Effect of Axle Load Measurement Errors on Pavement Performance and Design Reliability

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In traffic characterization, axle load spectra (ALS) are One of the most critical inputs in the new Mechanistic–Empirical Pavement Design Guide (MEPDG). The main reason for their significance is the associated high degree of uncertainty. In addition, the effects of traffic-related inputs are more pronounced because of inaccuracies and systematic bias. While WIM data accuracy depends on the sensor technology, calibration errors and drift over time may introduce a systematic bias. Several studies have investigated the impact of traffic data collection technologies, data coverage, accuracy, and calibration errors on pavement loading and performance prediction. However, these studies were limited to a few distress measures and did not address design reliability aspects considered in the MEPDG. This study investigates the impact of probable errors on the ALS and quantified the costs of these errors on the performance of both flexible and rigid pavements. Furthermore, the impact of uncertainties in ALS on design reliability is discussed in this paper. Although most findings reinforce existing concepts, the study provides a systematic overview of ALS data accuracy and calibration requirements, and the effect of associated uncertainties in the pavement design process. The results show that cracking in both flexible and rigid pavements is the distress most affected by ALS variations. while rutting in flexible pavements is moderately affected.

Traffic characterization and related inputs play a vital role in the analysis and design of pavements in the new Mechanistic–Empirical Pavement Design Guide (MEPDG). The main reason for their significance is the associated high degree of uncertainty. In addition, the effects of traffic-related inputs are more pronounced because of inaccuracies and systematic bias. While WIM data accuracy depends on the sensor technology, calibration errors and drift over time may introduce a systematic bias. Several studies have investigated the impact of traffic data collection technologies, data coverage, accuracy, and calibration errors on pavement loading and performance prediction. However, these studies were limited to a few distress measures and did not address design reliability aspects considered in the MEPDG. This study investigates the impact of probable errors on the ALS and quantified the costs of these errors on the performance of both flexible and rigid pavements. Furthermore, the impact of uncertainties in ALS on design reliability is discussed in this paper. Although most findings reinforce existing concepts, the study provides a systematic overview of ALS data accuracy and calibration requirements, and the effect of associated uncertainties in the pavement design process. The results show that cracking in both flexible and rigid pavements is the distress most affected by ALS variations. while rutting in flexible pavements is moderately affected.

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Through the Research Record of the Transportation Research Board, No. 2160. Transportation Research Board of the National Academies, Washington, D.C. 2010. pp. 107-117. 0011-1411/2160 12 wheelbase, etc.) (1-3). Among the three traffic-related inputs, ALS require extensive efforts in data collection, and several sensitivity studies have shown that ALS significantly affect pavement performance (4-7). In practice, traffic data collection is carried out by a combination of sensor technologies that include weigh-in-motion (WIM) systems, automatic vehicle classifiers (AVC), and automated traffic recorders. Each of these technologies has inherent uncertainty in the measurements. For example, two approaches are commonly adopted to collect axle loads: static and WIM scales. While Static weighing has higher accuracy, a number of practical issues and inefficiencies accompany this practice. The most important limitation of static weighing is the amount of axle load data that can be collected. On the other hand, since pavement design and analysis require a large and representative amount of traffic data, state-of-the-art WIM technology is popular because of its ability to collect traffic data continuously, albeit with less accuracy. In addition, WIM system errors introduced by sensor technology, environmental effects, pavement condition, and other factors need to be considered to address concerns over measurement accuracy (8).

Because of extensive traffic data requirements in the MEPDG, data from sites having similar traffic loading and classification attributes are used to complement data collected at a particular pavement design location. To compensate for the levels (site-specific, regional, and national) or traffic data collection, three traffic input levels are specified in the MEPDG. These traffic input levels have associated uncertainty in performance prediction. An FHWA study highlighted the need for optimum traffic data collection for specific pavement design applications (9). Traffic data collection strategies were evaluated by considering a combination of technologies and coverage (duration of data collection). The results of this sensitivity study showed that discontinuous traffic data collection scenarios involving site-specific WIM data had significantly more potential for error when compared with continuous coverage of site-specific AVC data (10). Further, the error in performance prediction can range from 10% to 27% depending on the reliability of regional axle load data instead of site-specific data. When the regional axle load data are used for a site, the life prediction errors may range from 30% to 1076% (9). These findings demonstrate that variations in ALS can cause significant changes in a particular pavement design. Axle load underestimation is considered the most critical problem as it leads to the overestimation of pavement life and thus CIL produce pavement structures with insufficient structural capacity. It should be noted that all the uncertainty associated with the traffic data is assumed to be contributed by a combination of traffic data collection technology and its coverage.

It is typically assumed that ALS are measured accurately and extensively for most analysis and design scenarios. However, measurement