Year	Title	Author(s)
2009	Comparative Analysis of Input Traffic Data and MEPDG Output for Flexible Pavements in State of Arizona	Ahn, Soyoung; Kandala, Srivatsav; Uzan, Jacob; El-Basyouny, Mohamed
2008	Monte Carlo Simulation Approach to Mechanistic-Empirical Analysis of Flexible Pavement	Wang, Feng; Machemehl, Randy B.
2008	Assessing Spring Load Restrictions Using Climate Change and Mechanistic-Empirical Distress Models	Crowder, J; Shalaby, A; Van Cauwenberghe, R; Clayton, A.
2008	High Speed Weigh-in-Motion System Calibration Practices	Papagiannakis, A. Thomas; Quinley, R; Brandt, S.R.
2007	Axle Load Distribution for Mechanistic–Empirical Pavement Design	Wang, Yuhong; Hancher, Donn E; Mahboub, Kamyar
2007	Influence of Various Material and Traffic Inputs on Flexible Pavement Design Methods for Alabama Roadways	Stroup-Gardiner, Mary; Turochy, Rod E; Carter, Alan
2007	Evaluation of Weigh-in-Motion Data for Developing Axle Load Distribution Factors for Mechanistic-Empirical Pavement Design Guide	Tran, Nam H; Hall, Kevin D.
2007	Quantifying the Effects of Truck Weights on Axle Load Spectra of Single and Tandem Axle Configurations	Haider, Syed Waqar; Harichandran, Ronald S.
2007	Piezo: Data on a WIM	Halvorsen, Don
2007	EsalCalc Online	
2007	LTPP WIM Cost Online	
2006	Investigations of Environmental and Traffic Impacts on “Mechanistic-Empirical Pavement Design Guide” Predictions	Zaghloul, Sameh et al
2006	LTPP Data Analysis: Optimization of Traffic Data Collection for Specific Pavement Design Applications	
2006	LTPP Field Operations Guide for SPS WIM Sites	MACTEC
2006	Sensitivity of NCHRP 1-37A Pavement Design to Traffic Input	Papagiannakis, A. et al
2006	Traffic Data Collection Requirements for Reliability in Pavement Design	Papagiannakis, A T; Jackson, N. C.
2005	Estimating Cumulative Traffic Loads, Volume II: Traffic Data Assessment and Axle Load Projection for the Sites with Acceptable Axle Weight Data. Final Report for Phase 2.	Hajek, J. J; Selezneva, O. J; Mladenovic, G; Jiang, Y. J.
2005	Freight Data Assessment	Felsburg Holt & Ullevig, Cambridge

		Systematics
2005	Improving Traffic Characterization to Enhance Pavement Design and Performance: Load Spectra Development	Al-Yagout, Mohammad A et al
2005	Sensitivity Analysis of Rigid Pavement Systems Using Mechanistic-Empirical Pavement Design Guide	Guclu, Alper; Ceylan, Halil
2004	LTPP WIM Index Software Manual, Version 1.0	
2004	Pavement Smoothness at Weigh-in-Motion Sites: Developing Specifications for the Long-Term Pavement Performance Program	Karamihas, S. M et al
2004	Traffic Load Spectra Development for the 2002 AASHTO Design Guide	Buchanan, M. S.
2003	A Traffic Data Plan for Mechanistic- Empirical Pavement Designs (2002 Pavement Design Guide)	Cottrell, B. H; Schinkel, T. O; Clark, T. M.
2002	Cumulative Traffic Prediction Method for Long-Term Pavement Performance Models	Byrum, C. R; Kohn, S. D.
2002	Improving Reliability of Pavement Loading Estimates with Pavement Loading Guide	Hajek, J. J; Selezneva, O; Jiang, J. Y; Mladenovic, G.
2002	ITS: Enriching Our Lives - State Truck Activities Reporting System	Stephens, J; Carson, J; Hult, D. A; Bisom, D.
2002	North American Travel Monitoring Exhibition and Conference 2002 (NATMEC 2002) and	

Year	Title	Author(s)
	Third International Conference on Weigh-in-Motion (ICWIM3), Orlando, Florida, May 12-16, 2002	
2002	Pavement Smoothness Specifications for LTPP WIM Locations	Rada, G. R; Karamihas, S; Perera, R.
2002	Vehicle Classification Validity checks for LTPP WIM Data	Southgate, H.
2001	Framework for the Development of a Statewide Equivalent Single Axle Load (ESAL) Table for Use in Pavement Management Systems	Alavi, Sirous et al
2001	Guide to LTPP Traffic Data Collection and Processing	
2000	Equipment Selection and Site Installation for LTPP SPS WIM Sites	
2000	Estimating Cumulative Traffic Loads, Final Report for Phase 1	Hajek, J. J; Selezneva, O. I.
2000	Smoothness Criteria for Construction and In-Service Conditions for LTPP SPS WIM Sites	
2000	Verification of LTPP SPS WIM Sites	
1999	Effect of Weight-Mile Tax on Road Damage in Oregon	Rufolo, Anthony; Bronfman L; Kuhner, E.
1998	Accuracy of LTPP Traffic Loading Estimates	
1998	Long Term Pavement Performance Program Protocol for Calibrating Traffic Data Collection Equipment	Hallenbeck, Mark
1998	LTPP Traffic Data Collection and Monitoring	Kombe, E. M.
1998	North American Travel Monitoring Exhibition and Conference	
1998	Understanding Traffic Variations by Vehicle Classifications	
1998	Why Does LTPP Require Site-Specific Traffic Loading Data?	
1998	WIM Scale Calibration: A Vital Activity for LTPP Sites	
1994	SHRP-LTPP Traffic Data Collection and Analysis: Five-Year Report	German, J. L; Copeland Jr, C. R.
1992	LTPP Central Traffic Database (CTDB)	
1992	National Traffic Data Acquisition Conference, Sacramento, California, October 25-29, 1992, Proceedings	Copelan, Craig A.
1991	Piezo-Electric Automatic Vehicle Classification System. Final Report	Laylor, H. M.
1991	The SHRP LTPP Traffic Database. Strategic Highway Research Program Products. Proceedings of a Specialty Conference Sponsored	

	by the Highway Division of the American Society	
Year	Title	Author(s)
	of Civil Engineers and the Federal Highway Administration. Denver Marriott	
1989	Analysis of Texas Traffic Monitoring Program. Final Report	Cunagin, W. D; Nassiri, H. S.
1989	Evaluation of Low Cost WIM Alternatives. Final Report	Cunagin, W. D; Majdi, S. O.
1989	Framework for Traffic Data Collection for the General Pavement Studies' Test Sections	

Title: Assessing Spring Load Restrictions Using Climate Change and Mechanistic-Empirical Distress Models

Author(s): Crowder, J; Shalaby, A; Van Cauwenberghe, R; Clayton, A.

Date: 2008

Publisher: 2008 Annual Conference of the Transportation Association of Canada Corp. Authors

Abstract/Synopsis:
Nearly 58% of the Manitoba Provincial pavement network is subjected to spring load restrictions, and most of these roads consist of a thin flexible pavement or an asphalt surface treatment. This paper relates pavement deflection data from FWD testing to environmental indices such as the thaw index. Deflection data collected since 1990 on pavement sections and the LTPP site in Manitoba are used to establish network-level and statistically representative values for pavement properties during the thaw weakening and recovery period. The base and subgrade moduli during spring thaw are computed using a back-calculation algorithm and categorized in terms of ranges of the thaw index. The data is used with the prediction models of the AASHTO Mechanistic Empirical Design Guide to assess the impact of spring load restrictions on pavement service life. Five scenarios are considered and these accounted for base conditions on an unrestricted road and for the cases of reducing axle loads, with and without an increase in the number of trips, required to transport a certain payload.

Application/Use: The results of this paper are directly related to pavement engineers in Manitoba, but can also be used by other state agencies interested in the relationship between the structural properties of pavements and freeze-thaw environmental conditions.

Contribution: Cost Savings; Improvement in Knowledge

Present Benefit: A better understanding of the effects of the freeze thaw cycles on pavement performance is of great benefit to agency officials and pavement engineers that have networks in freeze/thaw conditions. This study evaluates the effectiveness of load restrictions on pavements during the freeze/thaw cycle. This research study was heavily dependent upon the LTPP database to identify the relationship between distress and freeze/thaw conditions.

Future Benefit: A significant cost savings can be achieved by agencies with pavement networks in freeze/thaw zones. Mandating load restrictions to reduce the impact of truck loads on pavements and to limit distress is an important consideration for agencies. The LTPP database will continue to be used as more agencies calibrate this prediction model for their specific region.

Title: High Speed Weigh-in-Motion System Calibration Practices

Author(s): Papagiannakis, A. Thomas; Quinley, R; Brandt, S.R.

Date: 2008

Publisher: NCHRP Synthesis of Highway Practice No. 386, Transportation Research Board

Abstract/Synopsis:
Weigh-in-motion (WIM) is the process of weighing vehicle tires or axles at normal roadway speeds ranging up to 130 km/h (80 mph). WIM systems consist of sensors embedded onto the pavement surface and a data acquisition system equipped with software capable of processing sensor signals into weight, computing additional traffic data elements, and summarizing them into various database formats. There is an urgent need for ensuring WIM data accuracy. This is accomplished through routine WIM system calibration and periodic WIM data quality control. The way these tasks are carried out varies widely between agencies. This study synthesizes the state of the practice in high speed WIM system calibration. The study is likely to be of interest to those responsible for long-term pavement performance, pavement design, bridge design, monitoring highway usage, highway cost allocation, and enforcement of truck loads. Two main tools were used in conducting this study—a thorough review of the European and North American literature on the subject and an on-line survey addressed to highway and load enforcement agencies administering WIM systems in the United States. The survey was supplemented by telephone interviews.

Application/Usage: This paper is directly applicable for engineers, pavement designers, bridge designers, and those responsible for allocating highway costs and enforcing truck load limits.

Contribution: Cost Savings; Improvement in Knowledge; Implementation/Usage

Present Benefit: Pavement performance is significantly dependent upon the loads imposed on the pavement structures. Therefore, calibration improvements resulting in more accurate WIM data is of great value. The LTPP program utilizes WIM equipment for traffic data collection and has provided validation, calibration, and installation protocols for WIM equipment.

Future Benefit: Traffic volumes are increasing on the nation's pavement networks, and the ability to accurately quantify the traffic loads imposed on the pavements is a significant factor in pavement design. The LTPP database will continue to provide researchers and engineers with information to improve the quality and practice of data acquisition.

Title: Comparative Analysis of Input Traffic Data and MEPDG Output for Flexible Pavements in State of Arizona

Author(s): Ahn, Soyoung; Kandala, Srivatsav; Uzan, Jacob; El-Basyouny, Mohamed

Date: 2009

Publisher: Transportation Research Board 88th Annual Meeting

Abstract/Synopsis:
This paper is concerned with the effects of input traffic parameters on the pavement performance predicted by the Mechanical Empirical Pavement Design Guide (MEPDG) for the state of Arizona. This study examined the differences in input traffic data from different sources and their impact on the pavement distresses at the end of a design year. Moreover, the national default load distribution factors were compared with the site-specific distribution factors measured as part of the Long Term Pavement Performance (LTPP) program by evaluating the errors associated with predicting various pavement distresses. Findings showed that average daily truck traffic (ADTT) varied significantly between two data sources (LTPP and Arizona Department of Transportation), resulting in large differences in predicted longitudinal and alligator cracking. A further sensitivity analysis revealed that the longitudinal and alligator cracking increased by a larger factor with respect to increases in ADTT. The use of national default load distribution factors revealed a similar result, such that the errors associated with predicting cracking were large.

Application/Usage: The results from this project are directly applicable to Arizona pavement managers and maintenance engineers interested in predicting pavement performance based on traffic data. However, the principles discovered in this project are also applicable to pavement engineers within other state agencies.

Contribution: Improvement in Knowledge

Present Benefit: The ability to accurately predict pavement performance based on traffic data is an important tool for pavement managers to effectively plan for pavement rehabilitation projects and to optimize the allocation of funds to meet pavement needs. Therefore, comparing the differences in the LTPP traffic data with the state agency traffic data is important when looking at the impact it has on accurately predicting pavement performance in their network.

Future Benefit: As pavement design continues to shift toward mechanistic-empirical design methods, the LTPP database will be an ongoing source of information for pavement researchers and pavement managers to improve existing prediction methods. As these methods are refined, pavement engineers will be better equipped to strategically plan maintenance and rehabilitation projects to improve the health of their pavement network.

