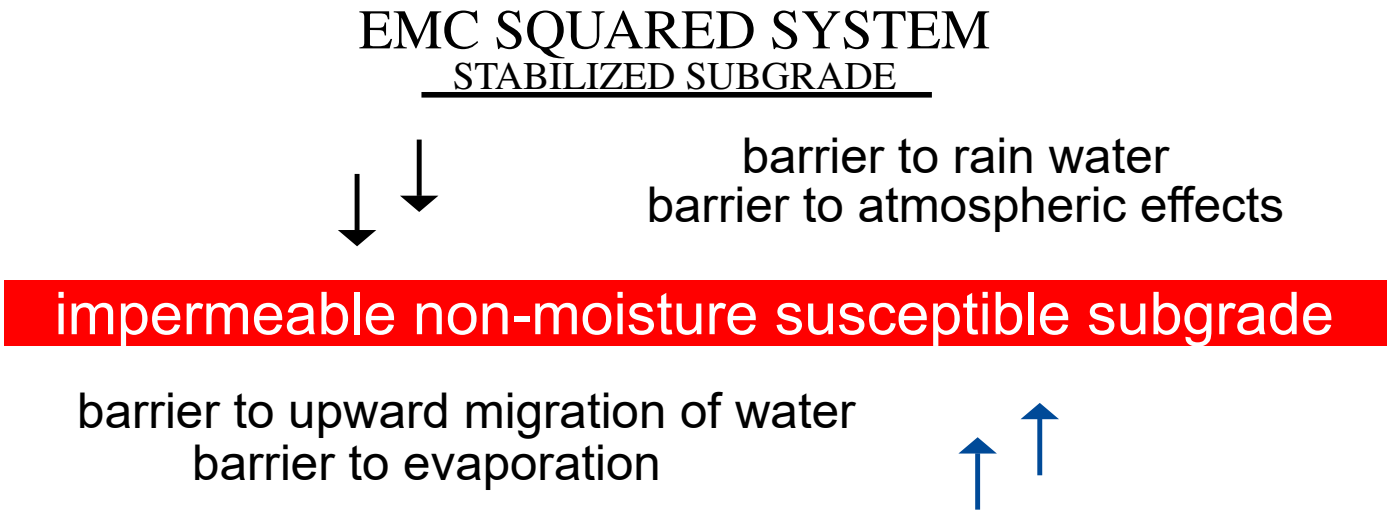
Interstate Highway Projects Connect New Mexico With Texas In More Ways Than One

Highway Subgrades Constructed with Advanced Stabilizer Products Demonstrate Exceptional Smoothness (Ride Quality) and Extended Service Life

Abstract

The good pavement condition and smooth-running performance of segments of Interstate highway pavements in New Mexico and Texas constructed on top of worst case soils and ground conditions have something important in common. They were built above subgrade soils treated with a family of advanced stabilizer products known as the EMC SQUARED System.

Following is a presentation of test results from studies that were conducted by University-sponsored materials testing facilities dedicated to the evaluation of pavement, base and subgrade soil materials used for road and highway construction and products that increase (or enhance) the performance of those materials. This presentation specifically addresses material testing studies focused on the **EMC SQUARED**® System stabilizer products manufactured by Stabilization Products LLC (SPLLC) and their application for improving the engineering performance of soil and flexible base materials and their ability to function as moisture barrier layers within pavement systems.



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Subgrade Stabilization – Laboratory and Field Testing Conducted in Texas

Treatment of Subgrade Soils

The most relevant state-of-the-art information available regarding treatment of subgrade soils was developed from research studies conducted in the McNew Lab of the Texas Transportation Institute (TTI), associated with The Texas A&M University System based in College Station, Texas. The study was conducted under the direction of Dr. Robert Lytton, an internationally recognized expert on expansive clay soils.

The title of the research study was **Highway Planning and Operation for District 18, Phase 3**, and identified as Research Study Number 7-3929. The study including sampling soils from the locations of two future TxDOT construction projects in the Dallas District that would be traversing areas with deep deposits of expansive clay soils known to be highly problematic, specifically a section SH 161 that was scheduled to be upgraded and become a section of the new President George Bush Turnpike (PGBT) and a section of Interstate 635 (I-635) where new frontage roads were to be constructed.

The graphs and charts illustrated on the following pages present test results from the 7-3929 Research Study that was conducted at the initiative of the TxDOT Dallas District. In the interest of convenience for the reviewer, the test results specific to the **EMC SQUARED** System stabilizer products are presented in the case of each test method as an average of the results of the tests conducted with the soils sampled from the SH 161 and I-635 project locations. The test results are presented in the order the researcher recommended as the method for establishing suitability of a particular stabilizer product as the most appropriate subgrade soil treatment for a project specific application. To qualify for further evaluation, a treated soil sample would first be required to pass the Electrical Conductivity and Dielectric Constant tests (See Pages 4 and 5). Passing these qualifying tests, treated soil samples are then subjected to a curing period before conducting Triaxial Testing to evaluate their strength and stiffness (See Pages 6 and 7) and Permeability Testing if time allows (See Page 8). If project timelines allow for several months or more to conduct permeability and accompanying swell tests, then these tests are additionally recommended. In the case of this research study, the permeability and swell tests required four months to run to completion.

What is especially meaningful is that the data from this research study was accompanied by construction of a field test, as recommended in the study's final report, and the construction of full scale projects that were monitored by the District and then included in a 2017 study conducted by Harold Von Quintus, P.E., from the Austin Area Office of Applied Research Associates (ARA). Full report may be found here: **https://stabilizationproducts.net/docs/18779.pdf**. Harold was assisted in this study by Bob Boykin, P.E., TxDOT Field Engineer for the Dallas District. Bob Boykin was involved from the beginning of the research study at TTI and played a major role in observing the construction of the highway projects that followed and their monitoring through 2017. ARA had the contracts with TXDOT and NTTA in 2017 to evaluate the annual test results in correlation to International Roughness Index (IRI) data. Harold Von Quintus was given approval by TxDOT and NTTA to review and comment on the IRI test results and conduct a pavement condition survey of the six highway projects that had been constructed in the Dallas District seventeen years earlier on subgrades treated with the **EMC SQUARED** System stabilizer products.

Given the fact that the study was focused on identifying a stabilizer product technology for subgrade treatment that would provide a more effective answer than was currently available for reducing roughness of highway pavements constructed above deposits of expansive clay soils, the stated goal was to find a stabilizer treatment with a unique package of benefits: 1) provide a stiffened working platform that would support construction equipment operations and remain water resistant during wet weather conditions, and 2) reduce permeability and soil suction sufficiently so that the treated subgrade layer would not suction water from below or allow penetration of surface water from above into the native subgrade underneath the pavement structural section. This moisture barrier would reduce the amount of moisture fluctuation and movement in the soils below the treated subgrade that generate roughness in the pavement running surface.

The 7-3929 program conducted an extensive laboratory testing series in the McNew Lab and identified the **EMC SQUARED**® System stabilizer products as meeting the performance goals defined by the study. The final report recommended the use of these products for the treatment of the subgrade soils for both the SH 161 and I-635 construction projects. The research study further recommended that the Dallas District conduct a field test of the stabilizer products to evaluate their performance in service as a working platform, which the District accomplished by monitoring the performance a stabilized working platform constructed to support a portable concrete batch plant operation. Based upon the recommendations of the TTI study and on a positive evaluation of the field test, six full scale highway construction projects were approved by the District and constructed on subgrades treated with the **EMC SQUARED** System stabilizer products according to a set of TxDOT Special Specifications prepared by the Dallas District: **https://stabilizationproducts.net/docs/18850.pdf**. *See page 9 for the installing contractor's evaluation of three of the highway projects.*

The formal report of the 7-3929 Study addressed the fact that the permanence of the benefits provided by the application of these stabilizer products would be determined by monitoring the performance of these pavement projects over time. The 2017 study conducted by ARA rated the Pavement Surface Condition of both the SH 161 and I-635 Projects as Excellent after 17 years in service over deep deposits of expansive clay soils, and categorized the IRI measurements as GOOD.

