Ontario Road Builders' Association

Quality of Asphalt Review

KPMG LLP

August 2018

Document information

KPMG LLP ("KPMG") prepared this report for the Ontario Road Builders' Association ("ORBA") for its uses in better understanding quality of asphalt issues in Ontario (technical and non-technical) and potential solutions to current challenges.

Viewpoints, background and data were gathered through a combination of primary and secondary research, including publicly available information (e.g., literature review, jurisdictional benchmarking, government publications); consultations with industry, owners and subject matter experts conducted by KPMG; online opinion surveys and industry-owner roundtable sessions conducted for ORBA by Global Public Affairs ("GPA"); and technical research and analysis conducted for ORBA by the Texas A&M Transportation Institute ("TTI"). Additional information about approach, methodologies and sources are included herein. This report represents KPMG's synthesis of these work streams. KPMG also supported ORBA's development of a continuous improvement framework to guide future efforts to improve the quality of asphalt in Ontario.

KPMG provided Advisory Services to ORBA. The procedures KPMG performed do not constitute an audit, examination or review in accordance with standards established by the Chartered Professional Accountants of Canada, and KPMG has not otherwise verified the information presented in this document. KPMG expresses no opinion or any form of assurance on the information presented to it by stakeholders, and makes no representations concerning the accuracy or completeness of such information. KPMG does not accept any liability or responsibility to any third party that may use or place reliance on this document.

August, 2018

KPMG

Table of Contents

1 Executive Summary

1.1 Purpose and Objectives

In 2017, ORBA and the Ontario Asphalt Pavement Council ("OAPC") undertook a comprehensive, industry-led review of asphalt quality in Ontario ("Quality of Asphalt Review" or "the Review"). The purpose of the Review was to address current issues that negatively affect asphalt quality.

Asphalt quality issues and relevant background were gathered from a variety of sources, including:

- Publicly available information, such as prior government reviews (municipal and provincial), subsequent policy changes by owner authorities, a North American literature review and international benchmarking research;
- Consultation with ORBA and OAPC members, and a broad sample of Ontario owners, such as municipalities, regions and the Ministry of Transportation of Ontario ("MTO");
- Consultation with subject matter experts and key stakeholders, such as independent laboratories, academia, the Ontario Good Roads Association ("OGRA") and the Municipal Engineers Association ("MEA"); and
- Office of the Auditor General of Ontario, "2016 Annual Report".

The objectives of the Quality of Asphalt Review were to:

- Ensure ORBA and OAPC understand and internalize members' and owners' concerns about asphalt quality issues, such as premature cracking;
- Improve the industry's relations with and outcomes for road owners; and
- Work towards continuous improvement in industry performance as it relates to asphalt quality.

1.2 Parties involved

ORBA engaged its membership and external advisors to support the Review, which included input from the following parties:

- **The Ontario Road Builders' Association.** ORBA represents the interests of more than 200 companies in Ontario's transportation infrastructure sector. Its diverse membership consists of contractors and other goods & services providers that employ more than 30,000 people. ORBA's mission is to promote the growth of Ontario's transportation infrastructure industry through a dynamic slate of programs and services.
- **Ontario Asphalt Pavement Council.** OAPC is a Council of ORBA that was established on January 1, 2017, from the amalgamation of ORBA and the Ontario Hot Mix Producers Association. OAPC is the respected voice for asphalt producers and asphalt cement ("AC") suppliers across Ontario. Producer members represent over 95 percent of hot mix asphalt producers in Ontario.
- **KPMG Infrastructure.** KPMG Infrastructure is the largest infrastructure advisory services practice in Canada and a leader in providing commercial and financial advisory services for

infrastructure development. KPMG has provided commercial, financial, procurement and technical advisory services for major infrastructure projects and programs across North America for more than 30 years.

- **Texas A&M Transportation Institute.** TTI is a public organization focused on materials research. It provides a variety of technical research activities for U.S. departments of transportation, transportation agencies and other organizations and clients. It is widely recognized as a leading expert in best practices for asphalt design, paving and testing.
- **Global Public Affairs.** GPA is Canada's largest privately-owned public affairs and communications firm. Its Infrastructure Lab is a platform to promote collaborative approaches to designing, building and maintaining infrastructure. GPA's infrastructure-related client work extends across a multitude of sectors and areas, including transportation and local and municipal governments, among others.

1.3 Technical Findings

TTI's technical analysis of data from field projects in Ontario revealed three primary causes of premature cracking under the six MTO contracts referenced in the Office of the Auditor General of Ontario, "2016 Annual Report" and examined by TTI:

1. Dense aggregate gradations that did not provide sufficient room for the asphalt binder in the mixture, leading to mixes that were more susceptible to early cracking
2. The lack of bonding between layers of hot mix asphalt ("HMA"), which were related to the quality of specifications and oversight of tack coat application;
3. Cracks that reflected from lower pavement layers through asphalt overlays.

1.3.1 Asphalt Quality

It should be noted that TTI researchers were not able to investigate the quality of asphalt binder beyond the two sections from which samples could be retrieved (Highway 10 and Highway 12 sections referred to in the Office of the Auditor General of Ontario, "2016 Annual Report"). Generally, deterioration of binder quality plays a role in premature cracking of asphalt pavements along with other considerations such as traffic, mixture design, and pavement design. The road sections examined by TTI showed a good binder quality on Highway 10 and marginal quality binder on Highway 12, so the impacts of poor binder quality based on a narrow sample were inconclusive.

1.4 Non-Technical Findings

KPMG's primary research revealed that current owners and industry participants believe there are several asphalt quality issues that are non-technical in nature and that these topics will require long-term partnering and stronger discussion between industry and owners to address effectively. These issues include Quality Assurance ("QA") at municipal owners, the current ORBA-MTO relationship, the need for knowledge sharing, and several commercial practices.

GPA industry and owner surveys of over more than 100 respondents revealed that:

- Only 13% of survey respondents experienced no failure in the first five years following pavement. However, 85% of respondents were satisfied with the paving work delivered by contractors.
- 60% felt paving work was consistently of good quality.
- 11% found the work done to be of poor or varied quality.
- 70% of contractors felt the current approach to delivering paving was fair. However, only 44% felt it delivered value to taxpayers; and only 36% felt it delivered quality.

2 Introduction

Ontario possesses a vast paved road network. As Canada's second largest province by area, Ontario's geography covers more than 1 million square kilometres, representing an area larger than France and Spain combined.[1] The Province's roads and highways are owned and operated by a mix of municipal, regional, provincial and private authorities. In total, there are 444 municipalities in Ontario.[2]

Ontario has more than 150,000 centre line kilometers of paved roads, of which 95 percent are paved with asphalt.[3] MTO highways consist of approximately 40,000 km of highway lanes that cover a distance of roughly 17,000 km.[4]

The road-building industry in Ontario has come under increased scrutiny in recent years. Two high profile government reports[5] identified several technical and non-technical issues that affect asphalt quality on the Province's highway and municipal road networks. This report specifically or only addresses the quality of asphalt concerns.

