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FINAL REPORT

INVESTIGATION OF MATERIALS FOR THIN BONDED OVERLAYS ON BRIDGE DECKS

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16 Abstract

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The overlay materials selected by the Kansas Department of Transportation (KDOT) had promising results from laboratory testing. Four different overlay materials were selected based upon KDOT's laboratory results and were tested on four separate bridge decks. Three of the bridges are located in Greenwood County and one in Sedgwick County. All four bridges were new construction; the three in Greenwood County are pre-stressed concrete girder design and the Sedgwick County Bridge is a steel girder design. The data from the testing and monitoring were used to determine if there are benefits to using thin bonded overlays for bridge deck wearing surfaces and which types of thin bonded overlays have the largest benefits.

The materials chosen for the overlays were: Type IP cement concrete, Type IP cement with 3% silica fume concrete, Type I / II cement with 5% silica fume and polypropylene fibers concrete, and Type II cement with 5% silica fume and steel fibers concrete. Construction samples and bridge deck cores were tested for compressive strength, permeability, chloride concentration, overlay adhesion, and cracking resistance.

The permeability tests showed the overlays containing the Type IP cement were the least permeable while the steel and polypropylene fiber overlays were the most permeable. The Type IP cement overlays meet the design specification of passing less than 1,000 coulombs (1.5 inch thickness); however, the overlays with the fibers do not. The ability of each overlay to resist chloride ion migration will only truly be known as "in service" time accrues. Based upon the chloride ion contamination after five years, all overlays would appear to be functioning equally unless there is cracking in the overlay.

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Final Report

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A Report on Research Sponsored By

THE KANSAS DEPARTMENT OF TRANSPORTATION
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ABSTRACT

Bridges in Kansas are exposed to winter conditions, including deicing chemicals used to keep the roads and bridges clear of ice and snow. These chemicals and water are harmful to the concrete and the steel reinforcing bars used in bridge structures. The objective of this study was to develop a durable thin bonded overlay with chloride resistance to protect the reinforcing steel of the bridge deck. Overlays were developed and monitored after their initial placement on four bridges.

The overlay materials selected by the Kansas Department of Transportation (KDOT) had promising results from laboratory testing. Four different overlay materials were selected based upon KDOT's laboratory results and were tested on four separate bridge decks. Three of the bridges are located in Greenwood County and one in Sedgwick County. All four bridges were new construction; the three in Greenwood County are pre-stressed concrete girder design and the Sedgwick County Bridge is a steel girder design. The data from the testing and monitoring were used to determine if there are benefits to using thin bonded overlays for bridge deck wearing surfaces and which types of thin bonded overlays have the largest benefits.

The materials chosen for the overlays were: Type IP cement concrete, Type IP cement with 3% silica fume concrete, Type I / II cement with 5% silica fume and polypropylene fibers concrete, and Type II cement with 5% silica fume and steel fibers concrete. Construction samples and bridge deck cores were tested for compressive strength, permeability, chloride concentration, overlay adhesion, and cracking resistance.

The permeability tests showed the overlays containing the Type IP cement were the least permeable while the steel and polypropylene fiber overlays were the most permeable. The Type IP cement overlays meet the design specification of passing less than 1,000 coulombs (1.5 inch thickness); however, the overlays with the fibers do not. The ability of each overlay to resist chloride ion migration will only truly be known as "in service" time accrues. Based upon the chloride ion contamination after five years, all overlays would appear to be functioning equally unless there is cracking in the overlay.

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CHAPTER 1 - INTRODUCTION

1.1 Problem Statement

While passenger and commercial travel on highways has increased dramatically in the past 10 years, the United States has been seriously under investing in needed road and bridge repairs, even failing to maintain the substandard conditions currently existing. This is a dangerous trend that is affecting highway safety as well as the health of the economy (Turner, 1999). According to the FHWA, of the nation's 581,862 bridges, 182,726 (31.4%) are rated structurally deficient or functionally obsolete (Turner, 1999). A structurally deficient bridge is closed or restricted to light vehicles because of its deteriorated structural components (Turner, 1999). Substandard road and bridge design, pavement conditions, and outdated safety features are a factor in 30% of all fatal highway accidents according to the FHWA (Turner, 1999).

In 1994, the Kansas Department of Transportation (KDOT) researched new overlay materials for bridge decks that would increase the life span of the structure, be more impermeable to corrosive chlorides, have better safety properties, and be easier to install. New overlay designs would allow bridges to be upgraded; thereby, helping to resolve the problems with the United States and Kansas infrastructure.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, Section 6005 established the Applied Research and Technology (ART) Program which included the Thin Bonded Overlay and Surface Lamination (TBO) Program. The program was established to assess the state of technology with respect to thin bonded overlays and surface lamination of pavement and to assess the feasibility of costs and benefits associated with the repair, rehabilitation, and upgrading of highways and bridges with overlays. Such projects shall be carried out so as to minimize overly thickness, initial construction costs, and time out of service, and maximize lifecycle durability.

The KDOT was granted federal funding in accordance with ISTEA Section 6005 (TBO) in 1995 to study thin bonded overlays on four bridges.

1.2 Scope of Study

The objective of this study was to develop a durable thin bonded overlay with chloride resistance to protect the reinforcing steel of the bridge deck. Overlays were developed and monitored after their initial placement on the bridge.

The data from the testing and monitoring were used to determine if there are benefits to using thin bonded overlays for bridge deck wearing surfaces and which types of thin bonded overlays have the largest benefits.

Four different overlay materials were selected based upon KDOT's laboratory results and were tested on four separate bridge decks. Three of the bridges are located in Greenwood County and one in Sedgwick County. All four bridges are new construction; the three in Greenwood County are pre-stressed concrete girder design and the Sedgwick County Bridge is a steel girder design.

The materials chosen for the overlays were: Type IP cement concrete, Type IP cement with 3% silica fume concrete, Type I / II cement with 5% silica fume and polypropylene fibers concrete, and Type II cement with 5% silica fume and steel fibers concrete. Construction samples and bridge deck cores were tested for compressive strength, permeability, chloride concentration, overlay adhesion, and cracking resistance.

1.3 Background

Thin bonded overlays are designed to provide a durable, cost effective wearing surface with low permeability to water and chlorides and to minimize the amount of “out of service” time during placement. The surface should withstand the anticipated traffic without cracking or debonding and exhibit appropriate skid resistance for improved safety.

Bridges in Kansas are exposed to winter conditions, including deicing chemicals used to keep the roads and bridges clear of ice and snow. These chemicals and water are harmful to the concrete and the steel reinforcing bars used in bridge structures. Minimizing the permeability and eliminating cracks in the concrete wearing surface will maximize the life of the overlay as well as the bridge itself.

The overlay materials selected by the KDOT had promising results from laboratory testing. Those materials included pozzolan cement (IP), micro-silica (condensed silica fume), polypropylene fibers, and steel fibers.

The use of Type IP cement (portland-pozzolan) decreases the permeability and helps to reduce damaging alkali-silica reactions that occur between alkali reactive aggregates and the cement used. This reaction creates an expansive gel which breaks down the concrete thereby decreasing the strength and life of the concrete.

The use of silica fume has been shown to create very low permeability to chloride and water intrusion, extremely high electrical resistivity (20 to 100 times greater than ordinary concrete), high compressive strengths (8,000 to 18,000 psi), and increased abrasion resistance (Norchem).

Polypropylene fibers and steel fibers reduce the amount of plastic shrinkage cracking and increase the impact resistance. Steel fibers can also add additional strength to the concrete just as the reinforcing steel does.

CHAPTER 2 - RESEARCH

KDOT research in 1994 included the use of steel and polypropylene fibers in concrete. Four concrete mix designs for fiber concrete were developed and tested. They consisted of a control mix containing no fibers, a mix with polypropylene fibers, and two mixes with steel fibers. The difference between the two steel fiber mixes was the aggregate used; one contained an aggregate gradation that was specified by the supplier of the steel fibers, and the other aggregate gradation was a KDOT standard gradation.

