TECH**BRIEF**

Exploring the Importance of Traffic Data Input Levels for Mechanistic-Empirical Pavement Design

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INTRODUCTION

This TechBrief summarizes an exploratory analysis of the AASHTOWare Pavement ME Design™ (PMED) software's pavement-performance predictions.(1) The research team analyzed the sensitivity of PMED outputs to traffic input levels based on data from a sample of Long-Term Pavement Performance (LTPP) program sites. In this TechBrief, MEPDG refers to the method for analyzing and designing pavement structures described in the AASHTO's *Mechanistic–Empirical Pavement Design Guide, A Manual of Practice* (MEPDG), while PMED refers specifically to the AASHTOWare Pavement ME Design™ software product that uses the MEPDG method.(1,2)

The PMED software predicts pavement distresses over time by taking into account the interaction of traffic, climate, materials, and pavement structure. It uses the MEPDG method, which utilizes a hierarchical approach for developing most inputs, including traffic. The hierarchy of traffic inputs includes site- or segment-specific measured data (level 1), knowledge-based or regionally derived estimates (level 2), and statewide or national default values (level 3).(2,3)

The hierarchical input approach allows agencies to start using the PMED software with limited site-specific data and/or without the high cost of collecting certain types of data, including traffic loading data. Also, in the case of new pavement alignments, when site-specific traffic data are not known, the PMED software allows users to estimate certain input parameters (e.g., axle loads, truck volumes by class).

To better understand the sensitivity of the MEPDG pavement-performance prediction models included in PMED software to traffic input levels, the Federal Highway Administration (FHWA) sponsored an exploratory research study. This TechBrief describes the study and summarizes the key findings from a comprehensive literature review of existing research and States' practices for developing MEPDG traffic inputs. It also presents results and conclusions from a proof-of-concept analysis that compared PMED outputs based on different traffic input levels with data from LTPP sites.

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OBJECTIVES

The objectives of the exploratory study were as follows:

1. Review current and emerging MEPDG traffic data needs and summarize the traffic inputs for PMED software.
2. Summarize the current knowledge about how traffic inputs, including the quality and quantity of data, affect MEPDG pavement performance parameters.
3. Identify knowledge gaps related to traffic data use in MEPDG analyses, determine research needs, and develop a data analysis plan to address the identified needs.
4. Assess the availability of LTPP data necessary to support the data analysis plan.
5. Conduct a preliminary proof-of-concept analysis using LTPP data and the PMED software to assess the sensitivity of PMED outputs to selected traffic inputs.
6. Present findings and recommendations for further analyses in a report.

KEY FINDINGS FROM THE LITERATURE REVIEW

The research team reviewed more than 30 research studies related to the research objectives and summarized findings in the phase 1 report. The literature review indicated that, over the years, several highway agencies have investigated the sensitivity of the MEPDG pavement performance parameters to traffic inputs and traffic input levels. Most of the studies were conducted by State highway agencies and focused on the agencies' traffic data needs for MEPDG implementation. See the appendix for a complete list of MEPDG traffic input parameters.

MEPDG Pavement Performance Parameters Impacted by Traffic Inputs

The literature review revealed that the rigid and flexible pavement distresses that are traditionally known as load-related distresses typically had the highest sensitivity to axle loads and to the number of heavy axle-load applications. For asphalt concrete (AC) pavements, the distresses most affected by traffic inputs are fatigue cracking and rutting. For jointed plain concrete pavements (JPCP), the most affected distress is slab cracking. The International Roughness Index (IRI) was also sensitive to traffic and traffic input levels in some studies. The IRI is predicted for flexible and rigid pavements using regression equations based on load- and non-load-related distresses.

The review also showed that input parameters other than traffic may cause these distresses, such as foundation instability due to exposure to water, insufficient layer thickness and/or mixture strength, or from construction defects. These additional contributing factors may explain some variability in the conclusions observed in the reviewed studies.

Traffic and Other Input Parameters with the Highest Effect on MEPDG Pavement Performance Prediction

Load-related pavement distresses typically develop over time because of repeated heavy axle- load applications and the number of overloaded trucks. The literature review showed that MEPDG distresses are most sensitive to traffic inputs that describe the number and magnitude of axle loads, including average annual daily truck traffic (AADTT) values, vehicle class distribution (VCD), and axle-load distribution factors (ALDF). The number and the percentage of heavy and overloaded trucks was found to be very important. Truck volume growth is another important parameter affecting the number of axle-load applications applied over time. The literature review also showed that non-traffic MEPDG inputs, including pavement thickness, the material properties of the asphalt and concrete layers, and subgrade or foundation support are important PMED input parameters.

Effects of Traffic Data Quality and Quantity on MEPDG Outputs

The results of the literature review showed that both the quantity and quality of traffic data affect the computed MEPDG traffic input parameters and pavement-performance predictions. Multiple researchers have investigated weigh-in-motion (WIM) data quality issues, including the effect of biased or imprecise WIM data on MEPDG axle-loading inputs and MEPDG outcomes.

