### Pavement Research Technical Guidelines

**For**

**Canadian Long Term Pavement Performance (C-LTPP)**

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ORGANIZATION
1.0 ORGANIZATION

The organizational structure of the Canadian Strategic Highway Research Program (C-SHRP) replicates some aspects of the Strategic Highway Research Program (SHRP), while also containing features to support the four components of C-SHRP. The program is organized and managed through several committees with responsibilities for overall coordination, management and execution of the program by the National Coordinator.

2.0 C-SHRP STAFF

2.1 National Coordinator

The National Coordinator is a full time staff member of the Roads and Transportation Association of Canada. He is responsible for the overall coordination, management and execution of the Program. His responsibilities include support of the committee operations, project management of contract research, management of agency executed projects, as well as the overall coordination of Canadian involvement in SHRP.

2.2 Visiting Researcher

A loaned staff member from a provincial highway agency. The Visiting Researcher provides technical assistance for the C-LTPP Study and other related complementary projects within C-SHRP. This person serves as a direct contact with pavement engineers from participating highway agencies in C-SHRP pavement studies.

2.3 Administrative Assistant

The Administrative Assistant is a full time staff member of the Roads and Transportation Association of Canada. She provides administrative and support services for C-SHRP.

3.0 HIGHWAY AGENCY STAFF

C-LTPP Contact Engineer
The C-LTPP Contact Engineer is the staff member designated by each participating highway agency to manage and coordinate the technical activities of the C-LTPP program in their jurisdiction. The engineer also serves as the contact person between C-SHRP and the agency for project implementation.

4.0 COMMITTEES

4.1 C-LTPP Project Committee

The C-LTPP Committee is made up of individuals considered to be experts in the area of pavements. These individuals are drawn from highway agencies and are selected to achieve a balance of regional and institutional representation. The committee is responsible for providing advice and guidance on the technical aspects of the C-LTPP project which includes field and laboratory testing, monitoring and data collection activities.

4.2 Advisory Committee

The Advisory Committee structure shadows similar committees within SHRP, for each of the four technical research areas. The advisory committees are comprised of individuals recognized for expertise in their field. These individuals are drawn from highway agencies, the academic community and the private sector, and are selected to achieve a balance of regional and institutional representation on each committee. Each advisory committee is responsible for providing advice and guidance on the technical aspects of activities within their discipline. These activities include the planning, implementation and execution of research projects as well as the monitoring, reviewing and interpretation of SHRP research.
4.3 Technical Steering Committee

The Technical Steering Committee is the primary operational Committee of the program. Each of the thirteen funding agencies of C-SHRP has appointed a coordinator to act as the first point of contact for their agency’s involvement in C-SHRP. These individuals are nominally the “State Coordinators” for provincial participation in SHRP. Collectively, the thirteen coordinators form the Technical Steering Committee. Also sitting on the committee as non-voting members, are the Canadian representatives on SHRP advisory committees, the Visiting Researcher to SHRP and the C-SHRP National Coordinator. The Technical Steering Committee is responsible for the overall technical content of the Program and for its delivery within the budgetary and policy guidelines set by the Executive Committee.

4.4 Executive Committee

The Executive Committee establishes the policies and procedures for the Program and provides the overall program direction. The committee is comprised of representatives from the standing councils of RTAC (Council on Highway Transportation Research and Development; Technical Council) and the major funding agencies of the Program. Its membership also includes the RTAC Director of Technical Programs and the chairman of the Technical Steering Committee. The chairman of the Executive Committee is selected from the membership of the RTAC Board of Directors.

5.0 SUMMARY

The C-SHRP organizational structure, the four components of C-SHRP program and the current membership (April, 1990) of the various committees are given in the following pages. The listings are given in this order:

- C-SHRP Organizational Structure
- C-SHRP Program
- C-SHRP Staff
- C-LTPP Contact Engineers
- C-LTPP Committee
- Pavements Advisory Committee
- Technical Steering Committee
- Executive Committee
C-SHRP PROGRAM

MONITORING
- National Coordination
- Newsletter
- Information Management
- Seminars and Conferences
- Committee Operations

INTEGRAL PROGRAM
- Visiting Researchers
- Contributions to SHRP Research Projects

COMPLEMENTARY PROGRAM
- Pavements
  - Pavement Response
    - C-LTPP
  - Bituminous Roads
- Asphalts
  - Quality Asphalts
- Highway Operations
  - Surface Defects
  - Ravelling Shoulders
- Concrete/Structures
  - Concrete Structures Rehabilitation
    - Shotcrete Rehabilitation
  - Epoxy Coated Rebar

TECHNOLOGY TRANSFER
- Pavements
- Asphalt
- Highway Operations
- Concrete and Structures
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CANADIAN LONG TERM PAVEMENT PERFORMANCE
PROJECT STATEMENT

GOAL

The overall project goal is to increase pavement life through the development of cost effective pavement rehabilitation procedures, based upon a systematic observation of in-service pavement performance.

OBJECTIVES

1. To evaluate Canadian practice in the rehabilitation of flexible pavements, and to subsequently develop improved methodologies and strategies.
   1.1 To evaluate the cost effectiveness of different rehabilitation strategies on targeted original pavements.
   1.2 To evaluate the effect of site condition on the performance of specific rehabilitation strategies.
   1.3 To develop a cost effectiveness framework for the selection of rehabilitation strategies for pavements, under all conditions.

2. To enhance the applicability in Canada of pavement performance prediction models developed by SHRP.
   2.1 To provide an independent data set for the validation of pavement models developed by SHRP.
   2.2 To develop a comprehensive data set sufficient to calibrate SHRP pavement prediction models, for application to Canadian conditions.
   2.3 To create a national database for development of independent Canadian prediction models.

3. To establish common methodologies for long term pavement evaluation, and to provide a national framework for continued pavement research initiatives.
   3.1 To develop and document national protocol and procedures for pavement evaluation and monitoring.
   3.2 To update Canadian pavement practice through the transfer of state of the art pavement evaluation techniques.
   3.3 To establish mechanisms whereby other research initiatives may interface with C-LTPP.
C-LTPP is the systematic observation of pavement performance and the creation of a national pavement database. The C-LTPP database will contain comprehensive characterization and performance data for a small core of pavement sections, strategically selected to emphasize performance factors of national interest.

**TARGETED PAVEMENTS**

- asphalt concrete pavements
- granular base courses
- scheduled for rehabilitation
- asphalt concrete overlays
- hot mix recycling
- milling

**MAJOR STUDY VARIABLES**

- traffic loading
- subgrade strength/susceptibility
- moisture availability
- freezing index
- condition prior to rehabilitation

**OTHER PROJECT CONSIDERATIONS**

- maximize agency participation
- independent results
- compatible with SHRP

Each test site will contain a minimum of two adjacent test sections. These sections will consist of the agency's designed rehabilitation treatment and a compatible alternative treatment(s). The use of paired test sections allows the population of monitoring sections to be greatly increased, without increasing the long term monitoring efforts.

The C-LTPP analysis plan includes paired comparisons of the adjacent sites, and statistical analysis of the factorial population, both with and without the input of SHRP data.
# Canadian Long Term Pavement Performance (C-LTPP)

## Test Site Sampling Matrix

<table>
<thead>
<tr>
<th>Environment</th>
<th>Wet</th>
<th>Dry</th>
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<tr>
<td>Low</td>
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<tr>
<td>Fine</td>
<td>Ontario</td>
<td>Quebec</td>
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<tr>
<td>Coarse</td>
<td>Ontario</td>
<td>Quebec</td>
</tr>
<tr>
<td>High</td>
<td>Ontario</td>
<td>Quebec</td>
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</tbody>
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| Low         |     |
| Fine        | 1   |
| Coarse      | 2   |
| High        | 3   |
| Dry         | 4   |

### Notes:
- **Ontario**
- **Quebec**
- **Nova Scotia**
- **New Brunswick**
- **British Columbia**

- **5 sites**
- **8 sites**
- **2 sites**
- **10 sites**

### Instructions:
- **Cell identification number**
- **Those jurisdictions having pavements under these cell conditions**
- **Minimum test sites required**
  - *3 OL* = three overlay sites having two test sections each
  - *2 OP* = two other paired test sites having recycled/milled sections
## PROJECT ACTIVITIES/RESPONSIBILITIES

<table>
<thead>
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<th>ACTIVITY</th>
<th>RESPONSIBILITY</th>
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<td>Materials Sampling</td>
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<td>Site Rehabilitation</td>
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## C-LTPP PRODUCTS

### OBJECTIVE 1
- Evaluation of rehabilitation practices
- Improved rehabilitation strategies
- Improved original pavement designs
- Quantification of environmental influence
- Improved life-cycle models
- Influence of original pavement condition on rehabilitation performance
- Determination of materials influence
- Influence of loading on rehabilitated pavements

### OBJECTIVE 2
- SHRP models calibrated to Canadian conditions
- Improved original pavement designs
- Quantification of environmental influence
- Improved life-cycle models
- Determination of materials influence
- Independent validation of SHRP models
- Influence of loading on rehabilitated pavements

### OBJECTIVE 3
- Standardization of pavement evaluation
- Upgrading of pavement evaluation methodologies
- Framework for national study on maintenance
- Establishment of a Canadian national pavement database
### REHABILITATION STRATEGIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Illustration</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>OL1</td>
<td>Thin Overlay</td>
<td></td>
<td>OL2</td>
</tr>
<tr>
<td>OL2</td>
<td>Thick Overlay</td>
<td></td>
<td>OL1</td>
</tr>
<tr>
<td>OL3</td>
<td>Milling + virgin overlay</td>
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<td>OL1, OL2</td>
</tr>
<tr>
<td>R1</td>
<td>Milling + hot mix recycled asphalt</td>
<td></td>
<td>OL1, OL2</td>
</tr>
<tr>
<td>R2</td>
<td>Milling + mixed recycled and virgin asphalt</td>
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<td>R3</td>
<td>Milling + hot mix recycled + virgin asphalt</td>
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<td>OL1, OL2, OL3, R1, R2</td>
</tr>
</tbody>
</table>

### ALTERNATIVE STRATEGIES (Associated experiments)
- Cold mix recycling
- Open graded overlay
- Innovative asphalt materials
- Innovative techniques

### C-LTPP: FIRST YEAR SCHEDULE

<table>
<thead>
<tr>
<th>Activity</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
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<td></td>
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</tr>
</tbody>
</table>

PC: Project Committee  
C-S: C-SHRP  
A: Host Agency  

- Minimum time required for an activity  
- Slack time
Site Selection
1.0 INTRODUCTION

The site selection criteria for the Canadian Long Term Pavement Performance (C-LTPP) study was adapted with modifications from the U.S. program to account for local and regional factors. The selection criteria address the immediate needs and priorities of Canadian highway agencies while allowing flexibility to adapt to changes. All highway agencies are encouraged to participate so that an extensive data base for pavement performance under different climatic, subgrade and traffic conditions can be developed.

2.0 TEST SITES

2.1 Site Selection

Test sites for C-LTPP will be selected from scheduled rehabilitation projects. Agencies are asked to review their 1989/1990 programs and complete the Candidate Project Form (Form SS1) for each suitable project. Form SS1 with instructions to complete are shown in the Appendix. To reduce the effort required for agencies in nominating projects, a "Possible Test Site Distribution" (Table 1) has been prepared which targets particular cells that can be filled by each agency.

The cells which are defined in Table 2 (Test Site Sampling Matrix), show the different conditions under which an agency can select sites to satisfy C-LTPP requirements. The Test Site Distribution table is a guide to aid in filling the minimum requirements for C-LTPP. Agencies should feel free to nominate as many sites as possible in the cells which will satisfy their interest.

2.2 Site Acceptance

A C-SHRP representative will meet with each agency after possible test sites have been identified. This meeting will consider any necessary adjustments to prevent the sampling population and discuss the compatible treatments (Table 3a) to be constructed as part of the rehabilitation strategy for the test sites. The field program and first year schedule (Table 3b) will also be discussed.

Once the C-LTPP requirements are met, C-SHRP will send the site acceptance form (Form SS2) for each site to the agency. This form will show the existing structure, the rehabilitation strategy and the C-SHRP assigned identification numbers.

2.3 Site Layout

The C-LTPP experiment is designed to maximize the possibilities in analyzing pavement performance while minimizing construction and monitoring efforts required. The C-LTPP concept, merges the principles of SHRP, GPS and SPS experiments and results in a strategic grouping of two or more test sections into well organized test sites. Figure 1 shows an illustrative example of a test site.

The test sites will be incorporated into scheduled rehabilitation projects, being built across Canada. The test sections at each site will consist of the highway agency's planned rehabilitation technique and one or more compatible alternatives. The alternatives will be achieved by modifying one or more aspect of the agency's design for short sections (150 m) within the overall project.

Modification of the agency design can be relatively simple, such as a change in overlay thickness, or more involved; changes in materials (virgin to recycled) or in surface preparation (milling).

The constituents of a test site are:

- The approach (150 m): Built using the basic (normal practice) rehabilitation strategy, this section has to be smooth and consistent to ensure a proper approach for high speed monitoring equipment and to normalize dynamic loading effects from normal on-line traffic.
- Section 1 (150 m): The first monitoring section is constructed using the basic rehabilitation strategy.
- Section 2 (150 m): The second section will be rehabilitated using a modified strategy compatible with the basic one.
- Section N (150 m): Additional section(s) may be built using other modified strategy(s) or alternative strategy(s) if the agency so chooses.
- Follow-out zone (75 m): This section acts as a transition zone protecting the test site from uncontrolled maintenance activities. The follow-out zone is preferably constructed using the same strategy as the last monitoring section.
- Transition zones (min. 10 m): These short sections will ensure smooth passage between different rehabilitation types. In cases where thicknesses are different, the difference in thickness will pinch out within the transition zone. In cases where thicknesses are the same and material are different, the joint between the two strategies will be in the middle of the transition zone. In normal cases, transition zones will not be required between the approach, follow-out and adjacent sections (same material and thicknesses). The transition zone length will be dependant upon the change in rehabilitation type.

### TABLE 1

<table>
<thead>
<tr>
<th>Agency</th>
<th>Sites</th>
<th>Overlay</th>
<th>Cell #</th>
<th>Recycle/Mill</th>
<th>Cell #</th>
<th>Total Sites</th>
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<td></td>
<td>2</td>
<td>8/4</td>
<td>3</td>
</tr>
<tr>
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<td>1</td>
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<td>2</td>
<td>2/6</td>
<td>3</td>
</tr>
<tr>
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<td>4/8</td>
<td></td>
<td>1</td>
<td>8</td>
<td>3</td>
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<td>1</td>
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<td>3</td>
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<tr>
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<td>-</td>
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<td>1/5/6</td>
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<td>5</td>
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<tr>
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<td>0</td>
<td>-</td>
<td>1</td>
</tr>
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<td>1/5</td>
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<td><strong>Total</strong></td>
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<td><strong>10</strong></td>
<td></td>
<td></td>
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<td><strong>30</strong></td>
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</table>

30 sites x 2 sections/sites = 60 test sections

Version 1.0
TABLE 2
Canadian Long Term Pavement Performance (C-LTPP)
Test Site Sampling Matrix

<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>FREEZING INDEX</th>
<th>SUBGRADE</th>
<th>TRAFFIC</th>
<th>WET</th>
<th>DRY</th>
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<tr>
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<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Ontario Quebec Nova Scotia New Brunswick British Columbia (3 OL/2 OP)</td>
<td>Ontario Quebec Nova Scotia Newfoundland New Brunswick British Columbia Prince Edward Island (3 OL/1 OP)</td>
</tr>
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<td>COARSE</td>
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<td>4</td>
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<td>Ontario Quebec Nova Scotia New Brunswick British Columbia Prince Edward Island (3 OL/2 OP)</td>
<td>Alberta Saskatchewan Manitoba Northwest Territories Yukon (3 OL/2 OP)</td>
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<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOW</td>
<td></td>
<td>Ontario Quebec Nova Scotia New Brunswick British Columbia (3 OL/2 OP)</td>
<td>Ontario Quebec Nova Scotia Newfoundland (3 OL/1 OP)</td>
</tr>
<tr>
<td></td>
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<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOW</td>
<td></td>
<td>Ontario Quebec Nova Scotia New Brunswick British Columbia (3 OL/2 OP)</td>
<td>Alberta Manitoba Saskatchewan (3 OL/2 OP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HIGH</td>
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<td>10 sites</td>
<td>8 sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>10 sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30 sites</td>
<td></td>
</tr>
</tbody>
</table>

- **Ontario** Quebec Nova Scotia New Brunswick British Columbia
- **cell identification number**
- those jurisdictions having pavements under these cell conditions
- minimum test sites required
- *3 OL = three overlay sites having two test sections each*
- *2 OP = two other paired test sites having recycled/milled sections*
# TABLE 3A
Rehabilitation Strategies

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Illustration</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>OL1</td>
<td>Thin Overlay</td>
<td></td>
<td>OL2</td>
</tr>
<tr>
<td>OL2</td>
<td>Thick Overlay</td>
<td></td>
<td>OL1</td>
</tr>
<tr>
<td>OL3</td>
<td>Milling + virgin overlay</td>
<td></td>
<td>OL1, OL2</td>
</tr>
<tr>
<td>R1</td>
<td>Milling + hot mix recycled asphalt</td>
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<td>OL1, OL2, OL3, R1, R3</td>
</tr>
<tr>
<td>R2</td>
<td>Milling + mixed recycled and virgin asphalt</td>
<td></td>
<td>OL1, OL2, OL3, R1, R2</td>
</tr>
<tr>
<td>R3</td>
<td>Milling + hot mix recycled + virgin asphalt</td>
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<td></td>
</tr>
</tbody>
</table>

**ALTERNATIVE STRATEGIES** (Associated experiments)
- Cold mix recycling
- Open graded overlay
- Innovative asphalt materials
- Innovative techniques

# TABLE 3B
C-LTPP: First Year Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
</tr>
</thead>
</table>

PC: Project Committee
C-S: C-SHRP
A: Host Agency

Minimum time required for an activity
...... Slack time

Version 1.0
SITE REQUIREMENTS

- Good visibility
- Absence of intersection and culvert
- Homogeneous soil type and condition

Illustrative Example of a Test Site

FIGURE 1

3.0 GENERAL PROVISIONS FOR SELECTION OF TEST SITES

The following presents criteria and guidelines for selecting candidate projects for inclusion in the Canadian long term monitoring program. While maintaining compatibility with SHRP, the criteria includes parameters and features identified by highway agencies as elements required to focus the program on Canadian needs, concerns and conditions.

3.1 General Project Criteria

3.1.1 Candidate projects must be relatively moderate in horizontal alignment and profile. Projects in which high degrees of curvature, steep grades, or deep cuts or fills are unavoidable should not be included. Safety issues, such as adequate sight distance, should be considered when selecting candidate projects.

3.1.2 Candidate projects should have at least one kilometre of continuous pavement between bridge abutments, large culverts, at-grade railroad crossings or other discontinuities.

3.1.3 Projects should experience uniform traffic movement over the one kilometre distance.
3.1.4 Projects should be 8-12 years old and be representative of the agency's pavement design practices.

3.2 Structural Criteria of Original Pavement

3.2.1 Surface Type: The program is restricted to dense graded hot mix asphalt concrete (HMAC) surface pavements which are planned for rehabilitation in 1989 or 1990.

3.2.2 Base Types: The program focuses upon pavements having untreated granular bases. For consistency with SHRP, one or more subbase (crushed or uncrushed gravel, sand, lime or cement treated fine grained soil) layers may be present, but are not required. Treated subgrades should be identified as subbase layers.

3.2.3 Subgrade Types: The study includes both coarse-grained, (AASHTO A-1 through A-3) and fine grained (AASHTO A-4 through A-7) subsoils. Subgrade material should be relatively constant over the one kilometre distance. If a treated subgrade is present it should be identified as a subbase layer.

3.2.4 Layer Thicknesses: Pavement surfaces which have been scarified by grinding, milling or other means for purposes other than preparation for subsequent rehabilitation should not be included as candidate projects. The total thickness of HMAC layer(s) must be equal to or greater than 100 mm and the total thickness of base and subbase layers (excluding treated subsoil layers) must be equal to or greater than 150 mm for the project to be acceptable.

3.3 Rehabilitation Criteria

3.3.1 Rehabilitation Strategies: The experiment will be populated by pavements being rehabilitated using hot mix asphalt concrete (HMAC) overlays. The HMAC must be mixed at a central plant. The HMAC overlay material may be virgin or may include recycled asphalt pavement (RAP). Where the HMAC is recycled, the RAP may be obtained either from the site or from existing off-site sources. Finally, the projects may incorporate milling of the original pavement surface (as part of the recycle process or as a surface preparation) prior to placement of the overlay.

3.3.2 The thickness of the overlay or recycled HMAC layer must be equal to or greater than 25 mm.

3.3.3 Timing for Rehabilitation: Pavements scheduled for rehabilitation in the near future (1989 or 1990) are acceptable, with the majority of sections scheduled for 1989.

3.3.4 Pavement surfaces that are at their first rehabilitation cycle since original constructed are acceptable.

3.3.5 Reasons for Rehabilitation: In order to strengthen the experimental analysis, projects must be receiving rehabilitation treatment as a result of general pavement deterioration due to the combined effects of load and environment. Pavements having singular or overwhelming warrants should not be submitted.

This provision, together with the age restriction is intended to eliminate special warrant rehabilitation projects triggered by excessive rutting, over or under designing, or isolated construction problems.

Projects within the experiment should exhibit a variety of distresses such as fatigue cracking, moderate rutting, thermal cracking, localized ravelling, etc. caused by the interaction of load and environment over a reasonable service life.

3.4 Environmental and Traffic Criteria

3.4.1 Environmental Parameters: Two parameters, annual average precipitation and annual average freezing index, will be used in the site selection process. Candidate project locations will be classified as wet or dry areas as specified by SHRP. Agencies are encouraged to select candidate sites at locations which encompass a range of annual average freezing indices experienced in their jurisdiction.
3.4.2 Traffic Loading: Projects currently subjected to at least 100 trucks per day, as determined from the product of the AADT and percent heavy trucks and combinations, are acceptable candidates for the experiments. Agencies are encouraged to select candidate projects which encompass a range of truck traffic loadings. Traffic will be classified either as low or high using 30 KESAL/Lane-Yr. for boundary. Safety issues, such as the effect of traffic volume on field sampling and data collection activities, should be considered when selecting candidate projects.

4.0 CONTRACTUAL CONSIDERATIONS

The construction of a C-LTPP test site will generate modifications to normal practice and is likely to have contractual implications. The following items, likely requiring special contractual provisions, are listed for agencies consideration.

- Drilling and sampling activities will take place on the site prior to rehabilitation. These activities include digging of a test pit, coring the original asphalt layer and drilling through the entire pavement structure. Repair of the affected areas may be needed prior to rehabilitation.

- Each test site will require extremely careful work on approximately 700m (one lane) of the rehabilitation project. This special work can be expected to be slower than normal work, to cause delays (changes in strategies) and to create some minor inconveniences (cold joints, loss of materials...). Construction schedules and quantities will have to be adapted accordingly.

- Each rehabilitation strategy used will involve minor localized changes in material specifications and/or thicknesses.

- Frequent transitions are required within specific areas while always achieving maximum smoothness through the transition.

- The project organization may have to accommodate additional engineers or technicians, involved in supervising test site construction and in undertaking preliminary marking of the test sections.

- Width of shoulders adjacent to the test site should be made sufficient to accommodate parked vehicles whenever possible, to ease subsequent operations related to monitoring activities.
APPENDIX
CANDIDATE PROJECT FORM INSTRUCTIONS

The following contains instructions for completing the Candidate Project Form. Copies of the forms, use one for each candidate project, follow this section of instructions. Topics described in the instructions are the same order as they appear on the data forms.

1. Jurisdiction: The highway agency submitting the candidate project.

2. Highway No.: The number assigned to the highway in which the project is located.

3. Project Location Description: A brief description of project location. For example, between junctions of highways 21 and 816, approximately 16 km east of Halifax.

4. Project Length: The length of the project to the nearest tenth of a kilometre.

5. Year Original Pavement Surface Opened to Traffic: The year the original, non-rehabilitated, pavement was opened to traffic.

6. Year Rehabilitation Planned: Pavement surfaces must be planned for rehabilitation in the near future (1989 or 1990). Pavement surfaces rehabilitated since they were originally constructed are not acceptable.

7. Planned Rehabilitation Strategy:
   a) Indicate whether or not milling of the original pavement surface is planned in conjunction with the rehabilitation. When appropriate, include the depth of milling planned.

   b) Characterize the overlay material as either virgin or recycled, where recycled mixes may contain some virgin aggregate and asphalt. If the rehabilitation calls for a lift of recycled material to be overlain by a lift of virgin HMAC, check the third box, "both virgin and recycled HMAC layers."

   c) For recycled mixes, report the percentage of recycled material used in the mix design and indicate whether the recycled material will be obtained from the site or from an offsite location.

8. Layer Description of Planned Rehabilitated Pavement: As many as eight layers may be identified. Layer number 1 is the subgrade soil and the last layer is the surface layer of the rehabilitated pavement. For all structures, the upper most layer will be a HMAC layer. (virgin or recycled).

Layer Description Codes: Code numbers to be used to describe component layers of the rehabilitated structure are as follows:

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Code Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMAC Overlay</td>
<td>1</td>
</tr>
<tr>
<td>Seal Coat</td>
<td>2</td>
</tr>
<tr>
<td>Original HMAC Surface Layer</td>
<td>3</td>
</tr>
<tr>
<td>HMAC Layer(s) below Original Surface Layer</td>
<td>4</td>
</tr>
<tr>
<td>Base Layer</td>
<td>5</td>
</tr>
<tr>
<td>Subbase Layer</td>
<td>6</td>
</tr>
<tr>
<td>Subgrade</td>
<td>7</td>
</tr>
<tr>
<td>Interlayer</td>
<td>8</td>
</tr>
<tr>
<td>Porous Friction Course</td>
<td>9</td>
</tr>
</tbody>
</table>

Version 1.0
NOTES:

(1) HMAC layer(s) below the original pavement surface having different mix characteristics than the original HMAC surface layer should be identified as Code 4.

(2) Separate lifts having the same mixture are not to be identified as separate layers.

(3) Treated subgrade soil layers should be reported as subbase layers (Code 6).

Thickness: The thickness of each component layer to the nearest millimetre. The layer thickness may be provided from as-built plans and project files. Estimated thicknesses from these sources coupled with those of the planned rehabilitation activity will suffice.

Material Type Classification Code: A code number identifying the type of material in each layer of the pavement structure, including the subgrade, is required. Material code numbers for pavement surface, base and subbase layers are presented in Table 4. Material code numbers for subgrade soils, thin seals and interlayers, are given in Tables 5a and 5b, respectively.

9. Number of Through Lanes: The total number of through lanes (exclusive of access roads) in each direction.

10. Lane Width of Rehabilitated Structure: The width of each lane to the nearest tenth of a metre.

11. Shoulder Type of Rehabilitated Structure: Identify whether the shoulders of rehabilitated structure are paved or unpaved.

12. Shoulder Widths: The width of the shoulders to the nearest tenth of a metre. Identify inside outside lane shoulder widths of candidate projects on divided highways.

13. Maintenance Effort: Indicate whether or not maintenance of the original surface involved sealing all cracks on a routine basis to minimize penetration of moisture.

14. Average Annual Total Precipitation: The average annual total precipitation, expressed in terms of millimeters of rainfall, in the vicinity of the project (10 mm of snowfall = 1 mm of rainfall). Sources of this information are Meteorological Stations and “Canadian Climatic Normals”, publications of the Canadian Climate Program, Atmospheric Environment Services, Environment Canada.

15. Average Annual Freezing Index: The average annual air freezing index, expressed in °C-days, in the vicinity of the project (1°C-day = 1.8°F-days). A distribution of mean freezing index values for Canada is shown as isolines in Figure 2. This figure should only be used to estimate FI values when more accurate, local information is unavailable. Note: Isolines in figure are in °F-days.

16. Traffic Data: Traffic data requirements include average annual daily traffic, percent heavy vehicles and an estimate of equivalent single axle loads (ESALS). The traffic volumes should be specific to the location of the project or obtained from a nearby site on the same highway having similar traffic characteristics.

Year of Count: The year of the traffic count from which the traffic information was obtained. This should be the most recent year possible.

Average Annual Daily Traffic: The two-way annual average daily traffic volume, all vehicles, across all lanes.

Percent Heavy Trucks and Combinations: The percentage of trucks in the AADT, excluding all pickups, panels and other two-axle four tire trucks. This percentage should be a site specific estimate.
<table>
<thead>
<tr>
<th>Layer Description</th>
<th>Layer Description Code</th>
<th>Material</th>
<th>Material Classification Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade</td>
<td>7</td>
<td>Fine-grained</td>
<td>See Table 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coarse-grained</td>
<td></td>
</tr>
<tr>
<td>Subbase and Base</td>
<td>6 and 5</td>
<td>Gravel (Uncrushed)</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crushed stone, gravel or slag</td>
<td>23</td>
</tr>
<tr>
<td>Layer(s) respectively</td>
<td></td>
<td>Sand</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil/Aggregate</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bituminous treated Soil/Aggregate (Mixed in Place)</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cold Mix Asphalt Concrete (Plant Mix)</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement Treated Base (Mixed in Place)</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lean Concrete (Less than 3 sacks of Cement/0.75 m³)</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lime-Treated Subgrade</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement-treated Subgrade</td>
<td>37</td>
</tr>
<tr>
<td>Original Subsurface HMAC Layer(s)</td>
<td>4</td>
<td>HMAC</td>
<td>28</td>
</tr>
<tr>
<td>Original HMAC Layer</td>
<td>3</td>
<td>HMAC</td>
<td>01</td>
</tr>
<tr>
<td>Overlay HMAC Layer(s)</td>
<td>1</td>
<td>HMAC</td>
<td>01</td>
</tr>
<tr>
<td>Recycled HMAC Layer(s)</td>
<td>1</td>
<td>HMAC</td>
<td>10</td>
</tr>
</tbody>
</table>
## Table 5a

### Material Type Classification Code Numbers for Subgrade Soils (after, SHRP)

<table>
<thead>
<tr>
<th>Soil Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fine-Grained Subgrade Soils:</strong></td>
<td></td>
</tr>
<tr>
<td>Clay (Liquid Limit &lt; 50)</td>
<td>51</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>52</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>53</td>
</tr>
<tr>
<td>Silt</td>
<td>54</td>
</tr>
<tr>
<td>Sandy Silt</td>
<td>55</td>
</tr>
<tr>
<td>Clayey Silt</td>
<td>56</td>
</tr>
<tr>
<td><strong>Coarse-Grained Subgrade Soils:</strong></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>57</td>
</tr>
<tr>
<td>Poorly Graded Sand</td>
<td>58</td>
</tr>
<tr>
<td>Silty Sand</td>
<td>59</td>
</tr>
<tr>
<td>Clayey Sand</td>
<td>60</td>
</tr>
<tr>
<td>Gravel</td>
<td>61</td>
</tr>
<tr>
<td>Poorly Graded Gravel</td>
<td>62</td>
</tr>
<tr>
<td>Clayey Gravel</td>
<td>63</td>
</tr>
<tr>
<td>Shale</td>
<td>64</td>
</tr>
<tr>
<td>Rock</td>
<td>65</td>
</tr>
</tbody>
</table>

## Table 5b

### Material Type Classification Code Numbers for Surface Seals and Interlayers (after, SHRP)

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip Seal Coat</td>
<td>71</td>
</tr>
<tr>
<td>Slurry Seal Coat</td>
<td>72</td>
</tr>
<tr>
<td>Fog Seal Coat</td>
<td>73</td>
</tr>
<tr>
<td>Porous Friction Course</td>
<td>74</td>
</tr>
<tr>
<td>Woven Fabric</td>
<td>75</td>
</tr>
<tr>
<td>Nonwoven Fabric</td>
<td>76</td>
</tr>
<tr>
<td>Stress Absorbing Membrane Interlayer</td>
<td>77</td>
</tr>
<tr>
<td>Thin Asphalt Concrete Interlayer</td>
<td>78</td>
</tr>
<tr>
<td>Gravel Interlayer</td>
<td>79</td>
</tr>
<tr>
<td>Open-Graded Asphalt Interlayer</td>
<td>80</td>
</tr>
</tbody>
</table>
Equivalent Single Axle Loads/Lane/Year: The estimated number of 8.1 kN (18 kip) equivalent single axle loads (in thousands) applied to the outer lane during a given year. Estimated ESALS based on local loadometer or weigh scale data should be used if available. If not, the following expressions may be used for these estimates (SHRP).

