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White Paper

Beyond PCI -
A Comprehensive Approach to Pavement Management

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Executive Summary

This whitepaper explores the limitations of using the Pavement Condition Index (PCI) as the sole metric for pavement management. It argues for a multi-metric approach that incorporates additional indicators to provide a more comprehensive and accurate picture of pavement health, which can lead to more effective and economically sound pavement management strategies.

Introduction

Overview of PCI and Its Common Use in Pavement Management

The Pavement Condition Index (PCI) is an analytical tool that has been widely adopted by county and municipal agencies to evaluate the condition of roadway pavements. Developed by the U.S. Army Corps of Engineers in the late 1970s, PCI is a summary numerical index between 0 and 100 used to indicate the overall condition of a pavement. The index is calculated based on a visual survey of the pavement surface and rates the severity and frequency of various distress types observed on the pavement surface. The distress types and method of calculating the PCI are defined in ASTM D6433.

PCI has become popular in pavement management because the 0-100 score is easy for non-experts to understand. This makes the metric convenient for communicating road conditions to a wide variety of stakeholder groups. As such, it has become a staple in the toolkit of pavement management systems, often serving as the primary metric for assessing pavement health. However, the PCI score by itself does not provide enough information to allow pavement managers to select appropriate treatments and to prioritize maintenance activities.

Importance of Comprehensive Assessments

Assessing pavement comprehensively is not just about preserving infrastructure; it reflects an agency's dedication to public safety, fiscal responsibility, and long-term performance.

While PCI offers valuable insights into surface conditions, the overall health and functionality of roadways depend on a broad spectrum of attributes. These attributes can be divided into functional and structural categories. Functional measures include roughness, rutting, raveling and weathering, and cracking. These measures are captured to a certain extent in the PCI score. Other important functional measures like the friction of the pavement are not included in the PCI score. Structural attributes include the number, type, and thickness of pavement layers, and the resilient modulus (or stiffness) of each layer. These are also not captured in the PCI score.

Comprehensive pavement assessment is critical not only for the longevity of the infrastructure but also for the safety of its users. Effective pavement management goes beyond mere surface evaluations to include an understanding of underlying structural conditions, traffic, and environmental conditions, which together are responsible for the long-term pavement performance.

The safety of road users is directly influenced by the condition of the pavement. Issues such as inadequate skid resistance, structural failures which manifest themselves in certain surface distresses like rutting, and poor ride quality can lead to increased accident rates and pose significant risks to the traveling public. Moreover, premature pavement failures can result in unexpected road closures and costly emergency repairs, disrupting daily commutes and impacting local economies.

Furthermore, a comprehensive approach to pavement management supports sustainable infrastructure development. By accurately assessing all aspects of pavement conditions, agencies can implement more durable and cost-effective solutions, extending the service life of pavements and reducing the environmental impact of frequent repairs.

The Limitations of PCI

PCI's Focus on Surface Distress

PCI is designed to quantify the visible condition of road surfaces through a systematic survey of distress types, such as cracks, potholes, and surface wear. While this provides valuable information about current surface conditions, it inherently overlooks deeper, subsurface issues that are critical to pavement longevity and safety. Problems like base failure, subgrade moisture variation, and structural inadequacies can significantly impact pavement performance yet remain undetected by traditional PCI assessments. This surface-centric approach may lead infrastructure managers to prioritize short-term repairs on superficial damages while missing crucial opportunities for addressing underlying problems that could lead to more severe failures in the future. It can also lead to an erroneous selection of complete reconstruction of roads that have prominent surface distresses yet have a solid base which does not need to be dug up and replaced.

Roads with Same PCI Score May Behave Differently

Two roads with the same PCI may have very different surface distresses and may deteriorate very differently. There are many reasons a road can have a PCI of 70, for example. Knowing only the current PCI score does not explain what is wrong with the pavement or how to fix it. It also does not allow anyone to predict the future score of the pavement after some defined period of time, under the assumption that no maintenance is performed. Furthermore, high PCI scores may be achieved following the application of low-cost preventive maintenance treatments like slurry sealing, but these roads will deteriorate faster than new roads that also have high PCI scores. Two pavement sections with the same PCI score may also not deteriorate at the same rate if one is subjected to heavier traffic or harsher weather conditions. Decisions based on PCI alone may not only inflate maintenance costs but also detract from addressing more critical pavement sections that may appear to be in better condition based on their PCI score but are more degraded in terms of structural health.

