I. Call to Order and Opening Remarks  
   John Donahue – Chair (taking over from Greg Stellmach), Scott George – Vice Chair

II. Roll Call
   States present: CO, FL, GA, IL, KS, MD, MI, MN, MS, NY, OH, VA, WV

III. Approve August 2017 Technical Section annual meeting minutes
   Motion – MN, second - IL

IV. Old Business

A. 2017 COMP Ballot Items

<table>
<thead>
<tr>
<th>Ballot Name:</th>
<th>COMP 2017 Ballot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ballot Number</strong></td>
<td></td>
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<tr>
<td>Ballot Start Date:</td>
<td>9/2017</td>
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<tr>
<td>Ballot Due Date:</td>
<td>10/2017</td>
</tr>
<tr>
<td><strong>Item Number</strong></td>
<td>24</td>
</tr>
<tr>
<td>Description</td>
<td>Concurrent ballot item to adopt as full standard PP 67 Quantifying Cracks in Asphalt Pavement Surfaces from Collected Images Utilizing Automated Methods.</td>
</tr>
<tr>
<td><strong>Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.</strong></td>
<td></td>
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<tr>
<td>No comments</td>
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</table>

<p>| <strong>Item Number</strong> | 25 |
| Description | Concurrent ballot item to adopt as full standard and add &quot;concrete pavement surface&quot; to the Keywords section of PP 68 Collecting Images of Pavement Surfaces for Distress Detection. |</p>
<table>
<thead>
<tr>
<th>Item Number</th>
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<tbody>
<tr>
<td>26</td>
<td>Concurrent ballot item to adopt as full standard and add &quot;concrete pavement surface&quot; to the Keywords section of PP 69 Determining Pavement Deformation Parameters and Cross-Slope from Collected Transverse Profiles.</td>
</tr>
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**Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.**

No comments

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<tr>
<th>Item Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>27</td>
<td>Concurrent ballot item to adopt as full standard PP 70 Collecting the Transverse Pavement Profile.</td>
</tr>
</tbody>
</table>

**Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.**

Virginia Department of Transportation (Charles A. Babish) (andy.babish@vdot.virginia.gov)

The provisional practice is very generic. The practice should provide specific details on the data collection and equipment capabilities. DOTs need a standardized practice for transverse profile data collection otherwise the DOTs are relying on vendor specific algorithms making it difficult to compare data obtained from profilers. Does the Technical Section intend to improve this standard and include specific details on data collection and equipment capabilities in the future? **Response: No change - There are NCHRP and TPF-5(299) projects ongoing with the objective to improve the standard.**

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>28</td>
<td>Concurrent ballot item to make a few revisions and remain provisional standard TP 98 Determining the Influence of Road Surfaces on Vehicle Noise using the Statistical Isolated Pass-by (SIP) Method. See pp. 12-36 of the minutes.</td>
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**Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.**

No comments
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<thead>
<tr>
<th>Item Number</th>
<th>29</th>
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</thead>
<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot item to make a few revisions and remain provisional standard TP 99 Determining the Influence of Road Surfaces on Traffic Noise Using the Continuous-Flow Traffic Time-Integrated Method (CTIM). See pp. 37-59 of the minutes.</td>
</tr>
<tr>
<td>Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.</td>
<td></td>
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<tr>
<td>No comments</td>
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<th>Item Number</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot item to revise M 261 Standard Tire for Pavement Frictional-Property Tests with minor changes to match ASTM E501-08(2015). See pp. 60 of the minutes.</td>
</tr>
<tr>
<td>Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.</td>
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<tr>
<td>No comments</td>
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<tr>
<th>Item Number</th>
<th>31</th>
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</thead>
<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot item to revise M 286 Smooth-Tread Standard Tire for Special-Purpose Pavement Frictional-Property Tests with minor changes to match ASTM E524-08(2015). See pp. 60 of the minutes.</td>
</tr>
<tr>
<td>Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.</td>
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<tr>
<td>No comments</td>
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<table>
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<tr>
<th>Item Number</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot item to revise T 242 Frictional Properties of Paved Surfaces Using a Full-Scale Tire with minor changes to match ASTM E274/E274M. See pp. 60-62 of the minutes.</td>
</tr>
<tr>
<td>Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.</td>
<td></td>
</tr>
<tr>
<td>No comments</td>
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<tr>
<td>Item Number</td>
<td>33</td>
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<tr>
<td>-------------</td>
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</tr>
<tr>
<td>Description</td>
<td>Concurrent ballot item to revise T 279 Accelerated Polishing of Aggregates Using the British Wheel with minor changes to match ASTM D3319. See pp. 63 of the minutes.</td>
</tr>
</tbody>
</table>

**Affirmative 44/51. Negative 0/51. Did Not Vote 7/51.**

Maryland Department of Transportation (Sejal Barot) (sbarot@sha.state.md.us)

"Yes", with minor correction. AASHTO 5.3.2: Slider width 31.875 mm instead of 31.75 mm, per ASTM D 3319 Sec 5.3.2. **Response:** Change AASHTO slider width in 5.3.2 to 31.75 mm.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>34</th>
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</thead>
<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot to delete R 48 Determining Rut Depth in Pavements. See pp. 4-5 of the minutes.</td>
</tr>
</tbody>
</table>

**Affirmative 43/51. Negative 1/51. Did Not Vote 7/51.**

Affirmative votes

No Comments

**Negative votes**

Tennessee Department of Transportation (Brian K. Egan) (brian.egan@tn.gov)

The new standard (PP70) are for fully automated systems, and have not been fully implemented or excepted. R48 allows for a standard practice to measure ruts "manually" with a template from site to site. **Response:** TN withdrew negative per Egan 11/3/2017 e-mail.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>35</th>
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<tbody>
<tr>
<td>Description</td>
<td>Concurrent ballot to delete R 55 Quantifying Cracks in Asphalt Pavement Surface. See pp. 4-5 of the minutes.</td>
</tr>
</tbody>
</table>

**Affirmative 43/51. Negative 1/51. Did Not Vote 7/51.**

Affirmative votes

No comments

**Negative votes**

Tennessee Department of Transportation (Brian K. Egan) (brian.egan@tn.gov)