Compression and flexural strength tests were run on the samples. The results indicated the steel fiber concrete specified by KDOT had the largest compressive and flexural strength. Table 2.1 summarizes the results of this research. Additional details can be found in Appendix A.

TABLE 2.1: Summary of the 1994 Research

Mix Material	Average First Crack Beam Load (psi)	Average Compressive Strength (psi)
No Fibers	2270	6,120
Polypropylene Fibers	2850	5,690
Steel Fibers with KDOT Mix	2,950	6,760
Steel Fibers with Dramix Mix	2510	5,050

*Maximum Load

** First Crack Load

KDOT applied for and was granted federal funding in accordance with ISTEA Section 6005 (TBO) in 1995 to study thin bonded overlays on four bridges. KDOT then commenced research on experimental overlay concrete mixes with materials such as Silica Fume, Type IS (slag), Type IP, and Type I/II cements, Steel Fibers and Polypropylene Fibers. Nine different concrete mixes were batch mixed and four test cylinders from each mix were taken for lab testing. Three cylinders were used for 28 day compressive tests and one cylinder was used for 28 and 56 day chloride ion permeability tests and Kansas water permeability tests.

The research data from the experimental mixes shows that all had 28 day compressive strengths over 5,100 psi. (Table 2.2). The mixes of Type II cement with 5% silica fume and steel fibers and the Type IP cement having the greatest compressive strengths. The mixes with Type IS cement tended to have the lowest compressive strengths of the mixes tested.

The research data also shows that the mixes with Type IP cement with 3% silica fume and the plain Type IP cement have very low permeability, the mixes with the polypropylene fibers have low permeability and the mixes with the steel fibers have high permeability based upon the Rapid Chloride Permeability (RCP) Test at 56 days (AASHTO T 277). This test produced misleading results for mixes with the steel fibers due to the applied voltage potential and measurement of total charge passed.

KDOT attempted to get comparative permeability values for the steel fiber mixes and other mixes by using the Kansas Water Permeability Test. These tests indicated that the permeability of the steel fiber with silica fume concrete had Kansas Water Permeability results that were near those of the other concrete mixes used. No correlation between the Kansas test and the Rapid Chloride Permeability test was attempted. See Table 2.2 for tabulation of strength and permeability tests.

TABLE 2.2: Summary of the 1995 Test Results for Selected Overlays

Sample Material	28 Day Compressive Test (psi)	28 Day RCP Test (coulombs)	56 Day RCP Test (coulombs)	56 Day Kansas Water Permeability Test (cm/hr)
Type IP with 3% silica fume	6,930	873	325	N/A
Type IP cement	6,980	975	525	0.0122
Type II with 5% silica fume and steel fibers	7,080	N/A	N/A	0.0189
Type I / II with 5% silica fume and polypropylene fibers	5,850	1,750	1,366	0.0157

The laboratory test results were analyzed and the four experimental overlay design specifications were developed. The materials for the overlays chosen were: Type IP cement concrete, Type IP cement with 3% silica fume concrete, Type I/II cement with 5% silica fume and polypropylene fibers concrete, and Type II cement with 5% silica fume and steel fibers concrete. It should be noted that Type IS (blast furnace slag) cement concrete was included in the original request as an experimental overlay and subsequently approved by the FHWA. Ground granulated blast furnace slag was not available when placement of the overlay occurred; therefore, the overlay project requirements were changed to Type IP cement with 3% silica fume concrete. The four selected mix design specifications are located in Appendix B.

The overlays are designed to have a life of 20 to 25 years, a bond strength of 250 psi or greater, a compressive strength of at least 5,000 psi, and a permeability of less than 1,000 coulombs.

2.1 Shrinkage

Cracking is a major problem in concrete because it reduces the integrity, durability, and aesthetic appearance of the structure. Concrete shrinkage can be a significant source of cracking; therefore, it must be controlled in order to avoid excessive distress. KDOT investigated the Proposed Standard Method for Testing Cracking Tendency of Concrete in early 1997. The procedure is intended to determine the time to cracking of restrained concrete mixes on a comparative basis. The method could be useful for determining the relative likelihood of early concrete cracking and for aiding in the selection of concrete mixtures that are less likely to crack. The test can also be modified to evaluate other factors that affect cracking such as curing time, curing method, evaporation rate or temperature.

KDOT constructed the Initial Crack Test Equipment as developed by Wiss, Janny and Elstner Associates, Inc. to test the overlay materials for resistance to cracking. The apparatus included a base upon which a piece of 12 inch diameter pipe, 6 inches long with a 0.375 inch wall thickness was placed on end to form the 12.8125 inch ID of the concrete ring to be tested. A piece of 0.25 inch thick Plexiglas was used to form the 18 inch OD of the concrete ring. The top opening was covered with a 0.25 inch thick Plexiglas plate to control evaporation, temperature, etc. Strain gages were mounted to the pipe ID at 90 degree intervals to allow a computer and associated software to gather stress levels in the pipe to determine when the concrete first cracked (loss of stress in the pipe).

The testing performed with this equipment did not produce data that indicated a “first crack” with any confidence. The mixes and conditions were modified so as to make sure the concrete would develop a crack; however, the equipment did not detect any cracking but did detect the shrinkage of the concrete. The measured shrinkage was not enough to induce cracking.

2.2 Field Application

The four experimental overlays were placed on newly constructed bridge decks. Bridges #60, #61 and #62 in Greenwood County on Highway 96 (now Highway 400) and bridge #445 on Highway 254 in Sedgwick County were used for the experimental applications. The KDOT Special Provisions (specifications) and mix designs are in Appendix B, and the Concrete Field Measurement Data is in Appendix C.

2.3 Greenwood County Bridge #60

The overlay placed on bridge #60 was 1.5 inch thick Type IP cement with 3% silica fume concrete. The sub-deck surface was prepared for placement of the overlay by sandblasting to remove all dirt, oil and other foreign material, unsound concrete, laitance, and curing material and followed up with an air blast. The deck surface was saturated and covered wet burlap and polyethylene sheet to maintain a moist condition until placement of the overlay. Concrete trucks were backed onto the sub-deck with the polyethylene / burlap covering to prevent contamination of the prepared surface. The polyethylene / burlap cover was removed one sheet at a time, between the rear of the concrete truck and the overlay placement operation, as the overlay operation moved along the bridge deck. A thin cement and silica fume grout was applied to the exposed sub-deck immediately in front of the concrete placement operation. Care was taken to prevent the silica fume grout placement from extending too far out in front of the overlay operation.

The concrete placement machine used by the contractor was one with a vibrating drum roller. The edges of the deck were finished with a vibrating tamper.

The overlay was placed in two halves, the north half was placed on May 12, 1997 and the south half on May 5, 1997. All construction, finishing, tining and curing procedures, including the standard 7 day wet burlap cure, complied with KDOT Special Provisions 90P-158-R4 and 90P-4248.

The placement process went smoothly, and the overlay mix exhibited good workability. The 3% mix was more workable than the 5% silica fume overlay mix, which KDOT typically used. The 5% mix has a tendency to pull and tear during finishing, but the 3% mix did not exhibit those characteristics. The density test results were low on the south half (second pour), and this could have been due to the finishing methods used along the longitudinal joint. The percent air content was consistently low for both halves, and this could have been due to testing after the plasticizing agent was added; plasticizer can have an effect on the air content.

2.4 Greenwood County Bridge #61

The overlay placed on bridge #61 was 1.5 inch thick Type IP cement concrete. The subdeck preparation and the placement of this overlay were the same as used on Greenwood County Bridge #60.

The overlay was placed in two halves, the south half was placed on May 22, 1997 and the north half on May 29, 1997. All construction, finishing, tining and curing procedures complied with KDOT Special Provisions 90P-95-R3 and 90P-4248.