2.1 Context

Performance problems in asphalt pavements rarely have their roots in a single cause. TTI's North American literature review and technical research[6] cited numerous changes to the ways asphalt binders and mixtures have been specified and manufactured in North America over the past three decades, having both positive and negative impacts on quality. These changes include:

- The increased use of cokers at refineries, making asphalt a valued commodity;
- The increased use of polymer additives to improve the properties of asphalt binders;
- The increased use of Polyphosphoric Acid ("PPA") to improve the high-temperature properties of asphalt;
- The increased use of re-refined engine oil bottoms ("REOB") to improve the low-temperature properties of asphalt;
- The introduction of the Superpave approach to mix design developed by the U.S. Strategic Highway Research Program (1987-1993);
- The introduction of the Superpave Performance Grade ("PG") asphalt;
- Increased use of recycled/reclaimed asphalt pavement ("RAP") during the dramatic oil price increase of 2008;
- The use of mechanistic design (i.e., design based on performance models and mathematical modelling) to ensure the structural adequacy of asphalt pavements; and

[1] Government of Ontario, "About Ontario", available at: https://www.ontario.ca/page/about-ontario
[2] Association of Municipalities Ontario, "Homepage", available at: https://www.amo.on.ca/Home
[3] Ontario Asphalt Pavement Council, "2017 Asphalt Fact Sheet", available at: http://www.onasphalt.org/files/factsheets/2017%20Asphalt%20Fact%20Sheet%20FINAL.pdf
[4] Office of the Auditor General of Ontario, "2016 Annual Report", available at: http://www.auditor.on.ca/en/content/annualreports/arreports/en16/v1_310en16.pdf
[5] Ibid; and, for example, Toronto Auditor General, "Improving the Tendering Process for Paving Contracts," 27 June 2016
[6] Texas A&M Transportation Institute, "A Review of Ontario Asphalt Industry Practices", draft report, 22 January 2018

- The use of improved methods and specifications to achieve mixture density in the field.

Additionally, across North America and abroad, other factors have changed the performance of existing roadways. For example, the increased volume and weight of commercial trucks and the evolution from green-field construction to ongoing maintenance and rehabilitation have led to new quality challenges.

While inter-jurisdictional comparisons are inherently difficult and should be evaluated only at a high-level, KPMG examined four jurisdictions with similarities to Ontario's network: Indiana, Michigan, the United Kingdom and New South Wales in Australia.[7] Key findings from this jurisdictional research included:

- According to MTO's *Pavement Condition Data Catalogue*, 14% of Ontario's highway network is rated as poor condition.[8]
- According to the U.S. Department of Transportation's *Roads and Bridges Data*, 17% of Indiana's highway network is rated as poor condition.[9]
- According to Michigan's *Annual Road and Bridge Report*, 39% of Michigan's highway network is rated as poor condition.[10]

Unlike Ontario and the two U.S. states reviewed, the United Kingdom and New South Wales collect information based on their total road network, as opposed to their highway network.

- According to the Asphalt Industry Alliance's *Road Maintenance Survey*, 17% of the United Kingdom total road network is rated as poor condition.[11]
- According to New South Wales's *Roads and Maritime Services Annual Report*, 20% of the New South Wales total road network is rated as poor condition.[12]
- According to the Association of Municipalities Ontario's 2015 State of Ontario's Roads and Bridges Study, 34% of Ontario's municipal road network is rated as poor condition, in contrast to the MTO figure cited above, which is specific to Ontario's highway network.[13]

[7] Comparisons of pavement condition across jurisdictions should be made cautiously given variations in terminology and data collection methodologies. However, "poor condition" is a common term used in much the same way – in a technical sense – across Canada, the United States, the United Kingdom and Australia. Data presented here is raw data from primary sources on pavement condition from each jurisdiction. It is presented at ORBA's request and for the reader's information.
[8] MTO, "Pavement condition for provincial highways," 29 June 2016, available at: https://www.ontario.ca/data/pavement-condition-provincial-highways
[9] U.S. Department of Transportation, "Road and Bridge Data by State", available at: https://www.transportation.gov/policy-initiatives/grow-america/road-and-bridge-data-state
[10] Michigan Transportation Asset Management Council, "2016 Annual Report", 2 May 2017, available at: https://www.michigan.gov/documents/tamc/TAMC_Press_Release_2016_Annual_Roads_Bridges_Report_ 601734_7.pdf
[11] Asphalt Industry Alliance, "Annual Local Authority Road Maintenance Survey", 28 March 2017: http://www.asphaltuk.org/wp-content/uploads/ALARM-2017.pdf
[12] Government of New South Wales, "Annual Report 2016-17", available at: http://www.rms.nsw.gov.au/about/corporate-publications/annual-report/documents/RMS_Annual-Report-2016-17-VOLUME-1.pdf
[13] Public Sector Digest, prepared for the Association of Municipalities of Ontario, "State of Ontario's Roads and Bridges," 2015, available at: https://www.amo.on.ca/AMO-PDFs/Gas_Tax/Roads-and-Bridges/Roads-and-Bridges-Study-March-2015.aspx

2.2 Approach

ORBA commissioned independent, fact-based research that reviewed asphalt quality issues in Ontario from different perspectives and made recommendations for consideration. In order to evaluate a balanced evidence base, the Quality of Asphalt Review incorporated input from a variety of viewpoints, such as those from industry, owners and subject matter experts. These perspectives supplemented the secondary research. Given the complexity of the topic and lack of publicly available data[14], the Review used a variety of methodologies:

- TTI technical review of sample roadway sections in Ontario and literature review;
- GPA surveys and focus groups; and
- KPMG stakeholder interviews and jurisdictional research.

Each of these three research efforts are described in the following three sub-sections.

Key findings and recommendations from the Technical and Non-Technical research are described in Chapters 3 and 4 respectively. Based on the recommendations, ORBA worked with KPMG to prepare a framework for continuous improvement, presented in Chapter 5.

2.2.1 TTI Review

ORBA engaged TTI to conduct forensic analysis of six paving contracts cited by a recent Ontario government review of MTO road infrastructure.[15] TTI's review consisted of three inter-connected components:

1. A forensic analysis of the six Ontario roadway sections identified in the government review so that ORBA could better understand the technical causes of these specific pavement failures;[16]
2. A technical investigation into various issues cited by the government review to inform ORBA members of the broader technical context and background of these issues; and
3. A technical review of the potential implications of recent specification special provisions implemented by MTO[17] in response to the government review.[18]

[14] High-level data on overall pavement condition is available and appears to indicate that Ontario has similar or better outcomes than comparable jurisdictions. However, data on specific quality failures, such as premature cracking – and related causes – are not systematically tracked, aggregated or reported by owners in Ontario.
[15] Office of the Auditor General of Ontario, "2016 Annual Report", available at: http://www.auditor.on.ca/en/content/annualreports/arreports/en16/v1_310en16.pdf
[16] To assess the relevant issues, TTI performed (i) a literature review; (ii) physical identification of the pavement sections; (iii) retrieval of material samples from two roadways; (iv) a review of design, construction, traffic and performance information; and (v) a laboratory study.
[17] MTO changed several items in its specifications including adding asphalt binder tests, such as the extended-aging bending beam rheometer (EBBR) and the double-edge notch tension (DENT) test, eliminating incentives from specification pay items, and changing the density requirements for in-place asphalt mixtures. See also: MTO, "Action Plan for Highway Construction Contracts and Oversight", 17 February 2017.
[18] At the request of ORBA, TTI reviewed the following MTO Special Provisions and other documentation: (i) No. 111F09M: Additional Test Results and Samples for Performance Graded Asphalt Cement (March 2017); (ii) No. 103F31M: Asphalt Concrete Surface Smoothness (March 2017); (iii) 103F03: Amendment to OPSS 313, November 2016 (March 2017); and (iv) SP 103F03: Asphalt Mix Properties/Compaction (March 2017).

2.2.2 GPA Review

GPA surveyed more than 100 contractors and owners to assess the current approach to paving contracts in Ontario. Additional insights were gathered through smaller discussion groups, direct meetings and roundtables. MTO and municipal owners through OGRA and MEA were consulted during these sessions.

