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PROJECT TITLE
DRYING SHRINKAGE PROBLEMS IN HIGH PI SUBGRADE SOILS

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DRYING SHRINKAGE PROBLEMS IN HIGH PI SUBGRADE SOILS

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OVERVIEW High plasticity shrinking clay soils are encountered in many parts of Oklahoma. Moisture content fluctuations cause large volumetric strains within these types of subgrade soils. This is problematic in soils that support transportation infrastructure. Longitudinal pavement cracking on the local road network is one of the most prevalent pavement distresses caused by the moisture fluctuations. Annual maintenance to seal and repair these distress problems can cost the Oklahoma Department of Transportation (ODOT) millions of dollars. Therefore, this study investigated Oklahoma subgrade soils that have experienced drying shrinkage problems and developed simple and practical models that can be used in analyzing the suction and tensile stress distributions within the subgrade soil to enhance pavement design.

RESULTS Longitudinal cracks (Figure 1) generally occur within the *edge moisture variation distance*, where the moisture boundary conditions play a significant role in terms of changes in water content (or suction). In this study, thin-walled tube soil specimens were obtained from Oklahoma test sites in Norman, Lake Hefner, Ardmore, and Idabel for laboratory testing. The soil specimens were tested for the basic index properties as well as suction and unsaturated diffusivity measurements.

Figure 1 Longitudinal Dry Shrinkage Cracks

The Mitchell model and a commercially available finite element method software package was used to study the suction, tensile stress, and deformation profiles in the subgrade soils. The model parameters were obtained from the laboratory tests and climatic conditions of Oklahoma. An existing, water-content based analytical model was modified for unsaturated soils for prediction of tensile stresses in subgrades. The tensile stress predictions have been made using the new model for different moisture boundary conditions. The results from these simple models were compared with the results obtained from the commercially available software. The comparison of the suction profiles from the Mitchell model and the software were similar. However, there were some differences between the predicted horizontal tensile stresses between the new model that was introduced in this study and the results from the computer program. The major differences between the tensile stresses were at shallower depths near the ground surface, and those differences were attributed to the displacement boundary conditions considered in the finite element modeling. Furthermore, the comparison analysis was only based on limited range of soil and climatic boundary conditions.

Incorporating horizontal moisture barrier in the pavement design affects the suction and tensile stress distribution within the subgrade soil at the edge of the pavement. The horizontal moisture barrier can greatly control the distribution pattern of suction and keep the moisture variations below the pavement to a minimum. Different lengths of moisture barriers were modeled in this study. Figure 2 depicts the vertical subgrade soil displacements below the ground surface at the edge of the pavement for various scenarios. In spite of the simple elastic analysis in the finite element model, the displacements are not unreasonable for these soils. Similar to the effects of the barriers on the suction and stress distributions described in the full report, there is significant reduction in vertical displacements when horizontal moisture barrier is in place.

