
Standard Practice for Assessment of Highway Performance of Transverse Pavement Profiling Systems

AASHTO Designation: PP 109-24¹

Technically Revised: 2024

Technical Subcommittee: 5a, Pavement Measurement



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Assessment of Highway Performance of Transverse Pavement Profiling Systems

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1. SCOPE

- 1.1. This practice describes procedures to assess the accuracy and precision of the transverse pavement profiler (TPP) under typical dynamic operation. The particular specifications which will be assessed are: transverse measurement spacing, effective transverse width, longitudinal measurement spacing, and vertical measurement error.
- 1.2. In addition to the TPP specifications, the TPP will be evaluated on the following deformation parameters: rut depth, cross slope, vertical magnitude of an edge/curb, and transverse location of an edge/curb. Evaluations will be performed by comparing the resulting TPP deformation parameters to ones calculated from ground reference data conforming to PP 110.
- 1.3. The minimum requirements stipulated herein are intended to focus on the need for accurate and repeatable transverse measurements for network and project level data collection.
- 1.4. If any part of this practice is in conflict with referenced documents, such as ASTM Standards, this practice takes precedence for its purposes.
- 1.5. This standard practice is intended to be conducted in conjunction with three other standard practices to fully assess and certify the TPP in typical operating conditions. For static assessment see PP 106; for body motion assessment, see PP 107; and for assessment of drift mitigation, see PP 108.
- 1.6. *This practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this practice to establish appropriate safety and health practices and determine the applicability of regulatory limitations related to and prior to its use.*

2. REFERENCED STANDARDS

- 2.1. *AASHTO Standards:*
 - PP 106, Assessment of Static Performance in Transverse Pavement Profiling Systems
 - PP 107, Assessment of Body Motion Cancellation in Transverse Pavement Profiling Systems
 - PP 108, Assessment of Navigation Drift Mitigation in Transverse Pavement Profiling Systems
 - PP 110, Assessment of Ground Reference Data for Transverse Pavement Profiling System Assessment
 - PP 111, Definition of Terms Related to Transverse Pavement Profiling Systems and Ground Reference Equipment

■ R 87, Determining Pavement Deformation Parameters and Cross Slope from Collected Transverse Profiles

3. TERMINOLOGY

- 3.1. See PP 111 for definition of terms used in this standard practice.
- 3.2. Table 1 provides the physical parameter definitions, symbols, and default values to be used when administering this standard. The transverse width of the ground reference test section is dependent on the pavement deformation parameters of interest; the width is to be chosen by the certifying agency within the default range to comply with the agency requirements and the operating conditions available at the test site.

Table 1—Physical Parameter Definitions and Default Values

Physical Parameter	Symbol	Default Value(s)
Transverse Width of the Ground Reference Test Section for Edge/Curb Drop-off	W_{gr}	3.875 ± 0.375 m (12.7 $\pm$ 1.2 ft)
Transverse Width of the Ground Reference Test Section for Cross Slope	W_{gr}	3.750 ± 0.250 m (12.3 $\pm$ 0.8 ft)
Transverse Width of the Ground Reference Test Section for Rut Depth	W_{gr}	3.650 ± 0.150 m (12.0 $\pm$ 0.5 ft)
Longitudinal Length of the Ground Reference Test Section	L_{gr}	1.0 ± 0.002 m (39.4 $\pm$ 0.08 in.)
Height of Bounding Beams	h_b	70 ± 30 mm (2.75 $\pm$ 1.18 in.)
Transverse Width of Bounding Beams	w_b	70 ± 30 mm (2.75 $\pm$ 1.18 in.)
First Test Speed	V_1	32 ± 3 kph (20 $\pm$ 2 mph)
Second Test Speed	V_2	56 ± 3 kph (35 $\pm$ 2 mph)
Third Test Speed	V_3	89 ± 3 kph (55 $\pm$ 2 mph)
Transverse Width of TPP Point Neighborhood	w_M	50.0 mm (2.06 in.)
Longitudinal Length of TPP Point Neighborhood	L_m	50.0 mm (2.08 in.)
Minimum Number of Transverse Profiles Acquired in the Ground Reference Test Section at Each Speed	N_{isp}	100
Number of Measurements to Randomly Sample	N_r	200
Longitudinal Length of Virtual Region for Cross Slope and Rut Depth	L_m	100 mm