2.2.3 KPMG Review

KPMG performed three advisory services:

1. Project oversight and liaising with impacted stakeholders, including MTO senior leadership; 1 private toll road (407 ETR); 3 regions (Peel, Durham and Waterloo); and 12 municipalities (London, Mississauga, Brampton, Vaughan, Windsor, Markham, Toronto, Kingston, Middlesex County, County of Peterborough, Hamilton and East Ferris).[19] In addition to the extensive industry survey and consultation process undertaken by Global Public Affairs, KPMG undertook targeted industry and subject matter expert consultations to supplement its primary research.
2. Review of non-technical industry issues that may affect asphalt quality (e.g., procurement, commercial terms, construction, operations & maintenance) and jurisdictional benchmarking.[20]
3. Working with ORBA and OAPC to develop a continuous improvement framework and final report synthesizing all findings and recommendations.

[19] This sample of owners represents approximately 92,000 kilometers of road network, which forms over 62% of the paved roads in the province of Ontario.

[20] Specifically, KPMG performed initial research to review global pavement industry practices and outcomes, including those in the United States (Indiana, Michigan), Canada (British Columbia, Newfoundland and Labrador, Saskatchewan), the United Kingdom, Australia, New Zealand, Singapore, Norway, Finland and Sweden. From the initial research and in consultation with ORBA, KPMG investigated further Indiana, Michigan, the United Kingdom and New South Wales (Australia) based on their general similarities to Ontario's network, such as the commercial context, geography, economy/demographics and environment.

3 Technical Findings

TTI's technical analysis of data from field projects in Ontario revealed three primary causes of premature cracking under the six MTO contracts examined[21]:

- Dense aggregate gradations that did not provide sufficient room for the asphalt binder in the mixture, leading to mixes that were more susceptible to early cracking.
- The lack of bonding between layers of hot mix asphalt ("HMA"), which were related to the quality of specifications and oversight of tack coat application;
- Cracks that reflected from lower pavement layers through asphalt overlays.

3.1 Asphalt Quality

It should be noted that TTI researchers were not able to investigate the quality of asphalt binder beyond the two sections from which samples could be retrieved (Highway 10 and Highway 12 sections referred to in the Office of the Auditor General of Ontario, "2016 Annual Report"). Generally, deterioration of binder quality plays a role in premature cracking of asphalt pavements along with other considerations such as traffic, mixture design, and pavement design. The road sections examined by TTI showed a good binder quality on Highway 10 and marginal quality binder on Highway 12, so the impacts of poor binder quality based on a narrow sample were inconclusive.

3.2 Forensic Investigation

TTI's research team reviewed literature relevant to the performance of asphalt pavements in Ontario. The literature concerning the relationship between the quality of asphalt in Ontario and asphalt pavement performance is plentiful. TTI found that most of the effort in Ontario seems to have been directed toward the oxidative aging (embrittlement) of the binders that occurs over time and the cold temperature behavior causing the waxy materials in the binder to precipitate out (physical hardening). Oxidative aging occurs in all asphalt binders and it is non-reversible, whereas the physical hardening only occurs during periods of cold temperature and is reversible. Physical hardening has occurred in some asphalt binders in Ontario.

Two tests were developed to capture these behaviors and became part of MTO's asphalt specification:

- The double-edge notch tension ("DENT") test is intended to quantify the oxidative hardening characteristics. The DENT test is an intermediate temperature (15^{o}C) procedure in which the recovery of the aged binder after fracture is used as a measure of oxidative hardening.
- The extended bending beam rheometer ("EBBR") test is intended to capture the physical hardening characteristics of the aged asphalt binder after conditioning at very low temperatures for 72 hours.

Both of these tests can serve their intended purposes; however, TTI proposed that the DENT test could be replaced with less costly and time-consuming alternatives, and the EBBR test could either be replaced or improved by developing a shortened version. Results of TTI field trials revealed that

[21] This chapter on TTI's technical research is largely drawn directly from an Executive Summary document prepared by TTI for ORBA on 4 March 2018.

cracking was better predicted by using the standard BBR after only one hour of conditioning (AASHTO M320) than by using the EBBR method.

The Office of the Auditor General of Ontario, "2016 Annual Report" review had identified six field projects that cracked prematurely.[22] After technical review of these projects, TTI's forensic investigation revealed three primary causes for these pavement failures:

- The lack of bonding between layers of HMA;
- Cracks reflecting from existing lower pavement layers through asphalt overlays; and
- Dense aggregate gradations that do not provide sufficient room for the asphalt binder in the mixture or coarse gradations which may be sensitive to asphalt content, thus limiting the amount of asphalt in the mixture and which may be overly permeable.

These causes are described herein.

3.2.1 Lack of bonding between layers of HMA

Materials from only two of the six projects could be recovered and tested, which was not enough to conclude whether there is wide-spread asphalt binder problems. However, testing revealed that of the two projects one had excellent aging resistance while the other had marginal to poor aging qualities. Both of these projects cracked prematurely, leading TTI researchers to a more in-depth study on the asphalt mixtures' components and behaviors via a review of records. The information came from a combination of pavement design reports, asphalt mix design reports, QC/QA records and forensics reports provided by MTO and some contractors involved in these projects.

The chemical and rheological testing of binders extracted from the materials that could be obtained from the two projects was extensive. The chemical testing performed by TTI included Fourier Transform Infrared ("FTIR") analysis to examine the Carbonyl Area ("CA"), Saturates-Aromatics-Resin-Asphaltenes ("SARA") analysis to determine the stability of asphalt fractions and X-Ray Florescence ("XRF") to determine the presence and estimated quantity of possible additives, such as REOB. For the two sites where binder could be extracted from the asphalt mixture, one site showed potential for early aging and the other showed excellent resistance to aging. Neither site demonstrated the characteristics that would indicate the presence of REOB.

The rheological testing performed by TTI included Dynamic Shear Rheometer ("DSR") characterization at higher temperatures including stiffness ("G*"), aging susceptibility and the Multiple-Stress Creep Recovery ("MSCR") testing. The DENT test was used as another measure for aging susceptibility. Low-temperature testing of the binder was completed using the BBR and EBBR tests as adopted by the MTO. The researchers concluded that the DENT and EBBR tests – while they could identify problems with aging and low-temperature precipitation of waxy components which makes the binder stiffer – could be replaced with other test methods and shorter duration tests.

In at least four of the projects, de-bonding of pavement layers occurred, as the example in Figure 1 below illustrates.

[22] Office of the Auditor General of Ontario, "2016 Annual Report", available at: http://www.auditor.on.ca/en/content/annualreports/arreports/en16/v1_310en16.pdf

Figure 1: Hwy 400 Core exhibiting de-bonding in the surface and lower layers. Pre-design investigative core, Highway 400; McIntosh Perry, Hwy 400 Southbound)

Generally, when pavement layers are not firmly bonded to one another, they operate independently, which results in strains that are very much higher at the layer interface than when bonding is present. The result is that the pavement cannot transfer the strains to the lower layers and the layers crack in a much shorter time (often by about 90%) than the anticipated pavement design life.

If the pavement becomes coated in dust or mud after milling or the application of the tack coat, the bond may be severely affected because the materials to adhere the layers are not in direct contact with one or both layers. In addition, if the tack coat asphalt binder is diluted with water or the application rate is light the strength of the bond will be lower which can result in the stresses overcoming the bonding between layers. Finally, if too much equipment is allowed to traffic the tack coat, the tack coat will adhere to the tires and be removed from the pavement surface.

Options to resolve this problem include reviewing the current tack coat specifications and adjust them according to leading practice, such as allowing new types of tack coat, reducing the allowable traffic on tacked surfaces, and reviewing the tack coat application rate.

3.2.2 Cracks reflecting from existing lower pavement layers through asphalt overlays

In at least one of the pavements, the underlying pavement was cracked in its full depth prior to constructing an overlay (Figure 2).

