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Standard Guide for Classification of Automated Pavement Condition Survey Equipment[1]

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1. Scope

1.1 This guide covers information for classifying the measurement capability of pavement condition survey equipment or instrumentation that measures longitudinal profile, transverse profile or cracking of pavement surfaces while operating at or near traffic speeds.

1.2 The measuring equipment or instrumentation, addressed by the guide, samples and stores measurement data while operating at or near traffic speeds.

1.3 This guide does not address equipment that operates at traffic speeds but is incapable of measuring profile or individual crack characteristics, such as response-type roughness measuring systems and semi-automated distress recording systems.

1.4 This guide provides measurement criteria and classification for use in a range of applications.

1.5 The measurement criteria apply to longitudinal profile, transverse profile, or the cracking of pavement surfaces.

1.6 This guide does not address the processing of measured data.

1.7 *This standard 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 standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 177 Practice for the Use of the Terms Precision and Bias in ASTM Test Methods[2]

E 456 Terminology Relating to Quality and Statistics[2]

E 867 Terminology Relating to Traveled Surface Characteristics[3]

E 950 Test Method for Measuring the Longitudinal Profile of Vehicular Traveled Surfaces with an Inertial Profilometer[3]

E 1082 Standard Test Method for Measurement of Vehicular Response to Traveled Surface Roughness[3]

E 1170 Practice for Simulating Vehicular Response to Longitudinal Profiles of a Vehicular Traveled Surface[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *characteristic*—a directly measurable distinguishing property of the pavement surface. Examples are pavement longitudinal profile, transverse profile, and separations in the continuity of a pavement surface.

3.1.2 *dynamic intermediate precision*—the precision of the measurement of a characteristic determined under dynamic intermediate precision conditions in which the same equipment moving at operating speed measures the characteristic at the same location repeatedly, in accordance with the procedure specified in 7.2.

3.1.3 *longitudinal profile*—the perpendicular deviations of the pavement surface from an established reference parallel to the lane direction, usually measured in the wheel tracks.

3.1.4 *resolution*—the smallest increment that a characteristic-measuring process must distinguish and display.

3.1.5 *stationary repeatability precision*—the precision of the measurement of a characteristic determined under repeatability condition with the instrumented equipment stationary, in accordance with the procedure specified in 7.1.

3.1.6 *tolerance*—the defined limits of allowable (acceptable) departure from the true value of a measured quantity.

4. Significance and Use

4.1 Highway agencies, equipment manufacturers, and other organizations can use this guide to classify the measuring capabilities of pavement condition survey equipment that operates at traffic speeds and collect some of the data useful in characterizing pavement conditions.

4.2 The vertical measurement resolution, sample interval, and crack width capabilities as specified in Section 5 are subject to user verification.

5. Guidelines

5.1 *Classification*:

5.1.1 *Attribute Measurement Category*:

5.1.1.1 The measuring capability of condition survey equipment is described by a set of attribute measurement categories, each designating the capability of measuring an individual pavement attribute. The designated attributes covered are:

(1) longitudinal profile,

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[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

(2) transverse profile, and

(3) crack width.

5.1.2 *Code*:

5.1.2.1 The measurement capability in each category is designated by the sequence of codes each representing a type or level of measurement capability, as follows:

(1) First code—Measured attribute (alphabetic),

(2) Second code—Stationary repeatability precision (numeric),

(3) Third code—Longitudinal sampling interval (numeric),

(4) Fourth code—Transverse sampling interval (numeric), and

(5) Fifth code—Transverse coverage (numeric).

5.1.3 *Code values*:

5.1.3.1 The values of each code are defined in the following sections:

5.2 *Equipment for Measuring Longitudinal Profile*—Equipment capability is defined by vertical-measurement stationary repeatability precision, transverse sampling frequency, and longitudinal sampling interval. Equipment capability is divided into the classes shown in Table 1.

5.2.1 If equipment can measure vertically with a stationary repeatability precision of 0.15 mm (0.06 in.), a moving longitudinal sampling interval of 125 mm (5 in.) and a transverse sampling of three profiles per pass, it is a Code L221 unit.

5.3 *Equipment for Measuring Transverse Profile*—Equipment capability is defined by vertical-measurement stationary repeatability precision, transverse sampling interval and longitudinal sampling interval. Equipment capability is divided into the classes shown in Table 2.

5.3.1 If equipment can measure vertically with a stationary repeatability precision of 0.3 mm (0.012 in.), a moving longitudinal sampling interval of 2 m (6.5 ft), a transverse sampling interval of 150 mm (6 in.) and a transverse coverage of 2.0 m (6.5 ft), it is a Code T3233 unit.

5.4 *Equipment for Measuring Cracking of Pavement Surfaces*—Equipment capability depends on the stationary repeatability precision with which crack width can be measured, the transverse sampling interval and the longitudinal sampling interval. The capability of equipment is divided into the classes shown in Table 3.