Title: Axle Load Distribution for Mechanistic–Empirical Pavement Design

Author(s): Wang, Yuhong; Hancher, Donn E; Mahboub, Kamyar

Date: August 2007

Publisher: Journal of Transportation Engineering Vol. 133 No. 8, American Society of Civil Engineers

Abstract/Synopsis:
Mechanistic–empirical (ME) pavement design often demands default or assumed axle load spectrum data. Using single and tandem axles of the Vehicle Class 9 as examples, this study analyzed the spatial and temporal variations of the load distributions from the long-term pavement performance program traffic database. The study found that both spatial and temporal variations are significant; therefore, it may be questionable to use a single default load distribution factor (LDF) for each axle type of vehicle class in design. However, when conducting cluster analysis, the study found that the large amount of data can be classified into a limited number of clusters, from which multiple load distributions can be developed. These distributions, together with spatial and temporal information, may assist engineers in identifying more accurate load distributions for ME design. Based on trial design results using the mechanistic–empirical pavement design guide software, it was found that different LDFs resulted in months of the difference in predicted pavement lives at the same threshold levels for various types of distresses.

Application/Use: The results from this paper are applicable for pavement managers and designers interested in traffic axle load distributions.

Contribution: Improvement in Knowledge; Lessons Learned

Present Benefit: Load spectra data is a significant factor in predicting the expected pavement life using the MEPDG. Therefore, the ability to more accurately determine the load distribution factors, which affects the load spectrum data, is important for equipping pavement engineers with the tools needed to better predict the expected pavement life for pavements in their network. With this tool, pavement managers will be able to better plan for rehabilitation and maintenance work in their pavement networks and be more strategic in the allocation of those funds. Data from the LTPP program was used in this project to determine the variations in the LDF and for determining the appropriate LDF to use in pavement design.

Future Benefit: As pavement design shifts toward a mechanistic-empirical design, it is important to refine these methods, by improving the accuracy of the design inputs. By doing this, pavement engineers will be better equipped in making decisions for cost-effectively improving their pavement networks, and for designing new pavements considering the effects of traffic loads. The LTPP database will continue to be an essential resource for refining existing design methods so that higher performance pavements can be designed and implemented cost-effectively.

Title: Influence of Various Material and Traffic Inputs on Flexible Pavement Design Methods for Alabama Roadways

Author(s): Stroup-Gardiner, Mary; Turochy, Rod E; Carter, Alan

Date: August 2007

Publisher: Journal of Transportation Engineering Vol. 133 No. 8

Abstract/Synopsis:
Statistical analyses of over 2,000 pavement designs using the 1993 American Association of State Highway Transportation Officials Design Guide was conducted. Variations in traffic levels, and subgrade, base, and hot mix asphalt (HMA) moduli and thickness showed that the only significant material and traffic design inputs were the subgrade modulus and the initial equivalent single axle loads. A plus or minus 5% change in the design traffic level did not statistically influence the determination of the structural number (SN). A subgrade modulus of 3,000 psi and a linear growth rate of 4% for roadways with annual average daily traffic of more than 10,000 is recommended for determining the SN. The growth rate for lower traffic volume roadways will vary significantly between 0 and 3%. A more limited evaluation of the 2002 Design Guide showed that a mechanistic–empirical method of flexible pavement design is strongly influenced by the HMA thickness and the distribution of truck types within the annual average daily traffic. Selecting the appropriate roadway functional classification defines the default percent of traffic that is comprised of trucks and is important to the program output. Performance data for two Alabama long-term pavement performance sections was used to verify both design methods.

Application/Use: The results from this study are directly applicable to pavement engineers in Alabama, and can also be used by pavement engineers in other agencies.

Contribution: Improvement in Knowledge; Implementation/Usage

Present Benefit: A better understanding of the effect of traffic and material properties on pavement performance is beneficial for pavement managers and can assist them in being more effective in their decision-making processes for maintaining their pavement network. Additionally, it can also benefit pavement designers as they consider the importance of these factors on the overall pavement performance. The LTPP program was important for verifying the design methods presented in this project.

Future Benefit: As pavement design continues to move toward a mechanistic-empirical approach, the ability to quantify the impact from pavement material properties and traffic conditions will be a valuable asset for pavement engineers. The LTPP database will be utilized to improve existing methods and to verify alternative design methods.

Title: Evaluation of Weigh-in-Motion Data for Developing Axle Load Distribution Factors for Mechanistic-Empirical Pavement Design Guide

Author(s): Tran, Nam H; Hall, Kevin D.

Date: 2007

Publisher: Transportation Research Board 86th Annual Meeting, Transportation Research Board

Abstract/Synopsis:
Axle load spectra are essential to structural pavement design using the new Mechanistic-Empirical Pavement Design Guide (MEPDG) developed under National Cooperative Highway Research Program (NCHRP) Project 1-37A. The axle load spectra can only be determined from traffic data collected at weigh-in-motion (WIM) stations. Studies have shown that traffic data collected at WIM sites, especially for those using temperature-dependent piezoelectric sensors, often have errors. Thus, quality control checks should be performed on the WIM data which are used for developing the design inputs. This paper presents the results of an extensive quality control evaluation of traffic data collected at 25 WIM sites selected for the development of statewide axle load spectra in Arkansas. The data were evaluated using the quality control procedure recommended by the Long Term Pavement Performance (LTPP) program. In addition, the influence of the WIM data accuracy on predicted pavement performance was also evaluated using the MEPDG software. Among the 25 sites, only ten stations provided WIM data suitable for the development of statewide axle load spectra in the MEPDG. Pavement performance predictions provided by the MEPDG software were found to be sensitive to underestimated and overestimated WIM data. The effect of misestimated WIM data can be minimized if the data meet the quality requirements specified by the LTPP.

Application/Use: The results from this study are directly applicable to pavement engineers considering the effect of traffic loads on pavements.

Contribution: Improvement in Knowledge

Present Benefit: Load spectra are important inputs that are used by the MEPDG to estimate the effects of actual traffic on pavement response and distress. Therefore, it is critical to ensure quality WIM data is being utilized in the development of the load spectra so that pavement engineers can more accurately analyze and design pavements. The quality control checks developed by the LTPP program were utilized in this paper to evaluate the accuracy in load spectra.

Future Benefit: As traffic volumes increase on the nation's pavement networks, pavement designers will need to be able to better quantify the effects on pavements from traffic loads. The protocols developed by the LTPP program will continue to provide insight for pavement engineers in collecting and assuring quality data is being used in pavement analysis and design.

Title: Quantifying the Effects of Truck Weights on Axle Load Spectra of Single and Tandem Axle Configurations

Author(s): Haider, Syed Waqar; Harichandran, Ronald S.

Date: 2007

Publisher: Haider, Syed Waqar; Harichandran, Ronald S.

Abstract/Synopsis:
Axle load spectra have been used in the mechanistic-empirical pavement design guide (M-E PDG). Use of these load spectra provides a more direct and rational approach for the analysis and design of pavement structures to estimate the effects of actual traffic on pavement response and distress. Several studies have shown that axle load spectra (ALS) and gross vehicle weights (GVW) exhibit a bimodal distribution in the field and thus can be characterized by bimodal mixture distribution models. In this paper, the parameters of bimodal mixture models for ALS and GVW are related using traffic data from the LTPP sites in the SPS-1 and the SPS-2 experiments. Also, it is hypothesized that the first peak corresponds to the average axle weight of empty/partially loaded trucks, while the second peak corresponds to the average axle weight of fully loaded trucks. The standard deviations associated with both peaks explain the variations of weights for empty/ partially and fully loaded trucks. Furthermore, the weight factors for each distribution type control the frequency of these trucks in each category. The specific results of this study show that only truck weights of Classes 5, 10 and 11 play a significant role in characterizing axle load spectra for single axle trucks. On the other hand, truck weights of Classes 9, 6 and 8 contribute substantially to axle load spectra involving tandem axles. However, due to the large presence of Class 9 trucks in the traffic stream, this truck type has the most critical role, not only in truck volumes but also in shaping axle load spectra for both single and tandem axle configurations.

Application/Use: The results from this paper are applicable for pavement managers and pavement engineers interested in the effects of traffic loads on pavement performance.

Contribution: Improvement in Knowledge

Present Benefit: Load spectra are used to quantify the effects of the traffic loads on pavement performance. Therefore, examining the relationship between truck weights and load spectra is critical to obtain a more accurate understanding of the effects of traffic loads on pavement performance. One of the benefits of this study is equipping pavement managers and designers to be more effective in incorporating the effects of traffic loads on pavement performance. Traffic data collected through the LTPP program was used in this study to better understand the effects of truck weights on load spectra of single and tandem axles.

Future Benefit: As pavement design continues to move toward a mechanistic-empirical design method, it is necessary to refine the current tools utilized by pavement engineers so that they can be more effective in designing higher performing pavements in cost-effective ways. As these methods and tools are refined and as pavement managers implement these tools in their pavement network, agencies can experience a significant cost-savings. The LTPP program will continue to be an invaluable resource allowing pavement researchers and engineers to refine existing pavement design methods to gain these benefits.

Title: Piezo: Data on a WIM

Author(s): Halvorsen, Don

Date: August 2007

Publisher: Traffic Technology International Vol. 2007 No. 8; Auto Intermediates Limited

Abstract/Synopsis:
This article describes the use of piezoelectric sensors for applications in weigh in motion (WIM) truck tolling. Data collection and monitoring is the most important component of WIM tolling, which is in turn essential for the FHWA Long Term Pavement Performance (LTPP) program. In the United Kingdom, WIM systems work by monitoring truck weight by axle. If it is found that if any one axle exceeds the weight limit, a photograph is taken by an automated camera and the truck is the fined. Piezoelectric sensors work by converting the vehicle load weight on the ground above into an electrical signal, which is then processed by algorithms into a weight datum. The sensors can be installed through a 20 mm wide slot in the road with a depth of 10 to 75 mm. Other factors relating to the implementation and efficacy of these sensors are also discussed.

Application:/Use: The results from this study are applicable for engineers utilizing WIM equipment, and agencies considering using WIM equipment to monitor traffic loads on their pavements.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology

Present Benefit: The ability to accurately weight a vehicle while in motion is a difficult task. However, monitoring traffic loads on pavements is an important part of refining the pavement design to meet the site loading conditions, and to monitor and enforce the load restrictions. The LTPP program utilizes WIM equipment and has provided information regarding the use and calibration of WIM equipment as well as the analysis of WIM data.

Future Benefit: Because pavement management is an expensive endeavor, the use of various pavement technologies to protect that investment is an important aspect that should be considered in pavement engineering. As agencies continue to implement and utilize WIM equipment on select areas in their pavement network, a significant long-term cost savings can be achieved by designing roads that effectively accommodate for the imposed traffic loads and enforce the load restrictions when necessary.

Title: Monte Carlo Simulation Approach to Mechanistic-Empirical Analysis of Flexible Pavement

Author(s): Wang, Feng; Machemehl, Randy B.

Date: 2008

Publisher: Transportation Research Board

Abstract/Synopsis:
The mechanistic-empirical study of pavement performance requires that immediate pavement responses due to tire loading be mechanistically computed for pavement structures, and the long-term pavement performance be related to the computed pavement responses. The problem becomes very complicated when variability is considered for loading, pavement and environmental conditions. A Monte Carlo simulation based mechanistic-empirical pavement analysis procedure was verified in this study. The complex tire-pavement interaction was more realistically handled and computed using finite element models and measured tire-pavement contact stress data. The computation time problem involved in pavement response computations was resolved by using a quick solution method that relates critical pavement responses to tire loading and pavement structural conditions. In the Monte Carlo simulation, different truck classes were drawn from the truck population empirically based on actual traffic volume data. Axle load spectra were characterized by actual axle load data collected at a weigh-in-motion site. Results from a survey of truck configurations were used to describe the distribution of truck tire pressure. Pavement structural parameters and relationships between material moduli and environment conditions were obtained from the LTPP data. The distress models developed in NCHRP Project 1-37A were employed to predict pavement performance. The simulation study estimates the effects of increased tire pressure and steering axle load on a typical pavement structure for 2 million truck passes. The Monte Carlo simulation method and models used in this study show a feasible approach to the development of flexible pavement design and analysis procedures.

Application Use: The results from this study are applicable to pavement managers, forensic pavement analysts, and rehabilitation engineers.

