



TEST REPORT

FIELD INSTALLED SOIL-SEMENT VALIDATING CONCEPT OF
SOIL-SEMENT SUITABILITY FOR ROAD CONSTRUCTION

THE EVALUATION OF STRENGTH GAIN IN
SOIL-SEMENT AMENDED UNPAVED ROADS,
SCOTTSDALE, AZ

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Summary & Comment

The testing in Scottsdale, AZ strongly suggests that Soil-Sement greatly influences if not dominates the structural performance (lift stiffness and material modulus) of silty sand / soil materials. So much so that the performance of Soil-Sement stabilized materials can be anticipated if not predicted. It is therefore possible to develop and implement construction specifications for Soil-Sement stabilized materials that can be widely employed with reasonable confidence even though contractors, site conditions and material sources may vary. This means added value to Midwest's customers since the quality of the in-place installation in addition to the stabilized material can be assured by design.

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The testing also identified significant structural improvement provided by the Soil-Sement stabilization of a sandy unpaved road. Stabilization provides for an increase in a road's resistance to deformation (stiffness) in reaction to traffic loading. The stiffer and uniformly stiff a roadway is, the longer period of time between repairs. Soon after Soil-Sement stabilization, stiffness increased to an average of ~ 23 MN/m with a uniformity represented by a coefficient of variation of $\sim 16\%$. This is equivalent to a quality low traffic volume road paved with several inches of HMA. Later in life, the Soil-Sement stabilized roads demonstrated a stiffness expected of a moderate volume paved road. This demonstrated structural performance improvement has the potential benefit of facilitating the construction of roads of a quality comparable to paved roads at 20% of the cost with fewer traffic interruptions. Five (5) miles of Soil-Sement stabilized roads can be constructed for every mile of paved road. Given the limited funds for road construction and the enormous demand for paved roads, in part driven by U.S. EPA mandates on communities in non-attainment areas, Soil-Sement road stabilization can provide a cost effective, high quality alternative to conventional paving on low to moderate volume roads.

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Summary

The testing of Soil-Sement stabilized roads in Scottsdale, AZ strongly suggests that Soil-Sement greatly influences if not dominates the structural performance (lift stiffness and material modulus) of the materials it is used with. So much so that the performance of Soil-Sement stabilized materials can be anticipated if not predicted.

The testing of Soil-Sement stabilized roads in Scottsdale, AZ identify structural improvement of the roads expressed numerically as 14 for non-Soil-Sement road to 18,21,23,27 and 29 for Soil-Sement stabilized roads from time of stabilization to 3 years after stabilization. This demonstrated structural performance improvement benefits the community by creating roads of a quality comparable to paved roads at 10% of the cost. This enables the community roads budget creation of 10 miles of Soil-Sement stabilized roads for every mile of paved road. Given the finite availability of funds for road construction and the enormous demand for paved roads, in part driven by U S EPA mandates on communities in non-attainment areas, the Soil-Sement road program accomplishes a much desired state, community and strategic outcome.

The data developed in this testing establishes it is therefore possible to develop and implement construction specifications for Soil-Sement stabilized materials that can be widely employed with reasonable confidence even though contractors, site conditions and material sources may vary. This means added value to Midwest's customers since the quality of the in-place installation in addition to the stabilized material can be assured by design.



Introduction

Two days of testing were conducted during 9 and 10 May with the Midwest Samitron on five (5) sections of Soil-Sement amended unpaved road in Scottsdale, AZ. The testing was performed at the request of Midwest Industrial Supply, Inc. Dennis Casamatta of Midwest and Melvin Main of Main Associates performed the testing. Marty Koether of EarthCare Consultants arranged for access to the roads tested.

Objective

The objective of the testing was to demonstrate that the performance of a Soil-Sement amended unpaved road is sufficiently well behaved to be predictable. This testing was intended as a precursor to the development of construction specifications test methods by Midwest to evaluate if not control the in-place quality of highway materials amended with Midwest products using in-place stiffness and achieving intended, predictable structural performance.