The population of highway pavements built upon subgrades treated with EMC SQUARED System stabilizers have clearly demonstrated the permanence of the benefits they provide. In the adjacent State of New Mexico, a segment of Interstate 40 was constructed with both base course materials and subgrade soils treated with EMC SQUARED System stabilizer products as part of a Federal Highway Administration (FHWA) Demonstration Project. This Demonstration Project included reconstruction of a segment of interstate constructed with Hot Mix Asphalt (HMA) pavement placed on a Cement Treated Base (CTB) layer that required full-depth reconstruction within three years. The same segment reconstructed with asphalt pavement placed on base course materials and subgrade soils stabilized with EMC SQUARED System stabilizer products are smooth running and free of repairs for 23 years and still counting. Once again, the EMC SQUARED stabilized treatments have excelled in the performance category known as PERMANENCE.

ELECTRICAL CONDUCTIVITY*

Clay Soil + **EMC SQUARED** System Stabilizer Treatment

E.C. (mS/cm)	E.C. + Water(mS/cm)
53.75	34.50

In regard to the suitability of stabilized soils for subgrade construction, this study set the upper limit for Electrical Conductivity at 100 milliSiemens per centimeter. As documented above, the soils stabilized with the **EMC SQUARED** System treatment easily passed this test requirement, and then tested even more impressively four months after being continually subjected to moisture conditioning treatment.

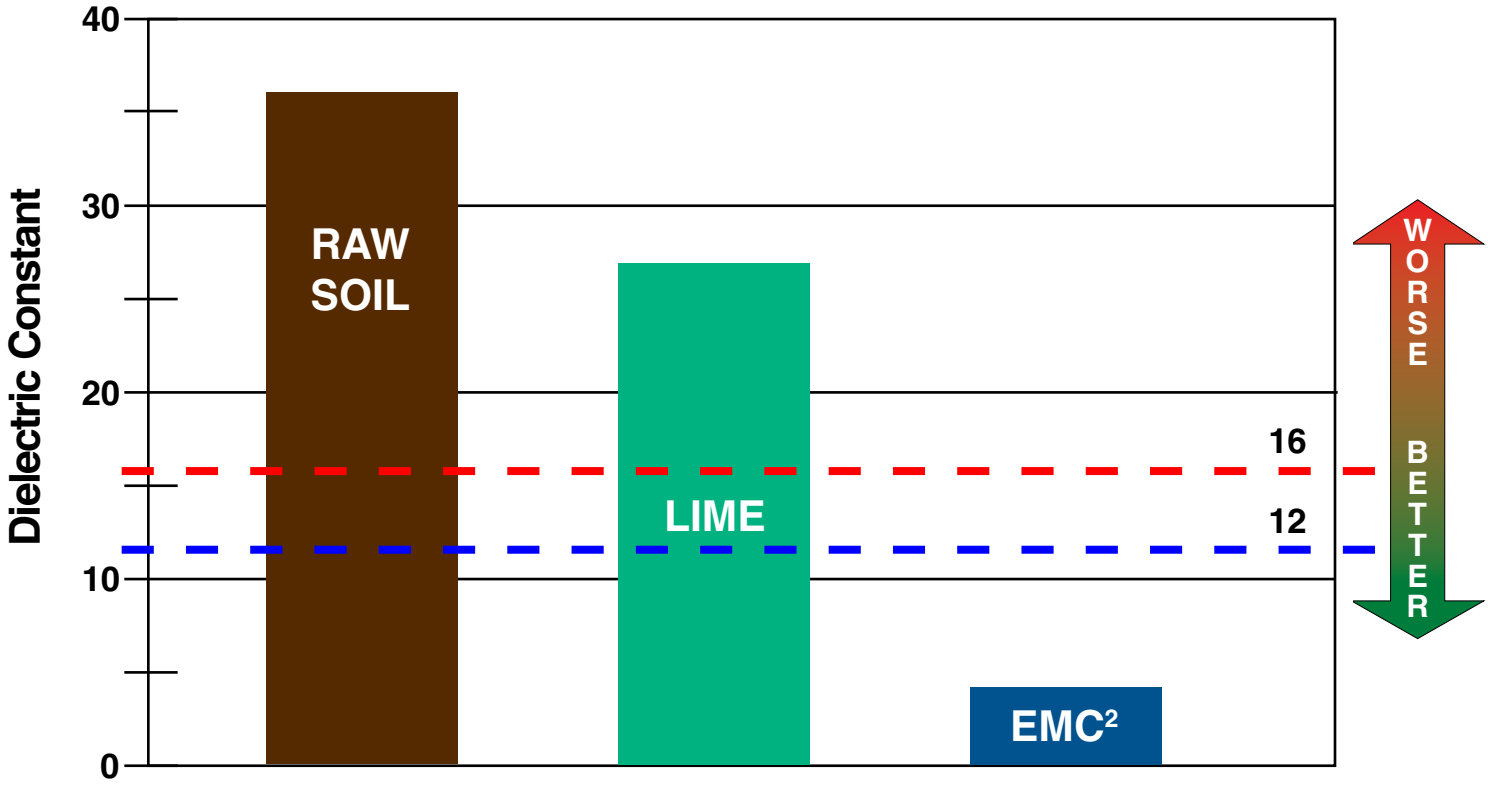
* Average of test results with soils sampled from Interstate 635 and State Highway 161 Projects

Dielectric Constant*

The 7-3929 study measured the Dielectric Constant of two **EMC SQUARED** stabilized soil materials, setting the upper limit as a Dielectric Value of 12, just below the Dielectric Value of 16, which is the point at which plastic deformation of the pavement is predicted as the result of the physical property changes in the soil driven by moisture infiltration and fluctuations in moisture content. Dielectric constants below 11 indicate that the treated soil can adequately resist plastic deformation and can maintain sufficient water tightness. This study also evaluated the untreated or "raw" soil, as well as the same soil treated with lime chemical. As indicated below, the soils treated with the **EMC SQUARED** System application were highly resistant to moisture infiltration, while the raw soil and the lime treated soils were highly moisture susceptible and unacceptable for subgrade construction.

