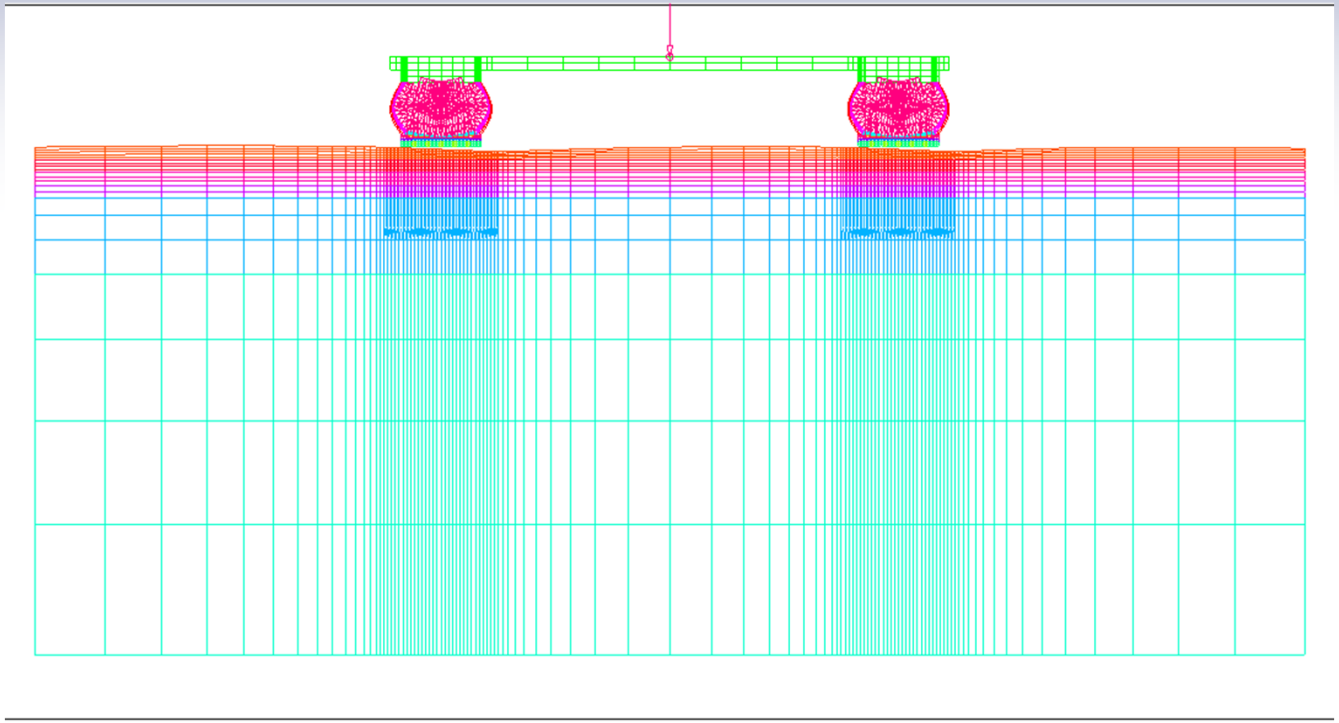
Effects of Rutted Surface on Near-Surface Pavement Response



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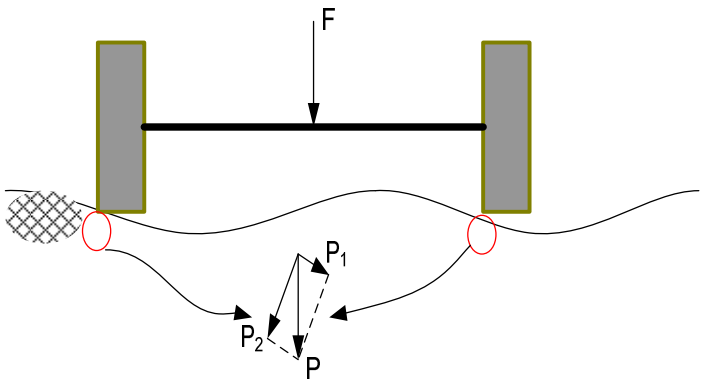
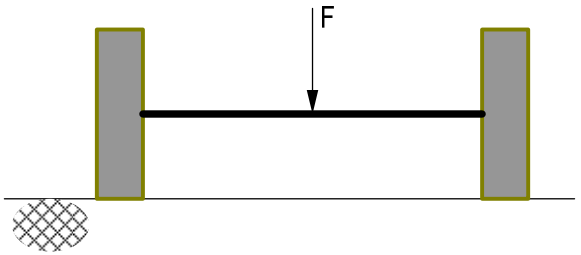
Outline

- Background
- Develop 2-D Axle-Tire-pavement Contact Model
- Investigate Rutted Surface on Near-Surface Pavement Response
- Conclusions & Recommendation

