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16. Abstract

This project focused on evaluating the effectiveness of the microcracking concept for reducing shrinkage cracking in cement-treated bases (CTB). Microcracking can be defined as the application of several vibratory roller passes to the cement treated base at a short curing stage, typically after 1 to 3 days, to create a fine network of cracks. In this project Texas Transportation Institute researchers monitored the performance of microcracking test sites on SH 47 and SH 16. Finally, the research team coordinated the construction and monitored the performance of controlled test sites constructed at Texas A&M's Riverside Campus. Compared to moist curing alone, microcracking improved the performance of CTB by reducing the crack width and in some cases reducing the total crack length. Through these mechanisms, microcracking reduces the risk of reflective cracking through the surface layer. Microcracking did not cause pavement damage. The structural capacity of the CTB was not diminished, the strength of the material recovered, and surface damage did not occur. Microcracking with three passes of the same (or comparable tonnage) steel-wheel vibratory roller after 2 to 3 days cure, combined with a 3-day moist curing period, can be considered a valid method of reducing shrinkage-cracking problems in CTB. In this project microcracking was accomplished with the rollers vibrating at maximum amplitude and traveling at 2 to 3 mph. For maximum effectiveness, microcracking must be combined with a reduced strength mix design system.

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EFFECTIVENESS OF MINIMIZING REFLECTIVE CRACKING IN CEMENT-TREATED BASES BY MICROCRACKING

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DISCLAIMER

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- Mike Arreyano, P.E.
- Magdy Mikhail, P.E.
- Andrew Wimsatt, P.E.

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EXECUTIVE SUMMARY

Over the years much work has been performed regarding cracking in cement-treated road base. These shrinkage cracks eventually reflect through the pavement surfacing. Although initially thought to be cosmetic in nature, these cracks allow water into the pavement which accelerates the rate of pavement deterioration. Faced with both negative public perception due to the cracking and the risk of early pavement distress, agencies and researchers alike continue their quest for solutions to the shrinkage cracking problem to this day. While numerous approaches to minimize shrinkage cracking exist, this project focused on field test sites for evaluating the microcracking technique for minimizing shrinkage cracking problems in cement-treated base (CTB).

The microcracking concept can be defined as the application of several vibratory roller passes to the cement treated base at a short curing stage, typically after one to three days, to create a fine network of thin cracks. The idea behind the microcracking concept is to prevent the wider, more severe shrinkage cracks from forming, and thus reduce the risk of problematic reflective cracking into the pavement surfacing. In this project Texas Transportation Institute (TTI) researchers monitored performance of microcracking test sites on SH 47 and SH 16. Finally, the research team coordinated the construction and monitored the performance of controlled test sites constructed under this project at Texas A&M's Riverside Campus. The Riverside test sites also included moist cured, dry cured, and asphalt-membrane cured sites for comparison. The research team used falling weight deflectometer (FWD) tests to control the microcracking process, periodic crack surveys to monitor crack performance, and FWD tests through time to track base moduli.

This report consists of seven chapters describing the work performed. The first two chapters are dedicated to background information relevant to CTB performance and field methods used at the test sites. Chapters 3-5 detail the work conducted at each of the three test sites. Chapter 6 discusses specific issues regarding microcracking that were brought to the research team's attention over the course of this project; finally, Chapter 7 presents the conclusions and recommendations from this project.

Based upon the performance of the test sites, the research team judged microcracking to indeed provide a valid method for reducing the severity of cracking problems in CTB. Microcracking reduced the crack width, the total crack length, or both. Through these mechanisms, microcracking reduces the risk of reflective cracking through the surface layer. Microcracking did not cause pavement damage. The structural capacity of the CTB was not diminished, the strength of the material recovered, and surface damage did not occur. Microcracking with three passes of the same (or comparable tonnage) steel-wheel vibratory roller after 2 to 3 days cure, combined with a 3-day moist curing period, can be considered a valid method of reducing shrinkage-cracking problems in CTB. In this project microcracking was accomplished with minimum 12-ton rollers vibrating at maximum amplitude and traveling at 2 to 3 mph. Based upon the promising results, Appendix A of this report provides a guide on microcracking for use by construction inspectors.

CHAPTER 1

LITERATURE REVIEW

SUMMARY

Over the years much work has been performed regarding cracking in cement-treated materials. Shrinkage of cement-treated materials can be divided into two categories: autogenous shrinkage (shrinkage resulting from the hydration of the cement) and drying shrinkage. Drying shrinkage is believed to be the major source of shrinkage; thus, good curing procedures are emphasized when constructing cement-treated layers.

Researchers have observed that shrinkage typically increases with more clayey materials and higher molding moisture contents. Relationships between cement content and shrinkage have sometimes, but not always, been observed. Numerous techniques for dealing with shrinkage cracking have been tried. Some of the methods that have been reported to improve the cracking characteristics of cement-treated layers include:

- specific curing procedures (prolonged moist curing or immediate coverage with a curing membrane),
- early opening to traffic,
- a combination of reduced cement content with the microcracking procedure, or
- a geofabric between the base and surfacing.

CAUSES OF SHRINKAGE CRACKS IN CEMENT-TREATED BASES

Shrinkage cracks result when the tensile stress in the base exceeds the tensile strength of the material *(1, 2)*. Numerous factors exist that result in shrinkage strains in cement-treated bases. The majority of shrinkage in cement-treated bases is thought to be due to drying *(3,4)*. Other factors that affect the shrinkage and cracking of cement-treated bases are:

- restraint imposed on the base by subbase or subgrade friction *(5,6)*;
- tensile strength of the base *(3,4)*;
- creep characteristics of the base *(4, 7)*;
- contraction of material with decreasing temperatures *(5,6)*; and
- traffic Loading *(5,6)*.

The crack spacing is thought to be primarily a function of subgrade friction and the tensile strength of the base *(3)*. Crack width is dependant on both the crack spacing and the ultimate shrinkage strain in the material. George has proposed a mechanism of cracking where microcracks initially appear in areas of pre-existing flaws in the base; then, as shrinkage stress increases, these microcracks become macrocracks *(5)*. He proposes that the longitudinal cracks initiate in the subgrade and reflect through the cement treated layer *(5)*.

FACTORS AFFECTING SHRINKAGE AND REFLECTIVE CRACKING

Several studies have been conducted on how shrinkage and cracking in cement-treated bases are affected by cement content, material type, density, pre-treatment moisture content, molding moisture content, curing time, and time to traffic loading.

Cement Content

George concluded that an optimal cement content exists where shrinkage will be minimized *(3)*. Similar observations were made on several materials studied at TTI *(8)*. Bofinger et al. found that an optimal cement content existed for minimal shrinkage only when test specimens were compacted in specific manners, but that when specimens were compacted and tested with conditions thought to best simulate field compaction and conditions, total shrinkage decreased with increasing cement content *(4)*. Nakayama and Handy did not observe any relationship between cement content and shrinkage *(9)*. Since more shrinkage is expected from fine-grained materials, and shrinkage is primarily thought attributable to moisture loss, Kuhlman hypothesized that any relationship between cement content and shrinkage was because finer grained soils require more molding moisture and more cement to meet soil-cement criteria *(10)*. Thus, it appears that while there may be an optimal cement content to minimize shrinkage for some materials, oftentimes there may not be a relationship between cement content and shrinkage. A recent report by Adaska and Luhr stated two ways by which high cement contents can increase problems with cracking *(11)*. First, the higher cement content uses more water for hydration and thus increases shrinkage. Second, the higher cement content increases tensile strength. The net result is an increase in both crack spacing and crack width *(11)*. The increased crack width is an undesirable effect of high cement contents.

Material Type

George observed that shrinkage was related to the amount and type of clay in the material, with montmorillonitic clay contributing more to shrinkage than other clays *(3)*. Thus, the use of granular material with a low fines content was recommended. Kuhlman reports that some agencies impose a specification on the minus #200 fraction to control the clay fraction (10).

Density

Published research indicates that cement-treated bases should be compacted to (but not beyond) their target density. George reported that cement-treated bases should be compacted to as high of densities as possible to minimize shrinkage *(3)*. Kuhlman states that, since higher densities are associated with more compactive effort and less molding moisture, attaining higher densities should minimize shrinkage *(10)*. In efforts to isolate the effect of density, Bofinger et. al. made shrinkage specimens with the same amount of molding moisture and cement content, but varied the density, and found that the autogenous shrinkage was greater with increasing density *(4)*. George reported that a clayey soil-cement should not be compacted to a higher density without a corresponding decrease in moisture content *(3)*. Adaska and Luhr report some designers are requiring 98 percent of modified Proctor at moisture content no greater than optimal in efforts to alleviate problems with shrinkage (*11*).

Pre-Treatment Moisture Content

When comparing the autogenous shrinkage of specimens prepared from dry soil, soil wetted to 2 percent below optimal, and soil pre-wetted to optimal molding moisture, Bofinger et al. found that shrinkage was smallest when the cement and molding water were mixed into dry soil (*4*). The soil that was pre-wetted to optimal molding moisture before the addition of cement exhibited the most autogenous shrinkage (*4*). Thus, the researchers recommended processing soil in the dry state, then adding water and cement for compaction together for mixing, and compacting the material as soon as possible after mixing (*4*).

Molding Moisture Content

George recommended that cement-treated bases be compacted slightly dry of optimal molding moisture (*3*). Similarly, Bofinger et al. found that more initial shrinkage resulted when soil-cement was compacted above optimal molding moisture (*4*). Thus, any error in molding moisture content should be on the dry side of optimum (*4*).

Curing Time

Since shrinkage in soil-cement is most attributable to the loss of moisture, curing times for as long as practical are typically recommended (*3, 4*). Numerous methods for preventing moisture loss have been reported. Application of water by a water truck is a common way for curing the base. George recommended surfacing the base as soon as possible, while Kuhlman recommends a 7-day cure via asphalt emulsion (*3, 10*). Jonker reported success in the field with regard to cracking by the direct paving onto the cement-treated base within one day after compaction and finishing (*12*). In contrast, Norling suggested delaying placement of the surface for as long as possible to allow the cracking to occur before placement and thus expose the surfacing to less movement and minimize the risk of reflective cracking (*13*).

Additives

Wang summarized the results of many research efforts investigating supplementary additives used in attempts to minimize shrinkage in soil-cement (*14*). A summary of the additives follows:

- NaCl added in levels up to 3 percent reduced shrinkage in montmorillonitic soil-cement.
- CaCl with 0.5 percent substituted for 1 percent cement improved shrinkage in some cases.
- Lignosulfonate reduced shrinkage in some cases.
- Lime, when replacing cement at levels up to 4 percent, resulted in significantly reduced shrinkage and crack intensity.
- Fly ash resulted in reduced shrinkage in sandy soil-cements.

- Sulfate salts added in levels of less than 1 percent generally resulted in reduced shrinkage.
- Expansive cements resulted in reduced shrinkage when specimens were molded at 3 percentage points above optimum.

Time to Traffic Loading

Some evidence suggests that early traffic loading may be beneficial with regards to crack performance. Syed and Scullion suggested the good cracking performance of several rehabilitated sections could be attributable to early trafficking, since the sections were opened to traffic at the end of each day (*15*). Similarly, Sebesta noted an absence of block cracks on maintenance repairs with cement where traffic was allowed on the sections each day (*16*).

AGENCY RECOMMENDATIONS FOR CONSTRUCTION OF CEMENT-TREATED BASES WITH REGARD TO SHRINKAGE AND REFLECTIVE CRACKING

Austria

The microcracking concept originated in Austria. Microcracking is the application of several vibratory roller passes to the cement treated base at a short curing stage, typically after one to three days, to create a fine network of thin cracks. The objective is to inhibit the occurrence of larger shrinkage cracks that eventually reflect through the surfacing. According to Litzka (pers. comm.), microcracking typically is performed by three passes of a roller 24 to 48 hours after compaction. Kloubert (pers. comm.) reports that 13-ton rollers are typically used. Brandl reported that, of available options for minimizing cracking on the Austrian-Hungarian Highway, the microcracking technique was most suitable (*17*). He reported applying microcracking after one day cure was sufficient; however, if the compressive strength of the material exceeded 725 psi after two days cure, an additional application of microcracking was applied at three days' cure. Brandl (*17*) reported that the microcracking process can be optimized by employing rollers equipped with continuous compaction control systems (*17*). Some such systems are available from GeoDynamik, Bomag, and Ammann Compaction.

Other methods for minimizing cracking have been investigated in Austria. Their guidelines suggest consideration of notches cut into the fresh cement-treated layer with depth of one to two thirds the layer thickness and a spacing of 10 ft. as an alternative to microcracking (Litzka, pers. comm.). In addition, Brandl reported that after 5 years of service, a test section utilizing a nonwoven geotextile has shown positive results (*17*). With respect to strength targets, Brandl reported a minimum unconfined compressive strength at seven days of 360 psi, with the average of three tests being at least 435 psi (*17*).

Louisiana Department of Transportation and Development

Work in Louisiana investigating the effect of cement content, base course thickness, polypropylene fibers, crack relief interlayers, curing membranes, and curing periods on cracking has recently been reported by Gaspard (*18*). Ten field test sections were constructed under the study. Within two weeks after construction, every base had shrinkage cracks. The sections were overlaid with hot-mix asphalt (HMA) within one month after construction. No reflective cracks in the HMA layer were observed within the first two years after construction. Thus, the researcher plans continued monitoring of the sections.

Texas Transportation Institute

In October 2000 TTI helped coordinate the construction of microcracking test sections in a city subdivision in College Station, TX. A description of this work is presented by Scullion (*19*). Based upon this work, draft specifications for microcracking in Texas were drafted (*19*). This draft specification calls for a reduction in average base stiffness of at least 40 percent from the microcracking process.

Portland Cement Association

The Portland Cement Association (PCA) has been actively collecting information to address concerns with shrinkage cracking in cement-treated layers. The PCA provides guidelines for addressing shrinkage cracking through design and construction practices (*20*). The PCA recommends a proper amount of cement, with 7-day unconfined strengths in the 300-400 psi range. Additionally, a stress relief layer such as a chip seal, geosynthetic, or thin unbound granular base can help relieve stresses from shrinkage in the base. During construction, the PCA recommends compaction at or slightly below optimal moisture content and moist curing until a moisture barrier gets placed. The PCA suggests delaying placement of the final HMA layer and microcracking as other techniques that can help reduce reflective cracking.

CHAPTER 2

RESEARCH TEST PLAN

To efficiently collect data for accomplishing the research objective of verifying the effectiveness of the microcracking procedure for minimizing cracking in cement-treated bases, the research team created a test plan for conducting field investigations. The following steps describe the basic sequence used:

1. Collect background information on the project (date cement treated, percent cement, date microcracked, etc.).
2. Divide the project into test sections for the desired curing time/rolling treatment combinations.
3. At the desired curing time, collect pre-rolling stiffness data with testing devices.
4. After collecting initial data, perform the desired number of passes with the vibratory steel wheel roller to induce microcracks in the cement-treated base.
5. Examine the base visually for any cracks. Collect post-rolling data with testing devices to investigate the effect of the roller passes on the base stiffness.
6. If the desired effects on the base were not obtained, perform additional roller passes and monitor the effect of rolling with measurements from the testing devices used.
7. Upon completion of the desired number of roller passes and collection of testing data, perform follow-up cracking surveys and base stiffness evaluations.

Based upon discussion with the Project Monitoring Committee and a review of available testing devices, the research team selected to use the Texas Department of Transportation (TxDOT) falling weight deflectometer as the standard measurement method, and a portable falling weight deflectometer as an alternative method. Attempts to test with a dynamic cone penetrometer were unsuccessful.

TxDOT Falling Weight Deflectometer

TxDOT's FWD, shown in Figure 2.1, served as the reference test device. TxDOT's FWD trailer uses a weight dropped from a variable height and seven geophones and measures load and deflections. These data, when input into TxDOT's Modulus 6.0 software, are used to backcalculate moduli of the pavement layers. TxDOT's FWD is routinely used statewide in pavement evaluation.

Figure 2.1. TxDOT Falling Weight Deflectometer.

Portable Falling Weight Deflectometer (PFWD)

The portable FWD, shown in Figure 2.2, uses a manually operated 22 lb. falling weight and a center geophone and measures applied load and deflection. The device is linked to a laptop computer that automatically processes the data and displays the calculated modulus.

Figure 2.2. Portable FWD.

CHAPTER 3

SH 47 FIELD TEST SITE

SUMMARY

The Bryan District rehabilitated five sections of SH 47 in Spring 2002, before this research project began, using in-place recycling with cement treated base. All the sites were microcracked after one to three days' curing. TxDOT collected FWD data on some of these sites, and after this research project began, the sites were monitored under the research project. From TxDOT's FWD, the precracking procedure typically resulted in a 60 percent reduction in base stiffness. As of this report date, only one site had any cracking. The first site in the southbound direction has two transverse cracks in it, and two other locations with cracking that do not appear to be shrinkage cracks. This section is 2300 ft. long, so overall the performance is still good. No cracks have been observed in any of the four other sites.

DESCRIPTION OF TEST SECTIONS

Based on lab tests, TxDOT selected 3 percent cement to recycle a 14 in. depth of specific sections on SH 47. The 7-day unconfined compression test yielded average strengths of 384 psi with the selected cement content (Goehl, pers. comm.). Three cement-treated sites were constructed in the northbound and two in the southbound direction. The sections have surfacing of 4 in. of HMA. The northbound travel direction was surfaced with CMHB-C and the southbound direction with Type C mix. These sites were constructed before this research study began and were monitored with TxDOT's FWD. Microcracking was accomplished with a 25-ton roller. Table 3.1 summarizes the location and time to microcracking at the sites.

Table 3.1. Location and Microcracking History of SH 47 Test Sections.

Section Number	Location	Begin Station	End Station	Date Cement Treated	Date Microcracked
1	NB IL	1346.76	1362.60	4/4/02	4/5/02
2	NB IL	1098.85	1127.64	4/11/02	4/12/02
3	NB IL	1154.04	1175.16	4/12/02	4/13/02
4	SB IL	2142.52	2165.59	4/16/02	4/17/02
5	SB IL	2281.84	2310.88	4/18/02	4/19/02
6	NB OL	1346.76	1351.33	4/23/02	4/25/02
7	NB OL	1351.33	1362.60	4/23/02	4/25/02
8	NB OL	1154.04	1175.16	4/24/02	4/25/02
9	NB OL	1098.85	1127.64	4/26/02	4/29/02
10	SB OL	2142.52	2165.59	4/30/02	5/1/02
11	SB OL	2281.84	2294.71	5/1/02	5/3/02
12	SB OL	2294.71	2310.88	5/2/02	5/3/02

Note: NB = Northbound; SB=Southbound; IL=Inside Lane; OL=Outside Lane

MONITORING RESULTS FROM NDT TESTING

This section will present the results of FWD monitoring on the SH 47 projects. Previous guidelines for microcracking specified targeting a 40 percent reduction in stiffness from microcracking (*18*). On SH 47, TxDOT performed some monitoring of the microcracking process with their FWD. TxDOT conducted pre- and post-microcracking FWD surveys on Sections 2, 5, 6, 7, and 8. Follow-up testing on the sections with TxDOT's FWD was conducted as part of this research project. As shown in Table 3.2, the average reduction in base modulus at the SH 47 sites was at least 60 percent. The actual reduction in modulus obtained at Section 2 cannot be determined since the first FWD survey on this site after microcracking did not occur until 3 days after the precracking procedure took place. At Section 6, the FWD before cracking was conducted the day before the base was microcracked, so the actual base modulus before cracking was assumed to be at least 272 ksi, so the reduction in modulus was at least 60 percent.

Table 3.2. FWD Monitoring Results from Microcracking SH 47 Sites.

<table>
<tr><th>Section #</th><th>Date Cement Treated</th><th>Date Cracked</th><th>Pre-Base E (ksi)</th><th>Date Pre-Tested</th><th>Post-Crack Base E (ksi)</th><th>Date Post Tested</th><th>% Stiffness Reduction</th></tr>
<tr><td>1</td><td>4/4/2002</td><td>4/5/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>4/11/2002</td><td>4/12/2002</td><td>311</td><td>4/12/2002</td><td>309</td><td>4/15/2002</td><td>-</td></tr>
<tr><td>3</td><td>4/12/2002</td><td>4/13/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>4/16/2002</td><td>4/17/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>4/18/2002</td><td>4/19/2002</td><td>484</td><td>4/19/2002</td><td>191</td><td>4/19/2002</td><td>60.54</td></tr>
<tr><td>6</td><td>4/23/2002</td><td>4/25/2002</td><td rowspan="2">272</td><td rowspan="2">4/24/2002</td><td rowspan="2">110</td><td rowspan="2">4/25/2002</td><td rowspan="2">>60</td></tr>
<tr><td>7</td><td>4/23/2002</td><td>4/25/2002</td></tr>
<tr><td>8</td><td>4/24/2002</td><td>4/25/2002</td><td>319</td><td>4/25/2002</td><td>122</td><td>4/25/2002</td><td>61.76</td></tr>
<tr><td>9</td><td>4/26/2002</td><td>4/29/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>4/30/2002</td><td>5/1/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>5/1/2002</td><td>5/3/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>5/2/2002</td><td>5/3/2002</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

A final FWD survey was conducted in March of 2003 in the outside lanes/outside wheel path of both travel directions. The average base modulus of the sections varied from 532 to 1051 ksi. Table 3.3 shows the results of an ANOVA test on this data. The data indicates no statistical difference in eventual base moduli for the sites on SH 47 that were cement treated and microcracked between 1 and 3 days curing. The overall average site base modulus as of March 2003 was 801 ksi.

Table 3.3. ANOVA Results for SH 47 FWD Data, October 2003.

Site(s)	*Count*	*Sum*	*Average (ksi)*	*Variance*
6-7	6	6305	1051	174249
8	4	2129	532	74398.9
9	10	7821	782	67646.1
10	20	18271	914	130888
11	6	4495	749	127937
12	7	5455	779	77859.2

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	862532	5	172506.3553	1.53065	0.19851	2.41284
Within Groups	5296968	47	112701.4403			
Total	6159499	52				

CRACKING PERFORMANCE

On June 18, 2004, the research team performed a final inspection of the cement-treated sites on SH 47. Currently, only one of the five cement-treated sections has any cracking. The SB site from STA 2142+52 to 2165+59 has two locations with transverse cracks and two locations with other cracking that does not appear related to the base.

Figures 3.1 through 3.3 show the northbound locations; none of these locations had any cracking. Figure 3.4 shows the first southbound site, which encompasses STA 2142+52 to 2165+59. Figures 3.5 through 3.8 show the cracking in this southbound site. Figure 3.5 shows a transverse crack in the shoulder and outside lane. Figures 3.6 and 3.7 show some longitudinal cracking in the site; this longitudinal cracking is likely due to other issues such as the subgrade (the previous distress on SH 47 was attributed to poor subgrade). Figure 3.8 shows a transverse crack in the shoulder near the end of this section. Figure 3.9 shows the second southbound site from STA 2281+84 to 2310+88; no cracks were apparent in this section.

Based upon the cracking performance of the test sites, the cement treated sections are performing well. Only one section had any cracks, and in this 2300 ft. section the total transverse crack length was only 28 ft. Two plausible explanations exist as to why this site has cracking and the other sites do not. First, the site may not have been microcracked enough. FWD data show the base modulus typically dropped by at least 60 percent. However, FWD data were not collected on this southbound site, so the possibility of not enough microcracking cannot be ruled out. Second, differences in the crack resistance of the surface mixes may exist. Although the second southbound site still is crack free, none of the northbound sites have any cracks, and the CMHB-C mix in the northbound direction had 4.7 percent asphalt as opposed to 4.4 percent in the Type C mix placed on the southbound sites (both mixes utilized PG 64-22 asphalt cement). Therefore, the possibility of a difference in crack resistance of the mixes cannot be ruled out.

The research team considered and ruled out other reasons regarding why this section is the only one with cracks. The section may have had more cement than others; however, plan sheets showed the cement content at this site was among the lowest (2.98 and 3.03 percent for the outside and inside lanes, respectively) of all the rehabilitated locations, so additional cement does not explain the cracking. For reference, cement contents ranged from 2.98 to 3.17 percent among all the sections. The time frame to microcracking was ruled out because, although this section was microcracked after one day curing, five other sections were likewise cracked after one day, and these sections remain crack deficient. Variations in traffic density could possibly explain the cracking; however, the fact that one of the transverse cracks is confined to the shoulder, and the observation that the second southbound site has no cracks, indicate traffic does not explain why only this section has cracking.

Figure 3.1. NB CTB Site on SH 47 from STA 1362+60 to 1346+76.

Figure 3.2. NB CTB Section from STA 1175+16 to 1154+04.

Figure 3.3. NB CTB Section from STA 1127+64 to 1098+85.

Figure 3.4. SB CTB Section from STA 2142+52 to 2165+59.

Figure 3.5. Transverse Crack in SB CTB Section on SH 47.

Figure 3.6. Longitudinal Cracking in SB CTB Section on SH 47.

Figure 3.7. Longitudinal Crack on SH 47.

Figure 3.8. Transverse Crack near STA 2164 on SH 47 SB.

Figure 3.9. SB CTB Section from STA 2281+84 to 2310+88.

CONCLUSIONS

Currently, data indicate the microcracking process was successful at the SH 47 project. After more than 2 years in service, only one of five sites has any cracks in the HMA. Unfortunately, no control section (not microcracked) was constructed on SH 47, so there is no standard to compare the sites to. The most recent data also indicate no significant difference exists in the mean base modulus among any of the sections. Microcracking at 3 days cure did not reduce the in-service modulus as compared to microcracking after only one day curing. The average base modulus is 801 ksi.

CHAPTER 4

SH 16 FIELD TEST SITE

SUMMARY

Four test sites constructed on SH 16 in the San Antonio District were monitored during this project. The sites were placed in March 2003. One test site served as the control and was not microcracked. One site was microcracked with three passes of a 12-ton roller after one day curing, one site was microcracked after 2 days cure with 3 passes, and one site was microcracked after 2 days curing with two passes. After 3 months of service, no cracks were observed in any of the sections. After 13 months of service, all the sites had a moderate amount of sealed cracks. Researchers tallied the total crack lengths in each of the sections, and the site microcracked at one day cure had the least amount of cracking per area of roadway (77 ft. per 1000 ft.^{2}). The research team does not believe all the cracks are attributable to shrinkage cracking. The crack pattern in many cases is not typical of shrinkage cracks.

DESCRIPTION OF TEST SECTIONS

On the SH 16 project, the existing roadbed was salvaged to a depth of 8 in. and treated with 3 percent cement and used as a subbase. A 5-in. new layer of Ty A Gr 6 flex base was added and treated in place with 2 percent cement. After placing an underseal, 2 in. of Type C HMA was placed as the final surfacing.

TTI researchers tested four sites on the SH 16 project. All sites were treated with cement on March 19, 2003. Figure 4.1 illustrates the arrangement and treatment of the different test sites. Site 1 was not microcracked, Site 2 was microcracked after one day curing, and Sites 3 and 4 were both microcracked after two days curing but received a different number of roller passes.

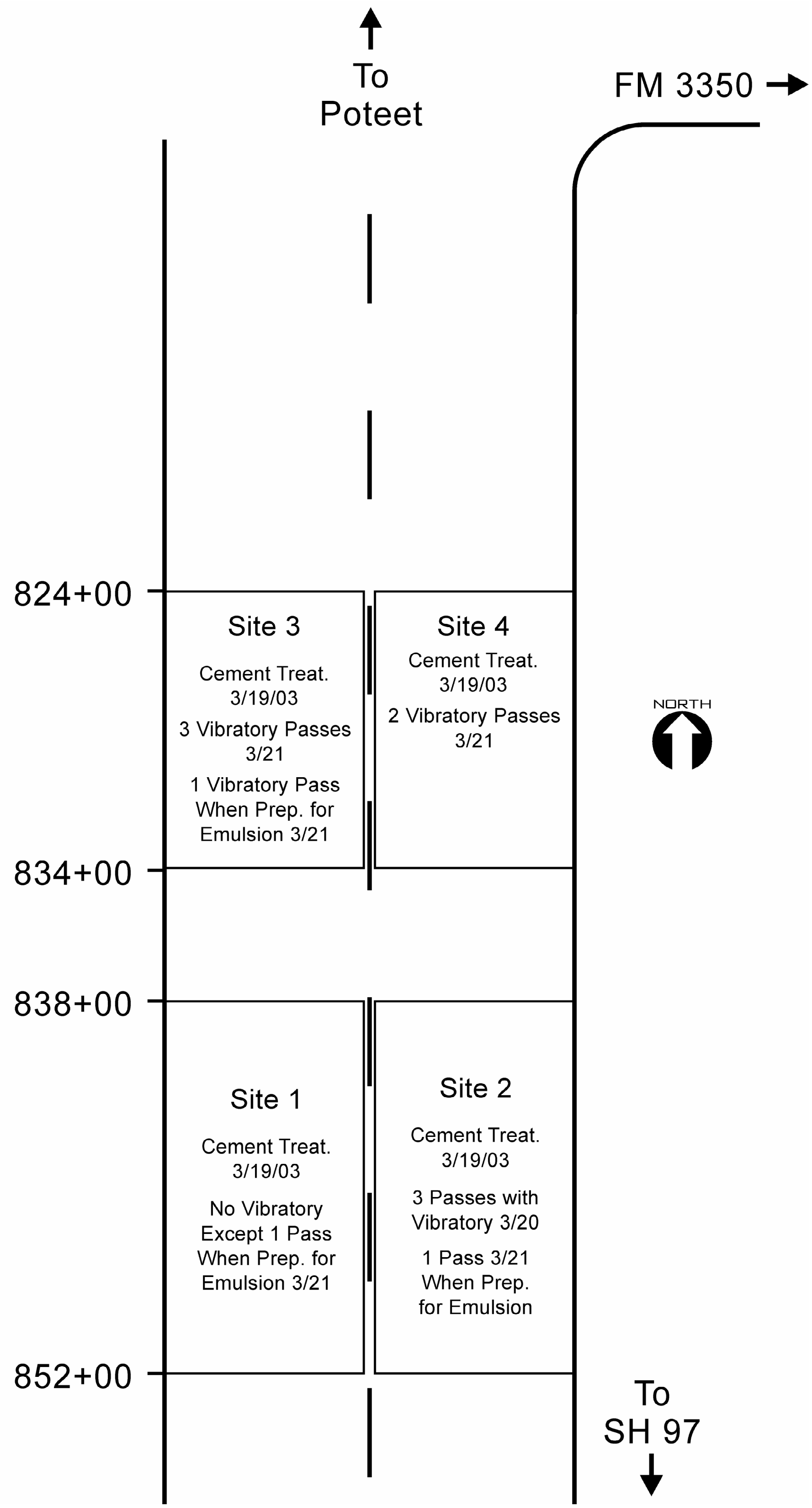

Figure 4.1. Test Sites on SH 16.