Test Sites

Main Associates tested Five (5) sites per the February 26, 2007 plan developed for Midwest. These sites were:

- Site 1: Davis Rd., ~ 200' west of intersection Scottsdale Rd., ~ 1 day & 2 days old (days after Soil-Sement installation)
- Site 2: 71st St., ~ 200' north of intersection with Windstone, ~ 2 days old
- Site 3: Via Donna Rd., ~ 500' east of intersection with Scottsdale Rd., ~ 2 months old



- Site 4: 76 th St., ~ 200' south of intersection with Via Donna, ~ 2 yr. old
- Site 5: Via Donna Rd., ~ 50' east of Hayden, ~ 3 yr. old

The soil at each site was a silty sand, AASHTO A-2-4. Each site was sealed with two coats of the same dilution.

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Tests Performed

Sixteen (16) Samitron measurements were made at each site (Appendix 1). Photographs of the testing are presented in Appendix 2. Measurements on all sites required the use of moist sand to seat the Samitron, as the surface was often hard and dry. The measurement data is presented in Table 1.

Table 1: Measurement Data

| Test Location | Stiffness MN/m | | | | | | All 48 hr. Data |
|-------------------------------|---------------------------|---------------------------|-----------------------------|--------------------------|--------------------------|---------------------------|--------------------|
| | Test Site 1 (~ 24 hr.) | Test Site 2 (~ 48 hr.) | Test Site 3 (~ 2 months) | Test Site 4 (~ 2 yr.) | Test Site 5 (~ 3 yr.) | Test Site 1 (~ 48 hr.) | |
| 1 | 17.21 | 17.53 | 19.56 | 26.85 | 25.39 | 27.42 | |
| 2 | 19.95 | 15.12 | 15.49 | 28.67 | 38.30 | 22.43 | |
| 3 | 18.04 | 15.96 | 24.44 | 24.80 | 30.23 | 15.74 | |
| 4 | 14.72 | 16.30 | 25.97 | 28.17 | 37.89 | 18.21 | |
| 5 | 13.98 | 19.94 | 28.87 | 26.50 | 28.65 | 24.63 | |
| 6 | 17.42 | 14.43 | 19.46 | 27.12 | 27.74 | 25.14 | |
| 7 | 16.34 | 24.45 | 25.87 | 21.74 | 20.47 | 21.62 | |
| 8 | 14.90 | 18.68 | 24.30 | 24.51 | 24.27 | 19.14 | |
| 9 | 16.89 | 21.62 | 26.96 | 31.51 | 33.29 | 18.69 | |
| 10 | 15.82 | 13.26 | 20.97 | 31.71 | 29.26 | 22.37 | |
| 11 | 18.00 | 22.33 | 22.69 | 25.34 | 23.32 | 23.61 | |
| 12 | 17.25 | 24.37 | 26.96 | 23.14 | 29.19 | 20.32 | |
| 13 | 17.36 | 23.12 | 26.09 | 31.71 | 34.61 | 23.51 | |
| 14 | 16.54 | 14.80 | 19.84 | 28.13 | 32.54 | 27.38 | |
| 15 | 19.40 | 20.98 | 20.91 | 27.68 | 27.68 | 27.22 | |
| 16 | 27.27 | 18.53 | 22.94 | 26.41 | 23.84 | 23.57 | |
| Average | 17.57 | 18.84 | 23.21 | 27.12 | 29.17 | 22.56 | 20.70 |
| Standard Deviation | 3.03 | 3.68 | 3.60 | 2.91 | 5.16 | 3.47 | 4.00 |
| COV (%) | 17.27 | 19.55 | 15.53 | 10.74 | 17.70 | 15.38 | 19.30 |
| Z re Site 1 Average, % | | 7.23 | 32.10 | 54.40 | 66.02 | 28.43 | 17.83 |

