Sustainable Road Construction Product Technology

EMC SQUARED®

Advanced Stabilization Technology

MAJOR COST SAVINGS
HIGH STRENGTH
BIG GREEN BENEFITS

U.S. Army Corps of Engineers Specify Advanced Stabilization Technology Stretching $60 Million Budget to Construct Over 100 Miles of Military Heavy Haul Roads in Texas and New Mexico

Testing Shows EMC SQUARED Stabilized Aggregate Retains Full Strength Under Heavy Loading at Both Low and High Temperatures

Cost-saving Alternative to Hot Mix Asphalt Pavement

SSPCo®

Soil Stabilization Products Company, Inc.

Cost-saving Clean Technology for Stabilization of Aggregate, Soil and Recycled Pavement Materials

INCLUDES FIELD AND LABORATORY EVALUATIONS

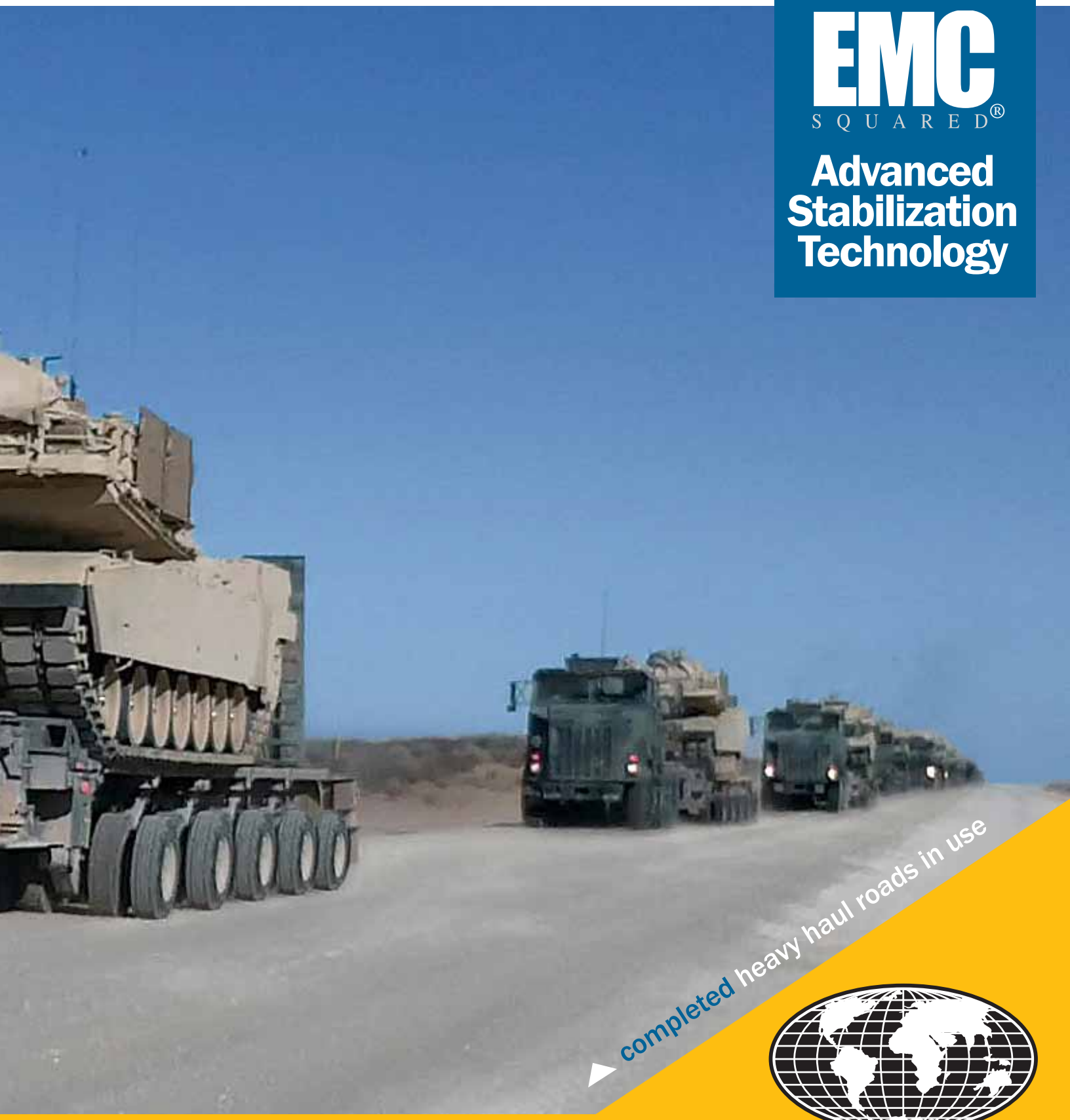
Advanced Stabilization Technology Reduces Construction Costs and Environmental Impacts on U.S. Army Corps of Engineers Projects at Fort Bliss

