Louisiana Transportation Research Technical Assistance Report

Report No. 03-01TA

New Product Evaluation
Aucem Cement Blend
Lone Star Industries, Inc.

Geophysical Group
January 2003

LTRC
Louisiana Transportation Research Center

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NEW PRODUCT EVALUATION

Aucem Cement Blend
Lone Star Industries, Inc.

Technical Assistance Report No. 03-01TA

by

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ABSTRACT

The Louisiana Department of Transportation and Development (DOTD) receives many requests to use new products for soil treatment, soil stabilization, or reinforcements on construction projects. The product information provided by the manufacturer generally does not give enough detailed performance characteristics for a complete evaluation. The Soil Stabilization Product Evaluation (SSPE) Sub-Committee was established to provide for a standardized and comprehensive review process to evaluate new products that could improve DOTD road systems or enhance competition.

Lone Star Industries, Inc. (LoneStar) produces a ground granulated blast furnace slag (GGBFS) called Aucem 120 Grade Slag. This slag is combined with Type I Portland cement to produce a slag-cement blend. LoneStar has requested approval to provide a blend (Aucem/Cement Blend) of 50% Portland cement and 50% Aucem slag as a substitute for 100% Portland cement. LoneStar was sent the new product evaluation procedure and submittal forms in a letter dated December 15, 1998. These documents are presented in Appendix A.

This report presents a summary of the SSPE Sub-Committee's findings regarding the LoneStar product Aucem/Cement Blend. LoneStar seeks to have its Aucem/Cement Blend approved for use in state projects by the SSPE Sub-Committee.

The SSPE Sub-Committee developed and utilized a new product evaluation procedure to ensure a complete and objective evaluation of the Aucem/Cement Blend. The process consists of the following three phases: Phase 1 begins when a manufacturer submits a SSPE Form to the DOTD. Phase 2 starts after DOTD has reviewed the product and established a testing program to be performed by the manufacturer to verify product claims. Phase 3 consists of DOTD and Sub-Committee evaluation, which may include site-specific laboratory and/or field testing. Upon completion of Phase 3, DOTD may approve or reject the submitted product, or require additional testing if the results of Phase 3 are inconclusive.

After LoneStar completed Phases 1 and 2, it advanced to Phase 3 where two test sections were constructed to evaluate the product's performance. The first site is located in St. Martin Parish, and the second site is located in Tangipahoa Parish. The test sections were constructed at no additional cost to DOTD. The Louisiana Transportation Research Center (LTRC) tested these sections during and after construction.

The SSPE Sub-Committee reviewed the results of the laboratory and field tests and concluded that the Aucem/Cement Blend is not equal to the standard product (pure Portland Cement) in design, construction, or performance. The two key factors in this determination were strength and durability. The SSPE Sub-Committee therefore recommends the Aucem/Cement Blend not be approved as a direct equal to pure cement. Further testing is recommended with higher additive rates and higher cement percentages.

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INTRODUCTION

The Louisiana Department of Transportation and Development (DOTD) receives many requests for new product approval. The product information provided by the manufacturer generally does not give enough detailed performance characteristics for a complete evaluation. The Soil Stabilization Products Evaluation (SSPE) Sub-Committee was established to provide for a standardized and comprehensive review of new products to determine if the products could improve DOTD road systems or enhance competition.

Lone Star Industries, Inc. (LoneStar) produces a ground granulated blast furnace slag (GGBFS) called Aucem. This slag is combined with Type I Portland cement to produce a slag-cement blend. LoneStar has requested approval to provide a blend of 50% Portland cement and 50% Aucem slag as a substitute for 100% Portland cement. LoneStar was sent the new product evaluation procedure and submittal forms in a letter dated December 15, 1998.

The evaluation procedure is a three phase process. Phase 1 deals with product information and history. Phase 2 is a laboratory program conducted by the manufacturer following a specific protocol established by the SSPE committee. Phase 3 is a full-scale field test constructed on a DOTD project and evaluated for constructability and performance by LTRC.

After review of the Phase 1 submittal, the SSPE committee has the following options.

1. The committee will establish a testing program to be performed by the manufacturer to verify product claims.
2. The committee may reject further evaluation of the product for one of the following reasons.
    a. The product does not fall within the scope of this committee and is referred back to the New Product Evaluation (NPE) committee.
    b. This product is not economically feasible at this time.
    c. The product qualifies for Qualified Product List evaluation.
    d. The product has been previously evaluated and rejected

After review of the Phase 2 documentation, the committee has the following options.

1. The committee shall refer the product to a DOTD evaluator. (Phase 3) Further evaluation will require a cooperative agreement between DOTD and the manufacturer for additional site specific laboratory and/or field testing.
2. The manufacturer will be informed that specific changes in the submitted documentation need to be revised or clarified. In this event, resubmittal and review of applicable materials shall be required.
3. A recommendation will be made to the NPE Committee that the documentation submitted by the manufacturer does not justify use by the department or further evaluation.

Upon completion of the Phase 3 evaluation, the committee will take one of the following actions.

1. The committee will recommend to the NPE Committee approval of the product for use on DOTD projects.

2. The committee will recommend to the NPE Committee the product be rejected for use on DOTD projects.

3. If the results of the DOTD evaluation are inconclusive, the committee may require further evaluation.

This report documents the results of the Aucem/Cement Blend evaluation process.

OBJECTIVE

The objective of this study was to evaluate the Aucem slag / Portland cement blend as an equal to Portland cement as an additive in base courses. The objective to measure the effectiveness of this new product was achieved with an extensive laboratory and field-testing program to verify its properties and capabilities. The results of this study will be used to determine if the Aucem slag / Portland cement blend should be approved as an alternate for pure Portland cement in base courses in the State of Louisiana.

SCOPE

The scope of this project was based on the Louisiana Department of Transportation and Development, New Product Evaluation Procedure and any additional requirements imposed by the SSPE committee. The scope of this report includes the results of Phase 1 through Phase 3 of the evaluation process. Additional information may be obtained in Phase 2 documents submitted by LoneStar to LTRC as required for evaluation.

The Phase 2 validation conducted by LTRC and the results of the Phase 3 evaluation conducted by DOTD and LTRC are documented in this report.

METHODOLOGY

Phase 1

In December 1998, LoneStar began Phase 1 of the evaluation process for their Aucem slag / Portland cement blend. The product is a mix of Aucem, a ground granulated blast furnace slag (GGBFS), and Type I Portland cement. LoneStar seeks to have this Aucem/Cement Blend approved for use in state projects.

Phase 1 included basic information for preliminary review: history, composition, benefits, application procedures, optimum moisture, costs, etc. The completed LoneStar Phase 1 submittal form is attached as Appendix B.

Phase 1 required no testing, only statements from the manufacturer on their product. The Sub-Committee reviewed this Phase 1 submittal and granted LoneStar permission to proceed to Phase 2 in March 1999. A letter dated March 8, 1999, outlines the testing required in Phase 2 and requests clarification on additional items not answered in Phase 1. This letter to LoneStar is attached as Appendix C.

Phase 2

In Phase 2, the Sub-Committee outlined specific information and tests required to continue the approval process. Information required included product history, design procedures, environmental requirements, laboratory testing, construction requirements, maintenance issues, and itemized costs.

The Laboratory testing in Phase 2 sought to compare the different soils prepared with the Aucem/Cement Blend versus pure cement. LoneStar hired Soil Testing Engineers, Inc. (STE) to perform the required laboratory tests. The testing protocol is detailed below.

Testing Procedures

The manufacturer testing program was performed in accordance with the following referenced test procedures.

LA DOTD TR 407	Mechanical Analysis of Soils
LA DOTD TR 418	Moisture - Density Relationships
LA DOTD TR 423	Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
LA DOTD TR 432	Determining the Minimum Cement Content for Soil Cement Stabilization
LA DOTD TR 428	Determining the Atterberg Limits of Soils
AASHTO T 135	Wetting and Drying of Compacted Soil-Cement Mixtures

ASTM	D 1883	California Bearing Ratio (CBR) of Laboratory Compacted Soils
ASTM	D 427	Shrinkage of Soils

Soil Samples

The testing program included four types of soil: three samples of untreated or unstabilized soil meeting the DOTD TR 423 classifications A-2-4, A-4, A-6; and a fourth sample of recycled soil cement base material. The recycled base material was supplied by DOTD.

Laboratory Tests

The following laboratory tests were performed on each soil sample as described below. For the purpose of this evaluation, cement treated soil refers to soil in which cement has been added that will produce a minimum of 300 psi (2100 kPa) in accordance with DOTD TR 432. The Aucem/Cement treated soil was treated with the same percentage of additive for each test (as applicable) as recommended by the manufacturer.

a. Soil classification for each sample type (DOTD TR 407 and TR 423)

b. Atterberg Limits for each sample type of untreated soil (DOTD TR 428)

c. Moisture-density relationships for each sample type (DOTD TR 418)
   i. Untreated soil
   ii. Cement treated soil
   iii. Aucem/Cement treated soil

d. Cement content vs. unconfined compressive strength for each sample type (DOTD TR 432)
   i. Cement treated soil @ 4, 6, 8, & 10 % cement by volume
   ii. Aucem/Cement treated soil @ 4, 6, 8 & 10 % by volume.

e. Durability tests for each sample type (AASHTO T 135)
   i. Cement treated soil
   ii. Aucem/Cement treated soil

f. Shrinkage (ASTM D 427) and swell tests (ASTM D 1883) for each sample type
   i. Untreated soil
   ii. Cement treated soil
   iii. Aucem/Cement treated soil

LoneStar submitted copies of the STE report with their Phase 2 submittal in October 1999. The complete report is available at LTRC for review. Appendix D consists of cover letters from this Phase 2 Submittal.

Verification Testing

The manufacturer delivered samples of each soil type used in the lab program to Louisiana Transportation Research Center for verification testing. Strength testing was randomly checked for comparison of results.

As the testing progressed, additional issues arose regarding the long-term strength gains of the Aucem/Cement Blend. LTRC asked LoneStar to conduct additional testing on the material with cure times longer than 7 days. DOTD District 7 also conducted tests to quantify these long-term strength values.

Phase 3

In January 2000, the SSPE Sub-Committee granted LoneStar permission to advance to Phase 3. Appendix E contains the letter documenting this approval. This approval allowed LoneStar to search for a suitable location on an existing DOTD project to build a test section using the Aucem/Cement Blend. The acceptance of this test section required a no-cost plan change approved by the contractor, the district, and the chief engineer. The results and performance of each section were used to compare the effectiveness of the Aucem/Cement Blend.

St Martin Parish – LA 314

The first Phase 3 test section is located in St. Martin Parish near Cypress Island, north of St. Martinville on La 314 between La 353 and La 31 as shown in Figure 1. This 1,000-foot long section from Station 30+00 to 40+00, was constructed in July of 2000. The top foot of subgrade along this 1,000-foot section was lime treated. The pavement section on the project included 8.5 inches of cement stabilized base course. The base material to be stabilized was silty sand with gravel as defined by the Unified Soil Classification System (USCS). The material classifies as A-1-a according to AASHTO.

The mix design of a cement-stabilized base requires a stabilization agent to achieve a minimum of 300 psi in seven days. The test section consisted of the above soil mixed with the Aucem/Cement Blend (50% Aucem Slag and 50% Type I Cement) at 9% by volume. The remainder of the project consisted of Portland cement treated with 6% by volume. Station 40+00 to 50+00 was used as a control section. The top foot of subgrade in this control section was also treated with lime.

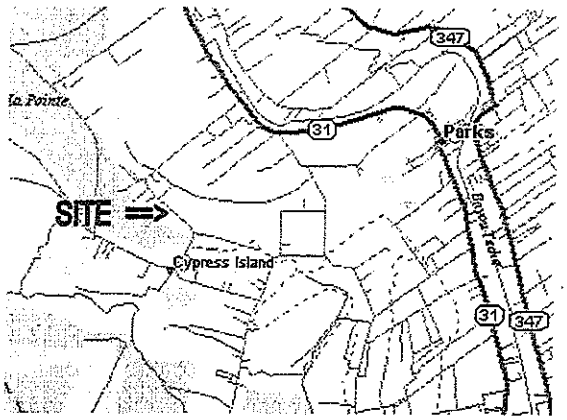


Figure 1: St Martin Parish, La 314

Tangipahoa Parish – LA 1063

The Tangipahoa Parish test section is located southwest of Independence on La 1063 between Interstate 55 and Black Cat Road West as shown in Figure 2. This 1,000-foot section was constructed between March and May of 2002. The project was originally an unstabilized sand, clay, gravel base. Although there was a contract item, no lime treatment was done on this project.

The mix design of a cement-treated base requires that a minimum strength of 150 psi be reached in seven days. The project was designed for 5% Portland cement additive by volume. The test section also used the same 5% Aucem/Cement Blend by volume.

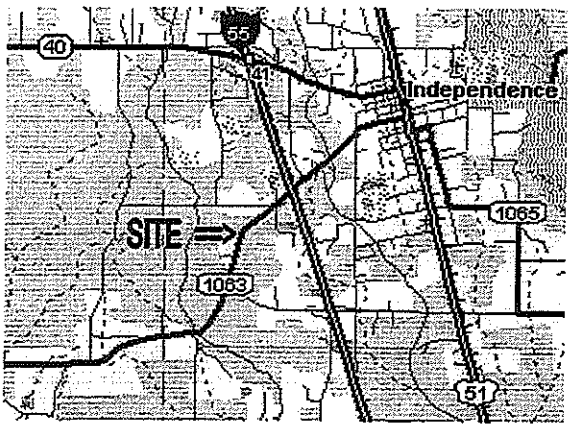


Figure 2: Tangipahoa Parish, LA 1063

Performance Monitoring

Surface Monitoring

The pavement surface was visually monitored for cracking, rutting, potholes, and any forms of distress.

Dynaflect

The "Dynamic Deflection Determination System" (DYNAFLECT), is a trailer mounted electro-mechanical device. A dynamic load is induced on the pavement and the resulting deflections are measured with five geophones spaced at one-foot intervals from point of load application. The pavement is subjected to a 1,000-pound dynamic load at a frequency of eight cycles per second produced by the counter rotation of two unbalanced flywheels. The load is transmitted vertically to the pavement through two steel wheels spaced 20 inches center-to-center. The deflection measurements are expressed in terms of milli-inches (thousandths of an inch).

Falling Weight Deflectometer Test

The falling weight deflectometer is a trailer-mounted device, which delivers an impulse load to the pavement. The equipment uses a weight that is lifted to a given height and dropped onto a 300 mm circular load plate. The plate is mounted with a thin rubber pad underneath. A load cell measures the force caused by the applied load to the pavement under the plate. The deflections caused by the impulse load are measured by seven sensors and can be displayed by the computer in either mils or microns. The peak load magnitude can be measured as both force and pressure in Metric units kPa and kN/m2, or lbf and psi. The first sensor is always mounted in the center of the load plate, while sensors 2-7 are spaced at various distances up to 10 feet from the load center. The impulse load can be varied by changing the mass of the falling weight, the drop height, or both.