5.4.1 If equipment can measure vertically with a crack width stationary repeatability precision of 0.7 mm (0.028 in.), a longitudinal sampling of 0.3 mm (0.012 in.), a transverse sampling interval of 5 mm (0.20 in.) and a transverse coverage of 2.0 m (6.5 ft), it is a Code C3253 unit.

TABLE 1 Equipment Capability—Measuring Longitudinal Profile

Characteristic	Code	Description
Measured Attribute	L	Longitudinal Profile
Vertical measurement		*Stationary Repeatability Precision*
	1	Less than or equal to 0.1 mm (0.004 in.)
	2	Greater than 0.1 mm to 0.2 mm (0.004 in. to 0.008 in.)
	3	Greater than 0.2 mm to 0.5 mm (0.008 in. to 0.020 in.)
	4	Greater than 0.5 mm (0.20 in.)
Longitudinal sampling		*Interval*
	1	Less than or equal to 25 mm (1 in.)
	2	Greater than 25 mm to 150 mm (1 in. to 6 in.)
	3	Greater than 150 mm to 300 mm (6 in. to 12 in.)
	4	Greater than 300 mm (12 in.)
Transverse sampling		*Number of profiles per pass*
	1	3 or more profiles
	2	2 profiles
	3	1 profile
Transverse coverage	NA[A]	NA[A]

[A]Not applicable.

TABLE 2 Equipment Capability—Measuring Transverse Profile

Characteristic	Code	Description
Measured Attribute	T	Transverse Profile
Vertical measurement		*Stationary Repeatability Precision*
	1	Less than or equal to 0.1 mm (0.004 in.)
	2	Greater than 0.1 mm to 0.2 mm (0.004 in. to 0.008 in.)
	3	Greater than 0.2 mm to 0.5 mm (0.008 in. to 0.020 in.)
	4	Greater than 0.5 mm (0.20 in.)
Longitudinal sampling		*Interval*
	1	Less than or equal to 300 mm (1 ft)
	2	Greater than 300 mm to 3 m (1 ft to 10 ft)
	3	Greater than 3 m to 30 m (10 ft to 100 ft)
	4	Greater than 30 m (100 ft)
Transverse sampling		*Interval*
	1	Less than or equal to 25 mm (1 in.)
	2	Greater than 25 mm to 100 mm (1 in. to 4 in.)
	3	Greater than 100 mm to 300 mm (4 in. to 12 in.)
	4	Greater than 300 mm to 600 mm (12 in. to 24 in.)
	5	Greater than 600 mm (24 in.)
Transverse coverage		*Width*
	1	Greater than 3.7 m (12 ft)
	2	Greater than 2.7 m to 3.7 m (9 ft to 12 ft)
	3	Greater than 1.8 m to 2.7 m (6 ft to 9 ft)
	4	Less than or equal to 1.8 m (6 ft)

6. Applications

6.1 The measures addressed by this guide support pavement management for roads, airfields, and other paved areas. Longitudinal profile, transverse profile, and crack information can

TABLE 3 Equipment Capability—Measuring Cracking of Pavement Surfaces

Characteristic	Code	Description
Measured Attribute	C	Cracking of Pavement Surface
Crack width		*Stationary Repeatability Precision*
	1	Less than or equal to 0.25 mm (0.01 in.)
	2	Greater than 0.25 mm to 0.5 mm (0.01 in. to 0.02 in.)
	3	Greater than 0.5 mm to 1 mm (0.02 in. to 0.04 in.)
	4	Greater than 1 mm to 3 mm (0.04 in. to 0.12 in.)
	5	Greater than 3 mm (0.12 in.)
Longitudinal sampling		*Interval*
	1	Less than or equal to 0.25 mm (0.01 in.)
	2	Greater than 0.25 mm to 0.5 mm (0.01 in. to 0.02 in.)
	3	Greater than 0.5 mm to 1 mm (0.02 in. to 0.04 in.)
	4	Greater than 1 mm to 3 mm (0.04 in. to 0.12 in.)
	5	Greater than 3 mm (0.12 in.)
Transverse sampling		*Interval*
	1	Less than or equal to 0.25 mm (0.01 in.)
	2	Greater than 0.25 mm to 0.5 mm (0.01 in. to 0.02 in.)
	3	Greater than 0.5 mm to 1 mm (0.02 in. to 0.04 in.)
	4	Greater than 1 mm to 3 mm (0.04 in. to 0.12 in.)
	5	Greater than 3 mm (0.12 in.)
Transverse coverage		*Width*
	1	Greater than 3.7 m (12 ft)
	2	Greater than 2.7 m to 3.7 m (9 ft to 12 ft)
	3	Greater than 1.8 m to 2.7 m (6 ft to 9 ft)
	4	Less than or equal to 1.8 m (6 ft)

contribute to understanding pavement performance. The appropriate measurement level depends on the application.

