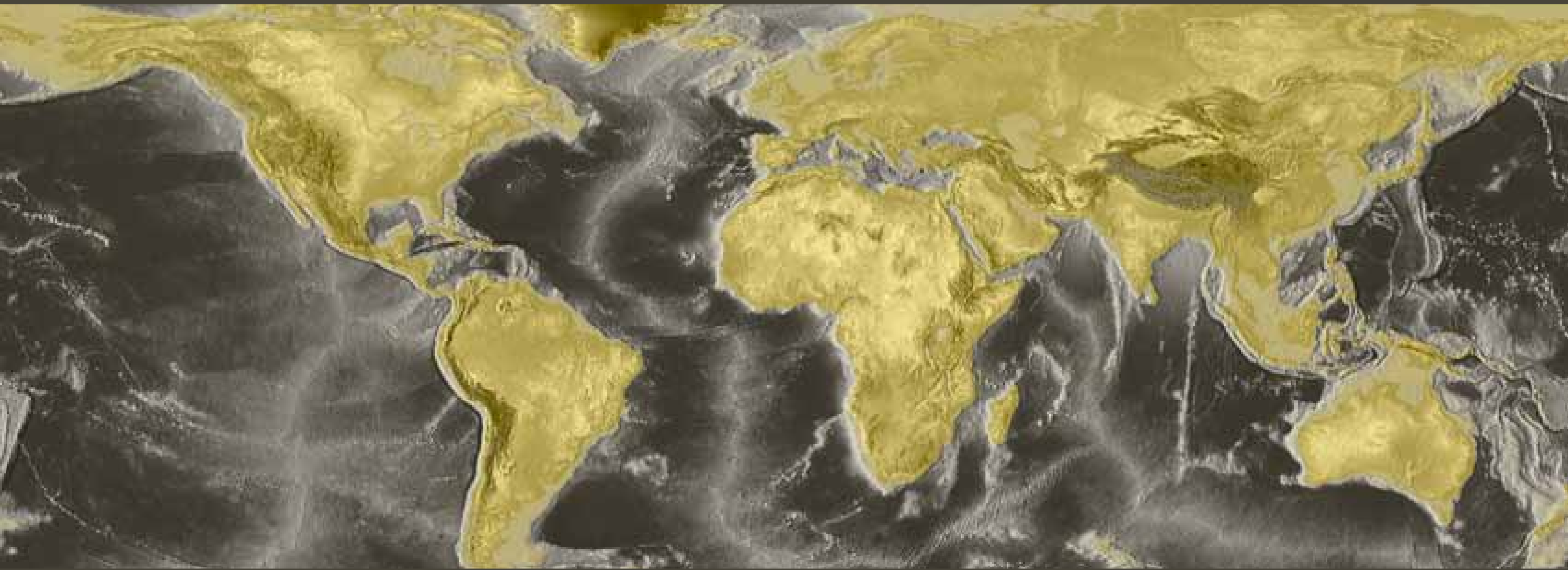
EMC® SQUARED

Advanced Stabilization Technology

OVERVIEW



Build Better Roads
Lower Construction Costs
Reduce Environmental Impacts

Master-Planned Community Soil Stabilization Case Study, see page 15.

EMC SQUARED

EMC SQUARED® System
Advanced Stabilization Technology

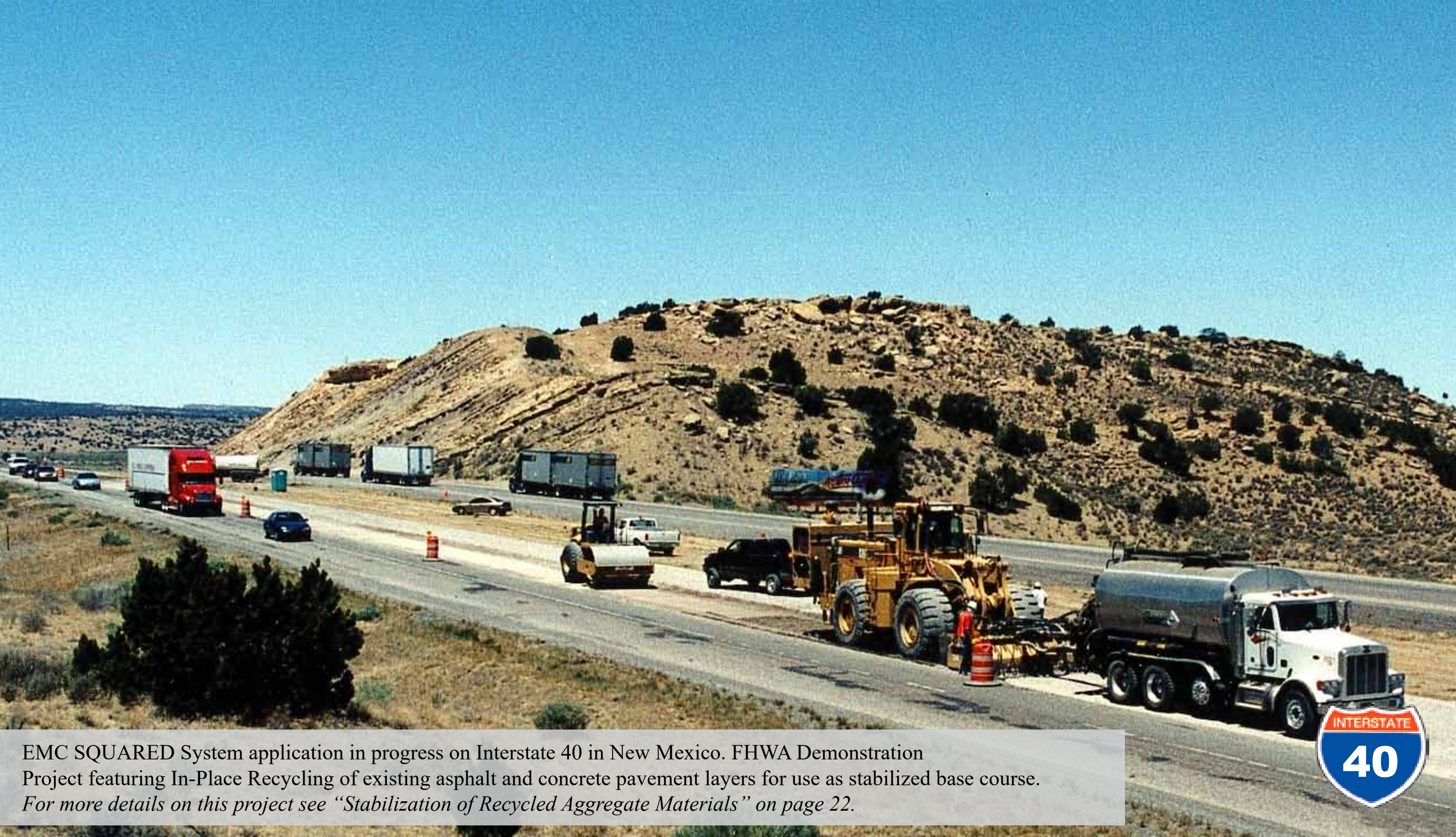
EMC SQUARED System treatments are utilized to improve the performance of soil materials, virgin aggregate materials, and recycled aggregate mixtures manufactured from crushed concrete pavement and recycled asphalt pavement (RAP) millings. The following project reports are grouped according to these three material categories.

Click on the given weblink to go to the applicable report on stabilizationproducts.net

Stabilization Products LLC

Intermodal Container Transfer Facility

Subgrade soils treated with EMC SQUARED® System and being compacted prior to placement of base course and pavement



EMC SQUARED System application in progress on Interstate 40 in New Mexico. FHWA Demonstration Project featuring In-Place Recycling of existing asphalt and concrete pavement layers for use as stabilized base course.
For more details on this project see "Stabilization of Recycled Aggregate Materials" on page 22.

The Evolution of the EMC SQUARED® System Advanced Stabilization Technology

The primary mission of Stabilization Products is the development and implementation of advanced technology for economical improvement of native soils, aggregate base rock and recycled pavement materials for use in the construction of roads and highways and earthworks. With a previous background in the production of aggregate, asphalt and concrete materials, and experience in general engineering construction, we are well aware that a huge area of need was unaddressed by available stabilization technology. We witnessed the destructive and costly effects of unstable soils under road structures, and were frustrated regarding the performance limitations and high costs of the chemical and mechanical stabilization products available at the time. Our research indicated that no other firm with our background in the industry was focusing on advancing stabilization technology.

Products such as cement and lime were introduced prior to the 1950's for soil stabilization applications. They are costly to use, effective in a limited range of soil problems, and can produce destructive side-effects worse than the problem they were intended to cure. Both cement and lime treatment can generate layer cracking and sulfate induced heave under asphalt and concrete pavements, resulting in reflective cracking of the pavement and rough riding road surfaces. Consequently, cement and lime and related calcium based stabilizers such as fly ash and cement kiln dust have limited usefulness in most areas of the country. More recently developed mechanical stabilization options such as geotextile fabrics, geogrids and geocells (formulated from petrochemicals and classified as "geosynthetics") also prove to be relatively costly, limited in their performance capabilities, and subsequently limited in the extent of their applications.

Our main goal was to develop product technology that would be far more economical and more broad spectrum in effectiveness than currently available chemical and mechanical stabilization products. More than thirty years down that road, we have that advanced technology, proven out in the materials testing laboratories and impressive field applications including a population of Interstate Freeway and Tollway projects. Along with this advanced product technology, more modern and sophisticated materials testing and highway design methodologies are being implemented on an international basis that clearly recognize and utilize the benefits offered by our EMC SQUARED System stabilization technology.

Green Stabilization Technology

In the field of soil stabilization, the EMC SQUARED System competes with the traditional calcium based products including cement, fly ash, cement kiln dust, and lime. Those fine-sized powder products are highly alkaline in composition and not known as being user friendly or environmentally friendly. Large projects require hundreds of truckloads of product in order to effectively modify soil. EMC SQUARED System products, on the other hand, are environmentally friendly and highly concentrated. A soil stabilization project using one hundred truckloads of cement or lime product typically could be handled by one or two truckloads of EMC SQUARED System product. That's part of the revolutionary aspect of the product technology. For more information how EMC SQUARED System products reduce construction costs while combating climate change, go to http://stabilizationproducts.net/docs/18796.pdf

EMC SQUARED® System application in progress on city expressway project in California. Stabilization of subgrade soils and recycled asphalt pavement (RAP) as a base course eliminated the need to import 640 truckloads of aggregate base course material. For more details on this project see “City Saves Dollars and Reduces Air Pollution” *on page 7.*

In contrast to cement and lime, EMC SQUARED® System products have long been understood to be user friendly (no special handling precautions) and environmentally friendly (neutral pH, non-toxic, non-reactive, non-corrosive, non-hazardous). EMC SQUARED System treatments have been approved for project specific applications at environmentally sensitive sites by the U.S. Fish and Wildlife Service, the National Park Service, the California Department of Fish and Wildlife, the City of San Francisco, and other agencies known for their strict review of construction products used at such locations. The EMC SQUARED System has been field tested by the U.S. Environmental Protection Agency (EPA) as part of their National Estuary Program (NEP), which documented the suitability of the product for use “in sensitive environmental areas.”

The EMC SQUARED System technology has a multiplier effect when it comes to being environmentally friendly. On the recent one mile long city expressway project pictured above, an EMC SQUARED System treatment of in-place soils and the recycled asphalt, produced by milling the existing pavement, eliminated the need for 16,000 tons of imported aggregate material, a vanishing and non-renewable resource. In addition to major cost savings, the elimination of the the need for 640 truckloads of aggregate also reduced the destruction of adjacent roads on the haul route, and the air pollution of several thousand hours of diesel truck operation. The project owner reported a fifteen percent reduction in the overall air pollution related to this construction project as the result of the EMC SQUARED System soil stabilization.

Revolutionary Cost Savings

The low cost of EMC SQUARED System treatment opens up a new world for stabilization technology. In regards to product cost, an EMC SQUARED System typically prices out at twenty to forty percent of the cost of the cement or lime product required for a similar project application. The cost advantages continue when it comes to cost of installation. The EMC SQUARED System treatment is easier and faster to apply. It doesn’t require a specialty sub-contractor with specialized equipment to apply. Because of its highly concentrated nature, the stabilizer product can be stored on site in drums or IBC totes, available at a moments notice for the contractor’s convenience.

Another market for the EMC SQUARED System is the widespread replacement of aggregate base rock materials by use of stabilized soils or stabilized recycled aggregate materials (asphalt millings and crushed concrete). The cost savings for the one mile long city expressway project pictured above was 25% of the overall project cost. While hot mix asphalt was still used as the pavement surfacing, a base course that would have required 16,000 tons of aggregate (640 truckloads) was replaced by a design using an EMC SQUARED System treatment of subgrade soils and of a four inch base course layer comprised of recycled asphalt from the original asphalt pavement previously milled and stockpiled on site. With a million dollar cost for the conventional design and construction savings of approximately $250,000.00 attributable to use of stabilization technology, this project demonstrated that significant cost savings can be realized. http://stabilizationproducts.net/docs/18796.pdf

EMC SQUARED® System - Project Reports

Stabilization of Soils

Interstate Freeway and Highway Subgrade Stabilization - Texas

The State of Texas is well known for its problems with expansive clay soils as well as its extensive use of calcium based stabilizers such as lime, cement and fly ash. These chemicals are applied to reduce the damage to highway pavements resulting from the volume change (shrinking and swelling) of soils below the pavement as they fluctuate in moisture content with changing weather conditions. Calcium based stabilizers do little to eliminate continuing moisture flow through the soil layer, but they do strengthen and stiffen soils to create a more rigid platform under the pavement. The high costs associated with their applications has generally been accepted in Texas as a basic fact of life, but when widespread highway damage (known as sulfate induced heave) was discovered to be a negative side-effect of calcium based stabilizer treatments, the Texas Department of Transportation (TxDOT) was forced to research alternative soil stabilization technology.

The EMC SQUARED System was reviewed, then subjected to an extensive two-year laboratory study, field tested for another year, and then utilized for soil stabilization on four freeway and additional road projects in the Dallas area at locations with high sulfate soils. The laboratory study was funded by TxDOT and conducted at the Texas Transportation Institute (TTI). The study found the EMC SQUARED System to be effective, recommended its use for Texas highway projects and went on to point out the unique benefits offered which were not provided by calcium base stabilizers. The expansive clay soils treated with EMC SQUARED System applications acted as moisture barriers. The soils proved to be stabilized in moisture content as well as being strengthened.

The performance of TxDOT installations subject to ongoing field monitoring indicates that this more advanced approach to soil stabilization is providing superior performance and lower cost while eliminating risk of sulfate induced heave. Based upon visual monitoring, the pavements constructed on top of soil subgrades treated with EMC SQUARED System applications are free of distress. Based upon the International Roughness Index (IRI) testing conducted annually by TxDOT, these highway pavements retain their smoothness and are superior to adjacent sections of highway constructed with calcium based stabilizers. The TxDOT District Field Engineer tasked with monitoring soil stabilization projects since 1999, reported on the section of the Dallas – Fort Worth Turnpike (Interstate Highway 30) constructed with the EMC SQUARED System subgrade treatment as follows “The project shows no sign of distress and ride quality is smooth and is the best riding section of I-30 in the district.”

These freeway and highway projects have now been in service under very heavy traffic volume for eighteen years since their construction. As shown below, 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 for Year 2018 demonstrate that the stabilized subgrades are performing very well. The 2018 ARA Report validates the findings of the Tx-98/3929-1 Research Study released twenty years ago and confirms the effective performance of EMC SQUARED System treatments in these subgrade stabilization applications. For more information, go to http://stabilizationproducts.net/docs/18468.pdf

Use and Performance of Advanced Soil Stabilization

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

* Harold L. Von Quintus, P.E., Applied Research Associates, Inc.

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

EMC SQUARED® System - Project Reports
Stabilization of Soils

City Saves Dollars and Reduces Air Pollution - California

The City of Clovis, California, reduced construction costs twenty-five percent by using advanced materials testing, advanced product technology and advanced design methodology. They then applied advanced field monitoring technology to verify that this section of road had been constructed to a higher load carrying capacity than adjacent sections of road constructed according to dated conventional practice. The city's project design consultant utilized Resilient Modulus testing and AASHTO 2002 M-E Pavement Design to select the EMC SQUARED® System for stabilization of subgrade soils and for stabilization of recycled asphalt materials used in base course construction. Quality control services during construction included standard compaction testing. Stabilized materials were sampled from the project site during construction, compacted in laboratory molds and then subjected to Resilient Modulus testing to verify that the performance of the stabilized subgrade correlated satisfactorily with the strength values designated for the structural section design. Once the stabilized layers were constructed and covered with asphalt pavement, Falling Weight Deflectometer (FWD) monitoring verfied that the pavement structural section performed according to design.