The literature shows that WIM measurement precision is affected primarily by the sensor type and site conditions. WIM measurement bias is affected by the sensor type, changes in site and environmental conditions, and frequency of equipment calibration. WIM measurement bias can be mitigated using appropriate and timely WIM calibration strategies. The ASTM E1318-09 WIM performance requirements for Type I WIM systems are typically used as a benchmark for setting WIM data precision goals and selecting WIM sensors for collecting traffic loading data for MEPDG applications.(4)

The previous research investigations found that measurement bias may lead to significant differences in MEPDG outcomes.[5,6] Accordingly, WIM systems that exhibit a bias of more than 5 percent should be calibrated, and data sets from the WIM systems with weight measurement bias of more than 10 percent should be avoided for MEPDG applications.[5] The previous research studies also found that MEPDG outcomes showed some sensitivity to the precision of WIM measurements, but additional investigation is needed to understand its effect for different types of axle-load spectra, especially for roads with high percentages of fully loaded or overloaded trucks.[6]

Several researchers have investigated the effects of traffic data quantity on MEPDG outputs to identify minimum traffic data sampling requirements and to develop the recommended minimum traffic data availability requirements.[7] The results of those previous investigations indicate that the effect of traffic data quantity on pavement design or analysis using the MEPDG method depends on the nature of truck traffic for a roadway. Thus, it is hard to define a minimum traffic data sampling period that would be optimum for all road types. Rather, the length of this period is a function of traffic volume and axle-loading variability at the site and the selected level of confidence. For roads with highly predictable and stable, day-of-the-week (DOW) and month-of-the-year (MOY) truck volume patterns, shorter data collection periods are acceptable. However, for roads with highly variable truck volume trends, longer data collection periods are necessary to accurately capture DOW and MOY changes. Therefore, it is difficult to identify one set of traffic data availability guidelines that fits all road types. Instead, the guidelines should be a function of the expected truck volume variability over time (higher traffic variability and higher reliability of traffic estimate requires longer data collection periods). Future planned land development may also have a significant effect on truck volume trends, especially for local roads, and must be considered in both traffic data collection plans and pavement designs.

The review of the available MEPDG sensitivity studies shows that use of unfactored traffic data from short-duration traffic counts should be avoided, as it may lead to large differences in the predicted distresses.[7] However, no research was found that investigated the effect of factored or annualized short-duration counts for deriving traffic inputs or on MEPDG outcomes.

States' Practices for Developing MEPDG Traffic Inputs

The research team also reviewed more than 20 State highway agencies' practices for preparing MEPDG traffic inputs. The agencies routinely collect truck volume by class counts using permanently installed Automatic Vehicle Classification (AVC) counters or portable, short-duration AVC counters. Thus, collecting truck volume data by class is not unique to MEPDG. However, most agencies have limited capabilities for collecting traffic loading data. Therefore, most agencies rely on level 2 or 3 inputs to determine MEPDG ALDF. The research team reviewed States' practices and identified several methodologies for estimating axle loading, including the following:

1. Use of default ALDF developed based on statewide load data (target MEPDG input level 3).
2. Use of multiple default ALDFs (defined by vehicle class or, most frequently, using all vehicle classes combined) assigned to different roadway groups (target MEPDG input level 2).
3. Use of default or site-specific ALDF selected based on loading pattern identified by site-specific portable WIM data (target MEPDG input level 2).
4. Use of site-specific ALDF from one or more nearby WIM sites located on roads with similar trucks carrying similar loads. The computed traffic parameters from multiple traffic monitoring sites are averaged to create a virtual traffic monitoring site (target MEPDG input level 1 or 2, depending on site location).
5. Use of an expanded WIM program to capture commodity flow of goods within and through the State, including all major roads to be designed based on the MEPDG method, and develop corridor-specific ALDFs (target MEPDG input level 1).

KEY FINDINGS FROM THE PROOF-OF-CONCEPT ANALYSES

The LTPP database is considered a valuable data source for proof-of-concept MEPDG studies. For the current proof-of-concept study, the LTPP sites with detailed, high-quality traffic data were used to compare PMED outputs based on best-case traffic inputs with PMED outputs based on the traffic defaults provided in the PMED software (also developed using LTPP traffic data). High-quality traffic data were represented by the continuously monitored (at least 210 days of data per year) truck volume and axle weight data from the LTPP WIM sites. These WIM sites were subjected to LTPP WIM calibration and data validation protocols detailed in the *LTPP Field Operations Guide for SPS WIM Sites*.(4) All of these WIM sites passed the LTPP Traffic Analysis Software (LTAS) data quality control checks and additional axle-loading data reasonableness checks detailed in the report *MEPDG Traffic Loading Defaults Derived from Traffic Pooled Fund Study*.(5) For all other input parameters, the best available data recorded in the LTPP database were used.

Effect of Traffic Input Level on Standard Deviation of Residual Errors for Selected MEPDG Pavement Prediction Models

In this analysis, MEPDG input levels 1 and 3 were used to evaluate their impact on the standard error of the residuals and the predicted pavement service life for a sample of LTPP test sections. The research team tested whether LTPP sections could be successfully used as a data source to investigate the effect of traffic input level on PMED-predicted distresses and pavement service life using a sample of 24 LTPP test sections from Specific Pavement Studies (SPS) experiments (SPS-1, SPS-2, and SPS-9) located in different States and climatic zones.

