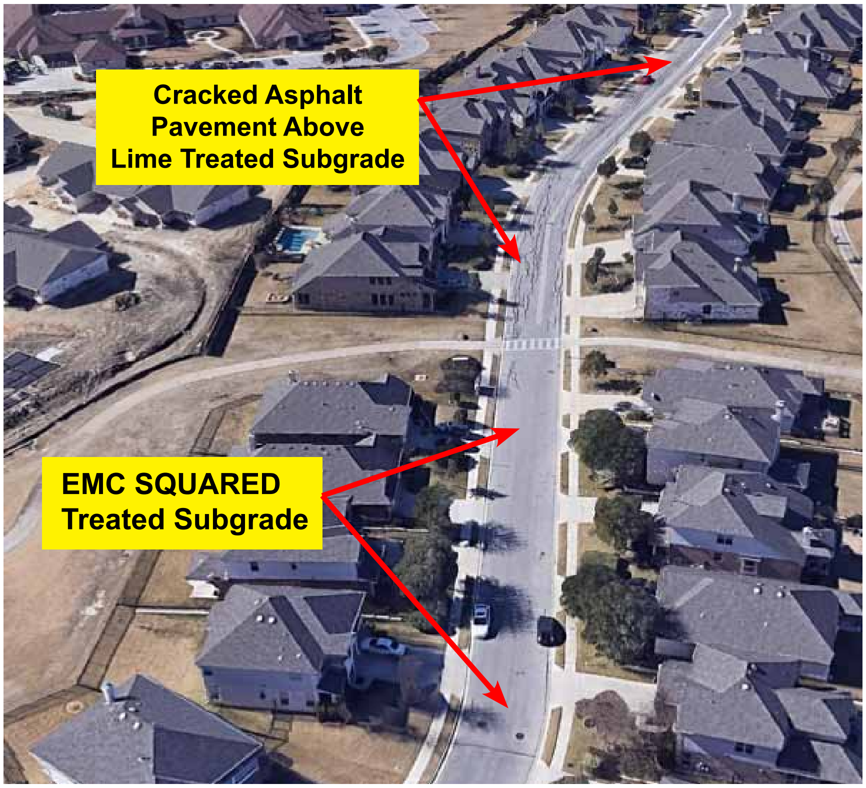
Advanced Stabilization Technology Solves Pavement Cracking & Roughness Problems

The Teravista Community is a master planned development on the northeast side of Austin, Texas. The associated road and street construction provide an outstanding case study of the use and benefits of innovation as many conventional design approaches proved unsatisfactory before the geotechnical engineering consultants identified a cost-effective solution. The first option was a super-thick structural section under the asphalt pavement that required importation of 18” of low-plasticity soil covered by 18” of crushed aggregate base course materials. While this pavement design proved effective and durable over time in many of the first phases of the development, it was prohibitively expensive. The next pavement design lowered costs by reducing the thickness of the base course by including geogrid reinforcement, but this left the asphalt pavement subject to cracking. Then another design was attempted with asphalt pavement placed on an 8” aggregate base course constructed on top of 8” of lime-treated soil. While the use of lime reduced costs, the asphalt pavements soon exhibited extensive cracking as well as differential settlement. Although 27 different soil types were detected in different areas of this 1500 acre development, a large portion of the development included a trend of expansive clay soils that run almost the entire length of Texas, north to south. These soils with organic and sulfate content are well-qualified to be the most problematic of soils on the North American Continent for built structures such as roads and highways. With a high degree of volume change (shrinking and swelling) behavior driven by fluctuations in soil moisture content, these expansive soils further endanger the integrity of built structures because their soil chemistry generates an extreme heaving phenomenon when cement, lime or fly ash are added to the soils in an attempt to reduce the volume change behavior. The damages from the heaving these products generate are worse than the problems created by the volume changes they were intended to solve. These three calcium based chemicals may effectively dry up overly wet soils, however, those benefits are short-lived. The heaving reactions they cause tilt large buildings and buckle and crack pavements, both enormously expensive to correct. A forty-one mile length of Texas State Highway 130 (SH-130), a four lane divided tollway southeast of Austin that runs from Mustang Ridge to Seguin, is an example of just how expensive a mistake in stabilizer product selection can prove to be. Despite treating subgrade soils under the 9” asphalt pavements and 12” aggregate base course layers with lime chemicals to a depth of three feet under the main drive lanes, the current owners of the privately financed highway recently completed a second round of reconstruction of 35 sections of the highway to depths as deep as eight feet at a reported cost of $90 million. Total reconstruction costs are projected to be $130 million. The original lime treatment proved to be ineffective, or worse, but was used again during the reconstruction program. Additional measures taken during the reconstruction included vertical impermeable barriers constructed along both sides of the tollway in order to keep water from penetrating into the lime treated soils and once again generating the shrinking and swelling problems. This area of Texas experienced extreme drought conditions in recent years, followed by flooding. In addition to sulfate related heaving and water related swelling in the lime treated subgrade, shrinkage cracking in the lime treated subgrade during the drought conditions was also reported as contributing to cracking the base course and asphalt pavement layers above via a pavement failure mechanism known as reflective cracking.