The new standard (PP68) are for fully automated systems, and have not been fully implemented or excepted. R55 allows for a standard
B. Technical Section letter ballot

<table>
<thead>
<tr>
<th>Ballot Name:</th>
<th>TS5a Reconfirmation Ballot 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballot Start Date:</td>
<td>9/2017</td>
</tr>
<tr>
<td>Ballot Due Date:</td>
<td>10/2017</td>
</tr>
<tr>
<td>Item No.</td>
<td>1</td>
</tr>
<tr>
<td>Description</td>
<td>Reconfirm M328</td>
</tr>
</tbody>
</table>

Affirmative 19/20, Negative 0/20, Did Not Vote 1/20

Subsection 1.3 states, "It is intended to be sufficiently detailed that the data collected from multiple profilers will be identical." It is unlikely that data from different profilers would ever be completely identical. This sentence could benefit from additional clarification.

Response: Profiler ETG consulted. For the 2019 production - Change the last 2 sentences in subsection 1.3 to: “The objective is to clearly define the function of an inertial profiler and specify standard outputs. The document provides technical specifications intended to ensure accurate and repeatable collection of roughness indices and the underlying profile from multiple devices.”

Subsection 4.1 states, "The equipment shall function independently from the vehicle suspension dynamics and vehicle speed throughout the operating range of 20 to 70 mph for high-speed profilers and less than 25 mph for low-speed profilers." Would it be beneficial to provide a lower limit (approximately 15 mph) for low-speed profilers? Response: Profiler ETG consulted. No change. The actual lower limits of speed for valid operation is not very consistent among manufacturers, individual units for a given manufacturer, and
road types. Note that the speed range for high-speed profilers could be thought of as an operational requirement, given that they have to make measurements on active roadways. For low-speed profilers, which operate on closed roadways, no such operational requirement exists, and the valid speed range will trade equipment cost and measurement efficiency off against validity.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>2</td>
<td>Reconfirm R37</td>
</tr>
<tr>
<td>3</td>
<td>Reconfirm R40</td>
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<tr>
<td>4</td>
<td>Reconfirm R54</td>
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<tr>
<td>5</td>
<td>Reconfirm R56</td>
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<tr>
<th>Item No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>6</td>
<td>Reconfirm R56</td>
</tr>
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</table>

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Illinois Department of Transportation (LaDonna Rowden) (ladonna.rowden@illinois.gov)

A revision was made in Section 8.3.1.9 on Page 6 of the standard to change "in./mile" to "in./mi" for the units, but other locations were left alone. This standard needs to be reviewed and be consistent on using either "in./mile" or "in./mi" for the units. **Response: editor to review**

Kansas Department of Transportation (Richard A Barezinsky)

Renumber the footnotes. **Response: editor to review**

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<tr>
<th>Item No.</th>
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<tbody>
<tr>
<td>6</td>
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</table>
V. New Business

A. Standards Requiring Reconfirmation

Stewards were contacted by John for comments prior to the meeting. The comments were reflected below.


FHWA commented that “annual calibration” should be “reference calibration”; this isn’t an editorial change.
Motion to approve as a Subcommittee ballot – MN, second – FL.

NOTE: After the 5a meeting a last minute change was submitted by Greg Uherek of AASHTO re:source to modify the FWD operator recertification frequency from two years to one year. He also submitted some editorial changes for the document references. Since the recertification duration revision was not reviewed and approved earlier by TS 5a, the R32 standard shall be on a concurrent ballot.


Reconfirmed.


FHWA had comments on this standard and John Donahue asked for language that can be included as a subsection (closed-loop check for the Dipstick); John offered to do the editing to include the additional wording and then it will go to Concurrent ballot.
Motion to move changes to Concurrent ballot – MN, second – NY.
NOTE: Upon further recommendation from the FHWA and after confirmation in the 5a meeting that no current State members even used the Dipstick® for profiling pavements, the R41 standard shall be submitted for sunsetting on a concurrent ballot.


There is an ASTM equivalent (E556); the AASHTO standard hasn’t been revised since 2001 and it should be compared to E556 for harmonization purposes; John Donahue would like to reconfirm T 282 this year and ask for review and comments next year. Reconfirmed.

B. Guidance Documents

i. Guide for Pavement Friction
   1. FHWA contract to provide recommendations to revise document expected in 2019
      The guide was first published in 2012 and no further revisions have been made; Andy Mergenmeier spoke about the plan for possible revisions.
   2. Task force formation?
      Motion to create a task force – MN, second – WV; the following will participate on the task force: FL, WV, AL, IL, FHWA; FL will chair the task force.

ii. Pavement Management Guide

C. Recruitment

i. New State members
   Email John Donahue (John.Donahue@modot.mo.gov) and Casey Soneira (csonieira@aashto.org) if you are interested in joining.

ii. Friends of Committee

iii. Standard and guidance document stewards
   Email John Donahue if you would like to volunteer to be a steward; the list of standards can be found at https://materials.transportation.org

D. Active Research

i. NCHRP approved funding for a TS 5a RNS – “Project 20-07/Task 411 Review and Update of AASHTO Standard Practice R 87”
Amir Hanna provided an update of active NCHRP projects related to pavement characteristic measurements.

ii. NCHRP has several ongoing projects that are expected to impact TS 5a on macrotexture and cracking measurement.

iii. TPF-5(299) contract to update R36, Andy Mergenmeier, FHWA. If interested in participating in the project, contact your State research administrator to submit your commitment letters at http://www.pooledfund.org/Details/Study/543 (Next meeting is at RPUG in September.)

Andy gave an update on the Pool Fund study; will be starting another study in about a year. Next meeting is in September 2018 in South Dakota.

iv. Proposed RNS’s (Please submit any proposals to Curt Turgeon, TS 5a Research Coordinator.)

Jia (Jack) Xiaoyang from TN DOT spoke about a proposed RNS. See pages 25-26.

E. Faulting measurement using 3D pavement data presentation, Georgene Geary, GGfGA

Presentation given at meeting. Georgene will draft language for a proposed Method C to R36 using 3D data collection to measure faulting. Subcommittee ballot in Spring 2019.