Contribution: Cost Savings; Improvement in Knowledge

Present Benefit: Analyzing flexible pavements using the Monte Carlo simulation method is useful in estimating the effect of increased tire pressure and steering axle load on pavement structures. With this knowledge, pavement engineers may be able to improve the effectiveness of their pavement analysis procedures by incorporating the tire-pavement interaction in their analysis of flexible pavements. As these methods are refined, a significant cost savings can be achieved by an agency, freeing up resources that can be allocated to meet other pavement needs. Due to the variability and the complexity of this interaction, the LTPP database was used to determine pavement structural parameters and to examine the relationships between material moduli and environmental conditions.

Future Benefit: The LTPP database offers an extensive amount of information for pavement researchers and engineers that will continue to be used in further pavement advancements. The data collected through the LTPP project will continue to be an invaluable resource to assist pavement researchers and engineers in quantifying complex pavement interactions and gaining a better understanding of pavement behavior and pavement performance. The end result will be cost-effective pavement designs with better overall pavement performance.

Title: EsalCalc Online

Date: 2007

Publisher: FHWA

Abstract/Synopsis: ESALCalc is the computer program that computes an annual ESAL estimate for each experimental section based on necessary information such as pavement structure, functional class, material type and monitored axle distributions found in IMS tables provided with the Standard Release.

Application/Use: ESALCalc has been used to estimate the traffic loading experienced at LTPP test sections.

Contribution: Cost Savings; Improvement in Knowledge; Implementation/Usage.

Present Benefit: The availability of site-specific traffic loading information together with inventory and performance data is extremely beneficial. This data collectively provides the information required to link pavement performance to onsite conditions. Because the current AASHTO pavement design manual is based on the concept of ESALs, measured ESAL values can be used to study actual pavement performance relative to the pavement design. This type of onsite information coupled with measured performance data is quite limited outside of the LTPP database.

Future Benefit: As pavement design moves towards the M-E PDG, site-specific traffic information will become increasingly valuable. This holds true not only for the implementation process of the M-E PDG but also in performing Level 1 pavement designs. The LTPP traffic data will be extremely useful in this regard.

Title: LTPP WIM Cost Online

Date: 2007

Publisher: FHWA

Abstract/Synopsis: LTPP WIM Cost Online allows users to calculate the costs associated with the placement of Weigh-in-Motion (WIM) sites. The application takes into account costs such as equipment, staff, and maintenance required to keep the site operating at the level established by LTPP

Application/Use: This can be used by State Highway Agencies interested in installing and maintaining WIM sites.

Contribution: Cost Savings; Implementation/Usage; Advancement in Technology.

Present Benefit: This software provides the cost information necessary to develop an effective strategy for installing a network of WIM equipment given a known budget. Conversely, a budget can be established given the number of WIM sites required to accurately account for traffic loading on a highway system.

Future Benefit: The need for site-specific traffic data will increase with the implementation of the M-E PDG because load spectra are a required input. WIM Cost Online will provide valuable insight into the costs associated with traffic data collection and will be a tool that can be used in developing a network of WIM equipment.

Title: Investigations of Environmental and Traffic Impacts on "Mechanistic-Empirical Pavement Design Guide" Predictions

Author(s): Zaghloul, Sameh; Ayed, Amr; Abd El Halim, Amir; Vitillo, Nicholas P; Sauber, Robert W.

Date: 2006

Publisher: Transportation Research Board

Journal Title: Transportation Research Record: Journal of the Transportation Research Board No. 1967

Abstract/Synopsis: The "Mechanistic–Empirical Pavement Design Guide" (MEPDG) represents a major improvement on its predecessors, particularly in its comprehensive coverage of environmental impact on pavement performance. Another improvement is the approach introduced to assess and accumulate damage created by traffic. A major strength of the MEPDG is the consideration given to the interaction between environmental, material, and traffic parameters, rather than consideration of only the parameters themselves. The process through which these interactions are considered sounds very comprehensive; however, is it practical? The Enhanced Integrated Climatic Model (EICM) is a core component of the MEPDG; it controls the material properties used in the analysis to a great extent. As a result, EICM predictions have a significant impact on MEPDG-accumulated damage and therefore on predicted service life. In a previous study, an effort was made to validate EICM predictions with field-measured temperature and moisture profiles outside the MEPDG. However, this effort was not successful. Therefore, the potential impacts of the accuracy of EICM predictions on MEPDG-predicted damage—and hence on expected pavement service life—were investigated. Eight weather stations closest to New Jersey's Long-Term Pavement Performance Specific Pavement Study 5 site were analyzed. In addition, to address the interaction between environment and traffic in the MEPDG, analyses were run with two traffic input levels: first with Level 3 traffic data and then with Level 1 traffic data.

Application/Use: This paper can be used to evaluate the adequacy of the EICM and the impacts of environment and traffic on M-E PDG predictions.

Contribution: Improvement in Knowledge

Present Benefit: The findings from this study are beneficial to the implementation and use of the M-E PDG. Understanding sensitivity and interactions between inputs into the performance models is very useful to designers. Additionally, an evaluation of the accuracy of the EICM will ultimately improve the pavement designs produced through the M-E PDG.

Future Benefit: This study will be used to understand the variability inherent in the EICM and its effect on pavement design in the M-E PDG. Findings from this study may be used to modify the M-E PDG.

Title: LTPP Field Operations Guide for SPS WIM Sites

Author(s): MACTEC Engineering and Consulting, Inc.

Date: 2006

Publisher: FHWA, Office of Infrastructure Research and Development, McLean, VA

Abstract/Synopsis: In response to the need to improve the quantity and quality of traffic data, particularly at the high-return SPS projects, the LTPP Team spearheaded a Pooled Fund Study. The SPS Traffic Pooled Fund Study (TPFS) included two principal elements: shifting the data collection from highway agencies to a national, centralized effort and standardizing data collection equipment and procedures. This document contains the guidelines for traffic data collection at SPS sites, including all aspects of field operations, and is divided into six major operational sections: Site Assessment, Site Validation—Weight, Site Validation—Classification, Pavement Smoothness, WIM Equipment Installation and Calibration Auditing, and Data for Use in LTPP Activities.

This document is supplemented by various other documents and tools including:

- LTPP Bending Plate Weigh-in-Motion System: Model Specification for Equipment—Hardware and Software
- LTPP Bending Plate Weigh-in-Motion System: Model Specification for Pavement and Installation
- WIM 2 TRUCK.XLS—A spreadsheet designed to store data from test truck runs and compute differences for graphing
- CLASSMACRO.XLS—A spreadsheet used to summarize the combinations of observed and reported classifications using the TMG 13-bin scheme
- WIM Smoothness Index Software (and associated user manual)

Application/Use: The guide documents the LTPP processes and procedures to collect and store the traffic data used in calculating pavement loadings. It also includes LTPP's instructions for the selection, location, installation and calibration of traffic data collection equipment.

Contribution: Cost Savings; Advancement in Technology; Improvement in Knowledge.

Present Benefit: Continuing its advancement of the quality of WIM and other automated traffic data, this document is an excellent resource for any practitioner interested in installing equipment and collecting quality traffic data. It also provides methods for assessing the performance of existing equipment and performing QA on installation and calibration activities.

The documents associated with the Field Operations Guide provide specifications for equipment hardware and software as well as the pavement conditions and installation procedures to ensure the equipment will function properly. A tool that has achieved wide distribution is the WIM Smoothness Index Software that utilizes longitudinal profile data to determine whether an existing pavement is sufficiently smooth to allow quality traffic data to be measured. The software can also be used to select the optimum location for equipment installation.

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. In July 2005, the first set of equipment was installed for the TPFS and the data downloading and processing procedures continue to be refined. The associated specifications and procedures for the TPFS will greatly assist practitioners in maximizing their investment in automated traffic data collection equipment. Further, the resulting traffic data—multiple site years of known quality—will be invaluable to analysts.

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

Date: 2006

Publisher: Federal Highway Administration

Journal Title : TechBrief No. FHWA-HRT-06-111

Abstract/Synopsis: 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 "Mechanistic-Empirical Pavement Design Guide" (M-E PDG). For the study, researchers used extended-coverage weigh-in-motion (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: (1) 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; and (2) Directions for future traffic data collection efforts to address both LTPP and State agency collection needs for pavement design applications. This TechBrief contains further discussion of the study findings and conclusions.

Application/Use: The finding from this paper can be used by pavement design engineers looking to implement and use the M-E PDG.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: Understanding the relationship between traffic data collection requirements and pavement design error is extremely beneficial. Significant cost savings can be realized when the error in pavement design minimized. The findings from this study also provide an understanding for the amount of traffic data that will be required in the implementation of the M-E PDG. With this knowledge, agencies can develop a plan for network-level traffic monitoring.

Future Benefit: The future benefit of this study will be realized as agencies begin implementing the M-E PDG. The findings from this study are not only useful in determining the effect of traffic on pavement design results, but can also be used in planning future traffic monitoring based on an established acceptable error. The error associated with traffic data collection requirements will also be included in the local calibration/validation process of the M-E PDG.

Title: Sensitivity of NCHRP 1-37A Pavement Design to Traffic Input

Author(s): Papagiannakis, A. Thomas; Bracher, Michael; Li, J; Jackson, Newton C.

Date: 2006

Publisher: Transportation Research Board

Journal Title: Transportation Research Record: Journal of the Transportation Research Board No. 1945

Abstract/Synopsis: This study deals with the sensitivity of the NCHRP 1-37A Pavement Design Guide predictions to traffic data input. A number of traffic data collection scenarios are simulated with the use of extended coverage (more than 299 days per year) weigh-in-motion (WIM) data from the Long-Term Pavement Performance (LTPP) database. These scenarios consist of combinations of site-specific, regional, and national data, including total truck counts, truck counts by class, and axle-load distributions by axle type. For each simulated scenario, traffic input to the NCHRP 1-37 Pavement Design Guide is estimated with the methodologies prescribed in the "Traffic Monitoring Guide." For discontinuous time coverage scenarios, all possible time coverage combinations are considered, and the range in the estimated traffic input parameters is computed. Pavement life predictions are obtained under mean traffic input for all traffic data collection scenarios and under low percentile input for the discontinuous traffic data collection scenarios.

Application/Use: The findings from this paper can be used by pavement design engineers looking to implement and use the M-E PDG.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: Understanding the sensitivity of the M-E PDG relative to traffic input is extremely beneficial to pavement design engineers. This sensitivity can be used to establish the level of data collection that is required for use in pavement design. The information can also be used to develop a plan for network-level traffic monitoring.

Future Benefit: The future benefit of this study will be realized as agencies begin implementing the M-E PDG. The findings from this study are not only useful in determining the effect of traffic on pavement design results, but can also be used in planning future traffic monitoring based on an established acceptable error. The error associated with traffic data collection requirements will also be included in the local calibration/validation process of the M-E PDG.

Title: Traffic Data Collection Requirements for Reliability in Pavement Design

Author(s): Papagiannakis, A T; Jackson, N. C.

Date: 2006

Publisher: Transportation Research Board

Abstract/Synopsis: This paper presents a comprehensive approach for establishing the minimum traffic data collection requirements for predicting pavement life within an acceptable error, given a reliability level. Pavement life is predicted for 30 long term pavement performance (LTPP) sites using the NCHRP 1-37A Pavement design guide (PDG). Seventeen distinct traffic data collection scenarios are simulated using extended coverage (i.e., more than 299 days/year) weigh-in-motion (WIM) data obtained from the LTPP database. These scenarios involve combinations of site-specific, regional, and national data, including total truck counts, truck counts by class, and axle load distributions by axle type.

Application/Use: The findings from this paper can be used by pavement design engineers looking to implement and use the M-E PDG.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: Understanding the relationship between minimum traffic data collection requirements and pavement design error is extremely beneficial. Significant cost savings can be realized when the error in pavement design is minimized. The findings from this study also provide an understanding for the amount of traffic data that will be required in the implementation of the M-E PDG. With this knowledge, agencies can develop a plan for network-level traffic monitoring.

Future Benefit: The future benefit of this study will be realized as agencies begin implementing the M-E PDG. The findings from this study are not only useful in determining the effect of traffic on pavement design results, but can also be used in planning future traffic monitoring based on an established acceptable error. The error associated with traffic data collection requirements will also be included in the local calibration/validation process of the M-E PDG.

Title: Estimating Cumulative Traffic Loads, Volume II: Traffic Data Assessment and Axle Load Projection for the Sites with Acceptable Axle Weight Data. Final Report for Phase 2.

Author(s): Hajek, J. J; Selezneva, O. J; Mladenovic, G; Jiang, Y. J.