MONITORING RESULTS FROM NDT

TxDOT's FWD served as the primary control process for microcracking on SH 16. Figure 4.2 illustrates a modulus reduction of 41, 72, and 48 percent was achieved by microcracking at Sites 2, 3, and 4, respectively. When rechecked at an age of approximately 3 months (June 2003), the average modulus at Site 4 appeared less than the other sites; this difference is not believed due to subgrade support, as the average subgrade modulus was in the 22 to 26 ksi range at all the sites on the test date. Traffic does not explain the difference either, as Site 2 and Site 4 are only 400 ft. apart in the same travel direction, with no intersections between them. Table 4.1 shows an ANOVA test indicates the mean modulus values indeed are not equal between the four sites. Table 4.2 shows a Tukey-Kramer multiple comparison procedure, which indicates that at the 95-percent confidence interval all of the following are true:

- The average modulus of Site 2 exceeds Site 4.
- The average modulus of Site 3 exceeds Site 4.
- There is no significant difference in average modulus among the remainder of the sites.

Appendix B presents the processed FWD data from the SH 16 sites.

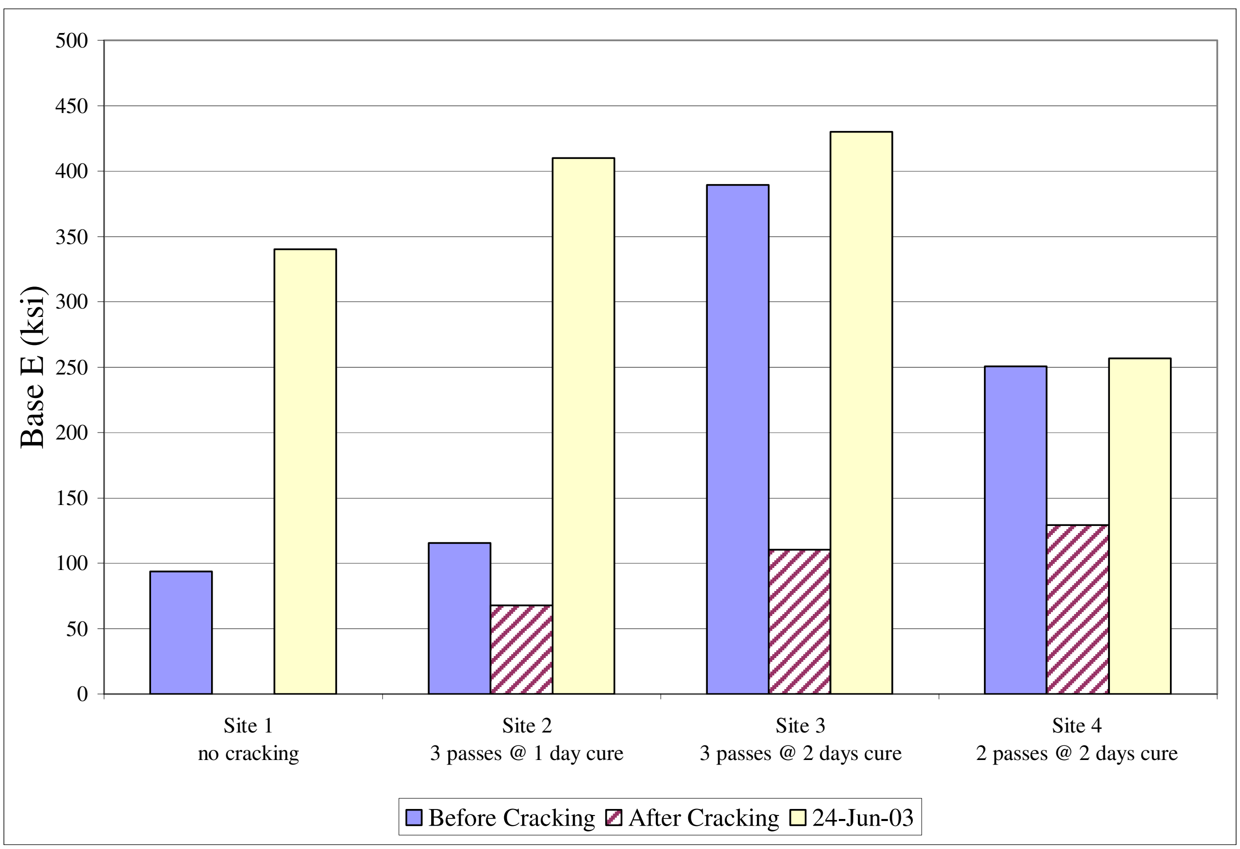

Figure 4.2. Average Modulus Results for SH 16 Test Site.

Table 4.1. ANOVA on SH 16 Modulus Data after 3 Months.

Groups	*Count*	*Sum*	*Average*	*Variance*
Site 1	27	9185	340.185	22674.5
Site 2	28	11476	409.857	42444.3
Site 3	41	17612	429.561	28449.2
Site 4	41	10539	257.049	6309.8

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	711263	3	237088	10.0876	4.9E-06	2.67269
Within Groups	3125894	133	23503			
Total	3837156	136				

Table 4.2. Tukey-Kramer Multiple Comparison Results for SH 16 Base Moduli.

	Site1-2	Site1-3	Site 1-4	Site2-3	Site2-4	Site3-4
Difference	-69.67	-89.38	83.14	-19.70	152.81	172.51
var(diff)	1709.87	1443.72	1443.72	1412.63	1412.63	1146.49
stdev(diff)	41.35	38.00	38.00	37.59	37.59	33.86
q*	-2.38	-3.33	3.09	-0.74	5.75	7.21
qcrit (95% conf.)	3.76	3.74	3.74	3.74	3.74	3.72
sig difference?	no	no	no	no	yes	yes

CRACKING PERFORMANCE

Figures 4.3 and 4.4 show the sites after three months in service. At this time, the sites did not exhibit any shrinkage cracks. On April 13, 2004 (approximately 13 months of service), a visual survey was again conducted. At this time, all the sites had been crack sealed, and based upon the amount of crack seal, all the sites had a fair amount of cracking. Figure 4.5 shows Test Sites 1 and 2, and Figure 4.6 shows Test Sites 3 and 4, at the time of this survey.

Figure 4.3. SH 16 Test Sites 1 (left lane) and 2 (right lane), June 24, 2003.

Figure 4.4. SH 16 Test Sites 3 (left lane) and 4 (right lane), June 24, 2003.

Figure 4.5. SH 16 Test Sites 1 (left lane) and 2 (right lane) on April 13, 2004.

Figure 4.6. SH 16 Test Sites 3 (left lane) and 4 (right lane) on April 13, 2004.

In most instances where crack seal was applied, no cracks were even visible. However, the survey did reveal some cracks that were not sealed. Most of these cracks were tight, as shown in Figure 4.7. Therefore, it was assumed the crack seal had been applied on similarly tight cracks, explaining why these cracks could not be seen through the crack seal. Based on these observations, the total crack length in each section was measured with a survey wheel by measuring both unsealed cracks and locations that had crack seal applied. Table 4.3 summarizes these results. The results as of this date indicate the site microcracked after one day cure has the best cracking performance, while there is negligible difference in the cracking performance between any of the three remaining sites.

Some peculiarities exist regarding the pavement condition at this time. Given the low (2 percent) level of cement treatment, the fact that the sections were opened to traffic at the end of each day, and the fact that the sections have both an underseal and 2 in. of Type C mix, the amount of cracking in the HMA seems abnormally high for the time frame (13 months). Furthermore, the crack pattern in many places is not typical of the shrinkage cracking that occurs from cement-treated layers. In many instances, such as in Figure 4.6, extensive longitudinal cracks exist absent the presence of transverse cracks. For these reasons, the research team does not believe all the cracks in the HMA are due to the base. It is hypothesized that at least some of the cracking is due to poor HMA quality, some may be due to the cement-treated subbase (which was not microcracked), and some cracking possibly may be due to the subgrade. Nevertheless, the cracking data shown in Table 4.3 indicate the site microcracked after one day curing has the best cracking performance both in terms of total cracking and transverse cracking.

Figure 4.7. Unsealed Crack on SH 16.

Table 4.3. Crack Survey Results for SH 16 on April 13, 2004.

		Crack Length per 1000 Square Feet Road								
		Shoulder Cracks (ft)			Lane Cracks (ft)			Combined Shoulder and Lane		
Site	Description	Longitudinal	Transverse	Total	Longitudinal	Transverse	Total	Longitudinal	Transverse	Total
1	No Microcracking	132	48	180	20	11	31	64	26	90
2	3 passes @ 1 day cure	69	20	89	61	9	70	64	13	77
3	3 passes @ 2 days cure	92	67	159	36	15	51	58	36	94
4	2 passes @ 2 days cure	114	50	164	33	15	48	66	29	95

CONCLUSIONS

The unusual crack patterns at the SH 16 sites make it difficult to confidently form conclusions regarding the cracking performance of the test sites. However, the data show the site microcracked at one day has the least amount of cracking, with no difference in cracking between the remaining two microcracked sites and the control. As of the last FWD survey, none of the microcracked sites had a modulus significantly different than the control; microcracking did not harm the pavement structure.

CHAPTER 5

TEST FACILITY AT TEXAS A&M RIVERSIDE CAMPUS

SUMMARY

Due to a shortage of suitable field construction projects for examining the microcracking procedure, TTI researchers arranged for construction of test sites at Texas A&M's Riverside Campus. Two sites were constructed in September 2003: one with 4 percent cement and one with 8 percent cement. Six treatments were applied to each site. The sites are not surfaced, so the research team can easily see cracks in the base. Currently, results show that with excessive levels of cement, extensive cracking occurs regardless of treatment. If the layer is properly designed, microcracking after two to three days curing shows considerable promise for reducing the severity of cracking. Using a prime coat as a curing membrane proved rather ineffective at these test sites.

DESCRIPTION OF TEST SECTIONS

The test facility at Riverside Campus was constructed with a locally available marginal river gravel base. Table 5.1 shows the bulk fractionation data for the material. Figure 5.1 shows the moisture-density relationship for the untreated material. The test facility consists of two sites: one with a design cement content of 4 percent and one with a design content of 8 percent. The 4-percent cement treatment level was based upon a laboratory mix design with the material; 8-percent cement is the treatment level that historically was recommended by the supplier. Table 5.2 shows the laboratory test results for determining the optimal design cement content. 4 percent cement was selected based on a minimum 7-day unconfined compressive strength (UCS) of 300 psi and a final dielectric value (ε) after the Tube Suction Test (TST) of less than 10.0 (*8*). A design base layer thickness of 6 in. was specified for both sites. Figure 5.2 shows the layout and treatments used at the test site. Prior to placement of the new base, the existing roadbed was pulverized to a depth of 6 in. and then proof rolled back in. Figure 5.3 shows an example of the prepared subbase. The contractor mixed cement with the base at their plant with a pugmill and then delivered the material to the construction site. Figure 5.4 shows the contractor rolling in the cement-treated base.

Table 5.1. Bulk Fractionation Data for Gravel Base used at Riverside.

Sieve Size	Percent Passing
1 ¾	100
1 ¼	98
¾	95.2
3/8	87.9
#4	73.5

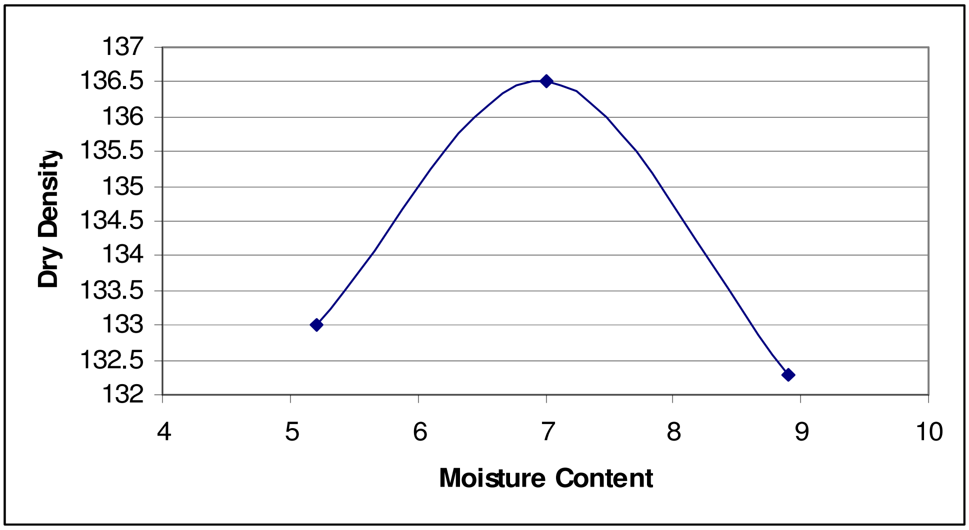

Figure 5.1. Moisture-Density Curve for Gravel Base Used at Riverside Campus.

Table 5.2. Lab Design Results for Gravel Base Used at Riverside Campus.

Cement Content (%)	Final ε in TST	7-Day UCS (psi)
2	12.0	267
3	11.2	298
4	6.1	383
5	5.7	466
6	5.3	492

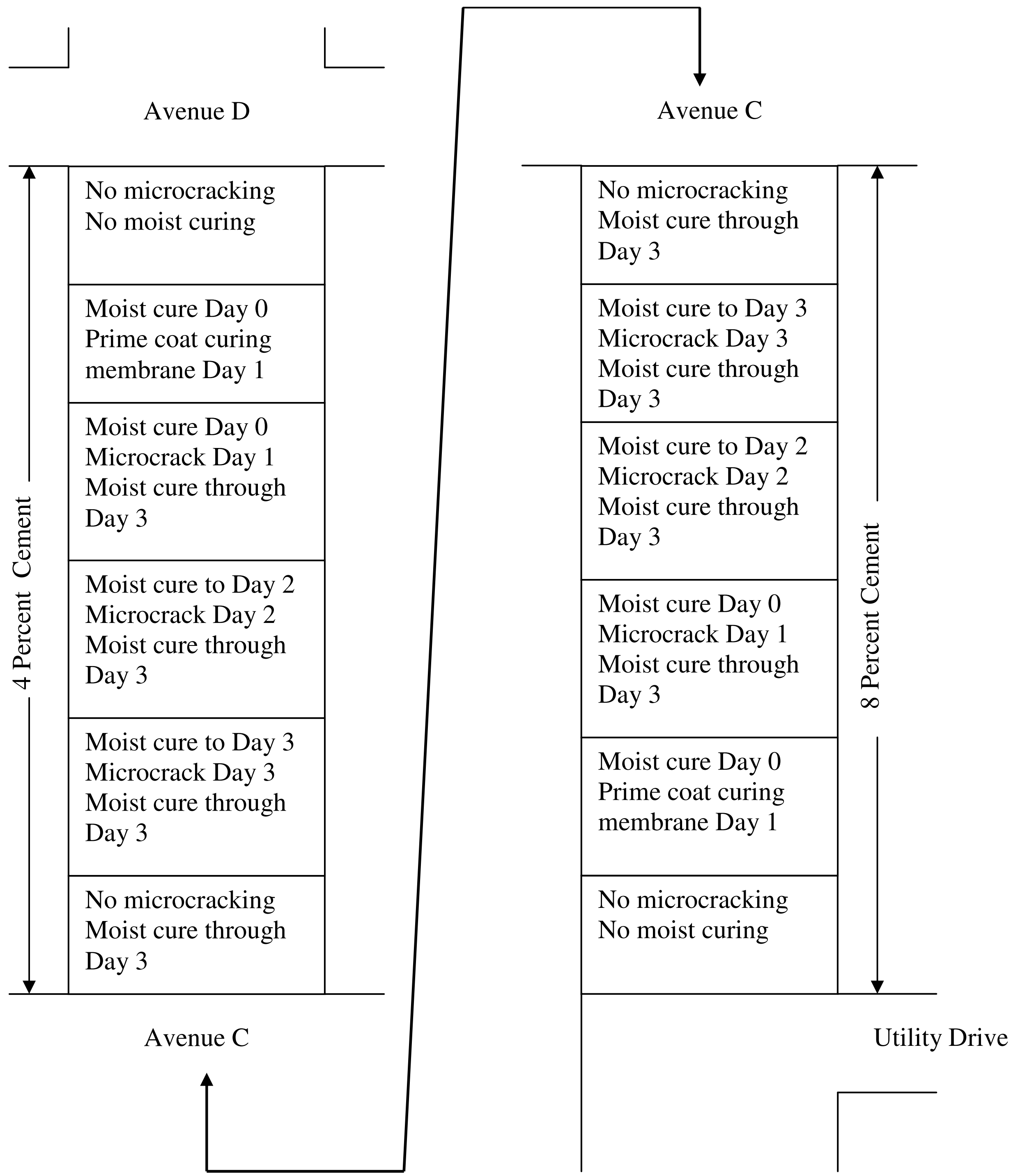

Figure 5.2. Site Layout for Microcracking Test Facility at Riverside Campus.

Figure 5.3. Prepared Subbase at Riverside Campus.

Figure 5.4. Rolling in CTB at Riverside Campus.

MONITORING RESULTS FROM NDT DEVICES

TxDOT's FWD served as the control mechanism for performing the microcracking on the Riverside test sites. The research team used the FWD to monitor the change in base modulus from microcracking and to investigate the long-term modulus of the layers. Additionally, the single-sensor portable FWD was used during construction to investigate the utility of this device for controlling the microcracking process. Appendix C presents the complete FWD modulus test results.

Figure 5.5 illustrates the average base modulus immediately before and immediately after microcracking for the sections. Microcracking resulted in a 51 to 70 percent decrease in average base modulus at the site with 4-percent cement, and a 58- to 69-percent reduction in average base modulus at the sites with 8-percent cement. Previous guidance recommended a minimum 40-percent reduction in modulus by microcracking (*19*). However, based upon the long-term performance of the sites used to develop that guideline, the research team targeted a minimum 50-percent reduction in base modulus at these test sites.

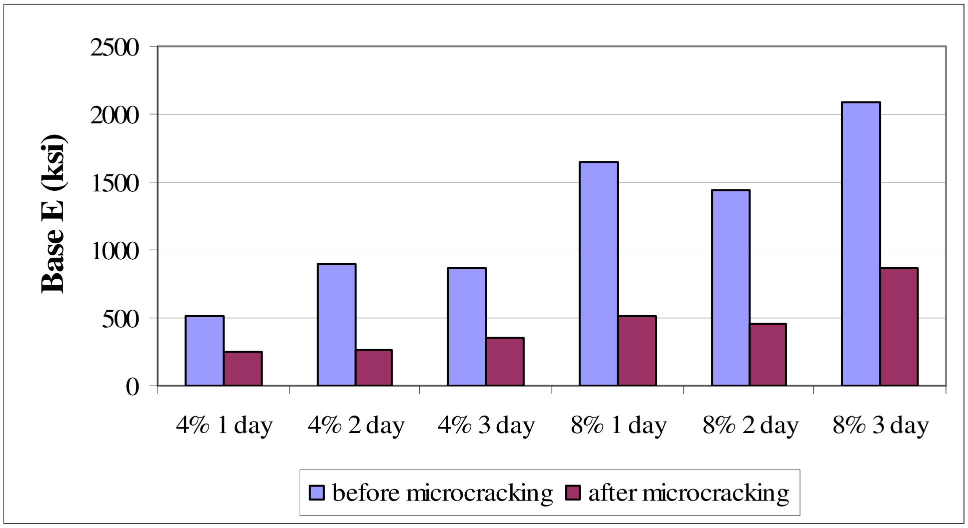

Figure 5.5. Base Modulus Immediately before and after Microcracking at Riverside Campus Sites.

Figures 5.6 and 5.7 illustrate the average base modulus of the sections through time for the 4-percent and 8-percent cement sites, respectively. The data show:

- The moist-cured sites exhibit a concave-down arc through time for both cement contents. The prime-cured site with 4 percent cement and the dry-cured site with 8 percent cement show a similar trend. The modulus values of the moist-cured sites are currently similar to the observed values at a curing age of only one week.
- All of the microcracked sites show a trend of increasing modulus with time. Therefore, the trends observed at the moist cured sites are not believed to be seasonal variations. The current modulus values on the microcracked sites with 4 percent cement are high; continued monitoring of crack performance should be performed.
- The subgrade modulus was relatively stable around 13 ksi throughout the tests and ranged from 9 to 20 ksi (data in Appendix C). The research team does not consider the instances of sudden, dramatic changes in base modulus attributable to changes in subgrade support.

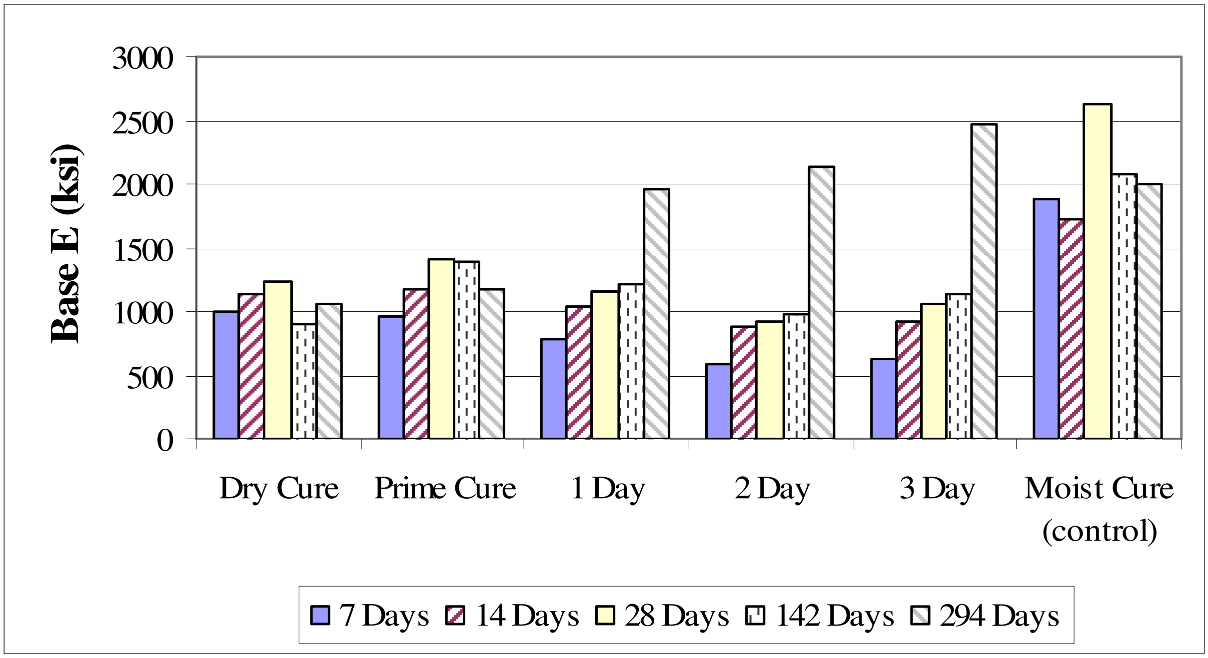

Figure 5.6. Base Modulus through Time for 4-Percent Cement Riverside Campus Test Sites.

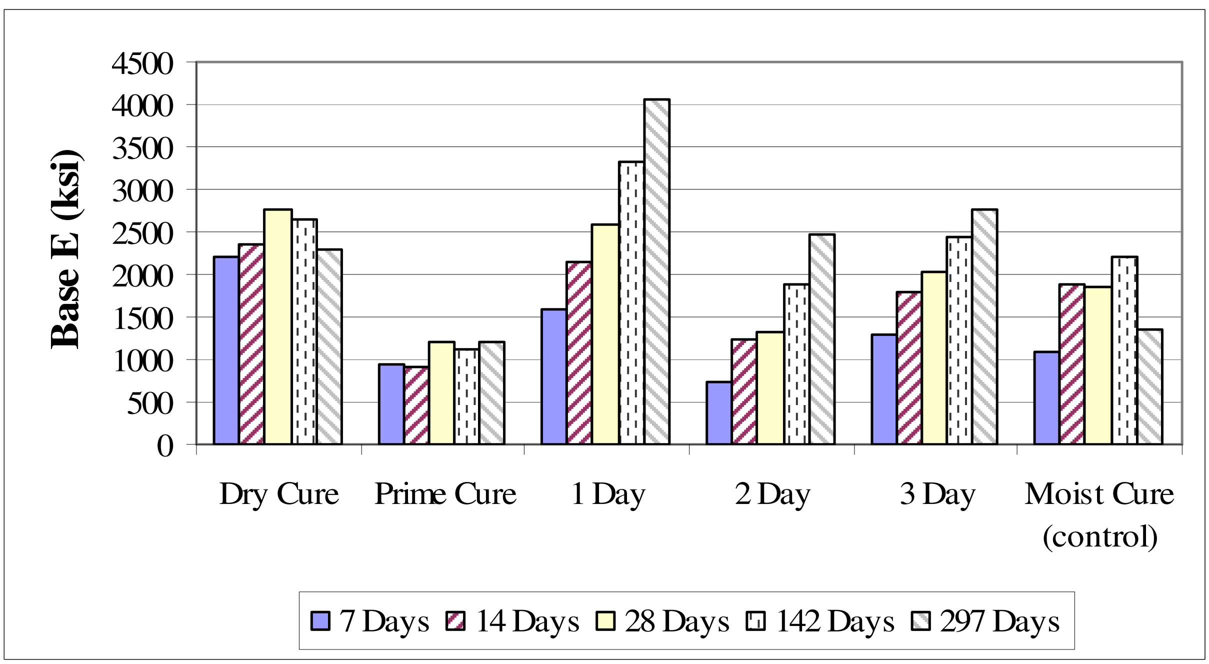

Figure 5.7. Base Modulus through Time for 8-Percent Cement Riverside Campus Test Sites.

Figure 5.8 contrasts the most recent FWD results for the sections between the 4-percent and 8-percent cement sites. The figure illustrates both the observed sample mean (the square marker) and the 95-percent confidence interval for the population mean from the sections. These data indicate:

- Microcracking has not resulted in reduced layer moduli when compared to the control (moist cured). No significant difference exists in the mean base modulus between the microcracked sections and the moist cured sections at the site with 4-percent cement. At the 8-percent cement site, the section cracked after one day, and the section cracked after 3 days, both have significantly greater moduli than the moist-cured section.
- With the exception of the dry-cured sections and the sections cracked at one day, currently no difference in modulus exists between the two cement contents when constructed and cured with identical techniques. The higher cement content in general has not resulted in a significantly increased in-service modulus.

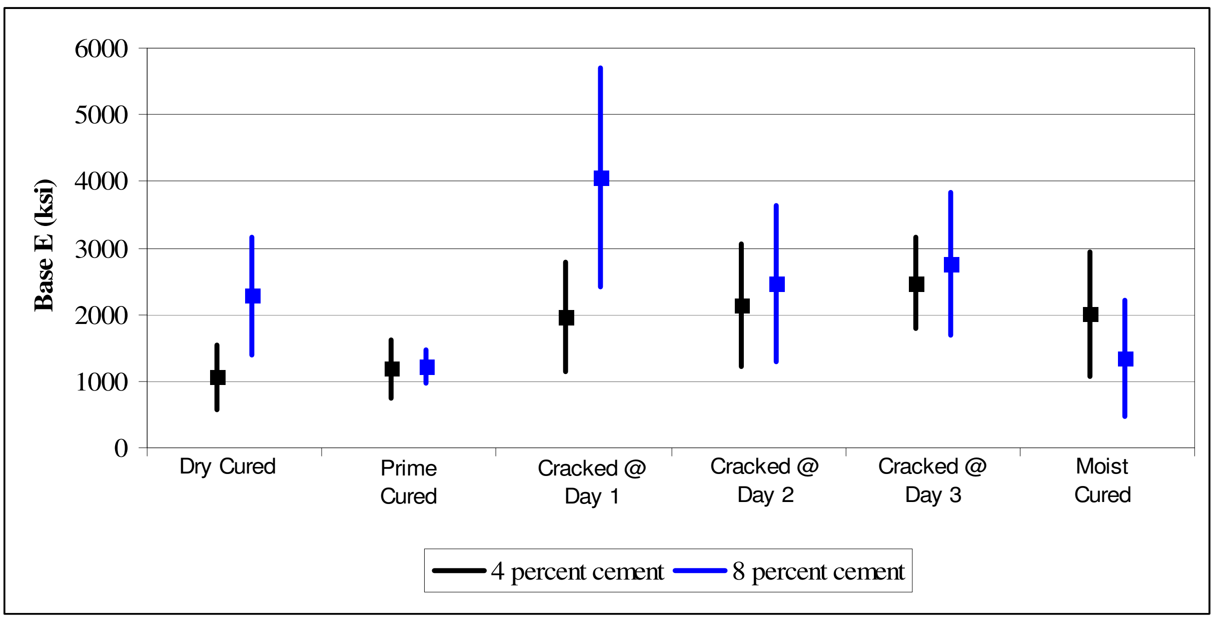

Figure 5.8. Summer 2004 FWD Results for Riverside Campus Test Sites.

Figure 5.9 shows TxDOT's FWD versus the PFWD results at the Riverside test sites. The PFWD imparted stress state was approximately 16 psi. There is a reasonable fit between the two devices for all the data; the devices track best at lower modulus values. This observation makes sense, since the PFWD is intended primarily for use on soils and unbound materials. The PFWD values were substantially lower than TxDOT backcalculated modulus values. Part of this variation is certainly due to the fact that the PFWD employed was a single-sensor device, so the calculated modulus will be a function of the entire effective depth of measurement. A three sensor PFWD is available, however, and future efforts should consider using a three sensor setup and performing a layered backcalculation. A better fit between the devices may be obtained by using the three sensor setup.

For purposes of this project, the primary reason for testing the PFWD was to evaluate the device's ability to monitor and control the microcracking process. Figure 5.10 shows the percent change in average modulus from TxDOT's FWD versus the percent change in average modulus for the PFWD and illustrates a reasonable fit between the two devices. The data indicate the PFWD could be used for control and monitoring of microcrcacking. However, the percent change in average modulus from TxDOT's FWD was approximately 1.4 times the percent change from the PFWD. Therefore, if targeting a 60-percent reduction in base modulus (as based on TxDOT's FWD), one would target a 40-percent reduction in average modulus from the PFWD.