Background

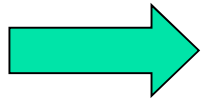
- Rutted Surface Affects Tire-Pavement Interaction
- Non-Uniform Contact Stress
- Top-Down Cracking and Instability Rutting

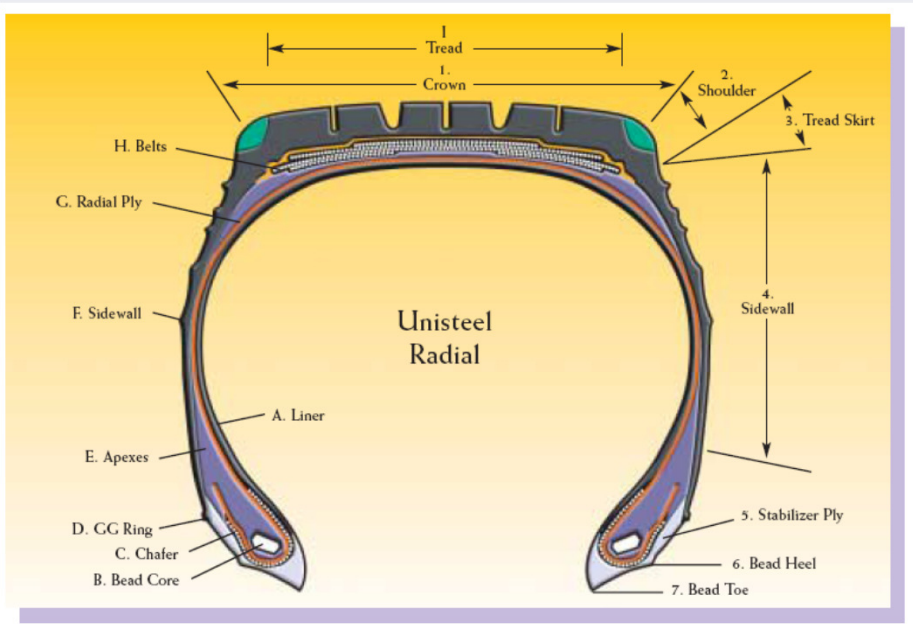




Develop 2-D Axle-Tire-pavement Contact Model

- Modeling of Tire

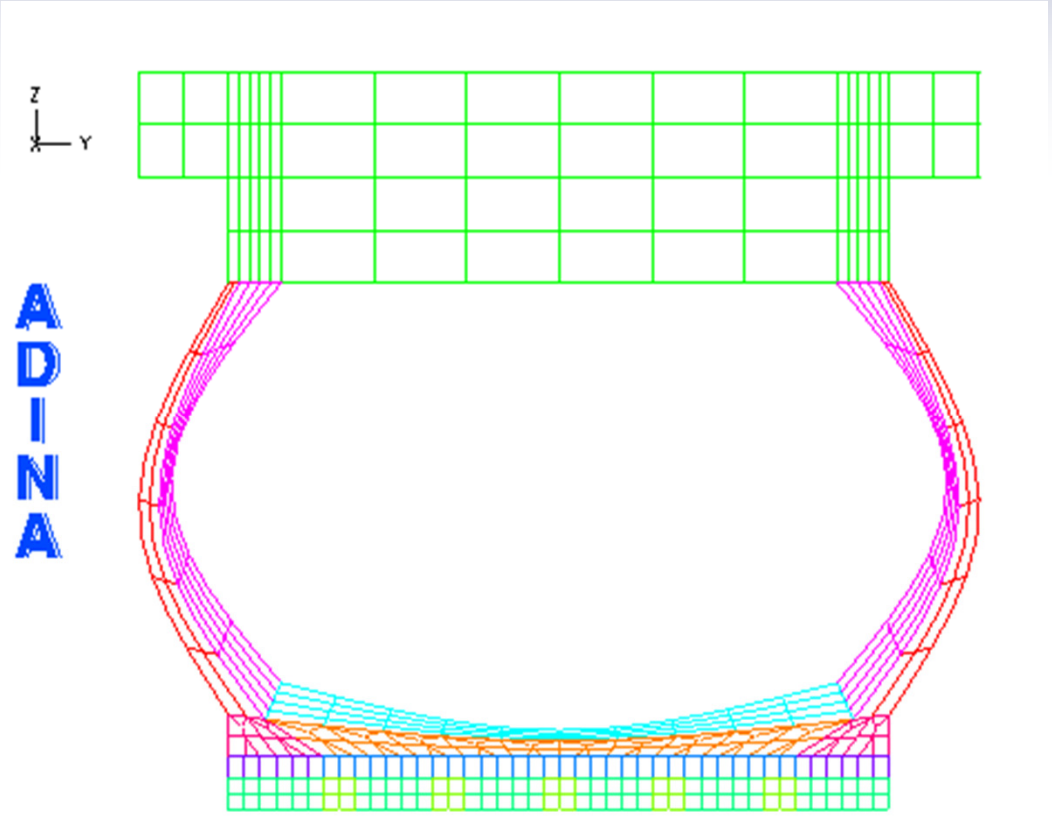




Tire to be modeled-Goodyear 425/65R22.5

Components of a unisteel radial tire (Goodyear after 2004)