The net savings reduced overall construction costs for the one mile long expressway project by approximately $250,000.00. Like many other areas throughout California and the nation, aggregate materials in the project area are mined from quarries and riverbed deposits that are rapidly being exhausted in the nearby area. Sine the construction of this project, round trip hauls for aggregate have gone from 20 to 30 miles out to 125 to 175 miles per load, so the savings today would be closer to $400,000.00. The cost advantages of EMC SQUARED System treatment become even more attractive. Then factor in the savings in the road wear by eliminating 640 truck trips averaging 150 miles per trip to build just one mile of new roadway. City, county and state taxpayers have subsidized the construction of new roads by providing the paved road network being destroyed by lengthy aggregate hauls, a terrible waste of public resources. As the transportation costs, the air pollution and road wear associated with these long hauls mount up, the built-in demand for proven stabilization treatement becomes apparent. This project was constructed in the San Joaquin Valley, an air basin with extreme air pollution problems. The city reported that the replacement of imported aggregate base rock materials by in-place stabilization of asphalt millings and native soils reduced project related air pollution by fifteen percent. Full report at http://stabilizationproducts.net/docs/18687.pdf

Federal Project Subgrade Stabilization Saves Dollars - California

The AASHTO 2002 M-E Pavement Design methodology was utilized by engineers from Kleinfelder Inc. to provide the most economical road design for the first phase of a large federal penitentiary project in Mendota, California. With over fifteen acres of paved road and parking lots to construct on top of highly expansive native clay soils, older design methods would have required thick layers of aggregate base rock hauled from over thirty miles away. Design engineers utilized Resilient Modulus testing to carefully evaluate an alternative base layer design constructed of stabilized soil. While lime treatment tested effectively and reduced construction costs, EMC SQUARED® System stabilization was selected as it offered superior performance in testing and additional savings of approximately $250,000.00 for this first construction phase.

The second construction phase which includes the asphalt paving work was delayed over two years due to funding problems. In the meantime, the contractor operated heavy truck and construction equipment through wet fall, winter and spring conditions without need for repair of the stabilized roads and parking lots while the rest of the construction site remained impassible due to the saturated heavy clay soils. The stabilized soil surfaces retained their stability and bearing strength with nothing more than two inches of aggregate spread on top as an all-weather traction layer. Full report at http://stabilizationproducts.net/docs/18626.pdf

EMC SQUARED® System - Project Reports
Stabilization of Soils

Military Suppy Route (MSR) Roads and Tank Trails - Texas & New Mexico

These roads service convoys of heavy military equipment including M1A2 Abrams Tanks, Bradley Infantry Fighting Vehicles and M-1070 Transporter units approaching their Gross Combined Weight Rating (GCWR) of 243,400 pounds when moving Abrams Tanks around the base on heavy duty semi-trailers. The old rough running haul road system had historically taken its toll on the military equipment operating on these routes, the road maintenance budget, and the environment.

Three contracts were awarded by the U.S. Army Corps of Engineers to remedy these problems on eight heavy haul road routes. The work included construction of an unpaved road structural section capable of supporting these extremely heavy loads. Faced with a limited repair budget but still with the need to stretch available funds to cover the reconstruction of as many miles as possible at Fort Bliss, the Army Corps of Engineers design staff's stabilized design option required construction of a twelve inch layer of stabilized native soil covered by an eight inch layer of stabilized aggregate surface course material. The need for manufacturing over one million tons of crushed aggregate subbase material was eliminated (over 40,000 truck loads at 25 tons per load), along with the related long distance trucking hauls. A $20 million dollar material requirement for these projects was eliminated as a direct result of implementing the use of an advanced product technology that could cost-effectively stabilize the wide variety of locally available soils, and aggregate surface course materials. In comparison to the estimated construction budget and miles of heavy haul roads submitted in the original request for funding the haul road improvements, the stabilized design cut construction costs by approximately 25% and stretched the available $60 million budget out to over 117 miles of heavy haul roads.

The EMC SQUARED System stabilization technology was specified by the U.S. Army Corps of Engineers because of its historically proven capability to improve the strength and moisture resistance of aggregate materials and a wide variety of soil types ranging from sandy silts and silty sands to caliche and clay soils. On just one of the heavy haul road construction phases, the contractor reported 22 distinct soil types over the length of their project. Afterwards, analysis of the Falling Weight Deflectometer (FWD) field testing data showed an average layer moduli for the stabilized soil subgrade layer of 40,000 psi, equivalent to the strength of crushed aggregate base course materials which typically have layer moduli ranging from 25,000 to 50,000 psi.

Aggregate trucking hauls and military equipment convoys used the stabilized subgrades in all weather conditions during construction operations. The new Fort Bliss heavy haul MSR roads supported loads far heavier than those allowed on the Interstate Highway System through all the region's extreme weather conditions, and did so without the need for protective asphalt or concrete pavement surfaces. The completed project demonstrated the EMC SQUARED System provided entirely new capabilities and opportunities for improving the performance of constructed aggregate and soil structures. For more information of the project see pages 16 and 31, or to see the full project report, go to: http://stabilizationproducts.net/docs/18676.pdf

EMC SQUARED® System - Project Reports
Stabilization of Soils

Subgrade Stabilization of Heavily Trafficked County Roads - North Dakota

Located in the center of North Dakota's Bakken Oil Boom, Mountrail County utilized advanced engineering and construction technology to greatly reduce the amount of aggregate base rock required for two county road projects constructed in 2012. The roads were redesigned from light duty farm roads to service the around the clock traffic of the oil field service trucks, aggregate haul trucks, construction equipment and oil field drill rigs operating in what has been the number one oil producing county in the state of North Dakota. Aggregate base rock is among the many construction materials that have skyrocketed in cost due to the tremendous market demand in the region and increasing transportation costs. The project design engineering consultants, Allied Engineering Services, Inc. (AES), investigated construction options to reduce costs. Conventional design methods would require a twenty-six inch thick aggregate base layer to properly support a six inch Hot Mix Asphalt surface course to service the heavy oil field truck traffic. Based upon the use of Mechanistic - Empirical Pavement Design (M-E) methodology, advanced laboratory and field test methods and an innovative soil stabilization product, the project engineers were able to develop a design which eliminated the requirement for fourteen inches of costly aggregate subbase material over most of the 15 mile total length of the two construction projects. The alternative they selected involved treating a twelve inch thick layer of locally available native soil with a concentrated liquid stabilization product technology known as the EMC SQUARED® System. The environmentally friendly and economical EMC SQUARED System products are incorporated in the compaction water applied to subgrade soils as part of the conventional moisture content adjustment and subgrade compaction operations typical of high standard road construction projects.

Based upon the input from Resilient Modulus testing of the stabilized subgrade soils, the M-E Design indicated that the two roads could be constructed on stabilized subgrades, thereby eliminating the requirement of almost 18,000 tons of imported aggregate base rock per mile of road. For added perspective, at 25 tons of aggregate per load, which eliminated 720 truck trips for each mile of road constructed. Key to this accomplishment was the extensive soil classification testing for both road projects and the resilient modulus testing conducted as preliminary steps so that the project design engineers would have the data necessary to develop the alternative structural section design. The resilient modulus method, which incorporates repetitive loading in the test procedure to model the dynamic effects of heavy loads constantly impacting that subgrade, showed that the EMC SQUARED System treatment more than doubled the average modulus value, or strength, of the subgrade after seven days of curing time (untreated = 4,934 psi, treated = 12,558 psi), and by almost four times after twenty-one days of curing time (treated = 19,467 psi).

Subgrade stabilization makes more sense than ever under roads in severe cold climate areas that are subject to high frequency truck traffic with heavy loads — often over the legal weight limit, even during the spring thaw season. As notable as is the strong performance of these two roads, the important fact is that they were constructed at far lower cost and environmental impact as the result of replacing the fourteen inch thick aggregate subbase layer required by conventional road design with twelve inches of native soil stabilized using the long-lasting and economical EMC SQUARED System stabilization product technology. Falling Weight Deflectometer (FWD) conducted in the field during the construction process documented the fact that the subgrade soils treated with the EMC SQUARED Stabilizer provided higher strength values (modulus) than the moisture susceptible state specification aggregate base course materials. While many state and county roads in North Dakota are subject to spring load restrictions due to their saturated subgrades, these two county roads with EMC SQUARED stabilized subgrades were permitted year round for fully loaded truck traffic without restriction, providing great economic benefit to oilfield operators and agricultural businesses. To get the full project report, including the extensive engineering tests that were conducted, go to http://stabilizationproducts.net/docs/18698.pdf

EMC SQUARED® System - Project Reports
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Interstate 40 Freeway EMC SQUARED *vs.* Lime - New Mexico

Two sections of the Interstate 40 freeway running through New Mexico have now been reconstructed utilizing EMC SQUARED® System treatments. The second project is included further on among the recycled aggregate projects. Both projects are located in an area where I-40 crosses the Continental Divide at the southern end of the Rocky Mountains and are impacted by both severe cold climate conditions in winter and a high frequency of heavy truck traffic. The Milepost 93-97 section (MP 93-97) just east of Grants had been a nightmare for the New Mexico Department of Transportation (NMDOT), typically requiring complete reconstruction on a three to five year cycle, and in between requiring maintenance to the extent that the entire annual budget of NMDOT's local maintenance station was exhausted taking care of this one short length of highway the year prior to reconstruction. Groundwater problems are extreme under the freeway alignment and the silty clay subgrade soils are regularly found to be in a highly saturated state when excavated during repair and reconstruction efforts. State maintenance staff reported that the eastbound lanes were particularly problematic and experienced significantly more differential settlement (more rolls and dips, or "roughness" in the running surface) than the westbound lanes. This is the "worst case" location where NMDOT put the EMC SQUARED System to the test during a reconstruction project completed in year 2000.

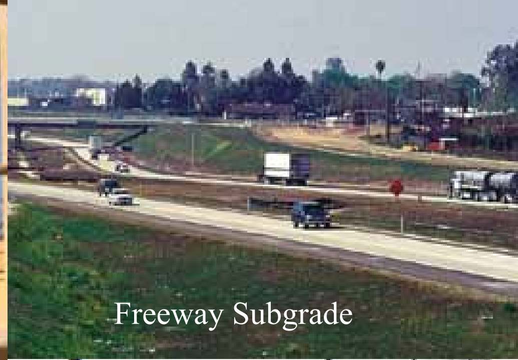
At the time of reconstruction the NMDOT's District Construction Engineer lamented the fact that they did not have an adequate budget to apply stabilization treatment to a greater depth than eight inches, given the history of rapid highway deterioration. Even with the addition of subgrade stabilization, he commented that this was no more than "a band-aid" repair and predicted that complete reconstruction would once again be required within three to five years. Approximately two miles of eastbound I-40 subgrade were constructed with EMC SQUARED System treatment. As part of the same project, the less problematic westbound subgrade was treated over a total of three miles with lime. This provided the opportunity to compare the older generation chemical treatment to the newer and more economical EMC SQUARED stabilizer treatment.

The Federal Highway Administration (FHWA) Area Engineer for the Milepost 93-97 project, and then an Area Engineer for another federal agency in New Mexico, continued to monitor project performance through visual observation and review of the annual IRI, or profilometer, data conducted by NMDOT as mandated by FHWA. NMDOT developed a formula to predict the percent of remaining pavement design life as related to the surface roughness of the pavement determined by the IRI data. In an August 2005 report, more than five years after construction, the Area Engineer noted that the pavements constructed above the lime and EMC SQUARED System treatments were free of cracking or disruption (no visible damage or requirement for maintenance) and that the loss of pavement design life, as predicted from the IRI data, was only ten percent. These sections of interstate freeway remained smooth running and testimonial to the cost-effectiveness of soil stabilization in preserving highway service life.

In December 2005, NMDOT's District Engineer, provided additional perspective important to the overall evaluation of the benefits of the soil stabilization applications under the I-40 pavement structural section. He commented that NMDOT had reconstructed approximately fifteen miles of I-40 freeway through this area, including the MP 93-97 project. While all of these projects utilized NMDOT's newer design with thickened layers of asphalt pavement and aggregate base course materials, only those built above the stabilized soil subgrades remain smooth running and free of pavement damage. While the costly addition of more asphalt pavement clearly contributed some incremental improvement, the soil stabilization treatments had provided a greater improvement in pavement performance and service life in the face of these highly problematic freeway service conditions.

After thirteen years of monitoring, the Area Engineer reported that the historically problematic eastbound lanes had been effectively stabilized with the EMC SQUARED System stabilization treatment and were in fact providing superior performance to that of the lime treatment under the westbound lanes which were beginning to develop significant roughness. According to the calculation formulas supplied by NMDOT and FHWA, the IRI test results indicated that the subgrade stabilized with the EMC SQUARED System treatment did the best job retaining pavement


Intermodal Yard


Freeway Subgrade


Marina Parking Lot


Arizona County Road

EMC SQUARED® System - Project Reports
Stabilization of Soils

performance and extending the Theoretical Design Life of this heavily traveled section of I-40. According to the NMDOT Materials Bureau model, this translates into a gain of load carrying capacity over the lime treated section of 5,155,966 ESALs, or 4,687,242 truck passes. For sake of perspective, at one truck pass per minute 24 hours per day, it can be predicted that the EMC SQUARED System treatment will extend pavement service life by approximately 9 years beyond that of the pavement constructed above the lime treated subgrade. Full report at http://stabilizationproducts.net/docs/18455.pdf

Intermodal Yard Subgrade Stabilization - California

The Intermodal Container Transfer Facility (ICTF) in Carson, California, is one of the world's largest and busiest facilities for the transfer of shipping containers between ocean going ships and rail transport. Located in proximity to the Port of Los Angeles and Port of Long Beach, the local high groundwater conditions at this location are further complicated by a major water conveyance channel adjacent to the ICTF site. With highly moisture susceptible silty clay soils to build upon, design engineers specified stabilization of fifteen inches of subgrade soil with the EMC SQUARED System prior to placement of the base course and asphalt pavement for the thirteen acre Red Zone truck parking area. For more information, go to http://stabilizationproducts.net/docs/18393.pdf

Freeway Subgrade Compaction Problem Solved - California

The Livingston Bypass project for the California Department of Transportation (Caltrans) was designed to eliminate many at-grade highway crossings and the last remaining stoplight on the San Joaquin Valley section of Highway 99, one of two major highway/freeway systems running through Central California, connecting the northern and southern ends of the state. Silty sand soils resisted the contractor's moisture conditioning and compaction efforts, making the timely attainment of the 95 percent ASTM D1557 Modified Proctor compaction specification a construction challenge. The contractor immediately field tested an EMC SQUARED System product as an additive to their compaction water and found they were able to rapidly attain the specified degree of soil density, hitting 97 percent Modified Proctor Compaction on their first day of use. The highly concentrated EMC SQUARED System subsequently facilitated the contractor's compaction productivity through a two year period involving a variety of compaction operations.

Marina Parking Lot - California

With historical soil contamination problems to deal with, a gravel parking lot adjacent to San Francisco Bay that is frequented by windsurfers presented the City of Berkeley's Parks, Recreation & Waterfront Department with a challenge: the limited budget they had available. With plans to place an impervious hot mix asphalt pavement surface course, the City could reduce disposal and construction costs by using the contaminated soils in place as a stabilized base layer under the pavement. The use of economical and environmentally friendly EMC SQUARED liquid stabilizer products solved their problems. Using the in situ soils, the existing gravel materials were incorporated in the upper of two nine-inch (9") stabilized lifts prior to placement of a three-inch (3") asphalt pavement on top of the stabilized layers. For more information, go to http://stabilizationproducts.net/docs/18775.pdf

County Road Stabilization - Arizona

County 14th Street becomes one of the Yuma County's busiest roads for agricultural truck traffic during harvest operations. This section of County 14th Street required annual reconstruction and repair and was historically the single worst segment of road the county maintained. The persistent presence of irrigation water, combined with heavy and high frequency traffic in an area of saturated unstable clay soils, created a worst case scenario that the county needed to solve. Also see page 25 for more of this project's details. Full report available at http://stabilizationproducts.net/docs/18667.pdf

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While the previous case studies involve stabilized subgrades that are covered by base course and pavement layers. EMC SQUARED System treatments are also utilized to stabilize soils for surface course applications as described on pages 12 and 13. These are the real proving grounds where the effectiveness of the treatment is tested under the direct impact of traffic and in all weather conditions.

Tank Trail Stabilization - Colorado

Fort Carson is located in Colorado, within view of Pikes Peak. Dirt roads on base are subject to year round traffic by equipment with gross vehicle weights well in excess of those permitted on the nearby interstate freeway. The combination of severe Rocky Mountain weather and heavy equipment traffic such as M1 Abrams Battle Tanks and heavy trucks, including giant lowbed haulers that can transport tanks, bulldozers and other large equipment, leaves untreated roads constructed of moderately expansive silty clay soils subject to rutting in wet weather conditions and requiring constant grading maintenance. A heavy haul road/tank trail was treated with an EMC SQUARED® System application to a thirty foot width and a six inch depth. During an onsite inspection provided the following year by a local geotechnical engineer, he observed both tank and armored troop transport equipment utilizing the treated road and reported that it was in extremely good condition and had performed without maintenance since treatment. Grading crews reported that the treated section of road was so highly cemented that they were unable to cut into it with their grader blades. The performance of the EMC SQUARED treatment was even more impressive considering the area had been subjected to record rainfall in previous months. The geotechnical engineer additionally noted that tanks were clearly turning on top of the treated material without damage to the road, and then were creating ruts as deep as two feet in the untreated shoulder areas as they maneuvered off the road. See http://stabilizationproducts.net/docs/18410.pdf

Road Stabilization - New Mexico

The largest natural gas producer operating in the State of New Mexico maintains many hundreds of miles of dirt roads servicing thousands of natural gas production sites in remote areas of the state. These roads service daily heavy truck traffic, but of limited frequency, so gravel or paved surfacing is simply not cost-effective. EMC SQUARED System applications have long been used to upgrade dirt access roads to oil and natural gas production sites for all weather access.

