EMC SQUARED® SYSTEM STABILIZER PRODUCTS SUPERIOR IN HEAD TO HEAD COMPARISON WITH ASPHALT, CEMENT, FLY ASH, AND LIME PRODUCTS

TEXAS HIGHWAY PROJECTS

ADVANCED STABILIZATION TECHNOLOGY IN SERVICE

INTERSTATE 30 · INTERSTATE 635 · PRESIDENT GEORGE BUSH TURNPIKE

Pavements Constructed on Top of EMC SQUARED System Stabilized Subgrades for TxDOT's Dallas District Remain Smoother Running and Have Required Far Fewer Repairs

INTERSTATE 30

"The best riding section of Interstate 30 . . . "

EMC SQUARED

EMC SQUARED® System
SUBGRADE STABILIZATION

- SPEEDED CONSTRUCTION
- COST SAVINGS
- EFFECTIVE WORKING PLATFORM
- MOISTURE BARRIER PERFORMANCE
- EXTENDED PAVEMENT LIFE
- SMOOTH RIDE QUALITY
- MULTIPLIER EFFECT (EMC²)

NORTH TEXAS TOLLWAY AUTHORITY PROJECTS

PRESIDENT GEORGE BUSH TURNPIKE

COMPARISON WITH LIME AND LIME - FLY ASH (LFA) TREATMENT

The SH 161 segment of the President George Bush Turnpike, or "the PGBT," is one of two PGBT segments constructed to date with **EMC SQUARED®** System subgrade treatment. The total construction value of the SH 161 (DNT-346) and SH 190 (DNT-323) projects was approximately $100 million. The SH-161 segment is located on the eastern side of Dallas-Fort Worth International Airport (DFW) in an area where swelling clays and sulfate-induced heave (attributable to the incompatibility of lime and other calcium based stabilizers such as cement and fly-ash) have long buckled and cracked highway pavements and building foundations. In response to these problems, TxDOT Dallas District funded a laboratory study that was conducted at the Texas Transportation Institute (TTI). Soils were sampled for the research study from two area projects in 1996. These projects included the SH 161 segment of the PGBT project and a nearby addition to the Interstate 635 Freeway, (the Lyndon B. Johnson Freeway), known locally as "the LBJ." The TTI research study was completed in 1998. It reported that the **EMC SQUARED** System was superior to lime treatment for these problem soils and recommended its use on both the SH 161/PGBT segment and on the Interstate 635 project. The two projects were subsequently constructed with **EMC SQUARED** System subgrade treatments. Both of these projects also included portions of subgrade constructed with calcium based stabilizers, and they illustrate the findings of the TTI research study regarding sulfate-induced heave generated by the addition of calcium based stabilizers.

The President George Bush Turnpike is currently operating as a six lane tollway. While funded through TxDOT, the engineering, construction management, and operation of the tollway are under the direction of the North Texas Tollway Authority (NTTA). The thickness of NTTA's pavement structural section design for the SH-161 is impressive and necessary due to the serious nature of the local soil problems. A thirty-four inch thick subgrade treated with **EMC SQUARED** System products supports a six inch thick base course constructed with hot mix asphalt, overlain by a thirteen inch thick continuously reinforced concrete pavement. The majority of the subgrade on this project was constructed with **EMC SQUARED** System treatments. A small area of subgrade was constructed with lime treatment. An additional area was treated with a lime-fly ash mixture (LFA), a combination of calcium based stabilizers thought to be slightly less reactive with sulfate bearing soils.

With nineteen inches of combined concrete and asphalt pavement structural section on the SH-161 segment of the PGBT, one might think that subgrade stabilization problems would be slow to surface. A project tour by NTTA, TxDOT and SSPCo personnel proved this is not necessarily true. While the main lanes built above subgrades constructed exclusively with **EMC SQUARED** System treatments were exhibiting no noticeable roughness or heave, this was not the case in areas where calcium based treatments were applied to the upper layer of the subgrade. The pavements above the lime-fly ash (LFA) treatment were exhibiting limited but noticeable roughness, which is not surprising given the calcium base of both lime and fly ash products. The pavement above the lime treated area has a prominent heave, or "roller coaster," as predicted by the TTI research study.

Applied Research Associates (ARA) in a summary study published in December 2018 surveyed the current condition of all six highway projects in Dallas that were constructed above subgrades that were treated with the EMC SQUARED System Concentrated Liquid Stabilizer products. Using profilometer data provided by NTTA and TxDOT to determine the ride quality or smoothness of these six highway projects approximately eighteen years after construction, ARA was also able to determine the International Roughness Index (IRI). The ARA study rated the pavement surface condition of NTTA's two segments of the PGBT (SH 161 and SH 190) as EXCELLENT and the ride quality as GOOD.

