Pavement Distress Surveys in the Strategic Highway Research Program's Long-Term Pavement Performance Study

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The pavement distress data collection of the Long-Term Pavement Performance (LTPP) study is a part of the Strategic Highway Research Program. Pavement distress data are an important component of the international data base that will be developed during the LTPP. The pavement distress information is to be collected on 500-ft (152-m) monitoring sections on a periodic basis to provide a historical data base to show relationships between distress, performance, traffic, axle loads, age, and significant pavement structural variables. Pavement distress measurements will, in most cases, be made every year on about 1,000 pavement sections. Various categories of distress data will be collected for both rigid and flexible LTPP test sections, using manual and automatic survey procedures. Detailed information is given in the contents of survey manuals to be used during this study. The distress identification and field survey manuals have as a primary objective the provision of a uniform basis for collection of distress data. It is expected that the distress identification, definitions, and measurement procedures described in these manuals will be adopted by highway and roadway agencies in this country and abroad, so that the resulting data base may offer broad opportunities for evaluating and understanding pavement performance under different circumstances.

The rapid deterioration of the national highway network is important because the United States spends more than $30 billion every year in maintaining and upgrading highways (*1*). In 1987, the Strategic Highway Research Program (SHRP) undertook major research in six areas, one of which was Long-Term Pavement Performance (LTPP), the study of which had the following specific objectives (*2*):

- Evaluation of existing design methods.
- Development of improved strategies and design procedures for the rehabilitation of existing pavements.
- Development of improved design equations for new and reconstructed pavements.
- Determination of the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance.
- Establishment of an international long-term pavement data base to support these objectives and future needs.

The LTPP data base, a major component of this research, will contain a broad range of data elements, described in the Data Collection Guide for Long-Term Pavement Performance studies (*3*). The information will cover approximately 1,000 LTPP test sections in the United States and Canada. However, additional data from other participating countries will be included in the data base to provide international coverage for pavement performance evaluation.

Pavement distress evaluation is a part of the LTPP monitoring data set. Various categories of distress data will be collected periodically in both rigid and flexible LTPP test sections using manual or automatic survey procedures.

The Texas Research and Development Foundation (TRDF), with The University of Texas at Austin as a subcontractor, has been selected for the SHRP–LTPP technical support project P001. The pavement distress-related end products completed thus far by the P001 team include the *Distress Identification Manual* (*4*) and the *Field Manual for Distress Survey of Pavements* (*5*). These manuals will be used during the periodic manual monitoring of the LTPP test sections.

LTPP DATA BASE

The data collection activities for the creation of the LTPP data base have been organized in a systematic way to achieve maximum efficiency in both data collection and analysis. The categories of data included in the LTPP study are summarized in the following paragraphs.

Inventory Data

The inventory data include information necessary to identify the test section and to describe its geometric details, its construction techniques, and the material properties of its structural constituents, among others. All of these data are expected to remain the same throughout the monitoring period, unless the pavement is resurfaced or rehabilitated. The inventory data items to be collected have been described in detail (*3*).

Monitoring Data

The monitoring data include pavement distress information, profile measurements, skid data, and deflection testing results. These measurements will be collected on a 500-ft (152-m) monitoring section on a periodic basis to provide a historical data base for developing relationships between distress,

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performance, traffic, axle loads, age, and other significant variables. It is expected that deflection, skid, distress, and serviceability measurements will be made every year on every LTPP section unless otherwise required in relation to the pavement's rate of deterioration.

Traffic Data

Traffic data are to be collected separately for each lane to be monitored. For the LTPP, collection will be done in the outside lane in one direction. The traffic data include average annual daily traffic (AADT), percent heavy trucks, distribution of traffic by vehicle classes, and distribution of axle loads for single, tandem, and tridem axles.

Environmental Data

These data will include information necessary to characterize the environment in which the LTPP pavement test section exists. The environmental data elements to be collected have been described elsewhere (*3*).

Maintenance Data

Maintenance guidelines (*6*) have been developed to allow the application of the same routine maintenance that a study site would have normally received if it had not been selected as a monitoring site, with limitations on treatments that influence the structural response of the pavement.