6.2 *Longitudinal Profile*—Applications of longitudinal profile data include the following:

6.2.1 Computing roughness statistics such as International Roughness Index (IRI) and ride quality statistics such as Ride Number,

6.2.2 Estimating road user costs,

6.2.3 Modeling roughness so that future roughness can be predicted,

6.2.4 Identifying probable causes of pavement deterioration from the nature of the elevation and wave band spectra,

6.2.5 Estimating the effect of pavement maintenance and rehabilitation on roughness and ride quality,

6.2.6 Estimating material quantity for overlay treatments, and

6.2.7 Providing a reference to determine construction quantities such as areas warranting grinding, leveling to correct grade and longitudinal profile, and milling requirements at faulted joints and cracks.

6.3 *Transverse Profile*—Applications for transverse profile data include the following:

6.3.1 Computing rut depth,

6.3.2 Modeling rut depth to predict future rut depth,

6.3.3 Using the shape of the transverse profile to indicate the cause of rutting, and

6.3.4 Estimating material quantities for overlays and correcting rutting.

6.4 *Cracking of Pavement Surfaces*—Applications for crack width data include the following:

6.4.1 Estimating pavement cracking distress or condition,

6.4.2 Estimating the quantity of crack seal material, and

6.4.3 Prediction of future cracking distress.

7. Procedure

7.1 *Stationary Repeatability Precision*—For the purposes of determining the measurement classification codes specified in Section 5, this precision shall be the d2s deviation (as specified in Terminology E 456) determined from a series of repeated measurements of the attribute being measured as follows:

7.1.1 *Longitudinal Profile Sensors*—(*1*) With the equipment stationary, place a flat level plate under each longitudinal profile sensor. (*2*) Switch on the sensor(s), record the sensor reading(s), and switch off the sensor(s). All sensors may be monitored at the same time. Perform this measurement cycle 10 times without adjustment of the instrumentation. (*3*) Normalize the measurements of a sensor by subtracting the mean value of the 10 readings from each reading. (*4*) Place a calibration block 25 ± 0.01 mm (1.0 ± 0.04 in.) thick on the plate beneath the sensor. (*5*) Perform the measurements ten times in the same manner as (*2*) and normalize the values as in (*3*). (*6*) Determine the standard deviation of the 20 normalized measurements performed for each sensor. Determine the d2s value for each sensor as 2.83 times the standard deviation of the measurements. Determine the stationary repeatability precision as the average of the d2s values for all longitudinal profile sensors.

7.1.2 *Transverse Profile Sensors*—For each transverse profile sensor, repeat the procedure described in 7.1.1 to determine the stationary repeatability precision for all transverse profile sensors.

7.1.3 *Cracking Sensors*. (*1*) With the equipment stationary, place a flat smooth plate, which is at least 50 % larger than the sensed area in each dimension and has no surface discontinuities greater than 0.01 mm (0.004 in.) in width or 0.01 mm (0.004 in.) in depth, beneath each cracking sensor. (*2*) Switch on the crack sensor(s), record the sensor reading(s), and switch off the sensor(s). Perform the measurement ten times. All sensors may be measured at the same time. (*3*) Normalize the measurements by subtracting the mean value of the ten readings from each reading. (*4*) Place a flat smooth plate having the same horizontal dimensions as the plate in (*1*), a thickness of 20 mm (0.75 in.), and a linear slot 3 ± 0.05 mm (0.125 ± 0.02 in.) wide and 15 mm (0.6 in.) deep traversing the full width of the plate, beneath each cracking sensor. (*5*) Perform ten measurements in the same manner as specified in (*2*) and normalize them as in (*3*). (*6*) Rotate the plate specified in (*4*) through 90°, and repeat the measurements specified in (*1*). (*7*) Determine the standard deviation of the 30 measurements performed for each sensor. Determine the d2s value for each sensor as 2.83 times the standard deviation of the measurements. Determine the stationary repeatability precision as the average of the d2s values for all cracking sensors.

7.2 *Dynamic Intermediate Precision*—With the equipment moving at normal operating speed, make ten repeat measurements at an identified pavement location using all sensors. The beginning and end of each test section shall be marked so that they are identified in the data. This may be done either by manual or automated means. Normalize the measurements by subtracting the mean value recorded for each sensor from each reading of that sensor. Perform similar sets of measurements at a total of three locations with conditions of the measured characteristics representing the range of conditions to be expected under normal operations. Calculate the d2s values for each sensor from all normalized measurements from that sensor. Determine the dynamic intermediate precision for the measurement of this characteristic as the average of the d2s values for all sensors.

8. Precision and Bias

8.1 The stationary repeatability precision, determined in accordance with 7.1, shall be used to determine the classification of equipment in accordance with Section 5.

8.2 Since there is no accepted reference method for determining the bias of the equipment in this guide for measuring pavement attributes, no statement on bias is being made.

9. Keywords

9.1 automated; pavement condition survey equipment; traffic speeds