MEPDG traffic inputs at level 1 (continuous WIM data) and level 3 (PMED defaults, including defaults representing different ALDF and VCD or Truck Traffic Classification (TTC)) were used to predict pavement distresses and IRI. The predicted distresses were compared with the measured distresses for each section. The residual errors or variance between measured and predicted values were computed and compared for the rigid and flexible pavement-performance indicators. The traffic input parameters for different input levels included VCD, axle-load distribution, axles per truck, truck traffic growth, monthly truck volume adjustment factors, and hourly truck volume adjustment factors.

An *F*-test was conducted to evaluate the statistical significance between the variance of the residual errors for each predicted rigid and flexible pavement distress using traffic input levels 1 and 3. Table 1 shows that no statistical significance between the variance of the residual errors was observed for the rigid pavement distress predicted using traffic input levels 1 and 3, except for mid-slab cracking for two sites (Washington and Colorado). Table 2 shows that no statistical significance between the variance of the residual errors was observed for the flexible pavement distress predicted using traffic input level 1 and 3.

Table 1. Statistical significance between the variance of the residual errors for each predicted rigid pavement distress using traffic input levels 1 and 3.

Distress	State	*F*-Value	*F*-Critical for α = 0.10	Significantly Different?
Mid-slab cracking	Arizona	1.178	1.56	No
Mid-slab cracking	Colorado	1.837	1.51	Yes
Mid-slab cracking	Kansas	1.160	1.56	No
Mid-slab cracking	Washington	1.884	1.68	Yes
Mid-slab cracking	Combined	1.204	1.26	No
Faulting	Arizona	1.019	1.56	No
Faulting	Colorado	1.323	1.51	No
Faulting	Kansas	1.020	1.61	No
Faulting	Washington	1.107	1.68	No
Faulting	Combined	1.034	1.26	No
IRI	Arizona	1.033	1.46	No
IRI	Colorado	1.032	1.40	No
IRI	Kansas	1.188	1.40	No
IRI	Washington	1.118	1.68	No
IRI	Combined	1.045	1.26	No

α = significance level.

Table 2. Statistical significance between the variance of the residual errors for each predicted flexible pavement distress using traffic input levels 1 and 3.

Distress	State	*F*-Value	*F*-Critical for $\alpha = 0.10$	Significantly Different?
Bottom–up cracking	Arizona	1.095	1.51	No
Bottom–up cracking	Florida	1.112	1.61	No
Bottom–up cracking	Nevada	1.139	1.70	No
Bottom–up cracking	Ohio	1.078	1.61	No
Bottom–up cracking	Combined	1.085	1.26	No
Total rut depth	Arizona	1.001	1.48	No
Total rut depth	Florida	1.040	1.56	No
Total rut depth	Nevada	1.008	1.51	No
Total rut depth	Ohio	1.092	1.51	No
Total rut depth	Combined	1.019	1.26	No
IRI	Arizona	1.095	1.46	No
IRI	Florida	1.043	1.51	No
IRI	Nevada	1.021	1.61	No
IRI	Ohio	1.043	1.40	No
IRI	Combined	1.141	1.26	No

α = significance level.

Results from the proof-of-concept study imply that the input level 3 VCD (i.e., the MEPDG TTC group defaults developed based on LTPP data) and MEPDG ALDF defaults (based on the research-quality LTPP WIM data), when selected using the guidance provided in the MEPDG for selecting the default or input level 3 values, provide a close simulation of input level 1, which is considered a significant finding.(2) However, the WIM data for some of the rigid and flexible pavement sites used in the proof-of-concept study were also used to develop the input level 3 ALDF defaults.

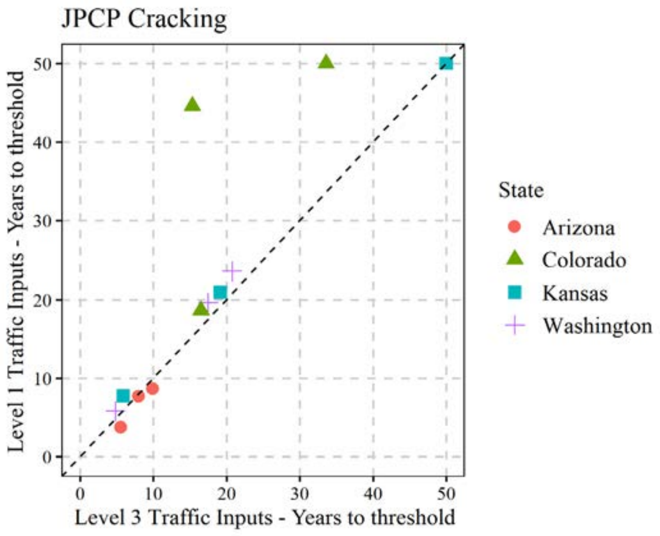
Given the findings from the proof-of-concept analysis, it is likely that more extensive LTPP data analysis will not result in a significant reduction in the standard error (or standard deviation of the residuals) for the rigid and flexible pavement-performance indicators or distresses resulting from using truck traffic input level 1 as compared to using truck traffic input level 3. This result from the proof-of-concept analysis does not mean that truck traffic has an insignificant impact on pavement distresses. Bottom–up fatigue cracking of asphalt pavements and mid-slab cracking of rigid pavements are dependent on traffic. Traffic, however, is not the single most important parameter; material properties, layer thickness, and construction quality are also very important.