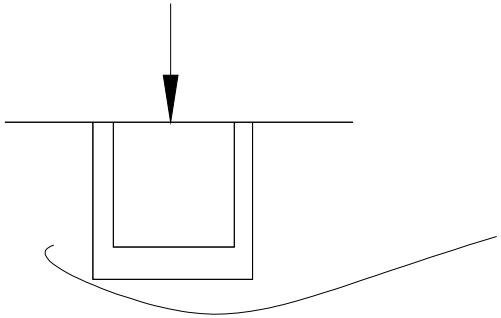
2D-Tire Mesh



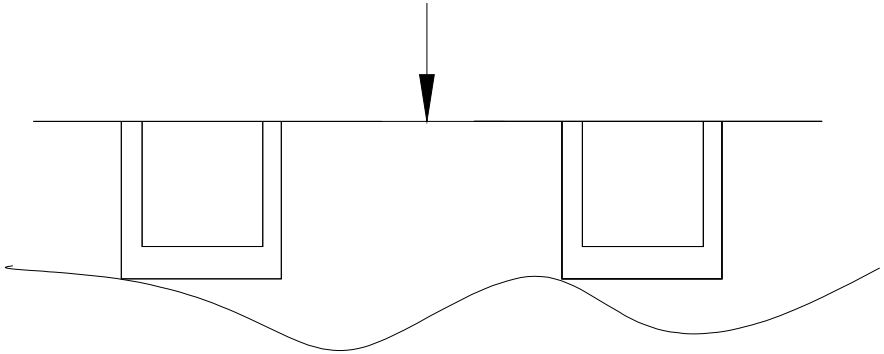
Developed 2-D finite element tire model

Modeling of 2-D Axle-Tire-Pavement Interaction

- Why need an axle?