Results & Analysis

When the test results for the Soil-Sement amended silty sand are graphically represented, the mean stiffness for all five sites, representing 3 years of aging, lie on the same logarithmic curve with a high degree of correlation (Figure 1). Since the cure rate of most materials is logarithmic, this data strongly suggests that the rate of strength gain is very consistent between the sites. More importantly, this suggests that the performance of the Soil-Sement road is predictable. The uniformity of roadway stiffness is higher than most sites Main Associates has evaluated. A uniformity represented by a coefficient of variation of ~ 13% for in-place material stiffness is



considered ideal by the FHWA. The largest coefficient for the amended silty sand is 19.6%.

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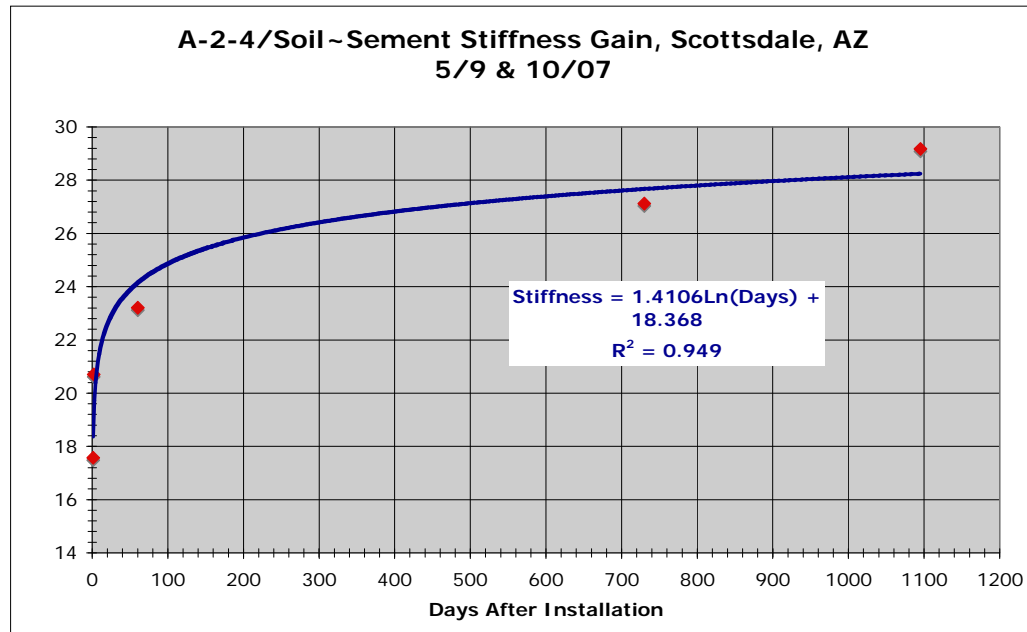
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Site Conditions

The weather on May 9 and 10 was sunny and dry, temperature in the 80s and winds below 5 mph. During both days, low traffic volume was experienced (< 10 vehicles per hour).

Figure 1



Samitron Bias & Precision

Samitron operation was verified on its inertial isolated mass before each day of testing. A coefficient of variation (COV) of less than 1% about the expected value of stiffness was measured on the mass for 3 Samitron measurements. Samitron measurements were repeated at Site 1 to evaluate measurement precision. At this site, the COV for 3 measurements was 3.3%. A COV of less than ~ 10% is considered good for most in-place geotechnical measurements.



Conclusions and Recommendations

Samitron measurements are readily able to quantify the rate of strength (stiffness) gain for the Soil-Sement amended silty sand. Judging from the consistency and uniformity of Samitron

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measurements, there is apparently good control of native material, stabilization (amendment with Soil-Sement) and compaction. Samitron measurements indicate that the rate of strength gain is predictable.

It is therefore possible to quantify from empirical Samitron data the needed roadway strength or stiffness. Using the Samitron, a prepared unpaved road can be evaluated as to whether it needs stabilization or not. If it does, then Samitron measurements can quantify the amount of stabilization (stiffening) achieved.