Rehabilitation Data

The rehabilitation data pertain to rehabilitation that will occur after initiation of test section monitoring. Most procedures, such as recycling or overlay, result in a test section having a modified pavement structure; whereas other procedures, such as undersealing, may be considered to restore without modifying the pavement's structure. Reworking of shoulders and placement of edge drains are other examples of improvements that may be made without changing the original pavement structure; however, any such rehabilitation converts the pavement from an original pavement to a rehabilitated pavement. Data items to be taken during rehabilitation will be similar to the items listed in the inventory data section. Additional detailed information for specific rehabilitation procedures will also be collected.

PAVEMENT DISTRESS DATA COLLECTION

The main objective of the pavement distress data collection is to provide practical, uniform, comprehensive, and reliable pavement condition information. The characteristics described previously must be reflected within all pavement data collection steps, which are

- Identification of LTPP monitoring test sections,
- Identification of pavement distress data to be collected,
- Following field distress survey procedures and data processing, and
- Training of raters and other personnel.

The information collected from such surveys is to be stored in the LTPP data base; it can be used to define the pavement's present condition as well as its condition trend under specific load and environmental conditions to develop pavement performance prediction models. A review of the pavement monitoring literature (*4*) revealed as many techniques and procedures as there are highway agencies involved in this process. Because the object of the LTPP studies is to produce an international pavement data base, preliminary studies were made by TRDF and CTR for recommending and defining a uniform condition survey to be used in the LTPP test sections.

LTPP MONITORING TEST SECTIONS

The LTPP monitoring data will be collected in the outside lane in one direction of traffic of existing highways in North America. These data are to be collected on 500-ft-long test sections of asphalt concrete and asphalt overlay surfaced pavements as well as jointed and continuously reinforced concrete pavements. Approximately 1,000 test sections located on existing pavements (general pavement sections, GPS) will be monitored, including preoverlay and presurface seal coat condition surveys.

IDENTIFICATION AND DEFINITION OF DISTRESS DATA

Pavement distress represents any undesirable manifestation of defects in the pavement surface able to affect pavement serviceability, structural capacity, or appearance. The review of the literature (*4*) revealed a large number of distress identification manuals from state agencies interested in developing such surveys. The distress type, severity levels, and extent descriptions included in these manuals are based on local distress manifestations and pavement conditions. In addition, a lack of uniformity in terminology and classification of pavement's defects has been observed. Because the objective of the LTPP study is to create a national data base for use in all regions of North America, there was a need to

- Standardize defect terminology for defining distress type, severity, and extent to obtain a uniform data base,
- Include distress types that have a significant influence on pavement performance as determined from previous studies,
- Obtain consistency between classification of distresses as well as use detailed measurements to minimize errors, and
- Standardize graphical and visual descriptions of distress types and severity levels to minimize different interpretations between raters.

The distress data to be collected in the LTPP test sections are presented in the *Distress Identification Manual* (*4*). Because asphalt concrete pavement (ACP), jointed (plain and reinforced) concrete pavement (JCP), and continuously reinforced concrete pavement (CRCP) present some noncommon defect manifestations, the distresses for each pavement type are presented separately.

The distresses for ACP surfaces have been grouped into one of the following general categories:

- Cracking,
- Patching and potholes,
- Surface deformation,
- Surface defects, and
- Miscellaneous distresses.

Table 1 presents a summary of distresses, severity levels, and units of measurement for this type of pavement surface. The cracking defect mode includes alligator (fatigue), block, edge, longitudinal, and transverse cracking, as well as reflection cracking of joints for the overlayed sections. The extent of these distresses must be determined for each severity level, using the corresponding measurement units (*5*). Because, from the examination of the specific distress types present in the pavement section the rater can identify possible pavement deterioration causes, the following possible defects causes have been defined (*7,8*): alligator (fatigue) cracking has been associated with load, moisture, and drainage, whereas block cracking is associated with climate and durability factors. Edge cracking is caused by load, climate, and durability factors, whereas longitudinal and reflection cracking at joints, in addition to climate and durability, are also associated with construction defects.

The second distress group includes the patching and pothole distresses, the extent of which must be monitored within each severity level defined. Patch-patch deterioration has been related to load, climate, and durability for asphalt concrete pavements, whereas potholes, in addition to the previous two causes, have been associated with moisture and drainage factors.

