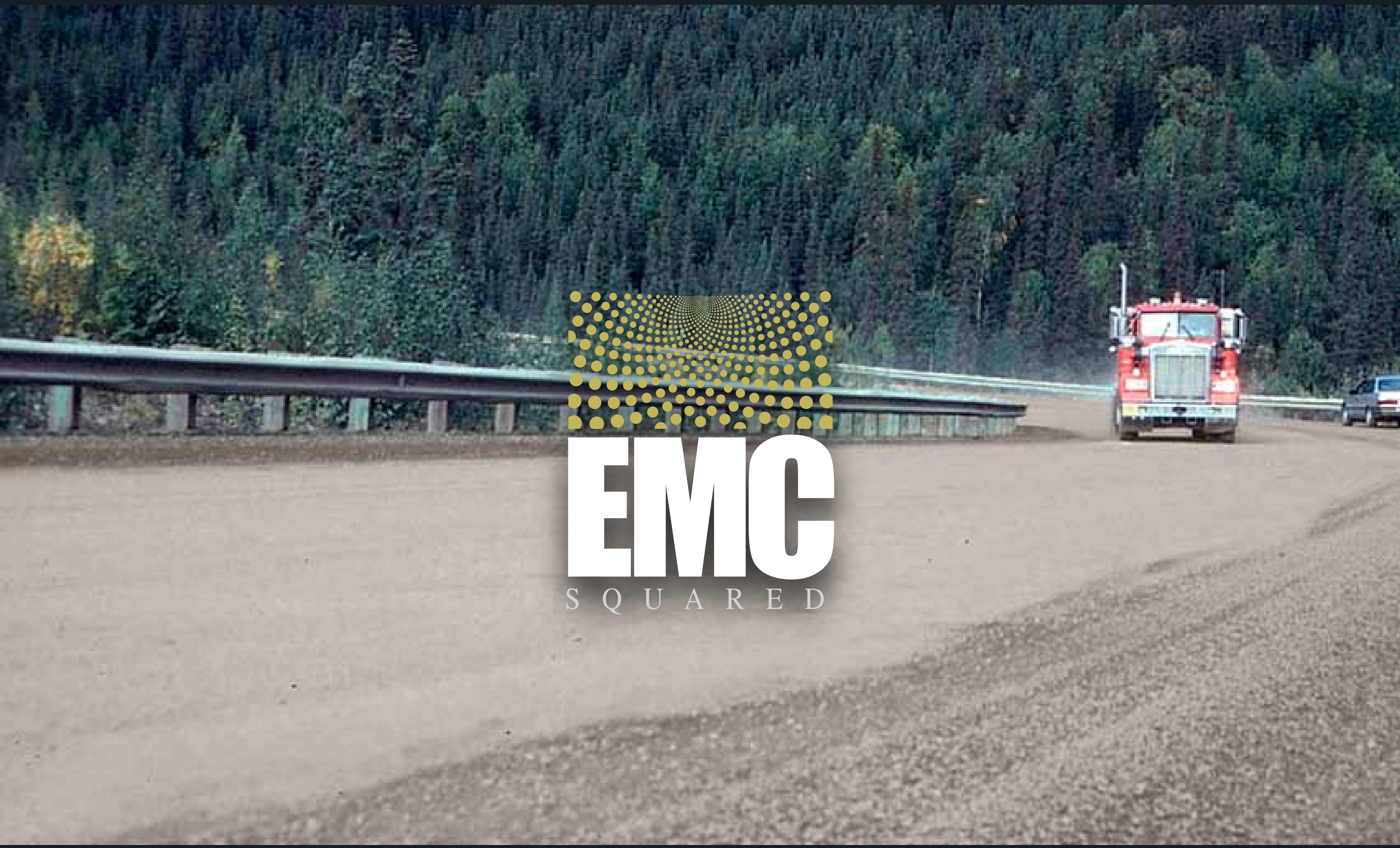


FHWA EXPERIMENTAL FEATURE PROJECT

Alaska Department of Transportation & Public Facilities (DOT & PF)

Including Laboratory Test Results:

