TECHNICAL BULLETIN

No. 18575.EMC^2/EMS 9/2021

Stabilization Products LLC

CONSTRUCTION HANDBOOK & GENERAL INFORMATION

The EMC SQUARED® System

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CONSTRUCTION HANDBOOK AND GENERAL INFORMATION

In USA
Stabilization Products LLC
(209) 383-3296 or
(800) 523-9992

In Canada
Milieu Road Technologies
(780) 875-9159

E-mail: info@stabilizationproducts.net
Website: https://stabilizationproducts.net

EMC SQUARED SYSTEM PRODUCTS

EMC SQUARED® Stabilizer (1000)
EMC SQUARED® 2000
EMS® Earth Materials Sealant™

DESCRIPTION OF TREATMENTS

The **EMC SQUARED** System is a family of liquid stabilizer products applied as compaction water additives to aggregates, soils and recycled materials according to pre-established engineering controls and construction procedures. With more than thirty years of use with a wide variety of soil types, aggregates and recycled materials, in climatic conditions ranging from arctic to temperate, and desert to tropical, this unique stabilizer product technology has proven effective in increasing density, cementation, moisture resistance, frost heave resistance, bearing strength, resiliency, shear strength, tensile strength and stability of natural earth materials and recycled pavement mixtures. **EMC SQUARED** Stabilizers precondition aggregate materials to behave more like conglomerate rock, clays like claystone, sands like sandstone, and silts like siltstone, catalyzing processes of consolidation and lithification that take millions of years in the natural world. Key to the effectiveness of this advanced technology are the use of rigorous engineering controls during construction and utilization of powerful modern compaction equipment. A single truckload of this advanced liquid chemistry, in combination with significant quantities of locally available water, can replace a requirement for hundreds of truckloads of cement or lime products. These conventional calcium-based stabilizer products are applied in bulk amounts in attempts to cement or radically alter the pH and chemical composition of aggregate and soil materials. The **EMC SQUARED** product technology instead activates water chemistry to reorganize and reconfigure the internal structure of the treated materials during the moisturization, mixing and compaction processes. As with the earlier examples of clays becoming claystone and sands becoming sandstone in a natural process during long periods of geological time, these soil materials obviously have the potentiality to change into a different physical form with greatly increased stability, strength and resistance to water. EMC is the acronym for Earth Materials Catalyst™. Catalysts are known to cause chemical reactions to happen at astronomically faster rates. A natural reaction that otherwise would take many millions of years can be accelerated into just a few hours when this state of the art chemistry is used in combination with modern engineering controls and construction equipment. Given this highly concentrated stabilizing power, the similarity with Albert Einstein's famous energy equation ($E=MC^2$) is no accident. Stabilization is now an affordable option to consider whenever natural or recycled materials are being compacted for load bearing or erosion resistant surfaces.

Today we can use **EMC SQUARED** Stabilizers in combination with modern compaction equipment and construction methods to accelerate into a matter of hours natural stabilization processes, which otherwise would take millions of years to occur. **EMC SQUARED** Stabilizers catalyze this process by activating compaction water and conditioning earth materials for maximum density during compaction. The stabilizing components of the formulations are then interlocked into the compacted material, reinforcing the cured structure for greater strength and improved resistance to moisture intrusion.

The **EMC SQUARED** Stabilizer is available in the standard **EMC SQUARED** Stabilizer formulation (Code No. 1000) and in a formulation specially prepared for compatibility with the **EMS** Earth Materials Sealant as part of the Dual Component Treatment (**EMC SQUARED 2000**). The 1000 formulation is not compatible for use in combination with **EMS**. (Also see PHYSICAL CHARACTERISTICS for EMC SQUARED Stabilizer (1000) and EMC SQUARED 2000 formulations on page 19.)

EMC SQUARED/EMS Dual Component Treatment™

The **EMC SQUARED** System also includes **EMS** Earth Materials Sealant. Though the **EMC SQUARED Stabilizer** (1000) solution may cost-effectively meet your project requirements as a sole treatment, the **EMS** booster is available to further expand the range of performance benefits, the range of material types, and the variety of site specific problems which can be addressed using the **EMC SQUARED** System. Available for use in combination with **EMC SQUARED 2000** and applied together as a single step process. **EMS** Earth Materials Sealant provides designers, materials testing engineers, contractors and owners with an additional option for treatment of moisture sensitive aggregate and soil materials. In cold climate regions, the Dual Component Treatment may also be effective in further reducing or eliminating frost susceptibility. As with the **EMC SQUARED** Stabilizer treatment, field evaluation or materials laboratory testing is recommended to address performance issues relative to the specific aggregate and soil materials and the service requirements unique to each individual project.

EMS is a non-petroleum resinous polymeric emulsion containing polymers of high molecular weight which contribute to further copolymerization and filling of void spaces while rendering clay soils less susceptible to ion exchange and shrink-swell phenomenon relating to moisture fluctuations. In combination with **EMC SQUARED 2000**, this complex of interlocking, coating and sealing reactions chemically change aggregate and soil materials, improving the resistance of load bearing structural sections and earthworks to the destructive effects of water absorption and adsorption and reducing the hydraulic conductivity of soil liner materials constructed for moisture barrier applications. (Also see PHYSICAL CHARACTERISTICS for EMS Earth Materials Sealant on page 19.)

NOTE: The **EMS** product is not applied as a sole treatment. **EMS** is formulated for application with **EMC SQUARED 2000**, applied in a single step process as part of the Dual Component Treatment.

PROJECT ECONOMICS

While the product costs for use of the **EMC SQUARED** System will typically be far less than treatments relying upon traditional asphalt emulsion, cement, lime, geotextile fabrics or geogrid products, the economics of the **EMC SQUARED** System are dependent upon selection of the specific treatment, the cubic yardage (or metric volume) of soil, aggregate or recycled material to be treated, and the costs involved in delivery of stabilizer product to a specific project location. If you know the specific type of earth material under consideration for treatment, the estimated volume requiring treatment, and the specific project location, Stabilization Products LLC staff can be of assistance in developing preliminary product cost estimates for your specific project to assist with evaluation and feasibility studies.

TYPES OF APPLICATIONS

EARTHWORKS, SUBGRADE AND BASE STABILIZATION

The **EMC SQUARED** System is used for a wide variety of applications for the improvement, modification and stabilization of compacted earth materials. This includes treatment of subgrade soils and aggregate base layers for road, street, highway and other types of transportation structures. The **EMC SQUARED** System is also utilized to improve the stability of earthwork structures such as levees and berms and to reduce the permeability or hydraulic conductivity of soil liner materials constructed for moisture barrier applications. The cost of treatment is significantly lower than cement and lime and other conventional treatments and greatly expands the cost-effective range of stabilization treatments. The **EMC SQUARED** System has additional advantages over cement, fly ash and lime treatment. These calcium based stabilizers have well known side effects that can be counterproductive to stability, including shrinkage cracking phenomena, which are unavoidable problems that accompany their use in treatment of base course aggregate materials and subgrade soils. Shrinkage cracking of subgrade and base layers can lead to costly reflective cracking damage of overlying pavements. While application of bituminous curing membranes and other methods are employed during curing of materials treated with cement, fly ash and lime, these measures add to project expenses and they are not expected to fully eliminate the shrinkage cracking to which the calcium based treatments are prone. In contrast, materials treated with the **EMC SQUARED** System are compacted in place at higher density, at far lower moisture content, and without any of the chemical reactions linked to calcium based stabilization, which create additional shrinkage cracking in treated materials. The **EMC SQUARED** System eliminates the need for costly and time consuming construction processes associated with use of calcium based stabilizers such as mellowing time, multiple day mixing efforts and extended periods of protection from heavy traffic.

Calcium based stabilizers also are known to have negative reactions with certain aggregate and soil components. For instance, organic carbon can inhibit lime stabilization reactions, and any more than one percent organic content in a soil is cause for concern. Also, all three calcium based chemicals (cement, fly ash and lime) have proven ineffective in treating sulfate rich soils. Sulfate swell is activated by the addition of calcium based stabilizers to sulfate rich aggregates as well as soils, and the resulting expansion causes heaving, cracking and buckling of pavements. Studies sponsored by FHWA and the Wyoming Department of Transportation documented sulfate swell of a cement treated base course (CTB) on two sections of highway on US-85 in Wyoming as the primary cause of rapid deterioration of the base layers and severe and ongoing cracking and buckling of the asphalt pavement. Sulfate content in the compaction water and sulfate content in the aggregate were both found to be causal factors in the expansive reaction of the treated base material.

According to information released by the Texas Department of Transportation (TxDOT), sulfate swell problems in highway subgrades are so severe that TxDOT could save $23 million per year in repair costs by switching to non-calcium based stabilizers in areas of sulfate rich soil. Reseach conducted on behalf of TxDOT at the Texas Transportation Institute (TTI) concluded that the **EMC SQUARED/EMS** Dual Component Treatment provided a suitable alternative to lime treatment for projects where sulfate rich soils are identified.

The **EMC SQUARED** System also offers a treatment system that has a demonstrated breadth of effectiveness with a wide variety of soils, aggregate and recycled pavement materials. As noted above, the **EMC SQUARED** System offers an option for treatment of sulfate rich clay soils where no effective treatment previously existed. In short, this low cost treatment provides an important option which should be reviewed wherever economical improvement of earth, aggregate or recycled pavement material is under evaluation.

DIRT SURFACES AND GRAVEL ROADS

The **EMC SQUARED** System is cost-effective for improvement of a wide variety of dirt, gravel and recycled pavement materials used as traffic bearing surfaces. Increased cementation and strength of treated materials reduces the susceptibility to washboarding, potholing and gravel loss. Improved resistance to moisture penetration eliminates or reduces susceptibility to rutting and to cold climate effects such as frost-heave and frost boils. Maintenance frequencies on gravel roads and dirt runways have been extended from weekly intervals to one to two times per year (light touch up) and, in some cases, years, and even decades without the need for grading maintenance. With the high costs for purchase and placement of aggregate materials, a stabilization treatment can be highly cost-effective by eliminating gravel loss from the running surface and by reducing maintenance frequency and maintenance costs. Road users benefit with greatly improved running surfaces which in many cases allow driving speeds similar to paved road surfaces. Dust control treatments may be applied on stabilized surfaces when a higher standard of dust control is desired. With carefully selected aggregate or recycled pavement materials, a relatively high quality running surface can be achieved at little additional cost beyond the aggregate and installation costs of an unstabilized road. Gravel road stabilization is an area where the **EMC SQUARED** System is uniquely effective as it can be applied at a small fraction of the cost of aggregate materials and has been proven effective with both plastic and non-plastic aggregates and recycled asphalt and concrete materials. Gravel road stabilization is an area where conventional cement and lime treatments are so costly and ineffective as to be eliminated from consideration.