Landfill Cap Stabilization - California

Compacted soils treated with an EMC SQUARED System application provide for the final cover of closure caps on hazardous waste disposal cells located in an arid desert environment just north of the border with Baja California, Mexico. Due to the lack of rainfall, vegetative cover is not a feasible option for a long term erosion control at this state-of-the-art facility in Westmorland, California. A total of two feet of compacted soil is placed over the geosynthetic membrane barrier systems. In a closure plan approved by Cal EPA, the top twelve inch lift is treated with an EMC SQUARED System application. The final surface is trimmed, compacted, and then additionally protected by an erosion control spray treatment. The project report may be found at http://stabilizationproducts.net/docs/18361.pdf

Road Stabilization - Alabama

Prior to stabilization, Southworth Road, a county road in the Mobile Bay area of Alabama's Gulf Coast, rutted so badly and driving conditions became so hazardous that school buses were unable to service the area, a situation that drew repeated coverage from a local TV station. A six inch deep EMC SQUARED System treatment proved to be the answer, providing a solid running surface during a year when the average annual rainfall was doubled over the previous year (from 60 to 120 inches) and was almost equaled by a single rainfall event. Hurricane Danny hit the Mobile Bay area in July 1997 and dropped 48 to 60 inches of rain (depending upon the specific location within the area) in a matter of days. The stabilized soil performed so well, in fact, the county engineering staff reported that the stabilized surface retained full traction and felt as solid as a concrete pavement during these extremely heavy rainfall events. Typical of many EMC SQUARED System stabilization installations, as shown in the photo on top of the next page, after more than a year of supporting traffic without a protective surface, the county placed a hot mix asphalt pavement directly on the stabilized soil base, further upgrading the road as part of a "staged" or incremental road improvement project. In the meantime, school buses and county motorists had a nearly maintenance-free all weather road. The excellent field performance of the stabilizer treatment was further confirmed by the laboratory testing. As graphed at bottom right on page 36 (Baldwin County, Alabama), the red colored clayey silty fine sand tested at more than four times the strength following applications of the stabilizer treatment. The full project report may be found at http://stabilizationproducts.net/docs/18781.pdf

Alabama stabilized road in service. Prior to stabilization, the road rutted so badly and driving conditions became so hazardous that school buses were unable to service the area. *See page 12.*

EMC SQUARED® System - Project Reports
Stabilization of Soils

Closure of Construction Site - Arizona

Faced with an annual cost of approximately $200,000.00 to spray apply dust control products to satisfy city, state SWPPP and Maricopa County permit requirements, the owner of this 74 acre parcel decided to apply a single treatment of EMC SQUARED System stabilizer product to provide long-term closure at an installed cost similar to that of a single dust control product application. While the owner did not anticipate that the site would still be vacant eleven years later, by selecting the soil stabilization option they have realized a cost savings of about 2 million dollars over this period of time. For more information and time sequenced photos, go to http://stabilizationproducts.net/docs/18768.pdf

Military Base Forward Landing Strips (FLS) - North Carolina

Army Engineers training for their combat airborne support responsibilities at Fort Bragg, North Carolina, practice their skills for rapid construction and maintenance of unpaved dirt runways known as Forward Landing Strips (FLS). The native sandy soils in this area of North Carolina do not have sufficient stability to support the landing and takeoff of loaded C-130 transport aircraft, so Fort Bragg was importing clay borrow soils that were becoming increasing limited in availability and more expensive as the haul from new sources grew more distant. The imported clay capping material would typically experience cracking after construction of the FLS was completed, and that would be the beginning of the soil erosion problems that could develop quickly in an area with an average annual rainfall of 45 inches. The Army Engineers were concerned about the increasing cost for frequently having to import more clay capping soil to maintain the FLS in proper condition. As the result of their research, they selected an EMC SQUARED® System stabilizer treatment that was one fourth the cost of the amount of conventional cement stabilizer product, which they could not install themselves using their own construction equipment.

Application of the EMC SQUARED System products was done by the 37th Engineer Battalion themselves with their own equipment. By penetrometer testing, EMC SQUARED System treated soils showed almost a seven-fold improvement. "This stuff locks in and creates an almost cement material," said Staff Sgt. Thomas McDonald, Company B, 37th Engineering Battalion. Reports from years later said the constructed strips remained "rock hard without any sign of damage."

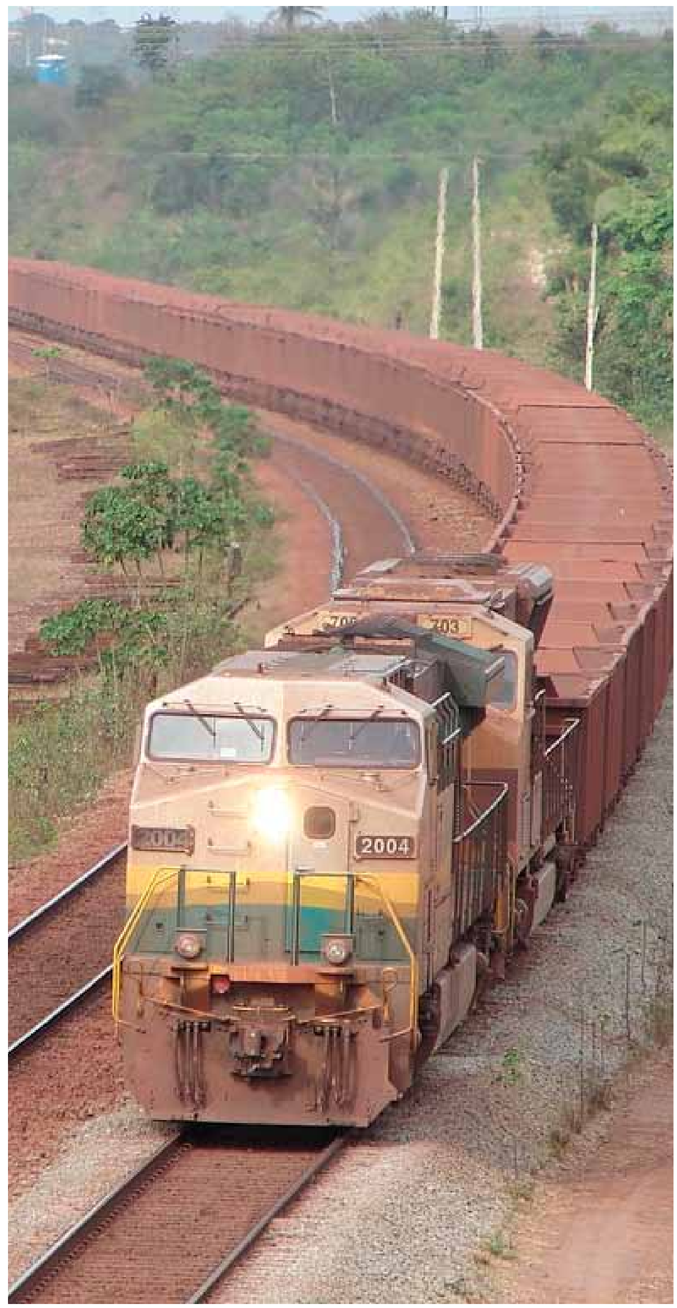
The only problem? The irony of the FLS soil stabilization projects was that EMC SQUARED System treatment was too successful. The erosion-resistant treatment was so effective that the need for maintenance grading was eliminated. Since FLS grading maintenance was a required part of their training program, the command at Fort Bragg informed the Battalion, after two FLS were stabilized in this manner, that soil stabilization was counterproductive to their required training and for that reason they would not be approving stabilization of any additional Forward Landing Strips at Fort Bragg. For more info, go to http://stabilizationproducts.net/docs/18797.pdf

37th Engineer Battalion applying EMC SQUARED Stabilizer to Forward Landing Strip surface

Water tanker application equipment parked at left while cross-shaft roatary mixer at distant right mixes stabilization treatment with soil and motor grader begins to grade and shape the treated soil.

EMC SQUARED® System - Project Reports
Stabilization of Soils

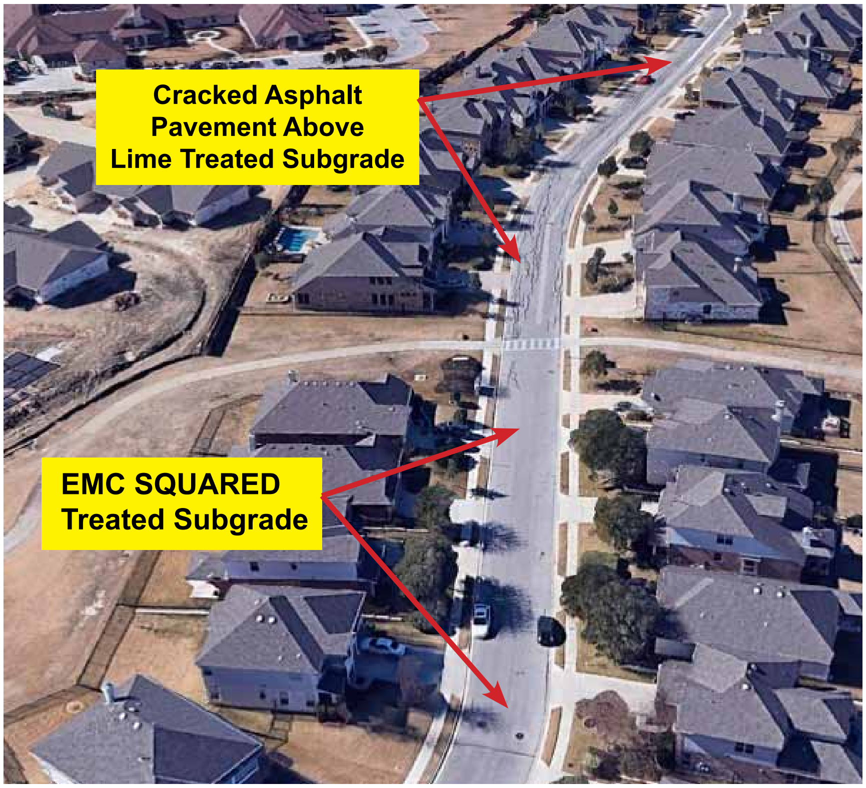
Advanced Soil Stabilization for the Biggest Train in the World - Brazil



VALE, the largest iron-ore producer in the world, and the second largest mining company, operates the world's most extensive iron-ore mine, located in northern Brazil. They are developing a railway for what is described as the biggest train in the world, stretching almost three kilometers in length with four engines and 330 iron ore cars. The company plan is to incrementally increase axel loads in order to add to the productivity of their Carajás Railway by increasing the trailing weight of the train by 40.8% to 44,160 tonnes. VALE, with an investment of $11.3 billion, is developing a new mine that will increase the total annual iron-ore production to be shipped by rail from 100 million tonnes to 230 million tonnes. Over half the new investment will be to expand infrastructure and improve the logistics of the railroad and port operations. The Carajás Railway, which runs from the state of Pará to the Ponta de Madeira Marine Terminal in the state of Maranhão, will be extended 100 kilometers in length to the location of the new mine facility, while 129.9 kilometers of the existing 892 kilometer railway will be duplicated, increasing transportation capacity to 150 million tonnes annually. The project will also include construction of approximately 470 kilometers of duplicate railway track. Operating a super heavy train three kilometers in length required construction of longer passing loops and new yards, new piers at the port, new ship loaders and use of the most advanced technology. Innovative technologies include new signaling systems and advanced soil stabilization systems to improve the strength of the native soils used in construction of the subballast layer that will support the track structure for the super heavy train. Subballast soils are stabilized with the EMC SQUARED System product technology from Stabilization Products LLC. The economical and environmentally friendly concentrated liquid stabilizer products are added to the compaction water and incorporated with the subballast soils using standard soil mixing and compaction procedures, offering broad spectrum effectiveness in stabilizing a wide variety of soil and aggregate materials, and increasing strength and reducing their susceptibility to fluctuations in moisture content. This is an excellent match of product technology and application of state-of-the-art stabilization technology incorporated in the subballast layer supporting the track structure for the Biggest Train in the World, which will be state-of-the-art in rail freight productivity. More photos are at http://stabilizationproducts.net/docs/18691.pdf

Advanced Stabilization Technology Solves Pavement Cracking & Roughness Problems - Texas

The Teravista Community is a master planned development on the northeast side of Austin, Texas. The associated road and street construction provide an outstanding case study of the use and benefits of innovation as many conventional design approaches proved unsatisfactory before the geotechnical engineering consultants identified a cost-effective solution. The first option was a super-thick structural section under the asphalt pavement that required importation of 18" of low-plasticity soil covered by 18" of crushed aggregate base course materials. While this pavement design proved effective and durable over time in many of the first phases of the development, it was prohibitively expensive. The next pavement design lowered costs by reducing the thickness of the base course by including geogrid reinforcement, but this left the asphalt pavement subject to cracking. Then another design was attempted with asphalt pavement placed on an 8" aggregate base course constructed on top of 8" of lime-treated soil. While the use of lime reduced costs, the asphalt pavements soon exhibited extensive cracking as well as differential settlement.



Teravista Community street 15 years after installation

Although 27 different soil types were detected in different areas of this 1500 acre development, a large portion of the development included a trend of expansive clay soils that run almost the entire length of Texas, north to south. These soils with organic and sulfate content are well-qualified to be the most problematic of soils on the North American Continent for built structures such as roads and highways. With a high degree of volume change (shrinking and swelling) behavior driven by fluctuations in soil moisture content, these expansive soils further endanger the integrity of built structures because their soil chemistry generates an extreme heaving phenomenon when cement, lime or fly ash are added to the soils in an attempt to reduce the volume change behavior. The damages from the heaving these products generate are worse than the problems created by the volume changes they were intended to solve. These three calcium based chemicals may effectively dry up overly wet soils, however, those benefits are short-lived. The heaving reactions they cause tilt large buildings and buckle and crack pavements, both enormously expensive to correct. A forty-one mile length of Texas State Highway 130 (SH-130), a four lane divided tollway southeast of Austin that runs from Mustang Ridge to Seguin, is an example of just how expensive a mistake in stabilizer product selection can prove to be. Despite treating subgrade soils under the 9" asphalt pavements and 12" aggregate base course layers with lime chemicals to a depth of three feet under the main drive lanes, the current owners of the privately financed highway recently completed a second round of reconstruction of 35 sections of the highway to depths as deep as eight feet at a reported cost of $90 million. Total reconstruction costs are projected to be $130 million. The original lime treatment proved to be ineffective, or worse, but was used again during the reconstruction program. Additional measures taken during the reconstruction included vertical impermeable barriers constructed along both sides of the tollway in order to keep water from penetrating into the lime treated soils and once again generating the shrinking and swelling problems. This area of Texas experienced extreme drought conditions in recent years, followed by flooding. In addition to sulfate related heaving and water related swelling in the lime treated subgrade, shrinkage cracking in the lime treated subgrade during the drought conditions was also reported as contributing to cracking the base course and asphalt pavement layers above via a pavement failure mechanism known as reflective cracking.

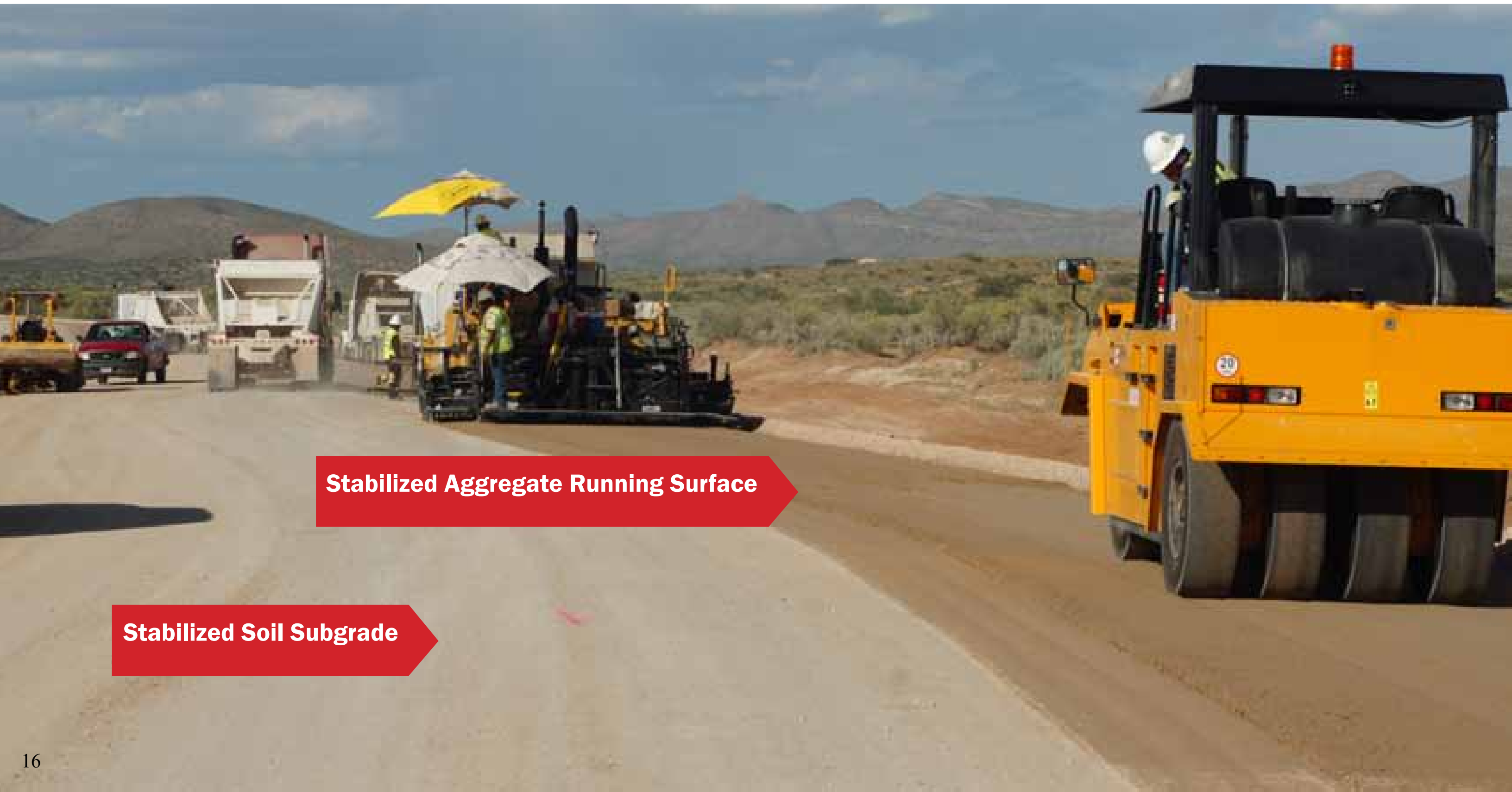
The same soil problems existed at the Teravista Community development as on the SH-130 tollway project and asphalt pavements and base courses constructed above lime treated subgrades exhibited similar differential settlement and cracking problems on the same rapid time line. Foresightedly, project geotechnical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

EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

Military Suppy Route (MSR) Roads and Tank Trails - Texas & New Mexico

The EMC SQUARED System stabilization technology was specified by the U.S. Army Corps of Engineers because of its historically proven capability to improve the strength and moisture resistance of aggregate materials and a wide variety of soil types ranging from sandy silts and silty sands to caliche and clay soils. On just one of the heavy haul road construction phases, the contractor reported 22 distinct soil types over the length of their project. Pictured above is a caravan of Heavy Equipment Transporters loaded with Abrams M1A2 Tanks driving on an EMC SQUARED Stabilized Aggregate running surface. This is part of a network of 117 miles of MSR Roads and Tank Trails built with EMC SQUARED System stabilization treatment.