DISCUSSION OF RESULTS

Phase 1

LoneStar submitted Phase 1 paperwork for its Aucem/Cement Blend in January 1999. The completed Phase 1 form, included as Appendix B, indicates that the product approval is being requested for base course stabilization. Expected benefits include increased shear strength, improved tensile strength, permeability reduction, and improved workability. The manufacturer indicated in the Phase 1 documentation that the Aucem/Cement Blend could be a direct alternate to cement stabilization without any additional requirements or adverse effects.

Phase 2

LTRC received the Phase 2 submittal from LoneStar in October 1999. Information provided on product history, design procedure, environmental requirements, laboratory testing, construction and post-construction requirements, and itemized costs are presented in Appendix D.

Soil Testing Engineers, Inc. (STE) of Baton Rouge, LA, conducted the Phase 2 laboratory program for LoneStar. Table 1 summarizes the properties of the soil used in the laboratory program. The tests conducted assessed the properties of the various materials involved in the test program. The test program asked for four different soil types: A-2-4, A-4, A-6, and Recycled Base Material. The STE test results in Table 1 indicate that the soils labeled as A-2-4 and A-4 actually classify as A-4 and A-6, respectively. None of the material classified as A-2-4. **Though the STE classifications are incorrect, they will remain as reported for consistency.**

Atterberg limits, including shrinkage limits, were included in the test program to aid in assessing the material's range of moisture workability, and potential shrinkage. Samples with high Plasticity Indexes (PI) will generally be more difficult to dry and have a larger potential to swell and shrink, due to their higher shrinkage limit and low shrinkage ratio. These limits were determined for the natural material as a baseline for comparison with the soils prepared with the Aucem/Cement Blend and pure cement.

Table 2 presents the moisture-density results from the Proctor Compaction Tests, and CBR - Swell test. The compaction tests were performed to establish the maximum dry density and optimum moisture content for each material. Additional tests were performed on samples prepared with the Aucem/Cement Blend and pure cement. The prepared samples' dry densities showed little if any increase in dry density compared to the natural soil. The CBR strength and moisture results were less than the corresponding Proctor Compaction tests.

Table 1
BASE COURSE MATERIAL PROPERTIES

Soil Type	Gradation				Atterberg Limits			Shrinkage Limit, %			Shrinkage Ratio, %		
	Sand %	Silt %	Clay %	Fines %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Natural	Aucem	Cement	Natural	Aucem	Cement
A – 2 – 4	60.2	23.8	16.0	39.8	22	14	8	12.4	11.8	14.4	1.88	1.91	1.79
A - 4	39.2	44.8	16.0	60.8	25	14	11	16.8	23.8	31.8	1.78	1.62	1.41
A - 6	47.5	28.5	24.0	52.5	29	13	16	20.7	28.1	30.5	1.65	1.46	1.47
Recycled Asphalt Base	61.0	16.4	11.6	28.0	15	15	0						

Table 2
MOISTURE - DENSITY RESULTS

Soil Type	Proctor Compaction Tests						CBR – SWELL DATA								
	Natural		Aucem		Portland		Natural			Aucem			Portland		
	Max Dry Density Pcf	Moisture Content %	Max Dry Density pcf	Moisture Content %	Max Dry Density pcf	Moisture Content %	Swell %	Dry Density pcf	Moisture Content %	Swell %	Dry Density pcf	Moisture Content %	Swell %	Dry Density pcf	Moisture Content %
A – 2 – 4	120.8	11.0	120.5*	11.3	120.3*	11.7	0.31	115.9	8.8	0.04	112.1	8.2	0.28	111.3	8.3
A – 4	114.3	14.3	114.0	14.2	114.5	14.3	1.44	112.5	11.5	0.57	108.8	11.0	0.77	108.8	11.0
A – 6	119.4	12.4	117.6*	12.6	118.8	12.3	0.00	111.9	11.8	0.11	109.2	12.2	0.00	107.4	12.9
Recycled Asphalt Base	128.3	9.4	126.8	9.4	129.6	8.2	Note: STE added Aucem and Portland on Proctor Tests at 8% by volume except where by weight *								

The shrinkage and swell tests conducted assessed the performance of the Aucem/Cement Blend in different moisture and drying conditions. Swell and shrinkage conditions can damage pavements and reduce pavement life, which ultimately leads to increased costs to the consumer/taxpayer. The shrinkage tests will assist in determining the likelihood of shrinkage cracks developing in the prepared base. In general, if the amount of additive percentage increases the likelihood of shrinkage cracks may also increase. These shrinkage cracks can reflect up through the asphalt/concrete. The swell tests gauge the potential of the prepared base to swell when exposed to water. The results indicate the different additives compare well to each other.

The shrinkage numbers in Table 1 show that there was less shrinkage in the Aucem/Cement Blend samples than pure cement samples. This may be due to the lower cement contents in the blend or slower cure times. Less shrinkage and lower cement content may be beneficial in reducing the number of reflective cracks that can appear with higher cement contents.

Figure 3 presents the average compressive strength results versus percent additive for the A-2-4 and A-4 materials. Each STE point represents the average of three compressive strengths tests. All samples were cured for seven days.

When combined with 4, 6, 8, and 10% pure cement, the A-2-4 material had strengths of 360.3, 410.7, 472.3, and 508.7 psi, respectively. The A-2-4 material mixed with the Aucem/Cement Blend at the same percentages had strengths of 211.0, 288.3, 360.0, and 389.0 psi, respectively. The two charts follow the same trend yet the pure cement produced results that averaged 126 psi higher. LTRC verification samples (single tests at 6% additive) were slightly higher than the cement samples at 487 psi and remarkably higher than the Aucem/Cement Blend samples at 468 psi. The verification samples compared well for each additive.

When combined with 4, 6, 8, and 10% pure cement, the A-4 material had strengths of 154.3, 176.0, 208.0, and 204.0 psi, respectively. The A-4 material mixed with the Aucem/Cement Blend at the same percentages had strengths of 117.0, 135.0, 159.7, and 198.7 psi, respectively. The two plots follow the same trend yet the pure cement produced results that averaged 33 psi higher than the blend. The strengths at 10% additive were similar, only 5.3 psi apart. LTRC verification samples (single tests at 6% additive) were higher than results of 264 psi for cement and 468 psi for the Aucem/Cement Blend. The LTRC verification samples compared well for each additive.

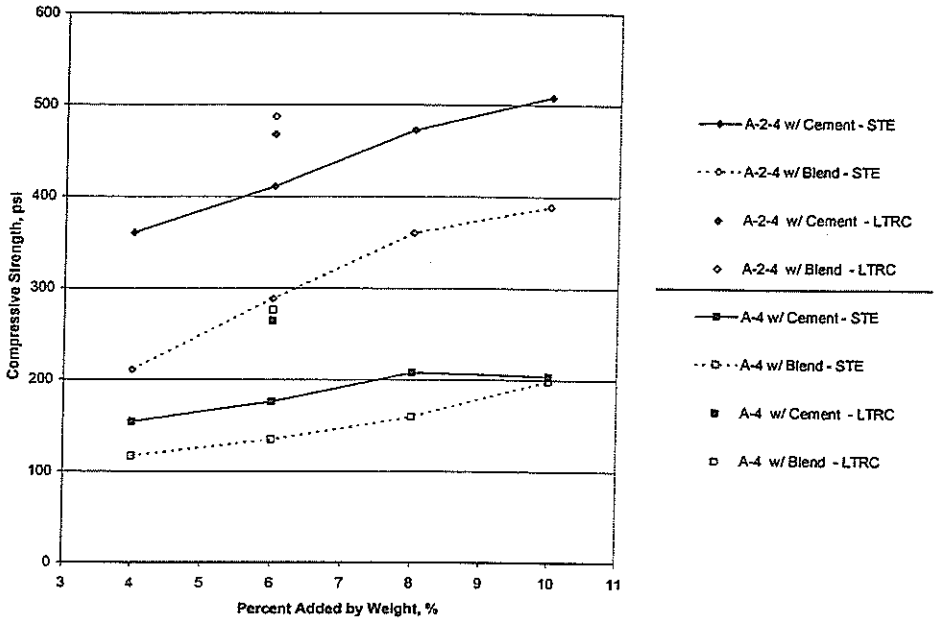


Figure 3
A-2-4 and A-4 Soils
7-Day Compressive Strengths versus Additive Percentages

Figure 4 presents the average compressive strength results versus percent additive for the materials A-6 and Recycled Base Material. All samples were cured for seven days. Each STE point represents the average of three compressive strengths tests.

When combined with 4, 6, 8, and 10% pure cement, the A-6 material had strengths of 302.7, 393.3, 449.3, and 528.3 psi, respectively. The A-6 material mixed with the Aucem/Cement Blend at the same percentages had strengths of 197.0, 248.3, 410.3, and 426.3 psi, respectively. The cement plot is straight, and while the Aucem/Cement Blend plot follows the same trend, the 8% sample is closer to the cement plot than other points. LTRC verification samples (single tests at 6% additive) were within the two plots and matched the data closely at 375 and 307 psi for cement and the Aucem/Cement Blend, respectively.

When combined with 4, 6, 8, and 10% pure cement, the Recycled Base Material had strengths of 84.7, 124.7, 157.7, and 183.7 psi, respectively. The Recycled Base Material prepared with the Aucem/Cement Blend at the same percentages had strengths of 65.0, 113.7, 151.3, and 172.0 psi, respectively. The two charts follow the same trend, and share nearly the same values with a maximum difference in strength of 19.7 psi. The 8% Aucem/Cement Blend sample is the only sample point to have exceeded the strength of its cement counterpart. LTRC verification samples (single tests at 6% additive) were both lower than the STE results with values of 76 and 57 for cement and Aucem/Cement Blend. The verification samples matched each other for both additives.

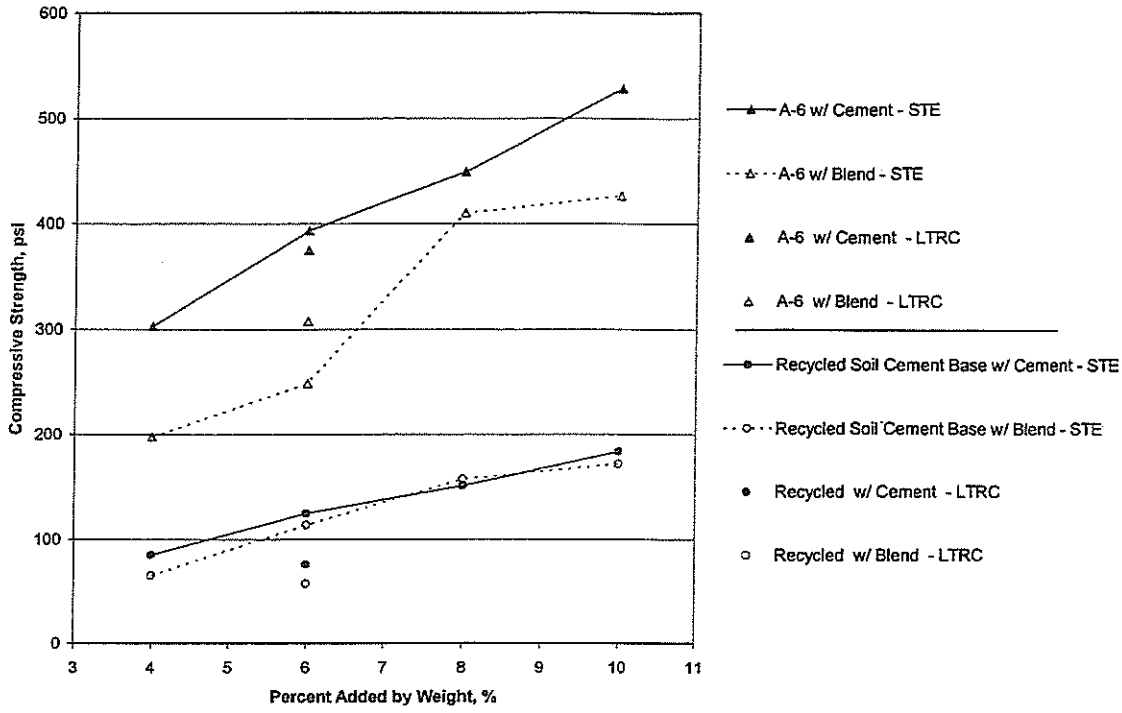


Figure 4
A-6 and Recycled Base Material
7-Day Compressive Strengths versus Additive Percentages

The next set of figures show the increase in compressive strength gained over cure times longer than seven days. Samples with different additive percentages were tested after different cure times to measure their compressive strengths. Figures 5 and 6 show the average strength results as conducted by DOTD District 7 for separate A-2-4 and A-4 materials, respectively. Figures 7 and 8 show the average strength results as conducted by STE for the A-6 and Recycled Base Material. The DOTD District 7 data is included as part of Appendix F; the STE data is from their Phase 2 submittal.

In most of the resulting plots, the compressive strength increased over cure time. Higher additive percentages also resulted in higher compressive strengths. Generally, slag-cement blends eventually reach and exceed the compressive strengths of soil prepared with pure cement.

The District 07 plots in Figures 5 and 6 show that the A-2-4 and A-4 soils prepared with pure cement produced higher compressive strengths than the Aucem/Cement Blend in all cases except one. The strength of the A-4 soil prepared with 5% Aucem/Cement Blend was only 7 psi higher than the same soil prepared with 5% pure cement.