Projects: **Fort Bliss Tank Trail Repairs, Phases 1,2 & 3**
Total Value of Construction Contracts: **$60 Million**
Project Owner: **U.S. Army**
Project Engineer: **U.S. Army Corps of Engineers**
Construction Management: **U.S. Army Corps of Engineers**
Stabilization Product Technology: **Soil Stabilization Products Company, Inc. (SSPCo)**

Convoy of Heavy Equipment Transporters (M-1070 HET) with GCWR's of 243,400 Pounds Moving Abrams M1A2 Tanks on High Strength Stabilized Aggregate Surfaced Roads

EMC SQUARED®

Advanced Stabilization Technology



completed heavy haul roads in use

SSPCo®

Advanced Stabilization Technology Reduces Construction Costs and Environmental Impacts on U.S. Army Corps of Engineers Projects at Fort Bliss

Subgrade Stabilization with Disc Mixing of Stabilizer Treatment

Fort Bliss Location and Environment

Fort Bliss is the Army's second largest installation following the adjacent White Sands Missile Range, and the Army's second largest Maneuver Area for heavy armor training activities. Fort Bliss headquarters are located within the city limits of El Paso, Texas, with most of the training area and practice ranges located to the north in southern New Mexico. The area has an annual average of twenty days over 100°F and sixty nights below freezing. It has also experienced as much as two feet of snowfall in a single storm. While rainfall averages 9.4 inches per year, extremely heavy summer monsoonal thunderstorms can create severe flash flooding and have generated as much as 15 inches of rainfall in a single week. The area is subject to high winds and blowing dust for extended periods during the spring months. Fort Bliss has hundreds of miles of unpaved heavy haul roads, also known as tank trails, military supply routes, or MSR's. These roads service convoys of heavy military equipment including M1A2 Abrams Tanks, Bradley Infantry Fighting Vehicles and M-1070 Transporter units approaching their GCWR's of 243,400 pounds when moving Abrams Tanks around the base on heavy duty semi-trailers. The old rough running haul road system at Fort Bliss has historically taken its toll on the military equipment operating on these routes, the road maintenance budget and the environment.

U.S. Army Corps of Engineers

Three contracts were recently awarded by the U.S. Army Corps of Engineers through the MATOC program to remedy these problems on eight heavy haul road routes. The work includes raising the road profiles to improve drainage conditions, construction of concrete low water crossings and placement of culvert structures and construction of an unpaved road structural section capable of supporting the extremely heavy loads. These heavy haul roads are being constructed over more than one hundred miles of varying soil types and drainage conditions to support frequent heavy loading, even through episodes of extended heavy rainfall. On just one of the heavy haul road construction phases, the contractor reported 22 distinct soil types over the length of their project. The new Fort Bliss heavy haul 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.

EMC SQUARED®

Advanced Stabilization Technology

Delivery of Stabilized Aggregate Mix from Pugmill Mixing Plant

Bid Options Provided to Contractors

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 gave bidding contractors two options. Contractors could provide bids based upon constructing the heavy haul roads with two layers of crushed aggregate, each layer being eight inches thick, or the second option specifying the EMC SQUARED Stabilizer product. The stabilized design required construction of a twelve inch layer of stabilized native soil covered by an eight inch layer of stabilized aggregate surface course material.

Stabilized Road Design Saves Big Money

Faced with the high cost of manufacturing crushed aggregate materials and long round trip trucking hauls, it is no surprise that contractors selected the stabilized design option for the construction of all three phases. **The need for manufacturing over one million tons of crushed aggregate was eliminated (over 40,000 truck loads at 25 tons per load), along with the related long distance trucking hauls. Using an average of $20.00 per ton as the delivered cost for untreated crushed aggregate materials, for sake of cost estimating purposes, 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. 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 100 miles of heavy haul roads.**

Selection of Stabilization Technology

The EMC SQUARED System stabilization technology from Soil Stabilization Products Company, Inc. (SSPCo) 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. Equally important in the selection of the EMC SQUARED Stabilizer product was

Advanced Stabilization Technology Reduces Construction Costs and Environmental Impacts on U.S. Army Corps of Engineers Projects at Fort Bliss

Placement of Stabilized Aggregate Mix by Asphalt Paving Machine

the fact that it is a proven performer for over two decades in stabilizing select aggregate and soil materials for service as road running surfaces supporting frequent truck and heavy equipment traffic. Stabilized running surfaces are challenging applications that have not been cost-effectively addressed by earlier generation stabilizer products such as asphalt emulsions, foamed asphalts, cements, fly ash materials and lime products. SSPCo has worked closely with the Army Corps of Engineers and contractors to help them take advantage of the full range of benefits available from this innovative stabilization technology. As well demonstrated in the stabilized heavy haul roads at Fort Bliss, the EMC SQUARED System provides entirely new capabilities and opportunities for improving the performance of constructed aggregate and soil structures.