<table>
<thead>
<tr>
<th>No. of Lanes In Each Direction</th>
<th>ESAL/Year/Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>138.6 AP</td>
</tr>
<tr>
<td>2</td>
<td>138.6 AP $[1.57 - 0.083 \ln(A/2)]$</td>
</tr>
<tr>
<td>3 (or more)</td>
<td>138.6 AP $[1.44 - 0.083 \ln(A/2)]$</td>
</tr>
</tbody>
</table>

where:  
A = AADT in 2 Directions  
P = Percent Trucks/100

Note:  
1000 Degree Days Fahrenheit = 555 Degree Days Celsius  
— Southern boundary of continuous permafrost  
—— Southern boundary of discontinuous permafrost

Normal Freezing Index for Canada in Degree Days Fahrenheit  
based on the period 1931 to 1960  

FIGURE 2
17. Compatible Rehabilitation Strategies Planned: Indicate your agency's preliminary plans for altering the as-planned rehabilitation treatment, in order to establish the required test section.

18. Alternative Strategies Considered: Identify any additional (optional) sections which are being considered in addition to those required for C-LTPP.

19. Comments: Report any information such as the presence of weigh station, etc. or any characteristic of the site that could influence the experiment.
CANADIAN LONG TERM PAVEMENT PERFORMANCE (C-LTPP) 
CANDIDATE PROJECT FORM

1. Jurisdiction: ___________________________________

2. Highway Number: ________________________

3. Project Location Description: ___________________________________

4. Project Length (km): ________________________

5. Year Original Pavement Opened to Traffic ___________________________________


7. Planned Rehabilitation Strategy
   - milling ☐ Yes ☐ No
   - overlay material ☐ virgin HMAC only
     ☐ recycled HMAC only
     ☐ both virgin and recycled HMAC layers
   - recycled mix ☐ RAP obtained from site
     ☐ RAP imported
     percentage of RAP in mix: _______
     ☐ not applicable

8. Layer Description of Planned Rehabilitated Pavement Structure:

<table>
<thead>
<tr>
<th>Layer Number</th>
<th>Layer Description Code</th>
<th>Layer Thickness (mm)</th>
<th>Material Type Classification Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subgrade (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Number of Through Lanes (One Direction): __________

10. Lane Width of Rehabilitated Structure (m):

11. Shoulder Type of Rehabilitated Structure: Paved ☐ Unpaved ☐

12. Shoulder Widths (m)
   Inside: __________  Outside: __________

13. Maintenance Effort Applied to Original Pavement Surface:
    All Cracks and Joints Sealed At All Times? Yes ☐ No ☐

14. Average Annual Total Precipitation at Vicinity of Site (mm): __

15. Average Annual Freezing Index at Vicinity of Site (°C-days): __

16. Traffic Data:

<table>
<thead>
<tr>
<th>Year of Count</th>
<th>Average Annual Daily Traffic</th>
<th>% Heavy Trucks and Combinations</th>
<th>ESAL/Lane-Yr (Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Compatible Rehabilitation Strategies Planned
   ☐ change in thickness
   ☐ change in mix (virgin to recycle or recycle to virgin)
   ☐ change in preparation (mill to no mill - no mill to mill)

18. Alternative Strategies Considered

19. Comments:

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

Version 1.0
C-LTPP Test Site Acceptance

REHABILITATION STRATEGIES
(YEAR ____________)

TEST SECTION 1  TEST SECTION 2  TEST SECTION 3  TEST SECTION 4

C-SHARP ID  C-SHARP ID  C-SHARP ID  C-SHARP ID

EXISTING STRUCTURE

Version 1.0
Test Site Identification

This guideline is based upon a similar document published by the Strategic Highway Research Program for the General Pavement Studies of the Long Term Pavement Performance initiative.

Version 1.0
A. TEST SITE ORGANIZATION

1.0 General Site Layout

The C-LTPP experiment is designed to maximize the possibilities in analyzing pavement performance while minimizing construction and monitoring efforts required. The C-LTPP concept, merges the principles of SHRP, GPS and SPS experiments and results in a strategic grouping of two or more test sections into well organized test sites (Figure 1).

The test sites will be incorporated into scheduled rehabilitation projects, being built across Canada. The test sections at each site will consist of the highway agency’s planned rehabilitation technique and one or more alternative treatments which vary some aspect of the agency’s design for short sections (150 m) within the overall project.

Modification of the agency design can be relatively simple such as a change in overlay thickness, or more involved; changes in materials (virgin to recycled) or in surface preparation (milling).

The constituents of a test site are the following:

- The approach (150 m): Built using the basic (normal practice) rehabilitation strategy, this section has to be smooth and consistent to insure a proper approach for high speed monitoring equipment and to normalize dynamic loading effects from on-line traffic.

- Section 1 (150 m): The first monitoring section is constructed using the basic rehabilitation strategy, as designed by the agency.

- Section 2 (150 m): The second section will be rehabilitated using a modified strategy, compatible with the basic one.

- Section N (150 m): Additional section(s) may be built using other modified strategy(s) or alternative strategy(s) if the agency so chooses.

- Follow-out zone (75 m): This section acts as a transition zone protecting the test site from uncontrolled maintenance activities. The follow-out zone is preferably constructed using the same strategy as the last monitoring section.

- Transition zones (min. 10 m): These short sections will insure smooth passage between different rehabilitation types. In cases where thicknesses are different, the change in thickness will be achieved gradually over the transition length. Where thicknesses are the same but materials are different, the joint between the two strategies will be in the middle of the transition zone. In normal cases, transition zones will not be required between the approach, follow-out and adjacent sections (same material and thicknesses). The transition zone length will be dependant upon the length required to achieve the change in rehabilitation type. Transition zones can also be used to avoid discontinuities in the section, such as culverts.

2.0 Test Site Location

Each test site description file should include two type of geographic reference.

- The site should be identified on a 8 1/2 x 11" photocopy section of the provincial/territorial map outlining routes and distances to major cities.

- The site should also be referenced by odometer to the nearest geographic marker (intersection, bridge, etc.).
3.0 Site Plan

As soon as all the required information is available, a detailed plan of each test site should be drawn. The test site plan should be reported on the form provided (Figure 2) and should include the following information:

- Rehabilitation strategy for each section (pavement structure)
- Transition zone lengths
- Geographic references

Illustrative Examples of Test Site

FIGURE 1
Test Site Plan

FIGURE 2

Date

* indicate north on the plan

* indicate travel direction for each lane

Approach 150m or _______ m

Test Site 719 m

C-SHRP ID

Test Section 1

C-SHRP ID

Follow-out 75m

Test Section 3

C-SHRP ID

Test Section 2

C-SHRP ID

10m

12m

22m

contract number
project length, description of contracted rehabilitation

distance and description to nearest geographic reference

Transition zones

* indicate north on the plan
B. SIGNING AND MARKING

4.0 General

The physical marking of test sections must accomplish three important functions. Firstly, it must permanently affix the location of each test section on the ground to guarantee that annual measurements and tests are performed on the same section of pavement. Secondly, the marking must be visible to crews carrying out various monitoring activities to ease locating the proper sites and in referencing discrete test points within the section. Lastly, the marking must provide some control function to prevent unwanted maintenance activities from being performed on the section and ruining the test.

5.0 Sign Locations and Details

5.1 A reflectorized sign, designated Sign A, should be installed facing the traffic, 150 m in advance of the first test section as shown in Figure 3. This sign will help inform the public and alert testing crews to the proximity of the test site.

5.2 A sign, designated Sign B, should be installed parallel to traffic direction at the edge of right-of-way exactly at the beginning of each test section as shown in Figure 3. This sign will serve as a long-lasting marker of the test section.

5.3 A reflectorized sign, designated sign C, should be installed facing the traffic, 75 m after the last test section as shown in Figure 3. The sign will indicate the end of maintenance control zone.

(Details of Signs A, B and C are shown in Figures 4, 5 and 6.)

5.4 Delineators with 3 and 2 Red reflectors (or consistent with agency practice) should be installed at the beginning and end of each test section, respectively, as shown in Figure 3. These delineators should be of the break-away variety and located a distance from the shoulder edge in accordance with agency requirements.

6.0 Marking Locations and Details

6.1 The test site should be marked (optional) by two white paint stripes, not less than 15 cm wide, across the test lane. The stripes should be located exactly at the beginning and end of the test site, as shown in Figure 1. This marked area constitutes the maintenance control zone.

6.2 Each test section will be identified by a C-SHRP ID number. The ID number should be painted at the beginning of each test section near the outside shoulder, as shown in Figure 7. The ID number will be designated by C-SHRP.

6.3 Each test section will be divided into five, 30 m long subsections. Therefore, "crosses" should be painted at the beginning of the test section and every 30 m, and marked consecutively with the numbers 0, 1, 2, 3, 4 and 5, as shown in Figure 7. The numbers "0" and "5" should be painted at the beginning and end of test section, respectively. Approximately 15 cm high letters should be used.

6.4 Surface markings will be lost during rehabilitation of the test site. Therefore, it is suggested that temporary stripes, crosses and numbers (with spray can) be applied during the site identification visit and that all surface references be restored with paint or tape after rehabilitation.
7.0 Permanent Referencing

- Monuments, in the forms of nails, spikes, or rebars, should be installed in the shoulder, exactly at the beginning and end of each test section, as shown in Figure 3. These monuments will serve as a permanent section marker in case of sign loss or paint wear.

General Layout of Test Site Showing Sign Locations

FIGURE 3
PAVEMENT TEST SITE

**PAVEMENT TEST SITE (ID # )**

PROV LOGO

<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>60 x 75</th>
<th>BACKGROUND</th>
<th>BORDER</th>
<th>MESSAGE/SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td></td>
<td>WHITE</td>
<td>RED</td>
<td>RED</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sign A Details

**FIGURE 4**
<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>60 x 75</th>
<th></th>
<th></th>
<th>COLOUR</th>
<th>BACKGROUND</th>
<th>BORDER</th>
<th>MESSAGE/SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WHITE</td>
<td>RED</td>
<td>RED</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sign A Details

FIGURE 4
C-SHRP SECTION
(ID #)

PROV LOGO

<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>24 x 30</th>
<th>C O L O U R</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td></td>
<td>BACKGROUND</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td></td>
<td>WHITE</td>
</tr>
</tbody>
</table>

Sign B Details

FIGURE 5

Version 1.0
SECTION D'ESSAI SUR LA CHAUSSÉE

SECTION C-SHRP
(ID # )

LOGO
PROV

<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>24 x 30</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td>BACKGROUND</td>
<td>BORDER</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td>WHITE</td>
<td>RED</td>
</tr>
</tbody>
</table>

MESSAGE/SYMBOL | RED |

Sign B Details

FIGURE 5

Version 1.0
<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>60 x 75</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td></td>
<td>BACKGROUND</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td></td>
<td>WHITE</td>
</tr>
</tbody>
</table>

Sign C Details

FIGURE 6

Version 1.0
FIN DU SITE D'ESSAI SUR LA CHAUSSEE

<table>
<thead>
<tr>
<th>DIMENSIONS (cm)</th>
<th>60 x 75</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION REFERENCE</td>
<td></td>
<td>BACKGROUND RED</td>
</tr>
<tr>
<td>ENLARGEMENT FACTOR</td>
<td></td>
<td>BORDER RED</td>
</tr>
</tbody>
</table>

LOGO PROV

Sign C Details

FIGURE 6

Version 1.0
Details of Monitoring Section Paint Configuration

FIGURE 7
Materials Sampling and Testing
Preface

This materials sampling and testing guidelines have been prepared for Provincial Highway Agencies (PHA) which are responsible for field sampling, field testing, sample handling and laboratory tests of materials.

The guidelines provide basic information on C-LTPP sites, field sampling and testing, field operations, laboratory testing, maintaining records and coordinating and scheduling.

Quality reliability and consistency of material samples, field and laboratory testing and test data will be ensured if all agencies follow these guidelines. The test results will be extended to and correlated with the results from the SHRP LTPP sites.
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   1.2 Outline of Activities
   1.3 Coordination
   1.4 Safety

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   2.2 Sample Handling and Packaging
   2.3 Coring of Asphalt Layers
   2.4 Boring for Bulk Samples
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   2.6 General Provisions

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   3.2 Raw Materials
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Appendix C – Construction Data (Rehabilitated Pavement) Form
Appendix D – Provincial Codes
Appendix E – Materials Testing Data Forms
Appendix F – Terminology for Pavements and Soils

Version 1.3
1.0 INTRODUCTION

1.1 Purpose

The Canadian Long Term Pavement Performance (C-LTPP) study is a complementary part of the larger SHRP.

The overall project goal is to increase pavement life through the development of cost effective pavement rehabilitation procedures, based upon a systematic observation of in-service pavement performance. To accomplish this, several objectives were set by the Canadian Strategic Highway Research Program (C-SHRP):

- to evaluate Canadian practice in the rehabilitation of flexible pavements, and to subsequently develop improved methodologies and strategies
- to evaluate the cost effectiveness of different rehabilitation strategies on targeted original pavements
- to evaluate the effect of site condition on the performance of specific rehabilitation strategies
- to develop a cost effective framework for the selection of rehabilitation strategies for pavements, under all conditions

To fulfill these objectives, the C-LTPP study must provide a viable linkage between material properties and long term pavement performance. This program is also necessary to allow proper evaluation of pavement design techniques within a specified time.

1.2 Outline of Activities

Field material sampling and field testing of sites are an integral part of C-LTPP. Provincial Highway Agencies (PHA) under the operations control of the authorized C-SHRP representative will perform the following work:

1. Provide site identification data (Form MT1, Appendix E).
2. Cooperation and coordination with agency staff and private contractors (if they are used) to provide traffic control, test pit restoration and patching.
3. Layout of sampling and coring locations based on drawings and instructions provided in this plan.
4. Drilling of AC.
5. Bulk sampling of untreated base, subbase and subgrade materials for moisture content, density and classification.
6. Shelby tube and/or splitspoon sampling of subgrade.
7. Sawing and other methods of removal of AC or treated layers at test pits.
8. In situ moisture and density tests using nuclear gauges on untreated bases, subbases and subgrade at test pits.
9. Field CBR tests on untreated bases, subbases and subgrade at test pits.
10. Detailed logging of each exploration.
11. Preparation of a summary report for each site.
12. Marking, packaging and shipping of all materials designated for laboratory testing and storage.

Version 1.3
13. Clean up and disposal of debris from drilling and bulk sampling.

14. Reconstruction of the test pit with material similar to the material that was removed (subbase, base and AC).

15. Coordination with the C-LTPP Engineer regarding schedule, scope-of-work and other technical details including other field monitoring operations (strength, distress, profile).

16. Sampling of materials used for rehabilitation.

17. Documentation of construction activities associated with rehabilitation.

18. Keep accurate records, handle sample, follow report procedures and test methods.

19. Perform laboratory test on field materials samples according to recognized standards (AASHTO, ASTM).

20. Report laboratory test results (the use of in-house forms to document the performance and results is encouraged).

The product of the C-LTPP field sampling and field testing will be the samples for each test section. These samples will be properly packaged and shipped to the provincial agency’s laboratory. The laboratory will test each sample and provide data for the national database. The in-situ nuclear moisture/density and CBR tests will also be used for the national database. Specially selected sites will be chosen later to represent sites in each region, on which specialized tests (resilient modulus, tensile strength, and creep compliance) will be conducted. At these sites the seasonal variation in strength will be better assessed.

1.3. Coordination

Efficient and timely conduct of the field material sampling and field testing activities will require a clear understanding of the administrative, supervisory, and operational responsibilities of the various agency personnel to provide the necessary close coordination between agencies and the scheduling of the activities.

The C-SHRP Pavements Engineer is responsible for the administration and management of all C-LTPP sites and for resolving questions and concerns that may arise during the day-to-day operations.

The PHA C-LTPP Engineer will ensure that the drilling and sampling contractor or another staff engineer will provide primary on-site supervision during the drilling and sampling operations at the work site at all times. Specific responsibilities include:

- arranging for coordination and scheduling of the work.
- including provisions for traffic control at the test section.
- coordination and scheduling of the other testing and monitoring methods (photo logging, Dipstick, FWD, Benkelman Beam).
- authorizing minor on site changes in work based on conditions encountered.
- implementing quality control and quality assurance procedures.
- obtaining photo documentation of exposed pavement layers in test pits.
- providing initial approval of work completion forms.

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The initial coordination activity will be a meeting in the province involving the PHA staff including the designated authorized C-LTPP Engineer, and the drilling and sampling contractor representatives. The names, addresses and telephone numbers of appropriate personnel will be exchanged. The scope of work, general locations of pavement test sections, schedules, PHA participation, duties and responsibilities of supervisory personnel, permits, reports, legal requirements and other concerns will be discussed. In the event that the PHA does their drilling and/or sampling, their work should be controlled by the C-LTPP Engineer on site.

The names, addresses, telephone numbers, and FAX numbers of the various personnel involved in the drilling and sampling activities will be provided.

Other information to be provided to the drilling and sampling personnel by the PHA include:

- Maps showing specific locations of test sections.
- Expected conditions at each test section such as type of pavement, layer thicknesses and location of utilities.
- Possible changes in scope of work including the need for contractor provided traffic control and test pit excavation.
- Standard C-SHRP forms for scheduling, data collection, and reporting of work accomplished as shown in Appendix A; a reproducible set of the forms printed single sided; and an example of completed forms.
- List of C-SHRP terminology and abbreviations to be used in boring logs and other reports (Appendix F).

Arrangements for traffic control, test pit excavation, test pit restoration and pavement patching will be on a province-by-province basis.

An essential activity of the field sampling and testing activity is the establishment and continuous communication with the PHA with regard to such items as planning, scheduling, responsibilities, and safety. A planning meeting to initiate this communication and coordination should be held in each province in advance of any field operations.

Daily coordination will occur in the field between the drilling and sampling contractor's crew chief and the C-LTPP Engineer in cooperation with the C-SHRP Engineer and PHA personnel. The crew chief must have the authority to respond to short-notice requests by the C-LTPP Engineer for overtime, standby time, nights or weekend work. The crew chief should contact the C-LTPP Engineer for the status and any possible changes in the schedule. By early afternoon of the day before the scheduled activities, the crew chief should recontact the appropriate personnel to confirm the schedule.

1.4 Safety

Any time drilling, sampling and testing activities are being performed on highway pavements, the safety of the operating crews as well as the travelling public is of the utmost importance. A comprehensive safety plan shall be developed and implemented throughout the drilling and sampling contract. The safety plan shall identify PHAs, drilling and sampling contractor, and other local requirements with regard to reflectorized vests, hard hats, safety glasses, adequate clothing, (including footwear) and first aid equipment. Standard operating procedures for drilling and sampling should be prepared and field crews will be made aware of PHA safety requirements. Where traffic control is provided by the drilling and sampling contractor, procedures will be as required by the PHA or other traffic control agency.

Visitors to the site will not be permitted within 6 m of drilling equipment.

Care should be exercised to minimize water from the drilling activities encroaching on pavement surfaces open to traffic. In case of freezing conditions, de-icing chemicals must be provided to prevent the formation of ice around the drilling operations and the pavement.
2.0 SAMPLING AND TESTING PRIOR TO REHABILITATION

2.1 General Procedures

2.1.1 The general procedures expected to be followed for each site are:

a) Upon arrival at the site, the C-LTPP Engineer will verify site limits and traffic control availability.

b) Lay out the initial sample location and commence the coring. Layout the remaining locations and continue sampling and testing.

The basic sampling and testing sequence of operations will be:

- Cutting and removal of pavement at the test pit location.
- Testing and sampling at the test pit location.
- Coring and augering at opposite end of test site.
- Bulk sampling, moisture, density and bearing ratio testing in the test pit as layers are removed.
- Split spoon and/or Shelby tube sampling as directed by the C-LTPP Engineer

- Variations of this procedure may be made by the Contractor or C-LTPP Engineer to optimize the efficiency of the operations. If any core/borehole location is unacceptable an alternate location should be selected and marked on the layout plan.

c) Complete any authorized extra work as applicable to the specific test section. This work may be completed on subsequent days, after approval by the C-LTPP Engineer.

d) Coordinate field monitoring tests (profile, distress, strength) which may be occurring at the same time.

e) Report any problems not covered by previous instructions to the C-SHRP Engineer and obtain further instruction.

f) Prepare samples for shipping, complete logs and other records and cleanup work.

An example schedule of activities is shown in Figure 2.1.

2.1.2 The C-LTPP Engineer will provide maps showing the C-SHRP identification (ID) number and the specific monitoring sections including the roadway designation, direction of traffic, lane number and a land marker for each zone. Preliminary data sheets, will also be provided for each section describing the expected conditions such as pavement type and layer thicknesses. The general layout of a site is presented in Figure 2.2. It shows the length of occupancy will be a minimum of 535 m (2 test sections) made up of a 150 m approach, a 150 m test section, a 10 m transition, a second 150 m section, and a 75 m follow-out. The transition may be longer depending on the thicknesses of the two sections. Two test sections are required per site but more sections could be added by PHA. The field sampling and testing will be done in the approach and transition wherever possible. In Figures 2.3 to 2.6, the sampling locations for the test sections are shown. The three 150 mm cores for sampling the AC can be taken either before the overlay is applied and again after it has been compacted or, all at once after the rehabilitation has been completed. In the event that there are more than two sections, a set of cores (or two sets) will be taken between each section in the transition.
<table>
<thead>
<tr>
<th>Activities</th>
<th>Time, hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up traffic control and locate test sections</td>
<td></td>
</tr>
<tr>
<td>Coring and boring sample Locations, C1, C2, C3, A1</td>
<td></td>
</tr>
<tr>
<td>Sawing AC and preparing base for tests</td>
<td></td>
</tr>
<tr>
<td>Moisture, density, bearing ratio tests on base, bulk sample, prepare subbase for tests</td>
<td></td>
</tr>
<tr>
<td>Moisture, density, bearing ratio tests on subbase, bulk sample, prepare subgrade for tests</td>
<td></td>
</tr>
<tr>
<td>Moisture, density, bearing ratio tests on subgrade, bulk samples, prepare subgrade for boring</td>
<td></td>
</tr>
<tr>
<td>Coring and boring, sample transitions, C4, C5, C6</td>
<td></td>
</tr>
<tr>
<td>Coring and boring of subgrade in test pit</td>
<td></td>
</tr>
<tr>
<td>Logging, labeling and packaging of samples</td>
<td></td>
</tr>
<tr>
<td>Backfill and Patching</td>
<td></td>
</tr>
<tr>
<td>Shipping Samples</td>
<td></td>
</tr>
<tr>
<td>Travel</td>
<td></td>
</tr>
</tbody>
</table>

Example of Schedule of Activities

FIGURE 2.1
General Layout of Test Site

FIGURE 2.2
Sample Locations for First Test Section

FIGURE 2.3
Sample Locations for Last Test Section

**FIGURE 2.4**

1. **NOT TO SCALE**
2. 75m FOLLOW OUT
3. 1.2m
4. 1.8m
5. TP
6. TP
7. 1.2 x 1.8m test pit into subgrade. Test pit excavation, density, moisture, bearing tests, removal of AC, bulk samples
8. 150mm core of original AC surface C4, C5, C6
9. LAST 150m MONITORING SECTION
10. OUTRER WHEEL PATH
11. TRANSITION
12. C6, C5, C4
13. 600 600
Sampling of Intermediate Sections
(where more than two sections exist)

FIGURE 2.5
LEGEND

N ........ NUCLEAR MOISTURE AND DENSITY TEST (ON AC BASE, SUBBASE AND SUBGRADE
J ........ JAR MOISTURE SAMPLE
B ........ BULK SAMPLE
R ........ BEARING RATIO OF SOILS IN PLACE

Test Pit Details for C-LTPP Sites

FIGURE 2.6
The coring and boring (split spoon and/or Shelby tube) will be taken through the core hole at A1, or in the gravel shoulder adjacent to A1 if difficulties are encountered during the augering.

Typical layouts for material sampling points and field testing points are shown in Figure 2.3 to 2.5 and more detailed sampling and testing plans are shown in Figure 2.6.

Throughout this plan, subgrade soils are defined as naturally occurring materials, either fine grain or coarse grained, beneath a base or subbase layer that have not been disturbed, or material which has been placed as fill material.

2.2 Sampling, Handling and Packaging

2.2.1 This section describes procedures for material sampling, packaging and handling of cores and other materials at test sections and shipping to the laboratory for testing. The major objective is to minimize the variability of material properties due to sampling and handling techniques by standardizing them as much as possible. Specific marking instructions are provided in subsequent sections.

Because of the research nature of this project, it is extremely important that the packaging be performed very carefully. Field preparation for shipping should be performed in accordance with ASTM D4220-83, Group B, for all soil and other unbound materials. Other specific instructions for each type of sample are given below.

General requirements for marking and packaging individual samples are as follows:

- Sample numbering systems (sample codes) are as provided later in this section.
- Indelible ink pens of black or other suitable colour shall be used for marking labels.
- Labels and tags shall be of high quality moisture resistant material.
- Bags for small portions of auger and bulk samples of materials to be used for laboratory moisture content determination shall be plastic lined cloth or heavy plastic and sealable against moisture loss or gain by tie-wires. Jars (200 mm) sealed with wax or other equivalent material may also be used for this purpose.
- Bags for large bulk samples shall be heavy cloth, plastic lined with wire-tie for closing.
- Jars for split spoon samples shall be 200 mm in length standard soil sample jars with tight fitting markable covers. Adhesive labelling should be used if covers are not markable. Jars shall be sealed with wax or equivalent material.
- Cores shall be wrapped for their entire length with acceptable tape (e.g. plastic transparent mailing tape, 50 mm wide) and shall be placed in "zip-lock" bags and sealed.

Instructions for combining the samples for shipment are as follows:

- All samples of like material and layer (e.g. AC surface and binder, base or subgrade) shall be placed in separate boxes or separate compartments of one box.
- Each sample shall be clearly marked to be read without opening a bag.
- Each core shall be surrounded with "bubble wrap" or other acceptable cushioning material on all sides.
- All shipping boxes shall be wood of suitable grade and construction to withstand shipping and subsequent moving without damage to the box or samples.

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• All boxes shall be adequately nailed or screwed and wire-banded for shipping.

• A copy of the Project Site Report shall be included with each shipment.

2.2.2 Sample Marking

All material samples shall be marked and labeled before packing in boxes and cartons. As a minimum the following information must be included on tags and labels.

• C-SHRP I.D.

• CORE/SAMPLE LOCATION (as marked on sample layout plans)

• SAMPLE CODE (four character code, as explained later in this section)

• DATE (mm-dd-yyyy, sampling date)

• FIELD SET (one digit number which will be 1 for the first round of sampling and 2 if a second round of sampling is done at the same general location in the future)

Every sample (core, bulk, block, Shelby tube, split spoon, pieces) should be identified by filling out coded tag with the above information and putting it with the individual sample before packaging. The labels outside the shipping boxes and other containers should include, as a minimum; test section I.D. location(s), date and field set number. These labels should be secured to the containers in a satisfactory manner.

The information given on the labels should also be provided on the container (box, bag, jars) by using permanent markers.

2.2.3 Sample Code

Each sample should be assigned a four character code. A code must be recorded on forms DS1, DS2 and DS3 for each sample collected. The sample code will consist of two letters on the left followed by two Arabic numerals on the right side.

The first letter on the left defines the "sample type." It can be one of the following seven letters: C (core sample), K (block samples), B (bulk samples), M (moisture sample), T (Shelby tube sample), J (split spoon sample), and P (broken pieces).

The second letter from the left indicates the sample material. It can be one of the following letters: A (asphalt concrete), T (treated or bound base/subbase), G (granular or unbound base/subbase), and S (subgrade material).

The third and fourth digits will be numeric and correspond to the sample number sequence.

Examples:

CA01 – core of asphalt concrete, number 01.

BG01 – bulk sample of granular or unbound base/subbase material, number 01

MG02 – for moisture content of granular or unbound base/subbase material, number 02

TS01 – a shelby tube sample of subgrade material, number 01

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If a bulk sample is contained in more than one bag then the number of bags should be recorded (1 of 3, 2 of 3, 3 of 3, etc.) but the bulk sample number should be the same on each bag.

2.2.4 Cores and Undisturbed Samples

All cores, Shelby tubes and split spoon samples shall be marked with a sample number after cleaning, drying, wrapping and packaging. Indelible ink marking pens of suitable colour shall be used.

If cores of the pavement surface layer and base/subbase layers are extracted as one piece no attempt should be made in the field to separate the core layers. Cores should be labeled separately, packaged in accordance with Section 2.2 and prepared for shipment to the laboratory.

Cores shall be placed in boxes having dividers to provide 100 mm and 150 mm longitudinal spaces, as applicable. All pieces from each coring operation shall be retained even if apparently unsuitable for testing and packaged as bulk material. Block samples of treated materials shall be packaged in boxes after being sealed with wax on all sides and cushioned with other appropriate material.

2.2.5 Bulk Samples

Bulk samples of untreated base, subbase and subgrade materials shall be obtained from the test pits and the auger locations. The auger locations are intended to corroborate the test pit results. Care shall be taken not to contaminate the samples with overlying or underlying materials nor with water from coring and sawing. Samples shall be placed in plastic lined heavy cloth bags. Two jar samples from each bulk sample from the test pit, and one jar sample from each bulk sample from the auger hole shall be placed in the large bag for laboratory moisture testing.

Each bulk sample shall be marked with 2 labels, one inside the bag and one on the outside. Sample numbering shall be in accordance with Section 2.2.3.

2.3 CORING OF ASPHALT LAYERS

This activity involves the coring of AC pavement at locations as shown in Figures 2.3 to 2.5 or as directed by the C-SHRP Engineer. Exploration logs must be completed using Form DS1 (Appendix A). If cores are broken and/or separated at a lift, this should be noted on Form DS1, using the Core Recovery and Materials Description columns. Each piece should be labelled to identify its position, lift, etc. Each lift will be coded using Table F.3 or Table F.4.


2.3.1 Apparatus – Carbide or diamond bit drilling is permitted. Mist or air cooled drilling is preferred. The bit size will be 150 mm ID. Coring may be performed by a truck mounted drill rig or coring equipment approved by the C-LTPP Engineer.

2.3.2 Core locations at the "C" locations shall be as shown at Figures 2.3 to 2.5. All coring shall be carried out to ensure the recovery of straight, intact, smooth-surfaced samples suitable for laboratory testing.

2.3.3 Water removal – In all cases, the minimum practical amount of water shall be used and excess water shall be removed from the hole immediately after core recovery in order to minimize wetting of the underlying layer(s). A wet vacuum apparatus or similar device should be used. Cores shall be dried before packaging.

2.3.4 AC – Cores shall be dried before packaging. If necessary to obtain cores of suitable quality, the pavement shall be cooled by dry-ice or other means prior to coring.

2.3.5 The cores shall be handled and packaged according to the general provisions outlined in Section 2.2. Each core will be identified with the appropriate C-SHRP ID number. In addition, each core will be numbered according to its location and assigned a sequential numbering code.
2.4 CORING AND BORING FOR BULK SAMPLES

This activity involves the coring of the asphalt pavement and boring to obtain samples of untreated base, subbase and subgrade materials at locations as shown in Figures 2.3 and 2.5. The samples obtained will include bulk material samples, moisture samples and undisturbed samples.

Reference Standard


2.4.1 Equipment - A truck mounted drill rig shall be used. Augers shall be 150 mm diameter helical, continuous flight, solid or hollow stem. Shelby tubes shall be 75 mm OD and 610 mm long.

2.4.2 Location - At the sample location (A1), the pavement surface layer shall be cored with a 150 mm diameter bit and all cores removed and retained in accordance with Section 2.3 (additional sample locations are required where more than two sections are present)

2.4.3 Drilling - Untreated base and subbase materials at A1 location shall be augered to obtain uncontaminated samples of each layer separately. The material raised by the auger from immediately below any core or pavement layer may be contaminated by water from the coring operations. As the auger proceeds into the unbound layer to be sampled, the operator should be on the alert for the presence of material from the next lower layer. Any mixed material should be discarded. All uncontaminated material will be retained as large bulk samples as specified in Section 2.2.5. A small jar sample for laboratory moisture testing shall be obtained as specified in Section 2.2.5. If the base or subbase material cannot be augered through the 150 mm hole, the sampling shall continue immediately adjacent in the shoulder and a special note made on Form DS2. (Appendix A)

2.4.4 The subgrade at A1 location and in the test pit shall be sampled to a depth of 1.5 m below the top of the subgrade using split spoon and/or Shelby tube sampling as directed by the C-LTPP Engineer. This sampling shall be accomplished in accordance with ASTM D1586-84, D1587-83, D2113 -87.

2.4.5 Upon completion of sampling for the base and subbase, undisturbed samples will be obtained from the subgrade. A truck mounted drill rig shall be used for Shelby tube sampling. Shelby tube samples shall be taken of all cohesive, fine grained subgrade soils except where the soils contain a significant amount of gravel or rock fragments, or where the soil is too hard to be sampled in accordance with ASTM D1587. Shelby tubes shall be 75 mm OD and 610 mm long. The provisions of D1587 for "Preparation For Shipping" of the tubes shall be followed.

If the subgrade material cannot be sampled using Shelby tubes, a truck mounted drilling rig shall be used for split spoon sampling. The sampling shall be done using only a 63.5 kg hammer, 762 mm drop and the sampler specified in D1586. Core retainers shall be used when necessary to retain soil. All blow counts shall be recorded.