- **Tube Suction Testing for Frost and Moisture Susceptibility**
- **Unconfined Compressive Strength Tests**
- **Increased Density with Stabilizer Treatment**
- **Effects of Increasing Compaction Energy**
- **Retained Strength Testing**
- **Influence on Compaction Characteristics**

Untreated Gravel Surfacing with 4-Day Maintenance Grading Frequency

The State of Alaska's Department of Transportation & Public Facilities (DOT & PF) maintains a unique state highway - formerly famous as the "Pipeline Haul Road," approximately 450 miles of unpaved road running north across the Arctic Circle through "The Land of the Midnight Sun" to supply the huge oil production operations at Prudhoe Bay and neighboring fields. Views from the highway regularly include wolves, arctic fox, grizzly bear and caribou as well as the parallel Trans-Alaska Pipeline. Intense year round truck traffic, severe climatic conditions and permafrost subgrades subject to melting and settlement combine to truly set the standard for "worst case conditions." The perpetual repair work and complete reconstruction of the asphalt pavements north of Fairbanks testify to the severity of the problem. Further north, gravel road maintenance crews report grading frequencies as high as once every four days. A trip up this road has historically been notorious for blinding clouds of dust and rock flying in all directions, kicked up by other trucks, buses and cars, and all too often directly impacting your windshield and headlights.

DOT & PF design engineers and maintenance staff started an effort in 1986 to stabilize the road. They wanted to prove out an alternative to constant grading, to high rates of gravel loss, and to a road that provided less than satisfactory performance as a safe and efficient running surface. While water soluble dust palliative treatments had been used on an occasional basis, they required application twice each summer, sometimes with disastrous effects on road stability when rains followed application. The initiative paid off in 1991 with stabilization funded by the Federal Highway Administration (FHWA) as an Experimental Feature Project during the placement of a new aggregate surface course on the section of road known as the Elliott Highway. Specifications for the aggregate allowed 8 to 15 percent passing the No. 200 Sieve with a plasticity index no greater than 6.

The **EMC SQUARED**® Stabilizer was processed into the aggregate for one section of the project by a stationary pugmill located next to the aggregate stockpile. The treated aggregate was then hauled by bottom dump trucks 20 miles to the road location.

For the second section of road, the **EMC SQUARED** stabilizer was applied to aggregate already placed on grade. A water truck was used to apply the stabilizer solution, and a motor grader was used to mix and process the treated aggregate. The contractor fabricated a special mounting bar for scarifier teeth on the motor grader to speed the mixing operation. Both sections of treated road were well compacted by a large vibratory smooth drum compactor. Truck and car traffic continued to use the road throughout the project with no more than a few minutes of delay.

Reports from state employees monitoring the project after over two years of service indicated that the stabilized sections have been essentially maintenance free while providing a safe running surface for a section of road that includes a series of high speed banked turns. Performance Rating - Excellent! As an interesting testimonial to the ease of application of the **EMC SQUARED®** product, the standard water truck and road mix procedure provided performance results equivalent to the performance of the road section that was constructed with the treated aggregate processed in the stationary pugmill.

The following section is excerpted from a Stabilization Products LLC (SPLLC) article covering three projects where the EMC SQUARED Stabilizer was applied in cold climate applications, "Treatment of Moisture and Frost Susceptibility, Field and Laboratory Studies."

The study is of particular interest as it utilizes state-of-the-art performance based testing known as Suction and Dielectric Testing (also described as Absorption and Tube Suction Testing)[1] for laboratory evaluation of both the untreated aggregate and the stabilized aggregate mixture. This laboratory testing methodology has been developed for prediction of the field performance of both untreated aggregates and of aggregates treated with stabilizers such as cement, lime and the EMC SQUARED System.

