AHTD TRC TRANSPORTATION RESEARCH COMMITTEE

TRC0208

# Certification Procedures for Lightweight Profilers

Tymli Frierson

Final Report

2013

Arkansas State Highway & Transportation Department

Transportation Research Committee

# Final Report

# TRC 0208

# CERTIFICATION PROCEDURES FOR LIGHTWEIGHT PROFILERS

**Final Report**

# TRC 0208
# Certification Procedures for Lightweight Profilers

By

Tymli Frierson
Research Study Engineer

Research Section
System Information and Research Division
Arkansas State Highway and Transportation Department

Conducted in Cooperation with the U.S. Department of Transportation Federal Highway Administration

December 2013

## TABLE OF CONTENTS

**CHAPTER** Page number

**LIST OF FIGURES**

# CHAPTER 1

## INTRODUCTION

Pavement smoothness is an important characteristic of newly-constructed roads. It not only affects the long-term performance of the roadway, but also the opinions and comfort of the traveling public. The Arkansas State Highway and Transportation Department (AHTD) currently uses pavement smoothness for acceptance. An incentive for all paving contracts is given based on criteria for pavement smoothness. A 10-foot straightedge is required to ensure that the profile grade line is correct. Currently, AHTD use either a California-style profilograph (ASTM E 1274) or an automated lightweight profilometer (ASTM E 950, Class I) that has been calibrated to the California-style profilograph to measure road smoothness for incentive payment.

As technology develops and AHTD moves toward new smoothness specifications, a certification program is necessary to ensure that the technician and equipment that are providing the smoothness data will meet the specific requirements and intent of those specifications. Due to technology for pavement smoothness advancing over the duration of this research project timeline, initial objectives for this research project were no longer deemed important or valid, giving AHTD the opportunity to advance this research project to formalize a profiler certification program for AHTD through CTTP.

# CHAPTER 2

## BACKGROUND

Since pavement smoothness for a newly constructed road is an important indicator of the future performance of that road, the necessity for quality smoothness measurements becomes important. Pavement smoothness affects driver's perception and attitudes.

Historically, pavement smoothness has been measured with a rolling straightedge in Arkansas. Specifications related to incentive pay for exceptional pavement smoothness were implemented in 1996. Measurements of pavement profile for incentive pay were performed using the California-style profilograph. Both the rolling straightedge and the California-style profilograph produce a localized measurement of the pavement profile, suitable for locating bumps and computing a Profile Index (PI). However, these devices also exhibit some limitations (1):

- They do not record the "true" profile of the road.
- Some roughness wavelengths are measured correctly; however, some wavelengths are amplified and some are attenuated.
- The turning radius of the equipment is limited.
- The operation is slow.

The 2003 Edition of the Arkansas State Highway and Transportation Department Standard Specification for Highway Construction allows the use of either the California-

style profilograph or a type of inertial profiler, commonly referred to as a Lightweight profiler (LWP), for smoothness-related incentive payments on all asphalt and concrete pavements (2).

An inertial profiler is a test vehicle that is equipped with transducers and profile computing and recording equipment. Inertial profilers may be of the lightweight style, or may be high-speed vehicle-mounted systems. LWP systems are typically mounted on a small utility vehicle such as a John Deere Gator or a Kawasaki Mule. High-speed profilers may be installed on standard highway vehicles in various configurations such as bumper mount, rear-mount, front-mount, mid-mount, or on trailer-style devices. Inertial profilers employ accelerometers, or transducers that provide an output that is proportional to acceleration, to measure the vertical acceleration of the vehicle as it moves in response to the pavement profile. Additional sensors detect the height and distance. The height sensor measures the distance between a vehicle reference point and the pavement, and the distance sensor provides a location reference as the vehicle travels. These three measurements are combined using computer software to eliminate the vertical movement of the vehicle, leaving only the profile of the pavement surface. Specific equipment requirements are given in AASHTO M328. The profile data can then be related to other measures of pavement smoothness, including PI and International Roughness Index (IRI). The data can also be used to identify sections of the pavement that require correction (i.e., 'must grind' areas).

Although each LWP has its own proprietary software and recommended settings, a more generic software was needed to normalize datasets derived from the various

profiler types. In response to this need, the Federal Highway Administration (FHWA) and Long Term Pavement Performance Program (LTPP) contracted with the TransTec Group, Inc. to develop such a software package, known as Profile Viewing and Analysis, or ProVAL. This software provides users with multiple tools for analyzing pavement profiles without the risk of bias toward a particular brand of LWP.

