Measured versus Default Interstate Traffic Data in New Mexico, USA

M. A. Hasan, M. R. Islam, R. A. Tarefder

Abstract—This study investigates how the site specific traffic data differs from the Mechanistic Empirical Pavement Design Software default values. Two Weigh-in-Motion (WIM) stations were installed in Interstate-40 (I-40) and Interstate-25 (I-25) to developed site specific data. A computer program named WIM Data Analysis Software (WIMDAS) was developed using Microsoft C-Sharp (.Net) for quality checking and processing of raw WIM data. A complete year data from November 2013 to October 2014 was analyzed using the developed WIM Data Analysis Program. After that, the vehicle class distribution, directional distribution, lane distribution, monthly adjustment factor, hourly distribution, axle load spectra, average number of axle per vehicle, axle spacing, lateral wander distribution, and wheelbase distribution were calculated. Then a comparative study was done between measured data and AASHTOWare default values. It was found that the measured general traffic inputs for I-40 and I-25 significantly differ from the default values.

Keywords—AASHTOWare, Traffic, Weigh-in-Motion, Axle load Distribution.

I. INTRODUCTION

THE recently developed AASHTOWare Pavement Mechanistic Empirical (ME) Design software uses four design inputs for pavement design and analysis [1]. These are traffic, climate, materials properties, and section property. Traffic is the one of the most important inputs required for the analysis of pavement; it represents the magnitude and frequency of the applied loading that is applied to a pavement. Four types of traffic inputs are provided in the AASHTOWare Pavement M-E Design software for structural design of pavement for analysis. These inputs are mentioned below:

- Type 1: Traffic Volume-Base Year Information
a) Two-way annual average daily truck traffic (AADTT)
b) Number of lanes in the design direction
c) Percent trucks in design direction
d) Percent trucks in design lane
e) Vehicle operational speed
- Type 2: Traffic Volume Adjustment Factors
a) Monthly Adjustment
b) Vehicle Class Distribution
c) Hourly Truck Distribution
d) Traffic Growth Factors

- Type 3: Axle Load Distribution Factors
- Type 4: General Traffic Inputs
a) Number of axles/truck
b) Axle configuration
c) Wheelbase distribution

Due to difficulties in measurement of traffic data or error in measured data researchers often use the default values available in the ME design software. However, it was observed that the predictions of performances were dependent on the accurate determination of traffic classification and weight distribution [2]. A few studies were conducted to show how the measured traffic data defer from the default data [3]-[10]. However, these studies did not compare all the input parameters. Therefore, authors of this study tries to compare the measured those traffic data in New Mexico with the national average data available in the ME design software.

II. DATA COLLECTION AND PROCESSING

Weigh-in-Motion (WIM) data were collected from two major interstate highways in New Mexico: Interstate 40 (I-40) and I-25 near the city of Albuquerque in New Mexico (USA) from November 2013 to October 2014. WIM station records the traffic data into two special formats (C-file and W-file). C-file counts the number of vehicles passing through a pavement section over a period of time and classifies the vehicles in different classes. W-file measures the number of axles, spacing between two axles, and weights of each axle. A data processing program called WIM Data Analysis Software (WIMDAS), was developed using Microsoft Visual Studio C-Sharp at the University of New Mexico. With help of WIMDAS required traffic inputs were developed from the collected WIM data. The main interface of WIMDAS is shown in Fig. 1.

III. MEASURED VERSUS DEFAULT TRAFFIC DATA

A. Percent Trucks in Design Direction

Unless a roadway has an unbalanced travel for trucks, the percentage of truck traffic in the design direction is 50%. Figs. 2 (a) and (b) show the directional distribution of truck traffic measured on I-40 and I-25 respectively. Fig. 2 (a) shows there are 53% truck passes through the negative direction (West) of I-40. For I-25 both of the directions have almost the equal traffic.