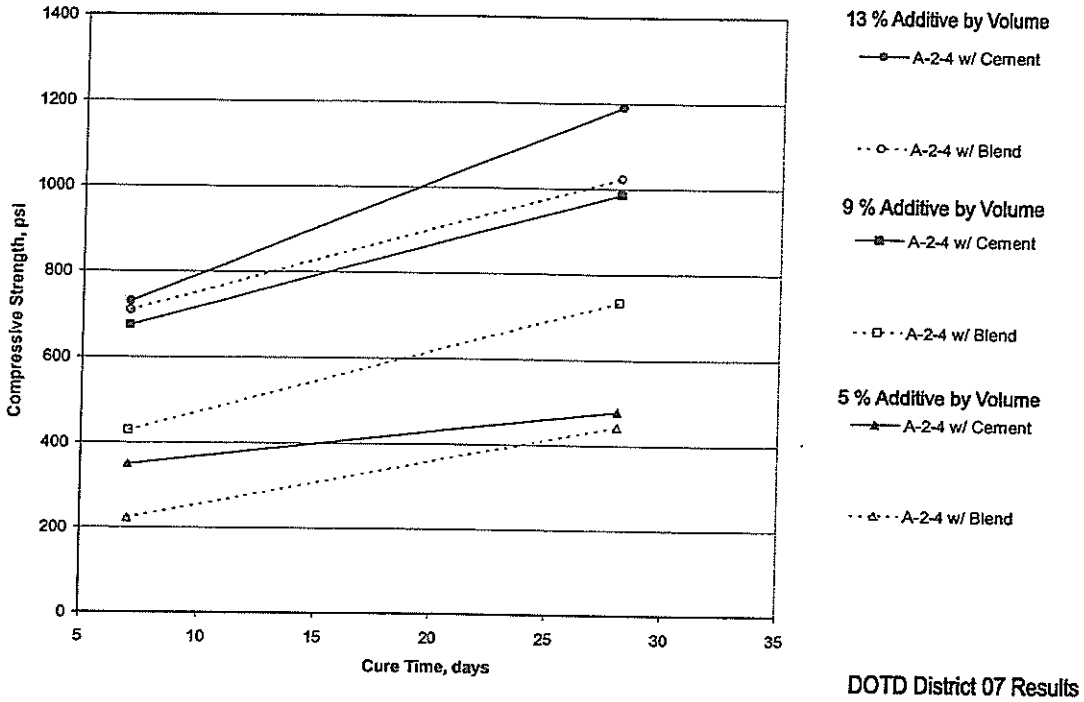


Figure 5
A-2-4 Soil
Compressive Strengths versus Cure Time

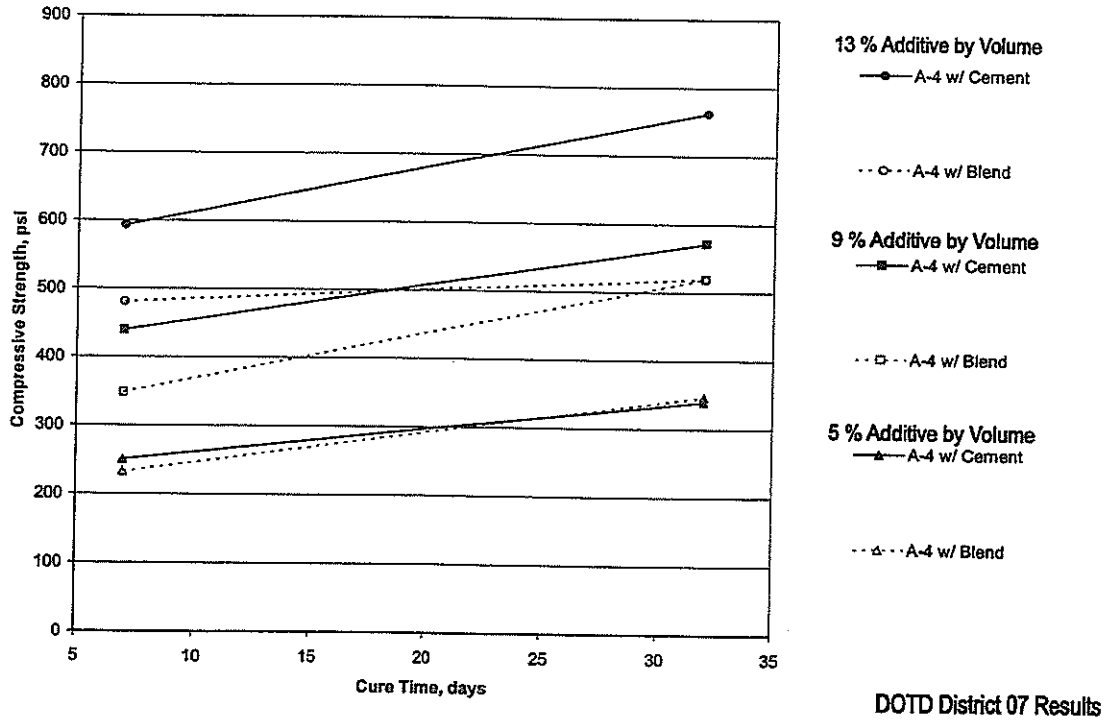


Figure 6
A-4 Soil
Compressive Strengths versus Cure Time

The STE plotted in Figure 7 show that the A-6 soil prepared with cement produced higher strength results than the Aucem/Cement Blend in all but one instance. The 5% additive of Aucem/Cement Blend to the A-6 soil surpassed its comparative cement results at the same additive percentage, though this data point does not seem to fit the trend of its previous points. The data used in Figures 7 and 8 is attached as Appendix H.

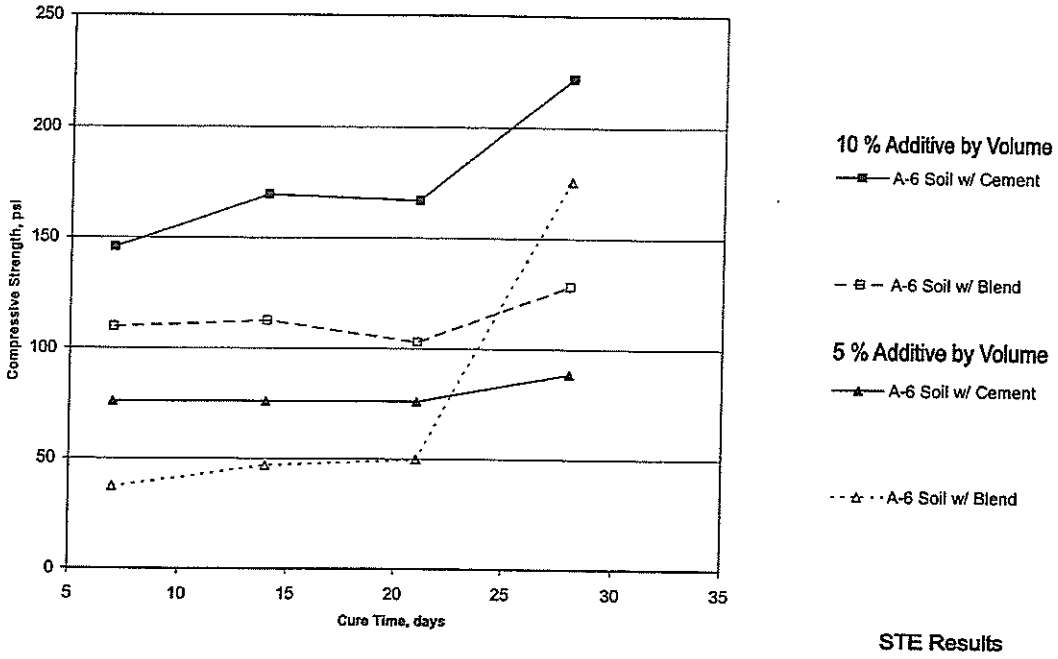


Figure 7
A-6 Soil
Compressive Strengths versus Cure Time

The STE results plotted in Figure 8 for recycled base material follow similar trends and strength results differed from only 3 psi to a maximum of 60 psi.

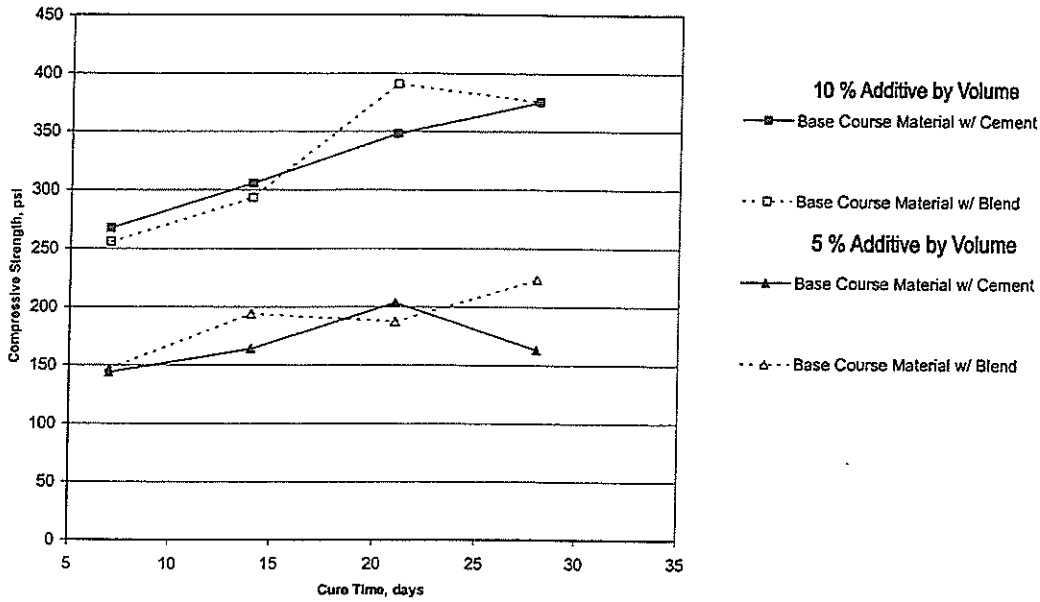


Figure 8
Recycled Base Material
Compressive Strengths versus Cure Time

LTRC conducted validation tests to determine whether there was an increase in compressive strength with longer cure times. The results (single test points) are shown on Figure 9, and show a gain in strength at the 28-day break. The test was conducted on A-1a material, and the results show the blend increasing in strength above the pure cement for this soil type.

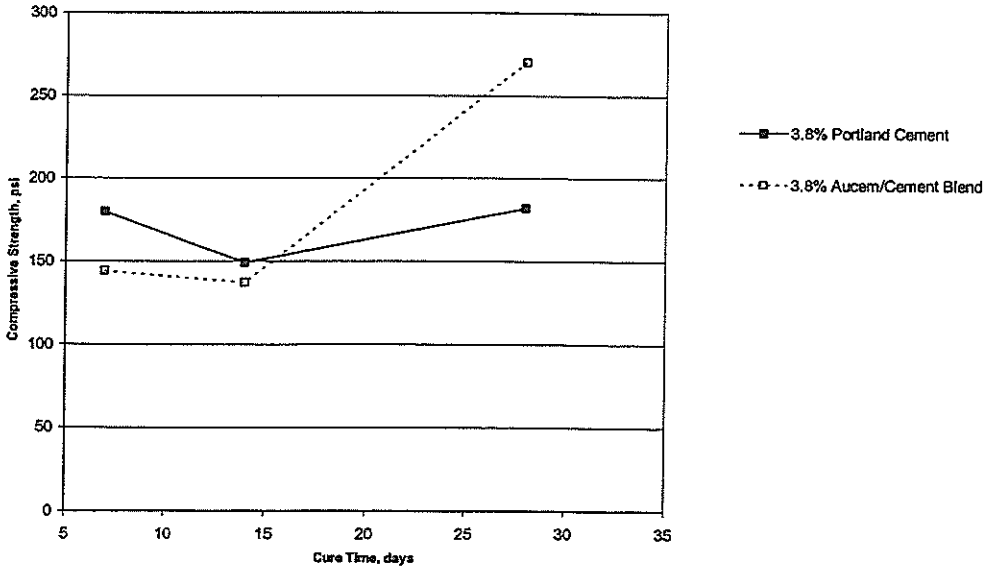


Figure 9
LTRC
Compressive Strengths versus Cure Time

Table 3
DURABILITY

Soil Type	Additive Type	Sample ID No.	Original Dry Weight (lbs)	Original Wet Weight (lbs)	Initial Moisture (%)	Retained Moisture (%)	Final Corrected Dry Weight (lbs)	Final Oven-Dried Weight (lbs)	Soil Cement Loss (%)
A-2-4	Type I	1	3.86	4.42	10.96	3.20	3.74	3.88	3.1
		2	3.85	4.41	10.96	3.23	3.73	3.75	5.6
	Slag	1	3.92	4.44	10.70	2.32	3.83	3.93	2.3
		2	3.91	4.43	10.70	2.35	3.82	3.65	8.8
A-4	Type I	1	3.69	4.29	13.20	2.70	3.59	3.64	2.6
		2	3.69	4.29	13.20	2.70	3.59	3.43	9.5
	Slag	1	3.72	4.30	13.50	1.84	3.65	3.37	1.8
		2	3.74	4.30	13.50	1.30	3.69	3.17	16.3
A-6	Type I	1	3.63	4.27	12.10	4.93	3.46	3.69	4.7
		2	3.61	4.25	12.10	5.02	3.44	3.53	6.9
	Slag	1	3.61	4.19	11.96	3.67	3.48	3.55	3.5
		2	3.64	4.24	11.96	4.04	3.50	3.41	10.0

The durability test (AASHTO T-135) consists of exposing soil cement specimens to a series of wet and dry cycles. The procedure begins by molding two specimens at the desired cement and moisture content. The first specimen (Specimen 1) is used to monitor weight loss and the other (Specimen 2) is used to determine volume change. After molding the specimens, they are placed in a damp room at 100 percent humidity for seven days. The specimens are then removed from the damp room and submerged in water for five hours. Next, both specimens are placed in the oven at 160° F for a minimum of 48 hours. Both specimens are then removed from the oven, weighed, and measured. Specimen 2 is then subjected to brushing with a wire scratch brush on its ends as well as longitudinally and then weighed. Both specimens are put through twelve cycles of wetting and drying as previously outlined. Specimens pass the test when there is less than a two percent change in volume in Specimen 1 and when the weight loss criteria is met in Specimen 2, as outlined in Table 4.

Table 4

Durability criteria

Soil groups	Passing weight loss
A-1, A-2-4, A-2-5, A-3	< 14%
A-2-6, A-2-7, A-4, A-5	< 10%
A-6, A-7	< 7%

The durability test results for samples prepared with cement passed the above criteria. Two of the three samples prepared with the Aucem/Cement Blend failed the above criteria.

Phase 3

Tables 5 and 6 summarize the results of field tests conducted on the St. Martin Parish and Tangipahoa Parish test sections during and after construction. The Dynaflect and Falling Weight Deflectometer results and the back calculations for Resilient Modulus and Structural Number are also shown on this table.

The St. Martin Parish test section field results are similar for both the pure cement portion and the Aucem/Cement Blend portion. The FWD subgrade results only varied by four ksi, and the FWD base results varied by a maximum of 36 ksi. The Dynaflect results for the two different additives were also similar varying by about 1,000 psi. The structural numbers and layer coefficients, since they are based on the Dynaflect results, are also similar to the structural numbers for pure cement and the Aucem/Cement Blend of 3.2 and 3.0, respectively. It should be noted that the Aucem/Cement Blend contained a higher percentage of additive.

The Tangipahoa test section field results were similar for the two different additives. The FWD moduli were only eight ksi apart. Both parish test sections have performed well since their construction and have not experienced significant problems.

Table 5

ST. MARTINVILLE, AUCEM TEST SECTION
LA 314, SP# 850-09-0007

		FWD RESILIENT MODULUS (KSI)		STRUCTURAL NUMBER		LAYER COEFFICIENT	
Date of Test	Pavement Layer	Pure Cement	Aucem Blend	Pure Cement	Aucem Blend	Pure Cement	Aucem Blend
July 12, 2000	Base			3.2	3.0	0.21	0.33
July 7, 2000	Subgrade			1.4	0.2		
October 10, 2000	Base	268	332				
	Subgrade	21	23				
October 24, 2000	Base	263	270				
	Subgrade	19	22				

Table 6

TANGIPAHOA PARISH, AUCEM TEST SECTION
LA 1063, SP# 853-34-0009

		RESILIENT MODULUS FWD MODULUS (KSI)		STRUCTURAL NUMBER		LAYER COEFFICIENT	
Date of Test	Pavement Layer	Pure Cement	Aucem Blend	Pure Cement	Aucem Blend	Pure Cement	Aucem Blend
April 4, 2002	Base			2.7	3.0	0.20	0.13
	Subbase			0.3	1.5		
June 3, 2002	Base	177	169	4.4	4.6		
October 21, 2002	Base	176	170	4.5	4.6		

Note: Base prepared on March 27, 2002. Hot mix laid on May 7, 2002.

