

ALDOT-448-12 EVALUATING PAVEMENT PROFILES

1. Scope

- 1.1. This procedure covers the certification requirements and the use of a roadway surface inertial profiler for ride quality measurement for both quality control (QC) and quality assurance (QA) construction testing.

2. Referenced Documents

- 2.1. *AASHTO Standards:*
 - 2.1.1. R 56, Standard Practice for Certification of Inertial Profiling Systems

3. Inertial Profiler

- 3.1. *Housing vehicle*, capable of traveling at consistent speeds while collecting pavement profile data.
- 3.2. *Distance measuring subsystem*, accurate to within 0.15 percent of the actual distance traveled.
- 3.3. *Inertial referencing subsystem*, capable of measuring the movement of the housing vehicle as it traverses the pavement under test.
- 3.4. *Non-contact height measurement subsystem*, capable of measuring the height from the mounted sensor face to the surface of the pavement under test.
- 3.5. *Integrated System*
 - 3.5.1. Shall include hardware and software capable of producing and storing inertial profiles by combining the data from the inertial referencing subsystem, the distance measurement subsystem, and height measurement subsystem.
 - 3.5.2. Shall have the capability of measuring and storing profile elevations at intervals sufficiently frequent to meet the requirements of Section 4.
 - 3.5.3. Shall have the capability of summarizing (computing) the profile elevation data into summary roughness statistics over a section length equal to 0.1 mile. The International Roughness Index (IRI) for each longitudinal path profiled is the summary roughness statistic prescribed in this procedure.
 - 3.5.4. Shall have design to allow field verification for the distance measurement (longitudinal) subsystem and the height measurement (vertical) subsystem described in Section 6.
 - 3.5.5. Shall be certified for use as described in Section 4.

- 3.5.6. Air pressure in the tires of the housing vehicle will fall within the vehicle manufacturer's recommendation. The housing vehicle and all system components shall be in good repair and proven to be within the manufacturer's specifications. The operator of the inertial profiler shall have all tools and components necessary to adjust and operate the inertial profiler according to the manufacturer's instructions.

4. Inertial Profiler Certification

- 4.1. This section provides minimum certification requirements for inertial profilers used for quality control for acceptance testing of surface smoothness on Department paving projects where the profile-based smoothness specification is applicable.
- 4.2. The certification process covers test equipment that measures longitudinal surface profile based on an inertial reference system mounted on a housing vehicle. The intent of minimum requirements stipulated herein is to address the need for accurate, precise, uniform, and comparable profile measurements during construction.
- 4.3. *Minimum Requirements:*
 - 4.3.1. *Operating Parameters:*
 - 4.3.1.1. The inertial profiler shall be capable of reporting relative profile elevations less than or equal to 4 inches that have been filtered with an algorithm that uses a cutoff wavelength of no less than 200 ft and no more than 300 ft.
 - 4.3.1.2. The inertial profiler shall also be able to calculate and report the IRI (in inches/mile) from the corresponding measured profile, where the operator is permitted to automatically trigger the start and stop of data collection at the designated locations. Measured profiles shall be provided in electronic text files suitable for importing into the latest version of Profile Viewing and Analysis (ProVAL) Software as described in Section 9.
 - 4.3.1.3. The inertial profiler shall also be verifiable for measurements in height and distance as described herein.
 - 4.3.2. *Equipment Certification:*
 - 4.3.2.1. Equipment certification involves using the inertial profiler to collect profile data on test sections designated by the Department for this purpose at the NCAT Pavement Test Track. NCAT certification personnel will administer this program. Before equipment certification, as a recommendation, the inertial profiler owner should verify the longitudinal and vertical calibration of his or her equipment following manufacturer's recommendations. This recommended verification should be conducted at the owner's facility prior to the scheduled date of certification testing.
 - 4.3.2.2. On an annual basis, the inertial profiler shall undergo certification tests at the NCAT Pavement Test Track to establish that it complies with the minimum

requirements for accuracy and repeatability set forth in this test method. At that time, the proficiency of certified operators will also be demonstrated as required in Section 5. An inertial profiler shall also undergo certification testing after undergoing major component repairs or replacements as identified in Section 7.

