Effects of Tire Axle Load and Inflation Pressure on Near-Surface Pavement Response

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Outline

• Background
• Develop 2-D Axle-Tire-Pavement Contact Model
• Investigate Tire Axle Load and Inflation Pressure on Near-Surface Pavement Response
• Conclusions & Recommendation
Background

- Damaging Effects of Overloaded/Heavy Loaded Vehicles to Pavements
• Pavement damage follows approximately a 4th-power rule, which means that if the load is doubled, the damage will be 16 \((2^4)\).
• If the load is increased by 20\%, the damage is doubled!
Background (Cont.)

Heavy/Over Load results in fewer allowable repetitions before failure

(Source: Wilde, 2012)
Background (Cont.)

- Damaging Effects of Under/Over Inflated Tires to Pavements
Background (Cont.)

- Top-down Cracking and Instability Rutting
Develop 2-D Axle-Tire-pavement Model

- Tire to Be Modeled

Michelin X One® XDA-HT™ Plus 445/50R22.5
Develop 2-D Axle-Tire-Pavement Model (Cont.)

- Modeling of Tire
Develop 2-D Axle-Tire-Pavement Model (Cont.)
Develop 2-D Axle-Tire-Pavement Model (Cont.)

- Model Verification

![Graph of Maximum Vertical Contact Stress (psi)]

- Model Verification

![Graph of Vertical Contact Stress (psi)]

- Model Verification

![Graph of Lateral Contact Stress (psi)]
Effects of Axle Load on Near-Surface Pavement Response
Effects of Axle Load on Near-Surface Pavement Response (Cont.)
Effects of Axle Load on Near-Surface Pavement Response (Cont.)

![Graph showing the relationship between axle load and stress. The graph has two lines: one for Max. Shear Stress and one for Principle Tensile Stress. The y-axis represents Stress (psi) ranging from 0 to 100, and the x-axis represents Axle Load (lbs) ranging from 13.5k to 22.5k. The graph shows an increase in both stress types as the axle load increases.]
Effects of Tire Inflation Pressure on Near-Surface Pavement Response

Over Inflation
Under Inflation
Correct Inflation

Tire Lateral Distance (in)
Vertical Contact Stress (psi)
Effects of Tire Inflation Pressure on Near-Surface Pavement Response (Cont.)

![Graph showing the effects of tire inflation pressure on near-surface pavement response. The graph plots transverse contact stress (psi) against tire lateral distance (in). Three lines represent tire inflation pressures of 80 psi, 100 psi, and 125 psi. The pressures are indicated by different markers: black diamonds for 80 psi, pink squares for 100 psi, and pink triangles for 125 psi.]
Effects of Tire Inflation Pressure on Near-Surface Pavement Response (Cont.)
Effects of Tire Inflation Pressure on Near-Surface Pavement Response (Cont.)

![Graph showing the relationship between tire inflation pressure and peak SIGMA-1.]
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.
- The maximum contact stress moved from the tire center towards the tire edges when the tire was heavily loaded or under inflated.
Conclusions (Cont.)

• Both peak SIGMA-1 and maximum shear stress increase with the axle load. The peak SIGMA-1 and maximum shear stress slightly increase with the decrease of the inflation pressure, which indicates that under inflation might increase the propensity of top-down cracking and instability rutting.
Future Research Recommendation

• Need to develop 3-D tire-pavement interaction model to further investigate the effects of tire axle load and inflation pressure on the near-surface pavement response.
Reference

Thank You