Date: 2005

Publisher: ERES Consultants, Incorporated; Federal Highway Administration

Abstract/Synopsis: In 1998, the Federal Highway Administration sponsored a study to estimate traffic loads on Long-Term Pavement Performance (LTPP) sites. This report contains findings of the second phase of the study. Phase 1 encompassed the development of the estimation methodology, including numerical examples, and was documented in report FHWA-RD-00-054 issued in July 2000. Phase 2, described in this report, included the assessment of the overall quality of traffic data for all 890 LTPP traffic sites, and the projection of axle loads for all LTPP sites with adequate traffic data. Phase 2 also included the distribution of comprehensive traffic data reports to all participating agencies and the incorporation of comments regarding traffic projections received from the agencies. Axle load projections were developed for all in-service years up to 1998 for 558 LTPP traffic sites that had adequate traffic monitoring data in the Information Management System (IMS) database. The axle load projections were expressed as annual axle load spectra for single, tandem, and triple axles, and were placed into IMS computed parameter tables. The projection results for all LTPP sites are summarized in Appendix A. To overcome the difficulty of estimating traffic loads for the remaining 332 LTPP sites, it was proposed to develop the LTPP Pavement Loading Guide (PLG). The report contains a description of the purpose, design parameters, and functionality of the PLG, a blueprint for the development of the PLG, and two examples of using the PLG to obtain traffic load projections for LTPP sites without site-specific truck class and/or axle load data. The recommended traffic analysis activities include the development of the LTPP PLG, completing traffic load projections for all LTPP sites, and the development of a comprehensive action plan for better utilization of the existing traffic data. The recommended components of the action plan include a comprehensive quality assurance process, use of monthly traffic data for estimating traffic loads, and regional traffic modeling utilizing both LTPP traffic data and other traffic data.

Application/Use: This study developed axle load projections for LTPP traffic sites. The data can be used by those interested in using LTPP traffic data.

Contribution: Improvement in Knowledge

Present Benefit: Traffic information is a key component to pavement performance modeling. The work conducted in this study is useful in that it provides information on the quality of traffic data as well as axle load projections for LTPP sites. Researchers can use this information to better understand the traffic data available in the LTPP database and use the axle load projects for modeling. Additionally, the methodology developed may be applied to other locations outside of LTPP.

Future Benefit: LTPP sections will likely be for local calibration and validation as part of implementing the M-E PDG. Because traffic is a critical input in the M-E PDG, the availability of traffic information in the LTPP database will benefit those agencies evaluating and/or utilizing the M-E PDG prediction capabilities at a local level.

Title: Freight Data Assessment

Author(s): Felsburg Holt & Ullevig, Cambridge Systematics

Date: July 2005

Publisher: Colorado Department of Transportation

Abstract/Synopsis: The importance of freight movement to Colorado is evident by the level of truck and train activity experienced on the state's highway and rail systems. With a large portion of the state's economy related to natural resources and agriculture, there are huge demands to move these products throughout the state. The rapidly growing urban areas in the state also need many products and goods to support their growth. Furthermore, Colorado is strategically located as a "bridge" state in the national and international infrastructure system for movement of freight, resulting in large quantities of goods flowing through the state. Yet, to date freight mobility has not been a major focus within either the statewide transportation planning process or the development of regional transportation plans. Recognizing the need to improve upon this situation, the Colorado Department of Transportation (CDOT) has undertaken a significant effort to determine the effect of freight activity on the state's transportation system and the corresponding needs that address those activities. As part of the CDOT freight planning process, Governor Owens, in conjunction with CDOT, created a Freight Advisory Committee (FAC) comprised of users and providers of freight transportation. Understanding that good freight transportation planning will rely on a solid base of relevant data, the Freight Advisory Committee recommended that CDOT fulfill a leadership role in the collection and dissemination of such data. CDOT, concurring with this recommendation, has undertaken this study as a first step in defining its appropriate roles and responsibilities and in developing a framework for a proper data collection program.

Application/Use: This assessment can be used by those interested in freight movement through Colorado.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: This freight assessment utilized LTPP traffic data, along with other data sources, to understand truck movement on key routes in Colorado. The results from the study will help Colorado in transportation planning. Because of the comprehensive nature of the LTPP program, the data can support a large variety of research, some of which is quite removed from pavement engineering while still beneficial to the traveling public.

Future Benefit: It is well recognized that the LTPP database will continue to support research in the pavement community. While the future benefit provided by the program to endeavors outside of pavement engineering is not as obvious, it is likely that the LTPP program will enable evaluations that otherwise could not have been performed. In other cases, the LTPP program will supplement existing information to produce more robust findings.

Title: Improving Traffic Characterization to Enhance Pavement Design and Performance: Load Spectra Development

Author(s): Al-Yagout, Mohammad A; Mahoney, Joe P; Pierce, Linda M; Hallenbeck, Mark E.

Date: March 2005

Publisher: Washington State Department of Transportation

Abstract/Synopsis: This research addresses the understanding of, and need for, load spectra in future pavement design procedures and as a stepping stone toward more complete pavement design. The primary objective of this project was to develop truck axle load spectra for Washington State. To do this, axle load data collected at WIM stations throughout Washington State were used. The developed load spectra encompass the principal truck axles on the roadway network: single, tandem, and tridem. Achieving this objective allows the Washington State Department of transportation, or any state highway agency with analogous traffic patterns, to accommodate the requirements of the 2002 Design Guide, developed through NCHRP Project 1-37A. A secondary objective of this project was to determine whether ESALs obtained from the developed load spectra are significantly different from historical values. Because the developed load spectra are transformable to ESALs, state highway agencies that decide not to use the new guide can still choose to employ the ESALs produced with the load spectra. The project concluded that the developed load spectra are reasonable. For single axles they are comparable to the 2002 Design Guide and MnROAD defaults. For tandem and tridem axles they are slightly more conservative than defaults of the 2002 Design Guide and MnROAD, but they are still within reason. In addition, the ESALs per vehicle class associated with the developed load spectra are comparable to Washington State historical ESALS for vehicle classes 9, 10, and 13. The use of the newly developed ESALs per vehicle will generally increase design ESALs, but that increase will be due to inclusion of the less predominant vehicle classes (4, 6, 7, 8, and 11).

Application/Use: This is directly applicable to traffic data analysis as well as pavement design.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology.

Present Benefit: Load spectra data offers a comprehensive summary of traffic loading information. Weigh-in-motion equipment installed specifically for the LTPP project can be used to supplement Agency's existing network of traffic monitoring devices. This information coupled with the inventory and performance monitoring data collected on LTPP test sections are extremely valuable for pavement research projects.

Future Benefit: Load spectra information available at LTPP sites will continue to provide benefit to State Highway Agencies, particularly in the validation and calibration of the M-E PDG. Upon proper implementation of the guide, the LTPP traffic information will be used as input into the pavement design process for projects within close proximity of the monitoring equipment.

Title: Sensitivity Analysis of Rigid Pavement Systems Using Mechanistic-Empirical Pavement Design Guide

Author(s): Guclu, Alper; Ceylan, Halil

Date: 2005

Publisher: Iowa State University, Ames

Conference Title: Proceedings of the 2005 Mid-Continent Transportation Research Symposium

Abstract/Synopsis: Pavement design procedures available in the literature do not fully take advantage of mechanistic design concepts, and as a result, heavily rely on empirical approaches. Because of their heavy dependence on empirical procedures, the existing rigid pavement design methodologies do not capture the actual behavior of Portland Cement Concrete (PCC) pavements. However, reliance on empirical solutions can be reduced by introducing mechanistic-empirical methods, now adopted in the newly released Mechanistic-Empirical Pavement Design Guide (MEPDG). This new design procedure incorporates a wide range of input parameters associated with the mechanics of rigid pavements. A study was undertaken to compare the sensitivity of these various input parameters on the performance of concrete pavements. Two Jointed Plain Concrete Pavement (JPCP) sites were selected in Iowa. These two sections are also part of the Long Term Pavement Performance (LTPP) program, where a long history of pavement performance data exists. Data obtained from the Iowa Department of Transportation (Iowa DOT) Pavement Management Information System (PMIS) and LTPP database were used to form two standard pavement sections for the comprehensive sensitivity analyses. The sensitivity analyses were conducted using the MEPDG software to study the effects of design input parameters on pavement performance, specifically faulting, transverse cracking, and smoothness. Based on the sensitivity results, the rigid pavement input parameters were ranked and categorized from most sensitive to insensitive to help pavement design engineers to identify the level of importance for each input parameter. The curl/warp effective temperature difference (built-in curling and warping of the slabs) and PCC thermal properties are found to be the most sensitive input parameters. Based on the comprehensive sensitivity analyses, the idea of developing an expert system is introduced to help the designer identify the input parameters that can be modified to satisfy the predetermined pavement performance criteria.

Application/Use: This paper is useful in implementing the M-E PDG for PCC pavements and of particular interest for pavement designers in Iowa.

Contribution: Improvement in Knowledge

Present Benefit: The M-E PDG implementation process consists of evaluating the sensitivity of the predictions. This paper provides insight into sensitivity for PCC pavements and will aide in establishing the level of effort necessary to quantify material properties used in the M-E PDG.

Future Benefit: As additional agencies begin implementing the M-E PDG, findings from this study will continue to be used as a reference. The LTPP database will also be utilized by many agencies in the implementation process.

Title: LTPP WIM Index Software Manual, Version 1.0

Date: 2004

Publisher: FHWA, McLean, Virginia

Abstract/Synopsis: This document provides an overview of the computer program that implements the procedure developed by the LTPP Technical Support Services Contractor (TSSC) to process profile data for the evaluation and selection of Weigh-In-Motion (WIM) sites

Application/Use: This manual and the associated software have been used by agencies installing WIM equipment.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: Through work under LTPP, WIM smoothness has been identified as a key component in the calibration and accuracy of WIM equipment. Improved traffic loading estimates result in cost-effective pavement designs. This can lead to significant savings.

Future Benefit: Load spectra data is required for level 1 pavement design using the M-E PDG, and calibrated WIM equipment is essential for obtaining this level of traffic data. As the industry moves towards M-E pavement design, additional WIM equipment will be required. This manual and associated software will assist in the installation and calibration of these WIM sites.

Title: Pavement Smoothness at Weigh-in-Motion Sites: Developing Specifications for the Long-Term Pavement Performance Program

Author(s): Karamihas, S. M; Rada, G R; Ostrom, B. K; Simpson, A. L; Wiser, L. J.

Date: 2004

Publisher: Transportation Research Board

Journal Title: Transportation Research Record No. 1870

Abstract/Synopsis: Accurate traffic data are vital to the success of the Long-Term Pavement Performance (LTPP) program. To minimize dynamic motions and therefore improve the accuracy of traffic loading data at weigh-in-motion (WIM) scales, pavement smoothness specifications were developed to screen sites for excessive truck dynamic loading that exacerbates scale error beyond ASTM recommended tolerances. WIM scale error was related to pavement profile characteristics by using a large simulation study of the response of virtual trucks over measured profiles. A distribution of error was compiled over the truck population for steer axle, tandem axle, and total vehicle weight at each site. The error distributions were summarized by their 95th percentile absolute error levels. The error levels assigned to each site were then used as a correlation standard for the proposed roughness indices and for the selection of corresponding threshold values. Instead of a single index, two versions of the Butterworth filter were selected for use in the specifications. One addresses short-range roughness and the other long-range roughness. The short- and long-range WIM error indices were then statistically related to WIM scale error to set the threshold values. An overview is presented of the development of the pavement smoothness specifications, including indices and threshold values.

Application/Use: The smoothness specifications developed have been used by state highway agencies in evaluating existing WIM sites as well as selecting locations for proposed installations.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology; Implementation/Usage.

Present Benefit: Quality traffic data is essential to pavement design. Understanding and mitigating the effect of pavement smoothness on traffic data collection will result in more efficient pavement designs. The specifications developed as part of this study can be used by highway agencies in evaluating existing and proposed WIM locations.

Future Benefit: The findings as specifications will be used to evaluate and select locations for future WIM equipment installations. Improved data collected at these sites will provide better traffic estimates and will result in better performing pavement designs.

Title: Traffic Load Spectra Development for the 2002 AASHTO Design Guide

Author(s): Buchanan, M. S.