- 4.3.2.3. For certification, the inertial profiler's distance measurement subsystem shall be accurate to within 0.15 percent of the actual distance traveled.
- 4.3.2.4. Certification tests will be run on the swept inside lane of the NCAT Pavement Test Track on designated dense mix test sections with smooth, medium-smooth, and rough surface profiles, and on a designated open-graded mix test section with a smooth surface profile. Each section will be 528 ft in length with 300 ft of lead-in distance. Ten repeat runs shall be made of the inertial profiler with data produced for both test wheel paths in the prescribed direction of measurement. Inertial profilers will be evaluated by comparing results to those generated by the reference SurPRO profiler. The inertial profiler owner shall provide data to NCAT certification personnel that is suitable for importing into the latest version of ProVAL.
- 4.3.2.5. NCAT certification personnel will use the latest version of ProVAL to evaluate the repeatability of the owner's data and compare the accuracy of results generated by the owner's data to results generated by the reference SurPRO profiler. Performance will be differentiated between dense and open graded mixes. In order to earn certification for dense graded mixes, ProVAL generated values for accuracy and repeatability cannot exceed those values specified in AASHTO R 56. In order to earn certification for open graded mixes, a profiler shall have passed certification for dense graded mixes and shall also produce average IRIs within 5% of the SurPRO average in each wheelpath on the smooth OGFC section.
- 4.3.2.6. NCAT will report the results of the certification tests to include the following information:
- Make and manufacturer of inertial profiler tested.
 - Unique hardware serial number of inertial profiler tested.
 - Version number of software used to generate ProVAL import file.
 - Operator of the profiler tested.
 - Names of the NCAT certification personnel responsible for the evaluation.
 - Date of data collection.
 - Overall outcome of the testing process (i.e., pass or fail). A separate certification will be provided for dense and open-graded pavement

surfaces. It will be possible to pass on dense surfaces but fail on open-graded surfaces.

- The ProVAL report that shows the accuracy and repeatability of the tested inertial profiler on each of the four certification pavement surfaces.

4.3.2.7. A decal will be placed on the inertial profiler by NCAT certification personnel following successful certification. Separate decals will be used to designate acceptability for use on dense and open-graded pavement surfaces. Each decal will show the month and year of certification and the month and year the certification expires.

5. Operator Certification

- 5.1. Operators of inertial profilers used for testing of pavement ride quality shall pass a proficiency test and be certified to operate an inertial profiler in Alabama. NCAT certification personnel at the NCAT Pavement Test Track will administer the test for the Department. The test for the applicants for certification will include knowledge of Department's smoothness specifications, this ALDOT Procedure, verification of inertial profiler calibration, and collection of certification profile data.
- 5.2. To qualify as a certified inertial profiler operator in Alabama, the applicant shall pass the written examination with a score of 70 percent or higher, pass the practical examination for verification of inertial profiler calibration, and pass the practical examination for profile measurements. All practical examinations shall be demonstrated using the inertial profiler provided by the applicant.
- 5.3. The applicant shall demonstrate that he/she can perform the longitudinal and vertical verifications described under Sections 6.2, 6.3 and 6.4. Additionally, the applicant shall perform profile measurements along a given route established by NCAT. The route will be at least 2,500 ft long, with designated 0.1 mile test sections and "leave-out" segment(s). The applicant shall profile the designated wheel paths of the test route in the specified direction following the procedures given in this test method. The applicant shall provide the test data in electronic files suitable for importing into the most recent version of ProVAL. For the practical examination, the applicant's performance is evaluated as passing or failing.
- 5.4. Upon passing the written examination and proficiency test, the NCAT certification personnel will give the successful applicant an identification card, which will verify the certification to operate an inertial profiler for testing on Department paving projects. The card will identify the specific types or brands of inertial profilers for which the operator certification is valid. This card will also specify the expiration date of the operator certification. The Department has the authority to revoke the card and operator certification at any time because of misuse.
- 5.5. Recertification of the operator will require successful completion of another proficiency test as described in this section for initial operator certification. Proficiency of certified operators shall be demonstrated at the time of each inertial profiler's annual recertification. A new written examination for certifying operators shall be required every three years.

