

NOTES:  
1. Drill hole spacing(s) should be 460 mm CC or greater.

**Figure B-5.2 Typical Drilling Patterns for Temperature Gradient Data**

**APPENDIX B-6**

**FWD TESTING GUIDELINES  
FOR SPECIFIC PAVEMENT STUDIES (SPS) EXPERIMENT 6  
REHABILITATION OF JOINTED  
PORTLAND CEMENT CONCRETE PAVEMENTS**

## Introduction

This appendix provides guidelines and information for Falling Weight Deflectometer (FWD) testing at individual test sites for the Long Term Pavement Performance (LTPP) study experiment SPS-6, "Rehabilitation of Jointed Portland Cement Concrete Pavements." The intent of this document is to establish the specific testing requirements for SPS-6 sites based on a uniform set of assumptions. It is recognized that not all sites will conform to all assumptions contained herein. However, the objectives and approach to deflection data collection must be consistent so data obtained can be analyzed in a consistent manner. For deflection testing details not specifically addressed in the appendix, refer to the general guidelines in this manual.

The objective of the SPS-6 experiment is to investigate the performance of selected rehabilitation treatments for jointed PCC pavements. A variety of rehabilitation techniques can be applied to jointed PCC pavements to restore condition and extend service life. The techniques included in this experiment include a combination of types of pavement preparation ranging from minimal treatment to full "Concrete Pavement Restoration" (CPR) as well as cracking/breaking and seating. AC overlays of different thicknesses are included depending on the type and extent of pavement preparation. Characterization of materials and environmental conditions between test sections is required to explain performance differences and provide a basis for improved rehabilitation design.

In contrast to the LTPP General Pavement Studies (GPS), SPS has controlled construction of multiple test sections at a single site. On a SPS-6 site, there are 7 test sections and one control section. Five of the experimental sections have AC overlays. Experiment sites should conform to criteria contained in Specific Pavement Studies Guidelines for Nomination and Evaluation of Candidate Projects for experiment SPS-6, "Rehabilitation of Jointed Portland Cement Concrete Pavements", November 1989. The site characteristic affecting FWD testing is the number of sections.

Table B-6.1 lists the LTPP test sections in an SPS-6 experiment site. Criteria for selection limit the sites to a single structural cross section, constructed of the same materials throughout, under the same contract. Location of test sections should avoid cut/fill transitions, bridges, culverts, and side hill fills to limit the potential for variability of subgrade soils. A minimum of three Test Pits are used at a site.

## FWD Test Plan

### *General*

FWD testing for SPS-6 is performed 0 to 3 months prior to rehabilitation (labelled as "BEFORE"); immediately following cracking and seating of the PCC surface in sections 7 and 8, but before placement of the AC overlay (labelled as "DURING"); 3 to 6 months after rehabilitation is completed (labelled as "AFTER"); and bi-annually more than 6 months after the completion of rehabilitation (labelled as "LONG TERM"). The "BEFORE" testing is used to characterize the existing pavement structure and provide a baseline for comparison of the various rehabilitation techniques. Testing "DURING" construction is used to characterize the strength of the cracked and

Table B-6.1 - SPS-6 Test Section Numbering Scheme

| SPS-6 Section No. | Preparation          | Other Treatments                  | AC Overlay Thickness, Inches |
|-------------------|----------------------|-----------------------------------|------------------------------|
| 1                 | Routine Maintenance  |                                   | 0                            |
| 2                 | Minimum Restoration  |                                   | 0                            |
| 3                 | Minimum Restoration  |                                   | 4                            |
| 4                 | Minimum Restoration  | Saw and Seal Joints in AC Overlay | 4                            |
| 5                 | Maximum Restoration  |                                   | 0                            |
| 6                 | Maximum Restoration  |                                   | 4                            |
| 7                 | Crack/Break and Seat |                                   | 4                            |
| 8                 | Crack/Break and Seat |                                   | 8                            |

seated PCC layer. The "AFTER" testing is directed at verifying material properties and the as-built pavement section for use in evaluating the effectiveness and long term performance of the rehabilitations. "LONG TERM" testing is performed to evaluate the effects of temperature, moisture changes, and traffic loading on pavement deflection and performance.

Deflection Basin tests and Load Transfer tests are used in the SPS-6 testing. The specific FWD test plan to be implemented for SPS-6 is similar to the JCP and FLEX (modified) Testing Plan for GPS. Table B-6.2 contains the FWD Operational Categories corresponding to SPS-6 "BEFORE", "DURING", "AFTER", and "LONG TERM" testing periods. The factors inherent within each test plan are:

1. Test Point ID (J0, J1, J2, J3, J4, and J5; F1, F3, F4, and F5)
2. Lane for Each FWD Pass (Transverse Location)
3. Test Interval (Longitudinal Location)
4. Test Type (Basin or Load Transfer)
5. Deflection Sensor Spacing
6. Drop Sequence (Load Levels/Number of Drops)

**TABLE B-6.2 - SPS-6 FWD TESTING PERIODS AND APPROPRIATE FWD OPERATIONAL CATEGORY**

| SPS-6<br>SECTION<br>No. | "BEFORE" | "DURING" | "AFTER"                |
|-------------------------|----------|----------|------------------------|
| 1                       | JCP      | NONE     | JCP                    |
| 2                       | JCP      | NONE     | JCP                    |
| 3                       | JCP      | NONE     | FLEX                   |
| 4                       | JCP      | NONE     | JCP/FLEX<br>(SEE TEXT) |
| 5                       | JCP      | NONE     | JCP                    |
| 6                       | JCP      | NONE     | FLEX                   |
| 7                       | JCP      | FLEX     | FLEX                   |
| 8                       | JCP      | FLEX     | FLEX                   |

Note: See additional text on modifications to FLEX Testing Plan.

All FWD testing is done in the driving lane at several lateral offsets. For a given lateral offset, a single pass through the test section is made to collect a particular type of deflection data. When finished with a particular pass, the FWD returns to the beginning of the section to start another pass. All testing uses station 0+00 of the test section (not the SPS site) as the distance reference so FWD test point locations can be located for future testing.

The testing of joint load transfer efficiency for the saw and seal treatment, Test Section Number 4, requires additional lane specification codes to properly identify the location of the testing. The sawed joints will be tested in the OWP both on the approach and the leave side of the joint. The lane specification for the approach side shall be "F4," and for the leave side "F5" which correspond to the "J4" and "J5" specifications in "JCP." The following table briefly summarizes the lane specification codes for the "FLEX" category, as modified for SPS-6 rehabilitation treatments.

## "FLEX" Category Pavements

|    |   |
|----|---|
| F0 | basin tests at both TP sites                |
| F1 | all tests in the ML ( $P_1$ )               |
| F3 | all basin tests in the OWP ( $P_3$ )        |
| F4 | approach slab LT tests in the OWP ( $P_5$ ) |
| F5 | leave slab LT tests in the OWP ( $P_5$ )    |

The fixed sensor configuration for all testing (-305 mm, 0 mm, 203 mm 305 mm, 457 mm, 610 mm, 914 mm, 1219 mm, 1524 mm) is used for lane specifications F4 and F5 in pass  $P_5$ .

### *Naming Scheme/Data Storage*

A unique 6 digit code identifies the individual test sections at an SPS-6 site (similar to that for the GPS sections), with the fourth character being "6" for SPS-6.

The computer filenames are identical to those used in the GPS testing, with the 6 character test section code followed by two characters indicating the times a section has been tested and the number of the pass within the section. The "times tested" (character #7) is a single letter which corresponds to the number of times the section has been tested. Characters A and B are reserved for "BEFORE" and "DURING" construction testing; all SPS testing uses letter C as the first "AFTER" construction testing; and, the letter D as the first "LONG TERM" testing. The "pass" (character #8) is 0 for TP testing, 1 for ML testing, 2 for PE pass corner and mid-panel edge testing, and 3 or 5 for OWP load transfer testing, as used for GPS testing. For example, files from "BEFORE" FWD testing of section 1 at an SPS-6 site in Iowa would be: 190601A0, 190601A1, 190601A2 and 190601A3. Files representing data collected "DURING" construction (for sections 7 and 8 only) would contain a "B" in the seventh character position 190607B1 and 190607B3. The "AFTER" testing will result in filenames with a "C" in the seventh position while "LONG TERM" testing will have a "D".

### *Test Pit Areas*

As in the GPS testing, LTPP's plans to "link" the material sampling/testing program and FWD test results on all SPS-6 sites. At each SPS-6 experiment site, test pits (TP) are located approximately 15.2 m (50') to 18.3 m (60') from a particular test section. Due to the length of the SPS-6 sites, test pits are not located adjacent to every test section. As a rule, a minimum of three test pits are used at every SPS-6 site. Each potential test pit location has FWD measurements taken in the OWP pass. Subject to traffic control restrictions, this pass ( $P_0$ ) is completed for the entire SPS-6 test site prior to testing of pass  $P_1$  on any section. There may be occasions where time delays of days or weeks occur between FWD testing and sampling, and FWD operators must mark the location of the FWD tests in the TP areas. Also, pass  $P_0$  testing is only performed for the "BEFORE" time period.

### *Test Point Identification*

FWD operators must properly record all longitudinal distances with the distance measuring

instrument relative to 0+00 station reference for each section, and follow the guidelines for lateral offset for the PE, OWP and ML passes, so all FWD testing can be repeated in the same general location.

### *Detailed Test Plan (Test Pit Areas)*

TP areas are tested identical to the procedures outlined for GPS testing in the main part of this manual.

### *Detailed Test Plan (Test Sections)*

For SPS-6 test sections, FWD testing performed varies between "BEFORE," "DURING," and "AFTER", depending on the rehabilitation for the section.

"BEFORE" Rehabilitation Testing: For all SPS-6 sections, the testing "BEFORE" rehabilitation is similar to that outlined for JCP pavement sections (see Table B-6.2), except the number of tests is reduced. Figure B-6.1 illustrates the "BEFORE" testing pattern for all sections and the "AFTER" testing pattern for Sections 1, 2 and 5. For all sections except Section 2 and 5, 10 effective slabs are tested (the concept of "effective slab" is defined previously in this manual). For Sections 2 and 5, which are 304.8 meters (1000 ft) long, 20 effective slabs are tested. The "BEFORE" test plan includes three passes along each section; (P<sub>1</sub>) Mid-lane, (P<sub>2</sub>) Pavement edge and (P<sub>3</sub>) Outer wheel path. A preliminary pass (P<sub>0</sub>) will also be made to evaluate the test pit locations where applicable.

FWD operators must consider "end conditions" (joints, cracks, and patches) of the effective slabs when selecting slabs to test. The proportion of end conditions will determine the slabs tested. For example, if 24 total effective slabs are present with the following distribution:

- 6 terminated by a joint at one end and a joint at the other
- 6 terminated by a joint at one end and a patch at the other
- 6 terminated by a joint at one end and a crack at the other
- 6 terminated by a patch at one end and a crack at the other

two or three of each type of effective slab should be tested while attempting to get both types of end conditions in each category above (e.g. 1 or 2 with a joint at the approach end and a patch at the leave end, and 1 or 2 with a patch at the approach end and a joint at the leave end).

Five FWD tests are performed in each effective slab tested. These include a Deflection Basin test in the center of the slab (J1) on P<sub>1</sub>, a Deflection Basin test along the approach corner (J2) and edge of the slab (J3) on P<sub>2</sub>, and two load transfer tests at the joints (J4 and J5) on P<sub>3</sub>. Figure B-6.1 indicates the positions of the test locations for a given effective slab. Each test section should have 10 effective slabs (20 in Sections 2 and 5) for a total of 450 FWD points (not including TP locations). At a rate of 20 points per hour, the entire process (all eight test sections) will take approximately 23 hours. This does not include the time for testing TP locations or taking temperature gradient measurements. The total time for all tasks should be approximately 30 hours.

"DURING" Rehabilitation Testing: For test sections 7 and 8 (crack and seal sections), testing is performed "DURING" the construction process, on the cracked PCC surface. The FWD test pattern used "DURING" rehabilitation is the same as that for FLEX Testing Plan for GPS except the stations for the points should correspond to the J1 tests from the ML tests ( $P_1$ ) performed "BEFORE" rehabilitation. The testing pattern for these sections is illustrated in Figure B-6.2. No tests are conducted at the PE and no Load Transfer tests are performed.

"AFTER" Rehabilitation Testing: For test sections 1, 2 and 5, the test plan for the "AFTER" rehabilitation testing is the same as that for "BEFORE" rehabilitation testing, and the same effective slabs are tested.

The remaining sections all have an AC overlay and the test plan is different. Only Deflection Basin tests are performed for test sections 3, 6, 7 and 8. These are performed in both the pass  $P_1$  and pass  $P_3$  for each effective slab tested "BEFORE" rehabilitation. The stations for F1 and F3 must correspond to the stations for J1 tests performed "BEFORE" rehabilitation. The testing pattern for these sections is illustrated in Figure B-6.2. No tests are conducted at the PE and no Load Transfer tests are performed.

Test section 4 has the same Deflection Basin test plan as sections 3, 6, 7 and 8. In addition, Load Transfer tests are performed at the sawed and sealed joint locations corresponding to the J4 and J5 locations in the "BEFORE" testing. The sawed joints must correspond with the slab joints, transverse cracks and patches which were used to define the original effective slabs. Figure B-6.3 illustrates the testing pattern for this particular test section.

FWD operators must use their best judgement in the slab selection process and carefully note any abnormal conditions or unique situations encountered in the field. However, only 10 effective slabs should be tested within a given section, except for sections 2 and 5 where 20 slabs are tested.

## **Other FWD Operator Field Measurements**

### *Temperature Gradient Measurements*

Temperature gradient measurements for SPS-6 sites are obtained similar to that for GPS sections, with three exceptions as noted below.

For the "BEFORE" testing, temperature gradient measurements are required at 3 depths. Temperature gradient measurements are not required for the "DURING" construction testing. For temperature gradients measured "AFTER" and "LONG TERM", either 3 or 5 depths are used depending on whether or not an AC overlay is present. For sections with an AC overlay on an unbroken PCC layer (sections 3, 4, and 6), five depths per section are required. For sections 1, 2, and 5, three depths per section are used. Test sections 7 and 8, the cracked and sealed PCC with AC overlay, have three depths all in the AC overlay ONLY. Figures B-6.4 and B-6.5 illustrate the drilling patterns used for obtaining the temperature gradient data.

