RESEARCH
PROJECT CAPSULE [11-3P]
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TECHNOLOGY TRANSFER PROGRAM

The Rideability of a Deflected Bridge Approach Slab (LTRC Project 02-2GT Continuation: Phase II)

JUST THE FACTS:

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POINTS OF INTEREST:

Problem Addressed / Objective of Research / Mehodology Used
Implementation Potential

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PROBLEM

The Localized Roughness Index (LRI) is a parameter that was developed at the Louisiana Transportation Research Center (LTRC) to quantify localized pavement distresses, such as pavement surface dips and bumps, concrete slab joint faulting, bridge-end bumps, potholes and so forth (since there is currently no confirmed method available that does this). LRI quantifies localized pavement distresses with respect to the ride comfort of drivers by examining vehicular response through accelerometer outputs that high-speed profilers provide. However, this approach has significant shortcomings that relate to transportability issues. It has not yet been determined if the vehicular-response-based LRI can be made repeatable from vehicle to vehicle (differing suspension systems produce differing rides over the same profile and therefore differing LRI indexes). Transportability has been recognized as a major challenge for a number of decades, and it is widely known that it would be exceedingly difficult to cost-effectively address the issue with current technology.

Roughness indices based on pavement surface profiles, such as ride number (RN), profile index (PI), and international roughness index (IRI) have been successfully used to evaluate ordinary pavement riding quality, especially the IRI. However, these methods have traditionally had problems rating localized roughness. Independent research has shown that localized roughness indexing might be accomplished using the standard approach if the base length of the analysis is reduced from 328 ft to 25 ft. This method, termed the modified 25-ft. moving base-length IRI method [Fernando and Bertrand (2002); Chang et al. (2005)], has been developed and is gaining strength within the transportation community to index localized roughness. The method can be accomplished by using the "smoothness assurance" module that has been made available in FHWA's Profile Analysis Software (ProVAL). The method calculates a modified IRI using a continuous short interval of 25 ft. with a 9.82-in. filter applied to capture the localized pavement distresses. One strength of the 25-ft. method is that it is fully implementable without the need to modify equipment.

The method's greatest shortfall is that, although able to index high for short wavelength anomalies less than 25-ft., it is still a frequency-based analytical method. Frequency-based methods are known to have difficulty in resolving non-periodic or single-instance localized roughness, especially in cases where the effect is of very short duration. Preliminary comparative investigations by LTRC on bridge-end bumps have indicated that the 25-ft. method misses some cases of bridge-end bumps that the vehicular-response based LRI flags. Likewise, there are cases where the vehicular-response-based LRI misses some cases of bridge-end bumps that the 25-ft. method flags, which represent cases where drivers will not feel the bumps.

It can be concluded from this that neither type of index can individually address the issue of quantifying localized pavement distresses. However, it may be possible to combine the two in order to reach a solution. This is possible because the two types of indices are calculated using same high-speed profiler data stream (i.e., the indices are "physically" connected). Another possible reason is that the two indices describe the same physical phenomenon from different perspectives: one from surface profile and the other from vehicular-response. Understanding the correlation between the two will greatly enhance engineers' capability to quantify localized pavement distresses. It may be possible to use the modified 25-ft. moving base-length (or even shorter) method to overcome the vehicular-response-based LRI transportability issues. With the vehicular-response-based LRI, the shorter moving base-length IRI method could possibly do a better job of accurately indexing localized roughness both in terms of magnitude and in terms of locational accuracy.

OBJECTIVE

The objective of this research is to gain insight into the correlation that exists between the vehicular-response-based LRI approach and the 25-ft. (or shorter) base-length method and develop a recommendation that uses the best of these two indices to quantify localized pavement distresses, including bridge end bumps.

METHODOLOGY

The objective of the research will be accomplished by comparatively analyzing a large selection of pavement sections that have bridge end bumps. Preliminary efforts have indicated that the two methods do complement each other in a number of cases. But, the effort has indicated that there are differences as well. Comparison of the theory behind the two approaches suggests that the vehicular-response-based LRI, which was developed under LTRC research project 02-2GT, may be the more accurate of the two methods in terms of pure indexing of ride quality because it represents direct inertial measurement. However, given the difficulties that the transportability problem incurs, it may prove to be impossible to establish it as a mainstream application. Thus, the approach used in this study will be utilizing the LRI to help refine the 25-ft. method and proposing guidelines to help users know when the 25-ft. (or shorter) base-length method may or may not be dependable in finding and reporting localized roughness. The reverse can also be true wherein the 25-ft. method will serve to show where the LRI method has weaknesses.

A series of research tasks have been defined as follows:

Task 1: Literature Review

This study begins with a thorough review of available relevant literature. Special focus will be given to those issues associated with the difficulties that arise when attempting to index localized roughness. A focus will also be made on the effects of anti-aliasing and sampling as it is associated with the 25-ft. method as such matters can have an impact on the profiles correctness as it applies to localized roughness.

Task 2: Comprehensive Data Collection

All bridge approaches and exits located on Louisiana's Interstate10 that lie between the Texas and Mississippi borders will be tested using a high-speed laser profiler in the capacity that they can be analyzed both in terms of the LRI and 25-ft. method, so a comparative analysis can be made. This testing will be carried out using the LTRC's modified profiler. This profiler had been modified during phase one of the LRI research, so the accelerometer outputs of the vehicle could be properly accessed to allow for direct recording (LRI being determined as a function of the vertical acceleration at the forward bumper). A preliminary examination indicates that the proposed corridor contains 570 testable bridge structures.

Task 3: Comparative Analysis

A systematic comparison of 25-ft. method results with LRI results will be carried out. Preliminary research has indicated that this is best accomplished by first plotting the respective output streams next to each other so correlations can be viewed. This effort has indicated that a delay between signals sometimes exists. To carry out the comparison, two parameters will be compiled from the plots if excessive localized roughness is discovered in either plot. The first parameter to be recorded will be an ordered pair (25-ft. value and LRI value), representing the magnitude of the excessive roughness for a given location. The second parameter will be to note the delay that exists between peaks. The ordered pairs will then be plotted against each other in a summary plot and a cluster analysis carried out to look for correlations. The delay figures that were collected will be examined if outliers or anomalous patters emerge.

Task 4: Follow-up Testing

One of the objectives of the comparative analysis will be to isolate locations having the greatest disparity between roughness according to the 25-ft. method and roughness according to the LRI method. Discovery of such locations will trigger follow-up testing in the field at the problem locations. Follow-up testing will employ a panel survey to determine which method best indexes the condition. In addition, an effort will be made to examine the circumstance in order to determine why the disparity appeared. Also, an effort will be expended to determine if the settings for both indexes can be tweaked to better index the condition.

Task 5: Final Report

A final report will be presented to summarize findings and a series of guidelines will be drawn up that reflect discoveries to aid researchers who employ either the 25-ft. method or the LRI method of indexing localized roughness.

IMPLEMENTATION POTENTIAL

The results of this study intend to help the Louisiana Department of Transportation and Development (LADOTD) improve the quality of localized roughness evaluation across the state in a cost-effective and time-efficient manner and, in doing so, to improve the quality of future Louisiana highways. Currently, there is no confirmed method to systematically evaluate the onslaught and development of localized roughness. As such, there is no proper means of setting a remediation policy. Often, localized distresses that develop at places like bridge approaches get overlooked because automated distress surveys cannot index them properly. They often develop unnoticed until they become so severe that immediate mitigation becomes necessary. Usually, by such time, the distress has progressed beyond simple repair. Developing a workable localized roughness index can accomplish much in remedying this.