Evaluating the Performance of Guardrail Systems for Installation in Georgia by Driving Through Asphalt Layers (Phase I)

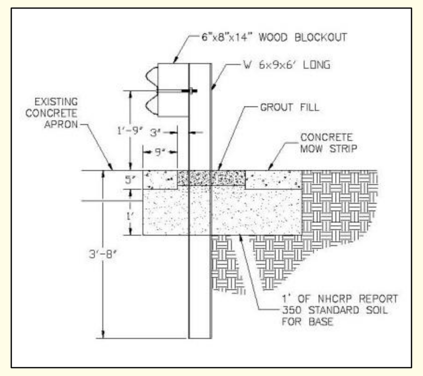
David W. Scott, Chloé Arson, Donald White,
Seo-Hun Lee, Esmaeel Bakhtiary

Georgia Institute of Technology
Georgia Transportation Institute
Georgia Department of Transportation

Problem Statement

Recent research suggests direct encasement of guardrail posts in a mow strip without leave-outs will cause excessive restraint at the ground line and prevent the post from functioning as intended in a vehicle crash.

Typical guardrail installation in Georgia (driving through a thin layer of asphalt)



Guardrail Installation detail incorporating grout leave-outs

The Georgia DOT (GDOT) seeks alternatives for guardrail post installation that will allow the barrier to function as intended without resorting to costly grout-filled leave-outs at each post.

Project Objective

Phase I

- Evaluation of structural performance of guardrail posts
  - Installed using current GDOT procedures and alternative methods
  - Static test paired with dynamic FE analysis
- Selection of a subset of promising alternative installation methods

Phase II

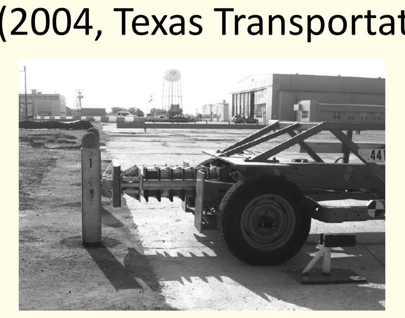
- Evaluation of post installation methods under dynamic loads

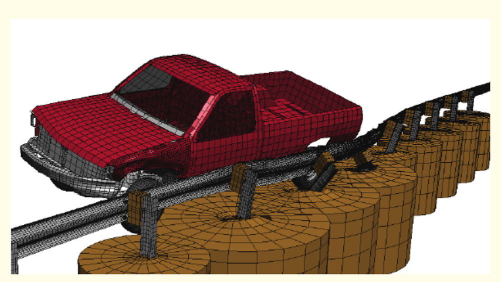
Phase III

- Full-scale crash testing for the most promising alternative installation method, followed by submission to FHWA for acceptance

Background

Dynamic Response of Guardrail Systems Encased in Pavement Mow Strips
(2004, Texas Transportation Institute)





- Subcomponent dynamic testing of 17 guardrail post configurations
- Dynamic FE analysis of full-scale model and full-scale crash testing (NCHRP 350)

Alternative Design of Guardrail Posts in Asphalt or Concrete Mowing Pads
(2009, Texas Transportation Institute)

- Performance evaluation of guardrail posts with 5 different types of leave-out

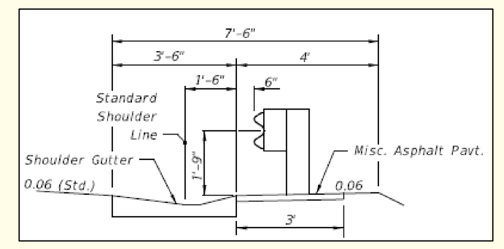
- <u>Lack of distinct objective criteria in the assessment process, especially for the asphalt mow strip without leave-out</u>