Presentation given at meeting.

G. Proposed standard for continuous friction measurement system based on side force friction testing, Andy Mergenmeier, FHWA

Presentation given at meeting.

VI. Other Items

A. “Hot Topics” for Roundtable.

None submitted.

B. Mid-year meeting.

There probably won’t be a need to have a mid-year meeting.

VII. Adjourn

Motion – WV, second – MD; meeting adjourned at 9:30 a.m.
### Summary of 2018 Ballot Items

<table>
<thead>
<tr>
<th>Num.</th>
<th>Ballot Item</th>
<th>COMP</th>
<th>Concurrent</th>
<th>TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R32-11(2015) ‘Standard Practice for Calibrating the Load Cell and Deflection Sensors for a Falling Weight Deflectometer’ – Concurrent ballot item to make revisions to standard to extend FWD operators certification from one year to two years, change ‘annual calibration’ to ‘reference calibration and minor editorial changes. See pages 11-24.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Standard Practice for

Calibrating the Load Cell and Deflection Sensors for a Falling Weight Deflectometer


Technical Section: 5a, Pavement Measurement

Release: Group 1 (April)
1. SCOPE

1.1. This standard practice covers the annual calibration of the load cell and the deflection sensors and monthly relative calibration of the deflection sensors of a falling weight deflectometer (FWD) or a heavy weight deflectometer (HWD). It is used to establish calibration factors for correcting FWD and HWD measurements.

For this practice, the term “FWD” also refers to an HWD unless otherwise noted.

1.2. This procedure is not applicable to the calibration of lightweight deflectometers or of cyclic loading and other types of pavement deflection testing equipment.

1.3. Annual reference calibration is performed at least once per year or as soon as possible after a deflection sensor or the load cell has been replaced on the FWD. It shall be performed by a certified technician.

1.4. Monthly relative calibration is performed on the deflection sensors at least once per month and immediately after a deflection sensor is replaced. A certified technician is not required.

1.5. The procedure results in calibration factors that are entered into the FWD software as multipliers. When the FWD measurements are multiplied by the calibration factors, the result is a set of measurements that have been corrected to agree with the calibration instrumentation.

1.6. Calibration procedures may vary slightly among FWD types. This procedure can be used for all types of FWDs with minor modifications within the limits of the reference calibration equipment.

1.7. This procedure has been automated in the software package WinFWDCal. It is required that the computer program be used to carry out the procedure.

1.8. To use this procedure, the FWD computer shall be capable of electronic data transfer.

1.9. Data files for all types of FWDs can be read by the WinFWDCal software. The PDDX file format (Section 3.1.11) is required for data input. FWD data files that are in native format can be converted to PDDX format using PDDXconvert, which is an integral component in WinFWDCal.

1.10. The values stated in SI units are to be regarded as standard. U.S. Customary units given in parentheses are for information purposes only.

1.11. This standard practice may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety concerns associated with its use. It is the responsibility of the...
user of this standard practice to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:

- R 33, Calibrating the Reference Load Cell Used for Reference Calibrations for a Falling Weight Deflectometer

2.2. Other Document:

- FHWA-HRT-07-040, FWD Calibration Center and Operational Improvements: Redevelopment of the Calibration Protocol and Equipment

3. TERMINOLOGY

3.1. Definitions of Terms Specific to this Standard:

3.1.1. certified technician—an individual who has demonstrated proficiency at performing FWD calibrations during an annual quality assurance review and is issued certification as an FWD calibration center operator. The individual shall be re-certified every 2 years. The certification procedure is described in detail in Report No. FHWA-HRT-07-040.

3.1.2. data acquisition system—the signal conditioner, data acquisition board, data acquisition software, computer, and cabling. It is connected to either the reference load cell or the accelerometer.

3.1.3. drop sequence—the sequence of replicate drops at one or more load levels used during reference or relative calibration.

3.1.4. final gain factor—the calibration factor for a load or deflection sensor at the end of the calibration procedure.

3.1.5. FWD—falling weight deflectometer; pulse loading device for measuring pavement structural response. The peak load is adjustable over a range from 13 kN (3000 lb) to 125 kN (28,000 lb).

3.1.6. FWD deflection sensor—device used to measure the pavement deflection response for a given load (e.g., geophones, seismometers, accelerometers, or other devices).

3.1.7. FWD load cell—device located under the loading mechanism in an FWD that measures the load response of the FWD system.

3.1.8. HWD—heavy weight deflectometer; pulse loading device for measuring pavement structural response. The peak load is adjustable over a range from 27 kN (6000 lb) to 270 kN (60,000 lb).

3.1.9. initial gain factor—the calibration factor for a load or deflection sensor that was present in the FWD operating program before the start of calibration.

3.1.10. interim gain factor—the calibration factor for a deflection sensor resulting from averaging all trials of reference calibration.

3.1.11. Pavement Deflection Data Exchange (PDDX)—the file format required by WinFWDCal. This format is described in Report No. FHWA-HRT-07-040.
3.1.12. *reference calibration*—the calibration of either the FWD load cell or deflection sensors against a separate reference measuring system. For load cell calibration, the reference system is a custom-made reference load cell, and for deflection sensors, it is a precision accelerometer.

3.1.13. *reference gain factor*—the calibration factor for a load or deflection sensor determined by one trial during reference calibration.

3.1.14. *relative calibration*—a calibration procedure in which the deflection sensors are calibrated relative to one another. No outside reference system is used.

3.1.15. *relative gain factor*—the calibration factor for a deflection sensor determined by one trial during relative calibration.

3.1.16. *WinFWDCal*—the software required for data acquisition and data analysis for FWD calibration.

### 4. SUMMARY OF METHOD

4.1. In annual calibration, the deflection sensors and load cell from the FWD are first calibrated against independently calibrated reference devices. This calibration process, which is called “reference calibration,” can be performed at a regional calibration center or any other properly equipped location. Information on the location of these centers is available from the Long-Term Pavement Performance (LTPP) Program.