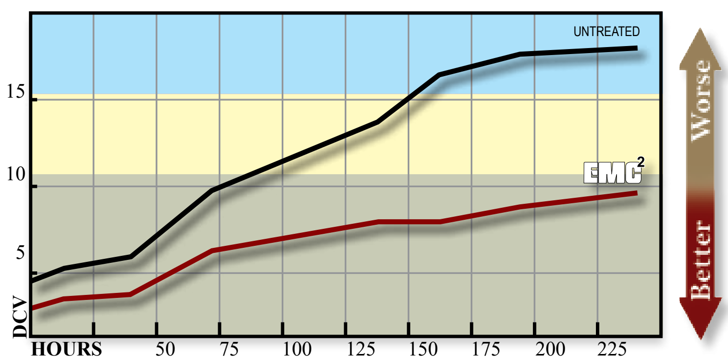
Suction & Dielectric Testing Results

For the purpose of general classification using dielectric measures of aggregates, a dielectric value greater than 15 indicates that the aggregate is wet or water saturated and extremely frost susceptible. A dielectric value in the range 10 to 15 indicates that a significant amount of free water has accumulated within the aggregate during the testing period and is a warning signal that the material is moisture sensitive and frost susceptible. Aggregate materials with a dielectric value of less than 10 are considered non-moisture sensitive and non-frost susceptible in service for road and highway base applications. Typical dielectric constant values for highway materials are tabulated below.

Field Performance & Other Related Testing

The Alaska aggregates were obtained from the stockpile used to supply a 1991 Federal Highway Administration (FHWA) Experimental Feature Project on the Elliott Highway, beginning north of Fairbanks at the transition point from asphalt to gravel road. Nicknamed "the Haul Road" (the Elliott Highway ties into the Dalton Highway), this gravel surfaced highway system provides access to the Prudhoe Bay oil fields. Alaska truckers drive approximately 17,000 truckloads a year up to Prudhoe Bay, operating on a year-round schedule. An aggregate surface course treated with the **EMC SQUARED** Stabilizer serviced haul truck traffic for over four years before this section of the road was upgraded with an experimental bituminous treatment placed over the stabilized base course section. This project, constructed under the direction of the Alaska Department of Transportation & Public Facilities (ADOT&PF) in early June of 1991, is more fully covered in Transportation Research Record 1589.[4]

The project goal was to compare the economics of stabilization treatment of a gravel surfaced road with the cost of annual applications of a calcium chloride dust palliative. The section adjacent to the stabilized aggregate was graded and re-treated with the dust palliative each summer. The material treated with the dust palliative was subject to constant potholing, washboarding, and gravel loss and required regular maintenance grading. After the second year of service, the stabilized section was described as essentially maintenance free with only minor touch-up required in the super-elevated curves. Involved ADOT&PF staff unanimously gave the stabilized road section an excellent performance rating after servicing many thousands of heavy truck loads in all weather conditions. The state's regional geotechnical engineer in his memorandum of final evaluation



Alaska Aggregate

Material	Dialectric Constant
Dry Aggregates	4-6
Asphalt Concrete	5-7
Portland Cement Concrete	7-9
Flexible Base	6-20*
Subgrades	0-25*

*Depends upon Moisture Content

[1] Saarenketo, T. and Scullion, Using Electrical Properties to classify the Strength Properties of Base Course Aggregates, NTIS: FHWA/TX-97/134-2 (TTI Research Report 1341-2), 1996.

commented that the **EMC SQUARED** Stabilizer also outperformed the calcium chloride dust palliative treatment in regards to dust control effectiveness and that it was less expensive to apply.[5] This project also included evaluation of the effectiveness of two different mixing methods in applying this stabilization technology. The aggregate for the first stabilized section was mixed in a portable pugmill unit located at the aggregate stockpile and then hauled in bottom dump trucks to the project location. The second section was treated after the aggregate was placed on the road in a mixed-in-place operation using a motor grader equipped with scarifier teeth for mixing and processing. In both cases, the thickness of the treated aggregate materials was approximately 150 mm (6 inches). Over the evaluation period, no difference in performance was observed between these two stabilized sections.