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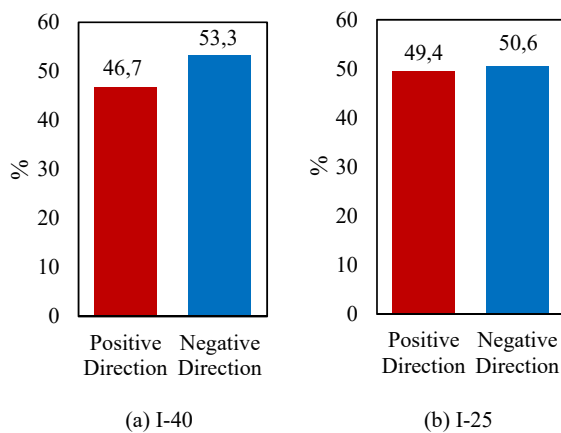Fig. 1 Interface of WIM data analysis Software

(a) I-40 (b) I-25

Fig. 2 Directional Distribution

busiest lane is the design lane.

(a) I-40 (b) I-25

Fig. 3 Lane Distribution Vehicle Operational Speed

B. Percent Trucks in Design Lane

Percentage Trucks in Design Lane means the percentage of total truck traffic that runs through the design lane, typically the outside lane (driving lane) in a multilane highway (more than one lane in each travel direction). This is because most of the traffic runs through the driving lane. Lane distributions of truck traffic for I-40 and I-25 are presented in Figs. 3 (a) and (b) respectively. For I-40 (Fig. 3 (a)), Lane 1 and Lane 2 are toward the positive direction (East) where Lane 3 and Lane 4 are toward the negative direction (West) of I-40. In the east bound lane, 85% trucks drives through the driving lane and 15% trucks uses the passing lane. The M-E Design software default value is 95% for the design lane/driving lane which is way conservative for I-40. In the west bound lane of I-40, 69% trucks drive through the driving lane and 31% trucks use the passing lane. Lane distribution on I-25 shows that the middle lanes in both directions (Lane 2 in north direction, Lane 4 in south direction) carry equal amount of truck. The outer lane, for example Lane 4 in south direction, carries the smallest amount of truck (25%). Therefore, it is not necessary that the outer lane has the lowest truck. In that case, the
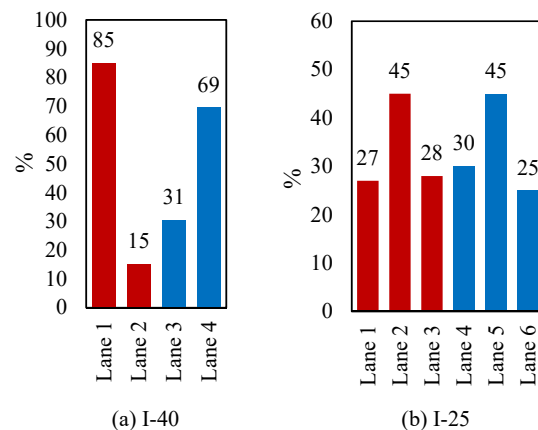
Vehicle operational speed can be obtained from the speed limit of the design site. For both I-40 and I-25 average vehicle speed is 70 mph. MEPDG default vehicle speed is 60 mph.

C. Vehicle Class Distribution

Vehicle Class Distribution (VCD) refers to AADTT distribution among the 10 vehicle types (Class 4 to 13). The TCDs measured on I-40 and I-25 is presented in Fig. 4. On I-40, Class 9 truck is the governing vehicle (72% of the total truck) with a percentage of bus lower than 2% and percentage of multi-trailer higher than 2%. The measured distribution is fairly similar to the default TTC-1. However, the measured percentage of heavy vehicle (upper than class 8) (82%) is less than default value (87%). On I-25, Class 5 truck is the governing vehicle (57%) which is quite similar to default Truck Traffic Class 12 (TTC-12). For I-25, percentage of heavy vehicle is 36% which is small than default value for TTC-12 (42%).
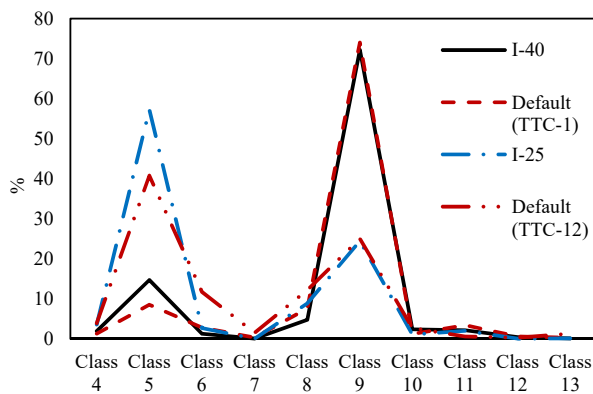
Fig. 4 Truck Class Distribution