Figure 2: Hwy 10 cores showing full-depth cracking (Golder Associates, 2004)

(Hwy 10, pre-design cores; Golder Associates 2004)

These types of underlying cracks will continue to actively move after the placement of an overlay and will greatly shorten the anticipated pavement design life. There are a number of ways to temporarily delay the onset of reflection cracking, such as the use of flexible interlayer materials or asphalt mixtures. However, TTI researchers believe that the only way to eliminate the problem is to either remove (mill) the existing pavement to the depth of the crack and replace it, or to use a "cushion" layer of unbound aggregate with a thick asphalt overlay.

3.2.3 Dense aggregate gradations

Based on documentation provided by contractors and MTO, all the pavement sections researched showed manifested issues with the design and production of the asphalt mixtures, for example insufficient asphalt content or very dense aggregate gradations.

This finding must be considered within the broader context of the Superpave system that was adopted in the mid-1990s. Superpave is a combination of aggregate quality and gradation guidance, a method to select asphalt binders, and a mixture design approach, which collectively are intended to improve the performance of asphalt pavements. However, as with any new technology, there were unforeseen problems that required years to correct.

For instance, mixtures designed for the highest levels of traffic were compacted to the point that they contained insufficient asphalt, making them brittle and susceptible to cracking. One of the biggest problems with the implementation of Superpave was that all of the decisions on mixture design were based upon rules-of-thumb and empirical relationships between volumetric parameters (air voids and asphalt content) and pavement performance outcomes developed decades prior. While there was supposed to be performance testing included in the implementation of Superpave (i.e., simple shear test), the test was never adopted by most U.S. Departments of Transportation due to its high cost.

The goal of asphalt mixture design is to proportion the asphalt, aggregate, and any additives to achieve performance goals while minimizing costs. In implementing the Superpave system, the assumption made by many was that, if the mixture was designed according to Superpave guidelines, the goal of enhancing asphalt performance would be achieved. However, there were flaws in the mix design system that were revealed with time and that were ultimately corrected. One

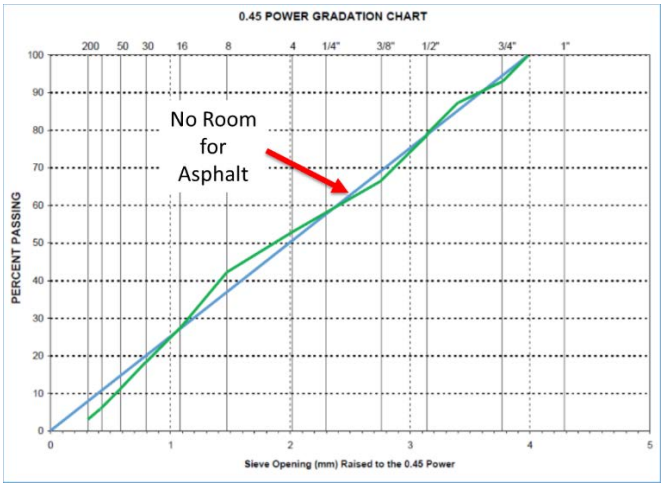
of these issues was that the gradation for specific mixtures had very broad bands, and the practice was to select any gradation that would fit between the boundaries. The bands were broad in order to allow mix designers to choose a gradation that would be feasible with local materials. In order to economize, some mix designers selected gradations where the aggregate occupied as much space as possible in the mixture to minimize the amount of asphalt binder, the most expensive component in the mixture.

In Figure 3, the “line of maximum packing” is shown in blue as a straight line extending from the ordinate to the largest sieve size. The gradation of the aggregate, shown in green, follows the line of maximum packing and there is little room left for the binder.

Figure 3: Example of Dense-Packed Gradation.

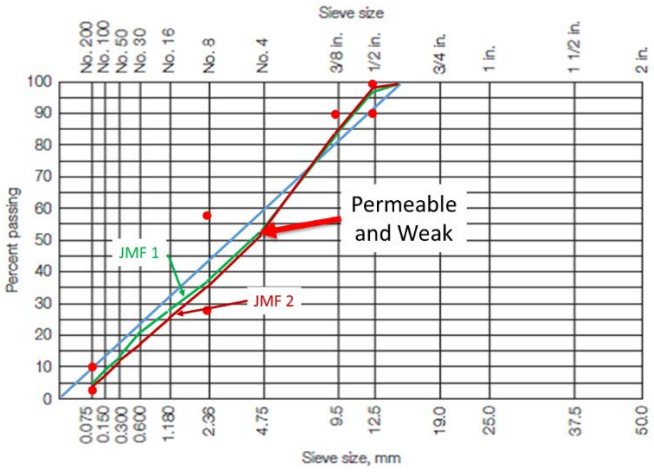
(NOTE: Green line: Size distribution of aggregate

Blue Line: Line of maximum packing (i.e. line that allows maximum volume of aggregate into the mix))



Also, because the bands were large, mix designers sometimes bent the gradation to go below the line of maximum packing (Figure 4). This type of coarse gradation can be beneficial in certain circumstances but it can also lead to low asphalt content and permeable mixtures that can be weak and susceptible to cracking.

Figure 4: Example of Coarse Gradations.



The gradations used in the mixtures on the contracts cited by the Office of the Auditor General of Ontario, "2016 Annual Report" in at least 4 projects led to low asphalt content values, creating a situation where there was little binder in the mixture to hold the aggregate together. Thus the mixture lacked cohesion and, through a combination of traffic and temperature changes, it cracked. All the mixtures examined by TTI had asphalt content values ranging between 4.5 and 5.0%. For a cold climate like Ontario, TTI researchers would expect to see asphalt contents of 0.5 to 1.0% higher at least. TTI suggested options to address these issues:

- Specifying a higher minimum asphalt content;
- Lowering the laboratory compaction effort (number of gyrations) in laboratory compaction;
- Lowering the air void content of the mix to allow more asphalt; and
- Introducing cracking testing on the asphalt mixes prior to finalizing a mix design.

3.3 Technical Investigation

In order to inform ORBA and OAPC members of the broader technical context and background of the issues cited by the Office of the Auditor General of Ontario, "2016 Annual Report", TTI investigated several related issues.

3.3.1 Testing

The Office of the Auditor General of Ontario, "2016 Annual Report" highlighted that the MTO had not adopted the DENT and EBBR tests within a 5-year time frame after they were developed. TTI researchers pointed out in their review that in the context of asphalt pavement industry-owner practice, it is not unusual for these types of changes to testing methods to take years or even decades to be adopted. It can also be noted that neither of these two tests have been adopted by other North American highway agencies as of this time.

The relationship between measures of a material's physical behavior and pavement performance is essential when using test results as an indication of expected pavement performance. The DENT and EBBR tests were correlated to the cracking performance of asphalt pavements from two different causes.

TTI cautioned against translating research into implementation in most instances as (i) there should be a search to streamline or use a simpler existing testing method, (ii) relationships between test results and performance must be established, (iii) the repeatability and reproducibility of results need to be quantified, and (iv) methods and specifications must be changed and phased-in to practice.

3.3.2 Industry-Owner Collaboration

User-producer groups exist to facilitate communication between the private and public sectors, and to work collaboratively on products, education, practices, test methods and standards. The degree of collaboration between ORBA and MTO was cited as being too close for appropriate oversight.

The function of user-producer groups is to ensure that the changes to specifications are reasonable and can be implemented in the field. For instance, the EBBR test, as proposed, requires that shipments of asphalt from suppliers to contractors be delayed three days in order to complete the testing. That would mean constructing a great deal of storage capacity and expending excess energy to keep the material hot for that period of time. Not only would this be an economic burden on the producer, it would also have an unwanted environmental impact (burning fuel to maintain heat in the tanks). Considering shorter conditioning times may be a helpful solution. TTI researchers believe one day of conditioning should be adequate.