Date: 2004

Publisher: Mississippi State University; Mississippi Department of Transportation; Federal Highway Administration

Abstract/Synopsis: Accurate knowledge of traffic volumes and loading is essential to structural pavement design and performance. Underestimation of design traffic can result in premature pavement failures and excessive rehabilitation costs. Overestimation can result in overly conservative pavement designs that are not cost effective for the owner agency. Traffic input for the anticipated National Cooperative Highway Research Program (NCHRP) 1-37A Design Guide will be in terms of axle load spectra along with several other important traffic parameters. Axle load spectra consist of classifying traffic loading in terms of the number of load applications of various axle configurations (single, dual, and tridem) within a given weight classification range. Long-Term Pavement Performance (LTPP) data from Mississippi sites were extensively reviewed to determine vehicle class distribution, monthly and hourly distribution factors, and axle load spectra. These data will serve as baseline data for Mississippi Department of Transportation implementation of the new mechanistic-empirical structural pavement design guide.

Application/Use: This study and LTPP traffic data will be used by Mississippi DOT in implementation and use of the M-E PDG.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: The LTPP program has collected extensive traffic data that can be used in developing axle load spectra for purposes of pavement design. Accurate traffic information is essential to cost-effective design.

Future Benefit: The traffic data available from the LTPP database will be valuable to agencies looking to implement and use the M-E PDG. The available data will serve as a crucial starting point for many agencies, and will supplement future data collection activities.

Title: A Traffic Data Plan for Mechanistic- Empirical Pavement Designs (2002 Pavement Design Guide)

Author(s): Cottrell, B. H; Schinkel, T. O; Clark, T. M.

Date: October 2003

Publisher: Virginia Transportation Research Council

Abstract/Synopsis: The Virginia Department of Transportation (VDOT) is preparing to implement the mechanistic-empirical pavement design methodology being developed under the National Cooperative Research Program's Project 1-37A, commonly referred to as the 2002 Pavement Design Guide (2002 Guide). The developers of the 2002 Guide have stated that transportation agencies in compliance with the Federal Highway Administration's *Traffic Monitoring Guide* will have the traffic data necessary to implement the new pavement design approach. The 2002 Guide is structured in a hierarchical manner with three pavement design levels. For Level 1 designs, all project-specific data will be collected, including axle load spectra information (and axle loadings by vehicle classification) and vehicle classification counts at the project location. For Level 2 designs, regional and project-specific data will be applied. For Level 3 designs, estimated project-specific and statewide average or default data will be used in the analysis.

The purpose of this effort was to develop a plan to position VDOT to collect traffic and truck axle weight data to support Level 2 pavement designs. This report serves as the basis for implementing and maintaining the truck weigh program necessary for the new pavement design approach and provides data for the current pavement design process used in Virginia (i.e., the 1993 pavement design methodology of the American Association of State Highway and Transportation Officials).

To keep program costs at a minimum, the proposed traffic data program for pavement design takes advantage of the flexibility permitted in the *Traffic Monitoring Guide* and the availability of weigh-in-motion data from the Virginia Department of Motor Vehicles. Truck weight Groups 1 and 2, which consist of interstate and arterial roads, where the majority of truck loading occurs, are the first priority for implementation. A traffic data plan and a phased approach to implement the plan were proposed.

Application/Use: The results from this study can be used by Virginia in preparing for the implementation of the M-E PDG.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: LTPP has contributed significantly to the advancement of traffic data collection. Data from LTPP sites will be utilized in establishing traffic information for the overall highway network in Virginia. Experience gained from collecting data on LTPP sites will also benefit Virginia as part of the M-E PDG implementation process. Additionally, equipment installed, calibrated and monitored as part of the SPS Traffic Pooled Fund Study will supplement the network of data collection equipment. Through

Virginia's LTPP traffic monitoring efforts, significant steps have already been taken towards their implementation of the M-E PDG.

Future Benefit: Traffic monitoring advancements made by the LTPP program will have a lasting effect on pavement design. The M-E PDG requires site specific load spectra data for Level 1 design. The procedures established through LTPP protocols ensure quality load spectra information will be collected. This will help agencies in installing new equipment and ensuring that LTPP equipment already installed will serve as an addition data source.

Title: Cumulative Traffic Prediction Method for Long-Term Pavement Performance Models

Author(s): Byrum, C. R; Kohn, S. D.

Date: 2002

Publisher: Transportation Research Board

Journal Title: Transportation Research Record No. 1816

Abstract/Synopsis: A method used to develop predictive models for estimating cumulative traffic volumes for Federal Highway Administration Long-Term Pavement Performance (LTPP) test sections is presented. The purpose of developing cumulative traffic prediction models for each LTPP site is so that distress and roughness development can be compared with cumulative traffic volumes for the various pavement types and conditions in the LTPP study. There are two types of LTPP traffic data: historical estimates and monitoring data. Predictive models from this study are based on the combined monitoring and historical LTPP traffic data available in January 2000 and designated Level E data. The models attempt to predict the cumulative kilo-equivalent single-axle loads for the LTPP test sections corresponding to any profiling date or distress survey date. The modeling method is described and consists of fitting an exponential growth curve to each site's data. As a result of the high variability of the LTPP traffic data and some apparent errors in the data, considerable judgment in the form of deleting and changing the reported LTPP data was required before the modeling process. Examples of reported versus back-predicted traffic curves are presented for various traffic conditions encountered. Some differences in historical and monitoring traffic data are shown. Some trends in the traffic data that affect the fitting of exponential growth-type predictive models to the data are described. Methods used to address these trends during model development are discussed.

Application/Use: This paper is directly applicable to those interested in estimating cumulative ESAL loads for LTPP sites.

Contribution: Improvement in Knowledge

Present Benefit: The benefit of this study is in the ability to link performance data (i.e., distress or profile information) to traffic loading, which is useful in prediction modeling and performance comparisons.

Future Benefit: Traffic data collected at LTPP sites can be useful in estimating traffic for design purposes in nearby locations. The algorithms developed in this study may also be useful in using other sources of traffic data to estimate cumulative loading for design or pavement evaluation purposes.

Title: Improving Reliability of Pavement Loading Estimates with Pavement Loading Guide

Author(s): Hajek, J. J; Selezneva, O; Jiang, J. Y; Mladenovic, G.

Date: 2002

Publisher: Transportation Research Board

Journal Title: Transportation Research Record No. 1809

Abstract/Synopsis: The development of the Long-Term Pavement Performance (LTPP) Pavement Loading Guide (PLG) was initiated to improve the reliability of traffic load estimates for the LTPP sections that do not have measured axle load data. The PLG contains extensive traffic data obtained from the LTPP database that may constitute the best available source of traffic data at the national level, a user-friendly graphical interface, and guidelines intended to help the user with the development of axle load spectra. Because of these features, the PLG will also facilitate traffic projections for

Title: ITS: Enriching Our Lives - State Truck Activities Reporting System

Author(s): Stephens, J; Carson, J; Hult, D. A; Bisom, D.

Date: 2002

Publisher: ITS America

Conference Title: 9th World Congress on Intelligent Transport Systems

Abstract/Synopsis: With the advent of automatic vehicle identification (AVI) and weigh-in-motion (WIM) technologies, the ability to collect data on commercial vehicle operations has been greatly enhanced. Still lacking however, is a means to effectively and efficiently utilize this data to achieve long-term infrastructure preservation. The Montana Department of Transportation (MDT) has recently developed a new system that focuses on just that. The State Truck Activities Reporting System, or STARS, consists of an array of WIM sensors deployed across the Montana highway system that feed data to customized software programs. The software can subsequently be used to characterize commercial vehicle operations by classification and weight, and to further perform extensive analyses specifically addressing overweight commercial vehicle operations. This implementation contributes to the accomplishment of the data collection objectives of the national Long Term Pavement Performance (LTPP) Program and the Commercial Vehicle Information Systems and Networks (CVISN) initiative. In cooperation with Montana State University (MSU), a project is currently underway to comprehensively evaluate the impact of STARS on various MDT activities. Specific tasks being evaluated in this regard include: (1) truck weight enforcement, (2) roadway design, (3) project-level engineering and long-range planning efforts and (4) data collection and reporting activities to meet FHWA Traffic Monitoring Guide (TMG), FHWA truck weight study, and LTPP program requirements.

Application/Use: WIM technology is applicable to many facets of very highway agency.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP.

Future Benefit: Quality traffic data will provide future benefit in more cost-effective pavement designs. The ability to collect traffic load spectra data is also very important as it is integral part of the M-E PDG.

Title: North American Travel Monitoring Exhibition and Conference 2002 (NATMEC 2002) and Third International Conference on Weigh-in-Motion (ICWIM3), Orlando, Florida, May 12-16, 2002

Date: 2002

Publisher: Florida Department of Transportation; Federal Highway Administration; Transportation Research Board

Conference Title: North American Travel Monitoring Exhibition and Conference 2002 (NATMEC 2002) and Third International Conference on Weigh-In-Motion (ICWIM3)

Abstract/Synopsis: This CD-ROM contains the presentations from the combined North American Travel Monitoring Exhibition and Conference 2002 (NATMEC 2002) and Third International Conference on Weigh-In-Motion (ICWIM3). There is a brief summary of each presentation with access to the PowerPoint presentations. Both combined and separate sessions were held for the two conferences. The NATMEC 2002 sessions featured presentations on data (Track A), management (Track B), and freight/Intelligent Transportation Systems (ITS) (Track C). Track A focused on traditional and non-traditional sensors, data archiving, quality control of data, Long Term Pavement Performance (LTPP) Specific Pavement Studies, automatic traffic recorder fundamentals, weigh-in-motion, and the forthcoming pavement design guide. Track B examined the privatizing of traffic monitoring programs, non-traditional data sources, travel time data collection and analysis, remote sensing, integration of data sources, metropolitan planning organization uses of urban traffic monitoring, and future data programs and performance measures. Track C focused on congestion management system (CMS) utilization of travel information and traffic data, issues in urban traffic data, the estimation of truck traffic volumes, making the connection between ITS and traffic monitoring, ITS archived data, monitoring for North American cross border traffic, innovative uses and applications of ITS/operation data archives, and geographic information system (GIS) and Web tools to organize urban traffic data. The ICWIM3 sessions discussed WIM testing; WIM standards; WIM products; WIM technologies; enforcement using WIM; data quality, management and use; application of WIM to structures; and freight mobility, road safety and pricing.

Application/Use: The proceedings from this joint conference can be of use in many areas of traffic monitoring and evaluation.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP.

Future Benefit: Quality traffic data will provide future benefit in more cost-effective pavement designs. The ability to collect traffic load spectra data is an integral part of the M-E PDG.

Title: Pavement Smoothness Specifications for LTPP WIM Locations

Author(s): Rada, G. R; Karamihas, S; Perera, R.

Date: 2002

Publisher: Iowa State University, Ames; Federal Highway Administration; Florida Department of Transportation; Center for Transportation Research and Education

Conference Title: Third International Conference on Weigh-in-Motion (ICWIM3)

Abstract/Synopsis: Accurate traffic data is of paramount importance to the Long-Term Pavement Performance (LTPP) study. To minimize dynamic motions and therefore improve data accuracy at Weigh-in-Motion (WIM) sites, LTPP has developed smoothness specifications for both short and long pavement wavelengths. They are intended to minimize axle motion effects and vehicle body bounce, respectively. The specifications, which are the subject of this paper, will be used for WIM verification and annual checks as well as acceptance of new WIM sites.

Application/Use: This paper will be used by state highway engineers interested in collecting high quality traffic data.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology.

Present Benefit: Traffic data is a key component in pavement design. Designs based on inaccurate traffic data can lead to overly conservative structural pavement sections or pavements with inadequate capacity. Either case leads to inefficient use of resources. Therefore, it is critical to collect high quality traffic data and the LTPP program has been a tremendous force in improving the practice. This document is just one testament to the contribution of the LTPP program to improved traffic data.

Future Benefit: The work done as part of the LTPP program in the traffic data collection arena will add tremendous value to the highway community. The protocol developed will continue to be used as agencies install new equipment, calibrate existing equipment, and review collected data. The end result will be cost-effective pavement designs with better overall pavement performance.

Title: Vehicle Classification Validity checks for LTPP WIM Data

Author(s): Southgate, H.

Date: 2002

Publisher: Iowa State University, Ames; Federal Highway Administration; Florida Department of Transportation; Center for Transportation Research and Education

Conference Title: Third International Conference on Weigh-in-Motion (ICWIM3)

Abstract/Synopsis: Traffic data from the Long Term Pavement Performance Program (LTPP) were examined for accuracy. A method was developed that would be more accurate than the current algorithms and misapplications within the data. The same method can be made applicable to both automatic vehicle classification (AVC) and weigh-in-motion (WIM).