There was difficulty in keeping the air content within the specified limits on the south half of the overlay. The air content of the third truck was 1% and the fourth truck was 3.7%. The air content for the north half all fell within specified limits. This material was “stickier” than the overlay material used on Bridge #60, which created greater difficulty with the finishing processes.

2.5 Greenwood County Bridge #62

The overlay placed on bridge #62 was 1.5 inch thick Type II cement with 5% silica fume and steel fibers concrete. The steel fibers were incorporated as an aggregate by modifying a 50/50 aggregate mix design to a 48.5%-48.5%-3% fine aggregate / coarse aggregate / fiber mix. The sub-deck preparation and the placement of this overlay were changed from those used on Bridges #60 and #61. KDOT research had shown the use of grout to be less beneficial than once believed and in some cases even decreased the quality of the bond between the overlay and the sub-deck. Therefore, grout was not used on this bridge deck. The deck was cleaned by sandblasting and air blasting as before, but then was saturated by soaker hoses before the placement of the overlay. The soaker hoses were placed underneath the polyethylene / burlap covering and left on overnight prior to the placement. This action created a saturated surface dry condition on the sub-deck during placing of the overlay to enhance the bond.

A 4.0 cubic yard test batch was mixed prior to the placement of the overlay, as per KDOT Special Provision 90P-4239. The test batch indicated that the mix containing the steel fibers was much less workable and harder to finish than other concrete mixes. Superplasticizer was used to increase the slump and workability, but caused the air content to decrease.

The overlay was placed in two halves, the north half was placed on June 23,1997 and the south half on June 25,1997. All construction, finishing, tining and curing procedures complied with KDOT Special Provisions 90P-158-R4 and 90P-4239.

Overall, the overlay mix with steel fibers placed on Bridge #62 was very difficult to keep within specifications and had very poor workability, and a quality finish was difficult to obtain. The steel fibers were thoroughly distributed throughout the mix. Adding plasticizer to increase slump and workability caused the air content to decrease; thereby, creating the need to add additional air entraining admixture. A slump of less than 4 inches caused the surface to “tear” when finishing. The slump was allowed to exceed specifications to allow for good bonding and a quality finish. Adding vibrators to the drum roller screed did not improve the finishing process; however, adding a vibrator to the float did help. The south half of the bridge deck did not appear to be saturated with water prior to the start of the placement, although the contractor claimed to have run the soaker hose overnight.

2.6 Sedgwick County Bridge #445

The overlay placed on bridge #445 in was a 1.5 inch thick Type I / II cement with 5% silica fume and polypropylene fibers concrete. The sub-deck preparation and the placement of this overlay were the same as used on Greenwood County Bridges #60 and #61.

The overlay was all placed in a single on May 5, 1997. Pump trucks were used to place the concrete on the bridge deck, working from west to east. The grout was misted and finishing aid was applied to prevent it from drying prior to the overlay placement. All construction, finishing, tining and curing procedures complied with KDOT Special Provisions 90P-158-R4 and 90P-4258.

The overlay mix was easy to place, workable and easy to finish. The polypropylene fibers did not decrease the workability of the mix.

2.7 General Notes

The contractor had difficulty keeping the percent air content within the specification range for the overlays on the Greenwood County bridges. The specified slump was too low on the steel fiber mix for a quality finish. A vibrating drum roller or vibrating screed should be used for improving the finishing process, except that a vibrating float worked better with the steel fiber mix. The environmental conditions were good for all four overlay placements with the evaporation rate less than 0.12 lb./sq. ft./hr. at all times.

Greenwood County Bridge #61 had a 12 square yard area of delamination in the eastbound lane along the shoulder that was removed and replaced. This delamination was caused by non-thorough cleanup of oil spillage on the sub-deck prior to placement.

Sedgwick County Bridge #445 had approximately eight square feet of delamination on the east end of the passing lane which was probably due to delays in placement at the end of the structure.

CHAPTER 3 - RESULTS OF FIELD DATA

Samples taken during construction and bridge deck cores taken between 14 and 70 days after overlay placement were tested for compressive strength, permeability, chloride concentration and overlay adhesion. The chloride concentration levels from testing of the deck cores will serve as the baseline levels for the overlay and the bridge sub-deck. The initial crack survey of the bridge decks was completed roughly 3 years after the overlay placement. Another crack survey was completed, and additional chloride samples were taken from the bridge decks 5 years after placement. The electrical half-cell potential tests were not performed due to the use of fusion bonded epoxy coated reinforcing steel in the bridge decks. Detailed test results of the field samples and the crack surveys are in Appendix D.

3.1 Compressive Strength

The compressive strength of the overlay materials placed on the bridges was 5,900 psi or greater. The mix containing Type IP cement with 3% silica fume and the Type IP cement mix overlay strengths were 6,900 and 6,600 psi, respectively, and comparable to the laboratory results. The steel fiber mix had a compressive strength of 5,900 psi which is 17% less than the lab results, and the polypropylene fiber mix had a compressive strength of 8,590 psi. which was 47% greater than the lab results. The field test results indicate the polypropylene fiber mix had the greatest compressive strength of the four overlays, and the steel fiber mix had the least; exactly opposite of the laboratory results. The difficulties meeting the mix specifications and the problems encountered when placing the steel fiber overlay, may have contributed to the lower field strength of this mix. The overlay compressive strength test results are shown in Table 3.1.

TABLE 3.1: Overlay Compressive Strength

Location	Overlay Material	7 Day (psi.)*	28 Day (psi.)*
Greenwood County Bridge #60	Type IP with 3% silica fume	4,870	6,900
Greenwood County Bridge #61	Type IP cement	4,590	6,600
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	4,140	5,900
Sedgwick County Bridge #445	Type I / II with 5% silica fume and polypropylene fibers	6,040	8,590

* Average values

3.2 Chloride Ion Permeability

The samples taken during overlay placement and the bridge deck cores obtained later were tested for chloride permeability by using the Rapid Determination of the Chloride Permeability of Concrete Test (RDCP) (AASHTO T 277).

The overlay from the core sample will give the best indication of the actual permeability of the overlay. The mixes with the Type IP cement have the lowest permeability (395 & 562 coulombs) and the polypropylene fiber mix the highest (2,124 coulombs). The Type IP cement overlay cores have less permeability than the placement samples; but the polypropylene fiber core samples have more permeability than the placement samples. The placement and finishing process and/or curing technique may have contributed to these differences. This field data is consistent with the results obtained from the laboratory research. The polypropylene fiber mix was much less permeable in the research test than the field tests (1,366 to 2,124 coulombs).

The RDCP test generally produces misleading results for mixes with steel fibers due to the applied voltage potential and measurement of total charge passed; therefore, the overlay with the steel fibers was not tested with this method. Table 4.1 gives the average results of the RDCP test.

TABLE 3.2: Overlay Chloride Ion Permeability by RDCP *

Location	Overlay Material	28 Day	56 Day	56 Day Core
Greenwood County Bridge #60	Type IP with 3% silica fume	1,194	798	395
Greenwood County Bridge #61	Type IP cement	2,240	945	562
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	N/A	N/A	N/A
Sedgwick County Bridge #445	Type I / II with 5% silica fume and polypropylen fibers	2,737	1,885	2,124

* Average permeability measured in coulombs (1.5” thick sample)

The following table is from AASHTO T277 and gives an indication of “Chloride Permeability Based on Charge Passed” for a 2” thick permeability sample:

Charge Passed (coulombs)	Chloride Permeability
>4,000	high
2,000-4,000	moderate
1,000-2,000	low
100-1,000	very low
<100	negligible

The permeability sample thickness used for the testing on this project was generally around 1.5 inches thick, since the overlay thickness was specified to be 1.5 inches. All data was converted to an equivalent thickness of 1.5 inches for this report. The AASHTO table above lists categories for permeability based upon a 2 inch thick permeability sample; therefore, the 1.5 inch thick permeability sample data listed above must be converted to an equivalent 2 inch thick permeability sample to use the table. Abou-Zeid, Meggers and McCabe with assistance from the KDOT, Materials &

Research Center, have proven the conversion is not linear; however, the linear equivalent will be conservative according to their research (Abou-Zeid et al.).