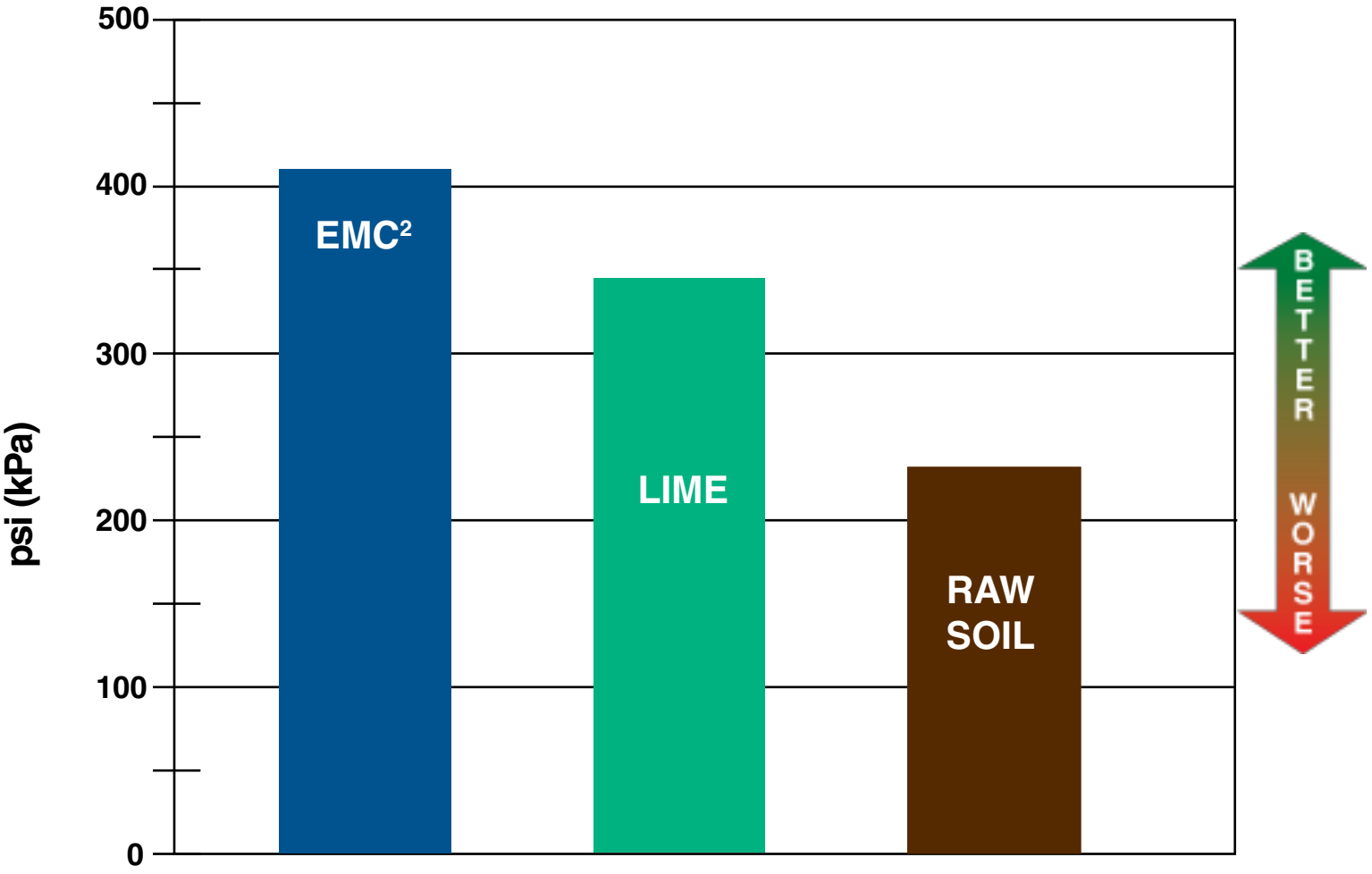
DIELECTRIC CONSTANT

Clay Soil + EMC SQUARED System Stabilizer Treatment



* Average of test results with soils sampled from Interstate 635 and State Highway 161 Projects

TRIAXIAL TEST — STRENGTH*



*Average of test results with soils sampled from Interstate 635 and State Highway 161 Projects

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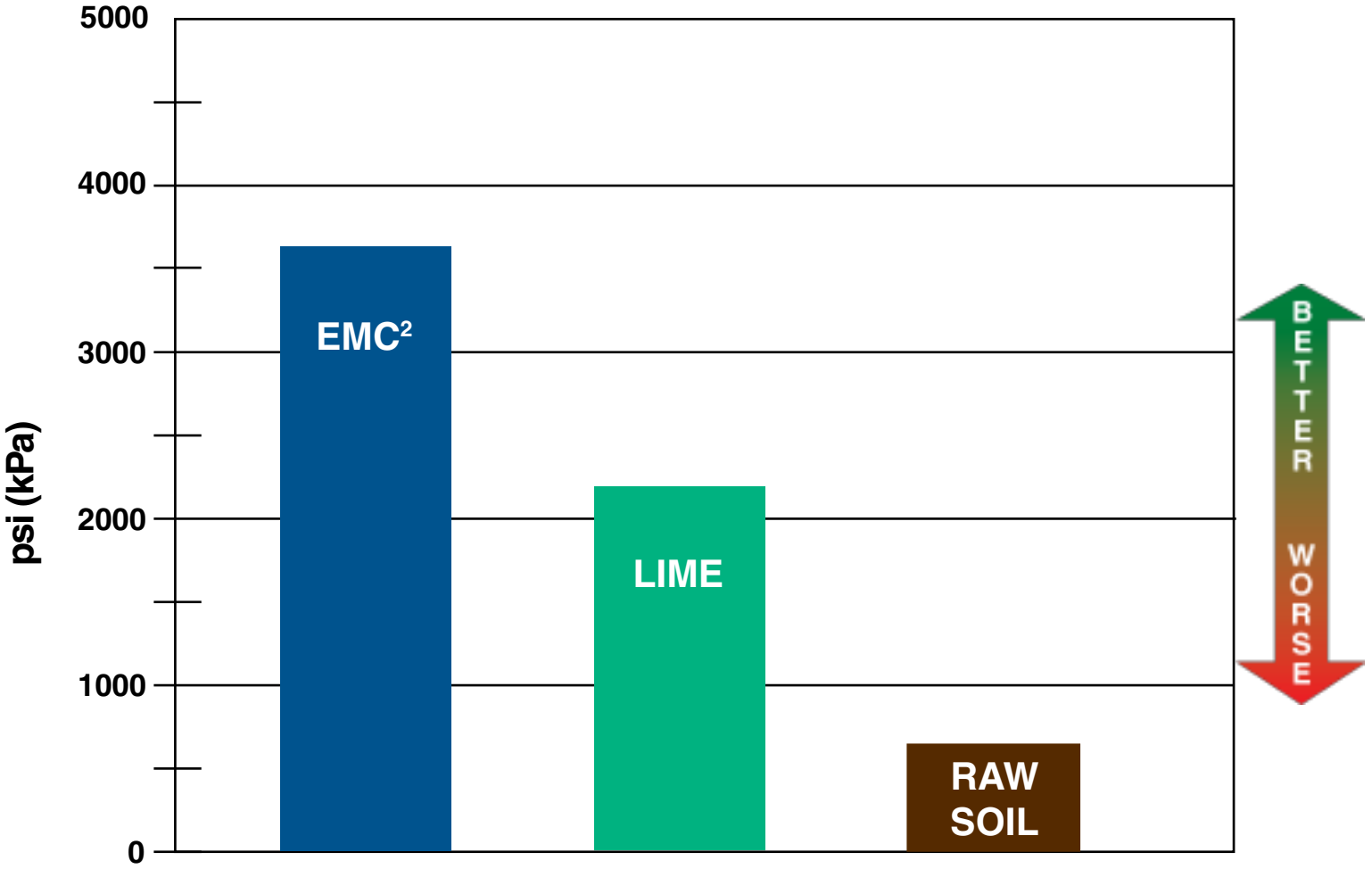
TRIAXIAL TEST — STIFFNESS*



*Average of test results with soils sampled from Interstate 635 and State Highway 161 Projects

Permeability*

A Measure of How Fast Water Passes Through a Soil

EMC SQUARED treated soil	7.785×10^{-10} cm/s
Raw Soil	3.00×10^{-9} cm/s
Lime treated soil	3.515×10^{-9} cm/s

Note: Based upon these permeability test results, the **EMC SQUARED** treated soils were greater than five times more resistant to water penetration than untreated Raw Soil, and approximately six times more resistant than the same soil with Lime treatment applied. Swell tests were conducted in conjunction with the permeability tests over a period of four months. The final report concluded, "**EMC SQUARED** treated samples show superior swell resisting properties."

*Testing Result Average of IH 635 and SH 161 Soils, Both Treated and Untreated

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From: "Ortiz, Abel" <Abel.Ortiz@Zachrycorp.com>
To: Bob Randolph
Date: 12/16/2013 5:48 AM
Subject: Zachry's experience with EMC2

Dear Bob,

As you are aware, in 2009, I was tasked by our Joint Venture (NorthGate Constructors, a Kiewit-Zachry Joint Venture) to evaluate alternative soil stabilization products for the DFW Connector Project. Our goal was to reduce the risk of sulfate-induced heave while also reducing construction costs. Sulfate-induced heave was a concern for us because we were constructing the project in an area known to have sulfate problems. As part of my due diligence, I looked in to several products among them EMC2. EMC2 appealed to us because TxDOT constructed a number of test projects in the Dallas District and after visiting all of those projects it was easy to realize the pavement placed over EMC2 was performing better than the pavement over other subgrade treatment options.