Effect of Traffic Input Level on Pavement Distresses and Service Life Predicted by PMED Software

The research team's preliminary analysis of pavement performance (i.e., pavement distress and service life prediction comparison of level 1 and level 3 traffic inputs) showed that, on average, using level 3 traffic inputs included in PMED software instead of site-specific level 1 inputs did not lead to consistent under- or overdesign for either flexible or rigid pavements. These early findings indicate that use of level 3 traffic inputs based on PMED software defaults is not likely to result in additional costs for a group of pavement design projects (i.e., for an agency-wide program of projects). However, for some individual designs, a more-than-50-percent difference in service life was observed between level 1 and level 3 traffic inputs, indicating that traffic input level will play a significant role for individual projects when level 3 traffic inputs are not representative of level 1 traffic inputs. The results were found to be section-specific. Therefore, an informed assignment of the appropriate traffic default values is very important.

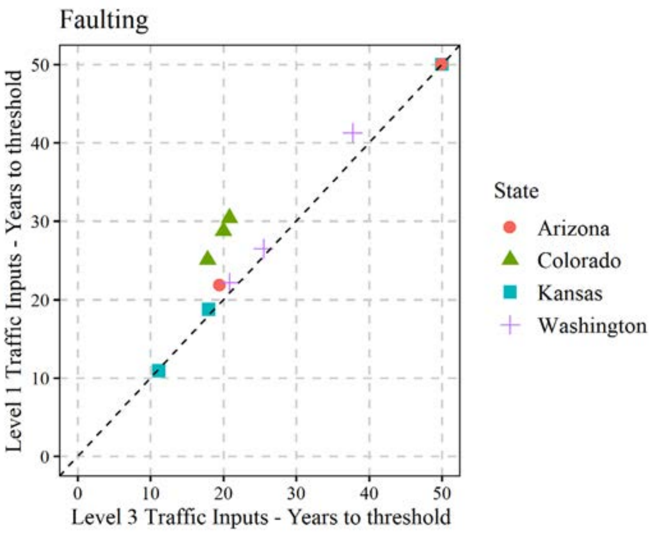
Figure 1 through figure 3 show a one-to-one comparison of PMED outcomes using input levels 1 and 3 for each rigid pavement distress. In general, a consistent difference between level 1 and level 3 traffic inputs is not observed for rigid pavements except for the Colorado sections. Figure 4 through figure 6 show a one-to-one comparison of outcomes using input levels 1 and 3 for each flexible pavement distress. With the exception of the Colorado JPCP sections, as shown in figure 1 through figure 3, no significant bias in the estimated years to the threshold values for each distress was observed for the sample of sites used in the analysis. This observation is also considered a significant finding and shows the value of using the LTPP database to support design decisions. The results also show that the MEPDG traffic defaults and default selection guidance, developed based on LTPP data, provided sufficient options for users to select the appropriate level 3 input values for the road types covered in the analysis (rural interstates and primary arterials) for the majority of the analysis sites.

Figure 1. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the JPCP cracking distress threshold limit for rigid pavements.



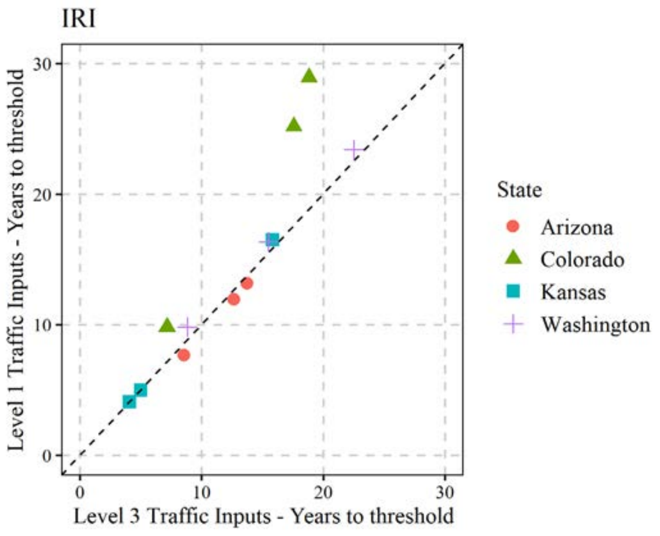
Source: FHWA.

Figure 2. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the faulting distress threshold limit for rigid pavements.



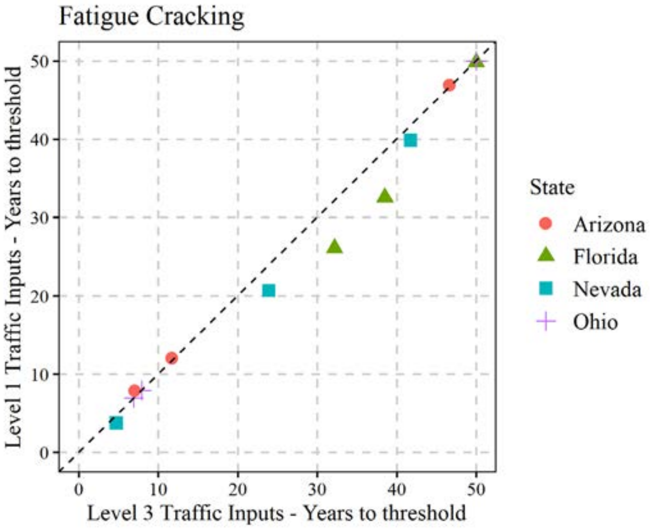
Source: FHWA.

