Impact of Wide-Base Tires on Pavements

Results from Instrumentation Measurements and Modeling Analysis

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Wide-base tire technology can reduce vehicle fuel consumption and greenhouse gas emissions because there is less rolling resistance at the tire–pavement interface. This study investigated the impact of wide-base tires on two typical flexible pavement structures—full-depth and thin asphalt pavements—through accelerated pavement testing and advanced finite element modeling. Three tire configurations (dual, the first-generation 425, and the new generation 455 wide-base tires) and various pavement sections with different asphalt layer and granular base layer thicknesses were considered. In particular, the advanced modeling simulated realistic tire–pavement interaction and considered appropriate material properties for each pavement layer. It was evident from this study that, of the three possibilities, the wide-base 425 tire configuration caused the greatest pavement damage. The wide-base 455 tire was found to cause greater bottom-up fatigue cracking and increased potential for subgrade rutting than the dual-tire assembly on most tested sections except the thin pavement section with the thickest granular base layer. However, the impact of wide-base tires on fatigue cracking and subgrade rutting potential became less significant with a stronger pavement structure. The finite element modeling results indicated that, compared with the dual-tire assembly, the wide-base 455 tire resulted in similar or less primary rutting potential in thin asphalt pavements and less near-surface cracking potential in thick asphalt pavements.

In 2008, the transportation sector produced 33% of the total greenhouse gas (GHG) emissions in the United States, second only to that produced by the electrical power generation industry (*1*). Factors related to pavements that contribute directly to vehicle operating costs and GHG emissions include the rolling resistance due to tire–pavement interaction and pavement roughness. Therefore, improvements in tire technology to reduce rolling resistance could result in reduced costs and GHG emissions.

Wide-base tires have been used as alternatives to the traditional dual-tire assembly on the nonsteering and driving axles since the 1980s in Europe and Canada. The technology has not caught on in the United States because the first generation of wide-base tires (wide-base 385 or 425) was found to cause relatively greater pavement damage than the dual-tire assembly. The new generation of wide-base tires (wide-base 445 and 455) entered the market in the 2000s. It has the potential to provide several benefits, including improved fuel economy, increased hauling capacity, lower wheel cost, reduced maintenance, and improved safety because of improved ride and handling in all weather conditions (*2, 3*).

Tire rolling resistance accounts for approximately 35% of the energy supplied by a vehicle's engine. Utilizing the new generation of wide-base tires reduces the rolling resistance by as much as 12%; the result is a significant reduction in fuel consumption. In a recent survey conducted in Canada, six of the seven truck fleet companies using wide-base tires reported a significant reduction in fuel consumption varying between 3.5% and 12% (*4*). Considering the reduction in fuel consumption, using the new wide-base tires would help reduce GHG emissions and the associated damage to the environment. Recent studies suggest that the consumption of a liter of fuel results in the emission of 68 g of carbon monoxide, 2,730 g of carbon dioxide, and 9.6 g of nitrogen oxide. Therefore, using the new wide-base tires could reduce carbon dioxide emissions by more than 4 metric tons annually with an average fuel saving of 1,500 L per truck (*5*). Bachman et al. measured fuel economy and nitrogen oxide emissions from a pair of Class 8 tractor–trailers on a test track and found that single wide tires and trailer aerodynamic devices resulted in increased fuel economy and decreased nitrogen oxide emissions relative to the baseline tests (*6*).

Several studies have focused on the impact of the new generation of wide-base tires on pavement performance, and their conclusions vary with pavement structure, damage type, and climate condition. A comprehensive study using field testing and numerical modeling was conducted in 2000 on the heavily instrumented Virginia Smart Road. This study considered several Interstate pavement designs, truck speeds, loads, as well as tire pressure levels (*7, 8*). Another comprehensive study was conducted in Europe; the study focused on the field monitoring of pavement responses and performance under various tire configurations including the wide-base 495 tire, which is only available on the European market (*9*). Several other studies on the new generation of wide-base tires have been conducted in Canada (*10*), by the National Center of Asphalt Technology (*11*), and by the Florida Department of Transportation (*12*).