EROSION AND SEDIMENT CONTROL

The erosion of road surfacing and shoulder materials, unpaved runway surfaces, landfill covers and other earthworks can create safety and maintenance problems. Replacement of lost gravel and soil materials can be expensive, along with the cost to restore these compacted structures. When the erosion of fine particle soil materials fills storm water detention basins or contributes to sedimentation of lakes, streams, rivers and estuaries, stabilization is often the most effective answer. The **EMC SQUARED** System is an economical and environmentally friendly solution which can often be applied as a sole treatment or in other cases used in combination with other products to address erosion and sediment control requirements for both trafficked and untrafficked soil and aggregate surfaces.

DUST CONTROL

The **EMC SQUARED** System is applied as an additive to aggregate and soil materials during the process of mixing, moisture conditioning and compaction. While the primary application is for the improvement of stability values, in many applications the improvements in dust control and reductions in fugitive dust emission can be significant. The increased cementation of treated aggregate and soil materials can reduce dusting and wind generated erosion of fine particle soil materials. Stabilization treatment alone may suffice as a dust control measure for many unpaved roads and for sites where the compacted surfaces will be protected from traffic or subject to relatively infrequent use. There are reported cases of gravel road stabilization where the **EMC SQUARED** Stabilizer treatment has provided a level of dust control equivalent to dust palliative treatments (which are seasonally applied and require repeat applications), but general experience indicates that stabilized road surfaces can be further improved by surficial application of dust palliative products when the highest standard of dust control and running surface is desired.

PRECONDITIONING FOR COMPACTION

Conventional stabilizers such as cement and lime generally reduce maximum density and raise the optimum moisture content for compaction well above that of untreated soils, making soils more difficult to compact. These calcium-based stabilizers are obviously counterproductive for contractors interested in reducing water hauling and compaction costs, or struggling with soils that are already difficult to compact. The **EMC SQUARED** System conditions soils in a very different manner. The maximum density of a treated soil is generally higher than that of an untreated soil and the optimum moisture content is generally lower than the optimum moisture content of the untreated soil. The net effect is that a soil or aggregate material can often be prepared for compaction at a lower moisture content and with a reduced volume of compaction water. The **EMC SQUARED** System further facilitates compaction operations by improved wetting and penetration of soils and aggregate materials during mixing operations, extending available water supplies and improving the effectiveness of available construction equipment during compaction operations. All these factors ultimately contribute to improved stability values, as well as to more efficient construction operations. Field evaluation or materials laboratory testing are recommended for contractors considering use of the products specifically for compaction operations in order to address performance issues relative to the site specific aggregate or soil.

Most uses of **EMC SQUARED** System products for compaction requirements occur as a response to jobsite problems. Examples would be the inability to achieve 95% Modified Proctor compaction after an extended application of compactive effort, or the use of inordinate amounts of water in order to precondition hydrophobic soils for compaction. These problems are usually addressed by conducting immediate field tests to confirm that the amount of improvement after treatment of the problem soil or aggregate is sufficient for project goals. For large scale projects where there are concerns preliminary to construction, compaction and soil densification, laboratory tests can be instructive. For example, in a compaction study for one aggregate material, a materials testing laboratory was able to demonstrate, using the **EMC SQUARED** additive, that fifteen percent less compactive effort was required to achieve the target level of compaction. Compaction tests also verified that the additive "flattened the compaction curve," providing the contractor with the ability to achieve specified levels of compaction at a wider range of moisture content than would be possible using water alone.

When it comes to use of an **EMC SQUARED** System product to address a construction compaction requirement, rather than a stabilization application where a specific product and a specific application rate of the product have already been specified, the **EMC SQUARED 2000** product is recommended. When used for compaction requirements, dilution ratios with water traditionally range from one thousand parts water up to five thousand parts water per one part **EMC SQUARED 2000**. Final selection of dilution ratios is best determined by field evaluation or materials laboratory testing.

Note that dilution ratios used specifically to address compaction have no relationship to the dilution ratios used for stabilization operations where application rates of the stabilizing agent per unit volume of soil are much higher and dilution ratios are much lower. Stabilization application dilution rates are determined by calculations based on the specified amount of stabilizer per unit volume of aggregate or soil, the volume of aggregate or soil to be treated, and the volume of compaction water required to bring that volume of aggregate or soil to its optimum moisture content for compaction (as determined by laboratory tests using the stabilizer solution). Application rates, dilution ratios and compaction requirements for stabilization projects are further addressed in the sections which follow specifically covering stabilization procedures.

STRUCTURAL SECTION DETERMINATIONS

Similar to cement and lime treatment of aggregate base course materials and subgrade soils, most applications of the **EMC SQUARED** System products are limited by available budgets and construction efficiency to single compaction lifts of six inch (150 mm) to eight inch (200 mm) thickness. Only the largest compactors are capable of compacting thicker lifts to specified density standards. Consequently, double and triple compaction lifts are often required to build up stabilized layers for thicker structural section requirements. For projects not strictly governed by budget and construction equipment limitations or by historical practice (in regard to thickness of modified or stabilized layers), the determination of the proper depth of treatment involves analysis of a number of variables. These can include strength values of untreated and treated subgrade soils, subbase and base course materials, the stability values assigned to native soils underlaying the constructed layers, proximity of groundwater, the local climatic conditions, the anticipated traffic volume and axle weights, the desired design life, the local historical experience with similar materials and similar applications, and other factors. These are issues to be addressed in engineering and economic evaluations by project engineers and project owners.

TESTING AND EVALUATION

BASELINE TESTING

Materials laboratory testing provides the fundamental data required for earthworks projects and construction with earth materials. Tests such as Gradation, Atterberg Limits, Hydrometer and compaction control tests (also known as Modified Proctor compaction tests or Moisture-Density Relations tests) provide the type of basic information required to understand the classification and general characteristics of the aggregate and soil materials for a specific project. These tests provide the baseline information for construction procedures and quality control testing operations. They are standard procedure for earthworks compaction operations and construction with aggregate and soil materials. Their proper application is equally if not more important for soil improvement and stabilization projects, and their use is highly recommended for projects where the **EMC SQUARED** System is being utilized. (See section with subheading COMPACTION on page 15.)

SITE SPECIFIC REQUIREMENTS

The broad spectrum improvement of aggregate and soil materials by the **EMC SQUARED** System is indeed a major step forward in the construction of earth materials structures. While all aggregate and soil materials have much in common, the variety of aggregate and soil types is surprising. The variety of construction applications, unique service conditions, and performance requirements for compacted earth material structures are equally impressive in number. When constructing with natural earth materials, stabilized or not, the challenge is always to properly address site specific conditions and performance requirements. It is recommended that individual field or laboratory tests be conducted whenever possible for final determination of the suitability of **EMC SQUARED** System treatments for specific project and performance requirements.

There are limits to appropriateness and cost-effectiveness for a particular application with any chemical or mechanical stabilization method. With different climates, different use factors, and the complex chemistry of different aggregate and soil types, field and laboratory tests are recommended whenever possible to first confirm that the amount of improvement provided by an **EMC SQUARED** System treatment is sufficient for project goals before commencement of the full scale project. Testing Guidelines are available to qualified Soil and Foundation Engineering Laboratories for the **EMC SQUARED Stabilizer** (1000) and for the Dual Component Treatment, **EMC SQUARED 2000** and **EMS** Earth Materials Sealant (Technical Bulletins No. 8427.EMC, No. 8337. EMC and No. 8378.EMC/EMS). Careful evaluation and testing are essential ingredients for a successful project, along with rigorous attention to construction specifications and quality control assurance during construction.

PREDICTIVE TESTING

Many public agency design systems require treated subgrade soils or treated (bound) aggregate base course materials to achieve specific strength values in laboratory index tests. Review of test methods is advised and every effort possible should be made to ensure that laboratory tests reflect field service conditions and the actual service environment as closely as possible. There are limits to the predictive value of accelerated testing programs in materials laboratories. Most standard tests provide index values, leaving predictions of success or failure in meeting performance requirements for a specific project to the individual reviewer.

When projects involve large volumes of aggregate or soil which might benefit from stabilization treatment, or when road owning agencies with hundreds of miles or kilometers of roads are evaluating the potential of stabilization treatment for their road system, a program which starts with both field and laboratory testing is, by far, the better answer. With field performance results in hand, laboratory index testing can be evaluated for its validity (i.e., ability to predict actual field performance). Index test results which do not correlate with these results can be abandoned as predictors. The same approach can be taken with overly “worst case” index tests which provide results suggesting a particular treatment would not be effective when actual field performance demonstrates that the opposite is true. Solutions to earthworks and road stability problems ultimately involve economic issues, and low-cost affordable treatment technologies warrant every effort in evaluation to assure that test results arrived at with laboratory apparatus do not mislead or distract project owners from solutions which are effective in solving field performance problems and lowering construction and maintenance costs. In this regard, field testing should be conducted whenever possible in conjunction with laboratory index testing. Accessed at a later date in perspective of field performance, index test results may be valuable predictors for other projects utilizing similar aggregates or soils for similar service conditions.

Performance based laboratory testing is gaining increasing attention for evaluation of base course and subgrade materials as well as for pavement materials such as asphalt and concrete. As performance based testing is implemented on a more wide spread basis for highway roadbed materials and geotechnical applications, the predictive value of accelerated tests in materials laboratories will be enhanced. For instance, Suction and Dielectric testing (also known as Tube Suction testing) uses electrical properties for the classification of strength properties of base course properties. Developed with FHWA sponsorship, this test also identifies frost and moisture susceptible aggregate materials and can be utilized to evaluate the effectiveness of stabilization treatments.