Superior Performance

Aggregate trucking hauls and military equipment convoys used the stabilized subgrades and stabilized aggregate surfaces in all weather conditions during construction operations. Once construction of each heavy haul road route was completed, the intense level of traffic from convoys of track equipment, such as the Abrams M1A2 Tanks and Bradley Infantry Fighting Vehicles, surprised even the Range Management staff at Fort Bliss. The surfaces of the stabilized heavy haul roads adjacent to state highways were treated with a dust control product during construction, as recommended by SSPCo, and are providing the most effective retention of rock materials in the running surface. SSPCo recommended that a dust control product be applied on all stabilized heavy haul road surfaces, but project managers made the decision to spend available funds on upgraded concrete low water crossings, rather than on dust control product for the rest of the new heavy haul road routes. The performance of the stabilized heavy haul roads without dust control treatment has also been excellent, even under the traffic of Abrams M1A2 Tanks (track equipment weighing almost 70 tons), but the light scattering of small rock on these haul road surfaces is evidence that the retention of fine particle materials in the stabilized surface is improved by application of the dust control product. It is clear in viewing all of these heavy haul roads that the stabilizer is effectively shedding water and maintaining stiff and solid running surfaces that are far superior to untreated aggregate surfaces. The only problem project and range managers are experiencing with the stabilized running surfaces placed by asphalt paving machines is enforcing speed limits for the trucking hauls and other traffic that are driving on these smooth running roads.

Falling Weight Deflectometer (FWD) testing conducted April 7, 2011 by Fugro Consultants, Inc., Austin, Texas.

EMC SQUARED®

Advanced Stabilization Technology

Engineering Field Evaluation of Stabilized Road in Progress

Sustainable Construction

The innovative EMC SQUARED System stabilization technology is facilitating construction of better performing roads at far lower cost than possible with conventional road construction products. The reductions in the overall environmental impacts and the financial burdens on taxpayers are extraordinary. At over 100 miles in total length and millions of dollars in cost savings, this is a big green success story. Use of the stabilized heavy haul road design cut the requirement for crushed aggregate materials and the related trucking hauls in half and reduced overall fossil fuel consumption and carbon emissions, greatly lessening the environmental impacts of the construction operations, and producing far more miles of upgraded roads with available funding.

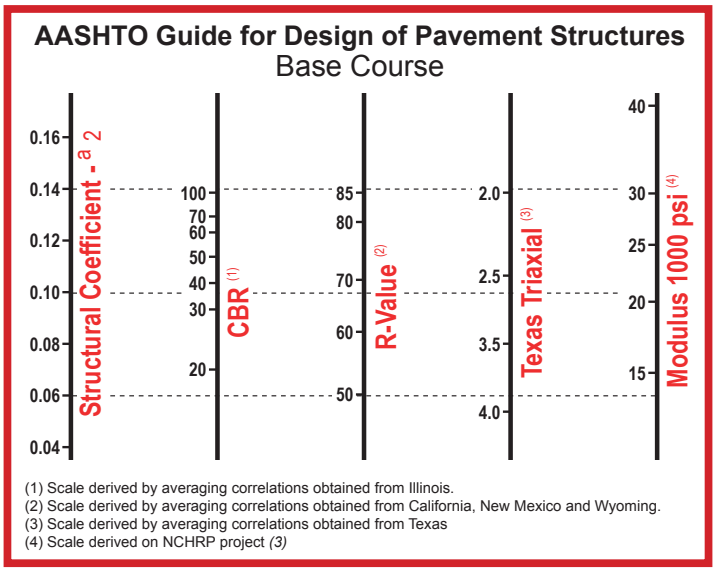
Field and Laboratory Evaluation

The results of field and laboratory engineering evaluations of the stabilized soil and aggregate materials are summarized in the four pages that follow. Note the effectiveness of the economical EMC SQUARED Stabilizer treatment, strengthening native soils to a performance level equivalent to crushed aggregate base rock materials. Even more interesting are the results of engineering tests conducted in a nationally recognized pavement materials testing laboratory to evaluate the performance of the stabilized aggregate surface course material and its relationship to Hot Mix Asphalt (HMA). While HMA is a viscoelastic material that weakens dramatically as temperatures increase, the stabilized aggregate retained consistent strength and demonstrated a high level of resistance to rutting and deformation in testing temperatures that include 130° F. These are excellent engineering properties for any layer in a pavement structural section. The consistent strength of the stabilized aggregate is ideal for worst case design requirements, such as Fort Bliss heavy haul roads where extremely heavy loads move at slow speeds during weather conditions ranging from below freezing to high temperatures and for other severe service applications such as mine haul roads, airport runway and taxiways, and pavement systems for port and intermodal facilities. The consistent strength of the stabilized aggregate is also an excellent match for viscoelastic HMA surface course materials that benefit from the support of strong flexible base course layers that retain their stability independent of changes in temperature and loading frequency.