CONCLUSIONS

The primary focus of this evaluation was to determine if the Aucem/Cement Blend could be added as an equivalent to Pure Cement. The testing protocol was established to determine if the product being evaluated could be considered an equal to the standard product in design, construction, and performance. Based on the results of this evaluation process, the Aucem/Cement Blend is not an equivalent to pure cement. Two key factors in this determination were strength and durability.

Generally, the seven-day strengths for materials stabilized with pure cement were higher than soils prepared with the Aucem/Cement Blend. It can be concluded from these results that the compressive strength of soils prepared with the Aucem/Cement Blend are less than the strength achieved by the same percentage of Pure Cement.

Higher additive percentages and longer cure times generally produced higher compressive strengths in both Aucem/Cement Blend and pure cement samples. However, the Aucem/Cement Blend samples with higher additive percentages and longer cure times rarely increased above the pure cement samples with the same additive percentage. The Aucem/Cement Blend performed better than the Cement samples in only 8 of 51 comparative tests (15.7%). Only four of those tests with higher compressive strengths can be attributed to longer cure times.

The Aucem/Cement Blend contains half the cement content of the same additive percentage of pure cement, and may be the cause of these lower strengths. Therefore, it may require higher additive percentages of Aucem/Cement Blend to produce equivalent pure cement strengths. Even with longer cure times, the Aucem/Cement Blend rarely reached the strength of pure cement.

The second key factor is durability. Two of three samples prepared with the Aucem/Cement Blend failed to meet the DOTD requirements. This may be due to the lower cement content in the blend. The low durability results may also be due to longer cure times required by slag-cements to reach their full strength.

The Resilient moduli and structural numbers for the Aucem/Cement Blend areas are within tolerable limits and compare favorably to the pure cement areas on each project. The field test sections are performing well, and show no significant differences between the Aucem/Cement Blend and the pure cement areas. Based on the field test results, the Aucem/Cement Blend is performing adequately. It can also be concluded that base courses prepared with Aucem/Cement Blend should perform well if the strength and durability requirements are met.

RECOMMENDATIONS

The testing protocol was established to determine if the product being evaluated can be considered equal to the standard product on a one-for-one basis without any changes to the existing DOTD procedures. Based on this criterion and the results of the evaluation program, the SSPE committee recommends that the Aucem/Cement Blend not be approved as a direct equal to pure Portland cement for base preparation.

Soil modifications with the Aucem/Cement Blend appear to be a viable option when strength and durability requirements are met. The full-scale test sections have performed well since their construction and the laboratory testing produced some advantages for reducing shrinkage and swelling potential. Other implementation options should be considered.

- Contractors could be allowed to use the Aucem/Cement Blend under a value engineering proposal. Approval would require the contractor to determine the appropriate additive rate based on strength and durability requirements. LoneStar will have to convince contractors that a cost benefit is realized even though additional field-testing and higher additive percentages may be required to use this product.

- LoneStar should consider the benefits of modifying the Blend to include a higher percentage of cement from current 50/50 mix. (i.e. 60/40, 70/30, etc.) A laboratory evaluation would be required to verify results.

- An implementation program could be initiated to allow LoneStar to compete as an alternate on several pilot projects (three maximum). LTRC would provide the design for the projects to determine the appropriate additive rate. This would allow DOTD to determine if there is any economic benefit to allowing an alternate product.

APPENDIX

Appendix A: 15 December 1998, LTRC letter from Mark Morvant to LoneStar (Ken Wetzel), regarding the New Product Evaluation Approval Process.

Appendix B: 1 January 1999, LoneStar Phase 1 Submittal, Soil Stabilization Product Evaluation Form for Aucem/Cement Blend.

Appendix C: 8 March 1999, LTRC letter from Mark Morvant to LoneStar (Ken Wetzel), Grants approval to proceed to Phase 2.

Appendix D: Phase 2 Submittal (cover letters only), Soil Testing Engineers, Inc. letter dated 9 September 1999, and LoneStar letter dated 26 October 1999

Appendix E: 1 January 2000, LTRC letter from Mark Morvant to LoneStar (Ken Wetzel), Grants approval to advance to Phase 3.

Appendix F: 8 June 2000, DOTD Memo from M.M. Cryer, Acting District 07 Lab Engineer, to Mark Morvant regarding tests conducted on the Aucem/Cement Blend.

Appendix G: 28 August 2001, LTRC letter from Mark Morvant to DOTD Chief Construction Division (Jimmy Little), requesting second test section.

Appendix H: Table 1, Revised Compressive Strengths from LoneStar (STE).

APPENDIX A

LOUISIANA TRANSPORTATION RESEARCH CENTER

LTRC

4101 GOURRIER • BATON ROUGE, LOUISIANA 70808 • (504) 767-9131
FAX NUMBER (504) 767-9108

December 15, 1998

New Products Evlauation
Offer Number 17.018
Aucem

Mr. Ken Wetzel
Lone Star Industries, Inc.
New Orleans Cement Operations
14900 Intracostal Drive
New Orleans, LA 70129

Subject: New submittal to the Soil Stabilization Product Evaluation Committee

Dear Mr. Wetzel,

A new products evaluation procedure for soil stabilization has been established by the Louisiana Department of Transportation and Development. This process has been established to insure a complete and objective evaluation of your product. A copy of the procedure is enclosed along with a Phase 1 submittal form for your Aucem product. As soon as the completed form is returned, the SSPE committee will consider whether a Phase 2 testing program to be performed by the manufacturer is warranted.

Please feel free to contact me if you have and questions.

Sincerely,

Mark J. Morvant, P.E.
Geopysical Research engineer
Chairman, SSPE Committee

MJM:mjm
enclosures
cc: Mr. Doug Hood

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
EVALUATION PROCEDURE FOR
SOIL STABILIZATION PRODUCTS

1. PURPOSE

This document has been prepared for the use of both manufacturers and committee members to insure an efficient and complete evaluation of soil stabilization materials in a timely manner.

The Department receives many requests to use new products as soil stabilization agents or reinforcements on construction projects. As is often the case, the product information submitted with the New Product Evaluation Form does not give enough detailed information for a thorough evaluation. This process hereby establishes formal procedures by which the manufacturer of a soil stabilization product shall submit proper documentation to the Louisiana Department of Transportation and Development (LA DOTD) for:

A. Evaluation of the product for subgrade treatment, base stabilization, moisture barrier, etc.,
B. Approval of that product for use on LA DOTD construction projects.

2. PRODUCT APPROVAL PROCESS

A. Manufacturers interested in having their products approved for use shall submit to the New Products Evaluation Committee (NPE) the completed NPE form. (Phase 1 submittal)
B. The product will be issued an evaluation number.
C. The manufacturer information and NPE form (upon receipt) will be forwarded to the Soil Stabilization Product Evaluation Committee (SSPE) Chair. At that time the SSPE Chairman, will forward the procedures and SSPE form to the manufacturer stating that all information and test data requested shall be returned within six (6) months for the evaluation process to continue. If information requested is not received in that time frame the SSPE will advise the NPEC and the file will be closed due to lack of interest.

D. Upon receipt of the information requested, the committee will do one of the following:

1. The committee will establish a testing program to be performed by the manufacturer to verify product claims.

2. The committee will reject further evaluation of the product by the SSPE for one of the following reasons.

    1. The product does not fall within the scope of this committee and is referred back to the NPE committee.
    2. This product is not economically feasible at this time.
    3. The product qualifies for Qualified Product List evaluation.
    4. The product has been previously evaluated and rejected.

E. If the product will be evaluated the manufacturer will be sent the testing requirements the committee considers necessary for a comprehensive evaluation.

F. The manufacturer shall submit the necessary documents as outlined herein. (Phase 2 submittal)

G. The manufacturer may be contacted to arrange an oral presentation of the product information. The manufacturer's representatives should include personnel who are qualified to answer specific questions regarding the testing, design and construction procedures submitted in the documentation.

H. Upon review of the manufacturer's documentation and presentation, the SSPE committee will take one of the following actions:

1. The committee shall refer the product to a DOTD evaluator. (Phase 3) Further evaluation will require a cooperative agreement between DOTD and the manufacturer for additional site specific laboratory and/or field testing.

2. The manufacturer will be informed that specific changes in the submitted documentation need to be revised or clarified. In this event, resubmittal and review of applicable materials shall be required.
3. A recommendation will be made to the NPE Committee that the documentation submitted by the manufacturer does not justify use by the department or further evaluation.

3. SUBMITTAL REQUIREMENTS (Phase 2 submittal)

Six complete sets of submittal documents shall be furnished to the SSPE Chairman as follows:

A. Product History

1. Practical applications with descriptions and photographs.
2. Limitations and disadvantages of the product.
3. Representative list of previously completed projects using the product in the proposed application. The list should include a variety of site conditions (i.e., soil types, moisture conditions, traffic loading, previous transportation application, etc.) Listed projects shall include the year built, name, address and telephone number of the owner and contact person.

B. Manufacturer Design Procedure (as applicable)

1. Determination of Application Rates
2. Minimum Strength Requirements
3. Estimated Design Life of the Product
4. Design manual, charts, computer programs, etc.

C. Environmental Requirements (as applicable)

1. Federal, State or Local Environmental Agency Approvals
2. Hazardous Material Designations
3. Special Handling Procedures
4. Special Disposal Procedures
5. Special Controls of Project Site Runoffs.

D. Laboratory Testing
Results of laboratory testing program as required by the SSPE committee.

E. Construction Requirements
1. List of equipment required for construction
2. Construction specification requirements
3. Quality Control testing requirements
4. Preparation requirements

F. Post Construction Requirements
1. Recycle Capabilities
2. Maintenance requirements

G. Itemized Costs: Costs shall be submitted on a square meter of surface area treated for various thicknesses. Material quantities shall be based on laboratory testing results.
1. Product costs
2. Installation costs

4. DEPARTMENT EVALUATION (Phase 3)
The committee may recommend that further laboratory testing, field testing or both be conducted to verify performance of the product.

A. Laboratory Testing may be conducted by DOTD to verify test results submitted by the manufacturer.

B. Field testing of the product may be performed to verify laboratory results and in-place performance. Field testing on a DOTD project will require the approval of the DOTD Chief Engineer.

C. Upon completion of the Phase 3 evaluation the committee will take one of the following actions.

1. The committee will recommend to the NPE Committee approval of the product for use on DOTD projects.

2. The committee will recommend to the NPE Committee the product be rejected for use on DOTD projects.

3. If the results of the DOTD evaluation are inconclusive, the committee may require further evaluation.

Soil Stabilization Product Evaluation Form

(Phase 1 Submittal)

OFFER NO. _____

Date received from NPEC: _____

Date Manufacturer Notified: _____

Requested forms and information received:

☐ YES ☐ NO

REPLY DUE DATE: _____

FOR NPE AND SSPEC USE ONLY

Trade Name: _____

Manufacturer: _____ Date _____

Representative: _____

Address: _____

City: _____

Phone: _____ Fax _____ State: _____ Zip: _____

E-Mail: _____

Application request:

___ subgrade treatment

___ moisture barrier

___ base course stabilization

Material Composition: _____

Soil type applications: AASHTO designation _____

Expected benefits:

___ Reduces P.I.

___ Improves shear strength

___ Improves tensile strength

___ Improves modulus

___ Permeability reduction

___ Improves workability

___ Expedites construction

___ Reduces moisture content

___ Lowers swell potential

___ Other (specify)

Briefly describe additional product benefits: _____

Product most effective in following moisture conditions:

___-8% ___-4% ___-2% ___optimum ___+2% ___+4% ___+ 8% ___saturated

Soil preparation requirements prior to application: _____

Recommended rate of application (base on soil type/condition if different) _____

Temperature requirements for application: _____

Equipment required for application: _____

Is the product approved for use by other state/government agencies? Specify. _____

Typical installed costs per square meter vs. thickness (i.e., 300mm, 600mm, etc.) Itemize material costs and installation costs. _____

The manufacturer is hereby notified that the Louisiana Department of Transportation and Development reserves the right to release or distribute any of the information included in or attached to this form and the results obtained as part of our laboratory testing and field evaluation.

The Louisiana Department of Transportation and Development *will not consider* any new product for testing until this form is completed, *signed by a responsible official of the manufacturer* which authorizes the evaluation, and returned to the address shown below. All DOTD correspondence will be directed to the official of the manufacturer listed below.

Louisiana Department of Transportation and Development
Louisana Transportation Research Center
Attention: Soil Stabilization Product Evaluation Chairman
4101 Gourrier Lane, Baton Rouge, LA 70808

Signed: _____
(Official of manufacturer)

Name: _____
(Please type or print)

Title: _____

Manufacturer: _____

Address: _____
(Street, City, State, Zip Code)

Date: _____

APPENDIX B

Soil Stabilization Product Evaluation Form

(Phase 1 Submittal)

OFFER NO. 17,012

Date received from NPEC: _____

Date Manufacturer Notified: _____

Requested forms and information received:

☐ YES ☐ NO

REPLY DUE DATE: _____

FOR NPE AND SSPEC USE ONLY

Trade Name: Lone Star Type I (Aucem Cement Blend) Date 1/29/99

Manufacturer: Lone Star Industries, INC.

Representative: Ken Wetzel

Address: 14900 Intracoastal Dr.

City: New Orleans State: LA Zip: 70129

Phone: (504)254-6429 Fax (504)254-6499 E-Mail: _____

Application request:

___ subgrade treatment

___ moisture barrier

___* base course stabilization

Material Composition: 50% Type I and 50% Aucem 120 Grade Slag

Soil type applications: AASHTO designation All Designations

Expected benefits:

___ Reduces P.I.

___ Improves shear strength

__*_ Improves tensile strength

___ Improves modulus

__*_ Permeability reduction

___* Improves workability

___ Expedites construction

___ Reduces moisture content

___ Lowers swell potential

___ Other (specify)

Briefly describe additional product benefits: Increased P.S.I. when Aucem Blended Cement is used in soil stabilization as compared to 100% Portland

Product most effective in following moisture conditions:

___-8% ___-4% ___-2% ___optimum ___+2% ___+4% ___✓+ 8% ___saturated

Soil preparation requirements prior to application: No special preperation required other than normal preperation for Portland Cement treatment

Recommended rate of application (base on soil type/condition if different) Normal rate as required by LADOTD

Temperature requirements for application: No Special Requirements

Equipment required for application: Normal Stabilization Equipment

Is the product approved for use by other state/government agencies? Specify. Yes- Aucem is approved LADOTD (seeOPL 7) and (see attached)

Typical installed costs per square meter vs. thickness (i.e., 300mm, 500mm, etc.) Itemize material costs and installation costs. Approximately same per square costs as Portland Cement

The manufacturer is hereby notified that the Louisiana Department of Transportation and Development reserves the right to release or distribute any of the information included in or attached to this form and the results obtained as part of our laboratory testing and field evaluation.

