TECH**BRIEF**

The Long Term Pavement Performance (LTPP) program is a 20-year study of in-service pavements across North America. Its goal is to extend the life of highway pavements through various designs of new and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soil, and maintenance practices. LTPP was established under the Strategic Highway Research Program, and is now managed by the Federal Highway Administration.

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Key Findings From LTPP Distress Data

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Introduction

Consistent, accurate, high-quality pavement distress data are essential to all aspects of pavement engineering. Network-level pavement management systems require accurate distress data to support sound conclusions as to where and when to invest highway maintenance, rehabilitation, and construction dollars. At the project level, distress data are essential to correctly diagnose the causes of pavement deterioration, and thus the selection of the most appropriate remedial measures. In pavement research, these data are critical independent variables in the development of structural design methods and performance prediction models for both new and rehabilitated pavements.

Within the Long Term Pavement Performance (LTPP) program, two approaches to pavement distress data collection have been used—"manual" distress surveys and photographic surveys. In both approaches, the type, severity, and extent of the distress observed on the pavement are determined and recorded by trained personnel using the definitions and measurement and rating criteria provided in LTPP's distress identification manual. Key differences between the two survey methods are summarized in table 1 on the following page.

The differences presented in table 1 suggest that some reconciliation of differences between the two survey methods may be needed before the data obtained with them may be combined for use in pavement performance analysis. For this reason, a study was undertaken to pursue this reconciliation. The planned outcome of the study was to be a "consolidated distress data set" in which data collected by both methods were combined **after** careful examination of the time trends in each distress type considered to reconcile differences attributable to the distress survey methodology. The findings of this study have some important implications for future work with the LTPP distress data and for agencies collecting similar distress data for their own applications.

Table 1. Key differences between LTPP manual and photographic distress surveys.		
	Manual	**Photographic**
Traffic Control	Full lane closure	Not required
Lighting Conditions	Daylight (uncontrolled)	Uniform artificial illumination (nighttime photography)
Permanent Record	Hand-drawn distress maps (subjective)	35-mm photograph (objective)
View of Pavement Surface	Direct, three-dimensional	Indirect (photograph), two-dimensional image
Ability to See Fine Cracks	Not limited by survey methodolgy	Limited by image resolution

Key Findings

The most important finding of this investigation is that there is **no systematic difference in the distress data that is attributable to the method of survey.** Thus, no reconciliation of data differences due to distress survey methods is needed prior to combining photographic and manual distress data for use in subsequent analysis.

It was also found that the majority of the distress data reflect rational time trends and are, therefore, suitable for use in future performance analysis.

Finally, the methodology applied to evaluate the LTPP distress data is very promising as a quality control tool. It is anticipated that this methodology will be used to enhance LTPP quality control measures. It could also be developed further to provide a quality control tool for State and other highway agencies to use in evaluating pavement distress data collected for their pavement management systems.

Distresses Considered

The distresses shown in table 2 (below) were the focus of this study, because they are the distresses most commonly observed in the LTPP test sections.

The review process involved plotting the distress data as a function of time to evaluate whether the distress progression made sense or not. The closeness of the actual data points to a linear regression line drawn through the data points was evaluated. If the data were not within a specified tolerance, the data for that section were examined more closely. Additional checks assessed the data in terms of logic (i.e., increasing distress with time and threshold values). If the data failed all of these checks, the distress was logged as discrepant.

Results of Review Process

The majority of the data showed plausible trends. Those

Table 2. Key distress types.		
HMA	**JC**	**CRC**
Fatigue Cracking	Corner Breaks	Longitudinal Cracking
Longitudinal Cracking	Longitudinal Cracking	Transverse Cracking
Transverse Cracking	Transverse Cracking	Patch/Patch Deterioration
Patch/Patch Deterioration	Patch/Patch Deterioration	Punchouts
Block Cracking		

that did not were initially categorized as discrepant and were examined more closely to determine the cause of the discrepancies. The largest number of discrepant surveys were those for which extensive longitudinal and transverse cracking were recorded regardless of pavement type. Nearly 75 percent of the surveys were found to be problem-free with actual percentages of 61, 78, and 75 for pavements with hot-mix asphalt (HMA), jointed concrete (JC), and continuously reinforced concrete (CRC) surfaces, respectively.

Causes of Discrepant Data

The causes of the observed discrepancies were categorized into five groups as shown in table 3 (below).

Discrepant survey data categorized as "human error" were both quantitative and qualitative in nature. Computational errors occurred in compiling numerical data such as total number of cracks or area of patches. Due to the subjective nature of evaluating visual distress, many surveys were labeled as being discrepant because of differentiating between the following:

- Fatigue cracking and longitudinal cracking in the wheelpath.
- Wheelpath longitudinal cracking and non-wheelpath longitudinal cracking.
- Block cracking and longitudinal and transverse cracking.

Although some discrepant survey data were attributed initially to "seasonal effects," this classification could not be confirmed as part of this review process.

Overall, the condition survey results were found to be independent of data collection methodology: manual and photographic distress surveys yielded similar results.

Evaluation strategies or erroneous assumptions made at the onset of this analysis accounted for approximately 36 percent of the questionable data. These included the following:

- Statistical analyses that did not account for the baseline measurement of distress in establishing variability measurements (i.e., standard deviation and variance).
- Statistical analyses that did not account for a non-linear increase in distress with time.
- Identification of maintenance and rehabilitation activities.

Table 3. Causes of discrepant data.

Human Error	Seasonal Effects	Data Collection Methodolgy	Evaluation Strategy	Unknown
17 percent	0 percent	6 percent	36 percent	41 percent
• Distress definition	• Thermal effects on crack width	• Manual vs. automated	• Nonlinear increase in distress	
• Summarization	• Visibility of distress due to surface moisture	• Color, contrast, and depth perception	• Insufficient quantities of distress	
	• Resolution (e.g., hairline cracking)	Undocumented maintenance and rehabilitation		

Approximately 41 percent of the discrepant data remain unclassified in terms of the problem source.

Application of Analysis Findings

Within LTPP, the most immediate application of the findings from this study is to improve the quality of the LTPP distress data through further examination and correction (where possible and appropriate) of those data found to be discrepant. This work has been assigned to the responsible data collection contractors and was completed in most cases. In addition, the findings are being used to improve the quality control measures applied to the LTPP distress data as they are collected.

Based on the findings of this study, the planned "consolidated distress data tables" will not be incorporated into the LTPP database since doing so is deemed unnecessary. Data collected via the two methods may be combined for analysis purposes, with no adjustments to account for between-method differences in the data.

Lastly, the possibility of further developing the methodology used in this study as the basis for an improved distress data quality control tool for use by highway agencies in the collection and processing of pavement distress data will be explored.

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Distribution—This TechBrief is being distributed according to a standard distribution. Direct distribution is being made to the Resource Centers and Divisions.

Availability—The publication upon which this TechBrief is based is *Distress Data Consolidation, Final Report* (Report No. FHWA-RD-01-143). It is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. A limited number of copies will be available from the R&T Report Center, FHWA, 9701 Philadelphia Court, Unit Q, Lanham, MD 20706, telephone: (301) 577-0818, fax: (301) 577-1421.

Key Words—Distress, condition evaluation, manual distress survey, photographic distress survey.