3.3.3 Bonuses

The Office of the Auditor General of Ontario, "2016 Annual Report" stated that MTO paid bonuses "for meeting the requirements of the contract, something contractors are always expected to do."[23]

TTI noted that the general intention of bonuses in these types of contracts is to incentivize contractors to provide materials with superior levels of desired characteristics, such as density and ride quality. Similarly, penalties are used as disincentives for inferior quality. The greatest amount of bonus payment is awarded to contractors who meet the highest quality standard with the best uniformity. These bonus/penalty mechanisms are widely used around the world on many infrastructure projects.

3.4 Specifications Review

MTO recently modified several specifications related to asphalt quality. TTI's review of these specification changes are described in the following sub-sections.

[23] Office of the Auditor General of Ontario, "2016 Annual Report", available at: http://www.auditor.on.ca/en/content/annualreports/arreports/en16/v1_310en16.pdf

3.4.1 DENT and EBBR Tests

Currently MTO is the only major North American transportation agency that has implemented EBBR and DENT tests for low temperature PG. TTI reviewed the tests and criteria used by other agencies in the North America. From this review, TTI found that none of the 51 transportation agencies (DOTs in 50 states and District of Columbia) in the United States have yet adopted EBBR and DENT tests (Asphalt Institute, 2018). Binder durability issues in 11 states have been addressed using the MSCR multiple stress creep recovery test along with either the ductility or elastic recovery tests per AASHTO specification.

3.4.2 QA/QC Samples

Special Provision No. 103F03, "Hot Mix Asphalt – End Result" directs that the QA sample be taken at the same time as the QC sample. The U.S. Federal Highway Administration recommends that the sampling for these two purposes should be independent of each other.[24]

3.4.3 Asphalt Content

It is noted in the specifications (OPSS 313.07.08) that the Job Mix Formula determined asphalt content may be lowered by 0.2% during production. In TTI's view, this may actually contribute to the cracking issues, as the tolerance band during construction is ± 0.5%. The recent MTO requirement that fine gradations will be the default is certainly a move in the right direction as it will result in more asphalt being used in the mix.

3.4.4 Bonuses

Pay adjustment factors have been changed from bonus and penalty to penalty alone [OPSS 313.10.01.02]. Under the new specification, the contractor has less monetary incentive to provide a higher quality product, and the level of quality may suffer. In addition, contractors potentially will respond with higher bid prices eventually to make up for revenue lost.

3.4.5 Air Voids

TTI researchers noted that voids in the pavement are controlled by voids in mineral aggregate ("VMA") – that is, space between aggregate particles – rather than the percent air voids. VMA are dependent upon the combined bulk specific gravity of the aggregate which will change during production, and not accounting for this change in the gravity of the aggregate will lead to errors in the measurement of air voids in the mixture.

It is suggested that the MTO control voids in the mixture on the basis of percent air voids in the mixture.

[24] Burati, J.L., R.M. Weed, C.S. Hughes, H.S. Hill (2002) Optimal Procedures for Quality Assurance Specifications. Report No. FHWA-RD-02-095. Federal Highway Administration, Washington, DC.

3.4.6 RAP Content

In 2017, MTO modified the OPSS 1151 & SP111F06 to disallow RAP from the surface course asphalt. This is in line with recent trends in other jurisdictions. However RAP content in the binder course is still allowed up to 40% content.

The overuse of RAP and recycled asphalt shingles ("RAS") has created a number of problems for both agencies and contractors. RAS, in particular, contains extraordinarily hard asphalt that is not likely to be rejuvenated and contribute to the binding qualities of the mixture. RAP, on the other hand, is generally less aged than roofing asphalt. Using RAP in modest quantities (e.g., 10 to 15%) in the surface course, with appropriate adjustments in the grade of the virgin binder, could work well to help the industry lower costs for delivering paving contracts to taxpayers, and would be environmentally friendly. Using modest amounts of RAP in the wearing course has worked well for many road owners for decades.

3.5 TTI Recommendations

Based on the key findings of the technical research, TTI recommends the following actions to address quality of asphalt issues in Ontario:

- Tack coat should generally be treated as separate contractual item from the HMA items, with robust specifications attached. Tack coat should include instructions concerning the rate of application in terms of residual asphalt and criteria concerning the cleanliness of the surface being tacked. Industry and owners should work together to advance research into the characteristics of tack coat alternatives for Ontario traffic conditions, such as the effects of layer thicknesses and traffic loads.
- Increasing the asphalt content of mixtures must be a high priority for improving pavement performance. One way to achieve this is to regress to a 3% Air Void level. This approach is being used by the Michigan Department of Transportation. Essentially the mixture is compacted to the asphalt content at 4% air voids, and then the mixture design asphalt content is regressed to the 3% air void level. Using the asphalt content for 3% voids ensures that more asphalt is used in the mixture.
- Pending further research and specification strengthening, overuse of PPA, roofing shingles and REOB should be avoided.
    - The overuse of PPA should be avoided while research advances in understanding its impacts on asphalt durability in Ontario weather conditions. Future research is required and the development of adequate specifications around the use of PPA would be beneficial.
    - Overuse of roofing shingles should be avoided. Rheological tests giving appropriate emphasis to binder phase angle should be able to pick up and control overuse of such materials.
    - REOB can be restricted with chemical identification tests, such as XRF. Generally, overuse of REOB should be avoided.
- MTO should evaluate further the predictive capabilities of Standard BBR compared to the Extended BBR for binders as extracted from aged pavement surfaces.

- Owners should validate asphalt binder hardening rates with Differential Scanning Calorimetry wherever possible.
- Some states such as Texas, Louisiana, California, New Jersey and Illinois have incorporated asphalt mixture cracking and rutting tests into their specifications. This would make an excellent research project for the industry and MTO to undertake.
- TTI believes there is an opportunity for Ontario researchers and asphalt technical practitioners to work with NCHRP 9-60 to evaluate rheological parameters for their ability to replace DENT as the PG (performance grading) parameter for age-induced surface cracking, for example, considering ΔTc before and after extended BBR, Glover-Rowe, loss tangent, crossover temperature and frequency, R-value and crossover modulus.