After opening the cylinder the recovered material shall be carefully examined and logged as to the length of recovery and description of the soil. If more than one type or obvious variation within type of soil is encountered the depth and description of each type shall be made. All uncontaminated material shall be placed in the specified jars, taking care to sample different soils separately.

2.4.6 Auger Probe - This item actively provides a method for determining if bedrock or other significantly dense hard layer exists within 6 m of the pavement surface. Agricultural or geological or other information should be used to assess the need for this probe. These sources may contain depth ranges to bedrock for mapped areas.
Where required by the C-SHRP Engineer, augering shall be performed with a truck mounted drill rig using 100 mm - 150 mm continuous flight, solid, helical augers. The auger probe shall be made in the shoulder at a location approximately in the middle of the test section.

Augering shall be performed to a depth of 6 m or to refusal, whichever is less. When refusal occurs prior to 6 m, the probe shall be continued at a nearby location (2 m to 3 m) as directed by the C-LTPP Engineer. If refusal occurs prior to 6 m at the second location, the auger probe activity shall be terminated.

Each probe shall be logged using Form DS5 (Appendix A) and include the types and thicknesses of materials encountered and the total depth of the probe.

2.4.7 Documentation

The record of each boring shall be as specified in AASHTO T 230-88 (1988) also includes:

a) Material type of each layer and descriptions of untreated materials and soils in accordance with ASTM D2488-84 and Appendix F and other instructions provided by C-SHRP.

b) Thickness of each layer as measured in the hole to the nearest 30 mm.

c) Presence and levels of any water encountered.

d) Sample numbers and number of bags per sample if more than one.

2.5 TEST PIT EXCAVATION, TESTING AND SAMPLING

This activity involves in-situ measurements of density and moisture, obtaining bulk samples and visual descriptions of each layer of the pavement structure. Test pit details are shown in Figure 2.6.

2.5.1 Equipment - The major equipment needed include a pavement saw, excavation machine, pneumatic pavement breaker, a backhoe and a dump truck. The backhoe should be equipped with a flat cutting edge (no teeth) to reduce the disturbance of the layers. Supporting equipment shall include devices for assistance in removal of pieces of pavement and properly loosening and removing base, subbase and subgrade layers and equipment for providing a reaction for the bearing ratio test.

2.5.2 AC Density - In-situ nuclear density measurements shall be made on the surface of AC pavement in the test pit area prior to sawing. The reference standard is ASTM D2922-81 Backscatter.

Two nuclear density measurements are to be made on the AC surfaces, one in the outer wheel path and one between the wheel paths.

Each measurement shall be the average of 4 readings, one minute each taken at the same location but with the instrument rotated 90 degrees between each reading.

2.5.3 AC Sawing - The pavement shall be sawed to the specified overall dimensions and into smaller pieces as necessary for removal. A 300 mm by 300 mm sample of AC surface layer from the outer wheel path must be recovered intact for packaging and shipment.

2.5.4 The AC pieces shall be retained in a cloth or plastic bag after removing any water. The slabs shall be placed with the upper surface down on a wood base prior to insertion in the bag and shall be maintained in that position throughout storage prior to shipping and when packaged for shipping.

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2.5.5 Base/Subbase - The base, subbase and subgrade materials shall be tested and sampled in accordance with Sections 2.5.6 and 2.5.7. Each layer shall be carefully removed to expose the next layer for testing. The excavation shall continue to a depth of 300 mm below the top of subgrade.

2.5.6 One in situ density, moisture and bearing ratio measurements shall be made on the surface of all untreated base, subbase and subgrade layers during excavation of the test pit. The reference standards are ASTM D2922 Direct Transmission, ASTM D2950-82, D3017-78 and D4429-84.

2.5.7 Subsurface Tests - One density and one moisture measurement shall be made on each untreated base, subbase and subgrade soil layer, using the direct transmission method for density and backscatter method for moisture. For the density test the rod shall be imbedded 100 to 150 mm below the layer surface as appropriate to test the full layer. Each measurement shall be the average of 4 readings of one minute each taken at the same general location but with the instrument rotated 90 degrees between each reading.

Prior to testing, the surface shall be carefully prepared, especially for the removal of any water from coring and sawing and as described in ASTM D2922 and D3017. Carefully create the hole for the rod. A jar sample shall be obtained beneath each test for laboratory moisture testing. Minimum sample sizes shall be: 500 g for material having a maximum particle size of 6 mm; 1.5 kg for 25 mm maximum particle material and 2.5 kg for over 25 mm maximum particle size materials. Extreme care shall be taken to obtain samples at true natural field moisture condition.

Immediately after the nuclear testing and before the bulk sampling, the bearing ratio test shall be taken. A truck or any piece of heavy construction machinery with a mass exceeding 3 t can be used for the reaction. The truck or machinery shall be equipped with a suitable metal beam and attachment, or attachments, at the rear end in order to provide a reaction for forcing the penetration piston into each layer. The test shall be done in accordance with ASTM D4429 using the correct surcharge masses and correcting the stress penetration curves for bedding in, surface irregularities etc.

Record the density, moisture, bearing ratio, type of material, rod end depth and thickness of the layer from the bulk sampling in Form DS4 (Appendix A). Report any unusual findings during the testing and bulk sampling such as volds, oversize aggregates or cobbles, foreign material, trapped water, etc. which may have affected the measurements.

Tests will not be required on subgrades containing an amount of rock sufficient to preclude accurate testing. Attach test report to the log of the excavation.

Large bulk samples shall be obtained from all untreated base, subbase, and subgrade layers as specified in Section 2.2. Weight requirements for bulk samples are given in Table 1. A small bulk or jar sample for laboratory moisture testing shall be obtained.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Weight Requirements for Bulk Samples of Unbound Base, Subbase, and Subgrade Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer</td>
<td>Bulk Samples from Test Pit, kg</td>
</tr>
<tr>
<td>Unbound Base</td>
<td>135 kg</td>
</tr>
<tr>
<td>Unbound Subbase</td>
<td>135 kg</td>
</tr>
<tr>
<td>Subgrade</td>
<td></td>
</tr>
<tr>
<td>• Coarse Grain</td>
<td>135 kg</td>
</tr>
<tr>
<td>• Fine Grain</td>
<td>90 kg</td>
</tr>
</tbody>
</table>
2.5.8 Documentation - Test pits shall be logged as the excavations progress using the log sheet (Form DS3, Appendix A). The record shall include the description of each layer, the thickness of each layer to the nearest 30 mm, sample numbers and number of bags per sample, test numbers, any water seepage, sloughing, voids and similar occurrences. The thicknesses shall be measured at least at one point on each end (shoulder and inner faces) and at least twice on the sides (transverse faces).

Additional measurements shall be made if there are variations of over 15 mm in the surface or 30 mm in the untreated layers. Measurements shall also be made of the shoulder surface and base/subbase layers. All measurements shall be recorded on Form DS3 and the log shall include a profile section transverse to the pavement.

The C-LTPP Engineer shall be responsible for obtaining good quality photographs of the test pit profile. Materials shall be described in accordance with the layer designations provided by the C-SHRP Engineer for each pavement section. Untreated materials and soils shall be further described in accordance with ASTM D2488-84, and Appendix F.

Excess materials shall be disposed of off-site in accordance with local legal requirements. Care shall be taken not to disturb pavement layers beyond the limits of the test pit. Test pit details including specific locations for bulk sampling, nuclear density/moisture testing, bearing ratio testing and sampling for moisture content are shown in Figure 2.6.

A report will be prepared for each site by the PHA or the contractor. Each report must be made in duplicate using C-SHRP standard forms (Appendix A) and signed by the C-LTPP Engineer. The report will include exploration logs, test records, and project site reports. One copy of the report for each site must be forwarded to the C-SHRP National Coordinator and one copy to be retained by the Provincial Highway Agency.

2.5.9 Test Pit Restoration

The PHA or Contractor will be responsible for removal of all debris and preparation of the hole for restoration and patching by the PHA personnel. The PHA foreman should be contacted to determine what to do concerning the restoration of the hole with material removed from it, or with new material. With proper coordination, it will be possible to restore AC sections to their original condition during the day of sampling and testing.

The PHA or the contractor will be responsible for removing from the work site all materials and debris created by the operations. This shall include, but not be limited to loose soil, particles of aggregate, concrete, asphalt, and mud coatings on the roadway and shoulder. Material removed from the test pit by the Contractor that are not required to be shipped or used to restore the test pit shall be disposed of in accordance with local legal requirements.

2.5.10 Project Site Report

A project site report (Form DS7, Appendix A) shall be prepared after completing the field work. An actual marked field material sampling and field testing plan (as illustrated in Figures 2.3 to 2.5) shall be attached to the project site report.
3.0 CHARACTERIZATION OF REHABILITATION

3.1 Overview

An important part of C-LTPP is the detailed characterization of the rehabilitation treatment. This characterization encompasses both materials and construction. The activities required to satisfy the characterization of the rehabilitation include:

- sampling of the raw materials at the plant
- description of equipment
- bulk sampling of fresh, uncompacted asphalt concrete
- documentation of compactive effort
- coring of compacted asphalt concrete
- laboratory testing (section 4)

In addition, a full set of quality control data normally obtained by the agency during paving will be used to supplement the site specific work described here. This data set should include the mix design, compaction control records, plant checks and any other routine quality control/assurance information (Form DS8, Appendix C).

3.2 Plant Materials

3.2.1 All tests shall be performed on recovered aggregate and asphalt cement from bulk samples obtained during paving. If required bulk samples of the aggregate and asphalt cement shall be obtained from the plant, as reserve materials for future testing (Form MT5, Appendix E).

3.2.2 The following samples should be obtained from the plant at the time of construction of the test sections. (Note that one set of samples should be retained for each separate mix run through the plant)

Asphalt Cement - a 4 kg sample of asphalt cement retained in a suitably sized container (ie. near capacity) shall be obtained in accordance with ASTM D140.

This sample should be transferred immediately and stored at suitable temperatures (10°C to 21°C) until needed.

Identify the sample with the following information:

- C-SHRP ID number
- sample location
- date
- sample code of the form BB00 (where the first B represents a bulk sample, the second B indicates that the sample is binder, followed by a two digit sequence number)

3.2.3 Aggregate - 20 kg samples shall be obtained for both the fine and coarse fractions according to ASTM D75. The samples should be transferred as soon as possible to the laboratory or other suitable location for storage until needed. Identification of each sample should include at least the following information:
* C-SHRP ID number
* sample location
* date
* sample code of the form BF00 and BR00
  (where B indicates a bulk sample, F identifies fine aggregate, R identifies coarse aggregate, followed by a two-digit sequence number)

3.2.4 Fresh Uncompacted Asphalt Concrete Plant - bulk samples of the mixed asphaltic concrete shall be obtained from the plant for each separate mix run through the plant. The samples should be transferred as soon as possible to the laboratory or other suitable location for storage until laboratory tested.

Identification of each sample should include at least the following information:
* C-SHRP ID number
* sample location
* date
* sample code of the form BBP1
  (where the first B represents a bulk sample, the second B indicates the sample is a binder, P represents plant, followed by a sample number).

3.2.5 Documentation - a materials sample inventory (Form DS6, Appendix A) should be completed at the time the materials are obtained from the plant location. The location where the material are to be stored should be noted under "General Remarks" on the form.

3.3 Fresh Uncompacted Asphalt Concrete

3.3.1 It is vital that site specific samples be obtained of the mix at the monitoring sections. Determination of in-situ gradations, asphalt content, etc., as described in Section 4.2.2 are necessary in order to accurately characterize site conditions.

3.3.2 Sampling Location - bulk samples of uncompacted AC will be obtained immediately ahead of each test section (see Figure 3.1). The distance ahead of each section that representative sampling can be achieved will be dictated by the change in treatment strategy being made in the transition zone. Care should be taken to ensure that the sample represents the material and thickness of the actual test section.

3.3.3 Method - a bulk sample should be obtained for each lift, and will be obtained in accordance with ASTM D979 as the material leaves the paver. Care should be taken to restore the sample area immediately following sampling.

The sample shall be labelled with at least the follow information:
* C-SHRP ID number
* sample location
* date
Sample of Materials Used for Rehabilitation
(for each test section)

FIGURE 3.1
• sample code of the form BA51
  (where B indicates a bulk sample, A identifies asphalt followed by a two digit sequence number beginning with 51)

3.3.4 Documentation - a materials sample inventory (Form DS6, Appendix A) should be completed at the time of sampling.

3.4 Construction Details

3.4.1 In addition to obtaining materials samples, information on the actual construction will be obtained. This information outlined in Form DS8 (Appendix C) should be obtained on the date of construction and consists of the following:
  • plant type
  • antistripping agent
  • moisture susceptibility
  • recycling agent
  • laydown temperature
  • compactive effort

A separate form should be completed for each test section.

3.5 Coring of Asphalt Concrete

3.5.1 Following completion of the rehabilitation effort (all lifts), cores shall be obtained in advance of each test section to obtain as built thicknesses and densities (Form MT3, Appendix E).

3.5.2 Location - a set of three cores will be obtained in the transition (or approach) ahead of each test section. Care must be taken that the cores be representative of the test section thickness. The location of the cores is shown in figure 3.1.

3.5.3 Method - coring shall be carried out in accordance with ASTM C42-84, D979-87 and AASHTO T230-60 and section 2.3 of this guide.

Packaging and shipping should be in accordance with section 2.2.

3.5.4 Identification - the cores shall be labelled with at least the following information;
  • C-SHRP ID number
  • core location
  • date
  • sample code - as per section 2.3.5 except that that sequence numbers shall begin with 51.

3.5.5 Documentation - logs shall be completed using Form DS1 and a materials inventory using Form DS6 (Appendix A).
4.0 LABORATORY TESTING FOR SOILS, AGGREGATE AND ASPHALT CONCRETE

4.1 Overview

The work by these provisions consists of performing laboratory tests on samples of pavement materials, submitting reports, cataloging and storing of samples and remnants of samples and other related work as herein specified.

The specifics of the work shall be as directed by the C-LTPP Engineer or a designated representative. In circumstances where the PHA contracts out the laboratory testing or any part thereof, these provisions shall apply to the contractor.

In most instances, two sets of testing will be required for each test section. The first set of testing will be performed using the samples obtained prior to rehabilitation, while the second set of testing will be performed on samples obtained during (and after) rehabilitation.

This guide deals with the basic test site configuration which consists of two test sections. Where more than two sections exist, the grouping and combining of samples for testing will depend upon the number of samples actually obtained. C-SHRP will work with agencies on a one to one basis to clarify the requirements in these situations.

4.2 Description of Work

4.2.1 Asphalt Concrete Cores (FORM MT2, APPENDIX E)

- A critical preliminary task to the proper testing of drilled cores will be the visual examination of the specimens. Upon receipt, all cores shall be examined and measured for length. This work shall be documented to show: actual length, usable length for testing and thickness of each type of course to the nearest 2 mm; general condition and defects, such as cracks, unusual voids, layer separation, unusual distribution of aggregates, bleeding, etc. and general type and shape of aggregate such as rounded gravel, angular crushed stone, etc.

- AC - Samples of AC will be in the form of 150 mm diameter cores and large pieces of saw-cut or broken AC. Cores and bulk samples should be stored flat side down, fully supported and at temperatures between 10°C and 21°C.

- Core Examination - Cores are to be visually examined for general condition and defects such as cracks, voids and general type and shape of aggregate. Length is to be determined in accordance with ASTM C174-87 as modified by the substitution of the initials "AC" for "concrete".

- Laboratory Tests - The layers of the cores shall be tested in the following sequence:

1. Bulk Specific Gravity - (ASTM D2726)
   Method A, saturated surface dry; on recovered cores, 150 mm diameter - if absorbed water exceeds 2 percent of the volume of the specimen use ASTM D1188

2. Maximum Specific Gravity - ASTM D2041-78

3. Quantitative Extraction of Bitumen - ASTM D2172 - 81
   Method A, using reagent grade of technical grade Type 1 Trichloroethylene; from bulk samples.

4. Marshall Stability and Flow, ASTM D1559. These values shall be obtained by recompacting the 150 mm cores. The stability value shall be corrected for the thickness of the recompacted briquette.

   It is suggested that recompaction be performed after the maximum theoretical density is determined and after the free moisture is removed by heating to constant mass at 100°C. It is further suggested that the sample be again heated to constant mass at 100°C after the stability and flow tests and the Quantitative
Extraction of Bitumen and the gradation of the recovered aggregate (Form MT2, Appendix E) be performed for every layer of every core. The sieves normally used by each PHA should be used and noted.

- Voids In Mineral Aggregates - This shall be calculated from specific gravities obtained from the bulk samples (test pit or rehabilitation) and from data recorded in Form MT4, Appendix E.

Note: The 1987 AASHTO interim specification deleted the reference to six test specimens from the original 1985 specifications. Therefore our sampling would not be "out of spec" but our subset would be 1 and 2).

4.2.2 Recovered Asphalt (from bulk samples) (FORM MT4, APPENDIX E)

Asphalt Cement - Asphalt cement in solution with trichloroethylene should be recovered shortly after the extraction is performed. The recovered asphalt cement can then be stored at temperatures between 10°C and 21°C until needed. The following tests shall be performed.

Penetration - ASTM D5-86 (Determined for 25°C and 4°C)
Ductility - ASTM D113-86 (Determined for 25°C and 4°C)
Specific Gravity - ASTM D70-82 (1986)
Ring and Ball Softening Point - ASTM D36-86
Viscosity - For two temperatures (60°C and 135°C) - ASTM D2171-85, ASTM D2170-85

Note: Test temperatures are subject to change by the C-SHPR Engineer. More than one Abson recovery may be required in order to obtain sufficient asphalt cement for all the tests.

4.2.3 Extracted Aggregate - Aggregate recovered from quantitative extraction may be stored in controlled conditions but it is recommended that the following tests be performed immediately (Form MT4, Appendix E):

Specific Gravity and Absorption of Coarse Aggregate C127-84
Specific Gravity and Absorption of Fine Aggregate - ASTM C128-84

Description of Coarse and Fine Aggregate
Visual description of the aggregate in accordance with Appendix F. Separately report the results for the coarse fraction (retained on the 5000 or No. 4) and the fine (passing the 5000 or No. 4).

Gradation - AASHTO T30-87b
Percentage crushed particles (Appendix B)

4.2.4 Unbound Granular Base/Subbase - Samples of unbound materials will be in the form of bagged bulk samples and jar samples, and the following tests carried out (FORMS MT6 AND MT7, APPENDIX E):

Hydrometer - AASHTO T88-86
Stop test at appropriate time to achieve particle size of 10 μm. Report to include percent finer than 20 um.
Atterberg Limits - ASTM D4318-84
Moisture - density relation - AASHTO T180-86
California Bearing Ratio - AASHTO T193-81 (ASTM D1883-87)  
Molded at in situ moisture and density, soaked.

Natural Moisture Content - ASTM D2216-80  
Perform on all jar samples and designated sealed small bulk samples.

Description of Material - ASTM D2488-84  
Visual description of the aggregate in accordance with Appendix F of the standard. Separately report the results for the coarse fraction (retained on the 5000 or No.4) and the fine (passing the 5000 or No. 4).

4.2.5 Subgrade Soil - Samples will be in the form of bagged bulk samples, jars and thin walled tubes. Jar samples and Shelby tubes will be assigned high priority for testing to minimize loss of moisture. The following tests will be performed (Form MT8, Appendix E):

Unit weight and moisture content should be determined for all tube samples.

Description and Classification:

Sieve Analysis AASHTO T27-84

Hydrometer (10 μm) ASTM D422-63 (72)

Atterberg Limits ASTM D4318-84  
Description of the soils in accordance with ASTM D2488-84, Appendix F and classification in accordance with AASHTO M145-82

Moisture Density Relation - AASHTO T180 (ASTM D1557-78)

California Bearing Ratio - ASTM D1883-87  
Molded at in-situ moisture density, soaked.

Natural Moisture Content - ASTM D2216-80  
On all jar samples and upper 30 percent of Shelby tube samples as appropriate.

Unconfined Compressive Strength of Cohesive Soil - ASTM D2166-085  
On all Shelby tube samples, from upper 30 percent of sample as appropriate.

4.2.6 Fresh Uncompacted Asphalt Concrete Plant - samples of uncompacted asphaltic concrete will be in the form of bulk samples and the following tests carried out (FORM MT5, APPENDIX E):

Bulk Specific Gravity - ASTM (D1188)

Theoretical Maximum Specific Gravity - ASTM (D2041)

Air Voids - ASTM (D3203)

Voids in Mineral Aggregates

Marshall Stability - ASTM (D1559)

Marshall Flow - ASTM (D1559)

Asphalt Cement Content - ASTM (D2172)

Effective Asphalt Cement Content - ASTM (D4469)
4.3 Laboratory Equipment and Personnel Accreditation

The PHA is expected to provide sufficient and suitable materials testing equipment, facilities and personnel to meet the requirements of ASTM E 329-77 (83), ASTM D 3666-83 and ASTM D 3740. The goals of the laboratory testing program are:

- To obtain the quantity and quality of work required for the C-SHRP as described herein.
- To maintain the planned and approved schedules without delays due to testing equipment breakdowns, lack of materials or tools, lack of proper storage and sample preparation facilities, or lack of trained personnel.

The minimum equipment requirements are as required in the specified test standards.

4.4 General Requirements

4.4.1 All samples to be tested for C-LTPP will be delivered in good condition. Record keeping, storage and disposition of samples, testing and data transmission will be in accordance with these specifications.

Each PHA will use the sieve series adopted by them except where required by the AASHTO or ASTM test standard.

The execution of work for laboratory testing will be guided by the following record keeping, sample handling, reporting procedures and test methods.

4.4.2 Record Keeping, Sample Handling and Reporting

Upon arrival, the samples shall be examined by the Laboratory Supervisor for completeness of the shipment and for possible damage resulting from shipping. Regardless of the condition of the samples they must be logged in by accurately duplicating the information provided in the sample submittal report prepared by the C-LTPP Engineer as well as individual sample markings and then assigning a laboratory control number. At this point, visual examination and length determination for all cores should be performed followed by initial test assignments for all the samples. Records of condition and test assignments should be included as part of the sample receipt report to the C-SHRP. The C-SHRP Engineer must be informed of the arrival and of any shipping damage to the samples.

Proper storage conditions must be maintained for all samples. Specifically, adequate moisture and temperature controlled storage of soils, aggregates and bituminous materials are considered as part of this contract and are the responsibility of the PHA. Specific, but not all inclusive, requirements for the various materials are contained in these specifications.

It is the responsibility of the laboratory to properly perform the specified tests. The use of in house forms to document the performance and results is encouraged. However, all test results submitted must be summarized accurately on forms provided by C-SHRP. The summary forms and supporting documentation shall be submitted for review by the C-LTPP Engineer.

It is the responsibility of the PHA to maintain storage facilities, with temperature and moisture controls as required. Materials should not be discarded without written approval by the C-SHRP Engineer. Untested samples should be maintained in controlled storage. Remnants should also be retained but not necessarily in a controlled environment. Specific instructions for disposal of materials will be provided by C-SHRP.

Close coordination with the C-SHRP Engineer will be necessary throughout the period of this contract. Transmittal of information between the C-LTPP Engineer and C-SHRP Engineer must be completely and carefully documented to ensure that C-SHRP receives the requested services.
Reporting the receipt and condition of samples should be done. This information must be complete and always include Section ID information, so that the C-SHRP Engineer can review laboratory testing.

Reporting results of laboratory tests is the prime output of this activity. It is imperative that the sample identification information be complete and accurate and associated with the proper test results. Transmittal of test data should be performed weekly.

4.4.3 Test Methods

It is the intent of C-SHRP C-LTPP to adhere to published test standards (AASHTO, ASTM) as much as possible. The listed procedures have been specified for the program, with appropriate additions and modifications as required. Tests should be performed in accordance with the prescribed methods listed and the results reported in accordance with the methods or as modified by this document. No changes in test procedures will be allowed without written approval and coordination by the C-SHRP Engineer.

Controlled storage, (catalogued and environmentally controlled), must be provided for all samples of all materials submitted to the laboratory, in strict compliance with the appropriate standards. Standard reporting formats will be specified due to the tremendous volume of data that will be generated in this study. Specific codes will be provided at the beginning of the work (Tables F.1 to F.14, Appendix F).

5.0 FIELD SAMPLING AND TESTING QUALITY

C-SHRP expects that each PHA or drilling and sampling contractor will use its own standard manual for quality assurance (QA) and quality control (QC) procedures and operate a program of periodic review and assessment of field operations. C-SHRP encourages this practice and will obtain and review such procedures and manuals. Field material sampling, field testing and laboratory testing are the cornerstone of C-LTPP. The C-LTPP Engineer, the contractor, field and office staff and other PHA personnel are all expected to be committed to achieve the desired level of uniformity, consistency and quality.

5.1 Crew Chief

The PHA and/or the contractor's field crew should include a qualified and experienced on site project supervisor (called crew chief in this guide). The crew chief must be familiar with all aspects of the drilling and sampling contract, this guide and the scheduling and coordination requirements with the authorized C-SHRP representative and PHA personnel. The crew chief should be cognizant of each crew member's responsibilities and specific duties and be familiar with on site safety, traffic control and other legal requirements. The crew chief should have authority to make timely decisions for the drilling and sampling contract on site.

The C-LTPP Engineer shall also assist in the implementation of the QA and QC procedures as well as any other special C-SHRP procedures for sampling and testing quality and consistency.

5.2 Locations of Exploration Holes, Test Pit and Field Test

The C-LTPP Engineer or the crew chief should have an ample supply of data forms and other necessary background material. The locations of all core and auger holes and the test pit should be clearly marked for each pavement site using Figures 2.3 to 2.5. The field locations should not generally vary more than 1 m in the longitudinal direction and 100 mm in the transverse direction on the pavement for all core and auger holes and the test pit.

The locations of field tests and bulk sampling in the test pit should not be outside a reasonable allowable tolerance, as shown on the plans or as instructed by the C-LTPP Engineer. The crew chief should identify these locations before authorizing the field crew to commence field testing.

The "as drilled, sampled or tested" locations should be marked by the crew chief on the plan and a copy should be attached with the Project Site Report.
5.3 Coring, Augering, and Test Pit Operations

Cores of various diameters are required on the AC layers. These requirements are described in Figures 2.3 to 2.6. The PHA or the drilling and sampling contractor should furnish sufficient cylinders of each size to the field crew. The C-LTPP Engineer will check the quality of cores.

Sections 2.3 and 2.4 describe C-SHRP requirements for augering, boring and test pit operations. The termination of an exploration above the required depth due to excessively dense materials, obstructions or "refusals" may occur. When this occurs, the work should be continued on a nearby location (2 m - 3 m) as directed by the C-LTPP Engineer.

All holes and test pits should be properly logged. Ground water conditions or seepage in bore holes should be observed and recorded.

5.4 Sampling

The requirements for base, subbase and subgrade sampling and bulk sampling of pavement layers are described in Sections 2.4.4 and 2.4.5.

Bulk samples of untreated pavement layers and subgrade should be collected from the test pit as shown in Figure 2.6. Adequate quantity of materials (70 kg to 135 kg or as directed) of each layer should be collected. Jar samples for moisture content determinations in the laboratory are also required. Bulk samples of the fresh uncompacted AC shall be collected from the approach and follow-out zones.

Samples should be properly marked and labeled. A separate label should always be kept inside the container where a bulk sample is secured. Labels should also be fixed on the outside of the container. No sample should be left unattended. The crew chief should prepare a list of samples using Form DS6 and get it verified by the C-LTPP Engineer.

5.5 Adhere to the Field Testing Procedures

The in-situ density and moisture test by nuclear devices and the bearing ratio test should be performed using the specified procedures and special provisions contained in Section 3.7.

5.6 Accuracy In Measurements

The PHA or the contractor must constantly be aware of the importance of accuracy in measurements. Inaccurate measurements will produce logs and test results which will be useless and misleading.

5.7 Equipment Maintenance and Calibration

Good, well maintained equipment is essential to conduct the field material sampling and testing work that meets the desired quality required by C-SHRP. Preventative maintenance program will be necessary to achieve this goal and reduce the down time on the project site.

It is imperative that all equipment be accurately calibrated so that quality sample and test data can be obtained. Calibration of measuring and testing equipment will be performed at regularly scheduled intervals.

In addition, the drill rigs will be calibrated relative to height of drop and weight of the drive hammer for the standard penetration test. Recalibration will also be performed at any time there is a question as to the accuracy of the equipment. All data forms will have locations for the recording of equipment identification numbers so that a check of test data can be made if problems are found with the calibration of equipment. Calibration records will be available at all times for review by the C-LTPP Engineer.
The nuclear density devices will be managed as follows:

a) The PHA or the contractor must be licensed by provincial and federal regulatory authorities for the possession and use of radioactive material for the purpose of moisture/density measurements.

b) Any special regulation in any province for the use of nuclear density devices must be followed.

c) Daily calibration checks must be performed by the field technician.

d) Leak tests must be performed as specified by regulation.

5.8 Review and Checking of Data

The crew chief is responsible for review and checking of all logging, sampling and test data. The C-LTPP Engineer will verify the information on all data sheets on each site. The contractor must use the format of sample data sheets included in Appendix A.

5.9 Presentation of Data and Reports

The crew chief will also present the data, project site report and materials samples inventory on C-SHRP standard forms. The contractor shall provide sufficient supply of printed forms to the field staff. The C-LTPP Engineer will verify these reports.

Version 1.3
APPENDIX A: Materials Sampling/Testing Data Forms

This Appendix contains C-SHRP standard forms required to be used in the field sampling and testing work. Explanation of various items on these forms is presented in the following sections.

GENERAL

Each of the standard forms (Form DS1 to DS7) is assigned a unique sheet.

General information about the sections contained in these forms includes:

PROVINCE: Two letter abbreviation of the province shown in Appendix D.

PROVINCE CODE: Two-digit code as shown in Appendix D.

C-SHRP ASSIGNED ID: Seven digit code of the C-LTPP site.

FIELD SET NO: Enter 1 for the first round of field sampling and field testing.

SHEET NO: All data sheets from the field work on a pavement section should be assigned sequential numbers starting from 1 for pavement core C1 followed by logs of other cores in increasing order (Form DS1); borehole logs A1, (Form DS2); test pit log (Form DS3); in-situ density and moisture test summary (Form DS4); material samples inventory (Form DS6); project site report (Form DS7); and sample location plans.

If the information cannot be completely filled up on one sheet for one type of sample/test then multiple sheets can be used with appropriate subnumber. For example: 15/1, 15/2, where 15 refers to the sequential sheet number which may record material sample inventory.

DATE: All dates should be recorded as mm-dd-yy. The CORING DATE, BORING DATE, EXPLORATION DATE, TEST DATE, and AUGERING DATE will be used in the C-LTPP data base. These should be actual dates of field work.

LOCATION: Important information; locate as shown in Figures 2.3 to 2.6. It should also show distance from outside shoulder, for example: O/S 1 m on bore log for A1 indicates that A1 was 1 m from the outside shoulder.

CORE HOLE NUMBER,
BORE HOLE NUMBER,
AUGER PROBE NUMBER: Important information (Forms DS1, DS2, DS5) as shown on Figure 2.3.

TEST PIT NUMBER: Important information (Forms DS3, DS4); it will be generally TP as shown in Figure 2.3. If a second test pit is excavated then that should be recorded as TP2.

SCALE: Use of metres and millimetres in all logs.

MATERIAL CODE/MATERIAL DESCRIPTION: Important information; use generic terminology based on guidelines given in Appendix F.

Further instructions specific to various forms are:

FORM DS1

Use the core sample coding system given in Section 2 for numbering cores. Core hole number (as shown in Figures 2.3 to 2.6) and size (millimetre, diameter) are also important data elements. Elevation in metres should be recorded for the surface (top) at each core location. The total thickness of the core should be recorded under thickness.
The Core Recovery Code should be used to describe the condition of the core. Material Code as given in Appendix F.

FORM DS2

The depths of strata changes should always be measured and recorded from the top of the pavement surface. This form is designed to record logs of borehole A1 and other similar types of boreholes. SPT results are recorded in N, the "blows per 300 mm" column, if used. Sample coding system must be followed for recording sample numbers. Subgrade soils and other unbound materials should be described using C-SHRP standard terminology and material codes. It is not necessary to describe subgrade soil as fill or natural soil.

FORM DS3

Same comments about sample numbers and material description as given in Form DS2.

FORM DS4

O.W.P. implies outer wheel path of the lane in the monitoring section. Between wheel path implies middle of the lane in the section. If the section contains more than two base/subbase layers then use additional sheets. Density and moisture tests should be performed on unbound (granular, untreated) layers and subgrade.

Depth from pavement surface to the top of the layer being treated should be obtained from Form DS3 record and entered on the specified cell on Form DS4.