The new Fort Bliss heavy haul MSR roads support loads far heavier than those allowed on the Interstate Highway System through all the region's extreme weather conditions, and do so without the need for protective asphalt or concrete pavement surfaces. The completed project demonstrates the EMC SQUARED System provides entirely new capabilities and opportunities for improving the performance of constructed aggregate and soil structures. For more information about the project see page 8, or to see the full project report, go to: http://stabilizationproducts.net/docs/18676.pdf. For laboratory testing at the Western Regional Superpave Center of the EMC SQUARED Stabilized Aggregate material, see pages 30, 31, and 32.



EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

Stabilized Super Heavy Haul Road - Texas

Pictured above is a heavy haul that involved moving the first of two electrical transformers of over 200 tons each. The heavy haul truck, with the transformer unit loaded on board, had a Gross Vehicle Weight (GVW) of over 325 tons. This heavy haul rig supported the load of the transformer and the transport trailer on 96 load bearing tires loaded to near their maximum load bearing capacity of 6,000 pounds each. Add to this two puller trucks and two pusher trucks, three of which were weighted down with concrete slabs to provide extra traction. The final stage of the transformer move would be over an unpaved road running up a hill to the substation. Note that the total weight of the cargo and special transport trailer exceeded the maximum legal load limit for a single truck on an interstate freeway by a factor of more than eight times, so total horsepower and traction were both important concerns.

With a steep grade to climb and relatively weak native subgrade soils to traverse, the project engineer specified an eight-inch thick EMC SQUARED stabilized aggregate surface course for the final section of the substation access road. An eleven-inch thick stabilized aggregate surface course was specified for construction of the lower section of road to bridge over a sandy area where the road detoured around a sand dune. The stabilized aggregate mixture for this project incorporated recycled asphalt pavement (RAP) millings mixed in with the virgin crushed aggregate material.
The EMC SQUARED Stabilized Aggregate surfaced road remained stiff and without any visible deformation as the loads were moved along the road. Testimonial to just how solid the stabilized aggregate layer was under the heavy haul truck, observers commented that they noticed loud popping sounds as pieces of aggregate scattered on top of the rock-solid stabilized road shattered under the impact of the heavily-loaded tires as the transport truck progressed up the road to the substation destination.

These heavy loading applications for the EMC SQUARED Stabilized Aggregate materials validate the outstanding results of the laboratory testing conducted at the Western Regional Superpave Center (WRSC) and the predictions that these stabilized aggregate materials would provide excellent performance under the worst case service conditions possible for a flexible material, which are slowly moving super-heavy loads. See pages 30, 31, and 32 for information regarding Dynamic Modulus and Repeated Load Triaxial (RLT) testing. More photos of the super heavy haul transport may be viewed at http://stabilizationproducts.net/docs/18764.pdf

Border Roads - California

National Guard troops have constructed and maintained the dirt and gravel road system along the border with Mexico as part of their annual training exercises. A section of border road southeast of San Diego was upgraded by National Guard forces. EMC SQUARED System treatment was applied as new aggregate materials were hauled in to elevate the running surface and increase load carrying capacity. This section of road had been highly problematic as it runs through a wetland area where water is ponded against the road embankment. Interestingly, while less problematic sections of the border road adjacent to the stabilized section have been re-treated annually with expensive dust control product applications, the section constructed with the EMC SQUARED System treatment is still providing a stable and hardened running surface through this "worse case" wetlands situation eight years after installation.

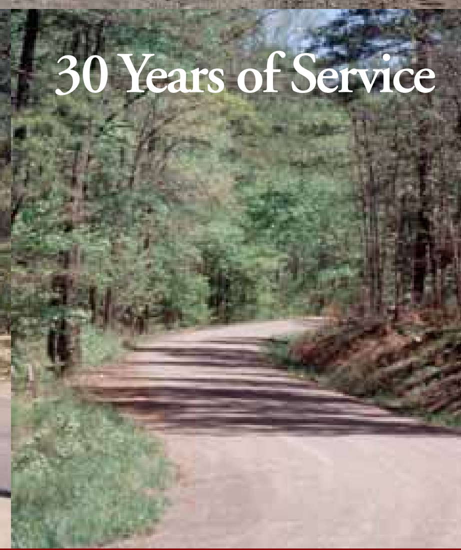

Wetlands adjacent to road

EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

Paving Machine Placement of Plant-Mixed Stabilized Base Course - Arizona

When the higher standard of base course construction process is selected, including proportioning the stabilizer to the aggregate and mixing the stabilizer with the aggregate in a stationary pugmill mixing plant mix, then the EMC SQUARED Stabilized Aggregate misture can also be placed with an asphalt paving machine. Paving machine placement can speed construction and minimize handling of the stabilized aggregate and reduce susceptibility to segregation and raveling during placement operations. As pictured, the EMC SQUARED Stabilizer product was combined with the aggregate base course material in a pugmill mixing plant located at the project site. The finished mix product was then transported to the paving machine by two large wheel loaders. It was reported that the contractor was achieving 97% and 98% ASTM D 1557 compaction with a minimum of compaction effort. Regarding the efficiencies of placing the stabilized aggregate mix by paving machine, the contractor noted that using this method was far superior as it eliminated all the grade control problems and unraveling problems that follow when trying to place and fine grade the base course aggregate with motor graders. For large projects, a material transfer machine would be included ahead of the paving machine that could hold several truck loads of stabilized aggregate material and conveyor it into the paving machine to facilitate a continuous supply and uninterrupted placement operations.

As this road was being constructed through a spectacular stand of large Saguaro Cactus that were highly treasured by the local community, every effort was made to minimize the visual impact of the new road and any deleterious effects on the root systems of the Saguaro. The designers wanted to maximize the bearing strength of the pavement structural section without having to visibly elevate the pavement section above the natural terrain or cut into the Saguaro's root systems. The EMC SQUARED Stabilized Aggregate mixture was evaluated by Resilient Modulus testing conducted at Oklahoma State University at the direction of geotechnical engineering firm Terracon Consultants and tested in the range of 100,000 to 110,000 psi, which is more than twice the modulus value that would have been typical for the unstabilized aggregate base course material. Based upon this information, a four inch deep EMC SQUARED Stabilized Aggregate base course was placed for an application that otherwise would have required an eight-inch deep aggregate base course layer. More photos of the project's installation are available at http://stabilizationproducts.net/docs/18663.pdf



EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

Nevada Road Base Stabilization Project - Las Vegas, Nevada

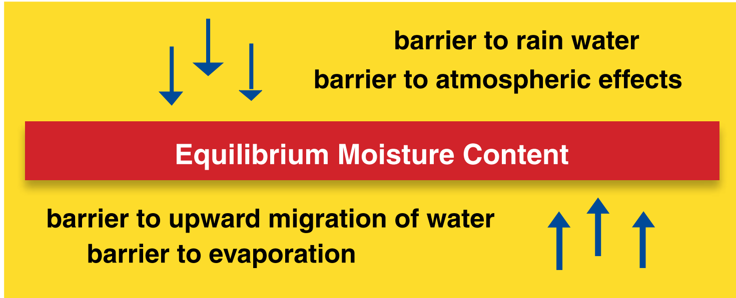
Concerns regarding problematic soil conditions under the access roads at the Las Vegas Springs Preserve, the historical birthplace of the City of Las Vegas, led to a design incorporating a base course stabilized with an EMC SQUARED System application prior to placement of the surface course. As described in the Laboratory Testing section on page 32, Resilient Modulus testing conducted at the University of Nevada Reno (UNR) pavement materials laboratory demonstrated highly effective base stabilization results. The strength of the aggregate base layer was improved by more than five times, providing a layer equivalency factor similar to that of hot mix asphalt. Given this level of effectiveness in the materials testing laboratory, the performance of stabilized aggregate materials described in the ongoing project reports, where stabilized aggregates provide near pavement-like proficiency, can be better understood. http://stabilizationproducts.net/docs/18793.pdf

Nevada Mountain Road Project - Reno, Nevada

A Nevada aggregate production company located at a mountainous site east of Reno wanted to place a stabilized aggregate layer on their steep and winding access road. Their goal was to run their heavy haul trucks on this surface through the winter season until the weather warmed adequately the following spring when they could place a hot mix asphalt pavement. The road has switchbacks and grades as steep as thirteen percent and it provides year-round access for 200 or more daily trips of dump trucks weighing 60 tons fully loaded. The EMC SQUARED System treatment provided a maintenance free running surface for the six month interim until the asphalt was placed. The road was attacked several times by winter flooding at the creek crossing in the middle picture above. Reports indicate that unstabilized aggregate road shoulder materials have been swept away clear to the vertical edge of the stabilized road surface. The asphalt pavement layers have also been swept away, but the stabilized base layer has been left in place without any visible erosion, looking much like a concrete slab. These flooding events provide further testimonial that the treated aggregate layer, which has survived years of freeze-thaw cycling, snow melt and wet weather conditions, is indeed highly resistant to moisture intrusion. For additional information on this Nevada Mountain Road Project, go to http://stabilizationproducts.net/docs/18587.pdf

Forest Road Stabilization 30 Years - Arkansas

A forest road improvement project was completed in 1988, upgrading heavily traveled New Blaine Road, which runs through the mountains of the Ozark-St. Francis National Forest in Arkansas. New gravel surfacing material was placed on the existing road and was stabilized in-place with an EMC SQUARED System treatment. This stabilized aggregate running surface continues to be effective after almost thirty years of service in this cold region location. The Forest Road Engineer described conditions prior to placement of the stabilized surfacing; “During the winter months, freezing and thawing, shrinking and swelling of the clay soils and the steep grade would make the road almost impassible.” This road services vehicular traffic between small communities as well as recreational use and logging truck traffic, and it has a winding alignment as well as grades in excess of twelve percent. These are worst case conditions where cement or lime treatment wouldn’t even be given consideration. The Forest Road Engineer summarized road performance in a September, 2005 letter; “At this time, the road continues to service the forests with outstanding performance. The original surfacing is still intact. The 12% plus grades remain free of corrugations (washboarding) and we continue to maintain a smooth running surface to support an arterial transportation system which supports management of national forest resources. Since seeing the early success with the New Blaine Road, we have continued to use these products with the same results.” http://stabilizationproducts.net/docs/18640.pdf



EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

Forest Road Stabilization
- Arizona

The Coronado National Forest in southeast Arizona is known for its high altitude *Sky Islands*, mountains rising up in near proximity to low altitude desert areas. Apache leaders Cochise and Geronimo hid from the U.S. Calvary troops in these mountains. Because of the remoteness of location, Forest Service engineers used innovative technology in construction of a section of Portal Road. They used a mobile rock crusher to pulverize creek-run cobbles and gravel on top of the road grade, and they stabilized the resulting aggregate mixture as part of the same process. Pictured above left is the mobile rock crusher working its way through a windrow of creek-run material that has just been treated with the EMC SQUARED System stabilizer solution. The road that was constructed with this stabilized aggregate mixture provided a low maintenance running surface for a two year period, in an incremental or staged construction sequence, before the road was surfaced with hot mix asphalt pavement. http://stabilizationproducts.net/docs/18637.pdf

BLM Road Stabilization
- Arizona, New Mexico and Utah

The USDI Bureau of Land Management (BLM), similar to the Forest Service, has thousands of miles of dirt and gravel roads to maintain in remote areas far from road maintenance crews. BLM crews and road contractors in southwestern locations have been using EMC SQUARED System treatments for over twenty years to stabilize soil and aggregate materials for dirt and gravel roads, remote landing strips and, in particular, to armor newly placed aggregate surfacing as roads run through arroyos where seasonal overtopping with flood waters cannot be avoided. This is one type of application where the effectiveness of the EMC SQUARED System is dramatically apparent. These stabilized road surfaces undergo water overtopping, for a period of days in some cases, without significant loss of aggregate surfacing. Pictured above right is a section of Quail Hill Road, connecting St. George, Utah, with the north rim of the Grand Canyon. Starting in 1996, sections of Quail Hill Road have been sequentially upgraded with stabilized aggregate surfacing and treated soil surfacing as funding has permitted. Continuing utilization of the EMC SQUARED System on BLM road systems is testimony to the broad spectrum effectiveness of the stabilizer treatments. http://stabilizationproducts.net/docs/18649.pdf

Canadian Border Road Stabilization
-Minnesota

The Minnesota Department of Transportation (MnDOT) funded a six mile long gravel road stabilization project in the northernmost portion of the state of Minnesota, working with Lake of the Woods County through the Local Roads Research Board of Minnesota. A statewide survey determined that a typical aggregate surfaced road in Minnesota is graded on average every 8.6 days. A goal of this field installation was to identify a stabilization treatment that could retain gravel materials (in this case, a nonplastic pit run gravel) and maintain the paving grade over a period of months or years. The road selected, Northwest Angle Road, which is located out on the end of a wet and wooded peninsula, is in a portion of the United States that is accessible only by driving through Canada, or by boating up the middle of Lake of the Woods through U.S. Waters to reach this isolated portion of Lake of the Woods County. North Angle Road runs across swampy terrain and supports logging truck and recreational vehicle traffic. Prior to application of the **EMC SQUARED** Stabilizer treatment to three inches of new pit run gravel surfacing and other reconstruction measures, this road had required two to three maintenance gradings per week. At last report, after thirteen years of service, the County Engineer reported that the stabilized running surface remained in excellent condition. Considering the poor quality pit run aggregate, the near proximity of ground water, the extreme cold climate, and service as a running surface for logging truck and vehicular traffic without protection by asphalt pavement or bituminous surface treatment, the EMC SQUARED System again proves effective under what are truly “worst case” field testing conditions. For more info, see http://stabilizationproducts.net/docs/18634.pdf

EMC SQUARED® System - Project Reports
Stabilization of Aggregate Materials

FHWA Experimental Feature Project - Alaska

The *Pipeline Haul Road*, known today as the Elliott Highway and further north as the Dalton Highway, was built to service the Prudhoe Bay oil fields and the Trans-Alaska Pipeline. It presents a maintenance challenge for Alaska Department of Transportation & Public Facilities (ADOT&PF) staff with 450 miles of gravel-surfaced road servicing year-round heavy truck traffic in severe conditions common to cold regions. In late spring of 1991, approximately 2.5 miles of new aggregate surface course material was treated with an EMC SQUARED® System application to a depth of six inches on the Elliott Highway, beginning at the transition from asphalt to gravel surfaces. This section of road was selected both because of its proximity to Fairbanks (for convenient monitoring) and its assortment of severe superelevated curves, reportedly the worst on the entire length of gravel road. The project was funded by the Federal Highway Administration (FHWA) as an Experimental Feature Project. State quality-control technicians provided tight moisture and compaction control inspection and grade controls were carefully observed to ensure alignment as a running surface for the expected high-speed traffic.

