JOINT TRANSPORTATION RESEARCH PROGRAM

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Development of Methods and Specifications for the Use of Inertial Profilers and the International Roughness Index for Newly Constructed Pavement

Introduction

The Indiana Department of Transportation (INDOT) is currently utilizing a profilograph and the profile index for measuring smoothness assurance for newly constructed pavements. However, there are benefits to implementing a new International Roughness Index (IRI)–based smoothness specification utilizing road profiles measured using inertial profilers. Technological advancements have improved the quality of road profiles measured using inertial profilers; furthermore, utilizing inertial profilers allows smoothness data to be collected much more quickly and efficiently than the methodology currently utilized by INDOT. Pavement smoothness quantified using IRI calculated using profiles provided by inertial profiles is better correlated to user response than what is currently being utilized by INDOT. Furthermore, INDOT currently utilizes IRI to monitor the pavement smoothness throughout the remaining life of the pavement. Consequently, Utilizing IRI for measuring the smoothness of newly constructed pavements allows seamless monitoring of pavement smoothness from cradle to grave.

This study presents an IRI-based draft smoothness specification for newly constructed pavements utilizing profiles provided by inertial profilers. The process of developing a draft specification included developing the following: pay factor tables, the methodology for calculating the smoothness bonus, the methodology for locating areas of localized roughness, and inertial profiler certification procedures.

Findings

The pay factor tables developed for this study used a linear model that utilized an IRI life cycle model and life cycle cost analysis (LCCA). The study demonstrated that a multitude of very different pay factor tables could be generated with this modeling scheme using reasonable model inputs. The pay factor table values were very sensitive to the pavement rehabilitation plan. Furthermore the pay factor table values proved sensitive to the annual average daily traffic (AADT), IRI threshold, and duration of the LCCA analysis. The proposed pay factor tables yield smoothness bonus values comparable to bonuses determined using the current specifications. Table 1 is the pay factor table developed for this study.

A pavement smoothness population study showed that the MRI (mean IRI) populations are not normally distributed, but are skewed to the right. The right tail of the MRI populations reflects the smoothness irregularities present in the pavement. These smoothness irregularities have a pronounced impact on the fixed interval and continuous MRI populations and the calculated smoothness incentives. The positive skewed characteristics were also present in the smaller MRI populations utilized for calculating the fixed interval MRI.

TABLE 1. PAY FACTOR TABLE

Start IRI (in/mile)	End IRI (in/mile)	Pay HMA	Factor PCC
30	35	1.06	1.08
35	40	1.06	1.07
40	45	1.04	1.05
45	50	1.03	1.04
50	55	1.02	1.02
55	60	1	1.01
60	65	1	1
65	70	1	1
70	75	0.98	0.99
75	80	0.97	0.98
80	85	0.96	0.96
85	90	0.94	0.95

More than 82% of the 2010 hot mix asphalt (HMA) continuous MRI population is eligible for a smoothness incentive, and more the 55% of the population qualified for the biggest pay factor (1.06). These numbers decrease to more than 79% and 48% respectively for the 2010 HMA fixed interval populations. Less than 39% of the 2010 PCC continuous MRI population qualified for a smoothness incentive, while less than 5% qualified for the biggest pay factor. These numbers decrease to less than 28% and 1% respectively for the 2010 PCC fixed interval populations.

The percentage of the HMA populations that qualify for the biggest pay factor (1.06) is large; however, the calculated incentive was reasonably close to incentives calculated using the current specification for many pavement sections.

Only 67.3% of PCC continuous MRI population met the 100% smoothness pay criteria, compared with 93.15% of the HMA continuous MRI population. There were instances where the proposed specification paid out much more than the current specification and cases where the proposed specification paid out much less.

The proposed smoothness specification utilizes the continuous IRI smoothness histograms of the individual wheel paths to calculate the smoothness quality assurance incentives. Utilizing the histogram of the continuous IRI/MRI was selected instead of the fixed interval method for the following reason: A histogram of pavement section provides a truer description of the pavement smoothness than the small population of values provided by the fixed interval method because the fixed interval values are strongly influenced by the characteristics of the lot population (skew to the right).

Utilizing the IRI values of the individual wheel paths was selected instead of the average MRI for the following reasons:

1. The IRI of the individual wheel path is directly defined by a quarter car model. The average IRI of the two wheel paths (MRI) is not tied directly to a physical model.
2. Utilizing IRI instead of MRI allows a more equitable disincentive when one wheel path is significantly rougher than the other.

A two-stage process was selected for locating areas of localized roughness for the proposed specification. The first stage, bump detection, utilizes a 150 in/mile threshold of the continuous IRI with a 25-foot window to locate bumps. The second stage, locating segments with excessive IRI, utilizes a 90 in/mile threshold of the 100-foot fixed interval IRI values to locate rough road segments.

For the populations examined, bumps accounted for about 1.1% and 1.08% of the length of the HMA and PCC pavement sections respectively.

For the populations examined, 5% and 10% of the HMA and PCC lots respectively were classified as rough (bad). Rough road segments occur in both wheel paths simultaneously about 25% of the time. Furthermore, 65% and 52% of the HMA rough lots and the PCC rough lots contain bumps respectively; consequently, greater than 50% of the rough lots could conceivably be corrected during bump removal corrective action.

The proposed certification procedure includes certification of both the inertial profiler and the profiler operator. The inertial profiler certification includes criteria for repeatability/precision, accuracy, and verification of IRI values. In order to be certified the operator must demonstrate he or she can successfully complete all of the tasks necessary for the smoothness evaluation of a newly constructed pavement.

Quality control/quality assurance is an important consideration for monitoring smoothness of newly constructed pavements. Consequently, INDOT's right to conduct verification testing to validate the quality of the inertial profile data collected and data analysis included as part of pavement smoothness quality assurance should be included as part of the pavement smoothness specification.

Training is an important facet of converting from the current smoothness specification and the implementation of the new pavement smoothness specification. The training should include INDOT personnel as well as the road construction contractors. The result of a proper training program is improvement in the quality of the pavement smoothness program and the smoothness of newly constructed pavements in the state of Indiana.

Implementation

The implementation of this draft specification will introduce a method of measuring the road smoothness and a new smoothness index that are much more correlated to user response than the method INDOT currently utilizes for measuring pavement smoothness. Furthermore, implementation of this new specification will ensure that pavement smoothness is measured the same from cradle to grave allowing continuity for tracking of pavement smoothness changes over the life of the pavement. The following tasks need to be addressed for implementation of the draft specification:

1. The draft smoothness specification needs to be written (codified in the design manual).
2. This draft specification needs to be approved by the specification committee.
3. Training materials need to be developed:
   a. Inertial profiler operation instructions need to be prepared.
   b. Training presentations for INDOT and contractors need to be developed.
   c. Online training possibly needs to be developed.
4. INDOT must decide if the smoothness quality assurance testing will be conducted by INDOT personnel:
   a. Purchase of one inertial profiler for each district if INDOT decides to do the smoothness assurance testing.
5. Road segments need to be selected for profiler certification.
6. INDOT and/or contractor inertial profiler and inertial profiler operators should be certified.

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