After linear conversion, the Type IP cement with silica fume overlay is categorized as “very low”, the Type IP cement overlay is also “very low” and the silica fume & polypropylene fibers overlay is categorized as “low”. After conversion, both the placement sample average and the overlay core average results from each type of overlay end up in the same AASHTO permeability category.

3.3 Kansas Water Permeability Test

The KDOT attempted to get comparative permeability values for the Type IP, Type IP with silica fume, Type I/II with 5% silica fume and polypropylene fibers, and Type II with 5% silica fume and steel fibers concrete mixes by using the Kansas Water Permeability Test as in the 1995 laboratory research. Again, the test results did not correlate to the RDCP results as the Type IP cement concrete had the highest permeability, followed by the Type IP cement with silica fume, the Type II cement with silica fume & steel fibers and Type I / II with the silica fume & polypropylene fibers as the least permeable. The RDCP results indicate the Type I/II cement with silica fume & polypropylene fibers are the most permeable of the three overlays tested, exactly opposite of this test. Therefore, these Kansas Water Permeability Test results must be considered inconclusive. Table 3.3 gives the average values obtained from the test.

TABLE 3.3: Kansas Water Permeability

Location	Overlay Material	Permeability *
Greenwood County Bridge #60	Type IP with 3% silica fume	0.013587
Greenwood County Bridge #61	Type IP cement	0.019457
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	0.011907
Sedgwick County Bridge #445	Type I/II with 5% silica fume and polypropylene fibers	0.009033

* Average permeability in cm/hr

3.4 Chloride Ion Content Test

Samples for the baseline chloride ion content tests were obtained from bridge deck cores taken within the first 70 days after the overlay placement. The baseline will be compared to future chloride contamination levels to determine which overlays offer the greatest protection against chloride migration into the bridge subdeck. The baseline values of the subdeck are well below the threshold of 1.01 lb/yd^3 of chloride ion required to start the reinforcing steel corroding process. The samples for the follow-up chloride ion content test were collected on September 17 and 18, and December 18, 2002. They were obtained by using a vacuum drill with a hollow bit.

The amount of chloride found in the overlay material during the follow-up investigations in September and December of 2002 is generally higher than what would be expected for a five year old overlay. The spring, summer and fall months prior to the sample dates were drier than normal (less rainfall) and possibly contributed to increased chloride levels.

The overlay chloride ion levels from the top surface of the deck to a depth of 0.75 inches were as follows (range includes samples taken on cracks – average does not include samples taken on cracks):

- Greenwood County Bridge #60 ranged from 1.60 to 3.46 lb/yd^3 for an average of 2.63 lb/yd^3
- Greenwood County Bridge #61 ranged from 1.79 to 4.25 and averaged 2.90
- Greenwood County Bridge #62 ranged from 0.24 to 5.26 and averaged 2.34; however, Bridge #62 was sampled to a depth of 1.25 inch due to miss-reading the depth gauge
- Sedgwick County Bridge #445 ranged from 4.99 to 11.43 and averaged 6.56

The overlay chloride levels from a depth of 0.75 inches to 1.5 inches were as follows (range includes samples taken on cracks – average does not include samples taken on cracks):

- Greenwood County Bridge #60 ranged from nil to 1.70 lb/yd^3 (11 of 18 samples were nil) for an average of 0.32 lb/yd^3
- Greenwood County Bridge #61 ranged from nil to 1.10 lb/yd^3 (11 of 18 samples were nil) and averaged 0.24 lb/yd^3
- Greenwood County Bridge #62 was sampled from a depth of 1.25 inches to 2 inches due to miss-reading the depth gauge; therefore, the test is invalid as both the overlay and subdeck were sampled
- Sedgwick County Bridge #445 ranged from 0.34 to 5.51 lb/yd^3 and averaged 0.84 lb/yd^3

The subdeck chloride levels from a depth of 1.5 inches to 2.25 inches were as follows (range includes samples taken on cracks – average does not include samples taken on cracks):

- Greenwood County Bridge #60 ranged from nil to 1.06 lb/yd^3 (14 of 18 samples were nil) for an average of 0.15 lb/yd^3
- Greenwood County Bridge #61 ranged from nil to 0.91 lb/yd^3 (13 of 18 samples were nil) and averaged 0.10 lb/yd^3
- Greenwood County Bridge #62 reported all 18 samples as nil; however, Bridge #62 was sampled from a depth of 2.0 inches to 2.75 inches due to miss-reading the depth gauge
- Sedgwick County Bridge #445 ranged from nil to 5.17 lb/yd^3 (2 of 18 samples were nil) and averaged 0.44 lb/yd^3

The chloride contamination went deeper when samples were taken on cracks in the overlay, as would be expected. Greenwood County Bridge #60 had two locations where the chloride level was 1.01 lb/yd^3 or more at the 2.25 inch depth, both on cracks. Greenwood County Bridge #61 had one location with a chloride level of 0.91 lb/yd^3 at the 2.25 inch depth. Sedgwick County Bridge #445 had four locations where the chloride level was 1.01 lb/yd^3 or more at the 2.25 inch depth, three of which were on cracks. The chloride levels of two other locations were 0.67 and 0.84 lb/yd^3 at the 2.25 inch depth. Otherwise, at all other sample locations contamination was less than 0.34 lb/yd^3 at the 2.25 inch depth for all the bridges.

Based upon the chloride ion contamination after five years, all overlays would appear to be functioning equally unless there is cracking in the overlay. Sedgwick County Bridge #445 has a higher concentration of chlorides at each depth sampled. This bridge is in an urban area and may get more deicing salt applied than the rural Greenwood county bridges. A summary of the average chloride ion contents found in the overlay materials and bridge sub-decks is provided in Table 3.4.

TABLE 3.4: Chloride Ion Content (Averages in lb/yd^3)

		Overlay		Sub Deck		
Location	Overlay Material	Baseline	2002*	2002**	Baseline	2002***
Greenwood County Bridge #60	Type IP with 3% silica fume	0.29	1.56	0.19	0.23	0.09
Greenwood County Bridge #61	Type IP cement	NIL	1.72	0.14	Trace	0.06
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	0.20	1.39♦	NA	0.18	NIL
Sedgwick County Bridge #445	Type I / II with 5% silica fume and polypropylene fibers	0.27	3.89	0.50	0.18	0.26

* 0 inch to 0.75 inch depth
** 0.75 inch to 1.5 inch depth
*** 1.5 inch to 2.25 inch depth
♦ 0 inch to 1.25 inch depth rather than 0 inch to 0.75 inch

3.5 Pull-Off Test

Pull-off tests were conducted on the bridge deck overlays within the first 70 days after the overlay placement. This test is to determine the strength of the bond between the overlay and the bridge sub-deck (overlay adhesion). The weak area is usually in the bond between the overlay and the bridge sub-deck; occasionally, the break will occur in the overlay or the bridge sub-deck. The majority of the samples broke at the bond interface between the overlay and sub-deck. The bond strength for the three grouted overlays was very consistent, ranging from 160 ~ 165 psi. The overlay where grout was not used had 50% greater bond strength (241 psi). The pull-off test results are listed in Table 3.5.

