | X | | |
| Surface Deformations and Distortions | Ripping and Shoving | | X | X | X | X | X |
| | Wheel Track Rutting | | X | X | X | X | X |
| | Distortion (Bumps & Sags) | | X | | X | X | X |
| | Corrugations (Ripples) | | | | | | X |
| | Utility Trenches and Maintenance Patches | | | X | X | | X |
| Cracking | Longitudinal Cracking | X | X | X | X | X | X |
| | Block Cracking | X | | X | | | |
| | Wheel Path Cracking | X | | | | | |
| | Reflection Cracking | | | X | | | X |
| | Transverse Cracking | X | X | X | X | X | X |
| | Pavement Edge Cracking | | X | X | X | X | X |
| | Alligator (Fatigue) Cracking | X | X | X | X | X | X |
| | Centerline Cracking | | | | | X | |
| | Longitudinal Meander and Mid-lane Cracking | X | X | | | X | |
| | Miscellaneous / Random / Map Cracking / Block Cracking | | | X | X | X | X |
| Paved Shoulder Distress Manifestations | Pavement Edge, Paved Shoulder (or curb) Separation | | | | X | X | |
| | Paved Shoulder Cracking | | | | X | X | |
| | Paved Shoulder Breakup and Potholes | | | | X | X | |
| | Paved Shoulder Distortion | | | | X | X | |
| | Lane-to-Shoulder Dropoff | | | X | | | X |
| | Water Bleeding & Pumping | | | X | | | |
| **Number of Distresses Measured** | | 7 | 11 | 15 | 18 | 16 | 17 |
| **Levels of Distress Severity** | | 0.8-2 | 3 | 3 | 3 | 5 | 3 |
| **Levels of Distress Density** | | m, $m^2$ | 6 | m, $m^2$ | 3 | 5 | m, $m^2$ |

The most commonly used methodologies for flexible pavement evaluation in Ontario municipalities were found to be as follows:

- MTO's Inventory Manual for Municipal Roads
- SP-022 Manual for Flexible Pavement Condition Rating (Municipal Roads)
- SP-024 Manual for Flexible Pavement Condition Rating (Provincial Roads)
- ASTM-D6433 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

Even though we found that MTO's Inventory Manual is the most used methodology for collecting pavement condition data in Ontario, the Pavement Condition Index (PCI), as standardized by ASTM-D6433 [5] was found to be the most used index for calculating pavement condition in Ontario as shown in **Figure 1**. The ASTM PCI index is also more widely adopted by transportation agencies in North America and more commonly used as the basis of many distress prediction modules developed by researchers; [14] [15]. However, the PCI calculation in the ASTM D6433 could be quite an extensive effort for a network size dataset due to the manually focused iterative process, which depends on using graphical curves instead of formulas and equations.

