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METHOD OF TEST FOR OPERATION, CALIBRATION AND OPERATOR CERTIFICATION OF INERTIAL PROFILERS

A. SCOPE

Inertial Profilers are used to measure a longitudinal surface elevation profile of highways based on an inertial reference system that is mounted on a host vehicle. The devices must be calibrated, and operators certified, to measure profiles for acceptance and verification on projects. The following procedures are used to assure the devices are calibrated, and operators are certified to perform profile measurements:

1 Verifying the calibration of an inertial profiling system.
2 Calibration of equipment.
3 Certification of operators.

B REFERENCES

AASHTO R 56 – Certification of Inertial Profiling Systems
AASHTO R 57 – Operating Inertial Profiling Systems
ASTM E2560 – Standard Specification for Data Format for Pavement Profile

C STANDARDS

1 Longitudinal
   a. The longitudinal verification standard will be a straight and level roadway test section of at least 528 ft in length
   b. Measure this length accurately to within 0.1 using a temperature-compensated steel survey measurement tape.

2 Vertical (Block Test)
   a. The vertical measurement standard will be flat plates or gauge blocks 0.25, 0.50, 1.0 and 2.0 in. in thickness.
   b. Mark each block with its known thickness. Verify the block thickness accurate to within 0.001 in., utilizing a calibrated digital caliper. Test a smooth base plate and the 0.25, 0.50, 1.0 and 2.0 in. gauge blocks.

3 Vertical (Bounce Test)
   a. The vertical displacement will be measured from flat plates centered on the ground beneath the height sensors.
   b. Performed over a simulated distance of 528 ft. A vertical displacement (bounce) of the vehicle of 1-2 in. will be performed.

D APPARATUS

1 Host vehicle, capable of traveling at a minimum speed of 15 mph while collecting pavement profile data.

2 Distance measuring subsystem, accurate to within 1.0 ft per 528 ft measured.

3 Inertial reference (accelerometer) subsystem, capable of measuring the movement of the host vehicle as it traverses the pavement being tested.

4 Non-contact height measurement (sensor) subsystem, capable of measuring the height from the mounted sensor face to the surface of the pavement being tested.

5 Inertial Profiler
- a. Must include hardware and software capable of storing inertial profiles by combining the data from the inertial referencing system, the distance measuring instrument and the height sensor.
- b. Must be capable of measuring and storing profile elevations at 1 in. intervals or less and outputting in ppf format.
- c. Must have the capability of summarizing the profile elevation data into summary roughness statistics over a section length equal to 0.1 mi.
- d. Must have a design to allow field calibration and verification of calibration for the distance measurement (horizontal)subsystem and the height measurement(vertical) subsystem described in ”Procedures” below.
- e. Must be on California’s Inertial Profiler approved list.

E PROCEDURES

VERIFYING CALIBRATION

1 Verifying Calibration—The following daily verification procedure is required for QA testing and is recommended when an inertial profiler is to be used as a QC instrument.
- a. Verify the tire air pressure on the wheels of the host vehicle daily and maintain according to the vehicle manufacturer’s recommendations.
- b. Maintain a log with the inertial profiler in accordance with AASHTO R 56.
- c. Longitudinal Verification of Calibration:
  - (1) Perform the longitudinal verification of calibration by navigating the inertial profiler over a measured test section of 528 ft +/- 0.1 ft.
  - (2) Warm up the vehicle tires and electronic systems in accordance with the manufacturer’s recommendations. Verify the inertial profiler’s distance measuring subsystem by measuring the length of the test section to 528 ft +/- 1 ft.
  - (3) Adjust the inertial profiler’s distance measurement system according to the manufacturer’s guidelines as required.
- d. Vertical Verification of Calibration:
  - (1) (Block) sensor check tests are run after the profiler has reached operational stability as defined and specified by the manufacturer. This test will be conducted with the inertial profiler on a flat and level area. Its purpose is to check the height measurements, in inches, from the height sensor(s) of the test vehicle using blocks of known heights. During the test, do not lean on the profiler or cause it to move in any way. Under windy conditions, it may be necessary to perform this test indoors. The test procedure consists of the following steps:
    - (a) Center the smooth base plate under the height sensor of the profiler and allow the system to take height measurements. Zero out the sensors.