RECOMMENDED DESIGN AND LABORATORY METHODS

The Manufacturer's Recommendation for the use of EMC SQUARED System stabilizer products is use of Mechanistic-Empirical (M-E) Pavement Design methods, based upon the Mechanistic-Empirical Pavement Design Guide (MEPDG), or modified M-E versions developed by various state DOT's and international organizations, and use of the Resilient Modulus laboratory test method, or associated test methods that can provide the Modulus Values that are the required input for M-E design methods. These advanced and more sophisticated design and test methods are internationally recognized, promoted in the United States by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) and being adapted by many state Department of Transportation (DOT) organizations. These modern design and test methods provide the engineering basis that most fully takes advantage of the outstanding cost-savings the advanced EMC SQUARED System stabilization technology makes available.

GRAVEL ROADS FIELD EVALUATION

Many gravel materials can be treated with low cost concentrated liquid stabilizer technology to eliminate moisture sensitivity and frost susceptibility and to stabilize for greater strength as hardened running surfaces for unpaved gravel roads. Every gravel source has a unique combination of characteristics such as gradation, percent crushed material, percent fractured faces, and the mineralogy of the fines (sometimes called “binder”). An open-graded aggregate material which is ideal as a pavement base course may not be a good choice for a gravel surfaced road, and vice versa. Good classification information on the aggregate material is important to have available if stabilization is being considered. Further laboratory testing can be of assistance, but, for gravel roads, field trials may be the more efficient means of evaluation.

The first step is to review the potential benefits of gravel stabilization. In the best of cases, heavily trafficked gravel roads have gone years after stabilization treatment without need for maintenance grading. In other cases, roads which formerly needed almost weekly grading have been improved to only needing minor spot touch ups on a once or twice a year basis. Going beyond the savings in grading maintenance, this improved performance also means that gravel loss has been reduced, and road users have a far higher quality running surface. When you total up the potential benefits of stabilization, it makes sense to run field tests and to evaluate compatibility of the stabilizers with locally available gravel resources so you can identify which materials perform best as stabilized running surfaces. Stabilization offers many multiples of benefits over dust palliative treatments and at lower long-term cost than annual dust control programs which offer little if any benefit in wet weather or winter conditions.

CONSTRUCTION QUALITY CONTROL

Aggregates and soils are natural earth materials. Engineering controls continue to improve through advances in geotechnical engineering and soil mechanics practice, but the reality is that most projects are unique in regards to their particular aggregate and soils as these are materials which have been made and arranged by nature (regardless of any crushing, screening and recombination processes to which they may later be subjected). While all aggregate and soil materials have much in common, the variety of aggregate and soil types is surprising. Consequently, the branch of engineering practice that relates to construction with earth or "geomaterials" must make extensive use of site specific monitoring and observational procedures.

To emphasize the individual nature of earth materials and the need for project specific quality control measures, a software program for modeling of soils for geotechnical engineering applications includes experimental data on over 5,000 different soils. The USDA Natural Resources Conservation Service (NRCS) has identified over 20,000 different kinds of soil in the United States alone. Given this variety, it is easy to understand why the use of laboratory compaction control tests has become standard practice for individual projects, preliminary to earthwork, subgrade, base course and surface course construction. Compaction control tests (also known as Modified Proctor Compaction tests or Moisture-Density Relations tests) determine the maximum density to which a given aggregate or soil can be compacted with a given amount of compactive effort, and they determine the optimum moisture content at which that maximum density result was achieved. This baseline information is used by construction crews to guide their construction operations and by quality control personnel conducting on-site monitoring tests during construction. **Because of the importance of the Moisture-Density controls to the ultimate performance of a stabilized aggregate or stabilized soil, when working on construction sites with variations in soil types from area to area, it is recommended that compaction check points be taken frequently to verify that the Moisture-Density Relations in use are suitable for the material being treated and compacted in a particular area.**

The standardization of compaction control tests highlights the fact that density and stability are highly interrelated. Soil strength is normally increased as its density is increased. Porosity and void ratios are decreased, thereby lowering the permeability, moisture susceptibility and compressibility of the soil. The attainment of high densities is fundamental to the stability of earth materials, and the application of stabilization treatments in no way reduces the importance of achieving the highest possible density during construction operations.

Adherence to compaction controls and compaction specifications normally requires mobilization of a significant amount of construction equipment and effort by construction personnel. Most professionals with construction and civil engineering backgrounds have been educated as to the importance of proper compaction. The following results from representative compaction studies provide further illumination as to the value gained from the investment in compaction.

Compactive effort has a dramatic effect on the strength and moisture resistance of both treated and untreated soils. A compaction study with untreated silty sand and sandy silt soils was conducted at three levels of Modified Proctor compaction effort. The CBR index of the soils went from an average of 7 at 80% Modified Proctor compaction effort to 33 at 90% compaction and 62 at 95% compaction. Notice that the bearing strength of the soil is almost doubled as the density of the soil is brought five percent closer to its laboratory maximum density (100% compaction). On another compaction study with a treated pit run aggregate material, the CBR index went from 24 at 90% Modified Proctor Compaction effort to 48 at 95% compaction (the untreated CBR at 95% compaction was 17). Again, the bearing strength and stability of this material was doubled simply by increasing the level of compactive effort applied.

Moisture content at time of compaction is similarly important to density and stability. A variation of one percent moisture from the determined optimum moisture content may reduce density by over two pounds per cubic foot (thirty-two kilograms per cubic meter) and consequently increase the void space by a far greater percentage. An increased void ratio reduces strength and increases the susceptibility of the material to moisture intrusion and ultimately the loss of bearing strength. A compaction study comparing the unconfined compressive strength of an **EMC SQUARED** Stabilizer treated expansive clay soil at different moisture contents (prepared with the same level of compactive effort) clearly indicates that proper moisture control is key to obtaining maximum strength. At a variation of 1.4 percentage points from optimum moisture content there was over 10% loss in strength, at 2.1 percentage points variation over 30% loss in strength and at a 5 percentage points variation over 40% loss in strength. As the above test results indicate, there are good reasons for strict moisture controls during compaction. **The maintenance of proper compaction moisture content and the achievement of specified compaction levels have direct bearing on the strength and moisture resistance of the compacted structure.**

APPLICATION RATES FOR STABILIZATION

Application rates for **EMC SQUARED** System treatments are determined by calculations based upon a specific volume of stabilizer per unit volume of aggregate or soil. While mix design testing is conducted on an occasional basis to determine the optimum addition rate of stabilizer treatment for a specific aggregate or soil material (or the optimum available aggregate source or soil borrow source to maximize the benefits available from stabilization treatment), the majority of projects utilizing **EMC SQUARED** System treatment are based upon **STANDARD APPLICATION RATES** of the stabilizer products. Unless otherwise indicated in project plans or specifications, the following **STANDARD APPLICATION RATES** should be utilized for all projects using **EMC SQUARED** System treatments for improvement, modification or stabilization of aggregate and soil materials. As expressed in the charts below, the standard application rates for both **EMC SQUARED Stabilizer** (1000) and **EMC SQUARED 2000** are based upon a rate of **1 gallon per 15 cubic yards of aggregate or soil material** (or 1 liter per 3 cubic meters). When the **EMS** product is used in combination with **EMC SQUARED 2000** as the Dual Component Treatment, it is utilized at a ratio of two parts **EMS** per one part **EMC SQUARED 2000** (a 2:1 ratio), or **2 gallons per 15 cubic yards of aggregate or soil material** (or 2 liters per 3 cubic meters), unless otherwise indicated in plans and specifications.

APPLICATION RATES FOR STABILIZATION

EMC SQUARED Stabilizer (1000) Treatment

ENGLISH UNITS		SI UNITS	
1 gallon EMC SQUARED Stabilizer (1000)	15 yd^3	1 liter EMC SQUARED Stabilizer (1000)	3 m^3
1 drum EMC SQUARED Stabilizer (1000) (drum = 55 gallons)	825 yd^3	1 drum EMC SQUARED Stabilizer (1000) (drum = 208.2 liters)	624.6 m^3

EMC SQUARED 2000/EMS Dual Component Treatment

ENGLISH UNITS		SI UNITS	
1 gallon EMC SQUARED 2000 & 2 gallons EMS	15 yd^3	1 liter EMC SQUARED 2000 & 2 liters EMS	3 m^3
1 drum EMC SQUARED 2000 & 2 drums EMS	825 yd^3	1 drum EMC SQUARED 2000 & 2 drums EMS	624.6 m^3

AREA COVERAGE

EMC SQUARED Stabilizer (1000) Treatment

ENGLISH UNITS			SI UNITS		
Gallon EMC^2	Depth (inches)	Area ($feet^2$)	Liters EMC^2	Depth (mm)	Area (m^2)
1	3	1,620	1	75	40
1	4	1,215	1	100	30
1	6	810	1	150	20
1	8	607.5	1	200	15
1	12	405	1	300	10

EMC SQUARED 2000/EMS Dual Component Treatment

ENGLISH UNITS			SI UNITS		
Gallon EMC^2 & EMS	Depth (inches)	Area ($feet^2$)	Liters EMC^2 & EMS	Depth (mm)	Area (m^2)
1 + 2	3	1,620	1 + 2	75	40
1 + 2	4	1,215	1 + 2	100	30
1 + 2	6	810	1 + 2	150	20
1 + 2	8	607.5	1 + 2	200	15
1 + 2	12	405	1 + 2	300	10

COMPACTION WATER AND DILUTION RATIOS

When addressing a specific volume of aggregate or soil requiring treatment, it is important to understand that the calculations for the amount of stabilizer required are independent of the calculations for the amount of compaction water required. Each of these determinations must be made independently.

