BURNS COOLEY DENNIS, INC.

GEOTECHNICAL AND MATERIALS ENGINEERING CONSULTANTS

VARIABLITY OF CEMENT-TREATED LAYERS IN MDOT ROAD PROJECTS

State Study 227

Project No. 105803 150000

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Abstract

The Mississippi Department of Transportation (MDOT) revised the specifications for cement-treated bases between the 1990 and 2004 editions of "Mississippi Standard Specifications for Road and Bridge Construction." The required compressive strength of laboratory specimens was reduced in an effort to reduce shrinkage cracking in the cement-treated base. The compaction effort of the in-place cement-treated base was increased to produce a stronger layer. These specification modifications were significant changes to the required minimum compressive strength and field compaction. These changes impact in-place properties and performance of the cement-treated base. Prior to this research, the author is not aware of any field studies that have been conducted to determine how these changes affected in-place properties. This research documents field and laboratory testing of two MDOT road projects. Findings were compared to project specifications and cement–treated base property variability was calculated and graphically illustrated.

Two previously constructed MDOT projects along highways 84 (Jefferson Davis County) and 25 (Winston County) were selected for sampling and testing. The cement-treated base on these projects was designed and constructed according to the 2004 edition of MDOT's specifications. Approximately one mile of the outside lane was selected from each of these projects for field investigation and testing. Twenty cores were drilled from the cement-treated base located just below the asphalt drainage layer. These cores were tested for unit weight, moisture content, compressive strength, and cement content.

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Introduction

Cement-treated bases are often used beneath flexible or rigid pavements to enhance performance of the pavement and to provide additional load carrying capacity. Cement-treated bases use portland cement and water to chemically bond aggregate particles together and compaction is used to remove voids to create a strong base. This combination of materials is commonly referred to as soil-cement. Soil-cement is defined by the Mississippi Department of Transportation (MDOT) in the Materials Division Inspection, Testing and Certification Manual (Test Method T-25) as "a mixture of pulverized soil and portland cement which has been moistened, compacted and permitted to harden." Soils for cement-treated bases constructed in Mississippi are typically imported or natural granular materials (less than 50 percent passing the No. 200 sieve) with a plasticity index of less than 15. Subgrade soils with a plasticity index of less than 15 can also be treated with cement to improve the strength of the natural or imported subgrade soils.

Revisions to MDOT's Cement-Treated Base (CTB) Specifications

Cracking of cement-treated bases can impact performance and long-term durability of MDOT roads. These cracks are natural characteristics of cement-treated materials (1). Cracking in cement-treated bases and reflective cracking in the surface paving led MDOT engineers to revise their specifications for cement-treated bases. Typical shrinkage cracking of a cement-treated layer is shown in Figure 1. MDOT revised the cement-treated base specifications between the 1990 and 2004 editions of "Mississippi Standard Specifications for Road and Bridge Construction."

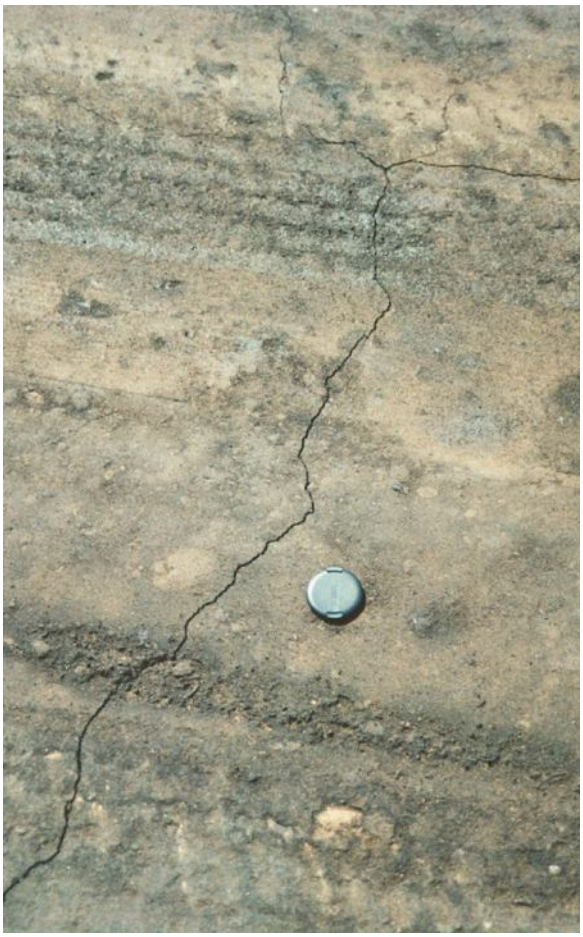


Figure 1 - Shrinkage Cracking of Cement-Treated Base

Significant changes were made to the compressive strength and compaction effort requirements. These revisions were implemented in an effort to reduce shrinkage cracking in cement-treated bases and surface paving. The degree of drying shrinkage is influenced by type of soil, degree of compaction, curing, cement content, and temperature and moisture changes (1). MDOT's revisions to the cement-treated base specifications focused on reducing cement content (compressive strength) and increasing compaction effort. Key changes to these specifications are summarized in Table 1.

Table 1 - MDOT Specifications for Cement-Treated Bases

Property	1990 Edition	2004 Edition	Special Provision 907-308.03.9.2
Field Compaction	Lot - 92% of maximum dry density Individual Test – 88% of maximum dry density	Lot - 98% of maximum dry density Individual Test – 94% of maximum dry density	Lot – 97% of maximum dry density Individual Test – 95% of maximum dry density
Design Compressive Strength	400 psi at 14 days	300 psi at 14 days	300 psi at 14 days

Influences on Shrinkage and Cracking of CTB

Shrinkage and subsequent shrinkage cracking tends to increase as cement content is increased to produce higher compressive strengths. This trend influenced MDOT engineers to reduce the 14 day compressive strength from 400 psi to 300 psi. Reducing the compressive strength requirement will ultimately result in lower cement contents in the cement-treated base. Reducing the cement content will reduce the amount of cement and water available to contribute to chemical shrinkage of this layer.

Chemical shrinkage is a reduction in absolute volume of solids and liquids in cement paste caused by portland cement reacting with water. This reaction between portland cement and water is called hydration. Portland cement and water occupy more volume in their individual state than when they are chemically combined (2). Consequently, as the cement-treated layer gains strength during hydration its volume shrinks.

When shrinkage of cement-treated layers is restrained, shrinkage cracks occur. Cement-treated layers are restrained by supporting soils. A combination of shrinkage of cement-treated layers and restraint is the mechanism that produces shrinkage cracking. This restraint of

shrinkage causes cracks to form as shrinkage stresses exceed the strength of the cement-treated layer. These cracks provide channels for water to get in and weaken the underlying supporting soils. More severe shrinkage cracks can reflect into and cause cracking of the surface paving.

Compaction also influences shrinkage and subsequent cracking of cement-treated bases. Well-compacted cement-treated mixtures will shrink less because the aggregate particles are packed tightly together creating less voids and less shrinkage (1). For this reason, MDOT engineers increased the compaction requirement from 92 to 97 percent of maximum dry density. In addition, higher strengths are associated with higher compaction effort. While the revisions should produce better cement-treated bases in Mississippi road projects, no data have been presented to evaluate these changes prior to this research.

Construction Methods

Cement-treated bases are constructed by either road mixing or plant mixing. The typical method for constructing cement-treated layers in Mississippi is road mixing. Road mixing of the soil and cement consists of spreading the cement at a specified rate across the full width of the area to be treated. Spreading may be accomplished with pneumatic sprayers attached to a tanker truck. The cement is then mixed into the soils either by discing, tilling, or blending to the specified depth, followed by wetting (if necessary) and compacting to specified density requirements. Central plant mixing typically consists of mixing the soil in a plant with measured amounts of cement and water to produce a material that can be placed and compacted to the specified density requirements.

General Requirements

There are some similarities between various DOTs regarding the placement of cement-treated layers. Generally, cement-treated bases are required to be compacted and graded within

two hours from the addition of water to the mixture. Most DOTs also require cement-treated bases to be primed or sealed following finishing procedures. The curing times and methods vary between most states from three to seven days and either by wet curing or by sealing with prime coats during this curing period.

Another similarity in construction is the environmental requirements on the cement-treated bases. Generally, most DOTs place a restriction on the mixing of cement when the temperature is below 40 degrees Fahrenheit or the forecast temperatures project the temperatures to fall below 40 degrees prior to the placement of the subsequent pavement layer.

MDOT special provision 907-308.03.7.2 requires that the temperature be 45 degrees Fahrenheit or above when mixing cement-treated bases. This special provision also prohibits mixing cement-treated bases if the temperature is projected to fall below 45 degrees Fahrenheit within 5 days of mixing. There are also stipulations in MDOT's 2004 edition of "Mississippi Standard Specifications for Road and Bridge Construction" prohibiting mixing cement-treated bases from November 15 to March 15 in Districts 1, 2, 3 and 5 or from December 1 to March 1 in Districts 6 and 7. MDOT also requires that soils are to be completely mixed within three hours from the addition of cement to the mixture and that vibratory compaction be completed within one hour from the addition of water to the mixture. On all MDOT projects, the cement-treated bases are required to be primed within 24 hours of finishing the construction of the layer.

Quality Control Testing

The requirements for the design methodology, placement, compaction and quality control/assurance of cement-treated bases vary widely throughout the southeastern United States. The wide range of different methods of laboratory testing, acceptance testing and construction of these layers has likely evolved from the separate transportation department's (DOT) using

practices that have been around for many years. These methods were established based on the availability of materials and the knowledge of local materials.

As a rule, road mixed cement-treated bases lack a true requirement for the determination of cement content of the in-place mixtures. For road mixed cement-treated bases, the cement content is typically "verified" by checking the spread rate by placing a board or pan of a known area in the path of the tanker truck's spray and measuring the amount of cement placed. Another typical method is to divide the amount of cement placed by the area treated for that day. These methods only verify the spread rate of the cement, not the actual cement percentage by mass of the soil-cement mixture. The only state that verifies the actual cement content other than by batch weights is the State of Virginia. Virginia tests only the central plant mixtures for cement content using titration methods as specified in Virginia Test Method - 40.

Similarly, the determination of the in-situ compressive strength of the cement-treated bases lack true requirements in most DOTs. Currently, Georgia requires the determination of the in-situ compressive strength of the cement-treated base. This is determined by testing the compressive strength of 6 in. diameter cores drilled from the cement-treated base after it has been in place a minimum of 7 days (GDOT SOP 29). Failing areas are specified as sections that fail to reach 300 psi.

Currently, the DOTs in the southeastern United States all require moisture density tests to be performed at various specified frequencies. These moisture density tests are generally required to be performed within two hours of the completion of compacting of the cement-treated layer. The thickness of the cement-treated layer is also typically required to be checked at frequencies similar to that of the moisture density tests.

MDOT special provision 907-308.03.9.2 requires five moisture density tests to be performed for each 2,500 linear feet of roadway constructed. The compaction requirement for cement-treated base is that the lot must have an average compaction that equals or exceeds 97 percent of standard maximum dry density with no individual reading below 95 percent. MDOT's Standards for Road and Bridge Construction, 2004 Edition requires the thickness of the cement-treated base to be plus or minus 1 in. from the design thickness but no testing frequencies or methods are specified within the Standard or the Materials Division Inspection, Testing and Certification Manual.

The verification of actual cement contents by mass of soil, along with moisture content, density and in-situ compressive strength are all highly important to determine the reliability of the cement-treated layer. The combination of the cement content, moisture content and density of the mixture provide the structure to produce the designed compressive strength and are all equally important to producing a reliable pavement structure.

As a result of the recent revisions to MDOT's cement-treated base specifications and the unknown field performance data of these layers, MDOT commissioned this research to document field performance of cement-treated base layers in two MDOT road projects. Field data documented in this study includes; unit weight, moisture content, compressive strength and cement content. Test results are compared to project specifications to determine if requirements were met. Variability of in-place properties of each core is calculated and graphically illustrated.

Chapter 2 – Project Descriptions

Introduction

Two MDOT road projects were selected by MDOT engineers to be used in this research. These two projects were Highway 84 in Jefferson Davis County and Highway 25 in Winston County. Each site was paved with asphalt cement concrete underlain with an asphalt emulsion treated drainage layer supported by a cement-treated base. This cement-treated base is the focus of this research.

Core Locations

Each project included a test section of approximately one mile in length. Five rows were selected for coring and they were spaced at 1000 ft. intervals. Figure 2 provides a typical layout of core locations. A total of four cores were drilled from each row providing twenty cores to be tested from each MDOT road project. Cores were marked according to the row number and location from the pavement edge. Core row numbers ranged from 1 to 5 with location from pavement edge ranging from A to D. For example; Core 1A is located at row number 1 and is the closest core to the pavement edge.

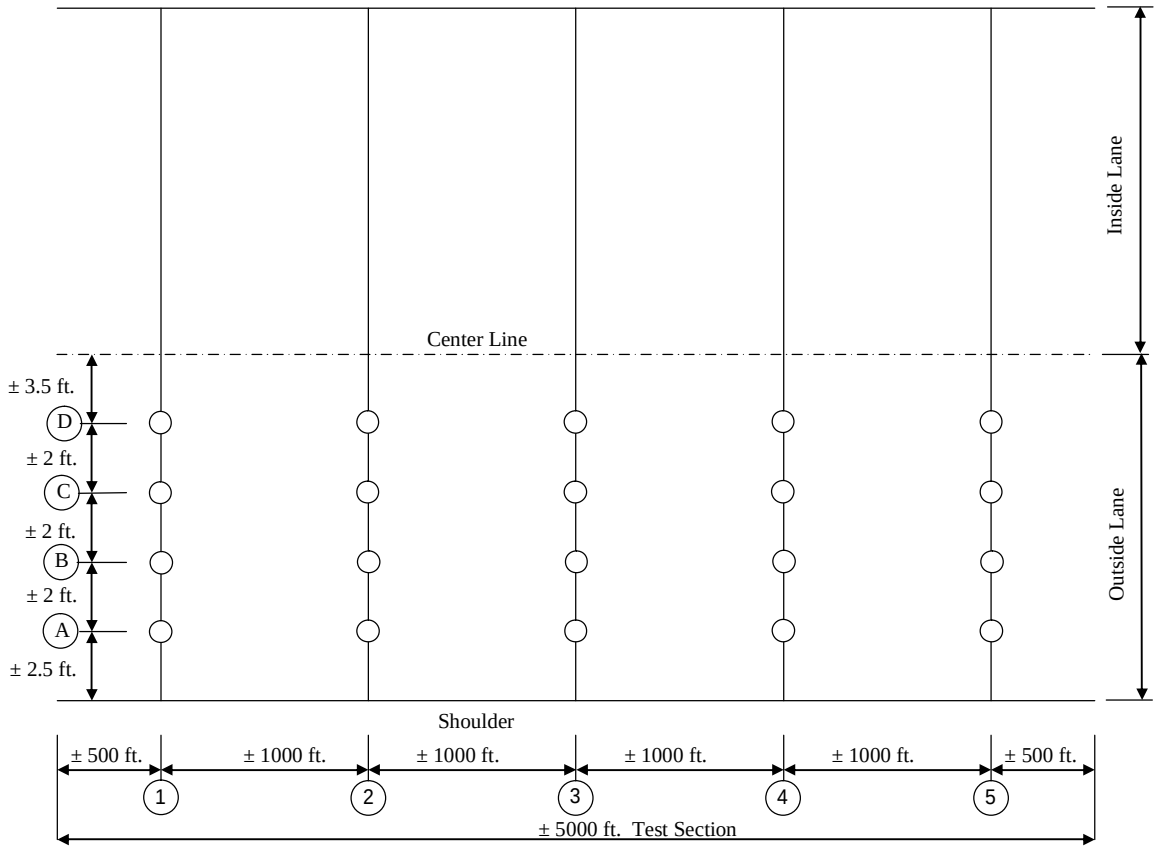


Figure 2 - Typical Layout of Core Locations

Highway 84

The test section for Highway 84 is located in Jefferson Davis County. This project is (MDOT's Project Number 102921301000, NH-0015-02(115) PH3). This roadway was constructed in 2006. An approximate one mile section of the outside east bound lane was identified for testing. This section is located approximately 3.5 miles west of the Covington and Jefferson County line. See Figure 3 for a Google Earth map of the location of this test section. Coring was performed on June 30, and August 8, 2010.

Highway 25

The test section for Highway 25 is located in Winston County (MDOT's Project Number 102674-301000, SDP-0056-01(076) P). An approximate one mile section of the outside south bound lane was selected by MDOT engineers for testing. This section is located approximately 1.4 miles south of the Winston and Oktibbeha County line. See Figure 4 for a Google Earth map of the location of this test section. Coring was performed on August 19, 2010.

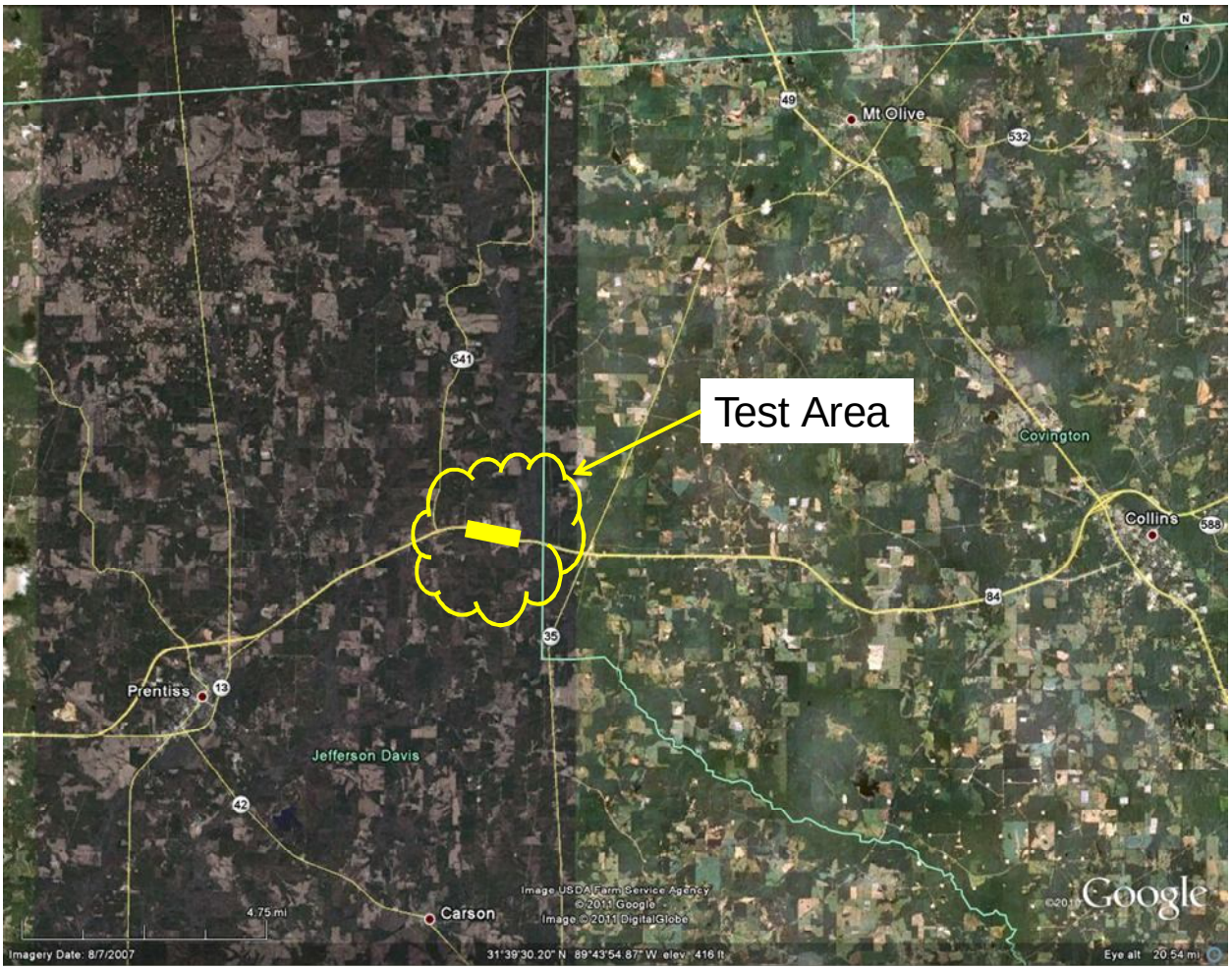


Figure 3 - Highway 84 (Google Earth)

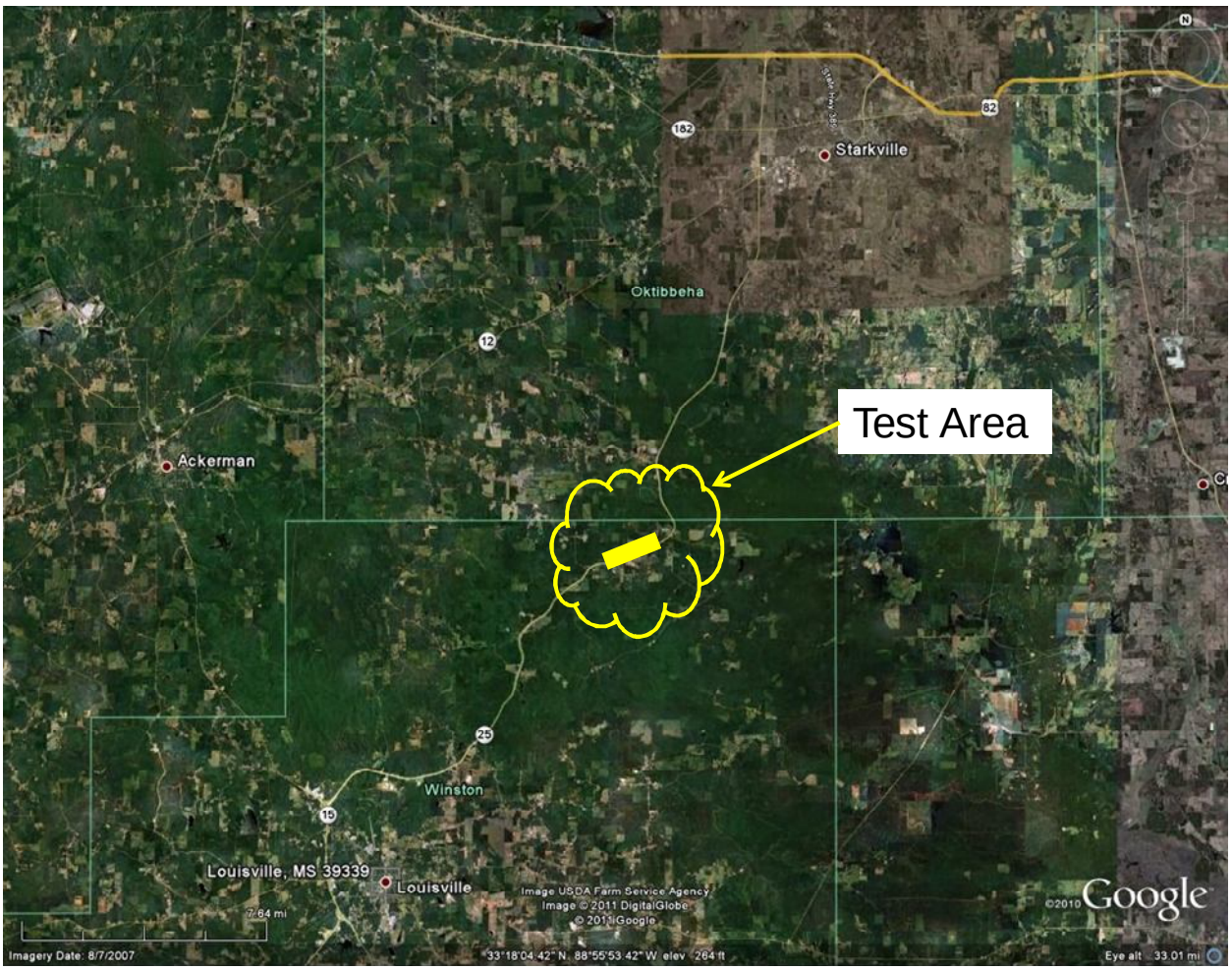


Figure 4 - Highway 25 (Google Earth)

Cement-Treated Base Project Mixture Design

The mixtures designs for the cement-treated bases were provided by MDOT engineers. See Appendix A for mixture design information provided by MDOT. A summary of mixture designs is presented in Table 2. MDOT mixture designs include the cement content for cement-treated bases. MDOT specifies the cement content for cement-treated bases by providing the percentage of cement by volume of soil. Laboratory testing to determine cement content of the in place cores performed in accordance with ASTM D806 "Standard Test Method for Cement Content of Hardened Soil-Cement Mixtures" provides results in percentage of cement by mass of

soil. Therefore, MDOT specifications for cement content were converted from percentage by volume to percentage by mass using Equation Number 1.

$$\%\ cement\ by\ volume = \left[\frac{\%\ cement by\ mass * \max imum\ dry\ s\tan dard\ density\ of\ raw soil}{94} \right] \quad \text{Eq. (1)}$$

Table 2 - Summary of Cement-Treated Base Project Mixture Design

Project	Cement Content (% by Volume)	Cement Content (% by Mass)	Thickness (in.)
Highway 84	5.0	3.8	6
Highway 25	4.0	3.1	6

Chapter 3 – Field and Laboratory Testing

Selection of Core Sampling Methods and Procedures

Obtaining field cores of low strength cement-treated bases presents challenges. A combination of low strength material and the depth of the core below the surface of the paving make it difficult to retrieve cores suitable for testing. Representatives of BCD decided to conduct a trail run for the coring operation. The purpose of this trail run was to determine the best methods of coring and to generate laboratory data for MDOT engineers to review before proceeding with additional coring. Preliminary trial coring was performed on row 1 of Highway 84 on June 30, 2010.

Both 4 in. and 6 in. diameter core bits mounted to a truck-rig were used during this trial. Trial coring was performed with and without the aid of water. Water is used in coring operations to cool the core bits and to wash out fine material. This aids in both drilling of the core and removing the core from the barrel when finished. The typical cores for this trial extended through 7 to 10 in. of asphalt pavement, 3 in. of asphalt drainage course, and 6 in. of cement-treated base.

A 4 in. diameter core barrel was used first to sample the cement-treated base. In addition, this first trial was tried without the use of water. Water was omitted because of the potential damage that the water may cause to this low strength layer. However, this proved to be unsuccessful because the core lodged tightly inside the core barrel and could not be removed without destroying the integrity of the core. This happened because water was not used to wash out fines produced from coring operations. Coring was also very difficult without the aid of water. The core barrel often became lodged in the core hole and the barrel would have to be

reversed multiple times to remove enough fines to allow the core rig to extend through the depth of the pavement structure. BCD determined that some water was necessary in order to avoid overheating the core barrel and to remove the fines generated from coring. On the second attempt, water was used and a 4 in. diameter sample was retrieved, but it was unsuitable for testing. The top of the core was rounded to a hemispherical shape because of the water and coring action.

The sample retrieval using a 6 in. diameter core barrel with no water was performed. This sample was also unsuitable for compressive strength testing because the core was lodged in the barrel and had to be dug out in pieces. The 6 in. core bit was used again with the least amount of water possible to remove the fines as the core sample was cut. The 6 in core bit with the aid of water provided an intact sample suitable for testing and this method was used to cut all cores that were tested and included in this research. Typical coring methods are shown in Figure 5.

Figure 5 – Typical Coring Methods

Coring of Highway 84 and 25

BCD's technicians finished coring operations for Highway 84 on August 8, 2010 and Highway 25 on August 19, 2010. Four test specimens were sampled from each row utilizing a 6 in. core barrel with the smallest amount of water possible. Vertical cracks were found in a few of the cement-treated specimens and core locations were moved approximately 12 to 24 in. and re-cored to obtain a specimen that could be tested. Specimens were towel dried and placed into two gallon Ziploc bags and prepared to be transported back to our laboratory. See Figure 6 for typical core prepared for transport.

Figure 6 – Typical Core Prepared for Transport

Once cement-treated cores were removed, concrete was mixed on site and placed in the core hole to the bottom of the asphalt drainage course and compacted with a 4 in. diameter tamper. Asphaltic cold patch was placed from the bottom of the drainage course to the roadway surface and compacted with the 4 in. tamper.

Collection of Untreated Granular Material Samples

In order to determine the cement content of a cement-treated core, samples of the granular material without cement had to be obtained. This material is referred to as virgin soil in raw data presented in Appendix C. These samples were collected from untreated material in the roadway shoulder. BCD used both a shovel and a hand auger to collect these samples. Virgin soil sampling is shown in Figure 7.

Figure 7 – Granular Material Sampling

Samples Received

Asphalt and cement-treated cores from Highways 84 and 25 were delivered to BCD's laboratory for processing and testing. Cement-treated samples arrived at the laboratory relatively undisturbed and sealed in two gallon Ziploc bags with sample row and location clearly marked on each bag. Cement-treated samples were removed from their storage bags and allowed to air dry in our climate controlled laboratory for 24 hours.

Measuring and Preparing Samples for Testing

Asphalt pavement core samples were measured for overall length and individual lift thicknesses. Typical asphalt cores had four layers along with an asphalt drainage course. See Appendix C for a core summary that includes asphalt measurements. No additional testing was

performed on the asphalt pavement or asphalt drainage course. However, there was a noticeable difference in the strength of the asphalt drainage course on Highways 84 and 25. The asphalt drainage course on Highway 84 was brittle and fell apart during coring operations. The asphalt drainage course on Highway 25 was strong and came out of the core hole intact and attached to the asphalt pavement.

Diameters of the cement-treated cores were measured in three locations near the mid-depth of the cores. These cores were also measured for length in five locations. The locations of length measurements included quarter points around the circumference and one measurement near the center. See Appendix C for data that includes details of core measuring. Core ends were sawed utilizing a masonry saw that was operated with no water to produce ends that were perpendicular to the axis of the core. This sawing prepared the cores for volume calculations to determine unit weight and also to receive sulfur mortar capping for compressive strength determination. Core end sawing is shown in Figure 8.

Figure 8 – Core End Sawing

Unit Weight Determination

The air dried unit weight was determined on each testable core by simply dividing the weight by the calculated volume. The volume was calculated by multiplying the area of the core by the length. The diameter used to calculate area was the average of three diameter measurements. The length of the cores was determined by averaging the five length measurements taken after the ends were sawed perpendicular to the axis of the core. See Chapter 4 for results from unit weight testing.

Compressive Strength Testing

After completion of unit weight calculations, cement-treated samples were capped with sulfur mortar in general accordance with AASHTO T231 / ASTM C617 “Standard Practice for Capping Cylindrical Concrete Specimens” to provide uniform loading for the plates of the

compression machine on the cores. The sulfur mortar capping material was allowed to set for a minimum of two hours before compression testing was performed. Compressive testing was conducted in general accordance with ASTM D1633 “Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders.” Compressive strength was then calculated by taking the maximum load applied to the core and dividing by the area of the core. The area of the core was calculated using the diameter of the core that was based on the average of three measurements taken near the mid-depth of the core. See Figure 9 for compressive strength testing.

Figure 9 - Compressive Strength Testing

Compressive Strength Correction Factors for L/D Ratio

When following the procedures given for soil-cement mixture design in MDOT MT-25, specimens are made in a small proctor mold when no plus ½ in. material is present. Varying cement contents are used in order to determine the optimum cement content to achieve the specified compressive strength. This small mold is approximately 4.58 in. tall with a 4.0 in. diameter, giving typical specimens an L/D ratio of approximately 1.15. Due to the typically thin thicknesses of cement-treated layers for highway construction and the difficulty of obtaining intact cores using 4 in. diameter core barrels, sawed cores will generally have L/D ratios less than 1.15. As noted in K.P. George's Soil Stabilization Field Trial (MDOT SS 133 Interim

Report) (3), there is a significant increase of approximately 30 percent in compressive strength when the L/D ratio of the specimen is 1.15:1 rather than 2:1. According to ASTM D1633, the increase is about 10 percent. Regardless the amount, it is clear that decreasing the L/D ratio has an influence on the measured compressive strength of cement-treated specimens.

During the field sampling portion of this study, intact core specimens were unable to be obtained when a nominal 4 in. diameter core barrel was utilized to sample the hardened cement-treated layers. When a nominal 6 in. diameter core barrel was utilized, intact specimens were generally obtained with relative ease. Additionally, due to the coring process, the specimens required sawing and capping to correct the end condition of the samples for proper compressive strength testing. When all of these procedures were completed, the specimens for compressive strength testing had L/D ratios less than 1.15 to 1 as made during the design phase of the projects.

As with concrete specimens, a correction factor for specimens with reduced L/D ratios should be used to give an accurate value for the compressive strength of the hardened cement-treated layer. The development of this correction factor was added to the scope of this study to attempt to accurately measure the compressive strength of the sampled cement-treated layers.

In order to develop this correction factor, a sample of material meeting MDOT's Class 9, Group C granular material was obtained. This granular material had a plasticity index of 3, and a gradation within the specified value for Class 9 granular material. Following the classification tests of the material, a cement-treated Proctor was run with a cement content of 5 percent by mass. Using this data, three compressive strength specimens were molded at heights varying by about 0.5 in. in a 6 in. inside diameter (I.D.) by 6 in. tall mold. This mold was selected in order

to create the varying L/D ratios needed to bracket the L/D ratios from specimens obtained from the field for the two MDOT projects. The specimens were molded using standard MDOT effort for the selected mold size and then trimmed by placing neoprene cylinder caps beneath the samples to produce the desired lengths. The specimens' densities were measured based on the full height (6 in.) molded specimens in order to verify that each length specimen had similar compaction levels. See Appendix B for data generated from mixes developed in the laboratory for L/D correction factor determination.

Following the molding and trimming, the specimens were capped with sulfur capping compound to duplicate the field sampled specimens preparation. All of the specimens were then broken at an age of 32 days following the procedures given in MDOT MT-25. This procedure was carried out twice, using the same material, in order to maximize the amount of data to develop the best possible correction factor for reduced L/D ratios. The samples with L/D ratio nearest 1.15:1, on average about 1.05, were given an average correction factor of 1.0 with the remainder of the specimens corrected based on this relationship to the known. Figure 10 presents a chart with correction factors for L/D ratios ranging from 0.547 to 1.068 represented with a second order polynomial regression line displayed with its corresponding equation and R^2 value.

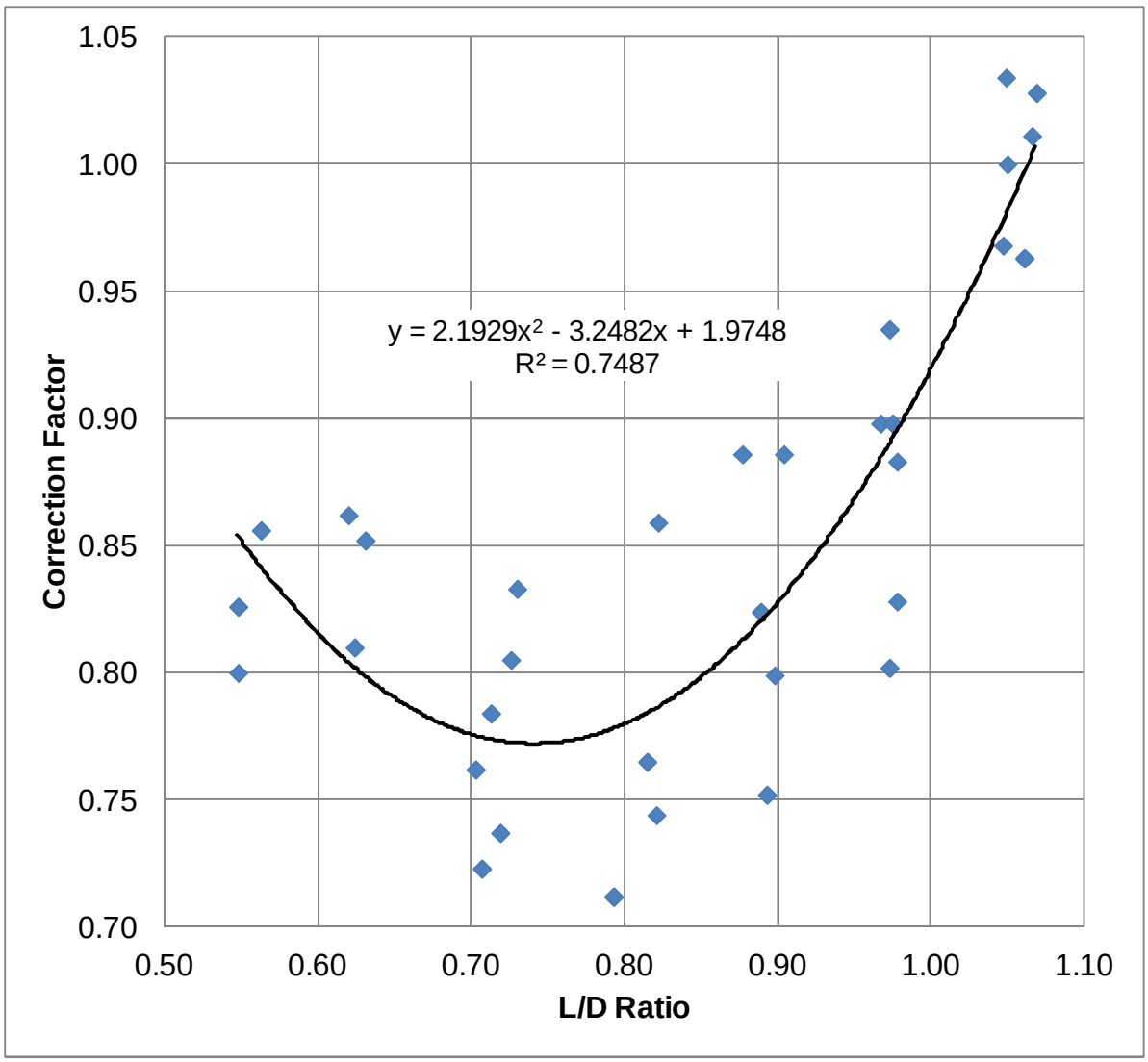


Figure 10 – Correction Factor for 6 in. Diameter Cement-Treated Cores with L/D (0.547 to 1.068)

As can be seen in Figure 10, the trend reverses itself at an L/D ratio of about 0.750. This trend does not match the known trends for compressive strength reduction based on a reduction in L/D found in AASHTO T22 / ASTM C39 "Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens" and AASHTO T24 / ASTM C42 "Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete", which has been found applicable for soil-cement, see ASTM D1633. Based on this knowledge and the

available data, the data points with an L/D ratio of less than 0.70 were disregarded. Figure 11 presents a modified correction factor chart that provides a reduction in the measured compressive strength but does not allow for a reduction in correction factor for L/D ratios less than 0.70. Corrections factor for L/D ratios less than 0.70 is assumed to be a constant equal to 0.75.

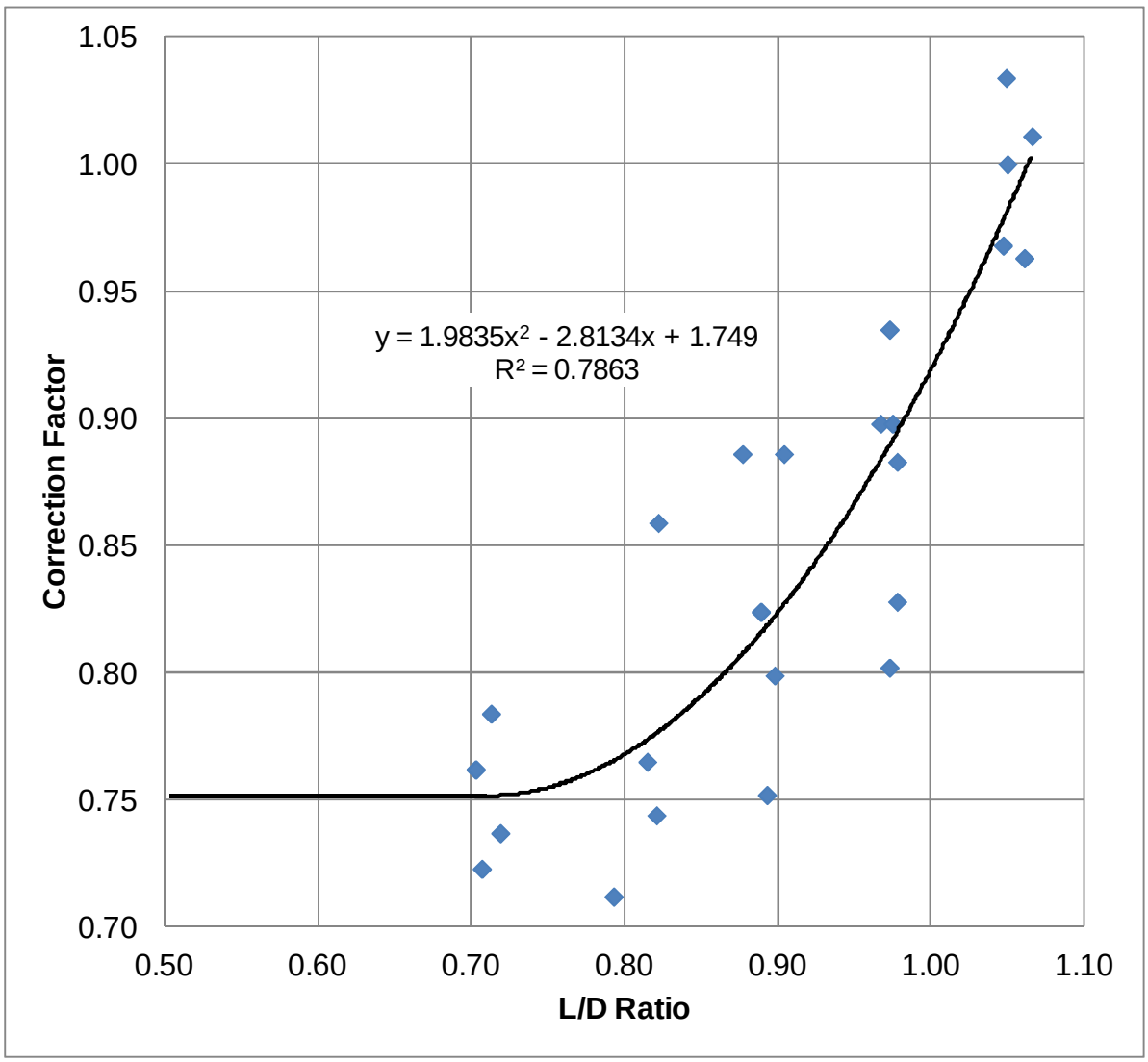


Figure 11 – Modified Correction Factors for 6 in. Dia. Cement-Treated Cores with L/D (0.547 to 1.068)

Compressive strengths presented in this report have been corrected based on L/D ratio using Equations 2 and 3 shown below. See Chapter 4 for results from compressive strength testing.

