TECH**BRIEF**

LTPP Data Analysis: Optimization of Traffic Data Collection for Specific Pavement Design Applications

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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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Introduction

Traffic loads are an essential input to the pavement analysis and design process. In the past, the impact of traffic was aggregated into equivalent single-axle loads and input into regression-based pavement performance equations. The recently developed *Mechanistic-Empirical Pavement Design Guide* (M-E PDG) (NCHRP 1-37A) characterizes traffic in terms of axle numbers by type and load frequency distribution, including axle load spectra. This is a significant improvement over past methods because it allows for a mechanistic pavement design approach.

Traffic data collection is carried out using several data acquisition technologies, including weigh in motion (WIM) systems, automated vehicle classifiers (AVC), and automated traffic recorders (ATR). The data coverage of traffic data acquisition systems can vary widely from operating continuously to providing simple 48-hour data coverage. Hence, there is wide variation in the characteristics of traffic data used for designing pavements.

The challenge for both pavement design and traffic engineers is to determine the combination of traffic data acquisition technology and the amount of time coverage required for particular pavement design situations outlined in the M-E PDG. The problem needs to be addressed in light of the sensitivity of pavement design and performance to the level of traffic data input. Understanding this sensitivity will allow for the optimization of traffic data collection resources allocated for pavement design processes.

Objective

The Long-Term Pavement Performance (LTPP) program conducted a study to establish the relationship between the traffic data collection effort, including the combination of traffic data acquisition technologies and length of time coverage, and the variability in predicted pavement life using the M-E PDG.

For the study, researchers used extended-coverage WIM data from the LTPP Standard Data Release (SDR) 16.0 to simulate a wide range of traffic data collection scenarios. This resulted in the development of two specific products:

- Guidelines for the type, amount, and quality of traffic data input required for particular design situations considering the sensitivity of the pavement design process to the variability in traffic load input.
- Directions for future traffic data collection efforts to address both LTPP and State agency collection needs for pavement design applications.

Analysis

To conduct the study, researchers established data collection scenarios by expanding the four traffic input levels of the M-E PDG, taking into consideration equipment technology and the length of the site-specific coverage. Table 1 provides a summary of the scenarios.

The researchers also used SDR 16.0 to identify LTPP sites with WIM data coverage exceeding 299 days per year. A total of 178 sites satisfied this criterion for multiple years. After identifying the sites, the researchers extracted daily traffic data summaries for these sites from the Central Traffic Database of SDR 16.0.

M-E PDG Traffic Input Level	Traffic Data Source	Time Coverage of Site-Specific Data Over a 1-Year Period	Scenario ID
1	**WIM Data = SS**	Continuous	1-0
	AVC Data = R	1 month/4 seasons	1-1
		1 week/4 seasons	1-2
2	WIM Data = R	Continuous	2-0
	AVC Data = SS	1 month/4 seasons	2-1
		1 week/4 seasons	2-2
		1 week	2-3
3	WIM Data = R	Continuous	3-0
	AVC Data = R	1 month/4 seasons	3-1
	ATR Data = SS		—
4	WIM Data = N	Continuous	4-0
	AVC Data = R	1 week/4 seasons	4-1
	ATR Data = SS	1 week	4-2
		1 weekday + 1 weekend day	4-3
	WIM Data = N	Continuous	4-4
	AVC Data = N	1 week/4 seasons	4-5
	ATR Data = SS	1 week	4-6
		1 weekday + 1 weekend day	4-7

SS: Site-specific, R: Regional, N: National (M-E PDG defaults)

Table 1. Traffic data collection scenarios.

The researchers then selected 30 sites (15 with flexible and 15 with rigid pavements) to represent a wide range of layer thicknesses and average annual daily truck traffic volumes for detailed simulation in the M-E PDG.

Following this step, the researchers obtained site-specific traffic simulations from the extended-coverage WIM data using procedures in the 2001 *Traffic Monitoring Guide* (FHWA-PL-01-021). To estimate regional averages, the researcher used clustering techniques to group test sections with similar traffic characteristics.

The researchers then conducted a sensitivity analysis to evaluate the variation in predicted pavement life using the various traffic data collection scenarios. Ranges in pavement life errors as a function of confidence interval for each scenario also were developed, using both mean and low-percentile traffic input (figures 1 and 2, respectively).

