



Highway Traffic Characterization for Design of Pavement Structures

The recently developed guide for the “Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures” (commonly referred to as the M-E Design Guide) proposes applying mechanistic principles to replace the traditional empirical design approach suggested in the AASHTO 1993 “Guide for the Design of Pavement Structures.” One of the most significant improvements offered in the M-E Design Guide is the methodology to account for highway traffic volumes and loads. This enhancement proposes replacing the number of equivalent single axle loads (ESALs) by using actual axle load distributions per axle type per vehicle class. These distributions are often referred to as axle load spectra.

The main goal of this research was to assess and address the implications of the axle load spectra methodology proposed by the M-E Design Guide. In addition, recommendations were developed regarding traffic data needs and availability. A methodology was also developed for specifying accuracy of WIM equipment based on the effect that this accuracy has on pavement performance prediction. Through rigorous statistical analyses, it was determined that the use of continuous distribution functions offers numerous advantages in comparison with the proposed discrete axle load spectra. Associated with these statistical analyses, the use of moment statistics was evaluated and was found to be the

best summary statistics to characterize axle load spectra from the view point of load-associated pavement damage. Regarding traffic volume variability forecasting, a methodology was developed that allows optimum use of available data by simultaneously estimating traffic growth and seasonal traffic variability.

What We Did ...

The research study evaluated the current version of the M-E Design Guide and determined the traffic data needs. Traffic data provided by the Texas Department of Transportation’s (TxDOT) Transportation Planning and Programming Division (TPP) was processed and used to conduct a pavement evaluation and sensitivity analysis. The findings of the sensitivity analysis were used to

quantify the effect of various traffic variables on pavement design and performance. A gap analysis between needs and available data in Texas was performed. Based on this analysis, recommendations for temporal and spatial distribution of weigh-in-motion (WIM) stations were developed.

In addition to running the mechanistic pavement analysis, the research team conducted rigorous statistical analyses of the traffic data sources available in Texas. These sources included data from TxDOT’s network of permanent WIM stations and traffic volume data contained in TPP’s TLOG database.

Through the analysis of WIM data, axle load distributions were developed for Texas that are consistent with levels 1, 2, and 3 for the M-E Design Guide (Figure 1). The

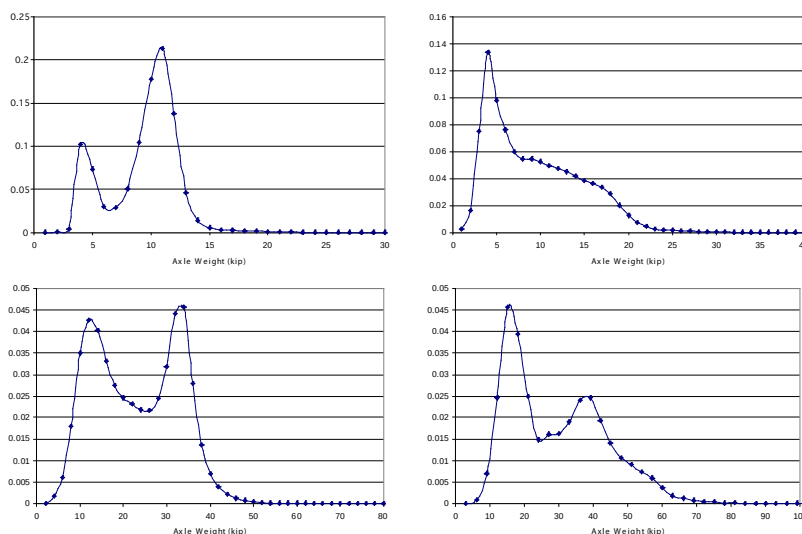


Figure 1: Axle load distribution for steering, single, tandem, and tridem axles



effects of WIM equipment systematic and random errors on pavement performance predictions were evaluated, and guidelines for equipment selection were developed (Figure 2). Finally, recommendations on data collection survey duration and intervals were provided based on the ability of short samples to capture the population characteristics.

Regarding traffic volume characteristics, analyses of traffic growth rate and growth factor were carried out, and tables for the selection of rate and factor were prepared that allow pavement designers to select these values based on the desired design reliability in terms of sample percentiles. In addition, a methodology was developed that combines traffic volume data for the prediction of short- (seasonal variability) and long-term (growth) traffic volume changes (Figure 3). This methodology makes optimal use of available data and is based on sound statistical principles.

What We Found ...

The basic principles behind the M-E Design Guide are sound and should be embraced. The M-E Design Guide is, to date, the single most comprehensive

pavement analysis tool ever developed. However, findings based on pavement performance predictions obtained with the current version of the guide should not steer research studies in Texas toward mechanistic-empirical design or traffic data collection and processing. Pragmatism, sound engineering judgment, and local experience should be used instead, until such time as the M-E Design Guide is locally calibrated and the Department gains enough confidence in the proposed models.