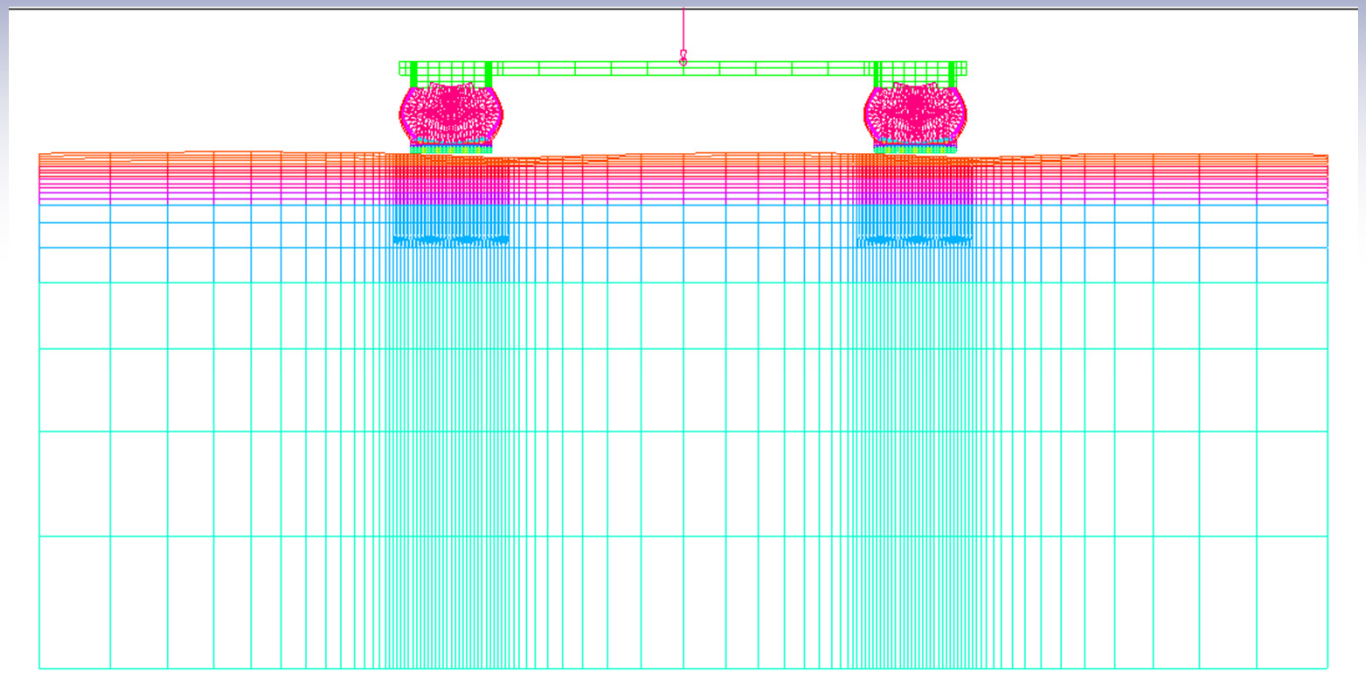


Unstable Structure



Stable Structure

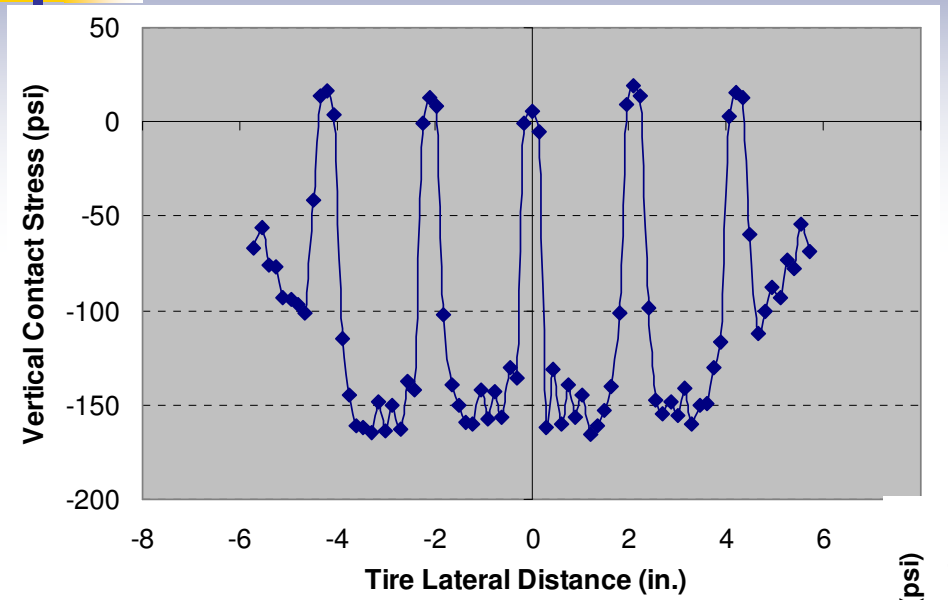
Developed 2-D Axle-Tire-Pavement Model

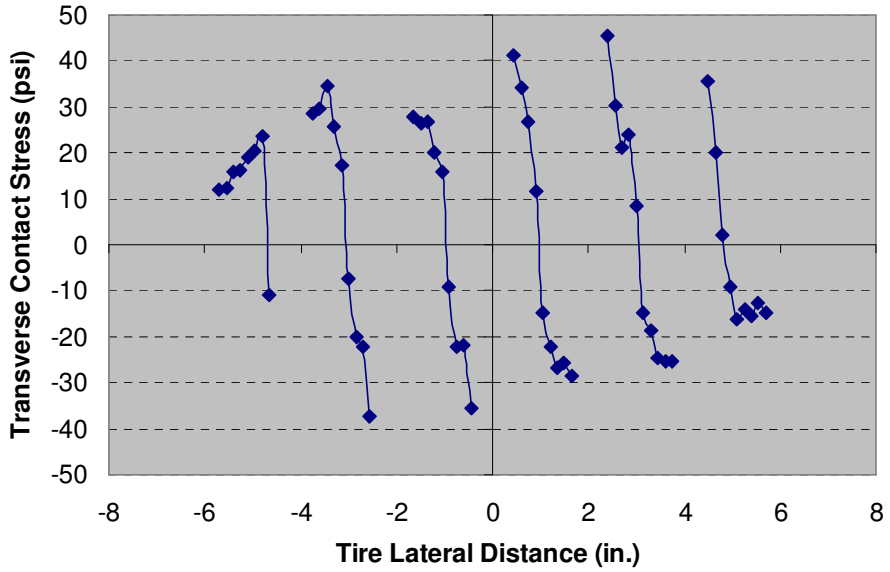


Flat Surface