The result of the shoulder auger probe(s), if done, from Form DS5 is also required to be entered on the bottom part of Form DS4, as indicated. If rock is not found at 6 m depth then enter "N" for Refusal and "UnKnown" for Depth of Rock (m) in the first probe results.

FORM DS5

Results of this form should be entered on Form DS4 as explained above. Elevation and depth to rock should be measured and recorded from the top of the pavement surface.

Enter S1 for the first probe in Auger Probe Number; S2 for the second probe and so on. Location should show location from start of section and distance from pavement edge in metres.

FORM DS6

An inventory of material samples for shipment to the laboratory is made on this form. The inventory should be made in the following sequence (starting from pavement surface layer in each case).

1. Samples from locations of C-type cores starting from cores of pavement surface layers.
2. Samples from borehole A1.
3. Samples from the test pit.

Sample condition should indicate the physical condition and the case where two layers came as one core. Typically, samples will include:
- All AC cores from C-type location, A1, and others.
- Block samples of AC layer and treated material as applicable.
- Bulk sample of fresh uncompacted AC.
• Bulk samples of granular layers and subgrade from the test pit, TP.

The bulk sample from one layer can be placed in more than one bag, if necessary. However, the sample number should be the same on both bags with indication of the number of bags on the labels and in the column of sample condition on Form DS6.

FORM DS7

This form is used to summarize the site activities and the samples obtained.
Log of Pavement Core

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Sample Number</th>
<th>Material Description</th>
<th>Material Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

General Remarks:

C-LTPP Engineer

Date (dd/mm/yy)
## C-LTPP Material Sampling/Field Testing

### Log of Bore Hole

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Strata Change (m)</th>
<th>SPT, N Blows 300 mm</th>
<th>Soil Sample Number</th>
<th>Moisture Sample Number</th>
<th>Material Description</th>
<th>Material Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

Note: ASTM D1586, D1587, D2113

General Remarks:

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C-LTPP Engineer

Date (dd/mm/yy)
## Log of Test Pit

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<th>Strata Change (m)</th>
<th>Moisture Sample Number</th>
<th>Bulk Sample Number</th>
<th>Material Description</th>
<th>Material Code</th>
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<td>2</td>
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</tr>
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</table>

**General Remarks:**

---

**Transverse Section**

---

**C-LTPP Engineer**

**Date (dd/mm/yy)**
C-LTPP Materials Testing

In-situ Tests (Test Pits)

Operator(s) ___________________________ sheet __ of __

Nuclear gauge ID ___________________ Location ________________________

Date of last calibration ______________________

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<th>Test Type</th>
<th>AC OWD</th>
<th>BWP</th>
<th>Base</th>
<th>Subbase</th>
<th>Subgrade</th>
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<tbody>
<tr>
<td>Density, kg/m³</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>2</td>
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<td>4</td>
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<td>M</td>
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<td>s</td>
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| Rod depth, mm
| Depth from top, mm
<table>
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<tr>
<th>ASTM D3017</th>
<th>D2216</th>
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<th>Rod Depth, mm</th>
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<td>Bearing Ratio</td>
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<td>(top of layer)</td>
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<td>(ASTM D4429)</td>
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Note: M – mean, s – standard deviation, OWP – outer wheel path, BWP – between wheel path

Remarks: __________________________________________

________________________________________

C-LTPP Engineer

Date (dd/mm/yy)
## Log of Shoulder Probe

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**Operator**

**Equipment**

**Location**

**Depth to bedrock, m**

**Sample Code**

---

**C-LTPP Engineer**

**Date (dd/mm/yy)**
C-LTPP  
Material Sampling/Field Testing

Material Samples Inventory

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<tr>
<th>Sample Location</th>
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General Remarks:


C-LTPP Engineer

Date (dd/mm/yy)
C-LTPP
Material Sampling/
Field Testing

Site Report

Host Jurisdiction
Site Location
Road # or Description
C-SHRP I.D. Number

Arrival On Site AM/PM Work Completed AM/PM

Weather C-LTPP Engineer

PHA Personnel

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Private Personnel

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General Remarks:

C-LTPP Engineer Date (dd/mm/yy)
APPENDIX B: Test Method For Determining Percentage Crushed Particles

1. SCOPE

This method outlines the visual determination and calculation of the percentage, by mass of crushed or fractured particles of extracted aggregate.

2. INTRODUCTION

A crushed or fractured particle is coarse aggregate which has at least two well defined fractured faces. A face is defined as having a surface area of at least 10 percent of the total surface area of the particle.

3. EQUIPMENT

A balance scale of sufficient capacity and sensitive to 1 g or less.

4. SAMPLING

4.1 The sample shall consist of aggregate from a previous extraction of AC by Method A of ASTM D2172-88. Note: The solution will be used in ASTM D1856-79 (Abson Method).

4.2 The test sample shall be prepared from the coarse aggregate fractions and be representative of the original AC.

4.3 The test sample shall have a mass of 1 kg(W).

5. PROCEDURE

5.1 The test sample shall be spread on a clean, flat surface large enough to allow all particles to be visually inspected.

5.2 Only those individual particles with a minimum of two crushed or fractured faces will be deemed to be a crushed particle. Separate the particles into two portions, crushed and uncrushed.

5.3 Weigh each portion to the nearest gram.

6. CALCULATION AND REPORT

6.1 Calculate the percentage of crushed particles using the following formula:

Percentage Crushed Particles = A/(A+B) x 100

Where A = mass of crushed particles, g
Where B = mass of uncrushed particles, g

6.2 Report the test result to the nearest whole percent.
Appendix C
APPENDIX C: Construction Data - Rehabilitated Pavement

Form DS8

This form is to record the construction data for the rehabilitated pavement. The overlay code is used to identify the asphalt concrete. The thickness of uncompacted asphalt concrete should be recorded. Note, the compacted thickness will be shown on Form MT3. The form also summarizes the compaction process data and the frequency should be measured with a Reed Tachometer or similar device. The amplitude is the setting used for the lift being placed and would be available from the contractor and/or the manufacturer.
**C-LTPP Materials Testing**

**Construction Data – Rehabilitated Pavement**

Sheet _______ of _________

1. Overlay code (Table F.2)
2. Thickness of rehabilitation, mm
3. Asphalt Plant
   - Batch
   - Drum
   - Continuous
4. Antistripping agent code (Table F.8)
5. Antistripping agent, % by mass
6. Moisture susceptibility test type
   - ASTM D1075
   - Other (specify)
7. Recycling agent code (Table F.9)
8. Recycling agent, % by mass

**Laydown Temperature, °C**
9. Mean
10. Minimum
11. Maximum
12. Air Temperature, °C

**Compaction Equipment (TABLE F.10)**

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<th>Roller Code</th>
<th>Number of passes</th>
<th>Mass, tonnes</th>
<th>Tire Press kPa</th>
<th>Frequency VPM</th>
<th>Amplitude mm</th>
<th>Speed km/h</th>
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<td>19.</td>
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PHA or C-LTPP Engineer ____________________ Date (dd/mm/yy) ____________________
Appendix D
# APPENDIX D: Table of Province Codes

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<th>PROVINCE</th>
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<th>CODE</th>
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<td>82</td>
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<td>Manitoba</td>
<td>MB</td>
<td>83</td>
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<tr>
<td>New Brunswick</td>
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<td>84</td>
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<tr>
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<td>NF</td>
<td>85</td>
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<tr>
<td>Nova Scotia</td>
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<td>86</td>
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<tr>
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<td>Northwest Territories</td>
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<td>92</td>
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<tr>
<td>Transport Canada</td>
<td>TC</td>
<td>93</td>
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</table>
Appendix E
APPENDIX E: Materials Testing Data

Form MT1
This form summarizes the data to identify the site.

Form MT2
This form summarizes the physical properties of the cores. The voids in mineral aggregate are calculated using specific gravities obtained from the bulk samples from the test pit. The Marshall Stability and Flow is done as stipulated in Article 4.2.1. The properties of the extracted materials will be summarized on this form.

Form MT3
This form records the thickness and bulk specific gravity of asphalt concrete cores from the rehabilitated asphalt concrete.

Form MT4
This form summarizes the physical properties of the materials from the bulk samples of either the test pit or rehabilitation.

Form MT5
This form summarizes the physical properties of the bulk samples from the hot mix plant.

Form MT6
This form summarizes the physical properties of the granular base course.

Form MT7
This form summarizes the physical properties of the granular subbase course.

Form MT8
This form summarizes the physical properties of the subgrade.
C-LTPP Materials Testing

Site Identification

Host Jurisdiction
Site Location
Road # or Description
C-SHRP I.D. Number

Sheet ______ of ________

1. Date of data collection/update (mm/yy)
2. C-LTPP Engineer (initial. surname)
3. PHA roadway number
4. Functional class (Table F.1)
5. Overlay code (Table F.2)
6. Number of lanes in one direction
7. Direction of travel (N, S, E, W)
8. Kilometre point
9. Elevation (m)
10. Latitude (northing/)
11. Longitude (easting)
12. Shoulder width, total (m)
13. Shoulder width, paved (m)
14. Lane width (m)
15. Subsurface drainage code
   - none
   - longitudinal
   - transverse
   - blanket

<table>
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<td>blanket/drains</td>
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<td>3</td>
<td>other</td>
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C-LTPP Engineer

Date (dd/mm/yy)
# Asphalt Concrete Cores

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<th>of</th>
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<td>Layer Code (Table F.4)</td>
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<td>Thickness (mm)</td>
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<tr>
<td>5.</td>
<td>Year Constructed</td>
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</table>

### Bulk Specific Gravity (ASTM D2726-88)

| 6.    | Mean | 9. | Number of Tests |
| 8.    | Maximum |

### Theoretical Maximum Specific Gravity, (ASTM D2041)

| 11.   | Mean | 14. | Number of Tests |
| 13.   | Maximum |

### Air Voids, % (ASTM D3203)

| 16.   | Mean | 19. | Number of Tests |
| 18.   | Maximum |

### Voids in Mineral Aggregate, %

| 21.   | Mean | 24. | Number of Tests |
| 23.   | Maximum |
| 27.   | Marshall Flow (x.25 mm) (ASTM D1559) |
| 28.   | Asphalt Cement content, % (ASTM D2172) |
| 29.   | Effective Asphalt Cement content, % (ASTM D4469) |

Note: Attach copy of PHA standard form for gradation of extracted aggregate

**PHA or C-LTPP Engineer**

**Date (dd/mm/yy)**
C-LTPP
Materials Testing

Asphalt Concrete Cores
(after rehabilitation)

Form MT3

Host Jurisdiction ____________________________

Site Location ________________________________

Road # or Description _______________________

C-SHRP I.D. Number __________________________

Sheet __________ of __________

1. Core Numbers
2. Surface Code
3. Layer Code
4. Layer Location
   -- Surface 1
   -- 2nd Intermediate 3
   -- 1st Intermediate 2
   -- Bottom 4
5. Year Constructed

Sample Code __________

Thickness of Cores (mm)
6. Mean
7. Minimum
8. Maximum
9. No. of Samples
10. Standard Deviation

Bulk Specific Gravity (ASTM D1188)
11. Mean
12. Minimum
13. Maximum
14. No. of Tests
15. Standard Deviation

PHA or C-LTPP Engineer ____________________________

Date (dd/mm/yy) ____________________________
# C-LTPP Materials Testing

## Materials Data (Bulk Sample)

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<td>22. Bulk specific gravity, fine agg. (ASTM C128)</td>
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<td>23. Absorption, fine agg., % (ASTM C128)</td>
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<td>27. Sieve series used by PHA, specify</td>
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Note: Attach standard gradation report used by PHA

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PHA or C-LTPP Engineer

Date (dd/mm/yy)
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</tr>
<tr>
<td>14.</td>
<td>Mean</td>
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<td>15.</td>
<td>Minimum</td>
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<tr>
<td>16.</td>
<td>Maximum</td>
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<tr>
<td>17.</td>
<td>Number of Tests</td>
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<tr>
<td>19.</td>
<td>Mean</td>
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</tr>
<tr>
<td>20.</td>
<td>Minimum</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Maximum</td>
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</tr>
<tr>
<td>22.</td>
<td>Number of Tests</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Marshall Flow (x.25 mm) (ASTM D1559)</td>
<td></td>
<td></td>
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<tr>
<td>26.</td>
<td>Asphalt Cement content, % (ASTM D2172)</td>
<td></td>
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<td></td>
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<tr>
<td>27.</td>
<td>Effective Asphalt Cement content, % (ASTM D4469)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

---

PHA or C-LTPP Engineer ____________________________

Date (dd/mm/yy) ____________________________
# C-LTPP Materials Testing

## Base Data

<table>
<thead>
<tr>
<th>Sheet of</th>
<th>Sample Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Layer code (Table F.4)  
2. Thickness (mm)  
3. Classification code (Table F.11)  
4. Description code (Table F.12)  
5. AASHTO code (Table F.13)  
6. Atterberg limits (ASTM D4318)  
   LL _, PL _, PI _  
7. Maximum dry density (ASTM D1557-78)  
8. Optimum Moisture content, % (ASTM D1557-78)  

### In situ moisture content, % (ASTM D3017) / Jar Sample (ASTM D2216-80)

<table>
<thead>
<tr>
<th>ASTM</th>
<th>D3017</th>
<th>D2216</th>
<th>ASTM</th>
<th>D3017</th>
<th>D2216</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td></td>
<td></td>
<td>12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td>13.</td>
<td></td>
<td></td>
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<tr>
<td>15.</td>
<td></td>
<td></td>
<td>17.</td>
<td></td>
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</tr>
<tr>
<td>16.</td>
<td></td>
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<td>18.</td>
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<td></td>
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</tbody>
</table>

### In situ density, kg/m³ (ASTM D2922)

<table>
<thead>
<tr>
<th>ASTM</th>
<th>D4429</th>
<th>D1883</th>
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</thead>
<tbody>
<tr>
<td>14.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Number of Tests
19. Sieve series used by PHA (specify) 

**Note:** Attach copy of PHA completed standard form for coarse and fine aggregate gradation.

### In situ bearing ratio, (ASTM D4429-84) / Laboratory (ASTM D1883-87)

<table>
<thead>
<tr>
<th>ASTM</th>
<th>D4429</th>
<th>D1883</th>
<th>ASTM</th>
<th>D4429</th>
<th>D1883</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.</td>
<td></td>
<td></td>
<td>23.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PHA or C-LTPP Engineer  
Date (dd/mm/yy)
### Subbase Data

1. Layer code (Table F.4)  
2. Thickness (mm)  
3. Classification code (Table F.11)  
4. Descriptive code (Table F.12)  
5. AASHTO code (Table F.13)  
6. Atterberg limits (ASTM D4318)  
   LL ____, PL ____, PI ____  
7. Maximum dry density, kg/m³ (ASTM D1557-78)  
8. Optimum Moisture Content, % (ASTM D1557-78)  

| In situ moisture content, % (ASTM D3017) / Jar Sample (ASTM D2216-80) |
|-----------------------------|-----------------------------|
| ASTM | D3017 | D2216 | ASTM | D3017 | D2216 |
| 9. Mean | ______ | ______ | 12. Number of Tests | ______ | ______ |
| 11. Maximum | ______ | ______ |                      | ______ | ______ |

<table>
<thead>
<tr>
<th>In situ density, kg/m³ (ASTM D2922)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Mean</td>
</tr>
<tr>
<td>16. Maximum</td>
</tr>
<tr>
<td>19. Sieve series used by PHA (specify)</td>
</tr>
</tbody>
</table>

**Note:** Attach copy of PHA completed standard form for coarse and fine aggregate gradation.

<table>
<thead>
<tr>
<th>In situ bearing ratio, (ASTM D4429-84) / Laboratory (ASTM D1883-87)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM</td>
</tr>
<tr>
<td>20. Mean</td>
</tr>
<tr>
<td>22. Maximum</td>
</tr>
</tbody>
</table>

---

PHA or C-LTPP Engineer  
Date (dd/mm/yy)
# Subgrade Data

1. Layer code (Table F.4)  
2. Classification code (Table F.11)  
3. Description code (Table F.12)  
4. AASHTO code (Table F.13)  
5. Atterberg limits, % (ASTM D4318)  
   - LL ___, PL ___, PI ___  
6. Maximum Dry Density, kg/m³ (ASTM D1557-78)  
7. Optimum moisture content (ASTM D1557-78)  
8. Bearing ratio (ASTM D1883-87)  
9. Relative density code (Table F.14)  
10. Percent by mass, finer than 20 um  
11. Frost susceptibility classification code  
   - very high: 1, low: 4  
   - high: 2, very low: 5  
   - medium: 3, negligible: 6  

In situ dry density, kg/m³ (ASTM D2922)  
12. Mean  
13. Minimum  
14. Maximum  
15. Number of Tests  

In situ moisture content, % (ASTM D3017) / Jar Sample (ASTM 2216-80)  

<table>
<thead>
<tr>
<th>ASTM</th>
<th>D3017</th>
<th>D2216</th>
<th>ASTM</th>
<th>D3017</th>
<th>D2216</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>______</td>
<td>______</td>
<td>20. Number of Tests</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Minimum</td>
<td>______</td>
<td>______</td>
<td>21. Stan. Dev.</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Maximum</td>
<td>______</td>
<td>______</td>
<td>22. Mean</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

In situ bearing ratio (ASTM D4429)  
22. Mean  
23. Minimum  
24. Maximum  
25. Number of Tests  
27. Unconfined compressive strength, kPa (ASTM D2166) (from representative sample)  
28. Attach copy of PHA's completed gradation form.

PHA or C-LTPP Engineer ______________________ Date (dd/mm/yyyy)
Appendix F
APPENDIX F: Terminology for Pavement and Soils (after SHRP)

Tables F.1 to F.14 describe terminology and material codes for pavement materials and soils. The following abbreviations are used to describe reference material types in this Appendix:

TABLE F.1. Functional Class Codes
TABLE F.2. Overlay Type Code
TABLE F.3. Pavement Surface Code
TABLE F.4. Layer Description Code
TABLE F.5. Grades of Asphalt Cement Code
TABLE F.6. Geologic Classification Codes
TABLE F.7. Crushed Particle Code
TABLE F.8. Anti-Stripping Agent Type Code
TABLE F.9. Recycling Agent Type Code
TABLE F.10 Roller Code
TABLE F.11 Soil Classification Code
TABLE F.12 Base and Subbase Materials Code
TABLE F.13 AASHTO Classification for Soil and Soil Aggregate
TABLE F.14 Relative Density of Coarse Grained Soil Code Material Types

The functional class is described in Table F.1 and the Trans Canada Highway is to be kept unique. The overlay code describes the size type recommended by the Pavement Advisory Committee and C-SHRP.

The pavement surface is described using the SHRP terminology as in Table F.3 Table F.4 further defines the pavement structure layer.

The grade of asphalt cement is described in Table F.5 with special emphasis placed on the new improved specification issued by the Canadian General Standards Board.

The quality of the coarse aggregate is of vital concern and the geologic origin and percentage of crushed particles are coded in Table F.6 and Table F.7 respectively. The crushed particle code is new in Canada and is a special test for C-LTPP.

The anti-stripping agent and recycling agent are also coded and from Table F.8 and Table F.9.

The success of the overlay is very dependent on the quality of construction and the equipment should be identified for future analysis (Table F.10).

In Table F.11, F.12, F.13 and F.14 are soil aggregate descriptions which were simply drafted from the SHRP terminology.

Version 1.3
Table F.1. Functional Class Codes

<table>
<thead>
<tr>
<th>Functional Class</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural:</td>
<td></td>
</tr>
<tr>
<td>Principal Arterial - Trans Canada</td>
<td>01</td>
</tr>
<tr>
<td>Principal Arterial - Other</td>
<td>02</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>06</td>
</tr>
<tr>
<td>Major Collector</td>
<td>07</td>
</tr>
<tr>
<td>Minor Collector</td>
<td>08</td>
</tr>
<tr>
<td>Local Collector</td>
<td>09</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
</tr>
<tr>
<td>Principal Arterial - Trans Canada</td>
<td>11</td>
</tr>
<tr>
<td>Principal Arterial - Other Freeways or Expressways</td>
<td>12</td>
</tr>
<tr>
<td>Other Principal Arterial</td>
<td>14</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>16</td>
</tr>
<tr>
<td>Collector</td>
<td>17</td>
</tr>
<tr>
<td>Local</td>
<td>19</td>
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</tbody>
</table>

Table F.2. Overlay Type Code

<table>
<thead>
<tr>
<th>Overlay Type</th>
<th>Code</th>
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<tbody>
<tr>
<td>Thin Overlay</td>
<td>OL 1</td>
</tr>
<tr>
<td>Thick Overlay</td>
<td>OL 2</td>
</tr>
<tr>
<td>Milling and Virgin AC</td>
<td>OL 3</td>
</tr>
<tr>
<td>Milling and hot RAC</td>
<td>R 1</td>
</tr>
<tr>
<td>Milling and RAC/Virgin AC</td>
<td>R 2</td>
</tr>
<tr>
<td>Milling and hot RAC and Virgin AC</td>
<td>R 3</td>
</tr>
</tbody>
</table>

Version 1.3
Table F.3. Pavement Surface Material Type Description

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Code</th>
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<tbody>
<tr>
<td>Asphalt Concrete (AC)</td>
<td>700 +</td>
</tr>
<tr>
<td>Hot Mixed, Hot Laid AC, Dense Graded</td>
<td>701</td>
</tr>
<tr>
<td>Hot Mixed, Hot Laid AC, Open Graded</td>
<td>702</td>
</tr>
<tr>
<td>(Porous Friction Course)</td>
<td></td>
</tr>
<tr>
<td>Sand Asphalt</td>
<td>703</td>
</tr>
<tr>
<td>PCC (JPCP)</td>
<td>704</td>
</tr>
<tr>
<td>PCC (JRCP)</td>
<td>705</td>
</tr>
<tr>
<td>PCC (CRCP)</td>
<td>706</td>
</tr>
<tr>
<td>PCC (Prestressed)</td>
<td>707</td>
</tr>
<tr>
<td>PCC (Fibre Reinforced)</td>
<td>708</td>
</tr>
<tr>
<td>Plant Mix (Emulsified Asphalt) Material, Cold Laid</td>
<td>709</td>
</tr>
<tr>
<td>Plant Mix (Cutback Asphalt) Material, Cold Laid</td>
<td>710</td>
</tr>
<tr>
<td>Single Surface Treatment</td>
<td>711</td>
</tr>
<tr>
<td>Double Surface Treatment</td>
<td>712</td>
</tr>
<tr>
<td>Recycled AC, Hot Laid, Central Plant Mix</td>
<td>713</td>
</tr>
<tr>
<td>Recycled AC, Cold Laid, Central Plant Mix</td>
<td>714</td>
</tr>
<tr>
<td>Recycled AC, Cold Laid, Mixed In Place</td>
<td>715</td>
</tr>
<tr>
<td>Recycled AC, Heater Scarification/Recompaction</td>
<td>716</td>
</tr>
<tr>
<td>Recycled AC, JPCP</td>
<td>717</td>
</tr>
<tr>
<td>Recycled AC, JRCP</td>
<td>718</td>
</tr>
<tr>
<td>Recycled AC, CRCP</td>
<td>719</td>
</tr>
<tr>
<td>Other (Specify)</td>
<td>720</td>
</tr>
<tr>
<td>PCC</td>
<td>730++</td>
</tr>
</tbody>
</table>

AC – a general term (Code 700) that describes asphalt concrete layer(s). It can be any or a combination of material codes 701, 702, 703, 709 to 716.

PCC – A general term (Code 730) that describes portland cement concrete layer(s). It can be any or a combination of material codes 704 to 708, 717 to 719.

Table F.4. Layer Description Codes

<table>
<thead>
<tr>
<th>Overlay</th>
<th>01</th>
<th>Base</th>
<th>05</th>
<th>Porous Friction Coarse</th>
<th>09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal Coat</td>
<td>02</td>
<td>Subbase</td>
<td>06</td>
<td>Surface Treatment</td>
<td>10</td>
</tr>
<tr>
<td>Original Surface</td>
<td>03</td>
<td>Subgrade</td>
<td>07</td>
<td>Other</td>
<td>11</td>
</tr>
<tr>
<td>HMAC (Below Surface Layer)</td>
<td>04</td>
<td>Interlayer</td>
<td></td>
<td></td>
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</table>

Version 1.3
<table>
<thead>
<tr>
<th>Asphalt Cements</th>
<th>Code</th>
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<tbody>
<tr>
<td>AC-2.5</td>
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</tr>
<tr>
<td>AC-5</td>
<td>02</td>
</tr>
<tr>
<td>AC-10</td>
<td>03</td>
</tr>
<tr>
<td>AC-20</td>
<td>04</td>
</tr>
<tr>
<td>AC-30</td>
<td>05</td>
</tr>
<tr>
<td>AC-40</td>
<td>06</td>
</tr>
<tr>
<td>AR-1000 (AR-10 by AASHTO Designation)</td>
<td>07</td>
</tr>
<tr>
<td>AC-2000 (AR-20 by AASHTO Designation)</td>
<td>08</td>
</tr>
<tr>
<td>AC-4000 (AR-40 by AASHTO Designation)</td>
<td>09</td>
</tr>
<tr>
<td>AC-8000 (AR-80 by AASHTO Designation)</td>
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</tr>
<tr>
<td>AC-16000 (AR-160 by AASHTO Designation)</td>
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</tr>
<tr>
<td>200-300 pen</td>
<td>12</td>
</tr>
<tr>
<td>120-150 pen</td>
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<td>85-70 pen</td>
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</tr>
<tr>
<td>60-70 pen</td>
<td>15</td>
</tr>
<tr>
<td>40-50 pen</td>
<td>16</td>
</tr>
<tr>
<td>Other Asphalt Cement Grade</td>
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</tr>
<tr>
<td>Type A (CGSB)</td>
<td>18</td>
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<tr>
<td>Type B (CGSB)</td>
<td>19</td>
</tr>
<tr>
<td>Type C (CGSB)</td>
<td>20</td>
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</table>
### Table F.6. Geologic Classification Codes

<table>
<thead>
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<th>DESCRIPTION</th>
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<td><strong>Igneous:</strong></td>
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<tr>
<td>Granite</td>
<td>601</td>
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<tr>
<td>Syenite</td>
<td>602</td>
</tr>
<tr>
<td>Diorite</td>
<td>603</td>
</tr>
<tr>
<td>Gabbro</td>
<td>604</td>
</tr>
<tr>
<td>Peridotite</td>
<td>605</td>
</tr>
<tr>
<td>Felsite</td>
<td>606</td>
</tr>
<tr>
<td>Basalt</td>
<td>607</td>
</tr>
<tr>
<td>Diabase</td>
<td>608</td>
</tr>
<tr>
<td><strong>Sedimentary:</strong></td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td>609</td>
</tr>
<tr>
<td>Dolomite</td>
<td>610</td>
</tr>
<tr>
<td>Shale</td>
<td>611</td>
</tr>
<tr>
<td>Sandstone</td>
<td>612</td>
</tr>
<tr>
<td>Chert</td>
<td>613</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>614</td>
</tr>
<tr>
<td>Breccia</td>
<td>615</td>
</tr>
<tr>
<td><strong>Metamorphic:</strong></td>
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</tr>
<tr>
<td>Gneiss</td>
<td>616</td>
</tr>
<tr>
<td>Schist</td>
<td>617</td>
</tr>
<tr>
<td>Amphibolite</td>
<td>618</td>
</tr>
<tr>
<td>Slate</td>
<td>619</td>
</tr>
<tr>
<td>Quartzite</td>
<td>620</td>
</tr>
<tr>
<td>Marble</td>
<td>621</td>
</tr>
<tr>
<td>Serpentine</td>
<td>622</td>
</tr>
</tbody>
</table>

### Table F.7. Crushed Particle Code

<table>
<thead>
<tr>
<th>Crushed Particles, 2 crushed faces (must be at least 10 % of area)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 50%</td>
<td>2204</td>
</tr>
<tr>
<td>51% to 60%</td>
<td>2205</td>
</tr>
<tr>
<td>61% to 70%</td>
<td>2206</td>
</tr>
<tr>
<td>71% to 80%</td>
<td>2207</td>
</tr>
<tr>
<td>81% to 90%</td>
<td>2208</td>
</tr>
<tr>
<td>90% to 100%</td>
<td>2209</td>
</tr>
<tr>
<td>Code</td>
<td>Anti-Stripping Agent Type Codes</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>01</td>
<td>Permatac</td>
</tr>
<tr>
<td>02</td>
<td>Permatac Plus</td>
</tr>
<tr>
<td>03</td>
<td>Betascan Roads</td>
</tr>
<tr>
<td>04</td>
<td>Pavebond</td>
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<tr>
<td>05</td>
<td>Pavebond Special</td>
</tr>
<tr>
<td>06</td>
<td>Pavebond Plus</td>
</tr>
<tr>
<td>07</td>
<td>BA 2000</td>
</tr>
<tr>
<td>08</td>
<td>BA 2001</td>
</tr>
<tr>
<td>09</td>
<td>Unichem &quot;A&quot;</td>
</tr>
<tr>
<td>10</td>
<td>Unichem &quot;B&quot;</td>
</tr>
<tr>
<td>11</td>
<td>Unichem &quot;C&quot;</td>
</tr>
<tr>
<td>12</td>
<td>AquaShield AS4115</td>
</tr>
<tr>
<td>13</td>
<td>AquaShield AS4112</td>
</tr>
<tr>
<td>14</td>
<td>AquaShield AS4113</td>
</tr>
<tr>
<td>15</td>
<td>Portland Cement</td>
</tr>
<tr>
<td>16</td>
<td>Hydrated Lime: Mixed Dry With Asphalt Cement</td>
</tr>
<tr>
<td>17</td>
<td>Mixed Dry with Dry Aggregate</td>
</tr>
<tr>
<td>18</td>
<td>Mixed Dry with Wet Aggregate</td>
</tr>
<tr>
<td>19</td>
<td>Slurried Lime Mixed with Aggregate</td>
</tr>
<tr>
<td>20</td>
<td>Hot Lime Slurry (Quick Lime Slaked and Slurried at Job Site)</td>
</tr>
<tr>
<td>21</td>
<td>No strip Chemicals A-500</td>
</tr>
<tr>
<td>22</td>
<td>No Strip Chemical Works ACRA RP-A</td>
</tr>
<tr>
<td>23</td>
<td>No Strip Chemical Works ACRA Super Conc</td>
</tr>
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<td>24</td>
<td>No Strip Chemical Works ACRA 200</td>
</tr>
<tr>
<td>25</td>
<td>No Strip Chemical Works ACRA 300</td>
</tr>
<tr>
<td>26</td>
<td>No Strip Chemical Works ACRA 400</td>
</tr>
<tr>
<td>27</td>
<td>No Strip Chemical Works ACRA 500</td>
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<td>28</td>
<td>No Strip Chemical Works ACRA 512</td>
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<td>29</td>
<td>No Strip Chemical Works ACRA 600</td>
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<tr>
<td>30</td>
<td>Darakote</td>
</tr>
<tr>
<td>31</td>
<td>De Hydro H866C</td>
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<tr>
<td>32</td>
<td>Emery 17065</td>
</tr>
<tr>
<td>33</td>
<td>Emery 17319</td>
</tr>
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<td>34</td>
<td>Emery 17319 - 6880</td>
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<td>35</td>
<td>Emery 17320</td>
</tr>
<tr>
<td>36</td>
<td>Emery 17321</td>
</tr>
<tr>
<td>37</td>
<td>Emery 17322</td>
</tr>
<tr>
<td>38</td>
<td>Emery 17339</td>
</tr>
<tr>
<td>39</td>
<td>Emery 1765 - 6860</td>
</tr>
<tr>
<td>40</td>
<td>Emery 6886B</td>
</tr>
<tr>
<td>41</td>
<td>Husky Anti-Strip</td>
</tr>
<tr>
<td>42</td>
<td>Indulin AS-Special</td>
</tr>
<tr>
<td>43</td>
<td>Indulin AS-1</td>
</tr>
<tr>
<td>44</td>
<td>Jetco AD-8</td>
</tr>
</tbody>
</table>
Table F.9. Recycling Agent Type Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA 1</td>
<td></td>
</tr>
<tr>
<td>RA 5</td>
<td></td>
</tr>
<tr>
<td>RA 25</td>
<td></td>
</tr>
<tr>
<td>RA 75</td>
<td></td>
</tr>
<tr>
<td>RA 250</td>
<td></td>
</tr>
<tr>
<td>RA 500</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Note: The recycling agent groups shown in this table are defined in ASTM D4552.

Table F.10. Roller Code

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.01</td>
<td>Steel Wheel Tandem</td>
</tr>
<tr>
<td>.02</td>
<td>Pneumatic Tired</td>
</tr>
<tr>
<td>.03</td>
<td>Single Drum Vibratory</td>
</tr>
<tr>
<td>.04</td>
<td>Double Drum Vibratory</td>
</tr>
<tr>
<td>.05</td>
<td>Articulated Vibratory</td>
</tr>
<tr>
<td>.06</td>
<td>Pneumatic Tired (Air On The Run)</td>
</tr>
<tr>
<td>.07</td>
<td>Other</td>
</tr>
</tbody>
</table>

Version 1.3
### Table F.11. Soil Classification and Description

**Subgrade:** The soil prepared and compacted before placement of the subbase and base that is used to support a pavement structure.

