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Summary Report

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CONTROLLING PAVEMENT ROUGHNESS WITH VERTICAL MOISTURE BARRIERS

PROBLEM STATEMENT

Expansive clay soils cause several billion dollars worth of structural damage annually, with highways and streets accounting for more than half of the estimates. When water seeps under the pavement coming in contact with expansive clay soils, the interaction between the clay and the moisture triggers upward swells. As the soil later loses its moisture, shrinkage occurs. These disrupted moisture flow patterns cause pavement cracks and bumps, the main source of roughness in pavement built on expansive soils. This roughness causes loss in riding comfort, reduced pavement service life, and costly rehabilitation.

To control damage associated with expansive soils, many different preconstruction methods have been proposed and tried, with varying degrees of success. Adding lime to the soil or prewetting the subgrade alters the characteristics of the clay and helps stabilize the subgrade moisture condition. However, there is now a method to control moisture flow patterns under roadways. The vertical moisture barrier, an impermeable fabric liner, is placed in a one-foot trench, backfilled with gravel or sand, then covered with a cement stabilized base cap. Once installed, the barrier protects the soil surrounding the pavement from drastic moisture changes. Vertical moisture barriers seem especially promising as an agent to prevent and mitigate damage because they can be used both before and after construction.

OBJECTIVES

The Texas Transportation Institute (TTI) conducted study 1165, *Moisture Movement Under the Pavement Structure*, in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA), to evaluate the vertical moisture barrier's ability to reduce roughness in pavements, and recommend suitable moisture control installations for various drainage, soil, and climatic conditions. The final report also offers good site investigation practices for the design of vertical moisture barriers.

FINDINGS

Data Collection

Eleven test sites were selected from six Texas locations in three different climatic regions: three test sections at Snyder, two each at Wichita Falls, Dallas, and Ennis, and one each at Seguin and Converse. Moisture barriers were installed at eight of these sites, and control sections without moisture barriers were established at each site. Researchers then measured the following over a five-year period at all of the sites:

1) Subsurface soil properties (whether the soil is likely to swell),
2) In situ soil suction (intensity with which a soil will attract water), and

Vertical Moisture Barriers will usually prove effective if . . .

- ✔ **Climatic area — wet to semiarid**
- ✔ **Depth of barrier — deeper than root**
- ✔ **Lateral drainage conditions — wet, normal, or dry**
- ✔ **Soil conditions — cracked or moderately cracked**

3) Roughness development of pavements (physical characteristics of the pavement).

Using an available flow and deformation (FLODEF) program, the *predicted* values for field soil suction and roughness development were compared with the field data. This led to recommendations about the effectiveness of instruments and methods used to determine vertical moisture barrier placement. By evaluating the in situ soil suction measurements taken outside and inside the installed moisture barriers and their corresponding control sections, and then comparing this to the roughness development at the sites, the conditions for the effectiveness of the vertical moisture barriers were found.

Effectiveness of Vertical Moisture Barriers

The study found that the vertical moisture barriers are effective in reducing the development of roughness in pavements on expansive soils *under certain conditions*. The table above shows where vertical moisture barriers will usually prove effective.

The barriers are not effective in extremely dry climates, such as in El Paso, when the pavement is subjected to "normal" and "slope" drainage conditions. Yet they will improve performance in dry climates with the "ponded" drainage condition where water stands in drainage ditches along the highway. Also, they are not effective in tight subgrade soils because roughness development on pavement built over tight soils is generally low, even without a moisture barrier.

With all climates except for extremely dry climates, and under all drainage conditions, vertical moisture barriers in cracked or medium cracked soils reduce the development of roughness. Barriers should be installed at a depth greater than (or at least equal to) the deepest vegetation root depth.

Effectiveness of Research Methods and Instruments

The instruments used to measure in situ soil suction—the thermal moisture sensor and the thermocouple psychrometer—have certain limitations. Thermal moisture sensors are not reliable when soils are too dry, and thermocouple psychrometers are not accurate in measuring extremely wet soils.

The suction compression index is a powerful tool in characterizing expansive soils and can reliably be estimated from the chart method. This procedure requires only the conventional soil tests such as the Atterberg limits and grain size distribution of soils, as well as the cation exchange capacity, which can be estimated with the plastic limit. The FLODEF Program is capable of predicting soil suction changes in the field and estimating vertical movement in pavements on expansive soils.

CONCLUSIONS

Because vertical moisture barriers are only effective under certain circumstances, thorough site investigation is essential before installation in pavements. The site investigation should include the soil borings and tests on samples such as the Atterberg limits, grain size distribution, specific gravity of soil particles, dry density of soil, natural moisture content of soil, and the filter paper suction. Also, engineers should obtain an estimation of the crack pattern of subgrade soils and rooting depth of vegetation.

The roughness prediction models currently available need improvement and refinement. Those used in this study are based on limited data collected from several expansive clay sites in Texas. Development of a complete database, including subgrade soil properties, drainage conditions, crack patterns of soils, geometries of road profiles, moisture barrier depths, and roughness measures such as Serviceability Index, International Roughness Index, and Maximum Expected Bump Height, would significantly contribute to the study of pavement roughness. TxDOT is pursuing implementation of this study's findings in study 187.1 and 2, which will monitor all the test sites for three years, calibrate the computer program, and ultimately reveal a simple way to determine when and how deep to place a vertical moisture barrier.

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The information in this summary is reported in detail in TTI Research Report 1165-2F, "Effectiveness of Controlling Pavement Roughness Due to Expansive Clays with Vertical Moisture Barriers," R. Jayatilaka, D.A. Gay, R. L. Lytton, W. K. Wray, November 1992. This summary does not necessarily reflect the official views of the FHWA or TxDOT.