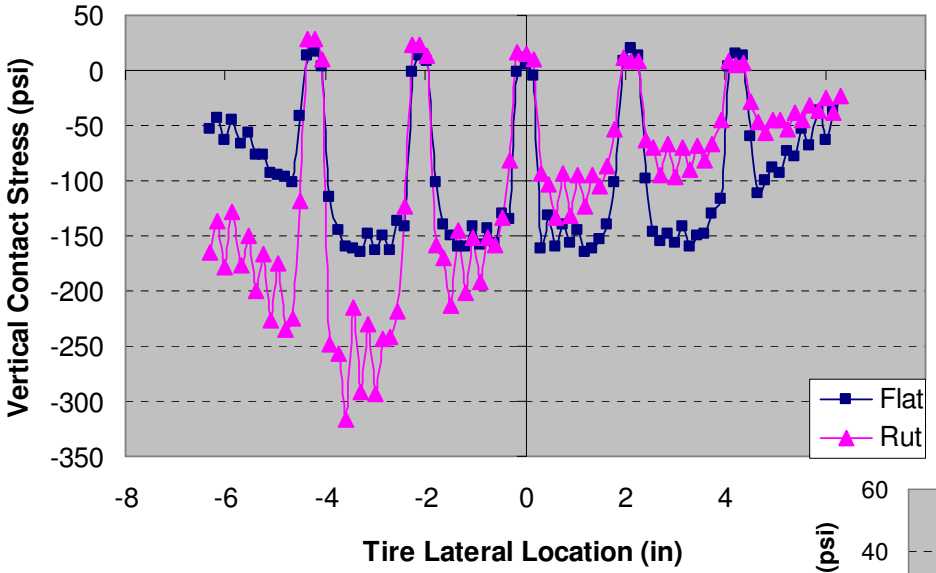
Rutted Surface

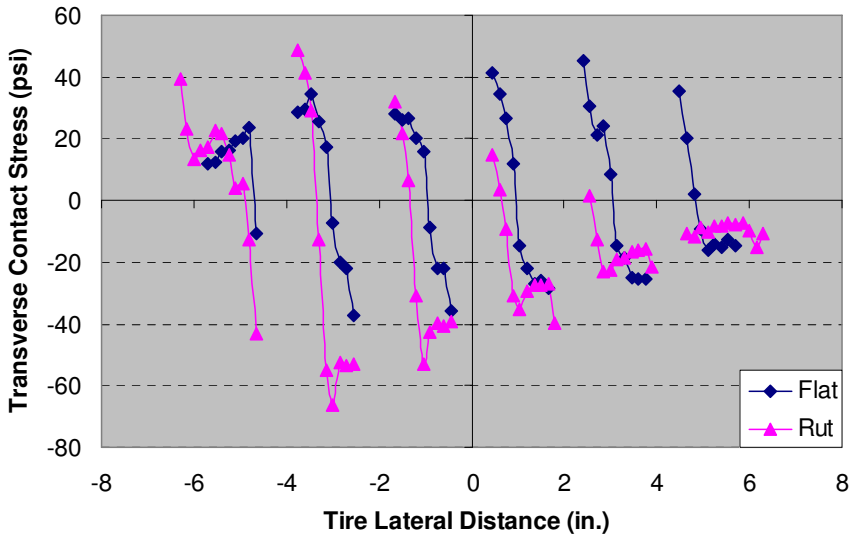
Model Verification



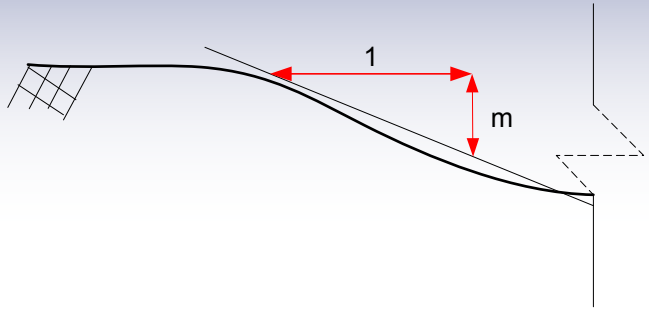


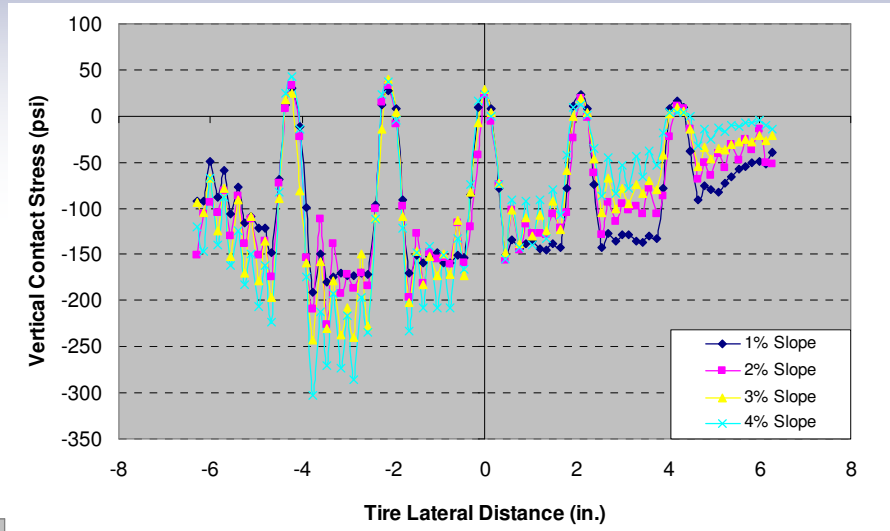
Effects of Rutted Surface on Near-Surface Response