For L/D Ratio ≤ 0.70

$$f_{cld} = 0.75 * f_c \qquad \text{Eq. (2)}$$

For 0.70 < L/D Ratio ≤ 1.009

$$f_{cld} = \left[\ 1.9835 * \left[\frac{L}{D}\right]^2 - 2.8134 * \left[\frac{L}{D}\right] + 1.749\ \right] * f_c \qquad \text{Eq. (3)}$$

where:

f_c = calculated compressive strength

f_{cld} = compressive strength corrected for L/D ratio

Cores Divided Into Top and Bottom Sections

Sulfur mortar caps were removed from the cement-treated samples previously tested for compressive strength by lightly tapping the cap with a small hammer. Once these caps were removed, the samples were dry sawed at mid-depth to divide the core into top and bottom sections to determine moisture and cement content of the top and bottom sections separately.

Samples for Moisture

Moisture content was determined in general accordance with AASHTO T265 "Standard Method of Test for Laboratory Determination of Moisture Content of Soils." Top and bottom portions of the cores were broken into approximate thirds in order to determine moisture and cement content on three separate samples from top and bottom sections. These samples were broken down further with a mallet to prepare for testing. Samples were then placed into pans and weighed. Weighed samples were placed into an oven for a minimum of 24 hours and then removed from the oven. Samples were allowed to cool and weighed again. Individual sample moistures were calculated. Average moisture content was calculated from three samples on the top and bottom sections. See Chapter 4 for results from moisture content testing.

Cement Content Determination - ASTM D806

Background

Cement content of the cement-treated base was determined in accordance with ASTM D806 "Standard Test Method for Cement Content of Hardened Soil-Cement Mixtures." This test method uses a chemical process to determine the calcium oxide (CaO) content of the raw soil, cement-treated soil and cement. Calcium oxide combined with water forms calcium hydroxide ($CaOH_2$). Calcium hydroxide is a compound that also occurs during hydration of portland cement.

Portland cement is the cementing ingredient in the cement-treated soils. Portland cement is hydraulic cement which means it sets and hardens by reacting chemically with water (2). This chemical reaction is called hydration. Portland cement is made of many compounds, and four of these compounds include tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite (2). The calcium silicates react with water to form calcium hydroxide

and calcium silicate hydrate. The calcium silicate hydrate is the most important compound that causes the cement-treated soil to set and gain strength. Calcium hydroxide is a solid that remains in cement-treated soils and does not contribute to the cementing action. The amount of calcium oxide present in the cement-treated sample can be determined by removing the hydroxides from this compound.

Cement Content Calculations

Removing hydroxide requires a chemical process as described in ASTM D806. The calcium oxide percentage by mass is determined according to equation No. 4 and the percent of cement by mass is then determined using Equation No. 5 as presented in ASTM D806. The percent of cement by mass in the cement-treated layer is determined by knowing the ratio of CaO content of the cement-treated soil to CaO content of the cement used to treat the soil.

$$CaO,\% = \left[\frac{(A-B)*C*.028}{D}\right]*100 \qquad \text{Eq. (4)}$$

Where:

A = $KMnO_4$ solution required for titration of the sample, ml

B = $KMnO_4$ solution required for titration of the blank, ml

C = normality of the KMnO4 solution

D = sample represented by the aliquot titrated, g.

0.028 = CaO equivalent of 1 ml of 1.0 N $KMnO_4$ solution

$$Cement,\% = \left[\frac{(G-F)}{(E-F)}\right] * 100 \qquad \text{Eq. (5)}$$

Where:

E = CaO in cement, %

F = CaO in raw soil, %

G = CaO in soil-cement mixture, %

The cement used for Highways 84 and 25 was supplied by Holcim (US), Inc. The cement for Highway 84 was produced in Theodore, Alabama and cement for Highway 25 was produced in Artesia, Mississippi. CaO contents of these cements were provided by Holcim (US), Inc. based on average data from the time period in which construction occurred for these two projects. CaO contents of cement used in this research are 64.2% for Highway 84 and 64.6% for Highway 25.

Cement content obtained using ASTM D806 is calculated in terms of hydrated cement. This calculation does not include cement grains that do not react with water to form calcium hydroxide. ASTM D806 notes that calculated values may be multiplied by a factor of 1.04 to approximate the equivalent percent of dry cement that was applied to the cement-treated sample. The cement contents in percentage by mass provided herein do **not** include this factor or any other factor to account for un-hydrated cement. The values provided in this research are based solely on the chemical process and formulas provided in ASTM D806.

Summary of Procedure Used to Determined Cement Content

Each core was sawed in two near the mid-depth and cement content was determined for each half. Both top and bottom sections of the cores were divided into three approximate equal fractions and ± 25 g samples were selected from each of the six sections for cement content testing. The following provides the reader with critical steps that were required to determine cement contents provided in this research:

Step 1 - Samples for cement determination were broken down into smaller size fractions with a mortar and pestle. These samples were sieved by hand through a No. 40 sieve.

Step 2 - A 25 g sample of material was selected and placed into a small tin container to prepare for cement determination. This container containing the 25 g sample was placed into an oven for a minimum of 24 hours. After this drying period, a 5 g sample was selected for cement content determination. The 5 g sample was placed into a 250 milliliter beaker (original beaker). 50 ml of hydrochloric acid (HCL 1+1) solution was added to the sample. The sample was allowed to boil.

Step 3 - 25 ml of hot water was added to the solution. The solution was stirred and allowed to settle momentarily. This solution was then filtered through Whatman No. 1 filter paper and received in a 250 ml flask. The filter paper was washed four times with 10 to 15 ml of hot water and the filter paper was discarded after this washing.

Step 4 – The solution was diluted to 250 ml with distilled water. A 50 ml pipet was used to remove 50 ml of the solution to be transferred to the original 250 ml beaker. The solution was diluted to 100 ml with distilled water and made slightly ammoniacal. The solution was boiled

for one or two minutes and the hydroxides were given time to settle out of solution. See Figure 12 for a picture showing settled hydroxides.

Step 5 - The hydroxides were filtered through Whatman No. 1 filter paper and the solution received in the 600 ml beaker. The original 250 ml beaker was washed through the filter with hot ammonium nitrate (NH_4NO_3) solution through the filter paper and into the 600 ml beaker. The filter paper was also washed with the hot NH_4NO_3 solution. The filtrate was set aside and the original 250 ml beaker was set under the funnel. The filter paper was perforated with a rod and the hydroxides were washed down into the original beaker using hot $NH4NO_3$ to remove the hydroxides from the filter paper. The filter paper was further treated with hydrochloric acid (HCL) and the filter was washed several times with hot water. The filter paper was discarded and the solution was diluted to 75 ml.

Step 6 – The solution was made slightly ammoniacal and boiled for 1 to 2 minutes. The precipitate was allowed to settle and then filtered through Whatman No. 1 paper and into the 600 ml beaker previously set aside. The 250 ml beaker and the filter paper were washed three to four times with NH_4NO_3 solution. The hydroxide precipitate was discarded. 2 ml of ammonium hydroxide (NH_4OH) solution was added to the solution to have between 250 ml and 350 ml of solution. The solution was heated to boiling and 10 ml of hot ammonium oxalate was added. The solution was kept near boiling until precipitate became granular. This granular precipitate is calcium oxalate as shown in Figure 13. The solution was filtered through Whatman No. 42 filter paper and the calcium oxalate granules were captured on the filter paper.

Step 7 – The filter paper containing the calcium oxalate granules was carefully opened and these granules were washed into the 600 ml beaker. The solution was diluted to 200 ml and 10 ml of

sulfuric acid (H_2SO_4) was added. This solution was heated just below the boiling point and the solution was titrated with the standard potassium permanganate solution ($KMnO_4$) to a persistent pink color. The filter paper was added to the solution and titration was continued until the pink color persisted for 10 seconds. See Figure 14 for titration with potassium permanganate.

Step 8 – The weight of the virgin soil or cement-treated soil was recorded and the amount of standard potassium permanganate solution used for titration was recorded and used to calculate cement content.

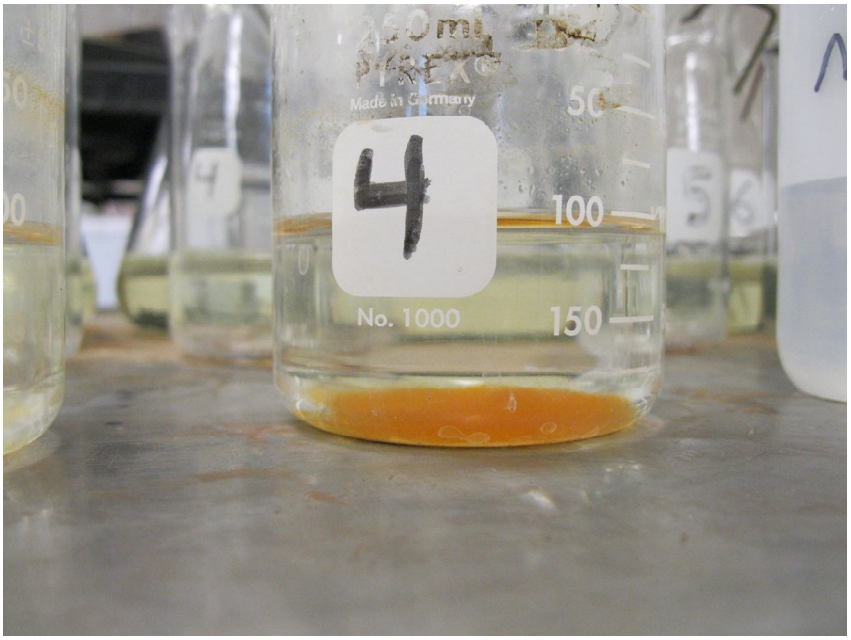


Figure 12 - Hydroxides Allowed To Settled

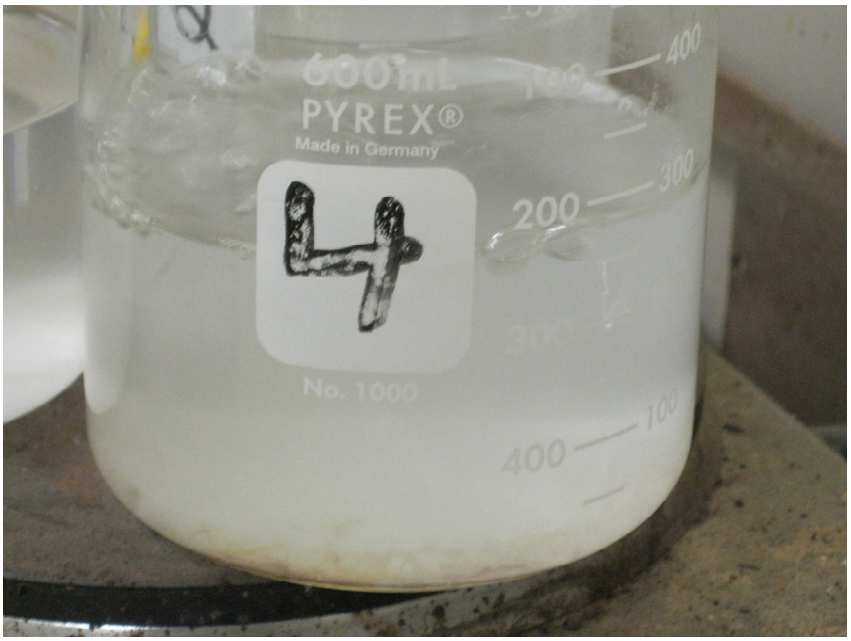


Figure 13 - Calcium Oxalate Granules

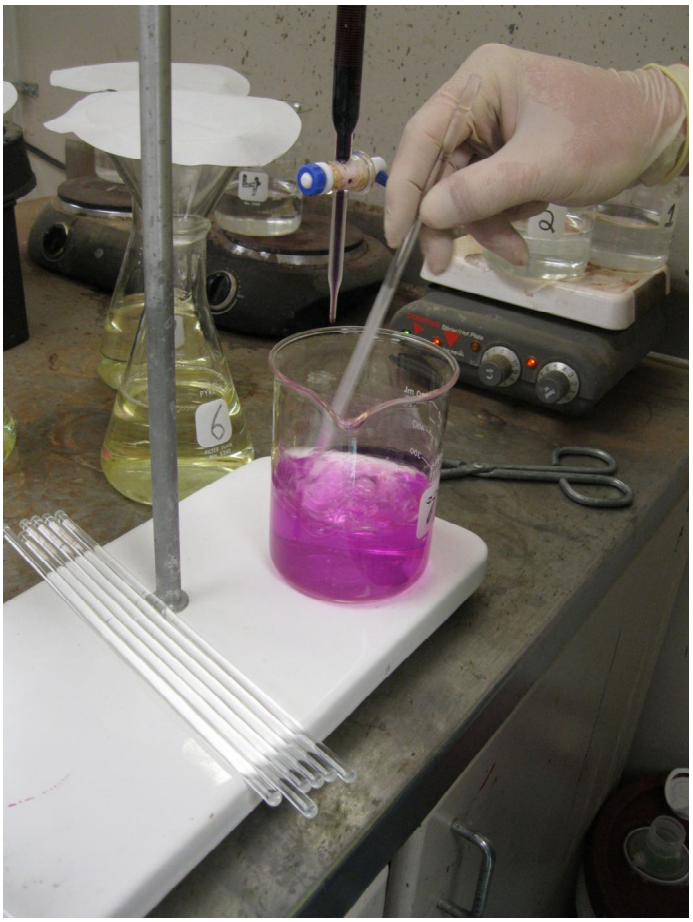


Figure 14 - Titration with Potassium Permanganate

Classification of Untreated Granular Material

Untreated granular material samples were taken from shoulder material at each row of cores. This was necessary to determine how much CaO was contributed to the cement-treated sample from the granular material. ASTM D806 was performed on samples of this material at each core row and the average CaO was used in Equation No. 5. Average CaO contents from the untreated granular material ranged from 0.03 percent to 0.72 percent by mass.

The untreated granular material samples from each core row were combined into a composite sample and soil properties were determined for Highways 84 and 25. Properties of

the untreated granular material are presented in Tables 3 and 4 for Highways 84 and 25, respectfully. These properties are provided for information only and are not used for any other purpose in this research.

Table 3 - Highway 84 Untreated Granular Material Properties

Property	Value
% Passing No. 10 Sieve	100.0
% Passing No. 40 Sieve	82.5
% Passing No. 60 Sieve	38.1
% Passing No. 200 Sieve	21.2
Liquid Limit	16
Plastic Limit	13
Plasticity Index	3
Specific Gravity	2.608
Specific Gravity @ 20ºC	2.607
AASHTO Classification	A-2-6

Table 4 - Highway 25 Untreated Granular Material Properties

Property	Value
% Passing No. 10 Sieve	98.6
% Passing No. 40 Sieve	80.3
% Passing No. 60 Sieve	61.9
% Passing No. 200 Sieve	17.8
Liquid Limit	Non-Plastic
Plastic Limit	Non-Plastic
Plasticity Index	Non-Plastic
Specific Gravity	2.655
Specific Gravity @ 20ºC	2.653
AASHTO Classification	A-2-4

Chapter 4 – Results from Laboratory Testing

Dimensional Data for Cement-Treated Cores

The structure number of an asphalt pavement is a function of the thickness of each layer. Each layer of the pavement structure is assigned a layer coefficient and that layer coefficient is multiplied by layer thickness to calculate the structure number for each layer. As the strength of the layer and thickness of the layer increases, the load carrying capacity increases as well. The average thickness of each cement-treated core was measured and is presented in Table 5 and Table 6. This thickness is an average of five measurements of the core. The average diameter of each cement-treated core is also presented in Table 5 and Table 6. The average diameter was determined using three measurements near the mid-point of the core.

Table 5 - Highway 84 Cement-Treated Core Dimensions

Core Location	Average Diameter (in.)	Average Thickness (in.)
84-1A	5.862	5.3
84-1B	5.851	6.0
84-1C	5.919	6.7
84-1D	5.878	6.2
84-2A	5.764	6.3
84-2B	5.890	6.2
84-2C	5.711	5.8
84-2D	5.800	5.3
84-3A[1]	-	3.3
84-3B	5.930	4.7
84-3C[1]	-	3.5
84-3D	5.855	4.6
84-4A	5.819	4.8
84-4B	5.925	5.7
84-4C	5.838	4.6
84-4D	5.832	4.0
84-5A	5.557	4.8
84-5B	5.805	5.2
84-5C[1]	-	-
84-5D	5.875	5.1

1. This core was not long enough to determine compressive strength or unit weight.

Table 6 - Highway 25 Cement-Treated Core Dimensions

Core Location	Average Diameter (in.)	Average Thickness (in.)
25-1A	5.853	5.9
25-1B	5.842	6.4
25-1C	5.835	6.4
25-1D[2]	-	4.7
25-2A	5.832	4.5
25-2B	5.851	5.0
25-2C	5.841	5.3
25-2D	5.791	5.5
25-3A	5.758	5.4
25-3B	5.884	5.4
25-3C	5.851	6.1
25-3D	5.807	6.3
25-4A	5.856	5.9
25-4B	5.820	4.8
25-4C	5.851	5.1
25-4D	5.862	5.3
25-5A	5.897	5.7
25-5B	5.898	4.9
25-5C	5.883	5.8
25-5D	5.901	5.6

2. Core separated during length measurement and was not suitable for compressive strength or unit weight testing.

Moisture Content of Cement-Treated Cores

Moisture content is a critical property that needs strict control during construction of cement-treated layers. Moisture is needed to hydrate the portland cement and is also needed for proper compaction. Both are critical to the ultimate strength of this layer. Moisture content was determined on each core based on the core in an air dry condition. Moisture content of the top and bottom sections were determined separately using three samples representing the top and three samples representing the bottom of the core. Average moisture contents for the cement-treated layer for Highways 84 and 25 are presented in Tables 7 and 8, respectively. Moisture content is provided for information only.

Table 7 - Highway 84 Cement-Treated Core Moisture Content

Core Location	Top Average Moisture Content (%)	Bottom Average Moisture Content (%)
84-1A	10.4	11.8
84-1B	11.5	9.9
84-1C	11.3	8.4
84-1D	10.3	9.1
84-2A	11.5	12.2
84-2B	8.3	6.5
84-2C	8.5	6.4
84-2D	11.2	10.0
84-3A	11.8	11.7
84-3B	9.5	8.0
84-3C	9.0	8.7
84-3D	6.8	6.5
84-4A	6.0	6.4
84-4B	10.1	7.8
84-4C	6.7	7.7
84-4D	9.1	6.9
84-5A	7.6	8.3
84-5B	9.5	8.5
84-5C[1]	14.1	-
84-5D	7.1	8.2

1. This core was not long enough to determine compressive strength or unit weight.

Table 8 - Highway 25 Cement-Treated Core Moisture Content

Core Location	Top Average Moisture Content (%)	Bottom Average Moisture Content (%)
25-1A	13.3	12.5
25-1B	11.3	11.4
25-1C	14.3	13.2
25-1D	9.0	8.3
25-2A	11.0	12.5
25-2B	11.5	13.0
25-2C	10.3	10.9
25-2D	10.6	12.2
25-3A	13.5	13.8
25-3B	11.4	12.0
25-3C	12.5	13.2
25-3D	12.8	11.6
25-4A	10.8	12.9
25-4B	10.8	10.3
25-4C	9.4	9.2
25-4D	9.5	12.2
25-5A	14.4	15.6
25-5B	12.3	13.1
25-5C	11.9	13.0
25-5D	13.7	13.4

Unit Weight, Cement Content, and Compressive Strength of Cement-Treated Cores

Unit weight and cement content significantly influences compressive strength of cement-treated bases. These properties along with compressive strength of each core are presented in Tables 9 and 10. Cement content is provided for the top half and bottom half of the cores. The overall average cement content for the cores is also presented in these tables. The measured compressive strength (f_c) is provided along with compressive strength (f_{cld}) corrected for L/D ratio. See Chapter 3 for a discussion of correction factors for L/D ratio.

Table 9 - Highway 84 Cement-Treated Core Properties

Core Location	Unit Weight (lbs/ft^3)	Top Cement Content (%)	Bottom Cement Content (%)	Average Cement Content (%)	Compressive Strength, f_c (psi)	Corrected Compressive Strength, f_{cld} (psi)
84-1A	122.6	3.85	5.06	4.46	549	445
84-1B	124.3	5.06	3.05	4.06	762	678
84-1C	126.8	5.91	4.59	5.25	997	818
84-1D	125.2	3.59	3.01	3.30	633	544
84-2A	145.9	2.28	2.41	2.35	1,097	845
84-2B	128.4	2.32	1.60	1.96	855	752
84-2C	134.1	3.10	1.61	2.36	747	627
84-2D	117.6	4.28	5.40	4.84	921	709
84-3A[1]	-	1.53	1.42	1.47	-	-
84-3B	128.1	5.47	2.12	3.79	1,259	944
84-3C[1]	-	2.09	1.11	1.70	-	-
84-3D	127.5	2.25	1.45	1.85	685	514
84-4A	128.0	2.32	2.27	2.29	883	662
84-4B	127.3	10.10	6.14	8.12	1,344	1,089
84-4C	126.1	4.01	3.55	3.78	860	645
84-4D	122.7	6.11	2.06	4.08	686	515
84-5A	116.9	3.71	3.08	3.39	546	431
84-5B	127.6	3.24	3.38	3.31	637	484
84-5C[1]	-	1.13	0.83	0.98	-	-
84-5D	125.2	3.04	3.36	3.20	774	588

1. This core was not long enough to determine compressive strength or unit weight.

Table 10 - Highway 25 Cement-Treated Core Properties

Core Location	Unit Weight (lbs/ft^3)	Top Cement Content (%)	Bottom Cement Content (%)	Average Cement Content (%)	Compressive Strength, f_c (psi)	Corrected Compressive Strength, f_{cld} (psi)
25-1A	120.7	2.87	3.14	3.00	231	199
25-1B	124.2	4.21	3.13	3.67	421	383
25-1C	119.2	3.69	2.75	3.22	289	243
25-1D[2]	-	3.10	2.52	2.81	-	-
25-2A	119.8	3.43	3.29	3.36	447	335
25-2B	118.8	4.66	4.54	4.60	408	306
25-2C	117.2	3.26	2.58	2.92	296	237
25-2D	117.2	3.71	3.76	3.74	298	229
25-3A	121.4	4.35	3.87	4.11	382	348
25-3B	120.2	2.99	3.03	3.01	519	389
25-3C	120.1	5.52	3.99	4.76	465	400
25-3D	121.5	4.87	4.69	4.78	446	415
25-4A	118.3	4.60	4.52	4.56	474	389
25-4B	119.5	2.36	2.45	2.41	293	220
25-4C	115.8	2.55	2.46	2.51	322	245
25-4D	118.2	2.33	3.29	2.81	338	257
25-5A	123.3	3.78	4.28	4.03	606	479
25-5B	126.9	3.56	3.69	3.63	849	637
25-5C	120.3	3.82	3.82	3.82	511	419
25-5D	123.6	4.13	4.59	4.36	705	585

2. Core separated during length measurement and was not suitable for compressive strength or unit weight testing.

Chapter 5 – Discussion of Results

Introduction

Core properties including length, unit weight, cement content and compressive strength are graphically illustrated in Figures 15 though 26. The project specific requirement for thickness and cement content is provided in these figures for reference. Tables that follow these figures present a summary descriptive statistical data for each property. Coefficient of variability (C_v) is calculated and provided in these tables for each set of data. C_v represents the ratio of the standard deviation to the mean and is shown as a percentage in this research. It is used herein for comparing the degree of variation from one data set to another. The author is not aware of acceptable values or ranges of values for C_v for properties determined from testing cement-treated cores. However, it is important to note that the higher the value the more variability in the data set and the lower the value the less variability in the data set.

Highway 84

Thickness

Nineteen of the twenty cores removed from Highway 84 were suitable for determining layer thickness. Core No. 84-5C was too thin and unsuitable to determine thickness. Average thickness measurements ranged from 3.3 in. to 6.7 in.

The specified thickness for the cement-treated base on Highway 84 was 6 in. with a construction tolerance of ± 1 in. providing an acceptable range of 5 in. to 7 in. Eleven of the cores or 58 percent had an average thickness within this construction tolerance. Eight of the cores or 42 percent had an average thickness less than 5 in. Four cores or 21 percent of the cores exceeded 6 in. Fourteen cores or 74 percent had a thickness that was less than 6 in.

Figure 15 presents a graphical illustration showing the average thickness measurements of the cores drilled out of the cement-treated base on Highway 84. Table 11 provides descriptive statics from average thickness measurements from the nineteen cores taken from Highway 84.

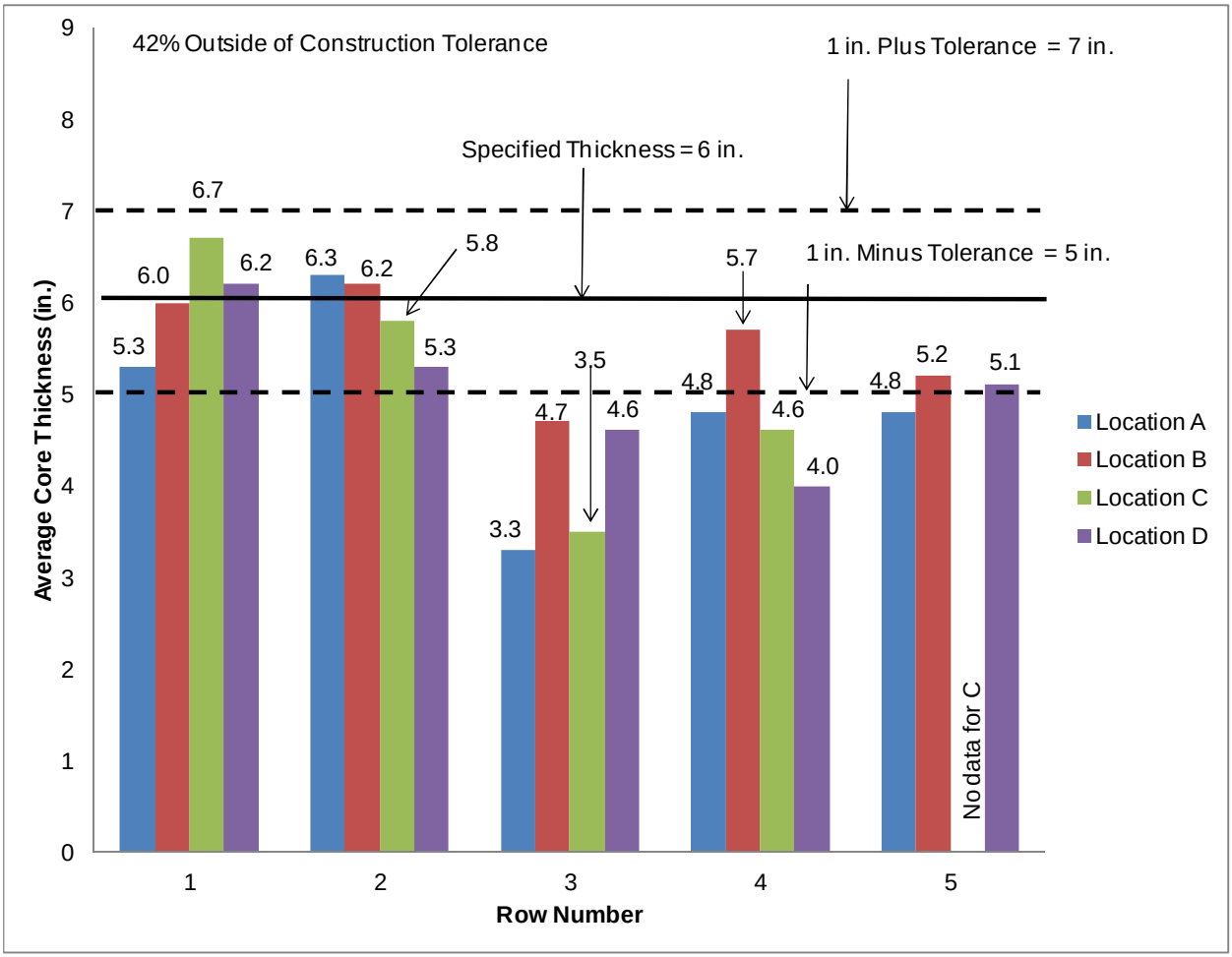


Figure 15 - Highway 84 Thickness

Table 11 - Highway 84 Statistical Data for Thickness of Cement-Treated Base

Statistic	Value
Mean	5.16
Standard Error	0.22
Median	5.2
Mode	5.3
Standard Deviation	0.94
Sample Variance	0.89
Range	3.4
Minimum	3.3
Maximum	6.7
Count	19
Coefficient of Variability	18.2

Unit Weight

The unit weight of the cement-treated cores was calculated based on the measured volume and air dry weight of the cores and presented in Figure 16. MDOT's standard Proctor maximum dry density for this material is 122.9 pounds per cubic foot. The calculated unit weight of the hardened cores is an indication of the compaction effort, but cannot be directly compared to this laboratory dry density. Unit weights ranged from 116.9 to 145.9 pounds per cubic foot.

Cores 84-3A, 84-3C and 84-5C were too short and not useful for determining unit weight. Unit weights calculated for Cores No. 84-2A and 84-2C are much higher than expected and represent potential outliers in this data set.

Figure 16 presents a graphical illustration of the unit weights determined from cores drilled out of the cement-treated base on Highway 84. Table 12 provides descriptive statics from unit weights determined from seventeen cores taken from Highway 84.

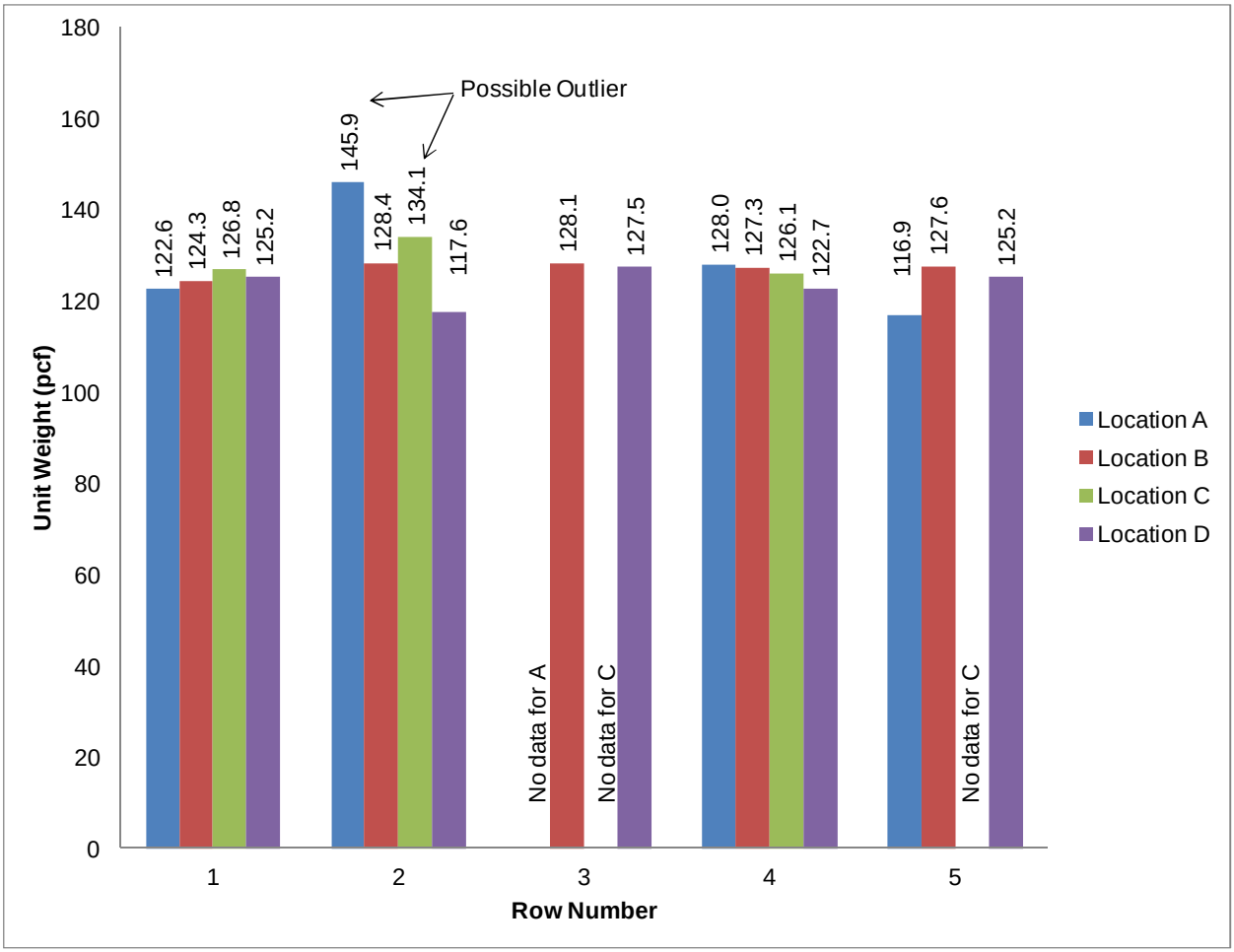


Figure 16 - Highway 84 Unit Weight

Table 12 - Highway 84 Statistical Data for Unit Weight of Cement-Treated Base

Statistic	Value
Mean	126.72
Standard Error	1.55
Median	126.8
Mode	125.2
Standard Deviation	6.39
Sample Variance	40.88
Range	29.0
Minimum	116.9
Maximum	145.9
Count	17
Coefficient of Variability	5.0

Cement Content

The average cement content determined from the cement-treated cores removed from Highway 84 is graphically illustrated in Figures 17 through 19. Figure 17 and 18 show average cement content for the top and bottom half of the cores, respectively. Figure 19 presents the overall average cement content for the core. MDOT's specified cement content of 3.8 percent is also shown in these figures and is used for comparison. There is no mention of construction tolerances for cement content in MDOT specifications. The overall average cement content ranged from 0.98 to 8.12 percent.

Sixty percent of these cores had cement contents in the top of the core that were less than the specified cement content of 3.8 percent. The overall average cement content for the core also had 60 percent that were less that specified. Eighty percent of the bottom half of the cores had cement contents that were less than the 3.8 percent specified. This data shows that the cement is not uniformly distributed throughout the depth of the cement-treated base. A large percentage of cement remained near the surface of the treated layer as a result of construction methods used on Highway 84.

Cores 84-3A, 84-3C and 84-5C had overall average cement contents ranging from 0.98 percent to 1.70 percent. This low cement content resulted in low strength cement-treated cores that were not suitable for unit weight or compressive strength testing.

Core 84-4B had an average cement content of 10.10 in the top, 6.14 in the bottom and an overall average of 8.12 percent. This is the highest cement content of any core tested in this research. This may indicate an overlapping of cement spreading or a cement spill in this location.

Descriptive statistical data for cement content are presented in Table 13. The high coefficient of variability (C_v) shown in this table indicates poor control of spreading and mixing of cement in this cement-treated layer.