Field and Laboratory Evaluations of Stabilized Materials

Stabilized Soil Subgrade - 40,000 psi

Pictured on top of page 7 is a Falling Weight Deflectometer (FWD) testing appartus evaluating the strength of a stabilized heavy haul road at Fort Bliss after several months in service under heavy haul trucks and tracked military equipment. The FWD equipment is capable of simultaneously providing Resilient Modulus measurement of both the Stabilized Aggregate Surface Course layer and the Stabilized Soil Subgrade layer below in a non-destructive manner while testing the performance of many miles of road in a single day. The analysis of the FWD field testing data resulted in an average layer moduli for the stabilized soil subgrade layer of 40,000 psi[1], equivalent to the strength of crushed aggregate base course materials which typically have layer moduli ranging from 25,000 to 50,000 psi. Using the comparative chart provided by the American Association of State Highway Transportation Officials (AASHTO) for correlation with other standard index tests for additional perspective, the FWD testing demonstrated that the stabilized subgrade soil was significantly stronger than 30,000 psi, the Resilient Modulus value that correlates with a CBR of 100, an R-Value of 85, a Texas Triaxial of 2.0 and a Structural Coefficient of 0.14. These test values from this group of five standard highway industry test methods are all representative of good quality crushed aggregate base course materials. The higher moduli of the native soil materials stabilized with the EMC SQUARED Stabilizer treatment (40,000 psi) at Fort Bliss demonstrates in materials engineering measurements the effectiveness of this advanced broad spectrum stabilization technology.



[1]FWD data analysis by Peter Sebaaly, Ph.D., P.E., Director of the Western Regional Superpave Center, Professor, Civil and Environmental Engineering Department, University of Nevada Reno.

Stabilized Aggregate vs Asphalt Pavement

Select aggregate base course materials treated with the EMC SQUARED Stabilizer are typically many times stronger than untreated aggregate and most closely resemble Hot Mix Asphalt (HMA) pavement materials in modulus properties. Historically compared with flexible asphalt pavement materials in resilient modulus testing, the EMC SQUARED stabilized layers are flexible, in contrast to cement treated layers, which exhibit rigid, slab-like behavior and a strong tendency to layer cracking. As illustrated in the table below with diametral resilient modulus test results conducted at 77° F in the pavement materials lab at University of Nevada Reno (UNR), the stabilized aggregate material from a Southern Nevada project provided a layer coefficient equivalent to the local HMA pavement materials.

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 University of Nevada Reno
** Analysis and reporting by Dan Ridolfi, P.E., Professional Service Industries (PSI), 1/16/04
*** Per PSI report, Standard practice in Southern Nevada is to assign a layer coefficient of 0.35 for dense graded hot mix asphalt.

Transition from Resilient to Dynamic Modulus Tests

The evaluation of asphalt pavement materials is in transition from Resilient Modulus to Dynamic Modulus testing, the test method specified by the nationally recognized AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) for evaluation of Hot Mix Asphalt (HMA) pavement. HMA pavement materials are viscoelastic in nature, exhibiting lower modulus values (strength loss) as pavement temperatures increase. Dynamic Modulus testing evaluates the impacts of temperature and frequency of loading on the pavement material. Given the similarities between aggregates treated with EMC SQUARED Stabilizer and HMA pavement, the laboratory evaluation of the stabilized aggregate surface course materials from Fort Bliss is also based upon current state of the art test methods for HMA pavement, the Dynamic Modulus and Repeated Load Triaxial (RLT) tests.

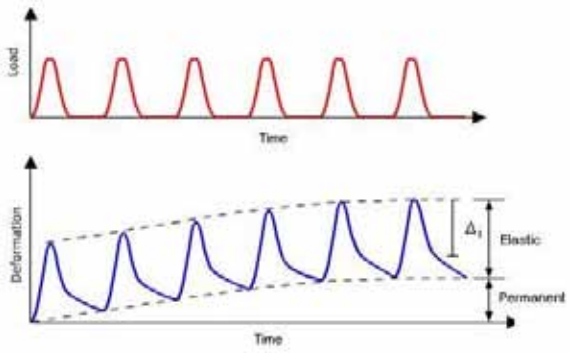
Laboratory Evaluation of Stabilized Aggregate Materials