At that time, I felt more at ease with the possibility of utilizing EMC2 because my company (Zachry Construction Corporation) had constructed 3 of these Dallas District projects: a section of Luna Road, a section of the I-30 Tom Landry Freeway and section of the I-635 frontage roads.

In the end, TxDOT's reluctance to utilize alternative products kept us from further pursuing these alternatives. As a result, the DFW Connector project removed and replaced over 200,000 cy of soil that was potentially high in sulfates.

Although many of the managers involved in the construction of the EMC2 projects are no longer employed by Zachry, I was able to speak with several managers that where either involved or had firsthand knowledge of these projects, among them, Mr. Mark Brown P.E. who is Zachry's Quality Manger, Mr. Duane Herbort who is Zachry's Project Controls Director, Mr. Gary Doty, V.P., who was the Project Manager for the Dallas High Five Project, Mr. JD White and Mr. Bob Hoffer, two of our dirt superintendents responsible for treating the soils. The consensus at Zachry is that when we applied EMC2 at our projects in Dallas, we found that it provided a stable working platform at a reduced cost over conventional stabilization methods and without any significant application challenges. Visiting the projects several years later confirmed to me that the pavements placed over EMC2 are performing better than the pavements placed over conventional stabilization products.

As a contractor with experience working in the DFW area, Zachry Construction welcomes further evaluation of products that can provide a stable working platform at a reduced cost, and in some markets we are very interested in products that can eliminate the risk of sulfate-induced heave. If I can be of any assistance please feel free to contact me at 281-830-3114.

Best regards,

Abel Ortiz
Project Manager

Mr. Ortiz has since left Zachry Construction Corporation for other positions in the heavy highway construction industry

TREATMENT OF BASE MATERIALS

The **EMC SQUARED** Stabilizer (1000) product was approved for use by the TxDOT Dallas District for several projects as an alternative to lime treatment for Type C Modification applications, applied to the layer below the treated subgrade layer where the previously discussed **EMC SQUARED** System Dual Component Treatment products, **EMC SQUARED 2000** and **EMS** Earth Materials Sealant, were applied. The District prepared a Special Specification at that time for use of the **EMC SQUARED** Stabilizer (1000) for Type C Mod requirements within the District. The **EMC SQUARED** Stabilizer (1000) product is also widely used for treatment of aggregate and flexible base materials for both surface course and base course layers. The 1000 product is most effective when applied to flexible base materials that have Plasticity Index (PI) test results of PI 6, or higher, and #200 fines content of six percent (6%) or greater. Test results that follow document the effectiveness of the product for treatment of aggregate moisture susceptibility problems and for increasing the modulus and stiffness of aggregate materials meeting the PI and gradation requirements listed above.

Testing of 3 Moisture Susceptible Crushed Aggregate Materials and One Pit Run Material

Texas Transportation Institute (TTI)

As provided in greater detail in **Texas Transportation Institute Paper No. 00-1147 (LINK)**, a study was conducted in the materials testing laboratory at TTI evaluating three crushed aggregate and one pit run gravel material. All four of these materials were evaluated in Tube Suction Testing and found to be highly moisture susceptible in their untreated state, in spite of the fact that they were all found to be acceptable according to TxDOT specification requirements. The Tube Suction Test (TST) measures the rate of capillary rise by measuring the dielectric constant at the surface of a sample to evaluate the amount of unbound water contained within samples of untreated and stabilized aggregate materials after a period of moisture conditioning. As documented in the TTI Paper, the **EMC SQUARED** Stabilizer (1000) treatment was fully effective in treating the three crushed aggregate materials. As the test results for the pit run gravel illustrate in the fourth graph that follows, the material was subject to almost immediate saturation with water in an untreated state, but demonstrated major improvement after application of the **EMC SQUARED** treatment, allowing it to resist saturation for 100 hours of moisture conditioning, but not the full ten day monitoring period established by the researchers as their goal for effective stabilizer treatment. Interesting to note, the pit run gravel from Texas and the crushed aggregate from New Mexico were by far the most moisture and frost susceptible in their untreated state. Both became highly saturated during the course of laboratory testing, indicating that they would be prone to dramatic loss of stiffness during field service and further damage during freeze-thaw cycles.

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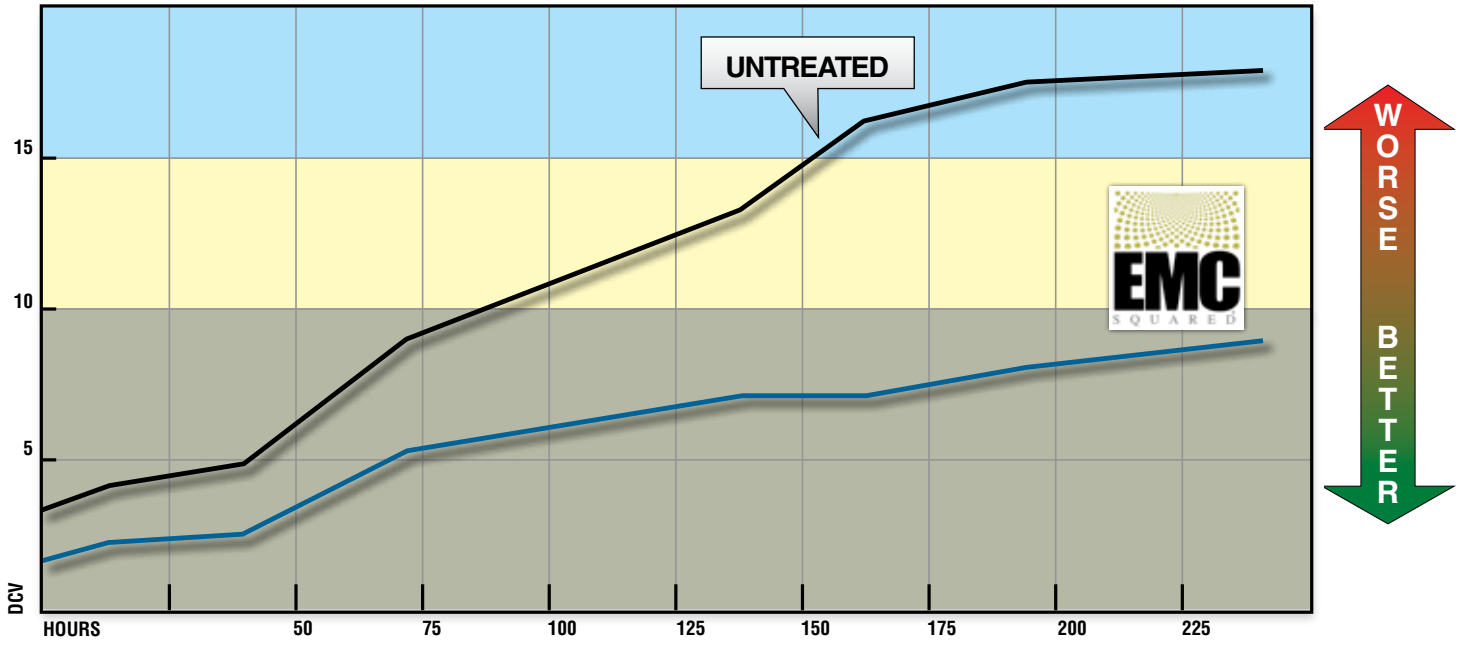
Suction and Dielectric Testing (Tube Suction Testing)*

#1 — Alaska Crushed Aggregate



A Dielectric Value of greater than 15
indicates that the aggregate is wet or water saturated and extremely moisture and frost susceptible

A Dielectric Value of 10 to 15
indicates that a significant amount of free water has accumulated within the aggregate during the testing period and is a warning signal that the material is moisture sensitive and frost susceptible