OPTIMUM MOISTURE CONTENT (OMC)

Aggregate and soil materials vary in their optimum moisture contents as well as in their gradations and mineralogy. Compaction control tests (Modified Proctor compaction tests or Moisture-Density Relations tests) define the maximum density to which a given aggregate or soil can be compacted with a given level of compactive effort, and they determine the optimum moisture content at which that maximum density result was achieved. Moisture content is expressed as a percentage of the weight of the aggregate or soil (at its maximum density) as determined by compaction control tests. The optimum point for a particular aggregate might be 6% moisture content, for instance, while a clay soil might test out at 20% or higher. Each aggregate source and each soil deposit has its own unique optimum moisture content which is a characteristic determined by laboratory testing procedures.

IN SITU MOISTURE CONTENT

Field conditions are entirely another matter. That same aggregate as it arrives from its manufacturing location might be at 3% moisture content. When it comes time for placement and final compaction, the moisture content will need to be increased from its field moisture content (the natural water content as it exists immediately preceding construction operations is known as the ambient or nominal moisture or, to refer specifically to an on site material, the in situ moisture content). Field conditions must also be anticipated where materials have moisture in excess of the in situ moisture requirements for stabilization and must be subjected to drying in preparation for treatment (see the subheading on page 10 titled EXCESS MOISTURE DRY BACK REQUIREMENTS).

COMPACTION WATER

In the case of the particular example above (in situ moisture content of 3% and an optimum moisture content of 6%), the aggregate moisture content will need to be increased by three percent to reach the 6% optimum moisture content figure. <u>The water added to adjust the moisture content is known as the compaction water.</u>

As is clear from the example, the compaction water requirements can vary widely, dependent upon what the optimum moisture content of the particular aggregate or soil is and what its in situ moisture content happens to be on the day of compaction operations. A clay soil, for instance, might need to be adjusted from a 10% in situ moisture content to a 20% optimum moisture content, requiring over three times the volume of compaction water as was required by the aggregate material in the example above (basing calculations on the same cubic volume of material). Compaction water calculations are project specific and they can change from day to day as weather conditions affect the moisture content of the untreated in situ material.

EXAMPLE CALCULATIONS FOR DETERMINATION OF COMPACTION WATER REQUIREMENTS

<u>**Summary of Method**</u>

1. Calculate the volume of aggregate or soil to be treated.
2. Multiply the volume by the unit weight of the aggregate or soil.
3. Multiply the total weight of the aggregate or soil by the % moisture needed to bring the material to optimum moisture.
4. Divide the weight of the water needed by the unit weight of water. This equals the volume of compaction water needed.

<u>**Example Using English Units**</u>

Using a section of road base course for sake of example that is 3,284 feet (1 km, or approximately six tenths of a mile) in length by 23 feet in width and calculating aggregate volume requirements for a base layer that will be compacted to a six inch depth, you have a total aggregate volume of approximately 1,400 cubic yards. Estimating that each cubic yard of this particular aggregate will weigh two tons, or four thousand pounds, you can then calculate the weight of water (and then convert to the liquid volume) required to increase the moisture content of the total volume of aggregate by 1%.

1,400 cubic yards x 4,000 pounds per cubic yard x 1% moisture = 56,000 pounds of water ÷ 8.34 pounds per gallon (the weight of 1 gallon of water) = 6,700 gallons of compaction water.

Using the figures above, this section of road of approximately six tenths of a mile would require the addition of 6,700 gallons of compaction water for every 1% increase in moisture content.

<u>**Example Using SI Units**</u>

Using a base course comparable to the example above, roughly one kilometer in length by 7 meters in width and a base layer that will be compacted to 150 mm in depth, we have an aggregate volume of approximately 1,050 cubic meters. Estimating that each cubic meter of this particular aggregate will weigh 2,400 kilograms, we can then calculate the weight of the water required to increase the moisture content of the total aggregate volume by 1% (and then convert to liquid volume since we know that 1 kilogram is the weight of 1 liter of water).

1,050 cubic meters x 2,400 kilograms per cubic meter x 1% moisture = 25,200 kilograms of water ÷ 1 kilogram per liter (the weight of water) = 25,200 liters of compaction water.

Using the figures above, this one kilometer section of road would require the addition of 25,200 liters of compaction water for 1% increase in moisture content.

COMPACTION WATER REQUIREMENTS

No less than two percent moisture (compaction water with stabilizer additives) should typically be added to aggregates and soils as part of the application of EMC SQUARED System products in order to properly disperse the concentrated stabilizers. On a practical basis, this will be very close to the 135 to 1 (135:1) dilution ratio requirement discussed below.

NOTE: In special circumstances, where existing soil moisture content is close to or at the optimum moisture content, reducing the dilution ratio to as low as 20 to 1 (20:1) is allowed.

DILUTION RATIOS

Because **EMC SQUARED** System products are highly concentrated, there is a recommended minimum dilution ratio (or minimum amount of compaction water) for soil improvement, modification and stabilization applications. The concentrated stabilizers must be highly diluted in order to be dispersed throughout the volume of aggregate or soil they are required to treat. If you will just visualize the relative sizes of a 15 cubic yard pile of aggregate and the 1 gallon of **EMC SQUARED Stabilizer** (1000) required to treat it or, in metric units, a 3 cubic meter pile and a treatment rate of 1 liter **EMC SQUARED Stabilizer** (1000), then it will be much easier to appreciate how essential the dilution water is to the process of dispersing and mixing the stabilizers with aggregate and soil materials. Each gallon or liter of concentrated **EMC SQUARED Stabilizer** (1000) or **EMC SQUARED 2000** applied at the Standard Application Rate, treats an amount of earth material equal to approximately 3,000 times its volume. A little bit goes a long way, but adequate dilution water is essential to its distribution. **The standard dilution ratio for the EMC SQUARED concentrated liquid stabilizer products, EMC SQUARED Stabilizer (1000) and EMC SQUARED 2000, is 135 parts water to 1 part concentrated liquid stabilizer (135:1).** In circumstances when soil moisture is already close to or at its optimum moisture content and dry back is not practical see the note in the previous section "COMPACTION WATER REQUIREMENTS".

Standard Dilution Ratio
135 parts water per
1 part **EMC SQUARED Stabilizer** (1000)
or 1 part **EMC SQUARED 2000**

NOTE: For Dual Component Treatments (in which both EMC SQUARED 2000 and EMS Earth Materials Sealant are added to the same compaction water), <u>the EMS is not used as part of the dilution calculations</u>. Unless otherwise noted in plans and specifications, the EMS product is simply added into the compaction water at a ratio of 2 parts EMS for 1 part EMC SQUARED 2000 (2:1 ratio).

NOTE: The above information on dilution ratios and % compaction water in no way eliminates the responsibility of contractors and construction personnel to adhere to project specific compaction control requirements and specified ranges of tolerance for moisture content during compaction operations.

MOISTURE CONTENT TOLERANCES

Moisture content at time of compaction has great influence on the density, strength and stability of treated materials. Once Moisture-Density Relations for a particular material have been determined by laboratory compaction control testing (ASTM D 1557), strict moisture content tolerances must be observed for the treated material.

In preparation for treatment, untreated materials should have a moisture content not more than two percentage points below and not greater than the optimum moisture content determined for the treated material.

For the treated material, the moisture content at time of compaction should not be below its optimum moisture content and not greater than two percentage points above the optimum moisture content determined for the treated material. Expansive clay soils may compact best at three percentage points above their treated optimum.

SUMMARY AND EXAMPLE

As discussed in the previous sections, top priority must be given to controlling the moisture content of the treated materials as they are being processed through the stages leading to final compaction. If the moisture content of the untreated aggregate or soil material is already within the required tolerances as earlier described, then the stabilizer solution (which typically approximates the addition of 2% compaction water) will provide the necessary compaction water to bring the material into the moisture content tolerances required for compaction of the treated material. If the untreated material is out of tolerance on the "dry side", for example, 6% below the optimum moisture content determined for the treated soil, then water must be added by sprinkling and mixing (to make up the first 4% of the 6% compaction water requirement for this example) prior to the addition of the stabilizer solution. The stabilizer solution will provide the balance of the compaction water requirement (typically 2%, as provided by the Compaction Water and Dilution Ratio requirements).

Having previously reviewed (1) the application rate charts on page 7, (2) the moisture content and compaction water requirements on pages 8 and 9, and (3) the dilution ratio and moisture content tolerance requirements on page 9, you have the ability to plug in project specific information and start the planning process for a particular stabilization project. You can now calculate the volume of stabilizer product required, the volume of dilution water required to make up the stabilizer solution, and the volume of water required (if any) to increase the moisture of the aggregate or soil to a point within the range of tolerance prior to addition of the stabilizer solution.

The project specific information needed will be (1) the volume of aggregate or soil to be treated, (2) the Moisture-Density Relations, or Compaction Control Testing results for the specific aggregate or soil (which provide the maximum dry density and optimum moisture content information), and (3) the current in situ or "in place" moisture content of the aggregate or soil as it exists at the project site, borrow site, or stockpile location.

Proceeding to an example calculation: A contractor is working on a highway project. Treatment of a 79,200 square yard, six inch deep aggregate base course is specified. Having the aggregate quantity available in the bid documents and a specification requiring use of the **EMC SQUARED Stabilizer** (1000) product, the contractor is able to figure the stabilizer quantity requirements and order the stabilizer product for storage on site. With 13,200 cubic yards of aggregate to treat, the contractor uses the "VOLUME COVERAGE" chart on page 7 under "APPLICATION RATES FOR STABILIZATION" to determine that 880 gallons (16 drums of 55 gallons each) of the concentrated liquid stabilizer will be required. The contractor also contracts with a materials testing firm to conduct the required compaction control testing. The testing firm collects aggregate specimens from the stockpile of aggregate already on site and obtains a sample of **EMC SQUARED Stabilizer** (1000) directly from Stabilization Products LLC. Upon completion of the laboratory testing, using ASTM Test Method D 1557, the laboratory manager provides the contractor with the required compaction control data necessary for the stabilizer treatment calculations and for the field compaction tests that will be required during construction. The maximum dry density determined for the aggregate material in this case is 130 pounds per cubic foot (pcf), the optimum moisture content is 8.5% and the in situ moisture content is 3.5%. The in situ moisture content is drier than allowed by the tolerances established for treatment with **EMC SQUARED** System stabilizer products, so the contractor is alerted to the fact that the aggregate will need to be moisture adjusted with additional water before the stabilizer solution can be added.

