Texas Transportation Institute Sealant Research Results

Findings

One of the most important effects of joint sealant effectiveness on concrete pavement performance is the potential for subbase erosion. An excel spreadsheet based application developed by Dr. Dan Zollinger at Texas A&M University in support of this research demonstrates several aspects of sealant effectiveness on pavement performance. The spreadsheet uses a mechanistic-empirical approach to consider the three main elements of subbase erosion: (1) the rate of erosion of the base/subbase, (2) existence of moisture under the slab (as reflected by the number of wet days), and (3) traffic. The model was calibrated with lab and field data and is useful for design and maintenance purposes.

Additional findings are as follows:

- The experimental results showed that if joint seals are properly installed, they can be very effective in preventing moisture infiltration. Unsealed joints have significantly higher inflow rates compared to joints with damaged sealants.
- The water infiltration rates for dirty joints, such as sealants installed in an unclean reservoir or dirt-filled unsealed joints, were as high as those for clean joints with 50% debonding.
- The management of a sustainable concrete pavement system requires greater emphasis on performance monitoring rather than performance repair; a concept not widely practiced and which challenges traditional repair and rehabilitation philosophies.

Background

The primary purpose for sealing joints in rigid pavement is to prevent or reduce the amount of water and incompressibles infiltrating into the pavement structure. It is well accepted that both issues contribute to a variety of distress types eventually deteriorating the pavement structure, resulting in decreased service life.

An inevitable consequence of water infiltration through joints in concrete pavement is the erosion at the slab/subbase interface. Subbase erosion directly contributes to the process of joint faulting which can involve several factors. Faulting as a major distress type in jointed concrete pavements is a key feature in designing pavements. The effects of faulting have implications on pavement, both structurally and in terms of serviceability.

As a consequence of these issues and the concerns that several agencies have elected to not seal pavements due to lack of compelling beneficial evidence, the Seal No Seal group contracted with Dr. Dan Zollinger of the Texas Transportation Institute (TTI) to conduct a study on sealing effectiveness.

However, this study did not attempt to research sealant effectiveness through traditional approaches such as characterizing sealant performance in terms of joint seal properties. Instead, TTI took a more rigorous and fundamental approach to evaluate performance in terms of the amount of infiltration through the joint and the consequential impacts on subbase erosion and pavement distress.

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This study characterized joint infiltration as a function of both construction quality and environmental factors. The impact of construction was assessed as a function of joint cleanliness, sealant damage, joint movement, and sealant type. The environmental factor was assessed as the predicted infiltration as a function of rainfall intensity, joint geometry, and cross slope. Three sealant types were evaluated: silicone, hot pour, and compression seals.

The impact of joint infiltration on pavement performance was determined by conducting laboratory tests to quantify subbase erosion, along with the development of a predictive model and supporting software. With these tools an owner can now determine the impact of sealing joints and joint condition on pavement performance.

Another aspect of the study evaluated the use of Ground Penetrating Radar to detect the existence of moisture under the slabs in the vicinity of the joint. The age-old question has always been how to determine when to reseal. Historically this was determined by applying weighting factors to sealant condition such as amount of adhesive and cohesive failure, missing sealant, etc. However, none of these surrogates address fundamental properties related to actual performance. With the use of GPR, it now seems feasible to detect the existence of moisture under the slabs in the vicinity of the joint (from a water infiltration standpoint) and more importantly, to assess when a sealant is no longer effective.

Study Approach

The TTI study consisted of both controlled field experiments and testing of in-service pavements. The controlled field experiments were conducted at TTI's Riverside Campus and are indicated in Figure 1. The controlled field experiments were designed to evaluate the effect of sealant damage and joint cleanliness on infiltration rates. After the first round of testing was conducted using the setup on the left side of Figure 1, a very novel approach was developed as indicated on the right photo of Figure 1. This approach allowed the joint opening width to be varied which then could be taken into account along with the joint seal damage.