Three manufacturers of LWP equipment that have been successfully used in Arkansas include: Ames Engineering, International Cybernetics Corporation (ICC), and KJ Law Engineers. See Figure 1.

**Figure 1.** K.J. Law, Ames and ICC Lightweight Profilers

The lightweight profiler uses a combination of a laser height sensor, a floating reference (typically an accelerometer mounted to the height sensor), and a distance measurement instrument (DMI) to calculate the profile of a pavement surface. This profile data can be related to common measurements of pavement smoothness, including the profile index (PI) and the International Roughness Index (IRI). The data may also be used to locate bumps, sags (or "dips"), and "must grind" areas of the pavement surface. The final determination of the pavement surface profile and

associated index values are determined by software proprietary to each brand of LWP. Within the software are user-selected settings for gain, sampling interval, "blanking band", and other pre-determined parameters. In order to compare results obtained from various LWP units, these settings must be applied in the same manner. It is important for LWP operators to understand equipment and software settings to produce consistent results.

The importance of initial pavement smoothness to the associated long-term pavement smoothness, coupled with the variety of factors that affect the measurement of pavement profile, emphasizes the importance of calibrating LWP units and certifying operators that submit profiles for incentive pavement consideration. In addition, increased confidence in contractor-submitted profile measurements might lead to final pavement acceptance based on LWP profiles rather than a 10-foot straightedge measurement.

A number of states have adopted specifications for smoothness requirements on new pavements, and are also using profilers for quantifying the smoothness (or the lack thereof) on older pavements. As this practice has become more popular, certification requirements for profilers and operators have also been implemented by many states. *(4)* Arkansas currently uses profilers in the construction specification for incentive pay, and a new Special Provision for smoothness on overlays has been drafted that will affect the 2013 construction season. Thus, a certification program is necessary to provide a means for certification on this item because the quality of smoothness measurements will directly affect contractor pay.

# CHAPTER 3

# WORK PLAN

The Center for Training Transportation Professionals (CTTP) currently facilitates training and certification programs for AHTD. Thus, the development plan for the Profiler Certification will be developed in a manner that is consistent with current CTTP programs and policies.

The overall structure of the Profiler Certification program will involve two components: a technician certification portion, and a laboratory certification (i.e., equipment certification) portion. In order for a profiler to be used on federally-funded highway construction projects, both the laboratory and technician certifications must be current and valid, as stated in the AHTD Manual of Field Sampling and Testing Procedures.

*Task 1: Review the Literature.*

Several types of inertial profilers are available, and at least three of these are currently owned by AHTD. A review of the available types of inertial profilers was performed. The literature also examined the details regarding the calibration and operation of each type of profiler. It will be important to identify some of the major differences among the available equipment types, as this information may comprise necessary knowledge to be required of technicians. Details regarding calibration, verification, and maintenance of the devices were also researched. The primary sources for this information that's incorporated in the program are from AASHTO and ASTM specifications relating to profile measurements and inertial profilers. Information regarding computer software

(ProVAL) was also reviewed. Finally, profiler certification programs conducted by other states were investigated, with a particular emphasis on 'lessons learned' when developing and implementing a certification program.

*Task 2: Establish Certification Criteria.*

In order for the certification exams to provide appropriate assessments of technician knowledge and equipment capabilities, AHTD must provide information that will most appropriately indicate "acceptable" levels of knowledge and performance. Specifically, the research team will need to know:

1. What will be the primary unit of measure acquired by the profiler? Profile Index (PI) and International Roughness Index (IRI) are both concepts that should be considered. The current value used for incentive considerations is the PI. However, there is the potential for a shift to IRI. Therefore, a decision is needed regarding a preference among the parameters, which parameter should receive the most attention, or whether both should be included equally. This decision will affect the content of the written exam, as well as the pass/fail criteria for the performance exam. At this time, the primary unit of measure acquired by the profiler is included equally, IRI and PI.

2. What specification limit / tolerances will be considered acceptable for the performance exam? A combination of measures for accuracy and precision is recommended. Actual limits were determined by AHTD based on discussions and recommendations by the research team.

