TECHBRIEF

Accuracy of LTPP Traffic Loading Estimates

PUBLICATION NO. FHWA-RD-98-124
FHWA Contact: Monte Symons, HNR-30, (703) 285-2730

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

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway
Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Introduction

The accuracy and reliability of traffic load estimates are key to determining a pavement's life expectancy. To better understand the variability of traffic loading rates and its effect on the accuracy of the Long Term Pavement Performance (LTPP) program's loading estimates, LTPP recently completed an analysis studying the effect of varying truck load rates and data-collection plans on Equivalent Single-Axle Load (ESAL) estimates at sample sites in the LTPP data base. Results of the analysis are documented in a report entitled, *Results of the Empirical Analysis of Alternative Data Collection Sampling Plans for Estimating Annual Vehicle Loads at LTPP Test Sites*. The purpose of this TechBrief is to present key findings and products that resulted from the report.

Key Products

Results from LTPP's analysis provided the basis for:

- LTPP's revised traffic-monitoring program.[1]
- Preliminary estimates of the accuracy and reliability of traffic loads used for LTPP research.

Key Findings

The LTPP analysis shows how various data-collection sampling plans for vehicle classification and weigh-in-motion (WIM) data affect the accuracy of annual loading statistics. It presents estimates of the sampling error created when short-duration vehicle classification and weigh-in-motion counts are used to estimate annual pavement loadings. Table 1

[1] LTPP's revised traffic monitoring program is presented in the "Revised Traffic Monitoring Protocol for LTPP Test Sites," Traffic Data Processing Directive 10 (TDR-10), April 1998. It is available from Monte Symons, Pavement Performance Division, (703) 285-2730, E-mail: monte.symons@fhwa.dot.gov.

summarizes the expected errors in the annual loading estimates for some of the most common data-collection schemes.

The study found (as expected) that traffic loading patterns differ dramatically across the Nation. Differences in loading patterns result from differences in truck volumes, including both the total number of trucks and the mix of trucks, as well as the weights carried by each class of truck. Some commonalities did exist at the test sites, and those commonalities can serve as the basis for improved traffic monitoring.

Variation of Truck Volumes and Loads

The most common finding was that weekend truck volumes tend to be much lower than weekday truck volumes. (See Figure 1.) This leads to a significant reduction in the pavement-loading rate on the weekend; in fact, weekend loadings in many locations are only 20 percent of the average weekday load. This means that loading estimates that do not account for differences in weekend truck volumes will over-estimate actual loading.

Weights per truck (by class) do not appear to be similarly differentiated by weekday/weekend at the majority of locations. (See Figure 2.) Therefore, it is not necessary at the majority of sites to weigh vehicles during weekends to accurately estimate annual loads. However, at sites where significant weekday/weekend differences in the average weight per vehicle by

Table 1. Summary of Expected Errors for Selected Sampling Plans.[2]

Sampling Plan		Expected Bias[3] to the Annual Estimate (percent)	Expected Error[4] (percent)	95-Percent Confidence Interval[5] (percent)
Classification	WIM			
1 weekday	1 weekday	+20	45	200
1 week	1 week	0	30	50
Continuous	1 weekday	0	30	50
Continuous	1 week	0	25	40
Continuous	1 weekday during each of 4 seasons	0	12	30
Continuous	1 week during each of 4 seasons	0	8	20