4. SIGNIFICANCE AND USE

- 4.1. Measured transverse profiles of road surfaces are used to extract pavement deformation parameters such as rut depth, cross slope, and edge/curb drop-off. The accuracy of the estimated pavement deformation parameters depends on the measured transverse profile accurately representing a transverse section of the road surface.
- 4.2. Requirements on the TPP specifications ensure that the measured profile accurately represents the road surface. In addition, it is essential that the TPP sensors be able to accurately and precisely measure the height and transverse location of the road surface points.
- 4.3. This practice outlines standard procedures for certifying and verifying the operational accuracy and precision of transverse pavement profilers related to dynamic measurement components. This standard prescribes a procedure to analyze the accuracy and precision of a TPP system by collecting multiple transverse profile measurements (TPP data) while the vehicle is moving at a full range of operating speeds during typical operating conditions. Because the data are used for subsequent calculations for rut depth, cross slope, and edge/curb drop-off, tables of the necessary accuracy and precision for certification are provided in the form of confidence intervals for each use.

5. EQUIPMENT

- 5.1. The TPP must be able to collect transverse profiles at a minimum sampling rate of 100 complete transverse profile scans per second, collect transverse profiles so that the longitudinal variation of each transverse profile is no more than L_m , collect transverse profiles that include both bounding beams, and be capable of operating across the range of speeds provided in Table 1.

Note 1—To cancel the body motion (which is critical in obtaining accurate profiles), ride frequencies must be accounted for and a minimum sample rate of 100 samples/second must be used for all measurements. This minimum sampling rate is for all mapping and localization sensors with the exception of GPS or GNSS measurements.

- 5.2. Provide all collected transverse profiles of the test section in electronic text files following the format prescribed in Annexes A and B.

6. DATA COLLECTION AND REPORTING

- 6.1. Assessment shall be performed over a range of road and pavement conditions. Test sites shall be formed from a segment of the road surface with a longitudinal length of L_{gr} and a transverse width of W_{gr} and shall be characterized based on the final data requirement of interest. The ground reference test section is shown in Figure 1.