Figure 3. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the IRI threshold limit for rigid pavements.



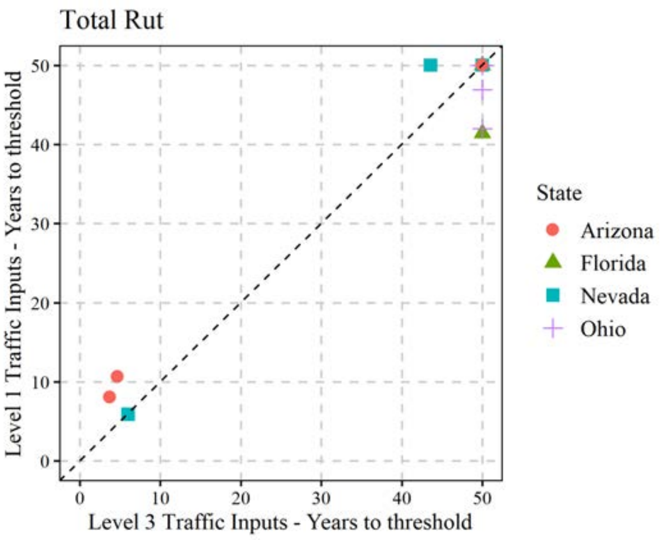
Source: FHWA.

Figure 4. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the bottom–up fatigue cracking distress threshold limit for flexible pavements.



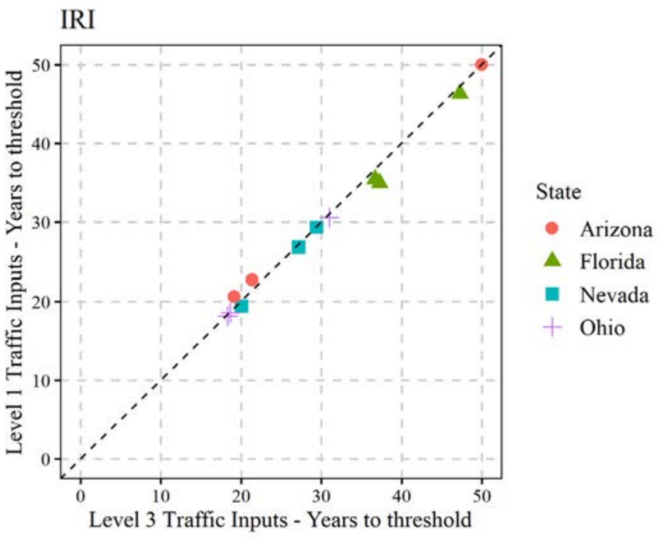
Source: FHWA.

Figure 5. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the rutting distress threshold limit for flexible pavements.



Source: FHWA.

Figure 6. Graph. Comparison of level 1 and 3 traffic inputs for years to reach the IRI threshold limit for flexible pavements.



Source: FHWA.

The results of the analysis of differences in service life for the flexible and rigid pavement sections are summarized in table 3 and table 4. As shown, the observed differences in service life predictions are generally of a similar magnitude for flexible and rigid pavements for each summary statistic. Overall, the preliminary analysis outcomes were characterized by high variability and wide confidence intervals (CIs). Further study needs additional test sections and data from different functional classifications of roadways because the results are found to be roadway section specific.

Traffic input level 3 default inputs included in the PMED software and guidance for selecting traffic defaults included in the MEPDG Manual of Practice were found to provide a good simulation of the impact of truck traffic on the performance of the roadway or prediction of pavement distress for the types of roadways included in the proof-of-concept study. Therefore, for the majority

Table 3. Average difference in service life prediction with respect to level 1 inputs for tested LTPP pavement sections.

Pavement Type	Mean	Standard Deviation	Min (Level 3 Over Predict)	Max (Level 3 Under Predict)	Number of Sections	95% CI Lower Limit	95% CI Upper Limit
Flexible	−0.5	3.3	−6.1	6.0	12.0	−2.6	1.6
Rigid	2.2	4.3	−1.8	13.6	12.0	−0.6	4.9
All combined	0.8	4.0	−6.1	13.6	24.0	−0.3	2.0

Table 4. Average percent change in service life prediction with respect to level 1 inputs for tested LTPP pavement sections.

Pavement Type	Mean	Standard Deviation	Min (Level 3 Over Predict)	Max (Level 3 Under Predict)	Number of Sections	95% CI Lower Limit	95% CI Upper Limit
Flexible	2.2	26.2	−26.7	56.3	12.0	−14.5	18.8
Rigid	6.4	24.1	−48.9	47.0	12.0	−8.9	21.7
All combined	4.3	24.4	−48.9	56.3	24.0	−2.8	11.4

of sites included in the proof-of-concept study, the level 3 PMED traffic default distributions, developed based on LTPP data, proved to be a viable alternative for level 1 PMED traffic design inputs.

WIM and Pavement Construction Cost Analysis

The research team also conducted an exploratory analysis to determine when the costs to install, calibrate, maintain, operate, and analyze the site-specific WIM data are equal to or less than the differential pavement construction costs resulting from using the ALDF defaults included in the PMED software. The analysis translated differences in surface layer thicknesses predicted by the PMED software, due to different ALDF input options, into differences between initial pavement construction cost.