Moving forward to construction, the contractor uses optimum moisture content as the target for their compaction effort. Figuring that the stabilizer solution (per application rate provided on page 7 and the dilution ratio instruction on page 9) will provide approximately two percent additional moisture, the contractor plans to sprinkle and mix in the amount of water required to increase moisture content by three percent in order to bring the moisture content within the required tolerance prior to treatment. The first section of the project is 840 feet long by 40 feet wide and the in place aggregate will be compacted to a six inch depth. Figuring an aggregate volume of 16,800 cubic feet at a maximum dry density of 130 pcf, the contractor calculates 1,092 tons of aggregate per section. At three percent moisture addition, 32.76 tons, or 7,856 gallons of water will be required to properly adjust the moisture content of the aggregate prior to application of the stabilizer solution.

In planning for the preparation of the stabilizer solution for this section, the contractor calculates a requirement for 41.5 gallons of **EMC SQUARED Stabilizer** (1000), per charts on page 7, and 5,602 gallons of dilution water (applying the 135 parts water to 1 part stabilizer Dilution Ratio) to treat the 16,800 cubic foot (622.22 cubic yard) quantity of aggregate. Limited by the 4,000 gallon capacity of his water truck application equipment, the contractor decides to divide the 840 foot length of base course up in to two twenty foot widths, so that both the compaction water and the batch of stabilizer solution can be cut in half in order to accommodate the capacity of the water truck. In this case 3,928 gallons of compaction water will be added to the 840 foot by 20 foot section, followed by the application of stabilizer solution (20.75 gallons of stabilizer and 2,801 gallons of stabilizer solution).

With the size of the individual sections now adjusted to accommodate the capacity of the water truck, and the quantity of compaction water and stabilizer solution calculated accordingly for the reduced section size, the fundamental mathematics for stabilizer application and compaction control have been addressed. As the project moves forward on subsequent days, changing field moisture conditions and changing materials (aggregates with different moisture-density relations, for instance) may be encountered, but the contractor now has necessary calculation process in hand to make adjustments as required.

EXCESS MOISTURE DRY BACK REQUIREMENTS

Situations can occur and should be anticipated where in situ moisture contents of materials to be treated have moisture contents in excess of the in situ moisture requirements for stabilization (i.e., in excess of the optimum moisture content as determined for the material during laboratory compaction control tests where the material has been treated with the stabilizer solution). An example would be a project inundated by significant rains the night before a planned stabilization application, leaving the subgrade soils to be treated wet of their optimum moisture content. Depending upon project schedules and time deadlines, one option would be to await natural drying of the soil until it is at or below its optimum moisture content. A second approach would be to aerate the soil during suitable weather with mixing equipment such as motor graders, cross-shaft rotary mixers or tractor drawn agricultural discs and plows. Dry back in this manner can often be accomplished in a relatively short period of time if weather conditions are favorable. Note that tractor drawn discs and plows are many times more efficient at aeration and drying than motor graders or cross-shaft rotary mixers and generally less expensive to operate. Greater drying efficiency is achieved with larger disc or plow units drawn by 4 wheel drive or rubber-tracked crawler tractors of suitable horsepower and speed to rapidly and continuously aerate large areas.

Note that application of **EMC SQUARED** System treatments to aggregates or soils already above their treated optimum moisture content is generally not advised. The addition of the stabilizer solution retards evaporation of the excess water in the material and is counterproductive to the dry back that must be accomplished before the moisture content of the material is adjusted within the standard tolerances for compaction operations. With the approval of the project engineer, stabilization treatment may be applied to an untreated soil that is already above its optimum moisture content. Dry back is then accomplished with mixing operations and aeration procedures that continue after the moisture content has been added in the form of stabilizer solution until that point where the treated mixture dries to a moisture content within tolerances for compaction. Care should be taken to ensure that the particular aggregate or soil can still be adequately pulverized and mixed when these operations are conducted with the total moisture content well above the laboratory determined optimum. Proceeding in this manner in no way changes the requirement that compaction operations be conducted within the specified range of tolerance for moisture content.

Dry back below optimum moisture content is not a requirement unique to **EMC SQUARED** System applications. Very similar procedures are required with calcium based stabilizers to ensure that project soils are dry enough to be suitably pulverized for blending with powder cement, fly ash and lime or lime slurry mixtures. The addition of cement as a drying agent preparatory to application of an EMC SQUARED System treatment should only be done with the approval of the project engineer. Laboratory testing is recommended preliminary to the use of cement in combination with the EMC SQUARED System treatment and the contractor will be fully responsible for the final constructed product. It is recommended that the addition rate of cement be limited to no more than two percent (2%) by dry weight of the soil in order to reduce the risk of shrinkage cracking generated by the addition of cement. The **EMC SQUARED** System products do not dry back excessively wet soils or aggregate materials. When wet weather conditions exist, or are anticipated, contractors using **EMC SQUARED** Stabilizer product should plan accordingly in regards to mobilizing construction equipment efficient for aeration and dry back operations.

FIELD ADJUSTMENTS

In spite of preliminary compaction control tests, on site monitoring of the moisture content of in situ materials and monitoring of the moisture content of treated materials (mixed and prepared for compaction), job site conditions such as extreme weather fluctuations may create requirements for adjustment of the moisture content outside the specified range of tolerance. Realizing the importance of compaction control points to the ultimate strength and stability of the compacted materials, variances should not be allowed without careful study of the specific problem and the approval of the project engineer.

HIGH WATER TABLE CONDITIONS

While adherence to specified compaction controls is essential to realizing the full performance benefits of the EMC SQUARED System stabilizer products, the presence of groundwater in close proximity to the layer being stabilized may call for modifications to the standard construction procedures and the use of different types of compaction equipment than might otherwise be used. If such conditions are anticipated, Stabilization Products LLC should be contacted as well as the project engineer for review and recommendations prior to the commencement of construction.

SPECIALTY APPLICATIONS IN THE ABSENCE OF COMPACTION CONTROL TESTS

The **EMC SQUARED** System can provide tremendous value for road maintenance operations and other applications where compaction control tests are not conducted and installations are generally not governed by specific plans and specifications. While other methods of moisture control are utilized in these situations, these methods in no way are acceptable substitutes when test measures and more exact methods of calculation are specified. Compaction control tests and jobsite compaction tests are always highly recommended.

In these maintenance type applications, the minimum dilution ratio requirement is still in effect. Lacking previous experience with use of the **EMC SQUARED** System for treatment of local materials, proper moisture control can be best “dialed in” by first conducting a test section. For example, since a gallon of the **EMC SQUARED** products treats fifteen cubic yards, calculate an area with that volume of aggregate or soil, add 135 gallons of water and a gallon of **EMC SQUARED Stabilizer** (1000), or a gallon of **EMC SQUARED 2000** and two gallons of **EMS**, into a mixing tank. Apply the stabilizer solution to the material and go through a mixing and compaction operation. If the mixed material is visibly too dry for proper compaction, then estimate the additional moisture content required and add the additional moisture in the form of untreated water. If the mixed material is visibly too wet, or if the treated material "pumps" or deforms during compaction, then reduce the amount of dilution water to a dilution ratio of not less than 20 gallons of water per gallon of EMC SQUARED product.

In the absence of compaction control test data and on site moisture content testing equipment, there is really no substitute for trial batches, test sections, field adjustments and common sense determination of a proper moisture content for compaction. During this process of adjusting moisture content of the material being treated, make sure to err on the wet side so that proper distribution of the stabilizer solution is assured. Then use aeration measures to adjust the moisture content of the treated mixture so that compaction equipment can be operated without creating bow waves or pumping action in the treated material. Concentrate on a thorough compactive effort. As discussed earlier (see page 6 under subheading CONSTRUCTION QUALITY CONTROL), the degree of compactive effort applied has huge impact on stability.

CONSTRUCTION PROCEDURES

The final performance of treated materials is dependent upon proper construction procedures and proper construction quality control measures. The performance of the compacted structure will depend upon factors such as the degree of pulverization attained in field mixing, the accuracy in application of the stabilizer solution, the thoroughness of mixing operations, the degree to which optimum moisture content is maintained during compaction operations, the effectiveness of compaction operations, the attainment of proper drainage conditions, and the quality of final grading and compaction efforts. It is essential for project owners, specifiers and contractors to implement proper construction procedures and quality control measures if the full benefits of stabilization treatment are to be realized.

TEMPERATURE AND WEATHER LIMITATIONS

Application of **EMC SQUARED** System treatments is not recommended if atmospheric temperature is below 40º F (4.4º C) and falling, but may be started when air temperature is above 35º F (1.7º C) and rising. **EMC SQUARED** System treatments are regularly applied for treatment of materials in areas which experience severe cold winter conditions, but application and construction operations are not recommended during freezing conditions or just before seasonal freeze-up is anticipated. There are no upper limitations on temperatures at time of application as long as compaction moisture content specifications can be maintained and surface materials maintained in an adequately moistened state to permit final compaction and grading operations to be conducted without unravelling or damaging the finished surface.

Application of **EMC SQUARED** System treatments is not recommended during periods of rainfall or when rainfall is predicted within 24 hours of application of the treatment. If rainfall is encountered during application of the stabilizer solution and excessive loss of solution due to washing occurs, these areas will require repeat treatment.

NOTE: In the event that stabilization operations are in progress and heavy rainfall is expected within a short period of time, application of additional stabilizer solution should be halted immediately and every effort made to blade treated materials back into a tight and smooth surface with restoration of as much cross slope and drainage as time allows. A compactive effort should also be applied to help seal the surface as much as possible against water penetration. If the stabilizer treatment is successfully protected in this manner from washing during the subsequent rains, then constructing operations should be resumed as soon as possible, and compaction moisture content readjusted, in order to protect the treated materials from dry back and curing preliminary to application of final compaction. Left to dry and harden ahead of final compaction and grading, the treated materials will be difficult to remix, and the entire area where stabilization measures were left in this condition may need to be re-pulverized and re-treated.