TEXAS DEPARTMENT OF TRANSPORTATION PROJECTS

DALLAS - FORT WORTH TURNPIKE

★★★ "THE BEST RIDING SECTION OF INTERSTATE 30" ★★★

The Dallas District Field Engineer who has been tasked with monitoring district soil stabilization projects since 1999, reported on the section of the Dallas - Fort Worth Turnpike constructed with the EMC SQUARED® System subgrade treatment (TxDOT CSJ 1068-04-112) as follows: "The project shows no signs of distress and the ride quality is smooth and is the best riding section of IH 30 in the district."

EMC SQUARED System treatment was utilized for stabilization of subgrade for the Interstate 30 Belt Line Road project in the year 2000. The completed project effectively doubled the width of the old highway. The new lanes in the former median area are HOV (High Occupancy Vehicles) lanes. The structural section incorporates continuously reinforced concrete pavement, hot mix asphalt base and an eight inch thick EMC SQUARED System stabilized subgrade. The ARA study reports the pavement surface remains in EXCELLENT condition and ride quality remains GOOD.

TEXAS DEPARTMENT OF TRANSPORTATION PROJECTS

THE LYNDON B. JOHNSON FREEWAY

COMPARISON WITH LIME AND LIME - FLY ASH (LFA) TREATMENT

The performance of the **EMC SQUARED®** System subgrade treatment on the Interstate 635 (LBJ) Freeway project has also proven out the recommendations of the Texas Transportation Institute study. This project (TxDOT CSJ 2374-07-041) involves three lanes in each direction with concrete pavement constructed above a hot mix asphalt base course and stabilized subgrade. These lanes were added as a frontage road system to existing freeway lanes.

EMC SQUARED System treatment was used for the majority of the subgrade construction requirements for lane additions on the eastbound freeway, while an asphaltic product was used under the eastbound exit lanes. Cement, lime and fly ash were used in various combinations for subgrade stabilization for the lane additions on the westbound side. Distinct roughness and heaving, or "roller coasters," as well as pavement cracking soon manifested itself through the pavements in the westbound lanes constructed above the calcium based cement, lime and fly ash stabilizer treatments and these sections required full depth reconstruction within a short period of years. The eastbound exit lanes constructed above the asphaltic stabilizer treatment also developed roughness and cracking and required repairs. At the same time, reports from the Dallas District indicated that the eastbound lanes above the EMC SQUARED subgrade retained overall smoothness with no pavement distress, meeting TxDOT's "smooth" classification in International Roughness Index (IRI) during annual profilometer testing.

In service in soil conditions described by TxDOT personnel as "probably the worst soil we have in the Dallas District", the ARA study reports that the pavement surface remains in EXCELLENT condition and the ride quality is GOOD.

COCKRELL HILL ROAD

COMPARISON WITH CEMENT TREATED BASE (CTB)

A year 2000 cooperative construction effort of TxDOT and the City of Dallas (TxDOT CSJ 0918-45-387) provided an opportunity to further test the **EMC SQUARED** System in an area noted for having some of the worst expansive clay soils in the Dallas area. With a construction project already in progress extending Cockrell Hill Road north to tie in to the Interstate 30 Freeway, the contractor submitted a value engineering proposal to speed construction and reduce costs. The original design called for concrete pavement on top of a cement treated base (CTB), a typical structural section for many road and street projects in Dallas. With the concrete pavement already in place for all six lanes from Interstate 30 south to the first intersection, and for the full extension of the northbound lanes, TxDOT and the City of Dallas decided to experiment and accept a proposal to eliminate the cement treated base for the southbound lanes yet to be constructed. *This portion of the project was constructed without a base course layer.* Instead, the concrete pavement was placed directly on subgrade treated to an eight inch depth with an EMC SQUARED System application.

The ARA study reports that one section of the Cockrell Hill Road project was plagued by very serious drainage problems. The condition of the pavement surface constructed directly on top of the EMC SQUARED subgrade in well drained areas is in FAIR condition with FAIR ride quality, while the surface condition is rated as FAIR but ride quality is now rated as VERY POOR in the area with inadequate drainage.

TEXAS DEPARTMENT OF TRANSPORTATION PROJECTS

LUNA ROAD EXTENSION

PERFORMANCE THROUGH FLOODED WETLAND

Luna Road is a major arterial in the northwestern Dallas area which now connects with Old Denton Road via an extension project which added a new segment of six lane highway and an overpass above Interstate 35E Freeway. This construction project (TxDOT CSJ 8037-18-002) presented a classic soil stabilization challenge. Alignment requirements dictated construction through a wetland area and lakes created by gravel mining operations. Pavement designers were forced to plan for construction of a tall embankment over saturated ground conditions. Once constructed, the embankment would be subjected to deeply ponded water on both sides. Controlling moisture content within the embankment was a concern due to the risk of volume change and differential settlement in the highly moisture susceptible expansive clay soils.