Original Test for Damaged Sealant Infiltration	Extendable Slabs Used to Vary Joint Width

Figure 1 Controlled Field Experiments at the Riverside Campus of Texas A&M

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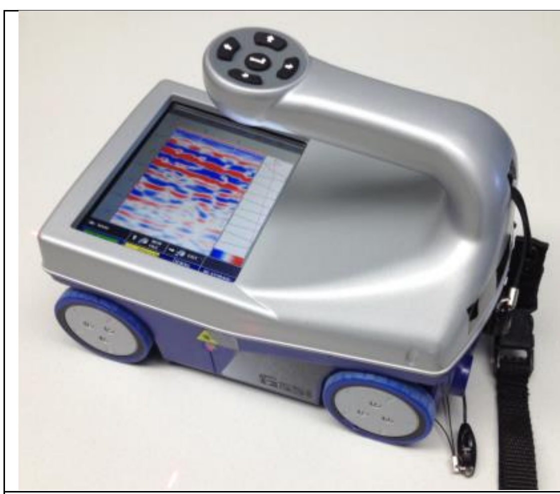
Testing of in-service pavements occurred on Route 59 in Plainfield, Illinois and on I-10 just west of Phoenix, Arizona. The purpose of testing in-service pavements was to relate sealant effectiveness (i.e. infiltration rates) to actual pavement performance. The Illinois project was approximately four years old and consisted of ten test sections which included sealed and unsealed joints. The Arizona project was an LTPP SPS-2 project which was 20 years old and consisted of twenty test sections including four different base types. The field testing consisted of conducting infiltration and FWD testing as indicated in Figure 2. Limited GPR

Joint Infiltration Testing

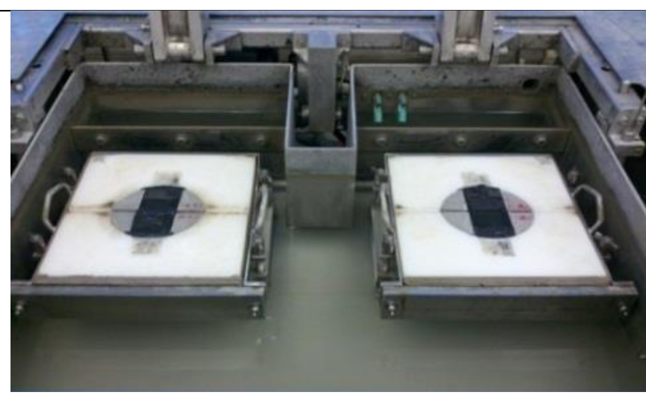
Falling Weight Deflectometer (FWD) Testing

Figure 2 Testing Conducted on In-Service Pavements

testing was also conducted at each of the sites to evaluate the potential for using GPR to detect when the sealant was allowing water infiltration into the joint. A handheld portable GPR unit was used for this testing as indicated in Figure 3. Subbase samples were also retrieved through core holes in the pavement to enable laboratory erosion testing using a Hamburg Wheel Rutting device as indicated in Figure 3.



Hand Held Portable GPR Unit



Subbase Erosion Testing using Hamburg Wheel Rut Test Device

Figure 3 Additional Field and Laboratory Testing Conducted

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Advancement of a Mechanistic-Empirical Fault Prediction Model

A mechanistic-empirical fault prediction model previously developed under National Ready Mixed Concrete Association (NRMCA) funding was improved upon as part of this research. The impact of joint seal effectiveness was directly employed within the fault prediction model.

One important factor that was addressed in the model was a means to evaluate the number of wet days. Number of wet days is the actual number of days per year that water exists underneath the slab at the slab/subbase interface. This number is not only a function of annual rainfall but also a function of surface inflow, sealant effectiveness and subbase drainability. The number of wet days was determined with respect to probability functions that can be used for each site to evaluate the number of days that water exists underneath a slab.

The erosion resistance of materials, number of wet days, and traffic load were defined and coupled in this model to effectively analyze the potential for faulting and erosion in jointed concrete pavements. The model can be calibrated for local conditions as a function of distinct characteristics of the subbase or subgrade, which is an important capability in life cycle analysis. The model has been successfully implemented into a spreadsheet format. Results show that the model fits well with the field data and can be implemented for design and maintenance management purposes.