Designation: E2583 – 07 (Reapproved 2015)

Standard Test Method for Measuring Deflections with a Light Weight Deflectometer (LWD)[1]

This standard is issued under the fixed designation E2583; 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 test method covers the determination of deflections of paved and unpaved surfaces with a Light Weight Deflectometer (LWD). This device is also referred to as a Portable Falling-Weight Deflectometer (PFWD). The LWD is lightweight, portable and generally used for testing unbound pavement layers. The deflections measured using an LWD can be used to determine the stiffness of bound and unbound pavement surfaces using appropriate back- or forwardcalculation analysis techniques.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.3 *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:*[2]

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D4695 Guide for General Pavement Deflection Measurements

2.2 *Other Standards:*[3]

FHWA-HRT-06-132 Version 4.1 Long-Term Pavement Performance Program Manual for Falling Weight Deflectometer Measurements

3. Summary of Test Method

3.1 This test method is a type of plate-bearing test. The load is a force pulse generated by a falling weight (mass) dropped on a buffer system that transmits the load pulse through a plate resting on the material to be tested. The test apparatus may be hand held or moved around with a dolly type device.

3.2 The weight is raised to the height that, when dropped, will impart the desired force pulse. The weight is dropped and the resulting vertical movement or deflection of the surface is measured using suitable instrumentation. Multiple tests at the same drop height (different heights are optional) may be performed at the same location.

3.3 The peak deflection resulting from the force pulse at each location is recorded in micrometres, millimetres, mils or inches, as appropriate.

3.4 The peak force imparted by the falling weight is recorded as the force in kN or lbf, or as the mean stress (the force divided by the load plate area) in kN/m^2 (kPa) or psi, as appropriate.

4. Significance and Use

4.1 This test method covers the determination of surface deflections as a result of the application of an impulse load. The resulting deflections are measured at the center of the applied load and may also be measured at various distances away from the load. Deflections may be either correlated directly to pavement performance or used to determine in-situ material characteristics of the pavement layers. Some uses of data include quality control and quality assurance of compacted layers, structural evaluation of load carrying capacity, and determination of thickness requirements for highway and airfield pavements (see Guide D4695).

NOTE 1—Since pavement and subgrade materials may be stress dependent, care must be taken when analyzing LWD test data on unbound materials so that the applied stress will closely match the stress value applied by the design wheel load at the pavement surface.

NOTE 2—The volume of the pavement and subgrade materials affected by the load is a function of the magnitude of the load. Therefore, care must be taken when analyzing the results, since the data obtained by the LWD may be obtained from a smaller volume of the unbound materials than under the influence of a heavy moving wheel load at the pavement surface.

[1] This test method is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.41 on Pavement Testing and Evaluation.

Current edition approved Sept. 1, 2015. Published December 2015. Originally approved in 2007. Last previous edition approved in 2011 as E2583– 07 (2011). DOI: 10.1520/E2583-07R15.

[2] 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.

[3] Available from the Federal Highway Administration (FHWA), 1200 New Jersey Ave., SE Washington, DC 20590.

5. Apparatus

5.1 *Instrument System,* conforming to the following general requirements:

5.2 *Instruments Exposed to the Elements,* shall be operable in the temperature range of -10 to 50°C (10 to 120°F) and shall tolerate relatively high humidity, rain or spray, and all other adverse conditions such as dust, shock, or vibrations that may normally be encountered.

5.3 *Force-Generating Device,* (a falling weight) with a guide system. The force-generating device shall be capable of being raised to a predetermined height and dropped. The resulting force pulse transmitted to the pavement shall be capable of providing a half-sine or haversine shaped load pulse, with a time of loading of between 20 and 40 msecs, and shall be reproducible within the requirements of 7.1.

5.4 *Falling Weight,* designed to operate with negligible friction or resistance.

5.5 *Load Plate,* capable of an approximately uniform distribution of the impulse load on the surface. The instrument shall be suitably constructed to allow pavement deflection measurements at the center of the point of impact, through a hole in the center of the load plate.

5.6 *Deflection Sensor(s),* capable of measuring the maximum vertical movement and mounted in such a manner as to minimize angular rotation with respect to its measuring plane at the maximum expected movement. The number and spacing of the sensors is optional and will depend upon the purpose of the test and the pavement layer characteristics. Sensors may be of several types such as displacement transducers, velocity transducers, or accelerometers.

5.7 *Data Processing and Storage System.* Load and deflection data shall be displayed and recorded. Supporting information such as air temperature, surface temperature, distance measurements, and identification data for each test point may be recorded either automatically or manually.