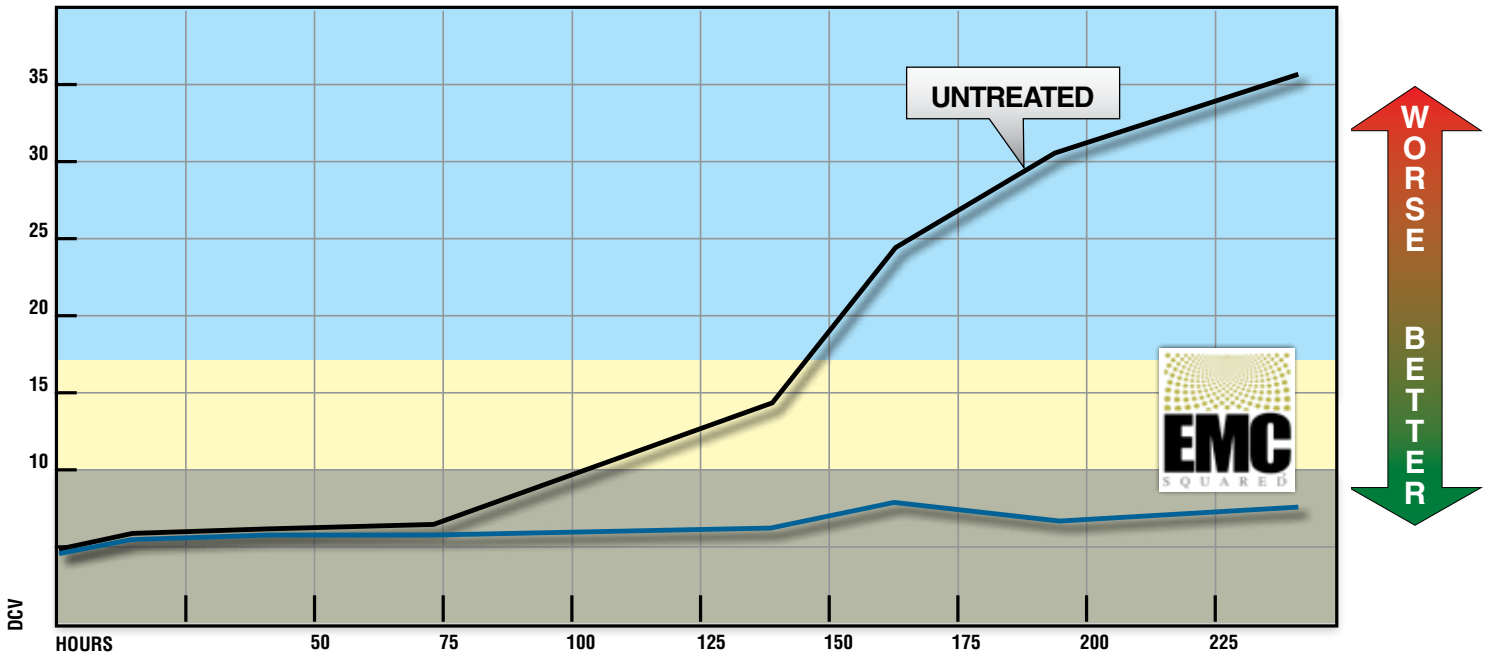
Aggregate materials with a Dielectric Value of less than 10
are considered non-moisture sensitive and non-frost susceptible in service for road and highway base applications

*Texas Transportation Instutue Paper No. 00-1147 and Syed and T. Scullion, Texas Transportation Institute, Texas A&M University, College Station, TX 77843-3135. R.B. Randolph, Soil Stabilization Products Company, Inc., Merced, CA 95344. Tube Suction Test for Evlauating Aggregate Base Materials in Frost and Moisture Susceptible Environments" Transportation Research Record 1709, January 2000, 78-90

Interstate Highway Projects Connect New Mexico With Texas In More Ways Than One

Suction and Dielectric Testing (Tube Suction Testing)*

#2 — New Mexico (NMDOT District 6) Crushed Aggregate



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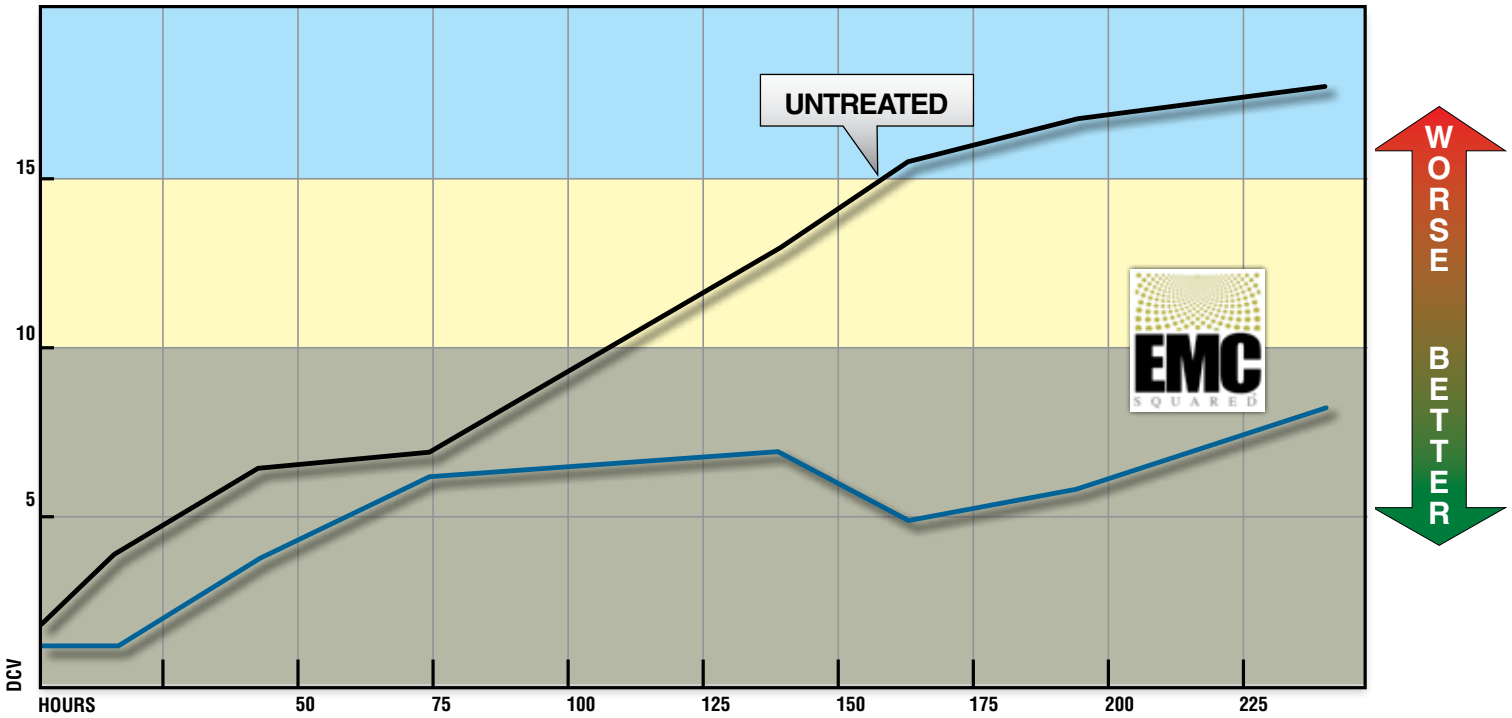
Suction and Dielectric Testing (Tube Suction Testing)*