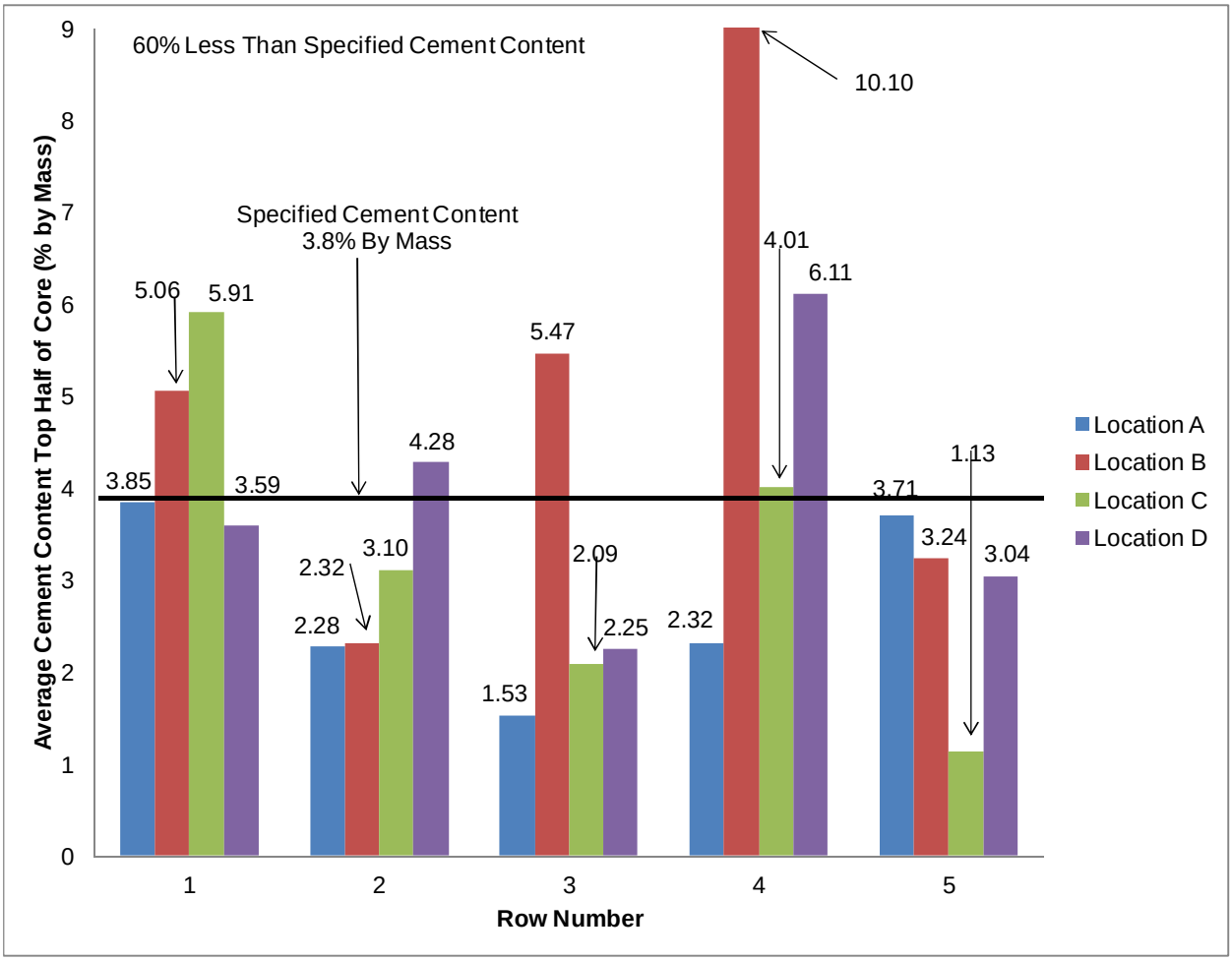


Figure 17 - Highway 84 Average Cement Content of Cement-Treated Core Top

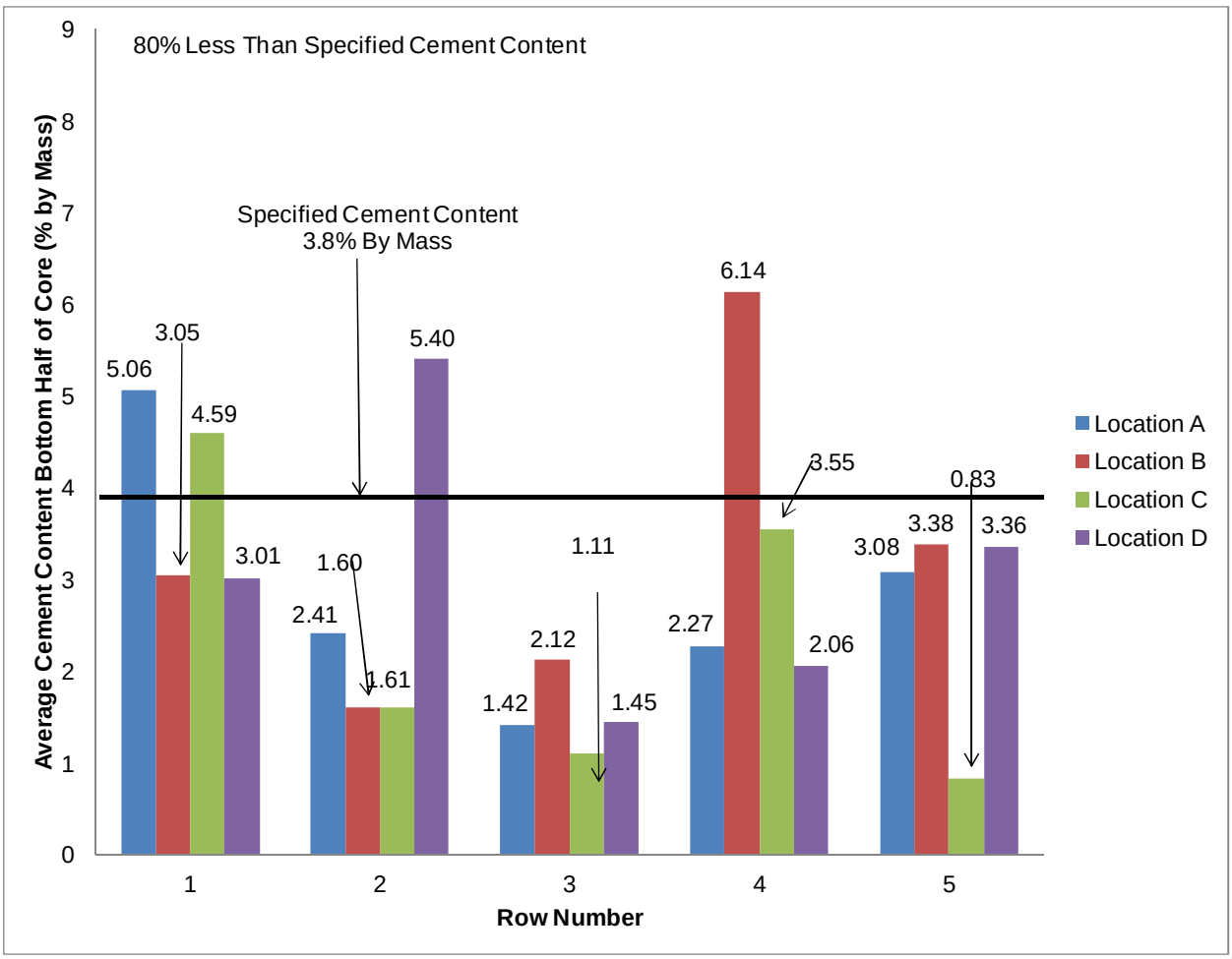


Figure 18 - Highway 84 Average Cement Content of Cement-Treated Core Bottom

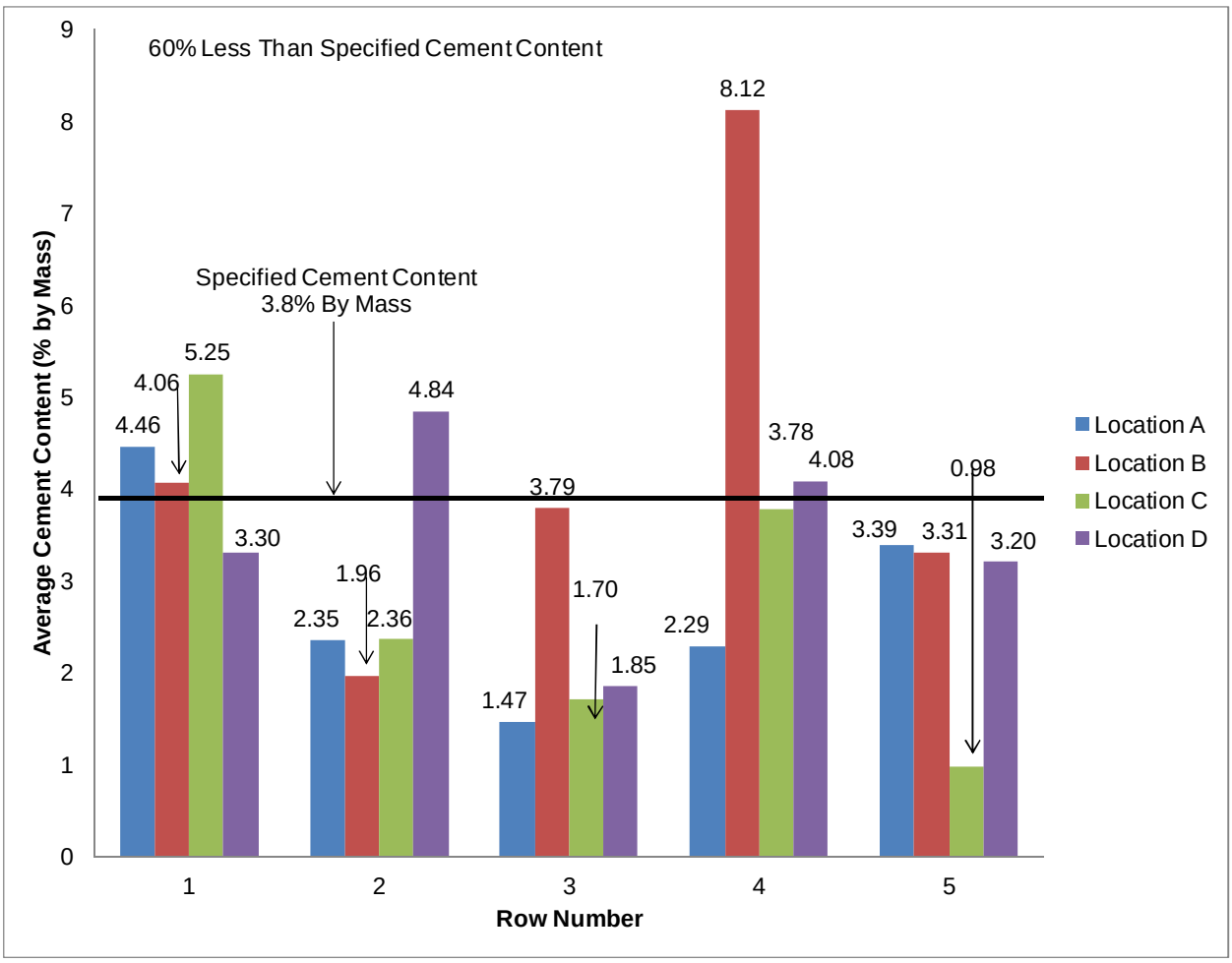


Figure 19 - Highway 84 Average Cement Content of Cement-Treated Core

Table 13 - Highway 84 Statistical Data for Cement Content of Cement-Treated Base

Statistic	Top of Core Value	Bottom of Core Value	Average Core Value
Mean	3.77	2.88	3.33
Standard Error	0.46	0.33	0.36
Median	3.42	2.71	3.31
Mode	2.32	NA	NA
Standard Deviation	2.05	1.49	1.63
Sample Variance	4.20	2.23	2.65
Range	8.97	5.31	7.14
Minimum	1.13	0.83	0.98
Maximum	10.10	6.14	8.12
Count	20	20	20
Coefficient of Variability	54.4	51.7	48.9

Compressive Strength

Compressive strengths for cement-treated cores taken from Highway 84 are presented in Figure 20. These compressive strengths have been corrected for L/D ratio as described in Chapter 3. Seventeen out of twenty cores were suitable for compressive strength testing. Compressive strengths ranged from 431 psi to 1,089 psi.

The compressive strength of all seventeen cores exceeded the specified design strength of 300 psi. Cores 84-3A, 84-3C and 84-5C could not be tested for compressive strength due to insufficient length caused by their lack of cement. Core 84-4B had a compressive strength of 1,089 psi which was the highest compressive strength of all cores tested in this research. This core also had an overall average cement content of 8.12 percent which is the highest cement content of all cores tested.

Descriptive statistical data for compressive strengths are presented in Table 14.

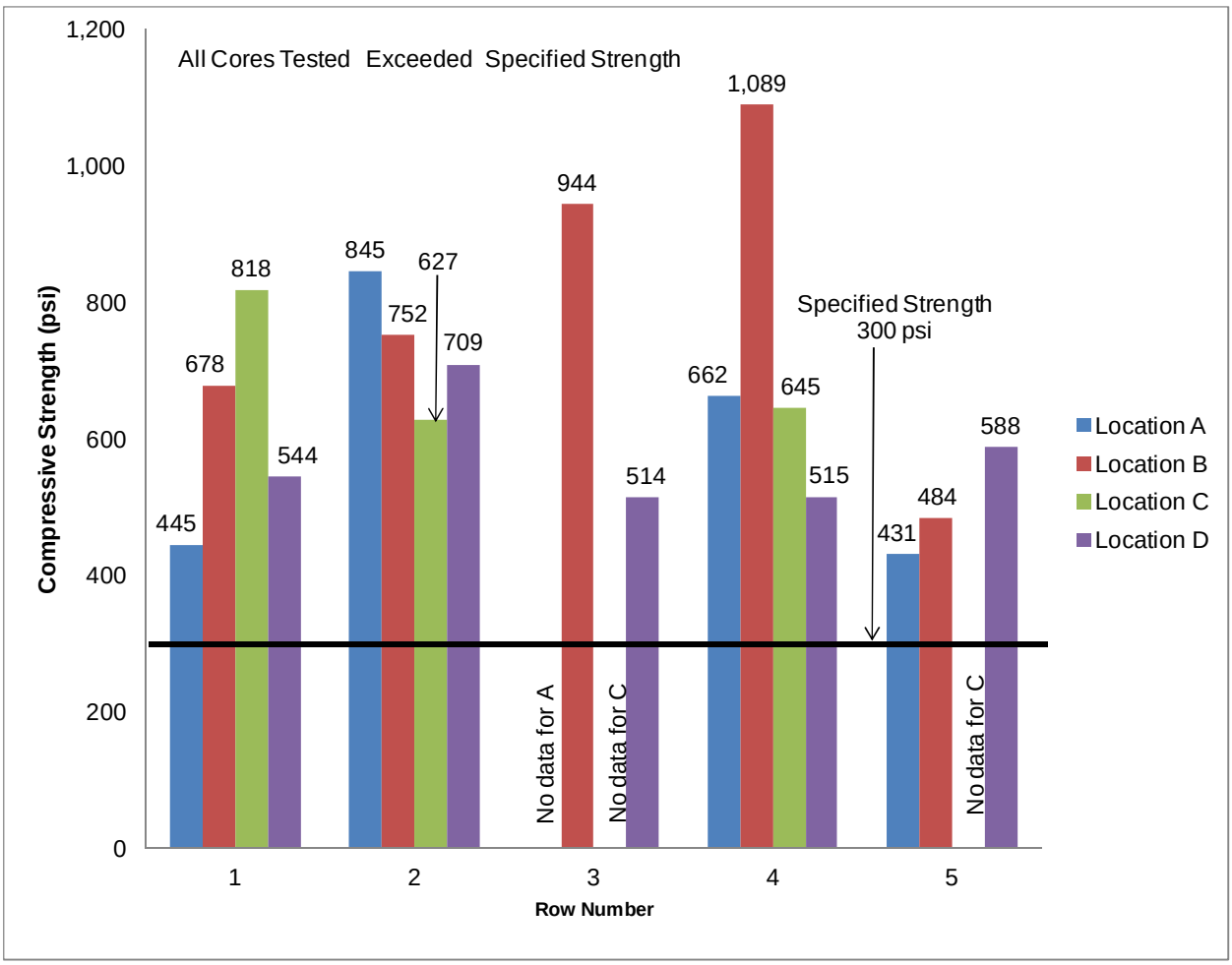


Figure 20 - Highway 84 Compressive Strength

Table 14 - Highway 84 Statistical Data for Compressive Strength of Cement-Treated Base

Statistic	Value
Mean	664.12
Standard Error	44.01
Median	645
Mode	NA
Standard Deviation	181.44
Sample Variance	32920.49
Range	658
Minimum	431
Maximum	1089
Count	17
Coefficient of Variability	27.3

Highway 25

Thickness

All twenty cores taken from the cement-treated base on Highway 25 were suitable for measuring thickness. Average thicknesses ranged from 4.5 in to 6.4 in.

The specified thickness for the cement-treated base on Highway 25 was 6 in with a construction tolerance of ± 1 in. providing an acceptable range of 5 in. to 7 in. Sixteen out of twenty or 80 percent had an average thickness within this range. Four out of twenty or 20 percent had an average thickness that was less than 5 in. Sixteen of the twenty cores or 80 percent of the cores from Highway 25 had a thickness less than the specified 6 in. Four out of twenty or 20 percent of the cores had thickness greater than the specified 6 in.

Figure 21 presents a graphical illustration of the average thickness measurements of cores drilled out of the cement-treated base on Highway 25. Table 15 provides descriptive statics from average thickness measurements from the twenty cores taken from Highway 25.

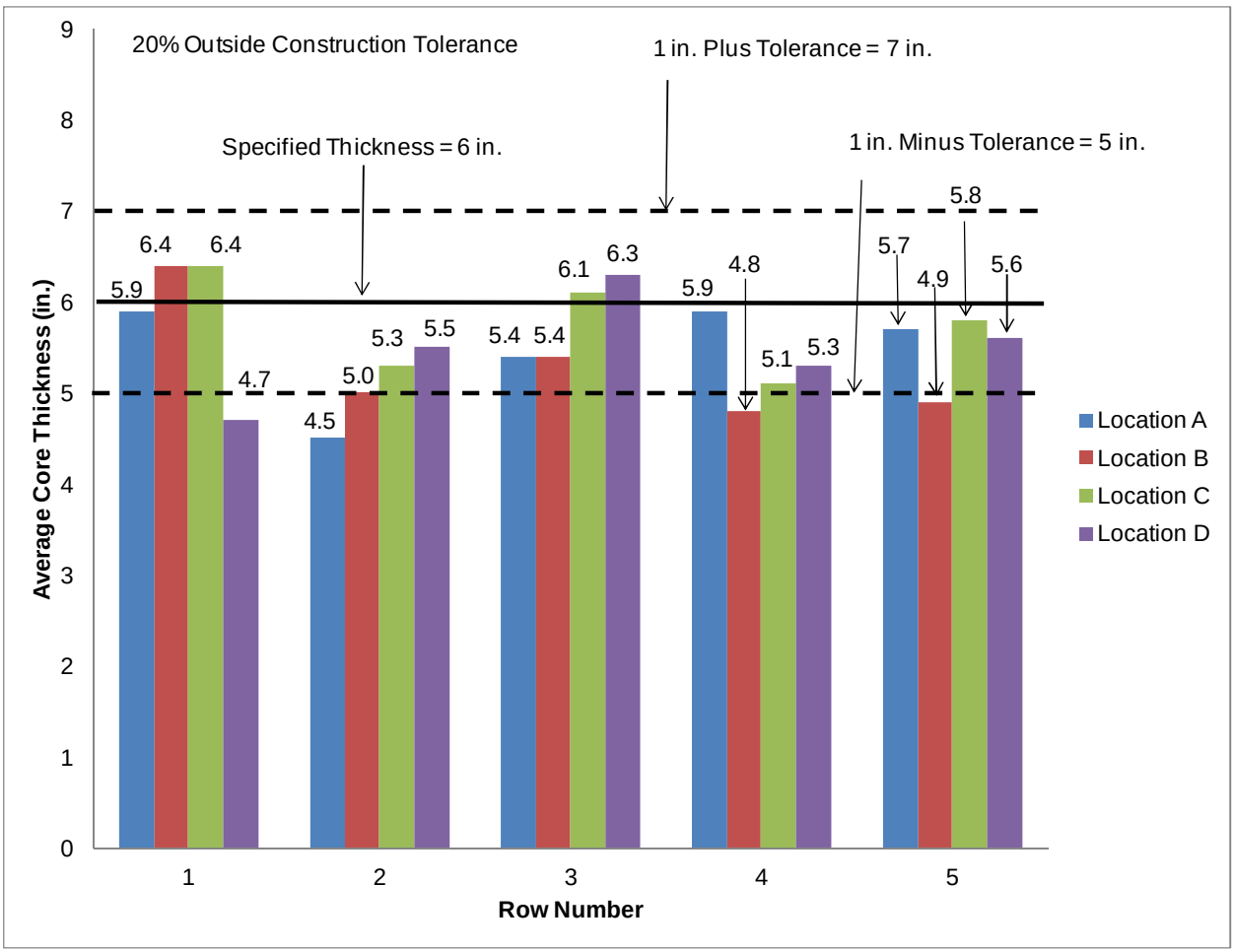


Figure 21 - Highway 25 Thickness

Table 15 - Highway 25 Statistical Data for Thickness of Cement-Treated Base

Statistic	Value
Mean	5.50
Standard Error	0.13
Median	5.5
Mode	5.9
Standard Deviation	0.57
Sample Variance	0.32
Range	1.9
Minimum	4.5
Maximum	6.4
Count	20
Coefficient of Variability	10.4

Unit Weight

The unit weight of the cement-treated cores was calculated based on the measured volume and air dry weight of the cores. MDOT's standard Proctor maximum density for this material was 121.4 pounds per cubic foot. The calculated unit weight of the harden cores is an indication of the compaction effort, but cannot be directly compared to this laboratory density. Unit weights ranged from 115.8 to 126.9 pounds per cubic foot.

Core 25-1D separated while being measured for length and was unsuitable for unit weight determination.

Figure 22 presents a graphical illustration of the units weights determined from cores drilled out of the cement-treated base on Highway 25. Table 16 provides descriptive statics from unit weights determined from nineteen cores taken from Highway 25.

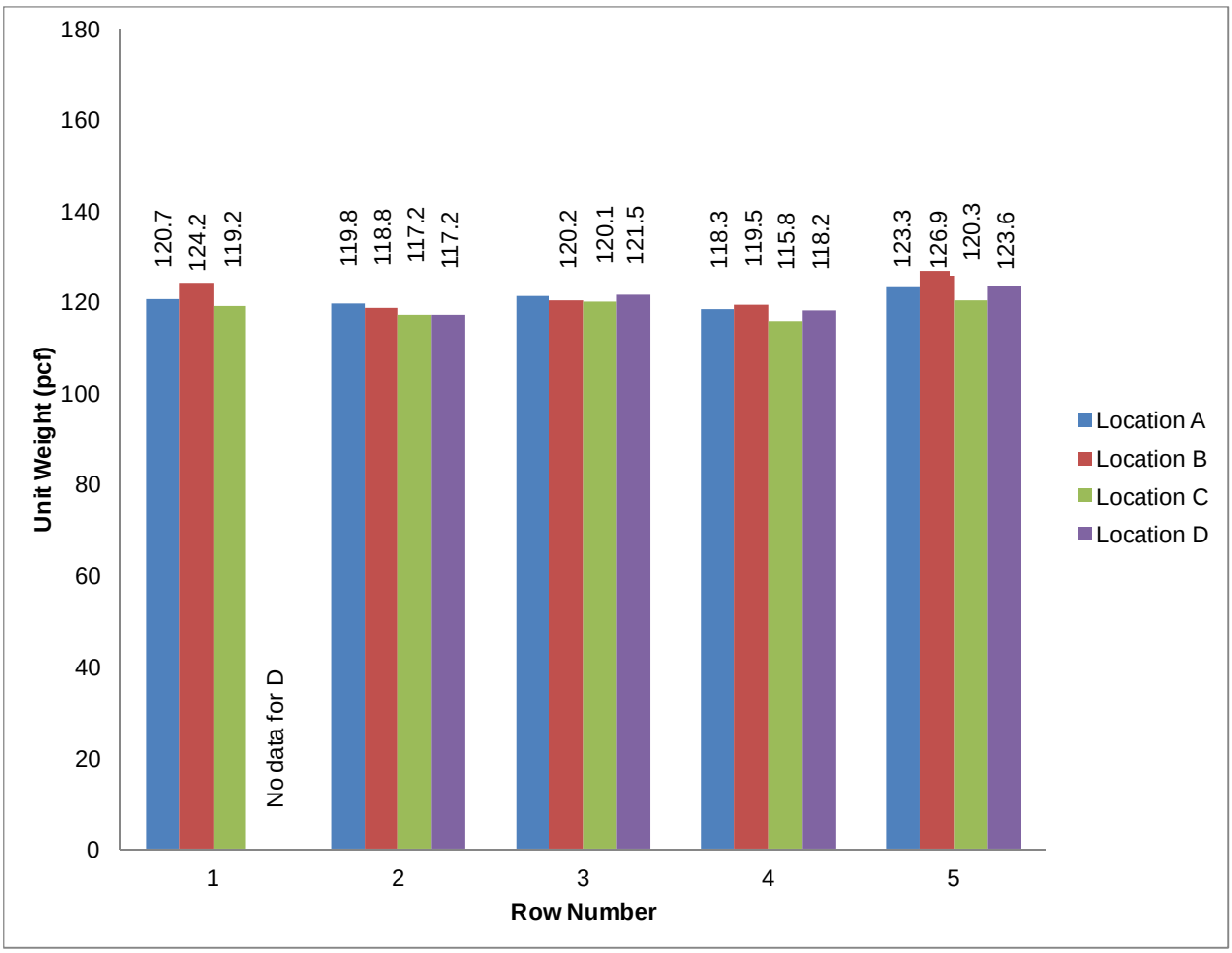


Figure 22 - Highway 25 Unit Weight

Table 16 - Highway 25 Statistical Data for Unit Weight of Cement-Treated Base

Statistic	Value
Mean	120.33
Standard Error	0.63
Median	120.1
Mode	117.2
Standard Deviation	2.73
Sample Variance	7.43
Range	11.1
Minimum	115.8
Maximum	126.9
Count	19
Coefficient of Variability	2.3

Cement Content

The average cement content determined from the cement-treated cores removed from Highway 25 is graphically illustrated in Figures 23 through 25. Figure 23 and 24 show average cement content for the top and bottom half of the cores, respectively. Figure 25 presents the overall average cement content for the core. MDOT's specified cement content of 3.1 percent is also shown in these figures and is used for comparison. There is no mention of construction tolerances for cement content in MDOT specifications. The overall average cement content ranged from 2.41 percent to 4.78 percent.

Twenty-five percent of the top portion of these cores had cement contents that were less than the specified cement content of 3.1 percent. Thirty percent of the bottom portions have cement contents less than specified. The overall average cement content for the cores had 35 percent less than specified. These data show that the cement was not uniformly distributed throughout the depth of the cement-treated layer.

Descriptive statistical data for cement content are presented in Table 17.

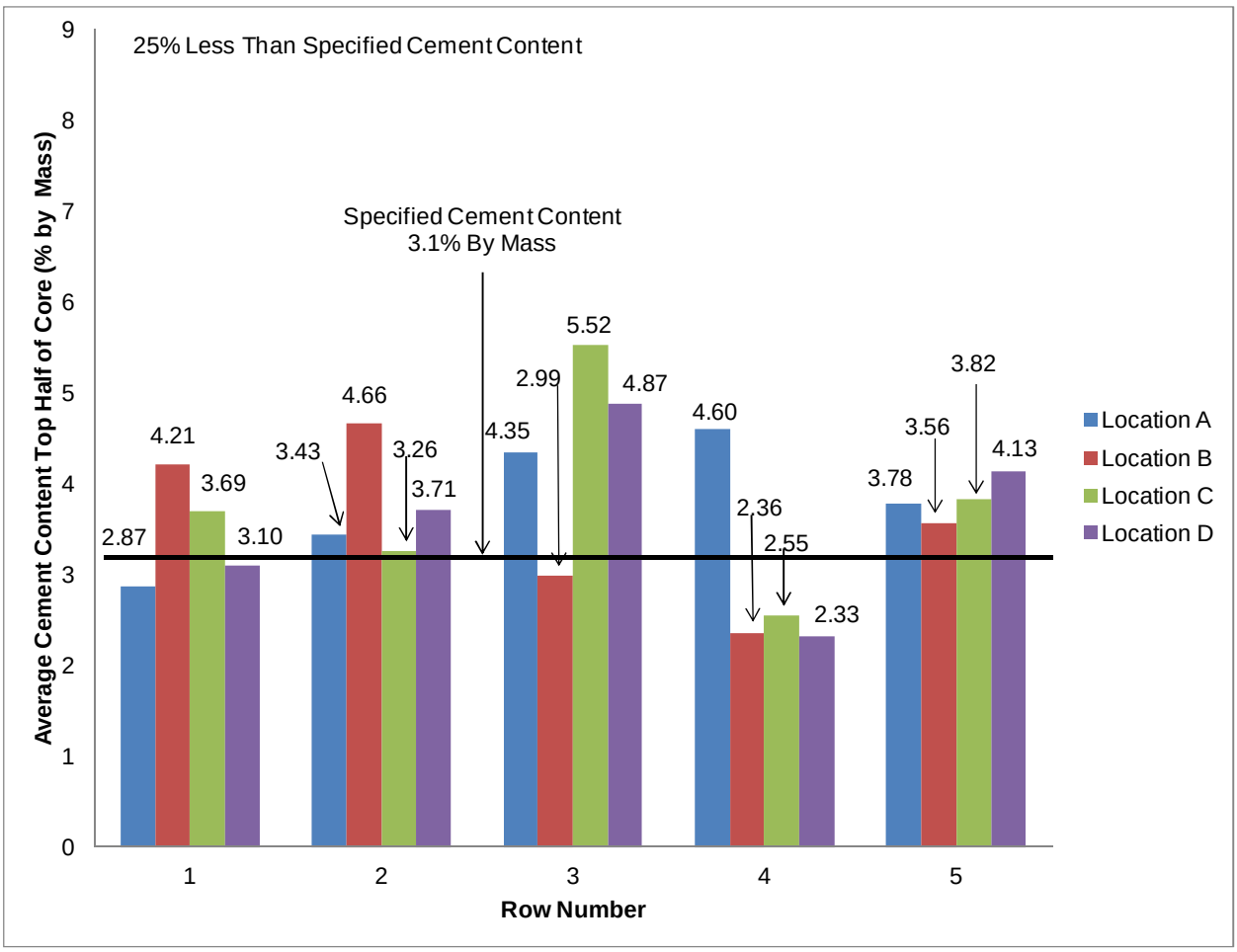


Figure 23 - Highway 25 Average Cement Content Top

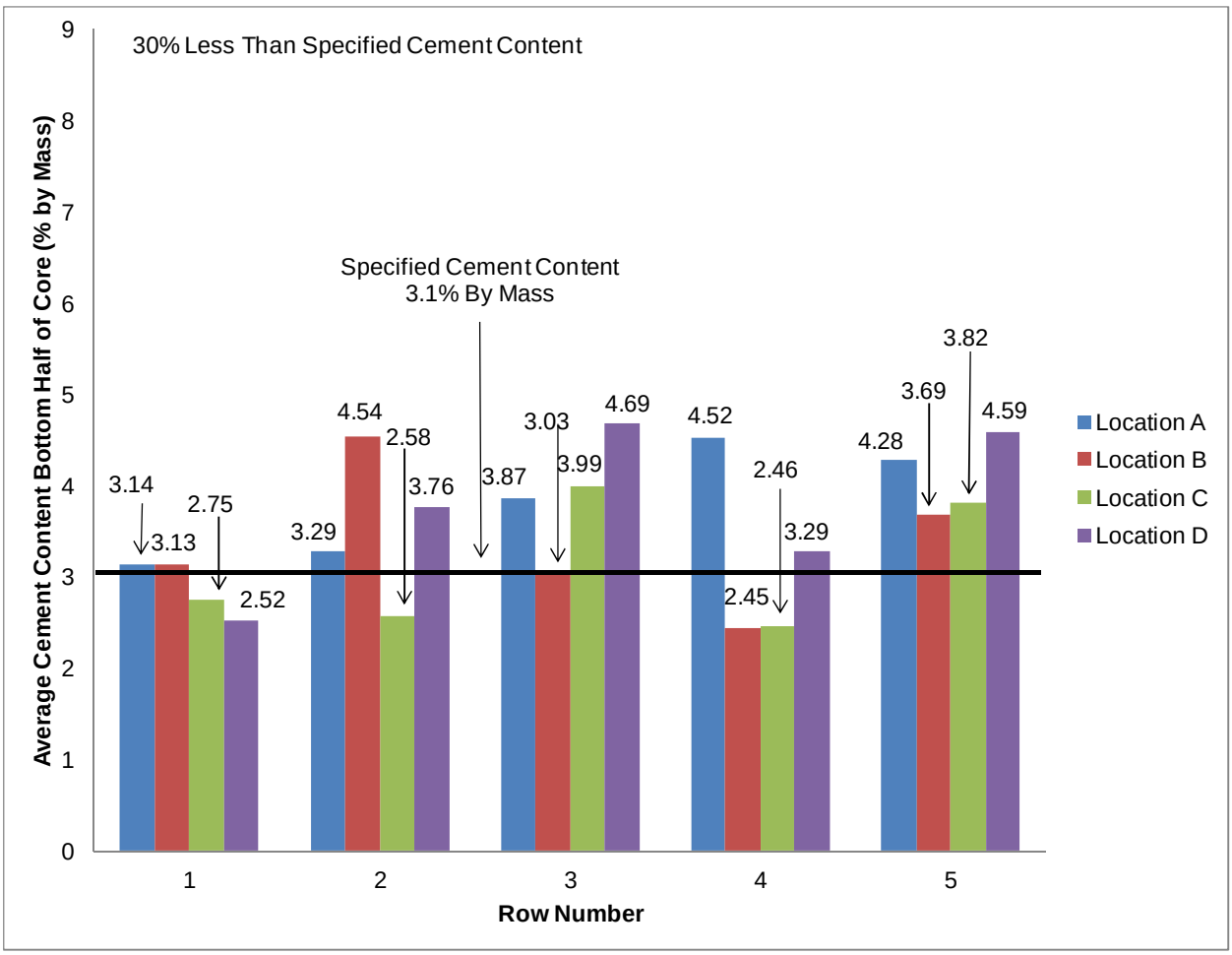


Figure 24 - Highway 25 Average Cement Content Bottom

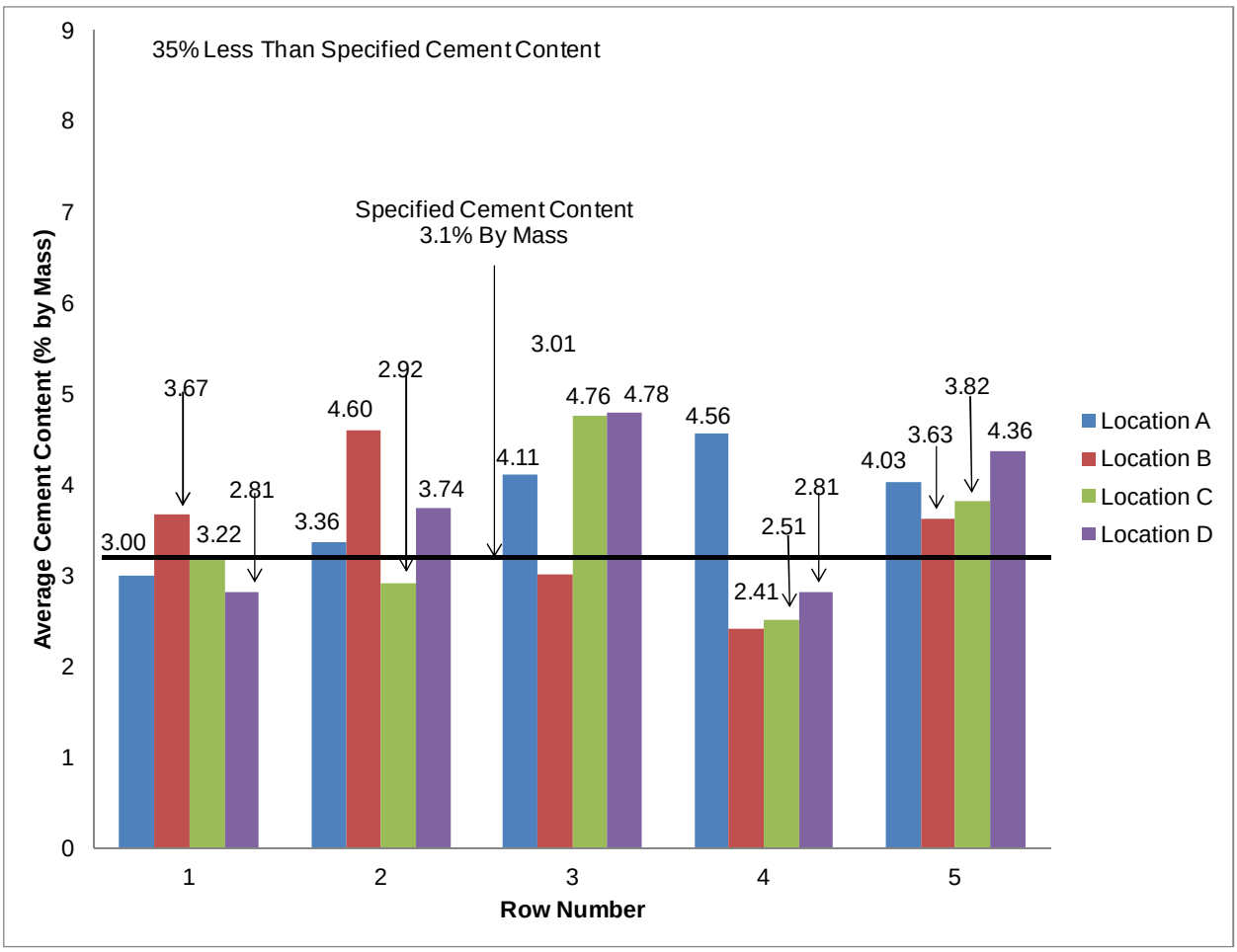


Figure 25 - Highway 25 Average Cement Content

Table 17 - Highway 25 Statistical Data for Cement Content of Cement-Treated Base

Statistic	Top of Core Value	Bottom of Core Value	Average Core Value
Mean	3.69	3.52	3.61
Standard Error	0.19	0.17	0.17
Median	3.70	3.49	3.65
Mode	NA	3.29	2.81
Standard Deviation	0.86	0.76	0.76
Sample Variance	0.74	0.58	0.58
Range	3.19	2.24	2.37
Minimum	2.33	2.45	2.41
Maximum	5.52	4.69	4.78
Count	20	20	20
Coefficient of Variability	23.3	21.6	21.1

Compressive Strength

Compressive strengths for Highway 25 are presented in Figure 26. These strengths have been corrected for L/D ratio. Nineteen of the twenty cores were tested for compressive strength. Core 25-1D could not be tested because it contained a shrinkage crack and fell apart during length measuring. Compressive strengths ranged from 199 psi to 637 psi.

Seven out of nineteen or 37 percent have a compressive strength that was lower than the specified design strength of 300 psi at 14 days.

Descriptive statistical data for compressive strength are presented in Table 18.

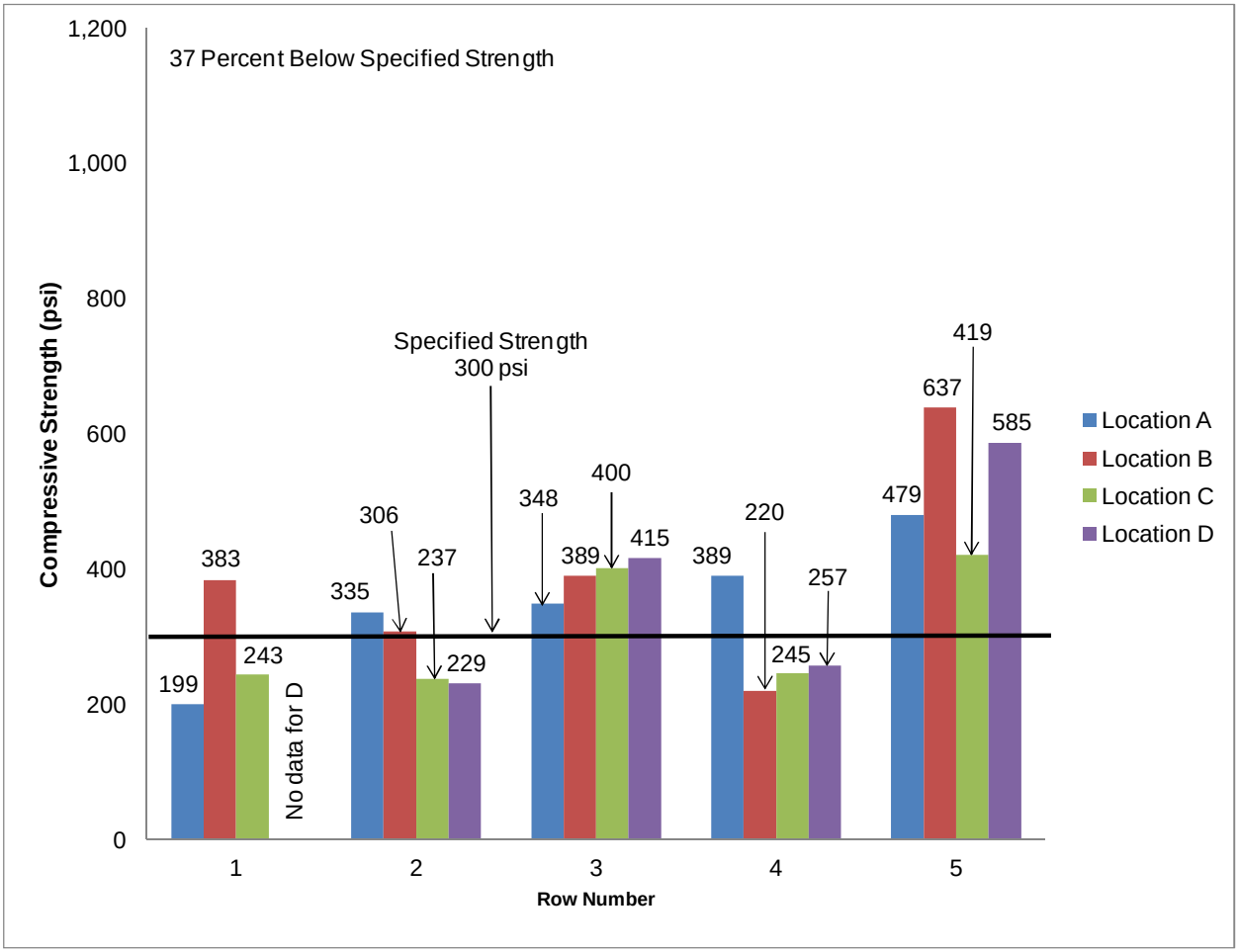


Figure 26 - Highway 25 Compressive Strength

Table 18 - Highway 25 Statistical Data for Compressive Strength of Cement-Treated Base

Statistic	Value
Mean	353.42
Standard Error	28.10
Median	348
Mode	389
Standard Deviation	122.48
Sample Variance	15001.59
Range	438
Minimum	199
Maximum	637
Count	19
Coefficient of Variability	34.7

Chapter 6 – Analysis of Data

Correlating Unit Weight, Cement Content, and Compressive Strength

Unit weight and cement content are two critical factors influencing compressive strength of cement-treated layers. As cement content and unit weight increases, compressive strength increases. Unit weight is the primary factor influencing compressive strength. Unit weight is a function of moisture content and compaction effort. Compaction effort should be considered the most critical process in constructing cement-treated layers.

Figure 27 presents a graph of compressive strength versus unit weight for Highways 25 and 84. This data shows good correlation between unit weight, cement content and compressive strength. Eight cores out of forty or 20 percent were considered outliers and removed from the data used to develop the graphs shown in Figure 27. These eight cores along with the reason they are considered outliers is presented in Table 19.

In order to develop graphs shown in Figure 27, cement contents had to be combined into manageable percentage categories. The categories selected were 2 percent, 3 percent, 4 percent and 5 percent. Cement content ranges were selected to delineate these categories. Table 20 presents these categories along with associated ranges. Data represented by the 2 percent, 4 percent and 5 percent categories have very good correlation with R^2 values ranging from 0.81 to 0.96. Data for the 3 percent category are more scattered providing a R^2 value of 0.48.