Significant gaps were identified between the data needs of the M-E Design Guide and data currently available in Texas. The most significant gap relates to the number of permanent WIM stations available and their distribution according to geographical and environmental regions and facility type. Most stations are located on the rural interstate (IH) and national (US) highway network.

The implementation of the axle load spectra approach, instead of number of ESALs, is one of the most significant improvements of the proposed M-E Design Guide. However, the need for more than 10,000 parameters to characterize traffic loadings seems excessive and is

unbalanced with other important data elements such as the distribution of traffic speed and tire inflation pressures.

The current practice for collecting and reporting WIM data on a 2-day-per-quarter basis is sound and has the potential to accurately characterize traffic loading patterns in both the short and long terms. It is believed that significant benefits could be obtained if WIM data were collected at 12-week intervals, which, over the long run, would allow the capture of the seasonal, monthly, and weekly variations.

The Researchers Recommend...

Traffic Loading

Traffic loading for the structural design of pavements is well captured by the axle load spectrum of each axle type of each vehicle class. It is, however, recommended that traffic loading data be pre-processed and only four axle load spectra—steering axles, single axles with dual wheels, tandem and tridem axles—be used for pavement design.

To increase the availability of WIM data, it is recommended that TPP’s

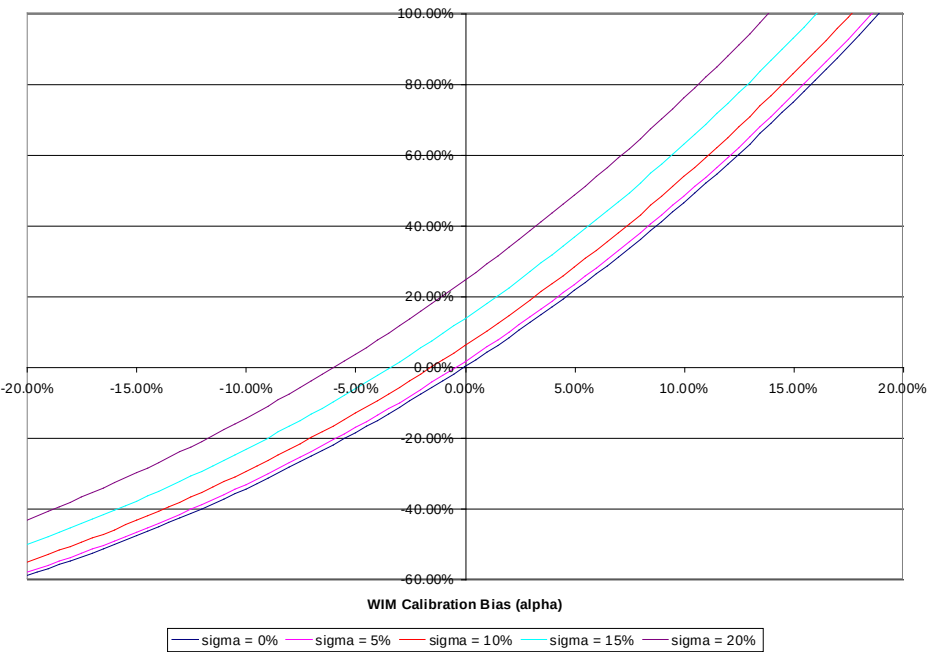


Figure 2: Effects of WIM accuracy on pavement performance predictions



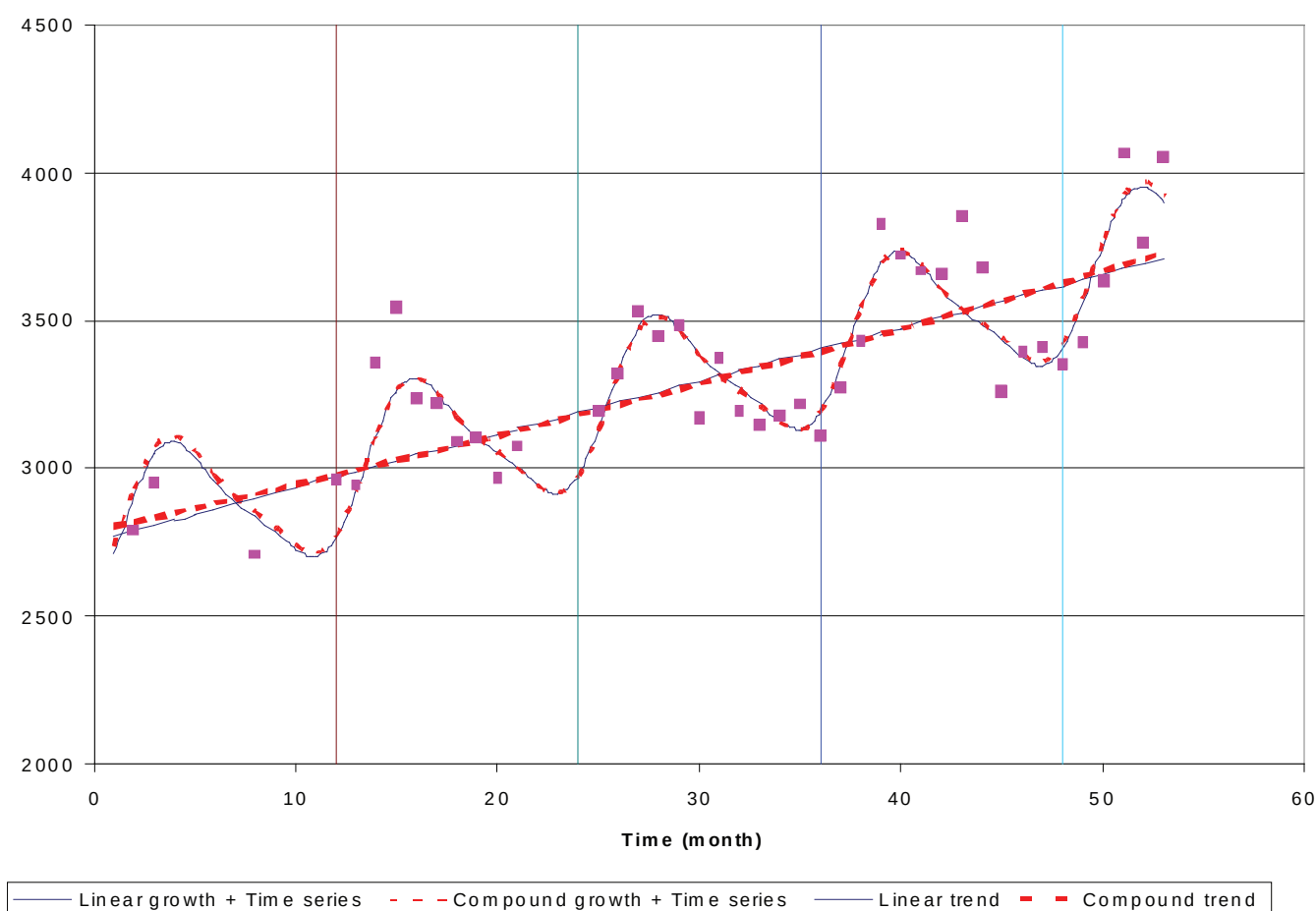


Figure 3: Prediction of traffic seasonality and growth using time series

strategic plan for WIM deployment be implemented in the short-term. In addition, the Department should consider a complementary system of temporary WIM stations that could operate around Texas in regions, environments, and facilities currently under-represented by the network of permanent stations.

Traffic Volume Forecasting