Measurements are obtained at only one location for each section. It is up to the FWD operator to



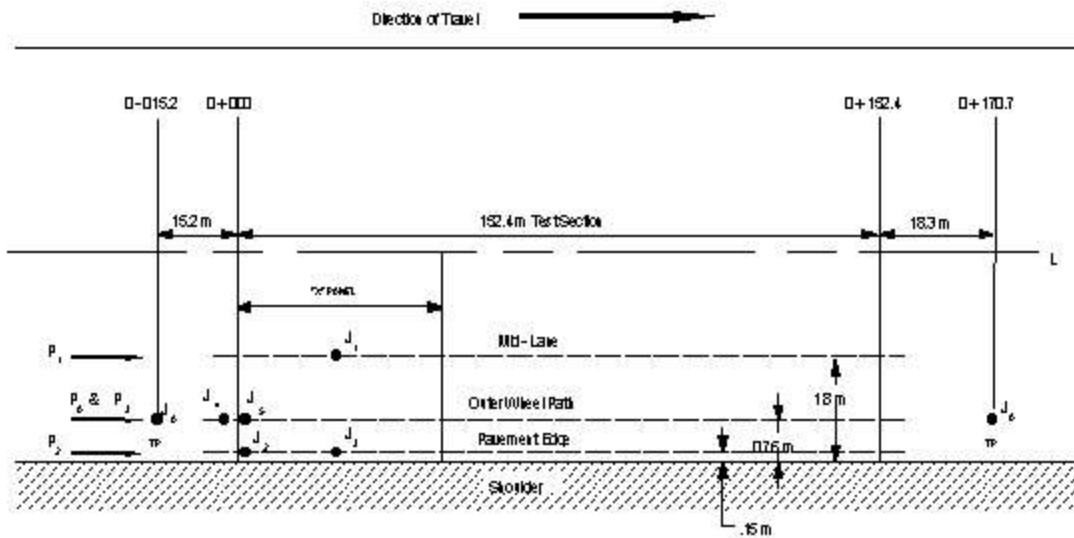
assess variations in sun and wind exposure to select the most representative location adjacent to the section limits for temperature measurements.

Temperature readings are obtained at 30 minute intervals with the first reading prior to starting FWD testing on a section and the last readings after completion of the FWD testing on the section.

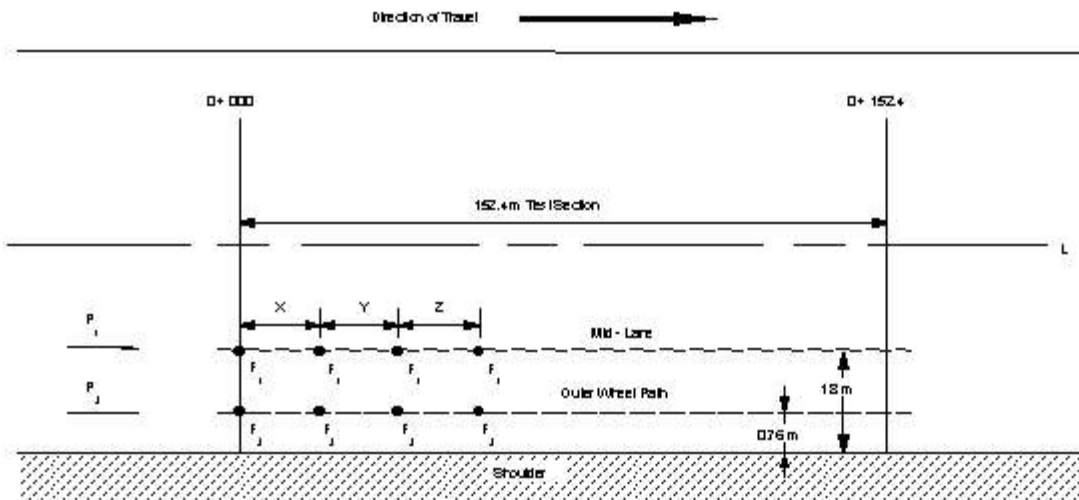
### *Joint/Crack Widths*

Joint and crack opening measurements for SPS-6 sites are obtained the same as for GPS sections, with one exception as noted below:

For Test Section 4, "AFTER" (after saw and seal), the width of the sealed sawcuts are measured and recorded for 25% of the sawcuts tested for load transfer efficiency.



**Figure B-6.1 FWD Test Plan for All Testing “Before” Rehabilitation and for Sections 1, 2 and 5 “After” Rehabilitation**



**Figure B-6.2 FWD Test Plan for Sections 7 and 8 “During” Rehabilitation and Sections 3, 6, 7 and 8 “After” Rehabilitation (F1, F3)**

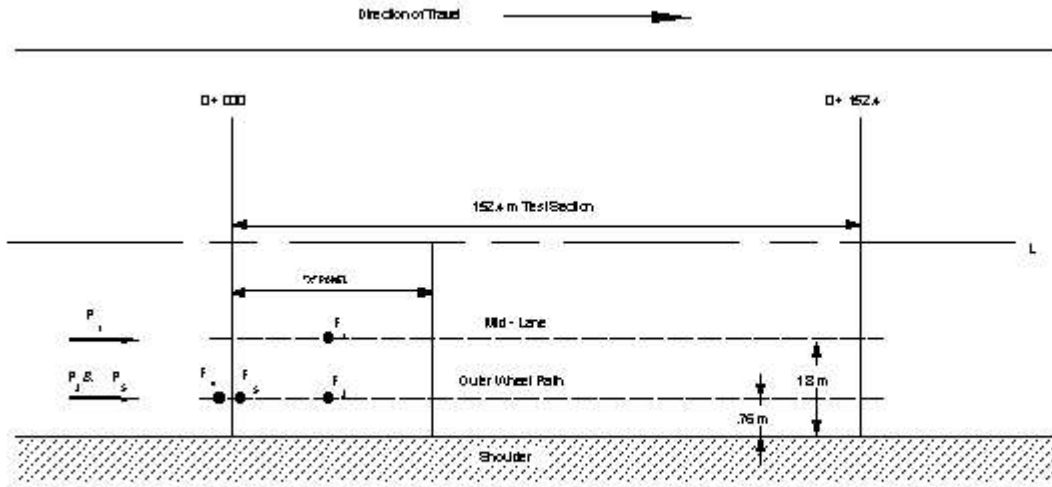
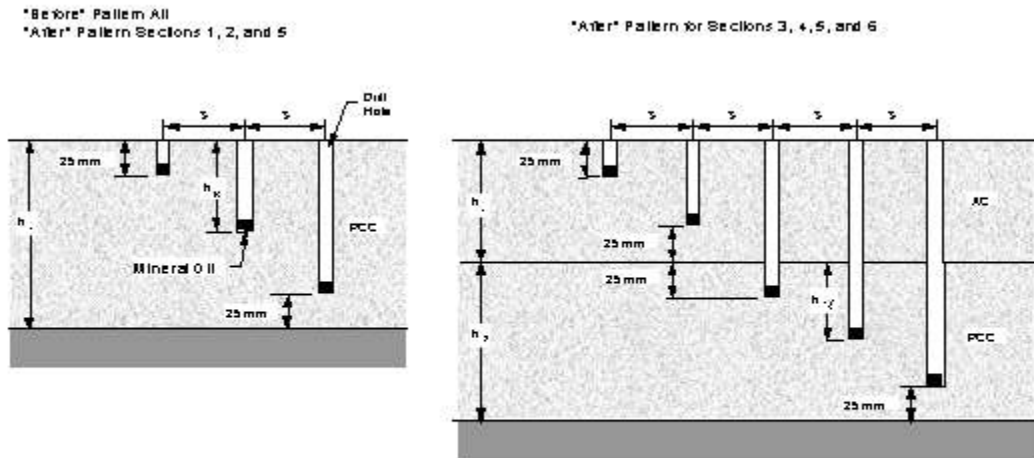
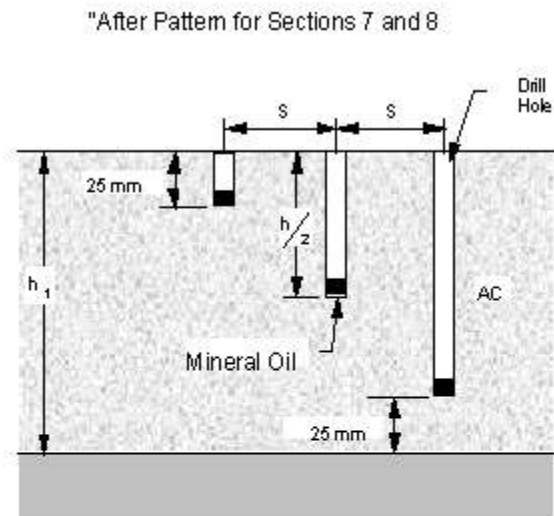


Figure B-6.3 FWD Test Plan for Section 4 “After” Rehabilitation



- NOTES:
1. Drill hole spacing(s) should be +50 mm O.C. or greater.
  2. See Figure B-6.5 for Sections 7 and 8.

Figure B-6.4 Typical Drilling Pattern for Temperature Gradient Data  
“Before” and “After”



NOTES:

1. Drill hole spacing(s) should be 450 mm CC or greater.
2. No Temperature Measurements in Broken PCC (Sections 7 and 8).

**Figure B-6.5 Typical Drilling Patterns for Temperature Gradient Data - Sections 7 and 8 "After"**

**APPENDIX B-7**

**FWD TESTING GUIDELINES  
FOR SPECIFIC PAVEMENT STUDIES (SPS) EXPERIMENT 7  
BONDED PORTLAND CEMENT CONCRETE OVERLAYS**

## Introduction

This appendix provides guidelines and information for Falling Weight Deflectometer (FWD) testing at individual test sites for Long Term Pavement Performance (LTPP) study experiment SPS-7, "Bonded Portland Cement Concrete Overlays." The intent of this document is to establish the specific testing requirements for these sites based on a uniform set of assumptions. It is recognized that not all sites will conform to all assumptions contained herein. However, the objectives and approach to deflection data collection must be consistent so data obtained can be analyzed in a consistent manner. For deflection testing details not specifically addressed in this appendix, refer to the general guidelines in this manual.

The objectives of the SPS-7 experiment are to measure the additional pavement life from bonded concrete overlays, to evaluate the effectiveness of surface preparation techniques prior to overlay, and to investigate the environmental influence on the performance of bonded concrete overlays. The experiment includes overlays on jointed plain (JPCP), jointed reinforced (JRCP) and continuously reinforced (CRCP) concrete pavements. The factors addressed in this experiment include surface preparation, use of bonding grout, and overlay thickness. Analysis of data from this experiment will provide improved tools for evaluating the effectiveness of bonded concrete overlays as a rehabilitation technique for existing concrete pavements.

In contrast to the LTPP General Pavement Studies (GPS), SPS has controlled construction of multiple test sections at a single site. On a SPS-7 site, there are 8 test sections and one control section. Four of the test sections have a 76.2 mm (3 in) thick concrete overlay and four have a 127 mm (5 in) overlay. Combinations of surface preparation, milling or shot blasting, and grout or no-grout cover the construction factors investigated in this experiment. Complete data records starting from construction, and multiple test sections constructed on similar subgrade and subjected to similar traffic and environmental conditions will allow for comparison of the experimental factors. Substantial deflection testing is required to evaluate the relative performance of the different sections.

Experiment sites should conform to criteria contained in "Specific Pavement Studies Guidelines for Nomination and Evaluation of Candidate Projects for Experiment SPS-7, Bonded Portland Cement Concrete Overlays", June 1990. The site characteristic affecting the FWD testing is the number of sections.

Table B-7.1 details the LTPP test sections in an SPS-7 experiment site. Criteria for selection limit the sites to a single structural cross section, constructed of the same materials throughout, under the same contract. Location of test sections should avoid cut/fill transitions, bridges, culverts, and side hill fills to limit the potential for variability of subgrade soils. A minimum of three Test Pits are used at a site.

Table B-7.1 - SPS-7 Test Section Numbering Scheme

| Section Number | Surface Preparation       | Cement Grout | Overlay Thickness (inches) |
|----------------|---------------------------|--------------|----------------------------|
| 01             | Control Section           | -            | -                          |
| 02             | Milling and Sand Blasting | Yes          | 3                          |
| 03             | Milling and Sand Blasting | No           | 3                          |
| 04             | Shot Blasting             | No           | 3                          |
| 05             | Shot Blasting             | Yes          | 3                          |
| 06             | Shot Blasting             | Yes          | 5                          |
| 07             | Shot Blasting             | No           | 5                          |
| 08             | Milling and Sand Blasting | No           | 5                          |
| 09             | Milling and Sand Blasting | Yes          | 5                          |

## FWD Test Plan

### *General*

FWD testing for SPS-7 is performed in multiple phases, 0 to 3 months prior to rehabilitation (labelled as "BEFORE"), 3 to 6 months after overlay construction (labelled as "AFTER"), and bi-annually more than 6 months after the completion of rehabilitation (labelled as "LONG TERM"). The "BEFORE" testing is used to characterize the existing pavement structure, and provide a baseline for comparison of the various construction factors. The "AFTER" testing is directed at verifying material properties and the as-built pavement section for use in evaluating the effectiveness and long term performance of the rehabilitations. "LONG TERM" testing is performed to evaluate the effects of the temperature, moisture changes and traffic loading on pavement deflections and performance.

Deflection Basin tests and Load Transfer tests are used in the SPS-7 testing. The specific FWD test plan to be implemented is similar to the JCP or CRCP Testing Plan for GPS. The factors inherent within the test plan are:

1. Test Point ID (J0, J1, J2, J3, J4, and J5 or C0, C1, C2, C3, C4, and C5)
2. Lane for Each FWD Pass (Transverse Location)
3. Test Interval (Longitudinal Spacing)
4. Test Type (Basin or Load Transfer)
5. Deflection Sensor Spacing
6. Drop Sequence (Load Levels/Number of Drops)

All FWD testing is in the driving lane at three lateral offsets. The three lateral offsets are the ML, PE, and OWP as defined in the GPS portion of this manual. For a given lateral offset, a single pass through the test section is made to collect a particular type of deflection data. When finished with a particular pass, the FWD returns to the beginning of the section to start another pass. All testing uses station 0+00 of the test section (not the SPS site) as the distance reference so FWD test point locations can be located for future testing.

### *Naming Scheme/Data Storage*

A unique 6 digit code identifies the individual test sections at an SPS-7 site (similar to that for the GPS sections), with the fourth character being "7" for SPS-7.

The computer filenames are identical to those used in the GPS testing, with the 6 character test section code followed by two characters indicating the times a section has been tested and the number of the pass within the section. The "times tested" (character #7) is a single letter which corresponds to the number of times the section has been tested. Characters A and B are reserved for "BEFORE" and "DURING" construction testing; all SPS testing use letter C as the first "AFTER" construction testing; and, letter D as the first "LONG TERM" testing. The "pass" (character #8) is 0 for TP testing (C0 or J0), 1 for ML testing (J1 or C1), 2 for PE testing (J2 and J3 or C2 and C3), or 3 for OWP testing (J4 and J5 or C4 and C5) as used in GPS testing. For example, files from "BEFORE" FWD testing of section 1 at an SPS-7 site in Minnesota would be: 270701A0, 270701A1, 270701A2 and 270701A3. The "AFTER" testing would have filenames with a "C" in the seventh position ("270701C3") while "LONG TERM" testing would have a "D" and higher ("270701D3").

