LONG TERM PAVEMENT PERFORMANCE PROGRAM DIRECTIVE

For the Technical Direction of the LTPP Program

Program Area:	Seasonal Monitoring	Directive Number:	SM-31
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Subject:	LTPP SMP Phase II Monitoring		

Background

The objective of the LTPP SMP Phase II monitoring is to continue to provide the data needed to attain a fundamental understanding of the magnitude and impact of diurnal, seasonal and annual variations in pavement response and properties due to the separate and combined effects of temperature, moisture and frost penetration on test sections which have the full suite of data required for pavement performance available. This directive presents monitoring activities to be performed by the Regional Coordination Office Contractors (RCOCs) in order to achieve that objective. They include subsurface temperature and moisture measurements, ambient air temperature and rainfall measurements, and pavement performance monitoring measurements.

Temperature-Moisture Measurements

Manual Surface Layer Temperature Profile

Manual surface layer temperature measurements at three depths are required. Measurements shall be made in accordance with the procedures specified in the current version of the LTPP Manual for FWD Testing; a data sheet for recording the temperatures is provided in that manual.

Moisture Profiles

Subsurface moisture profile measurements for unbound base, subbase, and subgrade layers are required at all test sections. These measurements shall be made using Time Domain Reflectometry (TDR) probes permanently installed at the site – 10 TDRs per site with most of them installed in the subgrade layer except for one or two in the base layer if unbound material. The measurements shall be performed as follows:

- At test sections instrumented for “continuous moisture” measurement, readings shall be

taken using the current version of the ONSPLUS software at intervals which vary depending on the amount of rainfall at the site as determined from the tipping-bucket rain gauge. The ONSPLUS software has been programmed to automatically trigger TDR readings based on rainfall at the site.

- At all other test sections, readings shall be taken at the start of the FWD test day and at 4-h intervals thereafter using the mobile data acquisition unit; a minimum of two sets of readings are required per FWD test day.

In case equipment or software for recording TDR traces does not function properly on the FWD test day, one set of manual measurements shall be taken using the chart recorder option on the Tektronix cable reader. Results of manual measurements shall be recorded on the current version of Data Sheet SMP-D01. Printed traces generated by the cable reader, labeled with test section number (STATE_CODE and SHRP_ID), test date and sensor number, shall also be attached to Data Sheet SMP-D01.

Automated Subsurface Temperature Profiles

Subsurface temperature profile measurements for the entire pavement structure (surface, base, subbase and subgrade layers) are required for all test sections. These measurements shall be made using a thermistor probe (with 18 thermistors) permanently installed at the site – 3 thermistors are located in the pavement surface layer and the remaining 15 thermistors are located in the underlying unbound layers. Automated subsurface temperature readings shall be taken continuously throughout the year and stored by a data logger permanently installed at the site. Measurements shall be taken at 1-min intervals; however, only daily temperature statistics (mean, minimum and maximum, time of minimum and maximum temperatures) for all thermistors and average hourly temperature for thermistors 1 through 5 shall be permanently stored in the data logger. In case the automated temperature reading equipment does not function properly, manual measurements shall be taken at 1-h intervals throughout the FWD test day using a RD200 temperature readout unit and recorded on the current version of Data Sheet SMP-D02.

Depth of Frost/Thaw

Measurements for frost and thaw depth determination are required for all test sections located in frost areas. An electric resistivity probe permanently installed at a site shall be used for these measurements – the probe has 36 electrodes evenly spaced every 50.8-mm (2-in) with most of them located in the subgrade layer. Frost/thaw depth (electrical resistance and resistivity) measurements shall be performed as follows:

- At test sections instrumented for “continuous moisture” measurement, readings shall be taken using the current version of the ONSPLUS software at intervals which vary depending on the minimum soil temperature at the site as determined from the thermistor probe. The ONSPLUS software has been programmed to automatically trigger electrical resistance/resistivity readings based on minimum soil temperature at the site.

- At all other test sections, readings shall be taken automatically at the start of the FWD test day and at 4-h intervals thereafter using the mobile data acquisition unit.

Manual readings are required at all test sections in frost areas a minimum of once per FWD test day. Manual contact resistance and four-point resistivity measurements shall be recorded on the current version of Data Sheets SMP-D03 and -D04, respectively, following the procedures detailed in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines, FHWA-RD-94-110, April 1994" (hereafter referred to as the 1994 LTPP SMP Guidelines) Comments noted on these sheets shall include general weather conditions, core hole condition, deviations from established measurement procedure(s), problems experienced with measurement equipment, and computed values for the check resistors. For manual ranging multimeters, the range setting for each reading shall be recorded. In general, volts shall be recorded in mV (millivolts - 10^{-3} volts) and amperes in mA (milliamperes - 10^{-3} A) units.