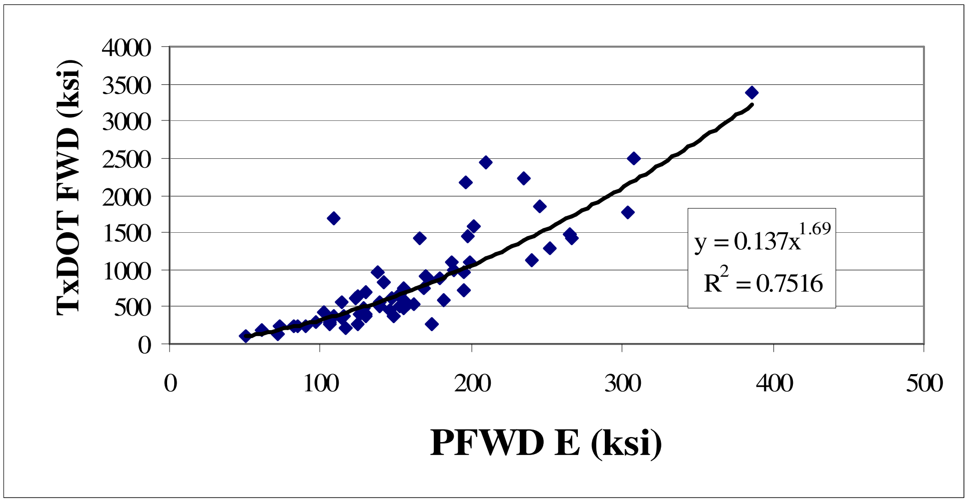

Figure 5.9. TxDOT's FWD versus PFWD Values at Riverside Campus Test Sites.

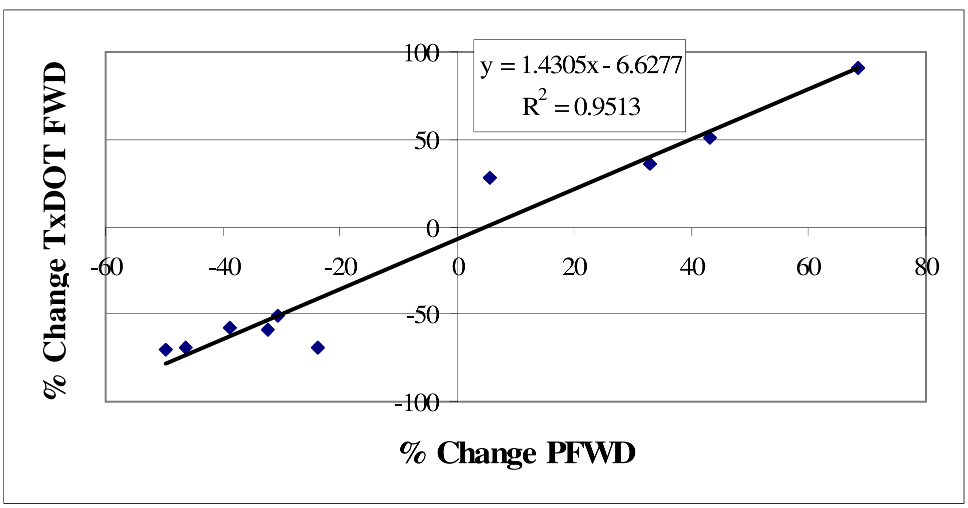

Figure 5.10. Percent Change in Average Modulus for TxDOT's FWD versus PFWD.

CRACKING PERFORMANCE

The research team carried out multiple crack surveys at the test sites at Riverside Campus. The contractor placed the base on September 8, 2003. The results of crack surveys conducted on September 9, 2003; September 15, 2003; January 28, 2004; March 29, 2004; and June 28, 2004 are summarized in Figures 5.11, 5.12a, and 5.12b. In the figures, the cracks are coded by color to indicate when they first appeared. Cracks in blue existed the morning of September 9, 2003, and are cracks that could not have been prevented regardless of treatment. Cracks colored in red occurred after the treatment was applied and thus are considered preventable cracks. Table 5.3 summarizes the crack length statistics for the sites. Several observations are evident from the surveys:

- In general, the sites with 8-percent cement exhibited more total cracking than their counterpart treatments with 4-percent cement. The most drastic differences exist in the dry-cured and prime-cured sections.
- Of the sites with 4-percent cement, the site microcracked at two days cure currently has the best cracking performance.
- Of the sites with 8-percent cement, the site moist cured currently has the least amount of total cracking; however, microcracking at 3 days cure was most effective at preventing additional cracks from occurring. For example, the site cracked after 3 days already had 80 ft. (24.4 m) of cracks per 100 linear ft. (30.5 m) road before microcracking; after treatment, the total crack length has increased by only 10 percent. In contrast, the moist-cured section initially had no cracks in it, but over time has progressively shown a steadily increasing amount of cracking.
- At the site with 8-percent cement, a prime coat curing membrane was ineffective at controlling cracking.

Two methods exist for microcracking to reduce shrinkage cracking problems. First, microcracking can reduce the total amount of cracking; second, microcracking can reduce the severity (width) of the cracks. Table 5.3 shows microcracking substantially reduced preventable crack length in the site with 8-percent cement. The only major reduction in total crack length at the site with 4-percent cement is with the section microcracked after 2 days cure. However, drastic differences in crack severity exist in the site with 4-percent cement. As noted in Table 5.3, the crack width in sections that were wet cured or dry cured is such that spalling is starting to occur. In contrast, the cracks in sections that were microcracked are less severe. Figure 5.13 contrasts the widest to the tightest cracks in the sections with 4-percent cement. In some cases (see Figure 5.13b), some of the cracks are so tight they are barely visible. Differences in crack severity also exist in the site with 8-percent cement, with cracks in the microcracked sections less severe than others. In general the research team observed crack severity decreased with microcracking as compared to the dry-cured, wet-cured, and prime-cured sections. Thus, the performance of the sites indicate that in some cases, especially on bases with high cement contents, microcracking will significantly reduce the amount of cracking in the base; however, even if total crack length is not substantially reduced, crack severity is significantly reduced by microcracking, regardless of mixture design.

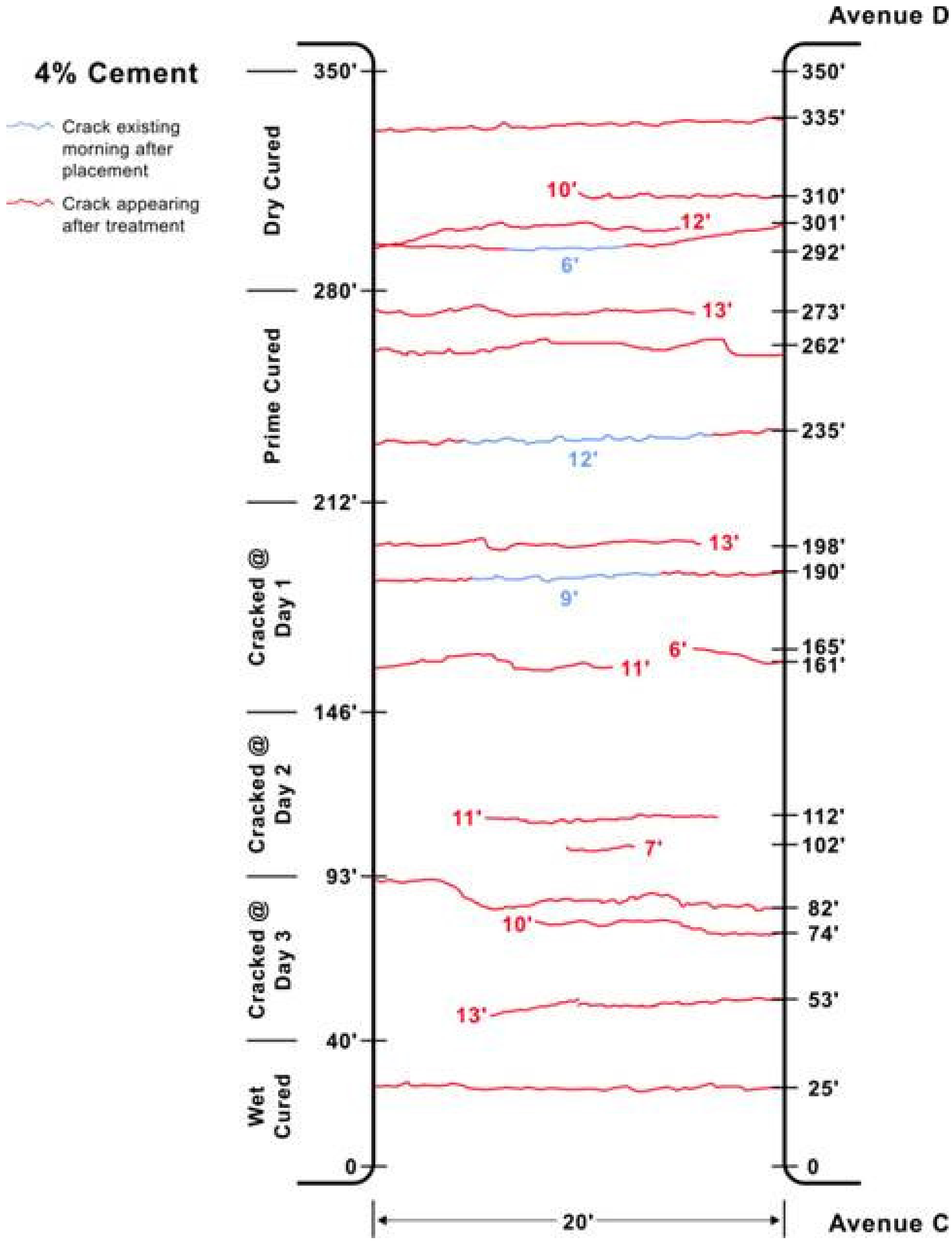

Figure 5.11. Cracking in 4-Percent Cement Section at Riverside Campus as of June 28, 2004.

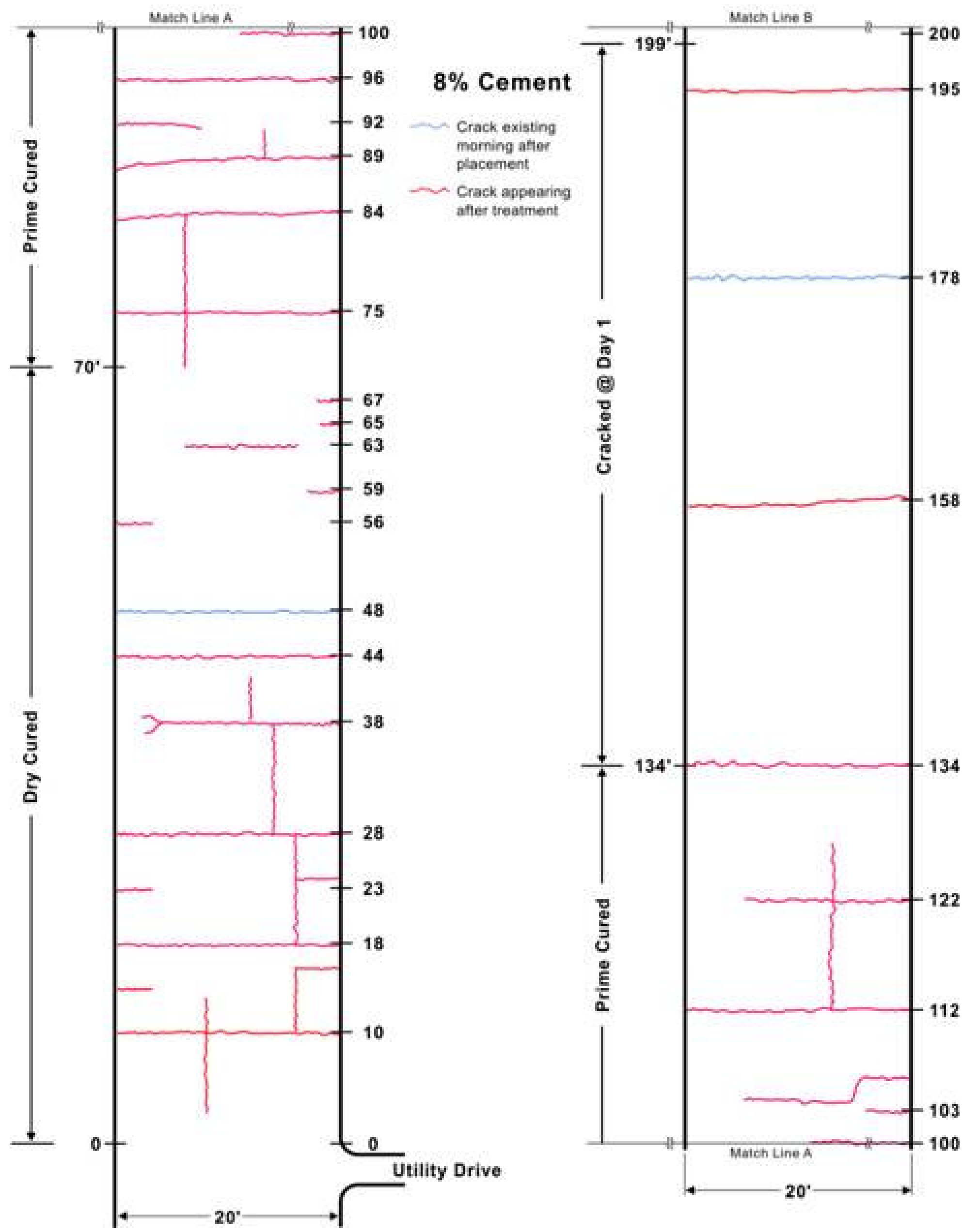

Figure 5.12a. Cracking in 8-Percent Cement Section at Riverside Campus as of June 28, 2004.

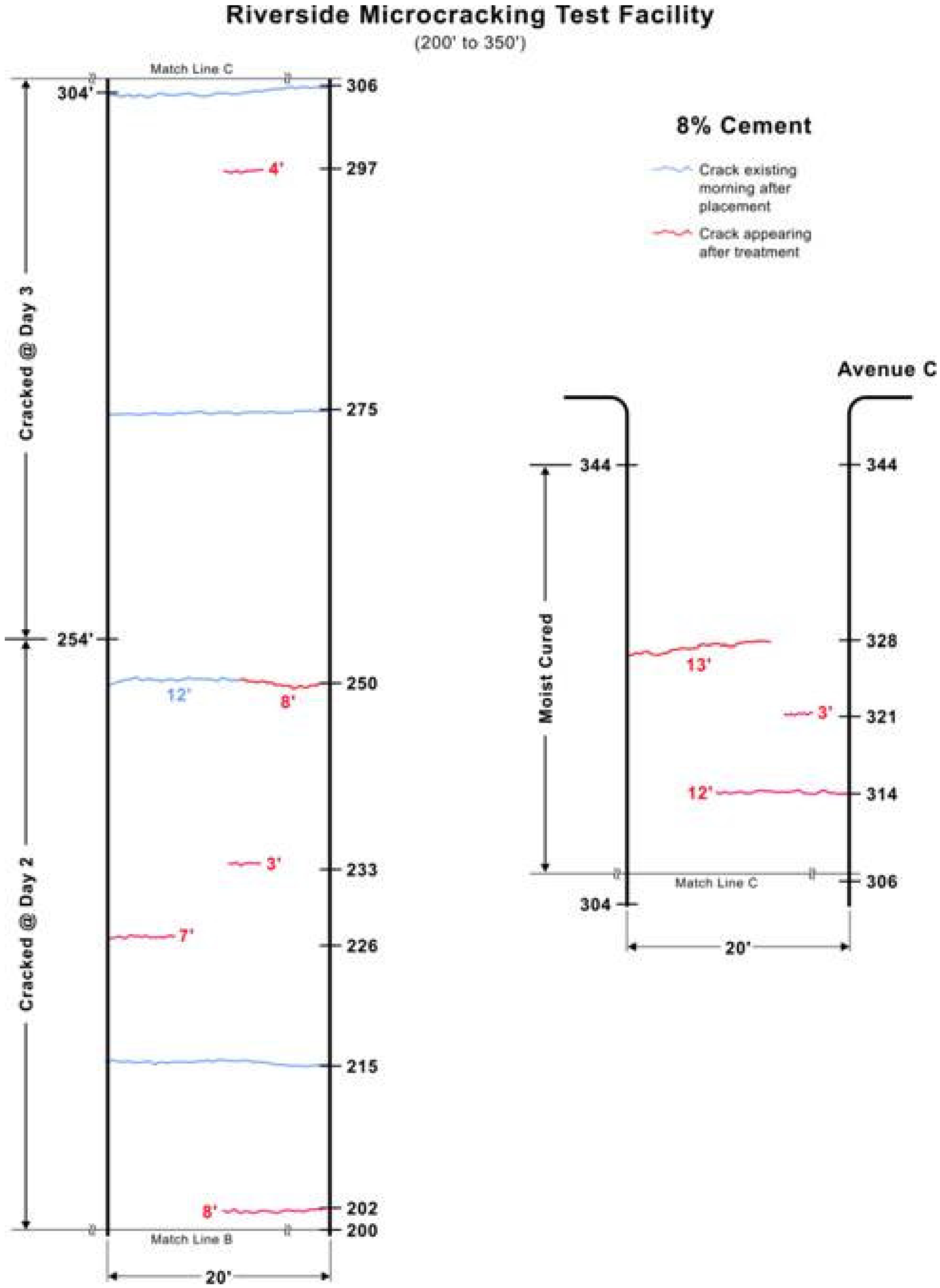

Figure 5.12b. Cracking in 8-Percent Cement Section at Riverside Campus as of June 28, 2004.

Table 5.3. Summary of Cracking Performance at Riverside Campus Test Sites.

Cement Content (%)	Treatment	Crack Length per 100 Feet						Comment
		9/9/2003	9/15/2003	1/28/2004	3/29/2004	6/28/2004	6/28/2004*	
4	Dry Cure	9	43	57	57	89	89	cracks spalling
	Prime Cure	18	29	51	59	78	60	
	Crack 1 Day	14	35	35	45	76	62	
	Crack 2 Day	0	0	17	19	34	34	
	Crack 3 Day	0	6	6	19	81	81	some cracks close in heat of day
	Moist Cure	0	8	50	50	50	50	cracks spalling
8	Dry Cure	29	29	46	76	277	277	cracks spalling
	Prime Cure	0	48	89	125	328	328	
	Crack 1 Day	31	62	62	92	92	62	
	Crack 2 Day	58	58	58	73	105	47	
	Crack 3 Day	80	80	80	80	88	8	
	Moist Cure	0	0	15	33	70	70	cracks spalling

*This column is only the crack length of preventable cracks

(a) Dry Cured

(b) Microcracked at 3 Days Cure

Figure 5.13. Worst (a) and Least (b) Severe Cracks in 4-Percent Cement Test Site.

CONCLUSIONS

The test sites constructed at Riverside Campus gave the research team an excellent opportunity to investigate the microcracking concept. The research team had full control over the construction, from start to finish, and the location provided an opportunity to leave the base exposed so cracking in the base could easily be investigated. Although the sections are not yet one-year old, the observations to date support the following:

- An asphalt curing membrane was minimally effective at reducing cracking problems, particularly with high cement contents.
- Excessively high cement contents result in extensive cracking in the base, regardless of treatment.
- Microcracking reduces the severity of cracks, regardless of cement content and, in some cases, also reduces the total crack length.
- Proper lab designed combined with microcracking at two days cure has provided a marked reduction in the extent and severity of shrinkage cracks.

CHAPTER 6

SPECIAL TOPICS

SUMMARY

Over the course of this research project, several questions were posed to the research team regarding possible detrimental effects of microcracking on the pavement layer. These questions specifically focused on whether the mechanical properties of the layer were compromised and whether microcracking causes surface damage to the layer. Additionally, questions arose regarding how soon CTB can be opened to traffic. This chapter will present results and observations from the research project regarding these topics. Data indicate the strength of the material is not compromised, the resilient modulus of the microcracked layers significantly recovers, and if the layer is properly designed, surface damage is not a problem. Data also indicate CTB sections can be opened to traffic after 4 to 24 hours curing.

EFFECT OF MICROCRACKING ON STRENGTH

Previous work conducted at TTI showed that even after completely failing cement-treated bases at a curing age of 7 days, with continued curing time to 21 days, the strengths recovered to exceed the original 7-day UCS (*8*). This testing supported the notion that microcracking at an early curing age would not detrimentally impact the strength of the base. The research team conducted additional testing regarding this subject during this research project. For example, Figure 6.1 illustrates the results of laboratory testing with the limestone base used on SH 16. The researchers treated the material in the lab with 2-percent Type 1 cement and performed compression tests in duplicate at curing times of 1, 2, 3, 7, and 28 days curing. Specimens tested at 1, 2, 3, and 7 days were taken past failure and then allowed to continue curing to an age of 28 days. At 28 days, researchers retested these specimens in compression. The results show that there was no major difference in the average 28 day strengths between any of the previously failed specimens and the control specimens that were simply cured to 28 days then tested.

Similarly, Figure 6.2 shows the results of strength rehealing tests conducted on the gravel base used at the Riverside test sites. For each treatment, tests were conducted in duplicate, and the results show no significant difference in the average 28-day curing strengths between any of the treatments. Thus, based upon previous work and the data collected in this study regarding strength rehealing of cement-treated base after early failure, the research team believes there is not a detrimental effect on strength from microcracking. Sufficient cement hydration continues after the early failure to the extent that 28-day strengths are not significantly different from strengths obtained by curing without microcracking.

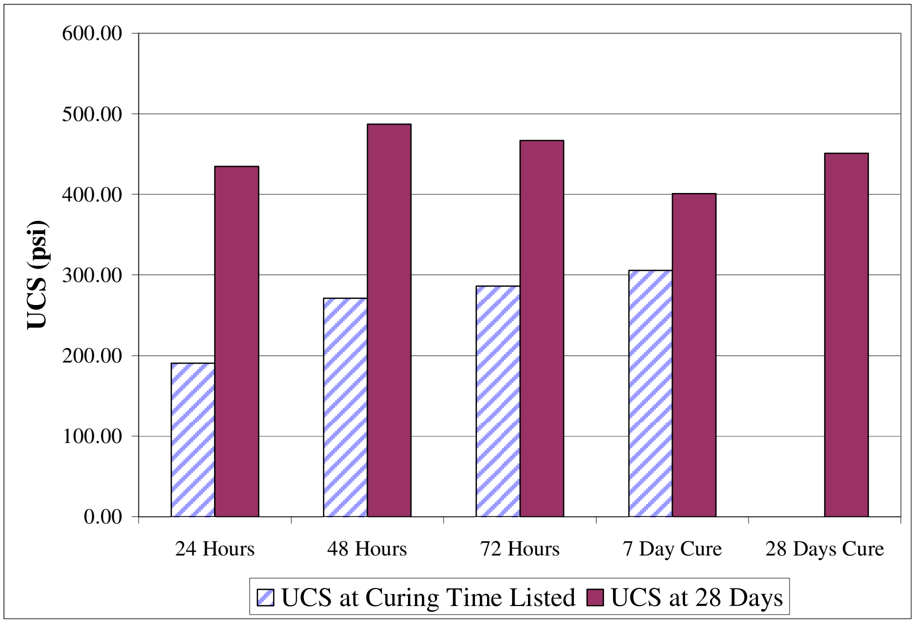

Figure 6.1. Strength Rehealing on SH 16 Base.

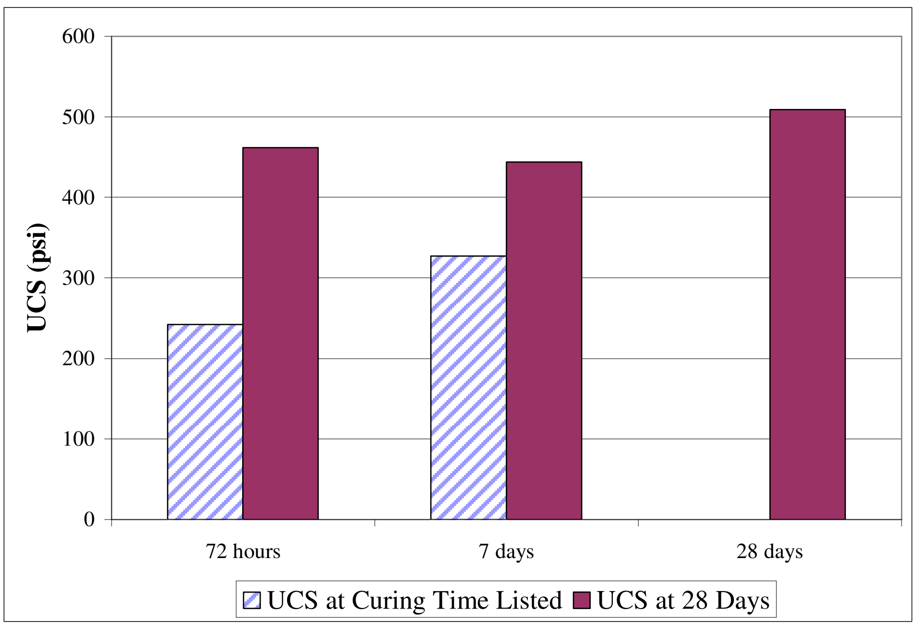

Figure 6.2. Strength Rehealing on Gravel Base Used at Riverside Campus Test Sites.

EFFECT OF MICROCRACKING ON LONG-TERM MODULUS

Another aspect of the microcracking concept is how the modulus of the layer is affected. Many cement treated bases end up very stiff, resulting in problems if the base sits on an expansive soil, so it would not necessarily be bad if microcracking resulted in a reduced in-service modulus. Figure 6.3 shows the average base moduli of the 4-percent cement sites from the most recent FWD measurements at the Riverside test site (June 28, 2004). The ANOVA results shown in Table 6.1 show no significant difference exists between the mean base modulus of any of the microcracked sites and the moist-cured site; microcracking had no adverse impact on the in-service modulus.

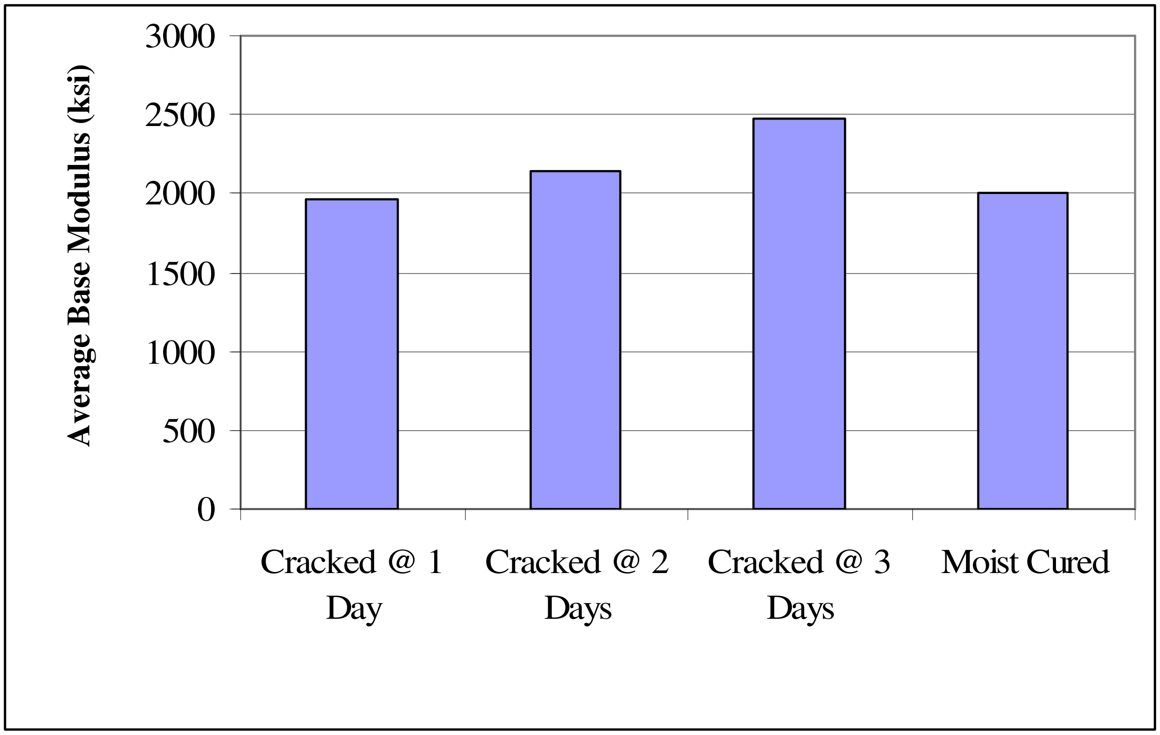

Figure 6.3. Average Base Modulus of 4-Percent Cement Sites at Riverside Campus.

Table 6.1. ANOVA Result on most Recent FWD Data at Riverside Campus with 4 percent Cement.

Groups	*Count*	*Sum*	*Average*	*Variance*
1d	8	15752	1969	965940
2d	7	14986	2140.86	974370
3d	8	19793	2474.13	673943
wet cure	6	12056	2009.33	779920

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1219915	3	406638	0.47896	0.69981	2.99124
Within Groups	2.1E+07	25	849000			
Total	2.2E+07	28				

EFFECT OF MICROCRACKING ON SURFACE DAMAGE

Some concern exists regarding the potential for surface damage to the base resulting from the microcracking process. Throughout the course of this research project, only one instance occurred where problems with surface damage were encountered. At the Riverside test sites when microcracking the site with 8-percent cement after 3 days curing, some surface breakup started to occur before the desired reduction in stiffness was achieved. Even though the modulus was reduced 58 percent, the average base modulus after cracking was still 874 ksi, and the research team wanted to reduce this value down to 500. Because of the surface breakup, the microcracking process was terminated and the section rolled statically to smooth the surface back out. This experience indicates 1) targeting a percent reduction in stiffness is more appropriate than targeting a specific modulus value, and 2) with stiffer materials, a larger roller may be necessary. Additionally, a roller appropriate to the base thickness should be employed; for example, on SH 47 (with a base thickness of 14 in.), TxDOT used a 25-ton roller.