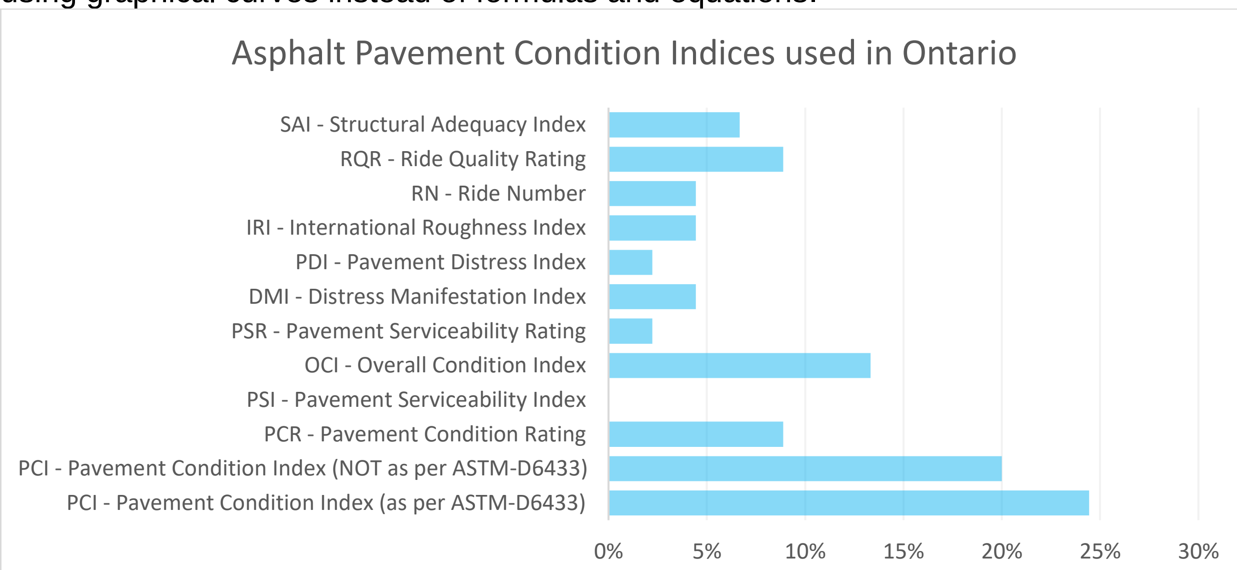


*Figure 1 - Indices used in calculating pavement condition in Ontario. Results from Good Roads Pavement Condition Evaluation Survey*

The more popular methodologies in Ontario municipalities, SP-022 and SP-024, were developed by The Ministry of Transportation Ontario as standards for recording pavement distresses and a condition rating scheme to meet the pavement management needs for local agencies. The SP-024 manual is mainly used by MTO for evaluating provincial highways, and the SP-022 *Manual for Flexible Pavement Condition Rating* was developed for municipal use to specifically address the unique condition evaluation and needs for municipal roads.

The rating scheme devised for SP-022 and SP-024 is similar and is represented by the Pavement Condition Rating (PCR). The two main parameters are used to calculate the PCR are:

- Distress Manifestation Index (DMI), and;
- Ride Condition Rating (RCR).

The *GR 2022 Pavement Condition Evaluation* survey, found that many municipalities in Ontario use SP-024, which may not be as suitable as SP-022 for evaluating pavement conditions for municipal roads. A comparison of the two manuals is presented in **Table-6** and in **Table-7**. The review and comparison of the two manuals revealed the following points:

- The SP-022 manual identifies four more unique distresses for municipal roads that are not included in SP-024, **Potholes**, **Pavement Edge Breaks**, **Manholes**, and **Utility Trenches**.
- Both manuals mentioned the use of Pavement Condition Rating (PCR) as the overall index, but neither manual had specific information on how to use the distress data to calculate the PCR
- There are follow-up studies that identify weights associated with the different distress types in SP-024 [16], but not for the unique distress types in SP-022 manual (e.g., potholes, catchbasins, etc.)
- The equation for calculating the Distress Manifestation Index (DMI) is slightly different between the two manuals (SP-022 vs. SP-024), as the constant $DMI_{max}$ is equal to 208 in SP-024 while it should be equal to 168 in SP-022, however this notation was not included in the SP-22 manual. This constant accounts for the different types of distresses used in either SP-024 and SP-022.
- The range of severity and density in the municipal version (SP-022) ranges from 0 to 3, while it ranges from 0 to 4 in the provincial version (SP-024).
- The numerical values for the Ride Condition Rating (RCR) refer to different qualitative conditions when comparing SP-22 to SP-24, as shown in **Table-6**
- Though both Density and Severity are required to be collected in both MTO manuals (SP-22 and SP-24), the PCR calculation cannot take more than one Severity value and one Density value for each distress. Unlike the ASTM-D6433 [5], where the PCI equations takes into consideration the exact Density of each Severity for each distress type.

**B – Agency Survey:**

A survey on the current practices on pavement condition evaluation was circulated by Good Roads and the Municipal Engineers Association to collect responses from municipal agencies across Ontario. The survey was open from January 14th to April 20th, 2022 and collected a total of 26 responses from across Ontario. The breakdown of the response rate is presented in **Figure 2**.

