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Summary Report

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DETERMINING END-RESULT SMOOTHNESS SPECIFICATIONS FOR RIGID AND FLEXIBLE PAVEMENTS IN TEXAS

PROBLEM STATEMENT

Because the smoothness of newly constructed pavements directly influences pavement performance and user cost, state transportation departments have become increasingly concerned about construction specifications meant to ensure such smoothness. Until recently, these specifications—which include those still used in Texas—were almost exclusively based on measurements made with a 10-foot straightedge. Called "method" specifications (because they rely on contractor conformance to agency-sanctioned methods and measuring devices), these specifications do not, as pavement engineers have discovered, always produce a pavement of sufficient quality, and, consequently, can ensure neither smoothness nor riding comfort. Moreover, specifications dependent on the straightedge are unable to relate quality of work to contractor compensation. Thus, method specifications are now perceived as an inadequate quality assurance system.

In response, state highway planners have begun to emphasize "end-result" or "quality assurance" specifications. Applied after the contractor completes a paving section, these specifications—successfully implemented in parts of the U.S. and in Europe—require that certain standards be used to compare the as-built pavement profile with the particular smoothness level desired by the state highway agency, using a designated instrument and measurement unit. In addition to providing a smoother pavement, there are other benefits to using such specifications: End-result specifications give the contractor the freedom to choose methods and equipment. At the same time, the contractor, under such a plan, is held accountable by the state for turning out an acceptable pavement—that is, the contractor is solely responsible for pavement quality, and, under the bonus incentives that frequently accompany such specifications, could profit considerably for high-quality work. For these and other reasons, highway agencies and contractors generally prefer end-result specifications, citing in particular the economic benefits, the contractor's responsibility for quality control, and the specification's success in ensuring pavement smoothness.

The Texas Department of Transportation, recognizing that new end-result specifications could improve the quality of flexible and rigid pavements in Texas, undertook with The University of Texas at Austin a study to correct deficiencies in the current Texas smoothness specification (which uses a 10-foot straightedge as the roughness measuring instrument). This summary describes the objectives, findings, and conclusions of that study.

OBJECTIVES

The Center for Transportation Research (CTR) of The University of Texas at Austin, in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA), sought to develop a methodology for determining a rational end-result smoothness specification for flexible and rigid pavements in Texas. In addition, the project researchers attempted (1) to define training guidelines for those personnel charged with implementing end-result smoothness specifications, and (2) to correlate roughness indexes with the output (profile index in inches/miles) of the instrument used with the end-result smoothness specification (California-type profilograph).

FINDINGS

Using those profilographs preferred by most state agencies (the Ames and the McCracken), the CTR researchers collected roughness measurements from several Texas road construction projects. Factorial experiments involving both flexible and rigid pavements from a number of roadway components were then performed to calculate the variability of each instrument (and to determine if the performance of the Ames differed from that of the McCracken).

Next, the CTR team tested their draft smoothness specification (as revised by TxDOT). Again, this testing used data from the main travel lanes of asphalt concrete and portland cement concrete collected from various paving projects across Texas.

Finally, the researchers correlated profilograph output with roughness indexes. Because the California-type profilograph—the instrument used by TxDOT to evaluate roughness for the new end-result specification—produces an output profilogram that is converted to a profile index (PI, in inches per mile), the PI, if the device is to be useful, should be related to the output of other devices used for evaluating the roughness of newly constructed pavements. Accordingly, the researchers compared the profilograph output with two roughness statistics: the International Roughness Index (IRI) and the root mean square vertical acceleration (RMSVA) of different base wavelengths. (The project team considered a comparison of profilograph output with other roughness devices impractical.)

Results of testing by CTR showed that:

(1) end-result smoothness specifications significantly improve the quality of pavement riding profiles;

(2) contractors generally support implementation of end-result smoothness specifications, since such specifications limit the awarding of contracts to inferior contractors;

(3) the California-type profilographs —the devices preferred by both contractors and state officials for enforcing these specifications—were effective, even though their design and operation are now considered obsolete;

(4) an analysis of main-lane data showed that none of the primary factors—profilograph type (Ames or McCracken), operator, or reader—had a significant effect on the smoothness evaluation for flexible or rigid pavements;

(5) using the data collected from main lanes, the study team identified possible modifications that could be made to the revised CTR smoothness specification for main travel lanes of both rigid and flexible pavements. Their analysis of a segment PI distribution suggested that two specifications should be defined for rigid pavements: one for segments constructed using continuous paving operations, and another for segments constructed using stop-and-go paving operations;

(6) draft specifications could be defined for segments located on shoulders, bridge approaches, and ramps (with such specifications based on the distribution of segment PI for these roadway components); and

(7) the California profilograph profile index could be correlated with both IRI and RMSVA of different base wavelengths.

Finally, the project researchers provide training guidelines regarding the operation of the California profilographs. These guidelines, along with instructions on the assembly and operation of both the McCracken and Ames profilographs, are appended to the report.

CONCLUSIONS

The study yielded many useful conclusions and recommendations. With respect to the profilographs, the researchers concluded that the McCracken and Ames devices are interchangeable, since they yield similar roughness evaluations. The study team also found that the California profilographs exhibited poor repeatability, a finding confirmed by other researchers. There were, additionally, several proposals regarding profilograph improvements, including a recommendation to automate the strip chart and interpreter system, and to motorize the entire unit.

With respect to the roughness specifications, the CTR investigators report that their revised draft smoothness specifications for main lanes can be used "as a starting point for an end-product smoothness specification for Texas." Furthermore, an analysis of the roughness distribution of newly constructed flexible pavements suggests that "it may not be necessary to provide bonus incentives, since smoothness is readily achieved for this type of pavement." Rigid pavements, on the other hand, require specifications (and bonus and penalty incentives) that cover stop-and-go paving operations, since the smoothness of those pavements has been determined to be more difficult to achieve. Finally, the study team created correlation models that may be used to compare roughness measurements of various instruments.

Overall, the report authors believe that the guidelines developed in this study can be used for continued implementation of end-result specifications in Texas. These guidelines will, according to the authors, provide many potential benefits, including lower bidding prices (since contractors confident of their work can factor-in bonuses in their initial bid), improved pavement quality (since inferior contractors cannot rely on bonus payments and, hence, must increase their bid), and lower labor and overhead costs. But they caution that any final specification must come after extensive field testing and modification based on agency policy.

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The information provided in this summary is reported in detail in Research Report 1167-2F, "End-Result Smoothness Specifications for Rigid and Flexible Pavements," by Dimitrios G. Goulias, Terry Dossey, and W. Ronald Hudson (October 1992). The contents of the summary report do not necessarily reflect the official views of the FHWA or TxDOT.