Phase I

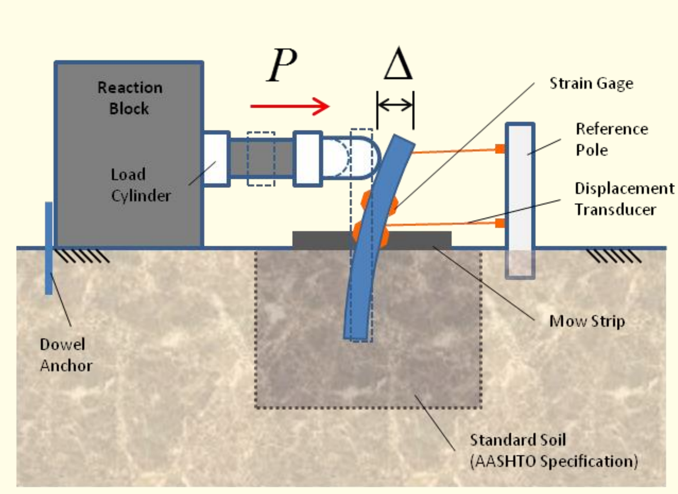
- **Synthesis of the state-of-the-art and current state of practice**
- **Development of proposed alternatives to the current Roadside Design Guide**

- Survey prior studies, technical reports, design specifications and standard drawings of GDOT or other state DOTs *(in progress)*
- Observe guardrail installation sites in Georgia *(in progress)*

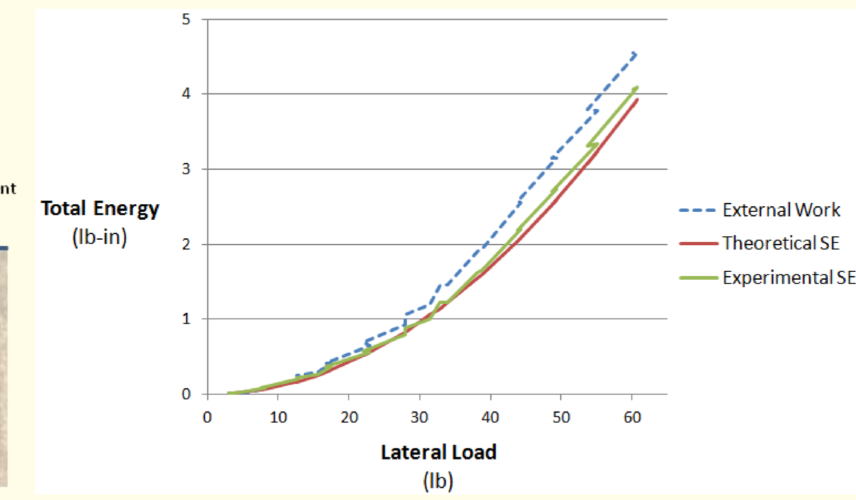
<u>e.g.</u>, Florida DOT Guardrail design (mow strip included)



- **Static testing plan of guardrail posts using alternative procedures**



Setup for static tests of guardrail alternatives



Energy approach verification with simplified mock-up guardrail post

Theoretical system identification (energy approach)

- The external work (W) done by the lateral load is the sum of the strain energy (SE) due to bending of the post and the dissipated energy (DE) into surrounding soil/mow strip.

$$W = SE + DE$$

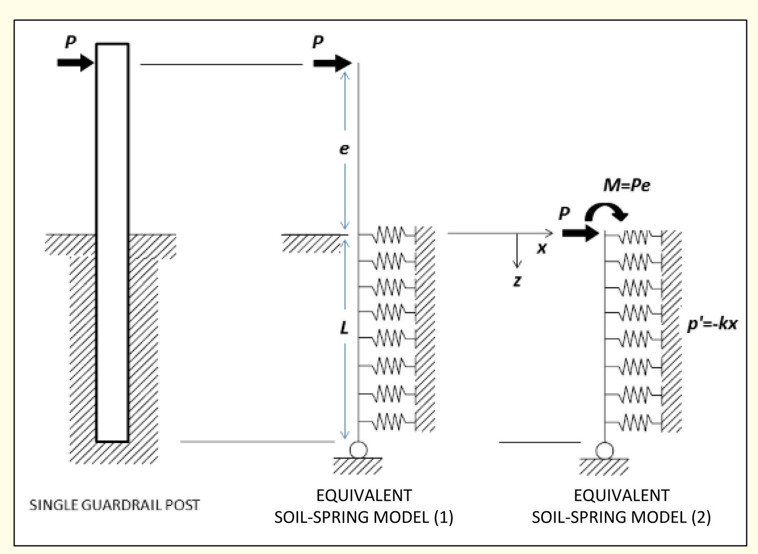
$$W = \int_0^{\Delta^*} P \cdot d\Delta \qquad SE = \int_V \int_0^{\varepsilon^*} \sigma \cdot d\varepsilon \, dV \qquad DE = W - SE$$