(b) Center a 0.25 in. block underneath the height sensor on top of the base plate and record the height measurement.
(c) Replace the 0.25 in. block from the base plate with a 0.50 in. block. Record the height measurement.
(d) Replace the 0.50 in. block with a 1.00 in. block and record the height measurement.
(e) Finally, replace the 1.00 in. block with a 2.00 in. block and record the height measurement.

(2) Each inertial profiler must be furnished with their own base plate and gauge blocks. The operator of the profiler will tabulate the gauge block measurements and record them in a calibration log. Determine the difference between each measurement on a gauge block and the base plate to get the thickness of the gauge block as measured by the height sensor. Repeat this calculation for each gauge block. Determine the absolute values of the differences between the computed thickness and the known average block thickness. The absolute differences should be less than or equal to 0.01 in. for each gauge block.
(a) (Bounce) test are performed by positioning the host vehicle on a flat and level surface. Power the system and ensure the profiler has reached operational stability as specified by the manufacturer. Follow the manufacturer's recommended procedure for performing the bounce test. [1,] The static portion shall result in an IRI of less than 3 in. per mile and the bounce portion shall result in an IRI less than 8 in. per mile. See Appendix X1 of AASHTO R 56 for further details concerning the bounce test.

(3) Failure to verify calibration of the above after two attempts will require adjustments and rescheduling of verifying calibration.

CALIBRATION EQUIPMENT

1 Calibration frequency must be as specified by Caltrans. The inertial profiler must successfully perform and pass calibration tests to establish compliance with the minimum requirements for accuracy and repeatability set forth in this procedure. Inertial profilers must be calibrated annually.

2 Calibration testing may be performed on two test sections, one a jointed plain concrete (JPC) surface and the other a hot mix asphalt (HMA) surface; having been established for the purpose of calibrating Inertial Profilers (IP). IP equipment calibrated for use on HMA surfaces will be tested on the HMA surfaced section, and equipment calibrated for use on JPC surface will be tested on either the HMA surfaced section or on both sections depending upon the availability of the JPC surfaced section.

3 An 800 ft long section with two wheel paths has been marked out on each test section. Calibration will be performed on a section a 528 ft +/0.1 ft long within the 800 ft test section. The beginning of the 528 ft calibration section may be adjusted by Caltrans to establish different profiles for calibration. A minimum 300 ft lead in distance to allow proper "settle" of the inertial profiler's filters and

[1] The only difference between a bounce test and a normal data collection run is that there is an artificial longitudinal travel signal supplied and the vehicle is not actually traveling along the road. The bounce test utilizes the same data collection software and routines used during normal data collection.

testing speed is required and is available for the test sections. A similar lead-out distance is also available. The ground distance of each test section will be established to within 1 ft.

4 Two longitudinal lines, identified by painted dots every five feet, have been painted on the test section surfaces 69 in. apart for the 800 ft lengths. IPs are required to follow these designated paths through each test section. Cones and/or other appropriate material will be used during the calibration procedure to define the start and end locations of the test sections. Caltrans will assure that the intended test path is clear of loose material and foreign objects.

5 Ten repeat runs of the IP must be made on each of the designated test section in the prescribed direction of measurement. Data collection must be automatically triggered at the starting location of each run of the section, and reported so that a longitudinal position of "zero" occurs at the starting location. An automatically detected mark at the end of the section must be used to verify the DMI repeatability and accuracy.

6 Test Data—Profile data must be reported in a ppf format.

a. During the calibration tests, the same profile is measured for all runs on a given test section.

(1) The performance of the profiler is evaluated by analyzing the test data using cross correlation as described in the following sections to establish the repeatability and accuracy for the application of the device. ProVAL software will be used to perform the calculations specified below. The version of the ProVAL software to be used for evaluation will be determined by Caltrans.