Repeated Load Triaxial (RLT) Test - Resistance to Permanent Deformation

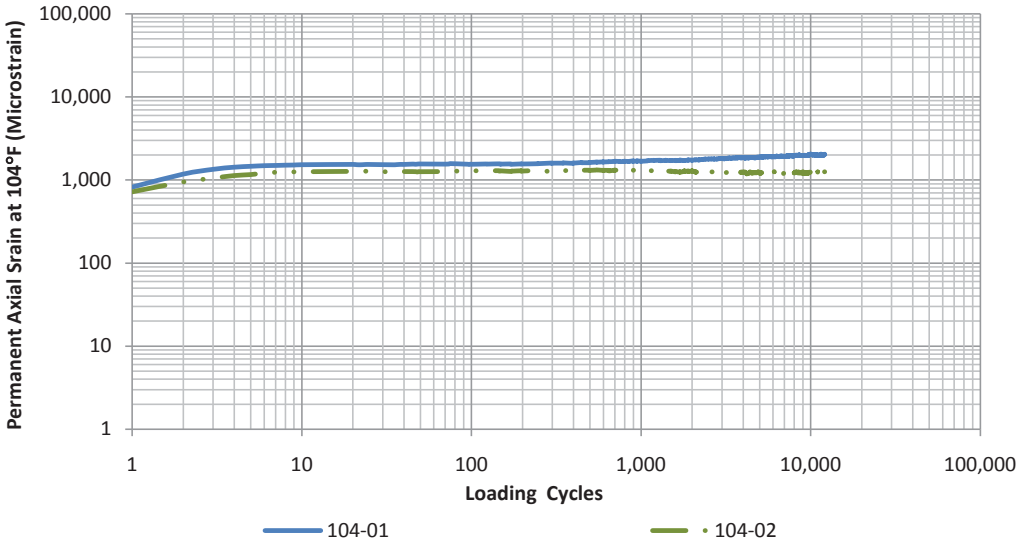
In the interest of referencing the performance of Hot Mix Asphalt (HMA) materials as a base line for evaluating the stabilized aggregate mixture sampled from the heavy haul road projects at Fort Bliss, Repeated Load Triaxial (RLT) and Dynamic Modulus (E*) testing was conducted in the Pavement/Materials Testing Laboratory at University of Nevada Reno. The results of the RLT tests, which measure resistance to rutting and permanent deformation, are provided below. Quoting from the final report, **"The RLT data generated in this evaluation indicated that the stabilized aggregate material from the Fort Bliss facility is not anticipated to generate any permanent deformation under a wide range of loading conditions. It should be noted that the worst loading condition on flexible pavements is slow moving loads in hot environments. The elastic behavior of the stabilized aggregate material from the Fort Bliss facility coupled with its relatively good level of E* makes it a good candidate for pavements loaded under such severe conditions. In addition, the stabilized aggregate material is expected to perform as well in pavements subjected to standard loading conditions."**

Repeated Load Triaxial Set-Up

Loading and Response



Permanent Deformation Characteristics of the EMC SQUARED Stabilized Aggregate Cured for 72 hrs at 104° F



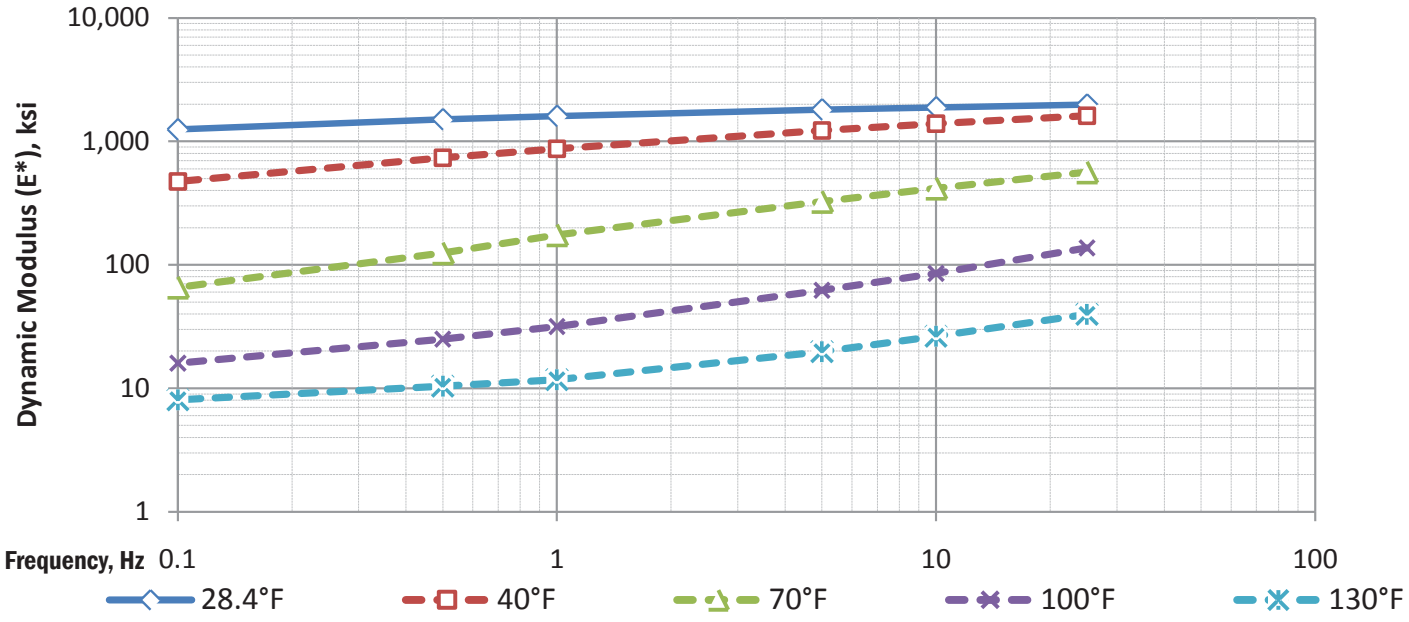
The engineering evaluation of the stabilized aggregate materials sampled from the U.S. Army Corps of Engineers project at Fort Bliss was conducted under the direction of Peter Sebaaly, Ph.D., P.E., Director of the Western Regional Superpave Center, one of five centers established by the Federal Highway Administration (FHWA) to support the implementation of the Superpave Technology for hot mix asphalt materials, Director of the Nevada Technology Transfer Center (funded by FHWA and Nevada DOT), and Professor of Civil Engineering in the Civil and Environmental Engineering Department at University of Nevada Reno where the Pavement/ Materials Program and materials testing laboratory are located. Peter Sebaaly also provided the analysis and review of the Falling Weight Deflectometer (FWD) field testing at Fort Bliss conducted by Fugro Consultants, Inc.