D. Hourly Truck Distribution

Hourly Truck Distribution (HTD) refers to the percentage of hourly AADTT among a 24 hour period starting at midnight. There are 24 HTDs in 24 hours of a day. To understand the importance the determining the HTD, the measured HTD from I-40 and I-25 site were compared with the AASHTOWare default values. The comparison is presented in Fig. 5. It can be seen that the measured HTD and AASHTOWare default HTD distribution are not close to the AASHTOWare default values, especially in early morning and late afternoon to evening. Therefore, measurement of HTD is important for developing accurate traffic data. However, hourly distribution has no effect on asphalt pavement (AASHTO 2008) but an important parameter for concrete pavement.
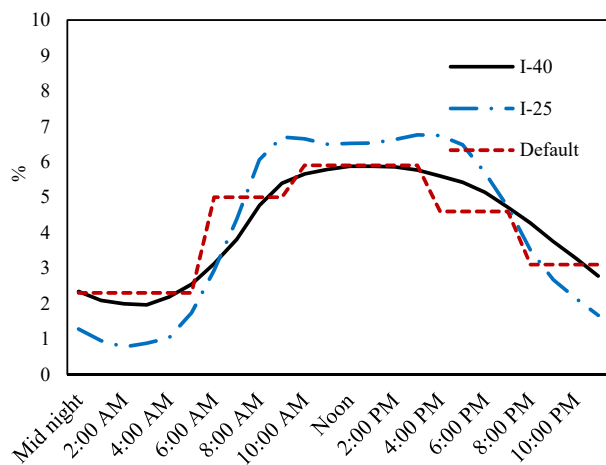

Fig. 5 Hourly Truck Distribution

E. Monthly Adjustment Factor

The Truck Monthly Adjustment Factor (MAF) reflects truck travel patterns throughout the year. There are 10 truck types (FHWA vehicle Class 4-13) that result 10 potential different temporal patterns over a 12 month period. Mathematically, the monthly adjustment factor for a given vehicle class and a given month is obtained by dividing the average Monthly Average Daily Truck Traffic (MADTT) for the month by the summation of all the 12 month MADTTs and then, multiplied by 12. There are a total of 120 MAFs [10 vehicle classes × 12 months = 120 individual MAF]. The measured MAF for Class 4 to Class 13 on I-40 is shown in Fig. 6. The AASHTOWare default values are unity for all months and classes. This means the AASHTOWare assumes the vehicles are equally distributed in each month. The measured values from I-40 are very different than the AASHTOWare default ones. For example, the Class 12 vehicle is 0.38 instead of 1 in the month of January (60% less than the default value).
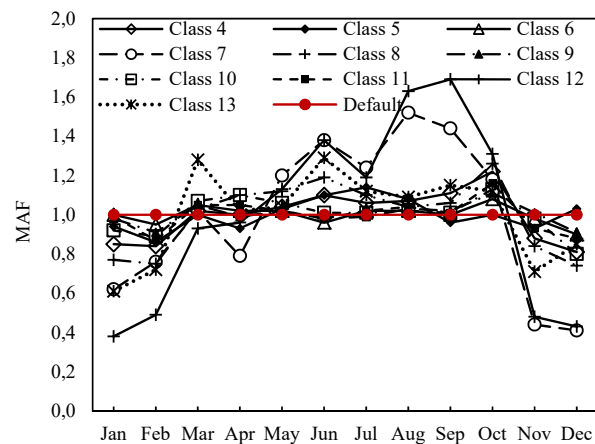

Fig. 6 Monthly Adjustment Factor in I-40

F. Axle Load Spectra

FHWA vehicles in Class 4 to 13 can have a variety of axle configurations, including single axle, tandem axle, tridem axle, and quad axle. For a given vehicle class and axle configuration, axle weight varies depending on vehicle load. Axle Load Distribution Factor (ALDF) is to capture that information in terms of distributions of vehicles based on axle weight under a given vehicle class and axle configuration for a given month. This is one of the most demanding data sets. Mathematically, the ALDF is the percentage of a given axle load among all axle loads under a given vehicle axle configuration.

i. Single axle: There are 39 axle weight groups for single axle configuration vehicles. The axle weight group ranges from 3,000 lbs. to 41,000 lbs. with increments of 1,000 lbs.

ii. Tandem axle: For tandem axle vehicles, the axle weight group starts at 6,000 lbs. and ends at 82,000, lbs. with increments of 2,000 lbs.

iii. Tridem axle: For tridem axle vehicles, the axle weight group start at 12,000 lbs. and ends at 102,000 lbs. with increments of 3,000 lbs.

iv. Quad axle: Similar to tridem for quad axle vehicles, the axle weight group start at 12,000 lbs. and ends at 102,000 lbs. with increments of 3,000 lbs.