The memorandum of evaluation included as an attachment a report of independent laboratory testing comparing untreated with treated aggregate specimens. ASTM D 2166 unconfined compressive strength tests were conducted after 14 days of curing, resulting in a strength measure of 1,850 kPa (269 lb/in^2) for the untreated material and 2,900 kPa (421 lb/in^2) for the treated material.[6]

The laboratory supervisor of the independent materials testing laboratory involved in monitoring the FHWA experimental feature project on behalf of the supplier of the **EMC SQUARED** product, made two site visits following the third summer, to obtain additional aggregate from the stockpile and to provide a video record of the stabilized and control sections. He reported only a few small potholes on the stabilized section, located in the worst stress area of the super-elevated curves, no larger than "half a grapefruit." He was able to drive the legal speed limit, approximately 90 km/hr (55 mph) on the stabilized section but had to reduce driving speed to less than 40 km/hr (25 mph) on the control section, which had been re-treated with the dust palliative only 4 months previously. Numerous potholes of 2 to 3 m (6 to 10 feet) diameter were observed in the control section.

[4] Randolph, R., Earth Materials Catalyst Stabilization for Road Bases, Road Shoulders, Unpaved Roads and Transportation Earthworks, Transportation Research Record 1589, 1997.

[5] McHattie, R.L., Final Evaluation of Experimental Features - Projects AK8701S and AK8701B. Departmental Memorandum, Alaska Department of Transportation & Public Facilities, Jan. 1994.

[6] Ibid

ARCTIC ALASKA TESTING LABORATORIES

A DIVISION OF SHANNON & WILSON, GEOTECHNICAL and ENVIRONMENTAL CONSULTANTS

2055 HILL RD., FAIRBANKS, AK 99709 Phone (907)479–0600 FAX (907)479–5691

June 6, 1995 K – 7626

Bob Randolph
Soil Stabilization Products Inc.
P.O. Box 2779, Merced Ca. 95344
FAX: (209) 383-7849

RE: **Material Property Tests on Soil Stabilized With EMC2**

The "Treated" and "Untreated" samples were tested for compressive strength on June 5, 1995 after being in our Fog Room since December 21, 1993. There were two intervals when the Fogger was not working. The first lasted a period of 10-14 days, and the second 4-7 days. With the exception of these periods the humidity was at saturation at 71°F ± 3°.
The samples were weighed periodically until equilibrium was reached. This occurred between April 27, and June 5, 1995.
The "Untreated samples showed evidence of subsidence (a bulge in the center).

UNTREATED

	Sample ID #3 @ 6.5%	Sample ID #4 @ 7.0%
Total Load:	420	500
Compressive Strength:	15.4psi	18.3psi

TREATED

	Sample ID #3 @ 6.5%	Sample ID #4 @ 7.0%
Total Load:	660	760
Compressive Strength:	24.1psi	27.8.psi

ARCTIC ALASKA TESTING LABORATORIES
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November 2, 1993

Soil Stabilization Products Company, Inc.
P.O. Box 2779
Merced, California 95344

Attn: Mr. Bob Randolph

RE: MATERIAL PROPERTY TEST ON AGGREGATE STABILIZED WITH EMC SQUARED (EMC²)

Per your request, an aggregate sample was collected on September 22, 1993 from the State of Alaska DOT&PF stockpile at 47.5 mile on the Elliott Highway by Randall K. Fletcher, of our firm. The sample aggregate was a well graded ¾″ (19 mm) maximum aggregate (GC) used by DOT&PF for aggregate surfacing on the Elliott Highway. The sample material was allowed to air dry to less than Optimum Moisture Content. Water was then added to bring the sample material to Optimum Moisture Content of 6.5%. A sample was prepared with the EMC SQUARED stabilizing agent added at the application rate recommended in the "EMC SQUARED General Information" guideline literature. The second sample was moisturized with water only. The moisturized aggregate materials were allowed to stand overnight in covered containers and then compacted into 6″ x 12″ (152.4 cm x 304.8 cm) steel cylinders. Samples were compacted using ASTM D 1557 Modified Proctor Compactive Effort (see Section 2 below). Both samples were allowed to cure in their molds for 24 hours, then removed and allowed to cure at room temperature until tested in compression at 14 days of age. The results of those tests are printed below:

Cylinder #1	EMC SQUARED Treatment	421 psi (2,900 kPa)
Cylinder #2	Untreated	269 psi (1,853 kPa)

Additional tests were conducted which demonstrated the effectiveness of the EMC SQUARED stabilizer in facilitating compaction, in increasing compacted density, and in translating increased compactive effort into increased strength.