3. What specifications will be referenced for profiler operation? Several ASTM and AASHTO specifications may be applicable, including:

   - AASHTO M 328 'Standard Specification for Inertial Profiler'
   - AASHTO R 54 'Accepting Pavement Ride Quality When Measured Using Inertial Profiling Systems'
   - AASHTO R 56 'Certification of Inertial Profiling Systems'
   - AASHTO R 57 'Operating Inertial Profiling Systems'
   - ASTM E 950 'Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference'
   - ASTM E 1926 'Standard Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements'
   - ASTM E 2560 'Standard Specification for Data Format for Pavement Profile'

*Task 3: Establish the System for Profiler Certification.*

The certification program will have two basic components: technician certification and laboratory (i.e., equipment) certification. As such, there will be two components of each certification. Technician certification will require the participant to successfully complete a written examination and a performance examination. The equipment certification will require successful completion of a verification of the equipment, as well as a

demonstration proving that the profiler is capable of properly measuring the longitudinal profile of three test sections. The profiler measurement of the three test sections will serve as the performance test for the individual, as well as confirmation of the equipment to provide accurate and repeatable results. Thus, the overall certification (technician + equipment) will require 3 stations: the written exam (required of each technician certification), the equipment verification (required for each equipment certification), and measurement of roadway profile sections (required for technician and equipment certifications).

*Task 4: Formalize the Locations of Written and Performance Exams.*

The desired site for performance testing of the profilers is on the frontage road of I-530, Section 5, in Pine Bluff (See Appendix A). This area contains sections of both concrete and asphalt, and currently exhibits a wide range of smoothness characteristics. Although this pavement section is along a high-volume roadway, the frontage road handles minimal traffic, primarily consisting of farm vehicles accessing adjacent property. The proposed Test Track is approximately 4600 feet long and begins in the southwest portion of the area. The first section is a relatively smooth asphalt surface that is approximately 2000 feet in length. The northbound lane is fairly smooth, though the southbound section contains core holes at 500-foot intervals. The next section is a 1250-foot concrete section that could be described as having 'mediocre' smoothness in both lanes. The final section is a 1350-foot asphalt section containing a rough area (i.e., poor smoothness). In order to establish this site as the performance test location

(i.e., Test Track), a complete profile will be necessary (using replicate testing), and should be performed by AHTD using the most desirable of the models available (i.e., the Ames LWP?).

*Task 4a*: *Determine the exact number and location of test sections within the Test Track.*

In order to properly evaluate the performance of the profiling equipment, the test sections should represent the full range of smoothness characteristics that are likely to be encountered during typical situations. Since profiling measurements are typical used to evaluate new pavements, this range should be relatively small, and would be expected to encompass only smooth pavements. However, if profilers were to be used in the future for forensic investigation or for pavement management documentation, rougher sections may be encountered. Thus, the certification program should include the full range of smoothness that may be tested in practice.

Based on the available data and literature, a single test section should be 0.1 mile in length, or 528 feet, and must include start-up and slow-down areas. Three levels of smoothness should be included in the performance exam, as follows:

1. First asphalt section, northbound lane – representing 'good' smoothness

2. Concrete section – representing 'medium' smoothness

3. Final asphalt section – representing 'poor' smoothness

In order to make a final determination of the exact starting and stopping points for each test section, the Principal Investigator and/or other members of the research team should visit the Test Track along with AHTD Research personnel to determine whether the three sections are feasible for a certification event involving up to 10 attendees. Special attention should be devoted to determining whether the proposed sections will allow adequate space to observe all necessary safety precautions, to provide adequate parking and staging areas, and to provide safe areas for proctor stations.

The written exam will be given at District 2 training room. Scheduling of certification events will be handled by AHTD's CTTP liaison, and will be at times mutually agreeable to AHTD and CTTP.

*Task 5: Prepare the Details of the Written Examination.*

A written exam will be prepared in order to assess the knowledge level of the individuals requesting certification. This exam will include information on general profiling concepts, inertial profiler operation, Profile Index, International Roughness Index, related ASTM specifications, and ProVAL software. Questions pertaining to brand-specific profilers will be discouraged, but may be a necessary component of the program if there are differences significant enough to warrant additional requirements.

However, this type of information will be avoided if at all possible in order to provide the greatest level of consistency and fairness in testing. If brand-specific information is included, it will be required knowledge of all participants, and separate tests will not be given based on the type of profiler that a particular technician uses.