(2) Equipment Repeatability—Evaluate repeatability using cross correlation of the filtered output as described in Section 8.3.1.4 of AASHTO R56. Calculate the repeatability agreement score of each trace. For single sensor set profilers, one score for each path will be determined. For dual-path profilers, two profiles will be used for each test section. The IRI filter should be used on the profiles for cross correlation. On each trace, cross correlate each of the ten profiles to each of the remaining nine. Maximum allowable offset is 3 ft. The repeatability agreement score for each trace is the average of all values. Cross correlation shall result in a score of 0.92 or greater.

(3) Equipment Accuracy—Evaluate accuracy using cross correlation of the appropriate filtered output as described in Section 8.3.1.4 of AASHTO R56. On each trace, cross correlate each of the ten profiles to the reference profile. The accuracy agreement score for each trace is the average of the ten individual cross correlation values. Cross correlation must result in a score of 0.90 or greater.

b. Test data must be submitted with the following file naming convention.

(1) The first three characters of the filename are reserved for identifying the profiler tested. This will be given to the operator on the day of testing.

(2) The fourth character must be "A" for asphalt or "C" for concrete.

(3) The fifth character must be "H" for high speed or "L" for lightweight device.

(4) The sixth character shall designate the path tested. "L" for left, "R" for right or "B" for both.

(5) The seventh and eight characters shall designate the run number (01 to 10).

c. Verification of Computed Ride Statistics (IRI)—Each IRI value should be comparable to the value from the reference profile with an error not greater than 5 percent.

7 Distance Measurement Index Test—Test the accuracy of the DMI on one of the test sections

a. Distance Measurement Index Test Section—The test section must be the same test section used for the ten repeat runs performed for repeatability and accuracy. The starting and ending points of the test section will be measured to 528 ft +/- 0.1 ft and clearly marked.

b. Three auto-triggered runs of the candidate inertial profiler shall be made on the designated length of pavement in the prescribed direction of measurement. At the end of each run, record the reading from the profiler's DMI.

c. Distance Measurement Index Accuracy—Compute the absolute difference between the DMI readings and the known distance of the path tested for each run. The average of the absolute differences shall be 1.0 ft of less to pass the test.

8 Test Results—The results of the calibration tests must be documented by Caltrans. Calibration documentation will include the following:

a. Identification of the profiler tested (i.e., make, model serial number, software version, owner);
   (1) Date of last calibration (if applicable);
   (2) Operator of the profiler;
   (3) Name and title of the individual performing the test;
   (4) Date of test;
   (5) Number of paths the profiler can measure in the same run;
   (6) Filter type, name of the filter program, and the applicable program version number used to evaluate the profiler accuracy;
   (7) Overall determination from the test: Pass or Fail;
   (8) Known longitudinal distance of the DMI test section; and
   (9) Average absolute difference between the DMI readings and the known distance, expressed in distance unit and as a percentage of the known longitudinal distance. The following information is to be provided for each trace:
      (a) Overall repeatability score;
      (b) Overall accuracy score;
      (c) The average percent difference of the IRIs computed profiles and those from the reference profile.

b. The report will also label each test result with a Pass or Fail depending on whether the given test value meets or fails to meet the prescribed criterion. The IP must pass all tests to be calibrated. A decal will be affixed to each accelerometer/sensor unit and a certificate of successful calibration will be issued at successful completion of the calibration procedure.

CERTIFICATION OF OPERATOR

Operators of inertial profilers used for project level acceptance testing of pavement ride

quality must pass a written and practical proficiency test to be certified to operate an inertial profiler in California. An operator must be certified annually.

F PRECAUTIONS

1 The Inertial Profiler Calibration Program is not a training program. It is expected that all participating operators be well-versed in the operation of the IP to be certified. Caltrans staff will serve as technical experts and may provide guidance during the certification process, but will not be responsible or accountable for the training of IP operators

2 The owner/operator of the IP must make all repairs and adjustments as needed before taking measurements at the test site. The owner/operator of the IP must have all tools and components necessary to adjust and operate the IP according to the manufacturer's instructions and recommendations. All equipment manufacturer specifications, and manuals, calibration logs and training records must accompany the IP to be certified.

G. HEALTH AND SAFETY

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

End of Text
(California Test 387 contains 6 pages)