Correlations between compressive strength and cement content can be made by analyzing data provided in cement categories 2, 4 and 5 percent. With constant unit weight, a 1 percent change in cement content results in a 13 percent change in in-place compressive strength of the cement-treated layer. With constant cement content, a 1 percent change in unit weight or

compaction effort results in a 15 percent change in in-place compressive strength of the cement-treated layer.

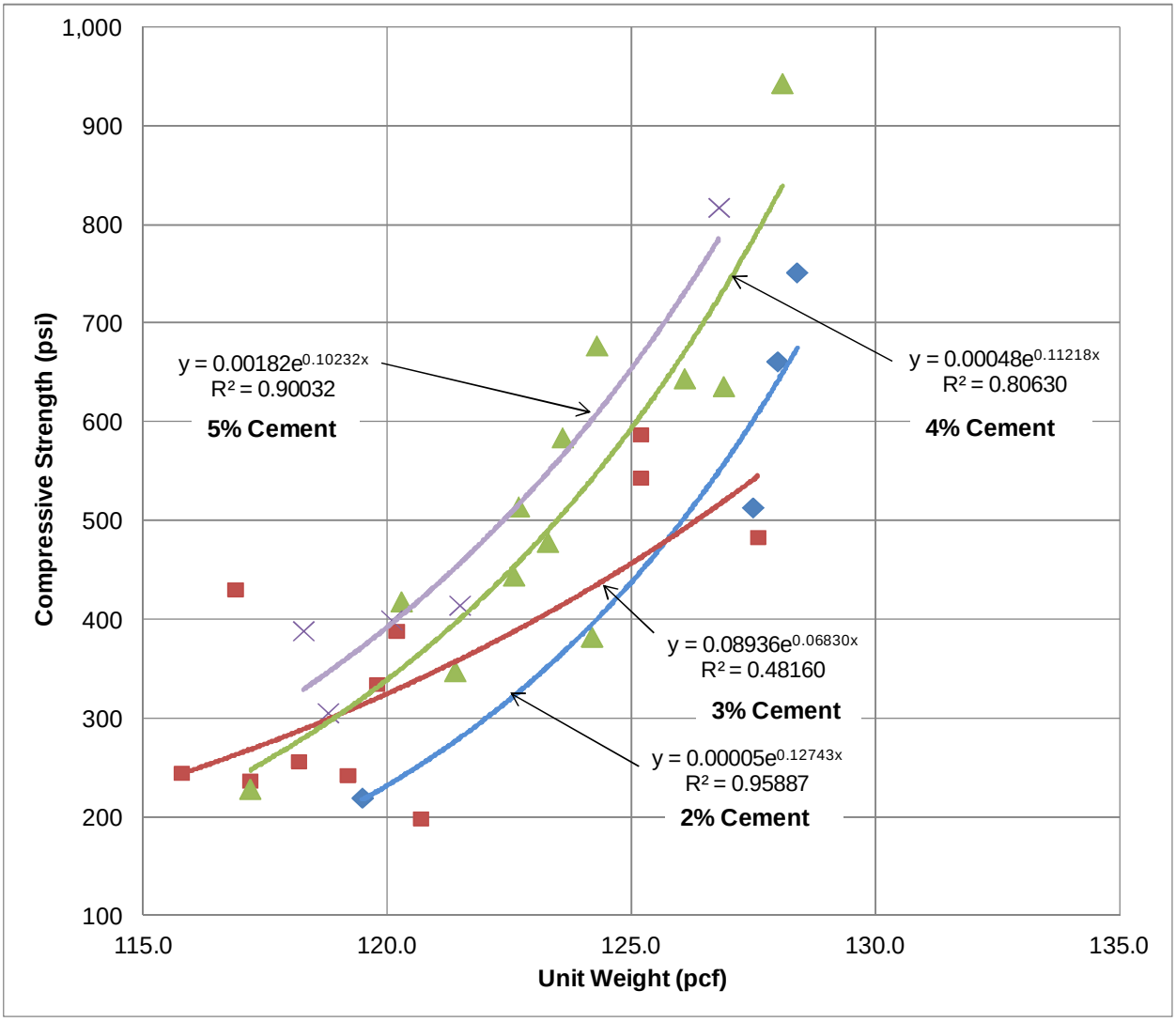


Figure 27 - Compressive Strength VS Cement Content and Unit Weight

Table 19 - Summary of Outliers

Core Location	Reason For Outlier
25-1D	Lack of data due to shrinkage crack.
84-2A	High unit weight.
84-2C	High unit weight.
84-2D	Deep grooves in core from coring operations.
84-3A	Lack of data due to low cement content.
84-3C	Lack of data due to low cement content.
84-4B	High cement content and high compressive strength.
84-5C	Lack of data due to low cement content.

Table 20 - Cement Content Categories

Cement Content Category (%)	Range of Cement Contents (%)
2	$1.85 \leq X \leq 2.50$
3	$2.50 < X \leq 3.50$
4	$3.50 < X \leq 4.50$
5	$4.50 < X \leq 5.25$

Variability is found in each data set and is described using coefficient of variability (C_v). A summary of C_v for thickness, unit weight, cement content and compressive strength is presented in Table 21. Higher C_v values indicate poor methods of construction and poor quality control. Lower values indicate good methods of construction and quality control.

C_v values show that much effort is being applied to unit weight or compaction in constructing cement-treated layers. Good construction practices and good quality control are associated with compaction. However, C_v values of all other properties including thickness, cement content and compressive strength indicate poor methods of construction and poor quality control.

Table 21 - Summary of Coefficient of Variability (C_v)

Highway No.	Property	Coefficient of Variability (C_v)
84	Thickness	18.2
25	Thickness	10.4
84	Unit Weight	5.0
25	Unit Weight	2.3
84	Overall Cement Content	48.9
25	Overall Cement Content	21.1
84	Compressive Strength	27.3
25	Compressive Strength	34.7

Chapter 7 – Conclusions and Recommendations

Conclusions

Conclusions and recommendations are based on data sets generated from this research. These conclusions and recommendations may not be applicable for cement-treated bases constructed with any other sources of materials or other mixture proportions than those used in this research.

Data in this research show a significant correlation between compaction effort and compressive strength of cement-treated layers. A 15 percent change in strength can be expected with each 1 percent change in measured density. These data also show that a 1 percent change in cement content results in a 13 percent change in in-place compressive strength. Compaction and cement content are two critical factors influencing the in-place compressive strength of cement-treated bases. Compaction is the primary construction process that influences strength.

Variability is found in each data set and ranges from 2.3 percent for unit weight up to 48.9 percent for cement content. Coefficient of variability (C_v) values show that much focus is given to compaction and compaction testing of cement-treated bases during construction. However, high C_v values show that methods of construction and quality control testing needs to be improved for thickness, cement content and compressive strength of cement-treated bases.

Recommendations

We recommend that cement-treated bases be compacted to a minimum of 98 percent of maximum standard dry density. This includes all individual tests within a lot. This

is because compaction is the primary property that influences compressive strength and small changes in compaction causes large changes in strength.

We recommend that quality control procedures be enhanced for measuring thickness of the cement-treated bases. Quality control for thickness should include GPS and/or surveying equipment capable of accurately measuring location and elevation. Data points of the underlying layer need to be established before construction of the cement-treated base begins. This same equipment should be used to determined elevation of the surface of the compacted cement-treated base. The difference between these two elevations will provide for accurate thickness determination for quality control.

We recommend cement content of cement-treated layers be specified as percent by mass in lieu of percent by volume. Percent by volume is a constant amount of cement and does not account for changes in density of the material. Therefore, when density increases less cement is provided per pound of untreated granular material effectively diluting the cement. Specifying cement content by mass will allow adjustments for variability in soil properties.

We recommend that compressive strength should be part of a quality control program for cement-treated bases. This can be accomplished by testing cores drilled from the base as documented in this research. Nondestructive testing such as the Clegg impact soil hammer has also been found useful in estimating in-situ compressive strengths of cement-treated bases (4).

Research Opportunities

1. As seen in Figures 10 and 11, the L/D ratio can significantly impact the actual strength of molded cement-treated specimens, and should be accounted for when sawed cores give L/D ratios less than 1.15. If sawed cores are used to measure in-situ compressive strength of cement-treated layers for acceptance or quality control, a more detailed study into the effects of L/D ratio on compressive strength should be performed to evaluate the potential impacts of material type, cement content and L/D ratio on the measured compressive strength values. This study should be managed in a laboratory environment where the cement content, material uniformity and various specimen lengths can be better managed rather than field mixed cement-treated materials.
2. The impact of capping cement-treated specimens should also be investigated. As part of the L/D ratio study performed by BCD, duplicate specimens were made and broken at 14 days curing with two samples capped and two samples tested without capping. The capped specimens provided an approximate 30 percent increase in compressive strength. The effects of not capping or capping cored cement-treated specimens could significantly affect the strength.
3. Variability of cement content in road mixed cement-treated bases should be reduced. Field studies can be performed using variations in methods of spreading the cement on the surface and methods of mixing. Chemical analysis as performed in this research could then be performed on the hardened cement-treated layer to determine which methods produce the least amount of variability.
4. Using nondestructive tests to estimate the in-situ compressive strength of cement-treated bases may be useful for quality control testing. A study should be performed to evaluate

the usefulness of the Clegg impact soil tester in estimating the in-situ compressive strength of cement-treated bases.

References

1. Wayne S. Adaska and David R, Luhr. “Control of Reflective Cracking in Cement Stabilized Pavements.” Portland Cement Association.
2. Steven H. Kosmatka, Beatrix Kerkhoff, and William C. Panarese. “Design and Control of Concrete Mixtures,” 14th Edition – Portland Cement Association.
3. K.P. George. “Soil Stabilization Field Trial Interim Report I” – Department of Civil Engineering, University of Mississippi.
4. Paul A. Okamoto, Brian T. Bock, and Peter J. Nussbaum. “Nondestructive Tests for Determining Compressive Strength of Cement Stabilized Soils” – Transportation Research Record No 1295 - 1991

APPENDIX A

MDOT PROJECT SPECIFICATIONS FOR

CEMENT-TREATED BASE

PROVIDED BY MDOT

Highway 84 – Specified Design

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
STANDARD DENSITY TEST DATA
(M-T-8) (M-T-9) (AASHTO T134) (AASHTO T180)

Contract ID CNH001502115 Fed/State Proj. # 102921301000 FMS Proj. # NH-0015-02(115)PH3
LAB ID CL003 Curve (Sample) ID 051730RGA0150
Revising Sample Number Date Sampled 2005-10-14 Date Completed 2005-11-02
Material Code 070300092 Material Description GRAN MTL CL 9 GP C Sample Test Number 1 Test Method ID FSL211m
Source and Location Technician L. SMITH
Component of Structure:

Treatment: Lime - % By Dry Weight: 1st Application RAW 2nd Application
Cement - % By Volume LIME /FLYASH % LIME % FLY ASH

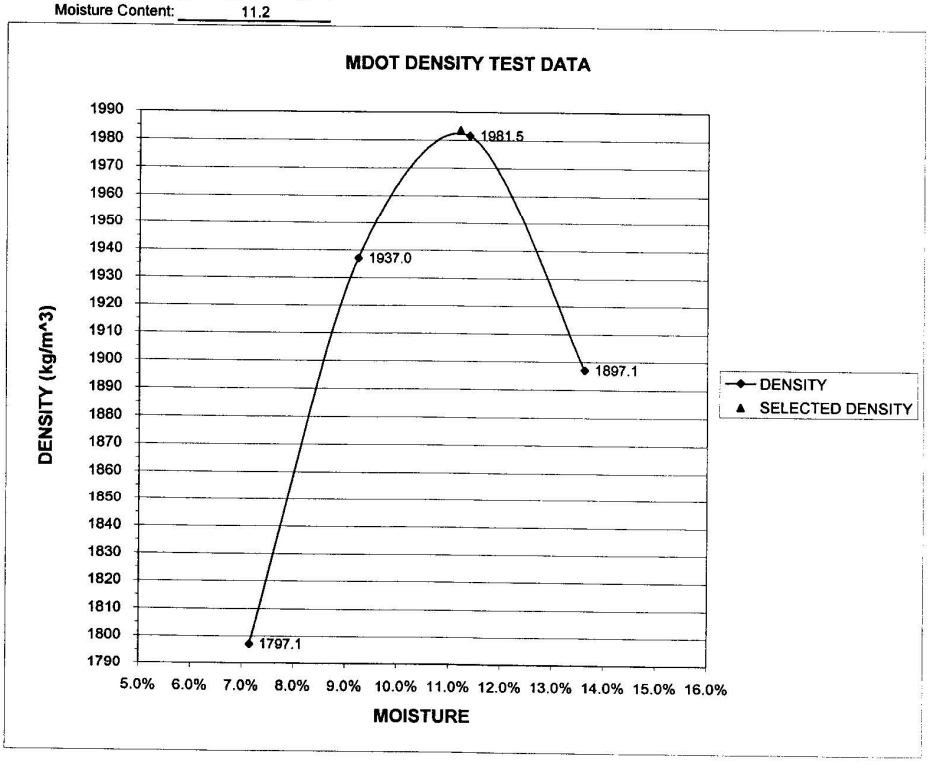
Mold Used: No. 1 Weight of Mold 1948.6 grams Volume of Mold 943.8 (Cu. cm)
Tested Under: Case 1 X Case 2 REMARKS
REMARKS
REMARKS

Trial No.	Wet Wt Soil & Mold (Grams)	Wet Wt Soil (Grams)	Moisture Determination					Dry Weight (Grams)	Dry Density (kg/m^3)
			Weight of Dish (Grams)	Wt. Wet Soil & Dish (Grams)	Wt. Dry Soil & Dish (Grams)	Loss (Grams)	Moisture Content		
1	3766	1817.4	66.6	191.0	182.7	8.3	7.1%	1696.1	1797.1
2	3945.5	1996.9	63.3	192.3	181.4	10.9	9.2%	1828.2	1937.0
3	4031.7	2083.1	68.8	190.1	177.7	12.4	11.4%	1870.2	1981.5
4	3983.1	2034.5	67.8	221.2	202.8	18.4	13.6%	1790.5	1897.1
5									

Enter Point Selected From Chart Below For (-) 1/2 Material
Std. Density: 1983.5
% Moisture: 11.2

(+) 1/2" Material
% of +1/2" Matl.:
Bulk Specific Gravity of +1/2" Matl:

Results of Total Sample
Standard Density kg^m3): 1983.5
Moisture Content: 11.2



Signed

Title

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District (As Instructed)

Highway 84 – Specified Design

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

STANDARD DENSITY TEST DATA

(M-T-8) (M-T-9) (AASHTO T134) (AASHTO T180)

Contract ID CNH001502115 Fed/State Proj 102921301000 FMS Proj. # NH-0015-02(115)PH3

LAB ID CL003 Curve (Sample) 051730RGA0150

Revising Sample Number Date Sampled 2005-10-14 Date Completed 2005-11-08

Material Code 070300092 Material Descri GRAN MTL CL 9 GP C Sample Test Number 2 Test Method ID FSL211m

Source and Location Technician LSMITH

Component of Structure:

Treatment: Lime - % By Dry Weight: 1st Application 2nd Application

Cement - % By Volume 5.0 LIME /FLYASH % LIME % FLY ASH

Mold Used: N 1 Weight of Mold 1948.5 grams Volume of Mold 943.8 (Cu. cm)

Tested Under: Case 1 Case 2 REMARKS

REMARKS

REMARKS

Trial No.	Wet Wt Soil & Mold (Grams)	Wet Wt Soil (Grams)	Moisture Determination					Dry Weight (Grams)	Dry Density (kg/m^3)
			Weight of Dish (Grams)	Wt. Wet Soil & Dish (Grams)	Dry Soil & Di (Grams)	Loss (Grams)	Moisture Content		
1	3716.7	1768.2	66.6	192.6	184.5	8.1	6.9%	1654.5	1753.1
2	3872.5	1924.0	67.6	193.2	183.4	9.8	8.5%	1773.9	1879.5
3	3999.8	2051.3	67.1	188.7	177.2	11.5	10.4%	1857.3	1967.9
4	4016.4	2067.9	66.1	250.8	230.3	20.5	12.5%	1838.4	1947.9
5									

Enter Point Selected From Chart Below For (-) 1/2 Material

Std. Density: 1968.5

% Moisture: 10.8

(+) 1/2" Material

% of +1/2" Matl.:

Bulk Specific Gravity of +1/2" Matl:

Results of Total Sample

Standard Density kg^m3): 1968.5

Moisture Content: 10.8

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Title_____

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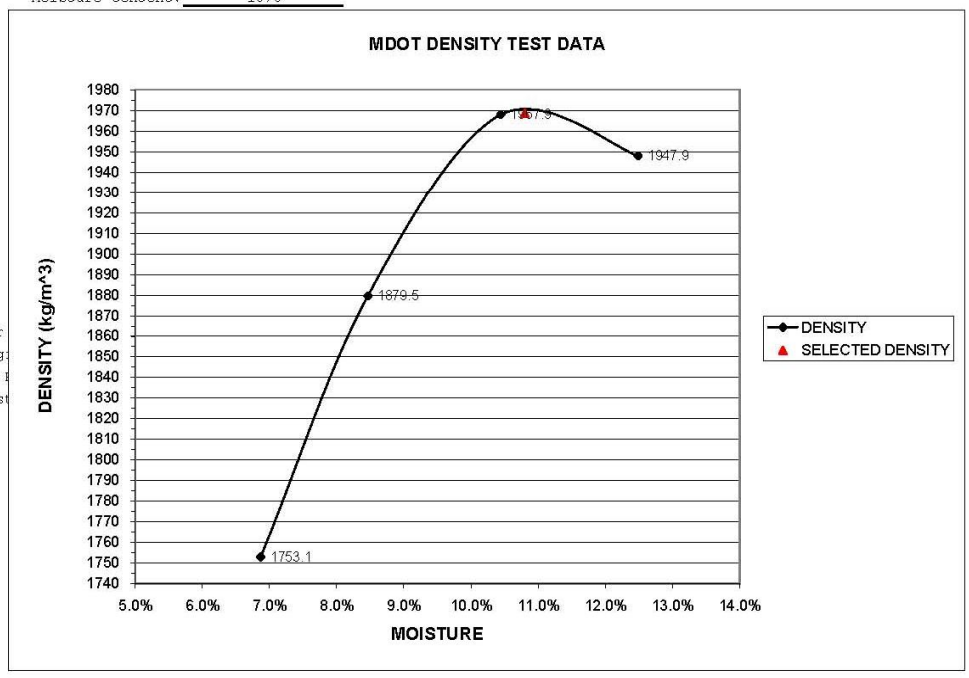
State Materials I

District (As Inst



Highway 25 – Specified Design

TMD-690cg -- MISSISSIPPI DEPT OF TRANSPORTATION - MATERIALS DIV --
SOIL ANALYSIS / DESIGN REPORT SEP 30 2003

Test	Code	Fund	Accnt	Func	Obj	Detail Code	Par	Quantity
				Cost Distribution				
0	101			154	846	00 0000 00 251 7 0	1	1.0

MDOT Lab Number: 9804564 Accept Code: 1 Responsibility Code: 00
Mtl: AGGR GRAN MTL CL 9 GP C Qty: 0.0
Project: 102674-301000 SDP-0056-01(076)P County: WINSTON
Producer: HILL BROTHER CONST CO Address: MS
Manufacturer: NOT SUPPLIED Address: (?),
Sampled By: - FRANKS Samp Id: 3 OF 3 Date: 09/02/2003
Submitted By: DISTRICT 1 LAB ~ (11-30) Date: 09/17/2003
Reported To: PROJECT ENGINEER 11-11 MARVIN O. VANDERFORD Date: 09/30/2003
Intended Use: SOIL CEMENT MIX DESIGN Test Desired: USUAL
Remarks: JOB CONTROL SAMPLE.
TEMP NO. 1

Total Sample Mass, g 4482.0

SIEVE ANALYSIS

P/F	Sieve Size	Mass Ret	%Pass	Mass Basis	Min	Max
_	2''					
_	1 3/4''					
_	1 1/2''					
_	1''					
_	1/2''					
_	#4					
_	#10				30	100
P	Pass#10	50.00	100	100		100
P	#40	10.46	79	79	20	100
P	#60	18.27	43	43	15	85
P	#200	7.79	27	27	6	40
_	#270		27			
_	%Silt		6			
_	%Clay		21			

P/F	Test	Result	Min	Max
	Colloids			
	Dust Ratio	34.09		
P	Liquid Limit	22		30
	Plastic Limit	15		
P	Plasticity Indx	7		10
	Shrinkage Limit	15		
	Shrinkage Ratio	1.77		
_	Volume Change	15		
	Sp Grav(-)#10	2.678		
	Sp Grav(+)1/2''			

CLASSIFICATION
U.S.C. SM-SC
AASHTO A-2-4
_ Group Index 0

MICA
X None _ Slight
_ Medium _ Heavy
VEG MATTER
X None _ Slight
_ Medium _ Heavy
pH ____

RECOMMENDED DESIGN DATA
See Memo Dated 09/30/2003
% Cement by Vol 4.0
% Lime by Mass ____
% Fly Ash by Mass ____

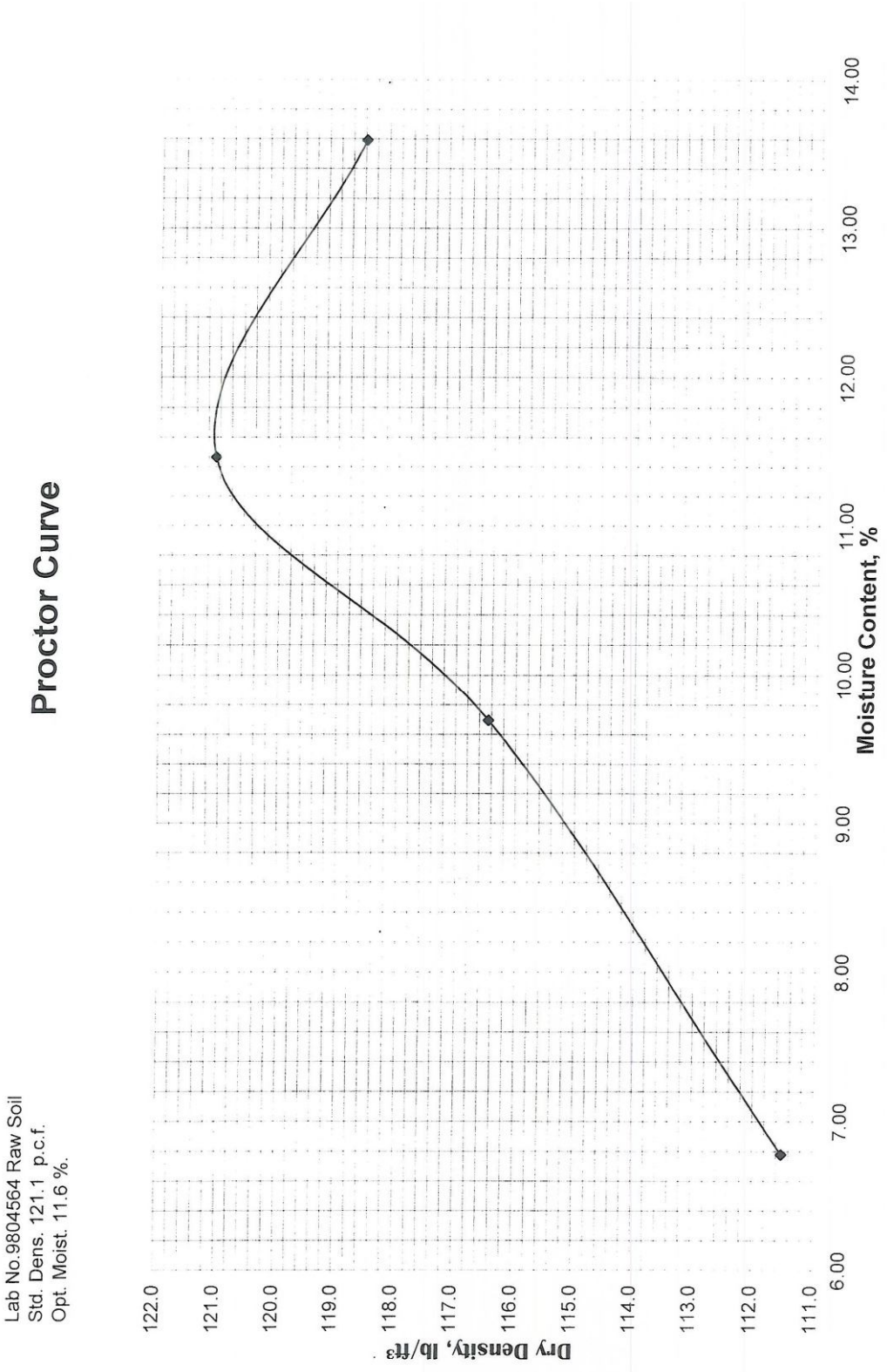
MOISTURE - DENSITY RELATIONSHIP
RAW SOIL
Optimum Moisture, % 11.6
Std Dens, lbs/cu ft 121.1
% Ret 1/2'' Sieve ____
Corr Std Density ____

TEST METHODS: Sample Prep (T87), Particle Size (T27,88 or MT23,23), LL (T89), PI (T90), Shrinkage (T92), Moist/Dens (T99, 134, or MT8,9), Sp Grav (T100), Classification (M145), Soil-Cement Design (MT25), Compressive Str (MT-26), Soil-Lime Design (MT27, T193)
NOTE: Optional Methods To Be Used For State Projects

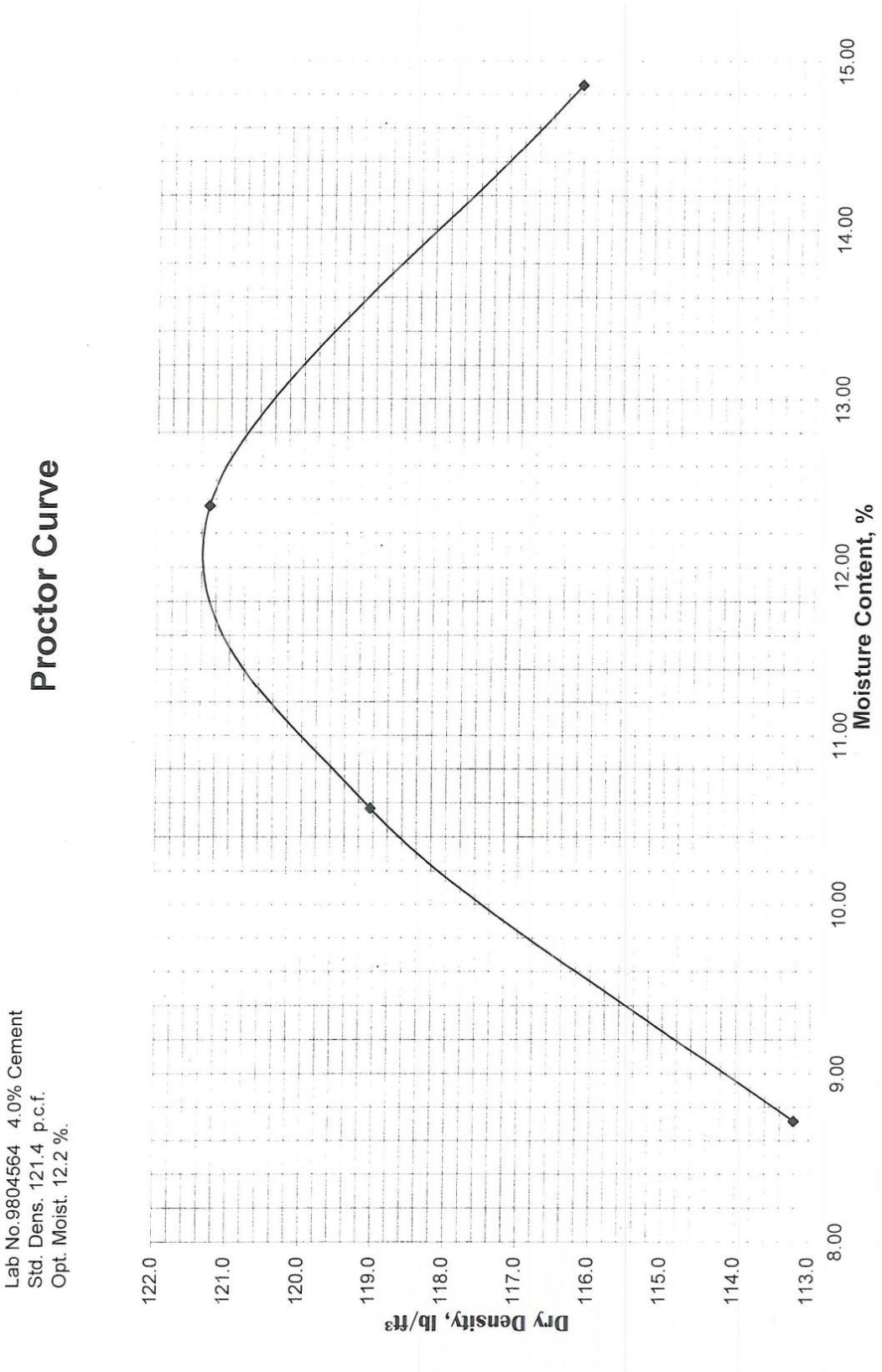
Remarks: USE 4.0% CEMENT BY VOLUME 14 DAYS CURING
Remarks
USE 4.0% CEMENT BY VOLUME 14 DAYS CURING
Mtl DOES meet the requirements of Section 703-8 {GRAN MTL 9/C}
Tested By SOILS LAB-RANDY DIXON

** SAMPLE ACCEPTED **

Highway 25 – Specified Design



Highway 25 – Specified Design



APPENDIX B

LABORATORY MIXTURES

FOR L/D CORRECTION FACTOR DETERMINATION

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 122.3 Optimum Moisture = 11.5

Unit Weight	14 day Capped		14 day Uncapped		32 day 6"			32 day 5.5"		
Weight of Mold + Soil	4146.5	4146.7	4140.8	4144.0	30.178	30.152	30.181	30.182	30.194	30.174
Weight of Mold	2083.4	2083.4	2083.4	2083.4	16.878	16.878	16.878	16.878	16.878	16.878
Wet Unit Weight	137.0	137.0	136.6	136.8	136.9	136.6	136.9	136.9	137.0	136.8
Dry Unit Weight	123.0	123.0	122.9	123.1	122.9	122.7	122.9	123.1	123.3	123.1
Percent Compaction	100.6	100.6	100.5	100.7	100.5	100.3	100.5	100.6	100.8	100.7
Average Compaction	100.6		100.6		100.4			100.7		
Moisture Content	14 day Capped		14 day Uncapped		32 day 6"			32 day 5.5"		
Wet Weight + Tare	242.3		229		252.3	219.5	272.5	253.3	236.2	264.1
Dry Weight + Tare	221.1		209.6		230	200.5	248.2	231.1	216	241
Weight of Tare	33.8		34.7		33.7	33.4	34.3	33.7	34.3	33.8
Moisture Content	11.3	11.3	11.1	11.1	11.4	11.4	11.4	11.2	11.1	11.1
Avg. Moisture Content	11.3		11.1		11.4			11.2		
Unconfined	14 day Capped		14 day Uncapped		32 day 6"			32 day 5.5"		
Load (lbs)	5321	5451	4277	4125	15046	14535	14074	16204	16493	16273
PSI	420	430	333	325	536	519	502	578	588	578
Actual Length	4.751	4.788	4.554	4.553	6.249	6.264	6.263	5.819	5.838	5.785
Actual Diameter	4.017	4.019	4.045	4.017	5.976	5.973	5.976	5.975	5.975	5.987
L/D	1.183	1.191	1.126	1.133	1.046	1.049	1.048	0.974	0.977	0.966
Average L/D	1.187		1.130		1.047			0.972		
Average PSI	424.8		329.2		519.0			581.4		

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 119.2 Optimum Moisture = 12.2

Unit Weight	32 day 5"			32 Day 4.5"			32 Day 4"		
Weight of Mold + Soil	30.170	30.189	30.212	30.198	30.219	30.244	30.217	30.243	30.225
Weight of Mold	16.878	16.878	16.878	16.878	16.878	16.878	16.878	16.878	16.878
Wet Unit Weight	136.8	137.0	137.2	137.1	137.3	137.6	137.3	137.5	137.4
Dry Unit Weight	122.8	123.3	123.6	123.7	124.3	124.3	123.6	123.9	123.8
Percent Compaction	100.4	100.8	101.1	101.2	101.6	101.6	101.1	101.3	101.3
Average Compaction	100.8			101.5			101.2		
Moisture Content	32 day 5"			32 Day 4.5"			32 Day 4"		
Wet Weight + Tare	231.1	267.8	259.6	247.7	231.7	222.2	272.4	237.9	228.5
Dry Weight + Tare	211	244.3	237.3	226.9	212.9	203.9	248.7	217.8	209.4
Weight of Tare	34.2	32.4	34.7	34.2	33.4	32.6	33.8	34.8	34.3
Moisture Content	11.4	11.1	11.0	10.8	10.5	10.7	11.0	11.0	10.9
Avg. Moisture Content	11.2			10.7			11.0		
Unconfined	32 day 5"			32 Day 4.5"			32 Day 4"		
Load (lbs)	15224	16418	16444	20433	22615	22016	19695	19095	20135
PSI	544	586	586	729	807	784	704	681	718
Actual Length	5.313	5.233	5.396	4.729	4.721	4.718	4.285	4.195	4.218
Actual Diameter	5.97	5.972	5.977	5.974	5.975	5.981	5.967	5.976	5.975
L/D	0.890	0.876	0.903	0.792	0.790	0.789	0.718	0.702	0.706
Average L/D	0.890			0.790			0.709		
Average PSI	572.0			773.0			701.1		

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 119.2 Optimum Moisture = 12.2

Unit Weight	32 Day 3.5"		
Weight of Mold + Soil	30.160	30.147	30.172
Weight of Mold	16.878	16.878	16.878
Wet Unit Weight	136.7	136.6	136.8
Dry Unit Weight	123.1	122.7	123.2
Percent Compaction	100.6	100.3	100.7
Average Compaction	100.6		
Moisture Content	32 Day 3.5"		
Wet Weight + Tare	298.9	277.6	225
Dry Weight + Tare	272.8	252.9	206
Weight of Tare	36.5	34.5	33.8
Moisture Content	11.0	11.3	11.0
Avg. Moisture Content	11.1		
Unconfined	32 Day 3.5"		
Load (lbs)	15721	16849	15556
PSI	558	602	552
Actual Length	3.745	3.693	3.723
Actual Diameter	5.989	5.969	5.988
L/D	0.625	0.619	0.622
Average L/D	0.622		
Average PSI	570.9		

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 122.3 Optimum Moisture = 11.5

Unit Weight	32 day 6"			32 day 5.5"			32 day 5"		
Weight of Mold + Soil	30.055	30.037	30.070	30.077	30.080	30.095	30.118	30.097	30.073
Weight of Mold	16.874	16.874	16.874	16.874	16.874	16.874	16.874	16.874	16.874
Wet Unit Weight	135.6	135.5	135.8	135.9	135.9	136.1	136.3	136.1	135.8
Dry Unit Weight	121.3	121.0	121.2	121.3	122.1	121.9	122.3	121.9	121.5
Percent Compaction	99.2	99.0	99.1	99.2	99.8	99.7	100.0	99.7	99.4
Average Compaction	99.1			99.6			99.7		
Moisture Content	32 day 6"			32 day 5.5"			32 day 5"		
Wet Weight + Tare	282.9	260.8	238.7	221.1	265.3	227.8	284	251.5	272.3
Dry Weight + Tare	256.5	236.7	216.9	201	241.8	207.7	258.3	228.8	247.2
Weight of Tare	32.5	34.5	36.5	33.8	34.1	34.4	33.7	33.2	34.3
Moisture Content	11.8	11.9	12.1	12.0	11.3	11.6	11.4	11.6	11.8
Avg. Moisture Content	11.9			11.6			11.6		
Unconfined	32 day 6"			32 day 5.5"			32 day 5"		
Load (lbs)	11210	10500	10670	11560	13040	13470	14380	13540	13110
PSI	398	373	379	410	463	478	510	480	465
Actual Length	6.348	6.397	6.381	5.823	5.855	5.825	5.343	5.373	5.319
Actual Diameter	5.990	5.990	5.990	5.990	5.990	5.990	5.990	5.990	5.990
L/D	1.060	1.068	1.065	0.972	0.977	0.972	0.892	0.897	0.888
Average L/D	1.064			0.974			0.892		
Average PSI	383			450			485		

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 119.2 Optimum Moisture = 12.2

Unit Weight	32 Day 4.5"			32 Day 4"			32 Day 3.5"		
Weight of Mold + Soil	30.034	30.107	30.073	30.039	30.075	30.061	30.062	30.084	30.098
Weight of Mold	16.874	16.874	16.874	16.874	16.874	16.874	16.874	16.874	16.874
Wet Unit Weight	135.4	136.2	135.8	135.5	135.9	135.7	135.7	135.9	136.1
Dry Unit Weight	120.6	121.7	121.4	121.0	121.4	121.4	121.2	121.6	121.8
Percent Compaction	98.6	99.5	99.3	98.9	99.3	99.2	99.1	99.4	99.6
Average Compaction	99.1			99.1			99.4		
Moisture Content	32 Day 4.5"			32 Day 4"			32 Day 3.5"		
Wet Weight + Tare	236.5	262.2	256.2	255.1	266.3	277.5	279.2	268.8	275.9
Dry Weight + Tare	214.4	238.2	232.6	231.3	241.6	251.8	252.9	244	250.4
Weight of Tare	34.5	36.8	33.8	33.1	33.7	34.3	33.5	34.4	33.1
Moisture Content	12.3	11.9	11.9	12.0	11.9	11.8	12.0	11.8	11.7
Avg. Moisture Content	12.0			11.9			11.9		
Unconfined	32 Day 4.5"			32 Day 4"			32 Day 3.5"		
Load (lbs)	12531	14053	14460	12910	13760	13391	12280	12769	13530
PSI	446	501	515	460	489	476	427	450	473
Actual Length	4.910	4.867	4.906	4.360	4.260	4.339	3.752	3.789	3.760
Actual Diameter	5.980	5.978	5.982	5.979	5.984	5.983	6.053	6.011	6.035
L/D	0.821	0.814	0.820	0.729	0.712	0.725	0.620	0.630	0.623
Average L/D	0.818			0.722			0.624		
Average PSI	487			475			450		

BCD Project No.: 090595 Project Name: State Study 227 - Variability of Cement Treated Layers in MDOT Road Projects

Effect of L/D on Unconfined Compressive Strength

Proctor Info: Max Dry Density 119.2 Optimum Moisture = 12.2

Unit Weight	32 Day 3"		
Weight of Mold + Soil	30.039	30.020	30.023
Weight of Mold	16.874	16.874	16.874
Wet Unit Weight	135.5	135.3	135.3
Dry Unit Weight	121.0	120.7	120.8
Percent Compaction	99.0	98.7	98.8
Average Compaction	98.8		
Moisture Content	32 Day 3"		
Wet Weight + Tare	298.4	289.5	294.0
Dry Weight + Tare	270.2	261.7	266.0
Weight of Tare	33.9	32.3	33.1
Moisture Content	11.9	12.1	12.0
Avg. Moisture Content	12.0		
Unconfined	32 Day 3"		
Load (lbs)	13685	13400	12560
PSI	479	464	448
Actual Length	3.295	3.316	3.356
Actual Diameter	6.029	6.062	5.973
L/D	0.547	0.547	0.562
Average L/D	0.552		
Average PSI	464		

APPENDIX C

RAW DATA

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84 **BCD Job Number** 090595

Row No. 1

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.008	5.044	5.019
	KMNO4 required to titrate (0.1 ml)		0.5	1.3	0.8
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.009	1.004
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.06	0.28	0.14

Average CaO Content of Virgin Soil, % 0.16

Highway No. 84
Core No. 1A

Top

Side

Bottom

Pavement Thicknesses

Surface Layer (in):	**2.00**	
Second Layer (in):	**4.50**	Asphalt
Third Layer (in):	**3.50**	Thickness
Fourth Layer (in):	**0.00**	**10.00**
Drainage Layer (in):	**4.50**	
Soil Cement (in):	**5.3**	

Soil Cement Core Properties

Avg Cement Content Top (%):	**3.85**
Avg Cement Content Bottom (%):	**5.06**
Avg Cement Content (%):	**4.46**
Unit Weight (lbs/ft^3):	**122.6**
Moisture Content (%):	**11.14**
Compressive Strength (psi):	**445**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 1A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	4.50	6.50
3rd Layer	3.50	10.00
4th Layer		10.00
ADC Layer	4.50	14.50
Soil Cement Layer	5.3	19.80