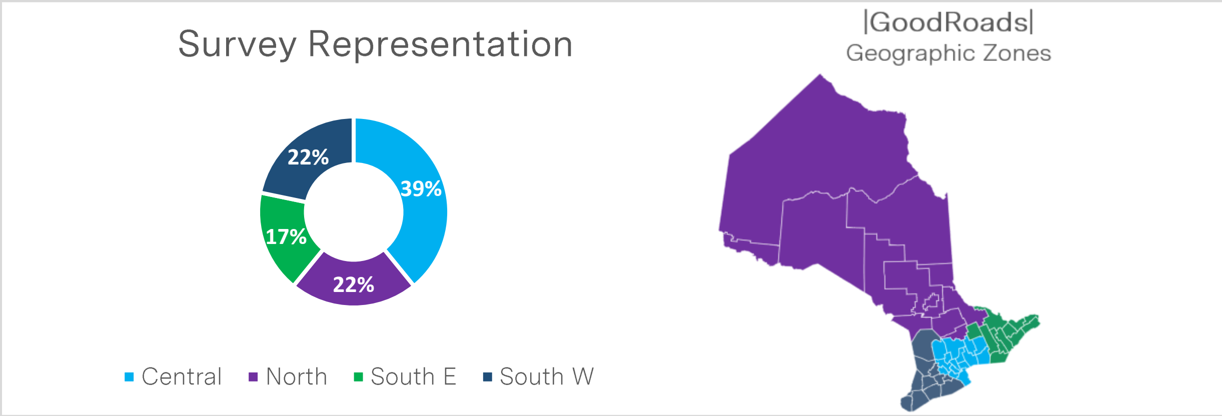


*Figure 2 - Breakdown of survey response rate by geographical zone*

The survey data showed that Ontario municipalities mainly depend on 3rd party consultants to conduct pavement condition evaluations, analyze the data, and calculate indices and metrics. However, a significant percentage of municipalities (37%) rely on their in-house staff to conduct such duties. The data is presented in **Figure 2.** Regardless of who performs the service, municipalities still have the authority to specify which methods, manuals, and indices to use for pavement condition evaluation. **Figure 4** shows that the MTO Inventory Manual is the most used for pavement evaluation in Ontario. Moreover, 31% of agencies that responded to the survey indicated that they either use a modified version of another manual or don't have a specific manual that they require.