The Louisiana Department of Transportation and Development *will not consider* any new product for testing until this form is completed, *signed by a responsible official of the manufacturer* which authorizes the evaluation, and returned to the address shown below. All DOTD correspondence will be directed to the official of the manufacturer listed below.

Louisiana Department of Transportation and Development
Louisana Transportation Research Center
Attention: Soil Stabilization Product Evaluation Chairman
4101 Gourrier Lane, Baton Rouge, LA 70808

Signed: David Weber
(Official of manufacturer)

Name: David Weber
(Please type or print)

Title: Sales Manager

Manufacturer: Lone Star Industries, Inc.

Address: 14900 Intracoastal Dr. New Orleans, LA 70129
(Street, City, State, Zip Code)

Date: 1/29/99

LONE STAR INDUSTRIES, INC.

2524 S. Sprigg Street, Cape Girardeau, MO 63703
573 335-5591
P.O. Box 520, Cape Girardeau, MO 63702-0520

MILL CERTIFICATION REPORT
PORTLAND CEMENT - TYPE I - LOW ALKALI

Certificate A
Location: New Orleans Terminal
Cement Type: I Low Alkali
Brand Name: Canakkale Cement
Istanbul, Turkey

Ship: M/V"ACE CONFIDENCE"

This Portland cement complies with current ASTM C 150-98, Federal SS-C-1960/3b, and AASHTO M-85 Specifications.

ASTM SPECIFICATIONS

CHEMICAL DATA

MgO		max 6.0%
SO3		max 3.5%
Loss on Ignition		max 3.0%
Insoluble Residue		max 0.75%
When C3A 8% or less.	SO3	max 3.0%
Na2O Equivalent		max 0.60%
C3S		None

PHYSICAL DATA

Fineness-Wagner	min 160 m2/kg
Blaine	min 280 m2/kg
Expansion	max 0.80%
Time of Set-Vicat	
	min 45 min.
	max 375 min.
Air Content	max 12%
Compressive Strength:	
1 day - psi (MPa)	None
3 day - psi (MPa)	1740 (12.0)
7 day - psi (MPa)	2760 (19.0)

Lab Cert. Number: 16-1

MILL CERTIFICATION VALUES

CHEMICAL DATA

MgO - %	1.7
SO3 - %	2.5
Loss on Ignition - %	1.7
Insoluble Residue - %	0.35
C3A - %	5.6
Na2O Equivalent - %	0.46
C3S - %	58.9

PHYSICAL DATA

Fineness-Wagner - m2/kg		217
Blaine - m2/kg		391
Expansion - %		0.00
Time of Set-Vicat		
Minutes		115
Air Content - %		4.7
Compressive Strength:		
1 day - psi (MPa)	2000	(13.8)
3 day - psi (MPa)	3840	(26.5)
7 day - psi (MPa)	4650	(32.1)

By _____
Steven E. Sebaugh - Chemist

LONE STAR INDUSTRIES

AUCEM MILL TEST REPORT ASTM 989
NEW ORLEANS GRINDING FACILITY

Date: 1/21/99

Certificate A

Product : Aucem Slag Grade 120
Silo Number : 25
Laboratory Number : 25-04
Date Sampled : 12\09\98 TO 12\15\98
Tons Produced : 3000

Purchaser :
Date Shipped :
Project :
Destination :

SLAG ACTIVITY INDEX

GRADE	Average of last 5				Individual Test			
	7 Day ASTM	AUCEM	28 Day ASTM	AUCEM	7 Day ASTM	AUCEM	28 Day ASTM	AUCEM
120	95%	101%	115%	128%	90%	100%	110%	127%

SLAG REFERENCE CEMENT MORTAR PERFORMANCE

Compressive Strength at 7 Days	33.03 MPa	4790 psi
Compressive Strength at 28 Days	53.09 MPa	7700 psi

REFERENCE CEMENT MORTAR PERFORMANCE

Compressive Strength at 7 Days	32.68 MPa	4740 psi *
Compressive Strength at 28 Days	41.51 Mpa	6020 psi *

* Av. of 5 samples

The undersigned certifies that the GGBFS Grade 120 was loaded from the pretested silo indicated above.

By: _____

SLAG CHEMICAL DATA

	ASTM Max	AUCEM
Sulfide sulfur (S) %	2.5	1.2
Sulfate ion reported as SO3 %	4.0	3.5

OTHER SLAG DATA

	ASTM Max	AUCEM
Blaine Fineness	na	640 m2/kg
Retained on 325#	20%	0.30%
Air Content of Slag Mortar	12%	4.60%
Slag Density	na	2.87 gm/cm3

REFERENCE PORTLAND CEMENT DATA (ASTM C 150)

Blaine Fineness (m2/kg)	349
Total Alkalis (Na2O+ 0.658 K2O) ASTM Range (0.6-0.9)	0.77
C3S	61.07
C2S	12.48

C3A	11.25
C4AF	6.91
CaSO4	4.88

The undersigned certifies that the samples represented by this report and loaded into the silo indicated above, were tested in accordance with the latest ASTM C-989 and AASHTO M 302 standard methods, and the GGBFS will comply with any applicable DOT specifications for Slag Cement . No GGBFS , not covered by a certified test report , has been added to the silo .

By W.D. Henry Robinson

W.D. "Henry" Robinson

Lone Star Industries, Inc

MATERIAL SAFETY DATA SHEET
(OSHA 29 CFR 1910.1200)
FOR GROUND GRANULATED IRON BLAST FURNACE SLAG CEMENT

SECTION I - IDENTITY

Manufacturer's Name and Address:	Lone Star Industries. Inc. 14900 Intracoastal Drive New Orleans. LA 70129
Emergency Telephone Number:	(317) 653-9766
Information Telephone Number:	(504) 254-6435 or (504) 254-6454 (800) 782-7236
Date of Preparation:	01/10/95
Common Name and Synonyms:	Slag Cement: Blast Furnace Slag Cement: Iron Slag Cement, Pig Iron Slag Cement Water Granulated Ground Blast Furnace Slag Cement

SECTION II - HAZARDOUS INGREDIENTS / IDENTITY INFORMATION

Ingredients*	CAS No.
Calcium Oxide	1305-78-8
Fused Silica Oxide	60676-86-0
Magnesium Oxide	1309-48-4
Aluminum Oxide	1344-28-1
Sulfur	7704-34-9
Manganese Oxide	7439-96-5
Potassium Oxide	12136-45-7
Sodium Oxide	12401-86-4
Titanium Oxide	13463-67-7
Ferric Oxide	1309-37-1

*Since Blast Furnace Slag Cement is manufactured from materials mined from the earth. and process heat is provided by burning fuels derived from the earth. trace but detectable amounts of naturally occurring metals. and possibly harmful elements may be found during chemical analysis. Ingredients are expressed as oxides for quantitative purposes. Actual oxides do not generally occur in "free form" but rather as complexed silica-based glasses or crystals. May contain free crystalline silica.

SECTION III - PHYSICAL L/ CHEMICAL CHARACTERISTICS

Solubility in Water - Up to 20%
pH - becomes alkaline when mixed with water. in the range 9.0 - 11.5
Specific Gravity - 2.7 to 3.1 g/cm^3
Light gray to tan or white colored fine powder with a detectable sulfur odor
The following properties are not applicable as ground blast furnace slag is a solid in powder form:
Boiling point. vapor pressure. vapor density. melting point. evaporation rate.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Ground Blast Furnace Slag is non-combustible and not explosive. Therefore. there are no flammable or explosive limits or unusual fire and explosion hazards.

SECTION V - REACTIVITY DATA

Ground Blast Furnace Slag is stable.
Ground Blast Furnace Slag will not polymerize.
Ground Blast Furnace Slag when wet may react with aluminum powder and other alkali and alkaline earth elements to liberate hydrogen gas. Hydrogen Sulfide gas may be released if the Slag comes in contact with acids. Hydrogen Sulfide is a toxic gas.

SECTION VI - HEALTH HAZARD DATA

OSHA (Occupational Safety and Health Administration), MSHA (Mine Safety and Health Administration), and ACGIH (American Conference of Governmental Industrial Hygieniests), classify the (PEL) Permissible Exposure Limit as 5 mg/m3 for respirable dust and 10 mg/m3 for total dust: for an 8 hour period. Ground slag is not known to cause cancer, however, some people believe crystalline silica can cause cancer. Free titanium oxide has been classified as having limited evidence of causing cancer in animals. Exposure to ground slag dust can affect the skin, the eyes, and mucous membranes.

ACUTE EXPOSURE: Contact with wet slag can dry the skin and cause severe chemicall/alkali burns. Contact with the eye can cause severe chemical burns and possibly leave permanent damage.

CHRONIC EXPOSURE : Breathing ground slag dust can cause inflammation of the lining tissue in the interior of the nose, throat, and lungs. Some individuals may develop an allergic dermatitis. Prolonged exposure to high concentrations of free silica may cause silicosis.

EMERGENCY FIRST AID PROCEDURES: Irrigate (flood) eyes immediately and repeatedly with clean water for up to 15 minutes. Wash exposed skin areas with soap and water. Apply sterile dressings. If clothing and shoes are exposed, remove immediately and wash the skin. Get prompt medical attention.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

If ground slag is spilled, it can be cleaned up using dry methods that do not disperse dust into the air. Avoid breathing the dust. Emergency procedures are not required since there are no hazardous substances in the ground slag as supplied. The slag can be treated as a common waste for disposal.

SECTION VIII - CONTROL MEASURES

In dusty environments, the use of an OSHA, MSHA or NIOSH approved respirator and tight fitting goggles is recommended.

Local exhaust can be used, if necessary, to control airborne dust levels.

The use of barrier creams or impervious gloves, boots, and clothing to protect the skin from contact with ground slag is recommended.

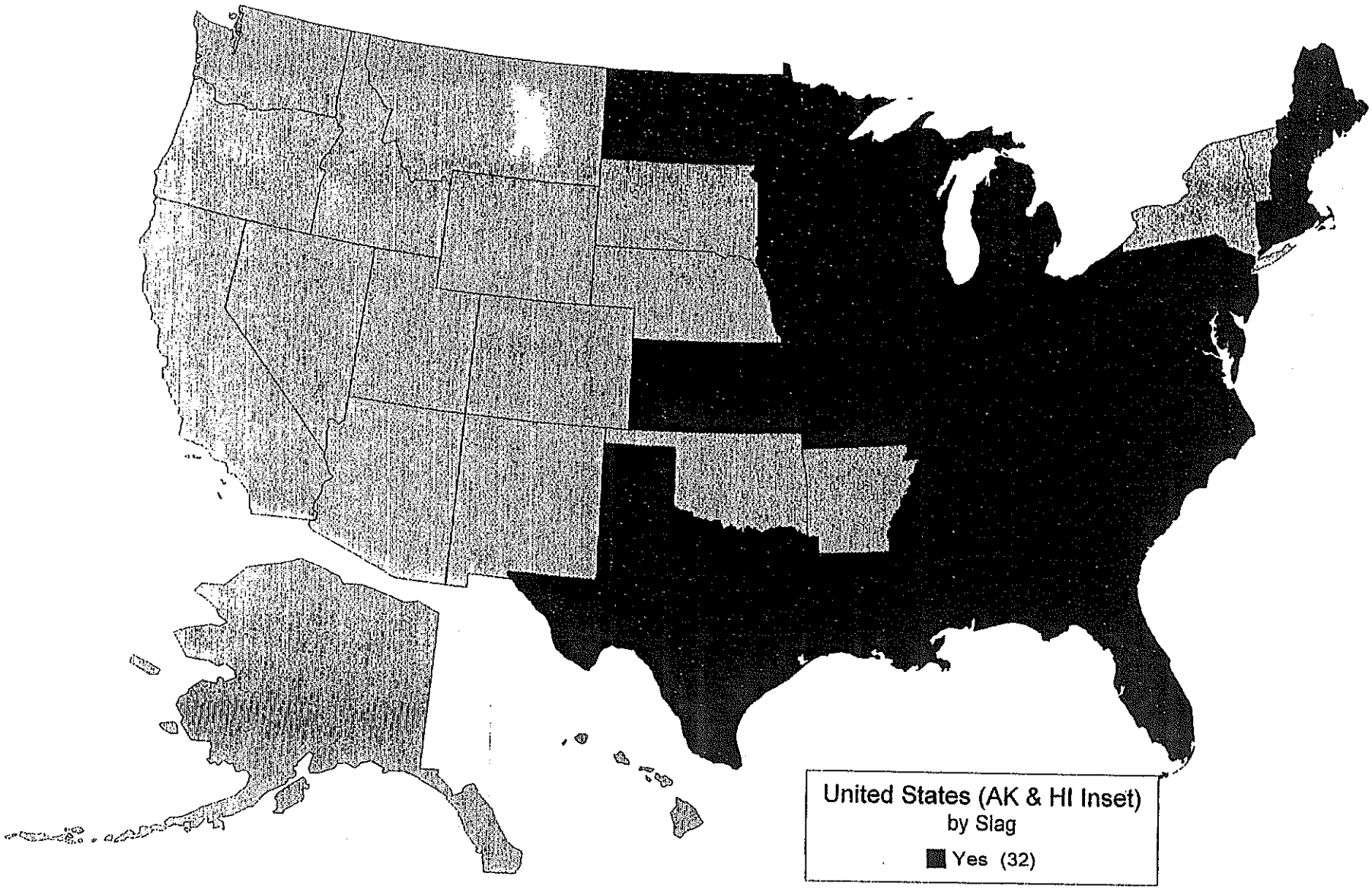
Following work with ground slag, workers should shower with soap and water.