Sensitivity to Minor Changes

PCI is also particularly sensitive to minor changes in distress types, which can lead to significant variations in calculated scores. Small, localized distresses can disproportionately influence the overall PCI rating, potentially skewing management priorities. For instance, a few additional cracks or a slight increase in patching area can lower the PCI significantly, prompting premature or unnecessary interventions. This sensitivity can lead to inconsistent condition scores and misinformed decisions even when using accurate survey equipment.

Complementary Metrics for Assessment

To overcome the limitations of PCI and achieve a more holistic understanding of pavement health, detailed surface condition attributes that address comfort, safety, and performance must be measured and reported. Additional metrics that address structural integrity should also be incorporated wherever possible. These complementary metrics can provide crucial insights that enable more informed decision-making and better allocation of resources.

Functional Testing

Ride quality is primarily assessed using the International Roughness Index (IRI), which measures the smoothness of the pavement surface from a user's perspective. High IRI values indicate a rough ride, which can negatively impact driver satisfaction and increase vehicle maintenance costs due to higher levels of vibration and wear. Rough roads are still the number one reason for driver complaints about road condition. Rough roads also deteriorate faster than smooth roads, especially when the roads have truck traffic. Said another way, smooth roads last longer. Regular monitoring of IRI allows transportation agencies to identify sections of road that require maintenance to improve ride quality, thereby enhancing user satisfaction and extending the lifespan of both the pavement and the vehicles that travel on it.

Rutting and alligator cracking are the most important surface indicators of structural problems on flexible (asphalt) pavements. These distresses indicate that preventive maintenance is likely no longer possible, and they can also lead to more serious problems. Rutting can cause water to pond in the wheelpaths, posing a hydroplaning risk during heavy rain or poor drainage. Alligator cracking can progress to potholes when the disconnected pieces of pavement are disturbed by traffic or snow plows.

Alligator cracking

Complementary Metrics for Assessment

Longitudinal and transverse cracking on asphalt pavements often indicate environmental deterioration, which is to say, aging and oxidation of the pavement surface. These cracks can progress to pattern cracking popularly called block cracking. But depending on the location and nature of the longitudinal and transverse cracking, it may also indicate construction quality problems, edge or curb integrity problems, or underlying discontinuities in the pavement structure (reflective cracking). On jointed concrete pavements, cracking can indicate structural problems due to either subbase weakness or washing away of supporting material.

Longitudinal and transverse cracking

Raveling on asphalt pavements is an important indicator of pavement surface integrity. This loss of aggregate can indicate poor pavement material health and suggest the need for remediation. The treatment options will depend on what other distresses are present.

Raveling

Faulting is an important health measure for jointed concrete pavement surfaces. It causes both an uncomfortable ride and premature failure of the slabs due to increased impact loading.

Complementary Metrics for Assessment

Structural Testing

Structural testing involves the use of advanced technologies to assess the integrity of pavement structures below the surface. Falling Weight Deflectometer (FWD) testing is the gold standard for measuring the structural capacity of the pavement. FWD tests involve dropping a known weight onto the pavement and measuring the resulting deflections with sensors. The data from FWD tests provide insights into the pavement's load-bearing capacity and can help predict its lifespan under continued use. By integrating structural testing into pavement management systems, agencies can prevent severe pavement failures by addressing not only the symptoms but also the root causes of pavement distress.