6. Verifying Calibration and Consistency

- 6.1. A longitudinal and vertical verification procedure shall be performed at least once before an inertial profiler is used for either QA or QC testing on a project. Although the specific steps to complete the verifications will vary in accordance with the manufacturer's recommendations, the basic procedures will not change. The results of all longitudinal and vertical verification checks shall be documented in a profiler log. The profiler log shall be a collection of the required equipment and operator certifications and BMT forms (BMT 202 through 207) found in the ALDOT Testing Manual. The Engineer will review the profiler log prior to use on the project.
- 6.2. Longitudinal verification
 - 6.2.1. The longitudinal verification standard will be a straight roadway test section at least 528 ft in length. This distance shall be measured accurately to within 0.15 percent using a steel measurement tape or electronic measuring device. An analog measuring wheel or roll-a-tape is not sufficient for accurate measurement and will not be allowed. The inertial profiler owner shall establish the longitudinal verification standard and notify the Engineer prior to the first time the longitudinal verification is performed.
 - 6.2.2. Air pressure on the tires of the housing vehicle shall be checked and maintained according to the manufacturer's recommendations and documented in the profiler log.
 - 6.2.3. Perform the longitudinal verification by navigating the inertial profiler over a measured test section at least 528 ft in length.
 - 6.2.4. If the inertial profiler's distance measuring subsystem measures the length of the test section to within 0.15 percent of its actual length, no additional verification is necessary.
 - 6.2.5. If the inertial profiler's distance measuring subsystem fails to measure the length of the test section to within 0.15 percent of its actual length, the calibration shall be adjusted according to the manufacturer's guidelines and the longitudinal verification repeated.
 - 6.2.6. The results of the longitudinal verification shall be documented on BMT 203 "Inertial Profiler Calibration Log."
- 6.3. Vertical verification - Block Test
 - 6.3.1. The vertical verification standard will be flat plates or blocks of known thicknesses and low thermal expansion. As a minimum, two uniform base plates and three 1-in. measurement plates will be needed. Alternatively, a precisely machined block that provides all the required heights is acceptable. The actual thickness of the three measurement plates shall be measured to within 0.001 in. All vertical calibration plates shall be provided and maintained by the inertial profiler owner. The

thicknesses will be certified by the NCAT certification personnel at the time of annual certification.

- 6.3.2. The vertical verification shall be performed on a flat and level area using a base plate and three flat 1-in. measurement plates. It is acceptable to perform the test indoors, which may be necessary when windy conditions exist.
 - 6.3.3. Place a uniform base plate under the inertial profiler's non-contact height sensor. The inertial profiler's height measurement subsystem shall use this as the reference height for the first set of measurements.
 - 6.3.4. Place the first 1-in. measurement plate on top of the uniform base plate below the non-contact sensor. The inertial profiler's height measurement subsystem shall measure this displacement to within 0.01 in. of the 1-in. plate's actual measured thickness.
 - 6.3.5. Place the second 1-in. measurement plate on top of the two existing plates below the non-contact sensor. The inertial profiler's height measurement subsystem shall measure this displacement to within 0.01 in. of the 2-in. total thickness of the two measurement plates.
 - 6.3.6. Place the third 1-in. measurement plate on top of the two existing plates below the non-contact sensor. The inertial profiler's height measurement subsystem shall measure this displacement to within 0.01 in. of the 3-in. total measured thickness of the three measurement plates.
 - 6.3.7. Remove the three measurement plates and verify that the inertial profiler's height measurement subsystem returns to zero, within 0.01 in., on top of the base plate.
 - 6.3.8. Vertical verification shall be performed for all non-contact height sensors.
 - 6.3.9. The results of the Block Test shall be documented on BMT 203.
- 6.4. Vertical Verification – Bounce Test
- 6.4.1. With the base plates in position simultaneously under both wheel path sensors, place the vehicle in an operating mode that simulates longitudinal movement and initiate profile data collection. Data is collected with the vehicle as motionless as possible for the time required to travel 828 ft.
 - 6.4.2. Without interrupting the data collection process, both sensors are repeatedly subjected to a vertical displacement of approximately 1 to 2 in. This bouncing motion shall be maintained and data collected for the time required to travel 528 ft.
 - 6.4.3. Without interrupting the data collection process, continue to collect data with the vehicle as motionless as possible for the time required to travel 828 ft.

