INTERNATIONAL

Designation: D4602 − 93 (Reapproved 2020)

Standard Guide for Nondestructive Testing of Pavements Using Cyclic-Loading Dynamic Deflection Equipment[1]

This standard is issued under the fixed designation D4602; 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 guide covers the preparation, equipment, calibration of equipment, location of test points, magnitudes and configurations of applied loads, cyclic frequencies, and presentation of data for nondestructive testing of pavements using cyclic-loading dynamic deflection equipment.

1.2 Cyclic-loading dynamic deflection equipment includes a group of devices that induce a steady-state sinusoidal vibration in the pavement through cyclic generation of a dynamic load. All such devices apply a static load on the pavement surface, resulting in a static deflection, and then induce some sinusoidal load and consequent deflection around the static load and deflection through an applied steady-state dynamic load.

1.3 As there are great differences between various cyclic-loading dynamic deflection devices, this guide is intended to give uniformly applicable guidance, rather than specific instructions, for their use. For instance, it will specify that calibration of the devices and their instrumentation be carried out at the frequencies and in accordance with procedures recommended by their manufacturers, rather than providing specific instructions. Also, data is specified for collection that should prove adequate for usual applications of such deflection data, but no procedures are included for "back-calculating" elastic moduli of pavement layers or other such applications.

1.4 This guide does not apply to static deflection equipment such as the "Benkelman Beam," automated beam deflection equipment such as the "California Traveling Deflectometer," or impulse deflection equipment such as the "Falling Weight Deflectometer."

1.5 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two separate systems of units, that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This guide has been written using the gravitational system of units when dealing with the inch-pound system. In this system, the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as nonconformance with this guide.

1.6 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *test location*—the point at which the center of the applied load or loads are located.

3. Significance and Use

3.1 Nondestructive testing of pavements to obtain deflection data for use in pavement evaluation and overlay design has become common. While the diversity of equipment and data applications makes specific procedures infeasible, this guide is intended to encourage the collection of sufficient deflection

[1] This guide 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 Nov. 1, 2020. Published November 2020. Originally approved in 1986. Last previous edition approved in 2015 as D4602 – 93 (2015). DOI: 10.1520/D4602-93R20.

data, adequate calibration of equipment, and implementation of general procedures leading to better quality and more uniform deflection measurements.

4. Apparatus

4.1 The most common commercially available devices are the "Dynaflect" device and various models of the "Road Rater."[2]

NOTE 1—This guide has not been written with the intent to exclude any current or future manufacturer of equipment or of newer models or modifications of equipment listed herein to perform these types of tests. The subcommittee welcomes information on such devices for inclusion in future revisions of this guide.

4.2 *Dynaflect*—A trailer-mounted device that has a static weight of 2000 to 2100 lbf (8.88 to 9.24 kN) has been found to be satisfactory. The load is applied through two steel wheels, each 4 in. (102 mm) wide and 16 in. (406 mm) in diameter. The loading surface of each wheel is coated with urethane having a uniform thickness of about ⅜ in. (9.53 mm). These wheels are spaced 20 in. (508 mm) apart, center to center, and apply a total peak-to-valley dynamic force of 1000 lbf (4.45 kN) at a fixed frequency of 8 Hz. The total force applied varies from approximately 1500 to 2500 lbf (6.67 to 11.12 kN). Deflections are measured implicitly by five velocity transducers suspended from a "placing bar" that may be lowered to place the sensors on the pavement. Sensor 1 is located equidistant between and in axial alignment with the load wheels. The other four are also equidistant from the load wheels, located at intervals of 1 ft (0.30 m) toward the front of the trailer.

