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Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth[1]

This standard is issued under the fixed designation E 1845; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the calculation of mean profile depth from a profile of pavement macrotexture.

[1] This practice is under the jurisdiction of Committee E-17 on Vehicle-Pavement Systems and is the direct responsibility of Subcommittee E17.23 on Surface Characteristics Related to Tire- Pavement Slip Resistance.

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1.2 The mean profile depth has been shown to be useful in predicting the speed constant (gradient) of wet pavement friction.[2]

1.3 A linear transformation of the mean profile depth can provide an estimate of the mean texture depth measured according to Test Method E 965.

1.4 The values stated in SI (metric) units are to be regarded as standard. The inch-pound equivalents are rationalized, rather than exact mathematical conversions.

1.5 *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 867 Terminology Relating to ~~Traveled Surface Characteristics~~ Vehicle-Pavement Systems[3]

E 965 Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique[3]

2.2 *ISO Standard:*

ISO 13473-1 Acoustics—Characterization of Pavement Texture using Surface Profiles–Part 1: Determination of Mean Profile Depth[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *baselength*, *n*—the length of a segment of a pavement macrotexture profile being analyzed, required to be 100 mm in this practice.

3.1.2 *estimated texture depth (ETD)*, *n*—the estimate of the mean texture depth (MTD), by means of a linear transformation of the mean profile depth (MPD).

3.1.3 *mean profile depth (MPD)*, *n*—the average of all the mean segment depths of all of the segments of the profile.

3.1.4 *mean segment depth*, *n*—the average value of the profile depth of the two halves of a segment having a given baselength.

3.1.5 *mean texture depth (MTD)*, *n*—the mean depth of the pavement surface macrotexture determined by the volumetric technique of Test Method E 965.[5]

3.1.6 *profile depth (PD)*, *n*—the difference between the amplitude measurements of pavement macrotexture and a horizontal line through the top of the highest peak within a given baselength.

4. Summary of Practice

4.1 This practice uses a measured profile of the pavement macrotexture.

4.2 The measured profile is divided for analysis purposes into segments each having a baselength of 100 mm (3.9 in.). The slope, if any, of each segment is suppressed by subtracting a linear regression of the segment. The segment is further divided in half and the height of the highest peak in each half segment is determined. The difference between that height and the average level of the segment is calculated. The average value of these differences for all segments making up the measured profile is reported as the MPD.

5. Significance and Use

5.1 This practice is suitable for the calculation of the average macrotexture depth from profile data. The results of this calculation (MPD) ~~has~~ have proven to be useful in the prediction of the speed dependence of wet pavement friction.[2]

5.2 The MPD can be used to estimate the result of a measurement of macrotexture depth using a volumetric technique according to E 965. The values of MPD and MTD differ due to the finite size of the glass spheres used in the volumetric technique and because the MPD is derived from a two-dimensional profile rather than a three-dimensional surface. Therefore a transformation equation must be used.

5.3 This practice may be used with pavement macrotexture profiles taken on actual road surfaces or from cores or laboratory prepared samples.

5.4 Aggregate size, shape, and distribution are features which are not addressed in this practice. This practice is not meant to provide a complete assessment of texture characteristics. In particular, care should be used when interpreting the result for porous or grooved surfaces.

5.5 This practice does not address the problems associated with obtaining a measured profile. Laser or other optical noncontact methods of measuring profiles are usually preferred. However, contact methods using a stylus also can provide accurate profiles if properly performed.

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[2] Wambold, J. C., Antle, C. E., Henry, J. J., and Rado, Z., International PIARC Experiment to Compare and Harmonize Texture and Skid Resistance Measurements, Final report, *Permanent International Association of Road Congresses* (PIARC), Paris 1995.

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

[4] Available from International Organization for Standardization, 1, rue de Varembe, Case Postale 56, CH-1211 Geneva 20, Switzerland.

[5] In the Test Method E 965, the mean texture depth is reported as $MATX_d$. In this practice it will be reported as MTD, which has more widespread use. The two terms are intended to be equivalent.

6. Profile Requirements

6.1 *Amount of Data Required*:

6.1.1 Ideally, a continuous profile made along the entire length of the test section should be utilized if possible.

6.1.2 A minimum requirement shall be ten evenly spaced profiles of 100 mm (3.9 in.) in length for each 100 m (3900 in.) of the test section. However, for a uniform test section, it is sufficient to obtain 16 evenly spaced profiles regardless of test section length. For surfaces having periodic texture (that is, grooved or tined surfaces) the total profile length shall include at least ten periods of the texture.