4.2. The FWD load cell is calibrated against a custom-made reference load cell, which enables the FWD load cell to be calibrated without being removed from the testing equipment.

4.3. The FWD deflection sensors are removed from their holders on the FWD and mounted in a rigid stand where they are calibrated against a precision accelerometer (with the accelerometer signal being double integrated by *WinFWDCal*). The sensors are stacked vertically in the stand, one above another in one or two columns, so that all sensors, including the accelerometer, are subjected to the same pavement deflection.

4.3.1. Next, the calibration of the FWD deflection sensors is further refined by comparing them to each other in a process referred to as “relative calibration.” In annual calibration, the same sensor stand is used for both reference and relative calibration.

4.4. Monthly relative calibration uses a relative calibration stand supplied by the FWD manufacturer. It is a quick means to periodically verify that the sensors are functioning properly and consistently. Monthly relative calibration assumes that the overall mean deflection, as determined from simultaneous measurements by the full set of deflection sensors, yields an accurate estimate of the true deflection. This assumption requires that the deflection sensors must have first been subjected to the annual calibration procedure.

4.4.1. The relative calibration procedure used for monthly relative calibration is different from that used for annual calibration.

4.5. Acceptance criteria for annual calibration and monthly relative calibration, based on the repeatability of the calibration factors, are identified in the calibration procedure. If accepted, the final gain factors shall be entered into the FWD operating program.
5. **SIGNIFICANCE AND USE**

5.1. Calibration of both the load cell and the deflection sensors provides a means of comparison of results from different FWD types and manufacturers.

5.2. Calibration ensures consistency in the data collection among various agency FWDs.

5.3. Calibration improves the accuracy of pavement layer moduli derived from FWD data by means of backcalculation and other interpretive methods.

6. **APPARATUS**

6.1. **Facilities**—Indoor space with easy access for FWD and towing vehicle, a level floor large enough so that the FWD can sit level during the test, a reasonably constant temperature (between 10 and 40°C (50 and 100°F)), heated, but not necessarily air-conditioned, and good security for the calibration equipment.

6.2. **Test Area**—Isolated concrete test slab having a smooth, crack-free surface with a clear zone around the perimeter for maneuvering FWDs and the reference data acquisition system. The test area may be isolated (by impregnated felt bond breaker, sawed and caulked joint, or similar means) from the surrounding floor area. While an isolated concrete test slab is recommended, it is not required, provided that all other facilities requirements, especially the deflection characteristics of the test area, are achieved.

**Note 1**—Slab dimensions of 4 by 5 m (12 by 15 ft) with a clear zone around the perimeter of 2.5 m (8 ft) wide are suggested.

**Note 2**—A modest amount of hairline cracking in the slab is permissible. If the test area develops cracks that are visibly open (1.5 mm (0.06 in.) or more), it should be replaced.

6.2.1. The deflection characteristics of the test area shall be deemed satisfactory, provided that the maximum acceleration and maximum number of replicate drops required by the WinFWDCal software are satisfied.

**Note 3**—For preliminary screening of a potential test area, the concrete slab should have a deflection of 300 μm (12 mils) or more due to a 70-kN (16,000-lb) load at the position of the deflection sensor calibration stand when the FWD is in the specified position for calibration. In general, a concrete pavement on a relatively weak subgrade will yield the required deflection amplitude.

**Note 4**—Calculations indicate acceptable fatigue life can be achieved with a 125-mm (5-in.) thick portland cement concrete slab resting on a 200-mm (8-in.) open-graded crushed aggregate base. A layer of filter fabric should be placed below the base to protect it from intrusion of subgrade fines. To achieve adequate deflections, the subgrade modulus should be less than 80 MPa (12,000 psi) when bedrock is deeper than 8 m (25 ft). Where bedrock exists at depths of 3 to 8 m (10 to 25 ft), the subgrade modulus should be 50 MPa (7500 psi) or less. Test areas located where bedrock is less than 3 m (10 ft) deep are likely to be very sensitive to minor variations in subgrade moisture and hence are not advisable.

6.2.2. The calibration stand holder (ball-joint anchor) should be located not closer than 300 mm (12 in.) from the edge of the test area, but it is not required, nor is it possible, that the test area shall deflect uniformly across the entire area of the pad.

**Note 5**—Placing the stand holder too close to the edge of the slab may result in excessive accelerations due to the nature of the surface waves near the edge of the slab.

6.3. **Equipment**—The following equipment is needed in the calibration facility:
Note 6—Drawings of each of the special items of equipment, cabling diagrams, and the data acquisition software, WinFWDCal and PDDXconvert, are available from AASHTO re:source the LTPP Program. The signal conditioner and data acquisition board described in the following sections are required for compatibility with the WinFWDCal software.

6.3.1. **Signal Conditioner**—Measurements Group Inc. Vishay Model 2310 signal conditioner with power cable and stabilizer bar.

6.3.2. **Data Acquisition Board (DAQ)**—Keithley Model KUSB-3108 data acquisition board or equal. Note 7—The DAQ board should be placed in a box housing to protect the wire connections.

6.3.3. **Connecting Cables**—Accelerometer to signal conditioner load cell to signal conditioner, signal conditioner to DAQ, and DAQ to computer USB port. A push-button cable powered by the DAQ is also required for communication with the WinFWDCal software.

6.3.4. **Computer**—A laptop or desktop computer capable of running Windows XP or higher software, having at least two and preferably four USB ports.

6.3.5. **Reference Load Cell**—Custom-built reference load cell (300-mm diameter) calibrated annually to a 106 kN (24,000 lb) capacity.

6.3.6. **Reference Accelerometer**—Silicon Designs Model 2220-005 ± 5 g accelerometer mounted in a custom-built aluminum box housing.

6.3.7. **Accelerometer Calibration Platform**—Custom-built aluminum platform capable of being leveled. Used for daily calibration of the accelerometer and for storage of the accelerometer when it is not in use.

6.3.8. **Data Acquisition Software**—WinFWDCal and PDDXconvert.