EARLY TRAFFICKING OF CTB

A secondary issue that arose from this work was questions regarding how quickly traffic can be allowed on cement-treated layers. TxDOT specifications require a 3-day moist cure as one option for curing; however, in instances of emergency repairs TxDOT needs to open the road sooner. Figure 6.4 shows the distribution of observed moduli for the Riverside test site with 4-percent cement the afternoon of placement, representing a curing time of approximately 4 hours, and the morning after placement, representing approximately 20 hours curing. The average base modulus the day of placement was 362 ksi, and 90 percent of these observations were greater than 65 ksi. The morning after placement the average modulus was 874 ksi with 90 percent of observations greater than 200 ksi. The data indicate earlier trafficking of the cement-treated base than what is typically allowed should not pose a problem.

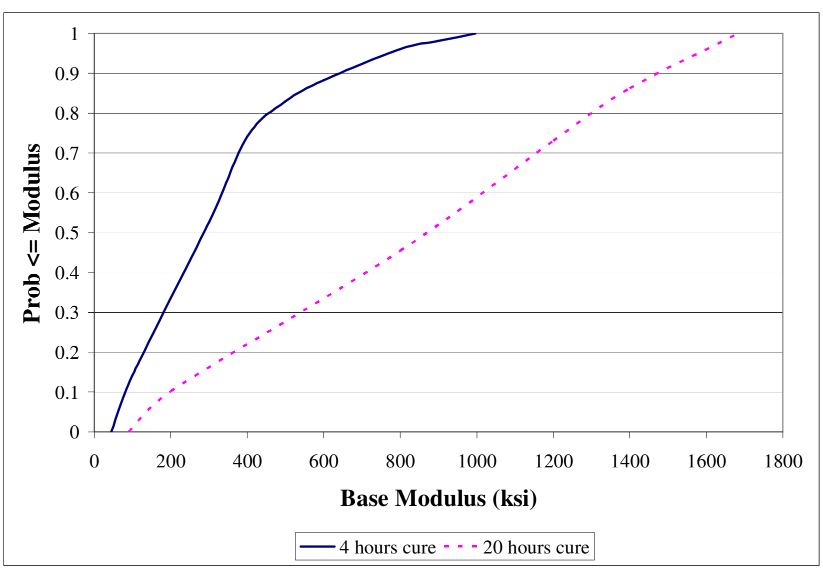

Figure 6.4. Early Modulus of Riverside Campus Site with 4-Percent Cement.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

This project focused on evaluating the effectiveness of the microcracking concept for reducing shrinkage cracking in cement-treated bases. Microcracking can be defined as the application of several vibratory roller passes to the cement-treated base at a short curing stage, typically after one to three days, to create a fine network of thin cracks. In this project, TTI researchers monitored performance of microcracking sites on SH 47 and SH 16. Finally, the research team coordinated the construction and monitored the performance of controlled test sites constructed under this project at Texas A&M's Riverside Campus. The test sections at Riverside Campus also provided the research team the opportunity to investigate two design cement contents and other alternative curing procedures. This chapter provides the key findings from the test sites, guidelines for performing the microcracking procedures, and recommendations for future work to further optimize the performance of CTB. Additionally, Appendix A of this report presents a guide explaining the microcracking concept for inspectors' use.

CONCLUSIONS FROM TEST SITES

Data from all the test sites indicated that microcracking was effective. At SH 47, only one of the five test sites has any cracking in it. At this 2300 ft. long site, only two transverse cracks exist. The SH 47 sites have 4 in. of HMA. At the SH 16 site, suspected problems with the HMA combined with crack patterns not typical of CTB cast serious doubt on the usefulness of the observations; however, microcracking at one day cure did appear to slightly reduce the total cracking in the HMA. The Riverside test sites provided the research team a unique opportunity to fully investigate microcracking under a controlled setting. Data from these sites indicated microcracking indeed reduced the shrinkage cracking problem in cement-treated bases. As a whole, the observations from the projects evaluated indicate:

- When properly applied, microcracking does not result in pavement damage. The surface does not break up, and the base modulus recovers.
- Without microcracking, excessively high cement contents result in problematic cracking in the base. This problematic cracking could be increased crack width, increased total crack length, or both.
- Microcracking reduces the severity of shrinkage cracks in the base, regardless of cement content, and in some cases also significantly reduces total crack length.
- The positive effect of microcracking means the technique is a valid method for reducing the likelihood of reflective cracking through the roadway surfacing.
- Proper lab design combined with microcracking by three passes of the vibratory roller at high amplitude after 2 to 3 days cure has provided a marked reduction in shrinkage cracking problems. The current data from the Riverside sites indicate the optimal time frame for microcracking a properly designed layer is 2 days.

- If using test equipment to monitor the microcracking process, a target reduction in average base modulus of 60 percent (based on TxDOT's FWD measurements) should be used.
- The PFWD shows promise for monitoring the microcracking process. With this device, target a reduction in average modulus of 40 to 50 percent.
- An asphalt curing membrane was minimally effective at reducing cracking problems.
- Moist curing without microcracking results in more severe (wider) cracks that will, thus, reflect sooner through the surfacing.
- In the long run, use of higher cement content in general did not provide a significantly increased base modulus. However, the increased cement content did result in more severe cracking problems. Historical design 7-day UCS targets were based upon achieving a high degree of confidence the material would meet durability criteria without actually performing the labor- and time-intensive "brush tests" (ASTM D559 and D560). With the recent development of much simpler, less time-consuming durability tests for CTB, such as the Tube Suction Test, strength requirements should be eased and the new durability tests should be run. Cement content design should be based upon a combination of adequate strength (300 psi) and passing the Tube Suction Test for moisture susceptibility.

In addition to evaluating microcracking, this project provided an opportunity to investigate the feasibility of opening cement-treated bases to traffic sooner. Figure 6.4 showed the distribution of observed moduli values for a properly-designed CTB at curing ages of approximately 4 and 20 hours. The data show that after only 4 hours curing, the average modulus was 362 ksi. The data indicate earlier trafficking of the cement-treated base than what is typically allowed should not pose a problem.

GUIDELINES FOR THE APPLICATION OF MICROCRACKING

A successful microcracking project does not begin at the project site, but rather begins in the laboratory. The research team recommends a laboratory design procedure that includes both 7-day strength and moisture susceptibility. The design cement content should be based upon:

- 7-day UCS: $\geq$300 psi, and
- Final dielectric value after the Tube Suction Test $\leq$10.

Once the proper cement content is determined, microcracking can be properly applied to the material in the field. No detrimental effects from the microcracking process have been observed; thus, microcracking can be applied to any properly designed CTB as follows:

- After placement and compaction of the base to project specifications, moist cure the base to an age of 2 days.
- Microcrack the section by using the same (or equivalent) vibratory steel wheel roller that was employed for compaction. If microcracking after 2 days is not feasible, waiting until the base age reaches 3 days is preferable to microcracking after only 1 day cure.
- Perform three full passes (one pass is down and back) over the entire section traveling 2 to 3 mph with the roller vibrating on maximum amplitude, unless otherwise directed by

the Engineer. A minimum 12-ton roller should be used. Ideally microcracking should be applied after 2 days of moist curing.
- After microcracking, continue moist curing the layer to an age of 3 days. At the completion of the curing stage, prepare the base for surfacing.

RECOMMENDATIONS FOR FUTURE EFFORTS

While this project provided good evidence to the effectiveness of microcracking, the research team believes ample opportunity and reason exists to further examine the microcracking process and further refine the optimization of performance from cement-treated bases. Data from this project support the validity of the microcracking concept; however, the quantity of test locations was quite limited. TxDOT should consider employing microcracking on field projects and periodically monitor the performance. Of critical importance is the inclusion of control (not microcracked) sections. Additional sites would allow for better familiarity with the concept and a larger number of case histories from which to evaluate the effectiveness of the microcracking concept.

In addition to more experience with field microcracking projects, the research team believes other construction methods may prove useful in conjunction with microcracking to further improve the overall cracking performance of pavement structures with CTB. For years, crack relief layers on top of the CTB have been suggested as one method of minimizing the risk of reflective cracks. TTI recently developed a new surface HMA mix that shows extremely promising results in both cracking and rutting performance. After microcracking the base, a thin 1 in. layer of this mix, followed by a final surfacing, could provide cracking performance superior to microcracking alone. At the conclusion of this project, the research team believes one travel direction of the test sites at Riverside Campus should be surfaced with this new mix. The other travel direction could be surfaced with a conventional mix such as Type D. Since the cracks existing in the base are already mapped out, the research team can monitor the effectiveness of each mix by monitoring the amount of reflective cracking that appears through time.

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APPENDIX A

GUIDE FOR APPLICATION OF MICROCRACKING

WHAT IS MICROCRACKING?

The “block cracks” common to cement-treated base (CTB) initially present a cosmetic problem and result in negative public perception; however, these cracks can allow water into the pavement structure which will accelerate the rate of pavement deterioration. Microcracking can help alleviate the severity of cracking in CTB and therefore help improve the perceived quality of TxDOT projects and extend the project life. Microcracking is the application of several vibratory roller passes to a CTB after a short curing stage, typically after one to three days, to create a fine network of cracks. Microcracking is one technique to help reduce the risk of cracks in the CTB reflecting through the pavement surfacing. The goal of microcracking is to form a network of fine cracks and prevent the wider, more severe cracks from forming.

Block cracking typical of CTB.

Microcracking in progress with the vibratory roller. TxDOT's FWD can serve as the control mechanism to determine when to stop rolling by measuring the reduction in average base modulus.

WHAT ARE THE BENEFITS OF MICROCRACKING?

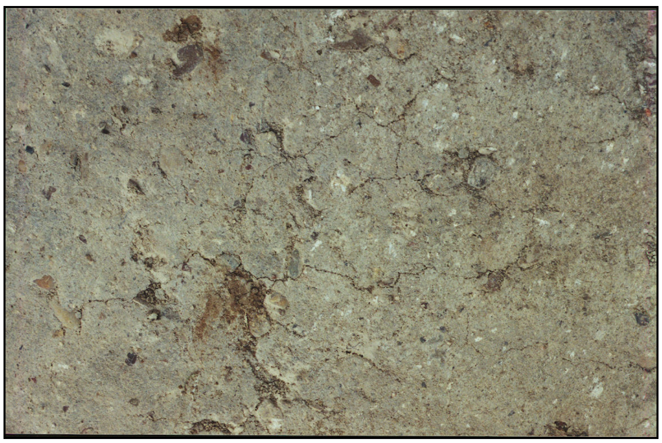
Microcracking reduces the severity of shrinkage cracking problems in CTB. Compared to moist curing alone, microcracking improves the performance of CTB by reducing the crack width, reducing the total crack length, or both. Through these mechanisms, microcracking reduces the risk of reflective cracking through the surface layer.

Crack in moist-cured section.

Crack in section microcracked.

WHAT DOES A MICROCRACKED CTB LOOK LIKE?

Upon introduction to the microcracking concept, most pavements personnel fear microcracking will rubblize or powder the base. Contrary to this fear, a properly microcracked CTB looks no different than an ordinary CTB. Typically, no visual changes are detectable in the base immediately after microcracking. On rare occasions, some visible hairline cracks may appear. However, use of some type of stiffness testing device, such as the falling weight deflectometer, is typically the only method to definitively detect a change in the base after microcracking.

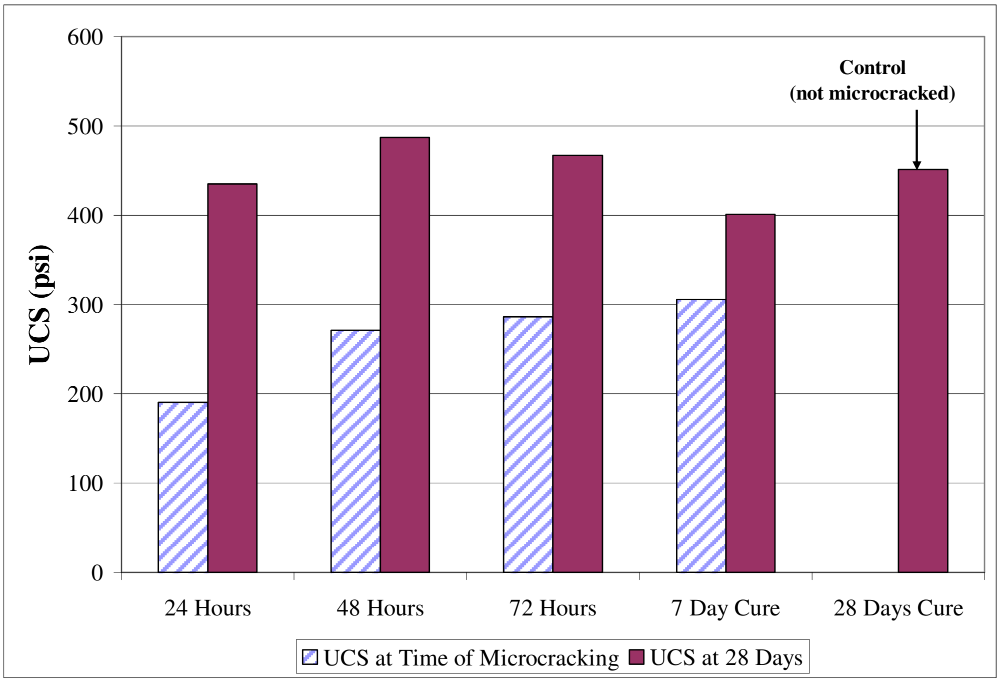


Visible cracks in CTB after microcracking are rarely observed.

A portable FWD provides a compact alternative to the FWD for controlling microcracking.

WHAT MATERIALS SHOULD BE MICROCRACKED?

Performance of microcracked field projects in Texas indicates no detrimental structural effects from microcracking. Even after failure at an early curing stage, the strength of the material recovers by continued cement hydration. At the end of the hydration stage, the strength of the previously failed material does not differ significantly from material simply cured to an age of 28 days. Given the observed benefits and the lack of negative effects, microcracking can be considered for any properly designed CTB.



28-day unconfined compressive strength of CTB is not harmed by microcracking at an early age.

HOW AND WHEN SHOULD MICROCRACKING BE PERFORMED?

After placement and satisfactory compaction of the CTB, the base should be moist cured by sprinkling for 48 to 72 hours before microcracking. Microcracking should be performed with the same (or equivalent tonnage) steel wheel vibratory roller used for compaction. A minimum 12-ton roller should be used. Typically three full passes (one pass is down and back) with the roller operating at maximum amplitude and traveling approximately 2 to 3 mph will satisfactorily microcrack the section. After satisfactory completion of microcracking, the base should be moist cured by sprinkling to an age of at least 72 hours.

WHAT TO LOOK FOR DURING THE MICROCRACKING PROCESS

Inspect the microcracking operation and look for:

1) Satisfactory completion of three full passes that achieve 100 percent coverage.
2) Signs of cracking in the CTB. Although new cracks are rarely observed (oftentimes some transverse cracking will have already taken place during the moist-curing stage), hairline cracks imparted by the roller occasionally may be visible. If available, the FWD can be used to ensure adequate completion of microcracking by testing every station immediately before microcracking, then retesting at each station immediately after completion of the three microcracking passes. The average base modulus should be reduced 50 to 70 percent by microcracking with three passes of the roller. If the actual reduction is greater than 50 percent but less than 60 percent, the Engineer may choose to accept the section, or direct the Contractor to perform additional microcracking passes. If using a PFWD for controlling microcracking, target a 40 percent reduction in average base modulus.
3) Signs of detrimental damage to the CTB. If properly designed and cured, microcracking should not damage the CTB. However, if the base appears to start to break up excessively at the surface, microcracking shall be ceased and the section rolled static until a satisfactory surface finish is obtained.
4) Satisfactory completion of continued moist curing to an age of at least 72 hours.

NEED MORE INFORMATION?

The oldest TxDOT project incorporating microcracking was SH 47 near Bryan, TX. Complete details can be obtained from the lab engineer in charge, Darlene Goehl, P.E., Texas Department of Transportation, (979) 778-9650, dgoehl@dot.state.tx.us. Texas Transportation Institute researchers evaluating microcracking include Stephen Sebesta, (979) 458-0194, s-sebesta@tamu.edu, and Tom Scullion, P.E., (979) 845-9910, t-scullion@tamu.edu.

APPENDIX B

SH 16 PROCESSED FWD DATA

16 SB sec 1 3/20/03

SH 16 site 1 pre-cracking test site after 1 days cure

Processed w/new base & old as composite layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

		Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
District: 0					
County : 0					
Highway/Road:	Pavement:	0.50	200,000	200,000	H1: v = 0.35
	Base:	12.00	25,000	1,000,000	H2: v = 0.25
	Subbase:	0.00			H3: v = 0.00
	Subgrade:	78.96	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
838+00 → 0.000	9,783	14.86	6.89	3.94	1.81	1.09	0.67	0.45	200.0	95.3	0.0	25.2	7.63	67.6
101.000	9,914	17.02	10.54	6.79	3.19	1.78	1.25	0.98	200.0	121.9	0.0	13.3	11.40	72.2
200.000	9,704	25.31	13.96	8.89	4.96	3.33	2.54	1.91	200.0	89.7	0.0	8.1	6.70	127.9
300.000	9,736	19.17	11.27	7.29	3.54	2.07	1.43	1.07	200.0	106.1	0.0	11.7	6.98	77.3
400.000	9,505	27.21	16.82	9.87	4.68	2.82	2.13	1.65	200.0	70.7	0.0	7.7	8.41	76.3
500.000	9,716	25.31	12.69	7.98	4.46	3.02	2.22	1.58	200.0	79.7	0.0	9.4	7.49	127.1
600.000	9,815	18.89	11.00	6.50	3.72	2.60	2.04	1.62	200.0	117.6	0.0	11.3	6.39	142.9
700.000	9,624	22.81	11.55	7.18	3.70	2.51	1.97	1.62	200.0	82.7	0.0	11.1	7.13	89.8
800.000	9,708	24.62	13.95	8.74	4.47	2.85	2.15	1.70	200.0	84.4	0.0	8.7	5.18	89.5
900.000	9,712	21.16	13.22	8.48	4.43	2.94	2.31	1.80	200.0	113.7	0.0	8.9	6.59	95.4
1000.000	9,716	23.29	13.31	8.46	4.55	2.96	2.20	1.65	200.0	95.2	0.0	8.8	4.69	106.4
1101.000	9,613	25.49	13.24	7.94	3.93	2.40	1.74	1.36	200.0	69.3	0.0	10.2	4.13	81.4
1200.000	9,708	17.89	9.26	5.39	2.71	1.76	1.30	1.00	200.0	96.3	0.0	16.3	3.52	82.0
1300.000	9,740	20.96	9.87	6.13	3.07	1.88	1.36	1.04	200.0	79.2	0.0	14.7	3.37	81.9
1400.000	9,787	17.07	7.95	4.90	2.77	1.90	1.45	1.16	200.0	104.2	0.0	17.9	5.96	128.9
Mean:		21.40	11.70	7.23	3.73	2.39	1.78	1.37	200.0	93.7	0.0	12.2	6.37	91.5
Std. Dev:		3.79	2.58	1.64	0.89	0.62	0.52	0.40	0.0	16.5	0.0	4.7	2.07	19.9
Var Coeff(%):		17.73	22.05	22.70	23.87	26.00	28.99	29.46	0.0	17.6	0.0	38.6	32.46	21.7

Site 1 838
SH 16 site 1 6/29/2003
Processed w/new & old base as composite layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District: 0
County : 0
Highway/Road:

	Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	2.50	229,300	229,300	H1: v = 0.35
Base:	11.50	25,000	2,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	181.85	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
838+00 → 0.000	10,034	9.69	6.94	4.78	2.61	1.38	0.98	0.67	229.3	195.8	0.0	23.9	14.77	96.9
50.000	10,077	6.75	4.41	2.91	1.58	0.94	0.71	0.54	229.3	309.1	0.0	37.6	9.82	118.2
100.000	9,982	6.46	4.78	3.49	2.12	1.35	1.05	0.79	229.3	507.7	0.0	28.0	6.68	170.6
151.000	9,998	10.94	8.29	6.26	3.98	2.52	1.96	1.40	229.3	279.7	0.0	15.1	5.90	165.0
200.000	9,974	8.19	6.30	4.75	3.10	2.13	1.73	1.31	229.3	484.8	0.0	18.4	5.61	300.0
251.000	9,994	7.17	4.50	2.99	1.88	1.29	1.05	0.82	229.3	344.6	0.0	31.5	4.74	300.0
301.000	9,926	7.85	5.58	3.98	2.36	1.50	1.18	0.89	229.3	342.6	0.0	24.8	6.77	168.6
350.000	9,883	9.36	6.54	4.44	2.56	1.54	1.19	0.90	229.3	223.5	0.0	22.9	8.60	132.8
400.000	9,954	11.25	7.91	5.59	3.38	2.09	1.65	1.23	229.3	205.9	0.0	17.6	6.40	147.6
451.000	10,014	7.00	5.13	3.81	2.58	1.81	1.50	1.17	229.3	616.4	0.0	22.2	4.64	300.0
601.000	9,934	8.50	5.19	3.58	2.28	1.61	1.31	1.05	229.3	284.1	0.0	25.8	3.91	300.0
651.000	9,966	7.29	4.96	3.48	2.16	1.42	1.18	0.93	229.3	393.2	0.0	27.3	6.21	207.3
702.000	9,918	5.72	4.05	2.96	1.98	1.42	1.17	0.91	229.3	771.2	0.0	28.5	4.64	300.0
752.000	9,787	9.87	6.89	4.93	3.06	2.06	1.64	1.30	229.3	268.7	0.0	18.7	5.37	249.4
800.000	9,807	9.69	7.12	5.30	3.28	2.22	1.70	1.26	229.3	309.2	0.0	17.4	5.25	262.2
851.000	9,835	9.38	6.75	4.85	2.91	1.84	1.37	1.06	229.3	269.8	0.0	20.2	6.95	163.9
900.000	9,648	11.98	8.33	5.61	3.12	1.89	1.54	1.22	229.3	152.5	0.0	17.9	9.13	132.0
950.000	9,688	10.76	7.68	5.42	3.25	2.09	1.61	1.30	229.3	216.5	0.0	17.5	6.31	179.2
1001.000	9,775	10.77	7.11	4.88	2.96	1.90	1.52	1.11	229.3	195.3	0.0	19.5	5.39	177.4
1050.000	9,775	9.05	6.06	4.30	2.59	1.62	1.23	0.92	229.3	254.6	0.0	22.7	5.50	155.6
1100.000	9,744	7.85	5.55	3.86	2.21	1.41	1.08	0.72	229.3	306.1	0.0	25.7	7.57	157.1
1150.000	9,823	6.65	4.58	3.31	2.02	1.25	0.99	0.64	229.3	429.5	0.0	29.5	6.13	148.7
1201.000	9,867	6.52	4.40	3.09	1.86	1.26	0.94	0.75	229.3	429.8	0.0	31.2	5.14	238.4
1251.000	9,795	7.67	4.39	2.73	1.65	1.14	0.89	0.61	229.3	246.6	0.0	35.2	4.40	248.3
1301.000	9,700	9.20	5.47	3.63	1.99	1.29	1.02	0.81	229.3	189.9	0.0	28.3	6.80	123.3
1350.000	9,823	6.08	4.12	3.01	2.00	1.39	1.11	0.88	229.3	617.7	0.0	29.0	3.88	300.0
1401.000	9,664	8.04	5.32	3.75	2.33	1.70	1.32	1.02	229.3	338.3	0.0	23.9	4.34	300.0
Mean:		8.51	5.86	4.14	2.51	1.63	1.28	0.97	229.3	340.1	0.0	24.5	6.33	195.9
Std. Dev:		1.74	1.33	0.99	0.60	0.38	0.31	0.24	0.0	150.6	0.0	5.8	2.26	65.0
Var Coeff(%):		20.41	22.72	23.89	23.96	23.46	23.95	25.08	0.0	44.3	0.0	23.8	35.68	34.3

SH 16 NB sec 1

SH 16 Site 2 3/20/03 after 1 days' cure

Processed 4 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	5.00	25,000	2,000,000	H2: v = 0.25
Subbase:	7.00	10,000	2,000,000	H3: v = 0.25
Subgrade:	75.73	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 838 → 0.000	9,974	18.28	6.91	3.86	1.69	1.05	0.76	0.63	200.0	90.6	52.6	24.7	6.97	63.6
100.000	9,712	21.80	9.03	4.61	1.94	1.33	1.06	0.87	200.0	94.9	31.8	19.7	6.60	61.7
199.000	10,550	21.09	8.61	4.91	2.55	1.94	1.44	1.21	200.0	75.2	83.7	18.4	9.04	88.9
201.000	10,189	23.54	8.75	4.48	2.39	1.70	1.39	1.15	200.0	72.5	44.2	18.9	10.87	97.3
300.000	10,884	14.64	7.80	5.00	2.51	1.66	1.21	0.96	200.0	198.2	113.6	19.2	3.47	80.7
400.000	9,672	19.52	10.14	6.31	3.28	2.19	1.71	1.36	200.0	80.6	136.0	12.6	5.12	91.3
500.000	9,910	17.69	7.67	5.02	2.81	1.97	1.55	1.26	200.0	69.4	221.6	16.9	7.60	122.1
600.000	10,479	13.30	5.87	3.87	2.16	1.56	1.23	1.00	200.0	130.7	192.1	24.2	7.61	117.8
702.000	9,716	16.70	11.00	7.22	3.60	2.12	1.62	1.30	200.0	213.5	114.6	10.2	7.72	82.0
800.000	9,763	24.31	15.39	9.87	4.70	2.60	2.20	1.87	200.0	123.6	71.5	7.7	9.96	76.7
900.000	9,926	16.08	9.54	6.59	3.83	2.67	2.06	1.64	200.0	96.2	450.4	11.0	4.60	159.0
1001.000	9,982	21.04	12.69	8.20	3.88	2.26	1.58	1.17	200.0	145.2	79.5	9.8	6.06	74.2
1100.000	10,022	18.93	11.10	7.01	3.36	2.15	1.56	1.13	200.0	127.6	101.1	11.6	5.41	74.9
1200.000	10,328	15.20	8.71	5.97	3.27	2.10	1.52	1.11	200.0	135.1	219.4	14.3	3.53	110.7
1300.000	9,664	22.06	11.64	7.48	3.76	2.23	1.63	1.25	200.0	82.2	95.5	10.7	4.66	84.0
STA 852 → 1401.000	10,185	16.10	9.03	5.65	3.13	2.20	1.78	1.44	200.0	110.8	206.5	14.6	5.06	116.5
Mean:		18.77	9.62	6.00	3.05	1.98	1.52	1.21	200.0	115.4	138.4	15.3	6.52	88.2
Std. Dev:		3.31	2.35	1.67	0.81	0.43	0.35	0.29	0.0	42.8	103.7	5.2	2.19	20.8
Var Coeff(%):		17.64	24.46	27.74	26.66	21.80	23.30	24.23	0.0	37.1	74.9	34.0	33.64	23.6

16 N11 sec 2

SH 16 Test Site 2 3/20/03 After 3 passes w/ vibratory processed 9 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	Moduli Range (psi) Minimum	Moduli Range (psi) Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	5.00	10,000	2,000,000	H2: v = 0.25
Subbase:	7.00	10,000	2,000,000	H3: v = 0.25
Subgrade:	85.34	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 838 → 1.000	10,185	17.31	6.87	3.54	1.65	1.00	0.74	0.59	200.0	105.6	49.2	28.0	4.57	68.7
100.000	9,954	23.35	8.55	4.28	2.02	1.43	1.12	0.91	200.0	74.1	32.2	21.8	8.98	70.8
200.000	10,204	21.28	9.96	5.29	3.05	2.20	1.73	1.41	200.0	81.8	77.3	16.2	7.39	146.4
300.000	10,061	13.80	6.39	3.77	2.03	1.42	1.08	0.85	200.0	142.4	106.8	25.0	5.08	100.0
400.000	9,724	25.33	11.26	6.69	3.38	2.31	1.80	1.45	200.0	55.5	75.3	12.9	6.74	84.3
500.000	9,664	20.86	7.01	4.17	2.61	1.85	1.46	1.21	200.0	32.6	535.2	20.3	10.23	300.0
600.000	9,493	17.36	6.13	3.28	2.02	1.49	1.20	1.00	200.0	88.2	70.9	23.6	14.27	248.4
704.000	9,434	26.80	11.30	6.91	3.48	2.31	1.80	1.44	200.0	44.0	83.4	12.0	7.00	84.0
798.000	9,346	39.73	14.18	7.43	3.63	2.43	1.92	1.51	200.0	23.3	47.1	10.7	8.45	78.8
901.000	9,668	25.91	8.56	5.30	3.29	2.43	1.96	1.57	200.0	24.2	831.5	14.8	10.02	286.6
1001.000	9,565	33.10	12.38	7.51	3.54	2.21	1.64	1.26	200.0	28.5	76.7	11.6	7.23	73.4
1102.000	9,835	22.65	9.28	5.31	2.53	1.59	1.18	0.89	200.0	59.7	61.8	17.5	4.88	72.8
1200.000	9,823	16.92	7.93	5.57	2.93	1.86	1.39	1.11	200.0	83.2	174.7	17.3	6.70	93.9
1300.000	9,521	25.49	11.23	6.57	3.20	2.06	1.59	1.26	200.0	57.2	58.0	13.2	5.59	77.3
STA 852 → 1400.000	9,624	16.38	9.14	5.59	3.02	2.19	1.74	1.40	200.0	120.5	129.9	14.7	5.29	104.2
Mean:		23.08	9.34	5.41	2.83	1.92	1.49	1.19	200.0	68.0	160.7	17.3	7.49	97.8
Std. Dev:		6.83	2.36	1.40	0.64	0.44	0.36	0.29	0.0	36.1	222.3	5.3	2.59	36.7
Var Coeff(%):		29.60	25.25	25.82	22.77	22.97	24.13	24.24	0.0	53.0	138.4	30.7	34.62	37.5