After reviewing the recently completed research study conducted at the Texas Transportation Institute (TTI) under the direction of Dr. Robert Lytton, design engineers made the decision to stabilize two different layers with **EMC SQUARED**® System applications. The first stabilized layer was constructed just above the elevation of the ponded water. The second stabilized layer was constructed at the top of the embankment (the actual pavement subgrade). The intent was to provide stable construction work platforms and to partially encapsulate the layer of untreated embankment soils between the two stabilized moisture barrier layers. As an additional response to the ponded water, they specified stabilization of a one-foot thick placement of a rock riprap cover to protect the embankment slopes against wave attack.

According to the report of the TxDOT Dallas District office "Even with the abundance of water along this roadway, no distress is evident in the pavement and the ride quality is very smooth. The conclusion could be drawn here is that the **EMC SQUARED** System treatment is effective in reducing and/or preventing water from entering the embankment". After 18 years in service, ARA rates pavement surface condition of Luna Road as GOOD and the ride quality remains GOOD

Moisture Barrier Performance

For highway engineers who have previously asked the question as to how well an EMC SQUARED System moisture barrier would perform with a lateral source of water ponded against the embankment below the moisture barrier, the Luna Road Extension project clearly answers this question with successful performance.

Soil stability, at its essence, has water as its common denominator. The engineering properties of any soil material are governed by variations in water content. The most direct and cost-effective route to stabilizing a soil is to stabilize its moisture content. This is the most fundamental benefit offered by the EMC SQUARED System in treatment of expansive clay soils. When moisture content in subgrade and embankment soils is maintained in a "near optimum" state, the soil platform is unaffected by volume change (expansion and shrinkage) and provides consistent support for the pavement. Key to this approach to stability is the selection of product technology that reduces soil moisture susceptibility and improves moisture barrier performance. This is not a benefit normally offered by cement, fly ash or lime treatment. TxDOT and other state transportation agencies have previously used plastic liners with some success to encapsulate expansive soils to control volume change, but the cost and complexities during construction were prohibitive. As indicated in the TTI research study, and verified in the field monitoring, the EMC SQUARED System treatment is performing well as a moisture barrier. The additional good news - *it's more economical and faster to apply than lime treatment.*

LABORATORY TESTING HIGH SULFATE SOILS

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. 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 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 treatment is obviously providing an effective moisture barrier. 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 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 EMC SQUARED System subgrade treatments. This moisture barrier performance promotes greater stability in soils below as well as within the treated layer, which is a quantum leap forward for construction of trouble-free, smooth-running pavements.

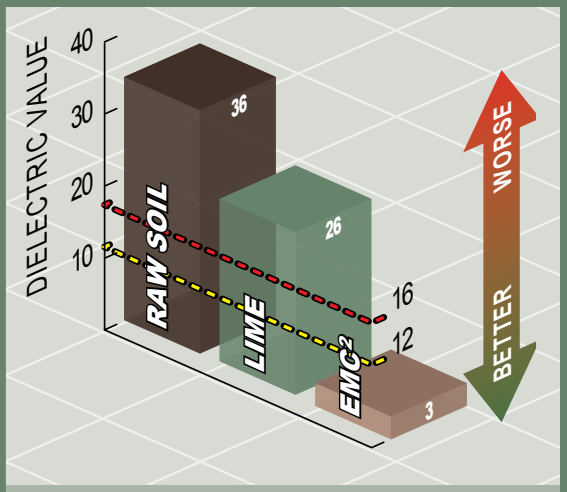
President George Bush Tollway SH 161

Triaxial 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 averaged 3, which is 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 soilat 36 and the lime treated soil at 26 greatly exceed the upper limit for Dielectric Value. The test values indicate that the lime treated soil is highly moisture susceptible.

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

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

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 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

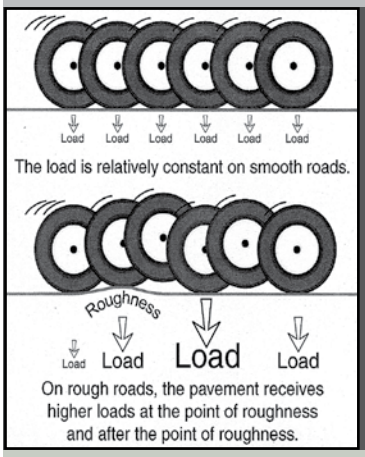
TxDOT took a conservative approach in its review of the unique **EMC SQUARED** System stabilizer products, starting with a literature search that led to the selection of these products for evaluation in a laboratory research study conducted at the Texas Transportation Institute (TTI) and a final report 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 prior to approval of the **EMC SQUARED** System products by the TxDOT Dallas District for use on full scale freeway and highway projects. A field study and review of surface condition and pavement smoothness was conducted after eighteen years of service. The positive reports further strengthen 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.