From a pavement design point of view, traffic underestimation is considered the most critical problem because it leads to the overestimation of pavement life and can produce pavement structures with insufficient structural capacity. As a result, the researchers considered the lower end of the percentile range computed for each traffic input element to be the most significant in the study. This enabled researchers to compute the range in mean error resulting from specifying the lowest percentile for all of the traffic inputs simultaneously.

While very conservative, this method addresses reliability by providing the magnitude of error that will not be exceeded for an input scenario at a given confidence level.

Conclusions

In addition to establishing approximate ranges for pavement life prediction errors for various collection scenarios, the researchers drew the following conclusions from the analysis:

- Discontinuous traffic data collection scenarios involving site-specific WIM data had significantly more potential error than continuous-coverage site-specific AVC data. This is because partial WIM coverage does not yield site-specific monthly adjustment factors, which are necessary for accurately modeling seasonal damage in the M-E PDG.
- Using continuous site-specific truck counts and classification with regional load data (scenario 2-0), engineers can predict pavement life with an error on the order of 10 percent,

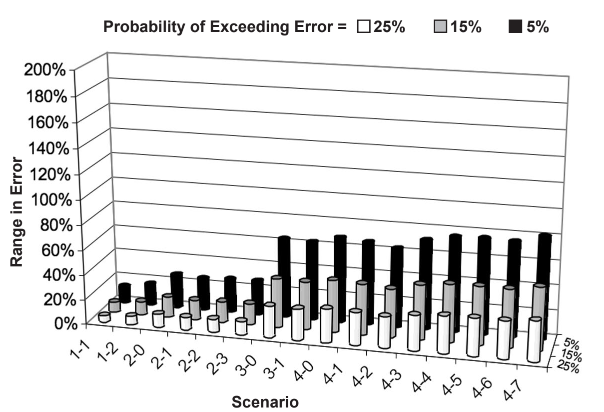

Figure 1. Range in M-E PDG pavement life prediction errors from mean traffic input.

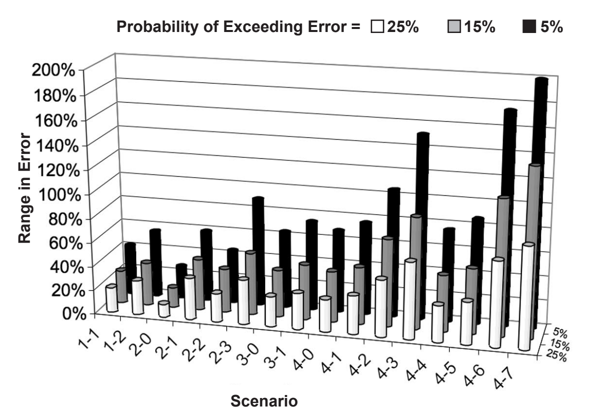

Figure 2. Range in M-E PDG pavement life prediction errors from low-percentile traffic input.

16 percent, and 27 percent for confidence levels of 75 percent, 85 percent, and 95 percent, respectively.

- Continuous, site-specific truck counts combined with regional load and classification data (scenario 3-0) produces life prediction errors ranging from 25 percent to 64 percent for the same confidence levels. Likewise, continuous site-specific truck counts combined with regional classification and national load data (scenario 4-0) also yields similar life prediction errors ranging from 27 percent to 68 percent.
- Using continuous site-specific truck counts combined with national load and classification data (scenario 4-4) yields life prediction errors ranging from 30 percent to 76 percent.

Application

Pavement design and traffic engineers can use the results from this study to establish traffic data collection scenarios considering a maximum acceptable pavement life prediction error under a selected confidence level. The data from this and subsequent analyses also could be used to implement traffic data collection procedures for given design situations.

In addition, pavement designers can use these findings to better understand the effect specific traffic data sources may have on predicted pavement life from the M-E PDG. Professionals also could use the final report to guide agencies in developing an implementation plan for the anticipated American Association of State Highway and Transportation Officials' pavement design guide, in terms of future traffic data collection procedures and use.

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

Availability–The publication from which this TechBrief was developed, *Optimization of Traffic Data Collection for Specific Pavement Applications* (FHWA-HRT-05-079), 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 Research and Technology Product Distribution Center, HRTS-03, FHWA, 9701 Philadelphia Court, Unit Q, Lanham, MD 20706, telephone: 301–577–0818, fax: 301–577–1421.

Key Words–LTPP traffic data, traffic data collection, NCHRP 1-37A, *M-E Pavement Design Guide*, axle load spectra, sensitivity analysis.