Depth to Ground Water Table

Ground water table depth measurements are required at all test sections at the start and end of each FWD test day. Measurement is from top of piezometer pipe to water table, recorded to accuracy of $\pm$10 mm (0.4 in). One observation piezometer is placed outside the pavement edge, midway between the first and last seasonal FWD test points; measurements shall be recorded on the current version of Data Sheet SMP-D05.

Note: At the start of monitoring or during equipment installation for Phase II monitoring, and at minimum one year intervals thereafter, the vertical distance (in meters) between top of the piezometer and pavement surface shall be measured. This value shall be obtained from elevation measurements recorded on Data Sheet SMP-D08 for AC pavements or SMP-D09 for PCC pavements. (Note: elevation surveys of pavement test section shall no longer be performed, except to establish single vertical distance between top of piezometer and pavement surface). The reference point on the pavement surface should be the elevation survey point on the outside pavement edge closest to the piezometer. This information shall be entered in the current version of the SMPCheck program to represent the elevation difference between the piezometer and pavement surface.

Ambient Air Temperature and Precipitation

Measurement of ambient air temperature and precipitation are required at all test sections. These measurements shall be taken using an air temperature probe and rain gauge tipping-bucket permanently installed at the site as specified in the 1994 LTPP SMP Guidelines. Readings shall be taken continuously throughout the year and stored on data loggers permanently installed at the site. Temperature measurements shall be taken automatically at 1-min intervals, but only average hourly temperature and daily temperature statistics (mean, minimum, and maximum, and time of minimum and maximum) shall be permanently stored by the data loggers. Continuous precipitation readings shall also be performed using a tipping-bucket rain gauge with a minimum resolution of 0.1 mm (0.004 in) increments and recorded by the Onsite data logger. Hourly and total daily precipitation shall be stored by the data loggers. Manual air temperature and precipitation measurements shall not be performed using the equipment installed onsite. RCOCs must monitor condition and functioning of equipment and repair it as soon as possible when a malfunction or problem is detected or suspected.

Pavement Performance Monitoring

Pavement performance monitoring addressed in this directive includes profile, distress, deflection, joint opening and joint faulting measurements performed by the LTPP RCOC contractors. Measurements shall be taken at established intervals until one of the following conditions is reached:

1. Test section goes out-of-study.
2. Application of overlay or other rehabilitation activity which alters the thickness of the pavement layers.
3. End of LTPP program.
4. Significant portion of moisture-temperature measurements equipment becomes inoperable -- 8 TDRs, 15 thermistors including two in surface layer, 28 electrodes in resistivity, and ambient air temperature and tipping bucket devices must be fully operational for section to remain in program.
5. Traffic control is no longer available to conduct the minimum number of test cycles per day, or at least six FWD test days per year.

Longitudinal Profile Measurements

Longitudinal profile measurements on LTPP SMP Phase II monitoring test sections shall be performed in accordance with established data collection guidelines, protocols and directives. They shall be performed four times per year; one survey per climate season, preferably in the middle of the season. In frost areas, an additional survey during late winter (fully frozen condition) is desired. For flexible pavements, only one survey per test day is required. Two surveys per day, a minimum of 4 hours apart, are required for rigid pavements; one in the morning and the other in the afternoon.

Distress Surveys

The collection of distress data at SMP Phase II monitoring test sections shall be done in accordance with current LTPP data collection guidelines, protocols and directives. Test sections shall be surveyed twice per year, a minimum of four months apart, using the manual distress data collection method; i.e., one in the summer and the other in late fall or spring, but always concurrent with a FWD test day. In addition, photographic distress surveys shall be performed once every other year. It is highly desirable that both manual and photographic surveys be performed at approximately the same time each year ($\pm$ 1 month). When possible, photographic surveys shall be performed within one month of the manual survey for that year. All surveys must be done by accredited LTPP distress raters over the entire length of the LTPP section.

Deflection Testing

Deflection testing on LTPP test sections shall be performed using Falling Weight Deflectometers (FWDs) in compliance with LTPP specifications following all applicable guidelines, protocols and directives. Each SMP Phase II test section shall be tested six (6) times per year using either fixed interval testing or direct event testing depending on the climatic regime at the site. Regional

contractors shall coordinate with FHWA and TSSC staff to tailor FWD test plans for each test section.

For flexible pavements, the test cycle shall be repeated a minimum of three times per test day, while for rigid pavements the test cycle shall be repeated a minimum of two times per test day. When three or less FWD test cycles are performed, this testing shall be performed during daylight hours. Where possible, additional FWD test cycles per day to cover a 12- to 24-h time span should be conducted for both pavements types. Also, when it is feasible to perform more than 3 test cycles in a day, the day's test program should start 0.5 h before sunrise.

