



# *Project Summary*

*Texas Department of Transportation*

## 0-5430: Realistic Design Guidelines for Low Classification Roads in High PI Clays

### *Background*

Low-volume roads comprise a significant part of Texas' transportation system. In many regions in the state these roads are built on problematic clayey soils. In spite of thick structural pavement layers, these pavements in some cases fail prematurely. One reason is that the current design procedures do not comprehensively account for the behavior of high-PI clay subgrades. It is therefore important to improve the laboratory procedures to evaluate these soils and then design pavements accordingly to extend the life expectancy of these roads.

The engineering and physical properties of the clayey subgrade soils, especially high-PI clays, are significantly influenced by moisture change. The changes in these properties influenced by moisture reflect as distress in the pavement that involves the formation of surface cracks, moisture infiltration through the cracks, and therefore, a reduction in the strength and stiffness of the soil. When these high-PI clays are subjected to drying in hot summer months, they tend to shrink significantly, causing longitudinal cracking.

### *What the Researchers Did*

The final product of this study is an expert system called "Expert System for Pavement Remediation Strategies (ExSPRS)." This expert system combines a number of analytical models with the opinions of experts to: 1) ensure the structural integrity of a pavement section, and 2) provide options to design engineers in an easy-to-understand language, for remediating the modes of failure of pavements.

An extensive survey of all districts in Texas revealed information about the predominant distresses that exist in the state. Several sites from across the state of Texas were selected for this research. At each site, distress and nondestructive testing surveys were carried out, subgrade materials were retrieved, laboratory testing was performed, and moisture and suction sensors were installed.

In the laboratory, extensive testing was carried out. Appropriate test protocols to quantify the variations in shrinkage or swell, stiffness, and strength of subgrade clays with change in moisture content were proposed.

Specimens were prepared at optimum moisture content and then subjected to different moisture conditioning (drying or wetting) according to these protocols. Relationships to estimate the changes in these properties from easily available index properties of soils were established. Analysis modules for the most prevailing low-volume road distresses including fatigue and rutting, subgrade shear failure, and excessive roughness were adapted from the literature.

### *Research Performed by:*

The University of Texas at El Paso (UTEP)

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### **Research Supervisor:**

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For the first time, a finite element model was developed and included in the expert system for estimating the longitudinal cracking potential of low-volume roads. The model predicts when and where in the pavement longitudinal cracking will occur.

ExSPRS acquires information from the initial design to the layer and environmental conditions, evaluates the adequacy of the proposed pavement structure, and provides solutions to improve the life of the pavement. Numerous remediation strategies are provided to guide the user in improving the pavement design. For each of the remediation strategies, a cost-benefit analysis module compares the cost with the effectiveness of the recommended strategies so that the user can make an informed decision on the cost-benefit of a given remedy.

The results from the instrumented field sites corresponded quite well with the results predicted by ExSPRS.

## *What They Found*

The most effective way to minimize the premature failure of low-volume roads is to characterize and strengthen the subgrade layer instead of placing thicker pavement layers.

Based on laboratory testing, multiple mathematical relationships were developed to predict the shrinkage strains, modulus and strength of clayey subgrades at particular moisture content from index properties (Atterberg Limits and moisture-density properties) of the clay.

For the first time, the potential for longitudinal cracking, the most prevailing mode of failure of low-volume pavements built on expansive clays, can be conveniently checked using a model incorporated in ExSPRS.

The engineering and cost-benefit of strengthening the pavements to ensure longer life for low-volume roads are compiled in one place so engineers can make more informed decisions.

## *What This Means*

Low-volume roads are more susceptible to heavy loads, environmental conditions, and subgrade soil properties than typical highways. A new tool is available to the districts to optimize the design of their low-volume roads. The program compiles the knowledge of experts with analytical models in an expert system shell. Therefore, the new program is not only useful to the experienced designers, but can also be used by less experienced engineers as a source of information.

The main lesson learned from this study is that placing thicker pavement layers is not the best solution to improve the overall performance of low-volume roads. Rather, ways to minimize the variations in the properties or moisture of the subgrade play a more important role.

*For More Information:*

0-5430-1 Impact of Moisture Variation on Strength and Deformation of Clays

0-5430-2 Expert System Design Guide for Lower Classification Roads over High PI Clays

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