Fig. 7 shows the annual (January to December) average axle load spectra for single, tandem, tridem and quad axle on I-40 and I-25 site. For both sites the axle load spectra are significantly different from the MEPDG default spectra. For example, Fig. 7 (a) shows that the AASHTOWare Pavement ME Design Guide default value has the maximum frequency of 17.7 at axle load of 10000 lbs for Class 9 vehicle. However, the measured data from I-40 shows the maximum frequency of 48.2 at axle load of 12000 lbs and for I-25 shows the maximum frequency of 25 at axle load of 12000 lbs. For I-40 tandem axle load spectra for Class 9 vehicle does not follow the double peak trend as MEPDG default spectra (Fig. 7 (b)). It is observed that 13% of the Class 9 vehicle have 33000 lbs whereas the default value has the maximum frequency of 6 at axle load of 32000 lbs for Class 9 vehicle. However, in I-25 Class 9 vehicle load spectra has two peaks but the corresponding values are different from the default.
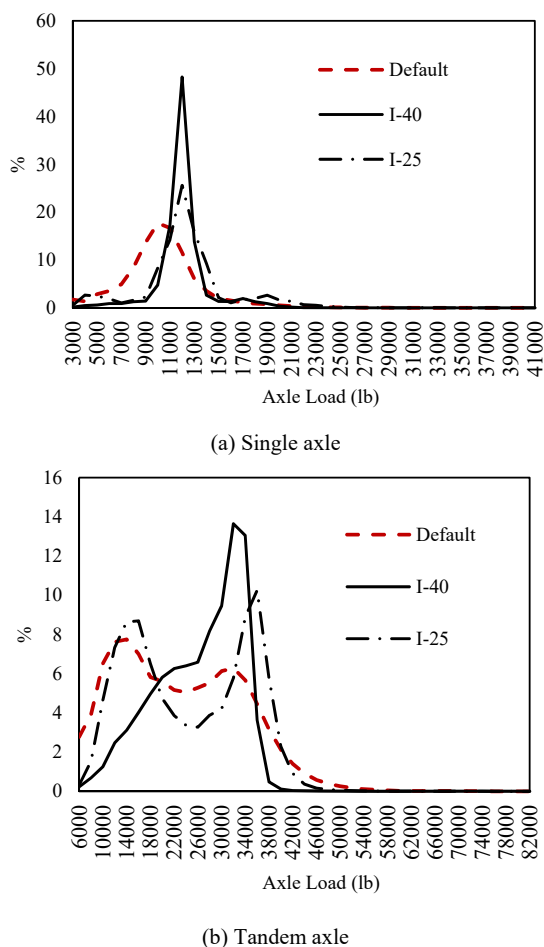

(a) Single axle

(b) Tandem axle

Fig. 7 Axle Load Spectra for Class 9 Vehicles

G. Axle per Truck

The number of axles per vehicle class for a given axle configuration is an annual average number of axles per vehicle category (per vehicle class and vehicle axle configuration). Table I lists the measured number of axle per

truck on I-40.

TABLE I
AXLE PER TRUCK IN I-40

Class Value	Single	Tandem	Tridem	Quad
Class 4	1.70 (1.62)	0.3 (0.39)	0 (0)	0 (0)
Class 5	2.00 (2.00)	0 (0)	0 (0)	0 (0)
Class 6	1.00 (1.02)	1.00 (0.99)	0 (0)	0 (0)
Class 7	0.48 (1.00)	1.04 (0.26)	0.48 (0.83)	0 (0)
Class 8	2.12 (2.38)	0.88 (0.67)	0 (0)	0 (0)
Class 9	1.16 (1.13)	1.92 (1.93)	0 (0)	0 (0)
Class 10	1.03 (1.19)	1.04 (1.09)	0.96 (0.89)	0 (0)
Class 11	3.00 (4.29)	0.88 (0.26)	0.08 (0.06)	0 (0)
Class 12	1.72 (3.52)	1.91 (1.14)	0.15 (0.06)	0 (0)
Class 13	1.25 (2.15)	1.69 (2.13)	0.82 (0.35)	0.06 0)

Values shown in parenthesis represent the default value.