The written exam will consist of 60 questions, including multiple choice, true/false, and fill-in-the-blank questions. A minimum score of 70 percent will be required to pass the exam, which is consistent with other CTTP course requirements.

*Task 6: Prepare the Details of the Performance Examination.*

The performance examination will involve two components: equipment verification and roadway profile measurements. In addition to these, a quality manual review will be used to check equipment documentation, including equipment maintenance, calibration, and verification records. Company and staff information pertaining to profiler operation will also be required. These procedures and requirements will be consistent with other CTTP laboratory certification requirements.

The equipment verification shall include two physical checks of the profiler: the bounce test and the block test. These two tests are described in AASHTO R 57. The block test is performed to check the vertical height sensors, either by manufacturer's instructions or by the procedure detailed in AASHTO R 57. In this test, the profiler must reach operational stability, and then a series of blocks of known height are placed under the height sensor. The block heights should be known to the nearest 0.001 inch, and the average difference of 10 measurements by the profiler should result in a maximum

difference of 0.01 inch for each gauge block. In the bounce test, a profile collection run is performed using a simulated travel speed and distance as the sensor(s) are moved vertically to create a 1 to 2 inch displacement. The vertical displacement is usually created by pushing down on the bumper of the host vehicle or by standing in the center of the vehicle and hopping up and down. The resulting data should result in an IRI of less than 3 inches per mile, and the bounce portion less than 8 inches per mile.

The roadway profile measurements will be performed singly by the course participant (i.e., individual operator), performing a series of 10 profile measurements on each of 3 test sections. These sections will represent a range of smoothness, as previously discussed. All profilers must use pre-determined settings, which will be determined by AHTD to ensure accurate and consistent methods for evaluation. At the completion of testing, the raw data file will be provided to CTTP/AHTD, using the provided USB flash drive. The data will then be analyzed by AHTD and/or CTTP using ProVAL software, and will be judged as acceptable or unacceptable based on the accuracy and precision limits set by the research team, as agreed to by AHTD. ProVAL settings will also be established by AHTD to ensure a fair assessment of each measured profile.

*Task 7: Establish Certification Responsibilities and Policies.*

CTTP will be responsible for accepting registrations from participants, communicating with session participants before and after the session, and maintaining records of certified technicians, test records, equipment records (including model and serial

numbers for the device(s) used during the performance exam, and a photo of the technician and device). Communication prior to the class will outline what is expected of the participants, and will provide them with a list of responsibilities and needed equipment.

AHTD Research personnel will be responsible for establishing profile measurements on the day prior to the certification. If possible, the profiles should be verified on the morning of certification in order to eliminate any variational effects of weather, etc. These profiles will serve as the "true" profile measurements, and all participant-measured profiles will be judged against these measurements.

The number of certifications that can feasibly be handled during a 1-day certification event must be established. Because the certification program will involve testing only (i.e., no "live" training), this limitation will be governed by the number of profiler runs that will be necessary. It is estimated that a maximum of 10 profiler certifications will be feasible for each event. However, this does not necessarily mean that 10 technicians will be able to attend an event. It is conceivable that multiple technicians may use a single profiler to certify, or that a single technician may desire certification using multiple profilers. Thus, the maximum enrollment will be based on the number of performance exams (i.e., profile measurement exams). Equipment verifications will be required only once for each profiler, regardless of the number of technicians that will certify by operating the profiler. Participants may request certification to operate as many as 3

inertial profilers at a given certification event. A request to certify in more than one profiler must be made in advance of the certification event.

Staffing issues will be the responsibility of both CTTP and AHTD, as a significant number of people will be needed to staff the examination day. It is anticipated that 4 to 5 CTTP staff members will attend the certification day, and an additional 5 to 7 staff members from the AHTD research section will be utilized as well. One member will proctor the written exam, while the others perform set up activities at the Test Track. At the performance test site, one staff member will be needed at the beginning and ending of each test strip, and 2 to 3 members will be needed at the equipment verification station. After the initial certification offering has been completed, staffing needs may be streamlined and/or reduced.

Collecting payment from the course participants will be the responsibility of CTTP. A cost for certification will be determined by CTTP, and is expected to be consistent with current CTTP course fees. Individual fees will be assessed for technician and equipment certifications.