After 18 Years – Surface Condition and IRI Rating

Use and Performance of Advanced Soil Stabilization

Synthesis Summary of Projects in Dallas, Texas — ARA Report No. 003563-1*

Project Identification	Surface Condition Category	IRI Category
Interstate Highway 30** (TxDOT - Dallas Fort Worth Turnpike)	Excellent	Good
SH 161 (NTTA - President George Bush Turnpike, DNT-346)	Excellent	Good
SH 190 (NTTA - President George Bush Turnpike, DNT-323)	Excellent	Good
Interstate Highway 635 Frontage Road** (TxDOT - LBJ Freeway)	Excellent	Good
Luna Road** (TxDOT)	Good	Good

For the past thirty years, road and highway projects constructed with EMC SQUARED® System stabilizers have demonstrated the capability of this advanced stabilization product technology to build roads that are strong, durable and uniquely smooth running. The five projects listed above included four Dallas Area freeways and a major arterial expressway. A later review study confirmed the contribution of the EMC SQUARED System product technology to the construction of smooth running highways. The study incorporated the most up to date IRI data collected by the two public agencies responsible for the construction and maintenance of these highway projects, the Texas Department of Transportation (TxDOT) and the North Texas Tollway Authority (NTTA).

As of 2018, these five projects had all been in service for approximately 18 years. All five projects presented the challenge of constructing pavements over famously problematic expansive soils with a history of cracking, buckling up and heaving asphalt and concrete pavements constructed on top of them. Two of the four freeway projects were the subject of the Tx-98/3929-1 Research Study that recommended the use of EMC SQUARED System products for subgrade stabilization. Lime treatment, the traditional chemical stabilizer used throughout Texas was found to be ineffective, and in fact counterproductive, when applied to these Dallas Area soils. The study was tasked with identifying an effective alternative to lime treatment. The study found that EMC SQUARED System products were superior to lime in strength, stiffness, swell resistance and permeability and it recommended use of EMC SQUARED System products for all projects with similar problem soils.

The four freeway projects that were subsequently constructed in Year 2000 and evaluated in 2018, as shown above, were all constructed on top of highly problematic soils. They were constructed with proper drainage conditions. The alignment of the fifth project, a major six-lane arterial (Luna Road) located in the Trinity River Watershed, required construction of a tall embankment running through two lakes. The design consultant (HDR Engineering) protected the stability of the clay embankment soils by including a 12-inch thick EMC SQUARED System moisture barrier layer within the lower portion of the embankment just above the water level of the lakes.

These freeway and highway projects have now been in service under very heavy traffic volume for more than twenty years since their construction. As shown above, results from ARA Report No. 003563-1 confirm that the pavements constructed on top of subgrades stabilized with the EMC SQUARED System treatments remain in Excellent condition overall. The International Roughness Index (IRI) test results demonstrate that the stabilized subgrades are performing very well. The ARA Report validates the findings of Dr. Robert Lytton at the Texas Transportation Institute (TTI) in his Tx-98/3929-1 Research Study recommending the EMC SQUARED System stabilizer products for effective treatment of these highly problematic soils.

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* Harold L. Von Quintus, P.E., Applied Research Associates, Inc.
Full report available upon request
** Built by Zachry Construction Corporation

SUMMARY

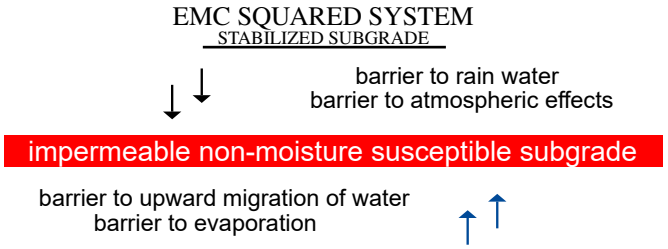
The **EMC SQUARED®** System has proven effective in stabilizing a wide variety of soil, aggregate, and recycled pavement materials at locations across the country and as far south as Brazil and as far north as Alaska. These highway subgrade stabilization projects in Texas are particularly noteworthy 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 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 cement and lime treatments have traditionally been utilized in the construction of almost every highway subgrade. To complicate matters, many soils have sulfate chemistry that negatively reacts with lime and cement and creates heaving of highway pavements and damage that is far worse than the problems generated by untreated expansive soils.

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.

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 IRI 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. (**https://stabilizationproducts.net/docs/18791.pdf**)



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.

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