#3 — Nevada Crushed Aggregate



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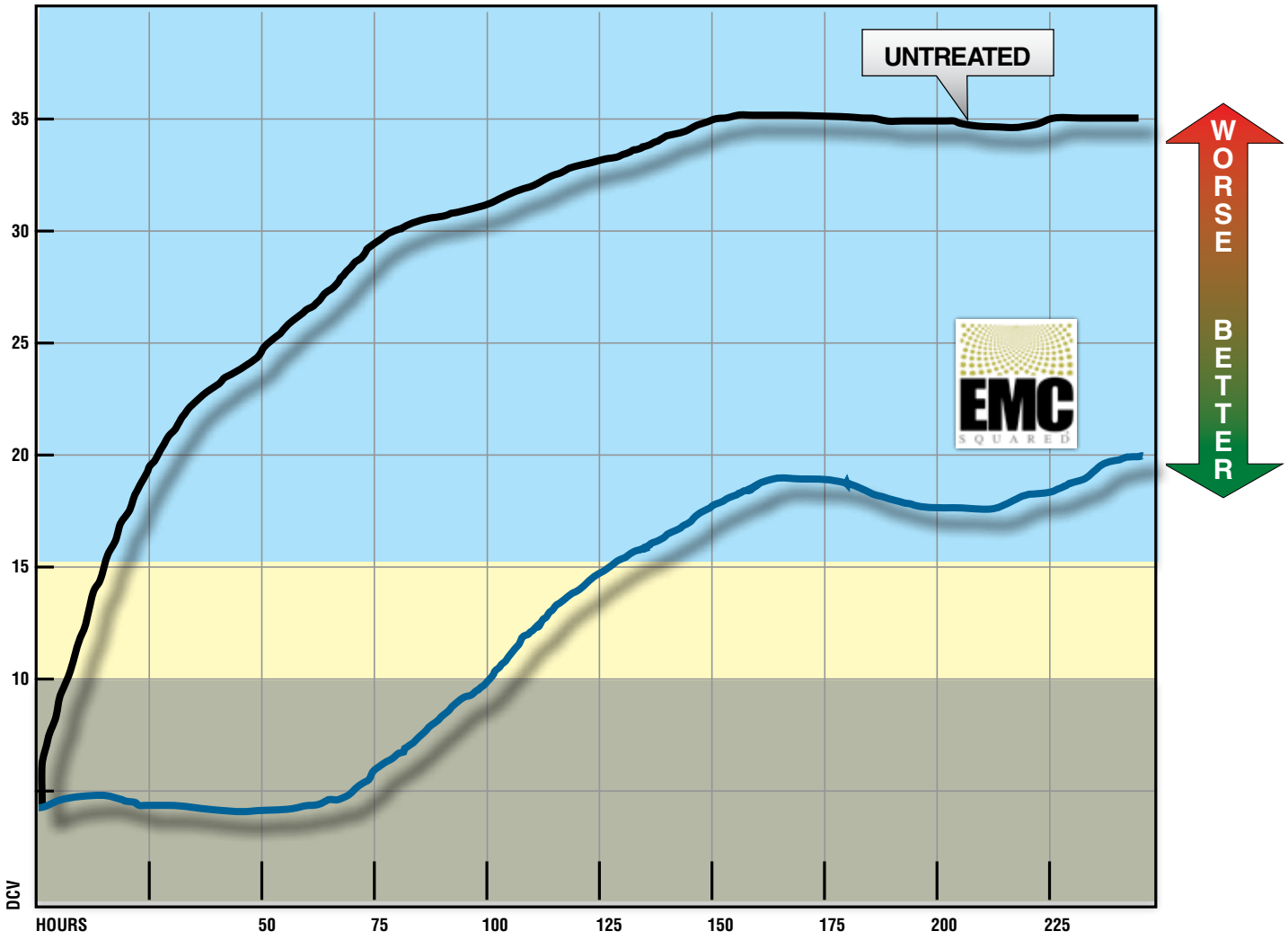
Suction and Dielectric Testing (Tube Suction Testing)*

#4 — Texas Pit Run Gravel with 1.5% Lime previously added*



*Texas Transportation Instutue Paper No. 00-1147 and Syed and T. Scullion, Texas Transportation Institute, Texas A&M University, College Station, TX 77843-3135. R.B. Randolph, Soil Stabilization Products Company, Inc., Merced, CA 95344. Tube Suction Test for Evlauating Aggregate Base Materials in Frost and Moisture Susceptible Environments" Transportation Research Record 1709, January 2000, 78-90

Testing of EMC SQUARED Stabilized Base Material in Dynamic Modulus and Repeated Load Triaxial Testing

EMC SQUARED Stabilized Aggregate materials have demonstrated impressive performance as running surfaces for roads servicing heavy truck and military tactical equipment traffic. They have proven equally extraordinary for over 116 miles of stabilized Main Supply Route (MSR) roads that overlays the state line between New Mexico and Texas on the Training Range of Fort Bliss Army Base. While **EMC SQUARED** Stabilized Aggregate materials from other project locations have previously been evaluated by resilient modulus testing, the opportunity was of interest to more directly compare the behavior of these stabilized aggregate surface course mixtures with the known behavior of typical Hot Mix Asphalt (HMA) mixtures using the Dynamic Modulus and Repeated Load Triaxial test apparatus available at the Western Regional Superpave Center. See: **https://stabilizationproducts.net/docs/18828.pdf**. Accommodating the viscoelastic nature of HMA mixtures required use of a test method that could subject both materials to a full range of temperature conditions ranging from hot weather to below freezing temperatures. As addressed in the final report, the **EMC SQUARED** Stabilized Aggregate provided good modulus values while retaining elastic behavior and demonstrating excellent resistance to any risk of permanent deformation under severe service conditions.

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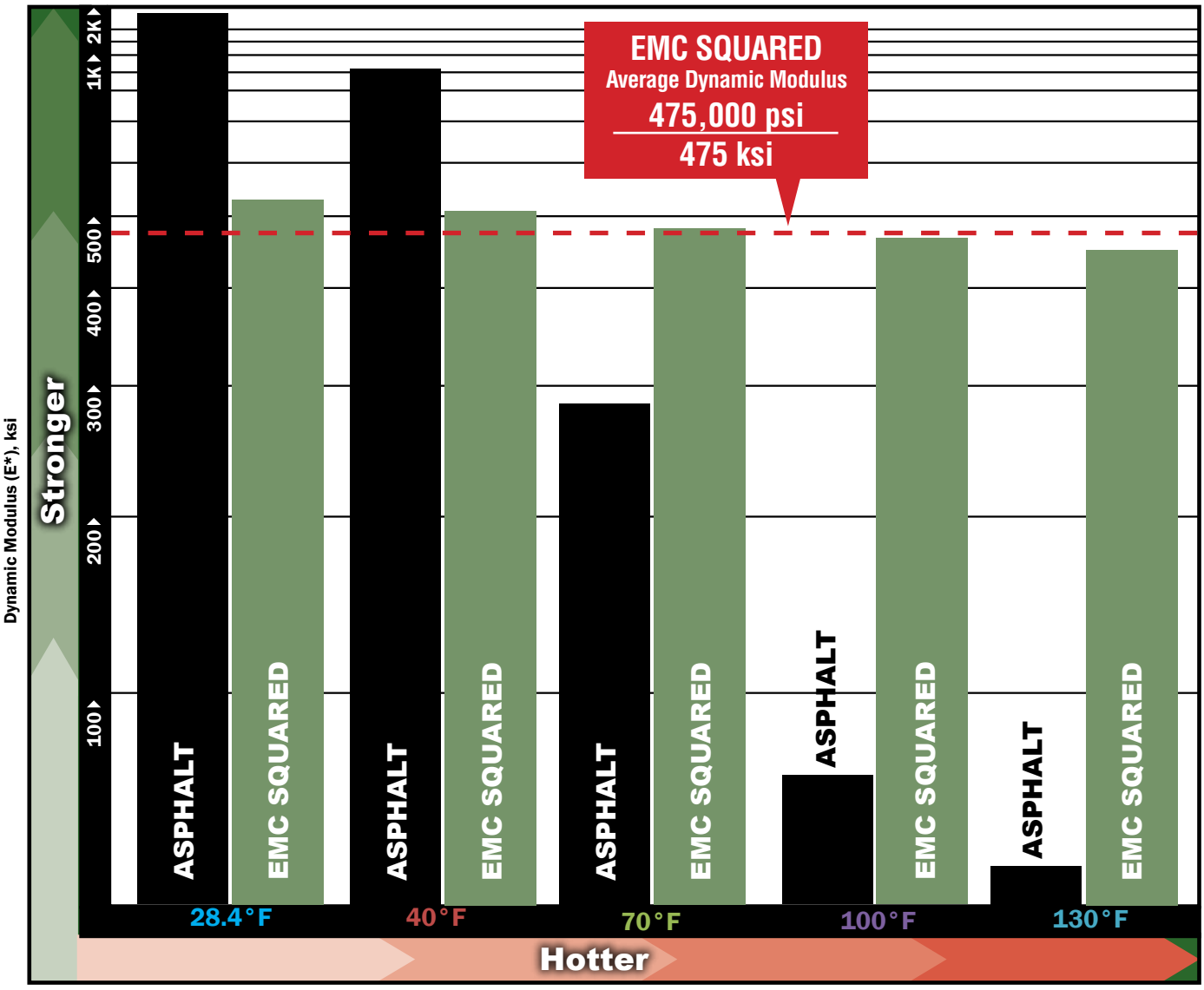
Dynamic modulus is the main input required for design of Hot Mix Asphalt (HMA) pavements using the nationally recognized AASHTO Mechanistic-Emperical Pavement Design Guide (MEPDG). HMA pavement materials are viscoelastic in nature and their dynamic modulus values vary dramatically in response to changes in loading rate and temperature. For example, HMA materials exhibit much lower modulus values (significant strength loss) as pavement temperatures increase. In contrast, dynamic modulus testing shows that **EMC SQUARED** Stabilized Aggregate materials retain a relatively consistent dynamic modulus (consistent strength) through the full range of loading rates and temperature changes, indicating elastic rather than viscoelastic behavior. Cold-mixed **EMC SQUARED** Stabilized Aggregate materials have the further advantage of gaining strength with additional curing time. For the sake of perspective, the modulus value typically assumed for untreated Aggregate Base Course (ABC) materials is 30,000 psi.