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.867	4.760	4.880	5.191
2	5.861	5.207	4.889	5.192
3	5.857	5.370	4.931	5.181
4		5.360		
5		5.809		
Average (in.)	5.862	5.3	4.900	5.188

Compressive Strength		
Test Date	8/17/2010	L/D Ratio
Correction Factor	0.81	0.885
Area ($in.^2$)	26.986	
Load (lbs)	14,806	
Compressive Strength (psi)	549	
Corrected Strength (psi)	445	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/17/2010
Weight (.1 g)	4281.0
Weight (lbs)	9.44
Volume ($in.^3$)	132.229
Volume ($ft.^3$)	0.077
Unit Weight (lbs/ft^3)	122.6

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 1A

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.16

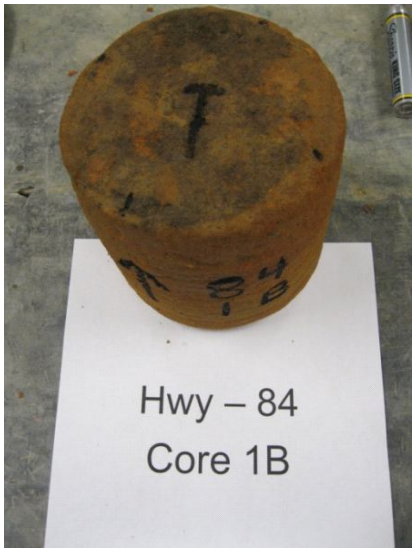
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	A12	A2	L	N	I	DE
	Wet Wt. + Tare (0.01)		961.90	852.90	811.00	858.60	789.70	984.20
	Dry Wt. + Tare (0.01 g)		894.40	797.60	757.40	797.70	724.40	907.10
	Tare Wt. (0.01 g)		264.60	251.70	246.20	260.80	185.00	266.70
	Wt of Dry Sample		629.80	545.90	511.20	536.90	539.40	640.40
	Wt of Water		67.50	55.30	53.60	60.90	65.30	77.10
	Water Content, %		10.72	10.13	10.49	11.34	12.11	12.04
	Average Moisture Content, %		10.44			11.83		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.026	5.029	5.040	5.065	5.066	5.009
	KMNO4 required to titrate (0.1 ml)		9.0	10.8	9.4	13.0	12.5	12.2
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.006	1.008	1.013	1.013	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.42	2.92	2.53	3.51	3.37	3.33
	% Cement by Mass of Soil	N/A	3.54	4.31	3.70	5.23	5.02	4.94

Average % Cement Top: 3.85

Average % Cement Bottom: 5.06

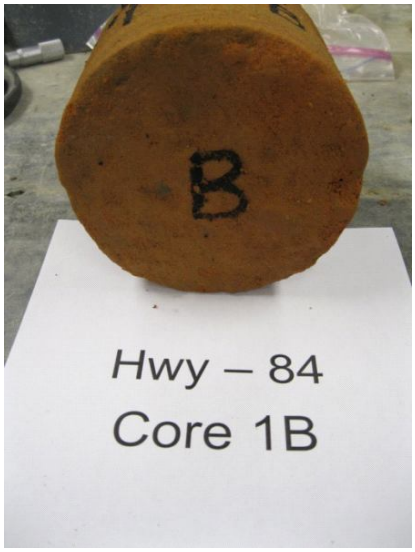
Overall Average Cement Content, %: 4.46

Highway No. 84
Core No. 1B



Top

Side



Bottom

Pavement Thicknesses			**Soil Cement Core Properties**	
Surface Layer (in):	**2.00**		Avg Cement Content Top (%):	**5.06**
Second Layer (in):	**2.25**	Asphalt	Avg Cement Content Bottom (%):	**3.05**
Third Layer (in):	**2.00**	Thickness	Avg Cement Content (%):	**4.06**
Fourth Layer (in):	**2.00**	**8.25**	Unit Weight (lbs/ft³):	**124.3**
Drainage Layer (in):	**2.50**		Moisture Content (%):	**10.67**
Soil Cement (in):	**6.0**		Compressive Strength (psi):	**678**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 1B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	2.25	4.25
3rd Layer	2.00	6.25
4th Layer	2.00	8.25
ADC Layer	2.50	10.75
Soil Cement Layer	6.0	16.75

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.840	5.880	5.365	5.669
2	5.850	6.026	5.384	5.760
3	5.863	6.026	5.355	5.654
4		5.880		
5		6.071		
Average (in.)	5.851	6.0	5.368	5.694

Compressive Strength		
Test Date	8/17/2010	L/D Ratio
Correction Factor	0.89	0.973
Area ($in.^2$)	26.887	
Load (lbs)	20,475	
Compressive Strength (psi)	762	
Corrected Strength (psi)	678	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/17/2010
Weight (.1 g)	4734.0
Weight (lbs)	10.44
Volume ($in.^3$)	144.332
Volume ($ft.^3$)	0.084
Unit Weight (lbs/ft^3)	124.3

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 1B

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.16

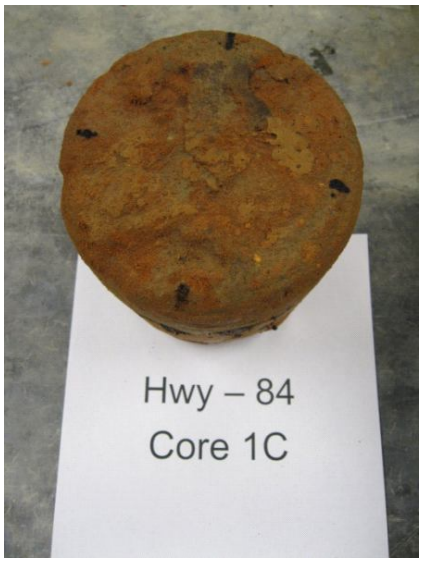
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	X	XY	A	F	N8	B
	Wet Wt. + Tare (0.01)		883.60	930.00	1193.80	984.90	1027.90	932.40
	Dry Wt. + Tare (0.01 g)		819.60	859.90	1093.90	920.30	956.90	871.90
	Tare Wt. (0.01 g)		244.90	253.80	244.00	262.60	244.40	253.40
	Wt of Dry Sample		574.70	606.10	849.90	657.70	712.50	618.50
	Wt of Water		64.00	70.10	99.90	64.60	71.00	60.50
	Water Content, %		11.14	11.57	11.75	9.82	9.96	9.78
	Average Moisture Content, %		11.49			9.86		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.016	5.016	5.032	5.039	5.032	5.041
	KMNO4 required to titrate (0.1 ml)		12.5	12.5	12.5	8.3	7.1	8.3
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.003	1.003	1.006	1.008	1.006	1.008
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.41	3.41	3.40	2.22	1.89	2.22
	% Cement by Mass of Soil	N/A	5.07	5.07	5.05	3.22	2.71	3.22

Average % Cement Top 5.06

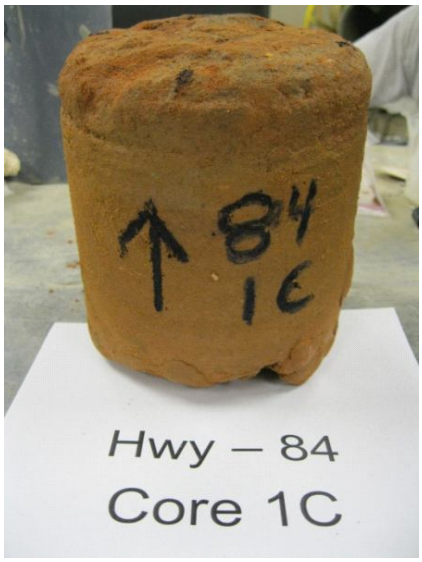
Average % Cement Bottom 3.05

Overall Average Cement Content, % 4.06

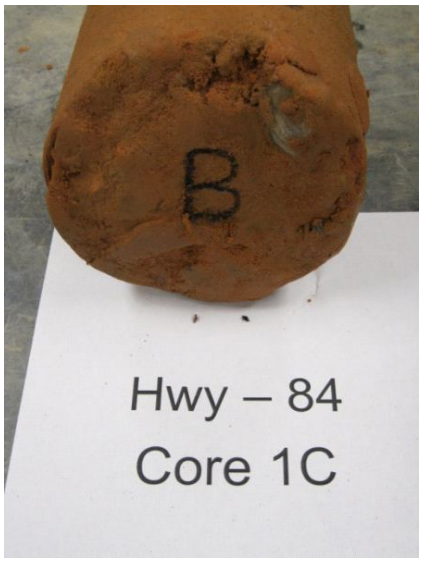
Highway No. 84
Core No. 1C



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**1.75**	Thickness
Fourth Layer (in):	**1.75**	**7.00**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**6.7**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**5.91**
Avg Cement Content Bottom (%):	**4.59**
Avg Cement Content (%):	**5.25**
Unit Weight (lbs/ft³):	**126.8**
Moisture Content (%):	**9.86**
Compressive Strength (psi):	**818**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 1C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	1.75	5.25
4th Layer	1.75	7.00
ADC Layer	4.00	11.00
Soil Cement Layer	6.7	17.70

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.925	6.115	5.038	5.325
2	5.902	6.570	5.072	5.329
3	5.929	7.050	5.002	5.342
4		6.810		
5		6.853		
Average (in.)	5.919	6.7	5.037	5.332

Compressive Strength		
Test Date	8/17/2010	L/D Ratio
Correction Factor	0.82	0.901
Area ($in.^2$)	27.513	
Load (lbs)	27,433	
Compressive Strength (psi)	997	
Corrected Strength (psi)	818	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/17/2010
Weight (.1 g)	4597.5
Weight (lbs)	10.14
Volume ($in.^3$)	138.592
Volume ($ft.^3$)	0.080
Unit Weight (lbs/ft^3)	126.8

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 1C

CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.16

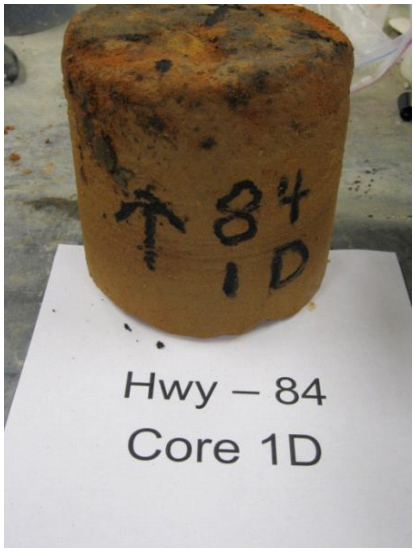
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	C	BO	D	X	A12	N
	Wet Wt. + Tare (0.01)		1168.20	937.60	750.30	999.20	951.60	869.30
	Dry Wt. + Tare (0.01 g)		1064.30	869.90	699.60	940.20	899.00	821.90
	Tare Wt. (0.01 g)		180.70	249.00	249.50	244.90	264.00	260.60
	Wt of Dry Sample		883.60	620.90	450.10	695.30	635.00	561.30
	Wt of Water		103.90	67.70	50.70	59.00	52.60	47.40
	Water Content, %		11.76	10.90	11.26	8.49	8.28	8.44
	Average Moisture Content, %		11.31			8.40		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.042	5.040	5.040	5.020	5.025	5.007
	KMNO4 required to titrate (0.1 ml)		14.3	13.2	16.0	10.1	11.8	12.3
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.008	1.008	1.008	1.004	1.005	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.89	3.58	4.36	2.73	3.20	3.36
	% Cement by Mass of Soil	N/A	5.82	5.35	6.56	4.02	4.75	4.99

Average % Cement Top 5.91 Average % Cement Bottom 4.59

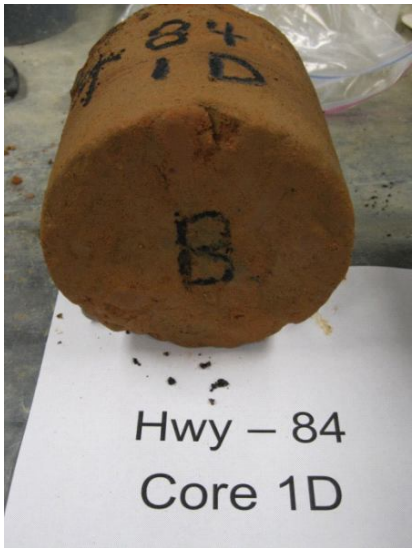
Overall Average Cement Content, % 5.25

Highway No. 84
Core No. 1D

Top



Side



Bottom

Pavement Thicknesses			
Surface Layer (in):	**2.00**		
Second Layer (in):	**1.50**	Asphalt	
Third Layer (in):	**2.50**	Thickness	
Fourth Layer (in):	**2.00**	**8.00**	
Drainage Layer (in):	**3.00**		
Soil Cement (in):	**6.2**		

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.59**
Avg Cement Content Bottom (%):	**3.01**
Avg Cement Content (%):	**3.30**
Unit Weight (lbs/ft³):	**125.2**
Moisture Content (%):	**9.67**
Compressive Strength (psi):	**544**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 1D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.50	3.50
3rd Layer	2.50	6.00
4th Layer	2.00	8.00
ADC Layer	3.00	11.00
Soil Cement Layer	6.2	17.20

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.870	5.965	5.242	5.519
2	5.882	6.135	5.212	5.542
3	5.882	5.625	5.179	5.545
4		6.138		
5		6.961		
Average (in.)	5.878	6.2	5.211	5.535

Compressive Strength		
Test Date	8/17/2010	L/D Ratio
Correction Factor	0.86	0.942
Area ($in.^2$)	27.136	
Load (lbs)	17,185	
Compressive Strength (psi)	633	
Corrected Strength (psi)	544	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/17/2010
Weight (.1 g)	4658.8
Weight (lbs)	10.27
Volume ($in.^3$)	141.407
Volume ($ft.^3$)	0.082
Unit Weight (lbs/ft^3)	125.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 1D

CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.16

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	L	I	A	Bo	N8	D
	Wet Wt. + Tare (0.01)		1034.70	758.80	841.30	765.00	1008.00	1057.20
	Dry Wt. + Tare (0.01 g)		959.80	706.80	785.10	723.50	943.10	989.60
	Tare Wt. (0.01 g)		245.90	184.50	243.80	249.00	244.00	249.40
	Wt of Dry Sample		713.90	522.30	541.30	474.50	699.10	740.20
	Wt of Water		74.90	52.00	56.20	41.50	64.90	67.60
	Water Content, %		10.49	9.96	10.38	8.75	9.28	9.13
	Average Moisture Content, %		10.28			9.05		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.008	5.046	5.044	5.007	5.004	5.015
	KMNO4 required to titrate (0.1 ml)		8.1	8.6	10.7	7.5	8.4	7.4
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.009	1.009	1.001	1.001	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.18	2.30	2.89	2.01	2.27	1.98
	% Cement by Mass of Soil	N/A	3.15	3.35	4.26	2.90	3.29	2.85

Average % Cement Top 3.59 Average % Cement Bottom 3.01

Overall Average Cement Content, % 3.30

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

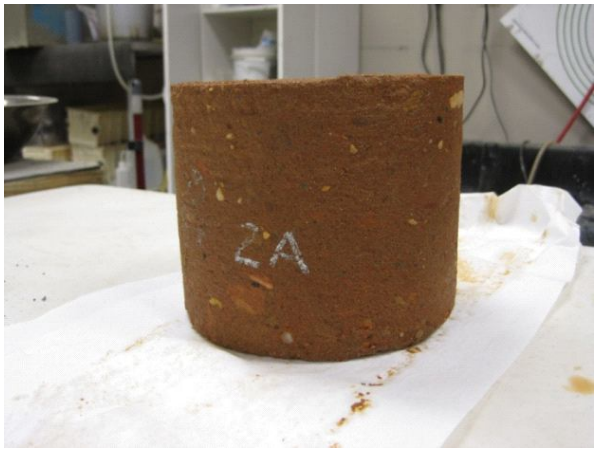
Hwy No. 84 **BCD Job Number** 090595

Row No. 2

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	1	1	1
	Oven Dry Sample Weight (.001 g)		5.013	5.005	5.023
	KMNO4 required to titrate (0.1 ml)		0.4	0.4	1.3
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.003	1.001	1.005
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.03	0.03	0.28

Average CaO Content of Virgin Soil, % 0.11

Highway No. 84
Core No. 2A



Side

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.25**	**8.00**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**6.3**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.28**
Avg Cement Content Bottom (%):	**2.41**
Avg Cement Content (%):	**2.35**
Unit Weight (lbs/ft³):	**145.9**
Moisture Content (%):	**3.81**
Compressive Strength (psi):	**845**

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive **BUS: (601) 856-2332**

RIDGELAND, MS 39157 **FAX: (601) 856-3552**

Hwy No. **84** Project No. 090595

Core No. **2A**

General Pavement Thickness Measurements as Sampled

	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.00	3.75
3rd Layer	2.00	5.75
4th Layer	2.25	8.00
ADC Layer	4.00	12.00
Soil Cement Layer	6.3	18.30

Core Dimensions

Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.850	6.250	4.386	4.668
2	5.762	6.250	4.314	4.615
3	5.679	6.250	4.417	4.768
4				
5				
Average (in.)	5.764	6.3	4.372	4.684

Compressive Strength

Test Date	7/30/2010	L/D Ratio
Correction Factor	0.77	0.813
Area ($in.^2$)	26.091	
Load (lbs)	28,610	
Compressive Strength (psi)	1,097	
Corrected Strength (psi)	845	

Unit Weight After Drying for 24 Hours in Lab

Test Date	7/30/2010
Weight (.1 g)	4368.7
Weight (lbs)	9.63
Volume ($in.^3$)	114.078
Volume ($ft.^3$)	0.066
Unit Weight (lbs/ft^3)	145.9

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive — **POST OFFICE BOX 12828**

RIDGELAND, MS 39157 — **JACKSON, MS 39236**

Hwy No.	**84**						**BCD Job Number**	090595
Core No.	**2A**							
CaO of Cement, %	**64.20**		**CaO of Virgin Soil, %**	0.11				

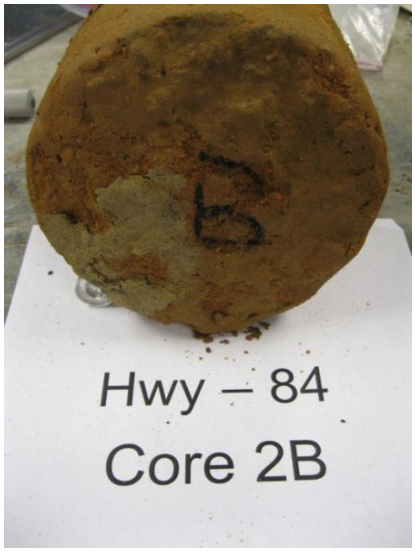
Note:
1. Average moisture content is based on an additional core taken near 2A. Disregard details and use average.

		Blank	**Soil Cement Cores**					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	14	6	17	2	12	4
	Wet Wt. + Tare (0.01)		81.59	78.23	60.50	67.90	70.83	70.57
	Dry Wt. + Tare (0.01 g)		79.62	75.87	58.50	66.12	69.63	69.40
	Tare Wt. (0.01 g)		23.14	22.98	23.13	23.21	23.18	23.13
	Wt of Dry Sample		56.48	52.89	35.37	42.91	46.45	46.27
	Wt of Water		1.97	2.36	2.00	1.78	1.20	1.17
	Water Content, %		3.49	4.46	5.65	4.15	2.58	2.53
	Average Moisture Content, %		11.51			12.22		
Titration	Tare #	NA	5	6	7	2	3	4
	Oven Dry Sample Weight (.001 g)		5.007	5.029	5.011	5.024	5.008	5.004
	KMNO4 required to titrate (0.1 ml)		6.0	5.8	6.0	6.8	5.9	6.0
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.006	1.002	1.005	1.002	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.59	1.53	1.59	1.81	1.56	1.59
	% Cement by Mass of Soil	N/A	2.32	2.22	2.31	2.65	2.27	2.32
			Average % Cement Top	2.28		Average % Cement Bottom	2.41	
	Overall Average Cement Content, %		2.35					

Highway No. 84
Core No. 2B

Top

Side



Bottom

Pavement Thicknesses			
Surface Layer (in):	**2.00**		
Second Layer (in):	**1.75**	Asphalt	
Third Layer (in):	**2.00**	Thickness	
Fourth Layer (in):	**2.50**	**8.25**	
Drainage Layer (in):	**4.00**		
Soil Cement (in):	**6.2**		

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.32**
Avg Cement Content Bottom (%):	**1.60**
Avg Cement Content (%):	**1.96**
Unit Weight (lbs/ft³):	**128.4**
Moisture Content (%):	**7.40**
Compressive Strength (psi):	**752**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. **84**

Core No. **2B**

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.75	3.75
3rd Layer	2.00	5.75
4th Layer	2.50	8.25
ADC Layer	4.00	12.25
Soil Cement Layer	6.2	18.45

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.918	6.391	5.378	5.705
2	5.866	6.044	5.361	5.706
3	5.885	6.310	5.411	5.672
4		6.210		
5		6.214		
Average (in.)	5.890	6.2	5.383	5.694

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.88	0.967
Area ($in.^2$)	27.244	
Load (lbs)	23,280	
Compressive Strength (psi)	855	
Corrected Strength (psi)	752	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	4950.8
Weight (lbs)	10.91
Volume ($in.^3$)	146.664
Volume ($ft.^3$)	0.085
Unit Weight (lbs/ft^3)	128.4

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 2B

CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.11

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	D	BO	A	C	XY	X
	Wet Wt. + Tare (0.01)		854.80	771.70	1165.40	768.90	753.00	1202.00
	Dry Wt. + Tare (0.01 g)		811.30	730.90	1092.10	732.90	722.00	1144.10
	Tare Wt. (0.01 g)		249.00	248.70	243.60	180.20	253.50	244.80
	Wt of Dry Sample		562.30	482.20	848.50	552.70	468.50	899.30
	Wt of Water		43.50	40.80	73.30	36.00	31.00	57.90
	Water Content, %		7.74	8.46	8.64	6.51	6.62	6.44
	Average Moisture Content, %		8.28			6.52		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.016	5.025	5.024	5.027	5.008	5.030
	KMNO4 required to titrate (0.1 ml)		5.1	7.5	5.5	4.5	4.5	4.1
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.003	1.005	1.005	1.005	1.002	1.006
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.34	2.01	1.45	1.17	1.17	1.06
	% Cement by Mass of Soil	N/A	1.92	2.96	2.09	1.65	1.66	1.48

Average % Cement Top 2.32 Average % Cement Bottom 1.60

Overall Average Cement Content, % 1.96

Highway No. 84
Core No. 2C

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**2.00**	
Second Layer (in):	**1.75**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.50**	**8.25**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**5.8**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.10**
Avg Cement Content Bottom (%):	**1.61**
Avg Cement Content (%):	**2.36**
Unit Weight (lbs/ft^3):	**134.1**
Moisture Content (%):	**7.49**
Compressive Strength (psi):	**627**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 2C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.75	3.75
3rd Layer	2.00	5.75
4th Layer	2.50	8.25
ADC Layer	4.00	12.25
Soil Cement Layer	5.8	18.05

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.868	5.810	4.959	5.228
2	5.500	5.660	4.939	5.225
3	5.766	5.825	5.012	5.282
4		5.745		
5		5.800		
Average (in.)	5.711	5.8	4.970	5.245

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.84	0.918
Area ($in.^2$)	25.619	
Load (lbs)	19,139	
Compressive Strength (psi)	747	
Corrected Strength (psi)	627	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	4501.6
Weight (lbs)	9.92
Volume ($in.^3$)	127.327
Volume ($ft.^3$)	0.074
Unit Weight (lbs/ft^3)	134.1

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 2C

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.11

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	B	N8	F	I	L	DE
	Wet Wt. + Tare (0.01)		964.50	909.60	951.40	816.90	876.70	917.80
	Dry Wt. + Tare (0.01 g)		914.30	855.30	893.70	780.60	835.40	879.60
	Tare Wt. (0.01 g)		253.20	244.00	262.00	184.70	245.90	266.30
	Wt of Dry Sample		661.10	611.30	631.70	595.90	589.50	613.30
	Wt of Water		50.20	54.30	57.70	36.30	41.30	38.20
	Water Content, %		7.59	8.88	9.13	6.09	7.01	6.23
	Average Moisture Content, %		8.54			6.44		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.024	5.016	5.030	5.024	5.008	5.016
	KMNO4 required to titrate (0.1 ml)		6.0	8.9	8.6	3.3	5.0	4.9
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.003	1.006	1.005	1.002	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.59	2.40	2.31	0.84	1.31	1.28
	% Cement by Mass of Soil	N/A	2.31	3.57	3.43	1.13	1.88	1.83

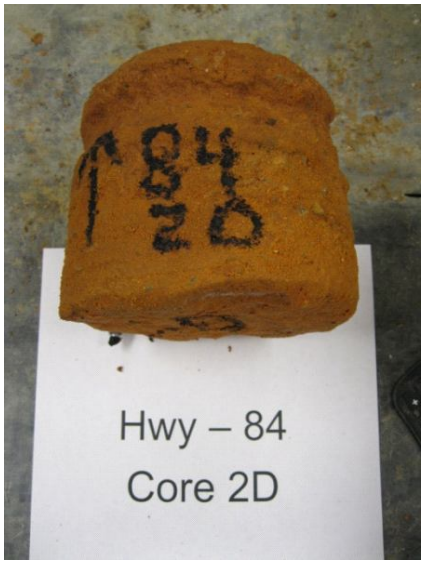
Average % Cement Top 3.10

Average % Cement Bottom 1.61

Overall Average Cement Content, % 2.36

Highway No. 84
Core No. 2D

Top



Side

Bottom

Pavement Thicknesses			
Surface Layer (in):	**2.00**		
Second Layer (in):	**1.50**	Asphalt	
Third Layer (in):	**2.00**	Thickness	
Fourth Layer (in):	**2.50**	**8.00**	
Drainage Layer (in):	**3.75**		
Soil Cement (in):	**5.3**		

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.28**
Avg Cement Content Bottom (%):	**5.40**
Avg Cement Content (%):	**4.84**
Unit Weight (lbs/ft³):	**117.6**
Moisture Content (%):	**10.59**
Compressive Strength (psi):	**709**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 2D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.50	3.50
3rd Layer	2.00	5.50
4th Layer	2.50	8.00
ADC Layer	3.75	11.75
Soil Cement Layer	5.3	17.05

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.800	5.482	4.472	4.746
2	5.800	5.350	4.436	4.723
3	5.800	5.260	4.381	4.709
4		5.230		
5		5.257		
Average (in.)	5.800	5.3	4.430	4.726

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.77	0.815
Area ($in.^2$)	26.421	
Load (lbs)	24,340	
Compressive Strength (psi)	921	
Corrected Strength (psi)	709	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3626.7
Weight (lbs)	8.00
Volume ($in.^3$)	117.035
Volume ($ft.^3$)	0.068
Unit Weight (lbs/ft^3)	117.6

Notes:
1. This core had a deep groove cut in it during coring. Diameter was adjusted to average diameter.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 2D

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.11

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	F	N8	B	N	I	L
	Wet Wt. + Tare (0.01)		896.20	594.00	867.80	1022.60	607.00	811.00
	Dry Wt. + Tare (0.01 g)		833.90	559.20	803.90	954.70	567.90	759.50
	Tare Wt. (0.01 g)		262.10	244.00	253.30	260.70	184.80	246.00
	Wt of Dry Sample		571.80	315.20	550.60	694.00	383.10	513.50
	Wt of Water		62.30	34.80	63.90	67.90	39.10	51.50
	Water Content, %		10.90	11.04	11.61	9.78	10.21	10.03
	Average Moisture Content, %		11.18			10.01		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.019	5.010	5.018	5.029	5.022	5.014
	KMNO4 required to titrate (0.1 ml)		10.7	10.2	10.7	12.8	13.3	13.2
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.004	1.002	1.004	1.006	1.004	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.90	2.77	2.90	3.48	3.63	3.60
	% Cement by Mass of Soil	N/A	4.35	4.14	4.35	5.26	5.49	5.45

Average % Cement Top 4.28

Average % Cement Bottom 5.40

Overall Average Cement Content, % 4.84

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84 **BCD Job Number** 090595

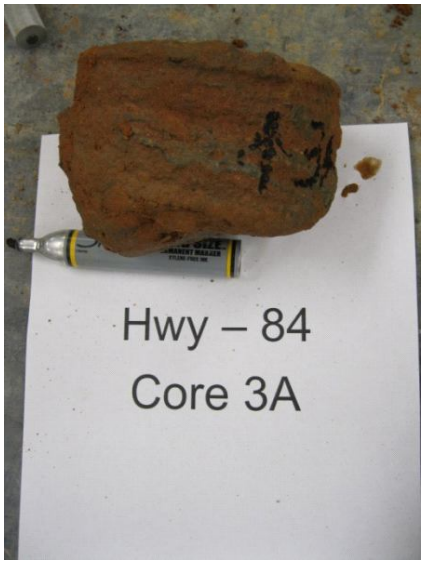
Row No. 3

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	1	2
	Oven Dry Sample Weight (.001 g)		5.024	5.027	5.016
	KMNO4 required to titrate (0.1 ml)		0.8	1.1	1.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.005	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.06	0.14	0.11

Average CaO Content of Virgin Soil, % 0.10

Highway No. 84
Core No. 3A

Top



Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**2.00**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**9.00**
Drainage Layer (in):	**4.25**	
Soil Cement (in):	**3.3**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**1.53**
Avg Cement Content Bottom (%):	**1.42**
Avg Cement Content (%):	**1.47**
Unit Weight (lbs/ft^3):	**0.0**
Moisture Content (%):	**11.76**
Compressive Strength (psi):	**0**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 3A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	2.00	4.00
3rd Layer	2.00	6.00
4th Layer	3.00	9.00
ADC Layer	4.25	13.25
Soil Cement Layer	3.3	16.55

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1		3.235		
2		2.928		
3		3.892		
4		3.259		
5		3.350		
Average (in.)		3.3		

Compressive Strength		
Test Date	NA	L/D Ratio
Correction Factor	1.00	
Area ($in.^2$)		
Load (lbs)		
Compressive Strength (psi)		
Corrected Strength (psi)		

Unit Weight After Drying for 24 Hours in Lab	
Test Date	NA
Weight (.1 g)	
Weight (lbs)	
Volume ($in.^3$)	
Volume ($ft.^3$)	
Unit Weight (lbs/ft^3)	

Notes:
1. This core was not long enough to determine compressive strength or unit weight.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 3A

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.10

		Blank	Soil Cement Cores					
			SAMPLE 1	SAMPLE 1	SAMPLE 1	SAMPLE 2	SAMPLE 2	SAMPLE 2
Sample Prep	Tare #	N/A	BO			N8		
	Wet Wt. + Tare (0.01)		1041.60			1191.20		
	Dry Wt. + Tare (0.01 g)		957.70			1092.10		
	Tare Wt. (0.01 g)		248.80			244.10		
	Wt of Dry Sample		708.90			848.00		
	Wt of Water		83.90			99.10		
	Water Content, %		11.84			11.69		
	Average Moisture Content, %		11.835			11.686		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.032	5.012	5.027	5.038	5.036	5.030
	KMNO4 required to titrate (0.1 ml)		4.0	4.1	4.4	3.8	3.8	4.2
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.006	1.002	1.005	1.008	1.007	1.006
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.03	1.06	1.14	0.97	0.97	1.09
	% Cement by Mass of Soil	N/A	1.45	1.50	1.63	1.36	1.36	1.54

Average % Cement Top 1.53

Average % Cement Bottom 1.42

Overall Average Cement Content, % 1.47

Highway No. 84
Core No. 3B

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**2.00**	
Second Layer (in):	**1.75**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.25**	**8.00**
Drainage Layer (in):	**4.25**	
Soil Cement (in):	**4.7**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**5.47**
Avg Cement Content Bottom (%):	**2.12**
Avg Cement Content (%):	**3.79**
Unit Weight (lbs/ft³):	**128.1**
Moisture Content (%):	**8.77**
Compressive Strength (psi):	**944**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 3B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.75	3.75
3rd Layer	2.00	5.75
4th Layer	2.25	8.00
ADC Layer	4.25	12.25
Soil Cement Layer	4.7	16.95

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.928	4.422	3.922	4.187
2	5.925	4.828	3.929	4.221
3	5.936	4.880	3.920	4.169
4		4.765		
5		4.847		
Average (in.)	5.930	4.7	3.924	4.192

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.75	0.707
Area ($in.^2$)	27.615	
Load (lbs)	34,780	
Compressive Strength (psi)	1,259	
Corrected Strength (psi)	944	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3660.9
Weight (lbs)	8.07
Volume ($in.^3$)	108.353
Volume ($ft.^3$)	0.063
Unit Weight (lbs/ft^3)	128.1

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 3B

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.10

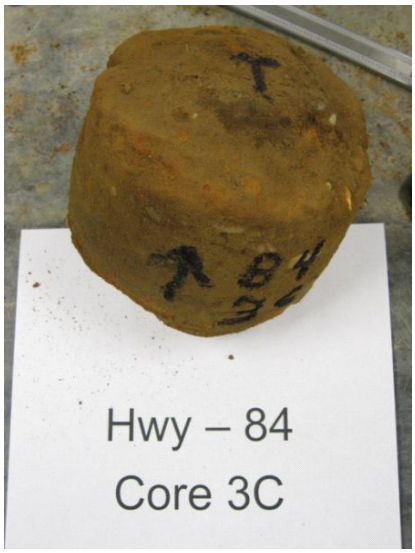
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	A	I	L	DE	C	XY
	Wet Wt. + Tare (0.01)		641.90	806.70	793.10	748.60	858.60	825.70
	Dry Wt. + Tare (0.01 g)		607.30	751.40	747.00	713.00	807.40	783.40
	Tare Wt. (0.01 g)		243.70	184.70	246.00	266.40	180.30	253.70
	Wt of Dry Sample		363.60	566.70	501.00	446.60	627.10	529.70
	Wt of Water		34.60	55.30	46.10	35.60	51.20	42.30
	Water Content, %		9.52	9.76	9.20	7.97	8.16	7.99
	Average Moisture Content, %		9.49			8.04		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.028	5.032	5.013	5.017	5.018	5.008
	KMNO4 required to titrate (0.1 ml)		13.9	13.8	12.9	5.2	6.8	5.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.006	1.006	1.003	1.003	1.004	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.70	3.67	3.43	1.28	1.73	1.37
	% Cement by Mass of Soil	N/A	5.62	5.58	5.20	1.85	2.54	1.98

Average % Cement Top: 5.47

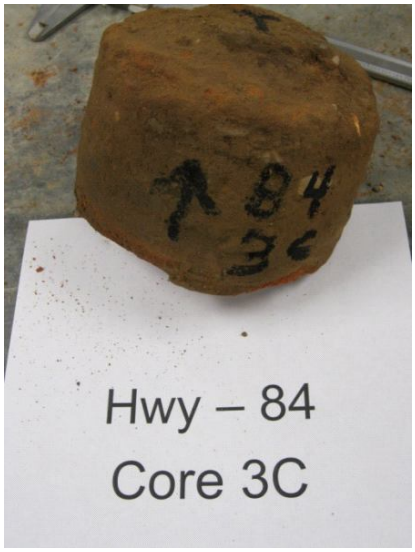
Average % Cement Bottom: 2.12

Overall Average Cement Content, %: 3.79

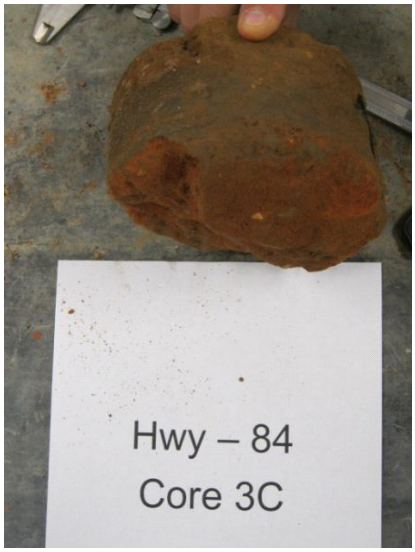
Highway No. 84
Core No. 3C



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.25**	
Second Layer (in):	**2.50**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.25**	**8.00**
Drainage Layer (in):	**2.25**	
Soil Cement (in):	**3.5**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.09**
Avg Cement Content Bottom (%):	**0.64**
Avg Cement Content (%):	**1.37**
Unit Weight (lbs/ft³):	**0.0**
Moisture Content (%):	**8.83**
Compressive Strength (psi):	**0**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 3C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.50	3.75
3rd Layer	2.00	5.75
4th Layer	2.25	8.00
ADC Layer	2.25	10.25
Soil Cement Layer	3.5	13.75

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1		4.075		
2		3.000		
3		2.785		
4		4.025		
5		3.775		
Average (in.)		3.5		

Compressive Strength		
Test Date	NA	L/D Ratio
Correction Factor	1.00	
Area ($in.^2$)		
Load (lbs)		
Compressive Strength (psi)		
Corrected Strength (psi)		

Unit Weight After Drying for 24 Hours in Lab	
Test Date	NA
Weight (.1 g)	
Weight (lbs)	
Volume ($in.^3$)	
Volume ($ft.^3$)	
Unit Weight (lbs/ft^3)	

Notes:
1. This core was not long enough to determine compressive strength or unit weight.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 3C

CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.10

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	N	MC	P	P-1	DE	XY
	Wet Wt. + Tare (0.01)		894.30	809.80	775.00	782.20	632.10	848.50
	Dry Wt. + Tare (0.01 g)		840.60	763.40	734.40	741.30	603.50	799.80
	Tare Wt. (0.01 g)		260.60	249.30	265.80	266.90	266.40	253.60
	Wt of Dry Sample		580.00	514.10	468.60	474.40	337.10	546.20
	Wt of Water		53.70	46.40	40.60	40.90	28.60	48.70
	Water Content, %		9.26	9.03	8.66	8.62	8.48	8.92
	Average Moisture Content, %		8.983			8.674		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.009	5.037	5.038	5.001	5.027	5.042
	KMNO4 required to titrate (0.1 ml)		5.2	6.1	6.0	4.1	2.9	0.3
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.007	1.008	1.000	1.005	1.008
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.29	1.53	1.50	0.98	0.64	-0.08
	% Cement by Mass of Soil	N/A	1.85	2.23	2.18	1.37	0.84	-0.29

Average % Cement Top 2.09

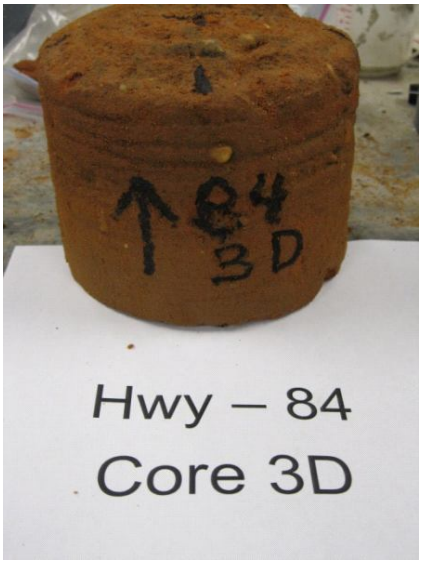
Average % Cement Bottom 1.11

Erratic Not Included

Overall Average Cement Content, % 1.70

Highway No. 84
Core No. 3D

Top



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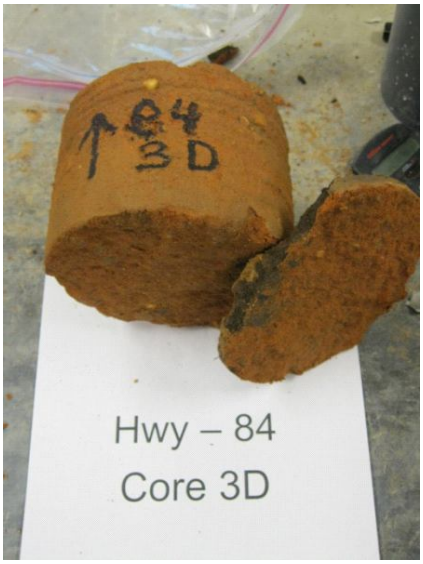


Bottom

Pavement Thicknesses		
Surface Layer (in):	**2.00**	
Second Layer (in):	**1.50**	Asphalt
Third Layer (in):	**1.75**	Thickness
Fourth Layer (in):	**2.75**	**8.00**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**4.6**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.25**
Avg Cement Content Bottom (%):	**1.45**
Avg Cement Content (%):	**1.85**
Unit Weight (lbs/ft³):	**127.5**
Moisture Content (%):	**6.62**
Compressive Strength (psi):	**514**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. **84**

Project No. 090595

Core No. **3D**

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	1.50	3.50
3rd Layer	1.75	5.25
4th Layer	2.75	8.00
ADC Layer	4.00	12.00
Soil Cement Layer	4.6	16.60