### *Test Pit Areas*

As in the GPS testing, efforts are made to "link" the material sampling/testing program and FWD test results on all SPS-7 sites. At each experiment site, test pits (TP) are located approximately 15.2 m (50') to 18.3 m (60') from a particular test section. This distance varies due to site conditions. Due to the length of the project sites, test pits are not located adjacent to every test section. As a rule, a minimum of three test pits are located at every site. Each potential test pit location has FWD measurements taken along the OWP pass (P<sub>0</sub>). This pass is completed for the entire test site prior to testing of pass P<sub>1</sub> on any section. There may be occasions where time delays of days or weeks



occur between the testing programs and FWD operators must mark the location of the FWD tests in the TP (Test Pit) areas. Also, pass  $P_0$  testing is only performed for the "BEFORE" time period.

### *Test Point Identification*

FWD operators must properly record all longitudinal distances with the distance measuring instrument relative to 0+000.0 (0+00) station reference for each section, and follow the guidelines for lateral offset for the PE, OWP and ML passes, so all FWD testing can be repeated in the same general location.

### *Detailed Test Plan (Test Pit Areas)*

TP areas are tested identical to the procedures outlined for GPS testing in the main part of this manual.

### *Detailed Test Plan (Test Sections)*

For SPS-7 test sections, the type of FWD testing does not vary between "BEFORE" and "AFTER" rehabilitation testing.

#### "BEFORE" Rehabilitation Testing

Jointed Pavements - For all SPS-7 sections, the testing "BEFORE" rehabilitation is similar to that outlined in the JCP Testing Plan for GPS, except the number of tests is reduced. The concept of "effective slab" is as defined previously. Figure B-7.1 illustrates the testing pattern for all "BEFORE" and "AFTER" testing. For all test sections, 10 effective slabs are tested. The "BEFORE" and "AFTER" test plan includes three passes along each section; ( $P_1$ ) Mid-lane, ( $P_2$ ) Pavement edge and ( $P_3$ ) Outer wheel path. A preliminary pass ( $P_0$ ) is also made in "BEFORE" testing to evaluate the test pit locations when appropriate.

FWD operators must consider the "end conditions" (joints, cracks, and patches) of the effective slabs when selecting slabs to test. The proportion of end conditions will determine the slabs tested. For example, if 24 total effective slabs are present with the following distribution:

- 6 terminated by a joint at one end and a joint at the other
- 6 terminated by a joint at one end and a patch at the other
- 6 terminated by a joint at one end and a crack at the other
- 6 terminated by a patch at one end and a crack at the other

two or three of each type of effective slab should be tested while attempting to get both types of end conditions in each category above (e.g. 1 or 2 with a joint at the approach end and a patch at the leave end, and 1 or 2 with a patch at the approach end and a joint at the leave end).

Five FWD tests are performed in each effective slab tested. These include a Deflection Basin test in the center of the slab (J1) on  $P_1$ , a Deflection Basin test along the approach corner (J2) and edge of the slab (J3) on  $P_2$  and the two Load Transfer tests (J4 and J5) on  $P_3$ . Figure B-7.1 indicates the positions of the test locations for a given effective slab. Each test section has 10 effective slabs for

a total of 450 FWD points (not including Test Pit locations). At a rate of 20 points per hour, the entire process (all eight test sections) will take approximately 23 hours. This does not include the time for testing Test Pit locations or taking temperature gradient measurements. The total time for all tasks should be approximately 30 hours.

**CRCP Pavements** - The pattern for testing SPS-7 CRCP is similar to the CRC Testing Plan outlined in the GPS portion of this manual, except the number of tests is reduced. Figure B-7.2 illustrates the testing pattern for all "BEFORE" and "AFTER" testing. Panels (slabs between transverse cracks) should be tested at approximate 15.2 m (50') intervals so 10 panels are obtained. The test pattern is the same regardless of the crack spacing (typically 0.3m-2.4m or 1'-8').

**"AFTER" Rehabilitation Testing:** For all test sections originally having JCP, the test plan for "AFTER" rehabilitation testing is the same as "BEFORE" rehabilitation testing and the same effective slabs are tested. This includes both Deflection Basin and Load Transfer tests in the same manner and locations as were done previously.

For CRCP's, transverse cracks which defined the panels tested in "BEFORE" testing may not ever reflect through the overlay. Edge tests (C3) and deflection basin tests (C1) are performed at the same stations as "BEFORE". Load transfer (C4 and C5) and "corner" tests (C2) are performed at the first transverse crack behind the deflection basin test.

**"LONG TERM" Rehabilitation Testing:** For all SPS-7 sections, the plan for the "LONG TERM" rehabilitation testing follows the same logic as that for the "AFTER" rehabilitation testing. The same effective slabs are tested as were tested previously. (Note: the location of CRCP test points, especially C2, C4, and C5, may change as additional cracks reflect through the overlay.)

FWD operators must use their best judgement in the slab selection process and carefully note any abnormal conditions or unique situations encountered in the field. However, only 10 effective slabs should be tested on a given section.

## **Other FWD Operator Field Measurements**

### *Temperature Gradient Measurements*

Temperature gradient measurements for SPS-7 sites are obtained similar to that for GPS sections, with three exceptions as follows.

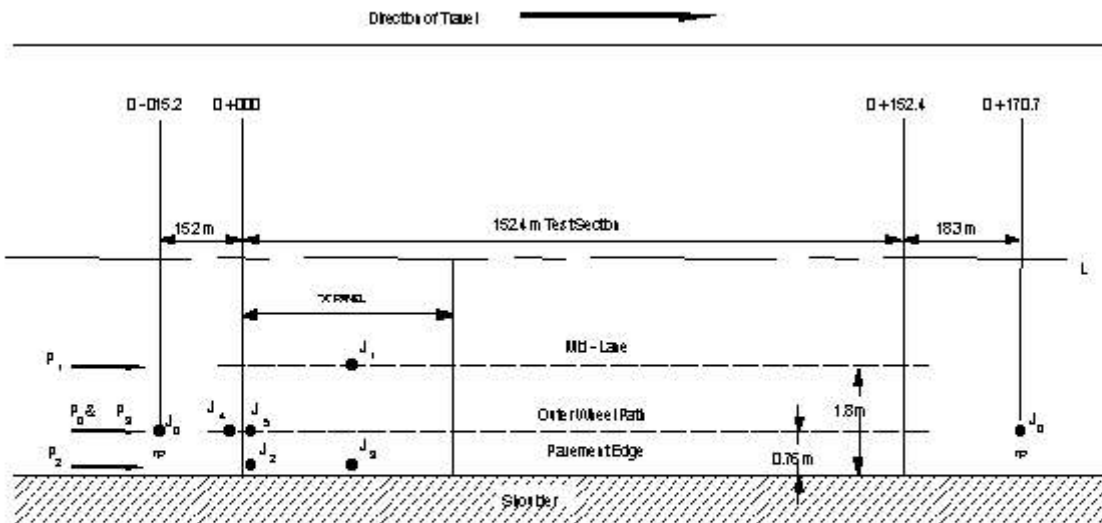
For all testing ("BEFORE", "AFTER", and "LONG TERM"), temperature gradients measured at 3 depths are required, as illustrated in Figure B-7.3.

Measurements will be obtained at only one location for each section. It is up to the FWD operator to assess variations in sun and wind exposures to and select the most representative location adjacent to the section limits for temperature measurements.

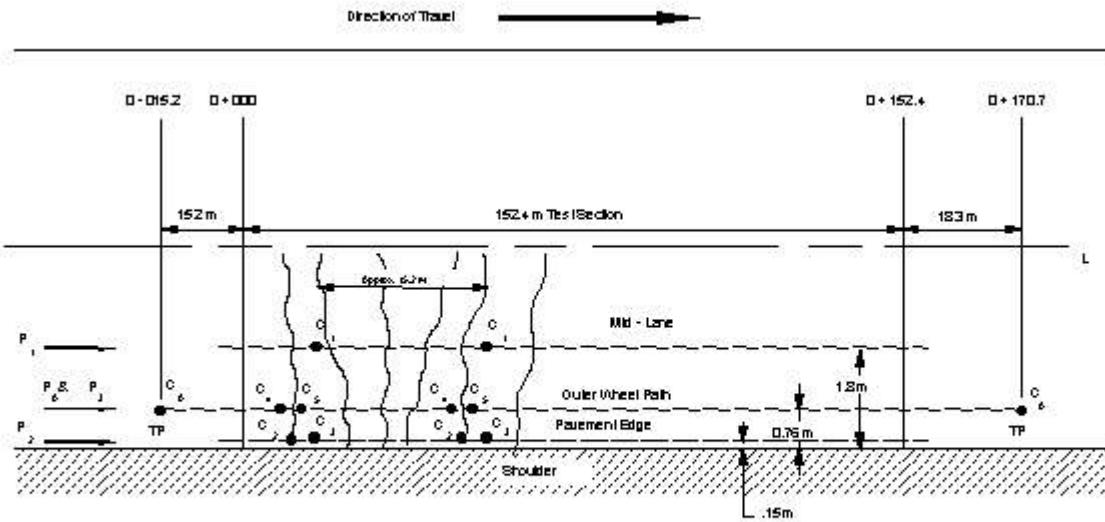
Temperature readings are obtained at 30 minute intervals, with the first readings prior to starting FWD testing on a section and the last readings after completion of the FWD testing on the section.

## Joint/Crack Widths

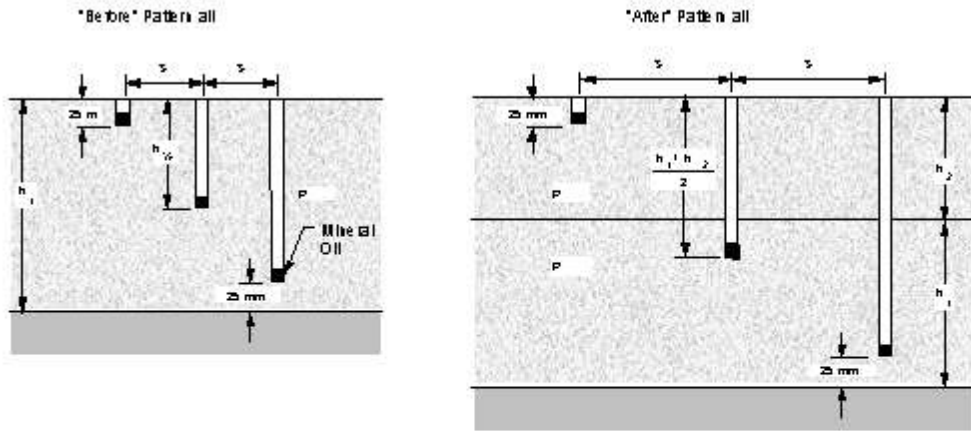
Joint and crack width measurements for SPS-7 sites are obtained the same as for GPS sections under the JCP and CRCP Testing Plans.



**Figure B-7.1 FWD Test Plan for All Testing “Before” and “After Rehabilitation on JCP Pavements**



**Figure B-7.2 FWD Test Plan for All Testing “Before” and “After” Rehabilitation on CRCP Pavements**



- NOTES:  
 1. Drill Hole Spacing( $S$ ) should be  $\geq 50$  mm O.C. or greater.

Figure B-7.3 Temperature Gradients Measured at 3 Depths

**APPENDIX B-8**

**FWD TESTING GUIDELINES  
FOR SPECIFIC PAVEMENT STUDIES (SPS) EXPERIMENT 8  
STUDY OF ENVIRONMENTAL EFFECTS  
IN THE ABSENCE OF HEAVY LOADS**

## Introduction

This appendix provides information for Falling Weight Deflectometer (FWD) testing at individual test sites for the Long Term Pavement Performance (LTPP) study experiment SPS-8, "Study of Environmental Effects in the Absence of Heavy Loads." The intent of this document is to establish the testing requirements for SPS-8 sites based on a uniform set of assumptions. It is recognized that not all sites will conform to all assumptions contained herein. However, the objectives and approach to deflection data collection must be consistent so data obtained can be analyzed in a consistent manner. For deflection testing details not specifically addressed in this appendix, refer to the general guidelines in this manual.

The objective of the SPS-8 experiment is to measure the deterioration in pavement performance in the absence of heavy traffic loads. The proposed experiment encompasses both flexible and rigid pavement structures built on conventional, non-drained base materials over coarse subgrade, inactive fine grained and active fine grained soils. The factors addressed are pavement type, layer thickness, and subgrade soil type across a factorial of temperature and moisture conditions. The analysis of data from this experiment will provide improved design of rigid and flexible pavements for environmental effects.

Experiment sites should conform to criteria contained in "Specific Pavement Studies Guidelines for Nomination and Evaluation of Candidate Projects for Experiment SPS-8, Study of Environmental Effects in the Absence of Heavy Loads", August 1991. Project sites may be included as part of new construction or reconstruction of flexible pavements or may be constructed as part of SPS-1 or SPS-2 projects.

## FWD Test Plan

FWD testing for SPS-8 is performed in two phases, "AFTER" and "LONG TERM". The "AFTER" testing (3 to 6 months after construction) verifies material properties of the as-built pavement section for evaluating the effectiveness and long term performance of the section. "LONG TERM" testing (bi-annually more than 6 months after construction) is used to evaluate the effect of temperature and moisture changes and traffic loading on pavement deflections and performance.

The pavement types in SPS-8 are flexible (asphalt concrete on a granular base) and rigid (jointed plain concrete on a granular base). These pavements are built on the same or separate projects. Deflection testing is done according to the FWD test plans developed for the SPS-1 and SPS-2 experiments. Table B-8.1 indicates the SPS FWD Plan applicable to testing of each SPS-8 pavement type.

For SPS-8 test sections, the type of FWD testing performed depends on the pavement type and appropriate test plan in Table B-8.1. Table B-8.2 summarizes the number of test points and approximate time requirements for each pavement type, including the time for the temperature gradient measurements (30 minutes per location).

Table B-8.1 - FWD Test Plan by Pavement Type

| Pavement Type          | SPS FWD Plan |           |
|------------------------|--------------|-----------|
|                        | AFTER        | LONG TERM |
| Flexible               | SPS-1        | SPS-1     |
| Jointed Plain Concrete | SPS-2        | SPS-2     |

Table B-8.2 - Number of Test Locations and Time Estimates

| Pavement Type          | AFTER |                  |                   | LONG TERM |                  |                   |
|------------------------|-------|------------------|-------------------|-----------|------------------|-------------------|
|                        | PLAN  | Number of Points | Time Estimate     | PLAN      | Number of Points | Time Estimate     |
| Flexible               | SPS-1 | 22 per section   | 3 hrs per section | SPS-1     | 22 per section   | 3 hrs per section |
| Jointed Plain Concrete | SPS-2 | 50 per section   | 5 hrs per section | SPS-2     | 50 per section   | 5 hrs per section |

FWD operators must use their best judgement and carefully note any abnormal conditions or unique situations encountered in the field. However, no more than 22 points on a given flexible section or 50 points on a rigid section are tested.



