



Project Summary Report 0-4518-5

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Project 0-4518: Re-evaluate Current Potential Vertical Rise (PVR)
Design Procedures

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Re-evaluation of Potential Vertical Rise Design Procedures

The Texas Department of Transportation (TxDOT), beginning in the 1980s, sponsored several years of monitoring activity on pavements built on expansive clay subgrades. Field observations and measurements of subgrade moisture and pavement profiles were made as the test sections became rougher with time and traffic. The test sections were representative of all the moisture climatic zones across Texas.

Profile analysis and modeling were done at the Texas Transportation Institute. Laboratory testing and data analysis were done by researchers at Texas A&M University, Texas Tech University, and The University of Texas at El Paso. This project was performed to determine whether the current potential vertical rise (PVR) pavement design procedures could be updated to reflect results of the monitoring.

The principal problems with pavements on expansive soils are that



Figure 1. A Typical Effect of Swelling Soil.

they swell and shrink, both of which cause the pavement to become rougher. [Figure 1](#) shows the effect of swelling. Shrinkage cracking of the pavement surface is common, especially in the vicinity of trees and other vegetation as was observed at one of the case study sites, shown in [Figure 2](#). The current PVR design procedure does not account for shrinkage.

What We Did...

We developed a new pavement design procedure based on results of the many years of monitoring and analysis. To make sure that

the new procedure worked well in practical applications, we performed three case studies: one in the Fort Worth District along IH820, one in the Atlanta District along US271, and one in the Austin District along MoPac Loop 1. These three case studies represented differing climatic, site, and traffic conditions.

The laboratory test procedures were written in standard TxDOT method format, and instructional CDs were provided. The test results were used in both of the two computer programs that were also developed as part of the project.



One of the programs calculates the changes of moisture and movement of an entire cross section over an extended period of years in response to the local weather patterns, drainage, vegetation, and moisture control measures that the designer wishes to consider. The other program is a design program that makes use of the subgrade movement-versus-roughness relationships that were developed during pavement monitoring. It permits the designer to consider either an asphalt or a concrete pavement, the expected level of traffic, the effects of inert or stabilized layers, moisture barriers, and roadside drainage and vegetation. The designer may also specify a desired level of reliability of the design. The output presents graphs of the predicted performance (both present serviceability index [PSI] and international roughness index [IRI]) of the selected pavement over a maximum 30-year period.

Examples of the output graphs produced by the design program are given in [Figure 3](#) (an asphalt pavement) and [Figure 4](#) (a concrete pavement). In both cases, a variety of treatments were considered. The designer is then able to select which of the treatments will provide the best solution to the expansive clay roughness that will occur on the site of the proposed project.

We used the design program to compare the successful treatments predicted by the new procedure with the criteria



Figure 2. A Typical Shrinkage Crack of the Pavement Surface in the Vicinity of Trees and Other Vegetation.

used in the current PVR design procedure.

What We Found...

The comparison showed in all cases that the existing PVR method overpredicted the swelling movement beneath the outer wheel path and did not provide a means to alert the designer to the likely distress due to shrinkage. The overprediction means that use of the PVR method will consistently lead to design treatments of the expansive clay subgrade that are overly conservative. Design should be based upon the rate of development of pavement roughness, such as PSI or IRI or both, over an extended time horizon at a high level of reliability.

The test methods developed in this project work very well, are repeatable, and proved efficient and accurate. They are easy to learn and to apply using the protocols and methods written in the TxDOT standard

format. The instructional CDs that accompany the test methods are simple to use and provide step-by-step illustrations showing how to run each of the tests. The tests and the data generated serve as a basis for making accurate predictions of the field behavior of clay subgrades.

The predicted behavior using both the analysis and the design programs matched the observed differential movements in the field in all of the case studies. The differential movements were observed as the difference in the thickness of overlays that were placed to restore riding quality and the shrinkage cracking that was observed in those pavement sections in which a substantial amount of shrinkage movement was predicted. The close correspondence of the predicted and the observed behavior shows the importance to design of not only the expansive nature of the subgrade soil, but also the initial moisture condition, the presence