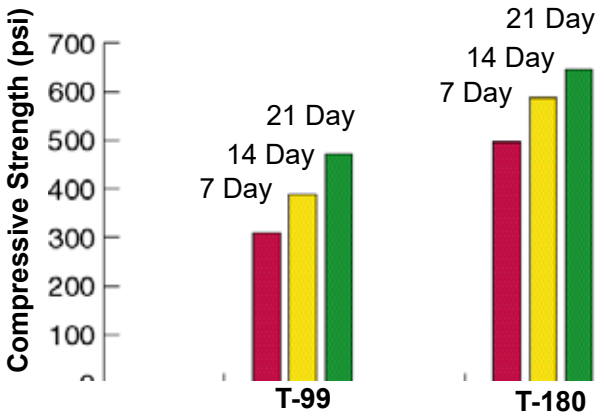
The above chart references data from a report by Peter Sebaaly, Ph.D., P.E. University of Nevada, Reno, Director of the Western Regional Superpave Center, after 7 days of curing time

Unconfined Compressive Strength (UCS) and Resistance Value (R-Value)

Unconfined Compressive Strength (UCS) tests have been used as a standard for evaluating various different materials used in road construction for over a century. They are quick and inexpensive to conduct, but produce only a limited amount of information. The Resistance Value (R-value) test method was invented approximately 80 years ago by two employees of the agency known at that time as the California Division of Highways. With the availability of modern computers for processing large data sets, more sophisticated test methods are advised that can apply thousands of repetitive loading cycles to stabilized base course materials and base course mixtures in order to more realistically model and predict their performance in the service environment, conditions that demand resiliency to endure decades of dynamic loading by heavy truck traffic. Permanency of base reinforcement, and subgrade stabilization measures, ultimately must be determined by monitoring pavement condition and pavement smoothness over the full number of years they were designed to be of service. When it comes to the suitability of a particular stabilized base course mixture for projects currently in design stage, the following modern laboratory test methods are recommended for determining resiliency and stiffness under repeated dynamic loading: Dynamic Modulus, Resilient Modulus and Repeated Load Triaxial. The results of the UCS and R-value testing conducted in conjunction with the construction of the FHWA Demonstration Project on Interstate 40 (MP 93 – MP 97)are nevertheless relevant and informative for reviewers interested in familiarizing themselves with this newer generation product technology that has shown such exceptional performance in prolonging pavement service life.

Compressive Strength Tests
EMC SQUARED System
by NMDOT Materials Bureau

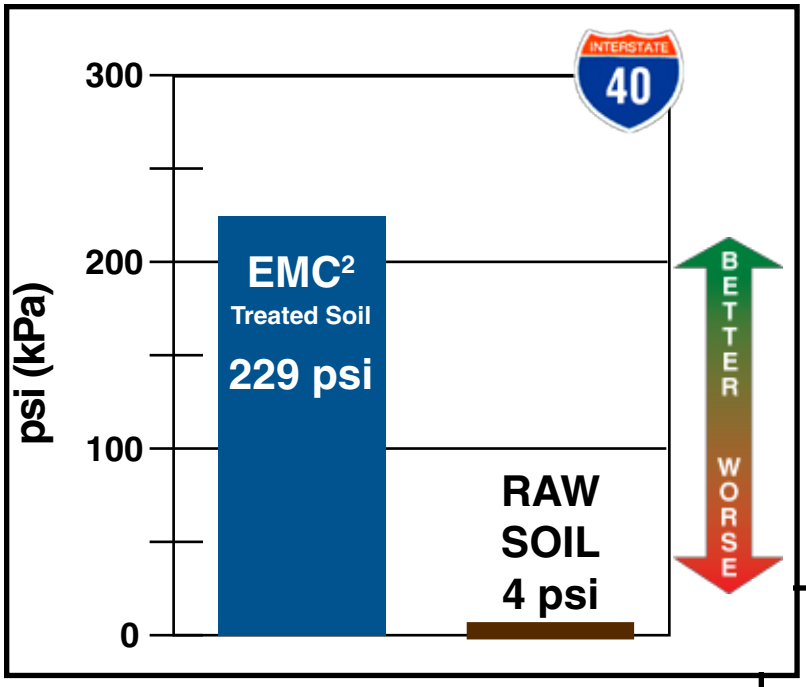
	T-99*	T-180**
7 Day	310 psi	496 psi
14 Day	388 psi	589 psi
21 Day	472 psi	646 psi