H. Axle Configurations

Several types of input are required to specify the axle configuration such as axle spacing, axle width, mean wheel location, traffic wander and lane width. Axle spacing is the distance between two consecutive tandem, tridem, and quad axles. Fig. 8 shows the average measured spacing for different wheel configurations from WIM data found for I-40 and I-25.
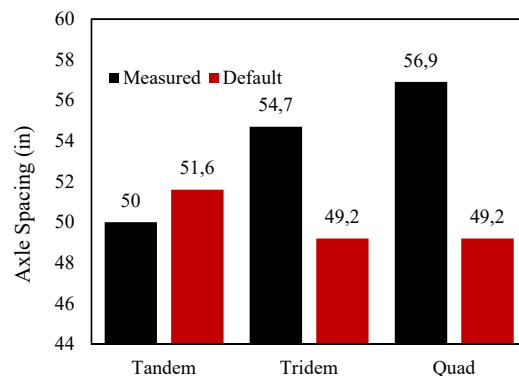

Fig. 8 Average axle spacing

The distance between the two outside edges of an axle is defined as axle width. The mean wheel location is the distance of the centerline of the wheel from the outer edge of the lane. Using axle strip sensing, it is measured to be 26.5 inches with a standard deviation of 12.7 inches for I-40 which is not close to the AASHTOWare Pavement M-E Design software. However, the mean wheel location does not affect the structural response or performance of flexible pavement [11]. The other AASHTOWare Pavement M-E Design software default values (average axle width, dual tire spacing, and tire pressure) are very close to the measured value on I-40. Therefore, the default values can be used reasonably.

I. Wheelbase Distribution

The distance between the steering and the first axle of a tractor or a heavy single unit is used to classify the truck as short, medium or long vehicle. The recommended values are 12, 15 and 18 ft for short, medium and long axle spacing, respectively. The measured wheelbase configurations on I-40

and I-25 are shown in Figs. 9 (a) and (b). It shows that the measured values are way different compared to the AASHTOWare default values. However, it has no effect on asphalt pavement [11].
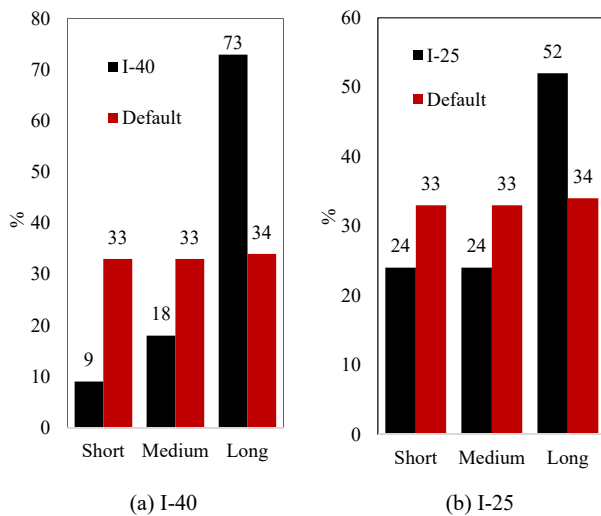

(a) I-40   (b) I-25

Fig. 9 Wheelbase Distribution

IV. CONCLUSION

This study examines the site specific traffic data compared to the default values used in the current design software. Traffic data from two WIM sites in New Mexico, USA were collected from November 2013 to October 2014. After that, the vehicle class distribution, directional distribution, lane distribution, monthly adjustment factor, hourly distribution, axle load spectra, average number of axle per vehicle, axle spacing, lateral wander distribution, and wheelbase distribution were calculated. Then a comparative study was conducted between the measured data and the default values. It was found that the measured general traffic inputs for I-40 and I-25 significantly differ from the default values. Therefore, careful measurement of traffic data is important.

ACKNOWLEDGMENT

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