Recently, two research projects that evaluated the impact of wide-base tires on flexible pavement responses and performance were conducted at the Illinois Center for Transportation (*13, 14*). In those projects, the impact of wide-base tires on two typical flexible pavement structures (full-depth and thin-asphalt conventional pavements) was investigated through in situ instrumentation under accelerated pavement testing (APT) and advanced finite element (FE) modeling. Three tire configurations—dual (11R22.5), wide-base (425), and a new-generation wide-base (455)—and various

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pavement sections with different asphalt layers and granular base layer thicknesses were considered in the study. Advanced modeling can simulate realistic tire–pavement interaction (such as nonuniform contact stresses and moving loads) and consider appropriate material properties for each pavement layer (such as viscoelasticity for the asphalt layer and nonlinear anisotropy for the granular base layer).

OBJECTIVE

This experimental work, modeling efforts, and key findings from instrumentation measurements and FE modeling are summarized with two main objectives:

1. Use APT to compare the measured pavement responses caused by various tire configurations, which include tensile strains at the bottom of the asphalt layer, compressive strains on top of the subgrade, and base pressure. These responses are related to the development of bottom-up fatigue cracking and subgrade rutting.
2. Use FE modeling to compare the calculated pavement responses caused by various tire configurations, which include the shear stresses and strains in the asphalt layer and the tensile and shear strains near the pavement's surface. These responses complement the measured responses to quantify the impact of wide-base tires on primary rutting and near-surface or top-down cracking.

TEST SECTIONS AND INSTRUMENTATION

Full-Depth Asphalt Pavement

The full-depth pavement sections used for accelerated testing were built as part of an extended-life pavement project (*15*). These sections were composed of asphalt layers with three different thicknesses (152, 254, and 420 mm) directly over a 305-mm lime-stabilized subgrade. Two asphalt binders were used in the asphalt layers: a PG 64-22 for the base course and a styrene–butadiene–styrene PG 70-22 for polymer-modified binder course and wearing surface. The asphalt content of the binder and base courses was 4.5%, and the asphalt content of the wearing surface was 5.4%. No liquid antistrips were used in any mixture. The aggregate used in all mixes was limestone. The subgrade was lime-stabilized to address the high water content in the natural soil.

H-type strain gauges were embedded at the interface between the asphalt layer and the lime-stabilized subgrade. The sensor has a 120-ohm resistance with a gauge factor of 2 and can measure up to 1,500 μstrain units. Type-T copper-constantan thermocouples were placed at various locations within the asphalt layer. The strain gauges and thermocouples were connected to a Labview data acquisition system.

Thin Asphalt Pavement

The thin asphalt pavement sections used in this study were originally built for a project that evaluated the effectiveness of geosynthetic reinforcement (*16, 17*). The pavement structures were composed of a 76-mm SM-9.5 (surface mix with maximum nominal aggregate size of 9.5 mm) asphalt layer and an unbound aggregate base layer with various thicknesses (203, 305, and 457 mm). A PG 64-22 binder was used in the SM-9.5 mix for the asphalt layer. Dense-graded crushed limestone aggregates were used for the granular base layer. The pavement sections were constructed on subgrade with a low California bearing ratio of 4%. Biaxial geogrids were installed before laying of the base course at the designated sections. For the pavement sections used in this study, the location of the geogrid reinforcement was at the bottom of the base layer in the sections with 203- and 305-mm granular base layer and in the top third of the 457-mm granular base layer.

During construction, H-type strain gauges were embedded at the bottom of the asphalt layer. Pressure cells and linear variable deflection transformers were embedded in the base layer and subgrade. The pressure cells can measure up to 400 kPa and have been specially designed to withstand moisture variations and environmental effects during the construction of the upper layers. The linear variable deflection transformers were modified by using two metal disks to maintain vertical placement in the layer during construction and a flexible-rubber cylinder to prevent water and harsh contact with aggregates. Type-T thermocouples were placed in the asphalt layer to monitor the pavement temperature.

Table 1 summarizes the pavement structures and instrumentation used in this study to investigate the impact of wide-base tires on pavement performance. More details on the construction and instrumentation of these pavement sections can be found elsewhere (*15–17*).