Rutting and shoving constitute the surface defects type. Both of these have no severity levels defined and must be monitored according to the *Distress Identification Manual* (*4*)

TABLE 1 SURFACE DISTRESS TYPES FOR ACP LTPP TEST SECTIONS (*4*)

Distress Type	Severity Levels			Surveying Units	Surveying Technique
Cracking					
1. Alligator (Fatigue) Cracking	L(a)	M(b)	H(c)	Square Feet	P(d)/M(e)
2. Block Cracking	L	M	H	Square Feet	P/M
3. Edge Cracking	L	M	H	Linear Feet	P/M
4. Longitudinal Cracking	L	M	H	Linear Feet	P/M
5. Reflection Cracking at Joints	L	M	H	Number	P/M
6. Transverse Cracking	L	M	H	Number	P/M
Patching and Potholes					
7. Patch/Patch Deterioration	L	M	H	Square Feet, Number	P/M
8. Potholes	L	M	H	Number	P/M
Surface Deformation					
9. Rutting		None		Inches	P/M
10. Shoving		None		Square Feet	P/M
Surface Defects					
11. Bleeding	L	M	H	Square Feet	P/M
12. Polished Aggregate		None		Square Feet	M
13. Raveling and Weathering	L	M	H	Square Feet	M
Miscellaneous Distress					
14. Lane-to-Shoulder Drop-off		None		Inches	M
15. Water Bleeding and Pumping	L	M	H	Number	M

(a) L = Low; (b) M = Moderate; (c) H = High; (d) P=PASCO; (e) M=Manual descriptions. Rutting is related to load and construction defects (inadequate compaction), whereas shoving is usually the result of heavy loads on unstable asphalt mixtures.

Bleeding, polished aggregate, and raveling and weathering constitute the surface defects type. Bleeding, raveling, and weathering have been related to climatic, durability, and material factors, whereas it is reported that polished aggregate is a load-related distress (*7,8*).

The last category of defects to be monitored in the asphalt-surfaced LTPP test sections is miscellaneous distresses. These include water bleeding and pumping (related to climate and durability), to be recorded in any of three severity levels, and lane-to-shoulder dropoff, which has no severity levels and is caused by factors such as consolidation of subgrade and load applications.

For JCP, the following categories of defects have been considered:

- Cracking,
- Joint deficiencies,
- Surface defects, and
- Miscellaneous distresses.

Table 2 presents a summary of distresses for each one of these categories with corresponding severity levels and units of measurement. As can be seen from this table, corner breaks and durability (*D*) cracks, as well as longitudinal and transverse cracks, are included in the cracking category. The extent of these distresses has to be recorded separately for each severity level using measurement units reported in Table 2

TABLE 2 SURFACE DISTRESS TYPES FOR JCP LTPP TEST SECTIONS (*4*)

Distress Type	Severity Levels			Surveying Units	Surveying Technique
Cracking					
1. Corner Breaks	L[(a)]	M[(b)]	H[(c)]	Number	P[(d)]/M[(e)]
2. Durability "D" Cracking	L	M	H	Number	P/M
3. Longitudinal Cracking	L	M	H	Linear Fee	P/M
4. Transverse Cracking	L	M	H	Number	P/M
Joint Deficiencies					
5. Joint Seal Damage of Transv. Joints	L	M	H	Number	P/M
6. Spalling of Longitudinal Joints	L	M	H	Linear Fee	P/M
7. Spalling of Transverse Joints	L	M	H	Number	P/M
Surface Defects					
8. Map Cracking and Scaling	L	M	H	Square Feet	P/M
9. Polished Aggregate		None		Square Feet	SR[(f)]/M
10. Popouts		None		Number/Square Feet	P/M Total Sq. Feet
Miscellaneous Distress					
11. Blowup		None		Number	P/M
12. Faulting of Transv. Joints/Cracks		None		Inches	M
13. Lane-to-Shoulder Drop-off		None		Inches	M
14. Lane-to-Shoulder Separation		None		Inches	P/M
15. Patch/Patch Deterioration	L	M	H	Square Feet, Number	P/M
16. Water Bleeding and Pumping	L	M	H	Number	P/M

(a) L = Low; (b) M = Moderate; (c) H = High; (d) P=PASCO; (e) M=Manual; (f) SR=Skid Resistance and defined in the *Distress Identification Manual* (*4*). The causes associated with each distress manifestation are as follows: corner breaks are related to load and moisture and drainage, whereas *D* cracking is related to climate and durability factors; longitudinal and transverse cracking are related to climate, durability, and load (*7,8*).