4 Non-Technical Findings

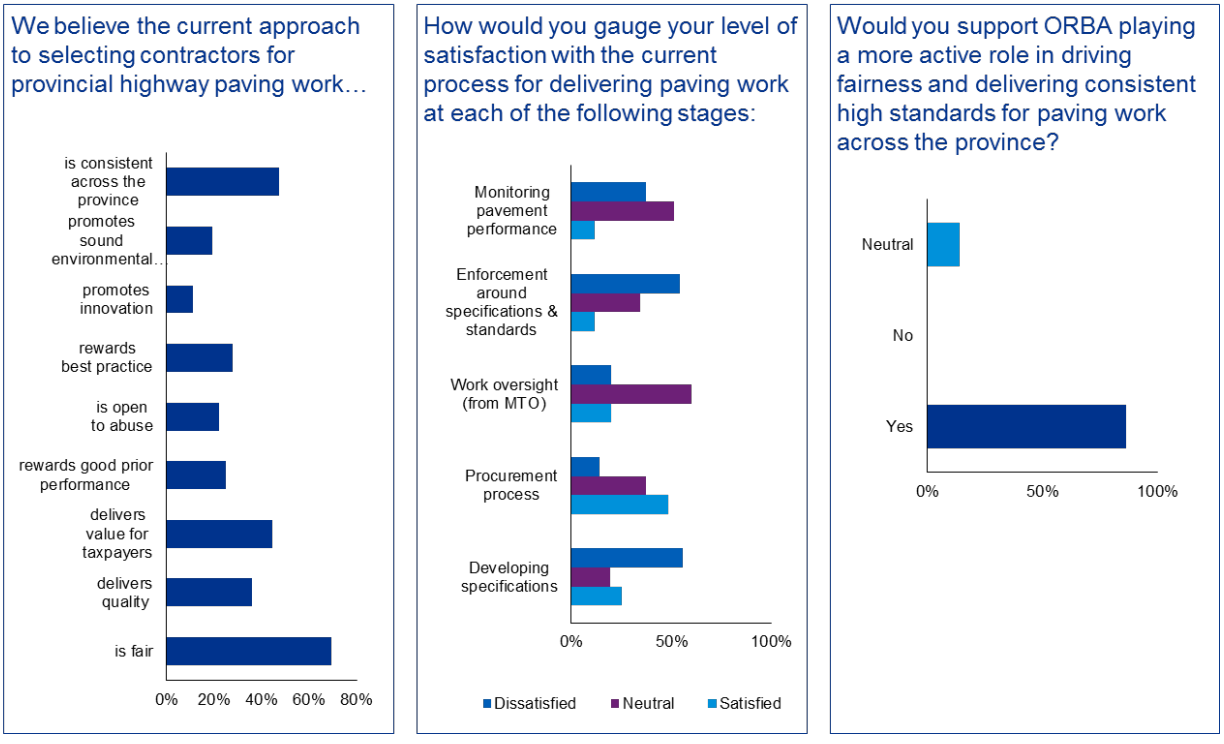
4.1 GPA Findings

GPA industry and owner surveys of over more than 100 respondents revealed that:

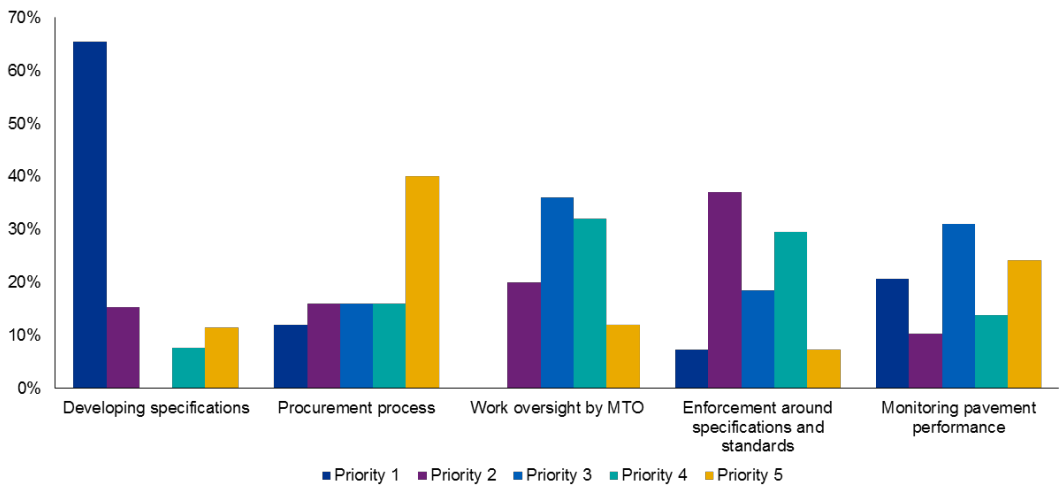
- Only 13% of survey respondents experienced no failure in the first five years following pavement.
- However, 85% of respondents were satisfied with the paving work delivered by contractors.
- 60% felt paving work was consistently of good quality.
- 11% found the work done to be of poor or varied quality.
- 70% of contractors felt the current approach to delivering paving was fair.
- However, only 44% felt it delivered value to taxpayers; and only 36% felt it delivered quality.

In focus group consultations, respondents stated that the “lowest-bid wins” procurement philosophy has, over time, reduced pavement quality. Roads are now requiring repairs much earlier than contract specifications. Additional survey responses are presented in the figure below.

Figure 5: GPA Survey Results



What specific actions would you like to see taken to deliver fairness and quality in paving contracts?



What changes would you like to see in the following stages of paving work that would deliver more fairness, quality and value?

Answer Choices	Responses
More effective process around developing specifications	79.31%
Uniform industry standards across province	79.31%
Strictly enforced industry code of conduct from ORBA	58.62%
Move beyond pure cost in procurement (eg. take into account prior performance, quality)	65.52%
More independent inspections/oversight	31.03%
Stricter penalty system for serious offences	27.59%
Incentive-based around performance	79.31%
Greater transparency on performance of pavement	75.86%
Other	6.90%
Total Respondents: 29	

4.2 KPMG Findings

KPMG's primary research revealed that current owners and industry participants believe there are several asphalt quality issues that are non-technical or commercial in nature and that these topics will require long-term partnering and stronger discussion between industry and owners to address effectively.

During the interview process, several factors were frequently cited by industry, owner and subject matter experts as contributors to Ontario's past history of high asphalt quality:

- Dense, locally sourced aggregates;
- High-quality petroleum products (asphalt binders);
- Broad-based owner and industry technical expertise in asphalt issues;
- Hands-on MTO engagement; and
- Well-funded municipal public works departments.

KPMG interviewees consistently cited the following issues as causes of current asphalt quality issues in Ontario, dating at least to the early-2000s:

- Governmental budgetary pressures requiring regional and municipal road owners to "do more with less", resulting in an exclusive focus on price competition for selecting pavement contractors using the lowest-compliant bid procurement model;
- Petroleum products used in AC became "over-refined" and of lower quality than in the decades preceding the early-2000s;
- Increased use of waste oils and other additives in the asphalt cement;
- Increased use of recycled aggregates and pavements included in surface hot mix asphalt design;
- Significant proliferation of unique and consistent asphalt specifications across owners, particularly at the municipal level;
- In the late-1990s the Province downloaded control of a number of provincial roadways to the municipalities and wound down a number of municipal road and transit subsidy programs. MTO is seen by most municipal owners as a leading organization in the areas of research and engineering of asphalt pavements. The resulting decrease in MTO involvement in municipal road management and maintenance was cited as a contributing factor of quality issues since the early-2000s; and
- Testing methods developed during the Superpave reforms were not well-suited to reliably indicate expected performance.

In addition, interviewees from MTO and several regional and municipal owner authorities stated that they believed the root cause of asphalt quality issues in Ontario was primarily AC quality, and that some industry participants sought to reduce costs but still meet specifications, through modifications to AC.

By contrast, interviewees from industry (contractors) frequently emphasized that poor design, inconsistent QA among municipal owners, less collaboration with MTO, and lack of robust asset management and maintenance processes were the more important causes of poor asphalt quality.

The following sub-sections describe key findings and recommendations on non-technical issues.

4.2.1 Quality Assurance at municipal owners

Interviewees stated that Quality Assurance ("QA") processes and practices were a significant contributing factor to poor asphalt quality in Ontario. MTO oversight on paving contracts was viewed by industry and several owners as strong and adequate. By contrast, QA processes and resource levels at most municipal and regional owners, with exceptions, was seen as considerably weaker, including a decline in asphalt expertise within municipal roads departments, insufficiently rigorous inspections, or inconsistent testing practices.

When comparing to MTO standards of quality assurance and resource levels, it was found that at a municipal level there are generally not enough qualified inspectors to provide adequate supervision and inspection of road pavement contracts. This was recognized by municipal owners and was frequently cited to be associated with budgetary constraints.

There was a broad-based perception in the industry and among many owners that, as a result of insufficient QA practices at a municipal level, there are contractors underbidding on projects because they anticipate they can "get away with cutting corners", resulting in an un-level playing field, lower asphalt quality and negative effects on industry's reputation as a whole.