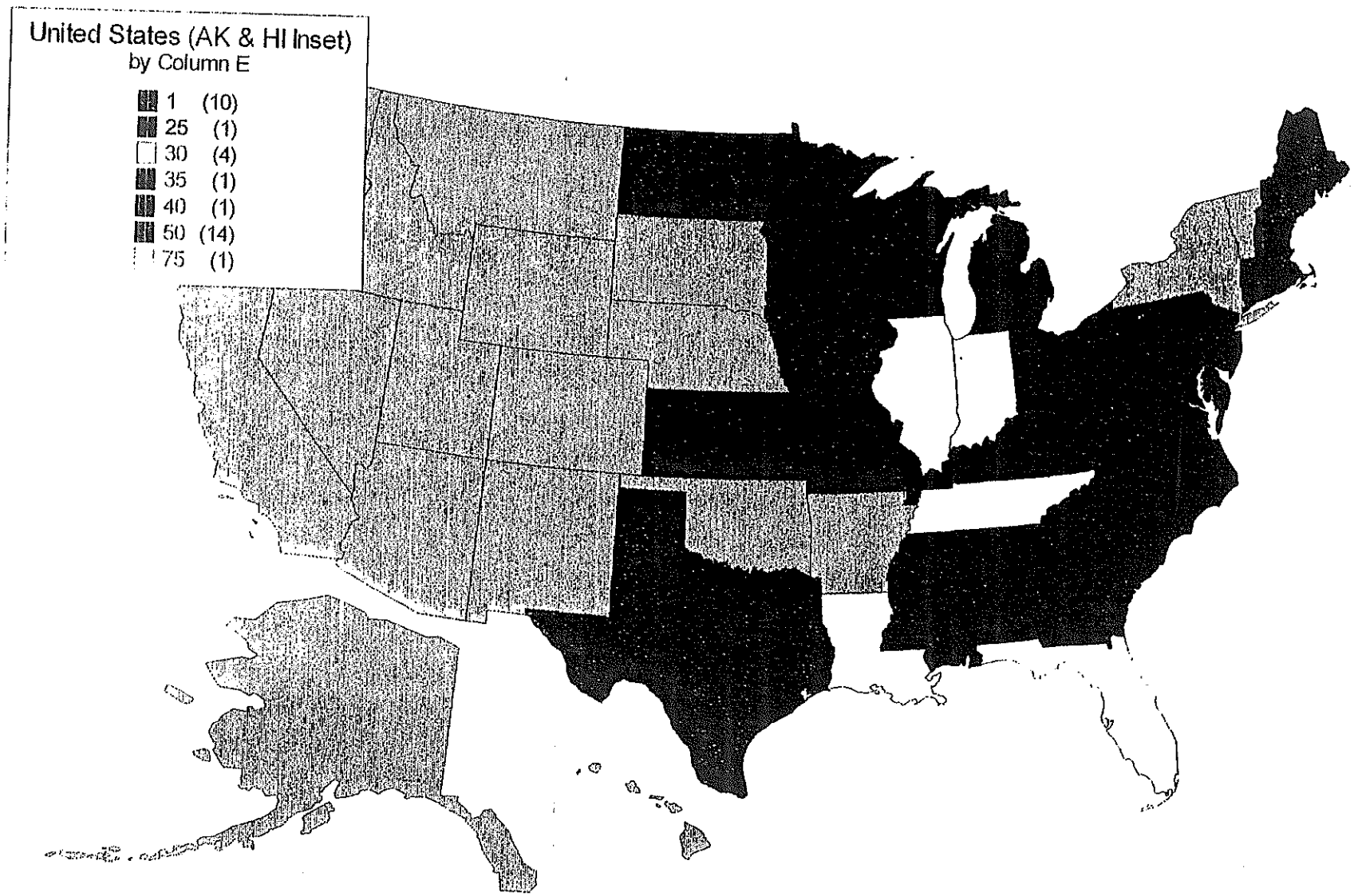
State DOT Approvals of Slag and Slag Blends

State	Slag	Max %	LSI	Blend	Max %	LSI	Specs	Sources of Info	
Alabama	Yes	50	Yes				Yes	Spec	
Alaska									
Arizona									
Arkansas									
California									
Colorado									
Connecticut	Yes	1						AASHTO	ML
Delaware	Yes	50							LTRC, ML
District of Columbia	Yes	1						AASHTO	
Florida	Yes	75	Yes				96, 91	Spec	
Georgia	Yes	50	Yes				95, 93	Spec	
Hawaii									
Idaho									
Illinois	Yes	30						AASHTO	PY, ML
Indiana	Yes	30						AASHTO	PY, ML
Iowa	Yes	1							ML
Kansas	Yes	1		Yes			Special	Spec	
Kentucky	Yes	50					Special	Spec	
Louisiana	Yes	30	Yes	Yes	50	Yes	Special	Spec	
Maine	Yes	1							ML
Maryland	Yes	50						AASHTO	LTRC, ML
Massachusetts	Yes	1							ML
Michigan	Yes	40						AASHTO	LTRC, ML
Minnesota	Yes	35							PY, ML
Mississippi	Yes	50	Yes	Yes	50		96, 90	Spec	
Missouri	Yes	25	Yes	Yes	25		Excerpt	Spec	
Montana									
Nebraska									
Nevada									
New Hampshire	Yes	50							LTRC, ML
New Jersey	Yes	1							ML
New Mexico									
New York									
North Carolina	Yes	50						AASHTO	LTRC, ML
North Dakota	Yes	1						AASHTO	
Ohio	Yes	50						AASHTO	LTRC, ML
Oklahoma									
Oregon									
Pennsylvania	Yes	50							LTRC, ML
Rhode Island	Yes	1							ML
South Carolina	Yes	50						AASHTO	LTRC, ML
South Dakota									
Tennessee	Yes	30							PY
Texas	Yes	50		Yes			82,	Spec	
Utah									
Vermont									
Virginia	Yes	50						AASHTO	LTRC, ML
Washington									
West Virginia	Yes	1						AASHTO	ML
Wisconsin	Yes	50							PY, ML
Wyoming									

Note: A max % of "1" indicates we don't know what the max % is for this state.

State DOT's Approving the Use of Slag




United States (AK & HI Inset)
by Column E
1 (10)
25 (1)
30 (4)
35 (1)
40 (1)
50 (14)
75 (1)

APPENDIX C

LOUISIANA TRANSPORTATION RESEARCH CENTER

LTRC

4101 GOURRIER • BATON ROUGE, LOUISIANA 70808 • (225) 767-9131
FAX NUMBER (225) 767-9108 • E-MAIL: LTRC@LTRC.LSU.EDU

March 8, 1999

Mr. Ken Wetzel
Lone Star Industries, Inc.
14900 Intracoastal Drive
New Orleans, LA 70129

Subject: Louisiana DOTD New Products Evaluation
Offer Number 17.018
Aucem Slag Cement

Dear Ken,

The SSPE Committee has approved continuing the evaluation process for base course stabilization for Aucem Slag Cement. Lone Star Industries will be required to submit a Phase II submittal to the committee for further evaluation. The Phase II submittal shall consists of providing the necessary documentation as detailed in the Evaluation Procedure for Soil Stabilization Products. A copy of this procedure is attached along with a list of additional items that need to be addressed. Also attached is the required laboratory testing program to be conducted by an independent lab. The laboratory test results shall bear the legible seal and signature of the responsible Professional Civil Engineer registered in the State of Louisiana. The Phase II submittal shall be completed in six months for the evaluation process to continue.

We look forward to working with Lone Star Industries representatives in providing a comprehensive evaluation of the benefits of your product. Please contact me at (504) 767-9124 if the you have any questions.

Sincerely,

Mark Morvant, P.E.
Geophysical Research Engineer

MJM:mjm

cc. Harold Paul
Doug Hood

Aucem/Cement Blend
Phase II Submittal
Laboratory Testing Requirements

1. Scope

This laboratory program is designed to satisfy the requirements of the manufacturer Phase II submittal for evaluation of the soil stabilization products. The Aucem/Cement Blend product is being tested for use as a base course stabilization agent.

2. Testing Procedures

The manufacturer testing program shall be performed in accordance with the following referenced test procedures. Any modifications from these procedures for the product being tested shall be noted and justified.

LA DOTD TR 407	Mechanical Analysis of Soils
LA DOTD TR 418	Moisture - Density Relationships
LA DOTD TR 423	Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
LA DOTD TR 432 (Method B)	Determining the Minimum Cement Content for Soil Cement Stabilization
LA DOTD TR 428	Determining the Atterberg Limits of Soils
AASHTO T 135	Wetting and Drying of Compacted Soil-Cement mixtures
ASTM D 1883	California Bearing Ratio (CBR) of Laboratory Compacted Soils
ASTM D 427	Shrinkage of Soils

3. Soil Samples

The testing program shall include for four types of soil: two samples of untreated or unstabilized soil meeting the DOTD TR 423 classifications A-2-4, A-4, A-6; and a fourth sample of recycled soil cement base material. The recycled base material shall be supplied by DOTD, however the manufacturer shall be responsible for picking up the sample from the DOTD laboratory facility as directed. Arrangement shall be made by contacting the SSPE chairman.

4. Laboratory Tests

The following laboratory tests shall be performed on each soil sample as described below. For the purpose of this evaluation, cement treated soil refers to soil in which cement has been added that will produce a minimum of 300 psi (2100 kPa) in accordance with DOTD TR 432. Aucem/Cement treated soil shall be at the same percentage of additive for each test (as applicable) as recommended by the manufacturer.

a. Provide soil classification for each sample type. (DOTD TR 407 and TR 423)

b. Provide Atterberg Limits for each sample type of untreated soil. (DOTD TR 428)

c. Provide moisture density relationships each sample type (DOTD TR 418)
   1. Untreated soil
   2. Cement treated soil
   3. Aucem/Cement treated soil

d. Provide results of cement content vs. unconfined compressive strength for each sample type (DOTD TR 432):
   1. Cement treated soil @ 4, 6, 8, & 10 % cement by volume
   2. Aucem/Cement treated soil @ 4, 6, 8 & 10 % by volume.

e. Provide results of durability tests for each sample type AASHTO T 135):
   1. Cement treated soil
   2. Aucem/Cement treated soil

f. Provide results of shrinkage (ASTM D 427)and swell tests (ASTM D 1883) for each sample type:
   1. Untreated soil
   2. Cement treated soil
   3. Aucem/Cement treated soil

5. Report

The laboratory report shall be included as part of the Phase II submittal. The report shall bear the legible seal and signature of the responsible Professional Civil Engineer registered in the State of Louisiana. All test results, charts, forms and calculations shall be included in the report. Any recommended additional test procedures or modifications to existing test procedures for the Aucem/Cement product shall be included with the test results and justifications.

6. Verification Testing

The manufacturer shall deliver 30 pounds of each soil type used in the lab program to Louisiana Transportation Research Center for verification testing. The Department shall be responsible for retaining samples of the recycled soil cement base for verification testing.

APPENDIX D

STE
Soil Testing Engineers, Inc.
316 HIGHLANDIA DRIVE (70810) • P.O. BOX 83710 (70884) • BATON ROUGE, LOUISIANA
PHONE (225) 752-4790 • FAX (225) 752-4878 • Email: www.steofla.com

GORDON P. BOUTWELL, JR., Ph.D.
DANIEL L. FRANKLIN, JR., MS
CHARLES S. HEDGES, MS
CHING N. TSAI, MS
DANIEL J. HOLDER, MS
KENNETH A. FLUKER, MS
ZIAD H. ALEM, MS
STEVE M. MEUNIER

REGISTERED PROFESSIONAL ENGINEERS

MICHAEL J. ALLEN

CERTIFIED PROFESSIONAL GEOLOGISTS

BILLY SINGLETON, BS Geology

September 9, 1999

Lone Star Industries, Inc.
14900 Intracoastal Drive
New Orleans, LA 70129

Attn: Mr. Ken Wetzel

Re: Louisiana DOTD New Products Evaluation
Office Number 17.018
Phase II Aucem Slag Cement
STE File: 98-5097

Ladies and Gentlemen:

We have completed the Phase II testing program on the referenced project. Enclosed are final Proctor curves, gradation curves, Atterberg limits data, shrinkage limit data, swell data, and durability test data. This final data is presented on tables or shown graphically. In addition to the final tables and curves, test worksheets are also included. Answers to "Additional Items to Be Addressed" are also attached.

Our test program followed LTRC's Testing Program as described in their letter dated March 8, 1999. Four types of soil meeting DOTD TR 423 classifications A-2-4, A-4, and A-6 and recycled soil cement base material (supplied by LTRC) were used for this program. The outline of the testing program and methods used are provided below:

A. Provide soil classification for each sample type (DOTD TR 407 and TR 423).

B. Provide Atterberg Limits for each sample type of untreated soil (DOTD TR 428).

C. Provide moisture density relationships for each sample type (DOTD TR 418):
   1. Untreated soil
   2. Cement treated soil
   3. Aucem/Cement treated soil

Additional Items to Be Addressed

1. How is traffic maintained?

2. What additional construction equipment is needed?

3. What is the time frame before traffic can be placed on the roadway?

4. Are there any special time requirements? (Additional time for initial set, time between final compaction and tight blading, pot life after mixing, etc.)

5. Are there any weather restrictions?

6. How do you handle moisture or material variations during construction?

7. Is there any effect or problem with using a nuclear gauge for moisture density control?

8. If the roadway failed to meet specifications and it was necessary to re-stabilize, are there any special requirements?

9. Can the roadway be re-stabilized in the future?

10. Are there any special testing requirements?

11. Is a curing membrane required?

12. Your Phase I submittal indicated the number of states where Aucem was approved for use. Please indicate the number of states that has approved Aucem for use as a soil cement base course.

13. Your Phase I submittal indicates that Aucem is most effective with moisture conditions of +8%. Considering soil cement specifications require cement stabilization at +/- 2 % of optimum, please explain your product requirements.

ADDITIONAL ITEMS TO BE ADDRESSED

1. Q. **How is traffic maintained?**
   A. When maintenance of traffic is required, all traffic will be routed onto shoulders or other suitable areas, same as portland.

2. Q. **What additional construction equipment is needed?**
   A. Aucem is pre blended and APPLIED with same equipment as portland.

3. Q. **What is the time frame before traffic can be placed on the roadway?**
   A. 72-hour curing period, same as Portland.

4. Q. **Are there any special time requirements (additional time for initial set, time between final compaction and tight blading, pot life after mixing, etc.)?**
   A. No; same requirements as Portland cement

5. Q. **Are there any weather restrictions?**
   A. None, other than mixing with frozen material or temperatures below 35°F in the shade at the project

6. Q. **How do you handle moisture or material variations during construction?**
   A. Additional laboratory testing and close on-site inspection; same as how soil/Portland cement projects would be handled

7. Q. **Is there any effect or problem with using a nuclear gauge for moisture density control?**
   A. No

8. Q. **If the roadway failed to meet specifications and it was necessary to re-stabilize, are there any special requirements?**
   A. None - However the maximum 3 hour delay set time can be extended, which is an advantage.

9. Q. **Can the roadway be re-stabilized in the future?**
   A. Yes

10. Q. **Are there any special testing requirements?**
    A. None

11. Q. **Is a curing membrane required?**

A. Yes, as per Louisiana Standatd Specifications for Roads and Bardges Section 303.08.

12. Q. **Your Phase I submittal indicated the number of states where Aucem was approved for use. Please indicate the number of states that has approved Aucem for use as a soil cement base course.**

A. Information will be supplied by Lone Star Industries, Inc., at a later date

13. Q. **Your Phase I submittal indicates that Aucem is most effective with moisture conditions of +8%. Considering soil cement specifications require cement stabilization at ±2% of optimum, please explain your product requirements.**

A. The original submittal is in error; the ±2% of optimum would be the preferred moisture content at time of compaction

LONE STAR INDUSTRIES, INC.

AUCEM SLAG CEMENT

14900 Intracoastal Drive
New Orleans, LA 70129
(504) 254-6454 Office
(504) 254-6458 Fax

October 26, 1999

Mr. Mark Morvant, P.E.
Chairman, SSPE Committee
LTRC
4101 Gourrier
Baton Rouge, LA 70808

Subject: New Products Evaluation Offer Number 17.018 AUCEM

Dear Mr. Morvant:

Lone Star Industries, Inc. is pleased to submit for your consideration the completed new product testing of our AUCEM 50/50 Blended cement for soil stabilization. Enclosed you will find six sets of submittal documents for your review. Lone Star selected Soil Test Engineers of Baton Rouge to perform all tests according to LA DOTD, AASHTO and ASTM test procedures.