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.865	4.654	4.155	4.355
2	5.836	4.661	4.131	4.390
3	5.864	4.481	4.136	4.325
4		4.570		
5		4.716		
Average (in.)	5.855	4.6	4.141	4.357

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.75	0.744
Area ($in.^2$)	26.924	
Load (lbs)	18,450	
Compressive Strength (psi)	685	
Corrected Strength (psi)	514	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3760.3
Weight (lbs)	8.29
Volume ($in.^3$)	111.484
Volume ($ft.^3$)	0.065
Unit Weight (lbs/ft^3)	127.5

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **Core No.** 3D

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.10

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	P-1	B	F	D	N8	BO
	Wet Wt. + Tare (0.01)		849.60	682.40	730.30	790.20	859.60	801.50
	Dry Wt. + Tare (0.01 g)		813.00	654.90	700.90	757.60	822.30	767.30
	Tare Wt. (0.01 g)		266.90	253.50	262.20	249.30	244.00	248.80
	Wt of Dry Sample		546.10	401.40	438.70	508.30	578.30	518.50
	Wt of Water		36.60	27.50	29.40	32.60	37.30	34.20
	Water Content, %		6.70	6.85	6.70	6.41	6.45	6.60
	Average Moisture Content, %		6.75			6.49		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.019	5.008	5.009	5.019	5.016	5.032
	KMNO4 required to titrate (0.1 ml)		5.8	7.0	5.6	4.3	4.3	4.3
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.004	1.002	1.002	1.004	1.003	1.006
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.45	1.79	1.40	1.03	1.03	1.03
	% Cement by Mass of Soil	N/A	2.11	2.63	2.02	1.45	1.46	1.45

Average % Cement Top 2.25

Average % Cement Bottom 1.45

Overall Average Cement Content, % 1.85

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84 **BCD Job Number** 090595

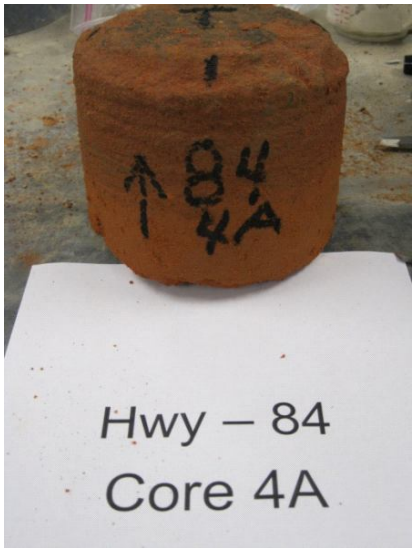
Row No. 4

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.022	5.021	5.014
	KMNO4 required to titrate (0.1 ml)		0.4	0.4	0.4
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.004	1.004	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.03	0.03	0.03

Average CaO Content of Virgin Soil, % 0.03

Highway No. 84
Core No. 4A

Top



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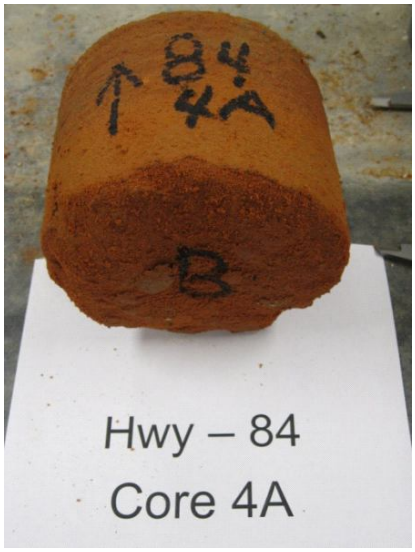

Bottom

Pavement Thicknesses			
Surface Layer (in):	**1.75**		
Second Layer (in):	**2.50**	Asphalt	
Third Layer (in):	**2.50**	Thickness	
Fourth Layer (in):	**2.50**	**9.25**	
Drainage Layer (in):	**4.00**		
Soil Cement (in):	**4.80**		

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.32**
Avg Cement Content Bottom (%):	**2.27**
Avg Cement Content (%):	**2.29**
Unit Weight (lbs/ft³):	**128.0**
Moisture Content (%):	**6.19**
Compressive Strength (psi):	**662**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

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RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 4A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.50	4.25
3rd Layer	2.50	6.75
4th Layer	2.50	9.25
ADC Layer	4.00	13.25
Soil Cement Layer	4.8	18.05

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.825	4.489	3.787	4.082
2	5.800	4.845	3.829	4.084
3	5.833	4.610	3.824	4.090
4		4.900		
5		5.004		
Average (in.)	5.819	4.8	3.813	4.085

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.75	0.702
Area ($in.^2$)	26.597	
Load (lbs)	23,480	
Compressive Strength (psi)	883	
Corrected Strength (psi)	662	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3422.5
Weight (lbs)	7.55
Volume ($in.^3$)	101.424
Volume ($ft.^3$)	0.059
Unit Weight (lbs/ft^3)	128.0

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **Core No.** 4A

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	A12	X	N	XY	C	DE
	Wet Wt. + Tare (0.01)		598.10	557.00	548.90	609.80	505.80	748.00
	Dry Wt. + Tare (0.01 g)		579.80	539.20	532.40	590.00	485.00	718.50
	Tare Wt. (0.01 g)		263.90	244.90	260.70	253.60	180.30	266.40
	Wt of Dry Sample		315.90	294.30	271.70	336.40	304.70	452.10
	Wt of Water		18.30	17.80	16.50	19.80	20.80	29.50
	Water Content, %		5.79	6.05	6.07	5.89	6.83	6.53
	Average Moisture Content, %		5.97			6.41		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.037	5.006	5.014	5.027	5.003	5.020
	KMNO4 required to titrate (0.1 ml)		5.1	7.0	6.0	5.1	7.0	5.7
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.007	1.001	1.003	1.005	1.001	1.004
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.25	1.79	1.51	1.25	1.79	1.42
	% Cement by Mass of Soil	N/A	1.90	2.74	2.30	1.91	2.74	2.17

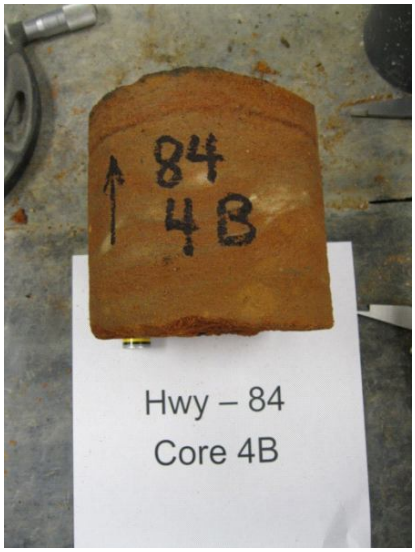
Average % Cement Top 2.32

Average % Cement Bottom 2.27

Overall Average Cement Content, % 2.29

Highway No. 84
Core No. 4B

Top



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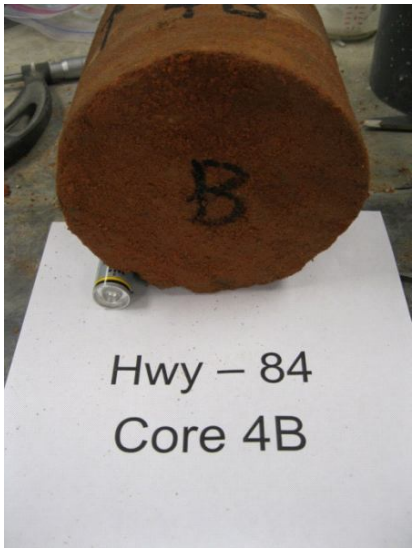


Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.50**	**8.00**
Drainage Layer (in):	**2.75**	
Soil Cement (in):	**5.7**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**10.10**
Avg Cement Content Bottom (%):	**6.14**
Avg Cement Content (%):	**8.12**
Unit Weight (lbs/ft³):	**127.3**
Moisture Content (%):	**8.97**
Compressive Strength (psi):	**1089**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 4B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.00	5.50
4th Layer	2.50	8.00
ADC Layer	2.75	10.75
Soil Cement Layer	5.7	16.45

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.938	5.862	4.995	5.265
2	5.909	5.700	5.015	5.243
3	5.927	5.525	4.958	5.234
4		5.662		
5		5.560		
Average (in.)	5.925	5.7	4.989	5.247

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.81	0.886
Area ($in.^2$)	27.569	
Load (lbs)	37,050	
Compressive Strength (psi)	1,344	
Corrected Strength (psi)	1,089	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	4616.6
Weight (lbs)	10.18
Volume ($in.^3$)	137.550
Volume ($ft.^3$)	0.080
Unit Weight (lbs/ft^3)	127.3

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 4B

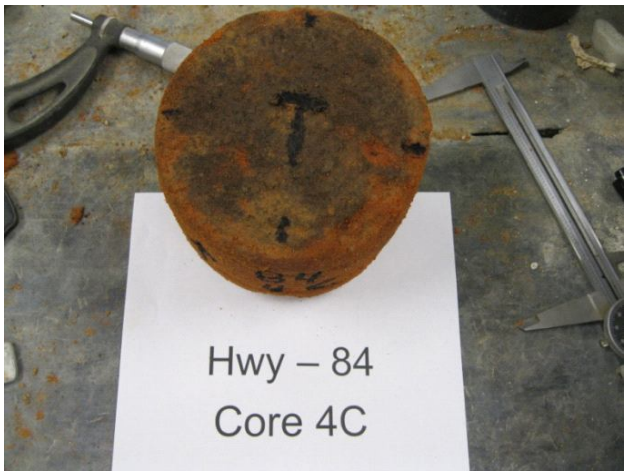
CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	F	B	P-1	P	MC	E
	Wet Wt. + Tare (0.01)		1120.60	945.10	970.10	1003.20	792.40	885.20
	Dry Wt. + Tare (0.01 g)		1045.90	879.50	904.20	948.30	753.80	840.70
	Tare Wt. (0.01 g)		262.00	253.20	266.90	266.10	249.30	267.90
	Wt of Dry Sample		783.90	626.30	637.30	682.20	504.50	572.80
	Wt of Water		74.70	65.60	65.90	54.90	38.60	44.50
	Water Content, %		9.53	10.47	10.34	8.05	7.65	7.77
	Average Moisture Content, %		10.115			7.822		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.040	5.016	5.019	5.006	5.030	5.021
	KMNO4 required to titrate (0.1 ml)		23.7	23.2	25.0	14.8	14.3	15.4
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.008	1.003	1.004	1.001	1.006	1.004
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	6.42	6.31	6.80	3.97	3.81	4.13
	% Cement by Mass of Soil	N/A	9.95	9.79	10.56	6.14	5.90	6.39

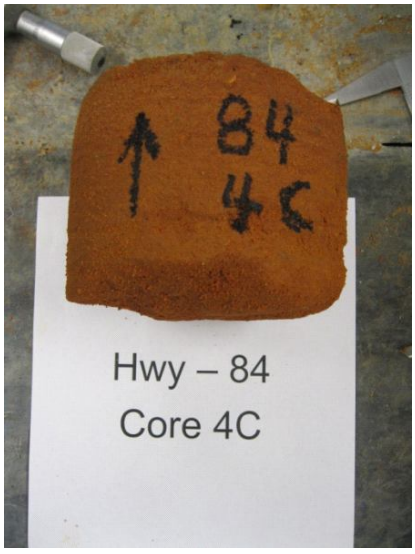
Average % Cement Top 10.10 Average % Cement Bottom 6.14

Overall Average Cement Content, % 8.12

Highway No. 84
Core No. 4C



Top



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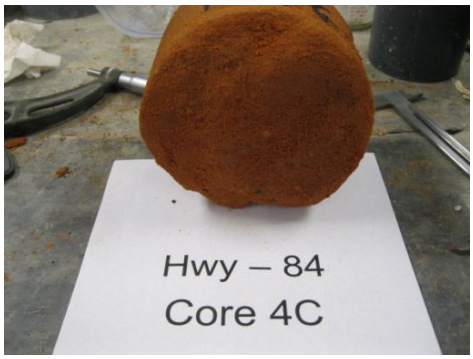


Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**1.75**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.50**	**8.00**
Drainage Layer (in):	**3.25**	
Soil Cement (in):	**4.6**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.01**
Avg Cement Content Bottom (%):	**3.55**
Avg Cement Content (%):	**3.78**
Unit Weight (lbs/ft³):	**126.1**
Moisture Content (%):	**7.22**
Compressive Strength (psi):	**645**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 4C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	1.75	3.50
3rd Layer	2.00	5.50
4th Layer	2.50	8.00
ADC Layer	3.25	11.25
Soil Cement Layer	4.6	15.85

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.850	4.515	3.060	3.310
2	5.838	4.640	2.955	3.260
3	5.827	4.460	2.941	3.254
4		4.430		
5		4.865		
Average (in.)	5.838	4.6	2.985	3.275

Compressive Strength		
Test Date	8/18/20110	L/D Ratio
Correction Factor	0.75	0.561
Area ($in.^2$)	26.771	
Load (lbs)	23,020	
Compressive Strength (psi)	860	
Corrected Strength (psi)	645	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	2630.3
Weight (lbs)	5.80
Volume ($in.^3$)	79.921
Volume ($ft.^3$)	0.046
Unit Weight (lbs/ft^3)	126.1

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 4C

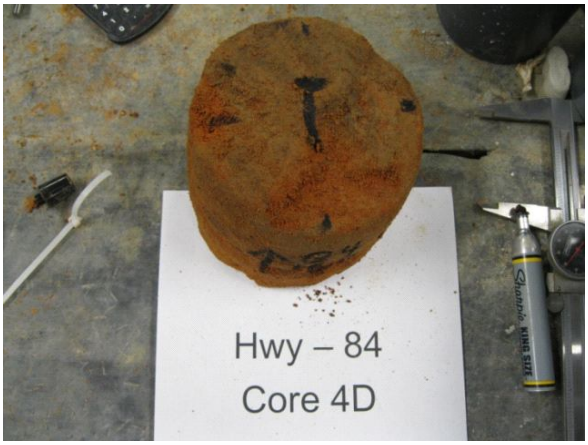
CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	C	BO	D	X	XY	A
	Wet Wt. + Tare (0.01)		787.40	533.80	518.30	564.70	790.50	538.30
	Dry Wt. + Tare (0.01 g)		748.90	515.80	501.50	542.30	750.50	517.70
	Tare Wt. (0.01 g)		180.40	249.00	249.60	245.10	253.70	243.90
	Wt of Dry Sample		568.50	266.80	251.90	297.20	496.80	273.80
	Wt of Water		38.50	18.00	16.80	22.40	40.00	20.60
	Water Content, %		6.77	6.75	6.67	7.54	8.05	7.52
	Average Moisture Content, %		6.73			7.70		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.036	5.034	5.036	5.013	5.016	5.009
	KMNO4 required to titrate (0.1 ml)		9.3	10.6	9.1	7.0	11.1	7.6
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.007	1.007	1.007	1.003	1.003	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.50	2.86	2.45	1.87	3.01	2.04
	% Cement by Mass of Soil	N/A	3.85	4.42	3.77	2.87	4.65	3.13

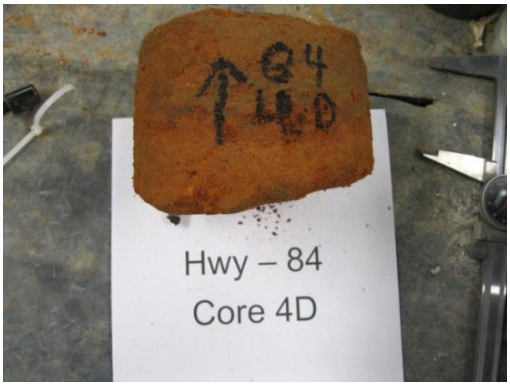
Average % Cement Top 4.01 Average % Cement Bottom 3.55

Overall Average Cement Content, % 3.78

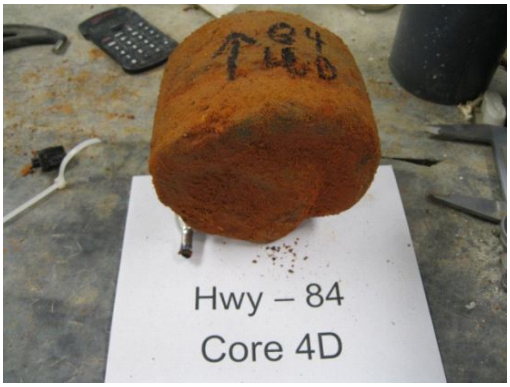
Highway No. 84
Core No. 4D



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**1.75**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**2.50**	**8.00**
Drainage Layer (in):	**4.50**	
Soil Cement (in):	**4.00**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**6.11**
Avg Cement Content Bottom (%):	**2.06**
Avg Cement Content (%):	**4.08**
Unit Weight (lbs/ft³):	**122.7**
Moisture Content (%):	**8.03**
Compressive Strength (psi):	**515**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. **84**

Project No. 090595

Core No. **4D**

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	1.75	3.50
3rd Layer	2.00	5.50
4th Layer	2.50	8.00
ADC Layer	4.50	12.50
Soil Cement Layer	4.0	16.50

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.850	3.910	2.921	3.158
2	5.822	3.797	2.874	3.182
3	5.825	4.348	2.859	3.167
4		4.020		
5		4.144		
Average (in.)	5.832	4.0	2.885	3.169

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.75	0.543
Area ($in.^2$)	26.716	
Load (lbs)	18,330	
Compressive Strength (psi)	686	
Corrected Strength (psi)	515	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	2503.2
Weight (lbs)	5.52
Volume ($in.^3$)	77.067
Volume ($ft.^3$)	0.045
Unit Weight (lbs/ft^3)	122.7

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **Core No.** 4D

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	P-1	Z	S	A12	A2	DE
	Wet Wt. + Tare (0.01)		832.60	759.10	722.50	795.70	626.70	806.60
	Dry Wt. + Tare (0.01 g)		787.30	716.30	684.20	761.30	603.00	770.60
	Tare Wt. (0.01 g)		267.00	268.10	264.40	264.40	251.70	266.60
	Wt of Dry Sample		520.30	448.20	419.80	496.90	351.30	504.00
	Wt of Water		45.30	42.80	38.30	34.40	23.70	36.00
	Water Content, %		8.71	9.55	9.12	6.92	6.75	7.14
	Average Moisture Content, %		9.13			6.94		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.011	5.003	5.014	5.007	5.006	5.008
	KMNO4 required to titrate (0.1 ml)		11.7	14.5	17.1	5.3	4.7	5.4
	KMNO4 required to titrate Blank (0.1 ml)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.001	1.003	1.001	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.19	3.97	4.69	1.40	1.23	1.43
	% Cement by Mass of Soil	N/A	4.92	6.14	7.26	2.13	1.87	2.17

Average % Cement Top 6.11

Average % Cement Bottom 2.06

Overall Average Cement Content, % 4.08

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84 **BCD Job Number** 090595

Row No. 5

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.002	5.040	5.016
	KMNO4 required to titrate (0.1 ml)		3.5	3.0	3.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.008	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.81	0.67	0.67

Average CaO Content of Virgin Soil, % 0.72

Highway No. 84
Core No. 5A

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.25**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**8.25**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**4.8**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.71**
Avg Cement Content Bottom (%):	**3.08**
Avg Cement Content (%):	**3.39**
Unit Weight (lbs/ft³):	**116.9**
Moisture Content (%):	**7.97**
Compressive Strength (psi):	**431**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
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Hwy No. 84

Core No. 5A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.00	3.25
3rd Layer	2.00	5.25
4th Layer	3.00	8.25
ADC Layer	3.00	11.25
Soil Cement Layer	4.8	16.05

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.583	8.821	4.341	4.695
2	5.558	8.716	4.282	4.692
3	5.531	8.811	4.394	4.616
4		8.580		
5		8.560		
Average (in.)	5.557	4.8	4.339	4.668

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.79	0.840
Area ($in.^2$)	24.256	
Load (lbs)	13,250	
Compressive Strength (psi)	546	
Corrected Strength (psi)	431	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3234.2
Weight (lbs)	7.13
Volume ($in.^3$)	105.248
Volume ($ft.^3$)	0.061
Unit Weight (lbs/ft^3)	116.9

Notes:
1. 3.9 in. was subtracted from the core thickness to accommodate lime/cement treated layer.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 5A

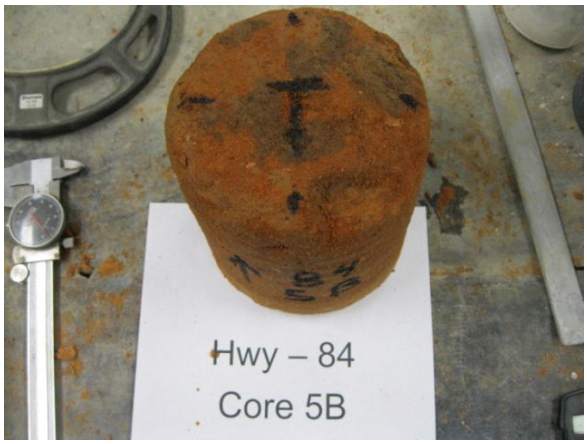
CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.72

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	DE	XY	D	BO	N8	N
	Wet Wt. + Tare (0.01)		666.90	745.20	864.40	702.00	737.70	687.80
	Dry Wt. + Tare (0.01 g)		639.00	710.20	820.20	667.80	698.70	655.50
	Tare Wt. (0.01 g)		266.30	253.60	249.30	249.00	244.00	260.50
	Wt of Dry Sample		372.70	456.60	570.90	418.80	454.70	395.00
	Wt of Water		27.90	35.00	44.20	34.20	39.00	32.30
	Water Content, %		7.49	7.67	7.74	8.17	8.58	8.18
	Average Moisture Content, %		7.631			8.307		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.005	5.010	5.011	5.010	5.006	5.007
	KMNO4 required to titrate (0.1 ml)		10.4	12.5	11.9	10.0	9.5	11.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.002	1.002	1.002	1.001	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.74	3.33	3.16	2.63	2.49	2.91
	% Cement by Mass of Soil	N/A	3.18	4.10	3.84	3.00	2.79	3.45

Average % Cement Top 3.71 Average % Cement Bottom 3.08

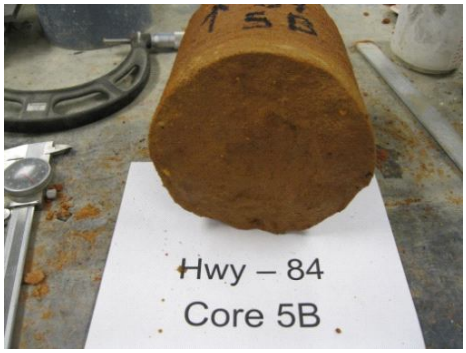
Overall Average Cement Content, % 3.39

Highway No. 84
Core No. 5B



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.25**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**8.25**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**5.2**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.24**
Avg Cement Content Bottom (%):	**3.38**
Avg Cement Content (%):	**3.31**
Unit Weight (lbs/ft^3):	**127.6**
Moisture Content (%):	**9.02**
Compressive Strength (psi):	**484**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 5B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.00	3.25
3rd Layer	2.00	5.25
4th Layer	3.00	8.25
ADC Layer	3.00	11.25
Soil Cement Layer	5.2	16.45

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.835	6.335	4.154	4.494
2	5.780	6.950	4.092	4.480
3	5.800	6.374	4.138	4.450
4		6.520		
5		6.429		
Average (in.)	5.805	5.2	4.128	4.475

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.76	0.771
Area ($in.^2$)	26.466	
Load (lbs)	16,865	
Compressive Strength (psi)	637	
Corrected Strength (psi)	484	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3647.6
Weight (lbs)	8.04
Volume ($in.^3$)	109.253
Volume ($ft.^3$)	0.063
Unit Weight (lbs/ft^3)	127.6

Notes:
1. 1.3 in. was subtracted from the core thickness to accommodate lime/cement treated layer.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84 **BCD Job Number** 090595

Core No. 5B

CaO of Cement, % 64.20 **CaO of Virgin Soil, %** 0.72

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	X	A12	A	I	L	E
	Wet Wt. + Tare (0.01)		819.50	724.40	860.40	646.40	750.90	934.00
	Dry Wt. + Tare (0.01 g)		755.40	690.30	814.30	610.00	712.10	881.20
	Tare Wt. (0.01 g)		244.80	263.80	243.70	183.40	246.00	268.00
	Wt of Dry Sample		510.60	426.50	570.60	426.60	466.10	613.20
	Wt of Water		64.10	34.10	46.10	36.40	38.80	52.80
	Water Content, %		12.55	8.00	8.08	8.53	8.32	8.61
	Average Moisture Content, %		9.543			8.489		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.036	5.023	5.013	5.005	5.019	5.021
	KMNO4 required to titrate (0.1 ml)		9.6	11.6	10.5	9.5	11.2	11.9
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.007	1.005	1.003	1.001	1.004	1.004
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.50	3.06	2.76	2.49	2.96	3.15
	% Cement by Mass of Soil	N/A	2.81	3.69	3.22	2.79	3.52	3.83

Average % Cement Top 3.24 Average % Cement Bottom 3.38

Overall Average Cement Content, % 3.31

Highway No. 84
Core No. 5C

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**1.75**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**8.25**
Drainage Layer (in):	**3.25**	
Soil Cement (in):	**0.0**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**1.13**
Avg Cement Content Bottom (%):	**0.83**
Avg Cement Content (%):	**0.98**
Unit Weight (lbs/ft³):	**0.0**
Moisture Content (%):	**14.10**
Compressive Strength (psi):	**0**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

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Hwy No. 84

Core No. 5C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	1.75	3.25
3rd Layer	2.00	5.25
4th Layer	3.00	8.25
ADC Layer	3.25	11.50
Soil Cement Layer	0.0	11.50

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1				
2				
3				
4				
5				
Average (in.)		#VALUE!		

Compressive Strength		
Test Date	NA	L/D Ratio
Correction Factor	1.00	
Area ($in.^2$)		
Load (lbs)		
Compressive Strength (psi)		
Corrected Strength (psi)		

Unit Weight After Drying for 24 Hours in Lab	
Test Date	NA
Weight (.1 g)	
Weight (lbs)	
Volume ($in.^3$)	
Volume ($ft.^3$)	
Unit Weight (lbs/ft^3)	

Notes:
1. This core was not long enough to determine compressive strength or unit weight.

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ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 5C

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.72

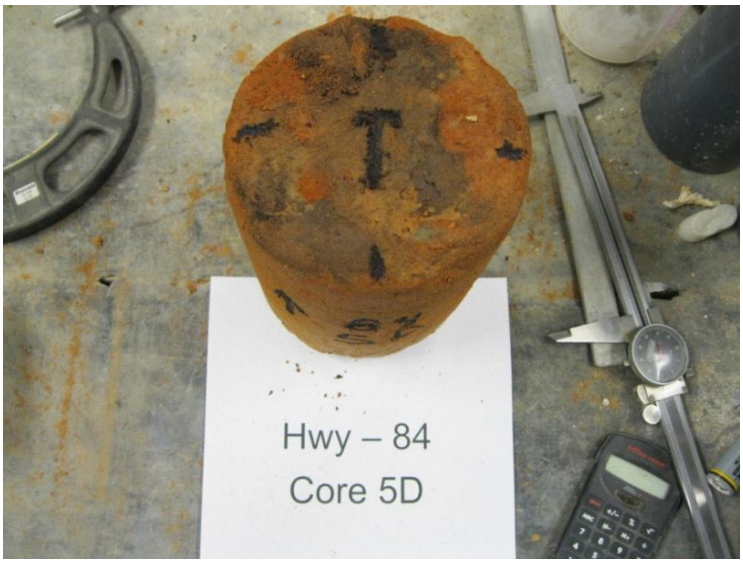
		Blank	Soil Cement Cores					
			SAMPLE 1					
Sample Prep	Tare #		X					
	Wet Wt. + Tare (0.01)		803.00					
	Dry Wt. + Tare (0.01 g)		734.00					
	Tare Wt. (0.01 g)	N/A	244.80					
	Wt of Dry Sample		489.20					
	Wt of Water		69.00					
	Water Content, %		14.10					
	Average Moisture Content, %		14.105					
Titration	Tare #		1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)	NA	5.004	5.003	5.006	5.013	5.018	5.008
	KMNO4 required to titrate (0.1 ml)		5.2	5.5	6.5	4.3	5.2	5.7
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.001	1.001	1.003	1.004	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.29	1.37	1.65	1.03	1.28	1.43
	% Cement by Mass of Soil	N/A	0.89	1.02	1.47	0.49	0.89	1.11

Average % Cement Top 1.13

Average % Cement Bottom 0.83

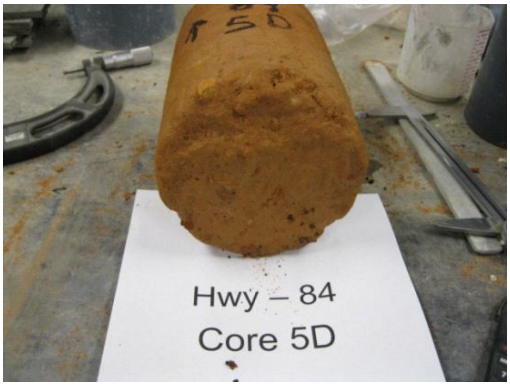
Overall Average Cement Content, % 0.98

Highway No. 84
Core No. 5D



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.00**	
Second Layer (in):	**1.50**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**7.50**
Drainage Layer (in):	**3.75**	
Soil Cement (in):	**5.1**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.04**
Avg Cement Content Bottom (%):	**3.36**
Avg Cement Content (%):	**3.20**
Unit Weight (lbs/ft³):	**125.2**
Moisture Content (%):	**7.64**
Compressive Strength (psi):	**588**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 84

Core No. 5D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.00	1.00
2nd Layer	1.50	2.50
3rd Layer	2.00	4.50
4th Layer	3.00	7.50
ADC Layer	3.75	11.25
Soil Cement Layer	5.1	16.35

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.872	8.080	4.357	4.604
2	5.872	8.570	4.396	4.630
3	5.880	8.560	4.390	4.584
4		8.809		
5		8.764		
Average (in.)	5.875	5.1	4.381	4.606

Compressive Strength		
Test Date	8/18/2010	L/D Ratio
Correction Factor	0.76	0.784
Area ($in.^2$)	27.105	
Load (lbs)	20,980	
Compressive Strength (psi)	774	
Corrected Strength (psi)	588	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/18/2010
Weight (.1 g)	3919.6
Weight (lbs)	8.64
Volume ($in.^3$)	118.749
Volume ($ft.^3$)	0.069
Unit Weight (lbs/ft^3)	125.2

Notes:
1. 3.5 in. was subtracted from the core thickness to accommodate lime/cement treated layer.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 84
Core No. 5D

BCD Job Number 090595

CaO of Cement, % 64.20

CaO of Virgin Soil, % 0.72

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	MC	P	P-1	B	F	C
	Wet Wt. + Tare (0.01)		702.50	716.70	800.30	834.20	886.70	742.70
	Dry Wt. + Tare (0.01 g)		673.20	686.40	764.70	790.80	839.80	699.30
	Tare Wt. (0.01 g)		249.40	266.10	267.00	253.20	261.80	180.20
	Wt of Dry Sample		423.80	420.30	497.70	537.60	578.00	519.10
	Wt of Water		29.30	30.30	35.60	43.40	46.90	43.40
	Water Content, %		6.91	7.21	7.15	8.07	8.11	8.36
	Average Moisture Content, %		7.092			8.183		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.017	5.019	5.015	5.002	5.012	5.014
	KMNO4 required to titrate (0.1 ml)		10.7	10.4	9.2	10.7	10.7	11.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.003	1.004	1.003	1.000	1.002	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.82	2.73	2.40	2.83	2.82	2.90
	% Cement by Mass of Soil	N/A	3.31	3.17	2.65	3.32	3.31	3.44

Average % Cement Top 3.04

Average % Cement Bottom 3.36

Overall Average Cement Content, % 3.20

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25 **BCD Job Number** 090595

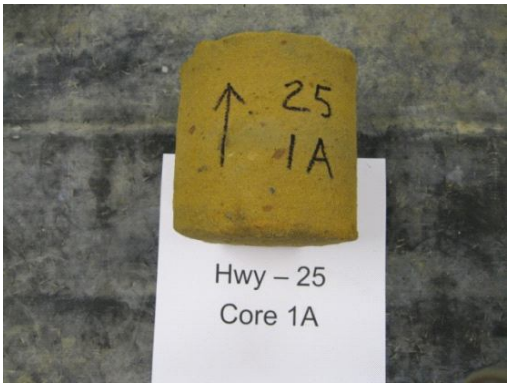
Row No. 1

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	
	Oven Dry Sample Weight (.001 g)		5.025	5.001	5.007
	KMNO4 required to titrate (0.1 ml)		0.7	0.8	0.6
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.000	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.03	0.06	0.00

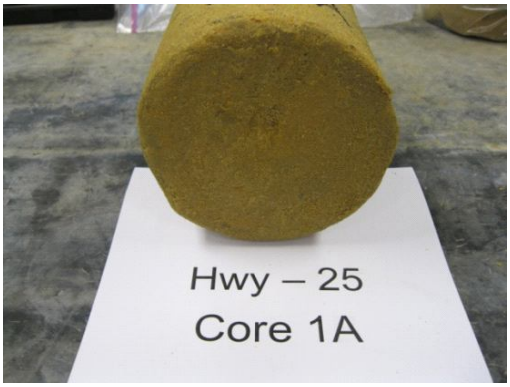
Average CaO Content of Virgin Soil, % 0.03

Highway No. 25
Core No. 1A

Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.25**	**9.00**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.9**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.87**
Avg Cement Content Bottom (%):	**3.14**
Avg Cement Content (%):	**3.00**
Unit Weight (lbs/ft³):	**120.7**
Moisture Content (%):	**12.90**
Compressive Strength (psi):	**199**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

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RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 1A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.00	3.75
3rd Layer	2.00	5.75
4th Layer	3.25	9.00
ADC Layer	3.50	12.50
Soil Cement Layer	5.9	18.40

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.853	5.926	5.152	5.497
2	5.856	5.914	5.216	5.501
3	5.850	5.883	5.207	5.470
4		5.840		
5		6.036		
Average (in.)	5.853	5.9	5.192	5.489

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.86	0.938
Area ($in.^2$)	26.906	
Load (lbs)	6,226	
Compressive Strength (psi)	231	
Corrected Strength (psi)	199	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4435.5
Weight (lbs)	9.78
Volume ($in.^3$)	139.686
Volume ($ft.^3$)	0.081
Unit Weight (lbs/ft^3)	120.7

Notes:
1. 7.0 in. lime treated below.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 1A

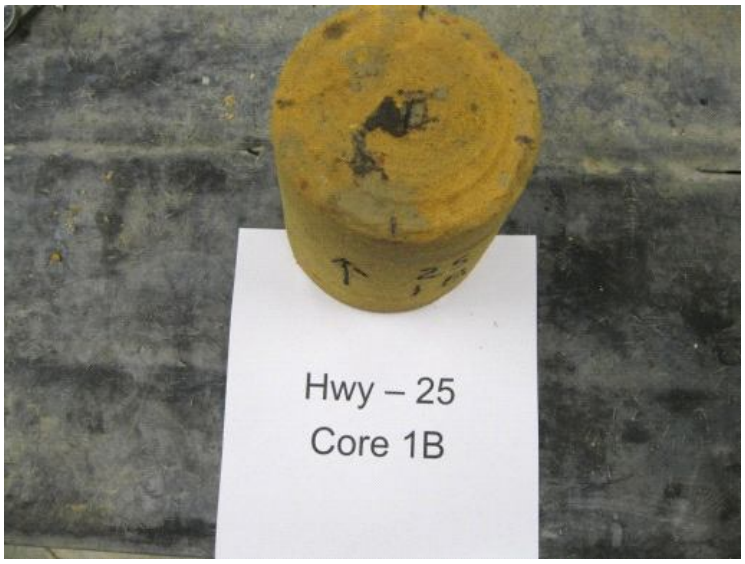
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	A12	A	E	L	I	F
	Wet Wt. + Tare (0.01)		687.00	989.80	1063.40	858.20	789.20	961.50
	Dry Wt. + Tare (0.01 g)		638.10	901.90	969.80	792.10	723.10	879.60
	Tare Wt. (0.01 g)		263.80	243.80	268.00	245.90	184.30	261.80
	Wt of Dry Sample		374.30	658.10	701.80	546.20	538.80	617.80
	Wt of Water		48.90	87.90	93.60	66.10	66.10	81.90
	Water Content, %		13.06	13.36	13.34	12.10	12.27	13.26
	Average Moisture Content, %		13.25			12.54		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.007	5.024	5.004	5.019	5.005	5.025
	KMNO4 required to titrate (0.1 ml)		7.0	7.9	7.1	7.8	8.3	7.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.005	1.001	1.004	1.001	1.005
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.79	2.03	1.82	2.01	2.15	2.01
	% Cement by Mass of Soil	N/A	2.73	3.10	2.77	3.06	3.29	3.06

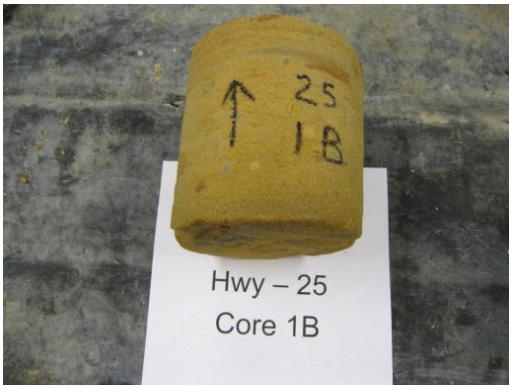
Average % Cement Top 2.87 Average % Cement Bottom 3.14

Overall Average Cement Content, % 3.00

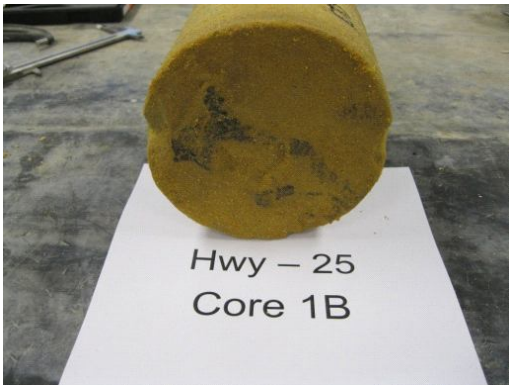
Highway No. 25
Core No. 1B



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.50**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.25**	**10.00**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**6.4**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.21**
Avg Cement Content Bottom (%):	**3.13**
Avg Cement Content (%):	**3.67**
Unit Weight (lbs/ft³):	**124.2**
Moisture Content (%):	**11.33**
Compressive Strength (psi):	**383**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

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FAX: (601) 856-3552

Hwy No. 25

Core No. 1B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.50	4.25
3rd Layer	2.50	6.75
4th Layer	3.25	10.00
ADC Layer	3.50	13.50
Soil Cement Layer	6.4	19.90

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.821	6.511	5.547	5.814
2	5.833	6.284	5.559	5.770
3	5.872	6.304	5.520	5.825
4		6.373		
5		6.421		
Average (in.)	5.842	6.4	5.542	5.803

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.91	0.993
Area ($in.^2$)	26.805	
Load (lbs)	11,286	
Compressive Strength (psi)	421	
Corrected Strength (psi)	383	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4845.9
Weight (lbs)	10.68
Volume ($in.^3$)	148.552
Volume ($ft.^3$)	0.086
Unit Weight (lbs/ft^3)	124.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 1B

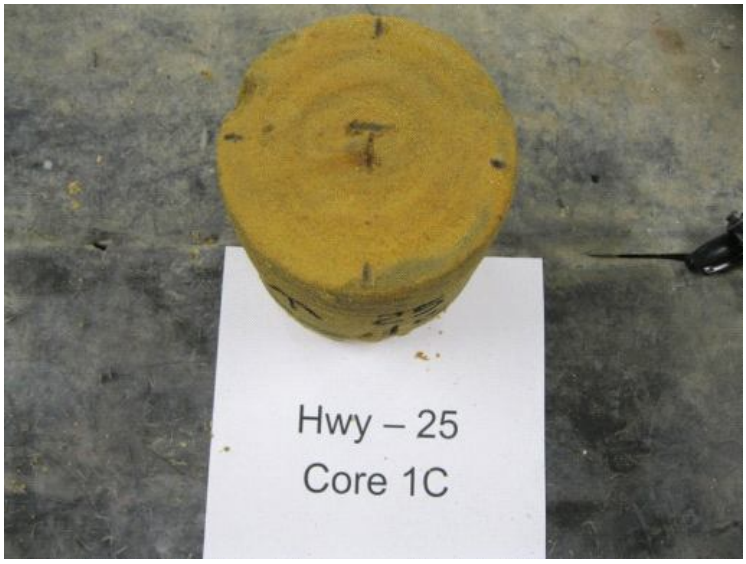
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	C	B	D	D	C	B
	Wet Wt. + Tare (0.01)		901.10	975.00	1158.10	741.90	986.90	1086.40
	Dry Wt. + Tare (0.01 g)		830.40	900.30	1065.20	692.60	911.80	991.80
	Tare Wt. (0.01 g)		180.10	253.20	249.20	249.30	180.00	253.20
	Wt of Dry Sample		650.30	647.10	816.00	443.30	731.80	738.60
	Wt of Water		70.70	74.70	92.90	49.30	75.10	94.60
	Water Content, %		10.87	11.54	11.38	11.12	10.26	12.81
	Average Moisture Content, %		11.27			11.40		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.013	5.006	5.006	5.007	5.005	5.008
	KMNO4 required to titrate (0.1 ml)		10.6	10.5	10.2	7.7	8.4	7.7
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.003	1.001	1.001	1.001	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.79	2.77	2.69	1.99	2.18	1.98
	% Cement by Mass of Soil	N/A	4.28	4.24	4.11	3.03	3.33	3.03

