Designation: E1489 – 08 (Reapproved 2013)

Standard Practice for Computing Ride Number of Roads from Longitudinal Profile Measurements Made by an Inertial Profile Measuring Device[1]

1. Scope

1.1 This practice covers the mathematical processing of longitudinal profile measurements to produce an estimate of subjective ride quality, termed Ride Number (RN).

1.2 The intent of this practice is to provide the highway community a standard practice for the computing and reporting of an estimate of subjective ride quality for highway pavements.

1.3 This practice is based on an algorithm developed in National Cooperative Highway Research Project (NCHRP) 1–23 (**1** and **2**),[2] two Ohio Department of Transportation ride quality research projects (**3** and **4**), and work presented in Refs (**5** and **6**).

1.4 The computed estimate of subjective ride quality produced by this practice was named Ride Number (RN) in NCHRP Research Project 1–23 (**1** and **2**) to differentiate it from other measures of ride quality computed from longitudinal profile. Eq 1 of Section 8.2 represents the mathematical definition of Ride Number.

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:*[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E867 Terminology Relating to Vehicle-Pavement Systems

E950 Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference

E1170 Practices for Simulating Vehicular Response to Longitudinal Profiles of Traveled Surfaces

E1364 Test Method for Measuring Road Roughness by Static Level Method

E1500 Practice for Computing Mean Square Numerics from Road Surface Elevation Profile Records (Withdrawn 1998)[4]

E1656 Guide for Classification of Automated Pavement Condition Survey Equipment

E1927 Guide for Conducting Subjective Pavement Ride Quality Ratings

3. Terminology

3.1 *Terminology* used in this standard conforms to the definitions included in Terminology E867.

3.2 *Definitions:*

3.2.1 *Rideability Index (RI)*—an index derived from controlled measurements of longitudinal profile in the wheel tracks and correlated with panel ratings of rideability.

3.2.2 *Ride Number (RN)*—rideability index of a pavement using a scale of 0 to 5, with 5 being perfect and 0 being impassable.

4. Summary of Practice

4.1 The practice presented here was developed specifically for estimating subjective ride quality from longitudinal profile measurements.

4.2 This practice uses longitudinal profile measurements for two wheel tracks as an input to a mathematical computation of estimated subjective ride quality (RN). The profile must be represented as a series of elevation values taken at constant intervals along the wheel tracks.

[1] This practice is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.33 on Methodology for Analyzing Pavement Roughness.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

4.3 The range of the computed subjective ride quality estimate is 0 to 5.0 Ride Number (RN) units where an RN of 5.0 is considered to be a perfect ride quality road. The 0 to 5.0 Ride Number scale is defined in Refs (**1**, **2**, **3**, **4**, and **5**).

4.3.1 In the 0 to 5.0 Ride Number rating scale, the end points and some of the intermediate points have the following descriptions:

Ride Number Rating Scale

Description	Ride Number
Perfect	5.0
Very good	4.5
	4.0
Good	3.5
	3.0
Fair	2.5
	2.0
Poor	1.5
	1.0
Very poor	0.5
Impassable	0.0

4.3.2 The end points are further defined by the following descriptions (**1**):

Perfect: A road which is so smooth that at the speed you are traveling you would hardly know the road was there. You doubt that if someone made the surface smoother that the ride would be noticeably nicer.

Impassable: A road which is so bad that you doubt that you or the car will make it to the end at the speed you are traveling—like driving down railroad tracks along the ties.

4.4 The quality of the computed subjective ride quality estimate (RN) produced by this practice is based on the processing of the longitudinal profile as measured with a road profile measuring device that meets the Class 1 requirements of ASTM Standard E950.

NOTE 1—Less accurate Ride Number values will result from Road Profile Data obtained from Profile Measuring Devices that are less accurate than class I (E950).

5. Significance and Use

5.1 This practice provides a means for obtaining a quantitative estimate of a pavement property defined as ride quality or rideability using longitudinal profile measuring equipment.

5.1.1 The Ride Number (RN) is portable because it can be obtained from longitudinal profiles obtained with a variety of instruments.

5.1.2 The RN is stable with time because true RN is based on the concept of a true longitudinal profile, rather than the physical properties of particular type of instrument.

5.2 Ride quality information is a useful input to the pavement manage systems (PMS) maintained by transportation agencies.

5.2.1 The subjective ride quality estimate produced by this practice has been determined (**6**) to be highly correlated (r = 0.92) with measured subjective ride quality and to produce a low standard estimate of error (0.29 RN units) for the ride quality estimate.

5.2.2 The subjective ride quality estimates produced by this practice were found to be not significantly different with respect to pavement type, road class, vehicle size, vehicle speed (within posted speed limits), and regionality over the range of variables included in the experiment (**1**, **2**, **3**, and **4**).

5.2.3 The subjective ride quality estimates produced by this practice have been found to be good predictors of the need of non-routine road maintenance for the various road classifications (**3**).

5.3 The use of this practice to produce subjective ride quality estimates from measured longitudinal profile eliminates the need for expensive ride panel studies to obtain the same ride quality information.

6. Longitudinal Profile Measurement

6.1 The elevation profile data used in this practice must have sufficient accuracy to measure the longitudinal profile attributes that are essential to the computation of estimated subjective ride quality.

6.1.1 The quality of the Ride Number estimates cited in this practice are based on the use of elevation profile measurements made with a Class 1 road profile measuring device as defined in Test Method E950.

6.1.2 *Wave Length Content*—The measured longitudinal profile used as input to this practice must have the wavelength content required for the application.