- FACILITATION OF COMPACTION (Reduction of Required Compactive Effort)

  Prepared mixture divided into two portions, Sample A brought to Optimum Moisture Content without use of additive and B brought to Optimum Moisture Content with use of EMC SQUARED additive. After compacting Sample A to a target density, Sample

The above report is a summary of related laboratory testing by the
Arctic Alaska Testing Laboratories of Shannon & Wilson, Inc., Fairbanks, Alaska.
Both strength improvements and issues related to compaction are addressed.

B was compacted to the same target density with approximately 15% less compactive effort required.

- INCREASED DENSITY

The treated and untreated samples subjected to unconfined compressive strength testing, as reported above, were compacted in 6″ x 12″ (152.4 cm x 304.8 cm) steel cylinders (conventionally used for testing concrete) using ASTM D 1447 Modified Proctor Compactive Effort. Compaction was applied by placing the material in 5 layers with 122 blows of a 10-lbf (44.5 N) rammer with an 18″ (457 mm) drop applied to each layer producing a compactive effort of 56,000 ft-lbf/f^3 (2,700 kN-m/m^3). The untreated aggregate specimen reached a unit weight of 137.84 pounds per cubic foot (2,203.50 kg/m^3), when compacted to 100% ASTM D 1557. The aggregate specimen treated with EMC SQUARED reached a unit weight of 141 pounds per cubic foot (2,254.01 kg/m^3), or 102.29% compaction.

- EFFECTS OF INCREASING COMPACTION

Two aggregate samples from the Elliott Highway aggregate source were treated with the same quantity of stabilizer, cured under similar conditions and tested in compression seven days after compaction. One specimen was compacted with full Modified Proctor effort while the second specimen was given only fifty-seven percent of that compactive effort, 31,920 ft-lbf/f^3 (511,294.6 kg/cubic meter). The sample which was compacted with reduced effort achieved only 60% of the compressive strength of the sample that was compacted to 100% ASTM D 1557 Modified Proctor effort. It is interesting to note that for this treated aggregate there was a very direct relationship between increased compactive effort and increased strength.

Sincerely,

ARCTIC ALASKA TESTING LABORATORIES
a division of SHANNON & WILSON, INC.

By Randall K. Fletcher
Randall K. Fletcher
Laboratory Supervisor

RKF/laf

RPT/#149.11/2/93.rkf/laf

K-7626

Additional Laboratory Testing

Additional laboratory testing with the aggregate material collected from the same stockpile by Arctic Alaska Testing Laboratories further illustrates the benefits of the **EMC SQUARED** Stabilizer treatment in regards to preconditioning aggregate materials for optimum ease of compaction, for achievement of higher maximum densities and for retention of stabilized strength values in the constant presence of moisture over prolonged periods.