DILUTION PROCEDURES

Pressurized distributor trucks, water trucks, water tankers and other water spray equipment which will be used for application of stabilizer solution must have water tanks with liquid volume capacity accurately measured. (See page 13, second paragraph under subheading APPLICATION OF STABILIZER SOLUTION for accuracy of distribution requirements for equipment spreading or otherwise distributing the stabilizer solution.) The capacity of the water tank must be known in order to accurately distribute stabilizer solution at the previously determined application rates and dilution ratios required to treat the previously determined aggregate or soil volume for a particular length of road or area of soil material.

With the application rates and dilution ratios in hand and construction planning completed in regards to determination of (1) the area or length of the project that can be fully constructed (from application of stabilizer solution to final compaction and grading) in one day using available water resources and construction equipment resources mobilized at the project site, (2) the volumes of stabilizer and dilution water required to prepare the stabilizer solution for treatment of the selected daily total volume of aggregate or soil, (3) the total number of loads of stabilizer solution that will be required during that construction day, given the measured liquid volume capacity of the pressurized distributor trucks, water trucks, water wagons or water spray equipment available for application of stabilizer solution, and (4) the area or length of project that will be completed in one construction sequence, then batches of stabilizer solution can be prepared for use. Given the need to achieve and maintain optimum moisture content within a strict range of tolerance during construction, it is normally best to work large stabilization projects on a section by section basis, for example, dividing a project up into sections each of which can be fully completed in four hours.

Once diluted, **EMC SQUARED** System stabilizer solution should be applied to project materials the same day. While water of potable quality is not required, water sources should be of relatively high quality and not contaminated with excessive organic content. If water sources with extreme pH, unusually high mineral content or high organic content are to be considered for use as the dilution water for stabilization applications, then laboratory testing or field testing is recommended using that particular water source as the dilution water for the stabilization treatment.

Unless otherwise specified, the concentrated liquid stabilizer should be added to the dilution water through measuring systems such as metered pumps. Use of metered pumps is highly recommended, both for accuracy in measurement and to minimize requirements for personnel climbing up on water trucks and water wagon tanks to load stabilizer additives. For large projects, charging hoses can be run from the metered pump to water standpipes and attached to the standpipe so that the concentrated liquid stabilizer can be loaded along with the dilution water directly into the fill hole of the pressurized distributor truck, water truck or water tanker.

Approximately 90% of the dilution water required to fill a single load of stabilizer solution should be first added to the mixing tank before the concentrated liquid stabilizer is added. The remainder of the water is then added. For systems set up with meters and flow rates that can meter the stabilizer input throughout the water loading operation, the stabilizers can also be added on a continuous basis. In either case, the turbulence provided by the addition of the dilution water will provide adequate mixing action to prepare the stabilizer solution.

NOTE: When using the **EMC SQUARED** System products, they must be stirred in the container before being pumped or poured into the mixing tank.

<u>Dual Component Treatment</u> - Dilution of EMC SQUARED 2000 and EMS Products

When preparing to mix water and concentrated liquid stabilizers for a Dual Component Treatment, the **EMC SQUARED 2000** and the **EMS** Earth Materials Sealant products are added individually to the compaction water and then applied together as a dilute solution. The products can be added to the dilution water simultaneously or one at a time (and in either order).

PREPARATION OF THE SURFACE

If an in-place aggregate or soil material which is to be stabilized is not already in a loose state, it must first be ripped, scarified, disked or rototilled into a well pulverized mixture. If efforts to loosen, rip, scarify, disk or rototill the hardened surface are hindered by a dry material with a high degree of natural cementation, the project engineer may allow use of as much as 10% of the stabilizer solution for the area to be treated to be slowly and uniformly applied to the hardened materials so as to facilitate operations and reduce wear on construction equipment. (Wetting applications with this portion of the stabilizer solution should be applied in multiple passes and continuous with the pulverization and mixing operations so as to minimize any loss of the stabilizer solution off the area to be treated.) Stabilization operations should then proceed immediately or no later than the morning following the loosening and pulverization operations in which stabilizer solution was utilized.

If the material to be treated is being imported and placed on an existing subgrade, the subgrade should first be inspected and all soft spots repaired. Proper compaction is fundamental to stabilization and if subgrade materials are unable to support compaction equipment, adequate density will not be achieved. **If the material to be treated is already above optimum moisture content, it should be aerated with mixing equipment or allowed to naturally dry back before application of the stabilizer solution to a moisture content not more than three (3) percentage points below and not greater than the optimum moisture content determined for the treated material.**

APPLICATION OF STABILIZER SOLUTION

Application of **EMC SQUARED** System stabilizer solutions should be limited to the area specifically shaped and sized to receive the solution. The area should be limited to such a size that all operations, including mixing, compaction and fine grading can be completed in one day. If overnight temperatures will not drop below 32º F (0º C), it is the project engineer's option to allow treated materials to remain in a stockpile or windrow overnight with the precaution that moisture content must be checked and properly adjusted for compaction when construction operations resume the following day.

For projects with construction specifications requiring use of cross-shaft rotary mixers with built-in metered additive systems supplying stabilizer solution directly into the mixing chamber, water trucks and water tankers can be directly coupled to the mixer. For other projects where use of pressurized distributor trucks, water trucks, water tankers and water spray equipment is permitted for application directly to the aggregate or soil ahead of mixing operations, spray equipment must be demonstrated to the satisfaction of the project engineer as capable of providing a uniform spray pattern and application rate. Unless otherwise specified, water spray equipment should have a pressurized spreader bar, a water tank with liquid volume capacity accurately measured, and an accurate speedometer to ensure uniform distribution of the stabilizer solution as required for in-place mixing operations. If the full width spray pattern is not uniform, placement of the treated materials into windrows will be required, followed by blade-mix processing until the treated material is homogeneously moisturized with the stabilizer solution.

Unless highly accurate metering systems are provided, such as those typical of pressurized distributor trucks or built-in metering systems on cross-shaft rotary mixers, multiple application and mixing passes are required to fully distribute the stabilizer solution. If application of the entire stabilizer solution during a single pass results in loss of stabilizer solution from the area to be treated or excessive puddling, rather than penetration, then multiple pass methods of application must be used. Multiple pass applications allow far more latitude for correction of inconsistencies and for making necessary adjustments. Unless otherwise indicated in project plans or specifications, the STANDARD APPLICATION RATES described on page 7 of this TECHNICAL BULLETIN should be used to govern project application rates and the allowable tolerances from the application rate will be ± 5% (plus or minus five percent).

MIXING AND PROCESSING

Tractor drawn construction discs equipped with depth gauge wheels or cross-shaft rotary mixers should be provided as primary mixing equipment. The operations of stabilizer application, mixing, compacting and finishing should be continuous. The number of mixing passes should be adequate to ensure a uniform mixing of the stabilizer solution and the material being treated. For heavy clays, in particular, cross-shaft rotary mixer equipment may be required due to the fact that heavy clays are more difficult to break down to a suitable gradation for treatment. Motor graders, while necessary for shaping and grading, are relatively inefficient for mixing operations on large scale projects. Motor graders equipped with scarifier teeth are often used for scarifier mixing of aggregate base rock materials undergoing stabilization treatment. When scarifier teeth are used in aggregate mixing operations, some method should be used to provide the motor grader operator with a marker indicating the depth of penetration of the teeth so that mixing operations proceed at the desired depth and not at a shallower or deeper depth.

While lime treatments often require two-stage mixing and two stage compaction procedures which involve delays of 28 to 48 hours or more for moist curing and "mellowing" between the two stages of mixing and compaction operations, no such two-stage procedure with extended time delays is required for **EMC SQUARED** System treatments.

Prewatering will be necessary on projects where the materials to be treated are extremely dry and more than 3 percentage points drier than the optimum moisture content determined for the treated material. In these situations materials should be preconditioned with a prewatering effort designed to increase the in situ moisture content to a moisture content not more than three (3) percentage points below and not greater than the optimum moisture content determined for the treated material.

If stabilizer solution is applied at a rate which exceeds the absorbency of the loosened aggregate or soil being treated, then the number of application passes should be increased so that a reduced volume of solution will be applied per pass. Regardless of the method of adjustment (reduced flow rate to the spreader bar or increased travel speed of the distribution equipment), the uniformity of distribution of the stabilizer solution must be retained. If ponding, runoff or flow of the stabilizer solution from the treated area is still observed, then mixing operations should more closely follow application equipment to minimize uneven distribution of the stabilizer solution and promotion of a pattern of excessively wet and excessively dry spots in the treated materials. When applying on hilly terrain, side hills, or center crowned roads, the motor grader should follow immediately behind the applicator truck and blade the stabilizer solution down into the aggregate or soil being treated.

It is critical to the stabilization process that the stabilizer solution be thoroughly dispersed and mixed with the material being treated. Adequate mixing passes must be used to pulverize and to blend the material to the satisfaction of the project engineer, or as noted in project plans and specifications.

The optimum moisture content for the material to be treated will be determined by laboratory compaction control testing procedures as described in ASTM standard D 1557. The compaction water should be prepared with the **EMC SQUARED** System stabilizer (or stabilizers) selected for the treatment of project materials. Application rates and dilution ratios should be determined according to the instructions in this TECHNICAL BULLETIN, unless otherwise indicated in plans and specifications. Field application and mixing operations should be conducted to bring the material being treated to a well pulverized and homogeneously treated mixture prepared to optimum moisture content for compaction. **Moisture content at time of compaction should be not more than two percentage points above and not below the optimum moisture content determined for the treated material.**

Mixing must be continued until all dry streaks and overly wet areas are uniformly blended with adjacent materials. If the entire quantity of stabilizer solution allotted for a designated material has been added without achieving a homogeneously wetted mixture within the range of allowable moisture contents for compaction, then water may be added to the mixture to bring it within specified tolerances using the same attention to uniform distribution as was given to the addition of the stabilizer treatment. Subsequent moisture control measures for the balance of the project should more accurately adjust the moisture content of materials prior to treatment. In other words, the preferred sequence is to adjust the moisture content of the untreated soil within tolerances prior to addition of the stabilizer solution, rather than adding adjustment water as a standard practice following the application of the stabilizer solution.