Teravista Community street 15 years after installation

The same soil problems existed at the Teravista Community development as on the SH-130 tollway project and asphalt pavements and base courses constructed above lime treated subgrades exhibited similar differential settlement and cracking problems on the same rapid time line. Foresightedly, project geotechnical engineering consultants for the Teravista road and street construction projects also field tested a non-calcium based alternative to lime treatment, the EMC SQUARED® System. Proven effective by an earlier Texas Department of Transportation (TxDOT) funded research study and free of risk for generating sulfate-induced heave, it was also documented by the same study as competent at keeping water out of the treated subgrade soils. Streets constructed on EMC SQUARED treated subgrades within the Teravista development as long as fifteen years ago remain smooth running and essentially clear of pavement cracking. Contractors responsible for the numerous street construction projects using EMC SQUARED applications during the build out have commented that those treatments were several times faster to apply at a fraction of the cost of lime treatment. Also of note for industry professionals, five freeway projects were constructed in the Dallas area where the predominant native soils are extremely problematic and similar to the native soils under the SH-130 alignment and the Teravista Community. Using the EMC SQUARED System stabilizer products as an alternative to lime treatment for subgrade construction, these five Dallas freeway projects have been in service for twenty years and were recently reported as smooth running with pavement surfaces in excellent condition.

Teravista Community street subgrade soils treated with Lime

Teravista Community street subgrade soils treated with **EMC SQUARED** System

Beginning in 1996, the **EMC SQUARED**® System was evaluated in a two year laboratory study at the Texas Transportation Institute (TTI), which was funded by the Texas Department of Transportation (TxDOT) Research & Technology Implementation (RTI) Office. The principal author of the study was Dr. Robert Lytton, Research Engineer for TTI, Director of the Center for Infrastructure Engineering at Texas A&M University, and more recently the Distinguished Lecturer for the Transportation Research Board (TRB) Annual Meeting. The study focused on identifying effective treatment for sulfate bearing expansive clay soils. Soils used in the laboratory testing were sampled from problem locations on Interstate 635 Lyndon B. Johnson Freeway (the "LBJ"), and the Highway 161 section of the President George Bush Turnpike (PGBT). The study found that the **EMC SQUARED** System treatment was superior to lime in strength, stiffness, swell resistance and permeability, and recommended its use for subgrade treatment in areas where application of lime treatment has historically led to sulfate-induced heave and costly damage to pavements.*

The table and graph on the right show the results of TTI tests with the SH-161 project soils evaluating the effectiveness of lime treatment in comparison to the **EMC SQUARED** System in strength and stiffness, and in reducing moisture susceptibility, the most important difference between lime and the **EMC SQUARED** System product technologies. The **EMC SQUARED** System, on the other hand, very directly targets moisture flow and moisture susceptibility problems. Research findings have clearly demonstrated that lime does little to impede moisture flow through treated subgrade soils and that lime, in fact, typically increases soil permeability.** Permeability, or "hydraulic conductivity" tests, were also conducted on the SH-161 soil specimens. At $8.9x10^{-10}$ cm/sec. permeability, the **EMC SQUARED** System treatment effectively reduced moisture flow to less than one thousandth of an inch per month. With the velocity of water flow reduced to this rate and soil moisture susceptibility effectively treated (see graph at right), the **EMC SQUARED** System is obviously providing an effective moisture barrier (see page 8). While the very low permeability is significant, keep in mind that it's the combination of lowered permeability and treated moisture susceptibility that creates a stable and effective moisture barrier layer. Without effective treatment of its moisture susceptibility (affinity for water), a low permeability clay (or lime treated clay) will still wet itself over time as it suctions water.

