Transportation Consortium of South Central States

# Evaluation of Comparative Damaging Effects of Multiple Truck Axles for Flexible Pavements

## Key Points

**Project Number:**
17PUTA01

**Start Date:**
05/08/2017

**End Date:**
11/08/2018

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University of Texas, Arlington

**Funds Requested to UTC:**
$120,000

**Funding Source(s):**
Tran-SET
University of Texas, Arlington
University of Texas at San Antonio

**Total Project Cost:**
$240,002

### Brief Project Description

This study aims to develop a strain measurement dataset that will allow revisiting pavement response under in-service traffic for the purpose of quantifying pavement damage under various truck/axle configurations. In addition, the pavement layer properties from the instrumented pavement site will allow comparing the measured versus estimated strains using conventional layer visco-elastic techniques. It involves installation of an instrumented site, laboratory characterization of the asphalt concrete properties at the site and finite element method (FEM) simulation of the pavement responses. The outcome will benefit pavement designers and road authorities that levy permit fees for commercial vehicles.

### Problem Statement

There is a need to harmonize truck load limit regulations between US states as well as between the US and our NAFTA neighbors. Considerable work was recently done in revisiting truck weights and dimensions under MAP-21 funding. This involves the quantification of relative pavement damage due to the load limit increase and the search for trucks with improved configurations. This was done using the state of the art AASHTOWare pavement Mechanistic-Empirical (ME) model. The National Academy of Sciences through its NCHRP Program (specifically NCHRP Project 1-37A) has dedicated significant resources in developing this new mechanistic-empirical pavement design method. This method accounts for local environmental conditions, local highway materials, and actual highway traffic distribution by means of axle load spectra. Texas DOT uses a different ME pavement design approach implemented in to the software package FPS21 for the design of flexible pavements. FPS21 uses similar mechanistic principles for quantifying pavement response to load.

A major limitation of these mechanistic-empirical approaches to flexible pavement design is that all materials are considered linear elastic, homogeneous and isotropic. This assumption is made to simplify the response calculations. The effect of loading speed is considered only by adjusting the dynamic modulus of the asphalt concrete based on the master curve data provided. This assumption has a major consequence: when a truck passes over the pavement structure, the strains induced by an axle group are treated independently from those induce by subsequent axle groups (e.g., steering

axle versus following tandems in a class 9 truck). In other words, there is no consideration of overlapping strain effects from the various axle groups of a truck. In-situ strain measurements from several instrumented pavement sections in the United States and overseas clearly proved that:

a) The transverse strain induced by the front axle of the truck does not completely recover before the strain induced by the following axles develops. Therefore, the transverse strains under the rear axles are much higher than those estimated by linear elastic models.
b) The strains under a multiple axle are much higher than those estimated by linear elastic models, even when the effect of the front axle(s) is removed.
c) The transverse horizontal strain at the bottom of the HMA layer is bigger that the longitudinal horizontal strain because of the compounding effects from multiple axles. Most pavement structural models, including AASHTOWare Pavement ME and FPS21, compute only the longitudinal strain because it is assumed to be the largest.
d) The compounding effect increases when the vehicle speed decreases and when the temperature in the HMA layers is high, as normally is in the South Central region of the United States.

**Intended Implementation of Research**

An important component of the implementation process will be the dissemination of findings through several seminars or webinars that will present the findings and discuss their significance to the transportation agencies as well as specialists in the truck transport industry, consultants and traffic enforcement agencies. The use of the findings from this research will not require any additional resources or testing to be implemented by various transportation agencies. Therefore, the proposed methodology has a great potential to be easily transferred to practitioners at the state level (e. g., engineers, technicians, etc.).

**Anticipated Impacts/Benefits of Implementation**

The outcome of the proposed project will help the south-central state DOTs and local agency officials make more informed decisions about the effect of truck axle loads and configurations on pavement response and damage. It will allow a proper estimation of pavement structural response, which will lead to improved flexible pavement design. It will also help with the local calibration of the AASHTOWare pavement ME software and the FPS21 software. Furthermore, it will provide solid evidence towards ascertaining equitable overweight permit fees and/or over-limit penalties to commercial vehicles. This is urgent, given the wide variation in over-weight truck permitting between jurisdictions.

**Weblinks:**

- Tran-SET's website (http://transet.lsu.edu/completed-research/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/view/1467211)