Late 1992, after two summers of service with only minor touch-up in the superelevated curves, the section stabilized with the EMC SQUARED System treatment was described as being essentially maintenance free. Involved ADOT&PF staff unanimously gave the stabilized road section an excellent performance rating. The supervisor of an independent materials testing laboratory involved in monitoring the project made two site visits during late September 1993. He reported only a few small potholes on the stabilized section, located in the worst stress area of the superelevated curves, no larger than "half a grapefruit." After five summers of service without protection of pavement or a surface treatment, state maintenance crews applied an experimental bituminous surface treatment to the stabilized test section in late summer 1995 after reworking the top 2 inches of the treated aggregate to prepare the surface. An October 1995 inspection after application of the bituminous surface treatment verified that the stabilized section of highway continued to provide excellent alignment, easily supporting driving speeds of 70 mph, whereas much of the adjacent 3-year-old asphalt pavement was unsafe to drive at 55 mph due to the development of "roller-coasters" resulting from serious differential settlement problems. This was an interesting and dramatic example of the unique moisture barrier performance of EMC SQUARED System treatment and its direct benefit retaining the smooth running alignment of the newly constructed road. The adjacent section of asphalt pavement developed severe roughness within the first year after full depth reconstruction. The roughness in the asphalt pavement developed in spite of the six-inch thickness of the pavement layer and the fact that the six-inch thick aggregate base course underneath was constructed with an asphalt emulsion treatment many times the cost of the adjacent EMC SQUARED System treatment. For more information, go to http://stabilizationproducts.net/docs/18643.pdf

Performance In Cold Regions

As indicated in the Laboratory Technology section on pages 37, 38, and 39, where examples of test results are reported, EMC SQUARED System applications can be highly effective in strengthening aggregate materials and treating their moisture and frost susceptibility, so that they retain their full strength in wet and freeze-thaw cycling as well as dry conditions. In cold climate locations, the ability to resist moisture infiltration becomes twice as important as the presence of free water within the untreated aggregate layer leaves the layer subject to damage during the freeze-thaw cycles typical of fall and spring weather conditions. Effective stabilization of aggregate materials in cold regions is a dramatic testimonial to the EMC SQUARED System as these are worst case situations. The reports for the projects located in Alaska, Minnesota, North Dakota, and mountainous areas in Arkansas, Arizona, Colorado, Nevada, New Mexico, and Texas address the performance of the EMC SQUARED System stabilization treatments in Cold Region locations with frequent freeze-thaw cycles. The sample labeled Alaska was collected from the FHWA Experimental Feature Project stockpile. The Nevada labeled sample refers to the road base stabilization project in the mountains east of Reno that is summarized on page 19. As demonstrated in the field performance of these stabilized aggregate materials, the similarity to asphalt and concrete in this laboratory testing series is no accident.

EMC SQUARED® System - Project Reports
Stabilization of Recycled Aggregate Materials

Full Depth Reclamation (FDR) - New Mexico Interstate 40 Freeway

Traditional reconstruction of interstate freeways requires detouring traffic from one side of the freeway to the other. A four-lane freeway, for instance, becomes a dangerous and slow two-lane highway with traffic in opposing directions until construction on all four lanes is completed. The need to move all traffic to the other side is necessitated by traditional reconstruction methods that rely on complete removal of the old pavement, base and subgrade materials. This leaves an excavation as deep as two feet or more below pavement elevation, a difference in grade that would be an unacceptable safety hazard if freeway traffic was allowed to continue close to the excavation while construction was in progress on an immediately adjoining lane. The ability to instead keep traffic moving in the adjoining lane, by utilizing in-place pavement recycling and base stabilization, as pictured above, limits the impact of the required detour on freeway traffic in regards to speed reductions and safety hazards. Three of four traffic lanes can remain open to traffic. Construction is greatly speeded by eliminating the need to remove and replace the base and subbase and stabilize subgrade soils. Construction is further speeded and reduced in cost by elimination of temporary detour crossing roads, temporary barriers and other safety measures necessary while the excavation in conventional reconstruction projects remains open.

When analyzing the overall savings potential on a seven-mile section of freeway that could result from use of in-place recycling and base stabilization, New Mexico Department of Transportation (NMDOT) engineers forecasted a cost-savings of approximately forty percent. Based upon these economics, the Federal Highway Administration (FHWA) agreed to fund a Demonstration Project on a mile long section of the I-40 eastbound lanes (west of Gallup, New Mexico). The existing structural section to be recycled in-place included the original concrete pavement, eight inches thick with metal dowels between the slabs, and a seven-inch thickness of accumulated asphalt overlays. Included in this recycled mixture would be geotextile fabrics used between the asphalt overlays, accumulated crack sealer placed over the years by state maintenance crews and some cement treated aggregate from the old base course below.

Key to this in-place recycling and base stabilization concept was innovative equipment and stabilizer product technology. A large pavement pulverization machine known as a Roto Trimmer was capable of crushing the full pavement depth (15 inches of asphalt and concrete plus additional base course from below) in a single pass. The EMC SQUARED System treatment had proven effective in stabilizing recycled aggregate mixtures for use as high-strength flexible base layers and could be metered into the mixing chamber of the Roto Trimmer during a second mixing and pulverization pass. The recycled aggregate was reduced to a gradation with one (1) inch maximum rock size. In conjunction with the Roto Trimmer equipment and EMC SQUARED System stabilization treatment, a unique piece of equipment known as an Impactor was used for multiple functions essential to this project specific construction process. The Impactor is a multi-purpose impact roller towed behind a tractor. It is capable of breaking and rubblizing asphalt and concrete pavement, of compacting thick layers of aggregate base rock to high density, and of compacting native subgrade soils to a depth of four feet or more. All these capabilities were called into play on the I-40 Demonstration Project.

In the actual construction sequence, the pavement was first broken up, or rubblized by multiple passes of the Impactor, then pulverized by the Roto Trimmer and stabilized with the EMC SQUARED System treatment on a second pulverization and mixing pass. The treated recycled aggregate mixture was then given five passes with the Impactor to compact the treated layer and to consolidate the compressible subgrade soils below. Once this was completed, the treated recycled aggregate was trimmed down several inches to paving elevation and compacted with a smooth drum vibratory roller in preparation for placement of nine inches of asphalt pavement surface course. The excess recycled aggregate was used to extend the highway shoulder.

Due to the extremely saturated native subgrade conditions under this section of freeway, only one of the two lanes of the demonstration project was completed using this in-place recycling and stabilization

EMC SQUARED® System - Project Reports
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process. The adjoining lane was reconstructed by conventional methods with as much as six-foot deep excavations to remove wet soft subgrade soils. While the in-place method could have been continued on top of these worst-case native subgrade conditions by applying slightly less compactive force through the stabilized layer, state engineers elected to err on the side of caution and resort to their conventional approach. For the conventional section, two feet of subgrade soil was removed throughout, with some problem areas subject to deeper excavation. The excavation was then backfilled with untreated asphalt millings and covered with geotextile separation fabric. A sixteen-inch layer of untreated recycled aggregate base (from the in-place recycled aggregate produced by the Roto Trimmer) was placed, followed by nine inches of asphalt pavement surface course.

The FHWA Area Engineer for the Demonstration Project continued to monitor project performance through visual observation and review of the annual IRI, or profilometer, monitoring conducted by NMDOT as mandated by FHWA. Three and a half years after construction, he reported that the pavement constructed on top of the stabilized recycled base had remained the smoothest running in that segment of freeway. The performance of this FHWA Demonstration Project on Interstate 40 is most interesting as NMDOT engineering staff had reported that this particular section had a historic recurrence of three years between full depth reconstruction due to a frequency of highly saturated expansive clay soil deposits under the freeway alignment. The adjoining lane constructed by conventional construction (excavation and import) was significantly rougher riding and required full-depth repair in three areas. He also reported that the demo project was eventually buried under new highway construction as the elevation was raised several feet in conjuction with a new bridge and freeway undercrossing structure. The NMDOT engineer monitoring the new construction reported that the stabilized base course was in excellent condition when the asphalt pavement was removed prior to raising the grade to accommodate the new undercrossing.

Samples of the stabilized recycled aggregate mixture were collected during construction and subjected to Resilient Modulus testing at the Materials Research Center and the University of New Mexico (UNM) ATR Institute under the supervision of research engineer R. Gordon McKeen. While untreated virgin aggregate typically tests in the range of 20,000 to 50,000 psi, the stabilized recycled aggregate tested at 234,000 psi, closer to the load carrying capability of a hot mix asphalt material. Given the laboratory performance of this stabilized base course mixture underlying the asphalt pavement on the Demonstration Project, the performance of the stabilized base course is no surprise.

For more information, go to http://stabilizationproducts.net/docs/18789.pdf

Recycled Aggregate Materials

Aggregate materials are mined from riverbed deposits and hard rock quarries. They are a non-renewable resource that is vanishing from near proximity to most urban areas. One-way haul distances to new sources of virgin aggregate materials are now often in the range of sixty to one hundred miles from the project site. Fortunately, recycling technology has improved to the point where a large portion of the old asphalt and concrete pavement is being milled and crushed for reuse during highway reconstruction projects. While these recycled aggregates are often substandard to virgin aggregate materials, they typically have the potential for outstanding performance when upgraded with EMC SQUARED® System treatments, providing strong but flexible layers similar in load carrying capacity to hot mix asphalt. For example, a recycled aggregate containing both asphalt millings and crushed concrete materials, was tested by Kleinfelder, Inc., following application of an EMC SQUARED System treatment. Using the Marshall Test apparatus (a standard test for evaluating hot mix asphalt pavement mixtures), they measured the Stability of the stabilized recycled aggregate material at 13,230 pounds, which is over twice the Stability of typical hot mix asphalt, and with a Flow value of 11, indicating a flexibility or elasticity in the stabilized layer similar to that of hot mix asphalt pavement materials. This impressive laboratory performance, where both high load carrying capability and flexibility are once again demonstrated, correlates well with the field performance of recycled aggregate materials stabilized with EMC SQUARED System treatments.


Port of Los Angeles


Mariposa County, CA

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Port Road Stabilization - California

The Port of Los Angeles was in the middle of a major facility expansion to accommodate the rapidly growing volume of container freight shipments. Pier 400, a $794 million expansion covering 484 acres, was constructed as the west coast hub for Maersk, the world's largest container ship operator. In addition to the Port's requirements for high performance products capable of addressing the load factors of heavy construction equipment and heavy truck traffic on the access roads, the site was expanded out into San Pedro Bay, so strict water quality regulations had to be addressed. Approval by the US Fish & Wildlife Service was also required because of an endangered species of bird that nests on site, the Least Tern. The EMC SQUARED System was selected for stabilization of the recycled aggregate surfacing layer composed of crushed pavement materials (known regionally as Crushed Miscellaneous Base, or CMB) for the Pier 400 access roads. The stabilized aggregate surfacing was treated with an environmentally friendly emulsion spray treatment. After two years as a stabilized surface course, servicing 400 to 600 heavy trucks per day, four inches of hot mix asphalt pavement was placed directly on top of the stabilized surface. As described by the Port of Los Angeles project engineers, the recycled aggregate material stabilized by the EMC SQUARED System treatment was still in such excellent shape after two years of service as a running surface that the contractor basically "brushed it off" and then began the asphalt paving operation. Full report at http://stabilizationproducts.net/docs/18639.pdf

County Road Base Stabilization - California

The County of Mariposa encompasses a large and varied land area in Central California, stretching from the foothill edge of the San Joaquin Valley up into the mountainous terrain of the high Sierra Nevada, including Yosemite National Park. In 1997, with funding available from the Federal Highway Administration (FHWA) for an upcoming road reconstruction project, the County took the initiative and specified a low cost mixed-in-place base stabilization treatment. Existing asphalt was milled and blended with imported aggregate and the mixture was then treated with EMC SQUARED System application to provide a stiffened and stable platform for the new asphalt surface. After ten years in service this five mile section of pavement remained in excellent condition and retained a smooth running surface. County road projects constructed without EMC SQUARED Stabilizer base course treatment provided a distinct contrast. Cracking was widespread in many locations. The crack sealing applications by the maintenance crews visually highlight the costs associated with paving on unstabilized base course materials. Additional info at http://stabilizationproducts.net/docs/18641.pdf

University Parking Lot Stabilization - California

Faced with a quandary – a need to put in something of so-called "temporary" classification that would function as a safe, low maintenance parking lot adjoining large student housing complexes, and to build it so that no sediment or contaminant materials would be generated and work their way into the adjacent natural drainages, the University of California's engineering consultants were searching for an appropriate product technology. The University wanted a functional and environmentally appropriate surface with a planned service life of one or two years, by which time they were expecting to have funding available to construct a new parking structure. The consultants were also challenged by University directive to make this a reality on a very low budget.

The University took the stabilized aggregate concept one step further. After their multi-acre parking lot was surfaced with the recycled aggregate material (known regionally as crushed miscellaneous base, or CMB), treated with EMC SQUARED System application and covered by a spray applied emulsion treatment, they decided to invest in the expense of painting parking lot striping to define an orderly parking pattern. The University facilities engineering staff commented that the stabilized surface performed well beyond their expectations as it eventually served as a parking lot surface for almost six full years. According to UCI Project Manager, the lot required no maintenance over the first five years, at which time they cleaned the lot and filled in a few depressions and repainted the parking stripes. He commented, "The service life of the lot was exceptional." In the sixth year, while the stabilized base course continued to be fully functional as a parking lot surface, the University decided to upgrade the parking lot from temporary to permanent status. For more info, go to http://stabilizationproducts.net/docs/18638.pdf

UC Irvine

Yuma County, AZ

EMC SQUARED® System - Project Reports
Stabilization of Recycled Aggregate Materials

County Road Stabilization - Arizona

Continued from page 11 – Reconstruction and stabilization work started with ripping and processing the upper 12 inches of asphalt and base materials. As soon as the pavement and gravel materials had been removed for processing by motor graders and an agricultural disc, high ground water conditions were discovered in the 800 feet of road at the westernmost end of the project. The distressed asphalt and base materials were crushed in place and then windrowed to one side. The subgrade soils under the intersections at the two ends of the project were excavated as deep as four feet and replaced with truckloads of 12 to 16 inch diameter stone. A six inch depth of the clay subgrade for the length of the road between the intersections was mixed and treated with EMC SQUARED Stabilizer and compacted. Once the clay layer was stabilized, additional aggregate base course materials were hauled to the site and blended with pulverized asphalt pavement materials to further elevate the road's structural section. The 12 inches of gravel and asphalt materials were treated with EMC SQUARED Stabilizer, rolled back into place in six inch lifts and compacted to form the stabilized base layer. The entire project was paved 2 to 3 inches deep with a cold mix asphalt surface course. Four months later a 3/8 inch minus chip seal was applied to complete the project.

After years of use, the County Highway Construction Supervisor reported that this road that was once a nightmare for the county was greatly improved. What was once the worst stretch of road in Yuma County became one of it's best examples of a sustainable farm to market arterial road, one that keeps the road maintenance budget for Yuma County under control while supporting the region's farm economy with an efficient and smooth running road.

City Expressway - California

The City of Clovis eliminated the traditional base course requiring 16,000 tons of Class 2 AB (640 truck loads) and replaced this section with a stabilized treatment of on-site subgrade soils and a stabilized 4-inch base layer comprised of recycled asphalt pavement (RAP) from the original roadway. See page 7 for the complete story.

Clovis, CA

EMC SQUARED® System - Project Reports
Stabilization of Recycled Aggregate Materials

Total Environmental Restoration Contract (TERC) - California

Cost saving military base closures were accomplished by significant environmental remediation requirements as these facilities are prepared for conversion to private sector utilization. The US Army Corps of Engineers managed a Total Environmental Restoration Contract (TERC) at Fort Ord, California, adjacent to Monterey Bay. In one phase of the project old landfills were excavated and consolidated within a single newly constructed landfill cell. The access and haul roads traversed sand dunes as they connected various work sites and the road alignment was a constant series of hills and curves. With an extended construction schedule and haul of 600 daily trips by dump trucks, an innovative road building program was used incorporating products that would stabilize the aggregate base rock surfacing materials and leave them clean of contaminants so that aggregate materials would be reusable for other road requirements once the access roads and haul roads were ripped up and removed at the completion of their use.

The roads were constructed with an aggregate base rock incorporating some crushed concrete material. This aggregate mixture was treated upon placement with EMC SQUARED Stabilizer to strengthen the structural section. The compacted surfaces were then treated with a light armor coat spray application of an environmentally friendly emulsion treatment to further bind the surface and provide dust control. The contractor maintained the haul roads with light sprays of the emulsion treatment applied as needed with their water truck from a bulk storage tank located on site. The haul road functioned as an efficient production tool and operations staff reported that this combination treatment “worked great.” The contractor was able to operate their access and haul roads for over a year without a single dust complaint. Haul trucks operated at nearly 100 percent availability, clearly demonstrating the cost-effectiveness of these advanced road construction product technologies on haul equipment efficiency.

For a copy of this project report, go to http://stabilizationproducts.net/docs/18642.pdf

One City Does It All

- Full Depth Reclamation
- Subgrade and Base Stabilization
- Aggregate Surface Course Stabilization
- Base Stabilization
- Stabilized Asphalt Millings Pavement Surface Course

The City of Gallup, New Mexico, has an impressive history of innovation in their engineering and street maintenance departments. Gallup is located at relatively high altitude just west of the Continental Divide in the southern end of the Rocky Mountains. The area has severe winter conditions and frequent freeze-thaw cycling, compounded by low bearing strength clay subgrade soils that are often in highly saturated condition. To compound the problem, the local aggregate supplies have clay content and are typically moisture and frost susceptible. If necessity is the mother of invention, city staff had good reason to be innovative.

While public agencies with road systems will admit that they have expensive problems, most will not accept the fact that they own both the problem and the responsibility to find solutions on a timely basis. The conventional wisdom is that it is better to wait until someone else solves the problem, regardless of the burden on taxpayers and the mounting backlog of deferred road maintenance. The City of Gallup has been fortunate to have staff whom have not bought into this attitude. They did their research and moved forward with implementation at a deliberate pace over a period of years as they identified effective answers. Their local county road department and state department of transportation had not previously identified cost-effective solutions. City staff had the confidence to both own and solve their own problems. Five years later the state DOT followed their lead, with strong encouragement and funding support from the Federal Highway Administration. The City of Gallup deserves recognition for promoting a problem-solving approach. The following case studies support the economic benefits.