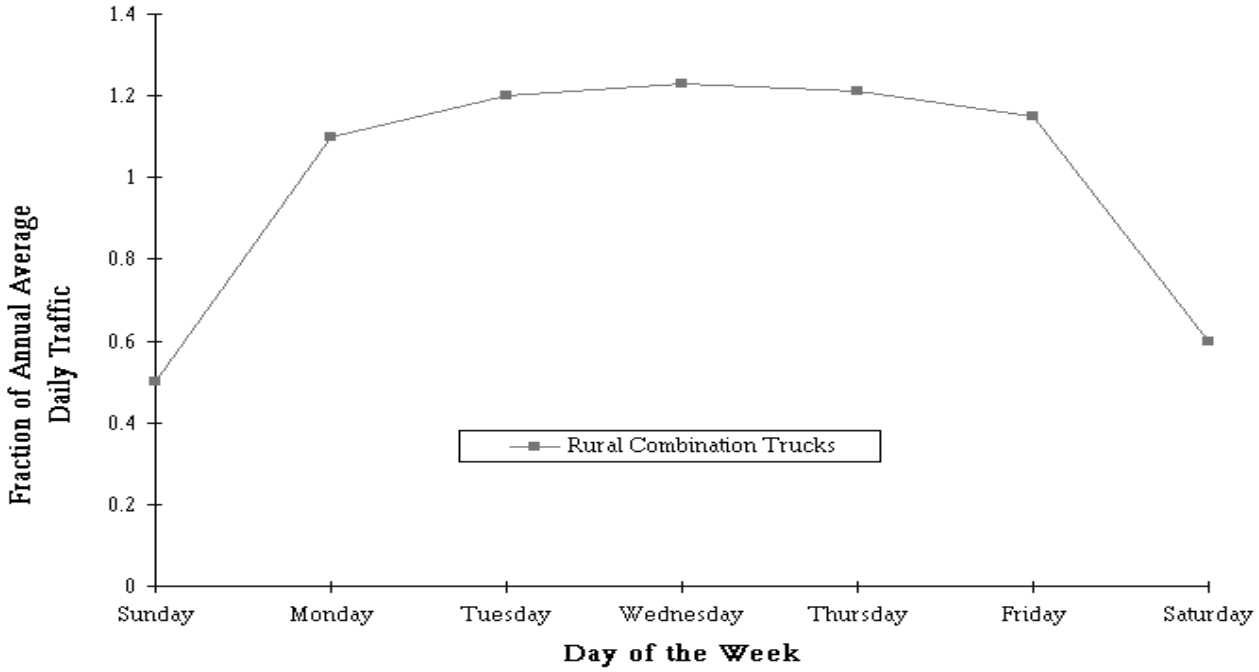
[2]All values expressed as a percentage of annual load. A positive value indicates an over-estimation of the actual loading conditions.

[3]The systematic error expected in the annual estimate produced from the data-collection sample that is caused by biases inherent in the sample being taken.

[4]This value is based on the mean absolute error computed from the samples taken during the empirical tests. This estimate removes the canceling effect that occurs when over- and under-estimation errors balance when a mean value is computed. For example, just because there is no bias in an estimate based on 1-week classification and WIM samples does not mean that such a sample should be expected to provide an estimate with no error. The "expected" error for that estimate will be approximately 30 percent. The user is just not sure whether that error is likely to be above or below the true value.

[5]A total of 95 percent of all estimates are expected to fall within (plus or minus) this percentage of the actual annual traffic loading estimate. Note that the expected error bounds are slightly wider than a normal distribution, and these figures reflect that slightly wider error spread.

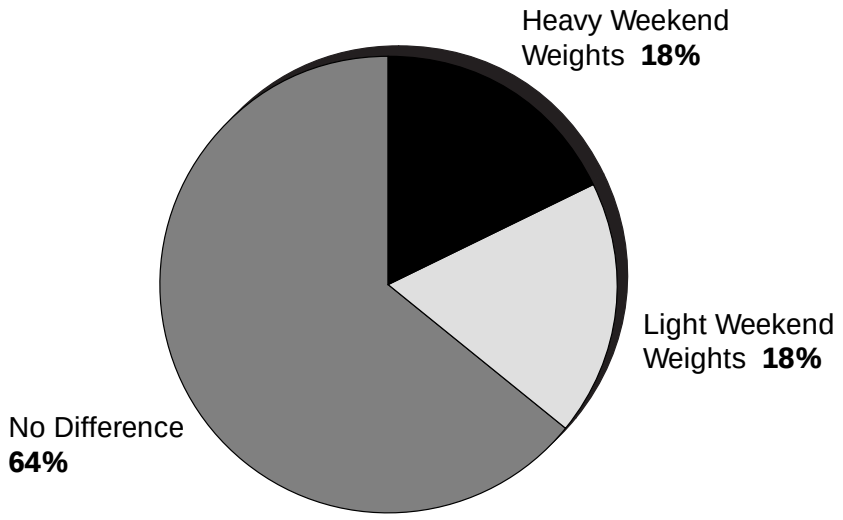
Figure 1. A common day-of-the-week volume pattern for combination trucks on rural roads.