If application of the calculated quantity of stabilizer solution results in an overly wet mixture after thorough mixing and processing operations, then the overly wet mixture should be subjected to additional mixing and aeration until moisture content is lowered within the specified tolerances for compaction moisture content. If mixing operations are unsuccessful in adequately drying the treated mixture to a suitable moisture content by the end of the day, moisture adjustment procedures should be continued on the following day until the treated materials are within tolerances required for compaction.

During periods of hot or windy weather, considerable amounts of water may be required to bring treated materials up to optimum moisture content. During rapid drying conditions, 5% of the total calculated stabilizer solution should be retained and applied as needed to the compacted surface during final compaction and grading operations to protect surface materials from desiccation and segregation while final surface finish operations are being conducted. The 5% stabilizer solution retained for treatment of the final surface should be calculated as part of the application applied to the full compaction lift.

Mixing operations for some projects are conducted at sites remote from the location where the treated material will be placed. There is no limitation on haul distances or time in transportation as long as treated materials are placed the same day so that compaction and final grading can be completed. Mix moisture content should be adjusted upward to compensate for drying conditions during transportation and placement operations preliminary to compaction. Treated materials with adequate moisture content will remain in a workable condition for many hours as long as moisture content is maintained during transport or while in temporary stockpiles, but the highly cohesive effects of the stabilizer treatment will make the mixture increasingly difficult to move (motor grader operators, for instance, report that mixed materials become increasingly "heavy" as they are moved with the blade, requiring use of lower gearing and smaller blade loads as the treatment begins to take effect). Trial batches and test pads are recommended if more specific details regarding behavior of the mixture are desired ahead of large stabilization projects where the option of performing mixing operations at a site remote from the location of placement is being evaluated.

Remote mixing can be conducted on approved mixing pads or mixing tables. While some central mixing plants, rotary drum mixers, and pugmill plants may not be capable of processing heavy clay soils or aggregates with high clay content, there is no reason why standard aggregate base course materials cannot be mixed with **EMC SQUARED** System products using stationary mixing plant equipment. While the **EMC SQUARED** System products are easily mixed with aggregate and soils on mixing pads or using standard mix-in-place operations, there are opportunities where it is simply more efficient to "plant mix" a material and eliminate some of the on site operations. A plant mix, for instance, could facilitate laydown of a treated aggregate by paving machine, thereby avoiding jobsite construction operations associated with stabilizer addition, mixing, moisture adjustment, shaping and final grading. For example, on long road projects of relatively narrow width which have a limited number of locations at which construction equipment and haul trucks can turn around, use of offsite mixing and mechanical placement equipment can speed construction.

COMPACTION

Laboratory compaction control tests must be conducted according to the standards of ASTM D 1557 Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft3 (2,700 kN-m/m3)), also referred to as the Modified Proctor Compaction Test. The lower levels of compaction effort specified by ASTM Standard D 698, known as the "standard effort test", do not provide adequate compactive effort to fully mobilize the benefits of **EMC SQUARED** System treatments, and its use is not advised for laboratory studies or field construction projects using **EMC SQUARED** System products. ASTM D 698 is derived from a test method proposed in 1933 by R. R. Proctor. ASTM D 1557, known as the "Modified Proctor", provides over four and a half times the compaction effort supplied by D 698 "standard effort" procedures and is far more appropriate in matching the capabilities of modern compaction equipment and addressing the importance of high density in regards to the stability of compacted earth materials. (Also see the fourth paragraph on page 6 under the subheading CONSTRUCTION QUALITY CONTROL.)

Field compaction standards for EMC SQUARED System treatments typically require compaction of treated materials to a density not less than 95% of the maximum density prescribed in ASTM D 1557 (Modified Proctor or Modified Effort compaction control tests). Densities above 95% ASTM D 1557 are considered beneficial, and there is no upper limit on densities achieved during compaction. Compaction equipment should be mobilized for the project that is capable of achieving timely compaction of treated materials to the required density. The use of sheepsfoot, tamping and pad type compactors is advised for proper compaction of most soil materials. Rubber-tire (Pneumatic), static steel-wheel rollers or smooth drum vibratory rollers should be used to construct the final compacted surface, unless otherwise noted in plans and specifications. Pneumatic rollers can be used in combination with steel-wheel rollers (static or vibratory) to further prepare compaction lifts and to provide the smoothest and most sealed surfaces. While vibratory compaction is generally recommended, compaction equipment and compaction operations should be adjusted as required at the project location to achieve the required density without cracking or otherwise damaging the treated layer. Regardless of method, compaction operations should produce a high quality surface that is smooth, dense, and free of cracks, compaction planes, loose material, ridges or ruts.

Compaction operations should begin immediately following attainment of (1) the proper application rate of the stabilizer treatment, (2) thorough pulverization and incorporation of the stabilizer treatment by mixing, and (3) adjustment of the moisture content within the required tolerances. **Moisture content at time of compaction should be not more than two percentage points above and not below the optimum moisture content determined for the treated material. Heavy clay soils may compact best at three percentage points above their treated optimum**

NOTE: While moisture content tolerances for both untreated and treated materials span a range of three percentage points (a range which is determined in both cases in relationship to the optimum moisture content determined for the treated soils), contractors working under field conditions may find that more exact moisture control may be advisable to address project specific conditions. For instance, in the event that compaction operations fail to achieve 95% or greater of the maximum dry density prescribed in ASTM D 1557 (while working within tolerances, either wet or dry of the optimum moisture content), then further wetting or drying of the treated material may be advised to more exactly approximate the optimum moisture content as this is the optimum point on the compaction curve, according to the compaction control tests, for achieving the highest possible density under a given compactive effort.

Another example where more exact adjustment of moisture content may be prudent is the case where stabilization operations are in progress and the onset of heavy rains is forecast within two or three days following compaction. As curing is slowed by cold temperatures, high humidity and rainy weather, any moisture content in the treated mixture which is in excess of the material's optimum moisture content will also slow curing.

FINISHING

The surface should be kept damp during final finishing operations. Upon completion, the surface should be in conformity with typical section, lines and grades as described in specifications, plans and drawings. Excessively wet spots that exhibit pumping action during compaction must be scarified, aerated in a timely manner and recompacted to the required density. The compacted thickness should not be more than 1/4 inch (6 mm) below the depth specified or shown in project drawings. Final grade elevation should be achieved by triming. If surface of compacted layer is below final elevation, the full depth layer must be reworked according to construction specifications. **Placement of a thin lift of aggregate or soil on top of the compacted grade during final grading to raise elevation or fill dimples created by compactors is not permitted.** The final surface should be smooth, dense and free of cracks, compaction planes, loose materials, ridges or ruts. The surface finish of stabilized materials that will serve as unpaved roads (or other types of applications where the stabilized materials will remain uncovered) should be smooth, sealed and free of loose rock materials. Attention should be given to maintenance of road crowns, cross slope and perimeter drainage during all grading operations.

FIELD QUALITY CONTROL TESTING

The contractor or construction crew should have in-place moisture content tests and compaction tests conducted during mixing and compaction operations, using conventional procedures such as the Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method and density tests such as the Sand-Cone Method, the Rubber Balloon Method or Nuclear Methods. The frequency of testing should be determined prior to construction if not clearly defined in project plans and specifications. Repeat tests should be conducted in any areas where test results indicate noncompliance with compaction and other specification requirements. All tests should be conducted under the direction of a registered engineer or certified testing laboratory.

The contractor or construction crew should have a written summary list available for the registered engineer or certified testing laboratory person providing on site inspection and field quality control testing services. The summary list should be available as a preliminary to daily construction operations and should include (1) a listing of the liquid volume capacity and planned fill levels for each pressurized distributor truck unit, water truck, water wagon or other water spray equipment which will be used to transport, spread or otherwise distribute the stabilizer solution, (2) the volume of the material to be treated that day in each section of project, (3) the calculated quantities of **EMC SQUARED** System products required for the volume of material to be treated in each section, (4) the total amount of stabilizer solution required for each section (using the compaction water calculations), and (5) the dilution ratio determined for preparation of the stabilizer solution. Preparation of the daily summary list will facilitate the planning, preparation and organization of construction operations and provide on site inspection and quality control personnel with the opportunity to review calculations used in the determination of stabilizer and water volume requirements and adherence to guidelines and specifications. Copies of the daily summary lists, compaction control test results and other quality control determinations should be retained by both construction and field quality control personnel in project files for review by project engineers and project owners.

CURING

With favorable weather conditions, materials treated with **EMC SQUARED** System products in accordance with the recommended moisture control and compaction procedures will gain noticeable strength and hardness during the first several days following final compaction. Cold, humid or rainy weather conditions following construction will slow the curing rate and adjustments should be made accordingly before returning the surface to use by traffic or conducting chip seal, paving or surface treatment operations. Unless otherwise approved by the Project Engineer or tested by proof rolling under the Project Engineer's direction, a three day minimum curing period is recommended before placement of pavements, chip seals or surface treatments is permitted on top of newly stabilized materials.

While shrinkage cracking is a natural and unavoidable problem which accompanies cement and lime treatments, **EMC SQUARED** System treatments have no built-in chemical reactions which create additional shrinkage cracking in treated materials. Procedures developed to retard shrinkage cracking of cement and lime treated materials, such as application of bituminous curing membranes or extended periods of surface watering following final compaction, are not a standard requirement for **EMC SQUARED** System applications. During stages of construction where treated materials will be exposed to desiccating weather conditions during an interim period until being covered by additional layers, project specifications may require application of water or emulsion treatments on an "as needed" basis to maintain the surface of the newly stabilized material in optimum condition.

Dust palliative treatments may be applied to **EMC SQUARED** System treated materials as soon after final compaction as the surfaces can be verified to be capable of supporting application equipment without rutting or damage to the compacted surface.

RESTORATION OF TRAFFIC

If a treated surface must be rapidly returned to service under traffic, surface curing conditions should first be proof rolled to verify that the entire surface is adequately cured and firm enough to resist rutting, unraveling or damage by sharp turns and rapid acceleration and braking. Construction crews are responsible for (1) protection of treated surfaces until adequately cured to support traffic, and (2) repair of any damage to the surface resulting from passage of heavy equipment, trucks or vehicular traffic while the surface is undergoing curing. Once the treated material has reached the initial stage of stability where the surface is not subject to damage, the stability of the treated layer will benefit from the additional compaction by traffic when placed back into service.