Successful participants will be provided with documentation (certificate and pocket card) stating that they are certified, and will indicate the specific type or brand of profiler that the technician is certified to operate, as outlined in AASHTO R 56. Certified technicians

will receive a pocket card with photo ID, and certified equipment will receive a certificate (consistent with the existing CTTP laboratory certification). Records for technicians and equipment will also be posted on the CTTP website for real-time access and continual updates. CTTP will be responsible for issuing all certification documents and providing certification summaries for each session to the AHTD liaison for CTTP. The certification will be valid for 3 years (as recommended in AASHTO T 56). *(3)*

Reciprocity will be considered, and may be granted if sufficient documentation is available to prove that the technician and/or equipment are currently certified in another state requiring a testing regimen that is at least as robust as that required by Arkansas. The specific requirements of reciprocity will be determined by the research team and will be mutually agreeable to CTTP and AHTD. Important factors for reciprocity should include determination of a broad-scope certification that is not brand-specific, a closed-book written exam, and a performance exam that includes a range of smoothness characteristics. Reciprocity requests will be reviewed on a case-by-case basis, and will require a comprehensive review of the requirements of the other state certification.

*Task 8: Prepare and Publish and Online Study Guide Module.*

Because this certification effort will not include a training component, some form of review will be helpful in letting participants gain a basic understanding of what will be required of them. A study guide will be developed and published as an online training module, which can be accessed at the time of registration (or can be made available to

the public). A knowledge check section will be included in order to provide sample test questions to the participants to offer an idea of the level of difficulty that will be required on the written exam.

*Task 9: Conduct Pilot Program.*

The Profiler Certification will represent a significant effort in terms of the logistics of testing and coordinating participant involvement, and will be quite different from the typical certifications offered by CTTP. Thus, it is recommended that the pilot program be performed using only AHTD profiler equipment and personnel (or other volunteer participants) as a 'mock' session. This pilot program will be conducted after the major policy decisions are made, and will provide great insight as to the effectiveness of those decisions. No certifications will be granted as a result of the pilot program. The pilot program experience will then be used to formulate recommendations for changes to the program, which will be implemented prior to the first official certification event. It is important for the pilot course to be treated as a true "dress rehearsal" and that all uncertainties/questions be answered (as much as is practical) before, not during, the pilot course.

*Task 10: Make Necessary Revisions to the Program.*

Although every effort will be made to anticipate the needs for this program, some level of revision and/or modification will be necessary. The final task of this development will

involve a review of the pilot event with a team from AHTD to identify any final changes that need to be made. These changes will be incorporated prior to initial certification events offered to Contractors.

# CHAPTER 4

# CONCLUSION

The Certification Program for LWP pertaining to the logistics and facilitation of the course will be conducted by the University of Arkansas' Center for Training Transportation Professionals (CTTP). CTTP will be responsible for all course registrations, scheduling, record keeping, and course examinations. Certified technicians and equipment will be documented on the CTTP website (www.cttp.org) similar to other CTTP certifications. Significant help will be required of AHTD from the Research Section in order to conduct the performance exam, to maintain and profile the certification test track, to generate current "true" profiles for each certification event, and to provide assistance with data analysis. The certification program will include:

- A written examination for technicians performing profile measurements
- A performance examination for technicians performing profile measurements
- An equipment verification for the profiling devices used by the technicians

It is expected that the Profiler Certification Program will be offered as needed in order to certify all contractors and equipment used in performing profile measurements for acceptance or pay. Preliminary estimations indicate that the program will be offered approximately twice per year initially, and then once per year. Offerings of this course will be need-based, and will be scheduled at the request of AHTD and/or contractors.

## REFERENCES


1. "Pavement Smoothness: Factors Affecting Inertial Profiler Measurements Used for Construction Quality Control", Course No. 131110, National Highway Institute, U.S.
Dept. of Transportation, Washington, D.C., 2001.

2. *Standard Specification for Highway Construction*, Arkansas State Highway and Transportation Department, Little Rock, Arkansas, 2003.

3. Fernando E., "TxDOT Certification Program.", *presented to the Annual Meeting of the Road Profiler User Group (RPUG)*, Austin, Texas, October 2003.

4. Gardiner, P., "Penn DOT Certification Process", *presented to the Annual Meeting of the*
*Road Profiler User Group (RPUG)*, Austin, Texas, October 2003.