**Fine-Grained Soils:**

Fine-grained soils are those having 50 percent or more

(1) Clay (C): (ASTM D2488-84)

Soil passing a 75 μm sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry.

For classification, a clay is a fine grained soil, or the fine grained portion of a soil, with a plasticity index equal to or greater than 4, and with a plasticity index versus liquid limit falls on or above the "A" line of Figure 3 of ASTM D2487.

(2) Inorganic clay (in which the organic matter does not influence the liquid limit) is classified as:

- Lean Clay (CL), if the liquid limit is less than 50
- Fat Clay (CH), if the liquid limit is 50 or greater

(3) Further classification of predominantly clay soils is done if less than 30 but more than 15 percent of the test sample is retained on the 75 μm sieve. Add the words "with gravel" or "with sand," whichever is predominant. (ASTM D2488-84)

- Clay with Gravel
- Lean Clay with Gravel
- Fat Clay with Gravel
- Clay with Sand
- Lean Clay with Sand
- Fat Clay with Sand

(Note: Codes 107, 108 and 109 will also apply, if the percent of sand is equal to the percent of gravel)

(4) For predominantly clay soils the following classification applies, if 30 percent or more of the test sample is retained on the 75 μm sieve. Add the word "gravely" or "sandy," whichever is predominant to the group symbol. (ASTM D2488-84)

- Gravelly Clay
- Gravelly Lean Clay
- Gravelly Fat Clay
- Sandy Clay
- Sandy Lean Clay
- Sandy Fat Clay

(Note: Codes 113, 114 and 115 also apply, if the percent of sand is equal to the percent of gravel.)

Further division is done by adding the words "with sand" if more than 15 percent sand is present; or the word "with gravel" if more than 15 percent gravel is present.

- Gravelly Clay with Sand
- Gravelly Lean Clay with Sand
- Gravelly Fat Clay with Sand
- Sandy Clay with Sand
- Sandy Lean Clay with Sand
- Sandy Fat Clay with Sand

Version 1.3
(5) Silty Clay (CL-ML) ......................................................... 131
Combined silt and clay. For material passing 85 percent or more on the 75 um sieve if the position
of the plasticity index (PI) versus liquid limit plot falls on or about the A-line and PI is in the range of
4 to 7. (ASTM D2487-85)

Silty Clay is further classified according to the percent of sand and/or gravel in the test sample.

Silty Clay with Gravel ....................................................... 132
(Less than 30 percent but equal to or more than 15 percent retained on 75 um sieve is
predominantly gravel.)

Silty Clay with Sand ......................................................... 133
(Less than 30 percent but equal to or more than 15 percent retained on 75 um sieve)

Gravely Silty Clay ............................................................ 134
(Gravel is predominant in the fraction of 30 percent or more of the test sample retained on the
75 um sieve.)

Sandy Silty Clay .............................................................. 135
(Sand is predominant in the fraction of 30 percent or more of the test sample retained on the
75 um sieve)

Gravely Silty Clay with Sand .......................................... 136
(Equal to or more than 15 percent sand is present in the predominantly gravel fraction of 30 percent
or more of the test sample retained on the 75 um sieve)

Sandy Silty Clay with Gravel .......................................... 137
(More than 15 percent gravel is present in the predominantly sand fraction of 30 percent or more
of the test sample retained on 75 um sieve)

(6) Silt (ML) ................................................................. 141
Soil passing the 75 um sieve that is non-plastic or very slightly plastic and that exhibits little or
no strength when air dry. For classification, a silt is a fine grained soil, or the fine grained portion
of a soil, with liquid limit less than 50 and a plasticity index less than 4, or the plot of plasticity index
versus liquid limit falls below the "A" line of Figure 3 of ASTM D2487-85 (ATM D2488-84)

Silt is further classified according to the percent of sand and/or gravel in the test sample.

Silt with Gravel ............................................................. 142
(Less than 30 percent but more than 15 percent retained on the 75 um sieve is predominantly gravel)

Silt with Sand ................................................................. 143
(Less than 30 percent but equal to or more than 15 percent retained on the 75 um sieve is
predominantly sand)

Gravely Silt ................................................................. 144
(Gravel is predominant in the fraction of 30 percent or more of the test sample retained on
the 75 um sieve)

Sandy Silt ................................................................. 145
(Sand is predominant in the fraction of 30 percent or more of the test sample retained on the
75 um sieve)
Gravelly Silt with Sand .................................................. 146
(15 percent or more sand is present in the predominantly gravel fraction of 30 percent or more of the test sample retained on the 75 um sieve)

Sandy Silt with Gravel .................................................. 147
(A silt soil containing predominantly sand fraction at 30 percent or more of the test sample retained on the 75 um sieve, of which 15 percent or more is gravel)

Clayey Silt ................................................................. 148
A silt soil containing some clay material with slight plasticity. (ASTM D2488-84)

(7) Peat ................................................................. 151
A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black colour, and an organic odour, shall be designated as a highly organic soil and shall be identified as peat. (ASTM D2488-84)

(8) Organic Soil (OL/OH) ............................................... 160
The soil is identified as an organic soil (OL/OH), if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black colour and may have an organic odour. Often, organic soils will change colour, for example, black to brown, when exposed to the air. Some organic soil will lighten in colour significantly when air dried. Organic soil normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy. (ASTM D2488-84)

For organic soils, the liquid limit after oven drying is greater than 75 percent of the liquid limit of the original specimen determined before oven drying. Organic soil is further classified according to the percent of sand and/or gravel in the test sample.

Organic Soil with Gravel ............................................. 161
(Less than 30 percent but equal to or more than 15 percent retained on the 75 um sieve is predominantly gravel)

Organic Soil with Sand ............................................... 162
(Less than 30 percent but equal to or more than 15 percent retained on the 75 um sieve is predominantly sand)

Gravelly Organic Soil ................................................. 163
(Gravel is predominant in the fraction of 30 percent or more of the test sample retained on the 75 um sieve)

Sandy Organic Soil .................................................... 164
(Sand is predominant in the fraction of 30 percent or more of the test sample retained on the 75 um sieve)

Gravelly Organic Soil with Sand .................................... 165
(15 percent or more sand is present in the predominantly gravel fraction of 30 percent or more of the test sample retained on the 75 um sieve)

Sandy Organic Soil with Gravel .................................... 166
(An organic soil containing predominantly sand fraction at 30 percent or more of the test sample retained on the 75 um sieve, of which 15 percent or more is gravel)
(9) In some cases, through practice and experience it may be possible to further identify the organic soils as organic silt or organic clay.

(a) Organic Clay ................................................................. 171
A clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 percent of its liquid limit value before oven drying. (ASTM D2487-85) Further classification is based on liquid limit (LL) and Plasticity Index (PI).

Organic Clay (OL) ............................................................... 172
If the liquid limit (not oven dried) is less than 50 percent; the plasticity index is 4 or greater and the PI versus LL plot falls on or above the "A" line.

Organic Clay (OH) ............................................................... 173
If the liquid limit (not oven dried) is 50 percent or greater; and the PI versus LL plot falls on or above the "A" line.

(b) Organic Silt ................................................................. 176
A silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 percent of its liquid limit value before oven drying. (ASTM D2487-85) Further classification is based on LL and PI.

Organic Silt (OL) ............................................................... 177
If the liquid limit (not oven dried) is less than 50 percent; the plasticity index is less than 4 or the position of the PI versus LL plot falls below the "A" line.

Organic Silt (OH) ............................................................... 178
If the liquid limit (not oven dried) is 50 percent or greater and the position of the PI versus LL plot falls below the "A" line.

(10) Lime Treated Soil .......................................................... 181
The addition of lime to the subgrade soil which results in decreased soil density, changes in the plasticity properties of the soil and increase soil strength.

(11) Cement-Treated Soil ...................................................... 182
The addition portland cement to subgrade soil that produces a hardened soil-cement which increases the stability of the subgrade.

Coarse-Grained Soils

The coarse-grained soils are those having 50 percent or less passing the 75 um sieve ............. 200

(1) Sand (S) ................................................................. 201
Granular material resulting from the disintegration, grinding, or crushing of rock which will pass the 2.00 mm sieve and be retained on the 75 um sieve. Coarse sand is sand passing the 200 um sieve and retained on the 75 um sieve. Fine sand is sand passing the 4425 um sieve and retained on the 75 um sieve. (AASHTO M146-70, 1980)

Poorly Graded Sand (SP) ...................................................... 202
Predominantly one size or a range of sizes of sand with some intermediate sizes missing and 5 percent or less fines.
Poorly graded sand is further classified according to the plasticity and type of fine fraction and percent of gravel in the test sample.

Poorly Graded Sand with Gravel .................................................. 203
(With 5 percent or less fines and 15 percent or more gravel)

Poorly Graded Sand with Silt (SP-SM) .......................................... 204
(With 10 percent fines of ML or MH type and less than 15 percent gravel)

Poorly Graded Sand with Silt and Gravel ..................................... 205
(With 10 percent fines of ML or MH type and 15 percent or more with gravel)

Poorly Graded Sand with Clay (SP-SC) ......................................... 206
(With 10 percent fines of CL or CH type and less than 15 percent gravel)

Poorly Graded Sand with Clay and Gravel ................................... 207
(With 10 percent fines of CL or CH type and 15 percent or more gravel)

Well Graded Sand (SW) ............................................................. 208
A wide range or particle and substantial amounts of the intermediate particle sizes with 5 percent or less fines. Well graded sand is further classified according to the plasticity and type of fine fraction and percent of gravel in the test sample.

Well Graded Sand with Gravel .................................................. 209
(With 5 percent or less fines and 15 percent or more gravel)

Well Graded Sand with Silt (SW-SM) .......................................... 210
(With 10 percent fines of ML or MH type and less than 15 percent)

Well Graded Sand with Silt and Gravel ..................................... 211
(With 10 percent fines of ML or MH type and 15 percent or more gravel)

Well Graded Sand with Clay ...................................................... 212
(With 10 percent fines of CL or CH types and less than 15 percent gravel)

Well Graded Sand with Clay and Gravel ................................... 213
(With 10 percent fines of CL or CH types and 15 percent or more gravel)

Silty Sand (SM) ................................................................. 214
Sands with 15 percent or more fines passing 75 um sieve having low or no plasticity and less than 15 percent gravel. The liquid limit and plasticity index based on minus 425 um sieve fraction should plot below the "A" line on the plasticity chart.

Silty Sand with Gravel ......................................................... 215
(Silty sand with 15 percent or more fines and 15 percent or more gravel)

Clayey Sand (SC) .............................................................. 216
Sands with less than 15 percent gravel and 15 percent or more fines passing the 75 um sieve that are more clay like and that range in plasticity from low to high. The liquid limits and plasticity indexes of soils in this group should plot above the "A" line on the plasticity chart.

Clayey Sand with Gravel ....................................................... 217
(Clayey sand with 15 percent or more fines and 15 percent or more gravel)
Rounded particles of rock which will pass a 75 mm sieve and be retained on a 2.00 mm sieve. Coarse gravel, passing the 75 mm sieve and retained on the 25 mm sieve. Medium gravel, passing the 25 mm sieve and retained on the 9.5 mm sieve. Fine gravel, passing the 9.5 mm sieve and retained on the 2.00 mm sieve. (AASHTO M146-70, 1980)

Poorly Graded Gravel (GP)

Poorly graded gravels, gravel sand mixtures, little or no fines. Predominantly one size or a range of sizes with some intermediate sizes missing. Poorly graded gravel is further classified according to the plasticity and type of fine fraction and percent of sand in the test sample.

Poorly Graded Gravel with Sand
(With 5 percent or less fines and 15 percent or more sand)

Poorly Graded Gravel with Silt
(With 10 percent fines of ML or MH type and 15 percent or more sand)

Poorly Graded Gravel with Silt and Sand
(With 10 percent fines of ML or MH type and 15 percent or more sand)

Poorly Graded Gravel with Clay
(With 10 percent fines of CL or CH type and less than 15 percent sand)

Poorly Graded Gravel with Clay and Sand
(With 10 percent fines of CL or CH type and 15 percent or more sand)

Well Graded Gravel (GW)

It has a wide range of particle sizes and substantial amounts of the intermediate particle sizes. (ASTM D2488-84) Well graded gravel is further classified according to the plasticity and type of fine fraction and percent of sand in the test sample.

Well Graded Gravel with Sand
(With 5 percent or less fines and 15 percent or more sand)

Well Graded Gravel with Silt (GW-GM)
(With 10 percent fines of ML or MH type and less than 15 percent sand)

Well Graded Gravel with Silt and Sand
(With 10 percent fines of ML or MH type and 15 percent or more sand)

Well Graded Gravel with Clay (GW-GC)
(With 10 percent fines of CL or CH type and less than 15 percent sand)

Well Graded Gravel with Clay and Sand
(With 10 percent fines of CL or CH types and 15 percent or more sand)

Silty Gravel (GM)
(With 15 percent for more fines having low or not plasticity and less than 15 percent sand)

Silty Gravel with Sand
(With 15 percent or more fines and 15 percent or more sand)
Clayey Gravel (GC) ................................................................. 306
Gravelly soils with 15 percent or more fines passing the 75 um sieve that are more clay like
and that range in plasticity from low to high and less than 15 percent sand. The liquid limits
and plasticity indexes of soils in this group should plot above the "A" line on the plasticity chart.

Clayey Gravel with Sand ......................................................... 307
(With 15 percent or more fines and 15 percent or more sand)

(3) Shale ............................................................................. 281
Gray, black, reddish or green rock which is fine grained and composed of, or derived by erosion of
sedimentary silts or clays, or of any type of rock that contains clay. The cleavage surfaces of shales
are generally dull and earthy.

(4) Rock ............................................................................... 282
Natural solid mineral matter occurring in large masses of fragments. (AASHTO M146-70, 1980)

(5) Cobbles .......................................................................... 283
Particles of rock that will pass a 300 mm square opening and be retained on a 75 mm sieve.
(ASTM D2488-84)

(6) Boulders .......................................................................... 284
Particles of rock that will not pass a 300 mm square opening. (ASTM D2488-84)
### TABLE F.12. Base and Subbase Materials Description

<table>
<thead>
<tr>
<th>Material Type and Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unbound Base/Subbase Material</strong></td>
<td></td>
</tr>
<tr>
<td>Base Course: A layer of specified or selected material of planned thickness constructed on the subgrade or subbase for the purpose of serving one or more functions such as distributing load, providing drainage, minimizing frost action, etc.</td>
<td></td>
</tr>
<tr>
<td>Subbase: A layer used in a pavement system between the subgrade and base course, or between the subgrade and portland cement concrete pavement.</td>
<td></td>
</tr>
<tr>
<td>No Base</td>
<td>300</td>
</tr>
<tr>
<td>Pavement placed directly on subbase</td>
<td></td>
</tr>
<tr>
<td>No Subbase</td>
<td>301</td>
</tr>
<tr>
<td>Base course directly placed on subgrade</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td>302</td>
</tr>
<tr>
<td>The product resulting from screening and (Uncrushed) blending of material from the deposit, consisting of particles with a shape and texture largely dependent on the nature of the deposit. The product may include some particles with fracture faces resulting from crushing oversize material. (ASTM D1139-83)</td>
<td></td>
</tr>
<tr>
<td>Crushed Stone</td>
<td>303</td>
</tr>
<tr>
<td>The product resulting from the artificial crushing of rocks, boulders, or large cobbles, substantially all faces of which have resulted from the crushing operation. (ASTM D1139-83)</td>
<td></td>
</tr>
<tr>
<td>Crushed Gravel</td>
<td>304</td>
</tr>
<tr>
<td>The product resulting from the crushing of gravel, with a requirement that at least a prescribed percentage of the resulting particles have fracture faces. Some uncrushed particles may be included. (ASTM D1139-83)</td>
<td></td>
</tr>
<tr>
<td>Crushed Slag</td>
<td>305</td>
</tr>
<tr>
<td>The nonmetallic product, consisting essentially of silicates and aluminosilicates of lime and other bases, that is developed simultaneously with iron in a blast furnace. The product resulting from the crushing of air cooled iron blast furnace slag. (ASTM D1139-83)</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>306</td>
</tr>
<tr>
<td>Fine aggregate resulting from natural disintegration and abrasion of rock or processing of completely friable sandstone. (ASTM C125-88)</td>
<td></td>
</tr>
<tr>
<td>Soil Aggregate (Predominantly Fine Grained Soil Mixture)</td>
<td>307</td>
</tr>
<tr>
<td>Natural or prepared mixtures of fine grained soil with a percentage of aggregates included in the mixture.</td>
<td></td>
</tr>
<tr>
<td>Soil Aggregate (Predominantly Coarse Grained Soil Mixture)</td>
<td>308</td>
</tr>
<tr>
<td>Natural or prepared mixtures of coarse grained soil with a percentage of aggregates included in the mixture.</td>
<td></td>
</tr>
<tr>
<td>Material Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A-1</td>
<td>The typical material of this group is a well graded mixture of stone fragments or gravel, coarse sand, fine sand and a non-plastic or feebly plastic soil binder. However, this group includes also stone fragments, gravel, coarse sand, volcanic cinders, etc. without soil binder. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-1-a</td>
<td>Subgroup A-1-a includes those materials consisting predominantly of stone fragments or gravel, either with or without a well graded binder of fine material. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-1-b</td>
<td>Subgroup A-1-b includes those materials consisting predominantly of coarse sand either with or without a well graded soil binder. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-2</td>
<td>This group includes a wide variety of &quot;granular&quot; materials which are border line between the materials falling in Groups A-1 and A-3 and silt clay materials of Group A-4, A-5, A-6 and A-7. It includes all materials containing 35 percent or less passing the 75 um sieve which cannot be classified as A-1 or A-3, due to fines content or plasticity or both, in excess of the limitations for those groups. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-2-4</td>
<td>Subgroups A-2-4 and A-2-5 include various</td>
</tr>
<tr>
<td>A-2-5</td>
<td>Granular materials containing 35 percent 05 or less passing the 75 um sieve and with a minus 425 um portion having the characteristics of the A-4 and A-5 groups. These groups include such materials as gravel and coarse sand with silt contents or plasticity indexes in excess of the limitations of Group A-1, and fine sand with non-plastic silt content in excess of the limitations of Group A-3. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-2-6</td>
<td>Subgroups A-2-6 and A-2-7 include</td>
</tr>
<tr>
<td>A-2-7</td>
<td>Materials similar to those described 07 under Subgroups A-2-4 and A-2-5 except that the fine portion contains plastic clay having the characteristics of the A-6 or A-7 group. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-3</td>
<td>The typical material of this group is fine beach sand or fine desert blow sand without silty or clay fines or with a very small amount of non-plastic silt. The group includes also stream deposited mixtures of poorly graded fine sand and limited amounts of coarse sand and gravel. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-4</td>
<td>The typical material of this group is non-plastic or moderately plastic silty soil having 75 percent or more passing the 75 um sieve. The group includes also mixtures of fine silty soil and up to 64 percent of sand and gravel retained on 75 um sieve. (AASHTO M145-82)</td>
</tr>
<tr>
<td>A-5</td>
<td>The typical material of this group is similar to that described under Group A-4, except that it is usually of diatomaceous or micaceous character and may be highly elastic as indicated by the high liquid limit. (AASHTO M145-82)</td>
</tr>
</tbody>
</table>
The typical material of this group is a plastic clay soil usually having 75 percent or more passing the 75 um sieve. The group includes also mixtures of fine clayey soil and up to 64 percent of sand and gravel retained on 75 um sieve. Materials of this group usually have high volume change between wet and dry states. (AASHTO M145-82) ................................. 512

The typical material of this group is similar to that described under Group A-6, except that it has the high liquid limits characteristic of the A-5 group and may be elastic as well as subject to high volume change. (AASHTO M145-82) ........................................... 513

Subgroup A-7-5 includes those materials with moderate plasticity indexes in highly elastic as well as subject to considerable volume change. (AASHTO M145-82) ........................................... 514

Subgroup A-7-6 includes those materials with high plasticity indexes in relation to liquid limit and which are subject to extremely high volume change. (AASHTO M145-82) ........................................... 515

TABLE F.14. Criteria for Relative Density of Coarse Grained Soils

<table>
<thead>
<tr>
<th>Penetration Resistance Blows/300 mm</th>
<th>Descriptive Term</th>
<th>Relative Density</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4</td>
<td>Very Loose</td>
<td>0% to 20%</td>
<td>2001</td>
</tr>
<tr>
<td>4 to 10</td>
<td>Loose</td>
<td>20% to 40%</td>
<td>2002</td>
</tr>
<tr>
<td>10 to 30</td>
<td>Medium Dense</td>
<td>40% to 70%</td>
<td>2003</td>
</tr>
<tr>
<td>30 to 50</td>
<td>Dense</td>
<td>70% to 90%</td>
<td>2004</td>
</tr>
<tr>
<td>Over 50</td>
<td>Very Dense</td>
<td>90% to 100%</td>
<td>2005</td>
</tr>
</tbody>
</table>

Includes (1) clean, fine gravels and sands, depending on distribution of grain sizes and (2) silty or clayey fine gravels and sands. Condition is rated according to relative density, as determined by laboratory tests or estimated from resistance to sampler penetration.
Surface Distress Monitoring
1.0 Introduction

Surface distress is a key measurement within C-LTPP as it is one of the most commonly used measures of pavement response. Difficulties arise in achieving consistent details of surface distress because of the subjective nature of the identification process. The objective in C-LTPP is to capture as much quantitative data for distress as possible since any number of qualitative assessments can then be accommodated. This procedure outlines a combination of mapping, coding and photographing aimed at documenting the pavement condition as thoroughly as possible. While ultimately distress or groups of distress are likely to be aggregated for analysis, maximum analytical flexibility will be gained by providing distress data in the rawest form possible.

2.0 Equipment Required

- 30 m measuring tape
- 30 cm ruler (with millimetre gradation)
- 35 mm camera with wide angle (35 mm) lens
- 100 ASA colour print film (1 - 24 exposure film per test section)
- condition rating guide
- distress mapping form
- traffic control signs

3.0 Distress Mapping Procedure

The monitored test section should be closed to traffic for the duration of the survey.

Before commencing actual mapping, walk the section at least once in order to obtain a general impression of the distresses occurring and problems affecting the section.

Five map sheets are required for each test section, with each covering one of the five subsections.

Mapping of a test section begins upstream ("0" marker) and proceeds in the direction of traffic. All distresses are reported on the mapping form (Form SD1) beginning at the bottom of the page and moving towards the top.

Localized or linear distresses (single or multiple cracks, potholes, small defects or deformation) and/or maintenance treatments are drawn to scale and coded according to Table 1. The appended condition rating guide is used to identify the type and severity. The code reported on the map should include distress type (Table 1) and severity (Class 1 to 5). For example, a moderate transverse crack should be coded as follows: C7/3.

Area distresses (alligator cracking, large defects or deformation) and/or maintenance treatments are contoured, hatched and coded according to Table 1 and the condition rating guide for type, and severity as shown in Figure 1.

Uniform distresses (covering 75% of the section or more) are described in the section earmarked for that purpose. Type, severity and density of distresses are coded to Table 1 and to the condition rating guide, as shown on Figure 1.

Shoulder distresses should be reported on the map or described in the "remarks" section of the form. Observed manifestations of shoulder distresses such as ravelling, drop off, erosion, softening, creeping, etc. should be noted and quantified.
C-LTPP
Surface Defects
Mapping Form

Localized Defects Mapping

<table>
<thead>
<tr>
<th>Host Jurisdiction</th>
<th>C-SHRP I.D. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Road # or Description

Site Location

Survey Date:

<table>
<thead>
<tr>
<th>UNIFORM DEFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Severity</td>
</tr>
<tr>
<td>Extent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Signature
# Flexible Pavements

<table>
<thead>
<tr>
<th>Item</th>
<th>Code</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAVEMENT DISTRESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse Aggregate Loss</td>
<td>A1</td>
<td>5</td>
</tr>
<tr>
<td>Ravelling</td>
<td>A2</td>
<td>5</td>
</tr>
<tr>
<td>Flushing</td>
<td>A3</td>
<td>6</td>
</tr>
<tr>
<td>Polishing of Aggregate</td>
<td>A4</td>
<td>–</td>
</tr>
<tr>
<td>Pothole</td>
<td>A5</td>
<td>–</td>
</tr>
<tr>
<td>Rippling Corrugations</td>
<td>B1</td>
<td>7</td>
</tr>
<tr>
<td>Shoving</td>
<td>B2</td>
<td>7</td>
</tr>
<tr>
<td>Wheel track rutting</td>
<td>B3</td>
<td>8</td>
</tr>
<tr>
<td>Distortion</td>
<td>B4</td>
<td>9</td>
</tr>
<tr>
<td>Cracking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheel track – single and multiple</td>
<td>C1</td>
<td>10</td>
</tr>
<tr>
<td>Wheel track – alligator</td>
<td>C2</td>
<td>11</td>
</tr>
<tr>
<td>Center line – single and multiple</td>
<td>C3</td>
<td>12</td>
</tr>
<tr>
<td>Center line – alligator</td>
<td>C4</td>
<td>13</td>
</tr>
<tr>
<td>Pavement edge – single and multiple</td>
<td>C5</td>
<td>14</td>
</tr>
<tr>
<td>Pavement edge – alligator</td>
<td>C6</td>
<td>15</td>
</tr>
<tr>
<td>Transverse – half, full and multiple</td>
<td>C7</td>
<td>16</td>
</tr>
<tr>
<td>Transverse – alligator</td>
<td>C8</td>
<td>17</td>
</tr>
<tr>
<td>Meander</td>
<td>C9</td>
<td>18</td>
</tr>
<tr>
<td>Midlane longitudinal</td>
<td>C10</td>
<td>18</td>
</tr>
<tr>
<td>Random and map cracking</td>
<td>C11</td>
<td>19</td>
</tr>
<tr>
<td>Maintenance Treatments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray patch</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>Skin patch</td>
<td>M2</td>
<td></td>
</tr>
<tr>
<td>Hot mix patch</td>
<td>M3</td>
<td></td>
</tr>
<tr>
<td>Cold mix patch</td>
<td>M4</td>
<td></td>
</tr>
<tr>
<td>Full width hot mix patch</td>
<td>M5</td>
<td></td>
</tr>
<tr>
<td>Utility cuts</td>
<td>M6</td>
<td></td>
</tr>
<tr>
<td>Crack sealing</td>
<td>M7</td>
<td></td>
</tr>
<tr>
<td>Crack routed and sealed</td>
<td>M8</td>
<td></td>
</tr>
<tr>
<td>Seal coat (chipseal)</td>
<td>M9</td>
<td></td>
</tr>
</tbody>
</table>

**Surface Distresses for Flexible Pavement**

**TABLE 1**

Version 1.0
C-LTPP
Surface Defects
Mapping Form

Localized Defects Mapping

Host Jurisdiction ________________________________
C-SHRP I.D. Number ________________________________
Road # or Description ________________________________
Site Location ________________________________
Survey Date: ________________________________

**UNIFORM DEFECTS**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ravelling (A2)</td>
<td>Slight</td>
<td>80%</td>
</tr>
<tr>
<td>Polishing of Aggregate</td>
<td>Moderate</td>
<td>75%</td>
</tr>
</tbody>
</table>

**REMARKS**

Ravelling Shoulders 30-50 mm dropoff
Average alligator cracking block = 150 mm
4.0 Photo Logging Procedures

Photo logging of the test sections must be done when the pavement and shoulders are dry and free of snow, ice and deicing chemical.

Photographs should be taken only on clear days with the sun forming an angle with the direction of the shot smaller than 120° and greater than 60° (Figure 2).

All pictures will be taken by a person standing in the middle of the lane facing downstream. The horizon line should be approximately at the upper quarter of the viewfinder (Figure 3).

The first picture will be taken 10 m upstream of the beginning of the section (marker 0) and the shots will be taken at 10 m intervals. The last picture will be taken 10 m upstream of the end of the section (marker 5) (Figure 4). Discrete points (10 m stations) marked in the wheel tracks for deflection testing should be used as reference for photo logging distances.

8.9 x 12.7 cm (3 1/2 x 5") colour prints will be assembled on the provided photo logging sheets (Form SD2). Colour copies of these sheets will be reported to C-SHRP.

Acceptable Conditions for Photo Logging

FIGURE 2
Typical View Finder Image
(with the horizon filling 1/4 of the picture)

FIGURE 3
C-LTPP
Surface Defects
Photologging
Sheet

<table>
<thead>
<tr>
<th>C-SHRP ID:</th>
<th>Picture #:</th>
<th>Station:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>Time:</td>
<td>Weather:</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C-SHRP ID:</th>
<th>Picture #:</th>
<th>Station:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>Time:</td>
<td>Weather:</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.0 SURFACE CONDITION RATING GUIDE

Surface condition rating for C-LTPP test sections will be done using guidelines adapted from the RTAC Pavement Condition Rating Systems manual (June 1987).

Each of the different distress manifestations has been assigned a code and will be evaluated in terms of its density and severity. The density of these manifestations will be captured through the mapping process while the severity level will be rated in the field using the photographic guide provided.

Each distress manifestation is described in qualitative terms and by the probable cause. The severity of each one is subdivided into five classes from very slight through to very severe. A typical illustration and specific quantitative criteria are provided for each of these levels, in order to achieve a unified assessment of severity by field rating personnel.

Unless otherwise specified, the criteria used for different categories of defects are the following:

- **Defects:**
  - illustration
  - description

- **Deformations:**
  - measure of distortion
  - relative motion of a moving vehicle

  Severity of Wheel Track rutting is classified according to depth from some established datum line as obtained from cross section profile measurements.

  Severity of distortion, rippling or shoving is assessed by raters in a subjective manner based on the relative motion of a moving vehicle on paved surface.

- **Cracking**
  - Single - multiple: crack opening
    multiplicity of cracking
    occurrence of spalling
  - Alligator: distortion
    crack opening
    occurrence of spalling disintegration or potholes

  Distortion in alligator cracking is the maximum depth of depression as measured from a 1.2 m ruler.

  Though it does not affect the severity of alligator cracking, the average size of polygon blocks should be noted to help in assessing the cause of the distress.

  Where two or more criteria are given, they should be used on a "and/or" basis. The predominant characteristic of the defect then dictates the severity level.
The criteria used to differentiate severity classes are the following:

<table>
<thead>
<tr>
<th>Class</th>
<th>Distortion/Rutting</th>
<th>Crack width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>1</td>
<td>Very Slight</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>2</td>
<td>Slight</td>
<td>5 - 10</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>10 - 20</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>20 - 50</td>
</tr>
<tr>
<td>5</td>
<td>Very Severe</td>
<td>&gt; 50</td>
</tr>
</tbody>
</table>
DEFECTS

A1 – Coarse Aggregate Loss A2 – Ravelling

Description: Coarse aggregate particles (> 6 mm) are removed from the surface (A1). Ravelling (A2) is the progressive loss of asphaltic material from surface downward or edge inward.

Possible Causes:
- Lack of bond between particles and mortar due to inadequate coating or to stripping under the action of water.
- Fracture of the particle through load or natural causes, allowing the loosened pieces to be picked out by traffic action.
- Disintegration of particles such as chert which are highly absorptive and fracture and disintegrate upon repeated freezing and thawing.
- Delamination of chert or shale particles.
- Clay-coated aggregate particles.
- Insufficient asphalt content.
- Poor adhesion of asphalt binder to aggregate particles due to wet aggregate.
- Poor compaction - especially cold weather paving - permits infiltration of water and salts which promote stripping of asphalt.
- Asphalt hardening due to aging.
Class 1: Very Slight
- Barely noticeable

Class 2: Slight
- Noticeable

Class 3: Moderate
- Pock-marked appearance
- Well-spaced

Class 4: Severe
- Pock-marked
- Pock marks closely spaced

Class 5: Very Severe
- Surface has ravelled appearance
- Surface disintegrated into small potholes

Severity Guide, Defects A1 – Coarse Aggregate Loss and/or A2 – Ravelling

FIGURE 5
A3 – Flushing

Description: The presence of free asphalt binder on the surface resulting from upward migration of the binder. Most likely to occur in the wheel tracks during hot weather.

Possible Causes:

- Too high asphalt content relative to void content in mineral aggregate. On the hot days, asphalt binder expands into air voids; if air voids are too low, continued expansion results in lower stability of the mix with the consequence that traffic will force out excess asphalt binder to the surface.

- Paving over flushed surfaces. The excess asphalt on the old surface may be pumped up through the new paving over a period of time.