TABLE 3.5: Pull-off Strength

Location	Overlay Material	Grout	Force (lbs.)*	Unit Strength (psi)*
Greenwood County Bridge #60	Type IP with 3% silica fume	Yes	520	165
Greenwood County Bridge #61	Type IP cement	Yes	503	160
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	No	758	241
Sedgwick County Bridge #445	Type I / II with 5% silica fume and polypropylene fibers	Yes	520	165

* Average values

Grout was not used between the overlay and the subdeck on Greenwood County Bridge #62; however, the bond strength was greatest on this bridge. Recall that all four of the bridges used for this project were new at the time of the overlay placement. Previous research done by Dave Meggers, KDOT, has shown that grout typically has a negative effect on the strength of the overlay bond when the overlay includes silica fume (Abou-Zeid et al.). The results of this test also indicate that using grout with a silica fume overlay decreased the bond strength.

3.6 Crack And Surface Survey

Crack surveys on the four bridges were taken by the KDOT in April 2000, almost three years after the overlays were placed (May & June 1997) and again in September / December 2002, five years after placement. These surveys show where cracks have developed on the bridge deck. Three of the four bridges showed cracking in the overlay.

Greenwood County Bridge #60 had the most cracks and about 50% of the surface showed scaling or loss of surface paste in the year 2000, increasing to 70% in 2002 with the westbound lane worse. The majority of the cracking was located eleven feet on either side of the centerline. The cracks appear to be shrinkage cracks and show up more in the traffic lanes than the shoulder. There is an area at the east end, south of the centerline that was map cracked 8 inches center to center. There is approximately 30% more length of cracking in 2002 than 2000; some are new cracks and some is lengthening of the existing cracks.

Greenwood County Bridge #61 had very little cracking, and those were generally within eleven feet either side of the centerline with the majority on the north side in the year 2000. In 2002, there is still very little cracking with approximately twice the length of cracking as 2000, most of which are new cracks. The cracks are still generally within eleven feet either side of the centerline, but now nearly equal on each side of the centerline. Most of the surface also had scaling with the westbound lane worse, 25-35% was shrinkage cracked in 2000 (increased to 50-60% in the traffic lanes and 10-20% on the shoulders in 2002), and there were longitudinal cracks at each end of the bridge. There was a concrete patch along the south edge approximately 210 feet from the west end (note that this area was patched prior to the bridge being put into service due to debonding of the overlay).

Greenwood County Bridge #62 had no visible cracks in the years 2000 or 2002. The surface had ± 25 (increasing to ± 50 in 2002) steel fibers exposed per square foot, 70% of the surface was worn to expose the aggregate in 2000, and it looked ugly due to the corrosion of the steel fibers at the surface. In 2002, the tining has nearly all worn away, and 3-5 fibers are missing per square foot. The traffic lanes are 80% shrinkage cracked (barely visible) and have 80-85% exposed aggregate. The westbound shoulder is 20% shrinkage cracked (barely visible) and has 95% exposed aggregate with some areas scaled to a depth of 0.385 inch. The eastbound shoulder is 20% shrinkage cracked (barely visible) and has 85-90% exposed aggregate and some scaling but not as deep as the westbound shoulder. Overall, the overlay surface performance is not acceptable.

Sedgwick County Bridge #445 had very little cracking, and those were generally within eleven feet either side of the centerline in the year 2000. In 2002 there is still very little cracking, a few new cracks and some lengthening of existing, and still generally within eleven feet of the centerline. The west one third of the deck is scaling to some extent and is shrinkage cracked (barely visible) in 2002. The majority of the cracks are transverse cracks. There are some longitudinal cracks at each end of the bridge. The west end of the bridge had two small concrete patches, and the east end had three small concrete patches.

The crack & surface surveys are located in Appendix D.

3.7 COST OF OVERLAY

The unit cost to install each type of overlay material was basically the same compared on an apples to apples basis. However, the actual unit cost of the silica fume and polypropylene fiber overlay was significantly less than the other three materials tested as can be seen in Table 3.6.

TABLE 3.6: Cost of Overlay

Location	Overlay Material	Material (yd^2)	Rate ($\$/yd^2$)	Total Cost	Total (ft^2)	Unit Cost ($\$/ft^2$)
Greenwood County Bridge #60	Type IP with 3% silica fume	1,276	30	$38,28	11,000	3.48
Greenwood County Bridge #61	Type IP cement	1,460	30	$43,80	12,584	3.48
Greenwood County Bridge #62	Type II with 5% silica fume and steel fibers	1,127	32	$36,06	9,680	3.72
Sedgwick County Bridge #445	Type I / II with 5% silica fume and polypropylene fibers	1,118	26	$29,06	9,920	2.93

The location of Sedgwick County Bridge #445 is near a major urban area compared to the other three bridges and might be the reason the contract rate to install the overlay is less, resulting in the lower unit cost. Assuming a rate of \$32 per yd^2 for Sedgwick County Bridge #445, would result in a total cost of \$35,776 and a unit cost of \$3.61 per ft^2 for an apples to apples comparison. The experimental nature of adding fibers to the overlay mix resulted in anticipated additional costs for the fibers, placement and finishing.

The unit costs vary from \$3.48 to \$3.72 per ft^2, using the apples to apples comparison above, for an additional 7% to add fibers to the overlay. The cost for a typical KDOT Type I / II cement with 5% silica fume concrete overlay is generally \$3.48 per ft^2. Therefore, to install an overlay with the materials in this study, would increase the overlay cost up to 7%.

CHAPTER 4 - CONCLUSIONS

The overlays all had compressive strengths greater than 5,900 psi, and all meet the design specification of at least 5,000 psi.

The permeability tests showed the overlays containing the Type IP cement were the least permeable while the steel and polypropylene fiber overlays were the most permeable. The Type IP cement overlays meet the design specification of passing less than 1,000 coulombs (1.5 inch thickness); however, the overlays with the fibers do not.

The ability of each overlay to resist chloride ion migration will only truly be known as “in service” time accrues. Based upon the chloride ion contamination after five years, all overlays would appear to be functioning equally unless there is cracking in the overlay. Chlorides have penetrated deeper into the deck at crack locations, as would be expected, and therefore, Greenwood County Bridge #60 is most likely to suffer from chloride attack based upon the number of cracks and level of contamination in the year 2002.

Grouting between the subdeck and the overlay had negative effects on bond strength in this study. The one overlay that did not use a bonding grout, had a significantly higher bond strength than the other three that did use a grout (241 psi vs. 163 psi (average value)).

Greenwood County Bridge #62 with the steel fibers had virtually no cracks, but the surface was almost entirely exposed aggregate. Sedgwick County Bridge #445 with the polypropylene fibers had minimal cracking and surface damage followed by Greenwood County Bridge #61 and Bridge #60. Based upon surface appearance and the amount of cracking after 5 years of service, Sedgwick County Bridge #445 might have the longest service life.

Greenwood County Bridge #62 was the most costly overlay at \$3.72 per ft^2 and Sedgwick County Bridge #445 the least costly at \$2.93 when comparing actual dollars spent. With the adjusted apples to apples basis, Greenwood County Bridges #60 and #61 were the least costly at \$3.48 since the adjusted cost of Sedgwick County Bridge #445 is \$3.61. The cost for a typical KDOT Type I / II cement with 5% silica fume concrete overlay is generally \$3.48 per ft^2. Therefore, to install an overlay using the fiber materials in this study, would increase the overlay cost up to 7%.

4.1 Ending Remarks

4.1.1 Five years after overlay placement

The KDOT commonly uses 7% silica fume overlays on many of the state bridges requiring overlays. None of the four overlay mixes tested in this project, are performing any better than the standard KDOT silica fume overlay.

The Type IP cement with silica fume concrete overlay on Greenwood County Bridge #60 is tending to crack and scale more than one would like to see; however, the chloride concentrations in the subdeck were not excessive at the 5 year inspection.

The Type IP cement concrete overlay on Greenwood County Bridge #61 had very few cracks, but had scaling over most of the surface. A concern would be that between years three and five the length of cracking almost doubled.

The silica fume and steel fibers concrete overlay on Greenwood County Bridge #62 was not performing at an acceptable level after five years due to erosion of the paste, tining and fibers; however, there are no cracks.