Data acquisition system detail for static test measurement (for each test)

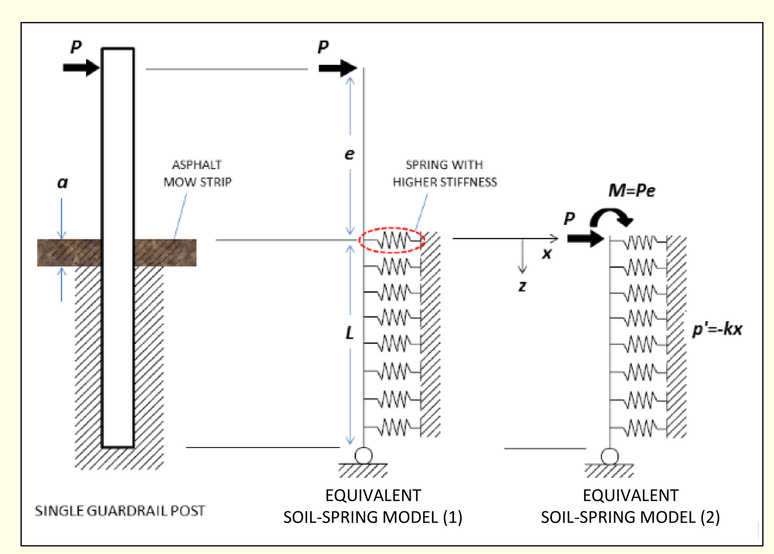
- 2 displacement transducers
- 10 (or more) strain gages
- Load cell (cylinder)
- NI DAQ (Data Acquisition) device with multiple channels

- **Development of a simplified equivalent soil-spring FE model**

- First phase assumption: linear elastic materials (steel, soil and asphalt), no yield criteria specified
- Lateral static loading is applied (within the linear elastic range).



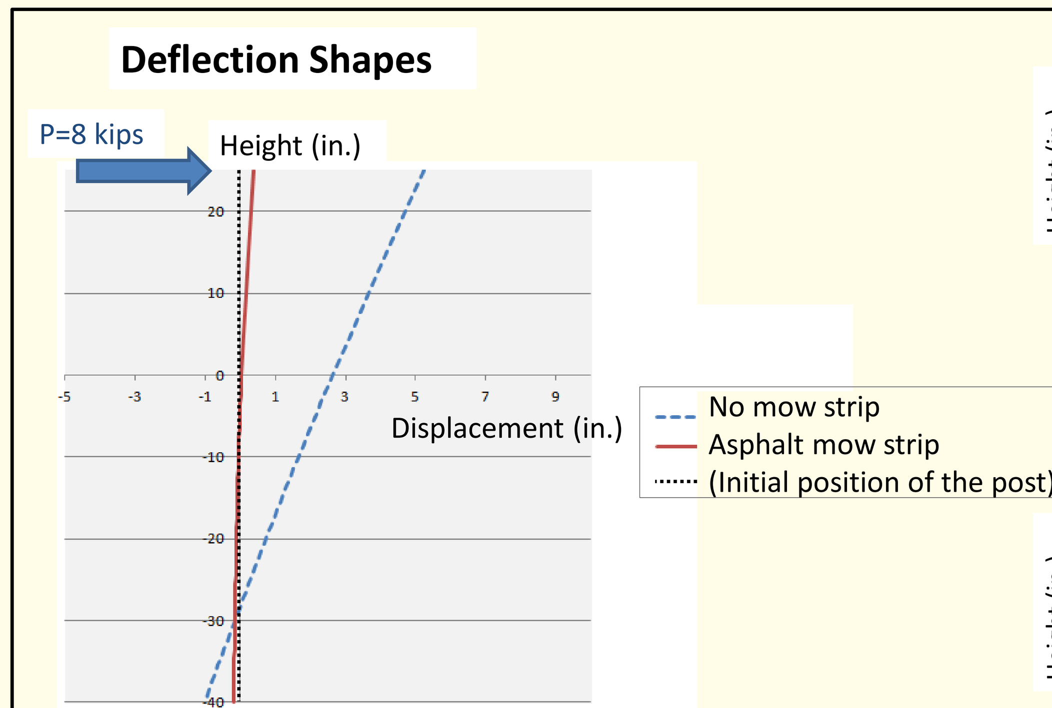
Single guardrail post <u>without mow strip</u>