The analysis relied on the following assumptions:

- A two-lane quartz piezoelectric WIM site, installed and maintained for a year, was used to compute site-specific ALDF. The LTPP WIM data show that quartz piezoelectric WIM sites consistently meet ASTM E1318-09 WIM performance requirements for Type I WIM systems. The cost of procurement, installation, initial calibration, and one year of operation of a two-lane quartz piezoelectric WIM site would be between $53,000 and $106,000 based on the cost data from the "WIM Technology, Data Acquisition, and Procurement Guide" in the *Weigh-In-Motion Pocket Guide*.(7) The cost of the default ALDF is assumed to be $0 because the axle-loading default values are available in the PMED software and an extended axle-loading default library is available in the *Long-Term Pavement Performance Pavement Loading User Guide* (LTPP PLUG).(1,8)
- A two-lane roadway with 12-ft-wide lanes was assumed. The two lanes consist of one lane in each direction or two lanes in one direction (divided or undivided). The cost of the asphalt mixture was determined on a per-mile basis that includes two lanes.
- The results of the analysis are highly influenced by the cost of asphalt. For this analysis, the unit weight of the asphalt mixture was assumed at 150 pounds per cubic foot (pcf) or 0.075 tons per cubic foot (tcf). For two lanes over 1 mi, this results in about 790 tons per inch of asphalt. The price of the in-place asphalt mixture is between $100 to $200 per ton of mixture. Using $150 per ton of asphalt mixture results in $118,500 per two-lane miles per inch of asphalt.

Figure 7 compares the cost of the WIM site installation and operation to the initial construction cost differential computed for the different surface layer thickness differentials for the two-lane, 1-mi project. Based on the assumptions previously discussed, a differential asphalt layer thickness greater than approximately 0.5 to 1 inches (range is given due to range in WIM costs) at $150 per ton of asphalt mixture is likely to result in a differential initial pavement cost for the two-lane, 1-mi project that is equal or greater than the cost to procure, install, and maintain a two-lane WIM site with quartz piezoelectric sensors.

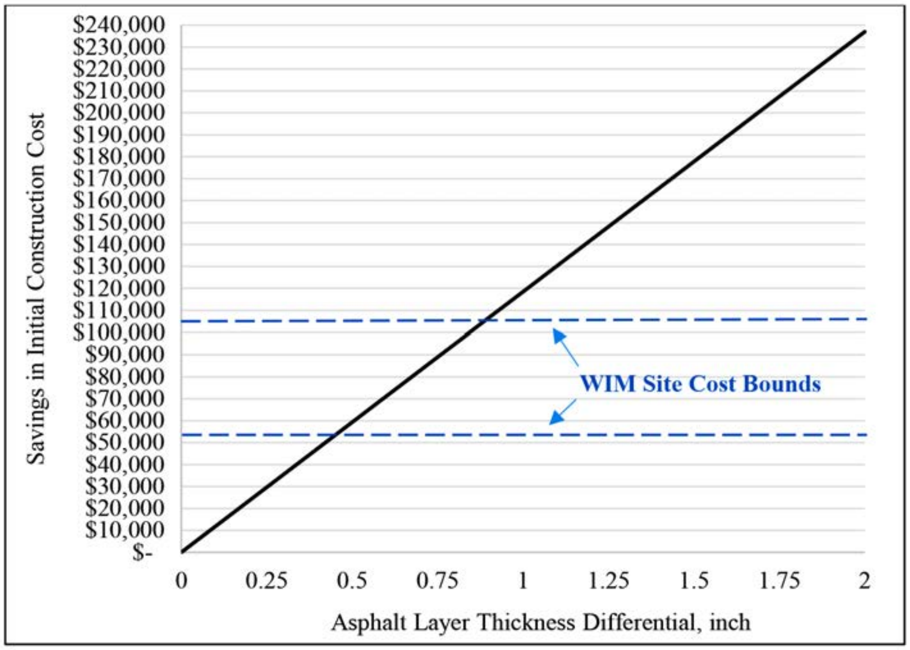
The research team used PMED ALDF defaults representing light versus heavy loading conditions to define the expected maximum difference in surface layer thickness that will result in the same predicted amount of cracking. Note that these defaults represent the loading conditions based on several years of data collected at multiple WIM sites located on arterial roads (interstate, primary, and minor) and do not represent the extreme loading conditions that may be encountered on roads primarily serving specific industries that result in atypically low or atypically high average truck weights.

The results of the analysis showed that up to 2 inches difference in the predicted surface layer thickness can be expected. The analysis of LTPP WIM data used in the proof-of-concept study showed that data from WIM sites typically fall between the extreme ALDFs included in the PMED software. Some ALDFs, as measured by a WIM, will be closer to the heavy ALDF and others will be closer to the light ALDF. Thus, on average, the difference in surface layer thickness will be about half of the total thickness difference between the two ALDFs extreme cases when the designer has little information regarding the ALDF.