The silica fume and polypropylene fiber concrete overlay on Sedgwick County Bridge #445 was performing the best of the four overlay mixes. There were very few cracks and minimal scaling only on the west one-third of the deck. However, the higher chloride concentration throughout the overlay and into the subdeck was of concern.

4.1.2 Ten years after overlay placement

A visual surface survey of the Greenwood county bridges on US-400 was made in March of 2007; this is 10 years after the overlays were placed. The overall appearance was generally the same as they appeared in September 2002.

The Type IP cement concrete with 3% silica fume Bridge #60 still has the most cracks. Seventy (70%) of the bridge's surface showed scaling or loss of surface paste (same as 2002), with the westbound lane still worse. The majority of the cracks appear to be shrinkage cracks and show up more in the traffic lanes than the shoulder. The eastbound lane is map cracked, approximately 8 inches center to center, nearly the entire length (not just the east end as in 2002). It appears that there are a few new cracks and some lengthening of the existing cracks.

The type IP cement concrete overlay on Greenwood county Bridge #61 still has very little cracking and the cracks are generally still on the north side or westbound lane. In 2007 it appeared that there are a few new cracks. The cracks are typically longitudinal cracks in or near the outer wheel path. The traffic lanes have shrinkage map cracking in both lanes that is barely visible and this cracking has increased to around 80% of the surface in 2007 (50-60% in 2002). There are still longitudinal cracks at each end of the bridge. Most of the surface still has roughly the same amount of scaling with the westbound lane the worse.

The silica fume and steel fibers concrete overlay on Greenwood County Bridge #62 continues to have no visible cracks in 2007. The surface appears to be generally the same as in 2002. The surface continues to look ugly due to the exposed steel fibers and the rough look of eroded paste exposing the aggregate. The original tining is nearly gone; however, the grooved surface from the original tining is still in place over the majority of the bridge. The 2007 review of this bridge showed very few loose steel fibers in the overlay and along the edges of the bridge (in 2002 there were many in both the overlay and along the edge of the bridge). The scaling continues to be worse in the westbound shoulder. Overall, the overlay surface looks bad; however, it appears to have stabilized without cracks and may continue to function for many years.

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APPENDIX A - RESEARCH

1994 laboratory testing of beams for flexural toughness and first-crack strength in third-point loading

Beams without fibers

KDOT aggregate blend 50/50, slump 0.25 in.

Specimen number	NF A	NF B	NF C	NF D	**average**
Type	cast beam	cast beam	cast beam	cast beam	
Average width, in.	4.05	4.00	4.10	4.05	
Average depth, in.	3.05	3.05	3.05	3.10	
Span Length, in.	14.0	14.0	14.0	14.0	
Maximum load, lbf	2238	2861	1938	1926	**2241**
Deflection at failure, in	0.0215	0.0064	0.0025	0.0115	**0.0105**
Modulus of rupture, psi	832	1076	711	693	**828**
Toughness at failure, lbf-in	24.1	9.2	2.4	14.5	**12.5**

Beams with polypropylene fibers

KDOT aggregate blend 50/50, slump 0.25 in

Specimen number	PF A	PF B	PF C	PF D	**average**	**percent change**
Type	cast beam	cast beam	cast beam	cast beam		
Average width, in.	4.10	4.05	4.05	4.05		
Average depth, in.	3.05	3.10	3.10	3.05		
Span Length, in.	14.0	14.0	14.0	14.0		
Maximum load, lbf	2639	2669	2862	2563	**2683**	**20%**
Deflection at failure, in	0.0052	0.0229	0.0046	0.0320	**0.0162**	**54%**
Modulus of rupture, psi	969	960	1029	952	**978**	**18%**
Toughness at failure, lbf-in	6.9	34.3	6.6	36.6	**21.1**	**68%**

1994 laboratory testing of beams for flexural toughness and first-crack strength in third-point loading, continued

Beams with steel fibers I

KDOT aggregate blend 50/50, 62.5 oz./yd^3 HRWR, slump 8.75 in.

Specimen number	SF A	SF C	SF D	**average**	**percent change**
Type	cast beam	cast beam	cast beam		
Average width, in.	4.05	4.05	4.10		
Average depth, in.	2.95	2.95	2.95		
Span Length, in.	14.0	14.0	14.0		
First-crack load, lbf	2277	1437	1625	**1780**	**-21%**
First-crack deflection, in	0.0235	0.0030	0.0120	**0.0128**	**23%**
First-crack strength, psi	904	571	638	**704**	**-15%**
First-crack toughness, lbf-in	25.3	2.1	9.7	**12.4**	**-1%**
Toughness index I5, lbf-in	3.9	5.5	3.3	**4.2**	
Toughness index I10, lbf-in	6.9	10.2	5.2	**7.4**	
Toughness index I20, lbf-in	12.1	17.6		**14.9**	
Residual strength factor R5,10; lbf-in	60	94.0	38.0	**64.0**	
Residual strength factor R10, 20; lbf-in	52		74.0	**63.0**	

Beams with steel fibers II

KDOT aggregate blend 50/50, 31.3 oz./yd^3 HRWR, slump 0.25 in.

Specimen number	SFII A	SFII C	SFII D	**average**	**percent change**
Type	cast beam	cast beam	cast beam		
Average width, in.	4.05	4.05	4.15		
Average depth, in.	3.05	3.10	3.05		
Span Length, in.	14.0	14.0	14.0		
First-crack load, lbf	2908	2636	2955	**2833**	**26%**
First-crack deflection, in	0.0151	0.0042	0.0021	**0.0071**	**-32%**
First-crack strength, psi	1081	948	1072	**1033**	**25%**
First-crack toughness, lbf-in	23.5	4.5	2.6	**10.2**	**-19%**
Toughness index I5, lbf-in	4.8	4.5	4.2	**4.5**	
Toughness index I10, lbf-in	8.4	8.1	6.9	**7.8**	
Toughness index I20, lbf-in			11.0	**11.0**	
Residual strength factor R5,10; lbf-in	72	72.0	54.0	**66.0**	
Residual strength factor R10, 20; lbf-in			41.0	**41.0**	

Density and strength of concrete used in 1994 laboratory testing of beams

Beams without fibers

KDOT aggregate blend 50/50, slump 0.25 in.

Specimen number	NF 1	NF 2	NF 3	
Type	core	core	core	
Dry weight, g	3905.4	3932.6	3837.4	
Saturated surface-dry weight, g	3932	3964	3870	
Submerged weight, g	2252	2255	2228	
Apparent specific gravity, lb/ft^3	147.40	146.32	148.86	**147.53**
Bulk specific gravity, lb/ft^3	145.07	143.63	145.9	**144.8667**
Bulk specific gravity, SSD, lb/ft^3	146.05	144.78	147.14	**145.99**
Unit load, psi	6030	6230	6090	**6117**
Modulus of elasticity, psi	4,523,188	4,537,460	4,596,462	**4,552,370**

Beams with polypropylene fibers

KDOT aggregate blend 50/50, slump 0.25 in

Specimen number	PF 1	PF 2	PF 3		
Type	core	core	core		
Dry weight, g	3873.7	3919	3950.8		
Saturated surface-dry weight, g	3910	3951	3980		
Submerged weight, g	2254	2280.0	2297		
Apparent specific gravity, lb/ft^3	149.27	149.27	149.07	**149.20**	**1%**
Bulk specific gravity, lb/ft^3	146	146.41	146.48	**146.2967**	**1%**
Bulk specific gravity, SSD, lb/ft^3	147.37	147.6	147.57	**147.51**	**1%**
Unit load, psi	5520	5710	5830	**5687**	**-7%**
Modulus of elasticity, psi	4,386,240	4,471,752	4,516,724	**4,458,239**	**-2%**

Density and strength of concrete used in 1994 laboratory testing of beams, continued

Beams with steel fibers I

KDOT aggregate blend 50/50, 62.5 oz./yd^3 HRWR, slump 8.75 in.