Site 2 852

SH16 Test Site 2 6/24/03

Processed 3 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0			MODULI RANGE(psi)	
County :0		Thickness(in)	Minimum / Maximum	Poisson Ratio Values
Highway/Road:	Pavement:	2.50	247,400 / 247,400	H1: v = 0.35
	Base:	11.60	100,000 / 2,000,000	H2: v = 0.25
	Subbase:	0.00		H3: v = 0.00
	Subgrade:	259.74	15,000	H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 852 → 0.000	9,573	8.43	6.42	4.98	3.31	2.27	1.79	1.35	247.4	399.7	0.0	18.9	4.79	300.0
50.000	9,589	6.17	4.58	3.54	2.43	1.71	1.36	1.06	247.4	647.7	0.0	25.7	3.24	300.0
101.000	9,613	9.80	7.00	5.33	3.57	2.35	1.80	1.32	247.4	281.7	0.0	18.3	4.45	208.9
152.000	9,609	10.90	7.59	5.57	3.64	2.48	1.96	1.50	247.4	224.5	0.0	17.5	3.79	279.1
200.000	9,656	7.72	5.85	4.49	2.96	2.01	1.57	1.17	247.4	432.6	0.0	21.5	5.22	271.5
251.000	9,624	11.41	8.19	6.14	3.88	2.46	1.90	1.34	247.4	203.4	0.0	16.7	7.13	166.1
301.000	9,613	10.31	7.14	5.02	3.14	2.02	1.57	1.18	247.4	199.0	0.0	20.5	6.63	179.7
350.000	9,617	10.23	7.46	5.41	3.24	2.04	1.58	1.13	247.4	212.3	0.0	19.6	9.36	160.4
400.000	9,573	8.49	6.33	4.73	2.99	1.95	1.52	1.11	247.4	319.3	0.0	21.4	6.96	196.1
450.000	9,581	8.11	6.13	4.72	3.18	2.19	1.72	1.27	247.4	423.1	0.0	19.8	4.27	300.0
500.000	9,668	6.63	5.06	3.94	2.76	2.01	1.63	1.25	247.4	667.1	0.0	22.2	3.41	300.0
550.000	9,577	6.04	4.35	3.25	2.26	1.61	1.31	1.04	247.4	632.4	0.0	27.7	3.08	300.0
601.000	9,692	7.43	5.64	4.39	2.91	1.98	1.59	1.21	247.4	481.9	0.0	21.8	4.79	277.1
651.000	9,585	8.74	6.17	4.49	2.80	1.90	1.48	1.18	247.4	280.1	0.0	22.5	5.62	268.9
700.000	9,799	5.20	3.83	3.04	2.19	1.68	1.37	1.12	247.4	1090.7	0.0	27.9	2.85	300.0
751.000	9,664	5.24	3.43	2.56	1.74	1.31	1.06	0.87	247.4	710.7	0.0	36.1	2.58	300.0
801.000	9,676	5.55	3.86	2.86	1.89	1.36	1.06	0.91	247.4	623.6	0.0	33.6	3.12	300.0
901.000	9,656	7.83	5.13	3.59	2.13	1.50	1.07	0.85	247.4	265.5	0.0	29.8	6.15	206.9
951.000	9,632	7.83	5.25	3.74	2.31	1.58	1.30	1.05	247.4	300.8	0.0	27.3	5.26	291.8
1001.000	9,672	6.44	4.75	3.59	2.33	1.67	1.35	1.08	247.4	552.0	0.0	26.6	4.58	300.0
1051.000	9,664	7.38	5.15	3.67	2.20	1.49	0.96	0.89	247.4	302.6	0.0	29.6	9.16	228.2
1101.000	9,664	6.68	4.74	3.51	2.29	1.55	1.14	0.91	247.4	440.3	0.0	28.6	5.09	263.4
1151.000	9,617	6.62	4.67	3.45	2.01	1.58	1.10	0.79	247.4	416.0	0.0	29.9	5.71	178.2
1201.000	9,577	7.33	4.72	3.27	2.03	1.48	1.02	0.96	247.4	295.5	0.0	31.3	4.14	300.0
1251.000	9,593	9.07	5.85	4.09	2.55	1.76	1.30	1.13	247.4	222.8	0.0	25.2	4.37	300.0
1300.000	9,708	7.82	4.76	3.15	1.91	1.24	0.99	0.80	247.4	234.4	0.0	34.5	5.12	190.5
1349.000	9,585	8.76	6.47	4.79	3.03	2.08	1.52	1.14	247.4	304.5	0.0	20.9	6.45	300.0
STA 838 → 1401.000	9,593	6.25	4.13	2.85	1.45	1.13	0.69	0.60	247.4	311.0	0.0	40.8	10.78	93.7
Mean:		7.80	5.52	4.08	2.61	1.80	1.38	1.08	247.4	409.8	0.0	25.6	5.29	273.8
Std. Dev:		1.68	1.24	0.94	0.62	0.37	0.32	0.20	0.0	205.9	0.0	6.2	2.02	88.5
Var Coeff(%):		21.53	22.38	22.96	23.87	20.38	22.98	18.68	0.0	50.2	0.0	24.1	38.16	35.9

16 SB Sec 3

SH 16 Site 3 test section 3/2[illegible]/03

Processed 4 laye

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	5.00	50,000	1,000,000	H2: v = 0.25
Subbase:	7.00	10,000	1,000,000	H3: v = 0.25
Subgrade:	96.12	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
Sta 824 → 0.000	10,220	12.53	8.20	6.01	3.73	2.64	2.06	1.65	200.0	179.9	513.2	14.0	3.97	289.6
95.000	10,570	9.60	6.61	4.85	2.98	2.11	1.60	1.31	200.0	318.0	569.1	17.6	4.40	250.1
202.000	10,089	21.50	13.31	8.64	4.36	2.75	2.11	1.68	200.0	188.9	62.9	10.5	5.73	85.8
299.000	10,010	15.67	11.04	7.74	4.20	2.62	1.85	1.40	200.0	525.6	88.6	10.7	4.48	109.1
399.000	10,137	15.37	9.36	6.04	3.18	2.01	1.50	1.20	200.0	250.5	96.9	15.1	3.84	94.6
502.000	10,014	18.46	12.39	8.19	4.04	2.43	1.73	1.33	200.0	443.2	48.1	10.9	5.68	80.7
604.000	10,097	14.81	10.87	7.78	4.31	2.75	1.95	1.44	200.0	664.2	102.9	10.3	4.63	120.3
702.000	10,145	12.52	8.56	5.90	3.38	2.17	1.59	1.18	200.0	410.0	164.3	14.0	3.88	141.8
805.000	9,958	12.89	8.57	5.69	2.78	1.61	1.09	0.81	200.0	682.7	64.3	15.8	4.82	76.8
905.000	9,720	17.15	11.37	7.27	3.69	2.27	1.66	1.28	200.0	363.9	59.5	11.7	5.03	86.0
1005.000	9,636	17.28	11.35	7.63	4.05	2.61	1.96	1.62	200.0	254.0	91.7	10.9	5.00	99.9
Mean:		15.25	10.15	6.89	3.70	2.36	1.74	1.35	200.0	389.2	169.2	12.8	4.68	108.6
Std. Dev:		3.31	2.03	1.23	0.55	0.36	0.30	0.25	0.0	176.3	186.9	2.5	0.66	36.4
Var Coeff(%):		21.73	20.01	17.81	14.89	15.33	17.01	18.56	0.0	45.3	110.5	19.7	14.06	33.5

16 SB Sec 4

SH 16 Test Site 3 After 3 vibratory passes 3/21/03
Processed 4 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	5.00	10,000	1,000,000	H2: v = 0.25
Subbase:	7.00	10,000	500,000	H3: v = 0.25
Subgrade:	74.96	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 824 -> 0.000	10,117	17.91	10.32	6.75	3.86	2.69	2.07	1.68	200.0	88.7	300.6	11.2	5.09	142.2
95.000	9,986	12.63	7.84	5.13	2.94	2.04	1.65	1.35	200.0	151.0	337.7	15.1	5.15	140.5
201.000	10,053	22.88	14.53	8.93	4.32	2.76	2.12	1.69	200.0	111.1	94.2	8.5	8.01	78.0
300.000	9,760	20.90	12.58	7.93	3.86	2.35	1.73	1.36	200.0	114.0	95.1	9.6	6.23	78.3
400.000	9,823	20.43	9.80	6.11	3.01	1.87	1.41	1.13	200.0	83.6	87.7	14.2	5.01	78.6
504.000	9,855	22.96	12.82	7.55	3.50	2.15	1.61	1.30	200.0	106.1	60.2	10.6	5.76	71.3
606.000	9,899	21.39	12.89	8.63	4.36	2.69	1.95	1.48	200.0	98.1	132.3	8.9	5.50	86.2
704.000	9,899	14.99	9.61	6.20	3.20	1.98	1.49	1.19	200.0	174.0	168.3	12.3	6.43	89.0
909.000	9,779	19.13	11.43	6.94	3.24	2.01	1.52	1.22	200.0	132.9	84.6	11.4	6.86	71.6
1010.000	9,628	24.85	11.48	7.38	3.81	2.48	1.85	1.42	200.0	44.7	178.2	10.5	5.33	90.6
Mean:		19.81	11.33	7.16	3.61	2.30	1.74	1.38	200.0	110.4	153.9	11.2	5.94	87.5
Std. Dev:		3.77	1.97	1.18	0.51	0.34	0.25	0.19	0.0	36.4	95.2	2.1	0.96	18.2
Var Coeff(%):		19.02	17.40	16.44	14.18	14.57	14.26	13.85	0.0	32.9	61.9	19.1	16.13	20.8

Site 3 824

SH 16 Site 3 6/24/03

Processed 3 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	2.50	274,900	274,900	H1: v = 0.35
Base:	12.00	10,000	2,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	197.64	15,000		H4: v = 0.40

STA 824

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	10,455	6.15	4.70	3.79	2.85	2.13	1.81	1.46	274.9	1059.4	0.0	20.6	3.11	300.0
25.000	10,312	5.96	4.64	3.80	2.79	2.09	1.77	1.45	274.9	1087.7	0.0	20.6	3.76	300.0
51.000	10,300	8.27	6.27	4.78	3.21	2.19	1.84	1.43	274.9	440.8	0.0	19.0	5.27	284.4
75.000	10,276	8.26	5.98	4.49	3.04	2.05	1.71	1.32	274.9	405.6	0.0	20.4	4.52	254.2
101.000	10,296	7.33	5.48	4.13	2.76	1.83	1.45	1.19	274.9	470.1	0.0	22.8	4.48	221.0
125.000	10,145	8.87	6.62	4.89	3.24	2.19	1.75	1.38	274.9	347.2	0.0	18.9	4.71	259.2
150.000	10,121	9.98	7.63	5.74	3.64	2.40	1.94	1.49	274.9	288.0	0.0	16.6	6.02	211.2
176.000	10,189	9.31	6.90	5.21	3.41	2.27	1.80	1.40	274.9	324.6	0.0	18.1	4.67	227.5
200.000	10,101	9.63	7.06	5.35	3.44	2.24	1.75	1.37	274.9	289.9	0.0	18.0	5.36	194.1
227.000	10,196	6.88	5.17	4.00	2.67	1.83	1.55	1.20	274.9	568.9	0.0	22.4	5.42	299.4
251.000	10,343	8.35	6.31	4.67	2.99	1.86	1.53	1.19	274.9	351.4	0.0	21.3	6.45	152.0
275.000	10,042	8.40	6.53	4.98	3.24	2.04	1.58	1.19	274.9	364.5	0.0	19.2	6.94	160.8
301.000	10,006	8.45	6.24	4.65	2.97	1.97	1.53	1.17	274.9	336.1	0.0	20.4	5.36	221.3
326.000	10,093	8.39	6.46	4.59	2.81	1.81	1.43	1.11	274.9	311.3	0.0	21.6	7.93	181.4
350.000	10,069	8.57	6.18	4.48	2.72	1.77	1.37	1.07	274.9	286.6	0.0	22.3	6.87	193.3
376.000	10,109	8.13	5.54	3.94	2.48	1.57	1.22	0.97	274.9	288.8	0.0	25.3	5.32	165.2
401.000	10,065	7.74	5.39	3.82	2.10	1.40	1.13	0.91	274.9	279.9	0.0	27.6	8.27	125.1
425.000	9,930	8.01	5.99	4.46	2.83	1.93	1.54	1.20	274.9	372.8	0.0	20.8	5.58	283.1
450.000	10,002	8.25	6.26	4.76	3.13	2.08	1.67	1.24	274.9	391.1	0.0	19.3	5.09	224.6
476.000	9,998	8.85	6.62	4.87	3.15	2.12	1.67	1.23	274.9	325.7	0.0	19.1	5.03	249.2
500.000	9,938	8.28	6.17	4.65	3.03	2.00	1.56	1.17	274.9	361.0	0.0	20.0	5.04	213.4
527.000	9,974	7.57	5.56	4.21	2.77	1.86	1.43	1.07	274.9	416.5	0.0	22.0	4.29	244.9
550.000	9,954	7.19	5.53	4.34	2.91	1.96	1.57	1.24	274.9	522.8	0.0	20.4	4.70	251.9
576.000	9,974	7.04	5.48	4.35	2.91	2.02	1.64	1.26	274.9	577.8	0.0	20.0	4.98	300.0
599.000	9,930	6.91	5.17	4.09	2.85	2.01	1.63	1.23	274.9	612.0	0.0	20.4	3.60	300.0
626.000	9,938	7.43	5.82	4.54	3.09	2.08	1.64	1.22	274.9	511.1	0.0	19.2	4.59	250.4
651.000	9,887	8.17	6.35	5.06	3.38	2.24	1.76	1.31	274.9	436.1	0.0	17.6	5.14	220.2
674.000	9,910	7.71	5.88	4.43	2.98	2.01	1.60	1.22	274.9	438.0	0.0	20.0	4.58	254.7
700.000	9,895	7.00	5.34	4.02	2.57	1.72	1.41	1.08	274.9	464.8	0.0	22.9	6.17	238.1
726.000	9,871	6.90	4.92	3.60	2.28	1.58	1.29	1.04	274.9	424.2	0.0	25.7	5.51	300.0
750.000	9,843	7.27	5.52	4.19	2.77	1.81	1.46	1.13	274.9	449.6	0.0	21.6	5.17	199.0
777.000	9,827	7.85	5.87	4.28	2.56	1.61	1.22	0.87	274.9	311.1	0.0	23.4	8.90	159.9
801.000	9,835	7.15	5.36	3.95	2.44	1.52	1.11	0.81	274.9	365.5	0.0	25.2	8.55	153.0
826.000	9,887	6.72	5.03	3.73	2.29	1.41	1.07	0.78	274.9	401.2	0.0	26.9	8.42	145.6
849.000	9,914	6.71	5.06	3.77	2.35	1.41	1.11	0.77	274.9	413.7	0.0	26.5	8.27	132.0
874.000	9,819	6.66	4.69	3.37	2.02	1.22	0.93	0.70	274.9	349.8	0.0	30.3	8.64	135.1
900.000	9,843	6.26	4.77	3.42	2.09	1.35	1.05	0.82	274.9	444.9	0.0	28.5	7.77	184.9
925.000	9,855	7.00	5.48	4.05	2.50	1.71	1.36	1.05	274.9	442.9	0.0	23.1	6.74	292.2
950.000	9,875	7.75	5.49	4.08	2.63	1.72	1.37	1.00	274.9	356.1	0.0	23.1	4.71	200.1
975.000	9,843	7.69	5.60	4.11	2.60	1.72	1.37	1.04	274.9	357.1	0.0	22.9	5.46	216.9
1001.000	9,783	8.09	5.99	4.48	2.91	1.96	1.56	1.20	274.9	365.7	0.0	20.2	4.94	251.3
Mean:		7.73	5.78	4.34	2.81	1.87	1.49	1.15	274.9	429.6	0.0	21.8	5.76	212.1
Std. Dev:		0.92	0.69	0.52	0.38	0.28	0.24	0.20	0.0	168.7	0.0	3.1	1.51	58.7
Var Coeff(%):		11.86	11.88	12.01	13.53	15.05	16.41	17.53	0.0	39.3	0.0	14.3	26.26	26.7

File 16 NB sec 3

SH 16 site 4 3/21/03 2 days after placement before cracking

Processed 4 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0			MODULI RANGE(psi)		
County :0		Thickness(in)	Minimum	Maximum	Poisson Ratio Values
Highway/Road:	Pavement:	0.50	200,000	200,000	H1: v = 0.35
	Base:	5.00	10,000	500,000	H2: v = 0.25
	Subbase:	7.00	10,000	500,000	H3: v = 0.25
	Subgrade:	92.00	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 834 →	0.000	9,819	20.72	12.30	8.35	4.85	3.22	2.44	1.85	200.0	85.9	191.3	9.9	3.56	164.1
	100.000	9,803	16.87	10.10	7.11	4.15	2.78	2.11	1.58	200.0	108.5	258.4	11.8	3.77	166.2
	200.000	9,994	20.80	10.52	6.38	2.92	1.75	1.22	0.89	200.0	183.5	35.8	15.3	5.43	69.0
	301.000	9,907	16.82	10.65	6.66	3.41	2.19	1.63	1.28	200.0	239.7	82.6	12.8	4.84	87.3
	400.000	10,149	18.80	12.39	8.06	3.93	2.37	1.73	1.34	200.0	352.4	55.4	11.0	6.06	78.4
	500.000	9,819	19.01	12.85	8.10	3.89	2.43	1.76	1.37	200.0	370.3	47.4	10.5	6.44	76.3
	601.000	9,744	16.12	11.19	7.43	3.88	2.34	1.71	1.33	200.0	454.7	72.7	10.8	5.42	93.9
	703.000	10,673	17.53	12.30	8.50	4.35	2.65	1.97	1.46	200.0	493.4	75.8	10.4	6.32	88.5
	801.000	9,791	14.60	9.77	7.01	4.09	2.74	2.04	1.58	200.0	202.7	233.2	11.4	4.08	165.4
	900.000	9,843	14.58	9.69	6.81	4.06	2.80	2.22	1.84	200.0	165.0	303.6	11.7	4.80	197.1
STA 824 →	1000.000	9,688	21.39	12.85	8.19	4.53	3.01	2.44	1.87	200.0	99.4	112.3	9.9	5.39	120.7
	Mean:		17.93	11.33	7.51	4.01	2.57	1.93	1.49	200.0	250.5	133.5	11.4	5.10	104.5
	Std. Dev:		2.41	1.24	0.76	0.52	0.41	0.37	0.30	0.0	144.8	95.4	1.6	0.99	35.1
	Var Coeff(%):		13.43	10.95	10.06	12.99	15.93	19.08	19.91	0.0	57.8	71.4	13.6	19.48	33.6

File 16NB Sec4

SH16 Test Site 4 3/21/03 after 2 passes

processed 4 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	5.00	10,000	500,000	H2: v = 0.25
Subbase:	7.00	10,000	500,000	H3: v = 0.25
Subgrade:	78.66	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
STA 834	0.000	9,815	23.84	12.62	7.93	4.24	2.84	2.23	1.74	200.0	61.0	150.2	9.8	5.05	103.0
	100.000	9,871	21.89	10.65	6.77	3.69	2.43	1.85	1.45	200.0	59.3	173.5	12.2	4.81	109.9
	200.000	9,847	21.74	10.58	5.92	2.71	1.61	1.20	0.93	200.0	121.2	39.5	14.9	4.49	68.7
	300.000	9,775	21.44	9.84	5.93	3.04	2.00	1.55	1.26	200.0	71.1	88.7	14.5	5.32	87.0
	400.000	9,831	17.86	11.43	7.62	3.76	2.32	1.67	1.31	200.0	193.2	105.5	10.2	6.25	80.3
	500.000	9,799	20.49	12.10	7.61	3.67	2.23	1.72	1.35	200.0	123.8	83.0	10.6	6.52	76.5
	600.000	9,760	17.47	11.95	7.65	3.70	2.28	1.64	1.31	200.0	289.1	82.4	9.8	7.55	77.0
	701.000	9,724	21.44	13.03	8.64	4.24	2.55	1.82	1.41	200.0	130.9	87.5	9.1	5.86	80.4
	800.000	9,823	15.46	10.33	7.28	4.17	2.80	2.09	1.63	200.0	156.4	287.9	9.8	4.79	145.7
	900.000	9,910	16.21	10.63	7.30	4.11	2.81	2.22	1.81	200.0	132.5	292.5	10.0	5.86	130.8
STA 824	1001.000	9,712	22.68	13.44	8.35	4.38	2.95	2.35	1.87	200.0	82.6	123.8	8.9	6.03	96.6
	Mean:		20.05	11.51	7.36	3.79	2.44	1.85	1.46	200.0	129.2	137.7	10.9	5.68	91.2
	Std. Dev:		2.81	1.20	0.87	0.53	0.41	0.35	0.28	0.0	67.5	83.5	2.1	0.90	19.3
	Var Coeff(%):		14.01	10.42	11.87	13.86	16.74	18.70	19.10	0.0	52.3	60.7	19.0	15.91	21.2

File Site 4 ...
SH 16 Test Site 4 6/24/03
Processed 3 layer

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	2.50	267,000	267,000	H1: v = 0.35
Base:	12.00	10,000	3,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	202.10	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	9,664	10.02	6.67	4.65	2.91	1.95	1.59	1.23	267.0	204.4	0.0	20.0	5.04	239.4
27.000	9,799	8.86	6.36	4.72	3.03	2.08	1.66	1.30	267.0	311.2	0.0	19.5	4.77	300.0
50.000	9,795	10.24	6.81	4.84	3.08	2.13	1.72	1.28	267.0	216.5	0.0	19.2	4.34	300.0
75.000	9,728	9.84	6.63	4.72	2.97	2.02	1.64	1.25	267.0	225.3	0.0	19.7	4.87	274.6
101.000	9,760	8.43	5.77	4.02	2.54	1.79	1.45	1.11	267.0	282.3	0.0	22.9	5.03	300.0
125.000	9,676	8.49	5.63	3.72	2.10	1.33	1.01	0.74	267.0	203.8	0.0	28.1	8.87	143.8
151.000	9,700	8.69	5.17	3.26	1.69	0.97	0.73	0.41	267.0	156.9	0.0	35.1	12.84	99.1
175.000	9,700	8.50	5.31	3.47	1.83	1.05	0.80	0.64	267.0	175.0	0.0	32.8	12.50	105.1
200.000	9,692	9.16	5.59	3.55	1.94	1.21	0.95	0.68	267.0	162.2	0.0	30.3	8.69	121.4
226.000	9,640	9.91	5.83	3.62	1.92	1.16	0.90	0.69	267.0	133.6	0.0	30.2	10.25	107.2
250.000	9,664	10.26	6.33	3.83	2.02	1.26	1.00	0.78	267.0	131.6	0.0	28.1	10.35	104.9
275.000	9,680	9.41	6.15	4.05	2.43	1.62	1.34	0.96	267.0	194.7	0.0	23.9	6.44	229.4
300.000	9,664	9.49	6.11	4.16	2.55	1.70	1.38	1.07	267.0	200.1	0.0	23.0	5.29	229.6
325.000	9,859	8.18	5.67	4.06	2.56	1.66	1.35	1.02	267.0	296.3	0.0	23.7	5.42	189.1
350.000	9,740	8.44	6.08	4.20	2.71	1.80	1.43	1.09	267.0	288.2	0.0	22.0	5.10	223.1
377.000	9,783	8.68	6.49	4.72	2.94	1.89	1.52	1.09	267.0	294.8	0.0	20.3	6.78	179.4
400.000	9,680	9.09	6.61	4.60	2.90	1.85	1.44	1.06	267.0	248.2	0.0	20.6	6.67	171.6
425.000	9,724	10.15	7.00	4.92	3.00	1.95	1.48	1.14	267.0	199.8	0.0	19.7	6.68	191.5
452.000	9,815	10.47	7.38	5.28	3.23	2.14	1.67	1.24	267.0	209.0	0.0	18.3	6.09	218.6
475.000	9,740	10.46	7.25	4.98	2.89	1.78	1.39	0.85	267.0	172.5	0.0	20.6	9.11	145.2
500.000	9,716	10.82	7.61	5.25	2.96	1.91	1.46	1.12	267.0	166.8	0.0	19.5	9.45	142.5
526.000	9,728	10.01	7.29	5.30	3.34	2.13	1.66	1.23	267.0	234.5	0.0	18.0	6.58	171.3
551.000	9,652	10.72	7.47	5.33	3.26	2.09	1.62	1.22	267.0	190.4	0.0	18.0	6.79	176.2
575.000	9,684	9.72	6.89	4.83	3.09	2.01	1.59	1.19	267.0	231.1	0.0	19.3	5.14	192.4
600.000	9,700	9.63	6.67	4.79	2.93	1.81	1.42	1.07	267.0	216.5	0.0	20.5	7.25	147.2
626.000	9,819	7.73	5.28	3.56	2.13	1.44	1.21	0.92	267.0	278.2	0.0	27.2	7.11	223.7
651.000	9,656	7.61	5.20	3.72	2.30	1.59	1.33	1.00	267.0	321.9	0.0	25.1	5.93	300.0
676.000	9,577	8.63	6.20	4.60	2.91	1.90	1.50	1.13	267.0	292.1	0.0	20.2	5.38	197.6
701.000	9,529	9.07	6.92	4.90	3.06	1.97	1.55	1.18	267.0	263.3	0.0	18.9	7.47	180.6
725.000	9,609	9.27	6.64	4.83	3.03	1.98	1.54	1.15	267.0	254.3	0.0	19.4	5.82	198.5
749.000	9,581	8.37	5.94	4.30	2.72	1.75	1.35	1.02	267.0	283.7	0.0	21.9	5.78	180.3
776.000	9,676	8.97	6.56	5.08	3.25	2.15	1.65	1.23	267.0	311.6	0.0	18.3	5.34	216.9
802.000	9,605	8.56	6.24	4.70	3.10	2.00	1.64	1.28	267.0	327.6	0.0	19.2	4.95	183.4
825.000	9,557	8.33	6.15	4.81	3.25	2.23	1.81	1.37	267.0	402.0	0.0	17.7	4.08	300.0
850.000	9,624	9.76	7.40	5.62	3.74	2.56	2.05	1.60	267.0	310.3	0.0	15.4	4.61	293.4
876.000	9,450	9.80	7.48	5.67	3.62	2.51	2.09	1.61	267.0	292.9	0.0	15.3	6.13	300.0
900.000	9,617	8.80	6.83	5.24	3.47	2.39	1.94	1.52	267.0	375.1	0.0	16.4	5.18	300.0
926.000	9,601	8.94	6.47	5.00	3.20	2.17	1.70	1.37	267.0	315.1	0.0	18.2	4.46	267.6
950.000	9,680	8.15	5.49	4.11	2.81	2.03	1.71	1.37	267.0	379.6	0.0	20.7	3.72	300.0
975.000	9,620	9.58	6.74	4.92	3.20	2.18	1.78	1.43	267.0	264.4	0.0	18.2	4.68	279.3
1000.000	9,672	7.70	5.85	4.60	3.21	2.31	1.87	1.50	267.0	526.5	0.0	17.6	3.62	300.0
Mean:		9.19	6.39	4.55	2.82	1.86	1.49	1.13	267.0	257.2	0.0	21.5	6.45	216.6
Std. Dev:		0.86	0.68	0.62	0.50	0.38	0.31	0.26	0.0	79.5	0.0	4.6	2.21	75.6
Var Coeff(%):		9.31	10.65	13.68	17.69	20.22	21.07	23.45	0.0	30.9	0.0	21.5	34.24	36.1

APPENDIX C

PROCESSED FWD DATA FROM RIVERSIDE CAMPUS

9/8/03 4% Cement Day of Placement
Tested between 5:11 & ~~6:07~~ 5:47 p.m.