classification exist, these differences must be measured directly to accurately estimate annual conditions. At roughly half of these sites, the weights per truck are heavier on the weekends, whereas at the other half, weekend weights are lighter.

Seasonal changes in loading patterns are not as consistent from site to site as the weekday/weekend patterns mentioned above, although some consistent regional patterns do exist. Many sites experience relatively little change in trucking activity over the year. Other sites show extremely large changes in truck volumes, truck mix, or truck weights by class (or some combination of these) during parts of the year. These changes occur because of seasonal changes in the level of commercial activity. For example, as an agricultural crop ripens, the trucks needed to transport that crop appear on the road, and the weights for that class of vehicle increase. Similarly, truck volumes on through routes can change according to the business cycles that affect the commodities carried on those roads and as a result of various changes in the Nation's (or region's) economic activity.

Figure 2. Weekday/weekend differences in weights per truck by class.



Sampling Design Issues

Unfortunately, from a national sample design standpoint, the timing of these changes varies throughout the year at different locations, and many of the seasonal changes last for only a few weeks. This makes it difficult to design a single national data-collection sampling scheme that accounts for all conditions. For example, a data-collection sampling scheme that accounts for the October harvest in one location will miss the decrease in vehicle weights that occurs because of spring load restrictions at another site.

Consequently, the major conclusion of this study was that highly accurate estimates of annual load can only be achieved by continuous monitoring of traffic conditions at specific LTPP test sites. This level of accuracy is needed to develop new pavement design procedures and other similar analyses. At the same time, smaller data-collection samples can be used to provide annual load estimates that are acceptable for many of the less critical LTPP analyses. These more limited levels of data collection are appropriate for locations that experience only modest seasonal changes in truck weights. Increased data collection is needed at sites that experience significant seasonal changes. However, the timing and length of those additional counts need to be based on the traffic variations specific to each site.

Finally, it is important to note that accurate traffic estimates can only be collected with calibrated data-collection equipment.[6] Errors caused by poorly calibrated WIM and classification equipment can be far larger than the sampling errors discussed in this paper.

---

[6]For additional information, see the LTPP TechBrief, *WIM Scale Calibration: A Vital Activity for LTPP Sites*, Publication No. FHWA-RD-98-104.

Researcher: This study was performed by Mark Hallenbeck, Washington State Transportation Center, University of Washington, Box 354802, University District Building, 1107 NE 45th Street, Suite 535, Seattle, Washington 98105-4631, (206) 543-6261; and Cindy Cornell-Martinez, Chaparral Systems, 649 Harkle Road, Suite E, Santa Fe, New Mexico 87505, (505) 984-6250. Contract No. DTFH61-93-C-00078.

Distribution: This TechBrief is being distributed according to a standard distribution. Direct distribution is being made to the Regions and Divisions.

Availability: The study on which this TechBrief is based, Results of the Empirical Analysis of Alternative Data Collection Sampling Plans for Estimating Annual Vehicle Loads at LTPP Test Sites, is available from Chaparral Systems Corporation's home page at http://www.chapsys.com/ltpp_web/ltpp7.htm.

Key Words: Vehicle classification, WIM, weigh-in-motion, LTPP, ESALs.