Application/Use: This paper will be used by state highway engineers interested in collecting high quality traffic data.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology.

Present Benefit: Traffic data is a key component in pavement design. Designs based on inaccurate traffic data can lead to overly conservative structural pavement sections or pavements with inadequate capacity. Either case leads to inefficient use of resources. Therefore, it is critical to collect high quality traffic data and the LTPP program has been a tremendous force in improving the practice. This document is just one testament to the contribution of the LTPP program to improved traffic data.

Future Benefit: The work done as part of the LTPP program in the traffic data collection arena will add tremendous value to the highway community. The protocol developed will continue to be used as agencies install new equipment, calibrate existing equipment, and review collected data. The end result will be cost-effective pavement designs with better overall pavement performance.

Title: Framework for the Development of a Statewide Equivalent Single Axle Load (ESAL) Table for Use in Pavement Management Systems

Author(s): Alavi, Sirous; Senn, Kevin; Kombe, Estomih; Papagiannakis, Thomas

Date: 2001

Publisher: University of Washington, Seattle

Conference Title: Fifth International Conference on Managing Pavements

Abstract/Synopsis: Establishing, maintaining, and enhancing the statewide network of roads are among the most important goals of any state highway agency. These require huge investments of both financial and human resources year in and year out. Accordingly, it makes good sense to apply sound engineering practices to ensure these resources are allocated wisely. One of the fundamental and universally sought parameters that influence all new pavement and rehabilitation design decisions is traffic. For a given road segment, accurate estimates of current and projected traffic [in terms of Equivalent Single Axle Loads (ESALs)] can result in significant cost savings, either from the standpoint of initial construction cost or from future maintenance and rehabilitation cost. The primary objective of this paper is to describe the methodology used to prepare a new ESAL design table for the State of Arizona’s highway network. This new table is based on analysis of traffic data collection procedures, traffic forecasting methodology, and ESAL development procedures, including the assignment of traffic ESAL values to the various highway segments. The new ESAL table is also based on recently acquired information such as provided by weigh-in-motion (WIM) systems. The research activities described in this paper take full advantage of the Federal Highway Administration’s Long-Term Pavement Performance (FHWA-LTPP) traffic data. The framework described in this paper can be utilized by other state agencies in developing new statewide ESAL (or load) tables based on the most recent and best available data. The framework described in this paper can be utilized in developing ESAL (or load spectra) tables for use in statewide pavement management systems.

Application/Use: The ESAL table developed was used by Arizona DOT for design and pavement management purposes.

Contribution: Cost Savings; Implementation/Usage.

Present Benefit: The data collected as part of the LTPP program served as a basis for the development of accurate traffic estimates for the Arizona DOT pavement network. Accurate traffic estimates are essential not only for cost-effective pavement designs, but also for proper selection and timing of pavement treatments as part of pavement management.

Future Benefit: Components of the ESAL table developed can support the development of load spectra data. This will be beneficial to Arizona DOT in the implementation of the M-E PDG.

Title: Guide to LTPP Traffic Data Collection and Processing

Date: 2001

Publisher: FHWA, Office of Infrastructure Research and Development, McLean, VA

Abstract/Synopsis: This document supersedes Chapter 4: Traffic Data Collection of the Data Collection Guide developed by SHRP. Data sheets and instructions for submitting traffic data for test sections, as well as the protocols for calibrating traffic data collection equipment, are included in this document. These guidelines reflect the revised traffic data collection plan developed for LTPP, as well as other minor changes that occurred since Chapter 4 was last produced in 1993. The document discusses traffic data relative both to the LTPP Central Traffic Database (CTDB) and to the LTPP Information Management System (IMS).

This guide is supplemented by various other documents including:

- LTPP Traffic QC Software Manual
- LTPP Traffic Directives

Application/Use: The guide documents the LTPP processes and procedures to collect and store the traffic data used in calculating pavement loadings. It also includes LTPP's instructions for the selection, location, installation and calibration of traffic data collection equipment.

Contribution: Cost Savings, Advancement in Technology; Improvement in Knowledge.

Present Benefit: The LTPP Program was at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

The documents associated with the Traffic Data Collection Guide (i.e., the QC Software Manual and Traffic Directives) further assist analysts in understanding the data contained in the LTPP database and practitioners in obtaining and preparing high quality traffic data. By utilizing these tools, practitioners can ensure they are not wasting resources obtaining traffic data of questionable value.

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. The Traffic Data Collection Guide and its associated documents will enable future users to understand the methodologies LTPP utilized to collect and process quality traffic data, including the differences in data present in the CTDB and the IMS.

Title: Equipment Selection and Site Installation for LTPP SPS WIM Sites

Date: 2000

Publisher: Wisconsin Department of Transportation

Conference Title: North American Travel Monitoring Exhibition and Conference (NATMEC)

Abstract/Synopsis: The Long-Term Pavement Performance Program (LTPP) has intensified its efforts to obtain sufficient quantities of research quality loading data at a number of Specific Pavement Studies (SPS) sites. As one part of this effort, the Federal Highway Administration (FHWA) has consulted with the Transportation Research Board LTPP Traffic Expert Task Group for a recommendation for equipment with a significant field history of reliable, low variability, continuous operations. LTPP acknowledges that more than one technology may be capable of achieving the specified performance, however, as with all other LTPP equipment protocols, a single package of sensors, software and pavement performance requirements has been selected as the basis of a set of model specifications. The model specifications are for high-speed bending plate weigh-in-motion (WIM) in a portland cement concrete slab 300 feet long. Installed equipment is expected to meet ASTM E-1318 tolerances for Type I equipment based on axle weights, gross vehicle weights, speeds and axle spacings. A separate smoothness specification has been developed which is partially referenced by incorporation in the grinding criteria for pavements. The details on the verification of scale performance are in a separate document. The specifications are provided as if they were actual contract documents. They are divided into two parts: a hardware and software package, and installation procedures including two options for a portland cement concrete slab.

Application/Use: The research conducted under LTPP in the area of WIM installation and data collection will be useful in all aspects of pavement design, maintenance, and research.

Contribution: Cost Savings; Advancement in Technology; Implementation/Usage.

Present Benefit: The specifications not only provide standards for internal use by LTPP but can also be used by agencies installing non-LTPP WIM systems. The protocols and specifications ensure the highest quality data is being collected. Accurate traffic information is crucial for design and research applications.

Future Benefit: The work conducted by LTPP with traffic data collection and monitoring will be beneficial to the highway community for many years to come. The advancement in technology will provide engineers with a better picture of traffic loading. The traffic data collected under these guidelines will not only be beneficial to the implementation of the M-E PDG but also in additional research supporting the M-E PDG and other endeavors.

Title: Estimating Cumulative Traffic Loads, Final Report for Phase 1

Author(s): Hajek, J. J; Selezneva, O. I.

Date: 2000

Publisher: ERES Consultants, Incorporated; Federal Highway Administration

Abstract/Synopsis: The knowledge of traffic loads is a prerequisite for the pavement analysis process, especially for the development of load-related distress prediction models. Furthermore, the emerging mechanistically based pavement performance models and pavement design methods (such as the anticipated "2002 Pavement Design Guide") require the knowledge of the load spectra acting on the pavement during its lifespan. This report describes a procedure for obtaining axle load spectra for Long Term Pavement Performance (LTPP) sections. The procedure has been demonstrated and evaluated by applying it to 12 LTPP sections for which different amounts of monitoring traffic data were available. Typically, for the majority of LTPP sections, there are only a few years for which the traffic load data were collected by automated equipment in the mid-1990s. To obtain axle load spectra for all in-service years, traffic loads must be projected: backcasted (for the years before the installation of traffic monitoring equipment) and forecasted (for the years after the automated equipment no longer provides data). This report also contains a review of the evolution of motor carrier technology (in terms of economical and political changes, regulatory changes in vehicle weights and dimensions, and engineering changes) and its impact on traffic loads, and a proposal to develop and use new summary statistical measures and tools for the management of load spectra. Major findings and recommendations include: (1) Traffic load projections for the majority of LTPP sites are feasible. (2) The accuracy and reliability of the traffic projections for many of the LTPP sites may not be as high as originally anticipated. (3) The involvement of State highway agencies (SHAs) in the traffic projection process is crucial. (4) The traffic projection process is very challenging and labor-intensive. The main reason for the labor-intensive process is the need to carry out extensive quality assurance activities to resolve inconsistencies in the reported traffic data. (5) The quality assurance process would greatly benefit from developing a knowledge base or a catalog documenting a typical range of traffic load variables. The process would also benefit from the availability of summary measures for traffic loads that are independent of pavement variables. (6) Traffic modeling and forecasting is a highly cost-effective way to extend limited sampling data and compensate for the lack of data. To obtain payback on the large investment in the traffic data collection effort by SHAs, it is necessary to allocate sufficient resources to utilize fully the available traffic data through the traffic prediction process. (7) It is recommended to proceed with carrying out traffic load projections for the selected LTPP sites (Phase 2 study). (8) Phase 2 study, and any future projection of traffic loads, should include the input from the representatives of SHAs.

Application/Use: This study developed axle load projections for LTPP traffic sites. The data can be used by those interested in using LTPP traffic data.

Contribution: Improvement in Knowledge

Present Benefit: Traffic information is a key component to pavement performance modeling. The work conducted in this study is useful in that it provides information on the quality of traffic data as well as axle load projections for LTPP sites. Researchers can use this information to better understand the traffic data available in the LTPP database, and can use the axel load projects for modeling. Additionally, the methodology developed may be applied to non-LTPP locations.

Future Benefit: LTPP sections will likely be used to locally calibrate/validate as part of implementing the M-E PDG. Because traffic is a critical input in the M-E PDG, the availability of traffic information in the LTPP database will add benefit to those agencies evaluating the M-E PDG prediction capabilities at a local level.

Title: Smoothness Criteria for Construction and In-Service Conditions for LTPP SPS WIM Sites

Date: 2000

Publisher: Wisconsin Department of Transportation

Conference Title: North American Travel Monitoring Exhibition and Conference (NATMEC)

Abstract/Synopsis: The Long-Term Pavement Performance Program (LTPP) has intensified its efforts to obtain sufficient quantities of research quality loading data at a number of Specific Pavement Studies (SPS) sites. Recognizing that pavement smoothness has a significant impact on the variability of the data obtained, the Federal Highway Administration (FHWA) has consulted with the Transportation Research Board LTPP Traffic Expert Task Group and the Distress and Profile Expert Task Group on the development of a pavement smoothness specification for weigh in motion (WIM) installations. The smoothness specifications apply to both newly constructed and in-service pavements. Newly constructed pavements are evaluated using both longitudinal and transverse profile measurements. In-service pavements are evaluated based on longitudinal profile measurements to eliminate the need to close lanes. Both short wave and long wave measurements are considered in evaluating the possible vehicle dynamic effects at the WIM site. The long wave length specifications are still in the preliminary stages of development.

Application/Use: This paper will be used by state highway engineers interested in collecting high quality traffic data.

Contribution: Cost Savings; Advancement in Technology; Implementation/Usage.

Present Benefit: Traffic data is a key component in pavement design. Designs based on inaccurate traffic data can lead to overly conservative structural pavement sections or pavements with inadequate capacity. Either case leads to inefficient use of resources. Therefore, it is critical to collect high quality traffic data and the LTPP program has been a tremendous force in improving the practice. This document is just one example of the many contributions by the LTPP program in improving traffic data.

Future Benefit: The work done as part of the LTPP program in the traffic data collection arena will add tremendous value to the highway community. The protocol developed will continue to be used as agencies install new equipment, calibrate existing equipment, and review collected data. The end result will be cost-effective pavement designs with better overall pavement performance.

Title: Verification of LTPP SPS WIM Sites

Date: 2000

Publisher: Wisconsin Department of Transportation

Conference Title: North American Travel Monitoring Exhibition and Conference (NATMEC)

Abstract/Synopsis: The Long-Term Pavement Performance Program (LTPP) has intensified its efforts to obtain sufficient quantities of research quality loading data at a number of Specific Pavement Studies (SPS) sites. As one part of this effort, the Federal Highway Administration (FHWA) has consulted with the Transportation Research Board LTPP Traffic Expert Task Group on a methodology to check the calibration of weigh-in-motion equipment. LTPP recognizes that there are multiple methodologies to actually calibrate WIM equipment, however, as with all other LTPP equipment protocols; a single methodology is being selected for verifying equipment calibration on a national basis. This provides a common reference for data users as to the quality standards expected of the data they have been provided. The methodology selected and the software referenced is included for participant reference. This document provides guidelines for verifying the accuracy of WIM systems for collecting LTPP traffic data at SPS 1, 2, 5, and 6 sites.