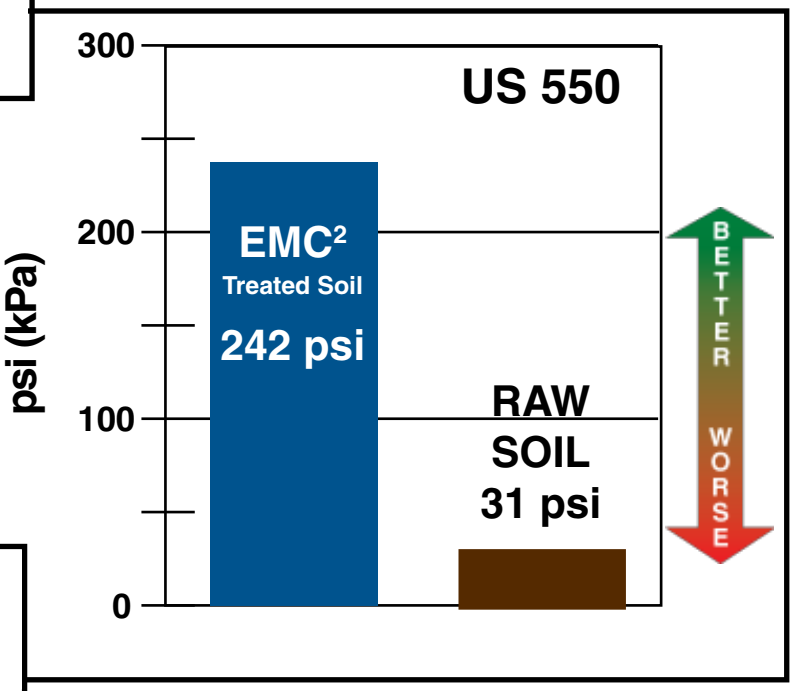


Date: 13-Jul-00 Project Number: IM-040-2(56)93

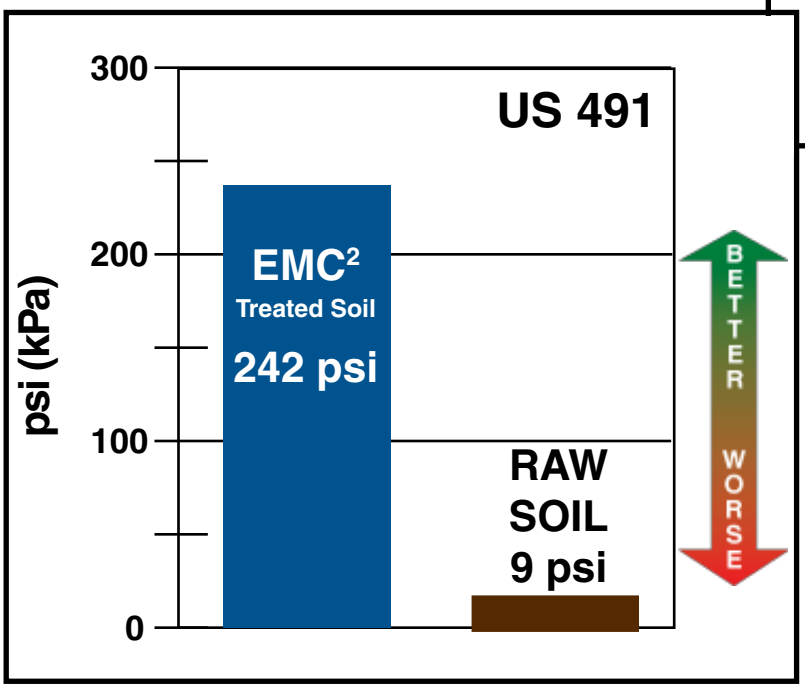
*** T-99 (ASTM D698)**
****T-180 (ASTM D1557)**

Unconfined Compressive Strength (UCS) Test Results

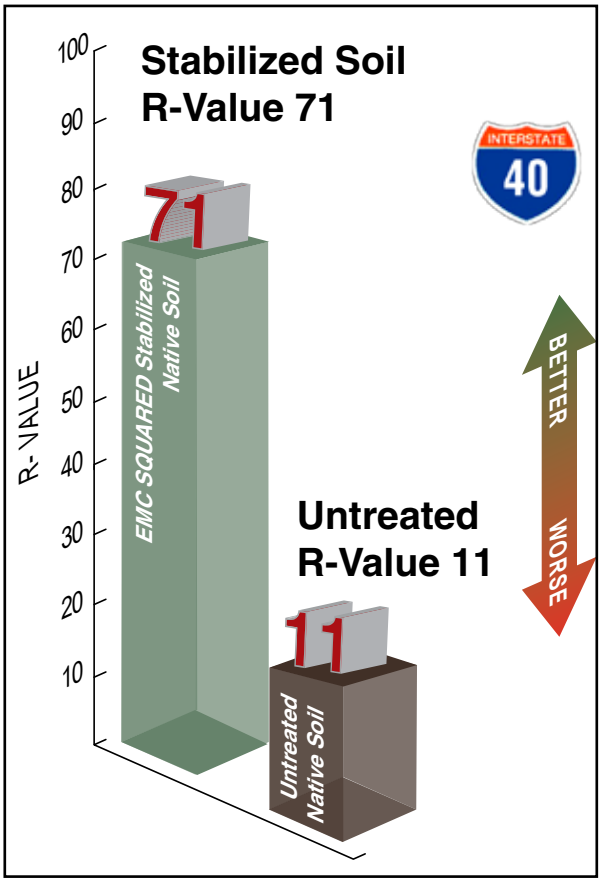


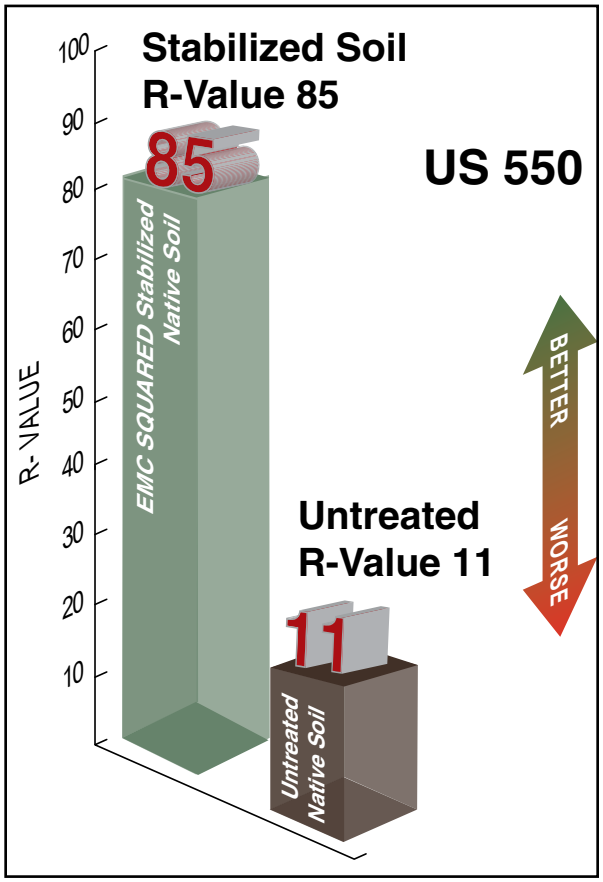


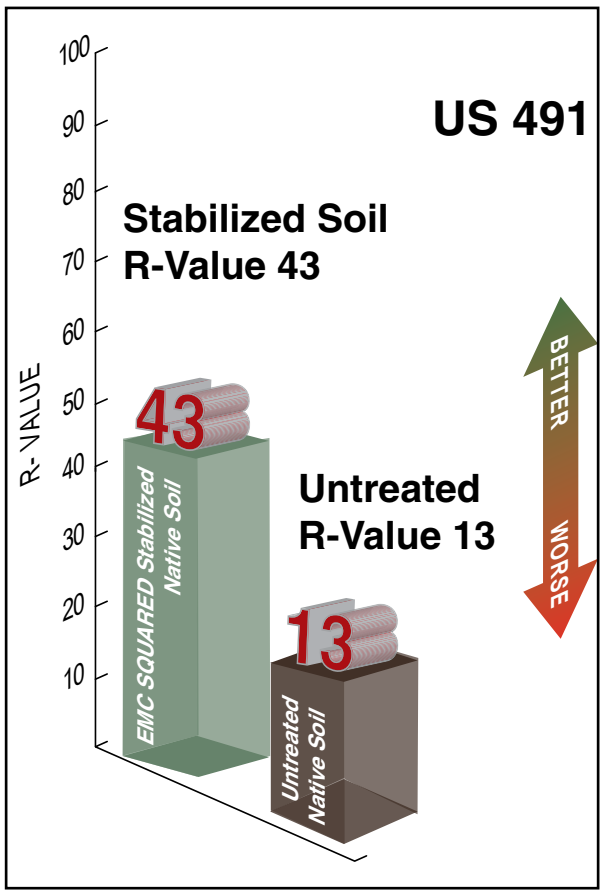
Laboratory testing and analysis conducted by the Albuquerque office of AMEC Earth & Environmental (now Wood Group)



Resistance Value (R-value) Test Results







Laboratory testing and analysis conducted by the Albuquerque office of AMEC Earth & Environmental (now Wood Group)

Click Here for Full Project Report