Average % Cement Top 4.21 Average % Cement Bottom 3.13

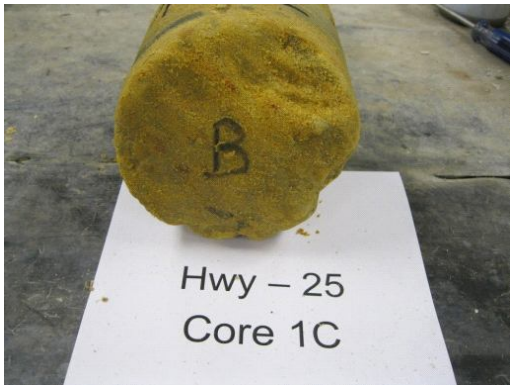
Overall Average Cement Content, % 3.67

Highway No. 25
Core No. 1C



Top

Side



Bottom

Pavement Thicknesses			
Surface Layer (in):	**1.25**		
Second Layer (in):	**2.00**	Asphalt	
Third Layer (in):	**2.50**	Thickness	
Fourth Layer (in):	**3.25**	**9.00**	
Drainage Layer (in):	**3.00**		
Soil Cement (in):	**6.4**		

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.69**
Avg Cement Content Bottom (%):	**2.75**
Avg Cement Content (%):	**3.22**
Unit Weight (lbs/ft³):	**119.2**
Moisture Content (%):	**13.74**
Compressive Strength (psi):	**243**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 1C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.00	3.25
3rd Layer	2.50	5.75
4th Layer	3.25	9.00
ADC Layer	3.00	12.00
Soil Cement Layer	6.4	18.40

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.813	6.165	5.123	5.366
2	5.839	6.305	5.063	5.362
3	5.852	6.554	5.111	5.359
4		6.435		
5		6.635		
Average (in.)	5.835	6.4	5.099	5.362

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.84	0.919
Area ($in.^2$)	26.738	
Load (lbs)	7,730	
Compressive Strength (psi)	289	
Corrected Strength (psi)	243	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4274.7
Weight (lbs)	9.42
Volume ($in.^3$)	136.335
Volume ($ft.^3$)	0.079
Unit Weight (lbs/ft^3)	119.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 1C

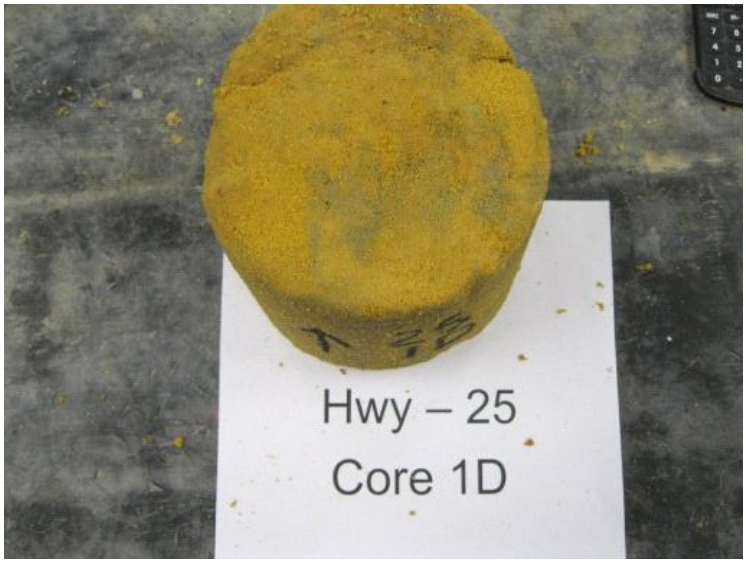
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	A12	A	L	I	F	E
	Wet Wt. + Tare (0.01)		771.30	920.60	965.10	558.00	710.60	956.60
	Dry Wt. + Tare (0.01 g)		708.40	838.00	872.00	514.40	661.20	872.40
	Tare Wt. (0.01 g)		263.70	243.70	245.90	184.20	261.80	267.90
	Wt of Dry Sample		444.70	594.30	626.10	330.20	399.40	604.50
	Wt of Water		62.90	82.60	93.10	43.60	49.40	84.20
	Water Content, %		14.14	13.90	14.87	13.20	12.37	13.93
	Average Moisture Content, %		14.30			13.17		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.002	5.012	5.015	5.013	5.007	5.013
	KMNO4 required to titrate (0.1 ml)		9.4	9.5	8.8	7.5	6.2	7.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.002	1.003	1.003	1.001	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.46	2.49	2.29	1.93	1.57	1.93
	% Cement by Mass of Soil	N/A	3.77	3.81	3.50	2.94	2.38	2.94

Average % Cement Top 3.69 Average % Cement Bottom 2.75

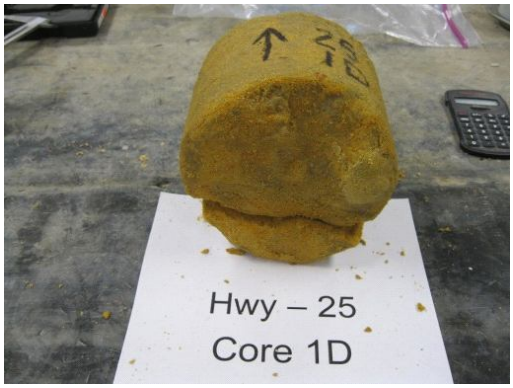
Overall Average Cement Content, % 3.22

Highway No. 25
Core No. 1D



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.25**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.50**	**9.25**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**4.7**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.10**
Avg Cement Content Bottom (%):	**2.52**
Avg Cement Content (%):	**2.81**
Unit Weight (lbs/ft³):	**0.0**
Moisture Content (%):	**8.66**
Compressive Strength (psi):	**0**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 1D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.00	3.25
3rd Layer	2.50	5.75
4th Layer	3.50	9.25
ADC Layer	3.00	12.25
Soil Cement Layer	4.7	16.95

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1		4.502		
2		4.930		
3		4.685		
4		4.664		
5		4.857		
Average (in.)		4.7		

Compressive Strength		
Test Date	NA	L/D Ratio
Correction Factor	1.00	
Area ($in.^2$)		
Load (lbs)		
Compressive Strength (psi)		
Corrected Strength (psi)		

Unit Weight After Drying for 24 Hours in Lab	
Test Date	NA
Weight (.1 g)	
Weight (lbs)	
Volume ($in.^3$)	
Volume ($ft.^3$)	
Unit Weight (lbs/ft^3)	

Notes:
1. Core separated during length measurement. Core was not suitable for compressive strength testing or unit weight.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 1D

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.03

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	P	P-1	DE	XY	X	BO
	Wet Wt. + Tare (0.01)		796.20	876.40	930.10	973.30	724.60	681.10
	Dry Wt. + Tare (0.01 g)		764.10	821.80	866.20	911.00	682.50	657.00
	Tare Wt. (0.01 g)		265.90	266.90	266.40	253.60	245.00	248.80
	Wt of Dry Sample		498.20	554.90	599.80	657.40	437.50	408.20
	Wt of Water		32.10	54.60	63.90	62.30	42.10	24.10
	Water Content, %		6.44	9.84	10.65	9.48	9.62	5.90
	Average Moisture Content, %		8.98			8.33		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.001	5.007	5.015	5.020	5.018	5.011
	KMNO4 required to titrate (0.1 ml)		7.3	7.9	8.4	6.7	6.2	6.7
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.001	1.003	1.004	1.004	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.88	2.04	2.18	1.70	1.56	1.70
	% Cement by Mass of Soil	N/A	2.86	3.12	3.33	2.59	2.37	2.59

Average % Cement Top 3.10 Average % Cement Bottom 2.52

Overall Average Cement Content, % 2.81

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25 **BCD Job Number** 090595

Row No. 2

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.007	5.031	5.007
	KMNO4 required to titrate (0.1 ml)		3.2	2.8	3.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.006	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.73	0.61	0.67

Average CaO Content of Virgin Soil, % 0.67

Highway No. 25
Core No. 2A

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.75**	Thickness
Fourth Layer (in):	**3.00**	**9.25**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**4.5**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.43**
Avg Cement Content Bottom (%):	**3.29**
Avg Cement Content (%):	**3.36**
Unit Weight (lbs/ft³):	**119.8**
Moisture Content (%):	**11.78**
Compressive Strength (psi):	**335**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 2A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.75	6.25
4th Layer	3.00	9.25
ADC Layer	3.50	12.75
Soil Cement Layer	4.5	17.25

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.811	4.363	3.603	3.871
2	5.862	4.580	3.602	3.892
3	5.822	4.363	3.632	3.898
4		4.594		
5		4.645		
Average (in.)	5.832	4.5	3.612	3.887

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.75	0.667
Area ($in.^2$)	26.710	
Load (lbs)	11,930	
Compressive Strength (psi)	447	
Corrected Strength (psi)	335	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3044.6
Weight (lbs)	6.71
Volume ($in.^3$)	96.486
Volume ($ft.^3$)	0.056
Unit Weight (lbs/ft^3)	119.8

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 2A

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.67

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	N8	N	MC	Q	R	S
	Wet Wt. + Tare (0.01)		758.70	684.50	691.40	432.40	473.80	504.70
	Dry Wt. + Tare (0.01 g)		704.30	641.40	651.40	388.20	420.30	451.40
	Tare Wt. (0.01 g)		244.00	260.50	249.30	19.00	19.00	18.90
	Wt of Dry Sample		460.30	380.90	402.10	369.20	401.30	432.50
	Wt of Water		54.40	43.10	40.00	44.20	53.50	53.30
	Water Content, %		11.82	11.32	9.95	11.97	13.33	12.32
	Average Moisture Content, %		11.03			12.54		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.025	5.010	5.008	5.017	5.007	5.012
	KMNO4 required to titrate (0.1 ml)		11.3	9.8	11.5	9.6	11.0	11.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.002	1.002	1.003	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.98	2.57	3.05	2.51	2.91	2.91
	% Cement by Mass of Soil	N/A	3.62	2.97	3.72	2.88	3.50	3.50

Average % Cement Top 3.43 Average % Cement Bottom 3.29

Overall Average Cement Content, % 3.36

Highway No. 25
Core No. 2B

Top

Side

Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.25**	**9.25**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.0**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.66**
Avg Cement Content Bottom (%):	**4.54**
Avg Cement Content (%):	**4.60**
Unit Weight (lbs/ft³):	**118.8**
Moisture Content (%):	**12.27**
Compressive Strength (psi):	**306**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 2B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.50	6.00
4th Layer	3.25	9.25
ADC Layer	3.50	12.75
Soil Cement Layer	5.0	17.75

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.836	4.821	3.782	4.088
2	5.847	4.948	3.729	4.053
3	5.870	5.054	3.842	4.046
4		5.335		
5		5.071		
Average (in.)	5.851	5.0	3.784	4.062

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.75	0.694
Area ($in.^2$)	26.887	
Load (lbs)	10,960	
Compressive Strength (psi)	408	
Corrected Strength (psi)	306	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3180.8
Weight (lbs)	7.01
Volume ($in.^3$)	101.751
Volume ($ft.^3$)	0.059
Unit Weight (lbs/ft^3)	118.8

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 2B

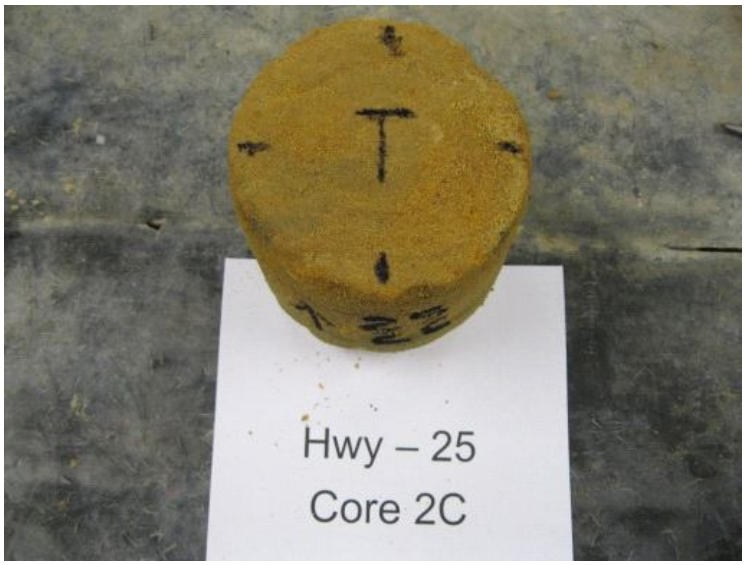
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.67

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	Z	V	T	KM	DC	PO
	Wet Wt. + Tare (0.01)		605.90	433.20	411.10	453.80	472.90	625.00
	Dry Wt. + Tare (0.01 g)		543.10	390.50	372.00	403.10	421.00	555.60
	Tare Wt. (0.01 g)		19.10	19.00	18.80	19.10	19.10	19.10
	Wt of Dry Sample		524.00	371.50	353.20	384.00	401.90	536.50
	Wt of Water		62.80	42.70	39.10	50.70	51.90	69.40
	Water Content, %		11.98	11.49	11.07	13.20	12.91	12.94
	Average Moisture Content, %		11.52			13.02		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.024	5.012	5.030	5.031	5.011	5.021
	KMNO4 required to titrate (0.1 ml)		14.1	13.3	13.7	14.0	12.7	13.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.002	1.006	1.006	1.002	1.004
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.76	3.55	3.65	3.73	3.38	3.60
	% Cement by Mass of Soil	N/A	4.84	4.50	4.66	4.79	4.24	4.58

Average % Cement Top 4.66 Average % Cement Bottom 4.54

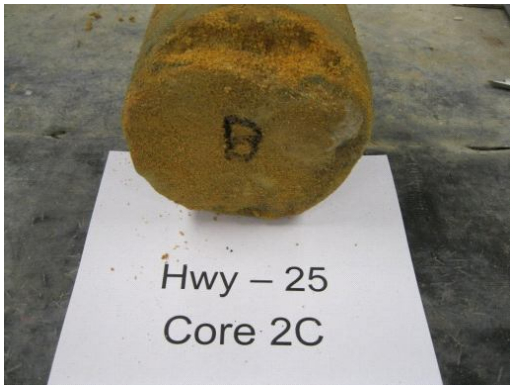
Overall Average Cement Content, % 4.60

Highway No. 25
Core No. 2C



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.00**	**9.00**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.3**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.26**
Avg Cement Content Bottom (%):	**2.58**
Avg Cement Content (%):	**2.92**
Unit Weight (lbs/ft³):	**117.2**
Moisture Content (%):	**10.62**
Compressive Strength (psi):	**237**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 2C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.50	6.00
4th Layer	3.00	9.00
ADC Layer	3.50	12.50
Soil Cement Layer	5.3	17.80

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.850	5.519	4.791	5.070
2	5.830	5.211	4.786	5.021
3	5.843	5.265	4.745	5.031
4		5.352		
5		5.315		
Average (in.)	5.841	5.3	4.774	5.041

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.80	0.863
Area ($in.^2$)	26.796	
Load (lbs)	7,920	
Compressive Strength (psi)	296	
Corrected Strength (psi)	237	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3933.8
Weight (lbs)	8.67
Volume ($in.^3$)	127.922
Volume ($ft.^3$)	0.074
Unit Weight (lbs/ft^3)	117.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25
Core No. 2C

BCD Job Number 090595

CaO of Cement, % 64.60

CaO of Virgin Soil, % 0.67

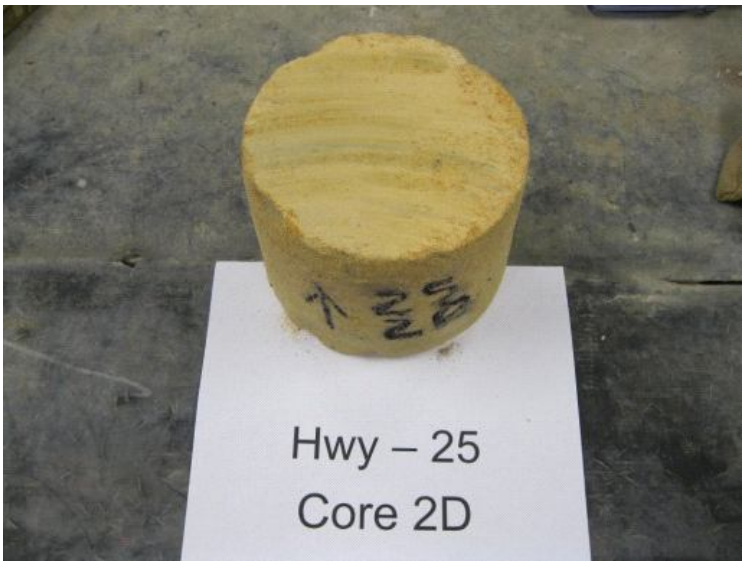
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	XY	D	C	PO	S	R
	Wet Wt. + Tare (0.01)		994.50	847.50	701.90	388.50	695.50	645.30
	Dry Wt. + Tare (0.01 g)		933.50	789.20	649.50	353.70	624.80	584.60
	Tare Wt. (0.01 g)		253.60	249.50	180.00	19.10	19.10	19.00
	Wt of Dry Sample		679.90	539.70	469.50	334.60	605.70	565.60
	Wt of Water		61.00	58.30	52.40	34.80	70.70	60.70
	Water Content, %		8.97	10.80	11.16	10.40	11.67	10.73
	Average Moisture Content, %		10.31			10.93		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.024	5.039	5.029	5.001	5.032	5.005
	KMNO4 required to titrate (0.1 ml)		9.6	10.9	11.0	8.1	9.8	8.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.005	1.008	1.006	1.000	1.006	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.51	2.86	2.89	2.10	2.56	2.29
	% Cement by Mass of Soil	N/A	2.87	3.43	3.48	2.24	2.96	2.54

Average % Cement Top 3.26

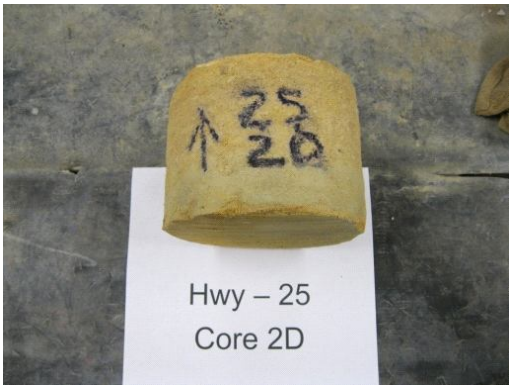
Average % Cement Bottom 2.58

Overall Average Cement Content, % 2.92

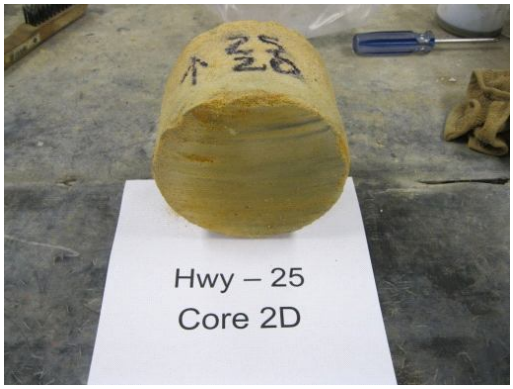
Highway No. 25
Core No. 2D



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.50**	**9.50**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.5**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.71**
Avg Cement Content Bottom (%):	**3.76**
Avg Cement Content (%):	**3.74**
Unit Weight (lbs/ft³):	**117.2**
Moisture Content (%):	**11.40**
Compressive Strength (psi):	**229**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 2D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.50	6.00
4th Layer	3.50	9.50
ADC Layer	3.50	13.00
Soil Cement Layer	5.5	18.50

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.753	5.370	4.417	4.662
2	5.839	5.665	4.416	4.695
3	5.782	5.370	4.356	4.691
4		5.499		
5		5.410		
Average (in.)	5.791	5.5	4.396	4.683

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.77	0.809
Area ($in.^2$)	26.342	
Load (lbs)	7,859	
Compressive Strength (psi)	298	
Corrected Strength (psi)	229	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3562.8
Weight (lbs)	7.85
Volume ($in.^3$)	115.808
Volume ($ft.^3$)	0.067
Unit Weight (lbs/ft^3)	117.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 2D

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.67

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	Q	V	KM	Z	DC	T
	Wet Wt. + Tare (0.01)		482.40	531.70	742.10	495.60	479.70	570.10
	Dry Wt. + Tare (0.01 g)		440.70	481.50	669.50	444.70	429.30	509.80
	Tare Wt. (0.01 g)		19.00	19.00	19.00	19.10	19.00	18.80
	Wt of Dry Sample		421.70	462.50	650.50	425.60	410.30	491.00
	Wt of Water		41.70	50.20	72.60	50.90	50.40	60.30
	Water Content, %		9.89	10.85	11.16	11.96	12.28	12.28
	Average Moisture Content, %		10.63			12.17		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.002	5.000	5.005	5.007	5.003	5.004
	KMNO4 required to titrate (0.1 ml)		10.2	12.0	12.2	10.6	12.8	11.4
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.000	1.001	1.001	1.001	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.69	3.19	3.24	2.80	3.41	3.02
	% Cement by Mass of Soil	N/A	3.16	3.94	4.03	3.33	4.29	3.68

Average % Cement Top 3.71

Average % Cement Bottom 3.76

Overall Average Cement Content, % 3.74

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

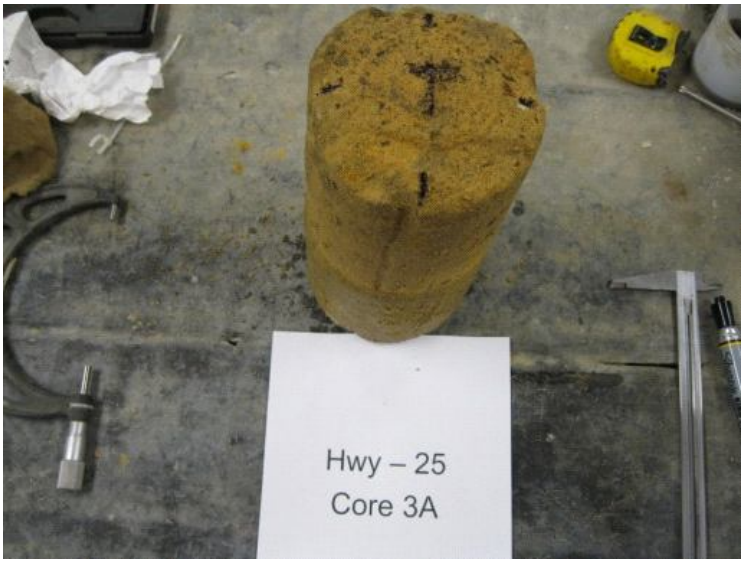
Hwy No. 25 **BCD Job Number** 090595

Row No. 3

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.006	5.005	5.001
	KMNO4 required to titrate (0.1 ml)		1.5	0.9	0.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.001	1.000
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.25	0.08	0.06

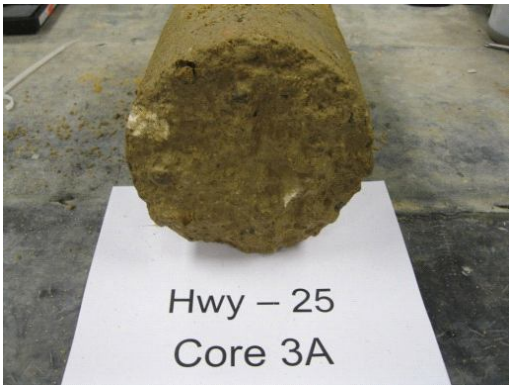
Average CaO Content of Virgin Soil, % 0.13

Highway No. 25
Core No. 3A



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.00**	**9.00**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.4**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.35**
Avg Cement Content Bottom (%):	**3.87**
Avg Cement Content (%):	**4.11**
Unit Weight (lbs/ft³):	**121.4**
Moisture Content (%):	**13.61**
Compressive Strength (psi):	**348**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 3A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.50	6.00
4th Layer	3.00	9.00
ADC Layer	3.50	12.50
Soil Cement Layer	5.4	17.90

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.726	11.097	5.290	5.713
2	5.793	11.640	5.460	5.746
3	5.754	11.520	5.256	5.722
4		11.668		
5		11.806		
Average (in.)	5.758	5.4	5.335	5.727

Notes:
1. 6.1 in. was subtracted from the core thickness to accommodate lime/cement treated layer.
2. 6.0 in. lime treatment below.

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.91	0.995
Area ($in.^2$)	26.036	
Load (lbs)	9,935	
Compressive Strength (psi)	382	
Corrected Strength (psi)	348	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4406.6
Weight (lbs)	9.71
Volume ($in.^3$)	138.913
Volume ($ft.^3$)	0.080
Unit Weight (lbs/ft^3)	121.4

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 3A

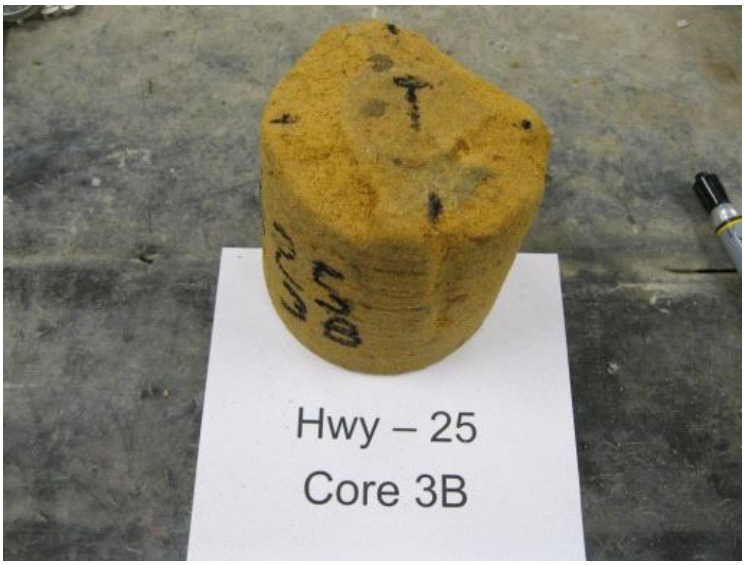
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.13

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	B	A12	A	L	BO	X
	Wet Wt. + Tare (0.01)		937.30	1011.00	1050.20	1035.60	838.70	761.80
	Dry Wt. + Tare (0.01 g)		854.10	922.60	956.50	935.50	768.90	701.00
	Tare Wt. (0.01 g)		253.20	263.70	243.70	245.90	248.80	244.90
	Wt of Dry Sample		600.90	658.90	712.80	689.60	520.10	456.10
	Wt of Water		83.20	88.40	93.70	100.10	69.80	60.80
	Water Content, %		13.85	13.42	13.15	14.52	13.42	13.33
	Average Moisture Content, %		13.47			13.76		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.010	5.020	5.000	5.010	5.024	5.004
	KMNO4 required to titrate (0.1 ml)		10.6	10.0	12.7	9.0	10.4	10.6
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.004	1.000	1.002	1.005	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.79	2.62	3.39	2.35	2.73	2.80
	% Cement by Mass of Soil	N/A	4.13	3.86	5.05	3.44	4.03	4.14

Average % Cement Top 4.35 Average % Cement Bottom 3.87

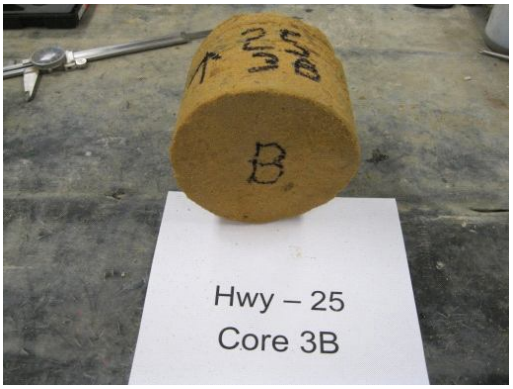
Overall Average Cement Content, % 4.11

Highway No. 25
Core No. 3B



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**8.50**
Drainage Layer (in):	**3.25**	
Soil Cement (in):	**5.4**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.99**
Avg Cement Content Bottom (%):	**3.03**
Avg Cement Content (%):	**3.01**
Unit Weight (lbs/ft³):	**120.2**
Moisture Content (%):	**11.67**
Compressive Strength (psi):	**389**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 3B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.00	5.50
4th Layer	3.00	8.50
ADC Layer	3.25	11.75
Soil Cement Layer	5.4	17.15

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.877	5.563	3.630	3.948
2	5.880	5.017	3.616	3.981
3	5.896	5.351	3.642	3.998
4		5.431		
5		5.542		
Average (in.)	5.884	5.4	3.629	3.976

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.75	0.676
Area ($in.^2$)	27.195	
Load (lbs)	14,106	
Compressive Strength (psi)	519	
Corrected Strength (psi)	389	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3107.1
Weight (lbs)	6.85
Volume ($in.^3$)	98.699
Volume ($ft.^3$)	0.057
Unit Weight (lbs/ft^3)	120.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 3B

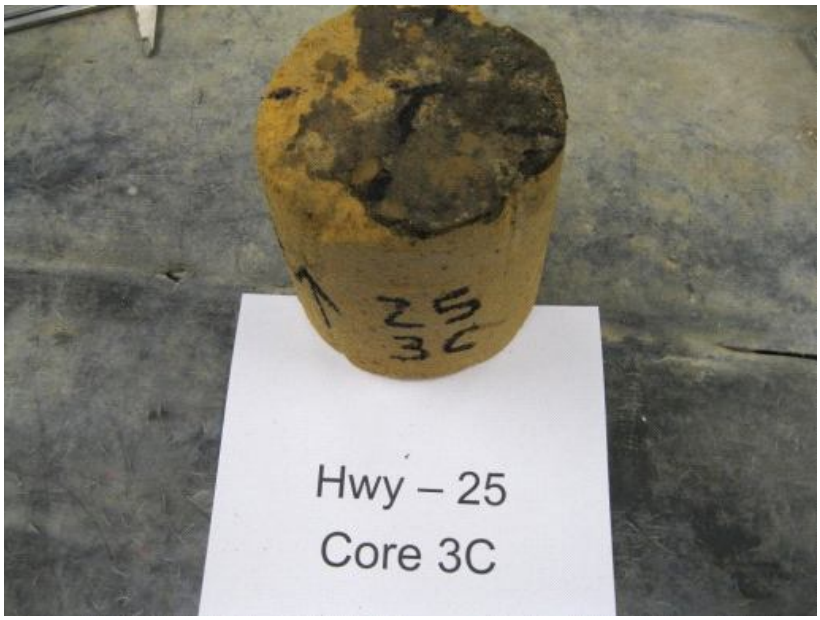
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.13

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	E	F	DE	I	P	MC
	Wet Wt. + Tare (0.01)		1005.70	674.40	648.70	590.80	746.10	668.00
	Dry Wt. + Tare (0.01 g)		934.00	630.00	610.10	549.70	693.10	622.00
	Tare Wt. (0.01 g)		268.00	261.70	266.50	184.20	265.80	249.20
	Wt of Dry Sample		666.00	368.30	343.60	365.50	427.30	372.80
	Wt of Water		71.70	44.40	38.60	41.10	53.00	46.00
	Water Content, %		10.77	12.06	11.23	11.24	12.40	12.34
	Average Moisture Content, %		11.35			12.00		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.001	5.021	5.019	5.016	5.025	5.017
	KMNO4 required to titrate (0.1 ml)		7.4	8.6	7.9	7.0	8.7	8.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.004	1.004	1.003	1.005	1.003
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.90	2.23	2.04	1.79	2.26	2.21
	% Cement by Mass of Soil	N/A	2.75	3.26	2.96	2.57	3.30	3.22

Average % Cement Top 2.99 Average % Cement Bottom 3.03

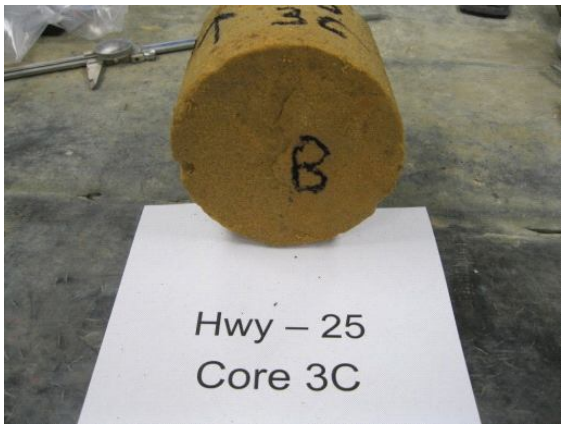
Overall Average Cement Content, % 3.01

Highway No. 25
Core No. 3C



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.50**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.00**	**8.50**
Drainage Layer (in):	**3.25**	
Soil Cement (in):	**6.1**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**5.52**
Avg Cement Content Bottom (%):	**3.99**
Avg Cement Content (%):	**4.76**
Unit Weight (lbs/ft³):	**120.1**
Moisture Content (%):	**12.88**
Compressive Strength (psi):	**400**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 3C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.50	1.50
2nd Layer	2.00	3.50
3rd Layer	2.00	5.50
4th Layer	3.00	8.50
ADC Layer	3.25	11.75
Soil Cement Layer	6.1	17.85

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.858	6.138	5.292	5.560
2	5.860	6.290	5.286	5.564
3	5.836	6.246	5.296	5.522
4		5.868		
5		5.992		
Average (in.)	5.851	6.1	5.291	5.549

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.86	0.948
Area ($in.^2$)	26.891	
Load (lbs)	12,495	
Compressive Strength (psi)	465	
Corrected Strength (psi)	400	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4467.5
Weight (lbs)	9.85
Volume ($in.^3$)	142.287
Volume ($ft.^3$)	0.082
Unit Weight (lbs/ft^3)	120.1

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 3C

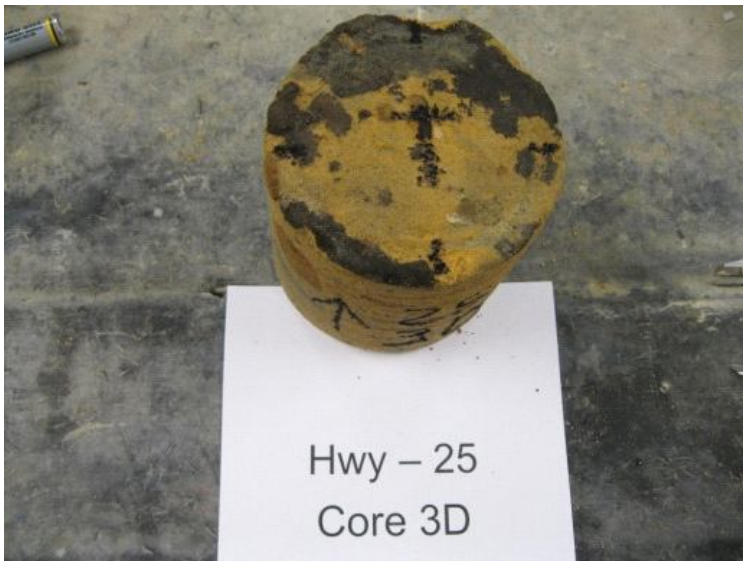
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.13

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	ZM	MS	PU	N	N8	P1
	Wet Wt. + Tare (0.01)		895.70	692.40	728.90	806.10	905.10	880.30
	Dry Wt. + Tare (0.01 g)		799.70	616.60	649.40	742.40	829.50	807.10
	Tare Wt. (0.01 g)		18.80	19.90	19.20	260.50	244.10	267.10
	Wt of Dry Sample		780.90	596.70	630.20	481.90	585.40	540.00
	Wt of Water		96.00	75.80	79.50	63.70	75.60	73.20
	Water Content, %		12.29	12.70	12.62	13.22	12.91	13.56
	Average Moisture Content, %		12.54			13.23		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.010	5.009	5.005	5.003	5.003	5.002
	KMNO4 required to titrate (0.1 ml)		13.2	14.5	13.7	10.8	10.2	9.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.002	1.001	1.001	1.001	1.000
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.52	3.88	3.66	2.85	2.69	2.58
	% Cement by Mass of Soil	N/A	5.26	5.82	5.48	4.22	3.96	3.79

Average % Cement Top 5.52 Average % Cement Bottom 3.99

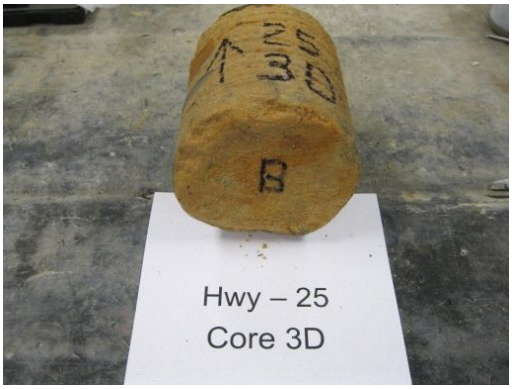
Overall Average Cement Content, % 4.76

Highway No. 25
Core No. 3D



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.00**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.25**	**8.25**
Drainage Layer (in):	**2.75**	
Soil Cement (in):	**6.3**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.87**
Avg Cement Content Bottom (%):	**4.69**
Avg Cement Content (%):	**4.78**
Unit Weight (lbs/ft³):	**121.5**
Moisture Content (%):	**12.24**
Compressive Strength (psi):	**415**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 3D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.00	1.00
2nd Layer	2.00	3.00
3rd Layer	2.00	5.00
4th Layer	3.25	8.25
ADC Layer	2.75	11.00
Soil Cement Layer	6.3	17.30

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.820	6.178	5.594	5.900
2	5.801	6.211	5.539	5.851
3	5.801	6.378	5.572	5.821
4		6.436		
5		6.171		
Average (in.)	5.807	6.3	5.568	5.857

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.93	1.009
Area ($in.^2$)	26.488	
Load (lbs)	11,815	
Compressive Strength (psi)	446	
Corrected Strength (psi)	415	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4687.7
Weight (lbs)	10.33
Volume ($in.^3$)	147.492
Volume ($ft.^3$)	0.085
Unit Weight (lbs/ft^3)	121.5

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 3D

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.13

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	B	A12	A	XY	D	L
	Wet Wt. + Tare (0.01)		1001.40	898.10	935.30	1050.70	1140.10	829.40
	Dry Wt. + Tare (0.01 g)		912.40	828.20	857.70	973.90	1041.00	768.20
	Tare Wt. (0.01 g)		253.10	263.50	243.70	253.90	249.30	245.90
	Wt of Dry Sample		659.30	564.70	614.00	720.00	791.70	522.30
	Wt of Water		89.00	69.90	77.60	76.80	99.10	61.20
	Water Content, %		13.50	12.38	12.64	10.67	12.52	11.72
	Average Moisture Content, %		12.84			11.63		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.003	5.008	5.004	5.014	5.013	5.011
	KMNO4 required to titrate (0.1 ml)		11.8	12.9	12.2	9.0	13.6	13.1
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.002	1.001	1.003	1.003	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.13	3.44	3.24	2.34	3.63	3.49
	% Cement by Mass of Soil	N/A	4.66	5.13	4.83	3.44	5.43	5.22