In summary, the exploratory analysis comparing WIM costs to the potential savings in initial pavement construction costs gained from installing and operating a WIM site resulted in the following observations:

- Truck traffic input level 1 can result in significantly different predicted distresses for individual projects, as compared to using traffic input level 3 (figure 8 shows predicted bottom–up fatigue cracking), if the designer knows little about the ALDF for the roadway and simply selects between the extremes of the available default ALDFs. Developing and understanding the loading conditions on the Nation's highways, documenting this knowledge (including key definitions describing traffic loading conditions), and providing guidance for selecting

Figure 7. Graph. Initial pavement construction cost differences compared to the cost to install and operate a WIM site for truck traffic input level 1.

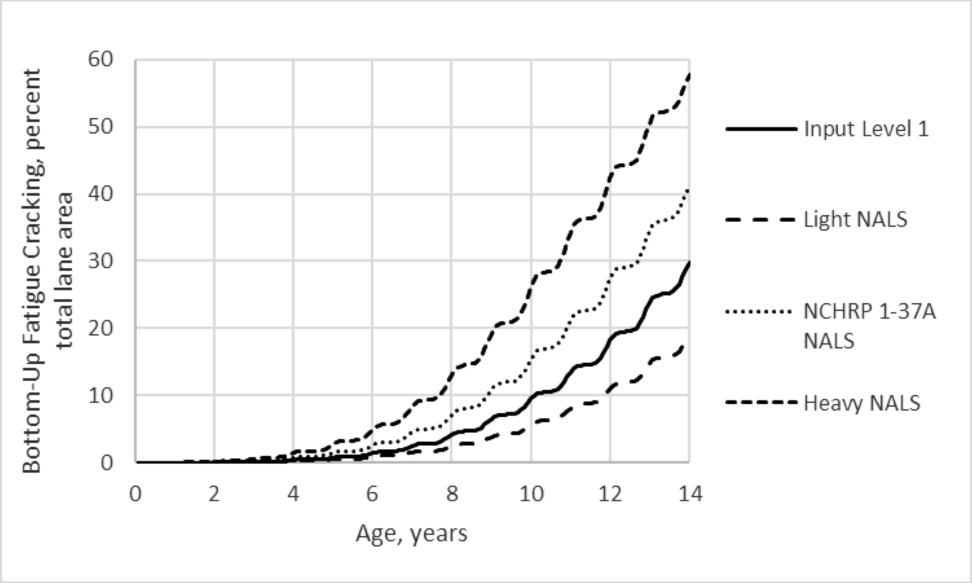


Source: FHWA.

the appropriate traffic loading defaults is critical for successful implementation of the MEPDG method and for ensuring tools such as LTPP PLUG and PMED defaults are more consistently and correctly utilized.(1,8)

- The costs to install, operate, collect data, and interpret WIM data are small compared to pavement construction costs. As such, it does not take much savings in layer thickness for both portland cement concrete (PCC) and asphalt pavements to offset the costs of the WIM. In summary, about 0.5 to 1 inches in asphalt thickness savings is enough to offset the cost of the WIM data collection necessary to develop level 1 traffic loading inputs (figure 7). These cost savings are based on two 12-ft-wide lanes that are 1-mi long.

Figure 8. Graph. Predicted bottom–up fatigue cracking for LTPP test section 04-0114 using different default ALDFs for input level 3 compared to input level 1.



Source: FHWA.
NALS = normalized axle-load spectra.

CONCLUSIONS

- The proof-of-concept analysis showed that level 3 default traffic inputs included in the PMED software and guidance for selecting traffic defaults included in the MEPDG Manual of Practice provide a good source of data for simulating the impact of truck traffic on roadway performance and pavement distresses for the types of roadways included in the proof-of-concept study (primary arterial interstate and non-interstate roads). This includes VCD (i.e., the MEPDG truck traffic classification group defaults developed based on LTPP data) and MEPDG ALDF defaults (based on the research-quality LTPP WIM data). This is considered a significant finding. Therefore, the PMED traffic default distributions, developed based on LTPP data and guidance for selecting traffic defaults included in the MEPDG Manual of Practice, proved to be a viable alternative for PMED level 1 traffic design inputs and did not lead to significantly different PMED outcomes for the majority of LTPP sites selected for proof-of-concept analyses.
- When compared with the measured LTPP pavement distress and IRI data, the standard deviations of the residual errors between the PMED software predictions were not statistically different between using traffic input levels 1 and 3. This means that while some individual projects may be under- or overdesigned, depending on how well the selected level 3 traffic defaults represent site-specific conditions, no significant cost savings are expected for the whole program of projects relative to the initial construction costs.
- The conclusions from the proof-of-concept analysis do not mean that truck traffic has an insignificant impact on pavement distresses. Bottom–up fatigue cracking of asphalt pavements and mid-slab cracking of rigid pavements are especially dependent on traffic. Truck traffic input level 1 can result in significantly different predicted distresses, as compared to using traffic input level 3 (see figure 8 for an example of predicted bottom–up fatigue cracking), if the designer knows little about the ALDF for the roadway and simply selects between the extremes of the default ALDFs. Therefore, it is important to develop a body of knowledge about traffic loading patterns observed on the Nation's highways and to develop a guidance document for selecting the appropriate MEPDG traffic loading defaults for a given roadway type.
- The costs to install, operate, collect data, and interpret WIM data results are small compared to pavement construction costs. About 0.5 to 1 inches in asphalt layer thickness savings is enough to offset the cost of the WIM data collection for a 1-mi project with two 12-ft-wide lanes. Similarly, 0.25 to 0.5 inches in asphalt thickness savings is enough to offset the cost of WIM data collection for a 2-mi project with two 12-ft-wide lanes. Therefore, if an engineering analysis shows that using default ALDF instead of site-specific ALDF is likely to result in a differential initial pavement cost that is greater than the cost to install and maintain a WIM site, it would be beneficial to install a WIM site and use site-specific level 1 ALDF.
- The predicted thickness difference, however, depends on distress type and design criterion for each distress, but not on the reliability (variance or standard deviation of the residuals) because there is no statistical difference in the standard deviations of the residual errors in the PMED software predictions between input levels 1 and 3. Guidelines should be developed to determine how the design criteria level and other factors impact the differential in surface layer thicknesses for asphalt and rigid pavements.