4.3 *Road Rater Devices*—Some models of Road Rater devices are trailer mounted, some models are mounted on the front of a vehicle, and other versions are mounted in a van so that the head is lowered just to the rear of the rear axle of the vehicle. Both loading frequency and magnitudes of dynamic loads may be varied by the operator. Depending on the model, normal operating frequencies range from 10 to 60 Hz and maximum dynamic forces range from 950 to 5500 lbf (2.00 to 24.46 kN). The four models in common use are as follows:

4.3.1 *Model 400B*—This model has a trailer weight of 3000 lbf (13.33 kN). Its maximum rated static load is 2400 lbf (10.66 kN), created by the weight of the force actuation system and hydraulic pressure against the trailer. The peak-to-valley magnitudes of dynamic forces applied range is from 500 to 3000 lbf (2.22 to 13.33 kN). The loads are applied through two standard loading plates 4 in. (102 mm) wide by 7 in. (178 mm) long, located on 9½ in. (241 mm) centers, with the long dimensions in the direction of trailer travel. Deflections are measured implicitly by four velocity transducers with Sensor 1 equidistant between, and in axial alignment with, the load feet. The other sensors are located at 1-ft (0.30-m) intervals. Additional sensors may be provided with different lengths of placement bars, or the same sensors can be mounted at different locations.

4.3.2 *Model 400A*—This model is similar to the Model 400B, but is mounted on the front bumper of the vehicle and provides peak-to-valley magnitudes of dynamic forces from 450 to 950 lbf (2.00 to 4.23 kN). Five preset operating frequencies range from 10 to 40 Hz. The centers of the loading plates are spaced at 10-in. (254-mm) intervals. This model may have from two to four sensors, depending on the age of the unit.

4.3.3 *Model 2000*—This model has a trailer weight of 4300 lbf (19.1 kN), a maximum rated static load of 3800 lbf (16.9 kN), and a peak-to-valley dynamic force ranging from 1000 to 5500 lbf (4.44 to 24.46 kN). A van version utilizes the same range of dynamic force. Loads are usually applied through a single plate 18 in. (457 mm) in diameter. Sensor 1 is located at the center of the loading plate, with the other three (or more) sensors located at 1-ft (0.30-m) increments, as for the Model 400B and the Dynaflect. There is an optional model for which two rectangular plates 4 by 7 in. (102.6 by 177.8 mm) are substituted for the circular load plate.

4.3.4 *Model 2008*—This model has a trailer load of 7000 lbf (31.09 kN), a maximum rated static load of 5800 lbf (25.76 kN), and a peak-to-valley dynamic force ranging from 1200 to 8000 lbf (5.34 to 35.54 kN). The same load plate and transducers as used by Model 2008 are used for Model 2000.

4.4 Either single or dual circular loading plates or load wheels may be used.

4.5 Although not critical to calculations using results of dynamic deflection testing, most devices now have Sensor 1 at the center of load (see Note 2) and the other sensors at 1-ft (0.30-m) intervals from that point. This appears to be a practical spacing, but greater spacing may sometimes be required for wide deflection basins experienced on heavy-duty airfield pavements. Similarly, most deflection measurement devices now have four or more sensors to satisfactorily measure the deflection basin. As many pavements have a number of different layers, five sensors is the preferred minimum number where layer elastic moduli are to be back-calculated. The number of layer moduli to be calculated cannot exceed the number of sensors.

NOTE 2—It is preferable that the sensors be in contact with the pavement and isolated from the loading plate (or plates).

5. Calibration

5.1 All cyclic-loading dynamic deflection devices shall be carefully maintained and calibrated in accordance with the manufacturer's operating and maintenance instructions for the devices. As a minimum, loading frequency and load cells measuring applied loads for devices with capabilities for varying magnitude and frequency of loading shall be checked every fifth day of production testing, or when the operator has reason to believe that indicated operating frequencies or measured loads are incorrect.

5.2 *Dynaflect*—Calibration of the dynamic load application device for the Dynaflect requires specialized equipment generally not available except at the manufacturer's location. The

[2] The Dynaflect device is manufactured by the SIE division of Geosource, Inc. of Fort Worth, TX. The Road Rater is manufactured by Foundation Mechanics, Inc. of El Segundo, CA. Cox and Sons, Inc. of California have built custom devices, including a very sophisticated device for the Federal Highway Administration nicknamed the "Thumper." The U.S. Army Engineer Waterways Experiment Station (WES) also uses a custom-built cyclic-loading dynamic device called the "WES 16-kip (71,172 N) Vibrator." Shell also developed a "4-kip (17,793 N) Vibrator" for pavement evaluation.