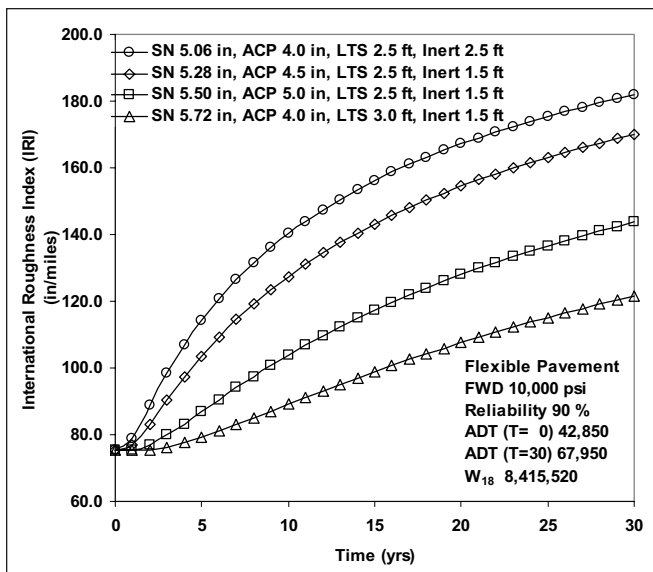


Figure 3. International Roughness Index versus Time, 90 Percent Reliability, Fort Worth Loop 820, Section B, Flexible Pavement.

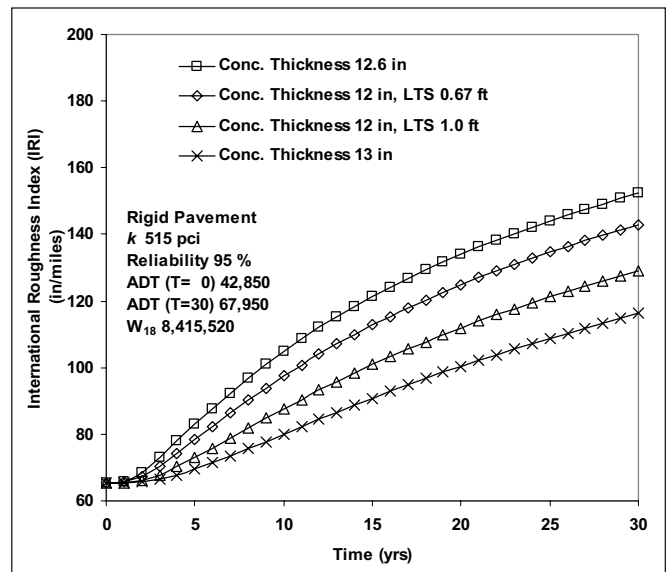


Figure 4. International Roughness Index versus Time, 95 Percent Reliability, Fort Worth Loop 820, Section B, Rigid Pavement.

of roadside vegetation including grass and trees, and slopes and drainage.

The analysis and design studies showed that the existing PVR method is generally too conservative. Acceptable performance can be achieved at a high level of reliability with both flexible and rigid pavements while using smaller amounts of subgrade treatment than is required by the presently used PVR criterion.

The use of the predicted PSI or IRI or both is a more reliable indicator of acceptable performance. This project showed predictions from those measures to be related to the total movement beneath the pavement, including both the swelling and shrinking movement, rather than the swelling movement alone. The design program of this project uses the total movement and predicts both the PSI and the IRI in any selected wheel path

and allows the designer to select the desired level of reliability. In this regard, it constitutes a substantial improvement in the design of pavements on expansive clay subgrades.

The Researchers Recommend...

The test methods, their instructional CDs, and the design and analysis programs and their user's guides are ready to be implemented in TxDOT districts. The districts of Beaumont, Bryan, Corpus Christi, Dallas, El Paso, Houston, Pharr, San Antonio, and Waco would benefit from having training schools on the testing, analysis, and design methods developed in this project. Their experience with actual case studies in their districts and their suggestions will help to refine the test protocols, design methods, and the user's guides and will provide TxDOT with sound methods for designing effective

treatments of pavements on expansive soils.

Other recommendations emerged from the experience of this project. One is a caution that the effect of sulfate swelling is not included in the analysis or the design method of this project. Designers in Texas are well aware of the problems caused by the growth of expansive minerals that result from the combination of lime, soluble sulfates, and clay minerals in the subgrade. Representation of the expansion that is a result of this crystalline growth will require further development of testing procedures, theory, and software that is capable of representing the effects accurately.

At present, it should be sufficient to use these design and analysis programs as they are intended, and that is under the assumption that no sulfate swelling potential is present in the subgrade soil.



For More Details...

The research is documented in:

Report 0-4518-1, *Design Procedure for Pavements on Expansive Soils*

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TxDOT Implementation Status—May 2005

The test methods developed by this project are being implemented by IPR 5-4518. This implementation covers the purchase of three sets of equipment to be used at the Cedar Park Laboratories, and in the Forth Worth and Bryan Districts. This implementation project will also include training classes for TxDOT personnel.

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