As a specific example, generally owners tend to outsource the QA role to external consultants or testing houses to keep internal QA staff costs at a minimum. This generally places excessive reliance on external engineering firms (versus building an appropriate internal QA team), and leads to low visibility and transparency over asphalt plant QC processes. Most owners do not have an owner's engineer regularly visit the refinery, the asphalt plant, or the aggregate quarry to inspect or verify quality processes at these source locations. Most owner inspectors are also not usually fully technically trained to fully understand the asphalt cement or hot mix asphalt chemistry and manufacturing processes.

This is in contrast to construction contractors who usually undertake the majority of testing at source and in the field, as part of their QC processes. In fact, many of the larger pavement contractors have vertically integrated the manufacturing component (i.e., they would own and operate asphalt plants), which forces them to focus on controlling and providing direct oversight of asphalt manufacturing processes.

Given challenges related to source control and protection of intellectual rights at refineries, some owners (including MTO) are only testing samples from the field rather than also trying to trace the asphalt cement quality back through the supply chain. This has transferred the risk of errors in the design mix to contractors and forces the private sector to self-police the quality of asphalt cement. Many owners (particularly the municipalities) face budgetary constraints that make it difficult to grow their QA teams and extend QA processes and controls.

4.2.1.1 Recommendations

ORBA should work with owners to review and support recommendations to increase the minimum required ratio of qualified municipal owner QA inspectors per lane kilometer of resurfacing, and

work with OAPC and the Canadian Council of Independent Laboratories ("CCIL") to increase the frequency of testing for conventional tests (Compaction and Air). Larger municipalities should target to adopt an in-house structure of at least 50% of the inspectors directly employed (with the remaining 50% employed by independent QA laboratories). Owners should have at least two QA inspectors per project with at least one QA inspector on-site fulltime. Inspectors should not oversee several projects simultaneously.

The development of QA processes that allow owners to independently verify the quantities of REOB in asphalt cement and the amount of RAP in asphalt are key issues that the international scientific community and American Association of State Highway and Transportation Officials ("AASHTO") in particular have not yet addressed effectively. ORBA and MTO/municipal owners could work with OAPC and the CCIL to design an accepted QA process and a specific test that enables owners to independently verify, weigh, control, and record the quantity of RAP that goes into hot mix asphalt in the plant. Industry stakeholders should agree and set RAP content testing frequencies that ensure specified quantities are not exceeded.

MTO and municipal owners should also design and enforce stronger independent QA inspection programs at refineries producing AC, and at independent AC supplier facilities (AC terminals).

Finally, owners and asphalt producers should work together to design and provide specific training to municipal QA inspectors around industrial processes and controls in AC manufacturing plants.

4.2.2 Strengthening the ORBA-MTO relationship

There is an opportunity to strengthen the ORBA-MTO relationship, promoting increased trust and collaboration towards the common goal of improving asphalt quality in Ontario.

In contrast to a prior, more collaborative relationship between ORBA and MTO, industry now feels that discussions occur on a "need to know" basis.

Some ORBA members believe that MTO should have been more consultative, transparent and forthcoming about recent changes to specifications. Many contractors also believe that MTO could generally share information more openly with ORBA, particularly around testing and research, new specifications, or changes to procurement methods and contracts.

On the other hand, ORBA leadership acknowledges that they could have involved MTO and other owners more closely in key initiatives or discussion on asphalt quality issues and industry task forces and forums, given MTO's vast experience in asphalt research, technology and management.

4.2.2.1 Recommendations

Both organizations should make every effort to maintain trust and increase collaboration. This starts at the top, with senior ORBA leadership and MTO officials setting the example.

ORBA and MTO should work together to develop a Memorandum of Understanding ("MOU") to communicate and acknowledge remaining concerns and to identify a formal go-forward engagement process. Key to successfully re-setting the relationship will be:

- Reducing the number of participants from both sides that participate in bilateral meetings;
- Elevating the seniority of attendees from each organization;

- Establishing clear rules of engagement and ensuring meetings are conducted in an open, collaborative manner;
- Identifying a concise list of tangible issues that could be advanced in the near term ("quick wins");
- Including independent advisors to ensure actions are recorded and pursued, to allocate responsibilities, and to drive the implementation of the actions decided. In addition, an independent third-party could help ensure transparency and facilitate collaboration;
- Establishing milestones for measuring progress on longer-term objectives, including the allocation of individual responsibilities and due dates for individual accountabilities and actions;
- Scheduling of a bi-annual partnering workshops where external training could be provided on contracting principles, best practices around QA and project oversight, collaboration cases and lessons learned from other jurisdictions[25]; and
- Addressing any specific complaints or conflicts separately and outside of the consultative process.

Several of these actions, or a similar framework, would be beneficial for formalizing ORBA's relationship with OGRA.

4.2.3 The need for specification consistency and training

Interviewees stated consistently that there has been a relative decrease in asphalt technical knowledge among municipal owners relative to the levels of asphalt technical expertise that existed in the 1970s to 1990s. This was partly associated to the lesser influence and leadership of MTO engineers over municipal pavement matters.

Interviewees stated their perception that as the previous generation of asphalt experts in Ontario retire, not enough younger technical experts are replacing them.

This has contributed to gaps in engineering design supervision, setting specifications, asphalt chemistry knowledge, hot mix design supervision, contract enforcement and project oversight.

Other general themes that arose in the interviews were:

- Industry interviewees believed that asphalt mix designs need to be stamped by professional engineers, which is currently not always the case.
- Specifications are not sufficiently consistent across municipal owners, they vary from one municipality to another.
- "Copy and paste" designs are frequent in the industry causing constructability and quality issues.
- A training and certification process for asphalt pavement technicians does not currently exist in Ontario. As a result, many owner inspectors did not have the technical expertise required to perform effective pavement design and construction oversight.

[25] The Asphalt Pavement Association of Indiana—Indiana Department of Transportation ("APAI-INDOT") partnering agreement in the United States is a useful model and framework to consider.

- Lessons learned with regards to poor performance and low quality are not centralized in a single database that can be shared across the industry. A training and certification process for asphalt pavement technicians does not currently exist in Ontario.

4.2.3.1 Recommendations

- ORBA and MTO should work to quickly identify and implement mandatory pavement technician and pavement inspector training and certification courses, such as the ones applied by the Indiana Department of Transportation (CTP Training) and the Michigan Department of Transportation (MDOT Training Courses).
- ORBA and MTO can do more to proactively share lessons learned with each other and municipal owners. There is currently isolated research led by MTO, but municipal owners would welcome increased collaborative efforts. Municipal owners would benefit from MTO's hands-on leadership and expertise. Many smaller owners look to MTO and other large owners for field-tested solutions they can implement.
- OPS specifications should be applied by Ontario municipalities with limited to no variation. If municipalities believe that modifications are necessary, they should seek the input of MTO and ORBA where feasible. Varying specifications do not help improve quality since contractors have to adapt their HMA manufacturing processes to the standards set by each municipality, which does not help them standardize their processes and reduce costs. It would be beneficial to implement tighter controls and mandatory rules at a provincial level that limit the ability for municipal owners to depart from OPS standards and specifications.
- It is suggested that MTO attempt consult and inform international experts and industry more broadly before making changes to OPS specifications. This recommendation to improve the consultation process should apply to municipal owners as well. While owners have the authority to make technical changes, if industry communicates significant concern with these changes, leading practice suggests that collaboration between owners and contractors ultimately yields the best results for product quality and maximizes benefit to taxpayers.
- A roster of qualified civil pavement independent engineers ("IE") should be established to avoid resurfacing over deficient pavement structures. The role of the IE should be to review previous designs and inspect pavements that are being targeted for repair prior to design commencing and decide whether full reconstruction is required or whether resurfacing is appropriate. For clarity, the IE should be independent from the EOR (Engineer of Record). A lifecycle cost/benefit analysis should be provided by the EOR for both options (reconstruction vs. resurfacing) upon which the IE would recommend which option is best. Any lifecycle cost analysis should be based on real data, and outcomes reviewed by independent third parties to ensure unbiased or subjective outcomes. Some countries like Ireland or the UK have long created a similar role (the Design Checker) as a "second set of eyes" in the Design process to ensure proper diligence and control over the final design solution proposed.
- Finally, ORBA and MTO should create a steering committee, including stakeholders like OGRA and MEA, which would meet periodically to provide leadership to the local road authorities with respect to seeking more consistency and less variance in specifications. There are 444 municipalities across Ontario. More consistency among the cities and regions with respect to specifications would be beneficial to the asphalt cement producers and create economies of scale that could lead to lower production costs.