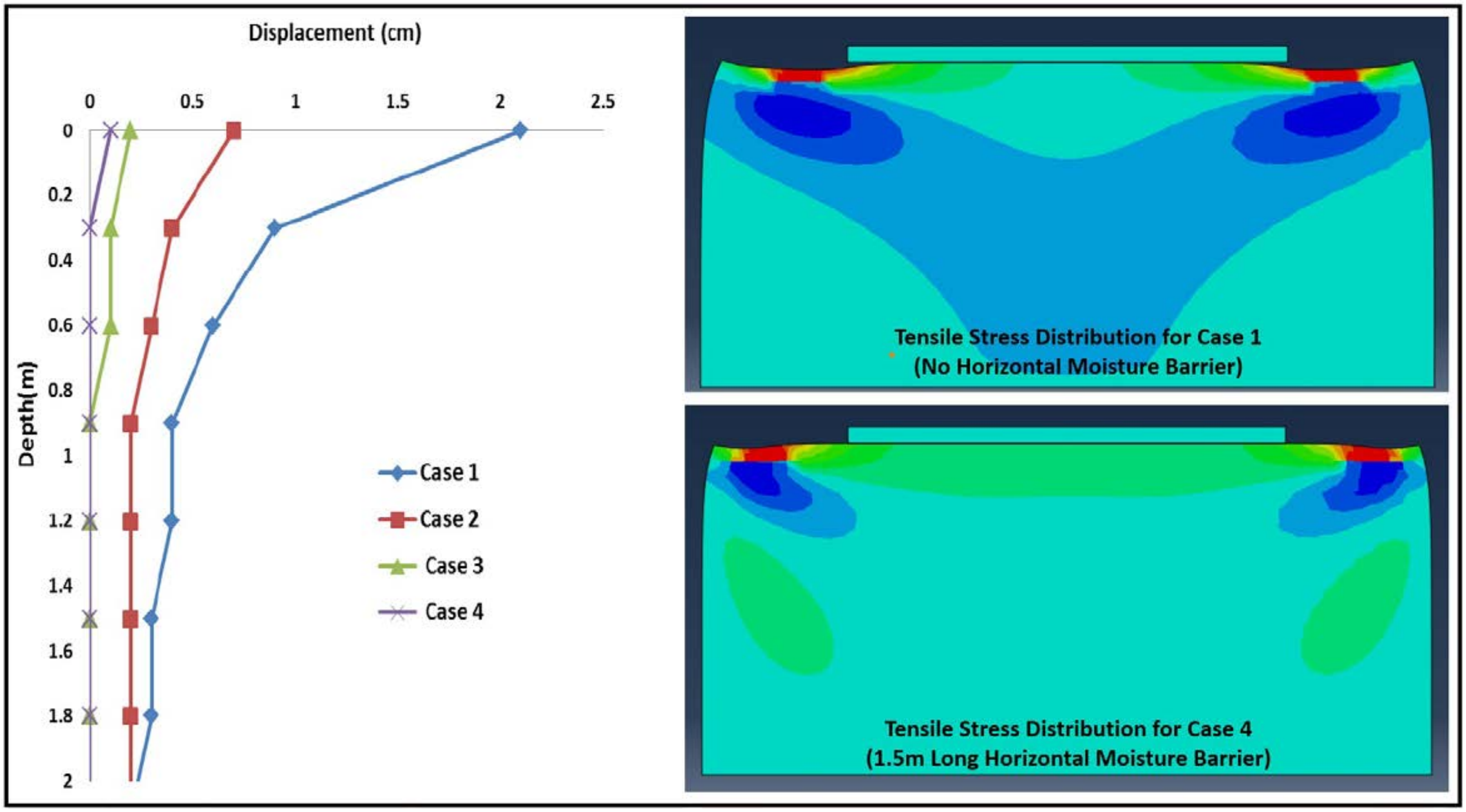

Figure 2 Displacement Profiles for Different Lengths of Moisture Barriers Investigated in this Study

The results of this study can support recommendations that could be considered for the verification and calibration of the approaches developed in the study with respect to the following items:

- a comprehensive field monitoring of suction (and possibly displacement) variations of the soil profile at the edge of the pavement; and
- measuring the tensile strength of the typical Oklahoma subgrade soils considering various soil parameters and suction boundary conditions.

The laboratory scale tests should be carefully designed such that the boundary effects are eliminated (or reduced) as much as possible.

POTENTIAL BENEFITS This study provides improvement in the understanding of the mechanism of drying shrinkage problems in high plastic soils to enhance pavement design. A rational approach in predicting the suction change below the pavement and corresponding tensile stresses in subgrade soils in response to various surface moisture boundary conditions is provided. The study demonstrated that the horizontal moisture barrier can greatly control the distribution pattern of suction and keep the moisture variations below the pavement to a minimum. It also showed that the lengths of the horizontal moisture barriers can be optimized using an analytical and numerical approach.