- Paving over excess primed surfaces.
Class 1: Very Slight

- Very faint coloring (veining)

Class 2: Slight

- Coloring visible (interconnected veining)

Class 3: Moderate

- Distinctive appearance (excessive asphalt free)

Class 4: Severe

- Free asphaltic material
- Surface wet look

Class 5: Very Severe

- Free asphaltic material
- Surface wet look
- Wheel noise noticeable

Severity Guide, Defect A3 – Flushing

FIGURE 6
DEFECTS

A4 – Polishing of aggregate

Description: The aggregates at the surface are worn or polished giving a smooth and brilliant appearance to the surface. This manifestation usually results in a poor texture and loss of skid resistance.

Possible Causes:
- Traffic action (especially where studded tire are allowed)
- Winter maintenance
- Burying of coarse aggregate in the binder.

Severity: The severity of this specific type of defect has to be estimated from a close inspection of the surface texture and the aggregate micro-texture. This evaluation can be facilitated by the comparison between aggregates and texture in the wheel-path and outside the wheelpath.

The following scale should be used.

Very slight: Aggregate wear barely noticeable.

Slight: Angularity and micro-texture of aggregate reduced.

Moderate: Very little angularity and micro-texture remaining. Wear of aggregate and loss of texture noticeable.

Severe: Aggregate worn, texture greatly reduced.

Very severe: Aggregate flush with binder surface. No texture remaining.

The rater should not differentiate between natural polishing of aggregates (rounded natural gravel) and polishing due to traffic action. For instance a new pavement built with natural gravel could have an absence of angularity or micro-texture and would therefore be rated "slight" or "moderate".
DEFECTS

A5 – Potholes

Description:

Irregularly shaped holes of various sizes in the pavement. Potholes are developing from other distresses, resulting in disintegration, with removal of material by traffic over weakend spots of the surface.

Note:

Pothole occurrence is the evolution of distresses such as ravelling, coarse aggregate removal, cracking and especially alligator cracking. Therefore, potholes should be indicated on the map and rated/analysed in relation to their cause as outlined elsewhere in the manual and not as independent distresses. Potholes are major distress manifestation and provide warrants for immediate intervention.
DEFORMATIONS

B1 – Rippling and B2 – Shoving

Description: Rippling (B1) is regular transverse undulation in the surface of the pavement consisting of closely-spaced, alternate valleys and crests. Considered due to faulty paver behaviour with some mixes. Generally results in a rough ride and becomes worse with time. Shoving (B2) is the asphalt surface being very uneven as a result of traffic moving it away from the wheel tracks, or forward or backwards in the wheel track.

Possible Causes:

- Faulty paver behaviour with some mixes.
- Heavy traffic on steep downgrade or upgrade, or pavement with too thick tack coat or too thick soft waterproofing membranes on bridge decks.
- Low stability mix.
- Lack of bond between asphalt surface and underlying layer - may be caused by excessive tack coat acting as a lubricant.
- Unstable granular base reflecting through the surface.
- Stop and start of vehicles at intersections.
Class 1: Very Slight
- Barely noticeable

Class 2: Slight
- Noticeable

Class 3: Moderate
- Rough ride

Class 4: Severe
- Very rough ride

Class 5: Very Severe
- Possible loss of control


FIGURE 7
DEFORMATIONS

B3 – Wheel Track Rutting

Description: Longitudinal depressions left in the wheel tracks after repeated load repetitions. It results from compaction under the load combined with a shoving sideways of pavement material. In some cases dual tracking is evident.

Possible Causes:

1. Poorly-compacted structural layers.
2. Unstable granular bases or subbases create by positive pore water pressures under loads at times of near saturation.
3. Unstable asphalt mixes (due to high temperature or low viscosity of binder).
4. Unstable shoulder material; does not provide adequate lateral support.
5. Overstressed subgrade will deform permanently.
Class 1: Very Slight
- < 5 mm

Class 2: Slight
- 5 mm - 10 mm

Class 3: Moderate
- 10 mm - 20 mm
- May include longitudinal cracks

Class 4: Severe
- 20 mm - 50 mm
- May include multiple cracks

Class 5: Very Severe
- > 50 mm
- May include multiple cracks or alligator cracks

Severity Guide, Deformation B3 – Wheel Track Rutting

FIGURE 8
B4 – Distortion

Description: Any deviation of the pavement surface from its original shape other than described for rippling, shoving and rutting. Generally distortions result from settlement, slope failure, volume changes due to moisture changes and to frost heaving, and from residual effects of frost heaving after each season.

Distortion may take the form of dishing, bumps, dips, tenting or stepping at cracks, all of which give rise to pitch and roll in a moving vehicle.

Possible Causes:

1. Differential frost heave in poorly drained cuts and transitions.
2. Differential frost heave at pavement edges or road centre.
3. Reverse differential frost heave at culverts.
4. Differential settlement of subgrade or base material.
5. Lack of subgrade support.

Severity:

Severity of distortion is assessed by raters in a subjective manner based on the relative motion of a moving vehicle over the paved surface. Distortion causes the vehicle to pitch and roll, and the rater must evaluate the severity on the basis of his past experience. The guidelines are intended to assist in developing uniformity in assessment of this defect.
Class 1: Very Slight

- Noticeable (swaying motion)

Class 2: Slight

- Good control of car still present

Class 3: Moderate

- Fair control of car when driving

Class 4: Severe

- Poor car control

Class 5: Very Severe

- Continuous distortion
- Dangerous at speeds greater than 50 km/h

Severity Guide, Deformation B4 – Distortion

FIGURE 9
CRACKING

C1 - Longitudinal Wheel-Track – single and multiple

Description: Longitudinal cracks which are situated at or near the centre of the wheel tracks.

Possible Causes: Due to overloaded vehicles at the weakest pavement period in the early spring. Fatigue failure of thin asphalt surfacings are initiated in this manner.

Version 1.0
Class 1: Very Slight
- Crack width < 5 mm

Class 2: Slight
- 5 mm - 10 mm crack width

Class 3: Moderate
- 10 mm - 20 mm crack width
- Single or multiple cracks

Class 4: Severe
- 20 mm - 30 mm crack width
- Spalling beginning to develop

Class 5: Very Severe
- Crack width > 30 mm
- Spalling developed
- Multiple parallel crack developed

Severity Guide, Cracking C1 – Wheel Track – Single and Multiple
FIGURE 10
CRACKING

C2 – Longitudinal Wheel Track – alligator

Description: Cracks which form a network of multi-sided (polygon) blocks resembling the skin of an alligator. The block size can range from a few millimeters to about a metre. The block size is indicative of the level (depth) at which failure is taking place. The small block sizes 100 mm to 150 mm, indicate that movement is occurring in the upper (granular base) layer. This type of alligatoring is mostly observed on "thin" (less than 75 mm) asphalt surfacings, accompanied at times by slight depressions (perhaps 12 mm). The large block sizes, 300 mm and more, indicate that movement is occurring in the deeper layers and subgrade. This type of alligatoring is accompanied by large depressions (perhaps as much as 50 mm) together with a lateral movement outward (and upward) of the pavement edge; it forms a "bird-bath" during rains.

Alligatoring is a consequence of the inability of a part of the structure to support the repeated loads due to a "softening" of the material normally associated with an increase in moisture content. Alligator failures which are deep-seated in the subbase or subgrade are progressive, i.e., under traffic, and rains, they tend to spread rapidly, and traffic causes blocks or surfacing to be displaced and broken up. Alligator failures which are in the upper layers, normally appear in the very early spring.

Alligator cracking is a major structural distress.

Possible Causes:

1. Insufficient bearing support.

2. Poor base drainage and stiff or brittle asphalt mixes at cold temperatures.
Class 1: Very Slight
- Alligator pattern just formed
- Distortion < 5 mm
- Crack width < 5 mm

Class 2: Slight
- Pattern established
- 5 mm - 10 mm distortion
- 5 mm - 10 mm crack width

Class 3: Moderate
- Pattern established
- 10 mm - 20 mm distortion
- 10 mm - 20 mm crack width

Class 4: Severe
- Polygon blocks begin to lift
- Spalling beginning to develop
- 20 mm - 50 mm distortion
- 20 mm - 30 mm crack width

Class 5: Very Severe
- Disintegration
- Potholes
- Distortion > 50 mm
- Crack width > 30 mm

Severity Guide, Cracking C2 – Wheel Track – Alligator

FIGURE 11
CRACKING

C3 – Centre line – single and multiple

Description: Crack(s) which run along or in the immediate adjacent vicinity of the road centre line.

Possible Causes:

1. Poor longitudinal joint construction.

2. Frost action - variable granular depths due to constructing lanes separately; differential frost heave along centre line due to insulating value of snow along pavement edges.

3. Moisture changes (swelling/shrinkage).

4. Faulty construction equipment appears to result in weak plane which then fails, due to thermal shrinkage.
Class 1: Very Slight
• Crack width < 5 mm

Class 2: Slight
• 5 mm - 10 mm crack width

Class 3: Moderate
• 10 mm - 20 mm crack width

Class 4: Severe
• 20 mm - 30 mm crack width
• Spalling beginning to develop

Class 5: Very Severe
• Crack width > 30 mm
• Spalling developed
• Multiple parallel crack developed

Severity Guide, Cracking C3 – Centre Line – Single and Multiple

FIGURE 12
CRACKING

C4 – Centre line – alligator

Description: Cracks which follow a course approximately parallel to the centre line of the pavement.

Two or more cracks closely spaced and interwoven with each other giving the appearance of loosely braided strands of rope or of alligator skin.

Cracking begins at the bottom of the asphalt surface where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading the cracks connect, forming many sharp-angled pieces.

Alligator cracking is considered a major structural distress.

Possible Causes: Alligator cracking generally occurs as the result of excessive loading and/or structural inadequacy. The occurrence of alligator cracking outside wheel paths suggests the predominance of structural factors such as:

- Poor base materials or thickness
- Moisture content and variability
- Frost action - frost heave along the centre line
- Faulty mix properties at the edge of the paver (segregation)
Class 1: Very Slight
- Alligator pattern just formed
- Distortion < 5 mm
- Crack width < 5 mm

Class 2: Slight
- Pattern established
- 5 mm - 10 mm distortion
- 5 mm - 10 mm crack width

Class 3: Moderate
- Pattern established
- 10 mm - 20 mm distortion
- 10 mm - 20 mm crack width

Class 4: Severe
- Polygon blocks begin to lift
- Spalling beginning to develop
- 20 mm - 50 mm distortion
- 20 mm - 30 mm crack width

Class 5: Very Severe
- Disintegration
- Potholes
- Distortion > 50 mm
- Crack width > 30 mm

Severity Guide, Cracking C4 – Centre Line Cracking – Alligator

FIGURE 13
CRACKING

C5 – Pavement edge – single and multiple

Description: Crack(s) which is parallel to and within 30 cm of the pavement edge and is either fairly continuous "straight" crack or consists of crescent-shaped cracks in a wave formation.

Possible Causes:
1. Frost action.
2. Insufficient bearing support and/or excessive traffic loading at the pavement edge.
3. Poor drainage at pavement edge and shoulder.
4. Inadequate pavement width forces traffic too close to pavement edge.

Version 1.0
Class 1: Very Slight

- Single longitudinal or wave formation
- Crack width < 5 mm

Class 2: Slight

- Single or multiple longitudinal or wave formation
- 7 mm - 10 mm crack width

Class 3: Moderate

- Progressive multiple cracks
- 10 mm - 20 mm crack width

Class 4: Severe

- Progressive multiple cracks
- Spalling beginning to develop
- 20 mm - 30 mm crack width

Class 5: Very Severe

- Progressive multiple cracks
- Spalling developed
- Crack width > 30 mm

Severity Guide, Cracking C5 – Pavement Edge - Single and Multiple

FIGURE 14
CRACKING

C6 – Pavement edge – alligator

Description: On some thin asphalt surfaces, pavement edge cracking progressively encroaches into the outer wheel tracks through the middle of the lane, and may even progress right across to the centre line. The pattern typical of alligator cracking is evident.

Possible Causes:

1. Frost action.
2. Insufficient bearing support and/or excessive traffic loading at the pavement edge.
3. Poor drainage at pavement edge and shoulder.
4. Inadequate pavement width forces traffic too close to pavement edge.
Class 1: Very Slight
- Alligator pattern just formed
- Distortion < 5 mm
- Crack width < 5 mm

Class 2: Slight
- Pattern established
- 5 mm - 10 mm distortion
- 5 mm - 10 mm crack width

Class 3: Moderate
- Pattern established
- 10 mm - 20 mm distortion
- 10 mm - 20 mm crack width

Class 4: Severe
- Polygon blocks begin to lift
- Spalling beginning to develop
- 20 mm - 50 mm distortion
- 20 mm - 30 mm crack width

Class 5: Very Severe
- Disintegration
- Potholes
- Distortion > 50 mm
- Crack width > 30 mm

Severity Guide, Cracking C6 – Pavement Edge – Alligator

FIGURE 15
CRACKING

C7 – Transverse – half, full and multiple

Description: Crack which follows a course approximately at right angles to the pavement centre line. Full transverse cracks tend to be regularly spaced along the length of the road, while half transverse and part transverse occur at shorter intermediate distances.

Possible Causes:

1. Natural shrinkage caused by very low temperatures.
2. High temperature susceptibility of asphalt cement binder in asphalt mixes.
3. Frost action.
4. Reflection cracks.
Class 1: Very Slight
- Partial and singular cracks
- Crack width < 5 mm

Class 2: Slight
- Full and singular cracks
- 5 mm - 10 mm crack width

Class 3: Moderate
- 10 mm - 20 mm crack width
- Multiple cracking begins to develop

Class 4: Severe
- 20 mm - 30 mm crack width
- Spalling beginning to develop
- Stepping beginning
- Progressive multiple cracks

Class 5: Very Severe
- Crack width > 30 mm
- Spalling developed
- Stepping
- Progressive multiple cracks

Severity Guide, Cracking C7 – Transverse – Half, Full and Multiple

FIGURE 16
CRACKING

C8 – Transverse – alligator

Description: Cracks which follow a course approximately perpendicular to the centreline of the pavement.

Two or more cracks closely spaced and interwoven with each other giving the appearance of loosely braided strands of rope or of alligator skin.

Cracking begins at the bottom of the asphalt surface and propagates to the surface either as a series of parallel transverse cracks that gradually connect or as the progressive development of a single transverse crack into the typical alligator pattern.

Alligator cracking is considered a major structural distress.

Possible causes: Alligator cracking generally occurs as the result of excessive loading and/or structural inadequacy.

The occurrence of alligator cracking outside wheel paths suggests the predominance of structural factors such as:

• Poor base material or thickness.
• Differential base density.
• Poor base drainage.
• Frost action.
• Stiff or brittle asphalt mixes at cold temperature.
Class 1: Very Slight
- Alligator pattern just form
- Distortion < 5 mm
- Crack width < 5 mm

Class 2: Slight
- Pattern established
- 5 mm - 10 mm distortion
- 5 mm - 10 mm crack width

Class 3: Moderate
- Pattern established
- 10 mm - 20 mm distortion
- 10 mm - 20 mm crack width

Class 4: Severe
- Polygon blocks begin to lift
- 20 mm - 50 mm distortion
- 20 mm - 30 mm crack width
- Spalling beginning to develop

Class 5: Very Severe
- Disintegration
- Potholes
- Distortion > 50 mm
- Crack width > 30 mm

Severity Guide, Cracking C8 – Transverse – Alligator

FIGURE 17
CRACKING

C9 – Meander and C10 – Midlane Longitudinal

Description: Meandering cracks (C9) are those which wander from edge to edge of the pavement, and are usually quite long in length. Mostly single, but secondary cracks do develop.

Midlane longitudinal cracks (C10) are usually straight and parallel to the centre line, situated at or near the middle of the lane. These cracks are usually singular, but occasionally secondary cracks do develop parallel to it.

Possible Causes:

1. Frost action - greater heave at pavement centre than at edges. More prevalent in mixes where asphalt stripped is extensive.

2. Poor construction practices.

3. Faulty construction equipment appears to result in weak plane which then fails, due to thermal shrinkage.
Class 1: Very Slight
- Crack width < 5 mm

Class 2: Slight
- 5 mm - 10 mm crack width

Class 3: Moderate
- 10 mm - 20 mm crack width
- Single or multiple cracks

Class 4: Severe
- 20 mm - 30 mm crack width
- Spalling beginning to develop

Class 5: Very Severe
- Crack width > 30 mm
- Spalling developed
- Multiple parallel cracks developed

Severity Guide, Cracking C9 – Meander and C10 – Midlane Longitudinal

FIGURE 18
CRACKING

C11 – Random or Map Cracking

Description: Crack which runs randomly across and along the surface sometimes in a serpen-
tine manner. The crack appears to have transverse and longitudinal cracks com-
bined (sometimes called map cracking).

Possible Causes:
1. Swelling or shrinkage.
2. Frost action.
3. Shrinkage of cement treated or other stabilized base.
Class 1: Very Slight
- Crack width < 5 mm

Class 2: Slight
- 5 mm - 10 mm crack width

Class 3: Moderate
- 10 mm - 20 mm crack width
- Single or multiple cracks

Class 4: Severe
- 20 mm - 30 mm crack width
- Spalling beginning to develop

Class 5: Very Severe
- Crack width > 30 mm
- Spalling developed
- Multiple parallel crack developed

Severity Guide, Cracking C11 – Random or Map Cracking

FIGURE 19
Maintenance Treatments

C-LTPP test sites are selected from pavements that are at the end of their first life cycle. In many cases, rehabilitation of these pavement may have been delayed by maintenance activities. After rehabilitation, test sites are likely to require maintenance over the 10-15 year monitoring period. Maintenance treatments should be identified and reported on the mapping form (Form SD1). Relevant information on the method of application (if known) and on the treatment condition should be noted in the "remarks" section of the form (figure 20). Although maintenance treatments will mask some of the monitored defects, the mapping process should indicate the current surface condition.

The maintenance treatments as listed in Table 1 are defined as follows:

- **Spray Patch:** A localized application of sprayed asphalt emulsion on which aggregate chips are spreaded and rolled.

- **Skin Patch:** The application of a thin layer of additional hot mix material on top of a distressed area (with or without a tack coat).

- **Hot Mix Patch:** Placement of hot mix asphalt on distresses that extend below the roadway surface and/or to restore pavement profile (may include some removal of distressed pavement and base material).

- **Cold Mix Patch:** Placement of cold mix asphalt on distresses that extend below the roadway surface (may include some removal of distressed pavement and base material).

- **Full Width Hot Mix Patch:** The placement of hot mix asphalt on a distressed area using a paver. Often applied to the full lane or surface width.

- **Utility Cut:** The repair of a trench dug for maintaining or retrofitting utility lines.

- **Crack Sealing:** Filling a cleaned or uncleaned crack with a prepared joint sealer.

- **Crack Routed and Sealed:** Filling of a cleaned and routed crack with a prepared joint sealer.

- **Seal Coats:** Spraying of asphalt (usually an emulsion) followed by the spreading and rolling of aggregate or crushed stone chips on a full width or travel width basis.
C-LTPP
Surface Defects
Mapping Form

Localized Defects Mapping

Host Jurisdiction
C-SHARP I.D. Number
Road # or Description
Site Location
Survey Date:

UNIFORM DEFECTS

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ravelling (A2)</td>
<td>Slight</td>
<td>80%</td>
</tr>
<tr>
<td>Polishing of Agg. (A4)</td>
<td>Moderate</td>
<td>75%</td>
</tr>
</tbody>
</table>

REMARKS

Ravelling Shoulders 30-50mm dropoff
Average alligator block 150 mm
Hot mix patch in good condition
"Band Aid" type crack filling (Tends to peel off)

Example of Maintenance Treatment Mapping

FIGURE 20
Benkelman Beam

The procedural aspects of this guideline have been adapted from the "Operations Manual for the Benkelman Beam" published by the Ontario Ministry of Transportation in February 1972.
1.0 Introduction

The Benkelman Beam was developed in 1953 to measure pavement deflection under typical test-wheel loadings. Since then, the Benkelman Beam has been widely accepted and extensively used throughout the world, with the result that most of the pavement technology used today is still based on this standard.

Despite the rapid evolution of new technologies in the past few years, the C-SHPP Pavement Advisory Committee has selected the Benkelman Beam as one of the standard monitoring devices for the Canadian Long Term Pavement Performance Project. The Benkelman Beam continues to be the only deflection measuring device easily available across the country. Its use will ensure the proper linkage with existing Canadian technology while providing a correlation opportunity with new pavement evaluation technologies. Benkelman Beam benchmarks in C-LTPP are vital, if current design methods are to be evaluated within the study.

Benkelman Beam deflection readings will be used for two key portions of the study. BB will be used to characterize the strength parameter before and after rehabilitation. In addition, in the first spring following rehabilitation, BB will be used to determine the peak deflection factor for each test section. Parallel measurements will also be made with the Falling Weight Deflectometer after rehabilitation has occurred.

<table>
<thead>
<tr>
<th>Benkelman Beam deflection schedule</th>
<th>Summer 1989 prior to rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall 1989 after rehabilitation in conjunction with FWD</td>
</tr>
<tr>
<td></td>
<td>Spring 1990 for spring factor</td>
</tr>
</tbody>
</table>

2.0 Operation Guidelines

The following guidelines were adapted from the MTO operations manual for the Benkelman Beam and are provided to Canadian agencies participating in C-LTPP to provide consistency in approach and to highlight some specific requirements for the project.

2.1 Equipment Required

2.1.1 The Test Vehicle

A loaded 5-ton truck, equipped with standard 10.00 x 20, 12-ply ribbed tires, inflated to 80 psi is used as the test load vehicle.

A rear-axle load of 8165 kg is used. The load must be evenly distributed over the rear axle so that each set of dual-tires carries equal load. The weight should be checked periodically to ensure the load has not shifted.

If available equipment differs from the test standard, the deviations should be noted in the "remarks" section of the data form.

If the material used to load the truck is sand or gravel, a covering tarpaulin must be provided to prevent rain water from soaking into the material and thereby increasing the weight.

Vehicles used for Benkelman Beam testing require the following additional equipment to be attached prior to testing:

1. A mounting rack on the side of the truck to carry the Beam between tests.
2. A distance measuring device, either a fifth wheel or odometer.
3. Provision for holding the right rear mudflap out of the way while testing.
4. A standard warning sign is also required for traffic control.

Version 1.1
Sketch of Component Parts of the Benkelman Beam

FIGURE 1

2.1.2 The Beam

The aluminum beam is equipped with a set of small wheels to facilitate transportation between test locations (Figure 1).

A dial-gauge with stem, having a range of 0.0025 to 25 mm (0.0001 to 1 inch) is attached to the shorter end of the Beam to provide indication of the probes movement.

A 6-volt battery and an electric vibrator are also attached to the Beam; the vibrator ensures freedom of movement of the Beam during testing.

2.1.3 Auxiliary Equipment

Thermometer -15 to 50°C with .5 degree divisions.

Hammer.

Device for making 5 cm deep hole in the pavement in which to place the thermometer to determine the temperature of the pavement.

Spare battery, dial gauge and extension stem.

Tire pressure gauge.

2.1.4 Crew

While individual agency requirements will prevail, it is recommended that the crew be comprised of 5 men when testing two-lane roads, which includes a driver, a beam operator, 2 flagmen and a party supervisor.

Version 1.1
2.2 Location of Measuring Points

Measuring points will be located in the outer-wheel path. If the wheel path is not distinct, testing will be located at specified distances from the edge of pavement as follows.

<table>
<thead>
<tr>
<th>Pavement Width</th>
<th>Distance from Pavement Edge (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.3 m</td>
<td>900 mm</td>
</tr>
<tr>
<td>6.7 m</td>
<td>750 mm</td>
</tr>
<tr>
<td>6.1 m</td>
<td>600 mm</td>
</tr>
<tr>
<td>&lt; 6.1 m</td>
<td>450 mm</td>
</tr>
</tbody>
</table>

The measurements will be taken in each section starting at the "0" marker, with each measurement at 10 m interval. The last measurement will be taken at the "5" marker. Discrete test points (10m stations) should be marked on the pavement surface and their exact location should be noted to facilitate their relocation after pavement rehabilitation (Figure 3).

An additional one-time deflection measurement will be required at the location of the test pit before performing the excavation.

3.0 Operating Procedure

3.1 Setting-up Before Testing

Firmly attach the dial-gauge to the Beam and make sure that the stem is positioned vertically (Figure 2). The dial-gauge stem should be centered in the clearance hole and unobstructed in its movements.

The Beam operator shall ensure that the main pivot bearing moves freely and with as little friction as possible. The 6-volt battery should then be attached and the buzzer checked to see that it is functioning properly.

Attaching the Dial-gauge and Extension Stem

FIGURE 2
Location of Measuring Points for BB Deflection Testing

FIGURE 3
3.2 Testing (see Figure 4)

1. Bring the truck to a stationary position with the rear wheels directly over the first point and apply the handbrake securely.

Warning
The driver of the test vehicle must ensure that the vehicle does not move backwards. The beam operator works quite closely to the rear wheels when placing the probe of the beam on the test point and when taking the reading of the dial-gauge.

2. Schematic Diagram of Benkelman Beam Testing

START POSITION

INITIAL READING POSITION

\[ \geq 10 \text{ m} \]

FINAL READING POSITION

FIGURE 4

Placing the probe-end of beam between the rear dual-wheels

Adjusting the beam to set the dial-gauge in the center of its range

FIGURE 5

FIGURE 6
Place the probe of the Beam between the right-hand set of dual-tires (from the rear) and just slightly ahead of the centre of the rear axle (Figure 5).

3. Lower the Beam until it rests on its supporting legs.

4. Unlock the Beam so that the probe is free to touch the pavement surface.

5. Adjust the Beam (by raising or lowering the rear supporting leg) so that the dial-gauge reading is approximately in the middle of its range (Figure 6).

6. Switch on the vibrator. (This is used to minimize friction between moving parts.)

7. Signal the driver of the test vehicle to drive forward slowly and as the vehicle moves away record the highest reading (initial) shown on the gauge (Form BB1). This will occur when the centre of the rear-axle passes over the probe.

**Note:** Make sure that the truck tires are not rubbing along the probe end.

8. The test vehicle shall be driven forward to the next measuring station, 10 m away from its initial position (Figure 7). The testing interval coincides with the 10 m minimum distance required between the load and the probe.

9. As the vehicle moves away, the pavement will rebound to its original unloaded position. (See Figure 4) Record the final reading when the dial movement is extremely slow or nullled (Form BB1).

10. The difference between the initial and final dial reading must be doubled to give the true pavement deflection at the end of the probe.

11. The temperature of the pavement should be recorded for each section. This is accomplished by inserting a thermometer into a small 5 cm deep hole which has been made in the pavement and filled with water. Leave the thermometer in the hole for at least 10 minutes before recording the temperature. The air temperature (in the shade) should also be recorded for each section (Form BB1).

Test vehicle moving ahead to the 10m position

**FIGURE 7**
12. Repeat the test for all other test locations. Remove the dial-gauge when travelling a distance of more than 8 km between testing locations.

4.0 Data Collection (Form BB1)

The data will be collected on Form BB1. This form will be used to record the deflection readings for each point at every test site. From this information the actual differential movement (deflection) of the pavement at each point and the average deflection and standard deviation for the section will be calculated.

Form BB1

Host Jurisdiction: The name of the highway agency.

C-SHARP ID Number: The seven digit number assigned to the test section by C-SHARP.

Road # or Description: The number or name assigned to the highway.

Site Location: A brief description of the test section location. For example, approximately 16 km east of Halifax between junctions of highways 21 and 86.

Date: Date of testing (yy/mm/dd).

Time Start and finish times: (am/pm).

Air temp: The air temperature in °C taken in the shade during testing.

Pavement temp: The pavement temperature in °C as described in Section 3.2.

Distance from pavement edge: The actual distance of the Benkelman Beam readings from the pavement edge in mm.

Weather: A general description of the weather conditions during testing.

Column 1: Number of measuring points in each test section.

Column 2: Described in the Test Site Identification Guidelines.

Column 3: Initial Benkelman Beam reading as described in section 3.2.

Column 4: Final Benkelman Beam reading as described in section 3.2.

Column 5: The Benkelman Beam reading (D/2) is obtained by subtracting the final reading from the initial reading.

Column 6: The actual differential movement (deflection) of the pavement is twice the Benkelman Beam reading. The average differential movement and standard deviation of the section are calculated.
C-LTPP
Benkelman Beam
Data Form

Host Jurisdiction ____________________________
C-SHRP I.D. Number _______________________
Road # or Description _______________________
Site Location _______________________________

Date ____________________________

Time (start) ______ / (finish) ________ Air T° (°C) ________ Pavement T° (°C) ________

Weather ____________________________

Actual distance of measurements from pavement edge

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Reference Marker</th>
<th>Deflection Readings (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
</tr>
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<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Pit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Σ
AVG.
σ

Crew Chief ____________________________

Version 1.1
Falling Weight Deflectometer

This guide is been adapted with modifications from the "SHRP LTPP Manual for FWD Testing" published by the National Research Council in January 1989.

Version 1.0
1.0 INTRODUCTION

The Falling Weight Deflectometer (FWD) is an automated device used to rapidly and non destructively measure pavement deflection. An impulse load which reasonably simulates traffic loading is applied to a spring loaded baseplate on the pavement surface. Deflections are measured at the centre of the baseplate and at six other predetermined radial points from the baseplate by velocity transducers (geophones).

Many jurisdictions are using the FWD for measuring deflection although it is not the standard deflection measuring device for the Canadian Long Term Pavement Performance Project (C-LTPP). The Benkelman Beam is the standard deflection measuring equipment for the C-LTPP study. The FWD is gaining wide acceptance across the country. The Strategic Highway Research Program (SHRP) has selected the FWD as the deflection measuring device for the LTPP study.

Using the FWD in the C-LTPP Project will provide the correlation opportunity with the Benkelman Beam (BB). It will provide the data base in the likely event that the BB is replaced by the FWD as the deflection measuring device. Analysis of pavement deflection studies by agencies using FWD, especially SHRP-LTPP study, will be facilitated.

FWD measurements will be used to define the deflection parameters, establish the peak deflection factor and plot the deflection basin. The measurements will be made in conjunction with the Benkelman Beam after rehabilitation has occurred. The duplication of the deflection testing by the FWD and Benkelman Beam will be coordinated with the provincial agencies.

Falling Weight Deflectometer schedule: Fall 1989 after rehabilitation in conjunction with the Benkelman Beam.

2.0 OPERATIONS GUIDELINES

The following guidelines were adapted with some modifications from the SHRP-LTPP Manual for FWD Testing. They are provided to Canadian agencies participating in C-LTPP to provide consistency in approach and to highlight some specific requirements for the project.

3.0 EQUIPMENT/CREW REQUIRED

3.1 The Test Vehicle

The FWD is a trailer mounted system with a 200 kg mass (load) system and seven velocity transducers (geophones). (Figure 1)

A warning sign and lights for traffic control to meet agency requirements.

3.2 The Towing Vehicle

Any vehicle capable of towing the trailer.

Provision to house associated computer hardware/software.

A distance measuring device to measure in metres.

3.2 Auxiliary Equipment

Thermometer -15°C to 50°C with .5° divisions.

Device for making a 50 mm deep and 5 mm diameter hole in the pavement in which to place the thermometer to determine pavement temperature.
Mineral oil, anti freeze or other suitable liquid to provide thermal conduction in the hole when measuring pavement temperature.

Tire pressure gauge to ensure consistent tire pressure through all testing program.

3.4 Crew

The FWD field testing is a one person operation.

Additional people will be required for traffic control. The number of people will be influenced by the class of highway being tested and agency requirements will prevail.

4.0 TRAFFIC CONTROL

The FWD testing is a stop and go operation and Agency requirements for traffic control will prevail.

5.0 LOCATION OF MEASURING POINTS

Measuring points will be located in the outer-wheel path. If the wheel path is not distinct, testing will be located at specified distances from the edge of pavement as follows:

<table>
<thead>
<tr>
<th>Pavement Width</th>
<th>Lane Width</th>
<th>Distance from Pavement Edge (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.3 m</td>
<td>3.65 m</td>
<td>900 mm</td>
</tr>
<tr>
<td>6.7 m</td>
<td>3.35 m</td>
<td>750 mm</td>
</tr>
<tr>
<td>6.1 m</td>
<td>3.05 m</td>
<td>600 mm</td>
</tr>
<tr>
<td>&lt; 6.1 m</td>
<td>&lt; 3.05 m</td>
<td>450 mm</td>
</tr>
</tbody>
</table>
The measurements will be taken in each section starting at the "0" marker, with each measurement at 10 m interval. The last measurement will be taken at the "5" marker. Discrete test points (10 m stations) should be marked on the pavement surface and their exact location should be noted to facilitate their relocation after pavement rehabilitation (Figure 3).

An additional one-time deflection measurement will be required at the location of the test pit before performing the excavation on any new C-LTPP sites (1990).

6.0 SENSOR CONFIGURATION

An optimal sensor spacing is not required for each pavement section. The difference in deflection basis shapes is most significant within 900mm from the peak deflection point. For all C-LTPP Projects the sensor spacing shown in Figure 2 will be used.