The joint deficiencies defects category includes joint seal damage of transverse joints (associated with climate and durability causes), and spalling of longitudinal and transverse joints, which in addition to the previous causes are related to load factors as well.

The category surface defects includes map-cracking and scaling, polished aggregate, and popouts. Of these distresses, only map cracking and scaling must be monitored for each severity level defined. Polished aggregate is a load-related distress, whereas map cracking and scaling and popouts are related to climate and durability; however, construction defects can also produce scaling (*7,8*).

Under the last category for JCP, miscellaneous distresses, are included blowups, faulting of transverse joints and cracks, lane-to-shoulder dropoff and separation, patch-patch deterioration, and water bleeding and pumping; only the last two distresses must be monitored by severity levels. These distresses and the possible causes associated with each one are blowups, related to climate and durability; faulting of transverse joints and cracks, related to subgrade erosion and construction defects; lane-to-shoulder dropoff caused by subgrade consolidation and pumping; lane-to-shoulder separation caused by subgrade consolidation and shoulder movement; patch-patch deterioration, caused by load, climate, durability, and moisture and drainage factors; and water bleeding and pumping, related to climate, durability, moisture, and drainage (*7,8*).

For CRCP, the last pavement type considered in the LTPP studies, the following distress groups have been included:

- Cracking,
- Surface defects, and
- Miscellaneous distresses.

Table 3 presents a summary of distresses under each of the above groups, with corresponding severity levels and units of

TABLE 3 SURFACE DISTRESS TYPES FOR CRCP LTPP TEST SECTIONS (*4*)

Distress Type	Severity Levels			Surveying Units	Surveying Technique
Cracking					
1. Durability "D" Cracking	L(a)	M(b)	H(c)	Number	P(d)/M(e)
2. Longitudinal Cracking	L	M	H	Linear Feet	P/M
3. Transverse Cracking	L	M	H	Number	P/M
Surface Defects					
4. Map Cracking and Scaling	L	M	H	Square Feet	P/M
5. Polished Aggregate		None		Square Feet	SR(f)/M
6. Popouts		None		Number/Square Feet	P/M Total Sq. Feet
Miscellaneous Distress					
7. Blowup		None		Number	P/M
8. Construction Joint Deterioration	L	M	H	Number	P/M
9. Lane-to-Shoulder Drop-off		None		Inches	M
10. Lane-to-Shoulder Separation		None		Inches	P/M
11. Patch/Patch Deterioration	L	M	H	Square Feet, Number	P/M
12. Punchouts	L	M	H	Number	P/M
13. Spalling of Longitudinal Joint	L	M	H	Linear Feet	P/M
14. Water Bleeding and Pumping	L	M	H	Number	P/M

(a) L = Low; (b) M = Moderate; (c) H = High; (d) P=PASCO; (e) M=Manual; (f) SR=Skid Resistance measurement. For this type of pavement, the following defects are included under cracking: *D* cracks and longitudinal and transverse cracks. *D* cracking is related to climate and durability, whereas longitudinal and transverse cracking, in addition to the previous causes, are related to load factors as well (*7,8*).

The second defect category considered for CRCP is surface defects, which includes map cracking and scaling, polished aggregate, and popouts. The considerations related to such distresses are similar to the one reported previously for surface defects of the JCP.

The last distress group is miscellaneous distresses (see Table 3), which includes blowups, construction joint deterioration, lane-to-shoulder dropoff, lane-to-shoulder separation, patch-patch deterioration, punchouts, spalling of longitudinal joint, and water bleeding and pumping. The extent of these defects in the pavement surface must be monitored using one of the three severity levels available, with the exception of blowouts, lane-to-shoulder dropoff, and lane-to-shoulder separation, for which no severity levels have been defined. The causes associated with blowups, lane-to-shoulder dropoff and separation, patch-patch deterioration, and water bleeding and pumping are as described previously for miscellaneous deficiencies of the JCP; construction joint deterioration is a manifestation of construction imperfections; whereas punchouts are related to load and loss of subgrade and subbase support; finally spalling of longitudinal joints is caused by load, climate, and durability causes.