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	25,000	1,200,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	200.74	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	9,132	44.77	26.58	11.54	5.41	3.26	2.48	2.12	200.0	53.5	0.0	8.7	14.23	76.8
0.000	9,207	46.70	27.10	11.64	5.45	3.36	2.48	2.13	200.0	49.1	0.0	8.6	14.29	76.6
0.003	9,215	22.52	14.98	8.13	4.99	3.26	2.30	1.87	200.0	288.2	0.0	12.1	1.60	186.9
0.006	9,251	21.48	14.31	8.44	5.37	3.58	2.54	2.05	200.0	393.9	0.0	11.7	3.53	216.2
0.008	8,993	25.71	16.17	9.41	5.90	3.82	2.75	2.24	200.0	257.5	0.0	10.3	3.48	180.6
0.011	9,100	18.12	12.09	7.31	4.78	3.25	2.35	1.86	200.0	531.9	0.0	13.0	5.21	247.1
0.014	9,406	17.96	12.37	7.20	4.54	3.00	2.12	1.71	200.0	497.2	0.0	13.9	2.35	196.3
0.017	9,148	18.87	12.44	6.94	4.37	2.88	2.07	1.71	200.0	382.2	0.0	14.0	3.03	192.4
0.020	9,017	23.58	13.05	7.14	4.48	3.03	2.14	1.76	200.0	198.9	0.0	13.3	5.95	223.8
0.023	9,311	16.57	12.27	7.63	4.99	3.35	2.33	1.89	200.0	767.7	0.0	12.6	2.32	202.2
0.025	9,152	16.13	10.31	6.80	4.72	3.21	2.29	1.83	200.0	777.4	0.0	13.7	7.96	229.2
0.028	9,283	15.40	11.97	7.64	5.06	3.41	2.43	1.98	200.0	996.5	0.0	12.2	2.56	228.6
0.031	9,021	23.17	14.44	7.57	4.78	3.20	2.28	1.86	200.0	236.1	0.0	12.4	3.76	220.6
0.033	8,850	34.58	16.42	8.12	4.78	3.09	2.20	1.81	200.0	66.8	0.0	11.4	3.83	177.6
0.036	8,937	26.70	16.83	9.29	5.93	3.92	2.71	2.14	200.0	225.1	0.0	10.2	3.60	205.9
0.039	8,870	25.85	16.41	9.78	6.11	3.97	2.73	2.19	200.0	267.8	0.0	9.9	2.80	187.2
0.042	9,025	21.32	14.18	8.89	5.96	4.07	2.83	2.22	200.0	494.9	0.0	10.5	5.66	206.7
0.045	8,882	26.28	17.53	9.89	6.28	4.17	2.97	2.38	200.0	268.9	0.0	9.5	3.05	219.2
0.048	8,894	25.11	15.37	8.63	5.57	3.80	2.77	2.23	200.0	247.2	0.0	10.8	6.13	267.7
0.050	8,965	24.17	16.04	9.22	5.76	3.80	2.67	2.14	200.0	298.9	0.0	10.4	2.42	205.7
0.053	8,965	22.49	14.20	8.76	5.81	4.00	2.80	2.18	200.0	396.1	0.0	10.7	6.66	215.9
0.056	8,941	21.94	13.54	7.98	5.21	3.43	2.41	1.91	200.0	326.5	0.0	11.9	5.43	194.0
0.059	9,025	22.02	13.96	8.02	5.04	3.31	2.31	1.87	200.0	307.8	0.0	12.1	3.33	192.8
Mean:		24.41	15.33	8.52	5.27	3.49	2.48	2.00	200.0	362.2	0.0	11.5	4.92	207.2
Std. Dev:		7.95	4.07	1.32	0.56	0.38	0.26	0.19	0.0	233.9	0.0	1.6	3.36	88.3
Var Coeff(%):		32.57	26.54	15.48	10.67	10.89	10.38	9.69	0.0	64.6	0.0	13.7	68.36	42.6

9/9/03 9:41 am

4% cement morning after placement starting after prime coat

1st drop is at location #11 from 9/8 data

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	50,000	1,750,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	217.26	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
drop 11 from 9/8 0.000	9,589	12.98	9.31	6.40	4.65	3.29	2.39	1.89	200.0	1684.2	0.0	14.0	5.99	253.2
0.000	9,664	13.69	10.81	7.22	4.77	3.07	2.32	1.90	200.0	1293.2	0.0	13.7	2.35	162.9
0.003	9,434	17.80	12.61	7.31	4.81	3.30	2.36	1.92	200.0	572.3	0.0	13.4	4.47	239.0
0.006	9,243	31.97	15.55	8.25	5.09	3.32	2.33	1.89	200.0	95.0	0.0	11.8	5.66	185.0
0.009	9,549	18.00	13.50	8.50	5.62	3.75	2.66	2.11	200.0	777.3	0.0	11.6	2.46	213.8
0.011	9,446	17.62	13.25	8.70	5.87	3.95	2.77	2.19	200.0	907.8	0.0	11.0	2.58	214.4
0.014	9,354	14.55	11.95	8.26	5.88	4.14	2.86	2.15	200.0	1598.8	0.0	10.7	1.79	191.5
0.017	9,418	19.14	14.19	9.08	6.06	4.03	2.90	2.30	200.0	740.5	0.0	10.7	2.93	210.6
0.020	9,128	17.55	13.55	8.37	5.67	3.88	2.85	2.22	200.0	828.2	0.0	10.9	3.91	265.8
0.023	9,330	18.34	13.76	8.22	5.30	3.69	2.65	2.13	200.0	651.0	0.0	11.7	4.12	255.0
0.026	9,311	15.15	11.68	7.73	5.42	3.83	2.74	2.12	200.0	1278.3	0.0	11.5	4.01	236.9
0.029	9,267	15.93	11.09	7.27	5.02	3.43	2.44	1.93	200.0	939.9	0.0	12.8	5.65	227.0
Mean:		17.73	12.60	7.94	5.35	3.64	2.61	2.06	200.0	947.2	0.0	12.0	3.83	223.8
Std. Dev:		4.90	1.71	0.76	0.48	0.35	0.22	0.15	0.0	451.2	0.0	1.2	1.43	32.5
Var Coeff(%):		27.64	13.59	9.63	8.97	9.50	8.60	7.15	0.0	47.6	0.0	10.0	37.38	14.5

9/8/03 8% Cement Day of Placement
Tested between 5:47 & 6:07 pm

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	25,000	1,200,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	289.66	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.091	8,735	42.39	17.08	8.56	5.08	3.35	2.45	2.04	200.0	36.8	0.0	10.9	3.48	202.0
0.094	8,882	27.15	13.11	7.02	4.56	3.16	2.32	1.93	200.0	122.4	0.0	12.9	9.33	296.8
0.097	9,029	20.78	13.31	7.57	4.94	3.40	2.48	2.02	200.0	356.0	0.0	12.7	5.21	280.3
0.100	9,140	18.15	11.37	6.70	4.41	3.09	2.24	1.85	200.0	447.6	0.0	14.5	6.34	261.8
0.102	9,156	14.85	9.66	5.79	3.94	2.82	2.10	1.76	200.0	673.1	0.0	16.6	7.06	300.0
0.105	9,052	17.71	10.22	6.08	4.08	2.89	2.19	1.87	200.0	418.4	0.0	15.7	9.56	300.0
0.108	9,017	18.26	9.87	6.11	4.20	3.01	2.29	1.93	200.0	407.8	0.0	15.5	12.15	300.0
0.111	8,981	17.46	10.02	5.97	4.07	2.94	2.24	1.89	200.0	437.4	0.0	15.7	10.60	300.0
0.114	8,842	21.54	10.78	6.33	4.34	3.14	2.35	1.98	200.0	239.1	0.0	14.4	13.59	300.0
0.117	8,766	16.31	11.68	7.60	5.32	3.78	2.78	2.27	200.0	861.1	0.0	12.0	4.74	297.1
0.120	8,814	20.30	11.91	7.84	5.52	3.90	2.85	2.33	200.0	502.3	0.0	11.8	9.85	282.1
0.123	8,945	16.62	12.04	8.11	5.65	4.02	2.94	2.40	200.0	939.3	0.0	11.5	4.14	286.7
0.126	8,878	17.89	12.87	8.19	5.61	3.91	2.86	2.32	200.0	707.8	0.0	11.5	3.80	290.8
0.129	8,727	27.76	16.23	9.32	6.12	4.22	3.09	2.54	200.0	209.6	0.0	9.9	7.45	300.0
0.132	8,715	37.68	20.02	10.83	6.86	4.75	3.49	2.87	200.0	91.2	0.0	8.5	6.65	300.0
0.135	8,667	35.08	19.94	11.13	6.96	4.66	3.43	2.87	200.0	123.4	0.0	8.4	5.18	247.5
0.137	8,635	35.83	19.67	10.33	6.57	4.46	3.24	2.67	200.0	98.3	0.0	8.8	5.45	273.4
0.141	8,870	27.24	16.73	9.78	6.55	4.47	3.24	2.61	200.0	258.6	0.0	9.6	6.65	272.7
0.144	8,663	23.60	15.31	9.74	6.67	4.57	3.35	2.70	200.0	421.7	0.0	9.5	6.03	281.7
0.146	8,937	17.92	13.63	9.19	6.49	4.50	3.29	2.61	200.0	922.4	0.0	10.2	2.76	292.4
0.149	8,818	22.52	15.46	9.82	6.67	4.61	3.26	2.60	200.0	485.5	0.0	9.6	4.21	235.0
Mean:		23.67	13.85	8.19	5.46	3.79	2.78	2.29	200.0	417.1	0.0	11.9	6.87	296.2
Std. Dev:		7.98	3.38	1.70	1.06	0.68	0.48	0.37	0.0	275.5	0.0	2.6	2.96	30.7
Var Coeff(%):		33.72	24.40	20.71	19.41	18.05	17.08	15.95	0.0	66.0	0.0	21.9	43.08	10.8

9/9/03 8% Cement day after Placement

10:05 a.m. 1st drop corresponds to Station 0.091 on data from 9/8

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum
Pavement:	0.50	200,000	200,000
Base:	6.00	500,000	3,250,000
Subbase:	0.00		
Subgrade:	274.61	15,000	

Poisson Ratio Values
H1: v = 0.35
H2: v = 0.25
H3: v = 0.00
H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.032	9,219	16.08	11.29	7.18	4.80	3.22	2.21	1.76	200.0	726.5	0.0	14.0	2.95	185.4
0.195	9,323	15.20	11.40	7.19	4.78	3.38	2.44	1.96	200.0	910.1	0.0	13.8	3.23	255.0
0.198	9,223	16.44	10.78	6.55	4.39	3.12	2.25	1.86	200.0	607.6	0.0	14.9	6.48	248.7
0.201	9,323	15.13	11.11	7.10	4.87	3.43	2.48	2.00	200.0	963.4	0.0	13.8	3.90	254.5
0.204	9,323	12.09	9.00	5.95	4.20	3.04	2.22	1.81	200.0	1494.3	0.0	15.9	4.68	264.6
0.206	9,398	10.30	7.95	5.40	3.91	2.87	2.15	1.76	200.0	2169.3	0.0	17.0	4.63	300.0
0.209	9,323	12.24	8.56	5.77	4.11	2.93	2.15	1.80	200.0	1411.6	0.0	16.5	5.92	272.8
0.212	9,207	11.09	8.23	5.54	4.01	2.92	2.22	1.87	200.0	1819.8	0.0	16.4	5.58	300.0
0.212	9,263	12.28	7.88	5.24	3.93	2.86	2.19	1.83	200.0	1370.8	0.0	17.4	10.19	300.0
0.215	9,736	11.78	8.72	6.00	4.43	3.32	2.47	2.02	200.0	2031.2	0.0	15.6	6.10	300.0
0.218	9,732	10.48	8.55	6.20	4.70	3.54	2.67	2.14	200.0	3117.9	0.0	14.3	3.69	300.0
0.221	9,267	11.07	8.76	6.57	4.98	3.23	2.50	2.08	200.0	2398.0	0.0	13.9	3.38	164.1
0.224	9,398	10.91	8.98	6.56	5.01	3.75	2.81	2.33	200.0	2957.4	0.0	13.0	3.16	300.0
Mean:		12.70	9.32	6.25	4.47	3.20	2.37	1.94	200.0	1690.6	0.0	15.1	4.91	281.1
Std. Dev:		2.20	1.31	0.67	0.41	0.28	0.21	0.17	0.0	814.6	0.0	1.4	2.00	57.3
Var Coeff(%):		17.36	14.10	10.72	9.12	8.68	8.98	8.76	0.0	48.2	0.0	9.5	40.67	21.4

7 day cure
4% cement drops 1-4
9/15/2003

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	50,000	3,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	228.28	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure No crack	0.000	9,390	21.04	15.84	8.80	5.33	3.36	2.36	1.88	200.0	392.4	0.0	11.8	2.94	153.0
	0.009	9,430	14.97	10.71	6.97	4.73	3.26	2.33	1.84	200.0	1007.9	0.0	13.8	4.51	233.7
	0.011	10,435	15.65	11.55	7.46	5.16	3.60	2.58	2.00	200.0	1167.9	0.0	13.9	4.45	235.5
	0.014	10,050	15.99	11.64	8.08	5.90	4.27	3.10	2.37	200.0	1493.3	0.0	11.7	5.82	258.3
	0.015	9,942	20.85	14.93	8.87	5.92	3.94	2.66	2.04	200.0	537.5	0.0	11.8	2.91	174.5
	0.020	9,386	10.99	9.65	6.07	4.11	2.83	2.05	1.67	200.0	1734.2	0.0	15.3	3.72	252.5
Prime coat	0.023	9,156	14.00	11.69	6.76	4.32	2.94	2.15	1.74	200.0	912.1	0.0	14.1	4.35	247.2
	0.025	9,287	12.68	10.35	6.38	4.25	3.00	2.20	1.80	200.0	1284.8	0.0	14.5	4.35	282.6
	0.028	9,330	17.76	11.83	6.72	4.28	2.95	2.09	1.74	200.0	444.6	0.0	14.8	3.77	223.6
	0.034	9,624	20.87	14.14	7.45	4.98	3.42	2.59	2.24	200.0	373.2	0.0	13.2	5.47	267.0
	0.041	9,195	33.83	15.83	8.26	5.30	3.46	2.54	2.04	200.0	81.5	0.0	11.5	6.93	184.2
1 day micro	0.041	9,084	26.35	16.34	8.56	5.33	3.58	2.57	2.08	200.0	196.3	0.0	11.2	3.09	233.7
	0.043	9,160	18.80	14.27	8.26	5.26	3.42	2.47	2.04	200.0	533.4	0.0	11.9	2.32	179.8
	0.045	9,064	15.94	11.80	7.11	4.61	3.12	2.25	1.81	200.0	711.5	0.0	13.4	3.10	236.8
	0.049	8,886	31.22	17.43	8.93	5.47	3.69	2.70	2.23	200.0	118.1	0.0	10.4	3.80	248.7
2 day micro	0.052	9,068	15.66	13.83	8.83	5.83	3.93	2.78	2.17	200.0	1085.4	0.0	10.5	2.87	231.4
	0.055	9,096	19.61	14.33	8.67	5.61	3.83	2.70	2.15	200.0	555.3	0.0	11.1	2.86	227.0
	0.056	9,013	19.94	15.39	9.25	6.00	3.98	2.81	2.23	200.0	571.4	0.0	10.3	2.25	211.4
	0.060	9,072	18.13	13.77	8.37	5.31	3.33	2.52	2.11	200.0	599.6	0.0	11.7	2.50	147.0
3day micro	0.062	9,029	19.09	14.53	7.42	4.96	3.49	2.50	2.06	200.0	434.5	0.0	12.3	6.26	243.1
	0.064	9,152	12.09	10.11	6.78	4.84	3.48	2.56	1.97	200.0	1910.8	0.0	12.6	3.42	286.0
	0.064	9,100	19.80	12.75	7.78	5.33	3.54	2.54	2.01	200.0	466.5	0.0	12.3	6.76	202.3
	0.065	9,450	10.88	9.56	6.41	4.54	3.26	2.35	1.81	200.0	2274.2	0.0	13.8	3.15	241.7
	0.067	9,398	8.15	6.80	4.72	3.48	2.45	1.86	1.52	200.0	3378.7	0.0	18.0	3.19	300.0
moist cure no micro	0.069	9,195	8.40	6.90	4.76	3.44	2.48	1.86	1.47	200.0	3058.7	0.0	17.7	3.56	300.0
	Mean:		17.71	12.64	7.51	4.97	3.38	2.44	1.96	200.0	1012.9	0.0	12.9	3.93	234.8
	Std. Dev:		6.21	2.81	1.24	0.71	0.45	0.30	0.23	0.0	872.0	0.0	2.0	1.36	47.0
	Var Coeff(%):		35.09	22.22	16.56	14.26	13.23	12.18	11.63	0.0	86.1	0.0	15.7	34.48	20.1

7 day cure 4% cement
drops 5-8
9/15/2003

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0						
County :0		Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values	
Highway/Road:	Pavement:	0.50	200,000	200,000	H1: v = 0.35	
	Base:	6.00	25,000	2,500,000	H2: v = 0.25	
	Subbase:	0.00			H3: v = 0.00	
	Subgrade:	210.30	15,000		H4: v = 0.40	

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
	0.000	9,728	10.71	10.51	6.84	4.58	3.05	2.18	1.72	200.0	2155.8	0.0	13.8	4.45	202.1
No CJM	0.000	9,446	16.27	12.60	7.29	4.64	3.08	2.15	1.63	200.0	696.9	0.0	13.5	3.14	202.8
	0.000	9,438	15.80	12.63	7.69	4.86	3.22	2.31	1.87	200.0	847.8	0.0	12.8	2.95	202.2
	0.000	9,505	27.61	13.90	7.43	4.60	3.13	2.27	1.86	200.0	136.5	0.0	13.2	6.61	252.3
	0.000	9,398	13.85	11.42	7.33	4.83	3.33	2.33	1.87	200.0	1269.2	0.0	12.7	2.83	207.3
	0.000	9,291	20.75	14.15	7.94	4.64	3.08	2.22	1.80	200.0	337.5	0.0	12.9	1.49	172.2
Prime	0.000	9,319	16.32	12.04	7.06	4.58	3.07	2.20	1.77	200.0	676.9	0.0	13.6	3.51	217.0
across crack →	0.000	9,275	13.95	11.73	7.74	4.43	2.76	2.02	1.65	200.0	976.4	0.0	13.5	4.91	143.5
	0.000	9,620	14.84	10.06	6.55	4.58	3.24	2.33	1.86	200.0	1089.0	0.0	14.3	7.61	238.7
	0.000	9,756	13.00	10.75	6.59	4.43	3.09	2.26	1.83	200.0	1382.4	0.0	14.3	4.58	274.8
1 day micro	0.000	9,756	13.49	10.02	6.50	4.44	3.06	2.19	1.77	200.0	1305.7	0.0	14.7	4.37	231.8
	0.000	9,569	15.19	12.71	7.89	5.27	3.54	2.45	1.90	200.0	1101.9	0.0	12.1	2.70	195.5
	0.000	9,414	18.59	13.77	8.23	5.28	3.58	2.58	2.05	200.0	620.3	0.0	11.9	3.56	247.0
	0.000	9,338	17.77	13.60	8.29	5.43	3.81	2.80	2.24	200.0	783.4	0.0	11.3	4.78	300.0
	0.000	9,390	20.73	14.73	8.72	5.45	3.88	2.93	2.41	200.0	492.6	0.0	11.2	5.54	300.0
2 day micro	0.000	9,168	22.37	15.05	8.17	5.55	3.96	2.91	2.31	200.0	341.5	0.0	11.4	7.10	300.0
	0.000	9,458	18.39	13.66	8.79	5.73	3.94	2.83	2.31	200.0	798.0	0.0	11.0	3.72	257.3
	0.000	9,199	21.38	15.91	9.52	6.00	3.84	2.74	2.24	200.0	479.7	0.0	10.3	1.59	167.4
	0.000	9,124	23.48	17.19	10.08	6.30	3.96	2.82	2.30	200.0	383.3	0.0	9.8	1.45	153.7
3 day micro	0.000	8,993	28.77	16.58	9.33	5.89	3.63	2.61	2.11	200.0	169.2	0.0	10.5	3.40	138.0
	0.000	9,148	23.10	14.15	8.28	5.30	3.44	2.46	1.98	200.0	292.2	0.0	11.9	4.54	177.6
	0.002	9,505	18.07	13.94	6.65	4.26	2.89	2.11	1.72	200.0	417.1	0.0	14.4	5.80	300.0
	0.002	9,470	12.69	9.89	6.59	4.56	3.22	2.29	1.82	200.0	1610.3	0.0	13.7	3.73	222.6
Moist cure	0.002	9,068	22.42	13.60	7.18	4.60	3.12	2.29	1.85	200.0	243.5	0.0	13.1	5.37	242.8
no micro	0.002	9,315	18.22	14.24	8.80	5.52	3.56	2.48	1.91	200.0	677.9	0.0	11.3	1.69	172.8
	Mean:		18.31	13.15	7.82	5.03	3.38	2.43	1.95	200.0	771.4	0.0	12.5	4.06	216.8
	Std. Dev:		4.64	2.01	1.00	0.58	0.36	0.27	0.23	0.0	496.6	0.0	1.4	1.70	50.0
	Var Coeff(%):		25.34	15.28	12.82	11.52	10.80	11.20	11.73	0.0	64.4	0.0	11.3	41.80	23.4

17 day cure 8% cement drops 1-4
9/15/2003

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

		Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:		0.50	200,000	200,000	H1: v = 0.35
Base:		6.00	75,000	3,500,000	H2: v = 0.25
Subbase:		0.00			H3: v = 0.00
Subgrade:		273.46	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure	0.000	9,287	10.68	9.90	7.29	5.58	4.03	3.01	2.33	200.0	3262.6	0.0	11.5	2.10	300.0
	0.003	9,243	10.70	9.49	7.02	5.26	3.93	2.90	2.31	200.0	3121.5	0.0	12.0	1.84	288.4
	0.006	9,338	10.65	8.91	7.15	5.63	4.33	3.23	2.55	200.0	3465.4	0.0	11.6	3.77	300.0 *
across crack →	0.007	9,183	14.12	12.15	10.07	4.88	3.65	2.70	2.22	200.0	1235.9	0.0	11.9	7.62	80.2
	0.009	9,259	13.33	10.10	7.60	5.55	4.22	3.00	2.40	200.0	2062.5	0.0	11.7	4.25	223.0
	0.013	9,311	12.23	10.35	7.50	5.47	4.00	2.97	2.41	200.0	2304.0	0.0	11.9	1.82	300.0
Prime Coat	0.015	9,148	22.38	15.67	9.23	6.13	4.26	3.02	2.48	200.0	428.1	0.0	10.6	3.91	236.2
	0.018	9,283	17.59	13.39	8.81	5.79	4.20	3.11	2.56	200.0	884.6	0.0	11.2	3.63	300.0
across crack →	0.020	9,140	21.44	15.84	8.37	5.74	4.10	3.00	2.46	200.0	416.5	0.0	11.1	6.05	290.9
	0.022	9,104	21.52	14.82	9.13	6.17	4.28	3.15	2.57	200.0	501.9	0.0	10.6	5.10	300.0
	0.027	9,029	12.00	9.23	6.48	4.78	3.47	2.59	2.12	200.0	1938.9	0.0	13.5	4.14	300.0
1 day micro	0.029	9,251	10.53	8.70	6.44	4.82	3.52	2.70	2.18	200.0	2934.9	0.0	13.3	2.55	300.0
	0.032	9,299	12.32	9.71	6.76	4.98	3.00	2.34	1.97	200.0	1579.4	0.0	14.4	3.48	117.7
	0.035	9,311	10.91	8.37	5.86	4.42	3.31	2.52	2.07	200.0	2426.2	0.0	14.8	5.52	300.0
	0.039	9,279	13.72	9.65	6.05	4.17	2.91	2.06	1.83	200.0	943.9	0.0	16.1	4.87	214.4
2 day micro	0.041	9,235	13.43	8.81	5.50	3.93	2.87	2.26	1.87	200.0	988.8	0.0	16.9	9.42	300.0
	0.044	9,227	14.91	9.79	6.09	4.22	2.98	2.26	1.91	200.0	778.6	0.0	15.8	7.73	300.0
	0.045	9,164	14.68	9.82	5.84	4.00	2.94	2.19	1.89	200.0	731.6	0.0	16.2	7.68	300.0
	0.048	9,362	10.47	7.80	5.17	3.73	2.71	1.97	1.66	200.0	1854.2	0.0	18.0	4.96	249.3
3 day micro	0.050	9,319	8.63	7.54	5.09	3.66	2.66	1.83	1.57	200.0	2768.3	0.0	18.0	2.22	177.8
	0.052	9,195	10.53	8.20	5.59	3.98	2.81	2.13	1.77	200.0	1956.8	0.0	16.5	3.33	300.0
	0.054	9,215	12.85	9.22	5.97	4.17	3.00	2.18	1.81	200.0	1206.8	0.0	15.9	5.29	256.1
	0.057	9,064	15.07	10.58	6.47	4.28	2.97	2.07	1.69	200.0	714.6	0.0	15.1	3.64	199.7
	0.059	9,195	10.97	8.55	5.81	4.09	2.91	2.14	1.72	200.0	1810.0	0.0	16.0	3.02	279.6
No micro moist cure	0.060	9,219	9.87	7.80	5.62	4.10	2.90	2.11	1.73	200.0	2484.9	0.0	16.2	2.21	252.9
	Mean:		13.42	10.18	6.84	4.78	3.44	2.54	2.08	200.0	1712.0	0.0	14.0	4.41	280.0
	Std. Dev:		3.74	2.37	1.37	0.79	0.60	0.44	0.33	0.0	951.2	0.0	2.5	2.05	124.3
	Var Coeff(%):		27.86	23.31	20.04	16.60	17.36	17.36	15.64	0.0	55.6	0.0	17.5	46.43	46.7

7 day cure 8% cement drops 5-8
9/15/2003

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	100,000	2,250,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	272.27	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
	0.000	9,259	13.24	11.08	8.09	6.04	4.42	3.17	2.45	200.0	2172.7	0.0	10.8	1.43	236.8
No ~~[illegible]~~ cure	0.003	9,275	13.54	10.90	7.80	5.63	4.16	2.94	2.29	200.0	1828.8	0.0	11.6	2.40	216.3
	0.006	9,072	17.98	13.10	8.86	6.24	4.52	3.36	2.72	200.0	966.2	0.0	10.4	5.15	300.0
	0.009	9,033	18.14	13.88	9.14	6.22	4.35	3.08	2.48	200.0	838.4	0.0	10.5	2.17	231.8
	0.013	9,291	13.77	11.48	8.09	5.86	4.22	3.07	2.44	200.0	1793.8	0.0	11.2	1.75	267.1
Prime	0.015	9,005	21.80	15.18	9.54	6.43	4.43	3.18	2.56	200.0	513.1	0.0	10.1	4.28	260.2
	0.018	9,112	20.62	14.70	9.17	6.17	4.30	3.18	2.63	200.0	576.7	0.0	10.5	4.27	300.0
	0.019	9,037	21.42	16.07	8.66	5.94	4.21	3.07	2.46	200.0	440.2	0.0	10.7	5.60	285.7
	0.025	9,088	15.44	12.18	8.27	5.82	4.21	3.02	2.40	200.0	1259.4	0.0	11.1	2.78	245.1
1 day micro	0.027	9,029	15.84	11.98	7.74	5.30	3.78	2.80	2.28	200.0	970.7	0.0	12.1	3.91	300.0
	0.030	9,033	16.90	11.93	7.37	5.11	3.65	2.77	2.31	200.0	754.4	0.0	12.6	6.11	300.0
	0.033	8,921	15.26	11.06	7.18	4.94	3.44	2.62	2.16	200.0	942.2	0.0	13.0	4.55	300.0
	0.038	9,076	18.34	12.63	6.84	4.43	3.23	2.49	2.16	200.0	428.6	0.0	13.8	6.26	300.0
2 day micro	0.040	9,386	20.82	13.18	7.56	4.94	3.47	2.56	2.15	200.0	376.9	0.0	13.1	6.15	300.0
	0.042	9,064	15.22	10.83	6.36	4.33	3.08	2.37	2.05	200.0	735.2	0.0	14.7	5.97	300.0
	0.045	8,993	14.65	10.22	6.52	4.35	3.12	2.28	1.92	200.0	857.9	0.0	14.6	5.33	277.2
	0.048	9,168	15.27	10.72	6.26	4.11	2.95	2.18	1.80	200.0	665.3	0.0	15.4	5.32	300.0
3 day micro	0.049	9,172	13.94	10.41	6.50	4.47	3.10	2.23	1.85	200.0	995.3	0.0	14.8	3.31	242.0
	0.051	9,211	16.11	10.81	6.43	4.31	2.93	2.22	1.83	200.0	600.9	0.0	15.2	5.61	238.7
	0.053	8,981	18.15	11.55	6.42	4.13	2.89	2.19	1.83	200.0	386.7	0.0	14.7	5.72	300.0
	0.057	8,941	26.83	14.06	7.10	4.67	3.25	2.37	1.87	200.0	134.5	0.0	12.6	8.05	279.1
No micro moist cure	0.059	8,989	19.25	13.54	7.53	4.75	3.30	2.40	1.93	200.0	408.4	0.0	12.8	3.61	281.2
	0.060	8,981	15.35	11.43	7.48	4.99	3.42	2.44	1.94	200.0	902.5	0.0	12.9	2.12	237.0
	Mean:		17.30	12.30	7.60	5.18	3.67	2.70	2.20	200.0	850.0	0.0	12.6	4.43	278.8
	Std. Dev:		3.32	1.64	1.00	0.78	0.57	0.39	0.29	0.0	505.6	0.0	1.7	1.74	30.1
	Var Coeff(%):		19.22	13.31	13.10	14.97	15.55	14.40	13.13	0.0	59.5	0.0	13.8	39.37	11.0

9/22/03 4% Cement @ 14 day cure corresponding to drop sites 1-4

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	3,250,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	227.92	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure	-3.000	10,304	14.24	11.48	7.26	4.52	2.98	2.08	1.74	200.0	1069.6	0.0	15.3	1.89	191.4
	15.000	10,260	11.31	9.04	6.08	4.17	2.89	2.11	1.70	200.0	1963.8	0.0	16.6	2.56	263.8
	34.000	10,395	10.74	8.92	6.21	4.48	3.23	2.39	1.83	200.0	2739.0	0.0	15.4	3.06	289.3
	50.000	9,934	19.37	13.10	7.87	5.18	3.56	2.52	2.00	200.0	542.4	0.0	13.3	5.12	223.7
	73.000	9,875	11.32	9.08	5.93	4.08	2.80	2.04	1.61	200.0	1763.0	0.0	16.4	2.75	252.1
Prime	88.000	9,950	14.19	10.46	6.31	4.07	2.77	2.24	1.70	200.0	928.4	0.0	16.3	4.93	240.3
	103.000	9,962	13.55	10.34	6.66	4.47	2.89	2.01	1.70	200.0	1164.8	0.0	15.6	1.32	164.7
	117.000	9,895	15.00	9.30	5.98	4.13	2.93	2.12	1.71	200.0	824.7	0.0	17.0	9.61	246.5
	140.000	10,081	15.69	11.35	7.15	4.64	3.09	2.31	1.91	200.0	873.6	0.0	14.9	3.36	204.1
1 day micro	154.000	9,541	28.23	13.68	7.94	5.28	3.64	2.68	2.07	200.0	154.7	0.0	12.6	11.39	282.1
	170.000	9,835	20.89	13.10	7.30	4.63	3.27	2.32	1.95	200.0	349.0	0.0	14.2	5.21	227.2
	186.000	9,891	16.77	11.95	7.14	4.64	3.06	2.15	1.74	200.0	657.6	0.0	14.8	2.68	190.4
	203.000	9,346	24.31	15.60	8.41	5.40	3.55	2.61	2.11	200.0	261.0	0.0	11.7	3.65	193.3
2 day micro	218.000	10,038	17.04	13.05	8.65	5.97	3.98	2.70	2.03	200.0	1048.6	0.0	11.8	1.84	175.9
	233.000	9,930	16.84	12.69	8.21	5.38	3.66	2.63	2.09	200.0	926.8	0.0	12.6	2.61	249.6
	243.000	9,771	19.18	14.00	8.53	5.83	3.89	2.76	2.15	200.0	679.7	0.0	11.8	3.78	210.5
	259.000	9,875	18.03	12.75	7.74	5.13	3.52	2.60	2.11	200.0	678.2	0.0	13.2	4.80	266.4
3 day micro	270.000	10,030	17.69	12.91	7.74	4.95	3.47	2.60	2.02	200.0	697.7	0.0	13.6	4.62	300.0
	284.000	10,248	12.04	9.28	6.03	4.28	3.12	2.24	1.79	200.0	1825.1	0.0	16.1	5.03	230.7
	296.000	9,970	15.52	11.29	7.18	4.91	3.34	2.46	1.89	200.0	1014.6	0.0	14.1	4.46	239.7
	312.000	10,065	11.01	8.38	5.77	4.06	2.86	2.03	1.57	200.0	2070.2	0.0	16.9	3.60	213.8
No micro moist cure	323.000	10,240	10.44	7.89	5.06	3.46	2.46	1.82	1.48	200.0	1843.7	0.0	19.9	4.99	286.5
	334.000	10,193	9.07	7.28	4.83	3.46	2.45	1.81	1.45	200.0	2704.4	0.0	19.8	3.81	278.3
	Mean:		15.76	11.17	6.96	4.66	3.19	2.31	1.84	200.0	1164.4	0.0	15.0	4.22	234.4
	Std. Dev:		4.66	2.23	1.10	0.67	0.42	0.29	0.21	0.0	731.0	0.0	2.3	2.31	39.5
	Var Coeff(%):		29.54	19.96	15.81	14.37	13.13	12.43	11.44	0.0	62.8	0.0	15.2	54.69	16.9