6.3.9. **Deflection Sensor Calibration Stands**—Custom-built welded aluminum stands with shelves and associated hardware for ten deflection sensors and one reference accelerometer. One design is used with geophones and another with seismometers. Used for annual calibration.

6.3.10. **Ball-Joint Anchor**—Custom-built hardware, bolted to the floor or test area, used for coupling the deflection sensor calibration stands to the pavement.

6.3.11. **Relative Calibration Stand**—Provided by the FWD manufacturer with as many positions as the number of active deflection sensors. Used for monthly relative calibration.

7. **FALLING WEIGHT DEFLECTOMETER SETUP**

7.1. The FWD shall be in good operating condition prior to performing reference calibration. Particular attention shall be paid to cleaning the deflection sensor bases, where appropriate, to ensure that they seat properly in the sensor stand. Also, verify that the FWD load plate is firmly attached to the load cell and the swivel (if so equipped) is well lubricated. All cables and electrical connectors shall be inspected and, if necessary, cleaned and firmly seated. Verify that the cables are connected to the correct channels.

7.2. A series of warm-up drops shall be performed immediately prior to beginning calibration. The warm-up may be performed before the FWD is moved into position for calibration.
7.3. During setup, FWD-specific information will need to be transferred electronically from the FWD computer files to the calibration computer. The WinFWDCal software will provide guidance to accomplish this.

7.4. If the FWD is trailer mounted, the trailer shall remain attached to the towing vehicle throughout the entire calibration period.

7.5. Before beginning any calibration work and throughout the entire calibration period, there shall be no data filters in operation in the FWD operating program. Verify that all smoothing or signal filtering has been turned off.

7.6. Hook up the reference system cables, and warm up the electronics as indicated by the software before beginning a calibration.

8. DEFLECTION SENSOR CALIBRATION SET UP

8.1. The signal conditioner excitation and gain must be set exactly to the specified levels. The software will provide guidance to accomplish this.

8.2. Calibrate the accelerometer using the calibration platform. The platform shall be carefully adjusted using the bubble level to assure that the accelerometer is aligned squarely with Earth’s gravity field. The accelerometer shall be calibrated in both +1 g and −1 g fields by inverting the box briefly. The WinFWDCal software will provide on-screen instructions. 

Note 8—Care must be taken to avoid dropping the accelerometer box during the calibration process because the shock may damage the accelerometer.

8.3. Position the FWD so the load plate is as close as possible to the ball-joint anchor.

8.4. Connect the sensor stand to the ball-joint anchor and tighten all bolts securely. Slippage between the stand and the base or between the base and the concrete shall not be allowed. The ball-joint shall rotate with slight friction. It is important that the FWD shall not come in contact with the sensor stand during the calibration.

8.5. Attach the accelerometer box in position in the sensor stand.

8.6. Determine the required accelerometer trigger level in accordance with the on-screen instructions. 

Note 9—Hold the calibration stand vertically with a moderate downward pressure at all times when readings are being taken.

8.7. The drop sequence used for reference calibration shall be determined as guided by the WinFWDCal software.

8.7.1. The FWD owner shall specify the load levels to be used during reference calibration. A minimum of three and a maximum of four load levels shall be specified. The highest load level shall not exceed 80 kN (18,000 lb) ± 10 percent.

Note 10—A heavyweight deflectometer (HWD) can achieve the target load levels by taking off all of the removable weights.

8.7.2. Determine the minimum number of replicate drops in accordance with the on-screen instructions. More than the minimum number of drops may be used, not to exceed ten drops per load level. 

Note 11—If three load levels are used, the minimum number of drops in the sequence shall be 18 and the maximum number shall be 30. For four load levels, the minimum number of drops shall be 20 and the maximum shall be 40.
8.7.3. Program the drop sequence in the FWD computer, progressing from the lowest to the highest load level. Provide a pause after each drop or manually control the FWD. The same number of drops shall be used at each load level.

8.8. Remove the FWD deflection sensors from the FWD and position them in the sensor stand in accordance with the WinFWDCal on-screen instructions.

9. ANNUAL DEFLECTION SENSOR CALIBRATION PROCEDURE

9.1. Reference Calibration—Deflection sensor reference calibration consists of performing at least two trials, in which all of the sensors are calibrated simultaneously in the sensor stand. The position of the sensors in the stand is inverted between each trial. Spare deflection sensors shall not be calibrated unless the FWD has separate, dedicated signal conditioning channels.

9.1.1. Perform the drop sequence for the first reference calibration trial. Review and accept or reject the data for each drop. The WinFWDCal software will graphically display the deflection-time history data after each drop.

**Note 12**—Excessive drift from the baseline shown on the time history graph should be cause for rejection of a drop. The software will provide an alert to the user when drift may be excessive.

9.1.2. At the conclusion of the drop sequence, transfer the FWD data electronically to the calibration computer and review the results. For each sensor, WinFWDCal will regress the FWD output (independent variable) versus the reference deflection sensor (dependent variable) forced through zero. The slope of the regression line for each sensor, when multiplied by the initial gain factor, gives the reference gain factor.

9.1.3. The slope for an individual sensor is acceptable if its standard error is not more than 0.0020. The trial is acceptable if the standard errors for all sensors are not more than 0.0020.

9.1.4. If the first trial is acceptable, continue with the second trial. Invert the sensors in the stand before the second trial according to the diagram displayed by WinFWDCal.

9.1.5. If the first trial is not acceptable, the data shall be rejected and the trial shall be repeated.

**Note 13**—The reason why the standard error exceeds 0.0020 should be investigated and corrected, if possible, before repeating the procedure. Verify that all sensors are held firmly in the stand.

9.2. Interim Gain Factor Acceptance Criteria—Evaluate the data as follows:

9.2.1. After two trials have been accepted, WinFWDCal will calculate the average reference gain factor for each sensor and display the results as the interim gain factors (one gain factor for each deflection sensor).

9.2.2. WinFWDCal will calculate the difference in the reference gain factors for each sensor between the two trials. If the difference for each sensor is no more than 0.005, then the reference calibration test is complete.

9.2.3. If any of the differences is greater than 0.005, perform two additional trials. Accept the results and continue, but note if any of the differences is more than 0.005.