Laboratory Evaluation of Stabilized Aggregate Materials

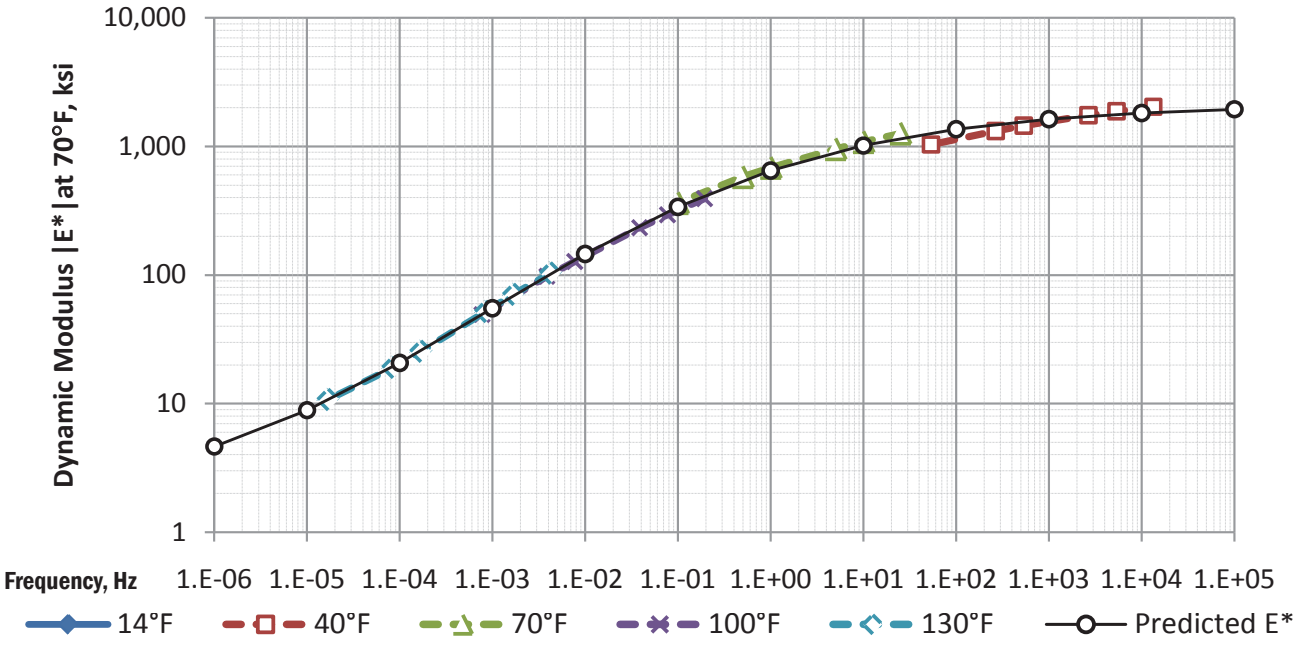
Dynamic Modulus Properties of Hot Mix Asphalt (HMA)

The fundamental definition of modulus is the relationship between the stress and strain of an engineering material. Dynamic Modulus measurements are the most up to date method for evaluation of Hot Mix Asphalt (HMA). HMA materials are viscoelastic in nature and their modulus values change with variations in both temperature and loading rate, a well known example being the tendency of asphalt pavement to lose strength and resistance to rutting as temperatures increase. As illustrated in the graphs below, *Typical Dynamic Modulus Data for Hot Mix Asphalt (HMA) Mixture* and *Components of the Dynamic Modulus Test and a Typical E* Master Curve for a HMA Mix*, the Dynamic Modulus (E*) of the HMA material declines by a Factor of approximately 100 times when temperatures are increased from below freezing (28.4° F) up to 130° F. This is not a positive aspect of HMA materials, but rather a problematic characteristic of HMA material that pavement material engineers and pavement design engineers must work around.