![Diagram of sensor configuration](image)

**FIGURE 2**

7.0 LOAD AND DROP SEQUENCE

7.1 Load Sequence

Deflection characteristics are influenced by pavement type and layer thicknesses. No standard is available for drop-height/load relationship that is applicable to all pavement sections.

The applied load range selected for C-LTPP Project is given in Table 1. Only the 200 kg mass (load) system will be used. For each drop-height/load relationships the acceptable tolerance is ±10%. If the tolerance exceeds ±10% adjustments to the target load range will be allowed. The operator will not change the 200 kg mass on the FWD during the C-LTPP Project.

<table>
<thead>
<tr>
<th>Load Sequence</th>
<th>Applied Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>h1</td>
<td>27</td>
</tr>
<tr>
<td>h2</td>
<td>40</td>
</tr>
<tr>
<td>h3</td>
<td>53</td>
</tr>
<tr>
<td>h4</td>
<td>71</td>
</tr>
</tbody>
</table>

7.2 Load Level Control Procedures

1. The operator should at a point outside the limits of the test section, experiment with the drop-height/load level settings and adjust the drop-height settings so that the target load is achieved.
NOT TO SCALE

WHITE PAINT STRIPE

SPIKE or NAIL
(300 mm from edge of travel lane)

SHOULDER JOINT
(IF EXISTS)

TRAFFIC

150m MONITORING SECTION

SHOULDER

30m

WHITE PAINT STRIPE

SPIKE or NAIL
(300 mm from edge of travel lane)

C-SHRP SECTION ID NUMBER

Location of Measuring Points

FIGURE 3

Lane Width

Version 1.0
2. If the target loads cannot be achieved within the normal range of drop-height settings, the minimum and/or maximum drop-height settings should be used. The FWD mass must not be changed.

3. The operator should try to achieve drop-height settings that results initially in loads slightly on the high side of the target load level. This will compensate for the expected decrease in FWD loads during the test day.

4. The greatest precision should be applied by the operator to achieve the 40 kN target load for all pavement types.

5. The FWD test is ready to begin. The operator should not adjust the drop-height settings during the entire test.

7.3 Drop (repetition) Sequence

FWD tests will have the same pattern of drop sequence at a given test point within the pavement test section. The drop sequence will be as follows:

<table>
<thead>
<tr>
<th>Sequence No.</th>
<th>No. of Drops</th>
<th>Drop Heights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>h3 *</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>h1 **</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>h2 **</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>h3 **</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>h4 **</td>
</tr>
</tbody>
</table>

* Drops used for seating only; no data recorded

** Store only deflection peaks for first three drops at each drop height for fourth drop at each drop height a complete deflection time history will be stored.

8.0 FWD OPERATOR FIELD MEASUREMENTS

8.1 Pavement Temperature

The temperature of the pavement should be recorded for each section. This is accomplished by inserting a thermometer into a small 50mm deep hole which has been made in the pavement and half filled with a thermal conductor such as mineral oil, antifreeze or other suitable liquid. The thermometer should be left in the hole for at least 10 minutes before recording the temperature.

8.2 Crack Mapping

Discontinuities of the pavement surface surrounding the point of load application should be recorded. The operator should map the crack type and frequency for the zone of influence of each test point using Form FWD3 (Appendix A).

8.3 Test Plan

The FWD deflection basin tests will be conducted at regular intervals of 10 m. The total number of test point locations for each test section will be 16 to correspond with the 16 Benkelman Beam locations (Figure 2). At each test point, 4 levels of load with 4 drops per height (load) will be used.

8.4 Test Pit Deflection
A one-time deflection measurement will be required at the location of the test pit to provide a "linkage" between the material sampling/testing program, the Benkelman Beam and the FWD results.

9.0 DATA ACQUISITION AND HANDLING

Collecting the FWD data and ensuring that the data is both valid and accurate is one of the primary responsibilities of the FWD operator.

To ensure that the data collected in each of the C-LTPP sections is uniform, the format shown in Form FWD1 (Appendix A), the Falling Weight Deflectometers Data Form will be used.

Operating Procedures for:
- setting up the software
- opening a testing file
- recording the FWD data
- closing a testing file
- data back-up procedures
- labelling back-up diskettes

should be established by the FWD operator and adhered to at all times in a consistent manner.

10.0 CALIBRATION

The deflection sensors and load cells used with the FWD must provide output results that agree with the same unit as well as with other FWD's on the C-LTPP Project.

The calibration procedure should be conducted by the FWD operator before the testing begins in each jurisdiction. In addition it should be carried out whenever problems are suspected.

The calibration log shown as Form FWD2 (Appendix A) should be completed for each calibration procedure and attached to the FWD results.
Appendix A
C-LTPP
Falling Weight Deflectometer

Data Form

Date: (yy / mm / dd): ______ / ______ / ______

Time (start): ___________ / (finish) ___________ Air Temp. (°C) _______ Pav Temp. (°C) _______

Weather: ________________

Distance of measurements from pavement edge: ___________________________

<table>
<thead>
<tr>
<th>Reference Marker</th>
<th>Drop Height</th>
<th>Drop Number</th>
<th>Deflection Readings (mm)</th>
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Relative Calibration Log

Date: (yy / mm / dd): __ / __ / __

FWD. SN: __________________________

FWD Operator: _______________________

FWD Owner: _________________________

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<th>Sensor</th>
<th>Serial Number</th>
<th>Old Relative Gain</th>
<th>Adjustment Factor</th>
<th>Need to Change?</th>
<th>New Relative Gain</th>
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</tbody>
</table>
C-LTPP
Falling Weight Deflectometer

Crack Mapping Form

Date: (yy / mm / dd): ____ / ____ / ____

Location Point #: __________
(1 to 16)

Host Jurisdiction: ____________________________
C-SHRP I.D. #: __ __ __ __ __ __
Road #/ Name: ____________________________
Site Location: ____________________________

Sensor positions

Scale: 1 div = 200 mm

Crack Type and Severity

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<thead>
<tr>
<th>Type</th>
<th>Longitudinal</th>
<th>Transverse</th>
<th>Alligator</th>
<th>Edge</th>
<th>Other (specify)</th>
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<tbody>
<tr>
<td>Severity</td>
<td>low</td>
<td>med</td>
<td>high</td>
<td>low</td>
<td>med</td>
</tr>
</tbody>
</table>

Remarks:

__________________________
__________________________
Profile and Cross-section
1.0 PROFILE

1.1 Introduction

Ride quality is a primary response measurement used as a basis for many pavement management systems and performance models. Ride quality is measured in many different ways and in different forms. Ride, roughness and profile are all methods of characterizing the longitudinal deformation in pavement structures.

Historically, rating panels composed of experts were used to subjectively evaluate the rideability of a pavement.

In more recent times, a variety of high speed devices have been developed to measure vehicle response as a function of road roughness. These devices include roadmeters, oxmeters, PURDS, accelerometers, etc. Similarly, the roughness value determined can be reported in numerous forms including IRI, counts, displacement, etc. The difficulty with these response-type measurements arises when comparisons among the various measurements become desirable. These problems in comparison are related to fundamental differences in the response being measured, methods of reporting and the change in vehicle response systems with time.

Many of the difficulties associated with response-type measurements are confounded when using them to characterize relatively short test sections and where the deterioration in ride is to be monitored closely. The only true repeatable measure of longitudinal deformation which can be measured uniformly across Canada is profile.

In using profile as the basis of ride characterization, the sample interval must be frequent enough to capture the deformation wavelengths which influence ride quality. While conventional road profiles are obtained at 30m intervals, proper characterization of the micro-texture influencing roughness requires that measurements be taken at intervals two orders of magnitude lower. In selecting the test section length for SHRP (and hence C-SHRP), 150m was determined to be adequate for capturing the significant deformation wavelengths.

1.2 Operational Guidelines

The uniform method of measurement for C-LTPP is profile determination using the digital incremental profiler Dipstick. The Dipstick allows a sample interval of 300cm and has the advantage of determining elevation (either absolute or relative) from which roughness coefficients can be calculated for each section. All reporting will be in the form of elevations, with data manipulation to be performed centrally to a consistent roughness index.

1.3 Equipment Required

traffic control (as determined by the agency)
dipstick with 300mm footprint
metric measuring tape
string line
data forms

1.4 Operating Procedure

Location of Test

The profile will be recorded in each of the wheel paths, in a continuous fashion in order to provide closure for the survey. Prior to the section being rehabilitated, the offset of the wheel paths should be measured from the shoulder reference markers, in such a way as to allow re-establishment of the line after rehabilitation. The offset distances should be determined and recorded for both wheel paths at each end of the test section.
After establishing the offset points, a string line is strung between the two ends of each wheel path, to provide a guide in walking the dipstick in as straight a path as possible along the wheel path.

Testing

Testing will begin at the "0" marker line in the outer wheel path, where the string line intersects the pavement stripe. Profiling will proceed along the string line towards the end of the test section. When the end of the section is reached, a marker should be placed in the dipstick file to identify the end of the first wheel path. Profiling should continue in the same survey, across the end paint strip, to the inner wheel path. (Note that the footprint of the dipstick may not coincide with the base length between wheel paths. When profiling across the end stripe to the inner wheel path, continue the survey along a line as close to the middle of the inner wheel path as is possible considering the equipment constraints). A file marker should be included in the file, when the string for the inner wheel path is reached. Continue profiling along the inner wheel path towards the beginning of the test section. A third file marker should be entered when the dipstick reaches start line in the inner wheel path. Finally, profile across the start line to the outer wheel path, and close the survey where it began.

1.5 Reporting

The profile results will be reported on diskette with one dipstick file for each test section. The file name should consist of (or contain) the C-SHARP ID number. In addition, a data form will be completed for each section identifying the location of the test and the elevations at each of the five intersecting points.

2.0 CROSS-SECTION

2.1 Introduction

Although rutting will be identified as part of the condition survey, the opportunity exists to obtain quantitative cross-sectional data using the dipstick.

2.2 Equipment Required

traffic control (as required by the agency)
dipstick with 50mm footprint
metric measuring tape
string lines
data forms

2.3 Operational Procedure

Test Location

With the string lines still in place from the longitudinal profile measurements, a line is laid out for cross-sectional measuring at each of the station markers (six cross-sections in all). Each cross-section profile will start as near the pavement edge as possible that will allow the cross-sectional profile to intersect the longitudinal profile.

Test Procedure

Having established the shoulder edge starting point, one dipstick file will be run for each station. Beginning at the shoulder edge, the survey will proceed towards the middle of the pavement and terminate at the painted centerline.
The footprint will be set at 50mm. File markers will be entered to identify the start and end of each cross-section and the two intersection points with the longitudinal profiles.

2.4 Reporting

Reporting will consist of a diskette containing the six cross-sections for each test section and an accompanying data sheet (Form PC1) which identifies the test locations and the values for each point of intersection and survey termini.

The digital file should name each cross section by the C-SHRP ID followed by the reference marker number.
C-LTPP Profile and Cross-section Data Form

Host Jurisdiction ____________________________________________

C-SHRP ID ____________

Road #/Name ________________________________

Site Location ____________________________________________

Date ____________________________

Time (start) __________ / (finish) __________ Weather ________________________________

OFFSET DISTANCE OF MEASUREMENTS: outer wheelpath ________________________________

REFERENCES FOR OFFSETS ________________ inner wheelpath ________________________________

PROFILE

ELEVATION READINGS

Reference Marker outer wheelpath inner wheelpath

0

CROSS-SECTION

ELEVATION READINGS

Reference Marker initial outer wheelpath inner wheelpath final

0

1

2

3

4

5

Version 1.0
Traffic Data Collection

This guide is adapted from the Strategic Highway Research Program "Framework for Traffic Data Collection for the General Pavement Studies' TEST SECTION".
1.0 INTRODUCTION

The Canadian Long Term Pavement Performance (C-LTPP) study has six specific objectives:

- Evaluate existing design methods
- Develop improved design methodologies and strategies for the rehabilitation of pavements
- Develop improved design equations for new and reconstructed pavements
- Determine the effects of:
  - loading
  - environment
  - material properties and variability
  - construction quality
  - maintenance levels on pavement distress and performance
- Determine the effects of specific design features on pavement performance
- Establish a national long term data base to support C-LTPP and LTPP objectives and future needs.

Traffic is one of the most important primary independent variables in a study of pavement performance. To analyze the effects of traffic and traffic loading on pavements an in-depth knowledge of traffic characteristics - volume, classification and axle load are needed. The quantity and quality of the data collected for this study will have a direct influence on the ultimate results that can be achieved.

The primary goal is to develop a national traffic data base that will assist in achieving the C-LTPP objectives. To accomplish these objectives reliable data on vehicle weight, classification and volume are required from each test site. The data will be used to calculate the total number of Equivalent Single Axle Loads (ESAL) that have been, and will be applied during the monitoring period to the C-LTPP test sites. The availability of sufficient data will also assist Provincial Highway Agencies and C-SHRP to establish relationships between loading and pavement performance.

2.0 TRAFFIC DATA FOR C-LTPP ANALYSIS

Traffic data is a fundamental component for all pavement design and performance models. The models are used to design new pavements and overlays to predict performance, to evaluate investment costs and benefits, and to schedule construction and maintenance operations. Some models are used as predictive equations to predict the cumulated number of traffic loads that a pavement may carry.

2.1 Equivalent Single Axle Load Concept

The traffic information needed to develop design and performance models is the total number of ESAL applications on the pavement. The ESAL concept was developed to conveniently deal with the large spectrum of axle loads and axle load repetitions actually applied to a pavement. The standard equivalency most widely used is the 80 kN (18 kip) equivalent single axle load (ESAL). The ESAL factor is derived by calculations or by measured stress, strain, deflection or loss in serviceability. The total ESAL applications are determined from the traffic volume counts, vehicle classification counts and truck weight measurements.

3.0 TRAFFIC DATA NEEDS

The C-LTPP study requires that Provincial Highway Agencies collect and provide traffic information for all C-LTPP test sites. The prohibitive cost of weigh-in-motion equipment, the limits of existing technology and the need to minimize cost have influenced but not compromised the type and quantity of data required for each site.
It is important that standard data collection methods and analyses be used. This will allow reliable and accurate estimates to be developed for:

- The total ESAL applied to the pavement since construction or last overlay (historical)
- The total ESAL that will be applied to the pavement each year during the C-LTPP monitoring period (monitoring)

The collection of historic traffic data since construction and the continuous monitoring of traffic at each test site will provide the information to estimate the total ESAL applications on the pavement.

The axle load information used to calculate total ESAL for the original pavement design and the rehabilitated pavement design is also needed. If this information is not available, the truck classifications by axles grouped in axle load categories would be required for the calculations of ESAL's.

The C-LTPP traffic data needs are limited to:

- Vehicle volumes crossing the test sections
- Vehicle classification
- Weight of the axles for each type of vehicle

Pavement researchers could also make use of the following vehicle-related information:

- Vehicle type
- Number of axles
- Axle spacing
- Axle weight (wheel load)
- Vehicle speed (loading time)
- Number of tires
- Tire type (radial, bias, studded)
- Tire pressure
- Date and time of vehicle crossing section
- Tire contact area (footprint)
- Stress distribution across tire contact area
- Vehicle suspension characteristics (for modelling dynamic response)

4.0 USE OF TRAFFIC DATA

Traffic data from the C-LTPP study will be used to improve and/or develop new pavement design models. Most pavement design models require traffic load as an input to establish relationships for pavement condition, thickness, strength and total number of ESAL applications.
4.1 Calculating the Equivalent Single Axle Load (ESAL)

Different methods are used to calculate the total number of ESAL applications on the pavement for the design period. However most methods utilize the same basic traffic information. The cumulative design traffic load is generally calculated by:

- Establishing a design period (expected pavement life)
- Estimating the traffic volume for the design period
- Establishing factors for:
  - directional distribution of traffic
  - lane distribution
  - percent trucks
- Calculating the ESAL truck factor for the test location
- Calculating the cumulative total ESAL application for the design lane

4.2 Load Equivalency Factor

Several methods are being used to establish load equivalency factors (ESAL factor). Two of the most widely used sources to convert axle loads to ESAL for pavement design are:


5.0 TRAFFIC DATA COLLECTION

Site specific information for traffic volumes, vehicle classification and axle loads are required for each C-LTPP test section. The data must be collected in the vicinity of each test location to ensure that any change in traffic patterns as a result of economic conditions, seasonal variations or enforcement activity are accounted for. The traffic data should reflect as accurately as possible the actual traffic conditions at each test location.

5.1 Monitoring Data Collection

Traffic data since rehabilitation are required for all test sites for the duration of the C-LTPP monitoring period. Ideally, the traffic data for volume, classification and axle-weights can be obtained by using automatic weigh-in-motion (WIM) systems continuously. This may not be practical or realistic and a minimum level of traffic data collection must be established. However, Provincial Highway Agencies are encouraged to collect more data than the minimum level wherever possible.

5.2 Minimum Level of Data

The minimum acceptable level of traffic data collection for the C-LTPP study is:

- Automatic Vehicle Classification Count (AVC)
  - a continuous 365 day count from June 1991.

- Weigh-in-Motion (WIM) Axle Weights
  - one 7 day continuous weighing for each truck season, consecutively by June 1993.

Version 1.0
A truck season is defined as a period of time during a calendar year when a significant change in expected truck weights or volumes occurs.

5.3 **Historical Traffic Data Collection**

Traffic load data for original pavement design or last overlay and traffic characteristics from that time will be collected. If this historic site-specific information does not exist, "backcasting" the current monitoring data to the time of construction or last overlay would be used to obtain the information. Research indicates that extrapolation of site-specific data would be better than information collected on other sites.

5.4 **Regional Weigh-In-Motion Sites**

The desirable or minimum levels of site-specific data must be supplemented with information from continuously operated regional weigh-in-motion sites. These sites will provide information on temporal variations in vehicle classifications and weight. The weigh-in-motion systems do not necessarily have to be located at the C-LTPP sites. Existing or proposed agency operated weigh-in-motion sites supplemented with specially constructed new sites will be adequate.

5.5 **Traffic Data Format**

Historical and continuously monitoring traffic data are required for the C-LTPP study. The data to be collected includes Average Annual Daily Traffic (AADT), percent trucks, distribution of traffic by vehicle class and distribution of axle loads for steering axles, singles, tractor tandems, tandems and tridems. The data is to be collected separately for the lane or lanes that are being monitored.

Collecting historical data may not be an easy task. However every effort should be made to gather as much information as possible from traffic inventory or other sources for the test sections. Forms, T1, T2, and T3, Appendix A, are designed to indicate the type of data that are needed and provide a convenient format to record them.

Traffic data for the monitoring period will be collected by Automatic Vehicle Classification (AVC) or Weigh-in-Motion (WIM) Systems and the data stored in a machine readable form. This data will be used to classify the traffic according to the Federal Highway Administration (FHWA) truck classification system.

6.0 **EQUIPMENT FOR DATA COLLECTION**

Traffic data collection for the C-LTPP study requires the use of automatic vehicle classification (AVC), portable weigh-in-motion (WIM) or permanent weigh-in-motion equipment. Many different types of AVC and WIM equipment are in use.

6.1 **Automatic Vehicle Classification Systems (AVC)**

The AVC equipment must be capable of counting the number of vehicles, the number of axles and measuring the location of axles on each vehicle. The basic components of an AVC system are:

- Sensors, which provide data on the presence or passage of the vehicle to be classified
- Detectors which receive and condition signals from the sensors and pass them on to a processor
- The processor which performs the basic calculation of vehicle length, number of axles, axle spacings and count, from which vehicle class is determined.
- The recorder which stores the data and manipulates it into presentation format.
6.2 Weigh-In-Motion Equipment (WIM)

Weigh-in-motion is an established but evolving technology. The different systems available for weighing vehicle in motion have a wide variety of different characteristics, strengths and weaknesses. Some of the technologies being utilized are:

- Bending plate systems
- Shallow weight scale systems
- Deep pit weight scales
- Bridge systems
- Piezo systems
- Capacitance systems

Uniformity of approach to using WIM equipment is not essential. It is important to note that accuracy of the equipment is not only a function of the device being used but also the site condition. Pavement approach profile and condition is probably the most important external factor.
Appendix A
C-LTPP
Traffic Data

Form T1

Host Jurisdiction

C-SHRP I.D. #

Road #/Name

Site Location

Date of Original Construction: ___ / ___ / ___  Date of Rehabilitation: ___ / ___ / ___

YYYY MM DD  (Start of C-LTPP) YYYY MM DD

Number of Lanes: ____________________ C-SHRP Lane Direction: EB: ___ WB: ___ NB: ___ SB: ___

ORIGINAL PAVEMENT DESIGN

AADT: ____________________  Percent Trucks: ________________  Total Trucks: ________________

ESAL Truck Factor: ________________  Total ESAL: ________________  Design Life (Yrs) ________________

Design ESAL (C-LTPP Lane): ________________  Other: ________________

REHABILITATION PAVEMENT DESIGN

AADT: ____________________  Percent Trucks: ________________  Total Trucks: ________________

ESAL Truck Factor: ________________  Total ESAL: ________________  Design Life (Yrs) ________________

Design ESAL (C-LTPP Lane): ________________  Other: ________________

TRUCK VOLUME AND DISTRIBUTION SINCE ORIGINAL CONSTRUCTION

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<th>Year</th>
<th>AADT</th>
<th>DDF</th>
<th>% Trucks</th>
<th>LDF C-SHRP Lane</th>
<th>% Trucks C-SHRP Lane</th>
<th>Total ESAL C-SHRP Lane</th>
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</table>

Note: Use backcasting calculations if necessary, to determine missing traffic data since original construction.

AADT = Average annual daily traffic

LDF = Lane distribution factor

DDF = Directional distribution factor

ESAL = Equivalent single axle load

Version 1.0
### C-LTPP
Traffic Data

**Form T2**

- Host Jurisdiction
- C-SHARP I.D. #
- Road #/Name
- Site Location

Start Date of Survey: \( \_\_\_ / \_\_\_ / \_\_\_ \)

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**TRUCK VOLUME SINCE REHABILITATION BY WEEK**

**TRUCK VOLUME BY CLASS**

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Version 1.0
C-LTPP  
Traffic Data

Form T3

Host Jurisdiction ____________________________
C-SHRP I.D. # ______________________________
Road #/Name ______________________________
Site Location ______________________________

Survey Period (C-SHRP Lane) From: __________/_________/______ To: __________/_________/______

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<td>5.5 &lt; 6.5</td>
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Note: Form T3 to be used for each of the five axle groups (Steering, single, tractor tandem, tandem, tridem)

Version 1.0
Climatic Data

This guide is based upon a similar document published by the Strategic Highway Research Program for the Long Term Pavement Performance Study.
1.0 INTRODUCTION

Climatic data are considered mandatory for the Canadian Long Term Pavement Performance (C-LTPP) studies. The data are needed to adjust design and construction standards, to update pavement materials specifications and to assist in analyzing pavement performance.

The climatic data to be collected are categorized as general historical, monthly (historical/monitored) and annual (historical/monitored) and will be collected for the period since construction/last overlay to the end of the monitoring period.

2.0 OPERATION GUIDELINES

The following guidelines were developed using the SHRP "Data Collection Guide for the Long Term Pavement Performance (LTPP) studies" as a guide to provide consistency in collecting climatic data for the Canadian Long Term Pavement Performance (C-LTPP) study.

3.0 SCOPE AND OBJECTIVE

The Canadian Long Term Pavement Performance (C-LTPP) experiments have been designed to "let the pavements tell us how they perform" over their design life and over a diversity of conditions. Climatic factors, traffic, materials, designs, construction techniques, quality control, maintenance strategies and other parameters have significant effect on pavement life and performance.

The goal of C-LTPP is to increase pavement life and performance by investigating various pavement parameters under different conditions.

Specific objectives of these guidelines are:

- to identify the climatic data items to be collected
- to develop details of climatic data collection

4.0 CLIMATIC DATA ELEMENTS

The climatic data, historical and continuous monitoring, will include all data necessary to characterize the environment in which the pavement has existed since construction and on through the monitoring period.

The following data elements have been identified:

- weather station identification/location
- average monthly temperature
- average maximum daily temperature by month
- average minimum daily temperature by month
- average monthly precipitation
- average monthly percent sunshine
- average monthly wind speed

Version 1.0
• general type of environment (climatic zone)
• average annual number of days of precipitation
• latitude
• longitude
• elevation above sea level
• frost penetration
• average number of annual freeze-thaw cycles
• freezing index
• average annual de-icing chemical application
• highest monthly mean solar radiation
• lowest monthly mean solar radiation
• Thornthwaite moisture index
• Load Ban Period

5.0 CLIMATIC DATA COLLECTION

Current pavement analysis and performance models are well served by climatic data collected on a monthly cycle. At the present time, there is no need for this data to be collected on a more frequent basis. Should the need arise, other statistical models, predictive and probabilistic, can be used to interpolate the data on a weekly, daily or hourly basis.

Most of the climatic data will be collected by C-SHRP. The host jurisdiction is responsible for obtaining the data on latitude, longitude, elevation above sea level, estimate of maximum frost penetration (FORM C1, Appendix A1), de-icers application rate and type and the load ban period.

The data will be collected both as inventory and monitoring data. It is expected that this information will be collected annually to give a complete data base for the life of the pavement. Historical data will be collected for each year separately and for each test site starting with 1970 or the year after 1970 in which pavement construction was completed.

Most or all of the climatic data should be available from existing documents or from the Canadian Climate Centre, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 or from one of their six regional offices across Canada. The addresses of the regional offices are shown in Appendix A4.

The only data expected to be difficult to obtain is solar radiation. For development of empirical models, lack of solar radiation may not be seriously, because the data elements for "latitude" and "average percent sunshine" will account for much the same effects as "solar radiation". However, solar radiation is used in common relationships for predicting temperatures within pavement surface materials, so it will be important for characterizing surface engineering properties for mechanistic pavement models that predict responses to applied loads.

The data items to be collected are grouped as historical and continuous monitoring, and are to be entered on forms C1 to C3, Appendix A. Details of the data items are discussed below.
5.1 General Historical Data (Form C1)

This form is to be used for entering general historical data that is either fixed with relation to time or changes very insignificantly. This data must only be entered once for each C-LTPP test site. It would be possible to calculate the Freezing Index and Thornthwaite Moisture Index over the life of the pavement to increase accuracy.

Section A of the form is to be filled by the Highway Agency and Section B by C-SHRP.

Latitude: Two two-digit numbers to express the degrees and minutes of latitude at which the test section is located.

Longitude: Two two-digit numbers to express the degrees and minutes of longitude at which the test section is located.

Elevation: A five-digit number for entering the approximate elevation of the test section in metres above sea level.

Frost Penetration: A four-digit number for estimating the maximum frost penetration in metres.

General Type of Environment: A one-digit code for identifying the general climatic zone in which the test section is located.

    Code 1: Wet – no freeze
    Code 3: Dry – no freeze
    Code 2: Wet – freeze
    Code 4: Dry – freeze

Figure 1 shows the climatic zones for C-SHRP/SHRP Long Term Pavement Performance experiments.

Freezing Index: A four-digit number for recording the freezing index by degree days over a one year period (Corp. of Engineers Method). One degree day represents one day with a mean air temperature of one degree below freezing. Ten degree days could be either ten days with a mean air temperature one degree below freezing, or five days with a mean air temperature two degrees below freezing, or two days with a mean air temperature five degrees below freezing, or any such combination. A distribution of normal freezing index values for Canada is shown in Figure 2.

Thornthwaite Moisture Index: A three-digit number to record the Thornthwaite Moisture Index which reflects the potential evapotranspiration. The Thornthwaite Moisture Index may be calculated or obtained from moisture index maps.

The method of computation of potential evapotranspiration using air temperature, precipitation and latitude to obtain the Thornthwaite Moisture Index have been discussed in several reports. Two of the more relevant reports are:


Source of Thornthwaite Moisture Index: A one-digit code to indicate whether the moisture index was calculated or simply taken from a map.

5.2 Monthly Data (Historical/Monitored) (Form C2)

This form is to be used for entering historical and monitored mean climatic data for each month of each year since the pavement was constructed including the year construction was completed to the end of the monitoring period. This type of data is available from Environment Canada. Interpolations of data between weather stations may be required if the test section is not within a few kilometres of a weather station.
FIGURE 1: Environmental Zones for C-SHRP/SHRP Long-term Pavement Performance Experiments

Version 1.0
FIGURE 2: Normal Freezing Index for Canada in Degree Days Fahrenheit Based on the Period 1931 to 1960
(After Boyd 1973, Environment Canada Rep. CL1 4-73)

Year: A two-digit number for entering the last two digits of the year of interest, e.g., 89 for the year 1989.

Mean Daily Temperature: A two-digit number for entering the mean daily air temperature in °C that have been measured near the test section during the year.

Mean Daily Maximum Temperature: A two-digit number for entering the mean for each month of the daily maximum air temperature in °C that have been measured near the test section during the year.

Mean Daily Minimum Temperature: A two-digit number for entering the mean for each month of the daily minimum air temperature in °C that have been measured near the test section during the year.

Total Precipitation: A number for entering the amounts of precipitation for each month in millimetres of water that fell at the test site during the year. Snow precipitation should be converted to equivalent millimetres of water and added to the rainfall to obtain total precipitation.
Percent Sunshine: A two-digit number for recording the averages for each month of percent of time of that time possible that the sun was shining near the test site.

Mean Wind Speed: A three-digit number for recording the averages for each month of the wind speed in kilometres per hour near the test site.

5.3 Annual Data (Historical/Monitored) (Form C3)

This form is for recording annual and general climatic information, both historical and for the monitoring period.

Year: A two-digit number for entering the last two digits of the year of interest, eg., 89 for the year 1989.

Number of Days of Precipitation During the Year: A three-digit number to identify the number of days that precipitation was recorded near the test section.

Number of Freeze-Thaw Cycles During the Year: A three-digit number for entering the number of freeze-thaw cycles (in the air near ground level) near the test section. A freeze-thaw cycle occurs when the air temperature drops below the freezing point and later rises above the freezing point, regardless of duration of time below freezing. This information may be obtained from the Canadian Climate Centre, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 or from one of their regional offices across Canada. The information may also be estimated by experienced persons if not available from other sources.

Highest Monthly Mean Solar Radiation: A four-digit number identifying the average of the maximum daily measurements of solar radiation near the test section, in megajoule per square metre (MJm⁻²) for the month experiencing the greatest solar radiation. The Canadian Climate Centre is the primary source for solar radiation data.

Lowest Monthly Mean Solar Radiation: A four-digit number identifying the average of the daily measurements of solar radiation in megajoule per square metre (MJm⁻²) near the test section for the month experiencing the least solar radiation. Use best data available in vicinity of monitoring section.

Average De-icing Chemical Application During the Year: A two-digit number for recording the average kilograms of de-icing salt or other de-icing chemicals spread per lane kilometre each year. Average data (actual or estimated) for the highways near the test section may be used if specific information from the test section is not available. This data is to be obtained by the provincial agency and sent to C-SHRP each year.

Load Ban Period: Record the time period/periods when load restrictions are in effect on the highway in the vicinity of the test sections. This information is to be forwarded to C-SHRP each year by the highway agency.

6.0 SUMMARY

These guidelines give an outline of the environmental elements and data needed to be considered and collected for the C-LTPP data base. They have been identified by researchers working on pavement design models and on a review of existing pavement analysis and performance models. The data items are required on a monthly interval, average or total monthly values or on a yearly basis.
Appendix A
C-LTPP
Climatic Data

Form C1

Host Jurisdiction ________________________________
C-SHRP I.D. # ________________________________
Road #/Name __________________________________
Site Location __________________________________

GENERAL HISTORICAL DATA

Section A (To be filled out by Highway Agency)

Latitude (Degrees and Minutes) ____________________ and ____________________
Longitude (Degrees and Minutes) ____________________ and ____________________
Elevation (Metres above Sea Level) __________________
Frost Penetration (Metres from surface) ________________

Section B (To be filled by C-SHRP)

General Type of Environment (Figure 1) ______________
Freezing Index (Corps of Engineers Method)(Figure 2) ______________
Thornthwaite Moisture Index __________________
Source of Thornthwaite Moisture index ______________

Calculated form available data ......................... 1
Moisture Index Map (Identify Map) ..................... 2

Version 1.0
MONTHLY DATA (HISTORICAL/MONITORED)

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ANNUAL DATA (HISTORICAL/MONITORED)

Year

Number of Days of Precipitation During the Year

Number of Freeze-Thaw Cycles During the Year

Highest Monthly Mean Solar Radiation (MJm⁻²)

Lowest Monthly Mean Solar Radiation (MJm⁻²)

Avg. Deicing Chemical Application Rate (kg/lane/km/year)

(specific de-icing chemical used: _________________________)

Load Ban Period: From: _____ / _____ / _____ To: _____ / _____ / _____

YY   MM   DD   YY   MM   DD

From: _____ / _____ / _____ To: _____ / _____ / _____

YY   MM   DD   YY   MM   DD

Version 1.0
CANADIAN CLIMATE CENTRE

REGIONAL OFFICES

Director, Pacific Region
Atmospheric Environment Services
700-1200 W., 73rd Avenue
Vancouver, BC V6P 8H9
Attn: Scientific Services Section

Director, Western Region
Atmospheric Environment Service
Argyll Centre
6325 - 103 Street
Edmonton, Alberta T6H 5H6
Attn: Scientific Services Section

Director, Central Region
Atmospheric Environment Service
Room 1000
266 Graham Avenue
Winnipeg, Manitoba R3C 3V4
Attn: Scientific Services Section

Director, Ontario Region
Atmospheric Environment Service
25 St. Clair Avenue, East
Toronto, Ontario M4T 1M2
Attn: Scientific Services Section

Director, Quebec Region
Atmospheric Environment Service
100 Alexis Nihon Blvd., 3rd Floor
Ville St-Laurent, P.Q. H4M 2N6
Attn: Scientific Services Section

Director, Atlantic Region
Atmospheric Environment Service
1496 Bedford Highway
Bedford, Nova Scotia B4A 1E5
Attn: Scientific Services Section

Version 1.0
Maintenance Data

This guide is adapted from the Strategic Highway Research Program "Data Collection Guide for the Long Term Pavement Performance Study".