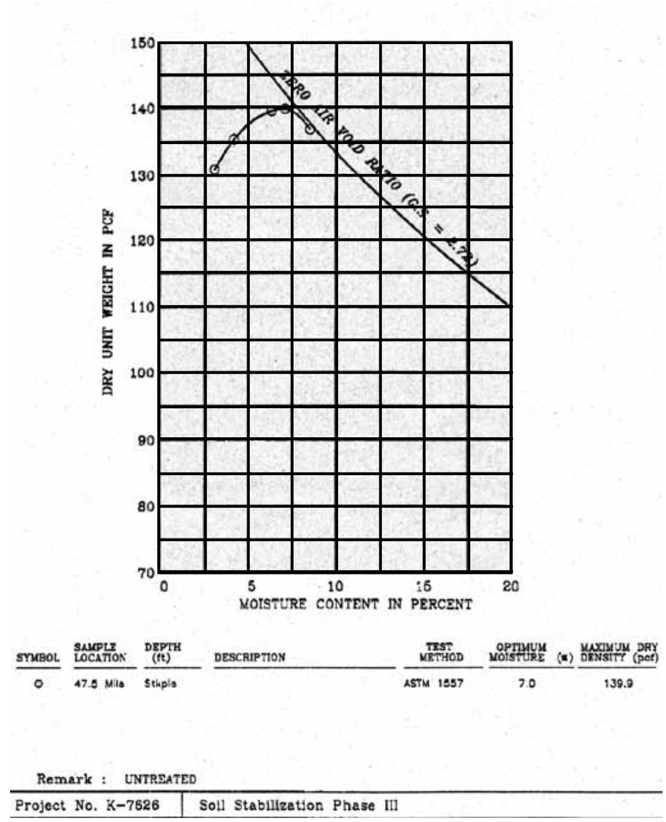
Influence on Compaction Characteristics

The second testing series conducted utilized specimens compacted in Proctor compaction testing molds, producing specimens with a height to width ratio of approximately 1 to 1 (the earlier tests specimens were prepared in the conventional steel cylinders used for unconfined compressive strength specimens, producing specimens with a height to width ratio of 2 to 1). The effects of the **EMC SQUARED** Stabilizer on compaction characteristics were first studied and results graphed below. As indicated in the earlier testing series, the aggregate treated with **EMC SQUARED** Stabilizer reached a higher compacted maximum density. The optimum moisture content for the treated aggregate was approximately 17% lower than the untreated aggregate (5.8% versus 7%). The shape of the compaction "curve" of the treated aggregate was also flattened, a phenomenon which contractors and construction supervisors appreciate as the flattened curve indicates an opportunity to successfully achieve specified levels of compaction and the highest possible degree of material densification while operating within wider tolerances in regards to the moisture content of the aggregate material at the time of compaction.

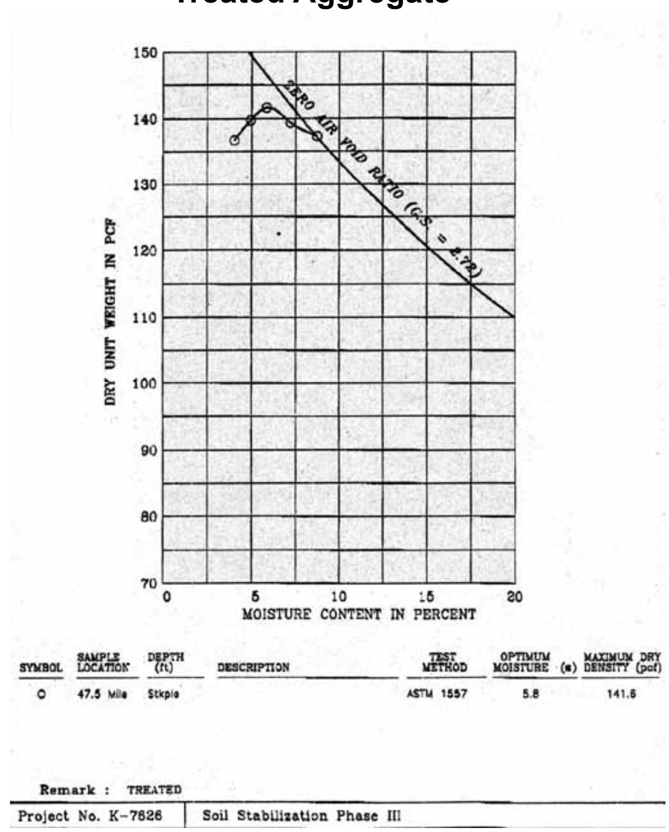
Retained Strength

Additional untreated and treated specimens were placed in a Fog Room and kept in a condition where humidity was at saturation, at a 71° F ± 3° temperature, for approximately a year and a half. After almost 18 months in the Fog Room the specimens were then subjected to strength testing as indicated on page 4. Interestingly, the strength advantages of stabilization treatment in the original percentage increase in unconfined compressive strength was retained in this comparison of untreated and treated specimens subjected to an extended period of moisture treatment representing the highest possible level of atmospheric moisture.

Untreated Aggregate



Treated Aggregate



Stabilization Products LLC

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