Typical Dynamic Modulus Data for Hot Mix Asphalt (HMA) Mixture.



Components of the Dynamic Modulus Test and a Typical E* Master Curve for a HMA mix.



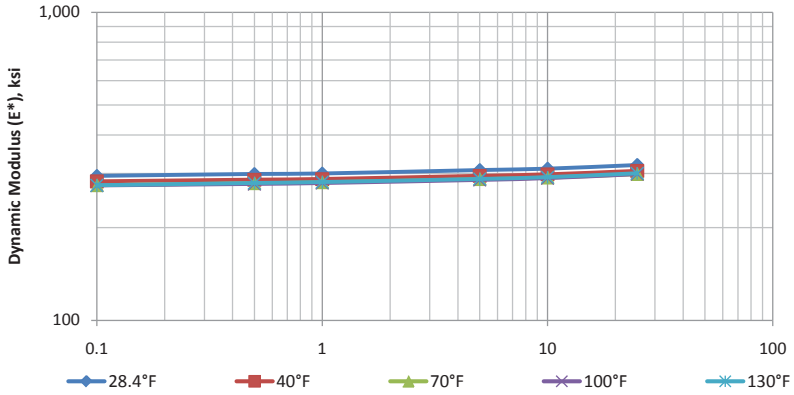
Laboratory Evaluation of Stabilized Aggregate Materials

Dynamic Modulus Properties of EMC SQUARED Stabilized Aggregate

The Dynamic Modulus measurements of the EMC SQUARED stabilized aggregate material have a modulus that is within the same range as the modulus of typical Hot Mix Asphalt (HMA) materials, but as illustrated in the graphs below, the stabilized material retains a consistent strength through the full range of temperatures and loading rates, which is in distinct contrast to viscoelastic HMA materials that undergo dramatic modifications in their behavior as a function of changes in temperature and loading rates. **"This indicates that the stabilized aggregate material does not behave as a viscoelastic material and its behavior is closer to elastic material."** As a result, the Dynamic Modulus (E*) for the EMC SQUARED stabilized aggregate can be represented as a constant, rather than the curve (E* master curve) as necessitated by the variability of HMA materials.

"The RLT data generated in this evaluation indicated that the stabilized aggregate material from the Fort Bliss facility is not anticipated to generate any permanent deformation under a wide range of loading conditions. It should be noted that the worst loading condition on flexible pavements is slow moving loads in hot environments. The elastic behavior of the stabilized aggregate material from the Fort Bliss facility coupled with its relatively good level of E* makes it a good candidate for pavements loaded under such severe conditions. In addition, the stabilized aggregate material is expected to perform as well in pavements subjected to standard loading conditions. Furthermore, the long-term cured material showed significant increase in the dynamic modulus property but not to the level of becoming brittle and causing shrinkage cracking."

Figure 1. Dynamic Modulus of EMC SQUARED Stabilized Aggregate Cured for 72 hrs at 104° F

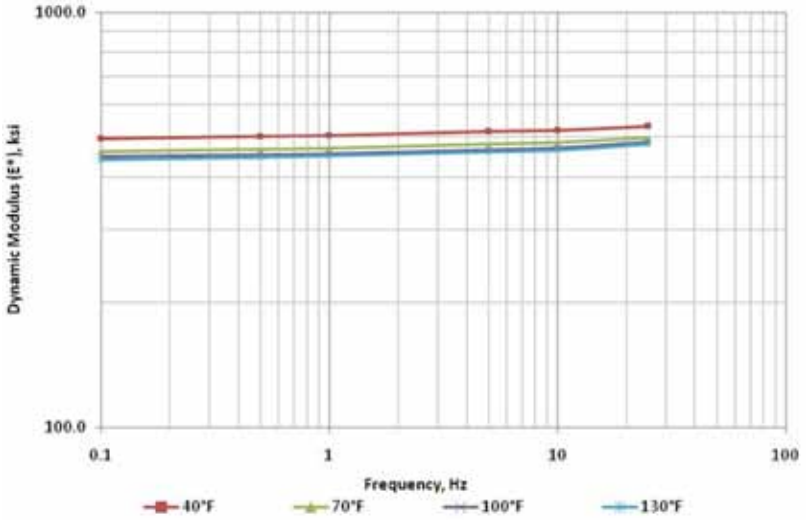


Average Dynamic Modulus for All Temperatures after 72 Hours

291,000 psi

291 ksi

Figure 2. Dynamic Modulus of EMC SQUARED Stabilized Aggregate Cured for 168 hrs at 104° F



Average Dynamic Modulus for All Temperatures after 168 Hours

475,000 psi

475 ksi

Stabilized Aggregate Sample in Dynamic Modulus testing Set-up

The upper chart (Figure 1) shows Dynamic Modulus results after 72 hours (3 days) of curing and provides an appropriate value for structural design and initial construction purposes. Results are also shown (Figure 2) for Dynamic Modulus testing conducted after 168 hours (7 days) of curing at the same temperature. The significantly higher Dynamic Modulus is associated with the long-term properties of the EMC SQUARED stabilized aggregate material.