9/22/03 4% Cement @ 14 day cure corresponding to drop sites 5-8

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	3,250,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	186.67	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure/	0.000	10,292	12.63	9.48	5.86	3.82	2.54	1.77	1.57	200.0	1256.0	0.0	17.2	3.57	194.8
No micro	0.000	10,320	16.34	12.07	7.25	4.56	2.91	1.93	1.65	200.0	761.3	0.0	14.8	1.57	155.7
	0.000	10,061	20.77	14.67	8.03	5.01	3.25	2.34	2.02	200.0	402.8	0.0	13.2	2.85	174.7
	0.000	10,208	22.57	14.94	8.39	5.12	3.28	2.31	1.96	200.0	343.6	0.0	13.1	1.36	163.5
	0.000	10,252	14.32	11.03	6.80	4.57	3.17	2.24	1.90	200.0	1258.4	0.0	14.2	4.99	213.9
Prime	0.000	10,316	16.80	12.34	7.28	4.62	2.89	2.04	1.79	200.0	707.3	0.0	14.6	2.28	140.6
	0.000	10,359	17.56	13.19	8.12	5.13	3.28	2.24	1.90	200.0	782.9	0.0	13.1	1.68	159.4
	11.000	10,252	12.60	10.17	6.79	4.81	3.22	2.33	1.92	200.0	1942.0	0.0	13.6	2.91	205.6
	44.000	10,880	10.67	8.90	6.15	4.20	2.94	2.09	1.72	200.0	2657.5	0.0	16.0	2.65	217.1
1 Day	56.000	10,101	11.55	10.95	5.21	3.71	2.67	2.01	1.73	200.0	1414.7	0.0	16.7	11.45	300.0
micro	68.000	10,272	12.00	10.00	6.25	4.17	2.85	2.04	1.67	200.0	1705.6	0.0	15.3	4.16	230.7
	86.000	10,057	19.37	13.60	7.68	4.91	3.33	2.47	2.00	200.0	496.6	0.0	13.4	5.15	241.1
	107.000	9,899	17.27	13.23	8.62	5.73	3.89	2.67	2.14	200.0	1041.2	0.0	11.0	3.18	188.8
2 Day	122.000	10,038	15.72	12.07	8.34	5.83	4.10	2.91	2.30	200.0	1552.4	0.0	10.9	4.31	224.7
micro	138.000	10,240	19.90	14.50	8.86	5.79	3.86	2.88	2.35	200.0	711.0	0.0	11.4	4.98	212.1
	163.000	10,061	20.26	15.00	8.98	5.87	3.83	2.71	2.19	200.0	640.4	0.0	11.2	3.43	182.3
3 Day	178.000	9,899	26.66	16.27	8.49	5.37	3.46	2.43	1.98	200.0	210.8	0.0	12.1	3.24	168.8
micro	192.000	10,050	14.43	10.97	6.89	4.56	2.99	2.15	1.79	200.0	1147.2	0.0	14.2	3.34	181.0
	198.000	10,145	13.52	9.75	5.92	3.93	2.80	2.07	1.72	200.0	1168.5	0.0	16.2	7.52	294.3
	216.000	10,208	11.22	9.58	6.32	4.32	2.99	2.08	1.63	200.0	2163.3	0.0	14.7	3.06	192.7
wet cure	225.000	9,966	15.95	11.00	6.50	4.22	2.76	1.99	1.68	200.0	678.6	0.0	15.7	5.15	177.7
no micro	238.000	9,970	16.03	12.70	7.72	4.78	3.11	2.12	1.77	200.0	865.8	0.0	13.2	2.42	177.6
	Mean:		16.28	12.11	7.29	4.77	3.19	2.26	1.88	200.0	1086.7	0.0	13.9	3.87	193.2
	Std. Dev:		4.08	2.11	1.10	0.66	0.42	0.31	0.22	0.0	623.7	0.0	1.9	2.22	34.3
	Var Coeff(%):		25.04	17.42	15.04	13.76	13.26	13.54	11.67	0.0	57.4	0.0	13.4	57.27	17.8

9/22/03 8% cement @ 14 days' cure corresponding to drops 1-4

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	200,000	4,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	273.78	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure	15.000	10,157	10.24	9.14	6.98	5.32	3.93	2.92	2.33	200.0	3908.5	0.0	13.0	1.40	298.6 *
	30.000	10,038	11.82	10.18	7.76	5.97	4.57	3.32	2.52	200.0	3410.3	0.0	11.4	1.82	252.5 *
	45.000	9,918	14.01	11.32	8.30	6.03	4.48	3.20	2.60	200.0	2058.4	0.0	11.6	2.38	231.4
	66.000	9,847	15.80	12.52	8.33	5.78	4.06	2.83	2.30	200.0	1192.0	0.0	12.3	1.63	201.9
Prime	81.000	9,760	21.09	15.31	9.24	5.91	4.21	3.11	2.55	200.0	542.4	0.0	11.4	3.94	300.0
	97.000	9,962	19.09	14.41	9.12	6.09	4.12	3.03	2.42	200.0	751.9	0.0	11.7	2.08	240.5
	109.000	8,973	24.28	17.11	9.94	6.46	4.40	3.21	2.58	200.0	357.3	0.0	9.7	2.97	272.4
	125.000	9,831	17.62	13.21	8.24	5.48	3.75	2.65	2.15	200.0	765.7	0.0	12.8	2.05	222.6
1 Day micro	140.000	9,851	10.74	9.00	6.63	4.96	3.72	2.76	2.25	200.0	3134.9	0.0	13.7	2.44	296.6
	155.000	10,149	10.54	8.70	6.41	4.80	3.66	2.71	2.17	200.0	3319.6	0.0	14.5	3.25	289.0
	170.000	9,811	9.56	7.65	5.76	4.38	3.33	2.52	2.06	200.0	3764.3	0.0	15.3	4.06	300.0
	196.000	10,057	12.06	9.17	6.14	4.31	3.19	2.37	1.96	200.0	1768.5	0.0	16.4	4.94	300.0
2 Day micro	211.000	10,181	12.52	9.06	5.74	4.04	2.93	2.22	1.90	200.0	1393.8	0.0	17.9	6.19	300.0
	226.000	9,859	13.54	9.27	5.87	4.14	2.95	2.28	1.91	200.0	1112.4	0.0	17.1	7.28	300.0
	235.000	10,208	14.96	9.69	6.12	4.17	2.98	2.21	1.93	200.0	855.5	0.0	17.6	7.61	300.0
	252.000	10,121	11.29	8.19	5.20	3.78	2.72	2.02	1.74	200.0	1637.9	0.0	19.3	6.10	291.7
3 Day micro	264.000	10,149	8.97	7.06	4.83	3.59	2.60	1.99	1.65	200.0	2988.7	0.0	20.0	4.28	300.0
	275.000	9,946	10.04	7.93	5.41	3.91	2.82	2.10	1.78	200.0	2394.4	0.0	18.0	3.49	300.0
	288.000	10,129	12.81	9.45	6.43	4.52	3.15	2.29	1.88	200.0	1534.0	0.0	16.3	3.68	255.7
wet cure no micro	303.000	9,942	12.82	9.97	6.52	4.44	3.13	2.22	1.80	200.0	1391.7	0.0	16.0	2.34	218.0
	316.000	10,101	9.78	8.04	5.63	4.12	3.06	2.24	1.73	200.0	2922.9	0.0	17.1	3.07	262.0
	324.000	9,807	9.31	7.73	5.72	4.33	3.23	2.34	1.87	200.0	3636.6	0.0	15.7	2.28	241.1
	Mean:		13.31	10.19	6.83	4.84	3.50	2.57	2.09	200.0	2038.3	0.0	14.9	3.60	280.3
	Std. Dev:		4.07	2.69	1.45	0.88	0.61	0.42	0.31	0.0	1158.9	0.0	2.9	1.81	35.7
	Var Coeff(%):		30.54	26.45	21.20	18.15	17.49	16.39	14.63	0.0	56.9	0.0	19.4	50.20	13.1

9/22/03 8% Cement @ 14 days cure corresponding to days 5-8

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	4,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	243.15	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
No cure	0.000	10,224	13.06	10.80	7.91	5.91	4.22	3.03	2.36	200.0	2449.0	0.0	11.9	1.51	234.7
	15.000	9,903	32.56	10.57	7.67	5.51	3.91	2.83	2.37	200.0	150.0	0.0	13.7	22.76	252.6 *
	30.000	10,030	16.76	13.14	8.91	6.26	4.61	3.30	2.57	200.0	1345.5	0.0	11.0	3.92	240.5
	45.000	10,121	17.85	13.72	8.94	6.01	4.11	2.93	2.39	200.0	949.6	0.0	11.8	2.06	237.6
	66.000	10,042	14.00	11.37	7.94	5.59	4.00	2.92	2.37	200.0	1783.6	0.0	12.3	2.34	273.3
Prime	81.000	9,831	20.20	14.89	9.58	6.58	4.52	3.18	2.55	200.0	758.7	0.0	10.6	3.45	219.6
	95.000	9,573	22.04	15.89	9.66	6.25	4.28	3.00	2.48	200.0	499.9	0.0	10.6	2.64	221.4
	110.000	10,038	15.68	12.63	8.22	5.89	4.17	3.05	2.45	200.0	1371.8	0.0	11.8	3.49	277.2
	125.000	10,042	18.34	13.81	8.96	6.00	4.19	3.01	2.38	200.0	894.2	0.0	11.6	3.21	252.2
1 Day micro	135.000	10,185	13.54	10.97	7.91	5.76	4.17	2.99	2.41	200.0	2150.7	0.0	12.1	2.35	234.8
	151.000	10,157	11.96	10.07	6.98	5.05	3.70	2.72	2.26	200.0	2394.0	0.0	13.5	3.05	279.5
	166.000	9,756	17.40	11.94	7.23	5.08	3.70	2.67	2.18	200.0	755.8	0.0	13.5	7.60	247.4
	195.000	9,942	16.45	11.95	7.04	4.74	3.34	2.45	2.07	200.0	765.5	0.0	14.5	4.99	283.7
2 Day micro	208.000	9,827	16.30	13.39	8.24	5.46	3.74	2.67	2.19	200.0	962.2	0.0	12.4	2.94	239.0
	222.000	10,236	14.15	10.31	6.70	4.66	3.31	2.41	2.02	200.0	1286.7	0.0	15.3	5.14	260.8
	232.000	9,891	12.28	9.37	6.23	4.34	3.15	2.33	1.95	200.0	1690.0	0.0	15.6	4.79	294.4
	248.000	9,851	13.05	9.34	5.97	4.17	3.02	2.22	1.78	200.0	1303.7	0.0	16.4	6.40	277.8
3 Day micro	261.000	10,030	11.06	8.61	5.70	4.06	2.87	2.09	1.73	200.0	1961.3	0.0	17.1	3.65	254.4
	272.000	9,875	11.89	9.14	5.94	4.10	2.91	2.16	1.77	200.0	1608.5	0.0	16.5	4.15	300.0
	284.000	9,767	14.43	11.02	6.65	4.22	3.01	2.18	1.83	200.0	911.8	0.0	15.5	4.18	300.0
Wet cure no micro	299.000	9,589	16.96	12.08	7.02	4.34	2.89	2.11	1.73	200.0	543.6	0.0	15.0	2.27	207.6
	309.000	9,752	12.86	9.70	6.15	4.22	2.99	2.15	1.75	200.0	1298.0	0.0	16.0	4.17	237.5
	318.000	9,763	13.18	10.31	6.89	4.89	3.42	2.43	1.98	200.0	1568.3	0.0	14.0	2.71	219.9
	Mean:		15.91	11.52	7.50	5.18	3.66	2.64	2.16	200.0	1278.4	0.0	13.6	4.51	249.7
	Std. Dev:		4.59	1.94	1.18	0.82	0.57	0.39	0.29	0.0	610.1	0.0	2.0	4.23	26.4
	Var Coeff(%):		28.84	16.80	15.78	15.75	15.55	14.67	13.48	0.0	47.7	0.0	15.0	93.67	10.4

10/7/03 4% Cement left side corresponding to drops 1-4

Note: had heavy rains in afternoon on 10/6

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	4,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	221.71	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)		SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	10,701	14.65	11.35	7.18	4.63	2.96	2.08	1.66	200.0	1064.5	No cure	0.0	15.8	1.41	155.7
18.000	10,411	11.63	9.86	6.39	4.40	3.04	2.13	1.72	200.0	1914.1		0.0	15.9	2.66	200.1
32.000	10,081	15.16	10.86	7.15	4.99	3.41	2.40	1.83	200.0	1161.9		0.0	14.0	4.87	208.3
48.000	10,336	14.77	11.87	8.50	6.20	4.43	2.32	1.89	200.0	1658.4		0.0	11.9	5.80	95.7
74.000	10,125	10.11	8.54	5.60	3.75	2.59	1.87	1.52	200.0	2121.9	Prime	0.0	17.8	2.98	242.0
89.000	9,644	22.89	12.21	6.63	4.17	2.78	1.99	1.62	200.0	205.2		0.0	15.2	6.14	206.5
106.000	9,942	12.24	10.00	6.62	4.59	3.06	2.07	1.60	200.0	1648.9		0.0	14.9	1.21	168.3
119.000	10,026	12.11	9.67	6.14	4.15	2.89	2.10	1.69	200.0	1555.5		0.0	16.1	3.64	256.6
147.000	10,057	21.63	13.67	6.37	4.13	2.96	2.20	1.83	200.0	254.6	1 Day	0.0	15.4	6.49	275.8
162.000	9,899	16.70	12.06	7.30	4.78	3.26	2.37	1.91	200.0	751.0		0.0	14.1	4.06	249.9
179.000	9,863	19.64	12.37	6.76	4.30	2.98	2.18	1.78	200.0	362.8		0.0	15.3	5.15	281.5
192.000	10,030	13.60	10.30	6.58	4.38	2.99	2.18	1.72	200.0	1223.2		0.0	15.5	3.38	245.9
208.000	9,414	21.50	13.94	7.72	4.72	3.30	2.41	2.01	200.0	320.3	2 Day	0.0	13.1	3.97	262.6
219.000	9,871	19.61	12.13	7.43	5.24	3.38	2.62	1.98	200.0	491.0		0.0	13.9	9.03	162.6
231.000	9,970	15.94	11.65	7.13	4.66	3.15	2.31	1.87	200.0	830.5		0.0	14.5	3.70	230.0
244.000	9,664	16.54	12.57	7.35	5.04	3.50	2.55	2.06	200.0	824.5		0.0	13.0	5.06	270.1
261.000	9,851	16.54	11.70	7.08	4.81	3.39	2.45	1.97	200.0	798.1	3 Day	0.0	14.0	5.97	252.0
272.000	10,018	16.07	11.22	6.77	4.39	3.11	2.27	1.86	200.0	749.0		0.0	15.3	5.71	273.8
285.000	10,006	10.11	8.25	5.28	3.80	2.82	2.11	1.67	200.0	2424.4		0.0	17.1	5.85	300.0
297.000	9,692	14.26	10.26	6.50	4.44	3.02	2.15	1.74	200.0	1044.4		0.0	15.1	4.62	223.8
313.000	9,918	9.44	7.37	5.35	3.81	2.72	1.98	1.64	200.0	2943.0	Moist cure	0.0	17.2	3.37	252.1
327.000	10,332	7.77	6.26	4.32	3.17	2.49	1.72	1.47	200.0	4100.1		0.0	20.8	5.26	177.6
335.000	10,467	8.01	6.37	4.35	3.13	2.28	1.71	1.39	200.0	3572.1		0.0	21.8	4.67	300.0
Mean:		14.82	10.63	6.54	4.42	3.07	2.18	1.76	200.0	1392.1		0.0	15.6	4.56	228.2
Std. Dev:		4.32	2.12	1.01	0.66	0.43	0.24	0.18	0.0	1052.5		0.0	2.3	1.73	74.1
Var Coeff(%):		29.13	19.90	15.50	15.04	13.87	10.83	10.01	0.0	75.6		0.0	14.7	37.98	32.6

10/6/03 4% Cement right side corresponding to drops 5-8

Note: had heavy rains at night on 10/5

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	4,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	201.84		15,000	H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
47.000	10,554	12.11	9.48	6.30	4.22	2.81	2.01	1.59	200.0	1714.9 No	0.0	16.4	2.16	198.0
47.000	10,403	20.87	17.45	6.41	4.04	2.70	1.99	1.61	200.0	274.4 cure	0.0	15.2	8.84	61.9
47.000	10,943	13.14	10.24	6.74	4.58	3.09	2.21	1.72	200.0	1659.8	0.0	15.7	2.82	219.2
47.000	10,363	21.97	15.06	8.71	5.31	3.23	2.33	1.92	200.0	387.3	0.0	13.2	1.08	128.0
47.000	10,490	15.51	12.17	7.21	4.68	3.17	2.26	1.81	200.0	969.5 Prime	0.0	14.6	4.18	230.2
47.000	10,912	15.15	11.89	7.00	4.33	2.97	2.05	1.68	200.0	943.9	0.0	16.1	3.95	189.6
47.000	10,582	16.57	13.15	8.53	5.24	2.62	2.03	1.69	200.0	799.0	0.0	14.2	7.16	81.5
47.000	11,007	11.14	9.46	6.63	4.83	3.59	2.50	1.97	200.0	3104.9	0.0	14.3	3.25	190.4
47.000	10,530	11.04	8.93	6.23	4.30	2.86	2.12	1.69	200.0	2317.0 1 day	0.0	16.0	2.40	194.8
47.000	10,637	12.94	9.87	6.30	4.19	2.87	2.09	1.70	200.0	1461.4	0.0	16.5	4.06	249.8
47.000	10,375	12.72	10.74	6.91	4.70	3.18	2.21	1.72	200.0	1689.2	0.0	14.4	2.60	193.4
60.000	10,518	15.09	11.35	7.14	4.76	3.22	2.37	1.88	200.0	1149.2	0.0	14.5	4.20	228.2
79.000	10,399	15.55	12.26	7.27	4.82	3.46	2.53	2.01	200.0	1079.9 2 day	0.0	13.7	6.11	277.4
78.000	10,669	15.11	11.35	7.70	5.45	3.81	2.82	2.17	200.0	1617.5	0.0	12.8	5.11	300.0
84.000	10,943	16.84	12.72	7.76	5.18	3.52	2.58	2.10	200.0	997.2	0.0	13.9	4.47	238.8
97.000	10,427	16.06	12.32	7.96	5.43	3.70	2.69	2.14	200.0	1218.9	0.0	12.6	3.81	245.8
111.000	10,522	17.27	12.85	8.06	5.30	3.43	2.51	2.05	200.0	892.1 3 day	0.0	13.3	2.84	169.0
124.000	10,355	24.06	15.16	8.03	4.79	3.19	2.28	1.85	200.0	257.7	0.0	13.8	1.80	202.0
138.000	10,618	14.81	10.80	6.78	4.59	2.99	2.23	1.79	200.0	1111.6	0.0	15.5	4.43	171.3
149.000	10,669	13.56	9.57	5.91	4.02	2.76	2.01	1.65	200.0	1179.2	0.0	17.7	6.29	251.3
163.000	10,324	11.02	9.00	6.04	4.20	2.97	2.15	1.71	200.0	2293.7 wet	0.0	15.7	3.55	245.9
175.000	10,272	13.97	10.80	6.75	4.55	3.10	2.18	1.77	200.0	1265.6 cure	0.0	14.8	3.63	207.3
183.000	10,304	13.17	10.73	7.07	4.74	3.30	2.30	1.81	200.0	1635.1	0.0	14.0	2.77	198.0
Mean:		15.20	11.62	7.11	4.71	3.15	2.28	1.83	200.0	1305.2	0.0	14.7	3.98	208.3
Std. Dev:		3.38	2.13	0.79	0.45	0.32	0.23	0.17	0.0	668.0	0.0	1.3	1.80	106.1
Var Coeff(%):		22.22	18.37	11.10	9.48	10.23	10.12	9.46	0.0	51.2	0.0	8.8	45.26	50.9

10/6/03 5% cement left corresponding to drops 1-4
Note! had heavy rain at night on 10/5

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness (in)	MODULI RANGE (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	4,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	275.84	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	10,455	15.86	12.55	8.90	6.49	4.66	3.36	2.57	200.0	1672.9	0.0	11.6	2.43	247.7
19.000	10,697	10.68	10.31	7.11	5.31	3.96	2.80	2.24	200.0	3328.9 No cure	0.0	13.9	2.94	208.5
34.000	10,614	10.03	9.00	7.14	5.65	4.34	3.33	2.76	200.0	3921.4	0.0	13.1	5.24	300.0 *
49.000	10,542	12.56	10.28	7.51	5.74	4.22	3.19	2.47	200.0	2805.3	0.0	12.9	2.93	300.0
64.000	10,836	13.76	11.50	8.02	5.71	4.07	3.06	2.48	200.0	2013.1	0.0	13.4	2.12	300.0
75.000	10,129	21.17	15.36	9.32	6.17	4.11	2.96	2.43	200.0	560.5 prime	0.0	11.8	2.28	212.1
88.000	10,220	16.74	13.02	8.62	5.98	4.28	3.08	2.50	200.0	1166.1	0.0	12.2	2.89	249.0
103.000	10,204	24.39	17.65	9.11	5.93	3.86	2.93	2.44	200.0	330.7	0.0	11.7	3.63	179.7
126.000	10,582	16.48	12.47	8.15	5.47	3.72	2.66	2.15	200.0	1018.9	0.0	14.0	1.71	236.9
141.000	9,986	11.37	8.75	6.56	4.94	3.65	2.72	2.17	200.0	2817.8 1day	0.0	14.2	4.01	300.0
156.000	10,423	9.57	8.13	6.12	4.69	3.61	2.74	2.25	200.0	4381.1	0.0	14.9	2.99	300.0
173.000	10,355	9.52	7.66	5.76	4.36	3.35	2.48	2.08	200.0	3963.3	0.0	16.2	3.91	283.1
194.000	10,371	11.74	8.30	5.59	4.11	3.01	2.29	1.90	200.0	1892.3 2day	0.0	18.2	7.01	300.0
208.000	10,463	13.23	8.91	5.64	4.02	2.93	2.20	1.87	200.0	1223.2	0.0	18.8	8.06	300.0
220.000	10,284	13.11	8.93	5.56	3.78	2.91	2.16	1.88	200.0	1136.6	0.0	18.9	8.49	300.0
232.000	10,220	13.64	8.94	5.63	3.93	2.87	2.19	1.85	200.0	1041.1	0.0	18.7	8.57	300.0
249.000	10,292	11.29	8.00	5.12	3.76	2.70	2.00	1.69	200.0	1663.3	0.0	19.9	6.82	283.8
262.000	10,304	8.53	7.13	4.94	3.61	2.67	1.72	1.51	200.0	3177.1 3day	0.0	20.5	2.18	135.8
272.000	10,312	10.02	7.57	5.18	3.69	2.68	2.07	1.72	200.0	2371.1	0.0	19.7	5.04	300.0
279.000	10,355	10.57	8.24	5.54	3.97	2.97	2.22	1.96	200.0	2319.8	0.0	18.2	4.90	300.0
285.000	9,990	13.22	10.19	6.58	4.54	3.25	2.41	1.93	200.0	1382.4	0.0	15.6	3.72	300.0
300.000	10,141	13.26	10.06	6.61	4.46	3.19	2.23	1.80	200.0	1325.4 moist	0.0	16.2	2.83	199.8
308.000	9,926	10.12	7.95	5.47	3.95	2.89	2.17	1.75	200.0	2447.9 cure	0.0	17.7	4.00	300.0
318.000	10,093	11.43	8.47	5.69	4.11	2.94	2.20	1.75	200.0	1860.0	0.0	17.7	4.90	300.0
Mean:		13.01	9.97	6.66	4.77	3.45	2.55	2.09	200.0	2075.8	0.0	15.8	4.32	282.3
Std. Dev:		3.75	2.61	1.38	0.92	0.62	0.46	0.34	0.0	1100.6	0.0	2.9	2.09	66.2
Var Coeff(%):		28.79	26.20	20.73	19.28	17.82	18.04	16.14	0.0	53.0	0.0	18.4	48.34	24.8

10/7/03 8% cement right side corresponding to drops 5-8
Note: had heavy rain in afternoon on 10/6

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	150,000	4,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	258.74		15,000	H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	10,276	11.11	10.11	7.45	5.65	4.18	3.10	2.35	200.0	3514.7	0.0	12.2	2.16	272.0
13.000	10,514	11.18	9.02	6.95	5.35	3.96	2.89	2.28	200.0	3572.0 No	0.0	13.4	2.63	256.4
31.000	10,320	14.05	11.28	7.95	5.84	4.23	3.10	2.54	200.0	1994.2 cure	0.0	12.4	2.94	275.7
44.000	10,042	16.16	12.17	8.43	5.99	4.24	3.06	2.42	200.0	1333.7	0.0	12.0	3.49	251.6
67.000	10,399	11.30	9.66	7.02	5.27	3.78	2.78	2.26	200.0	2987.3	0.0	13.7	1.51	275.7
80.000	9,938	24.02	15.32	9.22	6.06	4.09	2.92	2.39	200.0	366.9 Prime	0.0	11.7	5.25	237.7
93.000	10,117	17.07	13.01	8.43	5.82	4.12	2.98	2.46	200.0	1047.1	0.0	12.3	3.49	258.7
107.000	9,887	16.59	13.12	8.55	5.88	4.07	2.90	2.42	200.0	1075.9	0.0	12.0	2.05	233.7
128.000	10,240	14.89	11.68	7.72	5.33	3.74	2.68	2.18	200.0	~~1321.2~~	0.0	13.6	2.41	237.3
137.000	10,161	11.26	9.86	7.12	5.20	3.75	2.76	2.19	200.0	2830.1	0.0	13.4	1.88	281.9
149.000	10,228	12.79	10.10	6.95	4.87	3.69	2.70	2.09	200.0	1957.4 1 day	0.0	14.3	4.45	272.0
164.000	9,895	13.49	10.58	7.33	5.25	3.76	2.67	1.93	200.0	1722.9	0.0	13.3	2.73	212.5
178.000	10,602	12.46	9.64	6.52	4.70	3.40	2.47	2.03	200.0	1954.0	0.0	15.9	3.99	251.3
197.000	10,189	13.11	9.88	6.48	4.51	3.19	2.37	1.98	200.0	1467.3	0.0	15.9	4.18	300.0
208.000	9,708	16.34	11.46	6.54	4.26	3.11	2.29	2.02	200.0	622.4 2 day	0.0	15.5	5.82	293.8
220.000	9,942	11.75	8.78	5.67	3.81	2.80	2.13	1.86	200.0	1509.2	0.0	17.9	5.57	300.0
232.000	9,470	11.28	8.25	5.29	3.74	2.78	2.12	1.80	200.0	1603.5	0.0	17.6	6.98	300.0
252.000	9,990	10.51	7.75	4.92	3.51	2.57	1.93	1.62	200.0	1800.0	0.0	19.9	6.37	300.0
265.000	10,018	9.28	7.58	5.13	3.57	2.67	1.94	1.57	200.0	2623.4 3 day	0.0	19.1	3.80	248.7
277.000	10,212	10.45	7.93	5.15	3.62	2.59	1.93	1.63	200.0	1923.0	0.0	19.7	4.64	300.0
287.000	9,799	11.99	9.19	5.95	3.80	2.76	1.94	1.67	200.0	1316.2	0.0	17.6	3.08	300.0
301.000	9,720	17.89	10.91	6.26	4.09	2.72	1.93	1.61	200.0	412.4 most	0.0	16.6	5.33	199.0
314.000	10,026	9.41	7.66	5.24	3.73	2.77	2.00	1.63	200.0	2723.8	0.0	18.4	3.48	236.8
323.000	10,002	10.49	9.03	6.06	4.26	3.06	2.15	1.72	200.0	2290.6 cure	0.0	16.3	2.40	202.1
Mean:		13.29	10.17	6.76	4.75	3.42	2.49	2.03	200.0	1832.0	0.0	15.2	3.78	265.2
Std. Dev:		3.38	1.94	1.22	0.89	0.61	0.43	0.32	0.0	879.2	0.0	2.7	1.51	34.3
Var Coeff(%):		25.47	19.13	18.01	18.68	17.77	17.40	15.75	0.0	48.0	0.0	17.7	39.94	12.9