**APPENDIX B-9**

**FWD TESTING GUIDELINES  
FOR SPECIFIC PAVEMENT STUDIES (SPS) EXPERIMENT 9  
VALIDATION OF SHRP ASPHALT SPECIFICATIONS  
AND MIX DESIGN  
AND INNOVATIONS IN ASPHALT PAVEMENTS**

## Introduction

This appendix provides information for Falling Weight Deflectometer (FWD) testing at individual test sites for the Long Term Pavement Performance (LTPP) study experiment SPS-9, "Validation of SHRP Asphalt Specifications and Mix Design and Innovations in Asphalt Pavements." The intent of this document is to establish the testing requirements for SPS-9 sites based on a uniform set of assumptions. It is recognized that not all sites will conform to all assumptions contained herein. However, the objectives and approach to deflection data collection must be consistent so data obtained can be analyzed in a consistent manner. For deflection testing details not specifically addressed in this appendix, refer to the general guidelines in this manual.

The objective of the SPS-9 experiment is to compare the performance of asphalt pavements using specifications and mix design procedure developed by the SHRP Asphalt Research group to current participating agency specifications and procedures. The primary factors addressed are mix design method and asphalt concrete materials. Also, the study includes a detailed climatic factorial experiment. Accomplishing these objectives will provide improved tools for the design and construction of new and reconstructed flexible pavements and rehabilitation of rigid and flexible pavements using asphalt concrete overlays. FWD and laboratory testing will be used to characterize the materials and the variation within and between test sections to provide a basis for comparing the performance of the different sections at a site.

Experiment sites should conform to criteria contained in "Specific Pavement Studies Guidelines for Nomination and Evaluation of Candidate Projects for Experiment SPS-9, Validation of SHRP Asphalt Specification and Mix Design and Innovations in Asphalt Pavements", February 1992. Project sites are included as part of new construction on AC and/or PCC or reconstruction of flexible pavements or may be constructed as part of the rehabilitation of existing flexible, jointed concrete (JCP), or continuously reinforced (CRCP) pavements.

## FWD Test Plan

FWD testing for SPS-9 is performed in multiple phases. For project sites on existing pavements, testing is conducted 0 to 3 months prior to overlay construction (labelled as "BEFORE"), 3 to 6 months after construction (labelled as "AFTER"), and every 5 years more than 6 months after construction (labelled as "LONG TERM"). Projects constructed as part of new or reconstruction of flexible pavements only "AFTER" and "LONG TERM" testing will be performed. The "BEFORE" testing assesses the condition of the existing pavement structure. The "AFTER" testing verifies material properties of the as-built pavement section for evaluating the effectiveness and long term performance of the section. "LONG TERM" testing is performed to evaluate the effect of temperature and moisture changes and traffic loading on pavement deflections and performance.

The pavement types included in an SPS-9 project are summarized in Table B-9.1, along with the required FWD testing. Table B-9.2 presents the SPS FWD Plan to use for each pavement type. Table B-9.3 summarizes the number of test points and time requirements for each pavement type, including the time for the temperature gradient measurements (30 minutes per location).

Each SPS plan referenced in Table B-9.2 has test locations, layouts and other information presented in terms of the time of testing relative to construction of the overlay, i.e. "BEFORE", "AFTER", and "LONG TERM" testing. On rehabilitation projects, Test Pits may be excavated, based on the policy of the participating agency. Therefore, pass  $P_0$  testing included in the SPS-5 and SPS-6 FWD plans, will depend entirely on the agency's policy for Test Pit excavation.

Table B-9.1 - Required FWD Testing by Pavement Type

| Existing Pavement Type        | FWD Testing Required |       |           |
|-------------------------------|----------------------|-------|-----------|
|                               | BEFORE               | AFTER | LONG TERM |
| New or Reconstructed Flexible | No                   | Yes   | Yes       |
| Flexible                      | Yes                  | Yes   | Yes       |
| AC Overlay of Flexible        | Yes                  | Yes   | Yes       |
| AC Overlay of Rigid           | Yes                  | Yes   | Yes       |
| Jointed Concrete              | Yes                  | Yes   | Yes       |
| Continuously Reinforced       | Yes                  | Yes   | Yes       |

Table B-9.2 - FWD Test Plan by Pavement Type

| Existing Pavement Type                    | SPS FWD Test Plan |           |           |
|---|-------------------|-----------|-----------|
|   | BEFORE            | AFTER     | LONG TERM |
| New Construction or Reconstruction        | N/A               | SPS-1     | SPS-1     |
| Rehabilitation of Flexible                | SPS-5             | SPS-5     | SPS-5     |
| Rehabilitation of Jointed Concrete        | SPS-6             | SPS-6 (1) | SPS-6 (1) |
| Rehabilitation of Continuously Reinforced | SPS-7             | SPS-6 (2) | SPS-6 (2) |

- (1) FWD test plan is identical to SPS-6 test plan for sections 3 and 6.
- (2) FWD test plan is similar to SPS-6 test plan for sections 3 and 6, except testing is done at previously tested C1 locations.

Table B-9.3 - Number of Test Locations and Time Estimates

| Pavement Type              | BEFORE |                  |                | AFTER     |                  |                | LONG TERM |                  |                |
|----------------------------|--------|------------------|----------------|-----------|------------------|----------------|-----------|------------------|----------------|
|                            | PLAN   | Number of Points | Time Est.      | PLAN      | Number of Points | Time Est.      | PLAN      | Number of Points | Time Est.      |
| New or Reconstruction      | SPS-1  | N/A              | N/A            | SPS-1     | 22 per section   | 3 hrs per site | SPS-1     | 22 per section   | 3 hrs per site |
| Flexible                   | SPS-5  | 22 per section   | 3 hrs per site | SPS-5     | 22 per section   | 3 hrs per site | SPS-5     | 22 per section   | 3 hrs per site |
| Rehabilitation of Flexible | SPS-5  | 22 per section   | 3 hrs per site | SPS-5     | 22 per section   | 3 hrs per site | SPS-5     | 22 per section   | 3 hrs per site |
| Rehabilitation of Jointed  | SPS-6  | 50 per section   | 5 hrs per site | SPS-6 (1) | 20 per section   | 3 hrs per site | SPS-6 (1) | 20 per section   | 3 hrs per site |
| Rehabilitation of CRC      | SPS-7  | 50 per section   | 5 hrs per site | SPS-6 (2) | 20 per section   | 3 hrs per site | SPS-6 (2) | 20 per section   | 3 hrs per site |

- (1) FWD test plan is identical to SPS-6 test plan for sections 3 and 6.
- (2) FWD test plan is similar to SPS-6 test plan for sections 3 and 6, except testing is done at previously tested C1 locations.

## **APPENDIX C**

### **FWD TEST PLANS: SEASONAL MONITORING PROGRAM (SMP)**

## Introduction

It is widely recognized that temperature, moisture and frost/thaw related changes in pavement structures, both within a day and over the course of a year, can have a significant impact on structural characteristics of pavement layers, thereby affecting response of the pavement to traffic loads, and ultimately the life of the pavement. However, the magnitude and relationship of these effects are not well understood, making them difficult to address with any degree of confidence in pavement design and evaluation.

To overcome this limitation, an endeavor referred to as the Seasonal Monitoring Program (SMP) has been undertaken within the long-term pavement performance (LTPP) study. The program's primary objective is to provide data needed to attain a fundamental understanding of the magnitude and impact of temporal variations in pavement response and material properties due to the separate and combined effects of temperature, moisture and frost/thaw variations. The products of this effort will provide (1) the means to link pavement response data obtained at random points in time to critical design conditions; (2) the means to validate models for relationships between environmental conditions (e.g., temperature and precipitation) and in situ structural properties of pavement materials; and (3) expanded knowledge of the magnitude and impact of the changes involved.

Resource limitations make it impossible to monitor on a seasonal basis all of the approximately 3,000 LTPP test sections scattered across North America. As a result, 64 LTPP test sections were initially selected to obtain a balance of key pavement factors: pavement type, thickness, environment, and subgrade type. Those sections were monitored for five years as part of the SMP Phase I monitoring activities. Because of further resource constraints on the LTPP program resulting from the TEA-21 bill as well as the loss of test sections due to rehabilitation, a new effort known as SMP Phase II monitoring was started in the Fall of 1999 with a reduced number of test sections. More specifically, 24 of the original 64 test sections were selected for inclusion in the second phase of the SMP.

## FWD Test Plans

### *General*

LTPP SMP test sections 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. 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.

Please refer to LTPP Directive SM-31: LTPP SMP Phase II Monitoring or current applicable directive for further testing details.

### *Naming Scheme/Data Storage*

The following convention is used to name FWD data files obtained as part of the seasonal monitoring program:

$$\frac{4}{1} \frac{8}{2} \frac{S}{3} \frac{E}{4} \frac{9}{5} \frac{3}{6} \frac{C}{7} \frac{1}{8} \cdot \frac{F}{9} \frac{W}{10} \frac{D}{11} \frac{D}{12}$$

where characters

|            |   |   |
|------------|---|---|
| 1, 2       | = | agency code; e.g., "48" for Texas   |
| 3          | = | always "S" for seasonal   |
| 4          | = | seasonal site identifier within agency; e.g., "E" is the fifth seasonal in Texas. |
| 5, 6       | = | last two digits of seasonal monitoring year; e.g., "99" for 1993                  |
| 7          | = | sequential visit identifier or code; e.g., "C" for third visit of that year       |
| 8          | = | FWD pass number; e.g., "3" for outer-wheel path, etc.                             |
| 9          | = | “.”   |
| 10, 11, 12 | = | always "FWD" for FWD testing  |

All data for a single pass location on a single test date is to be stored in a single file. Testing over a period of 24 hours or less is counted as a single test date, whether it spans midnight or not.

### *Detailed Test Plan*

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 C-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



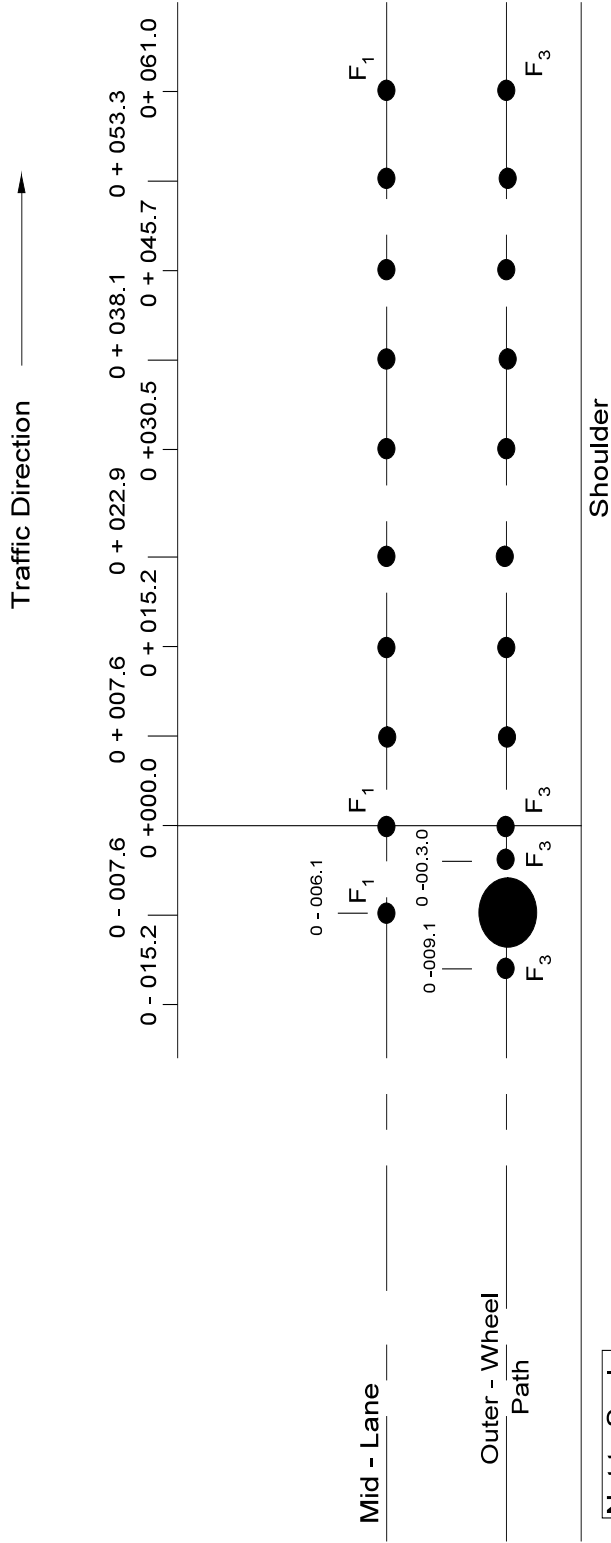
tested. The first test location shall conform with station 0+000.0 (0+00) or 0+091.4 (3+00), depending on the section end selected for seasonal monitoring. Three additional locations in the vicinity of the instrumentation shall also be tested; two test points in the outer-wheel path and one mid-lane 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 C-2 and C-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 C-2 and C-3.

Depending on which section end is selected, the location of the first joint will typically be between stations 0+000.0 (0+00) and 0+006.1 (0+20) or the location of the last joint will typically be between stations 0+146.3 (4+80) and 0+152.4 (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.

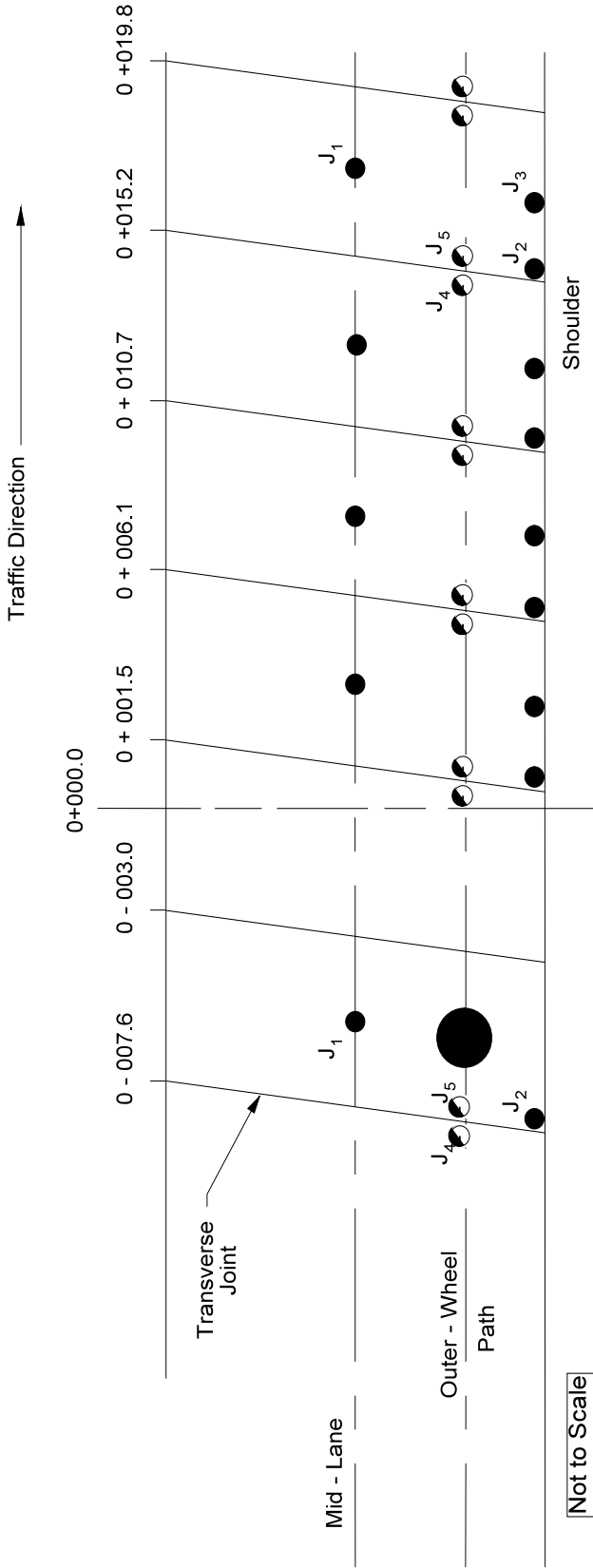
Monitoring of pavement surface and air temperature with the FWD is required during deflection measurements. Ordinarily, automatic sensors on LTPP FWD's shall be used. Should the sensors be inoperable, manual measurements shall be taken at intervals of 15 minutes or less. (Note: no data sheets are provided 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  $\pm 25$  mm (1 in) of the same locations.