METHODS FOR FIELD SURVEY OF LTPP PAVEMENT SECTIONS

Two pavement distress surveying techniques have been selected for use in the LTPP study: a visual or manual survey procedure and an automatic technique using the PASCO multifunction survey vehicle. The visual surveys are intended for use as a backup at times when it is not possible to schedule a visit by the PASCO vehicle. If PASCO has surveyed the test section within 3 months before maintenance and rehabilitation work, it is not necessary to perform the visual distress survey, which will be performed, however, in remote areas (e.g., Hawaii, Puerto Rico) not directly accessible to PASCO. About 233 GPS test sections have been surveyed to date with the PASCO equipment and it is expected that by the end of the fall of 1989 most of the LTPP test sections will be surveyed.

The *Distress Identification Manual* (*4*) should be used as a standard guide for interpretation, identification, and rating of observed pavement distresses. The *Field Manual for Distress Surveys* (*5*) provides instructions, data forms, and maps for use in visual collection of defect information for pavements with asphalt concrete (Chapter 2), jointed concrete (Chapter 3), and continuously reinforced concrete (Chapter 4) pavements.

Visual or Manual Pavement Distress Survey Procedure

In the visual pavement distress survey, raters walk along the pavement section and manually draw a map showing the type and exact location of all defects present on the pavement surface, similar to the procedure used at the AASHO road test (*9*).

The equipment necessary for performing field condition surveys is as follows:

- *Field Manual for Distress Surveys* (*5*);
- *Distress Identification Manual* (*4*);
- Extra blank data sheets and maps;
- Clipboard, pencils, calculator, 35-mm camera, film, video camera, tapes;
- Two tape measures, one at least 100 ft long, and an engineering scale or ruler;
- Straight edge (4-ft) or rut depth gauge; and
- Hard hat and safety vest.

The severity level of each distress is identified and recorded on the maps and the data sheets included in the *Field Manual for Distress Surveys* (*5*). The field maps (see example shown in Figure 1) provide the exact location of each defect type existing on the test section. Five sheets are used for mapping; each sheet contains two 50-ft maps that represent 100 ft of the LTPP section.

To map the test section, a 100-ft tape measure should be placed on the shoulder adjacent to the test section, from Station 0 to Station 1. Once the tape is in place, the distresses can be mapped and their longitudinal location can be read directly from the tape. The transverse location of the distresses can be recorded using the additional tape measure. Once the first 100-ft subsection is mapped, the tape measure should be moved to Station 1 through Station 2 to map the second 100-ft subsection, and the process is repeated throughout the 500-ft test section.

The defects are drawn on the map at the appropriate locations using the various distress symbols defined in the *Field Manual for Distress Surveys* (*5*). Once the distress is drawn, it is labeled and numbered using the relative symbols and corresponding severity levels (*L*, *M*, or *H*), if applicable. Any distresses that are not described in the manuals should be photographed and videotaped. The location and extent of them should be shown and labeled on the map.

If bleeding, polished aggregate, raveling, or weathering occurs in extended areas over an asphalt concrete surfaced pavement test section, the total extent is not mapped. For jointed concrete pavement sections and continuously reinforced concrete pavements, if map cracking or scaling, polished aggregate, or popouts occur in large areas over the test section, the total extent must not be mapped as well. Instead, the location, extent, and severity level (if applicable) of all the distresses must be noted in the space for comments at the bottom of each map. These distresses should be mapped only if they occur in localized areas.

Lane-to-shoulder dropoff for both CRCP and JCP and lane-to-shoulder separation for CRCP are not mapped but are recorded in the corresponding sheets.

The data sheets or forms included in the *Field Manual for Distress Surveys* (*5*) provide space for recording the state ID number, the SHRP ID (state code plus SHRP Section ID), the survey date, and the results of distress surveys, on different sheets for each pavement type. Except where otherwise indicated, entries have to be made for all distress data