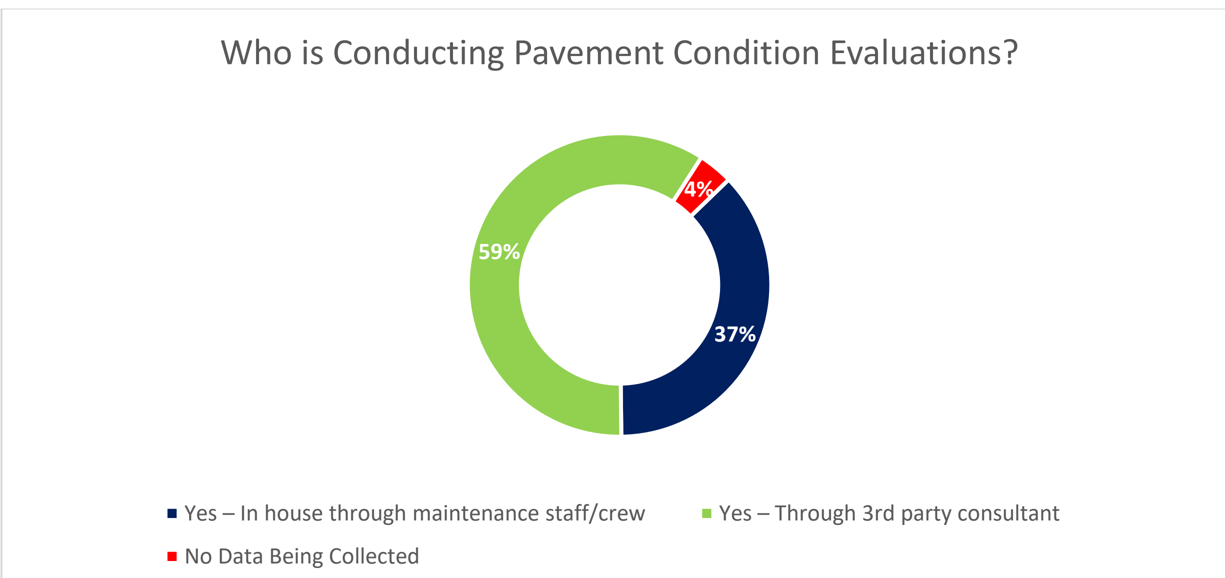


*Figure 3 - Parties responsible for conducting pavement condition evaluation*

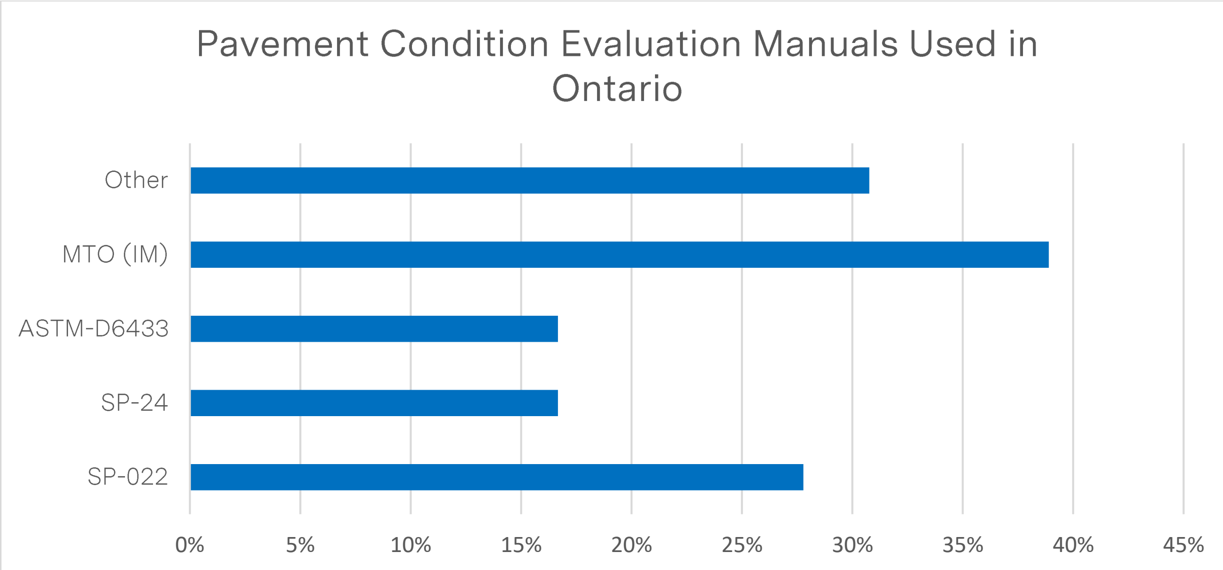


*Figure 4 - Most commonly used manuals for pavement condition evaluations as used by Ontario municipalities. Results from Good Roads Pavement Condition Evaluation Survey*

According to the survey data, the most used attributes to evaluate pavement condition are Surface Cracking, Rutting, Surface Defects, and Roughness. Few municipalities utilize other attributes such as Maintenance Patches, Structural Capacity, and Surface Friction. Collecting information on such attributes and distresses is mostly done manually. However, 35% of the responses indicated that they utilize an automated distress collection technology. Ontario's most common automated technology is found to be the Automatic Road Analyzer (ARAN), followed by phone-based artificial intelligence technologies.