5.8 *Load Cell.* A load cell shall be used to measure the applied load of each impact. It shall be placed in a position to minimize the mass between the load cell and the surface. The load cell shall be positioned in such a way that it does not restrict the ability to obtain deflection measurements under the center of the load plate. The load cell shall be water resistant and shall be resistant to mechanical shocks from impacts during testing or traveling.

5.9 *LWD Size,* shall be small enough to be considered portable, i.e. not requiring a vehicle or trailer for transport.

6. Hazards

6.1 Injury can occur when elevating and dropping the falling weight. Some LWDs have relatively heavy falling weights, thus requiring the operator/recorder to keep his/her back straight, lifting with the leg muscles. Likewise, the operator/recorder should take care that his/her hands or extremities are not positioned beneath the lifted weight or loading plate, to avoid injury when the weight is falling.

7. Calibration

7.1 *Force-Generating Device*—Prior to load and deflection sensor calibration, precondition the device by dropping the weight at least five times and checking the relative difference in each peak load level. Peak load levels measured by the load cell shall not vary from each other more than ±3 %. If the variation exceeds this tolerance, the height of the drop, cleanliness of the track, along with any springs or rubber pads that are used to condition the load, shall be checked. Improperly operating parts shall be replaced or repaired prior to calibration to ensure that the horizontal and shear forces are minimized.

7.2 *Load Calibration Platform*—Follow the manufacturer's recommendations for load cell calibration since several types of these devices are commercially available.

7.3 *Deflection Sensors*—Calibrate sensors at least once per year or in accordance with the manufacturer's recommendations.

8. Signal Conditioning and Recorder System

8.1 All signal conditioning and recording equipment shall allow deflection measurements to be displayed and stored with a resolution of ±1 μm (±0.04 mils) or less.

8.2 The peak load and deflection measurements shall be recorded within a time period or measurement window of 60 ms or longer while still adhering to the precision and bias requirements shown in Section 10.

8.3 Peak load measurements shall be displayed and stored with a resolution of ±0.1 kN or less if using SI units, or ±10 lbf or less if using U.S. customary units, or an equivalent quantity if the load is expressed as mean stress depending on the plate radius.

9. Procedure

9.1 Position the instrument over the desired test point. The test surface shall be as clean and smooth as possible with loose granules and protruding material removed. For gravel surfaces it is recommended that a thin layer of fine sand be placed over the test point. This helps in obtaining uniform contact between the load plate and the surface. A suitable rubber pad may be used for improving the load distribution.

9.2 Place the loading plate and the sensors to ensure they are resting on a firm and stable test surface.

9.3 Raise the falling weight to the desired height and allow it to fall freely.

9.4 Record the resulting peak surface deflection(s) and the peak load.

9.5 Perform at least two falling weight sequences (9.3) and compare the results. If the difference is greater than ±3 % for any sensor, note the variability in the report. Additional tests may be run at the same or at different load levels.

NOTE 3—It may be advantageous to use the first one or two drops for seating and use the subsequent drops for analysis.

10. Precision and Bias

10.1 *Equipment Precision*—The precision requirement for the deflection sensors is ±2 µm (0.08 mils). The precision requirement for the load cell is ±0.1 kN (22 lbf) or better

10.2 *Equipment Bias*—The bias requirement for both the deflection sensors and the load cell is ±2 % or better.

10.3 *Between Device and Test Point Reproducibility*—The single operator, single equipment coefficient of variation of the test method for typical field conditions is 10 to 20 percent for GM/GC/GP soils, 15 to 35 percent for SW/SM/SP soils, and 40 to 60 percent for ML/CL soils (see Practice D2487). The between device reproducibility of the test method for typical conditions is being determined and will be available on or before December 2009.

NOTE 4—Some LWD devices are designed and equipped such that the accuracy (precision and bias) as well as the load cell and sensor mounting requirements of this test method cannot be met. One or more of the following LWD features can lead to this conclusion: *(1)* The LWD is not equipped with a load measuring device (load cell); *(2)* The LWD measures the deflection of the load plate rather than the deflection of the surface under test through a hole in the center of the load plate; *(3)* The LWD uses a sensor (velocity transducer or accelerometer) that is not linear down to zero Hz or is not processed using a Fourier transform analysis or equivalent.

NOTE 5—For the LWD devices referred to in Note 4, the approximate surface or composite modulus of the tested layer has been estimated to lie between 0.5 and 0.75 times the composite modulus calculated using an LWD device that meets the precision and bias requirements of this test method. A separate test method is being developed to cover this type of LWD device.

11. Keywords

11.1 deflection surveys; deflection testing; Falling Weight Deflectometer (FWD); Light Weight Deflectometer (LWD); impulse deflection testing; load-deflection testing; Nondestructive testing (NDT); pavement deflection; pavement testing; pavement layer modulus; pavement layer stiffness; Portable Falling-Weight Deflectometer (PFWD)