Version 1.0
1.0 INTRODUCTION

The primary purpose of this maintenance guidelines is to establish a standard procedure for monitoring essential maintenance work on the Canadian Long Term Pavement Performance (C-LTPP) test sections. An outline of maintenance procedures, information, data forms and instructions for their use in gathering maintenance information and data regarding maintenance operations during the monitoring period are given.

Maintenance performed on the C-LTPP monitoring sites will influence the results of the pavement performance studies. However it is recognized that necessary maintenance work may be carried out on the monitoring sections to keep the pavements in a safe and serviceable condition. It is essential that an accurate record of all maintenance activities and occurrences be kept.

The data base created with the maintenance data and complemented by the SHRP LTPP data base will provide pavement researchers with an opportunity for evaluating and understanding pavement performance both nationally and internationally.

2.0 OPERATION GUIDELINES

The following guidelines were adapted from the SHRP "Data Collection Guide for the Long Term Pavement Performance (LTPP) studies".

3.0 SCOPE

Ideally all sections in C-LTPP should either receive the same level of maintenance effort, or a range of maintenance levels should be systematically applied to subsets of the experiment population. Unfortunately, neither option is practical in that a uniform level of maintenance would not likely coincide with the practice of any agency, and adding maintenance effort as an experimental variable would make the project unwieldy.

As a consequence, maintenance must be treated as a co-variable - one that is recognized, measured and recorded but not controlled. This guideline therefore is directed at accurately and consistently recording maintenance activities, in order to allow their effects to be accounted for in the analysis of the pavement's performance.

4.0 MAINTENANCE ACTIVITIES

All maintenance operations and treatments should be performed according to the Provincial highway agency's standard procedures and practice. It would be desirable that any necessary maintenance activity be carried out only after consultation with the C-LTPP Engineer.

4.1 Controlled Maintenance

Pavement maintenance activities, historical and future, can significantly influence the results of the C-SHRP C-LTPP pavement performance studies.

It is expected that essential maintenance work using agency's guidelines will be necessary to keep the pavement in a safe and serviceable condition. However maintenance activities should be deferred as long as possible to allow the collection of critical data as pavement deterioration accelerates. The apparent restrictions on maintenance activities are intended to eliminate those activities that would tend to reduce or destroy the amount of information that can be obtained from a monitoring section.

4.2 Maintenance Control Zone

A maintenance control zone should be established for each monitoring section. The control zone begins 150m before the first test section and ends 75m after the last test section. Figure 1 shows the control zone layout for a

Version 1.0
FIGURE 1:C-LTPP Monitoring Sections Maintenance and Control Zone

- Pavement marking (paint stripe) 75 m, past end of last Monitoring Section
- Paint stripe and special delineator located at end of Monitoring Section
- Paint stripe and special delineator located at end and beginning of Monitoring Sections
- Paint stripe and special delineator located at beginning of Monitoring Section
- Pavement marking (paint stripe) 150 m advance of Monitoring Section
two section test site. Any maintenance activity within this zone must be done with the approval and coordination of the C-LTPP Engineer. The control zone will reduce the influence of other maintenance activities, outside of the monitored section, on the pavement performance of the test sections.

4.3 Maintenance Records

All maintenance activities or observations performed on the C-LTPP monitoring sections should be documented. The location of the maintenance activity must be shown on a surface defects mapping form reproduced from the surface distress guidelines (Appendix A11). It is necessary to organize all activities in logical segments that promote communication, and efficiency in handling the large volume of data that would be collected.

Maintenance data collection is expected to be infrequent but should be closely coordinated with the C-LTPP Engineer for the highway agency so that valuable data is not lost.

4.4 Safety-Related Maintenance

Safety-related maintenance must be carried out according to the current Provincial highway agency’s standards. Safety-related maintenance includes patching of potholes, treatment of high severity surface defects, and restoration of skid resistance. The use of hot mixed asphalt concrete (HMAC) overlays to restore skid resistance or other repairs in the control zone is discouraged.

The C-LTPP Engineer should be notified in advance of any corrective measures on the test sections so that an observation and record of the pavement condition could be made.

4.5 Routine or Preventive Maintenance

Some routine or preventive maintenance work may be done on the C-LTPP test sections. Crack sealing and isolated spot sealing repairs may be carried out with prior notification of the C-LTPP Engineer.

Other types of maintenance activities include the application of the following seal coats:

- sand seal
- chip seal
- aggregate seal
- slurry seal
- fog seal

Any seal coat application should be carried out in coordination with the C-LTPP Engineer. It will be necessary for the C-LTPP Engineer to visit the test section prior to seal coat application and record the surface distress condition.

4.6 Restoration or Rehabilitation

It would be preferable that no major maintenance, restoration or rehabilitation activities be carried out on the test sections before failure or 15 years. In general, performing work of the nature described in this section will eliminate the sections from further monitoring in C-LTPP. These activities include:

- milling, grinding, use of heater-planer
- overlays, HMAC
- edge drains

Version 1.0
- other specialized types of maintenance activities that affect the structural response or performance of the test section.

If these treatments are applied outside of the maintenance control zone, a transition length should be maintained to ensure that performance of the test section is not influenced.

Agency's guidelines will be followed if any of the above treatments are required.

5.0 MAINTENANCE INFORMATION

The elements of maintenance data to be collected are shown in Table 1. (Appendix A). It is the intent to collect those data items during maintenance activities to reasonably identify existing pavement conditions prior to maintenance, properties and quantities of the materials used and construction techniques.

The data items to be collected are grouped in four categories. A discussion of the data items for each category is given below and the forms (M1 to M5) for entering the data are shown in Appendix A.

5.1 Seal Coat Application Data for Asphalt Concrete Pavements (Form M1)

The application of a seal coat automatically adds a layer to the pavement structure, which is to be identified by the next higher layer number above that assigned for the previous surface layer.

Date of Application: Three two-digit numbers to identify the year, month and day of the maintenance operation.

Reasons for Seal Coat: A single-digit code for indicating the primary reason for placing a seal coat. The codes appear on the data sheet, and space has been provided for entering a reason other than those for which codes were provided.

Average Crack Severity Level: A single-digit code used to identify the average severity level of the cracks in the test section. The codes are provided on the data forms. Leave this blank if crack sealing was not the primary reason for the seal coat.

Percent of Test Section Sealed: A three-digit number to enter the percent of the test section surface area over which the seal coat was placed.

Type of Seal Coat: A single-digit code to identify the type of seal coat (slurry, aggregate, fog, etc.) applied to the pavement surface. Codes are provided on the data sheet.

Type/Grade of Asphalt or Emulsified Asphalt in Seal Coat: A single-digit code used to identify the type or grade of bituminous material used in the seal coat. Table 2 in Appendix A (SHRP Table A.16) provides a comprehensive list of possible types and grades, as taken from information published by the Asphalt Institute. Leave this space blank if some other type of cement (such as sulplex, latex modified asphalt, etc.) was used.

Description of "Other": Space is provided to write in a description of a cement used in the seal coat if it is other than the conventional asphalt cements and asphalt emulsions commonly used.

Application Rate for Asphalt or Emulsified Asphalt: A three-digit number used to identify (to the nearest one-hundredth of a litre) the amount of bituminous material placed per square metre of pavement (water added to emulsified asphalt is included).

Application Rate for Aggregate: A three-digit number to record (to the nearest one-tenth kilogram) the amount by weight of aggregate, including mineral filler, placed per square metre of pavement.

Approximate Finished Surface Treatment Thickness: A three-digit code to record the approximate thickness of the applied seal coat, to the nearest 0.25mm.
**Weather Conditions:** One three-digit number to provide air temperature in degrees Celsius and a one-digit code to indicate whether the surface was dry or wet at the time the seal coat was applied.

**Aggregate Precoted:** A one-digit code to indicate whether the seal coat aggregate was precoated or not. The codes appear on the data sheet.

**Condition of Surface Before Sealing:** A one-digit code to indicate whether the surface of the existing pavement was clean, moderately clean, or dirty when the seal coat was placed.

5.2 **Seal Coat Application Data For Asphalt Concrete Pavement (FORM M2)**

This data sheet is for continuation of seal coat data recorded on FORM M1. The data elements to be collected are discussed below.

**Gradation of Aggregate:** Five three-digit and eight two-digit numbers to record the percent of the aggregate (including mineral filler) passing various standard sieve sizes, to the nearest one percent. Values will likely not be available for all thirteen sieve sizes. The objective is to provide sufficient sieve sizes to accommodate testing and specification practice for most agencies.

**Initial Preparation Of Existing Pavement Surface:** A single-digit code to indicate the method of initial surface preparation for the existing pavement. The codes appear on the data sheet, and space is provided to describe a method not coded, where applicable.

**Final Preparation Of Existing Pavement Surface:** A single-digit code used to record the final surface preparation used on the existing asphalt concrete surface prior to seal coat application. The codes appear on the data sheet, and space is provided to describe a surface preparation method not coded, where applicable.

**Roller Used for Seating Aggregate:** A one-digit code for indicating what type of roller was used for seating the aggregate into the asphalt. Codes appear on the data sheet.

**Curing Time for Seal Coat Before Open to Traffic:** A single-digit code used to identify the approximate length of time between application of the seal coat and opening the section to traffic. Codes are provided on the data form.

5.3 **Crack Sealing Data For Asphalt Concrete Pavement (Form M3)**

This data sheet is for reporting the details of filling of individual cracks to seal them so that moisture will not flow through them to the underlying layers.

**Date of Crack Sealing:** Three two-digit numbers used to record the year, month, and day of the maintenance activity.

**Total Length of Cracks Sealed:** A four-digit code to report the approximate total linear length of individual cracks sealed within the test section to the nearest metre.

**Average Crack Severity Level:** A single-digit code used to identify the average severity of the cracks in the test section. Codes are provided on the data forms.

**Method Used to Clean Crack Before Sealing:** A single-digit code used to record the procedure used to clean the debris from cracks prior to sealing. Codes are provided on the data sheet, and a space is provided for entering a method for which no code is provided.

**Material Used to Seal Cracks:** A single-digit code to record the type of material used to seal the cracks in the pavement surface. Codes are provided on the data sheet. If a proprietary crack/joint sealant or some other type not coded is used, spaces are provided to record information to identify the material.

Version 1.0
Weather Conditions: One three-digit number to provide air temperature in degrees Celcius and a one-digit code to indicate whether the surface was dry or wet at the time the cracks were sealed.

5.4 Patching Data For Asphalt Concrete Pavements (Form M4)

This data sheet is for reporting on patches within a test section with an asphalt concrete surface.

Date of Patching: Three two-digit numbers to record the year, month, and day that the maintenance work was performed.

Primary Reason for Patches: A single-digit code for indicating the primary reason for patching. Where patching was required for more than one reason, enter the cause resulting in the greatest area of patching. Codes appear on the data form, and space is provided for writing in a reason for which no code was provided.

Secondary Reason for Patches: A single-digit code for indicating a second reason for patching using codes as discussed above.

Patches: Four sets of two and four-digit numbers to enter the number and square metres of patches differentiated by vertical extent of patch; whether only the surface was replaced, the surface and a pavement layer that had been overlaid, all AC layers and part of the base, or all AC layers and all of the base (full-depth).

Method Used to Determine Location and Sizes of Patches: A single-digit code to specify the means of locating areas requiring patching and identifying the limits of the areas to be patched. Codes are provided on the data form. Where some method other than those listed was used, space is provided to specify.

Material Used: A single-digit code used to identify the type of surface material used for patching. Codes are provided on the data form. Where a material other than those listed is used, space is provided for specification. If more than one type of surface material is used, specify the one used in the greatest area of patches.

Method of Compaction: A single-digit code used to specify the method used for compacting the new patch material. Codes are provided on the data sheet.

5.5 Cost Data (Form M5)

This data sheet provides spaces for two four-digit and one five-digit numbers to record quantities in units specified, average costs per unit in dollars and total costs in thousands of dollars for each maintenance type of which data sheets have been provided.
Appendix A
**TABLE 1: Items of Maintenance Data to be Collected**

**MAINTENANCE MONITORING DATA:**

1. Asphalt Concrete Surfaced Pavements:

   **Seal Coat**
   - Date of Work
   - Reason for Seal Coat
   - Average Crack Severity
   - Percent of Test Section
   - Sealed
   - Type of Seal Coat
   - Asphalt Type and Application Rate
   - Aggregate Type and Gradation
   - Seal Coat Mixture Data
   - Time Curing Allowed
   - Surface Preparation

   **Crack Sealing**
   - Percent of Project Area
   - Cracked
   - Average Crack Severity
   - Surface Preparation
   - Material Used to Seal
   - Cracks
   - Material Manufacturer
   - Weather Conditions During Work

   **Patching**
   - Reason for Patching
   - Extent of Patch Placement
   - Method Used to Determine
   - Locations and Sizes
   - Material Used to Patch Pavement
   - Method of Compaction

2. Cost Data

   - Maintenance Type
   - Units
   - Quantities
   - Average Cost Per Unit
   - Total Cost

Version 1.0
# Table 2: (SHRP Table A.16) Grades of Asphalt, Emulsified Asphalt, and Cutback Asphalt Codes

<table>
<thead>
<tr>
<th>Asphalt Cements</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-2.5</td>
<td>1</td>
</tr>
<tr>
<td>AC-5</td>
<td>2</td>
</tr>
<tr>
<td>AC-10</td>
<td>3</td>
</tr>
<tr>
<td>AC-20</td>
<td>4</td>
</tr>
<tr>
<td>AC-30</td>
<td>5</td>
</tr>
<tr>
<td>AC-40</td>
<td>6</td>
</tr>
<tr>
<td>AR-1000 (AR-10 by AASHTO Designation)</td>
<td>7</td>
</tr>
<tr>
<td>AR-2000 (AR-20 by AASHTO Designation)</td>
<td>8</td>
</tr>
<tr>
<td>AR-4000 (AR-40 by AASHTO Designation)</td>
<td>9</td>
</tr>
<tr>
<td>AR-8000 (AR-80 by AASHTO Designation)</td>
<td>10</td>
</tr>
<tr>
<td>AR-16000 (AR-160 by AASHTO Designation)</td>
<td>11</td>
</tr>
<tr>
<td>200-300 pen</td>
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<tr>
<td>120-150 pen</td>
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</tr>
<tr>
<td>85-100 pen</td>
<td>14</td>
</tr>
<tr>
<td>60-70 pen</td>
<td>15</td>
</tr>
<tr>
<td>40-50 pen</td>
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</table>

## Emulsified Asphalts

<table>
<thead>
<tr>
<th>Emulsified Asphalts</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS-1</td>
<td>17</td>
</tr>
<tr>
<td>RS-2</td>
<td>18</td>
</tr>
<tr>
<td>MS-1</td>
<td>19</td>
</tr>
<tr>
<td>MS-2</td>
<td>20</td>
</tr>
<tr>
<td>MS-2h</td>
<td>21</td>
</tr>
<tr>
<td>HFMS-1</td>
<td>22</td>
</tr>
<tr>
<td>HFMS-2</td>
<td>23</td>
</tr>
<tr>
<td>HFMS-2h</td>
<td>24</td>
</tr>
<tr>
<td>HFMS-2s</td>
<td>25</td>
</tr>
<tr>
<td>SS-1</td>
<td>26</td>
</tr>
<tr>
<td>SS-1h</td>
<td>27</td>
</tr>
<tr>
<td>CRS-1</td>
<td>28</td>
</tr>
<tr>
<td>CRS-2</td>
<td>29</td>
</tr>
<tr>
<td>CMS-2</td>
<td>30</td>
</tr>
<tr>
<td>CMS-2h</td>
<td>31</td>
</tr>
<tr>
<td>CSS-1</td>
<td>32</td>
</tr>
<tr>
<td>CSS-1h</td>
<td>33</td>
</tr>
</tbody>
</table>

## Cutback Asphalts (RC, MC, SC)

<table>
<thead>
<tr>
<th>Cutback Asphalts (RC, MC, SC)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 (MC only)</td>
<td>34</td>
</tr>
<tr>
<td>70</td>
<td>35</td>
</tr>
<tr>
<td>250</td>
<td>36</td>
</tr>
<tr>
<td>300-400</td>
<td>37</td>
</tr>
<tr>
<td>400-500</td>
<td>38</td>
</tr>
<tr>
<td>800</td>
<td>39</td>
</tr>
<tr>
<td>3000</td>
<td>40</td>
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</table>

Taken from MS-5, "A Brief Introduction to Asphalt," and Specification Series No. 2 (SS-2), "Specifications for Paving and Industrial Asphalts," both publications by the Asphalt Institute

Version 1.0
<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
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</thead>
<tbody>
<tr>
<td>Crack Sealing (linear metre)</td>
<td>01</td>
</tr>
<tr>
<td>Transverse Joint Sealing (linear metre)</td>
<td>02</td>
</tr>
<tr>
<td>Lane-shoulder Longitudinal Joint Sealing (linear metre)</td>
<td>03</td>
</tr>
<tr>
<td>Full Depth Transverse Joint Repair Patch (sq. metres)</td>
<td>04</td>
</tr>
<tr>
<td>AC Shoulder Restoration (sq. metres)</td>
<td>05</td>
</tr>
<tr>
<td>AC Shoulder Replacement (sq. metres)</td>
<td>06</td>
</tr>
<tr>
<td>Spreading of Sand or Aggregate (sq. metres)</td>
<td>07</td>
</tr>
<tr>
<td>Reconstruction (Removal and Replacement) (sq. metres)</td>
<td>08</td>
</tr>
<tr>
<td>Asphalt Concrete Overlay (sq. metres)</td>
<td>09</td>
</tr>
<tr>
<td>Mechanical Premix Patch (using motor grader and roller) (sq. metres)</td>
<td>10</td>
</tr>
<tr>
<td>Manual Premix Spot Patch (hand spreading and compacting with roller) (sq. metres)</td>
<td>11</td>
</tr>
<tr>
<td>Machine Premix Patch (placing premix with paver roller) (sq. metres)</td>
<td>12</td>
</tr>
<tr>
<td>Full Depth Patch of AC Pavement (removing damaged material, repairing supporting material, and repairing) (sq. metres)</td>
<td>13</td>
</tr>
<tr>
<td>Patch Pot Holes - Hand Spread Compacted with Truck (no. of holes)</td>
<td>14</td>
</tr>
<tr>
<td>Skin Patching (hand tools/hot pot to apply liquid asphalt and aggregate) (sq. metres)</td>
<td>15</td>
</tr>
<tr>
<td>Strip Patching (using spreader and distributor to apply hot liquid asphalt and aggregate) (sq. metres)</td>
<td>16</td>
</tr>
<tr>
<td>Surface Treatment, Single Layer (sq. metres)</td>
<td>17</td>
</tr>
<tr>
<td>Surface Treatment, Double Layer (sq. metres)</td>
<td>18</td>
</tr>
<tr>
<td>Surface Treatment, Three or More Layers (sq. metres)</td>
<td>19</td>
</tr>
<tr>
<td>Aggregate Seal Coat (sq. metres)</td>
<td>20</td>
</tr>
<tr>
<td>Sand Seal Coat (sq. metres)</td>
<td>21</td>
</tr>
<tr>
<td>Slurry Seal Coat (sq. metres)</td>
<td>22</td>
</tr>
<tr>
<td>Fog Seal Coat (sq. metres)</td>
<td>23</td>
</tr>
<tr>
<td>Prime Coat (sq. metres)</td>
<td>24</td>
</tr>
<tr>
<td>Tack Coat (sq. metres)</td>
<td>25</td>
</tr>
<tr>
<td>Dust Layering (sq. metres)</td>
<td>26</td>
</tr>
<tr>
<td>Longitudinal Subdrains (linear metres)</td>
<td>27</td>
</tr>
<tr>
<td>Transverse Subdrainage (linear metres)</td>
<td>28</td>
</tr>
<tr>
<td>Drainage Blankets (sq. metres)</td>
<td>29</td>
</tr>
<tr>
<td>Well System</td>
<td>30</td>
</tr>
<tr>
<td>Drainage Blankets with Longitudinal Drains</td>
<td>31</td>
</tr>
<tr>
<td>Hot-mix Recycled Asphalt Concrete (sq. metres)</td>
<td>32</td>
</tr>
<tr>
<td>Cold-mix Recycled Asphalt Concrete (sq. metres)</td>
<td>33</td>
</tr>
<tr>
<td>Heater Specification, Surface Recycled Asphalt Concrete (sq. metres)</td>
<td>34</td>
</tr>
<tr>
<td>Mill Off AC and Overlay with AC (sq. metres)</td>
<td>35</td>
</tr>
<tr>
<td>Other</td>
<td>36</td>
</tr>
<tr>
<td>Location Description</td>
<td>Code</td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
</tr>
<tr>
<td>Outside Lane (Number 3)</td>
<td>01</td>
</tr>
<tr>
<td>Middle Lane (Number 2)</td>
<td>02</td>
</tr>
<tr>
<td>Inside Lane (Number 1)</td>
<td>03</td>
</tr>
<tr>
<td>Shoulder</td>
<td>04</td>
</tr>
<tr>
<td>Curb and Gutter</td>
<td>05</td>
</tr>
<tr>
<td>Side Ditch</td>
<td>06</td>
</tr>
<tr>
<td>Culvert</td>
<td>07</td>
</tr>
<tr>
<td>Other</td>
<td>08</td>
</tr>
</tbody>
</table>

Outside Lane is numbered 3 for three lanes in one direction, 2 for two lanes in one direction and 1 for one lane in one direction.

Note: C-SHRP C-LTPP only studies outside lanes
<table>
<thead>
<tr>
<th>Material Description</th>
<th>Code</th>
</tr>
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<tbody>
<tr>
<td>Preformed Joint Fillers</td>
<td>01</td>
</tr>
<tr>
<td>Hot-Poured Joint and Crack Sealer</td>
<td>02</td>
</tr>
<tr>
<td>Cold-Poured Joint and Crack Sealer</td>
<td>03</td>
</tr>
<tr>
<td>Open Graded Asphalt Concrete</td>
<td>04</td>
</tr>
<tr>
<td>Hot Mix Asphalt Concrete Laid Hot</td>
<td>05</td>
</tr>
<tr>
<td>Hot Mix Asphalt Concrete Laid Cold</td>
<td>06</td>
</tr>
<tr>
<td>Sand Asphalt</td>
<td>07</td>
</tr>
<tr>
<td>Hot Liquid Asphalt and Aggregate (Seal Coat)</td>
<td>08</td>
</tr>
<tr>
<td>Hot Liquid Asphalt and Mineral Aggregate</td>
<td>09</td>
</tr>
<tr>
<td>Hot Liquid Asphalt and Sand</td>
<td>10</td>
</tr>
<tr>
<td>Emulsified Asphalt and Aggregate (seal coat)</td>
<td>11</td>
</tr>
<tr>
<td>Emulsified Asphalt and Mineral Aggregate</td>
<td>12</td>
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<tr>
<td>Emulsified Asphalt and Sand</td>
<td>13</td>
</tr>
<tr>
<td>Hot Liquid Asphalt</td>
<td>14</td>
</tr>
<tr>
<td>Emulsified Asphalt</td>
<td>15</td>
</tr>
<tr>
<td>Sand Cement (Using Portland Cement)</td>
<td>16</td>
</tr>
<tr>
<td>Lime Treated or Stabilized Materials</td>
<td>17</td>
</tr>
<tr>
<td>Cement Treated or Stabilized Materials</td>
<td>18</td>
</tr>
<tr>
<td>Aggregate (Gravel, Crushed Stone or Slag)</td>
<td>19</td>
</tr>
<tr>
<td>Sand</td>
<td>20</td>
</tr>
<tr>
<td>Mineral Dust</td>
<td>21</td>
</tr>
<tr>
<td>Mineral Filler</td>
<td>22</td>
</tr>
<tr>
<td>Other</td>
<td>23</td>
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</table>
C-LTTP
Maintenance Seal Coat Data

SEAL COAT APPLICATION DATA FOR
ASPHALT CONCRETE PAVEMENT

DATE OF APPLICATION

REASON FOR SEAL COAT

<table>
<thead>
<tr>
<th>Reason</th>
<th>Code</th>
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<tbody>
<tr>
<td>Seal Cracks</td>
<td>1</td>
</tr>
<tr>
<td>Bleeding</td>
<td>3</td>
</tr>
<tr>
<td>Unknown</td>
<td>5</td>
</tr>
<tr>
<td>Improve Skid Resistance</td>
<td>2</td>
</tr>
<tr>
<td>Ravelling</td>
<td>4</td>
</tr>
<tr>
<td>Other (specify)</td>
<td>6</td>
</tr>
</tbody>
</table>

AVERAGE CRACK SEVERITY LEVEL
(Very Slight = 1, Slight = 2, Moderate = 3, Severe = 4, Very Severe = 5)
(Refer to surface Distress Monitoring Guidelines)
(ANSWER ONLY IF CRACK SEALING WAS A CONSIDERATION IN DECIDING ON SEAL COAT)

PERCENT OF TEST SECTION SEALED

TYPE OF SEAL COAT

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog Seal</td>
<td>1</td>
</tr>
<tr>
<td>Aggregate Seal</td>
<td>3</td>
</tr>
<tr>
<td>Cape Seal</td>
<td>5</td>
</tr>
<tr>
<td>Slurry Seal</td>
<td>2</td>
</tr>
<tr>
<td>Sand Seal</td>
<td>4</td>
</tr>
<tr>
<td>Other (specify)</td>
<td>6</td>
</tr>
</tbody>
</table>

TYPE/GRADE OF ASPHALT OR EMULSIFIED ASPHALT IN SEAL COAT
(See Table 2 for TYPE CODE)

DESCRIPTION OF "OTHER CEMENT"

APPLICATION RATE FOR ASPHALT OR EMULSIFIED ASPHALT (l/m²)

APPLICATION RATE FOR AGGREGATE (kg/m²)
(Interfacing Mineral Filler Where Applicable)

APPROXIMATE FINISHED SURFACE TREATMENT THICKNESS

WEATHER CONDITIONS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temperature</td>
<td></td>
</tr>
<tr>
<td>Surface Moisture</td>
<td></td>
</tr>
</tbody>
</table>
(Dry = 1, Wet = 2)

AGGREGATE PRECOATED?
(Yes = 1, No = 2)

CONDITION OF SURFACE BEFORE SEALING
(Clean = 1, Moderately Clean = 2, Dirty = 3)

Version 1.0
C-LTPP
Maintenance Seal Coat Data

SEAL COAT APPLICATION DATA FOR
ASPHALT CONCRETE PAVEMENT

GRADATION OF AGGREGATE
(Including Mineral Filler Where Applicable)

<table>
<thead>
<tr>
<th>SIEVE SIZE (mm)</th>
<th>TOTAL PERCENT PASSING</th>
<th>SIEVE SIZE (mm)</th>
<th>TOTAL PERCENT PASSING</th>
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<tbody>
<tr>
<td>26.5</td>
<td></td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>19.0</td>
<td></td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td></td>
<td>0.600</td>
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INITIAL PREPARATION OF PAVEMENT SURFACE

None ........................................ 1  Sweep Clean .................................. 2  Cold Mill .................................... 3  Shot Blast .................................... 4  Other (specify) ................................ 5

FINAL PREPARATION OF PAVEMENT SURFACE

None ........................................ 1  Primarily Air Blast ........................... 2  Cold Mill .................................... 3  Primarily Sand Blast .......................... 4  Sand Blast and Air Blast ....................... 5  Other (specify) ................................ 6

ROLLER USED FOR SEATING AGGREGATE

None ........................................ 1  Pneumatic ..................................... 2  Steel Wheel .................................. 3  Unknown ....................................... 4  Other (specify) ................................ 5

CURING TIME FOR SEAL COAT BEFORE OPEN TO TRAFFIC

None ........................................ 1  < 4 hours ..................................... 2  4 < 8 hours ................................... 3  8 < 24 hours .................................... 4  1 < 3 days ..................................... 5  3 to 7 days ..................................... 6  > 7 days ....................................... 7
C-LTPP
Maintenance Crack Sealing Data

CRACK SEALING DATA FOR
ASPHALT CONCRETE PAVEMENT

DATE OF CRACK SEALING

TOTAL LENGTH OF CRACKS SEALED (metres)

AVERAGE CRACK SEVERITY LEVEL
(Very slight = 1, Slight = 2, Moderate = 3, Severe = 4, Very Severe = 5)
(Refer to Surface Distress Monitoring Guidelines)

METHOD USED TO CLEAN CRACK BEFORE SEALING

None ......................................................... 1
Compressed Air ........................................ 2
Steel Wire Brush ...................................... 3
Brooming ............................................... 4
Routing ................................................. 5
Hot Air Lance ......................................... 6
Other (specify) ........................................ 7

MATERIAL USED TO SEAL CRACKS

Asphalt Cement ....................................... 1
Emulsified Asphalt Cement ......................... 2
Cutback Asphalt Cement ............................ 3
Slurry Seal (Emulsified Asphalt Cement) ........ 4
Emulsified Asphalt Cement with Sand .......... 5
Proprietary Crack/Joint Sealant
(Manufacturer/Sealant Name) ..................... 6
Modified Asphalt ..................................... 7
(Manufacturer’s Name) .............................. 7
Other (specify) ....................................... 8

WEATHER CONDITIONS
Air Temperature (°C)
Surface Moisture
(Dry = 1, Wet = 2)

Version 1.0
C-LTPP
Maintenance Patching Data

Form M4

Host Jurisdiction _____________________________
C-SHRP I.D. # ____________
Road #/Name _______________________________________
Site Location _______________________________________

PATCHING DATA FOR ASPHALT
CONCRETE PAVEMENTS

DATE OF PATCHING

____ / _____ / _____
YY MM DD

REASONS FOR PATCHES: PRIMARY SECONDARY

Alligator cracking .................... 1 Settlement .................... 2
Potholes ............................. 3 Ravelling .................... 4
Other (specify) ________________ 5

PATCHES

Surface Only
Surface and Overlaid
AC layers with Partial
Base/Subbase Replacement
Full Depth

NUMBER SQUARE METRES

METHOD USED TO DETERMINE LOCATION AND SIZE OF PATCHES

Deflection Testing .................... 1 Coring .................... 2
Visual (Surface Defects Form) ........ 3 Other Specify ________________ 3

MATERIALS USED

Hot Mix Asphalt Concrete ............................................. 1
Plant Mix with Cutback Asphalt, Cold Laid ......................... 2
Plant Mix with Emulsified Asphalt, Cold Laid ....................... 3
Road Mix with Cutback Asphalt ...................................... 4
Road Mix with Emulsified Asphalt ................................... 5
Other (specify) _________________ 6

METHOD OF COMPACTION

None .................... 1 Pneumatic Roller .................... 2
Vibratory Plate Compactor .................... 3 Vibratory Roller .................... 4
Steel Wheel Roller .................... 5 Other (specify) _________________ 6

NOTE: Full Depth patching refers to replacement of the pavement materials which includes AC layers, base and subbase to subgrade.

Version 1.0
**C-LTPP**

Maintenance Cost Data

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<tr>
<th>MAINTENANCE TYPE</th>
<th>UNITS</th>
<th>QUANTITY</th>
<th>AVERAGE COST/UNIT $</th>
<th>TOTAL COST ($100)</th>
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<td>(Length)</td>
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<td>Patches:</td>
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<tr>
<td>Surface Only</td>
<td>m²</td>
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<tr>
<td>Surface and Partial Base/Subbase Replacement</td>
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<tr>
<td>Full Depth</td>
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**NOTE:** Full Depth patching refers to replacement of the pavement materials which includes AC layers, base and sub-base to subgrade.
C-LTPP Surface Defects Mapping Form

Localized Defects Mapping

Host Jurisdiction ____________________________
Site Location ______________________________
Road # or Description _______________________
C-SHARP I.D. Number _________________________
Survey Date _________________________________

UNIFORM DEFECTS

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REMARKS

Signature ____________________________