9.2.4. The average of the reference gain factors for each sensor shall be reported as the interim gain factors.
9.3. **Relative Calibration**—Reference calibration is followed by relative calibration, using the same sensor stand. Two trials are performed. For each trial, 40 drops shall be applied from the highest drop height used in reference calibration. The sensors shall not be repositioned in the sensor stand before the first trial.

**Note 14**—The WinFWDCal software will adjust the FWD data collected in the relative calibration using the interim calibration factors internally. Do not enter the interim factors in the FWD operating program before performing relative calibration.

9.3.1. Perform the drop sequence for the first relative calibration trial.

9.3.2. At the conclusion of the drop sequence, transfer the FWD data electronically to the calibration computer and review the results. For each sensor, WinFWDCal will calculate the means ratio. The means ratio multiplied times the interim gain factor gives the relative gain factor.

9.3.3. WinFWDCal does an analysis of variance (ANOVA) for the data and reports the standard error. The trial is acceptable if the standard error is not more than 3 μm (0.12 mils) and there are no extreme outliers in the data.

**Note 15**—The WinFWDCal software will display a plot of the data for the 40 drops. The graph should be scanned to detect extreme outliers (for instance, due to a loose sensor in the stand). An extreme outlier would appear substantially outside the normal range of the deflection data.

9.3.4. If the standard error is greater than 3 μm (0.12 mils) or if there are extreme outliers in the data, the first trial is not acceptable, the data shall be rejected, and the trial shall be repeated. (Do not reposition the sensors in the sensor stand.)

**Note 16**—The reason why the data are unacceptable should be investigated and corrected, if possible, before repeating the procedure.

9.3.5. If the first trial is acceptable, continue with the second trial. Invert the sensors in the stand before the second trial according to the diagram displayed by WinFWDCal.

9.4. After two trials have been accepted, WinFWDCal will calculate the average relative gain factor for each sensor, and report the results as the final gain factors. The deflection sensor calibration procedure is complete.

9.4.1. If two acceptable trials cannot be obtained after performing four trials, no further effort shall be made to calibrate the deflection sensors.

10. **LOAD CELL CALIBRATION SETUP**

10.1. If the reference load cell has not been calibrated within the past 12 months, it shall be recalibrated in accordance with R 33.

10.2. Zero balance the signal conditioner with the load plate high so that there is no external load on the reference load cell. For accurate results, it is critically important that the FWD load plate be in the raised position. The signal conditioner excitation and gain shall be set exactly to the levels at which the reference load cell was calibrated. The software will provide guidance to accomplish this.

10.3. Position the FWD so that the load plate is near the center of the calibration test area, or on any stiff, smooth concrete surface. Sweep the area beneath the load plate to assure there will be no sand or other loose debris under the reference load cell.
10.4. Position the reference load cell beneath the FWD load plate, making sure that the three guides are aligned around the plate. Lower the FWD load plate to the reference load cell. Verify that the load cell sits squarely under the FWD load plate and squarely on the concrete.

**Note 17**—After applying three seating drops, it should not be possible to slide a piece of paper under the load plate anywhere around the perimeter of the plate or under any of the support feet of the reference load cell.

10.5. The same drop sequence shall be used for both load and deflection sensor reference calibration. If deflection sensor calibration was not performed, then the minimum number of drops specified in Note 11 should be used.

10.5.1. Program the drop sequence in the FWD computer, progressing from the lowest to the highest load level. Provide a pause after each drop or manually control the FWD. The same number of drops shall be used at each load level.

11. **ANNUAL LOAD CELL CALIBRATION PROCEDURE**

11.1. *Reference Calibration*—Reference load cell calibration consists of at least two trials.

11.1.1. The FWD load plate should not be raised at any time during the procedure.

11.1.2. Perform the drop sequence for the first reference calibration trial. Review and accept or reject the data for each drop. The *WinFWDCal* software will graphically display the deflection-time data after each drop.

11.1.3. At the conclusion of the drop sequence, transfer the FWD data electronically to the calibration computer and review the results. *WinFWDCal* will regress the FWD output (independent variable) versus the reference load cell (dependent variable) forced through zero. The slope of the regression line for each sensor, when multiplied times the initial gain factor, gives the reference gain factor.

11.1.4. The slope for the trial is acceptable if its standard error is not more than 0.0020.

11.1.5. If the first trial is acceptable, continue with the second trial.

11.1.6. If the first trial is not acceptable, the data shall be rejected and the trial shall be repeated. 

**Note 18**—The reason why the standard error exceeds 0.0020 should be investigated and corrected, if possible, before repeating the procedure. Verify that the load cell sits squarely under the FWD load plate and squarely on the concrete.

11.2. After two trials have been accepted, *WinFWDCal* will calculate the average reference gain factor and report the results as the final gain factor. If the range of the two reference gain factors is not more than 0.003, then the final gain factor shall be accepted. The load cell calibration procedure is complete.

11.2.1. If the results of the first two trials are outside the acceptable range, a third reference calibration trial shall be performed.

11.3. If the standard deviation of the gain factors for three acceptable trials is not more than 0.003, then the results of the three trials shall be averaged and reported as the final gain factor for the load cell. The load cell calibration procedure is complete.

11.3.1. If the standard deviation exceeds 0.003, the reference load cell calibration procedure shall be repeated, yielding a fourth reference gain factor.
11.4. If the standard deviation of all calibrations (four acceptable trials) is not more than 0.003, the average of all four results shall be reported as the final gain factor for the load cell, and the load cell calibration procedure is complete.

11.4.1. If acceptable results cannot be obtained after performing four trials, no further effort shall be made to calibrate the load cell.

12. **ANNUAL CALIBRATION ACCEPTANCE AND CERTIFICATION**

12.1. *Evaluation and Acceptance of Final Gain Factors*—The *WinFWDCal* software will perform the needed calculations. Evaluate the data as follows:

12.1.1. The final gain factors from this calibration shall be compared to the corresponding gain factors from the previous calibration (i.e., the initial gain factors). There shall be no more than a 1 percent difference, either higher or lower, for each individual deflection sensor and for the load cell. If this criterion is satisfied, the final gain factor for the sensor shall be accepted. If this criterion is not satisfied for a sensor, then evaluate it according to the next criterion.