NOTE 1—When characterizing a long test section with relatively short sample lengths, it is important to ensure that the texture is sufficiently homogeneous to provide a representative measure. It is necessary for the user to use sound judgment to determine the minimum number of samples to characterize a nonhomogeneous pavement.

NOTE 2—The texture of pavements that have been in service varies across the pavement. In this case the transverse location of the measurements shall be determined by the intended use of the data.

6.1.3 In the case of laboratory samples (either cores or rectangular slabs) the minimum requirement shall be at least ten profiles having a length of 100 mm (3.9 in.) evenly distributed over the surface of the sample. Care should be taken to avoid edge effects. For this reason, samples having a characteristic length of at least 150 mm (5.9 in.) are recommended.

NOTE 3—Measurements on laboratory samples have many different purposes. Therefore it is difficult to specify general minimum requirements. The specification here assumes that the purpose is to obtain values which are reasonably representative of pavements.

6.2 *Resolution*:

6.2.1 Vertical resolution shall be at least 0.05 mm (0.002 in). Vertical range shall be no less than 20 mm (0.75 in.) and vertical nonlinearity shall be no greater than 2 % of the range.

NOTE 4—For stationary devices on smooth pavements a lesser range may be used. In this case, non-linearity need not exceed the above requirement of 0.4 mm (0.015 in.). The higher range is usually required to allow for a sensor mounted on a moving vehicle.

6.2.2 Maximum spot size for a laser or other electro-optical device shall be no greater than 1 mm (0.04 in.). The stylus in a contact device shall have a tip having a major diameter no greater than 1 mm (0.04 in.).

6.2.3 The sampling interval shall not be more than 1 mm (0.04 in.). Variations of the sampling interval shall not be more than ±10 %. This requires that the sensor speed over the surface be maintained within ±10 % whether the device is stationery or mounted on a moving vehicle.

6.3 The angles between the radiating emitting device and the surface and between the radiation receiving device and the surface shall be no more than 30°. The angle of the stylus relative to the surface shall be no more than 30°. Larger angles will underestimate deep textures.

6.4 Calibration shall be made using calibration surfaces having a known profile. The vertical accuracy of the calibration surface in relation to its theoretical profile shall be at least 0.05 mm (0.002 in.). The calibration shall be designed to provide a maximum error of 5 % or 0.1 mm (0.004 in.), whichever is lower.

NOTE 5—One suitable calibration surface is a surface machined to obtain a triangular profile with a peak-to-peak amplitude of 5–20 mm (0.2–0.75 in.). This gives an indication of not only the amplitude, but also the nonlinearity and the texture wavelength scale.

7. Data Processing

7.1 *Outliers*—Invalid readings may be caused by dropouts as a result of deep surface troughs or local photometric properties of the surface. For this reason, those readings should be eliminated when their value is higher or lower than the range of the profile surrounding their location. The invalid value for that location shall be replaced with a value interpolated between the previous and following location. The maximum proportion of outliers shall be 20 %. When the proportion exceeds 10 %, caution should be used in interpreting the data and the proportion of invalid readings shall be reported.

7.2 *Lowpass Filtering*—In order to reduce the influence of noise and transients and to have a relatively uniform influence of narrow profile peaks, the profile shall be filtered to remove high frequency components. Spatial frequency components above 400 cycles per metre (10 cycles per in.) which corresponds to a texture wavelength of 2.5 mm (0.1 in.) shall be removed. Spatial frequencies below 200 cycles per metre (5 cycles per in.) which corresponds to a texture wavelength of 5 mm (0.2 in.) shall not be affected by the filter. Attenuation shall be at least − 3 dB at 2.5 mm (0.1 in.) and no more than − 1 dB at 5 mm (0.2 in.) with a slope of at least − 6 dB per octave. The filtering may be achieved with a digital filter or with an electronic filter. All or part of the filtering may be achieved by the effect of the finite size of the sensor spot or stylus tip.

7.3 *Segmenting the Profile*—The measured profile shall be divided into segments of 100 ± 2 mm (4 ± .075 in.) for analysis in the subsequent steps of this practice. See Fig. 1.

7.4 *Slope Suppression*—A linear regression of the profile values for each segment shall be performed and the regression line shall be subtracted from the profile values of the segment. This will produce a segment with a zero mean and suppress the slope of the segment, if any.