6.1.2.1 As a guide to the wavelength requirement, a repeating sine wave of the following wavelengths and peak-to-peak amplitudes in the absence of any other roughness will produce the following RN values:

Amplitude, mm	Wavelength, m	RN
25.4	91.4	4.95

Amplitude, inch	Wavelength, feet	RN
1.00	300	4.95

6.1.2.2 The quality of Ride Number estimates cited in this practice are based on measured longitudinal profile with wavelength content up to 91.4 m (300 feet).

7. Precision and Bias

7.1 *Precision and Bias*—The accuracy of the computed subjective ride quality estimate produced by this practice will be a function of the accuracy of the longitudinal profile measurements.

7.1.1 *Correlation*—The ride quality estimates (RN) computed by this practice have been determined to have a correlation coefficient of .92 (r) with actual measured subjective ride quality (**3**, **4**, **5**, and **6**).

7.2 *Standard Error of Estimate*—The ride quality estimates (RN) computed by this practice have been determined to have a Standard Error of Estimate of .29 RN units when compared to actual measured subjective ride quality (**3**, **4**, **5**, and **6**).

7.3 The Correlation Coefficient and Standard Error of Estimate values cited in Sections 7.1 and 7.2 are based on longitudinal profile measurements made with a road profile measuring device that meets the requirements of a Class 1 measuring device as defined by ASTM Standard E950 and wavelength content up to 100 m (300 feet).

7.4 It is not known how road profile measuring equipment with lesser resolution and precision and greater bias would affect the accuracy of computed ride numbers.

8. Ride Number Program

8.1 This practice consists of the computation of Ride Number (RN) from an algorithm developed in National Cooperative Highway Research Project (NCHRP) 1–23 (**1** and **2**), two Ohio DOT ride quality research projects (**3** and **4**), and the work presented in Refs (**5**) and (**6**).

8.2 Ride Number is defined in this practice by the equation:

$$RN = 5e^{-160(PI)} \quad (1)$$

where:

$$PI = \sqrt{\frac{PI_L^2 + PI_R^2}{2}} \quad (2)$$

and where:

PI_L and PI_R are Profile Indexes for the left and right wheel paths, respectively, and are the computed root mean square (RMS) of the filtered slopes of the measured elevation profiles of the individual right and left wheel paths (**6**). The wave length components of the profile slopes are modified by the filter shown in Fig. 7 (**6**).

8.3 A FORTRAN computer version of this algorithm has been implemented as described in Ref (**6**).

8.3.1 This practice presents a sample computer program "RNSMP" for the computation of the Ride Number equation from the recorded longitudinal profile measurement.

8.3.1.1 The computer program RNSMP is a general computer program that accepts the elevation profile data set as input, and then calculates the Ride Number using the equation presented in 8.2.

8.3.1.2 A listing of the RNSMP computer program for the computation of the Ride Number transform equation is included in this practice as Appendix X1.

8.3.1.3 A provision has been made in the computer program listing (Appendix X1) for the computation of the Ride Number transform equation from recorded longitudinal profile measurements in both SI and inch-pound units.

8.3.2 The input to the sample Ride Number computer program is an ASCII profile data set stored in a 1X, F8.3, 1X, F8.3 Fortran format. In this format, the profile data appears as a multi-row, two-column array with the left wheel path profile data points in column 1 and the right wheel path points in column 2. The profile data point interval is discretionary. However, the quality of the Ride Number estimates cited in this practice, are based on a data point interval of 150 mm (6 in.) (see Section 5).

8.3.2.1 If the input to the Ride Number computer program is in SI units, the elevation profile data points are scaled in millimetres with the least significant digit being equal to 0.001 mm.

8.3.2.2 If the input to the Ride Number computer program is in inch-pound units, the elevation profile data points are scaled in inches with the least significant digit being equal to 0.001 inch.

8.4 The distance interval over which the Ride Number is computed is discretionary, but shall be reported along with the Ride Number results.

8.5 Validation of the Ride Number program is required when it is installed. Provisions for the RN program installation validation have been provided in this practice.

8.5.1 The sample profile data set TRIPULSE.ASC has been provided in SI units in Appendix X2 for validation of the computer program installation.

8.5.2 Using the sample profile data set TRIPULSE.ASC (Appendix X2) as input to the Ride Number computer program (Appendix X1), a Ride Number of 3.66 was computed as shown in Appendix X3 for a profile data point interval of .15 m (.5 feet) and a distance interval equal to 15 meters of the profile data set.

9. Report

9.1 The report for this practice shall contain the following information:

9.1.1 *Profile Measuring Device*—The report data shall include the ASTM Standard E950 classification of the device used to make the measurements, the date of the last successful device calibration, and the highpass filter wavelength used in the profile measurement.

9.1.2 *Longitudinal Profile Measurements*—Report data from the profile measuring process shall include the date and time of day of the measurement, the location of the measurement, the lane measured, the direction of the measurement, length of measurement, and the descriptions of the beginning and ending points of the measurement.

9.1.3 *Profile Data Point Interval (Sample Interval) and Profile Reporting Interval*—Ride Number report data shall include the profile data point interval and the profile reporting interval.

9.1.4 *Ride Number Results*—The Ride Number results should be reported to two decimal places along with the distance interval over which the RN was computed.

10. Keywords

10.1 longitudinal profile; mean panel ratings (MPR); panel rating; pavement ride quality; profile index; rideability; ride number (RN); subjective ride quality; subjective ride quality estimate