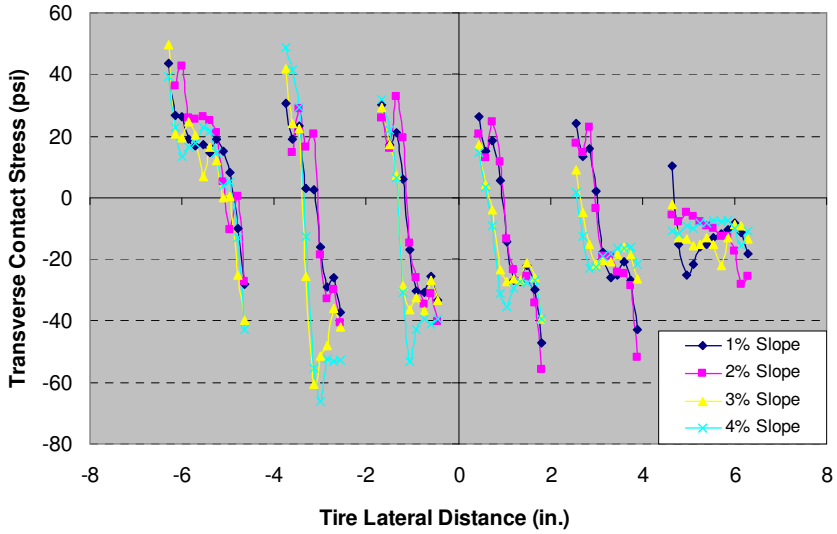




Effects of Rutted Surface on Near-Surface Response (Cont.)





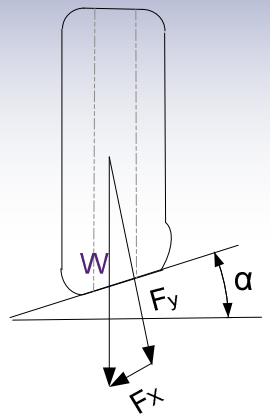


Statistical Summary

Table 1. Statistic results of the comparison of peak contact stresses

Items	Degree of Rutting Severity				
	0%	1%	2%	3%	4%
Peak Vertical Contact Stress (psi)	-165	-191	-226	-243	-303
Increasing Percentage (Relative to Flat Surface)	0%	16%	37%	47%	83%
Peak Transverse Contact Stress (psi)	45	47	56	61	66
Increasing Percentage (Relative to Flat Surface)	0%	4%	24%	36%	47%