After reviewing technical information on the EMC SQUARED® System and contacting other public agency personnel with previous field experience, the City's first experience was a Full Depth Reclamation (FDR) project, recycling the distressed asphalt access road to their corporate yard facility. The existing asphalt pavement and aggregate base materials were pulverized and mixed with the stabilizer solution by an asphalt reclaimer mixing machine. After proving out the 9-inch thick stabilized layer under their daily truck traffic, they surfaced the stabilized base with new asphalt pavement. This pavement remained in excellent condition.

The City was in the process of taking over an area from the county known as the South Annex. The street maintenance crew inherited almost five miles of potholed roads that were so deteriorated that winter access had become problematic even for four-wheel drive vehicles. The City first reviewed the stabilization program using cement, but their previous experience indicated that it would be five times the cost of the EMC SQUARED System treatment, slower to construct, and in need of immediate protection with an asphalt pavement surface course. EMC SQUARED System treatment was the clear choice given their limited budget. Using the asphalt reclaimer equipment once again, the city street maintenance crew mixed in the EMC SQUARED System treatment as they placed six inches of new gravel surfacing over the five miles of streets. The stabilized streets serviced industrial and commercial businesses, public schools and residential neighborhoods. The street superintendent reported that the stabilized aggregate streets required almost no maintenance and mentioned that the only complaint came from contractors cutting utility trenches through the stabilized base as they were unable to cut through the stabilized layer with tractor mounted backhoe equipment. Similar to their experience with cement treated base materials, cutting the utility trenches required the use of jackhammer equipment to penetrate the stabilized and highly bound layer.

The aggregate material from the street surfacing project was sampled and shipped to the Texas Transportation Institute (TTI) where it was evaluated in Suction and Dielectric testing (Tube Suction) along with other aggregate materials, and reported in the New Mexico test results on page 38 in the "Laboratory Technology" section. The test results indicated that the untreated aggregate would be highly unstable in the presence of moisture or during freeze-thaw cycles. This correlated with the City's historical experience. Results for the same aggregate material treated with the EMC SQUARED System indicated that the stabilized aggregate would retain its full strength, regardless of weather conditions, as specimens tested similarly to asphalt and concrete pavement. This test result was again verified in actual field performance.

Aggregate Stabilized with
EMC SQUARED® Stabilizer
(utilized for two years as a street surface)

Asphalt Millings (RAP) Stabilized with
EMC SQUARED Stabilizer
(utilized for five years as a street surface)

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Stabilization of Recycled Aggregate Materials

Two years after the stabilized aggregate surfacing was placed on the streets of the South Annex, the City was given access by the New Mexico Department of Transportation (NMDOT) to a large stockpile of recycled asphalt material milled off the surface of a nearby state highway. The street maintenance crew once again used their asphalt reclaimer machine to mix in the EMC SQUARED System treatment as they constructed a three inch thick pavement with the stabilized asphalt millings materials. After five years of maintenance-free performance the City allocated the budget to overlay the stabilized asphalt millings surface with hot mix asphalt pavement. The City's Street Superintendent reported that they filled in no more than a dozen small potholes in the entire five mile stabilized asphalt millings surface in preparation for placement of the hot mix asphalt overlay.

Coring Conducted March 28, 2003

Several days prior to placement of the asphalt overlay local geotechnical engineering firm AMEC Earth & Environmental Inc. cored the stabilized asphalt millings pavement in a number of locations as well as coring through the stabilized asphalt millings layer and the stabilized base course layer at one location. As the core samples pictured here clearly illustrate, the EMC SQUARED System treatment was effective in producing well bound flexible pavement layers that were water resistant and wear resistant under vehicular and truck traffic.

While the City of Gallup has included EMC SQUARED System treatment in ongoing projects for stabilization of aggregate surfaced roads and other aggregate base course layers, a parking lot reconstruction project at the Gallup City Airport presented unique stabilization challenges which deserve special mention. Similar to the NMDOT projects earlier discussed on Interstate 40, the subgrade under the parking lot was essentially a muddy bog. Saturated clays extend down far below the parking lot base course grade. Conventional lime stabilization was not feasible as any wind-blown lime would damage aircraft parked down wind. The contractor instead utilized an EMC SQUARED System application to gradually bridge the deeper soft subgrade, applying increasing compactive effort as the stabilizer treatment gradually stiffened the layer. The stabilizer treatment was then applied to the eight inch thick base course layer prior to placement of the asphalt pavement. This section of parking lot remained in excellent condition in spite of the problematic subgrade conditions below. For more information, go to http://stabilizationproducts.net/docs/18636.pdf

Advances in Technology Have Converged

Product Technology
Laboratory Technology
Field Monitoring Technology
Design Methodology

The historic ground rules for chemical stabilization of soils were set in the 1950's and were based upon cement and lime. The design system relied upon the relatively simplistic laboratory tests of the period, essentially limited to strength tests, and a less advanced understanding than we have today about soil properties, the mechanics of moisture movement through soils, the effects of dynamic loading by car and truck traffic, and the environmental factors that affect each layer in the road structural section. These 1950's era products and design methodologies still have a strong hold on a segment of the overall market, but their high cost of use necessarily limits their application.

The EMC SQUARED® System approaches the task of stabilization from an entirely different direction than cement and lime and its benefits show up far more clearly with the recent introduction of modern test methods, modern field monitoring and modern highway design methodologies. The EMC SQUARED System is a product technology that is well suited to advanced testing procedures and design methodology and at a fraction of the cost of cement and lime treatment. This is a time of convergence, a convergence of advancements in product technology, advancements in laboratory technology, advancements in field monitoring technology and advancements in design methodology.

Older laboratory tests and design systems automatically select the conventional choices – thick layers of aggregate base course and an occasional subgrade treated with cement and lime. It's the advent of the newer testing and design methodology that sets the stage for widespread implementation of the more innovative and economical technology.

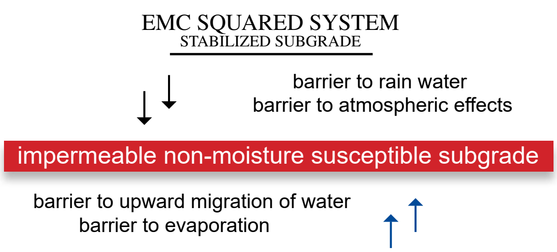
EMC SQUARED®

The Product Technology

The EMC SQUARED System (EMC^2) — Clean. Green. Low Cost. Concentrated power to improve stability of aggregates and soils. Applied with pre-established engineering controls and construction procedures during the moisture conditioning and compaction process. Preconditioning silts to behave more like siltstone, aggregates to become more like conglomerates, and clays to become more like clay stone, making them more stable in moisture content and more naturally cemented. Stabilization Products staff have participated in problem solving for thousands of projects, interacting with designers on stabilization challenges on every continent, from arctic to desert to tropical climates, and working on every sort of application from containment of hazardous and radioactive wastes to projects accessing nature preserves, from remote oilfield access roads to airport and freeway projects.

When cement and lime are utilized for soil stabilization treatment, they typically create rigid soil layers that provide strength without necessarily reducing moisture flow through the layer. Rigid layers are subject to cracking, similar to concrete pavements, which must be constructed with expansion joints to compensate for natural shrinkage phenomenon that otherwise propagate random cracking. In soil and base course stabilization there is no way to provide expansion joints, so cracking is an expected side effect of cement and lime treatment. This reduces their overall effectiveness and often subjects pavements above to reflective cracking generated from below.

EMC SQUARED® System treatments, on the other hand, typically create layers with improved flexural stiffness, more similar to the properties of hot mix asphalt, a flexible pavement. The EMC SQUARED System layer supports loads without a tendency to cracking. Equally important, EMC SQUARED treatments ordinarily 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. Stabilization in this manner is largely achieved by stabilizing moisture content in the constructed layers and soils below, rather than by constructing a single rigid layer with cement and lime treatment that remains susceptible to moisture flow moving through the layer. As evidenced in field monitoring 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 treated layer.



EMC SQUARED System products are unique and uniquely effective. The moisture barrier aspect separates them from cement and lime. Their ability to beneficially improve soils with organic and high sulfate contents, and their capacity to stabilize gravel-surfaced roads discriminates the EMC SQUARED System products apart from cement and lime. The facility to cost-effectively treat such a broad spectrum of aggregate and soil materials differentiates the EMC SQUARED System from any other form of soil stabilization treatment.

Laboratory Technology

Advances are being made in the materials laboratory in regards to the testing of aggregate and soil materials used in construction of transportation structures and earthworks. The very simplistic tests developed more than fifty years ago and still conducted on apparatus designed in that era provide an index number, such as Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR) and Resistance Value (R-Value). These test methods are slowly but surely being replaced by methods that more closely approximate actual field service conditions and that actually attempt to predict field performance. These older laboratory tests most often modeled “worst case” conditions that could only be answered with extraordinarily expensive road designs that relied on thick layers of aggregate base rock and cement or lime treated soil. In spite of the tremendous expense in building roads according to designs based upon these index tests, the road structures have often deteriorated rapidly due to dynamic loading and environmental factors not well addressed by the older tests. These old test methods have been written into public agency design manuals, accounting for their amazing longevity despite the availability of more sensitive modern test methods that provide improved correlation with field performance.

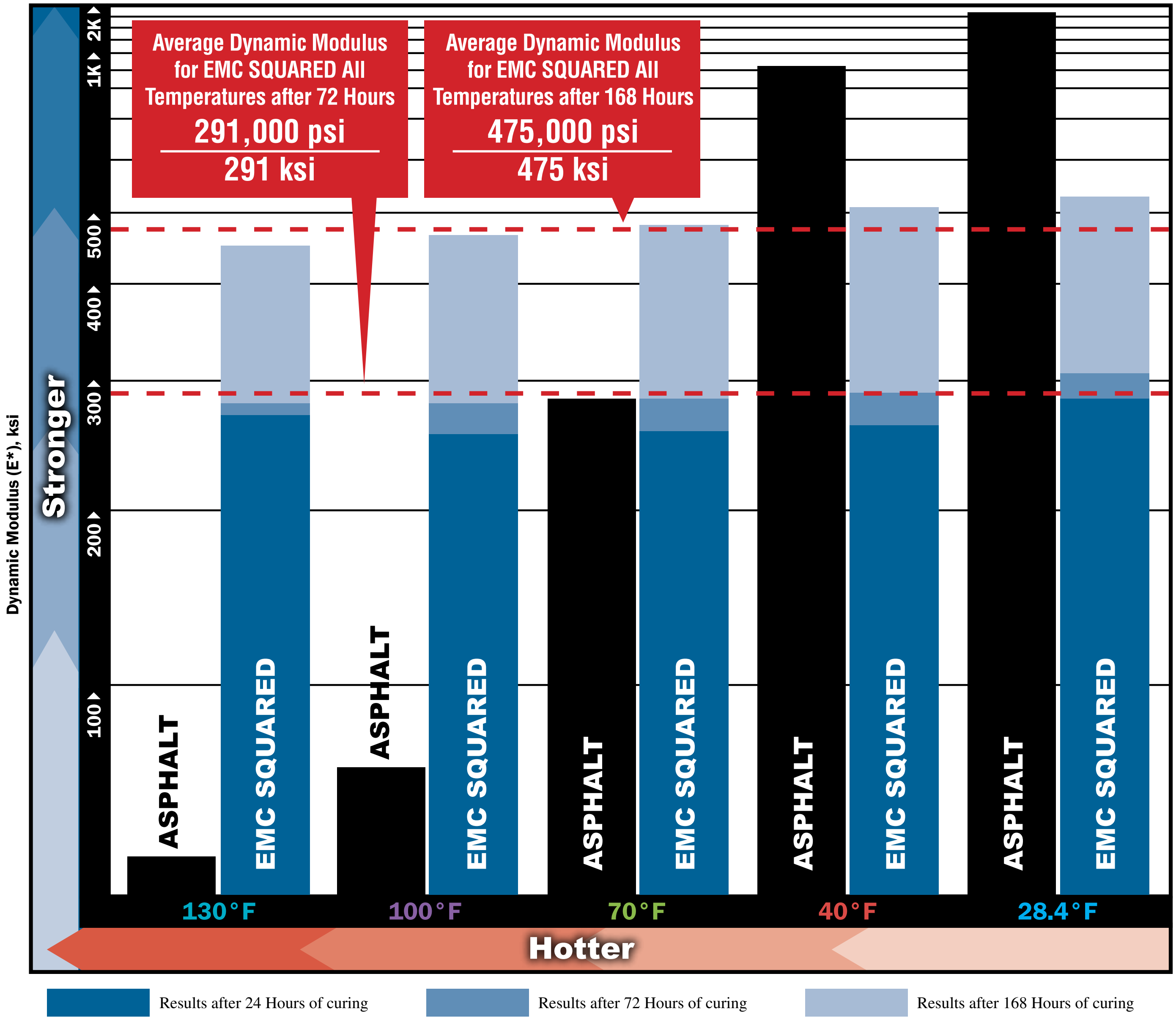
Dynamic Modulus Testing

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.

Dynamic Modulus Setup

The EMC SQUARED Stabilized Aggregate materials were subjected to laboratory evaluation at the Western Regional Superpave Center, one of five centers established by the Federal Highway Administration (FHWA) to support the implementation of the Superpave Technology for hot mix asphalt materials, included both Dynamic Modulus (E*) and Repeated Load Triaxial (RLT) testing. These are the state of the art test methods for evaluating Hot Mix Asphalt (HMA) materials and providing input for AASHTO MEPDG pavement designs. EMC SQUARED Stabilized Aggregate materials exhibit flexible, or elastic behavior, and modulus values most similar to HMA materials. Consequently, those test methods are equally appropriate for evaluation of EMC SQUARED Stabilized \Aggregate materials and for pavement design purposes. The study found that the Dynamic Modulus property of the stabilized aggregate after one week of curing was in the range of 450,000 to 500,000 psi and that it was a very stable material that could be expected to resist permanent deformation very effectively and without excessive stiffening and risk of shrinkage cracking. The final report states “The combination

Dynamic Modulus Data for Typical HMA Mixture and EMC SQUARED® Stabilized Aggregate Mixture



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. The original charts, including the Repeated Load Triaxial results, may be seen at http://stabilizationproducts.net/docs/18678.pdf

of the elastic behavior of the EMC SQUARED stabilized aggregate material with its good level of long-term modulus makes it an appropriate choice for pavements serving heavy loads at slower speeds (worst case conditions) as well as for pavements subjected to standard loading conditions." Unlike HMA materials, which are weakened by increasing temperatures and slower loading conditions due to their highly viscoelastic nature, the study found that changes in loading frequency and temperature, from below freezing to 130^{O}F temperature, had minimal impact on the modulus of the EMC SQUARED Stabilized Aggregate, and that the EMC SQUARED Stabilized Aggregate can therefore be represented by an average constant Dynamic Modulus property of 475,000 psi, versus the Master Curve required for HMA, which dramatically fluctuates in modulus value with changes in temperature or loading conditions.

As an example of a severe service application, it should be noted that the EMC SQUARED Stabilized Aggregate materials for this laboratory evaluation were sampled during the construction of military heavy haul road projects designed by the U.S. Army Corps of Engineers (USACE). This high-strength stabilized aggregate material was plant-mixed and placed by asphalt paving machines as a surface course, or running surface, to be used by convoys of military battle tanks and other tracked military equipment as well as heavy haul trucks weighing over 120 tons when fully loaded. The EMC SQUARED System Stabilizer product was specified by USACE for stabilization of subgrade soils as well as stabilization of aggregate surface course materials for 117 miles of heavy haul road construction projects. Of additional interest, the stabilization of subgrade soils eliminated the need to manufacture and transport over 1 million tons of crushed aggregate subbase material that otherwise would have been required for these projects.

Repeated Load Triaxial Testing

The Typical Deformation Curve for HMA Mix and the Permanent Deformation Characteristics of the EMC SQUARED Stabilized Aggregate, are developed from the results of Repeated Load Triaxial (RLT) testing. RLT testing measures the resistance of a material to rutting and permanent deformation. In comparison to the HMA Mix, the EMC SQUARED® Stabilized Aggregate Mix showed only 0.1% permanent axial strain. The report on the testing indicated that the deformation characteristics of the stabilized aggregate are expected to remain constant at all temperatures used in the related Dynamic Modulus testing and that the stabilized aggregate is not anticipated to generate any permanent deformation under a wide range of loading conditions.

The resistance of the EMC SQUARED Stabilized Aggregate material to permanent deformation evaluated in RLT testing resulted in a finding that under a wide range of loading conditions no permanent deformation would be anticipated. Furthermore, even in the worst case conditions for a flexible pavement layer, which are slow moving loads in hot environments, the behavior of the stabilized aggregate "...makes it a good candidate for pavements loaded under such severe conditions." according to the report.