TABLE 1 Pavement Structure and Instrumentation Used in Study

	Pavement Structure			Instrumentation		
Pavement Type	Asphalt Layer (mm)	Granular Base Layer (mm)	Subgrade	Strain Gauge	Pressure Cell	LVDT
Full depth	152	na	305-mm lime-stabilized + natural subgrade	Longitudinal and transverse at bottom of asphalt layer	na	na
	254	na			na	na
	420	na			na	na
Thin asphalt (control and geogrid reinforced)	76	203	Weak subgrade with CBR = 4	Transverse at bottom of asphalt layer	Vertical at bottom of base layer	Vertical at 150 mm below subgrade
		305				Vertical at bottom of base; 150 mm below subgrade
		457				

NOTE: na = not applicable; LVDT = linear variable differential transformer; CBR = California bearing ratio.

TABLE 2 Tire Configurations Used in Test

Tire Type	Loaded Radius (mm)	Overall Diameter (mm)	Overall Width (mm)	Tread Depth (mm)
Dual 11R22.5	488	1,049	285	22
Wide-base 425/65R22.5	522	1,130	421	18
Wide-base 455/55R22.5	498	1,078	448	22

TIRE CONFIGURATIONS AND TESTING MATRIX

Tire size and structure are important characteristics related to carrying a load. Three tire configurations were selected for applying the load in this study: wide-base 455, wide-base 425, and 11R22.5 dual-tire assembly. The 11R22.5 dual-tire assembly is widely used in commercial trucks. The wide-base 425/65R22.5 tire was originally designed for pavement testing only, and the wide-base 455/55R22.5 tire is the latest American market generation. The dimensions of the three tire configurations are compared in Table 2. Wide-base tires typically range from 400 to 460 mm in width as opposed to the 250- to 305-mm width for typical radial truck tires.

The tire loading was conducted unidirectionally to simulate field loading conditions with the Advanced Transportation Loading Assembly, housed at the University of Illinois at Urbana-Champaign (Figure 1). The parameters considered in this study were five wheel loads (26, 35, 44, 53, and 62 kN), three tire pressures (550, 690, and 760 kPa), two speeds (8 and 16 km/h), and four offsets (0, 152, 305, and 457 mm). No testing was conducted with the wide-base 425 tire on the thin asphalt pavement section with a 203-mm granular base layer. For each combination, tire loading was applied for 20 passes and the responses under loading were recorded at a rate of 100 Hz. The peak responses at different offsets were used in the analysis, and the average peak values for all 20 passes were determined. An in-house software based on Microsoft Excel Visual Basic for Applications was developed and used to organize and analyze the data efficiently.

The pavement temperatures were recorded at each pass and stored in a separate text file. The mean temperature of the measurements from thermocouples throughout the hot-mix asphalt layer was used as a testing temperature in the analysis. The collected strains were shifted to a reference temperature of 25°C to allow comparison between the responses tested at different temperatures under various tire configurations. Tests were repeated at various times of the day under the same loading conditions. Collected strain data were used to develop an exponential regression model with respect to testing temperature. A correction factor was then obtained to adjust the raw measurements to the correct reference temperature.

RESULTS FROM INSTRUMENTATION MEASUREMENTS

In the *Mechanistic–Empirical Pavement Design Guide,* critical pavement responses at specific locations are related to pavement damage prediction through transfer functions (*18*). For example, the tensile strain at the bottom of thin asphalt layers is related to fatigue cracking, whereas the compressive strain on the top of the subgrade is related to secondary rutting due to compression. In this study, pavement responses were used as indicators of pavement damage, considering the limited accuracy and high variability of the parameters used in the currently available performance transfer functions. The response ratio is used to compare pavement responses caused by various tire configurations. The response ratio is calculated as the ratio of the pavement response caused by the wide-base tires with respect to the pavement response caused by the dual-tire assembly. For each tire configuration, the averages and ranges of response ratios were calculated under all the environmental (temperature) and vehicular loading (load, tire inflation pressure, and speed) conditions.

Full-Depth Pavement

The measured data show that in the full-depth pavement sections, the measured longitudinal strain is greater than the transverse strain under a dual-tire assembly as well as a wide-base tire. Thus, the

(a) (b)

FIGURE 1 Advanced Transportation Loading Assembly with (*a*) dual-tire assembly and (*b*) wide-base 455 tire.