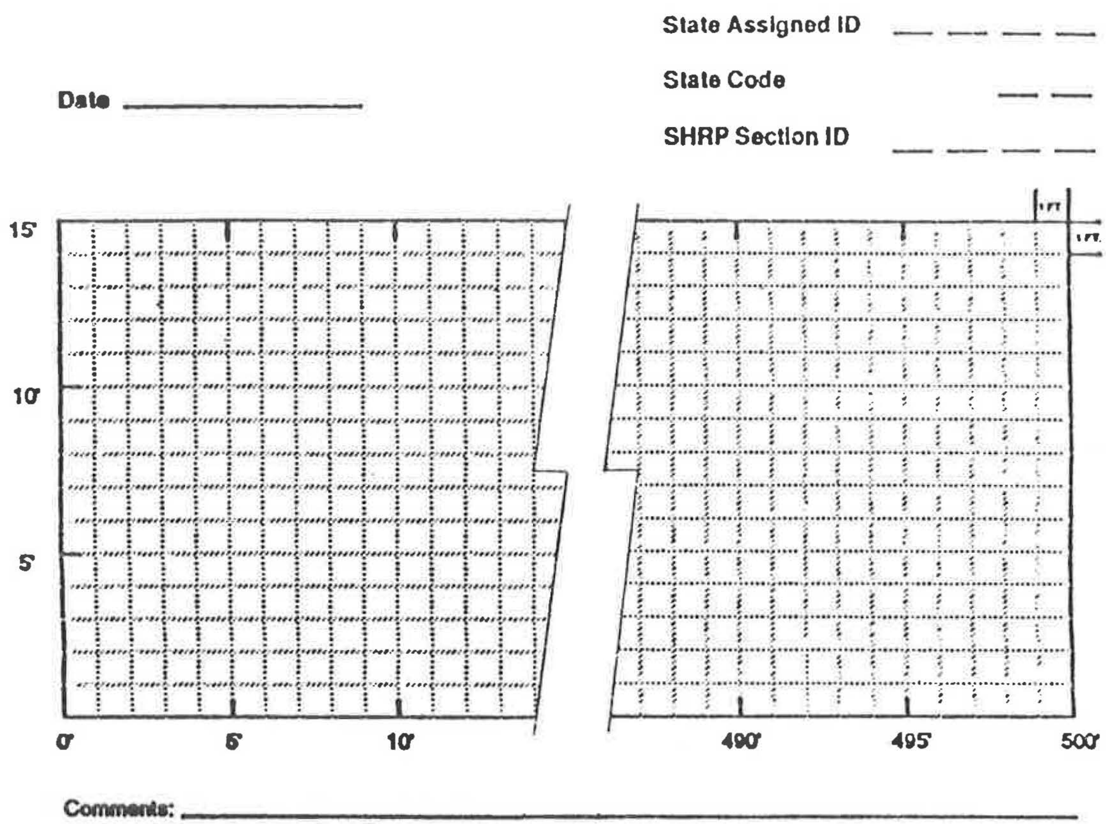

FIGURE 1 LTPP pavement distress map form (*5*).

elements. If a particular type of distress does not exist, a zero should be entered in the appropriate space. All data sheets and maps are to be completed in the field. Particular attention is required for monitoring the following distresses per pavement type.

In asphalt concrete pavements (ACP), shoving and polished aggregate are recorded only in extent. Rutting is measured as the maximum vertical depression (to the nearest 0.1 in.) of the pavement surface in a wheelpath, from the center of a 4-ft straight edge or rut depth gauge (*9*). Measurements are taken at the beginning of the test section and at 50-ft intervals. There should be a total of 11 measurements in each wheelpath, for a total of 22 measurements on each test section (see Table 4). Lane-to-shoulder dropoff is measured as the difference in elevation (to the nearest 0.1 in.) between the pavement and the adjacent shoulder surface. Measurements are taken at the beginning of the test section and at 100-ft intervals (a total of six measurements) at the lane-shoulder interface or joint. Lane-to-shoulder dropoff typically occurs when the outside shoulder settles. However, heave of the shoulder may occur due to frost action or swelling soil and if it is present, it should be recorded as a negative (−) value. At a point where there is no lane-to-shoulder dropoff, enter zero. In addition, space is provided to list other distress types found on the test section but not listed on the data sheets.