In translating the EMC SQUARED System laboratory findings to the actual field service environment, the TTI report went on to state, "The stabilized subgrade has a lower permeability and a lower suction than the untreated soil below it. This means that it will shed water and not soak up water from the soil below it...." The statement points out the fundamental advance in stabilization technology, which is achieved when upward and downward flow of water is controlled by a layer within the structural section that provides an effective barrier to moisture flow, and that helps further protect against pavement roughness by promoting a more consistent and stable moisture distribution in the untreated native subgrade soils below. This is the multiplier effect of the EMC SQUARED System subgrade treatments. It promotes greater stability in soils below as well as within the treated layer. This is a quantum leap forward for stability and trouble-free, smooth-running pavements.

*Summary Of Research Report 3929-1 at http://stabilizationproducts.net/docs/18588.pdf

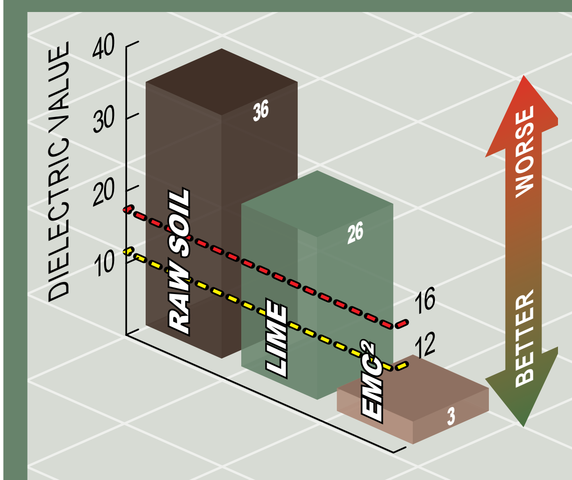
** Lime Treatment Tradeoffs at http://stabilizationproducts.net/docs/18392.pdf

President George Bush Tollway
SH 161
Testing by the Texas Transportation Institute

STRENGTH AND STIFFNESS

TREATMENT	STRENGTH psi (kPa)	STIFFNESS psi (kPa)
EMC SQUARED SYSTEM	399.04 (2,751.29)	5,000.00 (34,473.79)
LIME	341.55 (2,354.91)	3,166.67 (21,833.43)
NOT TREATED	232.56 (1,603.45)	588.24 (4,055.75)

REDUCTION OF MOISTURE SUSCEPTIBILITY



As indicated above, the dielectric measurements for the **EMC SQUARED** System treated specimens were well below 12, the value established by researchers as the upper limit for expansive clay soils if they are to be considered suitable for use as highway subgrade materials. This is also significantly below the dielectric value of 16, at which point it is predicted that plastic deformation will occur within the structure due to physical property changes in the soil which are driven by moisture infiltration and fluctuations in moisture content. Note also that the untreated or raw soil and the lime treated soil greatly exceed the upper limit for Dielectric Value. The test values indicate that both the raw soil and the lime treated soil are highly moisture susceptible.

EMC SQUARED FIELD TESTING

District and area engineers in TxDOT Dallas District worked together to locate a field test pad location with representative problem soils and a situation where a stabilized subgrade layer could be directly subjected to an extended period of intensive truck traffic without a protective pavement cover. A highway construction project under TxDOT supervision provided the perfect opportunity as the contractor was planning to locate a large portable concrete batch plant operation to supply the concrete requirements for this highway pavement and other projects planned for the year ahead in the local area.