Repeated Load Triaxial Setup

For more information on Dynamic Modulus and Repeated Load Triaxial Testing, go to http://stabilizationproducts.net/docs/18678.pdf

Resilient Modulus Testing

Resilient Modulus testing of road building materials has long been available, but it's only in the last several decades that nationwide attention has been focused on this particular test method. Resilient Modulus testing evaluates the response of pavement materials, base course materials and subgrade soils, to dynamic loading (representing repeated passes of loaded trucks over a pavement structural section). This is in contrast to the older generation tests, which rely on a single application of the test load and no measurement of axial deformation of the test specimens. A federally funded program was conducted to standardize laboratory-testing procedures in the interest of more reproducible test results. The Federal Highway Administration (FHWA) then funded studies and development of new design methodology based upon the laboratory results of Resilient Modulus testing. This AASHTO 2002 mechanistic-empirical pavement design procedure is now the required design method for federally aided projects. FHWA's long-term goal is to have all state transportation agencies fully adopt the AASHTO 2002 procedures as part of a nationwide standardization of testing and design methods.

Resilient Modulus testing measures the resilience of a material under repeated loading. Resilient Modulus testing provides a long needed laboratory testing procedure that more realistically characterizes the engineering properties of road building materials, and it provides a means to determine the equivalency of various materials in regards to their ability to support dynamic or repetitive loading. EMC SQUARED System treatments of aggregate base rock samples have in some cases, as illustrated below, produced stabilized layers with load carrying characteristics similar to that of hot mix asphalt. EMC SQUARED System treatments of soil samples have demonstrated equal or better performance than aggregate base layers and lime treated soils. This new ability to clearly demonstrate material equivalency using nationally standardized testing procedures will facilitate more widespread implementation of EMC SQUARED System stabilization technology.

RESILIENT MODULUS RESULTS AND LAYER EQUIVALENCY FACTORS

Sample ID	Average Resilient Modulus (psi)*	Layer Equivalency Factor**
Aggregate Base with EMC SQUARED	272,500	0.35***
Untreated Aggregate Base	51,000	0.10

*Resilient Modulus results reported by the University of Nevada, Reno
**Professional Service Industries, Inc.
***Standard practice in Southern Nevada is to assign a layer coefficient of 0.35 for dense graded hot mix asphalt

Tube Suction (Suction and Dielectric) Testing

Resilient Modulus testing has helped to illustrate the strength and flexibility that have long been evident in field applications of EMC SQUARED System treatments. Their unique effectiveness in treating the "affinity" of soil and aggregate materials for water (known as moisture susceptibility) has also long been evident in field applications, but not well addressed by older generation laboratory tests. These tests were simply not sophisticated enough to evaluate the moisture susceptibility of a particular aggregate or soil, or the effectiveness of a stabilizer treatment in addressing the moisture susceptibility problems specific to that material.

Fortunately, research conducted by the Texas Transportation Institute (TTI) and the Finnish National Road Administration (FNRA) has demonstrated that electrical properties, dielectric value and electrical conductivity, can be used to classify aggregate materials in regards to both strength and deformation properties as well as moisture and frost susceptibility. This test method, known as Tube Suction Testing (or Suction and Dielectric), has been incorporated in the National Cooperative Highway Research Program (NCHRP) for classification of aggregate materials. Many papers have been published by the Transportation Research Board (TRB) in the *Transportation Research Record* on this laboratory testing methodology, including a paper which reports on the effectiveness of the EMC SQUARED System.

The use of Tube Suction testing has proven out in evaluating the effectiveness of EMC SQUARED System treatments as it accurately measured the performances of aggregate materials following their field evaluation in both unstabilized and stabilized conditions while serving as running surfaces for gravel roads. The laboratory test results below correlate well with observed field performance. The untreated aggregate materials were highly unstable in the presence of moisture. Following treatment with EMC SQUARED® System applications, the stabilized aggregate road surfaces acted similarly to asphalt and concrete in their ability to retain strength in the presence of moisture while providing low maintenance running for surfaces servicing heavy truck and vehicular traffic.

Field performance is very important, but in a world where road design engineers have made a practice to use the materials testing laboratory as the basis for their design decisions, it's equally important to have success in the materials laboratory. Resilient Modulus testing and Tube Suction testing effectively translate the unique package of stability improvements available from the EMC SQUARED System product technology.

Aggregate Samples	Untreated	EMC SQUARED Stabilizer
Alaska	17.5	8.0
New Mexico	35.0	7.1
Nevada	17.3	7.7

SUCTION AND DIELECTRIC TESTING

References for Dielectric Constant Values of Highway Materials

MATERIAL	DIELECTRIC VALUE
Dry Aggregates	4 - 6
Asphaltic Concrete	5 - 7
Portland Cement Concrete	7 - 9

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

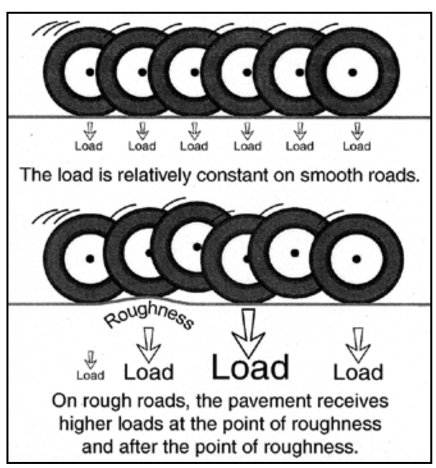
Advances in Field Monitoring

Prior to the introduction of modern non-destructive testing (NDT), the only ways to evaluate the performance of pavement structural sections were monitoring the rate they deteriorated to the point of repair and reconstruction, or destroying sections of pavement in order to excavate down through the various layers. Destructive test methods are similarly dated as the older generation of laboratory tests. They provide only a single point of analysis with no overall perspective or capability of comparative evaluation with national standards. Modern NDT methods allow for time efficient monitoring of entire road systems without any need for destructive coring or excavations through structural section layers. Additionally, the NDT information can be utilized to analyze the comparative performance of adjacent sections of road constructed with different materials and with different design methodologies.

International Roughness Index (IRI) and Falling Weight Deflectometer (FWD)

Sections of interstate freeway above subgrades constructed with EMC SQUARED® System treatments were monitored for performance over time by both the New Mexico Department of Transportation (NMDOT) and the Texas Department of Transportation (TxDOT). This population of projects has been in service for twenty years since the subgrades were constructed and includes two sections of Interstate 40 in New Mexico, a section of Interstate 30 in Texas, frontage roads for Interstate 635, as well as an additional group of highway projects. The pavement installations above subgrades constructed with EMC SQUARED System treatments have retained smooth running alignment, in contrast to the local experience with cement and lime treated subgrade soils. 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 actual field performance over time is the reality and smooth running surfaces are the ultimate goal.

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. The three primary NDT methods now in varying degrees of use are the International Roughness Index (IRI), Falling Weight Deflectometer (FWD), and Ground Penetrating Radar (GPR). Mandated for annual road system evaluation by the World Bank and by the U.S. Department of Transportation's Federal Highway Administration (FHWA), IRI testing is in international use as well by all 50 state transportation departments. FWD testing is used across the country on a more project specific basis. Both IRI and FWD testing are further described below as their application includes evaluation of stabilized base and subgrade layers. GPR testing at this time is primarily utilized to monitor the thickness of the pavement, base and constructed subgrade layers.



Pavement roughness leads to higher dynamic loads on localized pavement sections that increases pavement deterioration at those locations. This lowers ride quality and leads to a cycle of increasing deterioration rates and roughness severity.

International Roughness Index (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 criterion more directly than any other method of field monitoring. See http://stabilizationproducts.net/docs/18791.pdf

Falling Weight Deflectometers are capable of applying dynamic loads to the pavement surface and then monitoring the response of the pavement in terms of vertical deformation, or deflection, over a given area, in order to determine the actual load carrying capacity of the pavement structural section. The Resilient Modulus of the constructed pavement structural section can be back calculated with deflection data collected with Falling Weight Deflectometers, providing both input for the M-E Pavement Design and NDT monitoring of pavement structural section performance over time. Given the characteristics of base and subgrades stabilized with EMC SQUARED® System treatments, the FWD test results are typically going to be favorable to EMC SQUARED System applications as opposed to conventional designs utilizing layers of unstabilized aggregate base rock. For example, an expressway construction project for a California city was evaluated after construction with FWD testing. The one mile section of the expressway with twelve-inches of subgrade soils and a four-inch thick layer of asphalt millings stabilized with an EMC SQUARED System treatment provided a significantly higher modulus than the adjacent sections of expressway that were constructed with twelve-inches of aggregate base rock according to the conventional design methodology of the state departement of transportation. For more on FWD testing, see http://stabilizationproducts.net/docs/18673.pdf

Advancements in Design Methodology

The highway industry has long been hindered by a lack of standardization in testing, monitoring and design methodology. Each state has had its own department of transportation with its own set of standards and procedures. The Federal Highway Administration (FHWA) has promoted national standardization through AASHTO, the American Association of State Highway Transportation Officials, and these standards are typically used on federally aided highway projects. Prior to the recent introduction of the AASHTO 2002 program, design was based upon a highway field monitoring study (the AASHTO Road Test) conducted between 1958 and 1960 at a single location in Illinois, which had only modest traffic levels in comparison to the traffic volume of today. Starting in 1996, AASHTO sponsored the development of what is now known as AASHTO 2002 Mechanistic-Empirical Pavement Design Guide (MEPDG) , based upon an extended nationwide field-testing study and the use of Resilient Modulus laboratory testing. Mechanistic - Emperical Pavement Design (M-E) is far more sophisticated in regards to specific traffic loading, climatic conditions, design life and the ability to model real-world performance and changes in material properties. It facilitates better-informed decisions and takes advantage of new materials and features. M-E Pavement Design is already supporting the use of cost-saving EMC SQUARED System treatments and it will be fundamental to increasing the use of this advanced stabilization technology as more public agencies and engineering consultants become familiar and comfortable with the new design methodology.

Moving Forward —

Competing against products such as asphalt and cement, in use for over a century, and against lime with approximately seventy years of field use, it is understandable that EMC SQUARED System products are still viewed as the new kids on the block. It takes time to prove stabilization treatments out in the field. It takes time to prove them out with a vast assortment of aggregate and soil types. It takes time to prove them out in different climatic conditions. It takes time to prove them out with a broad spectrum of laboratory procedures and laboratory apparatus. EMC SQUARED System products are into their fourth decade of innovative soil stabilization product technology. EMC SQUARED System products are now on the way to achieving the status of an internationally recognized product technology. Soil and aggregate materials stabilized with EMC SQUARED System products have demonstrated permanence and resiliency for decades in extreme service conditions and at far lower cost than bulk applications of cement and lime products.

Aggregate supplies are being exhausted. Haul distances are increasing along with diesel fuel costs. Heavy trucks rapidly deteriorate road service life. Long hauls are increasingly unacceptable to the public agencies responsible for road maintenance and the taxpayers who are subsidizing new development by bearing these costs. Deteriorating air quality in many metropolitan areas is forcing change, and this is already beginning to impact developers and contractors as they are forced to mitigate the impact of large construction projects on air quality. EMC SQUARED product technology can save resources, improve road performance and dramatically lower construction costs while reducing wear on adjacent public road systems and reducing construction related air pollution. Advanced engineering and product technology can have beneficial impact on construction costs, service life and the environment.

As in past centuries, it often takes a convergence of advancements in related areas of knowledge and technologies before true breakthroughs are recognized and widely implemented. More refined laboratory, field monitoring and design methodology have systematically been introduced into the universe of highway and geotechnical engineering. The advancements in these related disciplines are essential to provide the logical basis for widespread implementation of breakthrough technology. The increasing acceptance of advanced stabilization technology demonstrates the fact that the EMC SQUARED System is a far more sophisticated stabilization technology than the bulk application of cement and lime.

Whether it's a case of replacing aggregate base rock with more economical soil stabilization treatment, or treating both aggregate base and soil subgrade layers to extend the smoothness and service life of newly constructed sections of freeway, a track record of success has been established. Applied with appropriate engineering controls, the EMC SQUARED System is highly effective in improving the stability behavior of a broad spectrum of aggregate and soil materials for service applications in a wide variety of climatic conditions. The product technology is both user friendly and environmentally friendly. It has significant cost advantages over conventional cement and lime treatment. The economics are so favorable that it opens up a far wider world of opportunity for the cost-effective application of stabilization treatments.

A Sampling of EMC SQUARED® System
LABORATORY TEST RESULTS

Stabilization of Soils

EMC SQUARED System vs. Lime Texas SH - 161 Project Testing

Prior to the application of the EMC SQUARED System for stabilization of expansive clay subgrade soils under the SH-161 section of the President George Bush Turnpike, the Texas Department (TxDOT) funded a research study at the Texas Transportation Institute (TTI).

For a summary of this research study and a picture of the completed freeway as the SH-161 alignment, see page 6. Results from six of the different laboratory tests that were conducted are summarized here.

Moisture Susceptibility Testing Using Electrical Property Measurements

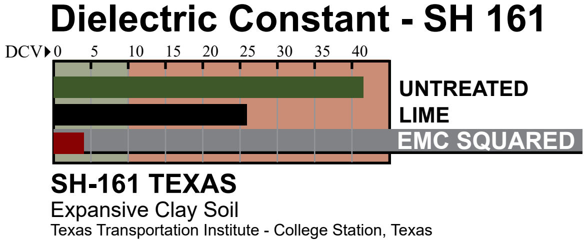
Texas Transportation Institute researchers subjected both untreated soil specimens and stabilized specimens to electric property measurement. One hundred milliSiemens per centimeter was set as the upper limit for Electrical Conductivity. Specimens testing above this value were classified as moisture susceptible and subject to loss of strength due to moisture infiltration. As indicated below, the Electrical Conductivity of EMC SQUARED treated SH 161 soil specimens remained well within acceptable tolerances prior to and following four months of moisture conditioning treatment.

Electrical Conductivity - SH 161
(EMC SQUARED)

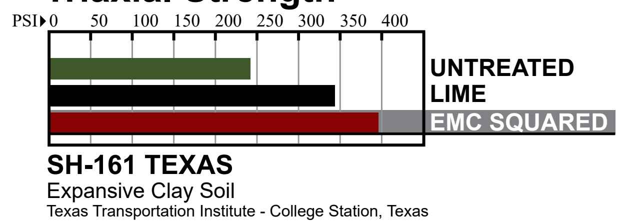
Dry	Moisture Conditioned
53.75 (mS/cm)	34.50 (mS/cm)

As indicated below, the dielectric measurements for the EMC SQUARED System treated specimens were well below 10, 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 15, 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 soil and the lime treated soil greatly exceed the upper limit for Dielectric Value. The test values indicate that both the raw soil and the lime treated soil are highly moisture susceptible.

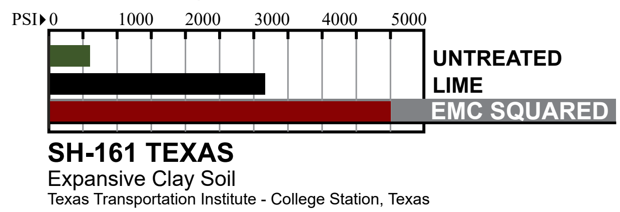
Dielectric Constant - SH 161



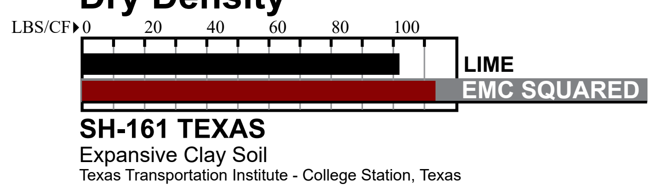
Triaxial Strength



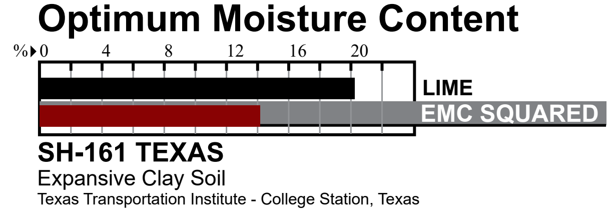
Triaxial Stiffness



Dry Density



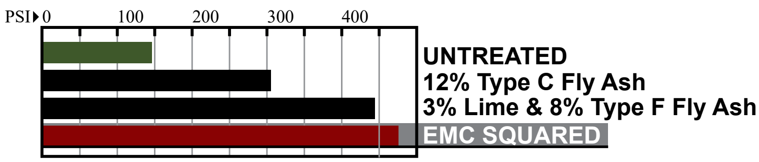
Optimum Moisture Content



Stabilization of Soils

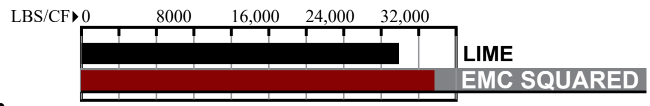
Expansive Clay
EMC SQUARED System vs. Lime

Triaxial Strength



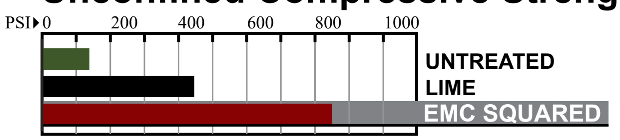
FRANKLIN COUNTY, TEXAS
Expansive Clay Soil
Terra Mar, Inc., Dallas, Texas

Resilient Modulus



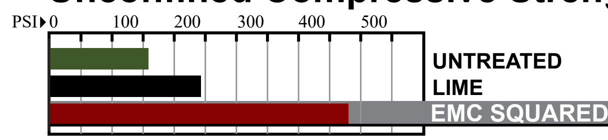
MENDOTA FEDERAL PENITENTIARY
Expansive Clay Soil
Kleinfelder, Inc., Fresno, California
(Terracon Consulting Engineers & Scientists)

Unconfined Compressive Strength



SH-N55 NEW MEXICO
Silty Clay
Kleinfelder, Inc., Stockton, California

Unconfined Compressive Strength

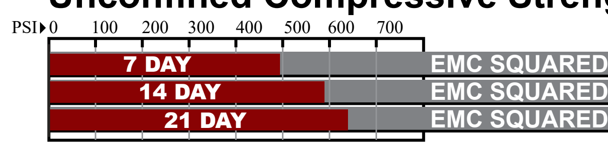


SH-N55 NEW MEXICO
Sandy Silty Clay
Kleinfelder, Inc., Stockton, California

Non-Expansive Soils
EMC SQUARED System

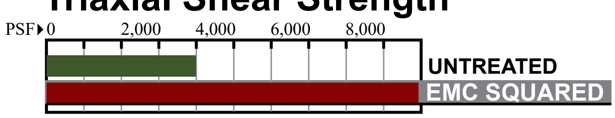
While expansive clay are often considered the most problematic soils due to their volume changing characteristics, shrinking in dry conditions and swelling in response to moisture, non-expansive soils can also be a problem. While non-expansive soils may not shrink and swell, they are subject to weakening with increasing moisture content if they contain fine particle silt and clay materials. EMC SQUARED System treatments are often applied to improve the all-weather stability and strength of low P.I. or granular soils with silt and clay content.