Specimen number	SF 1	SF 2	SF 3		
Type	core	core	core		
Dry weight, g	3528.9	3510.8	3510.8		
Saturated surface-dry weight, g	3560	3541	3539		
Submerged weight, g	1897.4	1847.2	1869.3		
Apparent specific gravity, lb/ft^3	134.97	131.69	133.46	**133.37**	**-10%**
Bulk specific gravity, lb/ft^3	132.45	129.34	131.21	**131.0000**	**-10%**
Bulk specific gravity, SSD, lb/ft^3	133.61	130.45	132.26	**132.11**	**-10%**
Unit load, psi	3260	3000	3081	**3114**	**-49%**
Modulus of elasticity, psi	2,910,000	2,693,067	2,786,120	**2,796,396**	**-39%**

Beams with steel fibers II

KDOT aggregate blend 50/50, 31.3 oz./yd^3 HRWR, slump 0.25 in.

Specimen number	SFII 1	SFII 2	SFII 3		
Type	core	core	core		
Dry weight, g	3991.6	4000.7	3991.6		
Saturated surface-dry weight, g	4023	4026	4018		
Submerged weight, g	2347.2	2348.7	2340.8		
Apparent specific gravity, lb/ft^3	151.47	151.12	150.88	**151.16**	**2%**
Bulk specific gravity, lb/ft^3	148.63	148.84	148.51	**148.6600**	**3%**
Bulk specific gravity, SSD, lb/ft^3	149.8	149.78	149.49	**149.69**	**3%**
Unit load, psi	6870	6750	6650	**6757**	**10%**
Modulus of elasticity, psi	5,014,885	4,969,781	4,918,575	**4,967,747**	**9%**

Mix designs of concrete used in 1994 laboratory testing of beams

CONCRETE MIX DESIGN (KDOT)

Date: 4/21/94
MIX Design # : NO FIBERS
Project: Fiber Beams No Fiber
W/C Max.: 0.39 Design: 0.39
Min. CF : 625 Design CF: 625
Design for 6 % Air
Admixture: AEA 5.47 ml/batch
Batch Volume (ft^3): 0.75

Batch Weight Calculations:
Agg #1 = lbs. Comb. Agg. x % Agg. #1 / 100 = (2967.984 x 50)/100 = 1484 lbs.* = 41.22 (BATCH)
Agg #2 = lbs. Comb Agg x % Agg #2 / 100 = (2967.984 X 50)/100 = 1484 lbs.* = 41.222 (BATCH)

Cement Type: Monarch I/II Source: Humbolt, KS
Water Source: Topeka City Water
AGG. #1 TYPE: Coarse Agg. Source: Bates County
AGG. #2 TYPE: Fine Agg. Source: Victory sand
Weight per Cu. Ft. Fresh Concrete: Design = 142.10 lbs.
Weight per Cu. Ft. Fresh Concrete: Air Free = 151.17 lbs.

CONCRETE MIX DESIGN (KDOT)

Date: 4/21/94
MIX Design# : STEEL FIBER
Project: Fiber Beams Steel Fiber
W/C: MAX.: 0.39 Design: 0.39
Min. CF: 625 Design CF: 625
Design for 6 % Air
Admixture: AEA 5.47 ml, HRWR 68.45 ml/batch
Batch Volume (ft^3): 0.75

Batch Weight Calculations:
Agg #1 = lbs. Comb Agg x % Agg #1 / 100 = (2967.984 X 50)/100 = 1483.992 lbs.* = 41.22 (BATCH)
Agg #2 = lbs. Comb Agg x % Agg #2 / 100 = (2967.984 x 50) / 100 = 1483.992 lbs.* = 41.22 (BATCH)

Cement Type: Monarch I/II Source: Humbolt, KS
Water Source: Topeka City Water
AGG. #1 TYPE: Coarse Agg. Source: Bates County
AGG. #2 TYPE: Fine Agg. Source: Victory sand
Weight per Cu. Ft. Fresh Concrete: Design = 142.1013 lbs.
Weight per Cu. Ft. Fresh Concrete: Air Free = 151.1716 lbs.

6005 TBO Experimental Overlay Concrete Laboratory Mixes

Mix Number	w/c ratio	cement factor lb/yd^3	slump in.	entrained air %	density lbs/ft^3	28 day unit strength psi	rapid permeability test, Coulombs 28 day	rapid permeability test, Coulombs 56 day	56 day water permeability cm/min.
Type 1S (Slag Cement) Concrete, I	0.38	625	1/8	4.5	145.4	6350	2564	1880	0.041
Type 1S (Slag Cement) Concrete, II	0.40	625	1 3/4	6.3	142.9	5177	3211	2608	0.073
Type 1S (Slag Cement) Concrete, III	0.39	625	1/2	4.6	146.3	6320	2682	1977	0.041
Type 1S (Slag Cement) Concrete, IV	0.38	625	1/8	5.0		6087			
Type 1S (Slag Cement) Concrete, V	0.40	625	1/2	5.0		6000			
Type 1S (Slag Cement) Concrete, VI	0.42	625	2 1/4	5.1		5773			
Type 1S with Silica Fume Concrete, I	0.40	595/30	1/8	4.2	147.9	6347	879	531	0.003
Type 1S with Silica Fume Concrete, II	0.42	595/30	1/4	4.2	144.9	5987	1293	906	0.012
Type 1S with Silica Fume Concrete, III	0.40	605/20	1/8	4.5	146.5	6347	1242	717	0.004
Type 1S with Silica Fume Concrete, IV	0.42	605/20	1/2	4.5	145.1	5953	1344	1052	0.011
Type 1S with Silica Fume Concrete, V	0.44	595/30	1 1/8	4.5	143.7	5793	1368	872	0.015
Type 1S with Silica Fume Concrete, VI	0.44	605/20	1 1/2	5.3	143.3	5597	1677	1284	0.028
Type 1P (Pozzolan Cement) Concrete, I	0.39	625	0	4.0	147.3	7150	874	493	0.012
Type 1P (Pozzolan Cement) Concrete, II	0.42	625	1 3/4	4.1	147.9	7280	972	557	0.012
Type 1P (Pozzolan Cement) Concrete, III	0.39	649	1/2	4.0	147.3	6793	930	478	0.011
Type 1P (Pozzolan Cement) Concrete, IV	0.44	625	1 1/2	5.2	145.1	6683	1115	570	0.012
1PSF3-D	0.40	605/20	1/2	4.5	146.6	6823	958	377	
1PSF5-D	0.40	595/30	1/4	3.8	147.3		788	272	
Type I/II Cement with 5% Silica Fume and Steel Fibers Concrete, I	0.40	595/30	1/2	5.9	145.9	6770	12870	5147	0.018
Type I/II Cement with 5% Silica Fume and Steel Fibers Concrete, II	0.39	595/30	3/4	6.8	146.8	7383	4842	6061	0.020
Type I/II Cement with 5% Silica Fume and Polypropylene Fibers Concrete, II	0.40	595/30	1/4	5.5	144.9	6027	2026	1485	0.020
Type I/II Cement with 5% Silica Fume and Polypropylene Fibers Concrete, I	0.39	595/30	0	5.8	145.1	5687	1489	1247	0.011
Type I/II Cement Concrete	0.39	625	1/8	5.0	146.9	6253	2455	2252	0.009
Type I/II Cement with 5% Silica Fume Concrete	0.40	595/30	1/2	5.5	145.1	6800	1858	1201	0.015
Type I/II Cement with 7% Silica Fume Concrete, I	0.40	580/45	0	4.6	145.4	6800	1561	837	0.013
Type I/II Cement with 7% Silica Fume Concrete, II	0.42	580/45	1 1/4	6.8	144.5	6067	1783	1146	0.008
Type I/II Cement with Silica Fume Concrete	0.40	575/30	0	5.4	146.1	6127	1997	1453	0.008