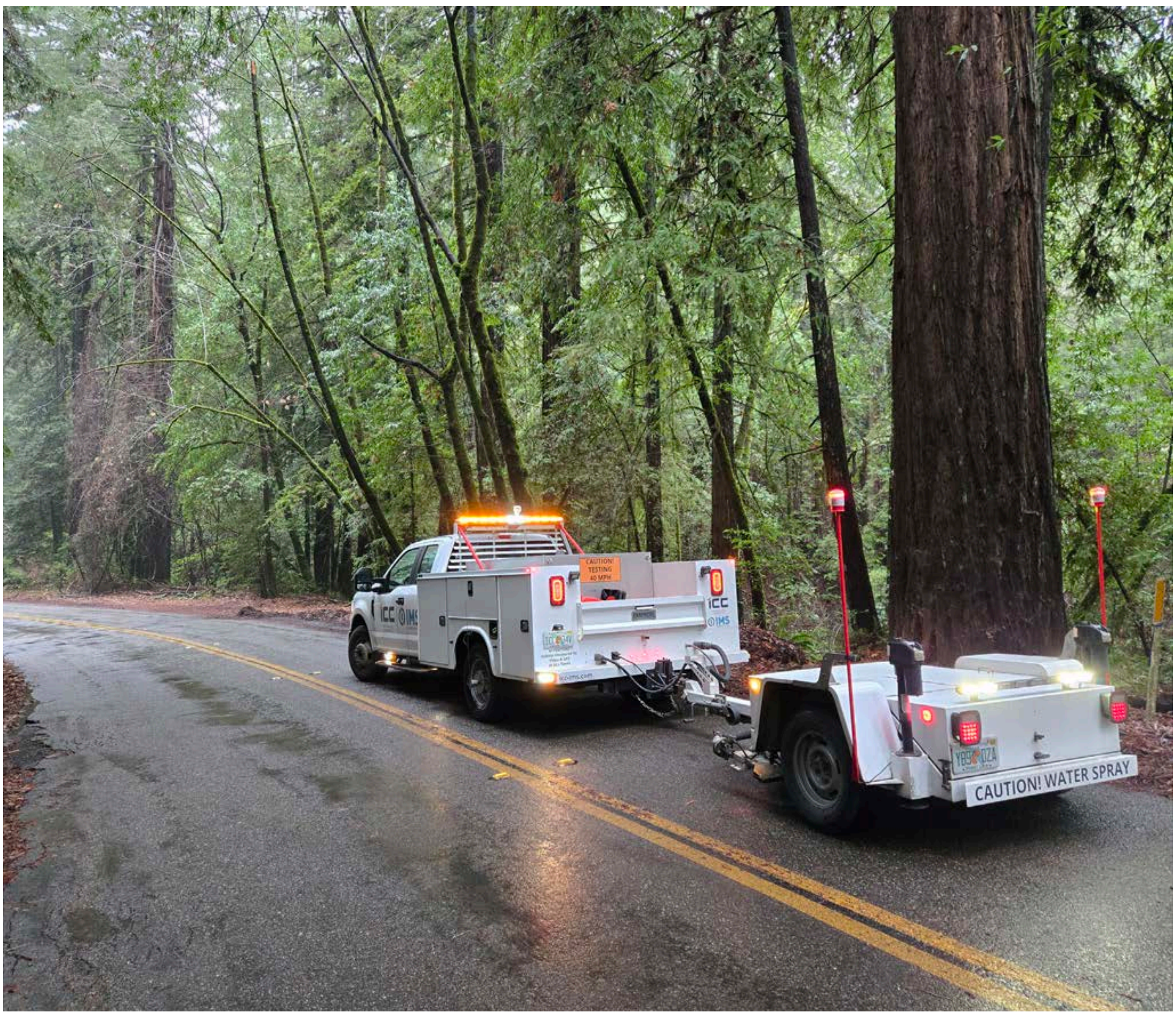
Ground Penetrating Radar (GPR) measurements are useful for detecting subsurface anomalies that are not visible on the surface. GPR uses radar pulses to image the subsurface, helping identify variations in material properties, moisture content, and thickness of layers, which are vital for assessing the pavement's structural health.