CBR measurements of stabilization on molded laboratory samples could be used to customize mixes for a variety of materials and related to expected in-place stiffness.¹ Using the Samitron on the same laboratory samples, cures rates (rate of strength gain) can also be defined. These laboratory measurements can be used to define the short-term strength gain of in-place stabilized materials and predict when the material can be released to loading and what its ultimate strength will be.

This approach to controlling the quality of stabilized materials with the Samitron could end the guess work of what material needs stabilization, determine when a materials is sufficiently stabilized and predict material performance in response to loading. All of which amounts to higher materials quality, lower cost and lower construction time.

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Appendix 3 is a recommendation of how the in-place performance in terms of stiffness should be defined and evaluated for a Soil-Sement



amended AASHTO A-2 soil. It is based on the recent testing in Scottsdale, AZ. It is assumed that the performance of the Scottsdale roads is satisfactory and typical. It is also preliminary until additional tests, like those done in Scottsdale, can be done on the same soil class on jobs elsewhere in the United States.

¹ Assessment Of In-Situ Test Technology For Construction Control Of Base Courses And Embankments, 2004, Murad Y. Abu-Farsakh, Ph.D., P.E., Khalid Alshibli, Ph.D., P.E, Munir Nazzal, and Ekrem Seyman, Louisiana Transportation Research Center, Baton Rouge, LA 70808, FHWA/LA.04/385

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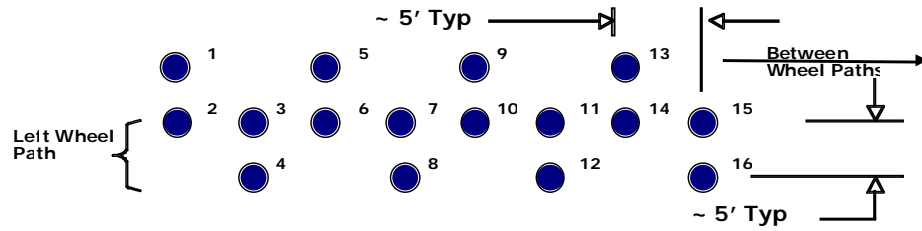
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Appendix 1

Stiffness Measurement Sampling

Sampling Pattern for All Sites





Attachment 2

Photographs of Testing

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Site 2 Looking South



Site 2 Looking South



Site 3 Looking East



Site 3 Looking West



Site 4 Looking North



Site 4 Looking South



Site 4 Surface



Site 5 Looking East



Site 5 Looking West



Site 5 Surface



Attachment 3

Recommended In-Place QC Method

Soil-Sement Amended A-2 Soil

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In-Place QA Measurements

At two different times early in the life of the installation separated by a minimum of 1 day (e.g., 1 and 3 days), a minimum of 16 stiffness measurements will be made on the roadway per ASTM D 6758. These measurements should be no closer together than 5 ft. and no farther apart than 100 ft. The installation will be judged acceptable if the average of all measurements and all individual measurements are within the limits defined in the following figure. The time intervals in the following table will be used to judge acceptance. The acceptable stiffness will be found between $X \pm Y$ days. For example, for measurements taken 3 days after installation, any stiffness found between 2 and 4 days on the figure will be acceptable. For measurements taken 60 days after installation, any stiffness found between 50 and 70 days on the figure will be acceptable.

| Days After Installation (X) | Time Interval In Days (Y) |
|--|--------------------------------------|
| 1 to 10 | 1 |
| 10 to 100 | 10 |
| 100 to 1000 | 100 |
| 1000 to 10000 | 1000 |



Acceptable Stiffness Limits
Soil-Sement Amended ASSHTO A-2 Silty Sand



The limits in this figure are valid for the same mix and construction methods as those used on the Scottsdale, AZ roads, from which the data in the figure came.

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