The EMC SQUARED® System

RANGE OF APPLICATIONS: The high performance EMC SQUARED System products are economical, sustainable and highly versatile. These concentrated liquid treatments have proven effective in stabilizing non-plastic (granular) and cohesive, highly plastic (expansive) soils, non-plastic and plastic aggregate materials, recycled asphalt pavement millings (RAP), and recycled pavement aggregates manufactured with pulverized asphalt and crushed concrete content. A partial list of EMC SQUARED applications includes subgrade soil stabilization for major interstate freeway, highway, and city expressway projects; stabilized soil layers directly exposed to traffic, such as military tank trails, solar array sites, construction sites, industrial sites, and landfill closures; stabilized base courses under streets and roads; Full Depth Reclamation (FDR) and Cold In-place Recycling (CIR); and stabilized aggregate running surfaces for a wide variety of public agency and industrial applications. EMC SQUARED stabilized aggregate and stabilized soil installations continue to provide effective performance after more than twenty years of service in direct exposure to traffic and the environment.

STABILIZED RUNNING SURFACES: Where EMC SQUARED System products stand head and shoulders above other stabilizing agents is in treatment of aggregate materials for road running surface applications. Aggregate materials treated with asphalt emulsion, foamed asphalt, cement, fly ash and lime products are traditionally covered by protective hot mix asphalt or concrete pavements because the treated materials are unable to stand up to the repeated pounding of high speed automobile and truck tires and direct exposure to wet weather and freezing conditions. On the other hand, when matched with aggregate base course and recycled aggregate materials that have suitable gradation and adequate binder content, as exemplified by the performance of the U.S. Army Corps of Engineers heavy haul road projects at Fort Bliss, EMC SQUARED System stabilization treatments can facilitate the construction of bound aggregate layers that most closely resemble hot mix asphalt pavement in layer equivalency evaluation.

COMPARATIVE ECONOMICS: The EMC SQUARED System stabilizer products are significantly less expensive and faster to apply than cement and lime based treatments, and more effective with a wider range of soil and aggregate materials. EMC SQUARED System treatments improve the flexible and elastic behavior of bound aggregate materials, in contrast to cement and lime treated materials, which exhibit rigid, slab-like behavior, susceptibility to layer cracking and contribution to reflective cracking in pavement layers above. EMC SQUARED System treatments are far less expensive than asphalt cement, asphalt emulsion and foamed asphalt treatments which can be five to twenty times more expensive on a cost per ton of aggregate or FDR material treated. These are big cost savings from a clean product technology that is safer for workers and the environment.

E=MC²: Given all the broad spectrum stabilizing power of this highly concentrated and environmentally friendly product technology, the similarity in name with Einstein's famous energy equation ($E=MC^2$) is no accident. The EMC SQUARED System is a breakthrough product technology that improves strength and moisture resistance at very low cost. Stabilization is now an affordable option that can be considered wherever soil, aggregate or recycled pavement materials are being processed and compacted for load bearing or wear resistant surfaces.

Soil Stabilization Products Company, Inc. (SSPCo) is completing our third decade as the leading edge stabilization product technology company, setting the standard for economic improvement of soil, aggregate and recycled pavement materials in construction applications. SSPCo has pioneered the implementation of green products in the highway industry. We have proven that clean technology can provide far more sophisticated, effective and environmentally appropriate answers than bulk application of asphalt, cement, fly ash and lime products. As former general engineering contractors and suppliers of aggregate and pavement materials, SSPCo's staff are conversant with the engineers who specify our products, the installing contractors, and the quality control personnel responsible for monitoring the essential engineering controls during construction processes. Our industry background and technical support services are essential to the success of a product technology that is reliant upon construction processes that must be conducted according to rigorous engineering quality controls. The cost-savings and performance advantages of the EMC SQUARED System are contingent upon thorough preliminary engineering reviews, competent designs and specifications, and proper installation. Contact us for assistance on your next design or construction project.

SSPCo®

Soil Stabilization Products Company, Inc.

www.sspco.com

PO Box 2779, Merced, CA 95344-0779

Ph: (209) 383-3296 or (800) 523-9992 Fax: (209) 383-7849

E-mail: info@sspco.com

SSPCo's 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.

This publication is solely for use by professional personnel who are competent to evaluate the significance and limitations of the information provided. It was reviewed carefully prior to publication. Soil Stabilization Products Company Inc., assumes no liability for its accuracy or completeness. Final determination of the suitability of any information or material for the use contemplated, or for its manner of use, is the sole responsibility of the user.