Effects of Rutted Surface on TDC and Instability Rutting

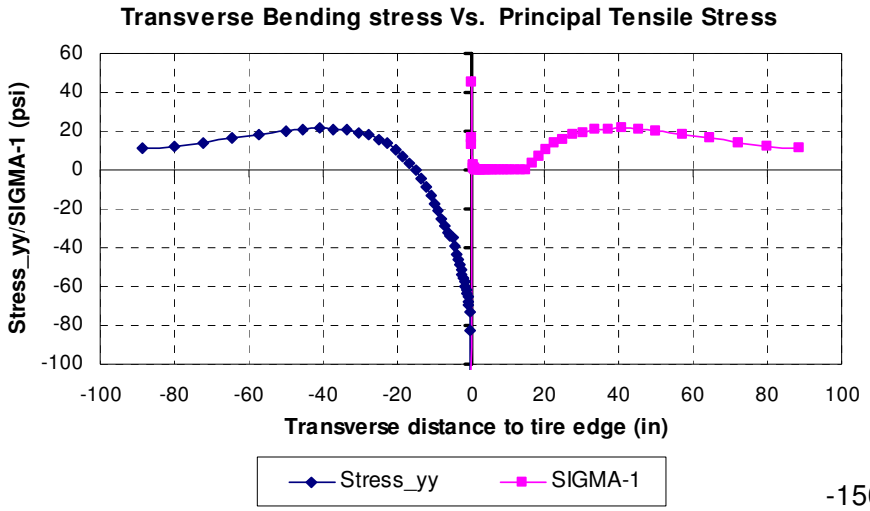


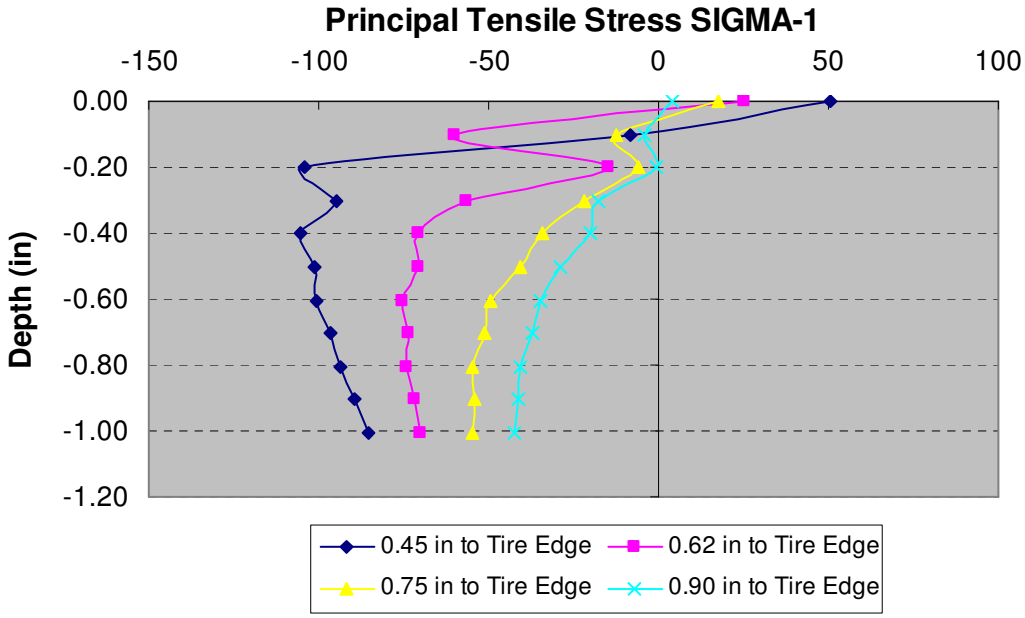
$$\frac{F_x}{W} = \sin\alpha \approx \alpha$$

Forces acting on a tire on a side of a rut

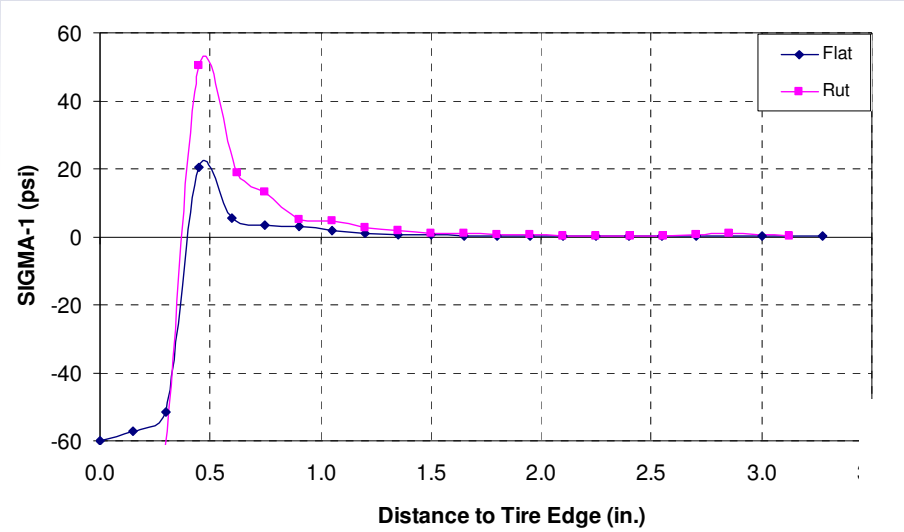
For one degree of inclination angle, a lateral force of 0.0174 lb/lb is produced in the "downhill" direction by the gravitational component. For radial tire, this lateral force might be responsible for creating rut or increasing severity of rut in asphalt pavement surface (Gillespie, TD. et al. 1993).

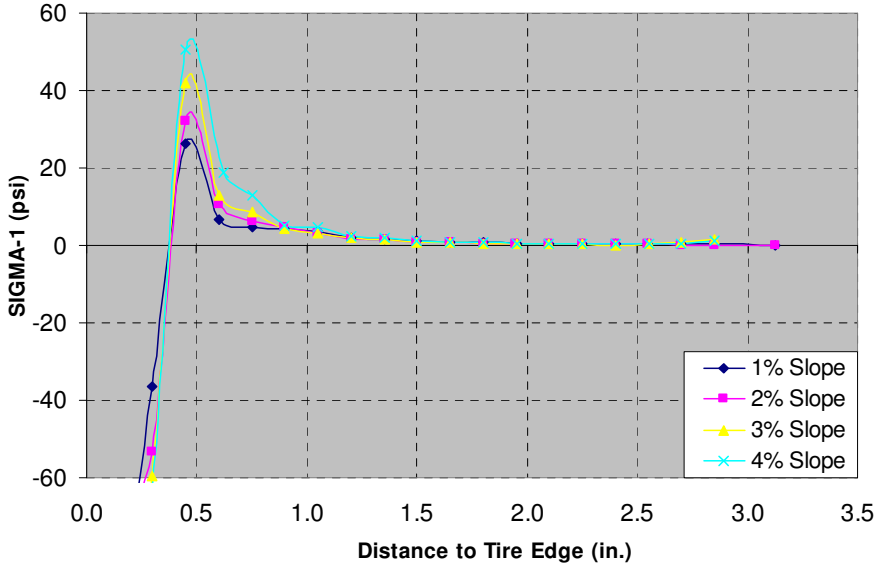
Critical Locations for TDC and Instability Rutting