TABLE 3 Ratios of Tensile Strains Between Wide-Base Tires and Dual-Tire Assembly: Full-Depth Pavement Sections

Asphalt Layer Thickness (mm)	Wide-Base Tire	Descriptive Statistics			*p*-Value for Two-Sample *t*-Test
		Average	SD	Range	
152	455	1.17	0.09	1.01–1.35	<.01
	425	1.28	0.10	1.06–1.47	
254	455	1.20	0.08	1.07–1.40	<.01
	425	1.31	0.09	1.13–1.44	
420	455	1.11	0.05	1.03–1.20	<.01
	425	1.17	0.06	1.08–1.27	

NOTE: SD = standard deviation.

longitudinal strain is selected as the critical strain response for bottom-up fatigue cracking in the full-depth pavement sections.

Table 3 summarizes the ratios of measured longitudinal tensile strains caused by the two wide-base tires with respect to the dual-tire assembly at three full-depth pavement sections. On average, the wide-base 455 tire results in 11% to 20% greater tensile strains than a conventional dual-tire assembly under all test configurations compared with a 17% to 31% increase when the wide-base 425 tire is used. It was found that the strain ratios between wide-base tires and the dual-tire assembly decrease as the asphalt layer thickness increases from 254 mm to 420 mm. A two-sample pooled *t*-test was conducted to test the null hypotheses of equality of the strain ratios caused by the two wide-base tires. The very small *p*-values (almost zero) clearly show that there is significant statistical difference between the means of the two data sets. This finding indicates that the new generation of wide-base 455 tire results in less fatigue cracking potential than the wide-base 425 tire.

Thin Asphalt Pavement

Table 4 summarizes the ratios of measured transverse tensile strains caused by the two wide-base tires with respect to the dual-tire assembly at thin asphalt pavement sections for the control sections and the geogrid-reinforced sections, respectively. It was found that compared with the conventional dual-tire assembly, the wide-base 455 tire causes 3% to 40% greater tensile strains in the sections with relatively thin granular base layers (203 and 305 mm) but 8% to 17% smaller tensile strains in the section with the thickest granular base layer (457 mm) regardless of geogrid reinforcement. In contrast, the wide-base 425 tire causes 29% to 60% greater tensile strains than the conventional dual-tire assembly, except that similar tensile strains were induced at the geogrid-reinforced section with the thickest granular base layer.

Table 5 summarizes the ratios of measured subgrade compressive strains caused by the two wide-base tires with respect to the dual-tire assembly at thin asphalt pavement sections for the control sections and the geogrid-reinforced sections, respectively. The subgrade compressive strain is calculated as the displacement differences measured at two different locations (one at the bottom of the base layer and another 152 mm below the top of the subgrade) divided by its distance.

The results show that the wide-base 455 tire causes 10% to 12% greater compressive strains than the conventional dual-tire assembly at the control sections. At the geogrid-reinforced section, compared with the conventional dual-tire assembly, the wide-base 455 tire causes 10% greater compressive strain at the section having a 305-mm granular base layer but 7% smaller compressive strain at the section having a 457-mm granular base layer. Similar to the tensile strains, the wide-base 425 tire causes 18% to 64% greater compressive strains than the conventional dual-tire assembly, except that similar compressive strains were induced at the geogrid-reinforced section with the thickest granular base layer.

The ratios of measured pressure at the bottom of the base layer caused by the two wide-base tires with respect to the dual-tire assembly at thin asphalt pavement sections for the control sections and the geogrid-reinforced sections, respectively, are summarized in Table 6. The results show that compared with the dual-tire assembly, the wide-base 455 tire causes 18% to 43% greater base pressure, and the wide-base 425 tire causes 13% to 26% greater base pressure. These findings indicate that the wide-base 455 tire results in greater pressure in the base layer. The elastic modulus of the granular base layer increases as the loading increases because of its stress-hardening behavior (*19*). This finding further necessitates the consideration of nonlinear stress-dependent behavior for the granular base layer when thin asphalt pavement responses under various tire loading conditions are predicted.