Not to Scale

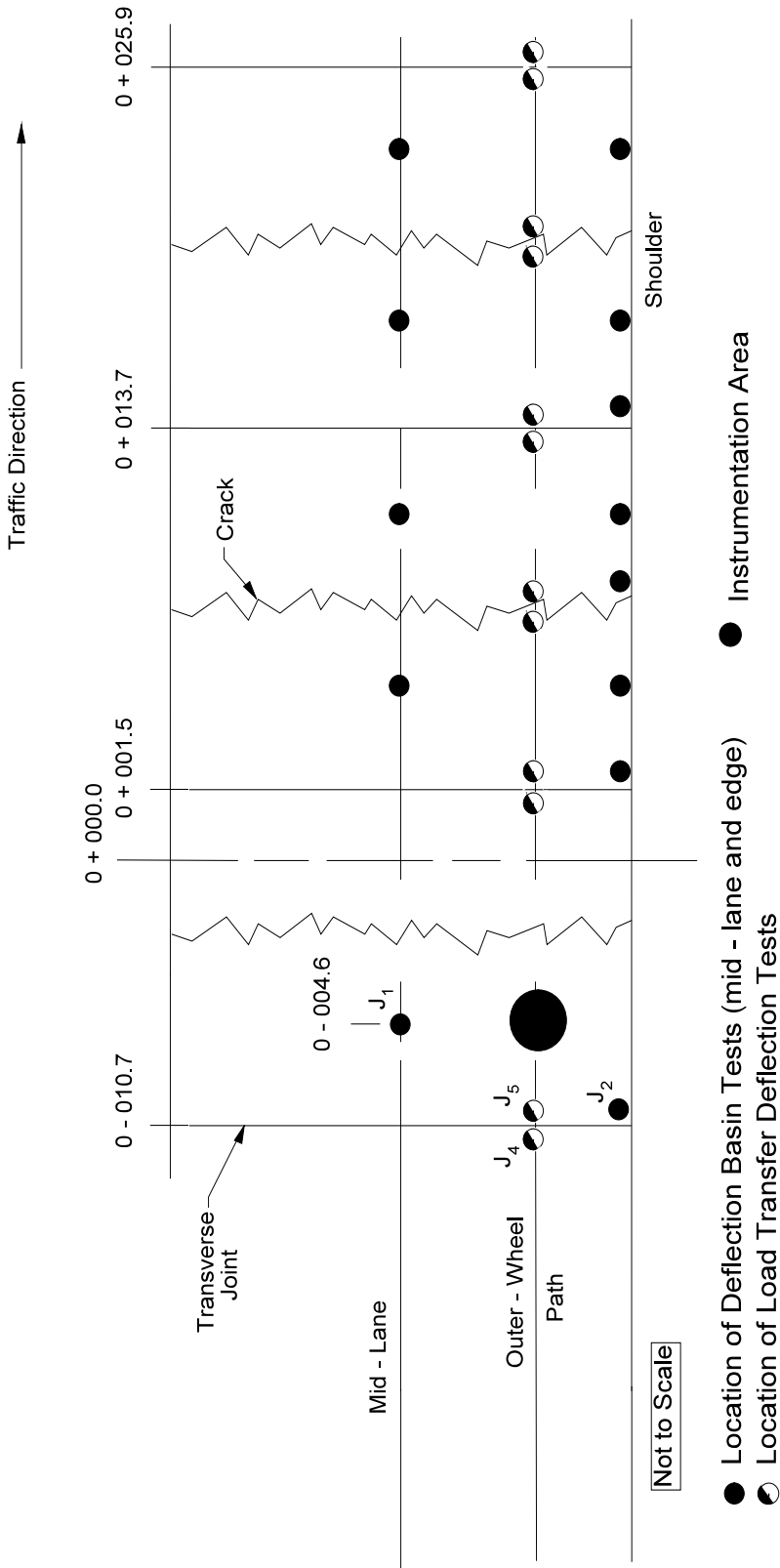
Figure C-1 Deflection Data Collection Plan - AC Pavements



- Location of Deflection Basin Tests (mid - lane and edge)
- ◐ Location of Load Transfer Deflection Tests

**Notes:** (1) One set of mid - slab, edge and load transfer deflection tests is performed on the slab with instrumentation. (No J3)  
 (2) Above layout assumes 4.6-m (15-ft) slab length. Distances will vary with different slab lengths.

Figure C-2 Deflection Data Collection - JPC Pavements



- Notes:**
- (1) One set of mid - slab, edge and load transfer deflection tests is performed on the slab with instrumentation. (No J3)
  - (2) Above layout assumes 12.2-m (40-ft) slab length with midpanel cracks creating two “effective panels” from each original slab. Distances will vary with different slab lengths.

Figure C-3 Deflection Data Collection Plan - JRC Pavements

## **APPENDIX D**

### **FWD TEST PLANS: DEFLECTION TESTING OF SUBGRADE AND BASE LAYERS SHRP PROTOCOL P59**

(Protocol modified from original for current LTPP 9 sensor configuration spacing of  
-305, 0, 203, 305, 457, 610, 914, 1219, and 1524 mm and \*.F25 file format)

## Introduction

This appendix covers the test method for measuring the surface deflection of subgrade and base layers; the appendix is a copy of SHRP Protocol P59, which was issued under LTPP Directive S-4: Deflection Testing of Subgrade and Base Layers for SPS-1, SPS-2 and SPS-8. The test shall be performed during test section construction for Specific Pavement Studies experiments SPS-1, SPS-2 and SPS-8. This protocol is based on ASTM D 4694-87 (Standard Test Method for Deflections with a Falling-Weight-Type Impulse Load Device). The test shall be performed in accordance with this standard (ASTM D 4694-87), as modified herein. Those sections of the ASTM standard included in this protocol by reference and without modification shall be strictly followed. All other sections of this protocol shall be followed as written herein.

### 1. Scope

- 1.1 This test method covers the measurement of deflections of paved and unpaved surfaces with a falling weight-type impulse load device. These devices are commonly referred to as falling weight deflectionometers (FWD).
- 1.2 This test method describes the measurement of vertical deflection response of the surface to an impulse load applied to the pavement surface. Vertical deflections are measured on the load axis and at points spaced radially outward from the load axis. An impulse load more nearly represents the moving vehicle load-pulse applied to prototype pavements than does a static load.
- 1.3 The values stated in SI units are to be regarded as the standard.
- 1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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. A specific hazard statement is given in Section 7.*

### 2. Referenced Documents

- 2.1 *ASTM Standards:*  
D 4695 Guide for General Pavement Deflection Measurements.
- 2.2 LTPP Manual for FWD Testing, Version 3.0, October 1999

### 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 weight dropped on a spring system and is transmitted through a plate resting on the pavement surface. The test apparatus is mounted in a vehicle or on a suitable trailer towed by a vehicle.

- 3.2 The load plate of the test apparatus is brought to a stop over the desired test location. The plate and deflection sensors are lowered to the pavement. The weight is raised to the height that, when dropped, will impart the desired force to the pavement. The weight is dropped and the resulting vertical movement or deflection of the pavement surface is measured using suitable instrumentation. Multiple tests may be performed before the apparatus is then raised and moved to the next test site.
- 3.3 Peak pavement deflections at each measured location resulting from the first force impulse is recorded in microns, millimeters, mils, or inches, as appropriate. In addition to the peak value, the deflection pulse shall be sampled at a number of intervals sufficient to completely define its shape (a minimum of 2 samples per millisecond per deflection sensor), beginning approximately 30 milliseconds (ms) before the peak deflection and ending approximately 30 ms after the peak deflection.
- 3.4 The peak force imparted by the falling weight is measured by a load cell and recorded, as force in kN, or mean stress (the load divided by the plate area) in  $\text{kN/m}^2$ . In addition to the peak value, the load pulse shall be sampled at a number of intervals sufficient to completely define its shape (a minimum of 2 samples per millisecond), beginning approximately 30 milliseconds (ms) before the peak load and ending approximately 30 ms after the peak load.

#### **4. Significance and Use**

- 4.1 This test method covers the determination of pavement surface deflections as a result of the application of an impulse load to the pavement surface. The resulting deflections, measured at the center of the applied load, and at distances away from the load, are used to estimate the in-situ material properties and to evaluate construction uniformity.

#### **5. Apparatus**

- 5.1 *Instrumentation System* - conforming to the following general requirements:
- 5.1.1 *Instruments Exposed to the Elements* (outside the vehicle) shall be operable in the temperature range of  $-10$  to  $-50^\circ\text{C}$  and shall tolerate relatively high humidity, rain or spray, and all other adverse conditions such as dust, shock, vibrations that may normally be encountered.
- 5.1.2 *Instruments Not Exposed to the Elements* (inside the vehicle) shall be operable in the temperature range of  $5$  to  $40^\circ\text{C}$ .
- 5.2 *Force-Generating Device* (falling weight), with a guide system. The force-generating device shall be capable of being raised to four predetermined heights and dropped. The device shall generate a force pulse approximating the shape of a haversine or half-sine wave while achieving a peak force of at least 50 kN. Specific load levels and drop heights are defined in 11.4.

- 5.2.1 *Guide System*, designed to operate with negligible friction or resistance and designed so the weight falls perpendicular to the pavement surface.
- 5.3 *Loading Plates*, capable of distributing an approximate uniform load to the pavement surface. The load plate shall be 300 mm in diameter for subgrade and base course testing. The plate shall be open in the center to allow a deflection measuring sensor to be installed and the plates shall be swivel suspended to tilt in any direction a minimum of 5° from the horizontal plane.
- 5.4 *Deflection Transducers*, capable of measuring the maximum vertical deflection of the pavement surface 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 transducers is defined in 11.3. Transducers may be of several types such as seismometers (absolute measurement transducers), velocity transducers, or accelerometers.
- 5.5 *Data Processing and Storage System* - A magnetic storage device shall be used to store the measured load, surface deflection data, and supporting information such as air temperature, pavement surface temperature, distance measurements, and identification data for each test point.
- 5.6 *Load Cell*, to measure the applied load on each impact shall be placed in a position to minimize inertial effects. The load cell shall be capable of deflection measurements at the center of the load, shall be water resistant, and shall be resistant to mechanical shocks from road impacts.

## **6. Signal Conditioning and Recorder System**

- 6.1 All signal conditioning and recording equipment shall allow data reading resolution to meet the following requirements:
  - 6.1.1 Load measurements shall be displayed and stored at a resolution of 200 N or less.
  - 6.1.2 Deflection measurements shall be displayed and stored with a resolution of 1 mm.
  - 6.1.3 The load and deflection measurements shall be recorded as specified under 6.1.1 and 6.1.2, respectively, within a time period or measurement window of at least 60 ms, to an absolute accuracy at the time of peak load and deflection, of  $\pm 2\%$  and a random accuracy for deflections of  $\pm 2$  mm.

## **7. Hazards**

- 7.1 The test vehicle, as well as all attachments to it, shall comply with all applicable state and federal laws. All necessary precautions shall be taken beyond those



imposed by laws and regulations to ensure maximum safety of operating personnel and other traffic.

## 8. Calibration

- 8.1 *Calibration* - Follow the recommendations for deflection sensor relative calibration and for deflection and load cell reference calibration specified in the SHRP-LTPP Manual for FWD Testing. Reference calibration shall be performed annually and after repairs to the sensors or the load cell. Relative calibration shall be performed monthly and immediately after reference calibration.

## 9. Procedure

- 9.1 Bring the device to the test location and locate the test plate over the desired test point. The test location shall be as clean as possible of rocks and debris to ensure that the loading plate will be properly seated. Gravel or soil surfaces shall be as smooth as possible and all loose material removed. (See ASTM D 4695)
- 9.2 Lower the loading plate and the transducers and ensure they are resting on a firm and stable surface.
- 9.3 Raise the force generator to the desired height and drop. Record the resulting peak surface deflections and peak loads.
- 9.4 Perform two loading sequences at each drop height and compare the results. If the difference is greater than that specified in the SHRP-LTPP Manual for FWD Testing (for deflections,  $\pm 2 \mu\text{m}$ ,  $\pm 1$  percent, and for load,  $\pm 2.6 \text{ kPa}$ ,  $\pm 2$  percent), it shall be noted in the report.

NOTE 1 - If the deflections indicate poor subgrade or base compaction, then this should be brought to the attention of the construction inspector.

## 10. Precision and Bias

- 10.1 *Precision* - At this time, no precision from a statistically designed series of tests with different devices has been obtained for testing unbound materials.
- 10.2 *Bias* - No statement is being made as to the bias of this test method at the present time.

## 11. Test Plan (see Table 1)

- 11.1 *Test Location* - Deflection tests shall be performed along the test section at the following two transverse locations in order of preference; (Note: Before performing the second pass, the influence of tow vehicle/trailer wheel rutting of the surface must be assessed. The second pass shall be omitted if rutting indicates some

additional compaction or shearing of the subgrade and/or unbound materials has occurred.)

