ODOT RESEARCH

HIGHLIGHTER

PORTABLE WEIGH-IN-MOTION FOR PAVEMENT DESIGN

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PROJECT TITLE
PORTABLE WEIGH-IN-MOTION FOR PAVEMENT DESIGN - PHASES 1 AND 2

FINAL REPORT ~ FHWA-OK-14-07
ODOT SP&R 2240

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OVERVIEW Keeping Oklahoma's roadways, highways, and bridges in good condition is necessary for safety and to reduce the significant annual expenditures for road repairs and replacement attributed mostly to exposure to heavy vehicles. The Federal Highway Administration issues the Mechanistic Empirical Pavement Design Guide (MEPDG) to aid engineers in improving paved road design in which precise truck weight input data is necessary to calculate optimal pavement thickness. To comply, many states have installed permanent Weigh-in-Motion (WIM) sites to gather such information. Expanding site coverage to include additional roadways and highways would improve road design accuracy; however, doing so requires significant roadside construction and costly infrastructure maintenance support.

This study provides deployment results of a novel portable WIM system and compares captured data with that collected at a nearby permanent WIM system. Design, algorithm development, and road-installation details of the portable WIM are provided in the final report. Outcomes demonstrate that the portable system maintains data quality for only short intervals, but provides a viable alternative to permanent systems at 10 percent of the cost.

RESULTS In this project, the portable WIM system uses off-the-shelf components and commercially available WIM controller, as illustrated in Figure 1. It was developed to provide an alternative WIM monitoring solution to permanent WIM systems and/or static scale stations, both of which are extremely expensive to install on highways. The portable WIM uses RoadTrax BL piezoelectric class-1 sensors, galvanized metal fixtures equipped with pocket tapes to house the sensors, and a trailer with cabinet to house WIM electronics, batteries, and REECE device for real-time monitoring. The system is solar powered with three 100-Watt panels. The total cost of system is $20,000.

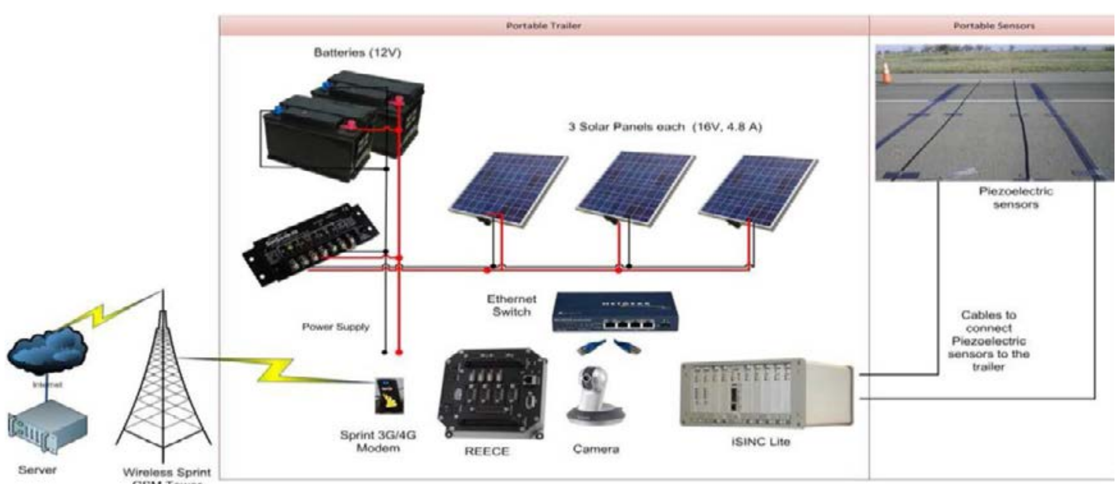

Figure 1 Portable Weigh-in-Motion System Architecture

The portable WIM system was deployed three times at two locations: US69 and US412. Affixing processes were developed to limit sensor vibration and allow extended deployment periods (Figure 2). System performance showed acceptable WIM measurement results with only slight variation during the first 15 days of deployment. Portable WIM data was compared to permanent WIM data collected at co-located sites, to include classification, *gross vehicle weight* (GVW), *first axle weight* (FXW), *first axle spacing* (FXS) and speed for each vehicle type. Shown in Table 1, the correlation coefficient is strong between portable and permanent WIM data. The best correlated WIM information is speed, followed by FXS and vehicle type classification. Notably, a 29% error (the highest) was calculated for GVW during the first 15 days of deployment.

