Rest Period Effect on Pavement’s Permanent Deformations under Truck Platooning Configurations
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Introduction

Enabling communication technologies in Connected and Autonomous Trucks (CATs) has the potential to reduce the distance between trucks from 200 ft to as low as 10 ft to form a platoon. This could result in reducing congestion and braking/accelerating, while improving safety, traffic flow, fuel efficiency. However, this could be detrimental to pavement due to the development of channelized traffic at a reduced spacing. The effect on pavement may manifest in an increase in the permanent deformation and fatigue cracking. The objective is to quantify the effects of various platoon scenarios on pavement response. Specifically, rest period and recovery characteristics of asphalt pavement. Advanced 3-D numerical models and experimental characterization of permanent deformation have been used in the study. Preliminary results show that strain recovery and rest period of a platoon contrastingly impact the AC permanent deformation; hence, should be included as part of the loading.

Previous Work

The following developments have been achieved in this project to date:

Wander 2D – A design framework that includes truck lateral position as an explicit input to calculate pavement damage.

Aerodynamics – Modeling actual platoon to obtain drag coefficients based on truck spacing and position.

Optimization Framework – Optimal platoon configuration is developed to predict pavement damage and fuel savings.

Objective and Scope

This study aims to understand permanent deformation under various loading and speed conditions. Numerical 3-D finite element modeling supported by experimental work were used to develop a surrogate function for incorporation in the optimization framework.

Pavement Modelling

Truck pacing and speed and pavement temperature profile are critical for analyzing the effect of strain recovery. The following levels for these parameters were considered:

- Simulation Matrix:
  - Speed: 40 and 70 mph (interstate limits)
  - Temperature: 50, 86, and 122 °F (low, intermediate and high)
  - Pavement structure: Asphalt concrete (AC) and granular base layer thickness are 14 and 12 in, respectively (pavement thickness)

Summary:
- Main outcome of the analysis:
  - Accumulated tensile strains at bottom of AC are critical and affect to recovery.
  - Transverse strains are more critical than longitudinal strains because the latter has greater recovery.
  - The scenario at 70 mph could be critical for tandem-axle because of the lower strain recovery

Experimental Methodology

- Various truck platoon scenarios were simulated using flow number tests.
- A 19.0-mm dense graded AC mix produced in accordance with Arizona Department of Transportation specification was used.
- The mix was reproduced using PG 70-10, PG 76-22 SBS, PG 76-22 TR+, PG 64-28 SBS binders.
- The following test matrix was adopted:
  - Wander effect was simulated by three stress levels at 140, 110, and 80 psi.
  - Temperature effect was considered using three levels: 54.4°C, 40°C, 28°C.
  - Rest period was used to simulate possible truck distances in a platoon at 0.18 sec (16 ft), 0.57 sec (50 ft), 2.5 sec (200 ft).

Analysis and Results

As rest period increases, permanent deformation intensifies. The effect of rest period could be as significant as that of temperature, stress, and/or binder type.

Summary and Findings

- Strain recovery and rest period of a platoon contrastingly impact the AC permanent deformation.
- Rest period should be included as part of loading to accurately determine AC permanent deformations.
- The extent of rest period impact on AC, which is a viscoplastic material, is important because of the AC hardening-relaxation phenomenon.

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