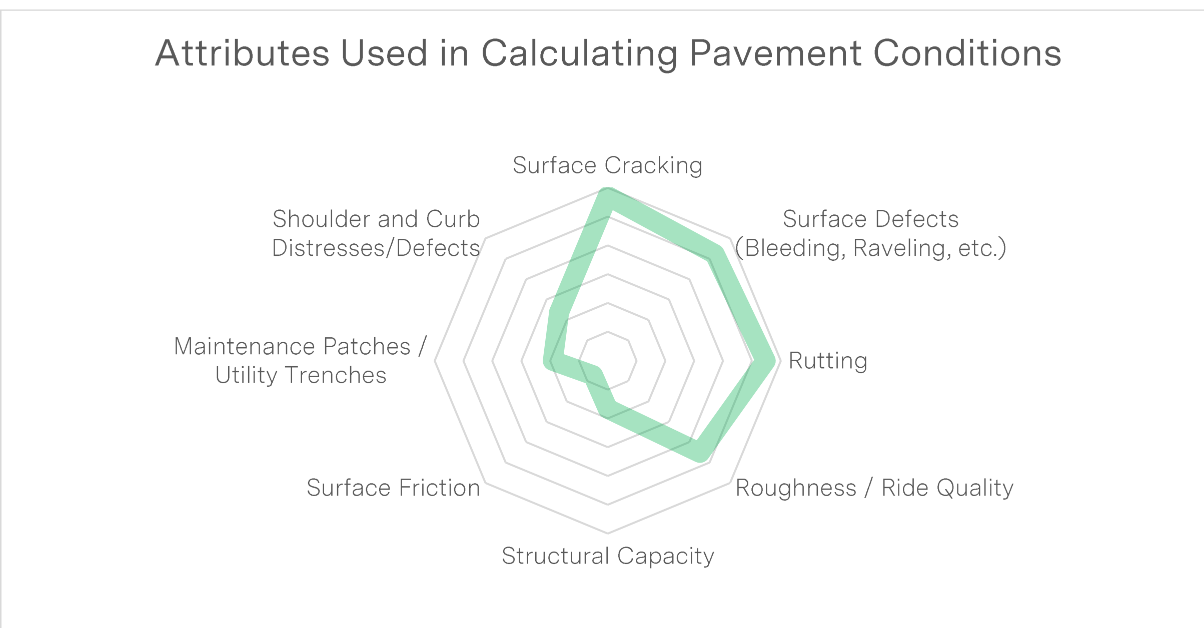


*Figure 5 - Pavement attributes most used by municipalities in calculating their indices for pavement condition*

## C – Field Application:

Four flexible pavement sections were evaluated on the day of May 12th 2022 using the ASTM D6433, SP-022 and SP-024 distress identification methods separately. For better understanding of the variations between the methodologies the road sections were selected to represent a range of pavement conditions from poor to good. A summary of the road sections is presented in Table-8

Table-9 and Figure-6 show the calculated indices of the evaluated road sections during the field application. PCR and PCI share the same quantitative scale of 0-100 although mathematically, distress damage is accounted for differently. Each manual also defers in translating the quantitative index into qualitative description of the road condition for example, East Dr is described as *Poor* in SP-22 while it is *Very Poor* according to ASTM D6433. The results also show that PCI value is less than the PCR for SP-024 in all sections, and less than PCR for SP-022 in most sections.

Although the pavement evaluation results were somewhat similar between the different methods, the ASTM D6433 method was more time consuming when conducting distress survey and a lot more time-consuming during calculation than SP-22 or SP-24.