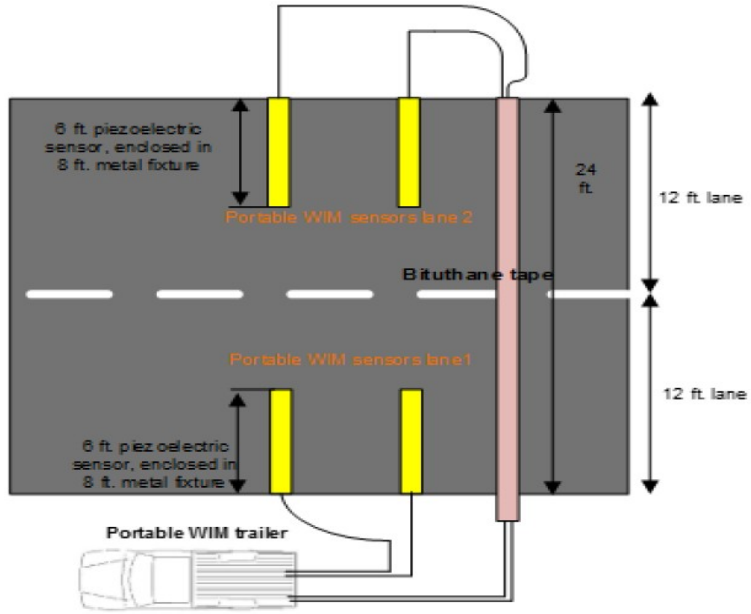

Figure 2 Two-Lane Deployment Schematic

Table 1 Comparison of Portable and Permanent WIM Systems Data

Parameter	Percent Error	Correlation Coefficient
Classification	3.4	0.9475
Gross Vehicle Weight (GVW)	29.0	0.8030
First Axle Weight (FXW)	26.8	0.3200
First Axle Spacing (FXS)	5.6	0.9611
Speed	4.0	0.9669

Many factors influence the accuracy of the WIM measurements made using a portable system. One of these is the piezoelectric BL sensor vibration, which was determined to be the primary factor for vehicles that went undetected. Improper installation of the sensor was suspected to allow the sensor to vibrate within its pocket when a vehicle axle impacted it. In turn, the WIM controller detects and registers a large number of “ticks” due to one axle impact. This results in either over counting or misdetection, depending on the WIM configuration—in particular, the tick filtering threshold. A method to firmly affix the sensor onto the ground was developed and proved successful. Another approach to limit vibration is to reduce the size of the piezoelectric strip (thus reducing its sensing capacity) and position the sensor to cover part of the lane area so only one tire impacts it. Six-foot sensors were found suitable for low vibration deployment. These two techniques provided extended periods of deployments with acceptable portable WIM measurement and data quality.

Default calibration factors used for sensors embedded in the roadway are not suitable for on-ground sensor installation used for portable WIM setups. Doing so causes significant weight error and inaccurate vehicle classification. Hence, portable WIM systems should be calibrated at the deployment site. A new calibration is required each time the portable WIM site is changed. It is advised to use calibration factors per speed bin to increase weight accuracy.

POTENTIAL BENEFITS The portable weigh-in-motion (WIM) system provides data that is highly correlated with permanent site data. However, it costs much less than other systems, so it can be deployed on more roadways and bridges statewide. The system will aid Oklahoma Department of Transportation (ODOT) engineers in improving paved road design through better information inputs (precise truck weight data), which is necessary to calculate optimal pavement thickness consistent with the Mechanistic Empirical Pavement Design Guide (MEPDG).