CLEANUP MEASURES

EMC SQUARED System treatments are neutral pH, non-corrosive, non-flammable, and non-hazardous. Equipment can be washed as required using normal washing procedures.

REPAIR PROCEDURES

Repair procedures for reworking fully cured materials previously treated with **EMC SQUARED** System products are similar to those utilized for reworking untreated materials. First, thoroughly saturate the area targeted for repair with the appropriate **EMC SQUARED** System solution, then scarify to the full depth of the treated layer, mix the material to its optimum moisture content with additional stabilizer solution, shape for proper alignment and drainage, and thoroughly compact and trim to final grade.

ENVIRONMENTAL ACCEPTABILITY

The **EMC SQUARED** System products are neutral pH, non-hazardous, non-flammable, non-reactive and non-corrosive. No special safety precautions are required for storage and handling. Tests have been conducted by independent certified analytical laboratories experienced in environmental acceptability testing on samples of **EMC SQUARED** and **EMS** products. These tests include the US EPA 7000 Series (TTLC or CAM 17) for metals and Method 8270 testing and verify that no organic solvents or identifiable EPA 8270 target compounds were detected in amounts which exceed US EPA or State of California regulatory standards as applicable to products whose intended use involves incorporation into compacted aggregate and soil materials during construction operations.

The **EMC SQUARED** System products are in use by private industries and public agencies with strict environmental review policies. **EMC SQUARED** System products are in service for US federal government agencies with major land management responsibilities including the US Air Force, the US Army, the Army Corps of Engineers, the Bureau of Indian Affairs, the Bureau of Land Management, the National Forest Service and the National Park Service and the US Fish & Wildlife Service.

USER FRIENDLY ALTERNATIVE

The **EMC SQUARED** System has many advantages in handling over conventional calcium based stabilizers (such as cement, fly ash and lime) not the least of which are a tremendous reduction in freight costs and the complete elimination of the on site problem of dealing with massive bulk quantities of dry or slurry products. These highly alkaline stabilization chemicals require protective clothing for safe handling including special face shields, head gear, gloves and boots. When calcium based powder products become airborne, they can become health hazards and are potentially damaging to structures, equipment, vehicles and aircraft within the vicinity of the project.

Liquid products based on sulfuric acid formulations and highly alkaline chemicals are sometimes added to soils. These extreme pH liquid concentrates are hazardous to laboratory and construction personnel and require extreme caution in handling and dilution activities. Reactive and corrosive in nature, they can also damage laboratory testing equipment and construction machinery. The **EMC SQUARED** System provides a neutral pH, non-hazardous, non-corrosive, user-friendly alternative for stabilization of aggregate and soil materials without the need for special handling requirements.

ENVIRONMENTALLY FRIENDLY

As previously discussed, the **EMC SQUARED** System provides stabilization product technology that can be utilized by construction and testing personnel without special handling precautions and that can be specified for construction requirements in natural areas and other types of project applications with strict environmental review. This environmentally friendly aspect of the **EMC SQUARED** System products is important, but the ramifications of their use, improving the durability of earthwork and transportation structures and reducing the use of natural resources, is of far greater potential impact.

At the simplest of levels, substitution of a highly concentrated stabilization system for cement and lime based stabilizers can eliminate dozens and even hundreds of truck trips per single project while freeing up these products, which are so energy intensive in their production, for higher value applications where substitute products are not available. The lower applied costs and unique effectiveness of the **EMC SQUARED** System open up additional application areas for stabilization such as treatment of gravel roads. Stabilization helps to retain expensive gravel resources that have been mined, crushed, screened and hauled to site. This assists in cutting the high maintenance costs associated with constant grading (itself an erosion factor), and equally important, reduce the maintenance costs suffered by road users operating vehicles and trucks on unstabilized roads. These potential benefits apply to dirt as well as gravel roads, and in both cases, effective stabilization also translates into road surface erosion control and protection of water resources from road generated sedimentation.

Savings in natural resources occur when locally available soils or natural gravel resources can be upgraded to replace crushed aggregate materials that must be mined, manufactured and imported to project locations. In many cases, unpaved roads can be upgraded with stabilized aggregate surface courses to provide low maintenance running surfaces during interim or staged construction projects (functioning as stabilized or "bound" base layers for pavements to be placed at a later date) or as low cost measures that address rutting and washboarding problems adequately so as to eliminate otherwise seemingly inevitable requirements for reconstruction and paving.

Probably of greatest ultimate value is the economical improvement of roadbed materials to reduce or eliminate moisture infiltration and frost heave phenomenon. Problems unsolved in roadbed construction evolve into failures of overlying asphalt and concrete pavements, products that have been placed at a very high cost in natural resource use as well as in financial outlay.

PACKAGING

EMC SQUARED Stabilizer (1000), **EMC SQUARED 2000** and **EMS** Earth Materials Sealant are all available in 55 gallon (U.S.) sealed plastic drums and in 275 gallon (U.S.) sealed bulk tote containers, and 208 litre or 1,000 litre packaging for international shipments

SHIPPING & STORAGE

EMC SQUARED System products are highly concentrated and consequently freight and storage costs are normally a very small percentage of the delivered cost. The products are non-hazardous and are shipped within the United States under NMFC Freight Class 55. No special handling precautions are required. The products must be maintained with an airtight seal to protect against contamination. As portions of product are drawn for use from drum or tote containers, caps should be immediately replaced and tightened to maintain an airtight seal. With proper transport and storage, **EMC SQUARED Stabilizer** (1000), **EMC SQUARED 2000** and **EMS** Earth Materials Sealant have the capacity for extended storage. In extreme cold climate regions, it is advisable to store **EMC SQUARED** System products in heat protected storage. While the stabilizer products can be stirred and used after being frozen without loss of effectiveness, the drums and bulk tote containers may fail if subjected to extreme low temperatures.

HANDLING

The **EMC SQUARED** System liquid concentrates are generally pumped from drums by electric, gasoline or hand operated barrel pumps equipped with metering devices. Use of heavy duty pumps capable of pumping higher viscosity fluids is recommended. All three products are neutral pH, non-hazardous, non-flammable and non-corrosive. Water can be used for all clean up requirements. There are no special handling precautions or special protective clothing requirements for construction personnel or materials testing laboratory personnel other than the use of standard safety glasses which are recommended when handling any liquid product.

The **EMC SQUARED** System products should all be stirred before using. If products are frozen during storage, extra mixing effort will be required.

CAUTIONARY NOTICE

The **EMC SQUARED** System products are unique in their effects on aggregate and soil materials. Calcium based chemicals such as cement, fly ash and lime and chemical formulations based on sulfuric acid or highly alkaline formulations all typically increase the optimum moisture content of an aggregate or soil for compaction (i.e., you need to add more water and prepare the mixture to a higher optimum moisture content than would be required for compaction of the untreated soil). These treatments can also reduce the maximum density and increase the permeability of treated materials. None of these effects on aggregate or soil materials are typical of **EMC SQUARED** System treatments.

Soils effectively strengthened by **EMC SQUARED** System treatments in comparative laboratory tests have actually been significantly weakened (strength and flexural stiffness reduced below values obtained with untreated soils) by addition of other liquid additives, though represented as effective in stabilization. For example, a liquid additive being evaluated in one materials laboratory testing program was generically lumped by research engineers prior to testing as being similar to the **EMC SQUARED** System. Test results demonstrated just how dangerous assumptions of this nature can be. In testing with two different clay soils the **EMC SQUARED** System treatment almost doubled the strength of the untreated soil and it improved stiffness by an average of over 5½ times. The liquid additive previously represented as an effective stabilizer in actual fact reduced the strength values by an average of 20 percent below the strength of the untreated soil and reduced the stiffness by 35 percent below the stiffness of the untreated soil.

Project owners, specifying engineers, contractors, and project inspectors are hereby advised in regards to guideline information provided for **EMC SQUARED** System products (and in regards to construction specifications written specifically for use of **EMC SQUARED** System products) that this information is specific to these unique products and their unique performance characteristics. No representation is made or intended that this guideline information is appropriate for the application of any other aggregate or soil treatment products.

PHYSICAL CHARACTERISTICS

EMC SQUARED Stabilizer (1000)

Phase	Liquid
Specific Gravity	1.2 -1.3
Solubility	Soluble in all %
Flash Point	None
Flash Point (dehydrated)	Above 300° F (149° C)
PH Range	7.0 ± 2
Buffer Capacity	None
Abrasiveness	None
Freezing Point	32° F (0° C)
Corrosive Characteristics	None
Inorganic Alkali Equivalent	None
Petroleum Solvents	None
Solvents (organic)	None
Detergents	None

EMC SQUARED Stabilizer (1000) should always be stirred before using. The EMC SQUARED Stabilizer (1000) is not compatible for use with EMS Earth Materials Sealant.

EMC SQUARED 2000

Phase	Liquid
Specific Gravity	1.040 -1.090
Solubility	Soluble in all %
Flash Point	None
Flash Point (dehydrated)	Above 300° F (149° C)
PH Range	7.0 ± 2
Buffer Capacity	None
Abrasiveness	None
Freezing Point	32° F (0° C)
Corrosive Characteristics	None
Inorganic Alkali Equivalent	None
Petroleum Solvents	None
Solvents (organic)	None
Detergents	None

EMS Earth Materials Sealant

Phase	Liquid
Specific Gravity	1.0-1.02
Solubility	Dispersible in all %
Flash Point	None
Flash Point (dehydrated)	Above 300° F (149° C)
PH Range	7.0 ± 2
Buffer Capacity	None
Abrasiveness	None
Freezing Point	32° F (0° C)
Corrosive Characteristics	None
Inorganic Alkali Equivalent	None
Petroleum Solvents	None
Solvents (organic)	None
Detergents	None

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 intended 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. 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.

Stabilization Products LLC

Phone: (209) 383-3296 or (800) 523-9992

Canadian Sales: Milieu Road Technologies, Ltd. (780) 875-9159

E-mail: info@stabilizationproducts.net

https://stabilizationproducts.net