- 6.4.4. Measured profiles shall be saved and analyzed in ProVAL using the Ride Statistics Continuous analysis option with a 528 ft base length and 300 ft of lead in and lead out. Computed IRI values in the first and last (static) 528 ft segments shall not exceed 3 in. per mile, while the IRI for the middle (bouncing) segment shall not exceed 8 in. per mile. If the computed IRI values exceed 3 in. per mile for the static test and/or exceed 8 in. per mile for the bounce test, then the manufacturer's recommendations for performing sensor operational checks shall be followed. The static and bounce tests shall then be repeated. If the tests fail to meet these requirements, the inertial profiler will be deemed to be not certified and barred from use on ALDOT projects until it passes the certification program at NCAT.
- 6.4.5. The results of the Bounce Test shall be documented on BMT 203.
- 6.5. IRI consistency
- 6.5.1. The Department will designate at least one control section in each Division that will be used as a basis for consistency measurements the first time an inertial profiler is used on a given project. Control sections will be established by selecting 1000-foot sections with a maximum IRI of 120 inches per mile that will maintain a consistent ride profile over the time period when daily checks are needed. Information regarding the control section locations is available from the State Materials and Tests Engineer.
- 6.5.2. An inertial profiler certified within the past 90 days shall be used to determine the IRI of the section by making a series of at least five profile measurements. The average IRI of the measurements shall be used to establish the IRI of the control section; provided that the cross correlation of the measurements as determined using the latest version of ProVAL is at least 88 percent (dependent upon the filters used, spectral content of the measured surface, operator, etc.). Once established, this control section can be used to validate that an inertial profiler is operating properly at any time.
- 6.5.3. An inertial profiler is consistent when a single IRI determination does not vary more than 5 percent from the initial control section IRI established by the inertial profiler owner.
- 6.5.4. After an inertial profiler has been used for the first time on a project, it is acceptable to re-run 528 ft of pavement that was measured on the previous day for comparison purposes. An inertial profiler is verified to be consistent when the current day's value does not differ by more than 5 percent from the previous day's value.
- 6.5.5. If the contractor owns more than one certified inertial profiler, it is acceptable to compare separate runs made by the two devices. A certified inertial profiler is consistent when it does not differ from another certified inertial profiler by more than 10 percent.
- 6.5.6. The Department may also choose to run random consistency checks by bringing in a certified inertial profiler. A contractor's certified inertial profiler is consistent when it does not differ from the Department's certified inertial profiler by more than 10 percent. If the contractor's inertial profiler differs by more than 10 percent from the

Department's certified inertial profiler, then the contractor's inertial profiler will be deemed to be not certified and barred from use on Department projects until it passes the certification program at NCAT.

- 6.5.7. The results of the initial IRI consistency check shall be documented on BMT 207 "Control Site Target IRI Report."
- 6.6. Major component repairs of the type referenced in Section 7 may be needed when specified longitudinal or vertical verification tolerances are not met or consistency cannot be verified. Major component repairs shall require recertification as described in Section 4.
- 6.7. The profiler log shall be kept with the inertial profiler at all times that is subject to review by the Engineer. Verifications, calibrations, consistency checks, and certifications shall all be included in the profiler log.

7. Repair and Adjustment of Inertial Profilers

- 7.1. All repair and adjustment of inertial profilers shall be documented on BMT 204 "Inertial Profiler Maintenance Log."
- 7.2. Major component repairs or replacement to an inertial profiler require recertification of the equipment. These may include but are not limited to:
 - Repair or replacement of the accelerometer and its associated hardware.
 - Repair or replacement of the non-contact height sensor and its associated hardware.
 - Repair or replacement of the distance measuring instrument.
 - Repair or replacement of any printed circuit board necessary for the collection of raw sensor data or the processing of the inertial profiles and IRI.
 - Modification of software parameters and scale factors as required by the manufacturer that are foundational to the certification process.
- 7.3. The operator of the inertial profiler may make minor adjustments to the equipment without having to complete the recertification process as long as the adjustments allow the equipment to fulfill the procedure in Section 5.
 - 7.3.1. Inspecting, resoldering, or replacing connectors is considered a minor adjustment.
 - 7.3.2. Cleaning components or normal adjustments to voltage levels as required by the manufacturer is considered a minor adjustment.
 - 7.3.3. Setting software parameters and scale factors as required by the manufacturer is considered a minor adjustment as long as they are not foundational to the certification process.