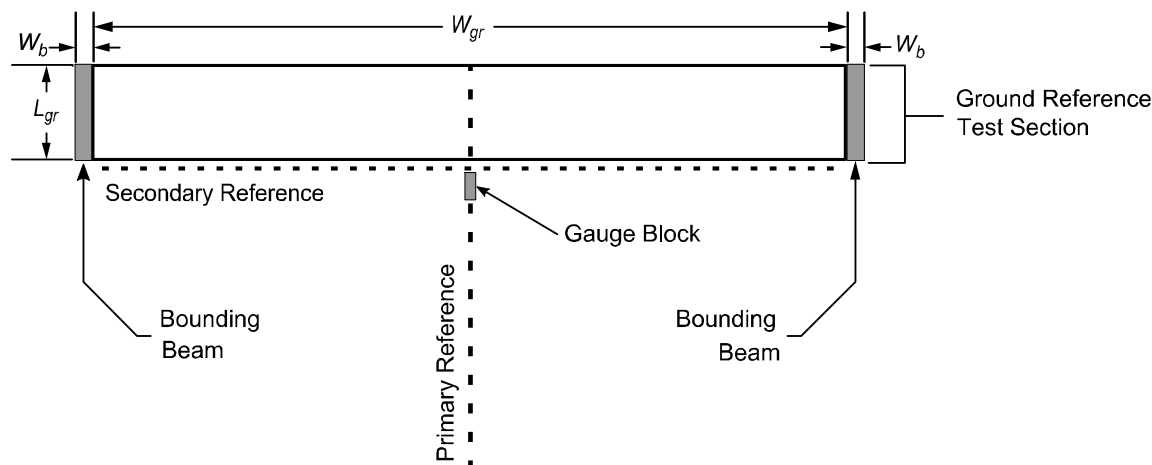


Figure 1—Schematic of the Ground Reference Test Section

- 6.1.1. For assessment of rut depth, test sites shall exhibit a range of rut depths from low level rutting to high level rutting. For low level rutting, the minimum allowable rut depth is 2.0 mm (0.08 in.). High level rutting is classified as rut depths greater than 20 mm (0.8 in.). The rut depth shall be established by the ground reference equipment. For assessment of cross slope, the test site shall contain a cross slope greater than 0.5 percent. Bounding beams shall be placed on the transverse edges of the test site while conducting the assessment. These bounding beams allow for any selected road surface to be used for assessment of edge/curb detection. A gauge block shall be placed immediately outside the ground reference test section and in line with the primary reference line to facilitate local registration of the data. The surface macrotexture for the test sites should reflect the variety of the pavement surfaces to be evaluated.
- 6.1.2. All test sites should have an ample length of road to allow for the TPP to achieve the target speed prior to entering the test site and come to a stop after exiting the test site. A minimum road length of 0.4 km (0.25 mi) is considered necessary to perform the full range of speeds. TPP

manufacturer recommendations for adequate lead-in distance/warm up time for the sensors/data fusion/data filtering must be provided and complied with as reasonably close as possible to emulate production data collection processes. It is permissible to increase the TPP scan rate to provide the required data density specifically to obtain data within the reference object region as described in the test procedures. All other settings shall remain the TPP settings used during typical network level data collection. The TPP must make as many runs as the system requires in order to provide at least N_{isp} scans for each test speed and at least two runs for each test speed.

- 6.2. Two reference lines (e. g., chalk lines) shall be marked on the road surface to ensure all bounding beams placed on the road surface are properly aligned. A central primary reference line shall be placed in the longitudinal direction of the test site. A secondary reference line shall be placed in the transverse direction. (Shown as dashed lines in Figure 1.)
- 6.3. The ground reference test section and the gauge block shall be centered in the transverse direction about the primary reference line. The secondary reference line will serve as the start of the ground reference test section.
- 6.4. Bounding beams of length L_{gr} and width w_b shall be placed along the transverse edges of the ground reference test sections. These blocks will remain along the transverse edges throughout the entire testing process and shall not be moved. The bounding beams shall conform to the specifications provided in Annex C.
- 6.5. The certification agency shall acquire ground reference data of the road surface corresponding to the ground reference test section that satisfies the requirement statement in PP 110. The procedure for collecting ground reference data is provided in Annex B.
- 6.6. The TPP operator shall collect three sets of data, one set at each test speed: V_1 , V_2 , and V_3 .
Note 2—TPP operator should check the scans to ensure both bounding beams have been captured.
- 6.7. At each test speed, the driver shall acquire data while driving through the complete ground reference test section. The TPP operator shall make at least two runs and may make multiple runs through the ground reference test section at each test speed until at least N_{isp} transverse profiles have been collected that span the entire transverse width of the test section and lie completely within the longitudinal length of the test section.
- 6.8. All reported TPP data shall be reported in a global reference frame with a structure conforming to the data format in Annex A, Section A1.

7. DATA REDUCTION

- 7.1. *Transverse/Longitudinal Measurement Spacing:*
 - 7.1.1. For each run at each test speed N_r measurements shall be randomly chosen and added to the set S . The N_r measurements for each test speed shall be used to estimate the transverse and longitudinal measurement spacing of the TPP reported data.
 - 7.1.2. For each measurement in the set S , the nearest neighboring point in each of four quadrants shall be identified (one neighboring point per quadrant). The nearest neighboring measurement per quadrant shall be identified as the measurement point that is located in the quadrant of interest and has the shortest three-dimensional Euclidian distance. The quadrants shall be defined by a set of two-dimensional orthogonal axes oriented at a 45-degree angle with respect to the transverse–longitudinal axes of the path coordinate system. See Figure 2 for an example of the quadrants for a selected point and the identification of the nearest neighboring point per quadrant.