Traffic volume seasonality (short-term variability) and growth (long-term change) can best be predicted by models that jointly capture both aspects simultaneously. Time series analysis combined with linear and compound growth models should be used to this end. A systematic plan for collecting traffic counts and classifications should be developed and implemented to better capture seasonality.

Other Important Traffic Characteristics

Some areas that are not adequately addressed by the current version of the M-E Design Guide and deserve further consideration are: 1) the differentiation between single axles with single wheels and single axles with dual wheels; 2) the distribution of tire inflation pressures; and 3) the distribution of vehicle speed. A sample plan to collect these data should be developed and implemented in the short-term for supporting the M-E Design Guide.

Traffic Summary Statistics

The need for summary statistics, such as ESALs, to capture traffic characteristics will remain for years to come. Accordingly, it is recommended that the first five standardized moments of

the axle load distributions be used. It is important to note that, except for a scale factor that is equal to the standard load, ESAL represents the fourth moment of the axle load distribution. A set of statistics should be developed to characterize the entire Texas highway network. This set will supplement the information provided by the number of ESALs.



For More Details...

Research Supervisor: Jorge A. Prozzi, Assistant Professor, (512) 232-3488
email: prozzi@mail.utexas.edu

TxDOT Project Director: Joseph Leidy, Construction Division, (512) 506-5848
email: JLEIDY@dot.state.tx.us

TxDOT Research Engineer: German Claros, Ph.D., P.E., Research and Technology Implementation Office,
(512) 465-7403
email: gclaros@dot.stat.tx.us

The research is documented in the following reports:

0-4510-1: *Evaluation of Equipment, Methods, and Pavement Design Implications of the AASHTO 2002 Axle Load Spectra Traffic Methodology*

0-4510-2: *Evaluation of Equipment, Methods, and Pavement Design Implications for Texas Conditions of the AASHTO 2002 Axle Load Spectra Traffic Methodology: Literature Review and Level 1 Data*

0-4510-4: *Traffic Characterization for a Mechanistic-Empirical Pavement Design*

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Randy Machemehl, P.E. (Texas No. 41921).



The University of Texas at Austin
Center for Transportation Research Library
3208 Red River #115
Austin, TX 78705-2650