A general trend was found from Tables 4 to 6; the response ratios decrease as the base layer thickness increases regardless of the type of wide-base tire. In addition, the response ratios become closer to unity in most cases as the base layer is geogrid-reinforced (except for the case of the wide-base 425 tire on the section with a 305-mm

TABLE 4 Ratios of Tensile Strains Between Wide-Base Tires and Dual-Tire Assembly: Thin Asphalt Pavement Sections

Section	Base Thickness (mm)	Wide-Base Tire	Descriptive Statistics			*p*-Value for Two-Sample *t*-Test
			Average	SD	Range	
Control	457	455	0.83	0.09	0.69–1.03	<.01
		425	1.29	0.11	1.21–1.48	
	305	455	1.11	0.18	0.87–1.36	<.01
		425	1.60	0.22	1.21–2.05	
	203	455	1.40	0.09	1.29–1.51	na
Geogrid reinforced	457	455	0.92	0.09	0.76–1.08	.04
		425	1.01	0.05	0.95–1.07	
	305	455	1.03	0.11	0.83–1.19	<.01
		425	1.50	0.22	1.21–1.99	
	203	455	1.25	0.18	1.08–1.58	na

TABLE 5 Ratios of Subgrade Compressive Strains Between Wide-Base Tires and Dual-Tire Assembly in Thin Asphalt Pavement Sections

Section	Base Thickness (mm)	Wide-Base Tire	Descriptive Statistics: Average	SD	Range	*p*-Value for Two-Sample *t*-Test
Control	457	455	1.10	0.23	0.75–1.84	<.01
		425	1.18	0.27	0.88–1.89	
	305	455	1.12	0.12	0.92–1.39	<.01
		425	1.44	0.23	1.09–1.99	
Geogrid reinforced	457	455	0.93	0.14	0.77–1.23	.04
		425	1.01	0.18	0.71–1.42	
	305	455	1.10	0.18	0.74–1.54	<.01
		425	1.64	0.28	1.02–2.03	

base layer). These findings indicate that the pavement is stronger and the aggregate interlock has been improved; the response differences between wide-base tires and the dual-tire assembly are smaller. The wide-base tires have different load distribution patterns and contact areas at the tire–pavement interface than the dual-tire assembly. However, the pavement responses at relatively greater depths become less sensitive to the load distributions and contact stresses at the tire–pavement interface. Therefore, the impact of wide-base tires on fatigue cracking and subgrade rutting potential becomes less significant as the pavement structure becomes stronger.

RESULTS FROM MODELING ANALYSIS

Model Validation with Field Measurements

FE methods provide a flexible and versatile framework for predicting pavement responses under various controlling parameters (such as nonuniform tire–pavement contact stresses, irregular tire imprint area, cracks or joints in the pavement, viscoelastic and nonlinear material properties, infinite foundation, material damping, dynamic analysis, bonded or debonded interfaces, and so forth). A three-dimensional FE model of flexible pavement was developed by the research group to analyze pavement responses caused by various tire configurations. This model uses the implicit dynamic analysis and simulates vehicular loading as a continuous moving load. In particular, the specific three-dimensional contact stress distributions under the dual-tire assembly and the two wide-base tires are used as the loading input. In the FE model, the asphalt layer is modeled as a linear viscoelastic material and the granular base layer is modeled as a nonlinear anisotropic material. More details about the tire–pavement contact stress distribution under various tire configurations and the FE model can be found elsewhere (*19–21*).

Table 7 compares the response ratios calculated with the FE model and the response ratios measured from APT. The tire loading condition used in the calculation is 35.5 kN at a speed of 8 km/h. The comparison shows that consistent trends were observed between the model predictions and field measurements. The model validation shows the potential of the model to predict the pavement responses that are not measured in the APT. These predicted pavement responses are presented in the next sections.

Near-Surface Cracking Potential in Full-Depth Pavements

Recently, surface-related cracking has been observed at the surface or near-surface of thick asphalt pavements or overlays as premature failure (*22*). Therefore, it is important to examine the pavement responses that are related to the failure at the pavement near-surface. Several factors contribute to the surface cracking mechanism. These include load-induced factors (tension, shear), material factors (fracture energy, aging), construction factors (longitudinal construction joints, segregation), and temperature-induced factors (thermal stress) (*23*). Among these factors, the high tensile or shear stresses and strains induced by tires at the pavement near-surface are the most well-recognized load factors.