4.2.4 Commercial practices that affect quality

4.2.4.1 Procurement

When interviewed by KPMG, Ontario owners generally acknowledged that their capital project and road maintenance funding requirements far exceed their annual capital works budgets and that these fiscal pressures drive the low bid procurement approach used to minimize upfront construction costs.

In most instances, the procurement model used by municipal owners was to select the lowest-cost bid that met the prescribed specifications, and in most cases past performance and quality are not factored in to the award decision. Prequalification processes are rare in municipal contracts. This was broadly seen by interviewees as creating a “race to the bottom” in both price and quality on many projects.

To obtain a competitive price advantage, there is a broad perception that some contractors push boundaries beyond a reasonable risk envelope through aggressive cost reduction strategies in HMA that can compromise quality (for instance overusing RAP or shingles or purchasing AC with excess REOB).

Asphalt pavement requires significant maintenance, and a narrow focus on the lowest price in the short term can result in higher costs over the long term. Yet the fiscal impact of premature cracking on service delivery and total lifecycle cost was not a parameter identified or systematically tracked by owners. This poses considerable challenges to effective procurement. Without taking lifecycle costs into consideration (based on prior performance outcomes) it is not possible to discern whether the lowest-priced bid will result in the lowest lifecycle cost asset.

Contractors interviewed by KPMG generally believed their job is to meet specifications, but not to exceed them. As evidenced by the GPA findings, there is a clear perception that the current approach to delivering paving could be improved to deliver higher quality and value for money. The primary challenge with using a lowest-compliant bid model is that it is purely a price competition. It often drives contractors to achieve the minimum threshold of the specification and, in some instances in doing so, to even fall short of the minimum threshold.

For a low-bid system to be most effective in driving performance, owners must be confident that achieving the minimum threshold for the specification will deliver long-term quality. They must be diligent in implementing QA processes to ensure they are receiving asphalt that meets the prescribed specification with minimal or no tolerance for variances.

There are, however, some recent positive signs of improvement in the procurement processes at a municipal level for asphalt pavement contracting. Through stakeholder consultations, several municipal owners indicated they have recently implemented:

1. Changes to minimum specification thresholds to improve the quality of the product they receive (for example increases to the AC content in Hot Mix Asphalt); and
2. Elements of pre-qualification to their contracting processes to limit the number of bidders invited to participate to those most qualified and experienced for each project based on past performance data and based on the quality of methods and resources presented in their tenders.

Prequalification processes are not always practical, nor possible. Many municipal owners consulted indicated that the number of contractors responding to their tenders was insufficient to allow for pre-

qualification (e.g., routinely only two or three contractors – or fewer – consistently in their market), and that pre-qualifying some may result in price increases driven by further reducing the number of bidders.

Recommendations

Owners should decide on the procurement model that best serves each project on a case by case basis. Generally, on the larger projects and where the contractor pool is large enough, prequalification processes may be beneficial in rewarding past performance and technical capabilities of each proponent. On smaller projects, enhanced specifications, or effective QA becomes the better tool to ensure asphalt meets the quality requirements.

4.2.4.2 Commercial Terms

Municipal owners acknowledged that political pressures were a significant factor in the implementation and enforcement of their contracts. They generally indicated that the dynamic at the municipal level is that residents have much more visibility into road work than in provincial or regional projects. For example, residents routinely call their local councillor, or the mayor's office, if they become frustrated with road closures. Because of this context, there is an inherent disincentive in many instances to fully enforce contracts, such as to require a contractor to remove and replace a segment of pavement that failed or was found not to meet the specifications within the warranty period. The most common remedy is to address a quality failure during the warranty period by negotiating an extension of the warranty period with the contractor rather than having them replace the road.

The issue noted above was common in many municipalities and is not conducive to a generally acceptable level of enforcement to ensure asphalt quality.

Recommendations

The typical warranty period in municipal pavement contracts is either one or two years. Since most asphalt pavements are designed to last 10-15 years, it is prudent to ensure contracts are fully enforced at a municipal level ensuring that defective or sub-standard pavements are removed when specifications have not been met.

Municipal owners should set a stronger tone around quality by rejecting poor quality asphalt and fully enforcing the completion of any removals and repairs required when quality issues arise during the contractual warranty period. Contracts at the municipal level should include unambiguous clauses that reflect this expectation and enable owner road authorities to act decisively. Premature failures can be mitigated by completing proper QC/QA testing and inspection.

The Province, municipalities and/or municipal associations (e.g., OGRA, MEA and AMO) should consider establishing a formal framework for implementing contract compliance programs, such as contract reviews and third-party independent program and project level contract compliance audits, aimed at increasing contract enforcement levels across Ontario.

For traditional construction contracts (bid build), wording on warranty clauses should clearly exclude liability associated to design issues (i.e. bad quality pavement design, or poor quality underlying pavement structure combined with an inadequate overlay).

In cases where owner and the contractors disagree on the root cause of the failure or defect, independent experts should be called to provide a third-party opinion or to mediate.

On major design/build or Alternative Financing and Procurement contracts (referred to as P3 contracts), where engineering design is the responsibility of the contractor, construction warranties of at least two years would drive improved behaviors by transferring increased levels of risk and ownership to the design/build contractor which tends to contribute to lower lifecycle pavement costs.

4.2.4.3 Asset Management

Through the consultation process, it became evident that all road owners – MTO and municipal owners alike – can improve the collection of asset health data across the road networks in Ontario. In most cases pavement condition data, maintenance reports, punch lists and lists outstanding defects, and O&M cost data figures per contract weren't easily accessible, or readily available.

As a result, asset investment plans are generally not effectively addressing asset health and condition issues at most owner organizations, which would have a negative impact in the prioritization of projects and ensuring capital is allocated to assets with higher risk and impact at failure.

Without proper historical pavement performance data, pavement performance and quality improvements will be hard to achieve. For example, when asked by KPMG, most owners were currently unable to link pavement failures to specific contracts and/or attribute responsibilities to capital or operations issues (project defects versus insufficient or inadequate maintenance).

Recommendations

MTO and municipal owners should undertake an independent review of their Asset Management Practices, reviewing processes, and creating new processes where necessary to ensure compliance with ISO 55000 and leading Asset Management practices.

Data collection and management processes should be the key focus of improved Asset Management processes at owner organizations. Maintaining an easily accessible and systematic record of individual assets or an asset inventory for provincial and municipal roads is the starting point for optimizing capital allocation to minimize risks and maximize value to the organization and to tax payers.

Many leading Asset intensive organizations around the world have deployed enterprise asset management (EAM) solutions to manage the maintenance requirements of assets, and to drive their capital investment planning processes.

5 Continuous Improvement Framework

ORBA, OAPC and all industry and government stakeholders are committed to the safety and quality of Ontario's roads and delivering value for money during construction and maintenance. As ORBA strives for continuous improvement, the Quality of Asphalt Review will help guide future efforts.