Also, you will find copies of previous laboratory tests that were performed at Delta Testing, Louisiana Testing, Pensacola Testing and Soil Test Engineers for your review. On October 21, 1999 the required soil samples were delivered to Mr. Kevin Gaspard. The required AUCEM cement samples were sent via UPS several weeks earlier. If there are any questions regarding these samples or concerning these submitted documents, please contact me at 1-800-432-7512.

We thank you for your patience and help while we were having the tests performed. We look forward to having the opportunity to meet with the SSPE committee and discussing the results of all of these tests.

Sincerely,

Ken Wetzel

Ken Wetzel

SUBMITTAL REQUIREMENTS (Phase 2 submittal) Lone Star - AUCEM

A. Product History

1. Aucem has been successfully used to stabilize soil as a treated base course for roads, parking lots and construction yards.
2. In consideration of using Aucem as an alternative to the use of pure portland cement for soil stabilization, we site no limitations or disadvantages.
3. Previously completed projects:
   a) St. Tammany Parish (Stoult Street Proj.) Completed Spring, 1999
   Jean Thibodaux, Parish Engineer 504-898-2552
   Conditions were as follows: Plasticity Index – 3.5
   Road was previously all dirt, no blacktop.
   b) Classic Home Builders (Perdido Estates) Escambia City, FL
   Completed July 2, 1998. Rick Faccine 850-944-6805
   See Pensacola Testing Lab Report #78049-1 (attached).
   c) Gilchrist Construction, Erath, LA, Construction yard.
   Completed May, 1999 Randy Gilchrist, owner. 318-448-3565.
   d) Various new subdivision streets in Livingston Parish
   Completed August, 1999. James Nolan, Contractor 225-664-5415

B. Manufacturer Design Procedure

1. Application rate similar to that of portland cement
2. Strength requirements as listed in LA Standard for Roads and Bridges
3. Design life similar to portland cement

C. Environmental Requirements

1. No special handling procedures

D. Laboratory Testing

1. See accompanying report prepared by Soil Testing Engineers, Inc. as required by SSPE Committee.
2. Please also see reports of previously completed tests by Louisiana Testing &Inspection, Inc., Delta Testing And Inspection, Inc., Blount Construction Company, Inc. and Soil Testing Engineers, Inc..

E. Construction Requirements

1. No special equipment, preparation or testing required

F. Post Construction Requirements

1. Aucem would recycle same as portland cement
2. No additional maintenance requirements

G. Itemized Costs

1. Product cost similar to portland cement, but dependent on freight to jobsite.
2. Installation costs are same as those of portland cement. Aucem is blended at the LADOTD approved facility of Lone Star Industries in New Orleans, LA and requires no additional blending by the contractor.

APPENDIX E

LOUISIANA TRANSPORTATION RESEARCH CENTER LTRC

4101 GOURRIER • BATON ROUGE, LOUISIANA 70808 • (225) 767-9131
FAX NUMBER (225) 767-9108 • E-MAIL: LTRC@LTRC.LSU.EDU

Mr. Ken Wetzel
Lone Star Industries, Inc.
14900 Intracoastal Drive
New Orleans, LA 70129

Date: January 31, 2000

From: Mark Morvant, P.E.
SSPE Committee Chairman

Subject: Louisiana DOTD New Products Evaluation
Offer Number 17.018
Aucem Slag Cement

Dear Ken,

The SSPE Committee has reviewed the Lone Star Phase II submittal. Although the results of the strength testing submitted in the report indicate that the Aucem product provides a lower compressive strength gain in seven days than did the pure cement samples, there is enough justification for further evaluation. I am pleased to inform you that the committee has recommended the Aucem product be advanced into Phase III testing. This phase will require the product to be tested on a minimum of two separate DOTD projects.

It is the responsibility of Lone Star Industries to arrange for such testing on a DOTD project with a local contractor at no additional cost to the Department. The test sections should be approximately 2000 feet long and must be constructed on cement stabilized base projects. A pavement section that requires a cement treated base course will not be allowed. District 07 has been selected by the committee as the location of the first test site. Please contact Mr. Lester LeBlanc, District 07 Construction Engineer, for possible projects awaiting construction. Should a project in District 07 cause undue hardship for Lone Star, please submit justification for an alternate district in writing to the committee. A second test site will be selected only after successful construction of the first section. The second test site must be located in a different district with different base material properties. Specific requirements of the second test site will be provided to you after completion of the first section.

The committee still has not received an adequate answer to the application and/or approval of Aucem by other state transportation agencies. This information must be provided before continuing with Phase III of this program. I have attached the results of the LTRC verification testing of the strength samples for your information.

We look forward to working with you in completing the evaluation of your product to the mutual benefit of DOTD and Lone Star Industries. Please contact me at (504) 767-9124 if the you have any questions.

MJM:mjm

cc. SSPE committee
Mr. Harold Paul
Mr. Gary Doyle
Mr. Lester Leblanc

APPENDIX F

STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
P.O. Box 1430
Lake Charles, Louisiana 70602-1430
(337) 437-9100

June 8, 2000

M. J. "MIKE" FOSTER, JR.
GOVERNOR

KAM K. MOVASSAGHI
SECRETARY

MEMORANDUM TO:

MARK MORVANT
DOTD STAFF ENGR MGR

Attached are summaries of results the District 07 Lab has obtained during testing with materials submitted by Mr. Ken Wetzel of Lone Star Industries, Inc. Design results were obtained using conventional methods utilizing LADOTD TR 432, Method B. An attempt was made to develop some understanding of the reaction between the supplied cements and local materials that would be normally used in soil cement construction.

Three cementious materials supplied by Lone Star and used in the testing included; (1) a Turkish cement, (2) AUCEM (slag), and (3) a 50/50 blend of Turkish cement and AUCEM. Two local materials were used in the testing regimen; (1) a natural occurring sandy loam from Beauregard Parish near DeRidder and (2) a sand shell material (sandy loam) destined to be recycled in situ during an upcoming rehab project on I-10 Service roads at Jennings in Jeff Davis Parish.

Another factor addressed is the tendency for some materials to gain strength with increased curing time. The strengths achieved at different curing times can be observed on the attached summary sheets. The primary interest was in the 7 day strengths as required in the standard design procedure; however, there were some significant strength gains for longer curing times. The number of specimens involved was minimal; therefore, that fact should be considered when evaluating the information.

The enclosed data was developed by laboratory personnel who routinely perform these functions; therefore, the information should be compatible with that normally developed as a result of soil cement design.

The results offered in this report immediately halts our intention of establishing three (3) test sections on the I-10 Service road (450-03-0061) for stabilization with these three(3) products. I do not feel that our present design/construction techniques lend themselves to constructing base courses with AUCEM. Based on the results I feel comfortable with the Turkish and 50/50 Blend

D. Provide results of cement content vs unconfined compressive strength for each sample type (DOTD TR 432):
   1. Cement treated soil at 4, 6, 8, and 10% cement by volume
   2. Aucem/Cement treated soil at 4, 6, 8, and 10% by volume

E. Provide results of durability tests for each sample type (AASHTO T 135):
   1. Cement treated soil
   2. Aucem/Cement treated soil

F. Provide results of shrinkage (ASTM D 427) and swell tests (ASTM D 1883) for each sample type:
   1. Untreated soil
   2. Cement treated soil
   3. Aucem/Cement treated soil

If you have any questions concerning this information, please feel free to contact us at (225) 752-4790.

Sincerely,
Soil Testing Engineers, Inc.

Daniel L. Franklin, Jr., P.E.
Manager, Baton Rouge Office

George L. Perkins, C.E.T.
Technical Services Manager

DLF/GLP/sla

DOTD TR 432 METHODS B & C

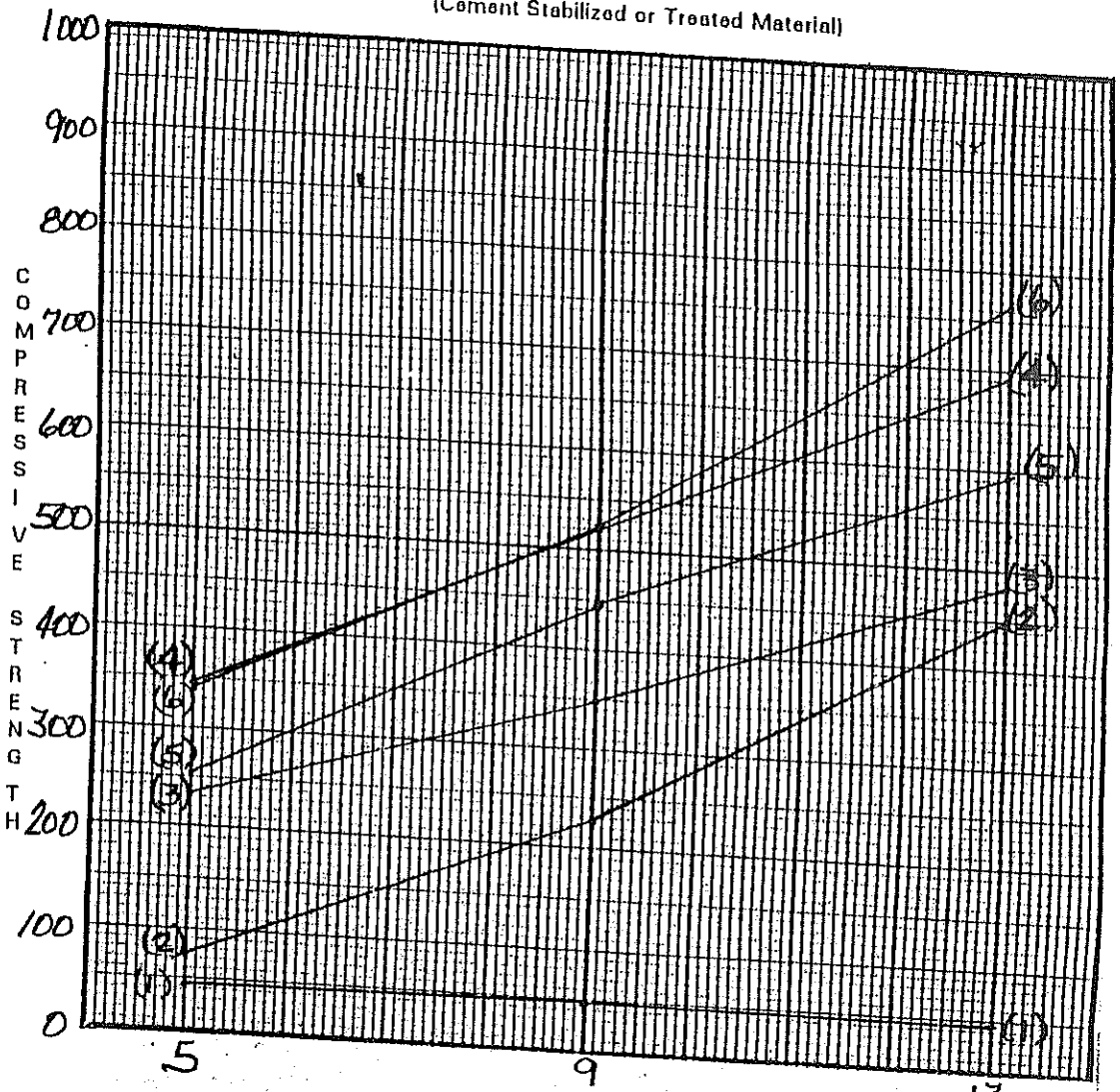
DOTD 03-22-0757
1/96

OJECT NO.: GENERAL (I-10)
PE SOIL: MATERIAL II
EAK DATE: VARIES
COMPOSITE NO(S).: SANDY LOAM, A-4
DATE MOLDED: VARIES
MIN. CEM. FACTOR: ____% By Wt. ____% By Vol.
SAMPLE NO.: ____
TESTED BY: ____
OPT. MOIST.,% ____
LAB NO.: ____
CHECKED BY: ____
MAX.DWD ____

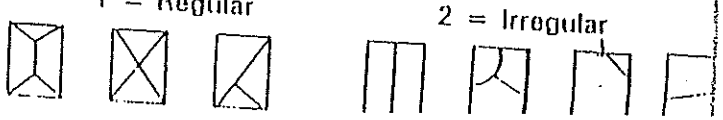
COMPRESSION TEST DATA

ylinder umber	% Cem't by Wt.	Break Code	Dial Reading	Failure Load (Z) (kN or Lb)	Compressive Strength (P) (MPa or PSI)	Average Compressive Strength (Q) (MPa or PSI)
	6					(1) AUCEM 7 DAYS (2) AUCEM 35 DAYS
	9					(3) 50/50 BLEND 7 DAYS (4) 50/50 BLEND 32 DAYS
	12					(5) CEMENT 7 DAYS (6) CEMENT 34 DAYS
	16					

(Cement Stabilized or Treated Material)



TYPE OF BREAK
1 = Regular
2 = Irregular
DESCRIPTION



MARKS: ____

STE
Soil Testing Engineers, Inc.
316 HIGHLANDIA DRIVE (70810) • P.O. BOX 83710 (70884) • BATON ROUGE, LOUISIANA
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CHING N. TSAI, MS
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ZIAD H. ALEM, MS
STEVE M. MEUNIER
REGISTERED PROFESSIONAL ENGINEERS

VERNON C. ASHWORTH, MS
MICHAEL J. ALLEN
BOBBY J. BAILEY
CERTIFIED PROFESSIONAL GEOLOGISTS

BILLY SINGLETON, BS Geology

November 5, 1998

Lonestar Industries, Inc.
14900 Intracoastal Drive
New Orleans, LA 70129

Attn: Mr. Ken Wetzel

Re: Slag Cement Soil Stabilization
STE File: 98-5097

Gentlemen:

We have completed Phase I of our Stabilization Study using different ratios of slag with cement. From this study and the strength data on Table 1, the optimum mix is the 50% slag with 50% cement. This mix was added to the soil at 10% by dry weight. The material (soil) used for this study came from Tangipahoa Parish, Trinity Materials Borrow Pit off of Louisiana Highway 16, coordinates N 30°37.185 and W 90°54.730 at approximately 1 to 5 feet in depth. Its classifications, based on AASHTO M 145, is a tan silty clay A-6 material. The recommended percent cement for this material in Tangipahoa Parish is 10% by weight as determined by DOTD TR432.

Enclosed along with Table 1 are the daily field report (sample pickup), location map, and Proctor curves. Additionally, I have enclosed a Qualified Product Evaluation Form which would be your next step for submittal to LADOTD.

If you need any additional assistance or have questions about this information, don't hesitate to call. It has been a pleasure serving Lonestar on this project. We look forward to serving you in the future.

Sincerely,
Soil Testing Engineers, Inc.