An elevated two acre pad was constructed in 1999 with the local highly expansive clay soils. An EMC SQUARED® System treatment was mixed in and highly compacted to create an eight inch thick working platform. This platform supported heavy use by cement trucks, aggregate haul trucks, large front-end loaders and concrete delivery trucks without rutting, cracking or need for repair. As much as 20,000 tons of aggregate was hauled in and stored on the stabilized pad for each production run. The stabilized working platform supported the stockpiling operations as well as thousands of loaded truck trips and thousands of front-end loader trips as stockpiled concrete aggregate was transported to the concrete batch plant. After a year in which three large projects were supplied, the batch plant was demobilized and the site reprofiled to restore agricultural operations. The EMC SQUARED System treatment proved to be highly effective, and at a fraction of the cost of cement or lime treatment.

EMC SQUARED IMPLEMENTATION

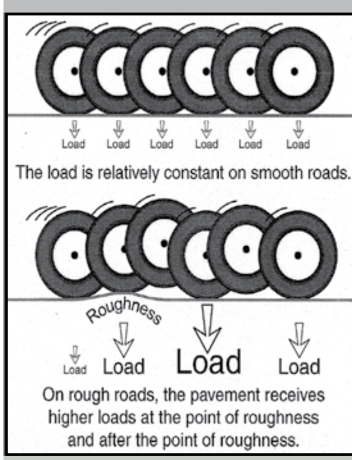
TxDOT took a conservative approach in its review of the unique **EMC SQUARED** System stabilizer products, starting with a literature search in 1995 that led to the selection of these products for evaluation in a laboratory research study conducted at the Texas Transportation Institute (TTI) and a final report in 1998 that recommended their use in place of lime and other calcium-based stabilizers. The report also recommended the stabilized test section that was constructed and monitored throughout 1999 prior to approval of the **EMC SQUARED** System products by the TxDOT Dallas District for use on full scale freeway and highway projects. These pavements have now been in service for 20 years. A field study and review of surface condition and pavement smoothness was conducted in late 2018 and further strengthens the engineering basis for more wide-scale utilization of the **EMC SQUARED** System products for all categories of transportation infrastructure construction.

EMC SQUARED MONITORING

INTERNATIONAL ROUGHNESS INDEX (IRI)

Pavement smoothness has become the most recognized international index for the evaluation of pavement performance. The rate at which a pavement develops roughness is a generally accepted index for predicting the limits of the remaining service life of a specific section of highway pavement. IRI measurement has been in nationwide use since 1990 when the Federal Highway Administration (FHWA) mandated implementation by all state highway agencies. The ultimate goal of subgrade stabilization, beyond providing an effective working platform, is to maintain pavement smoothness by protecting against differential settlements. IRI testing evaluates this fundamental performance criteria more directly than any other field test.

The highway projects under the control of the Texas Department of Transportation (TxDOT) and the North Texas Tollway Authority (NTTA) have been monitored annually for pavement smoothness and the data reviewed after eighteen years. The pavement installations above subgrades constructed with **EMC SQUARED** System Treatments were free of distress and retained smooth running alignments. To quote one well known highway researcher in regards to the comparative significance of testing in materials laboratory versus field monitoring of the smoothness of the actual pavement system, "Smoothness is what it's all about". Materials laboratory tests attempt to predict field performance, but field performance over time is the true measure of success.



HOW PAVEMENT ROUGHNESS GENERATES DYNAMIC LOADS

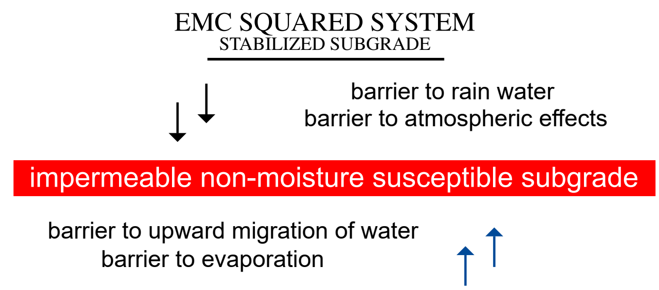
Pavement roughness leads to higher dynamic loads on localized pavement sections which increases pavement deterioration at those locations. This not only lowers ride quality, but also leads to a cycle of increasing deterioration rates and roughness severity.