Figure 1 illustrates the test pattern for asphaltic concrete (AC) pavements; both outer wheel path and mid-lane locations shall be tested. The lateral location (distance from edge reference) of test points shall be determined according to procedures specified in the current version of the LTPP Manual for FWD Testing. Along each pass, nine points at 7.6 m (25 ft) spacings shall be tested. The first test location shall conform with station 0+00 or 3+00, depending on the section end selected for seasonal monitoring. Three additional locations in the vicinity of the instrumentation shall also be tested; two test points in the outer-wheel path and one mid-lane test point. The longitudinal location of these test points depends on the instrumentation hole location. FWD measurements shall not be taken directly over the instruments to prevent possible damage to the instrumentation. As a minimum, the FWD load plate shall be 1.2 radial meters (4 radial feet) away from any instrumentation, borehole or test pit, except for the mid-lane test which is about 1 m (3 ft) from the instrumentation.

The testing pattern for jointed plain (JPC) and jointed reinforced (JRC) concrete pavements is illustrated in Figures 2 and 3, respectively. For both pavement types, four adjacent effective slabs within the test section shall be evaluated for mid-slab basin, corner, edge basin and load transfer deflection (5 tests per panel). The effective slabs and lateral location (distance from reference edge) of test points shall be determined according to procedures specified in the current version of the LTPP Manual for FWD Testing. Load transfer deflection tests, both approach and leave, shall be conducted on five successive joints within the test section as shown in Figures 2 and 3.

Depending on which section end is selected, the location of the first joint will typically be between stations 0+00 and 0+20 or the location of the last joint will typically be between stations 4+80 and 5+00. Also, J1, J2, J4 and J5 deflection tests shall be performed on the effective slab with instrumentation, outside the test section boundaries; no J3 deflection tests shall be conducted because of trench and location of bore hole. No FWD measurements shall be taken directly over the instruments; as a minimum, the FWD load plate shall be 1.2 radial meters (4 radial feet) away from any instrumentation, borehole or test pit except for the mid-panel test on the slab with instrumentation.
Monitoring of pavement surface and air temperature with the FWD is required during deflection measurements. Ordinarily, automatic sensors on LTPP FWD's shall be used. Should the sensors be inoperable, manual measurements shall be taken at intervals of 15 minutes or less. (Note: no data sheets are provided for recording pavement surface and air temperature as these data are stored in the FWD data files).

Finally, all test locations on each pavement section must be referenced so tests can be performed ideally within ± 25 mm (1 in) of the same locations.

Joint Gauge Measurements (Rigid Pavements)

Joint gauge measurements to monitor joint opening is required for all joints tested; 6 joints per rigid pavement section. Joint movement shall be monitored at each test joint shown in Figures 2 and 3 to the nearest ±0.01 mm (±0.0004 in), at 0.3, 1.8 and 3.4 m (1.0, 6.0 and 11.0 ft) from the outside pavement edge. At each lateral location, a digital caliper with 153-mm (6-in) range shall be used to measure the distance between two snap rings embedded in the slab on adjacent sides of the joint. Detailed instructions for installing the snap rings are provided in the 1994 LTPP SMP Guidelines. Measurements shall be recorded on the current version of Data Sheet SMP-D06.

Joint gauge measurements shall be made immediately before or after each joint is tested with the FWD, for every test cycle. On the first cycle, three readings shall be recorded on each pair of snap rings to establish measurement accuracy for the procedure. The caliper shall be closed after each set of readings for a joint to verify a "zero" reading; if not "zero," the reading shall be repeated. The last column on the current version of Data Sheet SMP-D06 is for joint opening (saw cut width) that is entered into the FWD field program after each load transfer test.

Note: Above procedure does not provide a direct measure of the joint opening; however, readings during hot summer days when the joints are completely closed provide a reference value by which joint movement can be determined.

Joint Faulting Measurements (Rigid Pavements)

Measurement of joint faulting is required for all PCC pavement joints tested; 6 joints per rigid pavement test section. The procedure to follow is outlined in the LTPP Distress Identification Manual, May 1993. Faulting shall be measured at each joint tested (see Figures 2 and 3), at 0.8, 1.8 and 2.9 m (2.5, 6.0 and 9.5 ft) from the outside pavement edge, immediately before or after each joint is tested with the FWD, once per test day; see Figure 3. Measurements shall be recorded on the current version of Data Sheet SMP-D07, which does allow readings for each cycle of FWD testing.

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