1/28/04 Riverside 4% Cement Corresponding to Drops 1-4

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	100,000	3,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	203.79	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)		SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.000	10,340	13.93	11.34	7.39	4.68	3.11	2.17	1.72	200.0	1294.5	no	0.0	14.3	2.12	202.3
0.002	10,141	18.63	14.91	9.67	6.03	3.66	2.42	1.83	200.0	776.0	cure	0.0	11.4	3.34	128.3
0.006	10,328	16.00	12.28	8.09	5.43	3.68	2.48	1.86	200.0	1173.2		0.0	12.7	2.16	169.8
0.009	9,275	16.46	13.50	9.08	6.26	4.29	3.09	2.34	200.0	1253.4		0.0	9.7	2.31	259.1
0.014	10,264	11.15	9.15	6.19	4.16	2.89	2.05	1.60	200.0	2082.6	Prime	0.0	15.9	2.42	216.6
0.016	10,069	20.06	13.80	7.98	4.85	3.22	2.33	1.83	200.0	436.1		0.0	13.7	2.16	206.7
0.020	10,173	13.77	10.97	7.24	4.93	3.38	2.33	1.85	200.0	1505.2		0.0	13.6	2.37	186.6
0.023	10,149	14.46	9.89	6.25	4.26	3.00	2.17	1.76	200.0	1065.4		0.0	15.9	7.31	247.6
0.027	9,887	16.96	11.06	6.76	4.42	3.06	2.34	1.92	200.0	625.8	1 day	0.0	15.1	7.73	284.3
0.031	10,042	19.52	12.02	6.87	4.57	3.15	2.30	1.83	200.0	421.3		0.0	15.1	7.53	270.8
0.034	9,787	19.58	11.42	6.20	4.01	2.80	2.09	1.74	200.0	318.8		0.0	16.2	7.77	300.0
0.036	9,946	12.53	9.72	6.44	4.30	2.98	2.17	1.72	200.0	1585.2		0.0	15.0	3.63	264.1
0.039	9,871	15.70	11.04	7.04	4.76	3.31	2.39	1.91	200.0	989.1	2day	0.0	13.8	6.11	250.4
0.042	9,978	14.94	11.96	7.53	4.89	3.21	2.23	1.76	200.0	1079.2		0.0	13.5	2.04	185.5
0.044	9,748	18.58	13.76	8.75	5.72	3.81	2.70	2.12	200.0	774.8		0.0	11.4	2.97	212.0
0.046	9,779	20.36	14.84	9.11	5.89	3.89	2.68	2.08	200.0	601.3		0.0	11.2	2.50	196.6
0.049	9,918	17.23	13.65	8.50	5.27	3.31	2.56	2.14	200.0	807.6		0.0	12.3	3.78	147.4
0.052	9,398	20.08	13.62	8.12	5.13	3.35	2.30	1.88	200.0	438.8	3day	0.0	12.5	2.65	184.2
0.054	10,244	12.09	10.06	6.62	4.42	2.92	2.05	1.59	200.0	1705.4		0.0	15.2	2.18	188.8
0.056	10,427	13.32	10.89	7.25	4.85	3.28	2.18	1.71	200.0	1576.8		0.0	14.2	1.26	158.1
0.059	10,189	11.43	9.54	6.82	4.82	3.39	2.32	1.73	200.0	2486.4		0.0	13.7	1.20	177.0
0.061	9,815	9.78	8.41	6.00	4.23	2.99	2.11	1.63	200.0	2935.0	wet	0.0	14.8	1.83	207.5
0.063	9,922	9.14	7.60	5.32	3.71	2.63	1.96	1.51	200.0	3015.5	cure	0.0	16.9	3.14	300.0
Mean:		15.47	11.54	7.36	4.85	3.27	2.32	1.83	200.0	1258.6		0.0	13.8	3.50	210.3
Std. Dev:		3.47	2.03	1.14	0.67	0.39	0.26	0.20	0.0	772.8		0.0	1.8	2.16	48.0
Var Coeff(%):		22.42	17.56	15.47	13.77	11.82	10.99	10.69	0.0	61.4		0.0	13.3	61.60	22.8

1/20/04 Riverside 4% Cement Corresponding TO drops 5-8

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	100,000	3,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	161.90	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
-0.001	11,289	17.76	13.48	8.62	5.50	3.47	2.33	1.77	200.0	1032.3 NO	0.0	12.6	2.09	147.6
0.002	10,300	25.62	18.64	10.52	6.17	3.74	2.61	1.90	200.0	358.7 cure	0.0	10.2	1.92	130.6
0.006	10,486	20.92	16.04	9.78	5.96	3.71	2.45	1.88	200.0	653.9	0.0	10.7	1.74	143.4
0.010	10,542	22.67	16.87	10.24	6.52	4.33	3.00	2.34	200.0	656.9	0.0	9.8	4.57	205.8
0.014	10,633	17.88	14.05	8.87	5.85	3.87	2.64	2.07	200.0	1093.8 prime	0.0	11.0	3.61	182.2
0.016	10,566	31.33	14.45	9.08	5.81	3.69	2.37	1.86	200.0	153.2	0.0	12.6	10.66	144.6
0.019	10,212	18.61	15.22	9.63	6.10	3.77	2.43	1.83	200.0	898.7	0.0	10.3	1.57	137.7
0.022	10,590	12.01	10.04	7.09	5.07	3.52	2.52	2.01	200.0	2716.7	0.0	12.3	2.93	229.2
0.027	10,284	11.51	9.93	6.88	4.71	3.00	2.03	1.68	200.0	2247.4	0.0	13.3	1.87	150.8
0.030	10,208	14.08	11.20	7.39	4.89	3.29	2.24	1.74	200.0	1538.9 1 day	0.0	12.4	3.14	176.9
0.033	10,280	13.26	11.96	7.95	5.23	3.36	2.22	1.78	200.0	1754.7	0.0	11.9	2.65	156.8
0.036	10,403	16.33	12.70	8.16	5.36	3.64	2.50	1.93	200.0	1235.9	0.0	11.5	4.17	187.2
0.039	10,276	16.91	12.57	8.28	5.55	3.90	2.62	2.07	200.0	1251.4	0.0	11.0	5.68	168.1
0.041	10,200	14.63	11.56	7.81	5.46	3.83	2.70	2.15	200.0	1795.5 2 day	0.0	11.0	4.56	212.5
0.044	9,708	20.52	16.36	10.09	6.02	3.40	2.67	2.23	200.0	620.9	0.0	9.8	5.07	104.3
0.046	9,875	21.22	15.80	9.96	6.56	4.37	2.97	2.29	200.0	771.3	0.0	9.2	4.55	184.6
0.049	10,316	18.73	14.30	9.24	6.00	3.80	2.53	2.07	200.0	933.5	0.0	10.6	1.96	153.0
0.051	10,300	20.62	15.26	8.79	5.19	3.38	2.44	1.95	200.0	528.4 3 day	0.0	11.9	4.31	183.8
0.054	10,455	13.72	11.02	7.02	4.67	3.16	2.24	1.82	200.0	1583.8	0.0	13.2	4.45	219.3
0.056	10,077	13.20	10.81	6.77	4.42	3.02	2.15	1.65	200.0	1536.5	0.0	13.3	4.83	226.8
0.059	10,248	12.01	10.09	7.16	4.98	3.41	2.32	1.73	200.0	2428.7	0.0	12.2	1.64	173.5
0.061	9,656	19.00	14.74	9.43	5.89	3.63	2.33	1.80	200.0	765.9 wet	0.0	10.1	0.74	137.1
0.063	9,978	17.19	12.57	7.89	4.93	3.15	2.13	1.70	200.0	824.1 cure	0.0	12.4	3.15	159.3
Mean:		17.81	13.46	8.55	5.51	3.58	2.45	1.92	200.0	1190.5	0.0	11.5	3.56	168.4
Std. Dev:		4.77	2.44	1.18	0.60	0.36	0.25	0.20	0.0	668.9	0.0	1.2	2.07	33.5
Var Coeff(%):		26.76	18.10	13.83	10.86	10.03	10.10	10.31	0.0	56.2	0.0	10.7	58.16	19.9

1/28/04 Riverside 8% Cement Corresponding to Drops 1-4

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	500,000	6,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	251.73	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.042	9,414	15.42	12.52	9.06	6.67	5.04	3.73	3.00	200.0	1872.1 No	0.0	9.6	3.89	300.0
0.045	10,141	10.81	10.33	8.34	6.54	4.78	3.14	2.59	200.0	4293.7 cure	0.0	10.4	4.46	147.8
0.049	10,109	11.76	11.39	9.23	7.43	5.72	4.10	3.01	200.0	5002.5	0.0	8.4	2.75	225.2
0.052	10,014	14.09	12.19	8.98	6.48	4.69	3.30	2.55	200.0	2145.2	0.0	10.7	1.03	212.4
0.056	9,406	14.29	12.05	8.29	5.85	4.11	2.89	2.34	200.0	1533.4 prime	0.0	11.4	1.63	212.8
0.061	9,648	16.33	13.14	8.85	6.09	4.31	3.08	2.48	200.0	1203.5	0.0	11.1	2.23	241.2
0.064	9,807	20.73	15.50	9.76	6.55	4.49	3.26	2.67	200.0	684.0	0.0	10.6	2.88	277.0
0.067	10,077	13.40	10.68	7.41	5.17	3.71	2.68	2.17	200.0	1715.3	0.0	13.6	2.76	249.7
0.070	10,268	8.73	8.38	6.52	4.93	3.61	2.43	2.05	200.0	4861.9 1 day	0.0	14.0	3.31	161.0
0.073	10,399	8.69	7.57	5.74	4.49	2.85	2.28	1.92	200.0	4225.0	0.0	16.6	3.35	142.7
0.076	9,958	8.38	7.35	5.47	4.29	3.39	2.56	2.08	200.0	5630.0	0.0	14.5	3.52	300.0
0.080	10,296	9.04	7.76	5.70	4.16	3.08	2.28	1.87	200.0	3797.8	0.0	16.7	2.41	286.3
0.083	10,157	10.46	8.00	5.34	3.87	2.87	2.15	1.83	200.0	2239.3 2day	0.0	18.2	5.91	300.0
0.085	10,061	11.50	8.37	5.57	3.75	2.81	2.11	1.79	200.0	1671.9	0.0	18.2	6.47	300.0
0.088	9,998	11.11	8.32	5.58	3.96	2.85	2.08	1.69	200.0	1879.5	0.0	17.7	4.84	258.4
0.091	10,069	8.54	6.80	4.68	3.37	2.45	1.89	1.61	200.0	3019.2	0.0	20.6	4.59	300.0
0.093	10,216	8.45	6.76	4.98	3.54	2.47	1.94	1.60	200.0	3385.1 3day	0.0	20.0	3.71	283.8
0.096	10,185	10.15	7.67	5.47	4.00	2.92	2.13	1.74	200.0	2616.3	0.0	17.9	4.88	254.1
0.098	10,193	10.43	8.53	6.02	4.21	3.01	2.24	1.85	200.0	2453.7	0.0	16.8	2.57	300.0
0.100	10,057	12.15	9.79	6.61	4.53	3.22	2.30	1.83	200.0	1736.4	0.0	15.5	2.43	228.1
0.102	9,855	9.31	7.93	5.85	4.34	3.25	2.37	1.81	200.0	3681.6 wet	0.0	15.2	2.46	255.1
0.104	9,938	9.14	8.17	6.21	4.61	3.41	2.46	1.95	200.0	4140.3 cure	0.0	14.4	1.35	237.0
Mean:		11.50	9.51	6.80	4.95	3.59	2.61	2.11	200.0	2899.4	0.0	14.6	3.34	258.2
Std. Dev:		3.14	2.38	1.61	1.20	0.90	0.60	0.43	0.0	1378.9	0.0	3.5	1.41	64.0
Var Coeff(%):		27.31	25.00	23.68	24.22	25.06	22.85	20.41	0.0	47.6	0.0	24.2	42.24	25.3

1/28/04 Riverside 8% Cement Corresponding to drops 5-8

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 5.1)

District:0
County :0
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.35
Base:	6.00	500,000	6,000,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	236.94	15,000		H4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)		SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
0.036	10,208	12.63	10.72	8.00	5.74	4.31	3.16	2.48	200.0	2705.9		0.0	11.6	2.39	280.4
0.032	10,053	17.17	13.46	9.50	6.54	4.58	3.18	2.45	200.0	1271.0	No	0.0	10.7	1.80	201.4
0.028	10,014	20.47	13.19	8.55	5.98	4.28	3.07	2.47	200.0	675.2	cure	0.0	11.9	8.53	242.8
0.027	10,081	15.67	12.80	8.93	6.39	4.59	3.29	2.57	200.0	1616.8		0.0	10.9	2.60	240.8
0.025	10,260	13.01	11.40	8.02	5.75	4.15	2.99	2.37	200.0	2244.5		0.0	12.1	2.45	244.7
0.023	9,756	15.05	11.57	7.90	5.52	3.93	2.83	2.30	200.0	1379.9	prime	0.0	12.2	3.69	247.7
0.020	9,815	21.16	15.30	9.86	6.70	4.62	3.20	2.55	200.0	690.9		0.0	10.3	3.71	201.8
0.017	10,069	18.89	14.67	9.53	6.54	4.56	3.25	2.53	200.0	958.0		0.0	10.7	2.81	238.4
0.015	10,085	16.25	13.80	9.57	6.66	4.66	3.24	2.54	200.0	1452.0		0.0	10.5	1.45	202.3
0.010	10,038	11.62	9.73	7.15	5.36	3.96	2.88	2.31	200.0	2945.5	1 day	0.0	12.5	2.49	254.6
0.007	10,022	13.76	10.78	6.80	5.08	3.73	2.77	2.19	200.0	1608.0		0.0	13.6	6.03	299.4
0.005	10,026	11.48	9.84	6.76	4.75	3.45	2.52	1.96	200.0	2264.8		0.0	14.2	3.25	267.6
0.002	9,883	10.43	9.74	6.72	5.49	3.59	2.64	2.13	200.0	3220.9		0.0	12.8	3.93	168.6
-0.002	9,875	12.53	10.24	6.49	4.28	3.18	2.42	2.00	200.0	1511.4	2 day	0.0	15.1	5.45	300.0
-0.004	10,065	15.43	11.07	7.02	4.70	3.26	2.45	2.04	200.0	972.3		0.0	14.8	5.01	288.2
-0.006	9,907	12.19	9.63	6.28	4.31	3.02	2.27	1.89	200.0	1599.4		0.0	15.7	3.65	300.0
-0.009	9,831	13.32	8.71	5.92	4.02	3.02	2.24	1.86	200.0	1279.8		0.0	16.7	8.93	300.0
-0.012	9,883	10.56	8.20	5.59	3.88	2.85	2.08	1.70	200.0	2111.9		0.0	17.3	4.65	260.5
-0.014	9,903	9.93	8.28	5.73	3.85	2.48	1.86	1.61	200.0	2088.7	3 day	0.0	18.0	2.64	159.0
-0.016	9,807	10.11	7.94	5.39	3.81	2.79	2.05	1.67	200.0	2277.4		0.0	17.5	4.63	272.1
-0.019	10,010	11.67	9.50	6.09	3.95	2.74	2.08	1.71	200.0	1543.8		0.0	16.9	3.62	284.5
-0.022	9,664	15.23	11.15	6.43	4.26	2.94	2.13	1.72	200.0	741.5	wet	0.0	15.6	4.30	255.7
-0.025	9,950	18.93	13.80	8.78	5.87	3.90	2.67	1.98	200.0	724.3	cure	0.0	12.0	2.42	186.4
Mean:		14.24	11.11	7.44	5.19	3.68	2.66	2.13	200.0	1647.1		0.0	13.6	3.93	243.4
Std. Dev:		3.34	2.14	1.43	1.02	0.71	0.46	0.33	0.0	729.6		0.0	2.5	1.91	49.5
Var Coeff(%):		23.44	19.30	19.17	19.56	19.35	17.31	15.43	0.0	44.3		0.0	18.6	48.60	19.8

Riverside 4% cement June 28, 2004

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.0)

District:		Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
County :					
Highway/Road:	Pavement:	0.50	200,000	200,000	H1: v = 0.38
	Base:	6.00	250,000	4,500,000	H2: v = 0.25
	Subbase:	0.00			H3: v = 0.00
	Subgrade:	161.64(by DB)	15,000		H4: v = 0.40

Dips 5-8

Dips ~~…~~ 1-4

	Station	Load (lbs)	R1	R2	R3	R4	R5	R6	R7	SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
			Measured Deflection (mils):							Calculated Moduli values (ksi):					
	9.000	9,815	16.75	13.41	8.52	5.52	3.53	2.32	1.86	200.0	1020.7	0.0	10.8	1.96	156.5
dry	25.000	8,806	23.09	17.78	10.65	6.62	4.11	2.58	2.11	200.0	466.4	0.0	8.3	1.26	143.0
	41.000	9,386	18.75	14.19	8.56	5.29	3.41	2.20	1.86	200.0	646.9	0.0	10.8	2.49	149.1
	57.000	9,271	21.02	16.48	9.92	5.96	3.81	2.68	2.10	200.0	574.8	0.0	9.3	3.49	169.9
	83.000	9,752	15.37	13.02	8.61	5.83	3.82	2.50	1.92	200.0	1404.0	0.0	10.2	1.72	152.7
	98.000	9,390	14.95	12.65	8.05	5.22	3.43	2.30	1.77	200.0	1220.9	0.0	10.7	2.96	169.6
Prime	111.000	9,942	16.75	12.97	8.32	5.39	3.57	2.27	1.69	200.0	1034.1	0.0	11.2	2.47	139.2
	127.000	9,414	13.15	10.94	7.34	5.06	3.52	2.44	1.90	200.0	1824.2	0.0	11.0	3.50	193.8
	150.000	8,981	11.23	9.27	6.45	4.49	3.12	2.12	1.70	200.0	2185.6	0.0	11.9	2.58	173.0
	167.000	9,279	11.12	9.70	6.89	4.80	3.29	2.22	1.71	200.0	2431.3	0.0	11.5	1.70	168.1
1day	182.000	9,390	10.18	9.03	6.51	4.63	3.25	2.24	1.71	200.0	3013.9	0.0	11.9	2.07	183.8
	195.000	10,300	11.30	10.32	7.50	5.33	3.70	2.50	1.92	200.0	3001.1	0.0	11.4	1.85	168.0
	213.000	9,692	13.26	11.36	7.95	5.70	3.97	2.66	2.04	200.0	2164.7	0.0	10.1	1.89	163.6
	225.000	10,447	11.20	9.72	7.04	5.15	3.59	2.41	1.94	200.0	3100.6	0.0	12.1	1.24	161.1
2day	237.000	8,723	14.54	12.50	8.56	5.97	4.00	2.69	2.16	200.0	1547.2	0.0	8.8	1.76	171.4
	250.000	9,509	22.04	12.01	8.20	5.68	3.92	2.67	2.04	200.0	367.0	0.0	12.2	14.15	179.1
	265.000	9,795	13.65	11.61	7.98	5.56	3.91	2.61	1.97	200.0	1967.6	0.0	10.4	2.53	162.1
	278.000	9,311	14.09	11.66	7.89	5.25	3.44	2.27	1.74	200.0	1457.0	0.0	10.7	1.43	157.4
3day	291.000	8,901	10.54	9.10	6.46	4.54	3.15	2.11	1.68	200.0	2498.4	0.0	11.6	1.64	162.2
	305.000	9,998	10.57	8.89	6.30	4.45	3.11	2.13	1.60	200.0	2836.4	0.0	13.3	2.28	176.7
	321.000	8,905	10.52	9.10	6.44	4.49	3.14	2.11	1.60	200.0	2488.8	0.0	11.7	1.93	164.6
wet cure	330.000	8,727	14.99	11.83	7.57	5.07	2.83	1.92	1.63	200.0	941.9	0.0	11.1	2.79	97.6
	341.000	8,731	15.01	12.09	7.33	4.75	3.10	2.03	1.59	200.0	945.8	0.0	11.1	3.32	153.7
	4195.000	9,521	18.46	14.48	8.97	5.82	3.63	2.28	1.56	200.0	785.0	0.0	10.2	1.48	136.2
dry	4208.000	9,350	16.63	13.13	8.09	5.70	3.89	2.60	1.94	200.0	1128.0	0.0	10.0	4.90	163.7
	4229.000	9,883	13.76	11.51	7.77	5.31	3.70	2.47	1.85	200.0	1801.1	0.0	11.0	2.85	162.3
	4246.000	10,061	14.10	12.21	8.45	6.00	4.19	2.77	2.10	200.0	2045.0	0.0	10.0	2.08	155.7
	4272.000	10,208	12.92	10.91	7.22	4.90	3.27	2.20	1.78	200.0	1839.8	0.0	12.5	2.44	166.1
Prime	4287.000	10,097	19.33	14.56	8.26	5.18	3.43	2.33	1.81	200.0	609.8	0.0	11.8	4.89	180.4
	4299.000	9,863	15.32	11.46	7.16	4.84	3.35	2.32	1.74	200.0	1203.2	0.0	12.2	6.28	192.1
	4313.000	9,756	21.00	13.82	7.57	4.67	2.96	2.00	1.59	200.0	348.6	0.0	13.2	2.22	152.6
	4344.000	9,732	13.98	10.50	6.80	4.77	3.36	2.34	1.91	200.0	1566.9	0.0	12.2	6.52	195.2
	4360.000	9,914	18.75	13.19	7.69	5.14	3.52	2.41	1.94	200.0	670.2	0.0	12.0	7.48	183.0
1day	4377.000	9,974	18.17	11.57	6.46	4.27	2.94	2.13	1.70	200.0	456.6	0.0	15.2	8.64	254.8
	4390.000	10,256	11.67	9.98	6.75	4.74	3.32	2.26	1.71	200.0	2425.9	0.0	12.7	3.07	172.5
	4405.000	9,640	14.25	11.57	7.40	4.98	3.41	2.24	1.80	200.0	1409.5	0.0	11.6	3.61	152.5
	4417.000	9,863	18.13	12.32	6.93	4.86	3.46	2.37	1.88	200.0	627.1	0.0	13.0	10.66	179.0
2day	4426.000	9,525	10.96	9.46	6.99	5.24	3.72	2.53	1.96	200.0	3182.3	0.0	10.8	1.35	170.8
	4440.000	9,907	11.19	9.66	6.92	5.07	3.56	2.47	1.91	200.0	2953.8	0.0	11.6	2.02	189.0
	4457.000	10,304	11.25	9.70	6.74	4.78	3.35	2.16	1.89	200.0	2649.4	0.0	12.8	1.89	139.5
	4472.000	10,260	13.81	11.23	7.08	4.90	3.29	2.29	1.81	200.0	1604.0	0.0	12.6	4.28	195.0
3day	4484.000	10,181	9.02	7.65	5.36	4.02	2.94	2.11	1.63	200.0	4034.1	0.0	14.7	4.27	224.4
	4495.000	10,010	11.56	9.84	6.95	5.10	3.57	2.41	1.86	200.0	2747.3	0.0	11.7	2.08	165.3
	4512.000	8,897	10.70	9.54	6.96	5.14	3.68	2.57	2.02	200.0	3035.7	0.0	10.1	2.01	197.9 *
moist	4525.000	9,811	10.61	8.69	5.93	4.24	2.93	2.07	1.67	200.0	2596.1	0.0	13.7	3.56	208.0
	4536.000	9,851	12.08	10.18	6.75	4.72	3.18	2.19	1.75	200.0	2046.9	0.0	12.5	2.81	183.6
	Mean:		14.39	11.45	7.48	5.11	3.46	2.34	1.83	200.0	1758.8	0.0	11.5	3.36	168.1
	Std. Dev:		3.55	2.09	1.00	0.53	0.33	0.21	0.16	0.0	941.2	0.0	1.4	2.57	26.1
	Var Coeff(%):		24.67	18.22	13.37	10.43	9.61	8.89	8.64	0.0	53.5	0.0	12.0	76.60	15.5

Riverside 8% Cement July 1, 2004

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.0)

District:
County :
Highway/Road:

	Thickness(in)	MODULI RANGE(psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	0.50	200,000	200,000	H1: v = 0.38
Base:	6.00	500,000	7,500,000	H2: v = 0.25
Subbase:	0.00			H3: v = 0.00
Subgrade:	215.22(by DB)	15,000		H4: v = 0.40

	Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	Calculated Moduli values (ksi): SURF(E1)	BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute ERR/Sens	Dpth to Bedrock
drops 5-8; Dry cure	0.005	9,620	12.28	11.10	8.24	6.24	4.67	3.30	2.53	200.0	3084.9	0.0	9.7	1.77	212.7
	0.008	9,215	12.57	10.89	8.07	5.83	3.98	2.93	2.41	200.0	2237.6	0.0	10.6	1.77	250.1
	0.011	9,068	18.02	14.18	9.57	6.54	4.53	3.26	2.68	200.0	1007.0	0.0	9.3	2.75	263.2
	0.014	9,088	16.52	13.23	8.99	6.18	4.48	3.12	2.49	200.0	1204.6	0.0	9.8	3.25	206.8
Prime	0.018	9,207	14.03	11.75	8.34	5.87	4.23	3.01	2.40	200.0	1758.7	0.0	10.4	2.39	231.3
	0.021	9,068	16.45	14.16	9.43	6.47	4.46	3.12	2.53	200.0	1186.5	0.0	9.4	2.31	214.7
	0.023	9,636	19.52	15.57	9.81	6.49	4.48	3.16	2.70	200.0	812.5	0.0	9.9	3.02	229.0
	0.026	9,223	17.48	13.70	9.19	6.28	4.39	3.07	2.54	200.0	1044.5	0.0	9.9	2.75	212.8
1day crack	0.031	9,803	11.51	9.98	7.27	5.30	4.03	2.86	2.33	200.0	2951.3	0.0	11.7	2.91	217.7
	0.033	9,593	11.20	9.74	7.06	5.14	3.84	2.76	2.28	200.0	2879.8	0.0	11.9	2.73	237.1
	0.035	9,060	11.14	9.34	6.65	4.84	3.57	2.61	2.20	200.0	2500.5	0.0	12.1	3.43	269.4
	0.037	9,871	10.34	9.16	6.35	4.66	3.45	2.43	2.02	200.0	2973.1	0.0	13.7	3.29	204.1
2 day crack	0.042	9,990	12.32	10.03	6.39	4.41	3.22	2.35	1.95	200.0	1691.4	0.0	14.8	5.22	265.4
	0.044	10,169	16.75	11.79	6.59	4.54	3.23	2.30	1.91	200.0	655.1	0.0	15.4	6.92	222.6
	0.046	9,283	11.32	9.70	6.68	4.70	3.40	2.38	1.91	200.0	2134.2	0.0	13.0	2.91	201.6
	0.049	9,736	9.55	8.30	5.78	4.21	2.96	2.20	1.90	200.0	2980.5	0.0	15.3	3.28	298.9
3day crack	0.052	8,905	10.83	8.69	5.82	4.13	2.94	2.07	1.70	200.0	1884.3	0.0	14.5	3.53	205.8
	0.055	9,533	9.71	8.27	5.78	4.13	2.97	2.05	1.67	200.0	2684.0	0.0	15.3	2.37	182.6
	0.057	9,005	11.06	8.79	5.84	4.01	2.82	1.95	1.62	200.0	1678.6	0.0	15.0	2.90	187.3
	0.059	9,295	13.67	9.80	6.23	4.15	2.84	1.94	1.63	200.0	993.2	0.0	15.3	4.03	177.9
wet cure	0.063	9,700	16.54	12.07	6.64	4.22	2.97	2.04	1.65	200.0	560.2	0.0	15.2	4.52	185.3
	0.064	9,108	17.29	10.93	6.75	4.52	3.07	2.10	1.74	200.0	515.3	0.0	14.3	6.86	181.0
	0.066	9,859	17.74	13.56	8.87	5.92	3.91	2.59	1.94	200.0	894.0	0.0	11.5	1.16	160.9
drops 1-4; Dry cure	0.005	8,866	14.48	12.16	8.52	6.13	4.70	3.43	2.76	200.0	1849.3	0.0	9.2	4.54	280.4
	0.007	8,866	11.40	10.27	7.54	5.48	4.09	2.94	2.43	200.0	2759.1	0.0	10.2	2.33	242.5
	0.010	8,866	10.67	9.69	7.71	6.05	4.63	3.27	2.63	200.0	4219.3	0.0	8.9	1.01	209.4
	0.013	8,886	14.60	12.76	9.04	6.62	4.94	3.46	2.78	200.0	1912.3	0.0	8.7	2.71	209.3
Prime	0.018	8,937	16.06	12.46	8.54	5.98	4.25	3.02	2.37	200.0	1221.9	0.0	10.1	3.78	231.9
	0.020	8,913	15.11	12.91	8.65	5.84	3.99	2.76	2.37	200.0	1228.2	0.0	10.3	1.92	199.5
	0.023	8,814	14.35	12.40	8.36	5.80	4.12	3.03	2.52	200.0	1483.7	0.0	10.0	3.42	300.0
	0.026	8,866	17.38	14.03	9.20	6.18	4.29	3.06	2.54	200.0	964.4	0.0	9.6	2.66	247.1
1 day crack	0.029	9,545	12.00	9.98	7.03	5.06	3.61	2.51	2.05	200.0	2149.0	0.0	12.6	2.21	193.2
	0.032	9,446	8.49	7.34	5.64	4.35	3.37	2.53	2.10	200.0	5359.9	0.0	13.0	2.71	300.0
	0.034	10,050	7.88	7.07	5.50	4.34	3.40	2.54	2.06	200.0	7012.3	0.0	13.5	2.00	299.8
	0.037	10,351	8.11	6.49	5.06	4.02	3.17	2.41	2.00	200.0	6680.6	0.0	15.2	4.91	300.0
2day crack	0.041	10,713	8.44	6.88	5.04	3.84	2.94	2.10	1.72	200.0	4751.6	0.0	17.7	4.38	214.9
	0.043	10,137	17.11	11.40	4.94	3.31	2.58	1.97	1.65	200.0	540.3	0.0	18.0	12.54	124.7 *
	0.045	10,145	9.82	7.49	5.17	3.74	2.76	2.02	1.70	200.0	2660.2	0.0	18.0	6.07	259.9
	0.047	10,006	9.89	7.57	5.01	3.63	2.70	1.93	1.72	200.0	2384.7	0.0	18.3	6.33	219.4
3day crack	0.052	10,129	7.65	6.26	4.55	3.41	2.59	1.87	1.61	200.0	4694.1	0.0	19.0	4.34	230.9
	0.054	10,260	8.11	6.94	5.09	3.66	2.65	1.98	1.64	200.0	4174.5	0.0	18.0	3.00	300.0
	0.056	8,953	8.48	7.44	5.33	3.91	2.85	2.04	1.69	200.0	3454.1	0.0	14.9	2.47	224.3
	0.058	9,573	10.01	8.31	5.76	4.11	2.98	2.08	1.69	200.0	2533.0	0.0	15.4	3.08	193.8
wet cure	0.061	9,120	11.70	9.91	6.70	4.51	3.08	2.07	1.63	200.0	1639.6	0.0	13.6	1.35	166.4
	0.063	10,276	10.61	9.08	6.26	4.48	3.23	2.22	1.80	200.0	2600.1	0.0	15.2	2.65	178.7
	0.064	10,018	11.45	10.28	5.96	4.33	3.15	2.23	1.76	200.0	1835.9	0.0	15.3	6.62	209.4
	Mean:		12.64	10.30	6.98	4.95	3.58	2.55	2.09	200.0	2357.0	0.0	13.1	3.55	221.7
	Std. Dev:		3.32	2.39	1.51	1.00	0.69	0.49	0.38	0.0	1523.9	0.0	3.0	2.00	43.1
	Var Coeff(%):		26.22	23.19	21.67	20.16	19.37	19.22	18.45	0.0	64.7	0.0	22.9	56.28	19.5