Application/Use: This paper will be used by state highway engineers interested in collecting high quality traffic data.

Contribution: Cost Savings; Advancement in Technology; Implementation/Usage.

Present Benefit: Traffic data is a key component in pavement design. Designs based on inaccurate traffic data can lead to overly conservative structural pavement sections or pavements with inadequate structural capacity. Either case leads to inefficient use of resources. Therefore, it is critical to collect high quality traffic data and the LTPP program has been a tremendous force in improving the practice. This document is one testament to the LTPP program's contribution to improving traffic data quality.

Future Benefit: The work done as part of the LTPP program in the traffic data collection arena will add tremendous value to the highway community. The protocol developed will continue to be used as agencies install new equipment, calibrate existing equipment, and review collected data. The end result will be cost-effective pavement designs with better overall pavement performance.

Title: Effect of Weight-Mile Tax on Road Damage in Oregon

Author(s): Rufolo, Anthony; Bronfman L; Kuhner, E.

Date: September 1999

Publisher: Oregon Department of Transportation, Federal Highway Administration

Abstract/Synopsis: Oregon's weight-mile tax was amended in 1990 to provide for a lower tax rate for trucks weighing more than 80,000 pounds if they added axles. The additional axles within a weight class reduce the amount of road damage. The tax break was largely based on equity considerations, since trucks within a weight class tend to do less road damage if they have more axles; however, the tax reduction also created an economic incentive to add axles and thus reduce road damage. This project attempted to determine if the tax break actually led to an increase in the number of axles within weight classes, which would result in a reduction in the amount of road damage. An analysis of statistical data indicated that there has been a small increase in the number of axles in most weight classes, but it was not possible to determine if this was due to the weight-mile tax. A series of structured interviews supplemented the statistical analysis and indicated that the tax incentive was not a major determinant of truck configuration. One probable reason is that regulatory constraints limit the effectiveness of the tax incentives.

Application/Use: This evaluation is applicable to those who are making policy decisions regarding road use tax rates.

Contribution: Improvement in Knowledge

Present Benefit: This report demonstrates the use of the LTPP database for purposes outside of pavement engineering. LTPP traffic data was one of the main sources used in the evaluation of the effectiveness of tax incentives. Because of the comprehensive nature of the LTPP program, the data can support a large variety of research, some of which is quite removed from pavement engineering while still beneficial to the traveling public.

Future Benefit: It is well recognized that the LTPP database will continue to support research in the pavement community. While the future benefit provided by the program for endeavors outside of pavement engineering is not as obvious, it is likely that the LTPP program will enable evaluations that otherwise could not be performed. In other cases, the LTPP program will supplement existing information to produce more robust findings.

Title: Accuracy of LTPP Traffic Loading Estimates

Date: 1998

Publisher: Federal Highway Administration

Journal Title: LTPP TechBrief

Abstract/Synopsis: 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" (available at http://www.chapsys.com/ltpp_web/ltpp7.htm). The purpose of this TechBrief is to present key findings and products that resulted from the report.

Application/Use: This study investigates the effect of loading rates on axle load projections for LTPP traffic sites. The data can be used by those interested in using LTPP traffic data.

Contribution: Improvement in Knowledge

Present Benefit: Traffic information is a key component to pavement performance modeling. The work conducted in this study is useful in that it provides information on the traffic data quality as well as axle load projections for LTPP sites. Researchers can use this information to better understand the traffic data available in the LTPP database and use the axle load projects for modeling. Additionally, the methodology developed may be applied to locations outside of LTPP.

Future Benefit: LTPP sections will likely be used to locally calibrate/validate as part of implementing the M-E PDG. Because traffic is a critical input in the M-E PDG, the availability of traffic information in the LTPP database will add value to those agencies evaluating the M-E PDG prediction capabilities at a local level.
Title: Long Term Pavement Performance Program Protocol for Calibrating Traffic Data Collection Equipment

Authors: Hallenbeck, Mark

Date: 1998

Publisher: Federal Highway Administration

Abstract/Synopsis: This document describes the procedures that the Long Term Pavement Performance (LTPP) program recommends for ensuring that traffic data collection equipment used for LTPP traffic monitoring efforts operates correctly and collects valid data. Recommendations are made for the following subject areas: steps for checking equipment calibration, quality control steps to be taken in the field, quality control steps to be taken in the office. The LTPP program acknowledges that weigh-in-motion (WIM) and automatic vehicle classification (AVC) are not mature technologies. As such, participating agency and site-specific conditions may legitimately warrant the use of procedures other than those presented in this document. In addition, LTPP recognizes that participating agencies use a variety of types of traffic data collection equipment and have different levels of available labor. Consequently, different participating agencies may prefer to use different methods for checking calibration and performing quality assurance on their data. As a result, while LTPP strongly recommends the use of the following procedures, agencies may request permission to substitute alternative, equivalent procedures.

Application/Use: The guide documents the LTPP processes and procedures to collect and store the traffic data used to estimate pavement loadings. It also includes LTPP's instructions for the selection, location, installation and calibration of traffic data collection equipment.

Contribution: Cost Savings, Advancement in Technology; Implementation/Usage.

Present Benefit: Continuing its advancement of the quality of WIM and other automated traffic data, this document is an excellent resource for any practitioner interested in installing equipment and collecting quality traffic data. It also provides methods for assessing the performance of existing equipment and performing QA on installation and calibration activities.

Present Benefit: The documents associated with this protocol provide specifications for equipment hardware and software as well as the pavement conditions and installation procedures to ensure the equipment will function properly.

Title: LTPP Traffic Data Collection and Monitoring

Authors: Kombe, E. M.

Date: 1998

Publisher: Arizona Department of Transportation; Arizona Department of Transportation; Federal Highway Administration

Abstract/Synopsis: Traffic data collection is a vital part of the Strategic Highway Research Program's (SHRP's) Long Term Pavement Performance (LTPP) Project. The Arizona Department of Transportation is an active participant in this program. The accurate monitoring and evaluation of traffic data, particularly along test sections (Specific Pavement Studies and General Pavement Studies), ensures that these studies are based on reliable traffic characteristics. This is an important parameter for the validity of study results and conclusions. According to the "Framework for Traffic Data Collection for the General Pavement Studies Test Sections" released by SHRP in January 1989, the LTPP Program has six specific objectives, which are: (1) Evaluate existing design methods; (2) Develop improved design methodologies and strategies for the rehabilitation of existing pavements; (3) Develop improved design equations for new and reconstructed pavements; (4) Determine the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance; (5) Determine the effects of specific design features on pavement performance; and (6) Establish a long term national data base to support SHRP's objectives and future needs. This report presents a summary of vehicle count, classification, and weight data collection and monitoring effort at the initial 27 program sites around the state of Arizona, most of which were installed in October/November 1992. It highlights procedures taken to identify performance shifts, calibration of equipment, and on-going efforts to upgrade and expand the data collection program.

Application/Use: This study is directly applicable to traffic data monitoring and processing.

Contribution: Cost Savings; Improvement in Knowledge; Advancement in Technology.

Present Benefit: This document serves as a testament to the significant contribution LTPP has made to the advancement of traffic monitoring. LTPP has established specifications, procedures, and guidelines to ensure consistent and quality traffic data is collected. Because traffic data is the most influential factor in pavement design, having accurate information is essential to selection of optimum layer structures.

Future Benefit: LTPP’s contribution to traffic monitoring will be a legacy that continues to reap rewards. As agencies turn to site-specific load spectra data for pavement evaluation, LTPP data and procedures will be extremely valuable.

Title: North American Travel Monitoring Exhibition and Conference

Date: 1998

Publisher: North American Travel Monitoring Exhibition and Conference (1998: Charlotte, N.C.); Federal Highway Administration

Abstract/Synopsis: This website provides access to the papers presented at the North American Travel Monitoring Exhibition and Conference held at Charlotte, North Carolina, on May 11-15, 1998. The conference was sponsored by the Office of Highway Information Management, Federal Highway Administration. The papers are presented as PDF files listed on a hyperlinked web front page. Contents: An Advanced Preformed Inductive Loop Sensor (2,181 K); Analysis of Vehicle Classification and Truck Weight Data of the New England States. (611 K); Calibration Needs for LTPP Traffic Data (32 K); Development of an ITS Data Management System (84 K); Incorporating Satellite Imagery in Traffic Monitoring Programs (217 K); Inside View of ITS at a Metropolitan Planning Organization (402 K); Installation and Evaluation of Weigh- In-Motion Utilizing Quartz-Piezo Sensor Technology (1,459 K); Interpretation of Computer Analyses of Traffic Data Using FHWA's VTRIS Program (3,697 K); ITS as a Data Source for TMS: The Kentucky Case Study (1,077 K); Traffic Data Collection Equipment Calibration (128 K); Revised Data Collection Plan for LTPP Test Sites (101 K); Manitoba Highway Traffic Information System Development (444 K); National Roadside Survey of Canada (22 K); New England Data Quality Partnerships (156 K); Oregon's Traffic Monitoring System for Highways (TMS-H) Outreach Program (32 K); Overview of the Travel Time Data Collection Handbook (151 K); Regional Travel Time Collection for the Hampton Roads Congestion Management System (15,501 K); Secondary Uses of ITS Data in Texas (236 K); Strategy for Handling the Statistics of Truck Weight Data in Alaska (258 K); Traffic Data Quality: Pooled Fund Study Update (212 K); Travel Time Data Collection Handbook (4,048 K); Truck Weight Enforcement M.O.E User Guide (255 K); Truck Weight Monitoring Plan Using Weigh-in-Motion Devices: Plan for WIM in Alaska (609 K); Using ITS-derived Data for Transportation Planning Programming, and Operations (96 K); Weigh In Motion Technology - Economics and Performance (60 K); Why Does LTPP Require Site-Specific Traffic Loading Data? (94 K); WIM Scale Calibration: A Vital Activity for LTPP Sites (103 K)

Application/Use: The proceedings from this joint conference can be of use in many areas of traffic monitoring and evaluation.

Contribution: Improvement in Knowledge; Advancement in Technology; Implementation/Usage.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP.

Future Benefit: Quality traffic data will provide future benefits in more cost-effective pavement designs. The ability to collect traffic load spectra data is also very important as it is an integral part of the M-E PDG.

Title: Understanding Traffic Variations by Vehicle Classifications

Date: 1998

Publisher: Federal Highway Administration

Journal Title: LTPP TechBrief

Abstract/Synopsis: To provide a better understanding of how short-duration truck volume counts can be used to accurately estimate the key variables needed for design, planning, and operational analyses, the Long-Term Pavement Performance (LTPP) program recently completed a study entitled "Vehicle Volume Distributions by Classification" (FHWA-PL-97-025, June 1997). This TechBrief presents key findings from the study. In summary, it was found that truck volumes vary considerably by time of day, day of week, season, and from location to location. States need to develop mechanisms that can adjust short-duration truck volume counts to account for these changes. These mechanisms must be sensitive to differences in the amount of through-truck traffic on specific roads, as well as differences in trucking patterns that occur as economic activity changes from one region to another.

Application/Use: The findings presented can be used by State Highway Agencies develop accurate traffic estimates from limited duration data collection.

Contribution: Cost Savings; Improvement in Knowledge.

Present Benefit: Quantifying variability in short duration traffic data is beneficial in many regards. First, accurate estimates of actual traffic can be obtained using short duration data collection, and the cost of the limited duration data collection is less than continuous approaches. Additionally, accurate traffic estimates support cost-effective pavement designs. This results in further cost savings and improved overall pavement performance.

Future Benefit: Traffic data collection will continue to be an essential component of pavement design, analysis, and management. Evaluations conducted on traffic loading will provide value to future pavement analysis.

Title: Why Does LTPP Require Site-Specific Traffic Loading Data?

Date: 1998

Publisher: Federal Highway Administration

Journal Title: LTPP TechBrief

Abstract/Synopsis: The purpose of this TechBrief is to discuss one of the Long Term Pavement Performance (LTPP) program's stringent data 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. This TechBrief is based on two studies: "Vehicle Volume Distributions by Classification" and "Results of an Empirical Analysis of Alternative Data Collection Sampling Plans for Estimating Annual Vehicle Loads at LTPP Test Sites," both by M. Hallenbeck and published in July 1997.