Average % Cement Top 4.87 Average % Cement Bottom 4.69

Overall Average Cement Content, % 4.78

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

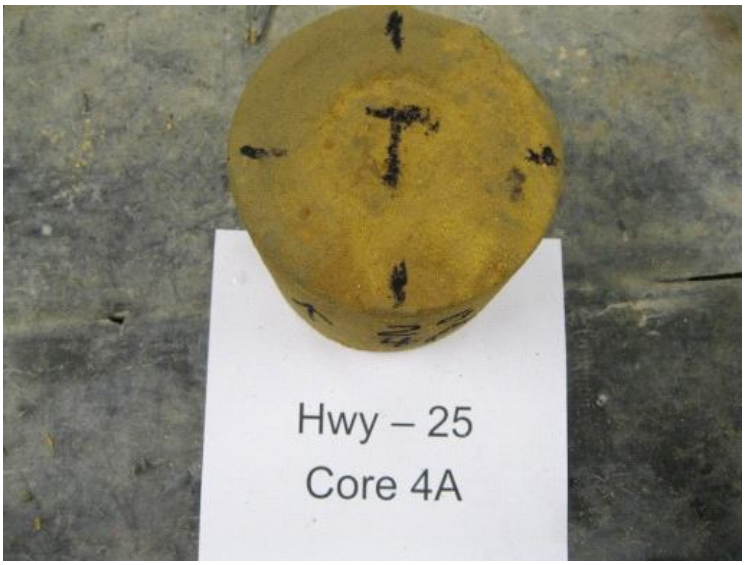
Hwy No. 25 **BCD Job Number** 090595

Row No. 4

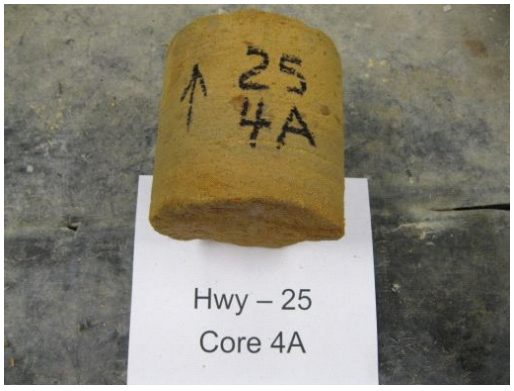
		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.003	5.004	5.008
	KMNO4 required to titrate (0.1 ml)		2.0	1.1	1.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.39	0.14	0.25

Average CaO Content of Virgin Soil, % 0.26

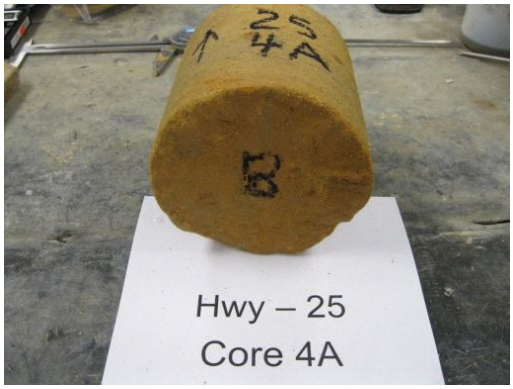
Highway No. 25
Core No. 4A



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.50**	Thickness
Fourth Layer (in):	**3.00**	**9.25**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**5.9**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.60**
Avg Cement Content Bottom (%):	**4.52**
Avg Cement Content (%):	**4.56**
Unit Weight (lbs/ft³):	**118.3**
Moisture Content (%):	**11.82**
Compressive Strength (psi):	**389**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 4A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.00	3.75
3rd Layer	2.50	6.25
4th Layer	3.00	9.25
ADC Layer	4.00	13.25
Soil Cement Layer	5.9	19.15

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.841	5.713	4.940	5.213
2	5.863	6.065	4.935	5.204
3	5.863	5.866	4.946	5.208
4		5.915		
5		5.867		
Average (in.)	5.856	5.9	4.940	5.208

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.82	0.889
Area ($in.^2$)	26.930	
Load (lbs)	12,776	
Compressive Strength (psi)	474	
Corrected Strength (psi)	389	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4133.0
Weight (lbs)	9.11
Volume ($in.^3$)	133.045
Volume ($ft.^3$)	0.077
Unit Weight (lbs/ft^3)	118.3

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 4A

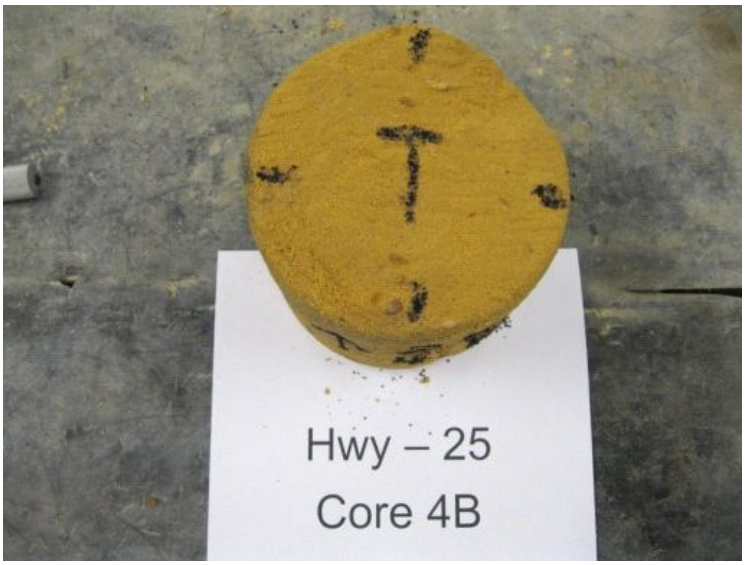
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.26

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	P	MC	N	P1	N8	E
	Wet Wt. + Tare (0.01)		853.10	1070.20	968.00	811.00	872.80	877.90
	Dry Wt. + Tare (0.01 g)		794.20	990.90	900.70	746.80	802.20	810.00
	Tare Wt. (0.01 g)		265.70	249.40	260.40	266.90	244.00	268.10
	Wt of Dry Sample		528.50	741.50	640.30	479.90	558.20	541.90
	Wt of Water		58.90	79.30	67.30	64.20	70.60	67.90
	Water Content, %		11.14	10.69	10.51	13.38	12.65	12.53
	Average Moisture Content, %		10.78			12.85		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.002	5.001	5.004	5.005	5.004	5.006
	KMNO4 required to titrate (0.1 ml)		11.4	12.4	12.5	11.9	12.1	11.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.000	1.001	1.001	1.001	1.001
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.02	3.30	3.33	3.16	3.22	3.13
	% Cement by Mass of Soil	N/A	4.30	4.73	4.77	4.51	4.60	4.47

Average % Cement Top 4.60 Average % Cement Bottom 4.52

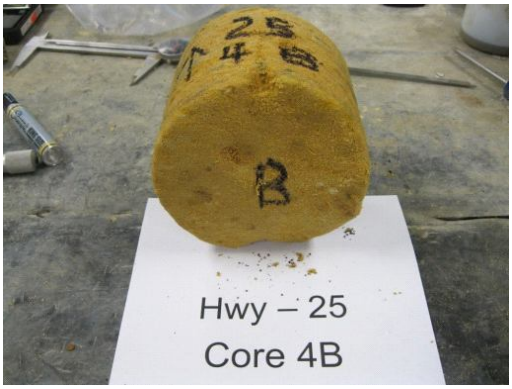
Overall Average Cement Content, % 4.56

Highway No. 25
Core No. 4B



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.25**	Thickness
Fourth Layer (in):	**3.00**	**9.00**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**4.8**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.36**
Avg Cement Content Bottom (%):	**2.45**
Avg Cement Content (%):	**2.41**
Unit Weight (lbs/ft³):	**119.5**
Moisture Content (%):	**10.42**
Compressive Strength (psi):	**220**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 4B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.00	3.75
3rd Layer	2.25	6.00
4th Layer	3.00	9.00
ADC Layer	4.00	13.00
Soil Cement Layer	4.8	17.80

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.858	4.855	3.587	3.865
2	5.825	4.484	3.599	3.902
3	5.778	4.945	3.591	3.848
4		5.100		
5		4.792		
Average (in.)	5.820	4.8	3.592	3.872

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.75	0.665
Area ($in.^2$)	26.606	
Load (lbs)	7,804	
Compressive Strength (psi)	293	
Corrected Strength (psi)	220	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	2979.3
Weight (lbs)	6.57
Volume ($in.^3$)	95.579
Volume ($ft.^3$)	0.055
Unit Weight (lbs/ft^3)	119.5

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 4B

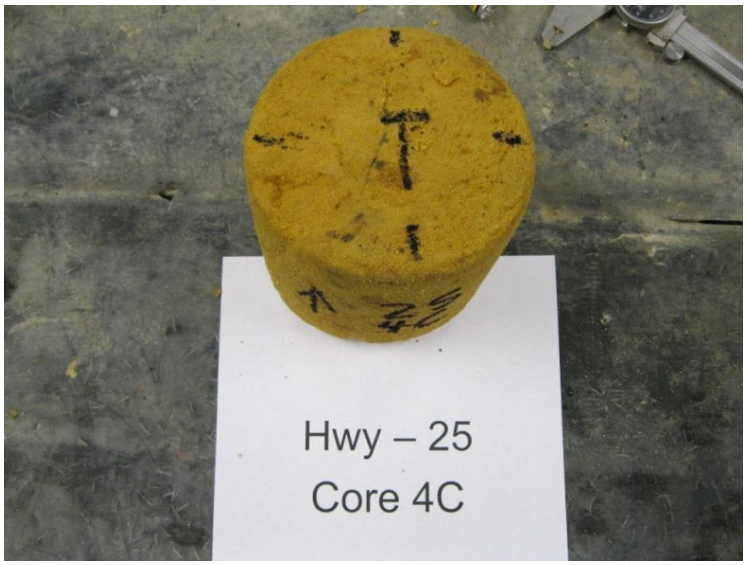
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.26

		Blank	Soil Cement Cores					
			Top 1			**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	F			DE	X	I
	Wet Wt. + Tare (0.01)		1058.40			821.90	933.90	583.50
	Dry Wt. + Tare (0.01 g)		980.70			770.30	869.50	546.10
	Tare Wt. (0.01 g)		261.80			266.40	244.90	184.10
	Wt of Dry Sample		718.90			503.90	624.60	362.00
	Wt of Water		77.70			51.60	64.40	37.40
	Water Content, %		10.81			10.24	10.31	10.33
	Average Moisture Content, %		10.81			10.29		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.008	5.007	5.001	5.014	5.006	5.010
	KMNO4 required to titrate (0.1 ml)		7.0	7.4	6.5	6.3	7.7	7.5
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.001	1.000	1.003	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.79	1.90	1.65	1.59	1.99	1.93
	% Cement by Mass of Soil	N/A	2.38	2.55	2.16	2.07	2.68	2.59

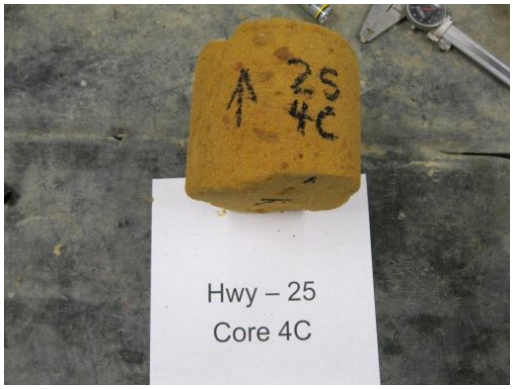
Average % Cement Top 2.36 Average % Cement Bottom 2.45

Overall Average Cement Content, % 2.41

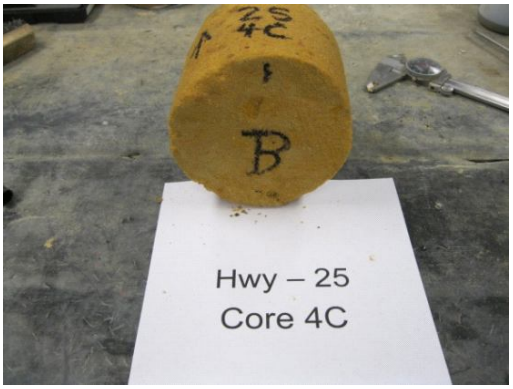
Highway No. 25
Core No. 4C



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.25**	
Second Layer (in):	**2.25**	Asphalt
Third Layer (in):	**2.25**	Thickness
Fourth Layer (in):	**2.75**	**8.50**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**5.1**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.55**
Avg Cement Content Bottom (%):	**2.46**
Avg Cement Content (%):	**2.51**
Unit Weight (lbs/ft³):	**115.8**
Moisture Content (%):	**9.31**
Compressive Strength (psi):	**245**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 4C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.25	1.25
2nd Layer	2.25	3.50
3rd Layer	2.25	5.75
4th Layer	2.75	8.50
ADC Layer	4.00	12.50
Soil Cement Layer	5.1	17.60

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.861	5.226	4.190	4.491
2	5.821	5.185	4.182	4.455
3	5.870	5.050	4.121	4.452
4		5.037		
5		5.132		
Average (in.)	5.851	5.1	4.164	4.466

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.76	0.763
Area ($in.^2$)	26.884	
Load (lbs)	8,657	
Compressive Strength (psi)	322	
Corrected Strength (psi)	245	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3414.2
Weight (lbs)	7.53
Volume ($in.^3$)	111.956
Volume ($ft.^3$)	0.065
Unit Weight (lbs/ft^3)	115.8

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25
Core No. 4C

BCD Job Number 090595

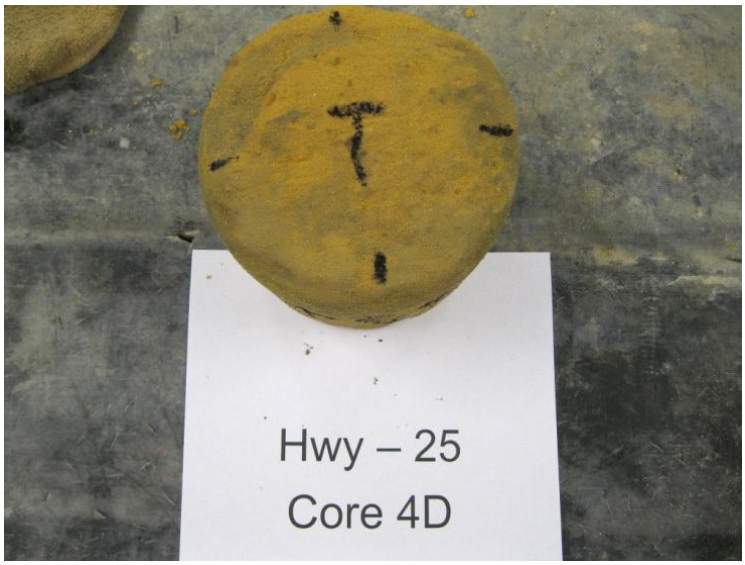
CaO of Cement, % 64.60

CaO of Virgin Soil, % 0.26

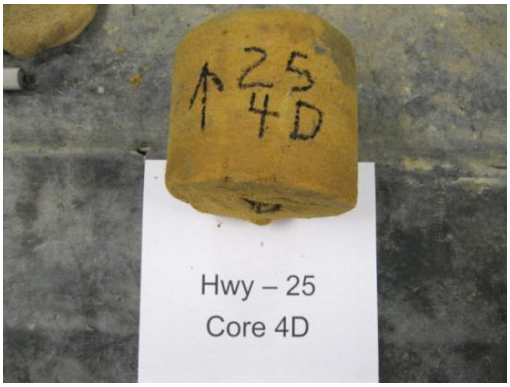
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	ZM	MS	S	PU	PO	DC
	Wet Wt. + Tare (0.01)		404.60	730.10	361.90	453.10	451.60	609.50
	Dry Wt. + Tare (0.01 g)		372.10	668.40	332.00	415.70	415.30	560.60
	Tare Wt. (0.01 g)		18.80	19.10	18.80	19.20	19.30	19.20
	Wt of Dry Sample		353.30	649.30	313.20	396.50	396.00	541.40
	Wt of Water		32.50	61.70	29.90	37.40	36.30	48.90
	Water Content, %		9.20	9.50	9.55	9.43	9.17	9.03
	Average Moisture Content, %		9.42			9.21		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.005	5.005	5.001	5.003	5.006	5.009
	KMNO4 required to titrate (0.1 ml)		6.5	8.1	7.6	6.4	7.9	7.3
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.001	1.000	1.001	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.65	2.10	1.96	1.62	2.04	1.87
	% Cement by Mass of Soil	N/A	2.16	2.86	2.64	2.12	2.77	2.51
			Average % Cement Top	2.55		Average % Cement Bottom	2.46	

Overall Average Cement Content, % 2.51

Highway No. 25
Core No. 4D



Top



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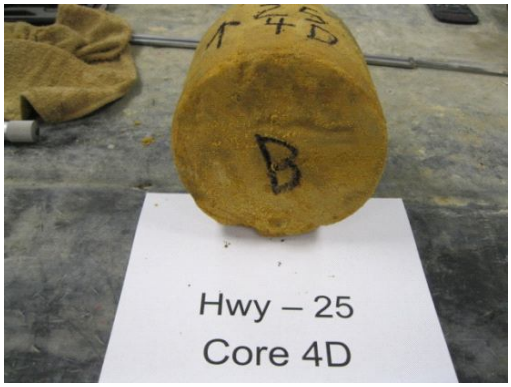


Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.25**	Asphalt
Third Layer (in):	**2.25**	Thickness
Fourth Layer (in):	**3.00**	**9.25**
Drainage Layer (in):	**4.00**	
Soil Cement (in):	**5.3**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**2.33**
Avg Cement Content Bottom (%):	**3.29**
Avg Cement Content (%):	**2.81**
Unit Weight (lbs/ft³):	**118.2**
Moisture Content (%):	**10.83**
Compressive Strength (psi):	**257**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 4D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.25	4.00
3rd Layer	2.25	6.25
4th Layer	3.00	9.25
ADC Layer	4.00	13.25
Soil Cement Layer	5.3	18.55

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.847	5.092	4.175	4.428
2	5.863	5.314	4.192	4.405
3	5.877	5.452	4.183	4.427
4		5.115		
5		5.320		
Average (in.)	5.862	5.3	4.183	4.420

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.76	0.754
Area ($in.^2$)	26.992	
Load (lbs)	9,118	
Compressive Strength (psi)	338	
Corrected Strength (psi)	257	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3482.9
Weight (lbs)	7.68
Volume ($in.^3$)	112.915
Volume ($ft.^3$)	0.065
Unit Weight (lbs/ft^3)	118.2

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 4D

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.26

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	R	Z	V	KM	Q	T
	Wet Wt. + Tare (0.01)		528.10	583.60	533.10	499.50	699.10	456.70
	Dry Wt. + Tare (0.01 g)		481.40	534.00	491.90	448.10	626.00	408.10
	Tare Wt. (0.01 g)		18.90	19.20	19.00	19.00	19.00	19.00
	Wt of Dry Sample		462.50	514.80	472.90	429.10	607.00	389.10
	Wt of Water		46.70	49.60	41.20	51.40	73.10	48.60
	Water Content, %		10.10	9.63	8.71	11.98	12.04	12.49
	Average Moisture Content, %		9.48			12.17		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.007	5.010	5.002	5.015	5.000	5.008
	KMNO4 required to titrate (0.1 ml)		6.2	7.5	7.0	9.5	8.8	9.0
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.002	1.000	1.003	1.000	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	1.57	1.93	1.79	2.48	2.30	2.35
	% Cement by Mass of Soil	N/A	2.03	2.59	2.38	3.46	3.16	3.24

Average % Cement Top 2.33 Average % Cement Bottom 3.29

Overall Average Cement Content, % 2.81

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects
ASTM D806 Cement Content of Hardened Soil-Cement Mixtures - Virgin Soil

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

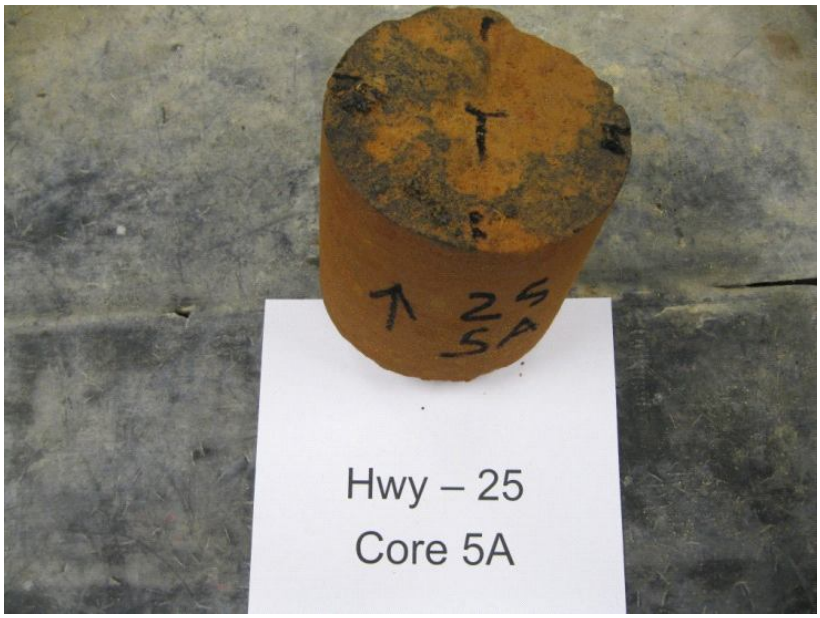
Hwy No. 25 **BCD Job Number** 090595

Row No. 5

		Blank	Virgin Soil		
			Sample 1	Sample 2	Sample 3
Titration	Tare #	NA	7	7	7
	Oven Dry Sample Weight (.001 g)		5.000	5.003	5.010
	KMNO4 required to titrate (0.1 ml)		3.1	3.1	3.1
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	0.70	0.70	0.70

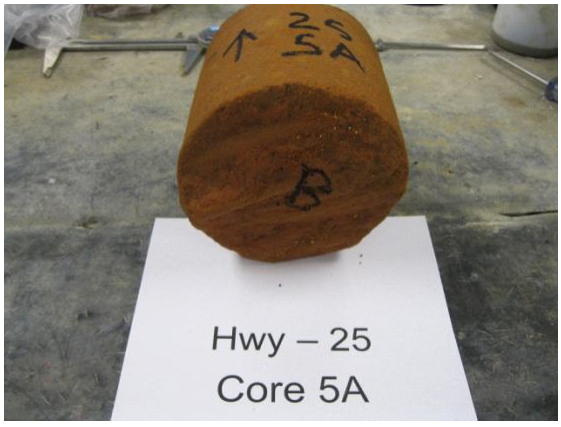
Average CaO Content of Virgin Soil, % 0.70

Highway No. 25
Core No. 5A



Top

Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.25**	Asphalt
Third Layer (in):	**2.75**	Thickness
Fourth Layer (in):	**2.75**	**9.50**
Drainage Layer (in):	**3.50**	
Soil Cement (in):	**5.7**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.78**
Avg Cement Content Bottom (%):	**4.28**
Avg Cement Content (%):	**4.03**
Unit Weight (lbs/ft³):	**123.3**
Moisture Content (%):	**14.98**
Compressive Strength (psi):	**479**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

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RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 5A

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.25	4.00
3rd Layer	2.75	6.75
4th Layer	2.75	9.50
ADC Layer	3.50	13.00
Soil Cement Layer	5.7	18.70

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.910	5.760	4.766	5.046
2	5.870	5.800	4.751	5.052
3	5.912	5.529	4.778	5.028
4		5.911		
5		5.465		
Average (in.)	5.897	5.7	4.765	5.042

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.79	0.855
Area ($in.^2$)	27.315	
Load (lbs)	16,560	
Compressive Strength (psi)	606	
Corrected Strength (psi)	479	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4197.6
Weight (lbs)	9.25
Volume ($in.^3$)	130.156
Volume ($ft.^3$)	0.075
Unit Weight (lbs/ft^3)	123.3

Notes:
1. 7.5 in. lime treatment below.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 5A

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.70

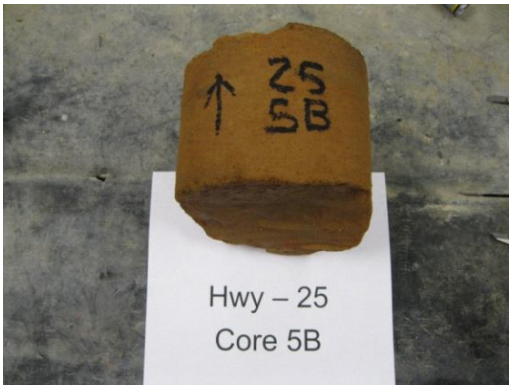
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	UN	BO	C	B	A12	BO
	Wet Wt. + Tare (0.01)		649.70	843.50	936.80	702.60	1092.00	918.50
	Dry Wt. + Tare (0.01 g)		572.20	767.50	841.50	642.70	978.30	828.40
	Tare Wt. (0.01 g)		18.90	248.90	180.00	253.20	263.70	248.90
	Wt of Dry Sample		553.30	518.60	661.50	389.50	714.60	579.50
	Wt of Water		77.50	76.00	95.30	59.90	113.70	90.10
	Water Content, %		14.01	14.65	14.41	15.38	15.91	15.55
	Average Moisture Content, %		14.36			15.61		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.009	5.005	5.003	5.002	5.003	5.002
	KMNO4 required to titrate (0.1 ml)		11.3	12.2	11.7	12.6	13.8	12.2
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.002	1.001	1.001	1.000	1.001	1.000
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.99	3.24	3.10	3.36	3.69	3.25
	% Cement by Mass of Soil	N/A	3.58	3.98	3.76	4.16	4.68	3.99

Average % Cement Top 3.78 Average % Cement Bottom 4.28

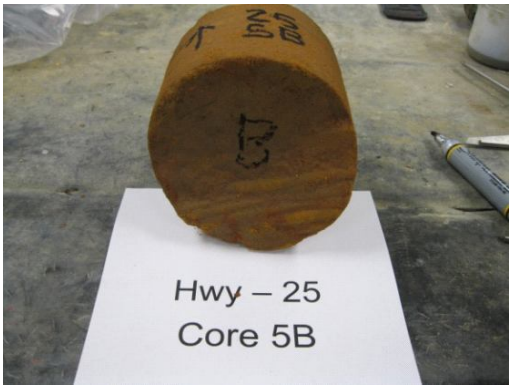
Overall Average Cement Content, % 4.03

Highway No. 25
Core No. 5B

Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.25**	Asphalt
Third Layer (in):	**3.00**	Thickness
Fourth Layer (in):	**2.50**	**9.50**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**4.9**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.56**
Avg Cement Content Bottom (%):	**3.69**
Avg Cement Content (%):	**3.63**
Unit Weight (lbs/ft³):	**126.9**
Moisture Content (%):	**12.73**
Compressive Strength (psi):	**637**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 5B

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.25	4.00
3rd Layer	3.00	7.00
4th Layer	2.50	9.50
ADC Layer	3.00	12.50
Soil Cement Layer	4.9	17.40

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.876	4.475	3.728	4.053
2	5.912	4.358	3.735	4.130
3	5.906	5.469	3.731	4.068
4		5.918		
5		4.457		
Average (in.)	5.898	4.9	3.731	4.084

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.75	0.692
Area ($in.^2$)	27.321	
Load (lbs)	23,206	
Compressive Strength (psi)	849	
Corrected Strength (psi)	637	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	3398.0
Weight (lbs)	7.49
Volume ($in.^3$)	101.944
Volume ($ft.^3$)	0.059
Unit Weight (lbs/ft^3)	126.9

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25
Core No. 5B

BCD Job Number 090595

CaO of Cement, % 64.60

CaO of Virgin Soil, % 0.70

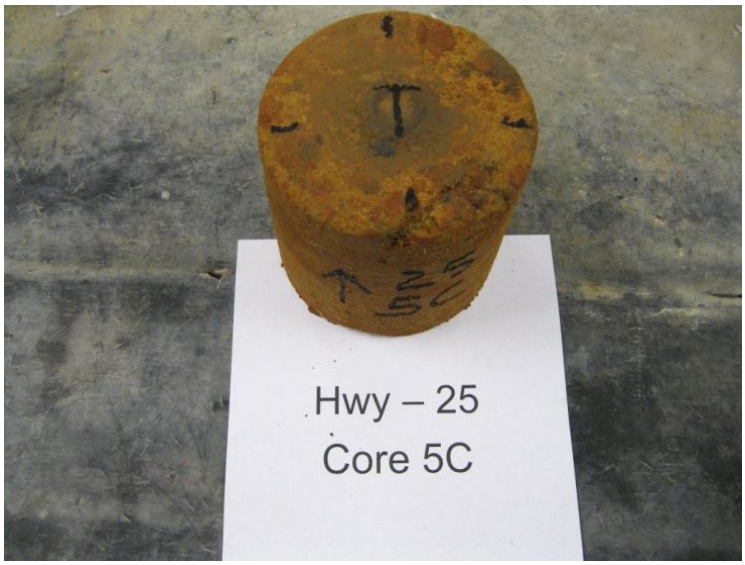
		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	P-1	N8	E	A	L	XY
	Wet Wt. + Tare (0.01)		739.50	808.10	796.50	783.90	688.90	769.40
	Dry Wt. + Tare (0.01 g)		687.80	747.20	737.40	721.00	638.90	708.00
	Tare Wt. (0.01 g)		267.00	244.10	268.00	243.80	246.00	253.60
	Wt of Dry Sample		420.80	503.10	469.40	477.20	392.90	454.40
	Wt of Water		51.70	60.90	59.10	62.90	50.00	61.40
	Water Content, %		12.29	12.10	12.59	13.18	12.73	13.51
	Average Moisture Content, %		12.33			13.14		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.006	5.001	5.001	5.009	5.002	5.001
	KMNO4 required to titrate (0.1 ml)		11.0	11.2	11.5	10.2	13.1	11.3
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.001	1.000	1.000	1.002	1.000	1.000
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	2.91	2.97	3.05	2.68	3.50	3.00
	% Cement by Mass of Soil	N/A	3.46	3.55	3.68	3.10	4.38	3.59

Average % Cement Top: 3.56

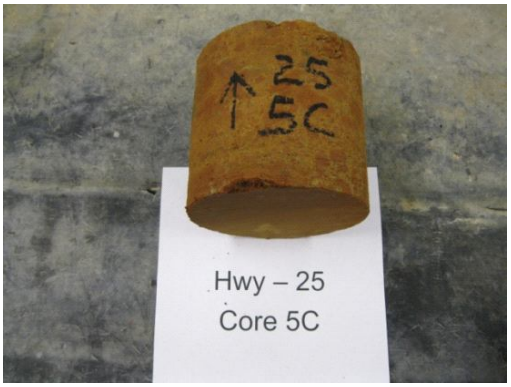
Average % Cement Bottom: 3.69

Overall Average Cement Content, %: 3.63

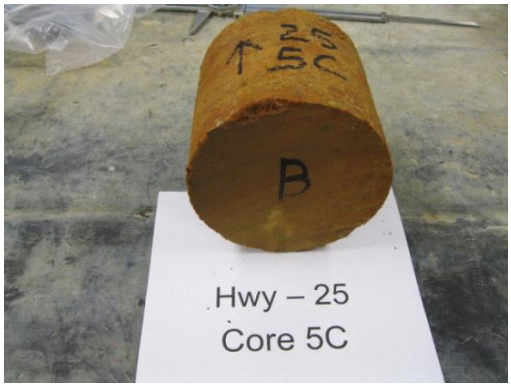
Highway No. 25
Core No. 5C



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**2.00**	
Second Layer (in):	**2.50**	Asphalt
Third Layer (in):	**2.25**	Thickness
Fourth Layer (in):	**2.75**	**9.50**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**5.8**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**3.82**
Avg Cement Content Bottom (%):	**3.82**
Avg Cement Content (%):	**3.82**
Unit Weight (lbs/ft³):	**120.3**
Moisture Content (%):	**12.43**
Compressive Strength (psi):	**419**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 5C

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	2.00	2.00
2nd Layer	2.50	4.50
3rd Layer	2.25	6.75
4th Layer	2.75	9.50
ADC Layer	3.00	12.50
Soil Cement Layer	5.8	18.30

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.880	5.760	5.052	5.370
2	5.871	5.729	5.063	5.261
3	5.897	5.710	5.072	5.229
4		5.788		
5		5.851		
Average (in.)	5.883	5.8	5.062	5.287

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.82	0.899
Area ($in.^2$)	27.179	
Load (lbs)	13,886	
Compressive Strength (psi)	511	
Corrected Strength (psi)	419	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4362.3
Weight (lbs)	9.62
Volume ($in.^3$)	137.591
Volume ($ft.^3$)	0.080
Unit Weight (lbs/ft^3)	120.3

Notes:
1. Bottom of core sawed before measuring.

BURNS COOLEY DENNIS, INC.

CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES

State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

ASTM D806 Cement Content of Hardened Soil-Cement Mixtures

278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 5C

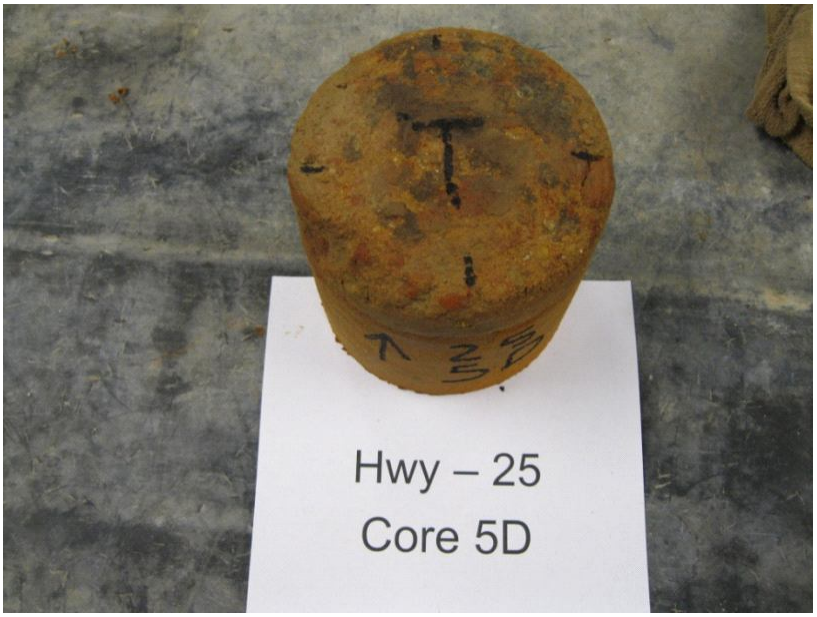
CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.70

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	D	P	MC	N	C	F
	Wet Wt. + Tare (0.01)		972.30	1111.40	628.20	960.50	769.90	783.20
	Dry Wt. + Tare (0.01 g)		896.00	1020.00	588.20	878.50	701.40	725.40
	Tare Wt. (0.01 g)		249.20	265.70	249.40	260.50	180.00	261.60
	Wt of Dry Sample		646.80	754.30	338.80	618.00	521.40	463.80
	Wt of Water		76.30	91.40	40.00	82.00	68.50	57.80
	Water Content, %		11.80	12.12	11.81	13.27	13.14	12.46
	Average Moisture Content, %		11.91			12.96		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.018	5.004	5.012	5.017	5.005	5.010
	KMNO4 required to titrate (0.1 ml)		12.0	12.1	11.4	11.0	11.7	12.8
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.004	1.001	1.002	1.003	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.18	3.22	3.02	2.90	3.10	3.41
	% Cement by Mass of Soil	N/A	3.88	3.94	3.63	3.45	3.76	4.24

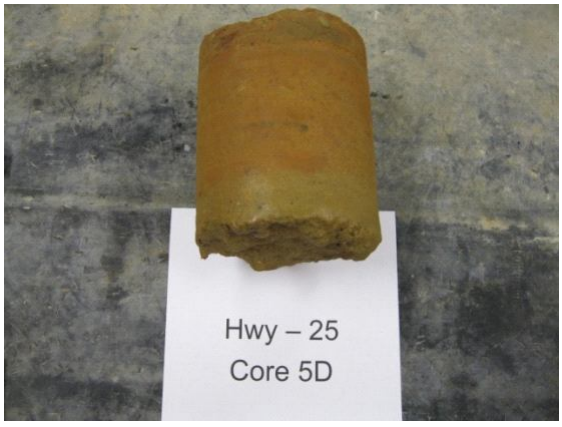
Average % Cement Top 3.82 Average % Cement Bottom 3.82

Overall Average Cement Content, % 3.82

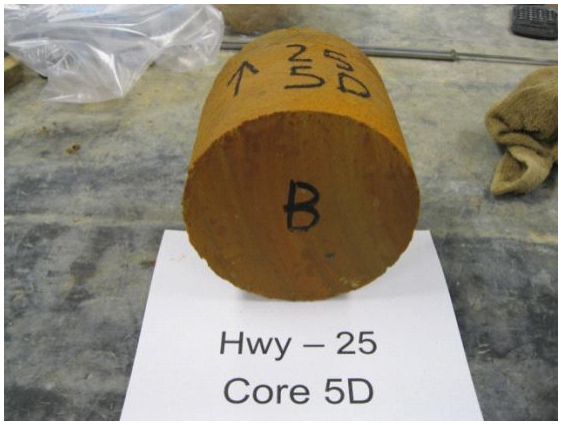
Highway No. 25
Core No. 5D



Top



Side



Bottom

Pavement Thicknesses		
Surface Layer (in):	**1.75**	
Second Layer (in):	**2.00**	Asphalt
Third Layer (in):	**2.00**	Thickness
Fourth Layer (in):	**3.50**	**9.25**
Drainage Layer (in):	**3.00**	
Soil Cement (in):	**5.6**	

Soil Cement Core Properties	
Avg Cement Content Top (%):	**4.13**
Avg Cement Content Bottom (%):	**4.59**
Avg Cement Content (%):	**4.36**
Unit Weight (lbs/ft³):	**123.6**
Moisture Content (%):	**13.52**
Compressive Strength (psi):	**585**

BURNS COOLEY DENNIS, INC.
CONSTRUCTION MATERIALS AND ENGINEERING TESTING SERVICES
State Study 227 - "Variability of Cement Treated Layers in MDOT Road Projects

DIMENSIONS, COMPRESSIVE STRENGTH, UNIT WEIGHT

278 Commerce Park Drive
RIDGELAND, MS 39157

BUS: (601) 856-2332
FAX: (601) 856-3552

Hwy No. 25

Core No. 5D

Project No. 090595

General Pavement Thickness Measurements as Sampled		
	(0.25 in.)	Cumulative
Surface Layer	1.75	1.75
2nd Layer	2.00	3.75
3rd Layer	2.00	5.75
4th Layer	3.50	9.25
ADC Layer	3.00	12.25
Soil Cement Layer	5.6	17.85

Core Dimensions				
Dimension	Diameter (.001 in)	Length Before Sawing	Length After Sawing	Length After Capping
1	5.909	5.518	5.047	5.377
2	5.887	5.564	4.940	5.328
3	5.906	5.610	4.799	5.330
4		5.567		
5		5.615		
Average (in.)	5.901	5.6	4.929	5.345

Compressive Strength		
Test Date	8/25/2010	L/D Ratio
Correction Factor	0.83	0.906
Area ($in.^2$)	27.346	
Load (lbs)	19,286	
Compressive Strength (psi)	705	
Corrected Strength (psi)	585	

Unit Weight After Drying for 24 Hours in Lab	
Test Date	8/25/2010
Weight (.1 g)	4374.3
Weight (lbs)	9.64
Volume ($in.^3$)	134.779
Volume ($ft.^3$)	0.078
Unit Weight (lbs/ft^3)	123.6

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278 Commerce Park Drive
RIDGELAND, MS 39157

POST OFFICE BOX 12828
JACKSON, MS 39236

Hwy No. 25 **BCD Job Number** 090595

Core No. 5D

CaO of Cement, % 64.60 **CaO of Virgin Soil, %** 0.70

		Blank	Soil Cement Cores					
			Top 1	**Top 2**	**Top 3**	**Bottom 1**	**Bottom 2**	**Bottom 3**
Sample Prep	Tare #	N/A	UN	V	Q	DE	X	I
	Wet Wt. + Tare (0.01)		541.70	728.80	956.80	900.60	1073.60	669.40
	Dry Wt. + Tare (0.01 g)		478.50	642.60	845.50	825.30	974.00	613.80
	Tare Wt. (0.01 g)		18.80	19.20	19.00	266.60	245.00	184.10
	Wt of Dry Sample		459.70	623.40	826.50	558.70	729.00	429.70
	Wt of Water		63.20	86.20	111.30	75.30	99.60	55.60
	Water Content, %		13.75	13.83	13.47	13.48	13.66	12.94
	Average Moisture Content, %		13.68			13.36		
Titration	Tare #	NA	1	2	3	4	5	6
	Oven Dry Sample Weight (.001 g)		5.002	5.001	5.010	5.006	5.005	5.010
	KMNO4 required to titrate (0.1 ml)		12.0	13.1	12.5	13.8	13.9	13.1
	KMNO4 required to titrate Blank (0.1 ml)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Normality of KMNO4 solution	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sample represented by the aliquot titrated (.001 g)	N/A	1.000	1.000	1.002	1.001	1.001	1.002
	CaO equivalent of 1 ml of (1.0N) $KMnO_4$ Solution	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	CaO equivalent of 1 ml of (0.1N) $KMnO_4$ Solution	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
	% CaO Present in Sample	N/A	3.19	3.50	3.33	3.69	3.72	3.49
	% Cement by Mass of Soil	N/A	3.90	4.38	4.11	4.68	4.73	4.37

Average % Cement Top 4.13 Average % Cement Bottom 4.59

Overall Average Cement Content, % 4.36