George L. Perkins, C.E.T.
Technical Services Manager

GLP/sla

cements. If you would be interested in trying these latter materials in two (2) adjacent test sections let me know promptly since we are now in the design stage of this project. Based on the delayed strength results for AUCEM it might be advisable to select a base project where there will be total traffic control to allow strength gain to adequately evaluate this product. Additionally, it is well known from testing and performance results that compatibility is necessary between the "soil" chemistry and the stabilizer for sufficient support value to be obtained in an actual situation. This characteristic was obvious in the differing results between the natural raw soil and the sand shell (when mixed with AUCEM); the sand shell achieved significantly higher strength. Note that we have no performance data to assist in the evaluation of these products.

If you have any questions concerning the development of this information feel free to contact me or Vance Droddy as necessary.

M. M. CRYER, JR.
ACTING DISTRICT LAB ENGINEER

Attachments
cc: Doug Hood
Lester LeBlanc
Pat Landry
Ken Wetzel

MEASURED @ DEKLOGER

CEMENT MIX DESIGN WORKSHEET
DOTD TR 432 METHODS B & C

DOTD 03-22-0757
1/96

OJECT NO.: GENERAL

PE SOIL: MATERIAL I

EAK DATE: VARIES

(JAMES)
COMPOSITE NO(S).: SANDY LOAM, A-2-4

DATE MOLDED: VARIES

MIN. CEM. FACTOR: ____% By Wt. ____% By Vol.

SAMPLE NO.: ____

TESTED BY: ____

OPT. MOIST., % ____

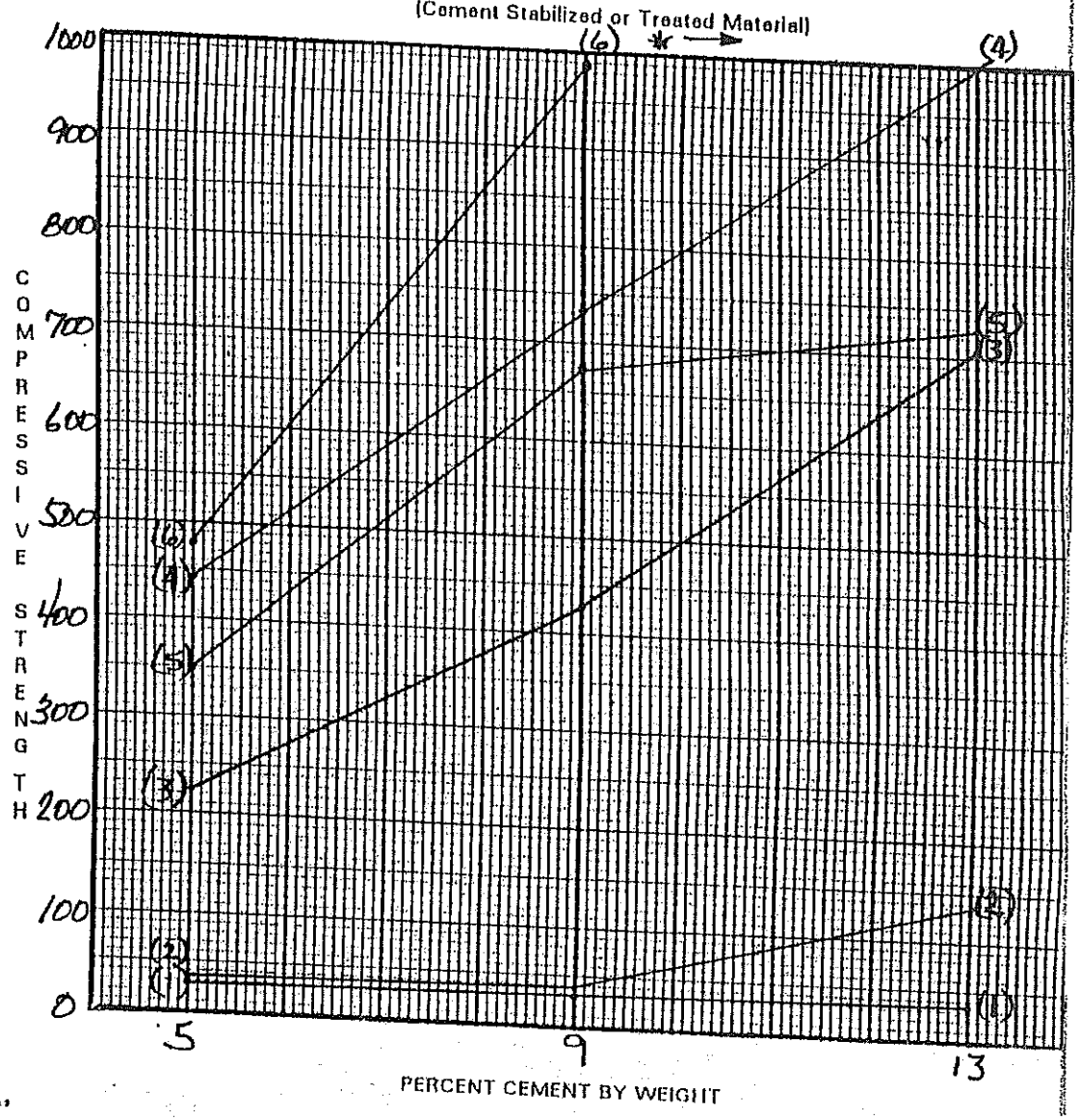
LAB NO.: ____

CHECKED BY: ____

MAX. DWD ____

COMPRESSION TEST DATA

Cylinder Number	% Cem't by Wt.	Break Code	Dial Reading	Failure Load (Z) (kN or Lb)	Compressive Strength (P) (MPa or PSI)	Average Compressive Strength (Q) (MPa or PSI)
	6					(1) AUCEM 7 DAYS (2) AUCEM 28 DAYS
	9					(3) 50/50 BLEND 7 DAYS (4) 50/50 BLEND 28 DAYS
	12					(5) CEMENT 7 DAYS
	16					(6) CEMENT 28 DAYS



MARKS: * 13% - 28 DAY BREAK, MAX. DIAL READING @ 1190+ P.S.I.

TYPE OF BREAK 1 = Regular 2 = Irregular

DESCRIPTION

DATA FOR "AULEM" FROM LONESTAR (KEN WETZEL)

MATERIAL I - (STOCKPILE @ JAMES CORP., DERIDDER, LA.)

JAMES SANDY LOAM, A-2-4, N.P., #40=11, #200=66, SILT=13, CLAY=10

DESIGN DATA:

RAW CURVE 122.0# @ 11.0% MOISTURE

9% ADDITIVE BY VOLUMN

TURKISH CEMENT	124.7# @ 10.3% MOIST.
50/50 BLEND	123.7# @ 10.6% MOIST.
"AULEM"	124.0# @ 10.3% MOIST.

MATERIAL II - (IN-PLACE BASE MATERIAL, SERVICE ROAD I-10)

I-10 SANDY LOAM, A-4, (N.P.), #40=11, #200=44, SILT=30, CLAY=15.

DESIGN DATA: (REMOVED ALL +#4 SIEVE MATERIAL, SHELL)

RAW CURVE 123.0# @ 10.3% MOISTURE

9% ADDITIVE BY VOLUMN

TURKISH CEMENT	118.7# @ 11.7% MOIST.
50/50 BLEND	117.2# @ 11.8% MOIST.
"AULEM"	121.0# @ 11.3% MOIST.

INDEX:

1 of 6	MATERIAL I W/AULEM
2 of 6	MATERIAL I W/50-50 BLEND
3 of 6	MATERIAL I W/ CEMENT
4 of 6	MATERIAL II W/ AULEM
5 of 6	MATERIAL II W/ 50-50 BLEND
6 of 6	MATERIAL II W/ CEMENT

JAMES SANDY LOAM, A-2-4 (N.P.), #40=11, #200=66, SILT=13, CLAY=10.

ALCEM, DESIGN @ 10.3% MOIST. W/9% ADDITIVE BY VOL. (D.W.D.=124.0)

% ADDITIVE BY VOL.	CURE DAYS	% MOIST. @ COMPACTION	% COMPACTION	P.S.I. OBTAINED
5	7	10.4	99.0	29
5	7	10.6	98.9	26
5	7	10.7	99.3	33
5	28	10.3	99.4	33
5	28	10.5	99.0	29
9	7	10.4	99.3	29
9	7	10.4	99.5	29
9	7	10.9	99.3	33
9	28	10.6	99.3	36
9	28	10.3	99.5	39
13	7	10.6	99.6	33
13	7	10.7	99.7	33
13	7	10.8	99.4	33
13	28	10.8	99.5	157
13	28	10.7	99.4	114

JAMES SANDY LOAM

50/50 BLEND, DESIGN @ 10.6% MOIST. W/9% ADDITIVE BY VOL. (D.W.D. 125.

% ADDITIVE BY VOL.	CURE DAYS	% MOIST. @ COMPACTION	% COMPACTION	P.S.I. OBTAINED
5	7	10.3	98.4	196
5	7	10.7	98.2	232
5	7	10.8	98.6	242
5	28	10.6	98.5	425
5	28	10.7	98.6	461
9	7	10.4	99.7	435
9	7	10.7	98.8	402
9	7	10.9	98.5	451
9	28	10.2	98.1	742
9	28	10.6	99.1	726
13	7	10.2	99.8	625
13	7	10.5	98.9	710
13	7	10.3	99.1	795
13	28	10.5	98.7	1027
13	28	10.2	98.1	1020

JAMES SANDY LOAM

CEMENT. DESIGN @ 10.3% MOIST. W/9% ADDITIVE BY VOL. (D.W.S. 124.7

% ADDITIVE BY VOL.	DAYS CURE	% MOIST. @ COMPACTION	% COMPACTION	P.S.I. OBTAINE
5	7	10.4	98.3	353
5	7	10.1	97.6	340
5	7	10.2	98.5	356
5	28	9.9	97.7	494
5	28	10.6	97.5	464
9	7	9.9	99.5	801
9	7	10.7	98.9	611
9	7	10.4	99.1	615
9	28	9.9	99.6	1086
9	28	10.3	99.0	886
13	7	11.0	99.1	703
13	7	10.1	100.4	801
13	7	10.5	99.8	687
13	28	10.3	100.5	1190+
13	28	10.1	100.2	1190+

I-10 SANDY LOAM, A-4 (N.P.) #40 = 11, #200 = 44, SILT = 30, CLAY = 15.
(RAW SAND-SHELL BASE, MATERIAL PREPARED USING - #4 SIEVE MATERIAL

ALLEM. DESIGN @ 11.3% MOIST. W/ 9% ADDITIVE BY VOL. (O.W.D. 121.0)

% ADDITIVE BY VOL.	CURE DAYS	% MOIST. @ COMPACTION	% COMPACTION	P.S.I. OBTAINED
5	7	11.6	99.4	46
5	7	11.1	100.2	49
5	7	11.5	100.2	46
5	35	11.6	99.3	75
9	7	11.6	96.5	33
9	7	11.3	99.5	46
9	7	11.2	100.2	52
9	35	11.5	98.1	226
13	7	11.6	98.5	42
13	7	11.2	98.5	42
13	7	11.3	98.5	39
13	35	11.4	98.8	475

I-10 SANDY LOAM

50/50 BLEND, DESIGN @ 11.8 % MOIST. W/ 9 % ADDITIVE BY VOL. (O.W.D. 117.

% ADDITIVE BY VOL.	CURE DAYS	% MOIST. @ COMPLETION	% COMPACTION	P.S.I. OBTAINED
5	7	11.7	100.3	232
5	7	11.9	99.9	232
5	7	11.7	100.8	235
5	32	11.4	100.7	347
9	7	11.6	101.1	392
9	7	11.5	100.8	311
9	7	11.1	100.4	343
9	32	11.6	99.5	520
13	7	11.7	100.3	520
13	7	12.0	100.0	455
13	7	11.8	100.5	468
13	32	11.8	100.9	690

I-10 SANDY LOAM

CEMENT, DESIGN @ 11.7% MOIST. W/9% ADDITIVE BY VOL. (D.W.D. 118.7)

% ADDITIVE BY VOL.	CURE DAYS	% MOIST. @ COMPACTION	% COMPACTION	P.S.I. OBTAINED
5	7	11.2	98.0	281
5	7	11.7	97.6	268
5	7	11.5	98.7	203
5	34	11.5	97.1	340
9	7	11.4	98.7	432
9	7	11.3	98.2	435
9	7	11.3	98.2	451
9	34	11.1	98.1	572
13	7	11.5	98.8	579
13	7	12.0	98.7	598
13	7	11.9	98.3	602
13	34	11.7	98.6	762

APPENDIX G

LOUISIANA TRANSPORTATION RESEARCH CENTER

LTRC

4101 GOURRIER • BATON ROUGE, LOUISIANA 70808 • (225) 767-9131
FAX NUMBER (225) 767-9108 • E-MAIL: LTRC@LTRC.LSU.EDU

State Project No. 277-03-0013
Tangapahoa Parish line – Junction LA 440
Route LA 10
Washington Parish

MEMORANDUM:

To: Mr. Jimmy Little
Chief Construction Division
Attention: Mr. Rick Holm

From: Mr. Mark Morvant
Pavement & Geotechnical Research Administrator

Date: August 28, 2001

Subject: New product evaluation of Aucem stabilization

Aucem is a 50/50 blend of cement and slag produced by Lone Star Industries. The Soil Stabilization Sub-committee to the New Product Evaluation committee is evaluating the product as an alternated to cement. A laboratory program has been completed and one cement stabilized test section has been constructed in District 03. The test section has been in place for one year and has not experienced any problems associated with this product.

To complete the evaluation, the committee has recommended construction of a cement treated test section located in a different district with different base material. The captioned project has been suggested by Lone Star Industries as a possible site. The district has been contacted and has no objections to the test section.

We are requesting a plan change be initiated to construct a 1000 – 1500 feet Aucem base course test section on this project. The Aucem will replace the cement treatment on a one to one basis. Construction specifications will not change. LTRC will be obtaining samples after pulverization for a laboratory evaluation. A field evaluation will include dynaflect and FWD testing. The contractor will need to provide access to the subgrade prior to mixing.

Please advise if any additional information is needed.

cc: Mr. Skip Paul
Mr. Joel McWilliams
Mr. Mike Ricca
Mr. Steve Perilloux
Mr. Doug Hood

APPENDIX H

LABORATORY DATA

TABLE 1 - Rev. 1

COMPRESSIVE STRENGTHS

Material Type	Days Cured	Compressive Strengths (psi)			
		5% PC	10% PC	5% Blend	10% Blend
A-6	7	76.1	145.8	37.2	109.8
A-6	14	76.0	169.5	46.9	112.6
A-6	21	76.0	167.0	49.7	103.0
A-6	28	88.7	221.9	175.6	128.3
Base Course Material	7	143.9	267.6	146.8	255.7
Base Course Material	14	164.1	305.9	193.9	293.1
Base Course Material	21	203.5	348.1	187.1	390.9
Base Course Material	28	163.2	375.3	223.6	375.6

Percent shown is by volume

PC = Portland Cement
Blend = 50% Slag/50% Portland Cement