Application/Use: This document provides information on the need for site-specific traffic measurements.

Contribution: Cost Savings, Advancement in Technology; Improvement in Knowledge.

Present Benefit: The LTPP Program has been at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. The site-specific data collected at LTPP sites will be a critical element in not only the calibration/validation of the M-E PDG but also in pavement designs using the new guide.

Title: WIM Scale Calibration: A Vital Activity for LTPP Sites

Date: 1998

Publisher: Federal Highway Administration

Journal Title: LTPP TechBrief

Abstract/Synopsis: Long-Term Pavement Performance (LTPP) data are the foundation for new pavement designs for years to come. As such, data collected at LTPP test sites need to be as accurate and complete as possible. For the collection of truck weight data, this requires direct calibration of weigh-in-motion (WIM) scales at LTPP test sites. The purpose of this TechBrief is to highlight the significance Teca-ect calibraterrosignn b y

Title: SHRP-LTPP Traffic Data Collection and Analysis: Five-Year Report

Authors: German, J. L; Copeland Jr, C. R.

Date: 1994

Publisher: Strategic Highway Research Program

Abstract/Synopsis: This report provides a summary of the Strategic Highway Research Program's Long-Term Pavement Performance (SHRP-LTPP) 5-year effort to better understand traffic's effect on pavement performance. The report also reviews the traffic data collection program over a 4-year period. It provides a connection with the reports and publications issued during the period by providing an extensive reference list. The design of this publication portrays the history of action by the Traffic Expert Task Group (ETG) and reflects their role in the traffic data collection and analysis program. The LTPP traffic database developed by this program will benefit state and federal highway agencies for many years. The LTPP central traffic database at the Transportation Research Board will be located parallel to the national pavement performance database, making the two readily accessible and usable to researchers.

Application/Use: Five-year reports can be used by those interested in early program activities. These reports were also used as internal planning tools.

Contribution: Cost Savings; Advancement in Technology; Implementation/Usage.

Present Benefit: Findings from status or summary reports can provide significant insight into the early activities of the LTPP program. This information can be used to understand how the program evolved and provides background on the decision process.

The LTPP Program was at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

Future Benefit: Establishing a national, long-term research program requires significant planning and coordination. Program documentation since the inception of the LTPP program will be extremely beneficial to future data users.

Title: LTPP Central Traffic Database (CTDB)

Date: November 1992

Publisher: FHWA

Abstract/Synopsis: The Central Traffic Database (CTDB) contains a large quantity of raw traffic data collected by the States and Provinces that supplement load, classification, and volume data available in the PPDB.

Application/Use: Approximately 200 GB of CTDB data has been distributed to fulfill 200 requests.

Contribution: Cost Savings; Improvement in Knowledge; Implementation/Usage.

Present Benefit: The information provided in the CTDB allows traffic engineers to summarize traffic data in a specific format of interest. For example, the data can be used to recalculate ESAL values to better match the factors used by their agency. The data available in the CTDB can also be used to develop load spectra information, a critical element in the M-E PDG.

Future Benefit: The availability of the raw traffic data provides endless benefit to traffic engineers. The information will be of great value in the implementation of the M-E PDG. The data is also available for various other traffic studies including forecasting and variability studies.

Title: National Traffic Data Acquisition Conference, Sacramento, California, October 25-29, 1992, Proceedings

Authors: Copelan, Craig A.

Date: 1992

Publisher: California Department of Transportation; Federal Highway Administration

Abstract/Synopsis: The National Traffic Data Acquisition Conference was attended by representatives from all 50 states and many foreign countries. Presentations and demonstrations indicated that the collection of traffic data will be an area of increasing importance due to recent and pending Federal Legislation. This publication contains the papers presented at the Conference. They are grouped according to session and preceded by session summaries. The sessions are as follows: Opening General Session; Planning and Research - Part I; Planning and Research - Part II; Intelligent Vehicle/Highway System (IVHS) and Commercial Vehicle (CVO) Technologies; SHRP-FHWA Long Term Pavement Performance (LTPP) Program; Vehicle Weight Enforcement; Data Collection, Processing and Analysis; The Implementation of the HELP Project; Design and Maintenance Program; and Closing General Session.

Application/Use: These proceedings can be used by those interested in traffic data.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The LTPP Program was at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

Documents developed by LTPP associated with the traffic data collection can assist agencies in obtaining and preparing high quality traffic data. By utilizing these tools, practitioners can ensure they are not wasting resources obtaining traffic data of questionable value.

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. The traffic data contained in the LTPP database and the associated documentation will enable future users to understand the methodologies LTPP utilized to collect and process quality traffic data.

Title: The SHRP LTPP Traffic Database. Strategic Highway Research Program Products. Proceedings of a Specialty Conference Sponsored by the Highway Division of the American Society of Civil Engineers and the Federal Highway Administration. Denver Marriott

Date: 1991

Publisher: American Society of Civil Engineers

Abstract/Synopsis: Because of the volume, variability and complexity of the traffic information being collected for the SHRP LTPP project, a separate database (the NTDB) has been designed to store and maintain the majority of the traffic information that is being collected for each GPS (General Pavement Studies) and SPS (Specific Pavement Studies) site. From this traffic database, summary information will be transferred to the national pavement performance database (NPPD). SHRP researchers will have access to traffic data both at the summary level (through the NPPD and the NTDB) and at the detailed level (through the NTDB). This paper briefly describes these databases.

Application/Use: These proceedings can be used by those interested in traffic data from the LTPP database.

Contribution: Advancement in Technology; Improvement in Knowledge.

Present Benefit: The LTPP Program was at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

The documents associated with LTPP traffic data further assist analysts in understanding the data contained in the LTPP database and practitioners in obtaining and preparing high quality traffic data. By utilizing these tools, practitioners can ensure they are not wasting resources obtaining traffic data of questionable value

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. The traffic data contained in the LTPP database and the associated documentation will enable future users to understand the methodologies LTPP utilized to collect and process quality traffic data.

Title: Piezo-Electric Automatic Vehicle Classification System. Final Report

Authors: Laylor, H. M.

Date: 1991

Publisher: Oregon Department of Transportation; Castle Rock Consultants

Abstract/Synopsis: Oregon has twelve pavement test sites that are part of the Strategic Highway Research Program (SHRP), Long Term Pavement Performance (LTPP) studies. Part of the data gathering on these sites involves vehicle weight and classification. This pilot project was to help SHRP show others how to specify, procure and install equipment that would provide the necessary data to characterize the sites for the LTPP program. Castle Rock Consultants (CRC) provided specifications and technical aid for the first phase of this project. After the first phase was completed, CRC produced a paper for SHRP titled, "Piezo-Electric Based Automatic Vehicle Classifier Pilot Project," December, 1989. This report complements the CRC report and discusses the total project from Oregon's perspective. This report covers procurement of equipment and installation on two pilot sites, one for asphalt concrete and the second for portland cement concrete. Oregon used the results from this study to write the specifications for contractor installation of the ten remaining sites.

Application/Use: This report can be used by those interested in traffic data.

Contribution: Improvement in Knowledge

Present Benefit: The LTPP Program was at the leading edge of automated traffic data collection, particularly for Weigh-in-Motion (WIM) systems. In the early 1990s, the technology was relatively unproven. As a result of LTPP, the consistency and accuracy of WIM (and other automated traffic) data has greatly improved. Many agencies have implemented calibration procedures based on those developed by LTPP.

Documents developed by LTPP associated with traffic data collection can assist agencies in obtaining and preparing high quality traffic data. By utilizing these tools, practitioners can ensure they are not wasting resources obtaining traffic data of questionable value.

Future Benefit: Traffic loads will continue to be a critical input in predicting pavement performance. The traffic data contained in the LTPP database and the associated documentation will enable future users to understand the methodologies LTPP utilized to collect and process quality traffic data.

Title: Analysis of Texas Traffic Monitoring Program. Final Report

Authors: Cunagin, W. D; Nassiri, H. S.

Date: 1989

Publisher: Texas Transportation Institute; Texas State Department of Highways & Public Transportation

Abstract/Synopsis: Recent national developments will have a potentially significant impact on the traffic monitoring program conducted by Texas and the other States. The most important of these are the implementation of the Federal Highway Administration (FHWA) Traffic Monitoring (TM) Guide and the traffic data portions of the experimental designs prepared for use in the Long Term Pavement Performance (LTPP) monitoring element of the Strategic Highway Research Program (SHRP). The objectives of this study were: (1) To assess the potential impacts of the FHWA TM Guide and the SHRP Long Term Pavement Performance monitoring requirements upon the Department's traffic monitoring programs; (2) To develop alternatives for meeting these requirements; (3) To develop a plan for implementing the alternative or combination of alternatives selected by the Department; (4) To determine if changes are needed in the guidelines presented by the Traffic Monitoring Guide; if so, to submit recommendations for those changes to the FHWA.

Application/Use: This paper can be of use in many areas of traffic monitoring and evaluation.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP.

Future Benefit: Quality traffic data will provide future value in more cost-effective pavement designs. The ability to collect traffic load spectra data is also very important as it is integral part of the M-E PDG.

Title: Evaluation of Low Cost WIM Alternatives. Final Report

Authors: Cunagin, W. D; Majdi, S. O.

Date: 1989

Publisher: Texas Transportation Institute; Texas State Department of Highways & Public Transportation; Federal Highway Administration

Abstract/Synopsis: Truck weight data are required for pavement and bridge design, truck size and weight enforcement, and the development of administrative policy and legislation. The efficient collection and analysis of these data require that truck weighing-in-motion (WIM) equipment be used. Unfortunately, the high cost of these devices (greater than $50,000 per unit) has prohibited the large scale implementation of WIM technology. Lower cost WIM systems are also necessary to provide new or expanded data required by both the Long Term Pavement Performance (LTPP) monitoring element of the Strategic Highway Research Program (SHRP) and implementation of the provisions of the recently issued Federal Highway Administration (FHWA) Traffic Monitoring (TM) Guide. Several possible technologies exist for low cost WIM systems. One of these, piezoelectric cable, was investigated in a research effort jointly sponsored by the States of Iowa and Minnesota and FHWA and in other work in the State of Washington and several European countries. A second approach is an inexpensive capacitive weigh mat WIM sensor and associated electronics developed for FHWA. A third alternative is a reduced cost configuration of the bending plate WIM transducer manufactured and distributed by the PAT Equipment Corporation. Each of these was evaluated in this study to determine its usefulness in providing effective truck weighing devices at a cost that would allow widespread implementation of in-motion truck weighing programs in Texas.

Application/Use: This paper can be of use in many areas of traffic monitoring and evaluation.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP. An important finding over time was that low-cost WIM equipment could not provide research quality data.

Future Benefit: Quality traffic data will provide future benefit in more cost-effective pavement designs. The ability to collect traffic load spectra data is also very important as it is integral part of the M-E PDG.

Title: Framework for Traffic Data Collection for the General Pavement Studies' Test Sections

Date: 1989

Publisher: Strategic Highway Research Program

Abstract/Synopsis: The General Pavement Studies (GPS) experiment, one component of the Strategic Highway Research Program (SHRP) Long Term Pavement Performance (LTPP) study, involves the observation and monitoring of selected in-service pavement test sections over a period of up to 20 years. A principal objective of the GPS experiment is to evaluate and develop pavement performance models used to predict the future performance of existing pavements and to design new pavements. All pavement performance and design models required detailed knowledge of traffic -- both volume and axle load information. The traffic information needed to evaluate most existing pavement design models is the total number of 18K equivalent single axle load (ESAL) applications in the study lane. Due to differences in methods for computing equivalent axle load factors, the original axle load information used to compute these factors according to the particular design method is needed. SHRP's proposed traffic data collection plan addresses two separate time periods or phases referred to as historic data and monitoring data. "Historic" or existing data refers to data that has been collected on or near the test section up to the time that enhanced GPS site-specific traffic data collection following the SHRP guidelines begins. "Monitoring" or new data is data collected on the GPS test sections following the data collection plan proposed by SHRP.

Application/Use: This paper can be of use in many areas of traffic monitoring and evaluation.

Contribution: Improvement in Knowledge; Advancement in Technology.

Present Benefit: The work conducted under the LTPP program for traffic monitoring and data collection has significantly advanced the state of the practice. Improvements in WIM data collection procedures, equipment installation, equipment maintenance, and data quality have been attributed to LTPP.

Future Benefit: Quality traffic data will continue to provide value in more cost-effective pavement designs. The ability to collect traffic load spectra data is also very important as it is an integral input for the M-E PDG.