*Table 8 - Field Evaluation Information Summary*

| # | Street Name | Length (m) | Width (m) | Area ($m^2$) | History | |
|---|---|---|---|---|---|---|
| **1** | East Dr | 770 | 10.7 | 8,239 | **Const.** | 1963 |
| | | | | | **Reconst.** | 1990 |
| **2** | Aloma Cr | 275 | 7.8 | 2,145 | **Const.** | 1978 |
| | | | | | **Overlay** | 2003 |
| **3** | Selby Rd | 650 | 10.7 | 6,955 | **Const.** | N/A |
| | | | | | **Reconst.** | 1992 |
| **4** | Peel Village Pkwy | 340 | 8 | 2,720 | **Const.** | N/A |
| | | | | | **Reconst.** | N/A |

*Table 9 - Indices of Evaluated Sections during the Field Application*

| **Street Name** | | East Rd. | Aloma Cr | Selby Rd | Peel Village Pkwy |
|---|---|---|---|---|---|
| **SP-022** | DMI | 6.1 | 9 | 8.7 | 8 |
| | RCR | 4 | 9 | 9 | 7 |
| | PCR | 35.6 | 88.8 | 85.6 | 73.2 |
| **SP-024** | DMI | 6.6 | 8.5 | 9.1 | 7.6 |
| | RCR | 5 | 8 | 9 | 8 |
| | PCR | 49 | 81.4 | 89.4 | 73.1 |

| | | | | | |
|---|---|---|---|---|---|
| **ASTM D6433** | PCI | 38.4 | 78.8 | 88 | 68 |

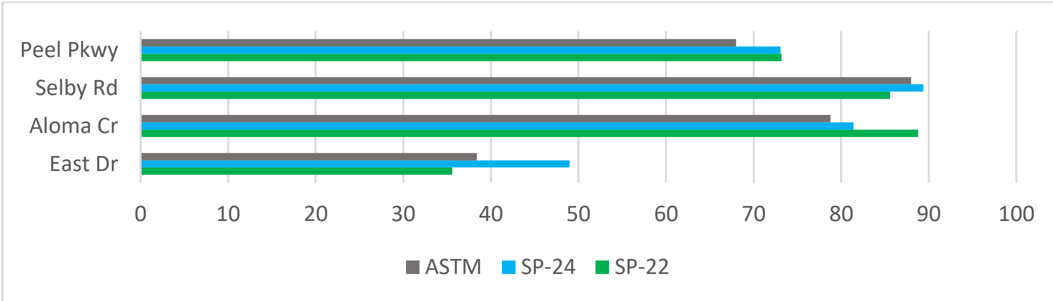


*Figure 6 - Results of Pavement Condition Evaluation According to ASTM-D6433, SP022, and SP024 Manuals*

## CONCLUSION

- More than four different manuals/methods and more about ten different indices are used by Ontario municipalities in evaluating their pavement conditions which create harmony issues
- Having local agencies use inconsistent pavement condition metrics results in considerable variability in reported levels of service for similar assets in similar geographical locations under similar loading conditions.
- Standardizing pavement condition evaluation would result in four key benefits:
    - Improved quality of the asset management plans being developed/refined;
    - Improved benchmarking capabilities allowing for municipalities to compare pavement network condition and costs;
    - More accurate allocations of funds as well as strategic funding decisions at both the provincial and municipal levels of government; and
    - The ability to establish a province-wide pavement monitoring and evaluation program and support other province-wide initiatives.
- The most used method for pavement condition evaluation in Ontario is the MTO Inventory Manual for Municipal Roads, and the most used index is the PCI as per the ASTM D6433 standard.
- Conducting field pavement condition evaluation and completing the calculation according to ASTM-D6433 was more time and effort consuming than when using MTO's SP-022 and SP-024 methods, while the evaluation results were similar between the different methods.
- Agency survey revealed that Ontario municipalities mainly depend on 3rd party consultants to conduct pavement condition evaluations, analyze the data, and calculate indices and metrics. However, a significant percentage of municipalities (37%) rely on their in-house staff to conduct such duties.
- Ontario's most common automated technology is found to be the Automatic Road Analyzer (ARAN), followed by phone-based artificial intelligence technologies.
- There is a need for organized effort between stakeholders in Ontario to move forward towards standardization and harmonization of distress collection and pavement condition evaluation to enhance the implementation and training of

pavement evaluation in terms of cost effectiveness, accuracy, and knowledge sharing and research potential.

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