TABLE 6 Ratios of Base Pressure Between Wide-Base Tires and Dual-Tire Assembly in Thin Asphalt Pavement Sections

Section	Base Thickness (mm)	Wide-Base Tire	Descriptive Statistics: Average	SD	Range	*p*-Value for Two-Sample *t*-Test
Control	457	455	1.42	0.13	1.24–1.74	<.01
		425	1.21	0.28	0.88–1.78	
	305	455	1.43	0.23	1.01–1.97	<.01
		425	1.18	0.13	0.89–1.45	
Geogrid reinforced	457	455	1.18	0.10	0.97–1.41	.04
		425	1.13	0.14	0.92–1.37	
	305	455	1.32	0.14	1.04–1.58	<.01
		425	1.26	0.17	0.87–1.53	

TABLE 7 Comparison of Response Ratios Between Wide-Base 455 Tire and Dual-Tire Assembly from APT and Model

Pavement Structure	Response Ratio for	Model Prediction	APT Measurement
Full-depth pavement with 254-mm asphalt layer	Longitudinal tensile strain at bottom of asphalt layer	1.25	1.20
Thin asphalt pavement with 305-mm base layer	Transverse tensile strain at bottom of asphalt layer	1.24	1.11
	Vertical pressure at bottom of base layer	1.20	1.43
	Compressive strain on top of subgrade	1.25	1.12

Figure 2, *a* and *b,* compares the transverse distributions of tensile and shear strains at the pavement near-surface for the full-depth pavement section with a 254-mm-thick asphalt layer under various tire loading conditions (35.5 kN, 724 kPa, 8 km/h, and 25°C). Compared with the dual-tire assembly, the wide-base 455 tire induces 25% smaller tensile strains and 10% smaller shear strains at the pavement near-surface. The strain responses at the pavement near-surface are affected by the localized tire–pavement contact stress distributions, which are different for the dual-tire assembly and the wide-base 455 tire. These findings indicate that the wide-base 455 tire could cause less cracking at the pavement near-surface and are consistent with the APT finding reported by Greene et al. (*12*). In their study, the surface tensile strains under various tire configurations were measured by using the foil-type strain gauge, and it was found that the wide-base 455 tire causes smaller surface tensile strains.

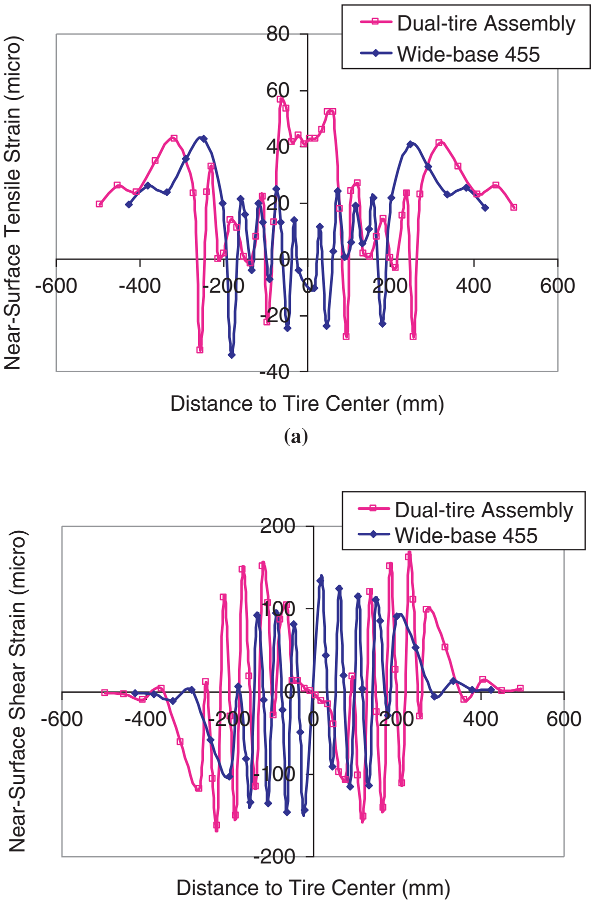

FIGURE 2 Effect of wide-base 455 tire at pavement near-surface on (*a*) maximum tensile strains and (*b*) shear strains.