Unconfined Compressive Strength



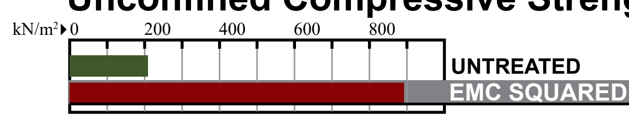
I-40 NEW MEXICO
Silty Clay Soil
New Mexico DOT Materials Bureau, Santa Fe, New Mexico

Triaxial Shear Strength



STATE OF CALIFORNIA
Silty Clayey Sand with Gravel
Kleinfelder, Inc., Santa Rosa, California

Unconfined Compressive Strength

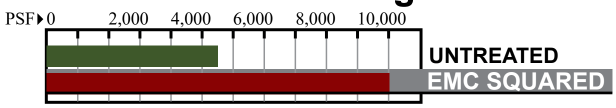


BALDWIN COUNTY, ALABAMA
Silty Fine Sand
Terra Mar, Inc., Dallas, Texas

Stabilization of Aggregate Materials

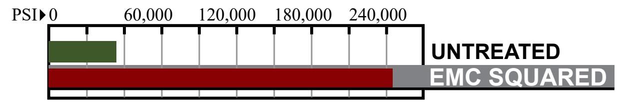
Aggregate Treatment
EMC SQUARED System

Triaxial Shear Strength



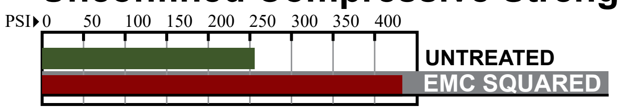
STATE OF CALIFORNIA
Aggregate Base (Non-Plastic)
Kleinfelder, Inc., Santa Rosa, California

Resilient Modulus



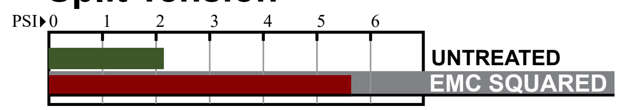
LAS VEGAS SPRINGS PRESERVE
Aggregate Base (Non-Plastic)
Professional Service Industries, Inc.
University of Nevada, Reno

Unconfined Compressive Strength



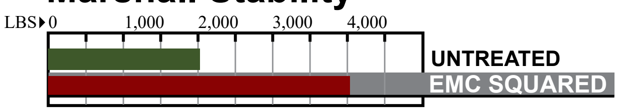
ALASKA DOT&PF - ELLIOT HWY
Aggregate Base (Plastic)
Shannon & Wilson Laboratory

Split Tension



USDA NATIONAL FOREST SERVICE ROAD
Aggregate Base (Non-Plastic)
Region 6 Materials Laboratory, Portland, Oregon

Marshall Stability

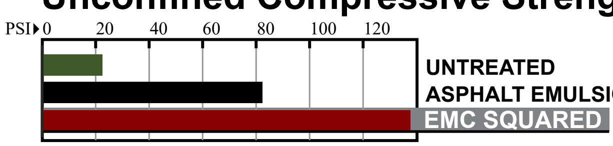


MISSISSIPPI DOT
Aggregate Base (Non-Plastic)
District 5 Materials Laboratory

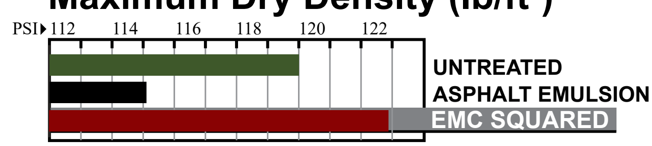
Aggregate Treatment
EMC SQUARED System vs. Asphalt Emulsion

Asphalt emulsions are used in some areas as binders for base course materials. Depending upon the rate and type of asphalt emulsion selected in the mix design, asphalt emulsion can run ten to twenty times the cost required for treatment than the EMC SQUARED System product for the same volume of aggregate. The results graphed below from a laboratory testing program at Oregon State University provide an opportunity to compare an EMC SQUARED Stabilizer treatment with a 6 percent asphalt emulsion treatment (CSS-1) in Unconfined Compressive Strength and Maximum Dry Density testing.

Unconfined Compressive Strength



Maximum Dry Density (lb/ft^3)



USDA NATIONAL FOREST SERVICE ROAD
Aggregate Base (Non-Plastic)
Oregon State University, Corvallis, Oregon

A Sampling of EMC SQUARED® System

LABORATORY TEST RESULTS

Stabilization of Aggregate Materials

Suction and Dielectric Testing (Tube Suction)

References for Dielectric Constant Values of Highway Materials

MATERIAL	DIELECTRIC VALUE
Dry Aggregates	4 - 6
Asphaltic Concrete	5 - 7
Portland Cement Concrete	7 - 9

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indicates that the aggregate is wet or water saturated and extremely moisture and frost susceptible

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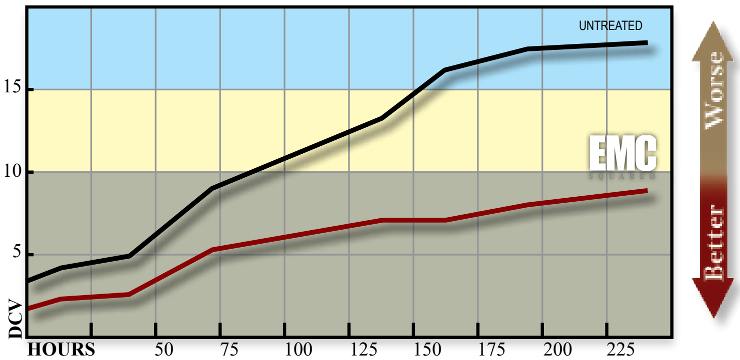
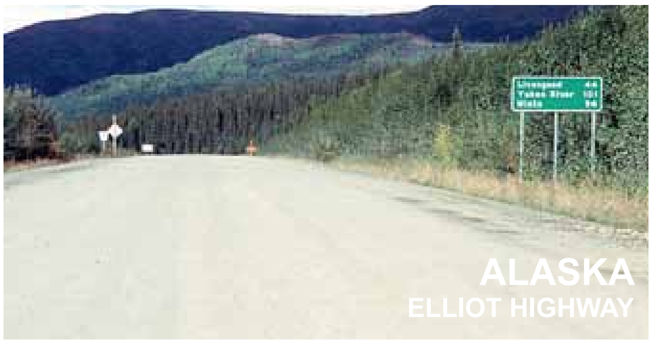
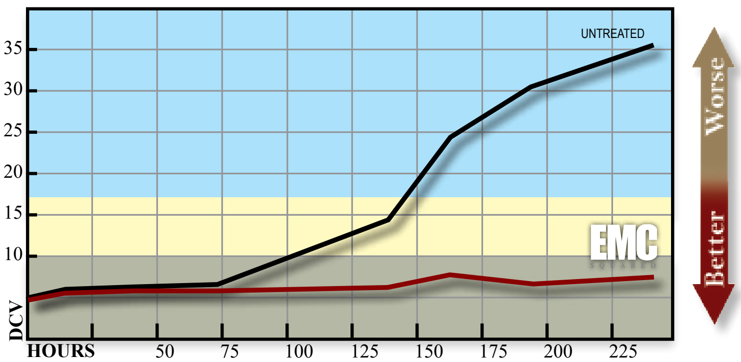
indicates that a significant amount of free water has accumulated within the aggregate during the testing period and is a warning signal that the material is moisture sensitive and frost susceptible

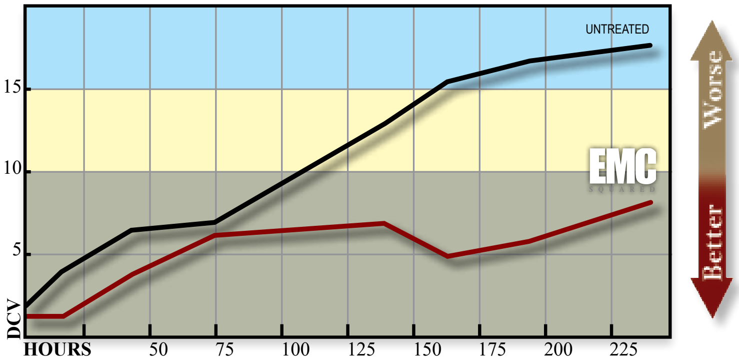
Aggregate materials with a Dielectric Value of less than 10
are considered non-moisture sensitive and non-frost susceptible in service for road and highway base applications

EMC SQUARED
Untreated









A Sampling of
EMC SQUARED® System
LABORATORY TEST RESULTS

The laboratory test results reported on the previous pages are specific to the aggregate or soil material sampled for testing and to the independent materials testing laboratory that conducted the testing. Performance results are project specific and laboratory testing should be conducted to determine suitability of each aggregate and soil material in regards to performance as a stabilized material.

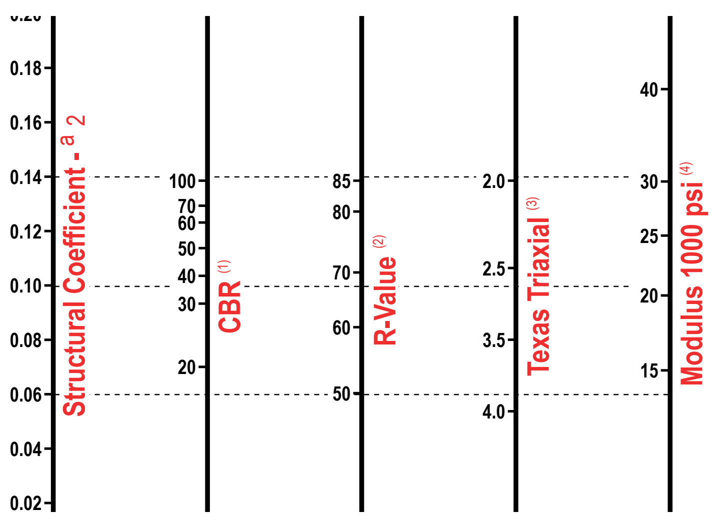
Index test methods such as the California Bearing Ratio (CBR), R-Value and Texas Triaxial are among the laboratory tests that have historically been used to evaluate untreated aggregate and untreated soil materials. When it comes to evaluation of stabilized aggregate and stabilized soil material, Soil Stabilization Products Company (SSPCo) recommends the use of the Resilient Modulus test method (AASHTO T 274), as standardized by the American Association of State Highway and Transportation Officials (AASHTO). As addressed earlier on page 32, Resilient Modulus testing evaluates the response of pavement materials, base course materials and subgrade soils to dynamic loading (representing repeated passes of loaded trucks over a pavement structural section). It is a laboratory testing procedure that more realistically characterizes the engineering properties of road building materials, and it provides a means to determine the equivalency of various materials in regards to their ability to support dynamic or repetitive loading. While local materials testing laboratories may not have Resilient Modulus testing equipment available in house, stabilized specimens can be prepared in the local laboratory and shipped out to materials testing laboratories currently providing Resilient Modulus testing services.

The Federal Highway Administration (FHWA) has promoted national standardization through AASHTO, and these standards are typically used on federally aided highway projects. Starting in 1996, AASHTO sponsored the development of what is now known as AASHTO 2002 Mechanistic-Empirical (M-E) Design Guide, based upon an extended nationwide field-testing study and the use of Resilient Modulus laboratory testing. M-E Pavement Design is far more sophisticated in regards to specific traffic loading, climatic conditions, design life and the ability to model real-world performance and changes in material properties. It facilitates better-informed decisions and takes advantage of new materials and features. FHWA's long term goal is to have all state transportation agencies fully adopt the AASHTO 2002 procedures as part of a nationwide standardization of testing and design methods.

AASHTO provides conversion charts which can be utilized with Resilient Modulus test results to provide equivalent CBR, R-Value and Texas Triaxial strength values and structural coefficients for base course and subbase applications. Using the Resilient Modulus test results at the top right of page 36, for example, the expansive clay soil treated with an EMC SQUARED System application provided a Resilient Modulus design value of 32,000 psi. The intended use of the stabilized soil layer, in this example's instance, was as a base course for a hot mix asphalt pavement surface course. Using the conversion chart provided by AASHTO shown below, the 32,000 psi Resilient Modulus base strength is equivalent to a CBR of 100, an R-Value of 87, and a Texas Triaxial value of 1.8. The corresponding structural coefficient is 0.14. For additional perspective, the California Department of Transportation (Caltrans) specifications require a minimum R-Value of 78 for aggregate base course. Using the AASHTO conversion chart, this is equivalent to a Resilient Modulus of approximately 25,000 psi.

AASHTO Guide for Design of Pavement Structures

Base Course



(1) Scale derived by averaging correlations obtained from Illinois.
(2) Scale derived by averaging correlations obtained from California, New Mexico and Wyoming.
(3) Scale derived by averaging correlations obtained from Texas
(4) Scale derived on NCHRP project *(3)*

EMC SQUARED System products are used in combination with natural earth materials such as aggregates and soils and mixtures of reclaimed asphalt and concrete pavements. The products are components in the construction of a final product. Engineering and construction controls are vital to the selection of all the ingredients and construction processes which will deliver the final product, and the excellence of that end result is, in large measure, dependent upon engineering judgements and construction quality control measures.

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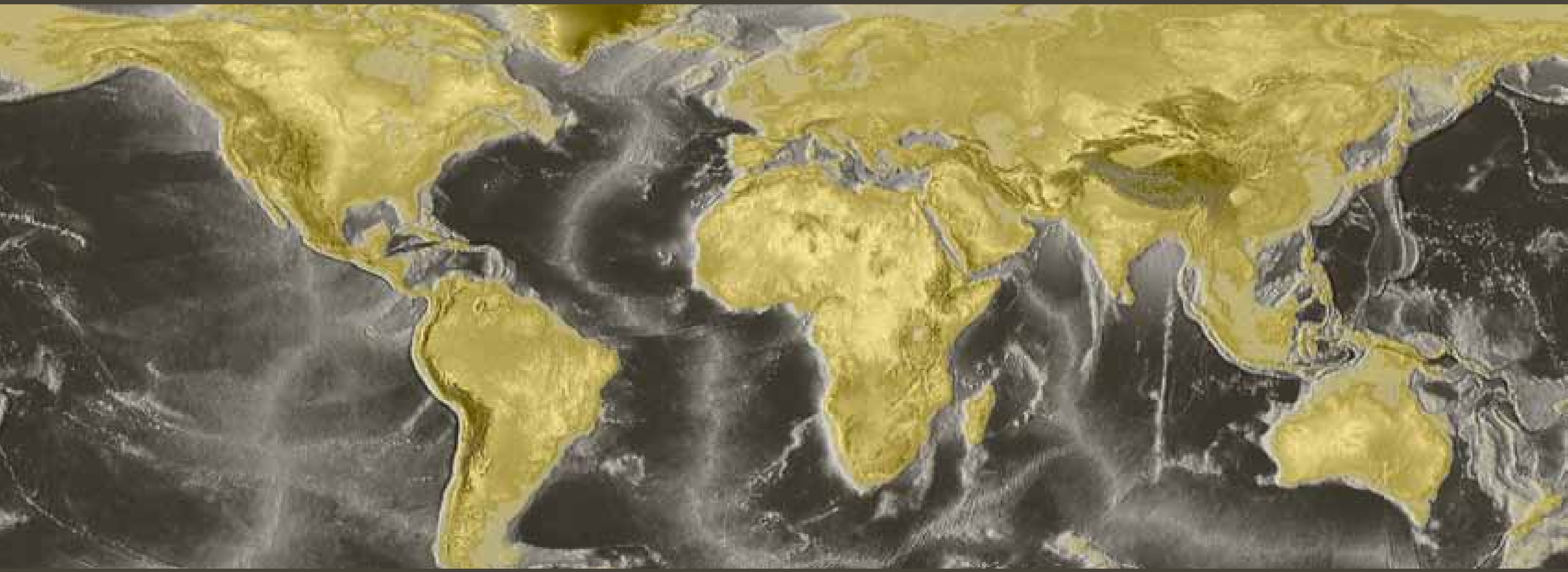
Liquid Stabilizer Treatments

for

Aggregate Base Course Materials
All-Weather Gravel Roads
Recycled Pavement Materials
Soil Subgrades and Earthworks



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