12.1.2. The final gain factor for the sensor shall fall within a range of 0.980 to 1.020. If this criterion is satisfied, the final gain factor for the sensor shall be accepted. If this criterion is not satisfied for the sensor, then evaluate it according to the next criterion.

12.1.3. If a historical record of previous calibrations according to this procedure is available for the sensor for a period of 4 years or more, and there are at least three previous calibration results over this period of time, then the best fit time rate of change of the final gain factor for the sensor shall be no more than 0.3 percent per year. If this criterion is satisfied, the final gain factor for the sensor shall be accepted.

12.2. *Certificate of Calibration*—If the final gain factors for all sensors meet an acceptance criterion in Section 12.1, a certificate of calibration in accordance with Section 14 shall be issued by the certified technician.

12.2.1. The final gain factors shall be entered into the FWD operating program.

13. **MONTHLY RELATIVE CALIBRATION PROCEDURE**

13.1. Monthly relative calibration can serve one of two purposes. With regular use, it is a means to verify that the deflection sensors are functioning properly and consistently. It can also be used to replace a damaged sensor, providing a temporary gain factor for the replacement sensor for short-term use until an annual reference calibration can be done.

13.1.1. Monthly relative calibration uses a calibration stand provided by the FWD manufacturer. The deflection sensors are stacked vertically in the stand, one above another, so that all sensors are subjected to the same pavement deflection. Position in the stand may have an effect on the deflection readings. To compensate for this, the sensors are rotated through all positions in the stand.

*Note 19*—This rotation procedure is different from the relative calibration procedure done for annual reference calibration.

13.1.2. Monthly relative calibration relies on collecting a large amount of data that can be averaged to reduce the significance of random measurement errors. Large deflections are needed for the results to be accurate. *WinFWDCal* does the statistical data analysis to compute adjustment ratios and final gain factors from the data. Since a large number of drops are involved, the properties of the
pavement materials may change due to compaction or liquefication during the procedure. However, since all of the sensors are equally affected by such changes, the adjustment ratios are still accurate.

13.1.3. Some FWDs have fewer than or more than seven active deflection sensors. If they do, this procedure shall be modified to calibrate the actual number of active sensors in use on the FWD. Any number of sensors up to ten will work as long as the calibration stand will accept them.

13.2. Monthly Relative Calibration Procedure—Remove all of the deflection sensors from their holders on the FWD. Make sure that the sensors are labeled (e.g., from one to seven) with respect to their normal position on the FWD.

13.2.1. Position the deflection sensors in the stand for the first set as illustrated by the WinFWDCal software.

13.2.2. Hold the calibration stand vertically with a firm downward pressure at all times when readings are being taken. Mark the location where the stand rests so that it can be relocated precisely on the same spot. This should be done by gluing a washer to the pavement or by chipping a small divot in the pavement with a chisel or a screwdriver.

13.2.3. Select the FWD drop height and the distance from the loading plate to the sensor stand to yield deflections near 500 μm ± 100 μm (20 mils ± 4 mils).

   **Note 20**—If deflections in this range cannot be achieved, choose another location. A concrete pavement on a relatively weak subgrade will usually yield the required deflection. This procedure may be carried out at any location that satisfies the deflection requirement.

13.2.4. Warm up the FWD and condition the test point by repeating a sequence of ten drops until the loads and deflections that are registered are nearly uniform.

13.2.5. Lower the FWD loading plate. Do not raise the loading plate or move the FWD during the relative calibration procedure. This will assure a constant distance between the center of the load plate and the base of the sensor stand.

13.2.6. For each set, make two seating drops (no data recorded) followed by five replicate drops (for which data are recorded).

13.2.7. At the end of each set, rotate the sensors in the stand as specified by the software.

13.3. Monthly Relative Calibration Data Analysis—Transfer the FWD data file electronically to the WinFWDCal software program for analysis. Options are provided in the software to indicate whether a normal data analysis or a sensor replacement analysis is desired.

13.4. Adjustment of Calibration Factors: Normal Analysis—Normal analysis is used when no sensor is being replaced.

13.4.1. The WinFWDCal software will report the adjustment ratios and the gain factors for each deflection sensor. Adjustment of the gain factors in the FWD operating program shall be made only when those changes are both significant and verified to be necessary. The following guidelines shall be used to evaluate the need for adjustment of the gain factors:

13.4.2. If all of the adjustment ratios are between 0.997 and 1.003 inclusive, they are not statistically significantly different from a ratio of 1.000. The calculated adjustments are trivial and no change of the gain factors shall be made. The monthly relative calibration test is complete.
13.4.3. When the adjustment ratios for one or more sensors fall outside the range 0.997 to 1.003, a second relative calibration trial shall be performed. Repeat Section 13.2. If the gain factors for each sensor in both trials agree within 0.003, the need for the adjustment has been verified. The gains shall be adjusted for all sensors. The gain factors for each sensor for the two trials shall be averaged and entered in the FWD operating program. The monthly relative calibration test is complete.

13.4.4. If, for one or more sensors, the difference in the gains for the two trials is greater than 0.003, reject the first two trials and perform two more trials. If the second attempt also exceeds the allowable difference, the annual calibration procedure (Section 12) shall be performed as soon as possible.

13.5. Adjustment of Calibration Factors: Sensor Replacement—When replacing a damaged deflection sensor, the monthly calibration procedure should be used to determine a temporary gain factor for the replacement sensor. The calculations are done by the WinFWDCal software, and a gain factor is reported only for the replacement sensor.

13.5.1. Two relative calibration trials shall be performed in accordance with Section 13.2. If the two gain factors for the replacement sensor agree within 0.003, then the gain factors for the two trials shall be averaged and entered in the FWD operating program. The relative calibration test is complete.

13.5.2. If the difference is greater than 0.003, two more relative calibration trials shall be performed. Repeat Section 13.2. WinFWDCal will report the average gain factor from the four trials and the standard deviation. If the standard deviation is not more than 0.003, then the temporary gain factor shall be entered in the FWD operating program. The relative calibration test is complete.

