TECHBRIEF

LTPP

The Long-Term Pavement Performance (LTPP) program is a 20-year study of inservice 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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Why Does LTPP Require Site-Specific Traffic Loading Data?

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Introduction

The Long Term Pavement Performance (LTPP) program is a 20-year research study of in-service pavements. The program's results provide the basis for pavement design, maintenance, rehabilitation, and construction procedures and methodologies for years to come. As with any research endeavor, however, LTPP's results are strongly influenced by the quality, quantity, and completeness of the input data. LTPP, therefore, has very stringent data requirements. The purpose of this TechBrief is to discuss one of these requirements—site-specific measurements for estimating pavement loadings—and to illustrate the effects of traffic loading data error on LTPP's ability to develop accurate and reliable design equations.

Effects of Traffic Loading Data Error

Although statewide or regional average loads per vehicle may cost less to determine than site-specific loads (and may be appropriate for many other types of analyses), the use of traffic loading data that are not site-specific can produce significant errors in the annual, cumulative, and design life estimates of pavement loadings. LTPP and American Association for State and Highway Transportation Officials research[1] has shown that the use of average loads can have negative impacts on the reliability of pavement life predictions. These reliability concerns are magnified when the loading estimates are being used as one of the primary independent variables in the development of new design equations. The cost of errors in new design equations that may occur as a result of using poor loading estimates far exceeds the near-term data collection cost-savings that can be gained by using statewide and regional averages.

Volumes

That traffic load varies considerably from site to site is well documented. Load varies because the number, size, and configuration of trucks change from road to road, and because the loading condition of those trucks changes from location to location. These conditions can change dramatically even between two directions on the same road.

A Washington State study found that, on average, 7.1 percent of the traffic on its rural primary arterial system consisted of Federal Highway Administration

(FHWA) Class 9 trucks (five-axle tractor semi-trailers). However, the standard deviation of that estimate was almost 5.2 percent. This means that more than 16 percent of the rural primary arterials carried less than 2 percent of Class 9 trucks, and another 16 percent carried more than 12 percent of Class 9 trucks. This level of variation is fairly typical for most States. Figure 1 illustrates the cumulative Equivalent Single-Axle Loads (ESALs) that a roadway would experience under these three different assumptions.[2] The only difference in the three estimates shown in figure 1 are the Class 9 truck percentages. For a 20-year pavement life, an error of roughly 2.4 million ESALs would occur if the State average were used rather than the "true" percentage for a road that had Class 9 truck percentages — one standard deviation from the mean value.

If LTPP used the "average" value for a test section that experienced a high loading rate (in the example above, this would happen on 15 out of every 100 LTPP test sites), the research results would conclude that the pavement was exhibiting much better performance than it really was. Pavement designs based on these faulty conclusions would result in premature pavement failures.

Weights

Truck volumes are not the only source of loading variation. Legal weights for specific truck configurations vary from State to State. This results in very different loading characteristics for individual truck types. In addition, the percentage of trucks that are fully loaded can change dramatically from site to site, and even from one direction to another.

Table 1 shows how varied traffic characteristics can be among LTPP sites. Three common vehicle classes are shown. The effects of Rhode Island's much higher weight laws are obvious. However, even within a State, considerable differences exist among many of the loading patterns.

These loading differences can compound the errors caused by using the wrong vehicle classification percentages. The ESAL loading rates per vehicle in figure 1 are based on a statewide average. If the loading rate at the LTPP test site is comparable to Minnesota site 3014 (which exhibits very heavy Class 9 trucks) and the site exhibits a Class 9 truck percentage equal to one standard deviation above the mean statewide average, the error resulting from the use of the statewide average is almost 13 million ESALs after 20 years. The growth in this error over time can be seen in figure 2.

Accurately Measuring Conditions

As illustrated by the examples, the traffic data submitted to LTPP show that the loading conditions found at LTPP test sites cover a range of loading conditions. Some sites have high truck volumes, but a large percentage of those trucks are very light (either empty or carrying light, bulky cargo). Other sites have high truck volumes of very heavy trucks. Still other sites have fairly low volumes of very heavy trucks, producing much higher loading conditions than might be expected for a low-volume road. Finally, some roads experience little loading whatsoever. The only way that LTPP engineers can accurately determine how well a State's pavement designs are functioning is if these different loading conditions are accurately measured at each site. Without this information, the results obtained from LTPP research are subject to significant uncertainty, and they have a high probability of misrepresenting the true performance of test pavements.

TABLE 1. ESAL loadings per vehicle by vehicle class at six LTPP sties.

CLASS	MN 1029	MN 1023	MN 4054	MN 3014	WA 6020	RI 7401
6	0.782	0.750	0.563	0.599	0.187	4.474
9	1.332	1.788	1.690	2.669	0.331	8.193
11	0.389	0.429	1.562	2.094	1.002	3.706

Foot Notes:

[1] *Traffic Forecasting for Pavement Design* (FHWA-TS-86-225), March 1988.

[2] These estimates are based on an Annual Average Daily Traffic of 5,000 vehicles per day, and truck percentages of 3.44 for all two-axle truck categories, 0.71 for all three-axle truck categories, 0.07 for all four-axle truck categories, and 0.18 for all non-FHWA Class 9 five-axle and larger truck categories. All other vehicles are assumed to be passengers cars. ESALs per truck values are 0.11, 0.47, 0.66, and 1.63 for the above catergories, respectively. The FHWA Class 9 vehicles are assumed to be 0.98 ESALs per vehicle.