7.5 *Peak Determination*—Each segment shall be further divided into two equal lengths of 50 mm (2 in.) and the maximum value of the profile shall be determined for each of the 50 mm (2 in.) subsegments. These two values shall be averaged arithmetically to obtain the mean segment depth. See Fig. 1.

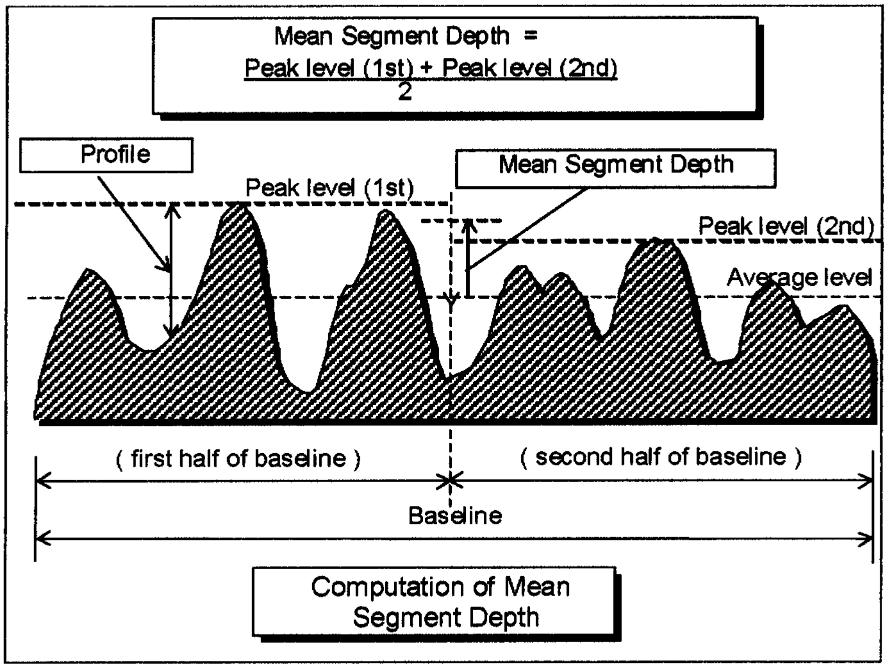

FIG. 1 Procedure for Computation of Mean Segment Depth

NOTE 6—Some devices invert the profile so that it is necessary to assure ensure that the profile for the segment being analyzed has the peaks as those asperities with the highest positive value.

7.6 *Determination of MPD*—The average value of the mean segment depths for all segments of the measured profile shall be averaged to obtain the M mean profile depth (MPD).

7.7 *Calculation of ETD (optional)*—The MPD may be transformed to an estimated texture depth (ETD) by one of the following transformation equations:[2]

$$ETD = 0.2 + 0.8\,MPD \tag{1}$$

where:

MPD and *ETD* are expressed in mm or:

$$ETD = 0.008 + 0.8\,MPD \tag{2}$$

where:

MPD and *ETD* are expressed in inches.

The use of this transformation should yield ETD values which are close to the MTD values of the volumetric technique according to Test Method E 965.

8. Report

8.1 The test report for each test surface shall contain the following items:

8.1.1 Date of profile measurement,

8.1.2 Location and identification of the test surface,

8.1.3 Description of the surface type,

8.1.4 Description of surface contamination which could not be avoided by cleaning, including moisture,

8.1.5 Observations of surface condition such as excessive cracking, potholes, etc.,

8.1.6 The position of the profile on the surface, for example in relation to the wheel track, etc.,

8.1.7 Identification of the profile equipment and its operators,

8.1.8 Type and date of calibration,

8.1.9 Measurement speed,

8.1.10 Percentage of invalid readings eliminated (dropouts),

8.1.11 Total profile length and the number of segments analyzed,

8.1.12 Mean profile depth (MPD),

8.1.13 Standard deviation of the mean segment depths which were averaged to obtain the MPD, and

8.1.14 The estimated texture depth (ETD)—*optional*.

9. Precision and Bias

9.1 *Precision*—The reproducibility using two different systems and test crews was found in the same experiment[2] to be 0.15

mm (0.006 in.) corresponding to 10 % of the average MPD values included in the experiment.

9.2 *Bias*—There is no basis for determination of the bias in mean profile depth. With respect to the MTD, the MPD is biased by 0.2 mm (0.008 in.) which is due to the finite size of the glass spheres used in the volumetric technique.

10. Keywords

10.1 macrotexture profile; mean profile depth; mean texture depth