13.5.3. If the standard deviation of the four trials is more than 0.003, no further effort shall be made to calibrate the replacement sensor. The annual calibration procedure (Section 12) shall be performed as soon as possible.

14. REPORT

14.1. The calibration certificate shall report the following information:

14.1.1. Calibration date, calibration center ID, and calibration center operator name;

14.1.2. FWD ID and FWD operator name;

14.1.3. Version number of the WinFWDCal software used in the calibration;

14.1.4. The FWD load cell serial number, initial and final gain factor;

14.1.5. The FWD deflection sensor position ID, serial numbers, and initial and final gain factors; and

14.1.6. Descriptive notes indicating whether the gain factors met the acceptance criteria.

15. PRECISION AND BIAS

15.1. Load Cell Calibration:

15.1.1. Seventeen load cell calibration trials were done in 2006 by three FWD calibration operators using a Dynatest FWD. No difference between operators was found. The overall standard deviation of the final calibration factor was 0.00152. The 95th percentile repeatability using a Student’s t-test uses a multiplier of 2.11.

In this case, the precision and bias statement would read:
**Precision and Bias Statement for Dynatest Load Cell Calibration:**

The 95 percent repeatability of the final gain factor: 0.321 percent.
No reproducibility statement is available at this time.
There is no bias expected in the final gain factor.

15.2. **Geophone Calibration:**

15.2.1. Nine geophone calibration trials were done in 2006 by three FWD calibration operators using a Dynatest FWD. No difference between operators was found. The overall pooled standard deviation of the final calibration factors for all nine geophones was 0.00245. By using the pooled standard deviation, the normal distribution multiplier of 1.96 may be used.

In this case, the precision and bias statement would read:

**Precision and Bias Statement for Dynatest Geophone Calibration:**

The 95 percent repeatability of the final gain factor: 0.480 percent.
No reproducibility statement is available at this time.
There is no bias expected in the final gain factor.

16. **KEYWORDS**

16.1. Calibration; falling weight deflectometer; FWD; geophones; load cell; pavement deflection; pavement testing; seismometers; sensors.

17. **REFERENCE**

17.1. AASHTO T 256, Pavement Deflection Measurements.

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1 Information concerning the [FWD Calibration Center Operator Certification Program](http://www.aashtoresource.org), the location of FWD calibration centers and data acquisition software is available from the AASHTO re:source, 4441 Buckeystown Pike, Frederick, Maryland, 21704; email: info@aashtoresource.org.

2 Customer Support Services of the Long-Term Pavement Performance Program at the Federal Highway Administration, Turner-Fairbank Highway Research Center, McLean, VA; E-mail: ltppinfo@dot.gov; telephone number (202) 493-3035.

3 Suitable signal conditioners are available from [Vishay Micro-Measurements](http://www.vishay.com); telephone number (484) 321-5300, website: [www.vishay.com](http://www.vishay.com).

4 Suitable data acquisition boards are available from [Measurement Computing](http://www.mccdaq.com); telephone number (800) 234-4232, website: [www.mccdaq.com](http://www.mccdaq.com).

5 Suitable sensors are available from [Keithley Instruments, Inc.](http://www.keithley.com); telephone number (800) 552-1115.
Proposed Research Needs Statement

Date: August 7, 2018

TITLE
Improvement of Certification Methods of Inertial Profiling Systems for Network Data Collection

BACKGROUND / NEEDS STATEMENT

As one of the national performance metrics, International Roughness Index (IRI) must be collected and submitted annually by state transportation agencies to Federal Highway Administration (FHWA) through Highway Performance Monitoring System (HPMS), per 23 CFR 490.309. State agencies utilize IRI, along with other performance metrics, to determine performance measures and develop performance targets for their National Highway System (NHS). With the intention of assisting States to collect reliable data, the National highway Performance Program (PM2) rule requires State transportation agencies to develop Data Quality Management Programs (DQMPs).

One of the critical elements of DQMP is the certification of data collection equipment, which follows AASHTO R56 “Standard Practice for Certification of Inertial Profiling Systems”. However, the repeatability and accuracy requirements in R56 are only used for test sections with IRI values less than 150 in./mi. Per MAP-21 final rules on pavement measures, the threshold for Fair/Poor section is 170 in./mi. Therefore, there is a gap of repeatability and accuracy requirements for test sections with IRI values greater than 150 in./mi. Additionally, per MAP-21 requirements, State agencies are required to develop performance targets based the performance measures. It is critical for the States to understand how the certification requirement may influence the performance measure related to pavement IRI measurement.

This project will involve researching and documenting influence of repeatability and accuracy on the national performance measure related to pavement IRI. The final delivery of this research project will be able to assist transportation agencies to select requirements for equipment repeatability and accuracy based on their needs for network data collection. The research team will then make recommendations for AASHTO Standard Practice to provide states and other transportation agencies information that can be used for certifying inertial profiling systems for network data collection.

RESEARCH OBJECTIVE

The research team shall develop recommendations for AASHTO Standard Practice regarding the certification of inertial profiling systems for network data collection.

WORK TASKS

Tasks anticipated in this project include the following:

- Collect nationwide certification test results of inertial profiling systems, which may cover different brands of inertial profiling systems, test sections with a range of roughness experienced during network data collection, and different pavement types.
- Conduct nationwide investigation into the influence of IRI variability on national...
performance measure related to pavement IRI at network-level.

- Identify the range of roughness for test sections and the associated repeatability and accuracy requirements for certify inertial profiling systems for network data collection.
- Develop and document recommendations for AASHTO Standard Practice that could be used by state transportation agencies to certify inertial profiling systems for network data collection.

**URGENCY**

In response to the pavement performance measurement reporting and performance target setting, per MAP-21 requirement, it is urgent that state transportation agencies utilize reliable certification methods of inertial profiling systems for network data collection and understand how the certification requirements may influence the performance measures.

**FUNDING REQUESTED AND TIME REQUIRED**

It is estimated that this research will take 12 months to complete and will require $75,000.