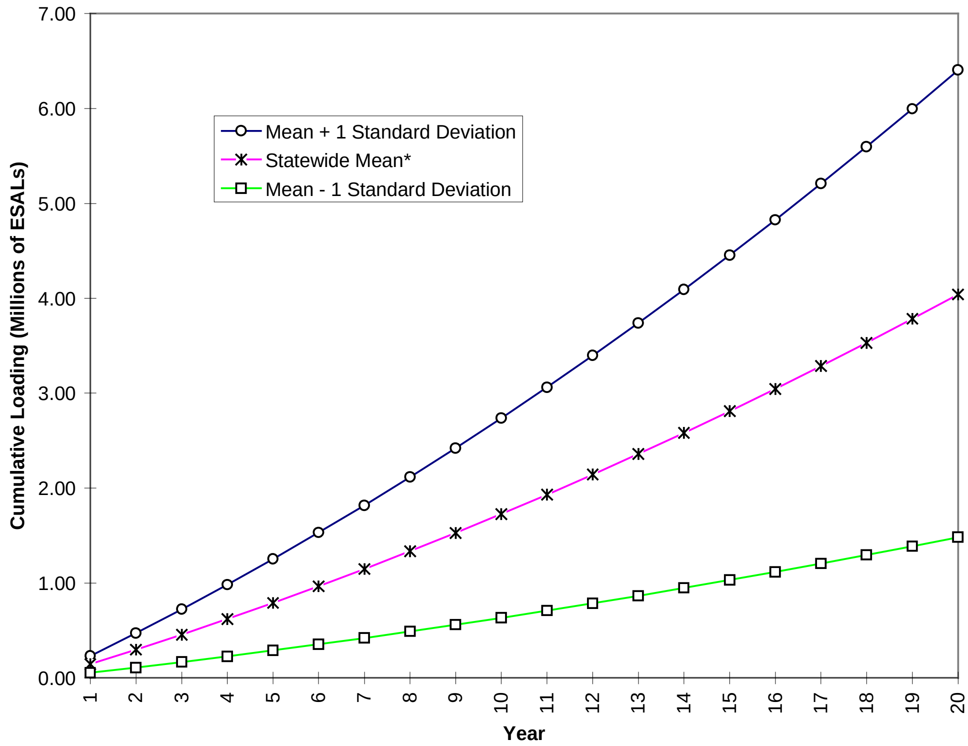

FIGURE 1. Cumulative ESAL loading as a function of truck percentage over time.

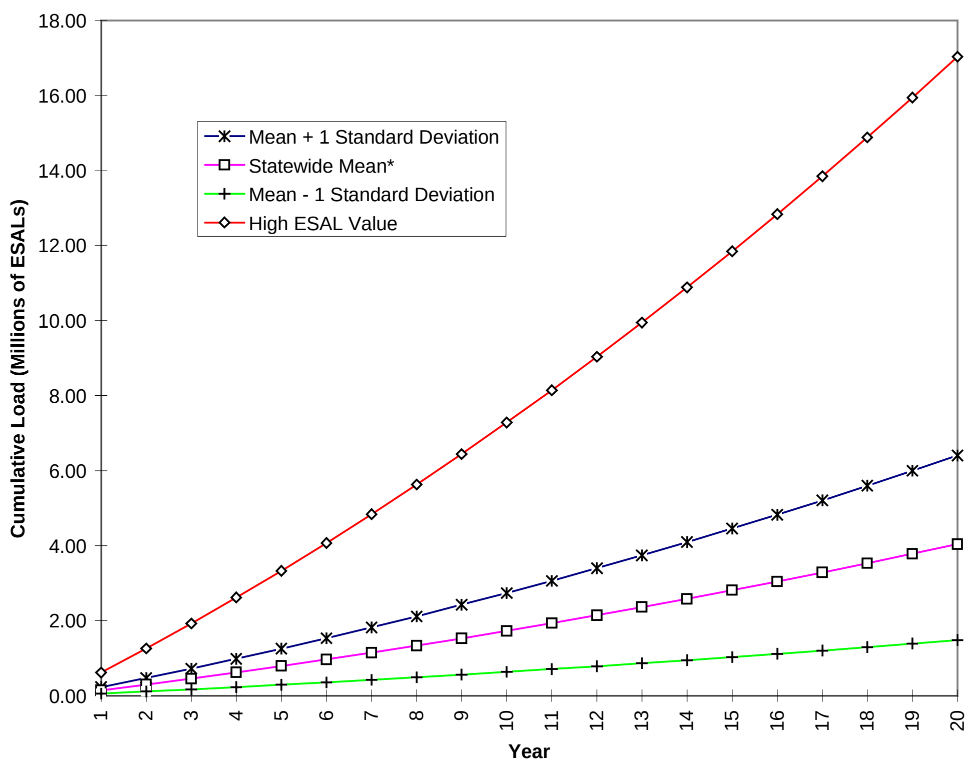

FIGURE 2. Effect of load and vehicle percentage on design ESALs.

* Mean value for the percentage by vehicle type for rural primary arteries from Washington State.

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