For portland cement concrete pavements, polished aggregate, popouts, and blowups are recorded only by extent. Faulting of transverse joints and cracks is measured as the difference in elevation (to the nearest 0.1 in.) between the pavement surface on either side of a transverse joint or crack. It is measured 1 ft from the outside slab edge. Measurements are taken at every joint and crack that has faulting. If more than 10 joints or cracks have faulting, record the measurements in additional copies of the corresponding data sheets or forms (see Table 5). The distance from the start of the test section to the point where the measurement is taken is recorded. The space to the left of the entry of measured faulting is filled with a positive or negative sign. If the approach slab is higher than the departure slab, a positive sign (+) is entered. If the approach slab is lower, a negative sign (−) is entered.

Lane-to-shoulder dropoff for both JCP and CRCP is recorded in the same way as for ACP. In addition, for both JCP and CRCP, lane-to-shoulder separation is measured as the width of the joint (to the nearest 0.1 in.) between the outside lane and the adjacent shoulder surface (*6*). Measurements (a total of six) are taken at the beginning of the test section and at 100-ft intervals. At each point where there is no lane-to-shoulder separation, a zero must be entered.

Automatic Pavement Distress Survey Procedure

The PASCO multifunction survey vehicle (*10*) has been selected for surveying the LTPP test sections. The photographs and other visual images of the pavement surface collected by this vehicle will be later interpreted in the office. This vehicle is used to speed up the field data collection time and provide a permanent visual record of the actual pavement condition. Cracking, patching, and other distresses are recorded using the ROADRECON-70 system. The vehicle travels at speeds

TABLE 4 MONITORING SHEET FOR RUTTING OF ASPHALT CONCRETE SURFACED PAVEMENTS (5)

Inner Wheel Path			Outer Wheel Path		
Point Number	Point Distance[1] (feet)	Rut Depth (inches)	Point Number	Point Distance[1] (feet)	Rut Depth (inches)
1	0.	_._	1	0.	_._
2	50.	_._	2	50.	_._
3	100.	_._	3	100.	_._
4	150.	_._	4	150.	_._
5	200.	_._	5	200.	_._
6	250.	_._	6	250.	_._
7	300.	_._	7	300.	_._
8	350.	_._	8	350.	_._
9	400.	_._	9	400.	_._
10	450.	_._	10	450.	_._
11	500.	_._	11	500.	_._

[1]Point Distance is the distance in feet from the start of the test section to the point where the measurement was made.

between 3 and 53 mph (5 and 85 km/hr). A continuous photographic record of the pavement surface is made using a 35-mm slit camera. The system synchronizes film feed speed and camera aperture with the speed of the vehicle to equalize image density and photographic reduction. Road widths of up to 16 ft (5 m) can be filmed. Photographing is performed at night using on-board lights. The lights are set at an angle to the road surface so that shadows are produced at cracks and other defects in the surface, making interpretation easier. Interpretations of the distresses are made by a technician viewing the developed 35-mm film enlarged 10 times on the ROADRECON Film Digitizer. A grid pattern is overlayed on the film to aid in qualification of the distress for input into a computer data base.

Rut depth surveys can be carried out at speeds up to 50 mph (80 km/hr) using the ROADRECON-75 system (*10*). A pulse camera mounted on the vehicle photographs hairline optical bars projected onto the road. The camera shutter and hairline projector are synchronized according to the distance covered by the projection vehicle, so that the system is able to create a photographic record of rutting at variable distance intervals. The film is projected onto a digitizing table and traced with a computer mouse, enabling the wave patterns to be processed into a transverse profile of the pavement surface.

TRAINING

Training of the raters before a manual field survey is an important aspect of pavement evaluation. Because of the need for fast but reliable estimates of distress, it is necessary to provide a well-organized training program for assigned personnel. This training will involve familiarization with objectives, definitions, and procedures, followed by field observation under controlled conditions.

Determination of extent (density) and severity is essentially subjective, depending on experience and engineering judgment in a particular area. For this reason, the *Distress Identification Manual* (*4*) will be provided to the raters, because it includes descriptions of each distress type and how density and severity are to be identified. Also, information related to procedures for recording distress included in the *Field Manual for Distress Surveys* (*5*) is vital.