- (1) Outer Wheel Path - located  $0.76 \text{ m} \pm 0.15 \text{ m}$  from lane edge. (Denoted as pass "3" for consistency with SHRP procedures)
  - (2) Mid-Lane - located  $1.8 \text{ m} \pm 0.15 \text{ m}$  from the lane edge. (Denoted as pass "1" for consistency with SHRP procedures)
- 11.2 *Test Interval* - A 15.4 m longitudinal test spacing shall be used for both passes. The starting station for the first pass shall be 0+000 and the second pass shall start at 0+007.5, resulting in a staggered test pattern.
- 11.3 *Sensor Configuration* - A deflection sensor shall be placed directly beneath the center of the load plate and at radial offsets of -305, 203, 305, 457, 610, 914, 1219, and 1524 mm (current LTPP configuration) from the center of the load plate.
- 11.4 *Load Levels/Number of Drops* - For subgrade testing, four drop heights shall be used as follows. The lowest load level shall be achieved by using the lowest possible physical drop height. The highest load level shall be achieved by determining the drop height required to obtain a maximum deflection of approximately 1524  $\mu\text{m}$ . The two intermediate load levels shall be achieved by setting the drop heights to positions that will produce evenly spaced load levels. For testing permeable asphalt treated, unbound granular base and lean concrete base courses the SHRP standard mass package and target load levels for flexible pavement testing shall be used. In all cases where excessive deflection measurements occur (greater than 1524  $\mu\text{m}$  [60 mils] ), only load levels that cause these high measurements shall be omitted.
- 11.5 *Drop Sequence* - At each test location, one seating drop at the lowest load level shall be applied prior to testing. Following the seating drop, two drops will be applied at each load level, starting with the lowest load level.
- 11.6 *Other Considerations* - Provision shall be made with the construction contractor for timely site access. Testing of subgrade shall be performed after completion of fine grading and prior to placement of base course materials. Unbound granular base testing shall be performed after completion of compaction and fine grading. Testing of permeable asphalt treated base course shall be performed after the material has been in place for a minimum of 48 hours and the prohibition of construction traffic on this material does not apply to the test vehicle and trailer. Lean concrete base material shall be tested no earlier than 7 days after placement. The prohibition of construction traffic does not apply to the test vehicle and trailer. Testing shall only be performed in the absence of standing water.

## 12. Report

- 12.1 *Test Identification Information* - Test Agency, SHRP Region, State Code, SPS

Experiment Number, SPS Project Code, Test Section Number, Field Set Number, Roadway Name and Route Number, Test Designation, SHRP Protocol Number, Technician Name, and Test Date.

12.2 *Load and Deflection Data* - Load and deflection data shall be recorded in ASCII format and may be stored in compressed form on 3-1/2 inch computer diskettes. File names will consist of eight characters; characters 1-6 shall be the SHRP Section ID of the SPS section, character 7 shall be a digit between 1 and 9, signifying the number of times that this section has been tested under this protocol. The first instance of testing will be denoted with a "1", whether the first testing occurs on the subgrade, a subbase course, or a base course. Character 8 shall be a number denoting the test location (1 - mid-lane, 3 - outer wheel path). A three character extension ".F25" shall follow the eight character file name. Example: 29B32013.F25 represents the file name for the first deflection testing of this section along the outer wheel path. A paper copy printout of the load and deflection data shall also be provided along with the computer file for each section.

12.3 *Additional Data* - In addition to the load and deflection data, the air temperature, and time of testing shall be recorded for each test location. Lane specifications shall also be recorded. All lane specification codes are two character codes where the first character indicates material information and the second character indicates test location; "1" for mid-lane testing and "3" for outer wheel path testing.

Material codes are as follows:

- S - Subgrade,
- G - Granular Aggregate Base,
- P - Permeable Asphalt Treated Base, and
- L - Lean Concrete Base.

An example of a lane specification, "G3", denotes testing of the granular aggregate base course in the outer wheel path.

Pavement temperature profiles are not required for any of the listed materials.

**Table 1. Test Plan Summary for Deflection Testing of  
SPS 1, 2, and 8 Subgrade and Base Layers**

---

|                                     |  |
|-------------------------------------|--|
| <b><i>Test Location:</i></b>        | Mid-Lane<br>Outer Wheel Path   |
| <b><i>Test Interval:</i></b>        | 15.4 m   |
| <b><i>Sensor Configuration:</i></b> | -305, 0, 203, 305, 457, 610, 914, 1219, 1524 mm<br>(current LTPP configuration)  |
| <b><i>Load Plate:</i></b>           | 300 mm Diameter  |
| <b><i>Load Levels:</i></b>          |  |
| Subgrade Testing                    | Non-SHRP mass package to achieve target loads:<br><br>Height 1 - lowest possible (7 kN)<br>Height 4 - to achieve 22 kN (maximum 1524 $\mu$ m)<br>Height 2, 3 - evenly spaced between heights 1 and 4                 |
| Base Course Testing                 | SHRP standard mass package and drop heights for target loads:<br><br>Height 1 - 27 kN<br>Height 2 - 40 kN (maximum 1524 $\mu$ m)<br>Height 3 - 53 kN(maximum 1524 $\mu$ m)<br>Height 4 - 71 kN(maximum 1524 $\mu$ m) |
| Drop Sequence                       | 1 seating drop<br><br>2 drops at each load level (record peaks for each drop and whole history for the second drop at each height)   |

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**SHRP-LTPP LABORATORY MATERIAL TESTING  
DEFLECTION TESTING OF SUBGRADE AND BASE LAYERS  
FIELD DATA SHEET T59  
SUBGRADE AND BASE LAYERS  
SHRP TEST DESIGNATION: SS13/SHRP PROTOCOL P59**

AGENCY PERFORMING TEST: \_\_\_\_\_

SHRP REGION: \_\_\_\_\_ STATE: \_\_\_\_\_ STATE CODE: [ ][ ]  
SPS PROJECT CODE: [ ][ ]  
ROADWAY: \_\_\_\_\_ TEST SECTION NO.: [ ][ ]

FWD Manufacturer: \_\_\_\_\_

Model: \_\_\_\_\_

S/N: \_\_\_\_\_

TESTED BY: \_\_\_\_\_

DATE TESTED: \_\_ - \_\_ - 19\_\_

1. PAVEMENT LAYER TESTED \_\_\_\_\_
2. LAYER NUMBER [ ]
3. COMPUTER FILE NAMES \_\_\_\_\_ .FWD

FWDGENERAL REMARKS:

\_\_\_\_\_  
\_\_\_\_\_

CERTIFIED BY, DATE

VERIFIED AND APPROVED BY, DATE

\_\_\_\_\_  
Participating Agency  
Affiliation: \_\_\_\_\_

\_\_\_\_\_  
SHRP Representative  
Affiliation: \_\_\_\_\_

**APPENDIX E**

**LTPP TEST SECTION MONITORING ADJUSTMENTS**

# LONG TERM PAVEMENT PERFORMANCE PROGRAM DIRECTIVE



*For the Technical Direction of the LTPP Program*



Program Area: General Operations Directive Number: GO-21

Date: October 1, 1999 Supersedes: D-5, FWD-10, P-2

Subject: LTPP Pavement Performance Monitoring Adjustments

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## Background

This directive presents pavement performance monitoring adjustments intended to achieve a balance in the data available for a test section relative to their use in development, verification, evaluation and validation of pavement performance prediction procedures while preserving the ability to support other types of pavement related investigations and analyses.

## Monitoring Guideline Summary

Table 1 summarizes the revised pavement performance monitoring guidelines for Long-Term Pavement Performance (LTPP) projects by experiment type. The measurements covered by these guidelines include profile, distress, and deflection data collection. These guidelines relate to frequency and intensity of data collection, not data quality. High data quality standards must be maintained for measurements performed regardless of test section or monitoring category.

The “Monitoring Category” shown in Table 1 is the key to the monitoring adjustment sequence. The recommended monitoring category is based upon assessment of test section compliance with the minimum data completeness requirements contained in LTPP Directive GO-19: LTPP Data Completeness and Monitoring Adjustment Process. For test sections that do not meet the data collection requirements or that have critical unresolvable deficiencies, monitoring adjustments shall be made in the following sequence:

S1 ⇐ S2 ⇐ G ⇐ C

For example, if a test section in the S2 monitoring category has pavement performance monitoring less than S2, but greater than the C monitoring requirements, the recommended monitoring category would be G.

Every effort must be made to maintain test sections at their highest potential category in order to reap the benefits of the investment in LTPP. The monitoring categories were tailored around the level of highway agency investment in the test site and relative utility of the data. The following is a description of the nature of the various monitoring categories.

- S1** These are high value flexible and rigid pavement experiments (SPS-1 and -2) which began with a new construction or reconstruction event. It is on these test sections that we have the opportunity to best measure the effects of pavement features such as drainable bases, widened lane, base type, etc. starting from construction within the context of a nationally coordinated experiment. Some agencies have estimated that they have invested up to \$500,000 to construct, test and monitor these test sections. In keeping with this level of investment, these test sections have been assigned the highest level and intensity of monitoring. These test sections will be the primary candidates for future special monitoring studies.
- S2** This category includes the SPS-8 experiment on environmental effects and the SPS-5 and 6 rehabilitation experiments. The SPS-8 experiment is an adjunct to the SPS-1 and 2 studies; two test sections from the SPS 1 and 2 studies were constructed on lower volume roadways where environmental effects are most likely to cause deterioration. The SPS-5 and -6 are the high value flexible and rigid rehabilitation experiments that start with construction of a specified series of treatments on contiguous test sections. These test sections are valuable since they are also based on a nationally coordinated experiment with similar test sections constructed in other parts of the country.
- G** The G category of pavements is mostly comprised of test sections in the General Pavement Study. These test sections are of vital importance to the program since they provide the greatest extent of coverage of environmental factors, paving materials and paving practices. Some of the monitoring requirements are less intensive than the S categories with provisions for performing measurements in response to changes in the pavement condition or other events.
- C** The C or close-out category of monitoring is still *an active monitoring status category*. Close-out monitoring means that one more round of pavement performance measurements will be performed on existing test sections, preferably at the end of their current life cycle when a rehabilitation treatment is applied. The objective is to preserve the previous investment in these test sections by obtaining a minimum level of performance information over the current pavement life cycle. Test sections are assigned to this category due to either an uncorrectable or minimum data requirement deficiency which will not be corrected, or because they are part of an experiment with limited national impact, limited product potential or whose study time period has expired.



Table 1. Summary of data collection requirements and monitoring frequencies.

|   |                                  |  |  |  | Monitoring |
|---|----------------------------------|--|--|--|------------|
| SPS 1 & 2                                 |                                  |  |  |  | I          |
| SPS 5 & 6                                 |                                  |  |  | FWD<br>2-year and responsive                                   | S1         |
| SPS 8                                     |                                  |  |  | 1- year manual and<br>2 -year photographic                     |            |
| <b>Experiment</b>                         | 1-year                           |  |  | testing<br>5-year and responsive                               | S2         |
|   | <del>Same as core sections</del> |  |  | 3-year photographic,<br>and responsive<br>One last measurement |            |
| <b>GPS 6A &amp; 7A, SPS 3, 4, &amp; 7</b> |                                  |  |  | testing  | G          |

Although required pavement monitoring activities for SPS-1, -2, -5, -6 and -8 project test sections are the same, the level of traffic monitoring and climatic data collection at SPS-1 and -2 project sites is more intensive, and hence the reason for subcategories (S1 and S2) within the S monitoring category. Traffic data collection requirements for the monitoring categories shown in the above table are being finalized and will be issued under a separate directive.

## Pavement Performance Monitoring

Pavement performance monitoring addressed in this directive includes profile, distress and deflection measurements performed by LTPP contractors.

### Definitions

In order to describe when pavement performance monitoring should be performed, the following definitions are used.

#### Rehabilitation

##### Construction Event

Performance of rehabilitation activities on a test section. Rehabilitation activities include overlays and associated pretreatments (patching, milling, joint repair, etc.), inlays (mill and fill), pressure relief joints in PCC pavements, subsealing and undersealing, retrofitted subdrainage, joint load transfer restoration, and shoulder restoration.

#### Maintenance

##### Construction Event

Performance of maintenance activities on a test section. Maintenance activities include seal coats, crack sealing, patching, crack and joint sealing, grinding, milling less than 25-mm deep, and grooving.

#### Out-of-Study

Monitoring is discontinued because a test section is either unsuitable for continued monitoring due to reconstruction, non-qualifying rehabilitation construction event, major deficiency or the respective highway agency is no longer willing to support the required monitoring activities. (Previously collected data will be retained by the LTPP program.)

#### Routine Monitoring

Pavement performance measurements (profile, distress, and deflection) taken at regularly established intervals, where the interval length is defined by the measurement type and test section monitoring category (S1, S2 or G). Routine measurements are repeated until one of the three following conditions are reached:

1. Test section goes out-of-study.
2. Application of rehabilitation activity.
3. End of LTPP program

Routine monitoring after performance of rehabilitation activity will be continued if the test section does not go out-of-study. Such monitoring will be performed in accordance with the

requirements for the post-rehabilitation LTPP experiment designation monitoring category.

Routine measurements do not apply to test sections classified in the C monitoring category.

#### Responsive Monitoring

Non-routine monitoring measurements performed on test sections that are triggered by changes in pavement condition, construction events, or status change.

Responsive monitoring based on change in pavement condition applies primarily to those test sections in the G monitoring category which have longer routine monitoring intervals than those in the S categories. The primary trigger for pavement related response monitoring are measurements and observations by the profiler operator who visits the site on a bi-annual basis. One or more of the following conditions may trigger the need for responsive monitoring:

- A change in average IRI over a two year period in excess 0.40 m/km.
- A significant change in pavement distress condition; e. g. appearance of fatigue cracking, increased rutting, or increase or decrease in severity or extent of other distress types.
- Report by highway agency personnel that rate of pavement deterioration appears to be accelerating.

Responsive measurements triggered by a construction event include:

- Maintenance construction event -- Profile and distress surveys shall be performed within six months prior to maintenance activities such as seal coats which cover the entire surface of the test section; no responsive post-treatment monitoring measurements are required. Routine monitoring measurements should continue in accordance with pre-maintenance routine monitoring schedule.
- Rehabilitation construction event -- Profile, distress and deflection measurements are required within six months prior to rehabilitation activity. If monitoring measurements are to be continued on a test section after rehabilitation, i.e. the test section does not go out-of-study, then a full suite of pavement performance

measurements are also required within six months following completion of rehabilitation construction.

A full suite of pavement monitoring measurements shall be performed either:

- When it is determined that a test section will be taken out-of-study.
- At the end of the field monitoring portion of the LTPP program.

Close-Out Monitoring: For test sections in the close-out monitoring category, only one more suite of pavement monitoring measurements (profile, distress and deflection) will be performed either:

- When it is determined that a test section will be taken out-of-study. This could be due to a construction event or at the option of the highway agency.
- At the end of the field monitoring portion of LTPP program.

## **Profile Measurements**

Profile measurements on LTPP test sections shall be performed in accordance with established data collection guidelines, protocols and directives. The three general categories of profile measurement frequency specified in Table 1 include:

1. Annual profile measurements
2. Profile measurements every 2 years
3. Close-out profile measurements

The frequency of profile surveys on supplemental SPS test sections shall be performed in accordance with that for the associated core sections.

### ***Annual Profile Measurements***

Routine profile measurements on test sections within this monitoring category shall be performed once per year. It is highly desirable that these measurements be performed at approximately the same time each year ( $\pm$  1 month). These measurements shall be repeated until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive profile measurements are required within six months prior to reaching any one of these conditions or within six months prior to application of maintenance construction event. Responsive profile measurements are also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be

monitored. Routine profile measurements after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

### ***Profile Measurements Every 2 Years***

Test sections in this monitoring category shall be surveyed once every two years; i.e., every other year. It is highly desirable that these measurements be performed at approximately the same time each test year ( $\pm$  1 month). These surveys shall be repeated until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive profile measurements are required within six months prior to reaching anyone of these conditions or within six months prior to application of maintenance construction event. Responsive profile measurements are also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be monitored. Routine profile measurements after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

### ***Close-Out Measurements***

For test sections within this monitoring category, one last round of profile measurements will be performed either when it is determined that the test section will be taken out-of-study (due to a construction event or at the option of the highway agency) or at the end of the field monitoring portion of the LTPP program, whichever comes first.