Assessing pavement load-bearing capacity using a Falling Weight Deflectometer (FWD)

Complementary Metrics for Assessment

Friction Testing

Skid resistance is a critical safety metric, especially in regions prone to wet conditions. It measures the pavement's ability to provide sufficient friction to stop vehicles that are braking and to prevent sideways skidding of vehicles going around curves. Regular testing for skid resistance is crucial for maintaining road safety and can be conducted using devices like the Surface Friction Tester (SFT). These measurements identify areas where the pavement surface may pose a hazard, especially during rain, allowing for targeted interventions that enhance public safety and reduce accident-related expenses.



Assessing pavement skid resistance using a Surface Friction Tester (SFT)

Complementary Metrics for Assessment

Drainage Evaluation

Effective drainage is paramount to maintaining pavement performance and longevity. Poor drainage can lead to water infiltration into the pavement layers and subgrade, causing a host of problems including potholes, rutting, and premature structural failures.

Evaluating drainage effectiveness involves assessing geometric properties like crossfall and grade and determining the condition of drainage features like inlets, pipes, and ditches.

It may also involve hydrological analyses to predict water flow and accumulation on the pavement surface. By ensuring proper drainage, pavement managers can prevent water-related damage and extend the life of the pavement infrastructure.

Conclusion

The Pavement Condition Index (PCI) serves as a valuable initial gauge of pavement surface condition, offering an accessible method for municipalities and agencies to prioritize maintenance and allocate resources. However, as this whitepaper has illustrated, PCI alone does not provide a comprehensive picture of pavement health. Its focus on surface distress, its imprecise and summary nature, and its sensitivity to minor changes in inputs can lead to misinformed decisions that may not address more significant underlying or long-term pavement issues.

To enhance the longevity and safety of roads, an integrated approach that encompasses a broader spectrum of metrics is needed. By incorporating detailed surface condition measures, structural testing, friction testing, and drainage evaluation into regular pavement assessments, agencies can achieve a more holistic understanding of their infrastructure's condition. This comprehensive assessment approach enables proactive management strategies that address both immediate and long-term needs, optimize spending, and improve overall service quality for the public.

We urge municipalities and transportation agencies to broaden their pavement management frameworks by integrating these complementary metrics into their evaluation processes. Investing in the necessary tools and technologies to monitor these additional metrics will not only improve the accuracy of pavement condition assessments but also enhance the safety and satisfaction of road users.

Embracing a multi-metric approach to pavement management is not just about adopting new technologies or methodologies; it's about making a commitment to the sustainable stewardship of our road infrastructure. Agencies that adopt this approach will be better equipped to make informed, cost-effective, and impactful decisions that benefit all stakeholders in the long term.

IMS takes a comprehensive approach to pavement management, helping municipalities, transportation agencies, and private sector clients across the USA and Canada make smarter, data-backed decisions. By going beyond Pavement Condition Index (PCI) alone, IMS integrates friction testing, structural assessments, surface imaging, and geospatial analytics to give a full picture of pavement performance. This holistic methodology empowers agencies to prioritize maintenance more effectively, extend pavement life, and stretch infrastructure budgets further—delivering better roads and better outcomes for the communities they serve.

Want to explore how IMS can support your pavement management goals?
Contact us here.

Go Beyond PCI: Reading & Resources

To help you go beyond PCI in your own asset management strategies, the following resources offer a deeper look at modern pavement evaluation, performance tools, and implementation best practices.

ASTM D6433-24
Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys
ASTM International
https://store.astm.org/d6433-24.html

ASTM E3303-21
Standard Practice for Generating Pavement Surface Cracking Indices from Digital Images
ASTM International
https://www.astm.org/e3303-21.html

ASTM E2583-07
Standard Test Method for Measuring Deflections with a Light Weight Deflectometer
ASTM International
https://store.astm.org/e2583-07r20.html

ASTM E274 / E274M-15
Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire
ASTM International
https://www.astm.org/e0274_e0274m-15.html

Roadway Departure Safety
Federal Highway Administration – Office of Safety
https://highways.dot.gov/safety/RwD

AASHTO Guide for Pavement Management
American Association of State Highway and Transportation Officials
(Available via https://store.transportation.org)

ASTM E3303 - The Basics
IMS Infrastructure Management Services
https://icc-ims.com/icc-ims-masterclass-astm-e3303-the-basics/

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