LIMITATIONS

The LTPP sites used to determine the MEPDG input level 3 ALDFs were some of the same sites included in the proof-of-concept study because only a limited number of LTPP General Pavement Study (i.e., GPS) and SPS sites had the high accuracy WIM data required for this study. The proof-of-concept analysis results show that the sensitivity of MEPDG performance prediction models to traffic input levels 1 and 3 is roadway section-specific.

APPENDIX: MEPDG TRAFFIC INPUT PARAMETERS

Table 5 provides a complete listing of the MEPDG traffic input parameters, including the assumption within the pavement design period.

REFERENCES

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Table 5. Truck traffic input parameters considered by the MEPDG.

MEPDG Input Parameter	Parameter Description
Two-way AADTT	Two-way AADTT is computed for the first full (base) design/analysis year. AADTT includes FHWA vehicle classes 4–13.
Number of lanes in design direction	Number of lanes is for the design direction (direction of LTPP lane). This value is used to compute design lane AADTT.
Percent of trucks in design direction	Percent of trucks in design direction (direction of LTPP lane) is for the base design/analysis year. Used to compute design lane AADTT.
Percent of trucks in design lane	Percent of trucks in design lane (LTPP lane) for the base design/analysis year. This value is used to compute design lane AADTT.
Vehicle class volume distribution (VCD)	The distribution is based on the FHWA 13-bin vehicle class scheme. One percentile distribution for vehicle classes 4–13 is provided to represent an average VCD for the base design/analysis year.
Monthly adjustment factors (MAF)	One set of 12 monthly coefficients is provided for each vehicle class (classes 4–13) to represent differences in truck volume between different calendar months for the base design/analysis year. Values are dependent on truck class, road use, and climatic regions. The sum of factors for all months for one truck class should equal 12.
Hourly distribution factors (HDF)	One set of 24-hour factors provide the representative percentage of total truck traffic for each hour. Values are the same for all truck classes and only apply to truck volume. The sum of factors for all hours should equal 100. This input parameter only applies to PCC pavements.
Axle load distribution factors (ALDF)	The ALDF parameter represents a percentile axle-load distribution for a typical day for each calendar month for a typical design/analysis year. One set of ALDF is provided for each vehicle class (classes 4–13), axle group type (single, tandem, tridem, quad), and calendar month (January–December). The ALDF parameter is dependent on season but independent of time and stay constant between the analysis years.
Number of axles per truck (APT)	One representative set of values provides the average number of single, tandem, tridem, and quad axles for each truck class (classes 4–13).
MEPDG vehicle class annual volume growth rate by vehicle class	Annual growth rate (expressed as a percent) is provided for each truck class (classes 4–13). It is used together with the growth function (linear or compound) to estimate truck volume from the AADTT values provided for the base design/analysis year for each year over the analysis/design period. The growth rate does not change over time for individual truck classes.
Vehicle class growth function	Type of truck volume growth function, linear or compound, is provided by vehicle class (classes 4–13). It is used together with the growth rate to estimate truck volume over the analysis/design period from the base design/analysis year AADTT values. The function does not change over time for individual truck classes.
Operational truck speed (mph)	This value is independent of truck class and defined as posted speed limit or the average speed of the heavier trucks through the project limits.
Axle spacing for tandem, tridem, and quad axles	Average representative axle spacing is required for tandem, tridem, and quad axles, computed in inches. Axle spacing does not change over time.
Average wheelbase length and percentage of trucks with short, medium, and long wheelbases	The average wheelbase length and the corresponding percentages of trucks with wheelbases are required for the following three categories: short (≤12 ft), medium (>12 ft and ≤15 ft), and long (>15 ft and ≤20 ft). For multi-unit and combination trucks, only the wheelbase of the truck power unit (i.e., first unit) is considered. These values are used for the top-down JPCP cracking model only.
Average axle width	One value, computed in ft, that represents the distance between two outside edges of an axle. This parameter is constant between all truck classes and does not change over time. Only needed for rigid pavement designs.
Mean wheel location	This parameter represents the mean distance in inches from the outer edge of the wheel to the pavement marking. This parameter is constant between all truck classes and does not change over time.
Truck wander standard deviation	This parameter represents the standard deviation from the mean wheel location, computed in inches based on measurements from the lane marking.
Dual tire spacing	This parameter represents the average spacing of dual tires, computed in inches. This parameter is constant between all truck classes and does not change over time.
Tire pressure	This parameter represents the hot tire inflation pressure. This parameter is constant between all truck classes and does not change over time.

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