### ***Distress Surveys***

Two methods are used to document surface distresses on LTPP sections: photographic and manual surveys. Regardless of method, distress data shall be collected in accordance with current LTPP data collection guidelines, protocols and directives. Table 1 provides the survey frequency that shall be followed for the collection of distress data according to LTPP experiment. Three general distress monitoring categories are provided in this table:

1. Photographic surveys every 2 years and annual manual distress surveys
2. Photographic surveys every 2 years and manual distress surveys every 3 years
3. Close-out manual distress surveys

A more detailed description of these monitoring categories is provided next.

### ***Photographic Surveys Every 2 Years and Annual Manual Distress Surveys***

LTPP test sections classified in this monitoring category shall be surveyed once every two years (i.e., every other year) using the photographic method and once per year (i.e., annually) using the manual method. It is highly desirable that these measurements 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.** Both photographic and manual surveys shall be repeated until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive manual distress surveys are required within six months prior to reaching any one of these conditions or within six months prior to application of maintenance construction event which hides the existing pavement surface, such as a seal coat. Responsive manual distress surveys are also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be monitored. Routine photographic and manual distress surveys after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

### ***Photographic Surveys Every 2-Years and Manual Distress Surveys Every 3-Years***

Photographic distress surveys on test sections within this category shall be performed once every two years (i.e., every other year), and manual distress surveys on these same test sections shall be performed on a nominal three (3) year interval. It is highly desirable that these measurements be performed at approximately the same time each year ( $\pm$  1 month). These surveys shall be repeated until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive manual distress surveys are required within six months prior to reaching any one of these conditions or within six months prior to application of maintenance construction event. Responsive manual distress surveys are also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be monitored. Routine photographic and manual distress surveys after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

Responsive manual distress surveys shall also be performed on test sections within this monitoring category based on changes in pavement condition as defined in the “Definitions” section of this directive.

### ***Close-Out Manual Distress Surveys***

For test sections within this monitoring category, one last manual distress survey will be performed either when it is determined that the test section will be taken out-of-study (due to a construction event or at the option of the highway agency) or at the end of the field monitoring portion of the LTPP program, whichever comes first.

### **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. The revised deflection testing frequency guidelines are

provided in Table 1 according to LTPP experiment. Three general FWD monitoring categories are provided in this table:

1. Deflection testing every 2 years
2. Deflection testing every 5 years
3. Close-out deflection testing

A more expanded description of each of these three monitoring categories is provided next.

### ***Deflection Testing Every 2 Years***

Deflection testing on test sections in this monitoring category shall be performed on a nominal two (2) year interval. This testing shall be repeated every 2 years until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive deflection testing is required within six months prior to reaching any one of these conditions. Responsive deflection testing is also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be monitored. Routine deflection testing after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

Responsive deflection testing shall also be performed on test sections within this monitoring category based on changes in pavement condition as defined in the “Definitions” section of this directive.

### ***Deflection Testing Every 5 Years***

Deflection testing on test sections within this monitoring category shall be performed on a nominal five (5) year interval. These surveys shall be repeated every 5 years until one of the following conditions is reached: test section goes out-of-study, application of rehabilitation construction event, or end of field monitoring portion of LTPP program. Responsive deflection testing is required within six months prior to reaching any one of these conditions. Responsive deflection testing is also required within six months after application of a rehabilitation (not maintenance) construction event if that test section will continue to be monitored. Routine deflection testing after application of a rehabilitation construction event will be done in accordance with requirements for the post-rehabilitation LTPP experiment designation monitoring category.

Responsive deflection testing shall also be performed on test sections within this monitoring category based on changes in pavement condition as defined in the “Definitions” section of this directive.

### ***Close-Out Deflection Testing***

For test sections within this monitoring category, one last round of deflection testing will be performed either when it is determined that the test section will be taken out-of-study (due to a construction event or at the option of the highway agency) or at the end of the field monitoring portion of the LTPP program, whichever comes first.

### **Other Monitoring**

Pavement performance monitoring by the RCOCs at times other than those specified in this directive (i.e., any standardized plan deviations) must first be approved by the appropriate FHWA COTR.

Questions concerning this directive should be addressed to the FHWA LTPP Team Leader.

Prepared by: TSSC Team

Approved by:

Monte Symons  
LTPP Team Leader



**APPENDIX G**

**EXAMPLE DYNA25 PROGRAM SCREENS  
AND  
EXAMPLE F25 UPLOAD FILE FORMATS AND LISTINGS**

## **EXAMPLE DYNA25 PROGRAM SCREENS**

### **Introduction**

This appendix provides example screen snap-shots from the Dyn25 program for the typical default settings used for LTPP FWD operation and data collection. Use of the software is described in Section III “Data Acquisition and Handling” in the main body of this document. All examples have been reproduced in “SYSOP” mode to give the maximum range of settings viewable. It should be noted that it is mandatory for all LTPP FWD data collection activities for GPS and SPS to be conducted using “Operator” mode.

Although every effort has been made to reproduce the most representative cross section of menu and screen data defaults, not all screens have been reproduced. In the event that a non-standard default setting and/or operator preference is selected, due care and attention must be taken by FWD operators in checking ALL resultant screen settings, so that specified LTPP test setups are correct. This can be achieved by previewing setup options within the “Measurements Window” prior to testing.

Note: Under the “General” setting and other screen dump references within this appendix the file W&B-SI.GSU (White on Black, Metric units) has been adopted. This setup was necessary to facilitate the production of the screen images for reference purposes. The correct default supplied with the FWD Dyna25 ver 2000 software is set at Color-SI.