8. Test Procedure

- 8.1. IRI measurements shall be in each wheel path, then averaged and summarized every 0.10 mile. Technically speaking, this average of the left IRI and right IRI is termed the Mean Roughness Index (MRI).
- 8.2. The Bounce Test, described under Section 6.4, and the IRI consistency check, described under Section 6.5, shall be performed daily before any data is collected. The results of the daily Bounce Tests and IRI consistency check will be documented by the Contractor and verified by the Project Engineer on BMT 202 “Daily Inertial Profiler Log.”
- 8.3. Locate and mark all sections that will not be included in the evaluation of pavement smoothness for payment of bonuses or penalties. Sections that will not be used include the first and last 25 ft of the paving project, 25 ft either side of bridge ends, and those areas as directed by the Engineer.
- 8.4. Contractor shall provide the distances and descriptions of features that may be subject to exclusion using BMT-206 “Project Feature Log.”
- 8.5. Clean the roadway path of all debris and other loose material before data is collected.
- 8.6. All data collected outside the certified speed range shall not be acceptable. Re-measure any pavement segment where the travel speed of the inertial profiler is less than or exceeds the manufacturer’s recommended operational speed at any point during data collection.
- 8.7. A pre-section length of roadway of up to 450 ft may be required to stabilize the inertial profiler’s filters and achieve the same accuracy in the first 0.1 mile that is achieved through the rest of the job. The pre-section length is dependent on the filter type, the grade change on entering the test segment, and the accuracy required of the first 0.1 mile of measured pavement. Typically, this pre-section shall be at least 300 ft in length and located immediately before the section of pavement to be tested. Shorter sections may be used at the discretion of the Engineer when the physical constraints of the project require it and other project conditions make it acceptable.
- 8.8. Inertial profiler measurements shall be made in both wheel paths of the paved surface using sensor path spacing of between 65 and 71 inches.
- 8.9. Measurements shall be made in the direction of traffic.
- 8.10. Data collection for payment purposes is meant to be performed at the end of the paving operation or staged as prescribed by the Department.
- 8.11. The contractor shall submit to the Engineer a table that identifies the lanes, wheel paths, and distance locations tested for each file created during profile testing on BMT-202 “Daily Inertial Profiler Log.” Profile elevation data shall be presented to the Engineer in an electronic format on a USB flash drive with a file format as described in Section 9. The Engineer will use the latest version of ProVAL to calculate the IRI values and applicable tables to determine associated pay factors.

8.12. The Engineer will:

8.12.1. Determine all features that will be excluded from the pay computations.

8.12.2. Calculate and record the IRI from each longitudinal line profiled for a pavement travel lane (The payment schedule will be based on the MRI calculated from both wheel paths in a travel lane.).

8.13. The Engineer will use the latest version of ProVAL to calculate the pay adjustment for segment lengths no more than 0.1 mile long.

9. Test Data Description and Format

9.1. Report test data in .ERD format that can be read directly into the latest version of ProVAL. This will permit the Department to directly input profile data, collected with any inertial profiler, into its data reduction program for QA testing.

10. References

10.1 AASHTO Standards

- M 328, Standard Specification for Inertial Profiler
- R 54, Standard Practice for Accepting Pavement Ride Quality When Measured Using Inertial Profiling Systems
- R 57, Standard Practice for Operating Inertial Profiling Systems
- R 43M/R 43, Quantifying Roughness of Pavements

10.2 ASTM Standards

- E 867, Standard Terminology Relating to Vehicle Pavement Systems
- E 950, Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference