DIVERGENT VIEWS ABOUT
HYDRAULIC CONDUCTIVITY AND PERMEABILITY

DIVERGENT VIEWS BETWEEN PAVEMENT DESIGNERS AND LANDFILL ENGINEERS

As manufacturers and suppliers of pavement materials and chemical and mechanical products for modifying, stabilizing, and reducing the permeability of soil and aggregate materials, we have had the opportunity over the past four decades to collaborate with engineers servicing the waste containment industry as well as the engineers servicing the highway construction industry. We have observed that these two branches of the engineering profession have wildly divergent understandings about the role that hydraulic conductivity and permeability play in the performance of the projects they design. There is something to be learned by looking more deeply into this dichotomy.

Landfill Engineers designing waste enclosures must meet mandated hydraulic conductivity and permeability standards. For example, the State of California requires the clay liner component in hazardous waste landfill liner systems to perform as impermeable barriers with hydraulic conductivities of 1×10^{-8} cm/sec, or less, which the State defines as a rate of water movement of not more than ¼-inch per year. In response to nationwide mandates, measures must now be taken by landfill engineers during design and construction to build clay liners that perform as impermeable barriers for long term storage of waste materials. Landfill engineers have proven that they can design landfill liner systems that effectively function as impermeable barriers. What was thought to be impossible in the 1950's is now possible. In addition to advances in knowledge about soil materials and soil compaction procedures, incorporating new product technologies such as flexible membrane liners (FML's) and geocomposite clay liners (GCL's) are what have made effective containment achievable. Much like a pavement structural section design for a road or highway, the design for landfill liners typically includes several different layers with different functions within the liner system.

Highway Engineers are tasked with designing pavement structural sections for roads, streets, and highways. The teaching over the past century has been that saturation of aggregate base course materials and subgrade soils is inevitable. In reliance on that teaching, the question can't even be asked as to whether it's possible to design an impermeable pavement structural section and keep water entirely out of the system. Consequently, the highway engineering community typically specifies highly permeable open-draining aggregate base course materials in pavement designs, often in combination with costly underdrain and edge drain systems. The goal of these designs is rapid transmission of water flow through the base course at rates measured in feet per day. This is in distinct contrast to landfill clay liners where water flow through the liner has been effectively reduced to a fraction of an inch per year. In a perfect world, both engineering theories have merit, with satisfactory end results in every instance. In real world road systems, regardless of climate or budget, open-draining pavement systems are rife with valid complaints. This dissatisfaction ranges from rough-riding roads with poor ride quality to painfully high construction, maintenance, and repair costs.

NOTE: Landscape architects promote the use of permeable pavement systems to reduce the volume of stormwater runoff, but permeable pavements that fail prematurely due to limitations associated their permeable design are not a sustainable solution.

IMPORTANT DIFFERENCES BETWEEN LANDFILL LINERS/CAPS AND PAVEMENT STRUCTURAL SECTIONS

Landfill Engineers have a unique problem to address when designing the capping systems for the closure of landfill cells. The waste materials contained in landfill cells typically decompose and settle over time, causing subsidence and potential differential settlement in areas of the landfill cap. In anticipation of such significant amounts of future movement, the final soil cover layer needs to remain flexible and resistant to cracking in order to maintain its integrity and water shedding function. Conventional cement and lime treatments reduce the natural plasticity of clay soils and produce rigid soil layers prone to cracking. Consequently, use of cement and lime is not permitted for landfill closure applications. A far more resilient stabilization treatment is required to increase the tensile strength and water shedding capability of the soil cover while retaining its natural plasticity and flexible behavior. The EMC SQUARED System stabilizer products are a perfect fit for this application and are frequently used to stabilize the exposed soil cover layer for landfill closures located in arid regions where maintenance of vegetative cover is not a practical option.

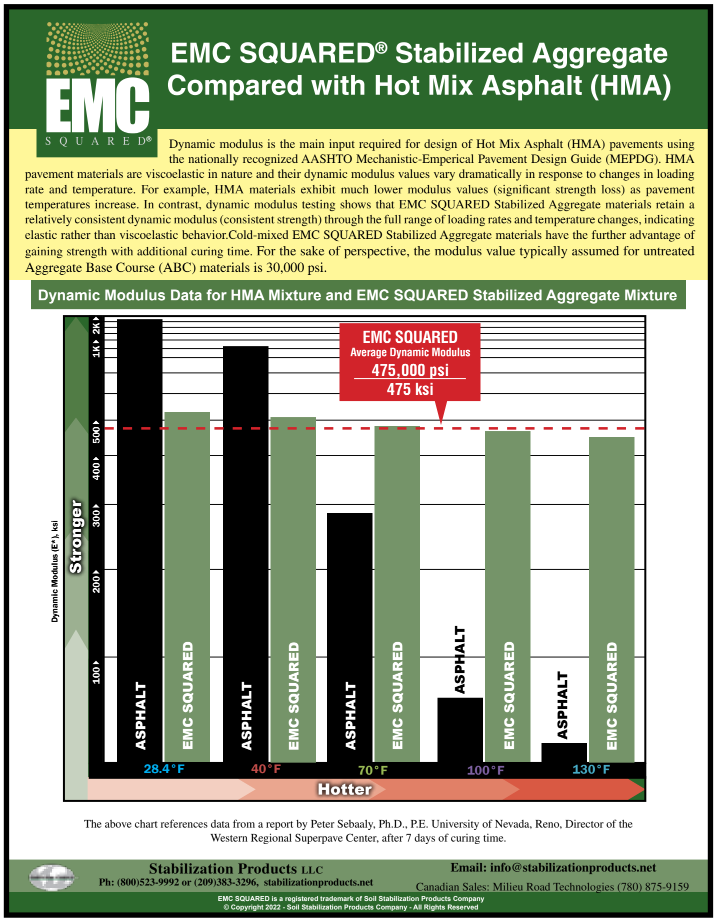
While attaining the exceptionally low levels of permeability required for landfill liners and landfill closure caps by federal and state regulations can be particularly challenging, landfill liners are not subjected high repetitions of dynamic loading by vehicles and heavy trucks. Highway engineers have a different set of variables to address in order to incorporate impermeable base course and subgrade layers in their design. In order to retain a consistent stiffness and high modulus after thousands of dynamic loadings, the base course and subgrade must remain permanently unsaturated and effectively impermeable, shedding rainwater from above while also not suctioning water from below. In other words, the base course and subgrade need to be non-moisture susceptible as well as impermeable. This is where the availability of advanced product technology becomes essential. The performance of pavement designs are increasingly being rated according to their ability to retain smoothness or good ride quality. While not yet widely recognized, an impermeable pavement structural section that caps off the movement of rainwater into the soils below the pavement and acts as a barrier to the upward flow of capillary water will reduce the amount of differential settlement below the pavement structural section and contribute to smoother running pavements far more effectively than open draining pavement systems that do nothing to counteract cycles of saturation and desiccation that otherwise accelerate the development of pavement roughness. The EMC SQUARED System stabilizer treatments have proven to offer a uniquely valuable combination of benefits:

1. Higher Modulus
2. Lower Permeability
3. Reduced Moisture Susceptibility
4. Retained Plasticity and Elastic Behavior

Historically, Highway Engineers did not have a chemical stabilizer product available that could provide improvement in all of these categories as their tool kits of the time only included the calcium-based stabilizer chemicals. Cement, Fly Ash, and Lime treated aggregate base and soil materials are ineffective as moisture barriers or capillary breaks. They still become saturated with water. Further limiting the application of chemical stabilization technology, calcium-based chemicals produce rigid, slab-like layers highly prone to brittle cracking under the pavement surface, which then generates reflective cracking in the asphalt and concrete pavements layers above.

Aerial photo of hazardous waste disposal landfill facility in arid desert location. Final soil covers constructed with EMC SQUARED Stabilizer treatments approved by CalEPA for ongoing permanent closures as disposal cells are filled.

Rather than rigid cement-treated or lime-treated layers that will inevitably be damaged by shrinkage and layer cracking, a better match under asphalt and concrete pavements are stiffened flexible layers that retain elastic behavior and remain resilient and resistant to permanent deformation under repetitive dynamic loading conditions. We have good news. Stabilized base course materials that match those requirements are now a reality, as shown by the test data from the Western Regional Superpave Center (WRSC) at UNR. *See* **https://stabilizationproducts.net/docs/18828.pdf**



IMPERMEABLE BASE AND SUBGRADE — WHY NOT?

What is the history behind these two divergent views among engineers about hydraulic conductivity and permeability? Why aren't highway design engineers reducing construction costs and lengthening pavement service life by designing impermeable structural sections? First, most highway engineers are still being educated with curriculum whose basis was developed a century ago. This old curriculum teaches that saturation is an inevitable fact, and that the pavement system must be designed around the assumption that saturation of the base course layer cannot be avoided. The only problem with this group think phenomenon is that it has everyone looking in exactly the opposite direction while the solution to the problem has already arrived. Aggregate base course and soil materials that are moisture susceptible can be effectively treated with modern liquid stabilizer products formulated to address this problem. Saturation is not inevitable.

FROM GOING BACK 100 YEARS IN THE HISTORY OF GEOTECHNICAL ENGINEERING EDUCATION

The brilliant Mechanical and Geotechnical Engineer and Geologist Karl Terzaghi single-handedly developed the principals of Soil Mechanics during the 1920's while teaching at the Massachusetts Institute of Technology (MIT). Soil Mechanics is the branch of Civil Engineering Science that postulates the theoretical basis for analysis in geotechnical engineering of many concerns such as the bearing capacity of building foundations and the base course and subgrade layers for transportation infrastructure. Working in an age before the availability of digital computing, a modern technology that enables engineers to solve far more complex problems, Terzaghi was forced to simplify and narrow the true applicability of his Soil Mechanics theory. His theory was exclusively based on working with soils that are fully saturated. Full saturation of soils was therefore a required condition during laboratory testing (Full saturation is a condition

Karl Terzaghi at Harvard University in 1940 where water content is so high that there are zero air voids). This is the area of practice now more correctly defined as Saturated Soil Mechanics, in contrast with the recently evolved Mechanistic-Emperical (M-E) Pavement Design, an engineering practice where the processing power of modern digital computers are necessary to address the far greater number of variables that must be considered in order to model the service environment more realistically.

UNSATURATED SOIL MECHANICS THEORY AND REPETITIVE LOAD TESTING

In Unsaturated Soil Mechanics, saturation is not automatically assumed in laboratory testing and design, so a far more complex set of variables must be addressed. Using Unsaturated Soil Mechanics, design engineers are no longer hostage to the results of outdated index tests conducted in the laboratory on specimens of base, subgrade and other layers that previously had to be pre-saturated with water prior to testing, according to the limits of Saturated Soil Mechanics teaching. With the evolution of Unsaturated Soil Mechanics, aggregate and soil materials in any state-of-being or condition can be evaluated with far more sophisticated repetitive load test methods such as resilient modulus, dynamic modulus, repeated load triaxial and Falling Weight Deflectometer (FWD), a group of tests that more accurately replicate unsaturated conditions in the service environment and the forces of dynamic loading that highway pavement systems must endure. Instead of a single static loading strength test, a test that defines only the strength of the pavement specimen at the point where it fractures and fails, the design engineer can instead have access to test data that evaluates the stiffness of each layer of the pavement structural section as it performs under thousands of repetitive loadings, and then design the pavement using an approach known as Bottom-up Design.

BOTTOM-UP DESIGN METHODS

In a Bottom-up Design, the design process starts with input of the modulus test data for the highway subgrade, followed by input for the base layers, and finally the surface coarse pavement. Bottom-up Design gives far more serious attention to the lower layers of the pavement structural section than conventional Top-down Design methods. Bottom-up Design uses data results from performance-based testing, so it can assign intelligent stiffness values to the functioning of the subgrade and base course layers within the pavement system. Working from the bottom up, the base course and subgrade layer, especially when stabilized, can play far more important roles in lowering the cost of highway and pavement construction by reducing the required section thickness of the pavement surface course layer. Resilient stabilized base courses and subgrades can reduce dependency on the thick layers of asphalt or concrete pavement materials that are no longer necessary when highway designers free themselves from the limits of Top-down Designs that have a built-in dependency on thick layers of asphalt and concrete pavements. Times have changed. Pavement systems are initially constructed with unsaturated base and subgrade layers. They can now be maintained in an unsaturated state with application of stabilization products formulated to effectively treat moisture susceptible materials.

See **https://stabilizationproducts.net/docs/18811.pdf**

GUIDELINE DOCUMENTS NEED TO BE BROUGHT UP TO DATE

To be fair to the engineers working in the early decades when geotechnical and highway engineering practice were in rapid evolution, along with test methods and highway design manuals, stabilizer products capable of strengthening and keeping water out of base course and subgrade layers had not yet been developed. Practitioners in the past simply did not have such a tool available in their tool kit. Other means, such as state-of-the art EMC SQUARED System liquid stabilizer product technology was not available until recent decades. Consequently, the use and availability of this advanced product technology was not written into state and federal design manuals and educational materials, which have substantially remained unchanged for the past fifty years or more in regard to available stabilization products. Great advances in stabilization product technology have been documented since many of these guideline documents were published. More recently developed products now facilitate construction of impermeable high modulus base course layers and subgrades at affordable cost. The time is here to update guideline documents to include the advances in product technology that have been introduced to the market in recent years.

REMEDY FOR SHRINKING VALUE OF HIGHWAY CONSTRUCTION DOLLARS

The cost for cement and petroleum-based products is skyrocketing. The short supply and escalating prices for diesel fuel and concrete and asphalt pavement materials are rapidly depleting the funds available for highway construction projects. Additionally, open graded aggregates materials are typically more expensive to manufacture than dense-graded aggregates. Highway designs that add pavement underdrainage systems and edge drains, as well as open-draining base courses, are even more costly. It is time to review every option.

Requirements for open-draining aggregate materials typically increase cost and they sacrifice the higher strengths than can be achieved by stabilizing dense-graded aggregate materials. The EMC SQUARED (EMC2) stabilization product technology can increase the modulus of most dense-graded aggregate materials by a factor of five to ten times while also eliminating their moisture and frost susceptibility problems. These stabilized aggregate base course layers shed water from above and resists uptake of groundwater from below. Conversely, open-draining pavements and/or cement and lime treated layers fail to cut off the atmospheric effects that drive the moisture fluctuations that generate movement in the ground below the pavement structural section. Impermeable stabilized base course and subgrade layers, on the other hand, can function effectively within the pavement structural section as well as providing important benefits below the treated layers. Impermeable stabilized base course and subgrade layers limit moisture fluctuations in the native soils below the pavement structural section and effectively isolate them from atmospheric effects that contribute to cycling between saturation and desiccation. By maintaining the moisture content in these soils in a state of equilibrium, the forces that drive ground movement and differential settlement below the pavement structural section are eliminated. These are the rarely considered problems that contribute to rough-riding pavement behavior and speed deterioration of the pavement. The ability to stop the movement of moisture through the pavement structural section and isolate the native subgrade from atmospheric influences is the multiplier effect, the exponential power of the EMC SQUARED System. The treatment is contributing to more than simply keeping water out of the base course and subgrade layers and increasing their modulus values.

A pavement design based upon using the time tested and proven stabilizer technology that imparts a base course with a far higher modulus and effective impermeability, can both reduce the required thickness of asphalt pavement and eliminate the need for an underdrain system. If costs need to be cut in a big way without sacrificing performance, utilization of more sophisticated pavement designs and stabilizer technology can stretch road construction budgets to deliver miles of additional road construction. Newly completed roads that incorporate stabilized layers can be evaluated post construction with non-destructive Falling Weight Deflectometer (FWD) equipment to verify that their performance is equal or better than adjacent roads constructed according to more costly conventional designs. If money matters, now is the time to take advantage of advanced proprietary product technologies that were recently approved by the Federal Highway Administration (FHWA) for use in the construction of federally funded highway projects. Use of Best Available Technology (BAT) is now possible.

IMPERMEABILITY AS A GOAL

As previously addressed, one of the four engineering performance criteria that need to be achieved in the construction of impermeable road base materials and road subgrade soils is a permeability so low that the layer effectively becomes impermeable and can bear heavy loads regardless of the weather conditions. Take a look at the comparative results of a laboratory permeability test where an EMC SQUARED System treatment reduced the rate of water movement by a factor of one hundred times, or Two Full Orders of Magnitude. This is where the EMC SQUARED System is clearly stand-alone product technology. You simply cannot achieve similar results by applying conventional calcium-based stabilizer products. EMC SQUARED System stabilizer applications also exhibit excellent strength and stiffness test results.

See **https://stabilizationproducts.net/docs/18825.pdf**

HYDRAULIC CONDUCTIVITY AND PERMEABILITY REDUCED BY TWO FULL ORDERS OF MAGNITUDE*

EMC SQUARED System Stabilizer Treatment

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*1 Order of Magnitude (10) x 1 Order of Magnitude (10) = 100. A reduction of 2 full magnitudes means the EMC SQUARED System stabilizer application reduced the rate of water flow through the soil by a factor of 100 times.

GeoTesting EXPRESS

Client:	Ninyo & Moore		
Project Name:	Musket/Laboratory Testing		
Project Location:	Pheonix, AZ		
GTX #:	314988		
Start Date:	2/16/2022	Tested By:	sjt
End Date:	3/3/2022	Checked By:	jsc
Boring #:	145972		
Sample #:	Treated (EMC2 Stabilizer)		
Depth:	---		
Visual Description:	Moist, brown silty sand (with stabilizer)		

EMC SQUARED

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Gradient

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	---

Sample Preparation: Material was mixed with EMC2 Stabilizer in accordance with client recommended mixing procedures. Target Compaction: 95% of the maximum dry density (125.4 pcf) at the optimum moisture content (10.4%). Values specified by client. Trimmings moisture content = 10.9%

Assumed Specific Gravity: 2.70

Parameter	Initial	Final
Height, in	2.00	1.88
Diameter, in	2.86	2.93
Area, in^2	6.42	6.74
Volume, in^3	12.8	12.7
Mass, g	434	435
Bulk Density, pcf	128	130
Moisture Content, %	20.2	20.6
Dry Density, pcf	106.7	108.2
Degree of Saturation, %	94	100

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	80.00	Increased Cell Pressure, psi:	85.00	Cell Pressure Increment, ps	5.00
Sample Pressure, psi:	70.00	Corresponding Sample Pressure, psi:	73.38	Sample Pressure Increment	3.38
				B Coefficient:	0.68

FLOW DATA

	Time,	Pressure, psi				Flow Volume, cc				Temp,		Permeability K @ 20 °C,
Date	sec	Cell	Inlet	Outlet	Gradient	In	Out	Δ In	Δ Out	°C	R_t	cm/sec
28-Feb	---	80.0	70.5	69.5	14.7	7.00	14.00	---	---	---	---	---
28-Feb	5,400	80.0	70.5	69.5	14.7	7.05	13.95	0.05	0.05	19.5	1.013	1.5E-08
28-Feb	----	80.0	70.5	69.5	14.7	7.00	14.00	---	---	---	---	---
28-Feb	5,400	80.0	70.5	69.5	14.7	7.05	13.95	0.05	0.05	19.5	1.013	1.5E-08
28-Feb	----	80.0	70.5	69.5	14.7	7.00	14.00	---	---	---	---	---
28-Feb	5400	80.0	70.5	69.5	14.7	7.05	13.95	0.05	0.05	19.5	1.013	1.5E-08
28-Feb	----	80.0	70.5	69.5	14.7	7.00	14.00	---	---	---	---	---
28-Feb	5400	80.0	70.5	69.5	14.7	7.05	13.95	0.05	0.05	19.5	1.013	1.5E-08

PERMEABILITY AT 20° C: 1.46 x 10^{-8} cm/sec (@ 10 psi effective stress)

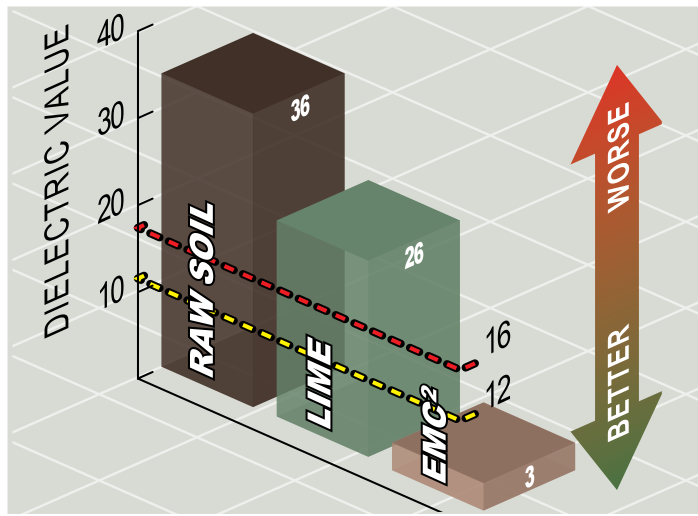
EMC SQUARED SYSTEM MEETS ALL FOUR REQUIREMENTS

Requirement #1. Impermeability

The conclusion of the report on a two-year long study at the Texas Transportation Institute (TTI) conducted under the direction Robert Lytton, a distinguished Geotechnical Engineer, recommended that an EMC SQUARED System stabilizer treatment be applied to the subgrade soils of the DNT-346 Section of the President George Bush Turnpike (PGBT) that was to be constructed along the alignment of old State Highway 161. The laboratory study demonstrated that the permeability test results for the EMC SQUARED treated soil were 8.9 x 10^{-10} cm/sec., a rate where water movement through the soil is reduced to less than one thousand of an inch per month. The treated soil would provide an impermeable barrier to water. TTI Research Report 3929-1 Summary here: **https://stabilizationproducts.net/docs/18588.pdf** Summing up the implications of the permeability and dielectric test results, the report states *"The stabilized subgrade has a lower permeability and 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..."*

Requirement #2. Resistance to Suctioning Water

In order to maintain a stable moisture content in the stabilized subgrade, the problem of the natural moisture susceptibility (the affinity of the clay soil for water) would also need to be addressed. The Dielectric Conductivity Testing conducted at TTI demonstrated that the EMC SQUARED System treatment was a highly effective solution.



As indicated in the graphic 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 soil at 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.

Additionally, Tube Suction Tests (TST) conducted seperately at TTI further demonstrate the effectiveness of the EMC SQUARED System in treating moisture susceptibility problems.
See **https://stabilizationproducts.net/docs/18587.pdf**

Requirement #3. High Strength & Stiffness

As illustrated in the chart below, Triaxial Testing conducted at TTI as part of the 3929-1 study confirmed that the soil treated with EMC SQUARED System stabilizer applications also exhibited excellent strength and stiffness.

President George Bush Turnpike
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)

Requirement #4. Retained Plasticity and Elastic Behavior

As discussed earlier in regard to landfill cover applications, earth materials treated with applications of EMC SQUARED Stabilizer retain their natural plasticity and elastic behavior, while gaining strength and resistance to water penetration. The summary of the Dynamic Modulus and Repeated Load Triaxial testing conducted at the Western Regional Superpave Center (WRSC) also addresses the elastic behavior, which in the case of this testing series was being observed in combination with impressive improvement in the long-term modulus of the treated material.

Dynamic Modulus

Repeated Load Triaxial

INTERNATIONAL ROUGHNESS TESTS VERIFY EFFECTIVE PERFORMANCE*

The national and international standard for evaluating highway pavement performance is the International Roughness Index (IRI), a pavement monitoring measurement typically taken on an annual basis to assess how quickly a particular pavement structural section transitions from smooth running to rough riding characteristics. This is the generally accepted index for predicting the limits of the remaining service life of a specific section of highway pavement. The IRI rating for the pavement structural section of the DNT-346 Section of the Turnpike, 18 years after construction, remained GOOD, which is a strong testimonial for the effectiveness of the EMC SQUARED System for prolonging smoothness in an area that is otherwise famous for its rough-riding pavements.

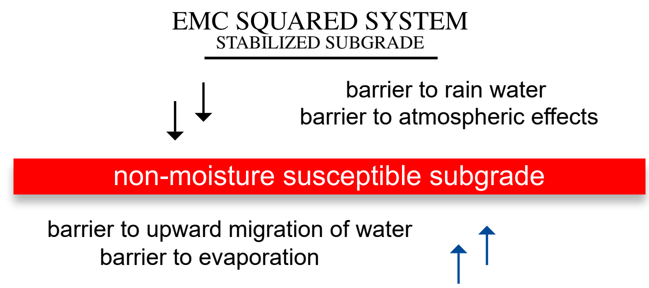
The five projects listed below, including the previously discussed SH 161 DNT-346 Section of the President George Bush Turnpike, were all built on top of deep layers of highly problematic clay soils. As of the date of this study of the International Roughness Index testing and pavement surface condition, this population of highway projects constructed on top of EMC SQUARED Stabilized subgrades had been in service for eighteen years.

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

*Summary of Projects in Dallas, Texas — Applied Research Associates, Inc., Report No. 003563-1, Harold L. Von Quintus, P.E.

The EMC SQUARED System (EMC2) — Advanced Stabilization Product Technology. Clean. Green. Concentrated power to improve the stability of earth materials at low cost. Applied as compaction water additives to aggregates, soils and recycled pavement materials with pre-established compaction controls and construction procedures, preconditioning aggregate materials to behave more like conglomerate rock, clays like claystone, sands like sandstone, and silts like siltstone, paralleling the natural processes of consolidation and lithification. These stabilizer products have been in use for over three decades for construction of city streets and expressways, county roads, interstate freeways, industrial and renewable energy sites, military supply routes and runways, remote unpaved highways, border roads, haul roads, forest roads, oilfield access roads, temporary and permanent closures of construction sites and landfills, and for other applications.

When cement and lime are utilized for soil stabilization treatment, they typically create rigid soil layers that give strength without necessarily reducing moisture flow through the layer. Cracking is an unavoidable side effect of cement and lime treatment. This reduces their overall effectiveness and often subjects pavements above to reflective cracking generated by the cracking in the cement and lime treated layer below. EMC SQUARED System treatments, on the other hand, typically create layers with improved flexural stiffness and retained elasticity. Equally important, the EMC SQUARED System stabilization treatments reduce the rate of moisture flow through the layer, shedding water off the surface and impeding the upward capillary flow of moisture from groundwater sources below. This ability to function in this manner as a moisture barrier is a revolutionary and fundamental advance in stabilization technology. The stabilized layer itself is not only stiffened, but it also impacts the stability of native soils below the constructed layers by promoting a more consistent and stable moisture distribution. As evidenced in the annual IRI testing of freeway projects, this ability of EMC SQUARED System treatments to beneficially influence stability at a deeper level is resulting in smoother running roads and highways with extended service life. This is the multiplier effect, the exponential power of the EMC SQUARED System (EMC^2) Stabilizer Technology. It promotes greater stability in soils below as well as within the stabilized layers.



The Convergence

With the development of more advanced laboratory test methods and the advancements of Mechanistic-Empirical Pavement Design, the economic and performance advantages of the EMC SQUARED System product technology can be demonstrated in laboratory evaluation, employed in pavement designs and field performance validated with nondestructive testing.

How to Use the EMC SQUARED System Stabilizer Products

Visit **https://stabilizationproducts.net**. Next, review the case histories and the materials laboratory and field testing reports and request a copy of the EMC SQUARED System Construction Handbook and General Information publication via **info@stabilizationproducts.net** or by calling 800.523.9992, or 209.383.3296. If you are then ready to take the second step, communicate by email or phone the project specific information that you have available and ask for a price quotation so that you can better understand the economic advantages over conventional stabilizer products, or the potential savings from replacing expensive crushed aggregate base course materials with an economical stabilized soil layer of equivalent stiffness (modulus). Request that you be supplied with a sample format of an EMC SQUARED® System Construction Specification for your specific project requirements. A more in-depth discussion with Stabilization Products LLC staff is also recommended to further review your expectations and the potential suitability of the stabilizer products for your unique project requirements. If the decision is made to move forward and order stabilizer product, then equip your in-house construction crew or contractor with the Construction Handbook and the Construction Specifications and ask that they review and prepare to apply the stabilizer product according to the Manufacturer's Recommendations and per construction specifications. Rigorous construction quality control measures are advised, starting with sampling the material to be stabilized and having the standard laboratory tests conducted such as Sieve Analysis, Atterberg Limits and Proctor compaction tests to determine the Moisture-Density Relations that will govern the construction and the compaction testing program during the stabilization operations.

If an additional engineering basis is desired before moving forward with construction, or engineering test data input is required in order to produce a pavement design defining the pavement structural section before the project can be advanced to the construction stage, then utilize in-house testing services, if available, or contract with a licensed materials testing laboratory that is equipped with the apparatus required to conduct the specific test methods that are recommended. EMC SQUARED System stabilizer products are best evaluated using the more sophisticated test methods that have been evolved during the modern age when testing apparatus are designed and operated by computer-assisted programs capable of modeling dynamic and repetitive loading similar to that which pavements experience under moving wheel loads. The recommended test methods are Resilient Modulus, Repeated Load Triaxial and Dynamic Modulus. These tests are appropriate for evaluating materials for flexible pavement designs and for applications of EMC SQUARED System products that produce base course and subgrade layers that are resilient and retain elastic behavior, in contrast to cement and lime treatments that produce rigid layers with unavoidable shrinkage cracking. Stabilization Products LLC will coordinate with your selected materials testing firm to supply stabilizer product and guidelines for laboratory testing, and to answer any questions they may have.

Use of the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG), which requires resilient modulus test results for input, is highly advised. First introduced by AASHTO in 2002, with support in its development provided by the Federal Highway Administration (FHWA), this computationally intensive computer-aided design method is far more sophisticated than the design systems that were based upon data from the AASHO Road Test, a field monitoring study conducted in the 1950's when AASHTO was still known as AASHO. Resilient modulus test data input furnishes a far more detailed understanding of the engineering parameters of the materials being considered during the M-E Design process for potential use in a pavement structural section. Stabilized base course, subbase and subgrade layers under the pavement surface course can provide a far more important contribution to the overall stiffness of pavement system when evaluated according to this advanced design methodology. The net effect is that the costly asphalt or concrete surface course pavements can be reduced in section thickness as the result of increasing the modulus of the base, subbase and subgrade layers with economical stabilization treatments. The other cost-saving options that can be reviewed by the design engineer are the complete replacement of aggregate base course materials with stabilized soils of equal or higher modulus, reduction in the layer thickness of the aggregate section by increasing its modulus with stabilization treatment, or recycling asphalt millings and base course materials as a high modulus stabilized base layer during highway reconstruction projects.

A field test pad or road test section may be other options to further confirm the suitability of the stabilizer products for a project specific application. Once again, the Manufacturer's Recommendations in the Construction Handbook should be observed and a designated project Construction Specification followed in order to obtain the full performance benefits of the stabilizer treatment. For test section or full scale construction projects, field testing the stabilized layers postconstruction with Falling Weight Deflectometer equipment should also be considered to validate that the performance of the constructed layers meets or exceeds the modulus values from the laboratory resilient modulus tests that were used as the input for the M-E Pavement Design. The construction cost savings realized from using the EMC SQUARED System stabilizer products in combination with the M-E Pavement Design method typically cover the cost of the preconstruction laboratory testing and postconstruction field testing many times over and lend confidence and confirmation that the pavement structural section design had a solid engineering basis.