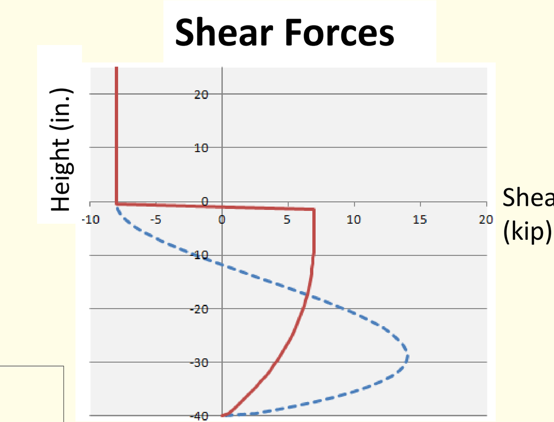


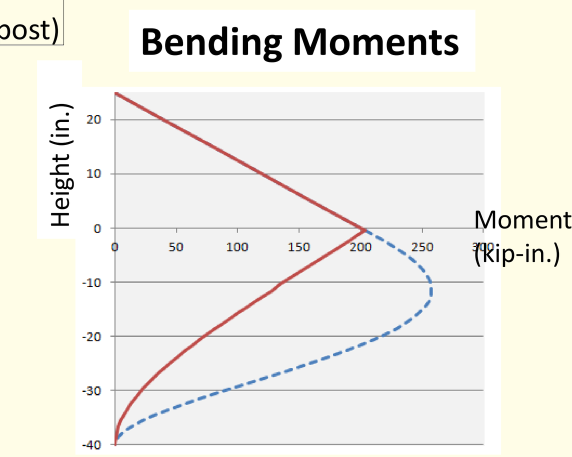
Single guardrail post <u>with asphalt mow strip</u>

- **Effect of asphalt mow strip on the structure performance of the guardrail post**

- When lateral load of P=8 kips is applied:







<u>In the simplified FE model, asphalt mow strip prevents the rotation of the post and increases the stiffness of the system</u>

- **FE modeling challenges (consideration for more realistic modeling)**

Simplified Static Model → Full-scale Dynamic Model (LS-DYNA, FLAC, ABAQUS)

- Consider continuum material models instead of discrete material models
- Benchmark existing rheological models of soils and interfaces for a FE model
- Implement new soil plasticity models if needed
- Investigate energy dissipation mechanisms (e.g., plasticity and failure mode of soil)
- Use experimental results as an input of FE model

Further Steps

- Calibration and verification of alternative guardrail designs
- Parametric study and performance assessment of alternative designs

- **Project deliverables and dissemination of results**

Rank the post installation alternatives in terms of:

- <u>Structural performance</u>
- <u>Economy</u>
- <u>Ease of installation</u>

→ **Top ranked installation alternatives will go to the Phase II for dynamic testing verification.**

Project Benefits

- Identification of cost-effective installation methodologies for steel guardrail posts with asphalt mow strips that meet FHWA safety and performance criteria
- Development of installation details for guardrail posts as alternatives to the one described in AASHTO Roadside Design Guide