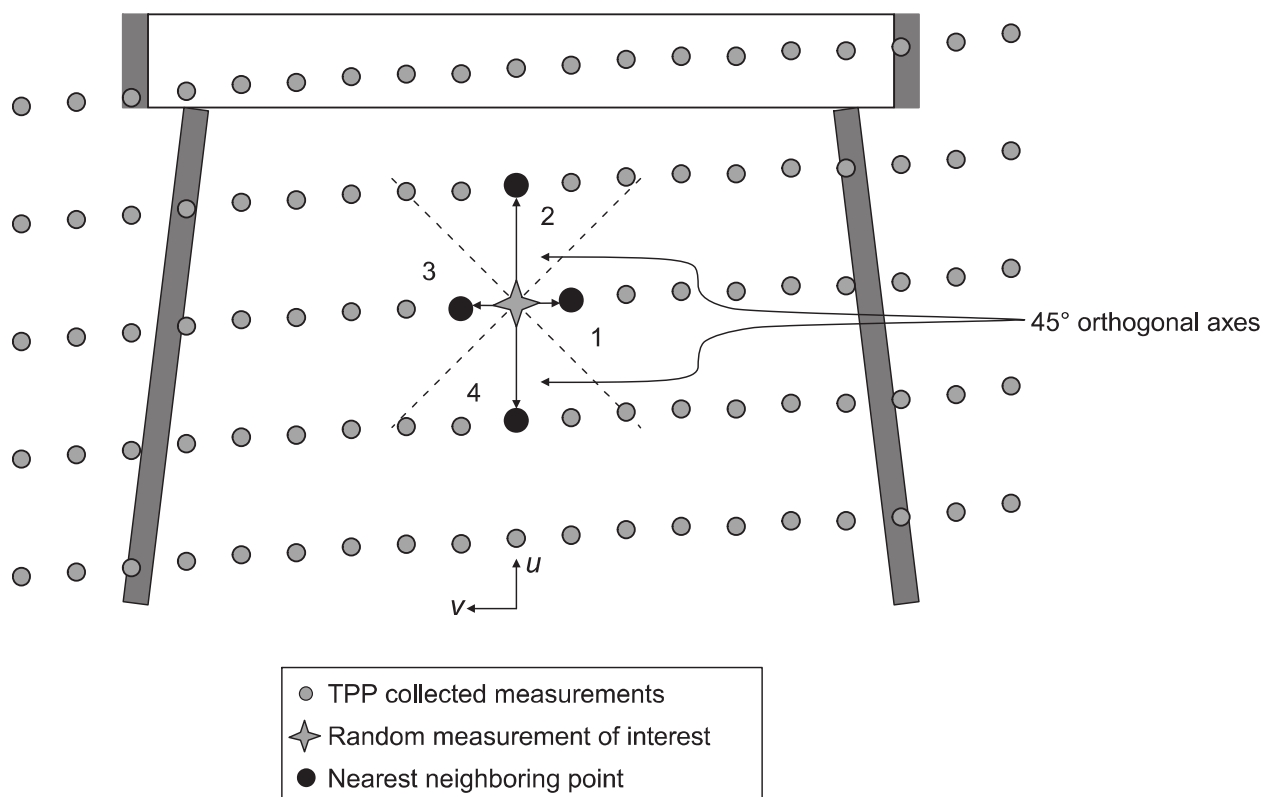


Figure 2—Illustration of Four Quadrants Oriented with Respect to the Path Coordinate System and Identification of the Nearest Neighboring Point in Each Respective Quadrant

- 7.1.3. For individual runs at each test speed, the identified nearest neighboring point in quadrants 1 and 3 shall each provide an estimate of the transverse spacing. The transverse point-to-point distance between the respective measurement in the set S and the identified nearest neighboring point in quadrant 1 and quadrant 3 shall be calculated and added to the set t_{prof} . The set t_{prof} shall serve as a sample from the population of true transverse measurement spacing.
- 7.1.4. For individual runs at each test speed, the nearest neighboring point in quadrants 2 and 4 shall each provide an estimate of the longitudinal spacing. The longitudinal point-to-point distance between the respective measurement in the set S and the identified nearest neighboring point in quadrant 2 and quadrant 4 shall be calculated and added to the set l_{prof} . The set l_{prof} shall serve as a sample from the population of true longitudinal measurement spacing.
- 7.2. *Effective Transverse Width:*
- 7.2.1. Per reported TPP dataset, each transverse profile as measured in the TPP body reference frame that spans the entire width of the test section and lies completely within the longitudinal length of the test section shall be uniquely identified by index i and added to the set $S_{t,i}$.
- 7.2.2. Per transverse profile in the set $S_{t,i}$, four critical points shall be identified: (1) the outermost left measurement, (2) the measurement corresponding to the inside edge of the left bounding beam, (3) the measurement corresponding to the inside edge of the right-angled bounding beam, and (4) the outermost right measurement. See Figure 3 for an illustration of the four critical points in a single transverse profile. The TPP body reference frame is the coordinate system centered transversely in the vehicle; that is, in the TPP body reference frame. The location $v = 0$