The **EMC SQUARED®** System has proven effective in stabilizing a wide variety of soil, aggregate, and recycled pavement materials at locations across the country and as far south as Brazil and as far north as Alaska. These highway subgrade stabilization projects in Texas are particularly noteworthy given the severity of the soil problems being addressed by **EMC SQUARED** System treatment.

When it comes to the subject of soil stabilization and the comparative effectiveness of various stabilization treatments, the Dallas-Fort Worth area is the epicenter of problematic soil conditions and the attempts to solve those problems with various stabilization treatments. This area of Texas is known for its highly expansive clay soils and extreme weather conditions. Extended periods of hot dry weather and heavy flooding rainfall bring out the worst behavior of expansive clay soils. As a consequence, costly chemical treatments have traditionally been utilized in the construction of almost every highway subgrade. To complicate matters, many soils have soluble sulfate chemistry that negatively reacts with lime, cement and fly ash additives and creates heaving of highway pavements that is far worse than the problems generated by the expansive soils.

The effort by the Texas Department of Transportation (TxDOT) Research & Testing Implementation (RTI) Office and the Dallas District to identify stabilizer technology that works without risk of "sulfate-induced heave" problems paid dividends. This publication summarizes laboratory testing and the field performance of highway projects in the Dallas District where subgrades were stabilized with **EMC SQUARED** System treatments in Year 2000 as part of this program to eliminate the risks associated with lime treatment. **EMC SQUARED** System subgrade treatments are performing well in extremely adverse conditions and outperforming cement, lime, and lime-fly ash (LFA) treatments in comparative field installations. These **EMC SQUARED** System applications provided serviceable working platforms during the highway construction phase. They were faster to install and far less expensive to purchase than lime, cement, lime fly-ash LFA soil treatments, and cement treated base (CTB) materials. They eliminated the risks of sulfate-induced heave and pavement failure associated with lime and cement treatment. Subgrades treated with the **EMC SQUARED** System are now supporting highway pavements that retain smoother alignments and require less maintenance in spite of the extremely problematic soil conditions.

The TxDOT RTI Office funded an extensive two year research study completed in 1998 at the Texas Transportation Institute (TTI). This study documented the effectiveness of the **EMC SQUARED** System treatment. The study noted that the soils treated with the **EMC SQUARED** System had a lower permeability and a lower suction, or moisture susceptibility, than the untreated soils below, with the results being that subgrade soil stabilized with the **EMC SQUARED** System treatment would shed water off its surface and not soak up water from the soil below.



Unlike lime treatment, which typically increases moisture flow though the soil layer, a negative trade off that comes along with the positive benefits it offers, **EMC SQUARED** System treatments typically reduce moisture flow and moisture susceptibility and promote moisture barrier benefits. A stabilized moisture barrier layer not only retains its own flexural stiffness, but also protects the stiffness of the clay soils below as it cuts off the wetting and evaporative effects that otherwise drive volume change below the treated subgrade and differential settlement, roughness and cracking in the pavement above. This is the *multiplier effect* (EMC^2) of **EMC SQUARED** System treatment.

Typical accelerated laboratory testing programs limit their scope to "swell" index tests in artificially induced laboratory conditions. These tests present lime treatment in the best possible light, while ignoring other test methods that demonstrate the limitations of lime treatment and the success of other product technologies in addressing important engineering concerns related to the preservation of pavement performance. This TTI research study used sophisticated test methods conducted over an extended period of time, allowing more accurate modeling of the field service environment and more profound evaluation.

As briefly addressed here, the **EMC SQUARED** System provides a method of improving pavement subgrade performance that is unique and distinctly different from lime treatment. Intelligent evaluation requires a basic understanding that this fundamental difference mandates utilization of tests and construction procedures that are compatible with proper application of the **EMC SQUARED** System stabilization methodology.

The performance reports from these projects located in the Dallas District clearly show how investments in more sophisticated laboratory procedures and in field implementation of research recommendations pay off in construction cost savings and improved highway pavement performance.