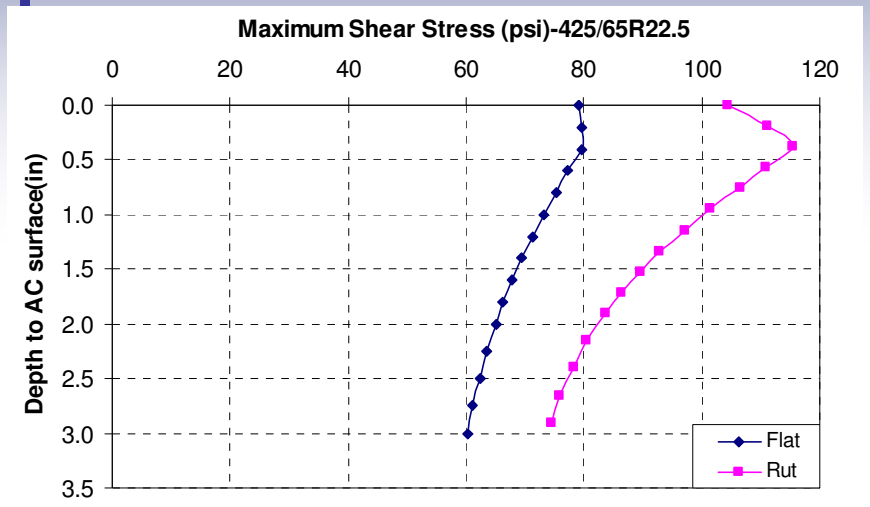


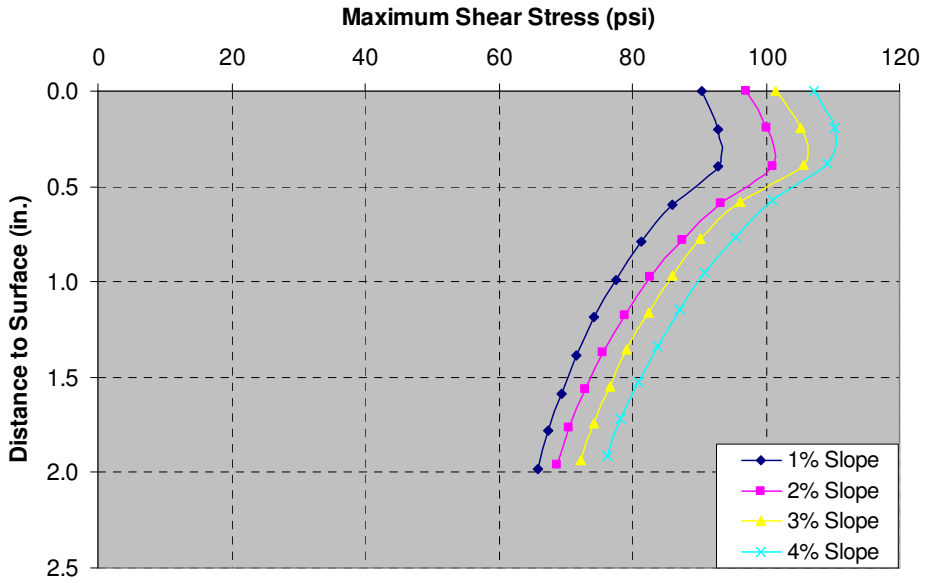
Effects of Rutted Surface on TDC





Effects of Rutted Surface on Instability Rutting





Statistical Summary

Table 2. Summary of Peak Principal Tensile Stress and Maximum Shear Stress

Items	Degree of Rutting Severity				
	0%	1%	2%	3%	4%
Peak Maximum Shear Stress (psi)	80	92	101	106	110
Increasing Percentage (Relative to Flat Surface)	0%	15%	26%	33%	38%
Peak Principal Tensile Stress (psi)	20	26	32	42	50
Increasing Percentage (Relative to Flat Surface)	0%	30%	60%	110%	150%

Conclusions

- The developed 2-D axle-tire-pavement finite element contact model can successfully capture patterns of both vertical contact stress and horizontal shear contact stress distributions
- Comparing with flat AC surface, contact stresses induced on the rutted surface are more concentrated on the tire shoulder and decrease along the "downhill" direction. The more severity the rut, the higher the localized contact stress on the tire shoulder.

Conclusions (Cont.)

- Comparing with flat surface, both peak SIGMA-1 and maximum shear stress due to rutted surface are increased significantly. The more severity the rut, the greater propensity for TDC and the more severity for instability rutting

Future Research Recommendation

- Need to develop 3-D tire-pavement interaction model to further investigate the effects of rutted surface on the near-surface pavement response

Thank You