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The Rideability of a Deflected Bridge Approach Slab

Introduction

The Louisiana Department of Transportation and Development (LADOTD) initiated the Louisiana Quality Initiative (LQI) entitled "Preservation of Bridge Approach Rideability" to explore different potential methods of solving what has been observed as an approach-slab settlement problem at bridge ends. For LQI research to proceed, it was determined that a means of indexing bridge approach slab rideability and approach slab deformation would have to be developed. Traditional methods of roughness indexing like the International Roughness Index (IRI) and Ride Number (RN) along with alternative methods of indexing were examined in an effort to ascertain how localized (non-steady state) distresses, such as occur, at bridge transitions might best be indexed.

Objective and Scope

The objective of this project was to examine possible methods of evaluating and indexing localized roughness, such as occur, at bridge bumps. A secondary objective was to carry the research beyond theory by developing a prototype device that would realize this proposed index in an inexpensive, implementable manner.

Methodology

Research efforts began with attempts to use IRI indexing methods to evaluate a number of bridge approaches in the vicinity of Baton Rouge. An examination of literature revealed that profile-based indexing, exemplified by IRI, does not work well on short-duration impulsive inertial phenomena, such as occur, at distressed bridge approaches. For this reason, it was determined that an inertial approach to indexing would be required. Of the various technologies available, it was determined that research would utilize a high-speed laser profiler as it allowed for quick field testing that would have a minimal impact on traffic.

Basing the proposed bridge index, which came to be termed the Localized Roughness Index (LRI), on vehicular response presented the problems that it would lack transportability (indexing results would vary from vehicle to vehicle because of differences in their suspension systems) and would suffer from suspension degradation problems. Literature showed that both problems could be overcome through the development of a transfer function that could translate one vehicle's response into that of another. Such a transfer function was developed and a prototype circuit realization was developed through the employment of classical circuit realization techniques commonly used in control systems engineering.

Three representative bridges exhibiting wide-ranging roughness characteristics were isolated from within LADOTD's inventory of bridges for use in calibrating the LRI. Each bridge was run at four different speeds and the LRI results were plotted versus speed. The LRI value corresponding to the bridge's posted speed, an index which came to be termed the Posted Speed Localized Roughness Index (LRI_{PS}), was interpolated from each plot. The LRI_{PS} scores were then used to establish performance ranges. Panel rating by a clipboard survey was used to qualify scores.

Additional randomly selected bridges were tested and rated using the system to evaluate the general ride quality of bridge transitions within a given parish. This was done in an effort to qualify the meaning of the LRI_{PS} scores. Testing was conducted in the same manner as was carried out in the calibration effort.

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Principal Investigator:

Mark Martinez, P.E.

LTRC Contact:

Zhongjie "Doc" Zhang, Ph.D., P.E.
Phone: (225) 767-9162

Louisiana Transportation Research Center

Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

4101 Gourrier Avenue
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

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Conclusions

It was discovered that the proposed LRI could be effectively expressed in terms of the output of a high-speed laser profiler's accelerometer as it produced an easily identifiable and unique oscillatory signal burst when it encountered a bridge bump or other such localized phenomena. Taking the squared variance of the accelerometer signal proved sufficient to serve as the basis for the proposed index.

The LRI, which is the squared variance of a high-speed laser profiler's accelerometer output, was sufficient to both identify and index bridge-bump type phenomena. The LRI_{PS} refinement effectively rendered the LRI index independent of speed. It was possible to develop a prototype transfer function circuit design to overcome transportability and suspension degradation issues.

Costs to implement the LRI system is expected to be minimal and should only require the retrofit of relatively inexpensive accelerometers and/or transfer function circuits. Calibration of the prototype by measurement of vehicular characteristics (suspension system masses, spring constants, and damping factors) is not expected to be costly or difficult.

Operation and post-processing of the LRI monitoring system should require little setup or operator attention both prior to and during field testing. The value of the LRI system lies in its ability to easily locate and rate localized roughness. This should make it valuable to maintenance and rehabilitation efforts and for construction quality assurance/quality control (QA/QC).

Recommendations

The LRI_{PS} indexing system should only be used to rate localized roughness (like bridge transitions). IRI style (profile-based) indexing adequately rates steady-state roughness and should continue to be used in that area.

A more intense program of comprehensive LRI_{PS} testing should be carried out since only 12 bridges were tested as part of this research. This is to be done in an effort to verify findings and to refine the system.

The transfer function circuit should be prototyped and fully tested, so the design can be refined. A procedural methodology should also be developed that outlines how calibration should be carried out.

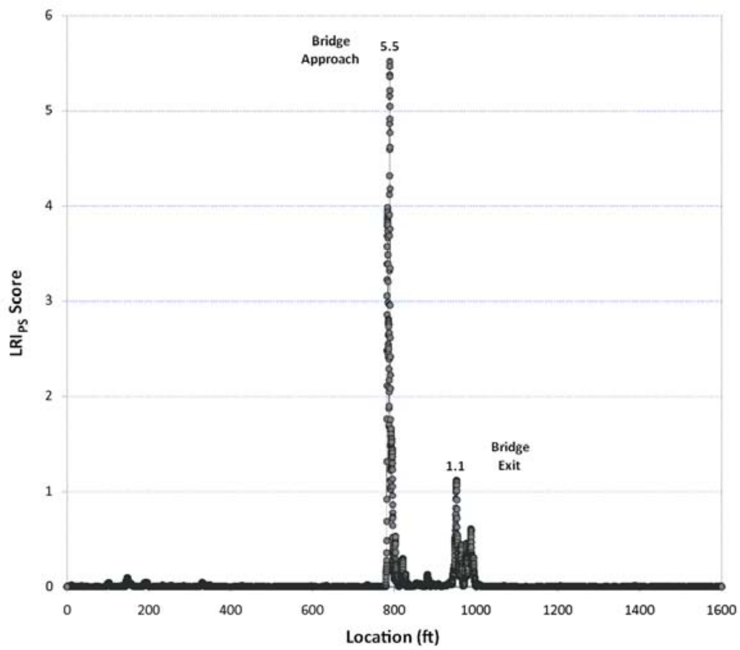

Figure 1
Typical LRI plot for a bridge (test run at 60 mph)

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