Figure G-1.1 Log-On Screen



Figure G-1.2 Page Sync



Figure G-1.3 Measurements Window



Figure G-1.4 Measurements - Create New File



Figure G-1.5 Pre-Open-File Prompts - File ID

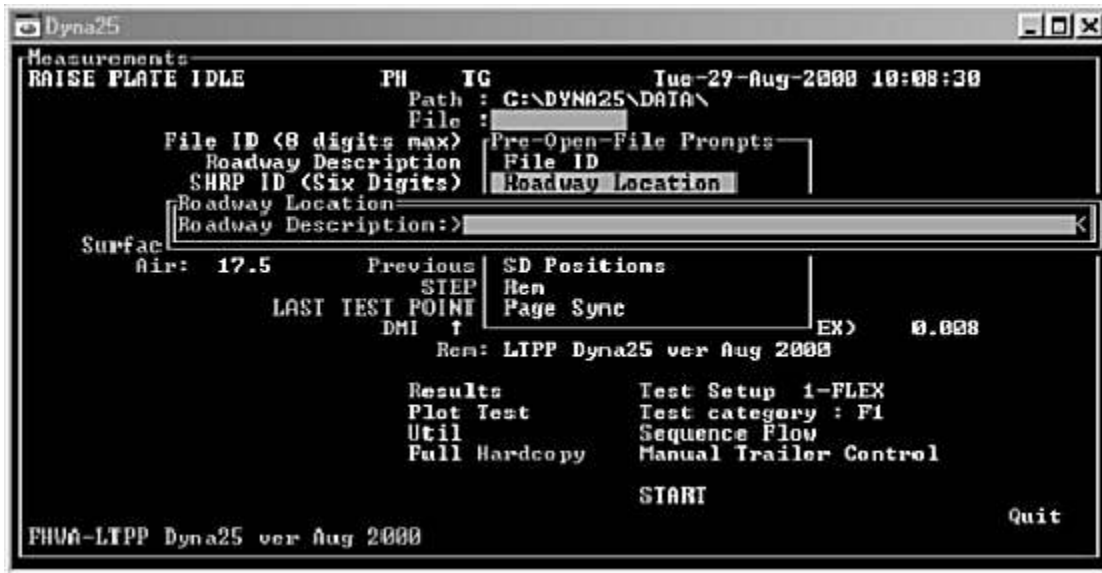


Figure G-1.6 Pre-Open-File Prompts - Roadway Location

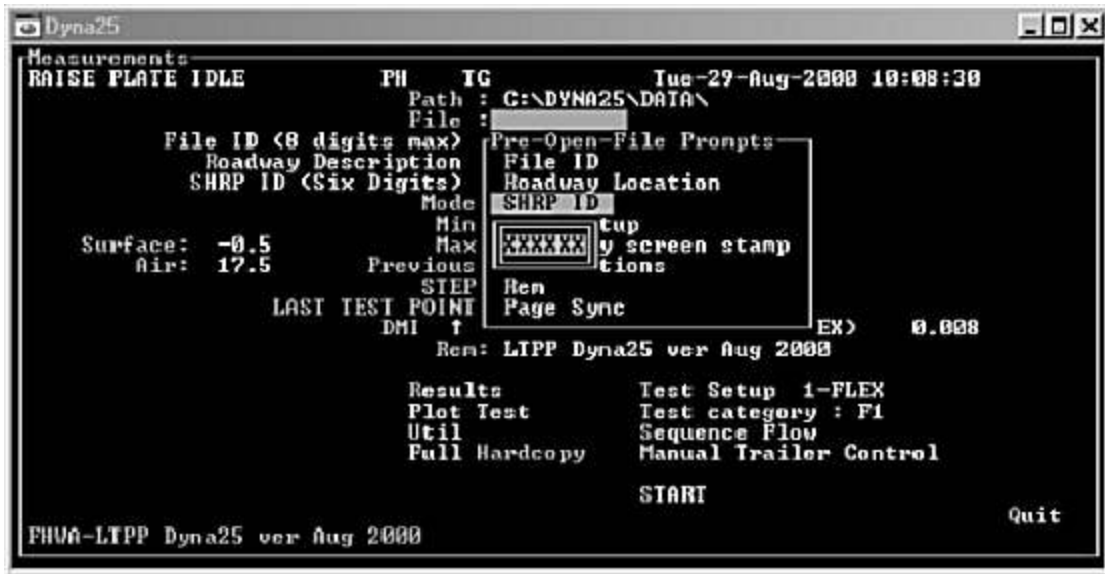


Figure G-1.7 Pre-Open-File Prompts - SHRP ID



Figure G-1.8 Pre-Open-File Prompts - Test Setup Files



Figure G-1.9 Pre-Open-File Prompts - Test Category



Figure G-1.10 Pre-Open-File Prompts - Test Pass Lane Code



Figure G-1.11 Pre-Open-File Prompts - Check Sensor Position



Figure G-1.12 Pre-Open-File Prompts - Test Category





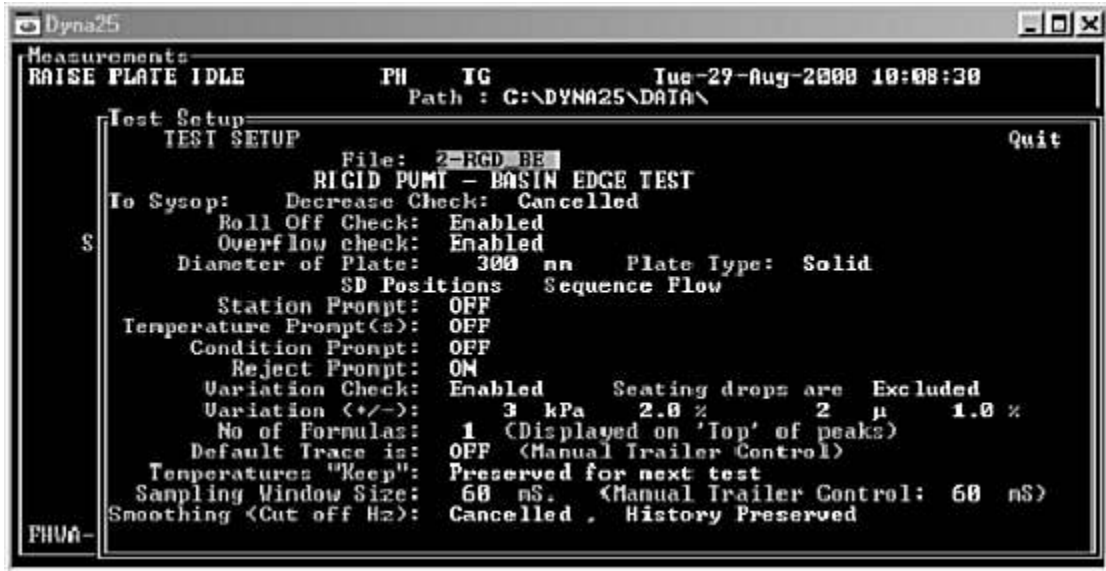


Figure G-1.15 Test Setup - Rigid Pavement - Basin Edge Test



Figure G-1.16 Test Setup - Rigid Pavement - Load Transfer Test

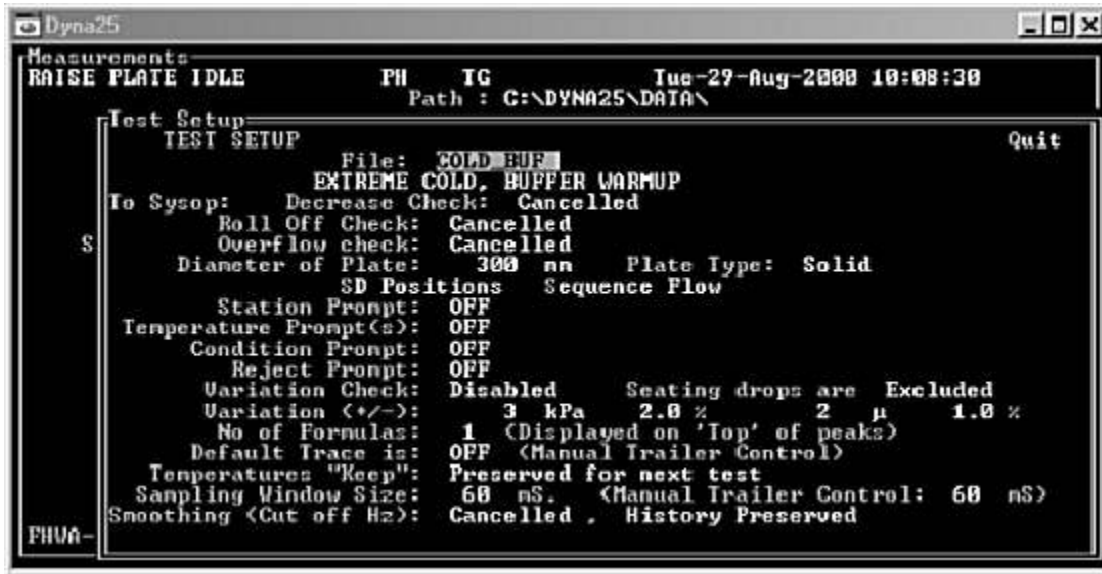


Figure G-1.17 Test Setup - Extreme Cold Buffer Warmup

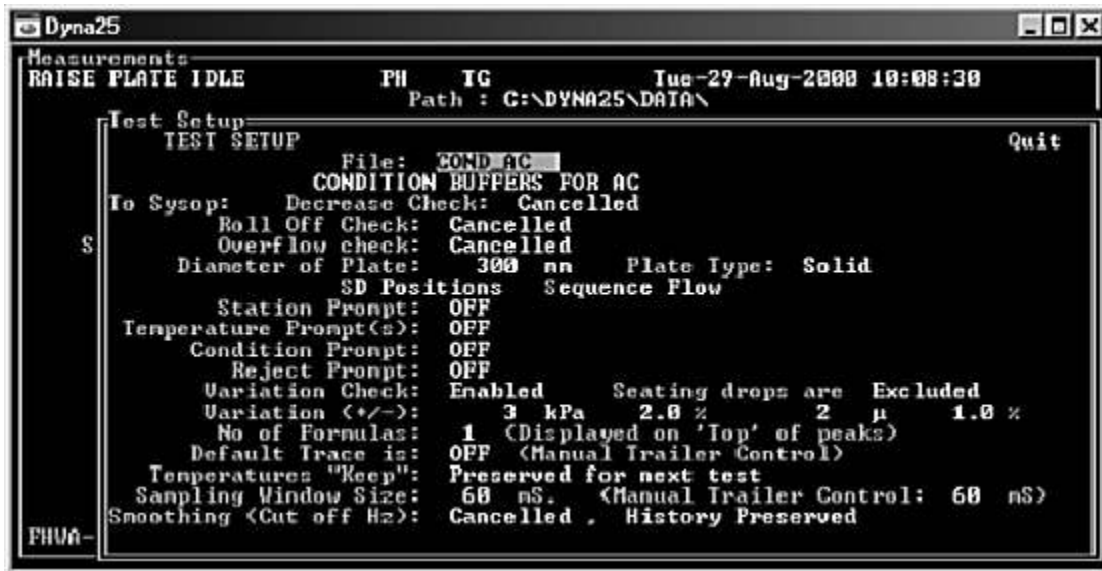


Figure G-1.18 Test Setup - Condition Buffers for AC

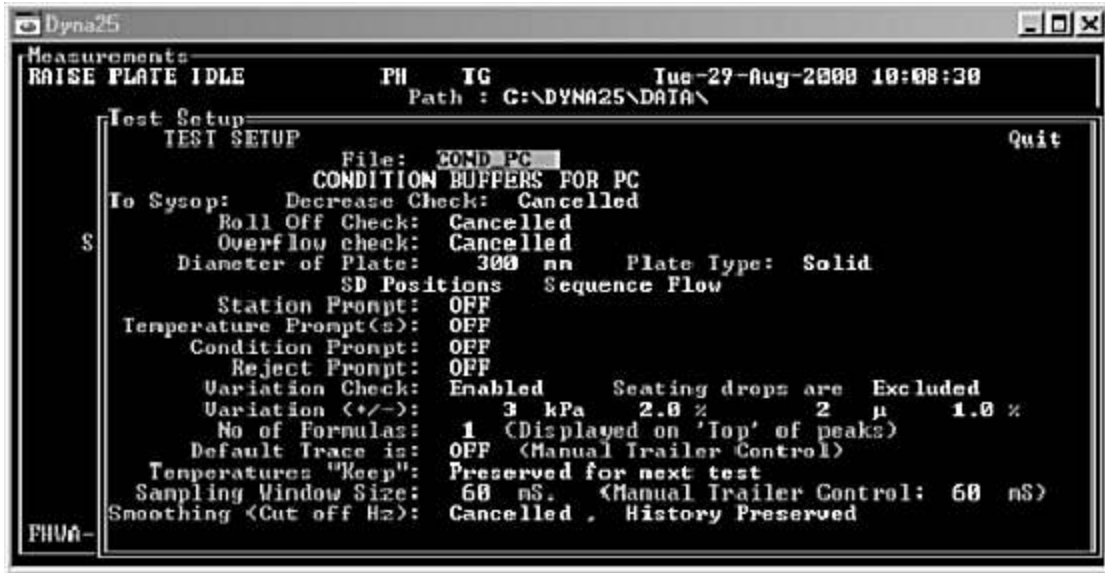


Figure G-1.19 Test Setup - Condition Buffers for AC

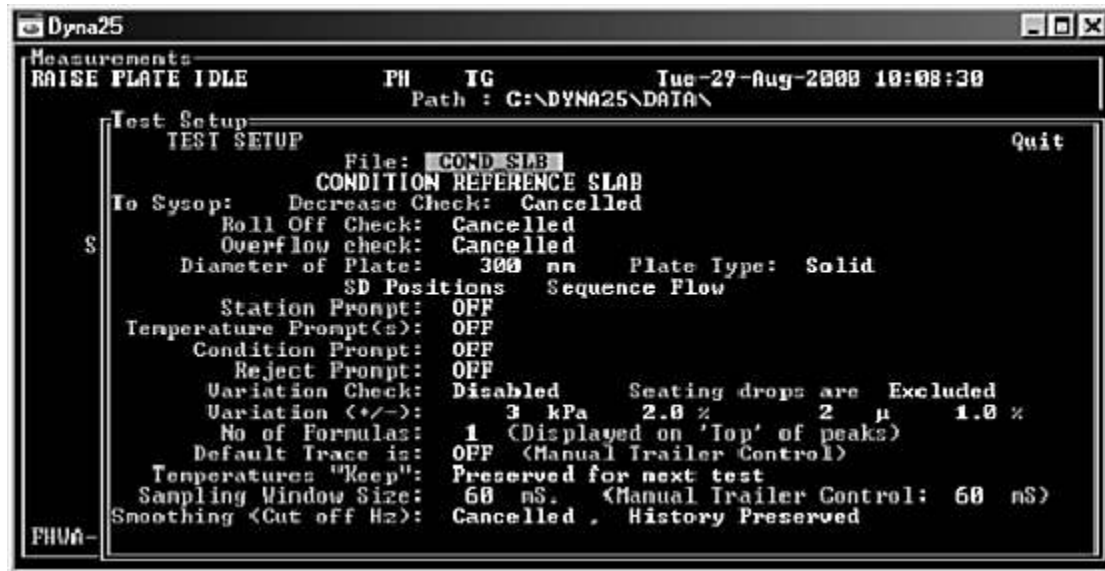


Figure G-1.20 Test Setup - Condition Reference Slab

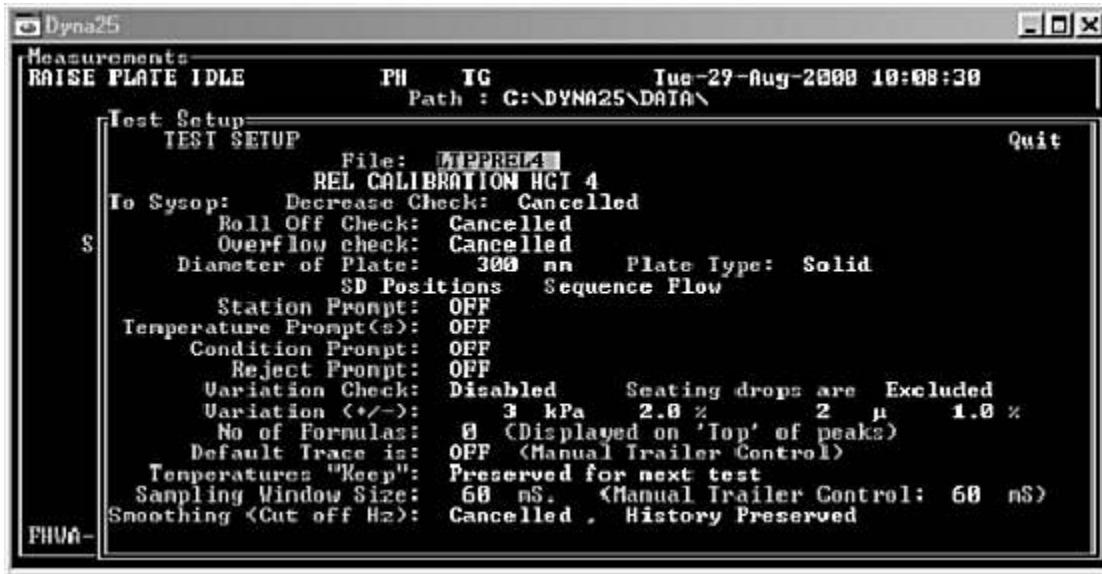


Figure G-1.21 Test Setup - Relative Calibration - Drop Height 4

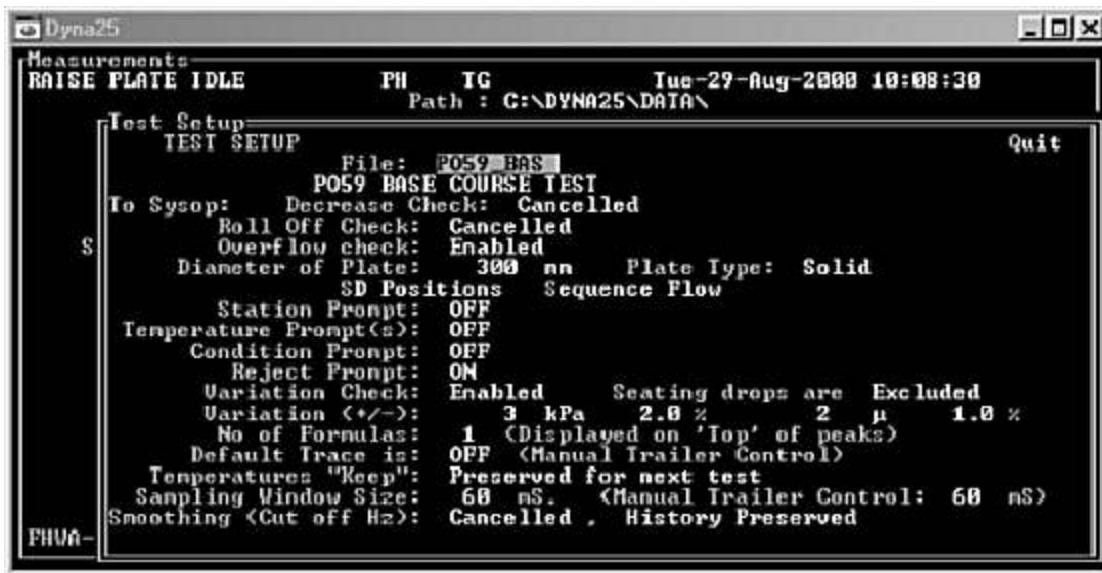


Figure G-1.22 Test Setup - P059 Base Course Test

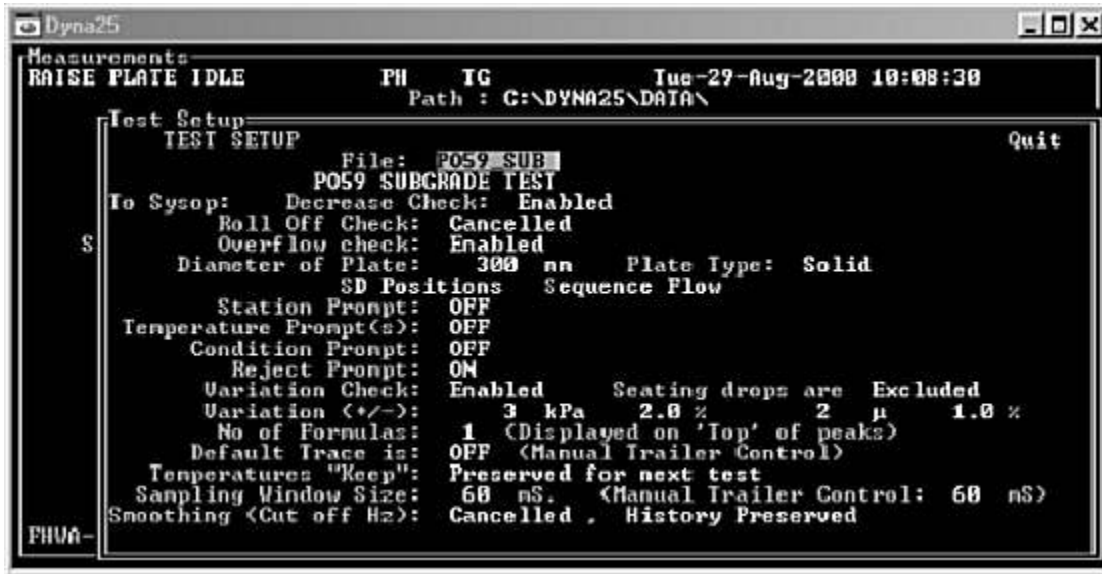


Figure G-1.23 Test Setup - P059 Subgrade Test

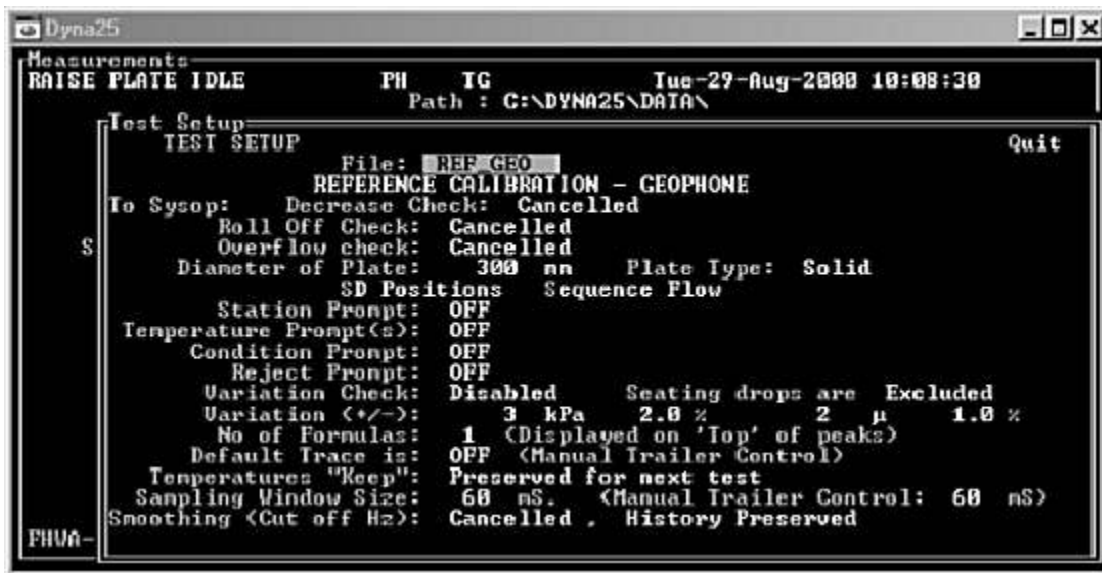


Figure G-1.24 Test Setup - Reference Calibration - Geophone