Experience indicates that training sessions should be repeated just before rating periods (*11*). If multiple teams are to be

TABLE 5 MONITORING SHEET FOR FAULTING OF TRANSVERSE JOINTS AND CRACKS OF JOINTED CONCRETE PAVEMENTS (*5*)

Joint Number[1]	Point Distance[2] (feet)	Joint Faulting[3] (inches)	Joint Number[1]	Point Distance[2] (feet)	Joint Faulting[3] (inches)
1	_ _ _ .	_ . _	1	_ _ _ .	_ . _
2	_ _ _ .	_ . _	2	_ _ _ .	_ . _
3	_ _ _ .	_ . _	3	_ _ _ .	_ . _
4	_ _ _ .	_ . _	4	_ _ _ .	_ . _
5	_ _ _ .	_ . _	5	_ _ _ .	_ . _
6	_ _ _ .	_ . _	6	_ _ _ .	_ . _
7	_ _ _ .	_ . _	7	_ _ _ .	_ . _
8	_ _ _ .	_ . _	8	_ _ _ .	_ . _
9	_ _ _ .	_ . _	9	_ _ _ .	_ . _
10	_ _ _ .	_ . _	10	_ _ _ .	_ . _

[1]Numbers represent only transverse joints or cracks measured.

[2]Point Distance is the distance in feet from the start of the test section to the point where the measurement was made.

[3]Enter either a positive or negative sign in the left space, depending on whether the "approach slab" is higher or lower than the "departure slab," respectively.

TABLE 6 MONITORING SHEET FOR LANE-TO-SHOULDER DROPOFF OF ACP, JCP, AND CRCP AND LANE-TO-SHOULDER SEPARATION FOR JCP AND CRCP (*5*)

Point Number (feet)	Point Distance[1]	Lane-to-Shoulder Separation (inch)	Lane-to-Shoulder Drop-off (inch)
1	0.	_ . _	_ . _
2	100.	_ . _	_ . _
3	200.	_ . _	_ . _
4	300.	_ . _	_ . _
5	400.	_ . _	_ . _
6	500.	_ . _	_ . _

[1]Point Distance is the distance in feet from the start of the test section to the point where the measurement was made.

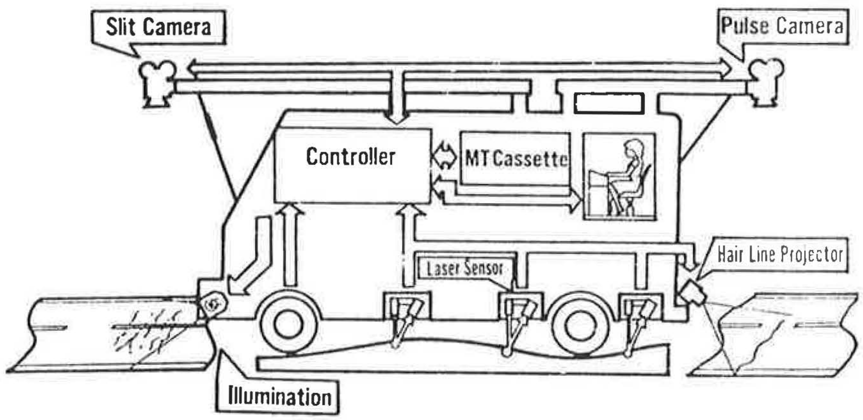

FIGURE 2 PASCO multifunction survey vehicle (*10*).

used, it will be important to calibrate the teams so that consistent ratings are obtained. This can be accomplished by repeatedly rating identical sections by each team until similar results are obtained. Wide variations have been experienced between rating teams on individual projects but when averages for a group of projects are compared between teams, the variation is significantly reduced. Criteria for the training exercise are not available; hence, some judgment must be applied. It is recommended that at least 10 sections be included as the base case (*11*). Each section should have a different amount of distress by type, extent, or severity.

SUMMARY

The distress surveys conducted as part of this long-term study will be used to quantify the condition of a pavement by classifying the amount and extent of distress present annually. The information to be collected from such surveys and to be stored in the LTPP data base is described in this paper and includes categories and types of distress data for both rigid and flexible pavements as well as the possible causes responsible for the manifestation of the defects. The manual and automatic survey procedures are also presented in this paper. Detailed information is given on the contents of survey manuals to be used during this study including identification of the LTPP test sections and monitoring and mapping of distress manifestations in related forms. The distress identification and field survey manuals discussed in this paper have as a primary objective the provision of a uniform basis for collecting distress data and it is expected that the definitions and procedures used in the SHRP LTPP study will be adopted by highway agencies interested in developing condition surveys.

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