Primary Rutting Potential in Thin Asphalt Pavements

Primary rutting in asphalt layers includes two types of deformation: volume reduction caused by traffic densification, and permanent movement at a constant volume or dilation caused by shear flow. Monismith et al. (*24*) demonstrated that the accumulation of permanent deformation in the asphalt layer is very sensitive to the layer's resistance to shape distortion (i.e., shear) and relatively insensitive to volume change.

Figure 3 shows the in-depth shear strain distribution in the asphalt layer at the thin pavement section with a 305-mm granular base

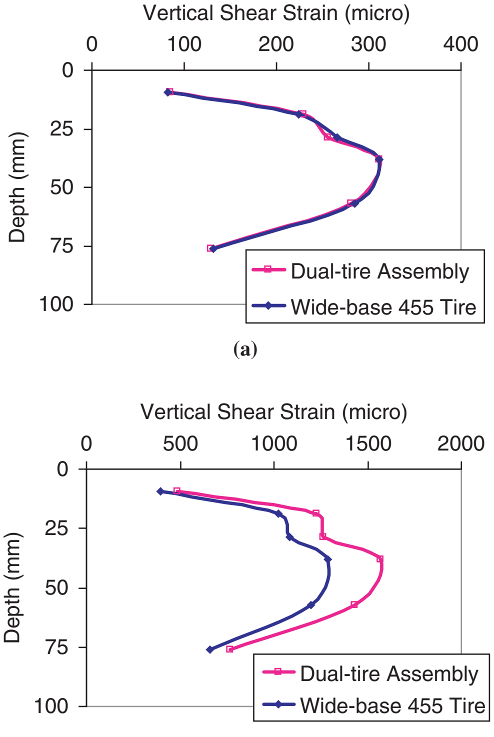

FIGURE 3 Effect of wide-base 455 tire on in-depth shear strain distribution at (*a*) 25°C and (*b*) 47°C.

layer under a dual-tire assembly and a wide-base 455 tire carrying the same load (35.5 kN, 724 kPa, and 8 km/h). The results show that compared with the dual-tire assembly, the wide-base 455 tire induced similar maximum shear stresses or strains at 25°C but 18% smaller maximum shear stresses or strains at 47°C at the shallow depth of the asphalt concrete layer. At intermediate temperatures, the pavement responses in the asphalt concrete layer are more controlled by the load-induced bending effect, whereas at high temperatures, the asphalt concrete layer becomes soft and the effect of localized contact stresses (vertical and tangential) under different tire configurations becomes more significant. These findings indicate that the wide-base 455 tire could cause similar or less primary rutting in the asphalt layer and are consistent with the findings reported in previous studies (*9, 12*) that the wide-base 455 tire causes similar or less primary rutting than the dual-tire assembly based on rut measurements after APT.

CONCLUSIONS

The impact of the environment-friendly wide-base tires on two typical flexible pavement structures is investigated through APT and advanced FE modeling analysis. The following conclusions are drawn from this study:

1. It was found from the instrumentation measurements that the wide-base 425 tire causes the greatest fatigue cracking potential and subgrade rutting potential among the three tire configurations, regardless of pavement structure and response type.
2. The wide-base 455 tire was found to cause greater bottom-up fatigue cracking potential and subgrade rutting potential than the dual-tire assembly at most tested sections, except the thin pavement section with the thickest granular base layer.
3. The instrumentation results show that the impact of wide-base tires on fatigue cracking potential and subgrade rutting potential becomes less significant as the asphalt layer or base layer thickness increases because surface contact stresses become less influential as pavement depth increases.
4. The FE modeling results indicate that compared with the dual-tire assembly, the wide-base 455 tire results in similar or less primary rutting potential in thin asphalt pavements and less near-surface cracking potential in thick asphalt pavements. These findings show that pavement responses at the near-surface are more affected by the localized tire contact stress distribution, especially at high temperatures.

The measured and calculated pavement response ratios presented in this study can be used to further analyze the impact of wide-base tires on pavement service life. A future study will be conducted to evaluate the impact of wide-base tires on pavements by using an approach that considers economic and environmental aspects, such as life-cycle cost analysis and life-cycle assessment.

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