6005 TBO Experimental Overlay Concrete Field Mixes

Mix Number	w/c ratio	cement factor lb/yd^3	slump in.	entrained air %	density lbs/ft^3	28 day unit strength psi	rapid permeability test, Coulombs 28 day	rapid permeability test, Coulombs 56 day	56 day water permeability cm/min.
Bridge deck wearing surface, Type I/II cement	0.39	625	N/A	N/A	142.6		N/A	866	0.019
K-7 bridge wearing surface over 119th st., 1	0.36	636	1/4	9.2	143.2		N/A	1425	0.074
K-7 bridge wearing surface over 119th st., 2	0.36	636	1/4	8.4	144.1		N/A	1282	0.050
K-7 bridge wearing surface over 119th st., 3	0.36	636	1/4	8.8	142.2		N/A	4383	0.064
K-7 bridge wearing surface over 119th st., 4	0.36	636	1/4	8.2	146.0		N/A	1810	0.017
K-7 bridge wearing surface over 119th st., 5	0.36	636	1/4	8.4	144.1		N/A	N/A	0.026
K-7 bridge wearing surface over 119th st., 6	0.36	636	1/4	8.2	146.0		N/A	N/A	0.022
K-7 bridge wearing surface over 119th st., 7	0.36	636	1/4		142.6		N/A	1715	0.019
K-7 bridge wearing surface over 119th st., 8	0.36	636	1/4		144.2		N/A	2198	0.062
Silica fume concrete from various bridges, I	0.4	639/30	5 1/2	4.1	144.2	9124	N/A	1333	0.003
Silica fume concrete from various bridges, II	0.4	595/30	N/A	N/A	147.0		N/A	717	0.005
Silica fume concrete from various bridges, III	0.4	595/30	N/A	N/A	145.4		N/A	480	N/A
Silica fume concrete from various bridges, IV	0.4	595/30	N/A	N/A	147.9		N/A	1774	0.004

APPENDIX B - SPECIFICATIONS

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KANSAS DEPARTMENT OF TRANSPORTATION SPECIAL PROVISION TO THE STANDARD SPECIFICATIONS EDITION OF 1990

NOTE: This special provision is generally written in the imperative mood. The subject, "the Contractor" is implied. Also implied in this language are "shall", "shall bell, or similar words and phrases.
The word "will" generally pertains to decisions or actions of the Kansas Department of Transportation.

SECTION 720
BRIDGE DECK WEARING SURFACE

Delete this Section and replace with the following:

720.01 DESCRIPTION.

Furnish materials for, and construct a wearing course of Portland cement concrete on the prepared surface of reinforced concrete bridge decks. Place the wearing surface according to the grades, thickness' and cross-sections shown on the Plans.

BID ITEMS	UNIT
Bridge Deck Wearing Surface (*)	Square Yard
Material for Bridge Deck Wearing Surface	Cubic Yard (Set Price)

* Denotes Thickness

720.02 MATERIALS.

(a) Portland Cement.

Portland Cement, Section 2001, except only Type IP, Type 11 or Type I/II is permitted.

Fly Ash modified concrete will not be permitted.

(b) Coarse Aggregate.

Standard Specifications 1102.02(a); delete articles (1) through (2.1) incl. and replace with the following:

1. Description. This specification covers the quality, size and other requirements of coarse aggregate for use in the wearing surface. Use naturally

2. Quality.

(2.1) Soundness, minimum	0.95
(2.2) Wear, maximum	40%
(2.3) Acid Insoluble Residue, minimum	55%

3. Gradation.

SIEVE SIZE	PERCENTAGE RETAINED
¾”	0
½”	0-10
3/8”	15-50
#4	85-100

(c) Fine Aggregates.
Standard Specifications, Type FA-A.

(d) Fine Aggregates for Grout.
Standard Specifications, Section 1102 Type FA-M. In lieu of using FA-M it will be permissible to furnish aggregate complying with the grading requirements of FA-A, provided the plus No. 4 material is removed.

(e) Water.
Standard Specifications, Section 2401.

(f) Curing Materials.
Standard Specifications, Section 1400 and/or as specified in Subsection 720.04 (e) of this specification.

(g) Admixtures.
(1) Air Entraining Admixture. Section 1400.
(2) Water Reducing and Plasticizing Admixtures, Standard Specifications, Section 1400.

(h) Precure / Finishing Aid Material.
This material is a pigmented, water based material as described in ACI 345R, capable of producing a monomolecular film over freshly placed concrete, which serves to retard evaporation from the surface. Use "Aquafilm" by Conspec, "Confilm" by Master Builders, "Euco-Bar" by Euclid Chemical, or an approved equal. For review and approval of proposed equals, submit complete technical data and material safety data sheets to the Bureau of Materials and Research. Prepare and use the material in strict accordance with the manufacturer's instructions. Precure will be accepted on the basis of a brand name.

(i) Concrete Masonry Coating.
Standard Specifications, Section 1-700---(90P-2-09, latest revision).

720.03 EQUIPMENT.
Equipment is subject to approval of the Engineer and must comply with the following:

(a) Surface Preparation Equipment.
Use sand-blasting, steel shot blasting and/or water jetting equipment capable of removing rust, oil, dirt, loose disintegrated concrete and concrete laitance from the existing surface of the bridge deck. Wet sand blasting may be used only with permission of the Engineer.

(b) Proportioning and Mixing Equipment.
Section 401 of the Standard Specifications with the following exceptions: For batch mixers a 2 minute minimum mixing time is required. Provide sufficient mixing capacity to permit the intended pour to be placed without interruption.

(c) Placing and Finishing Equipment.
Include adequate hand tools for placement of plastic concrete and for working down to approximately the correct level for striking-off with the finishing screed.

Use a finishing machine consisting of a mechanical strikeoff capable of providing a uniform thickness of concrete slightly above finish grade in front of an oscillating screed or screeds. The finishing machine will be inspected and approved by the Engineer before work is started on each project.

Use at least one oscillating screed capable of consolidating the concrete by vibration to 100 percent of the vibrated unit weight with the following features:

-Identical vibrators installed such that at least one vibrator is provided for each 5 ft. of screed length.
-Bottom face at least 5 in. wide with a turned up or rounded leading edge.
-Effective weight of at least seventy-five pounds for each square foot of bottom face area.
-Positive control of vertical position, the angle of tilt, and the shape of the crown.
-Design together with appurtenant equipment such that positive machine screeding of the plastic concrete will be obtained as close as practical to the face of the existing curb line.
-Length sufficient to uniformly strike-off and consolidate the width of the lane to be paved.
-Forward and reverse motion under positive control.

-Supporting rails which are fully adjustable (not shimmed) to obtain the correct profile, unless otherwise approved by the Engineer. Provide supports, which are sufficiently rigid that they do not deflect under the weight of the machine. Anchor the supporting rails to provide horizontal and vertical stability.
-Equipped to travel on the completed lane when placing concrete in a lane abutting a previously completed lane.

Manufacturer's specifications and/or certification may be used as verification of the finishing machine requirements.

(d) Fogging Equipment.

Fogging will be accomplished using high pressure equipment that generates at least 1200 psi at 2.2 gpm, or with low pressure equipment having nozzles capable of supplying a maximum f low rate of 1.6 gpm. In either case, the fog spray is produced from nozzles which atomize the droplets, and are capable of keeping a large surface area damp without depositing noticeable water. Use during placement and initial curing. Apply the fog over the entire placement width.

(e) General.

Provide an overall combination of labor and equipment with the capability for proportioning, mixing, placing and finishing new concrete at the following minimum rates except when noted otherwise on the Plans:

TOTAL SURFACE AREA PER BRIDGE (SQ. YD.)	MINIMUM REQUIREMENT (C.Y./HR.)
0-328	1.0
329-492	1.5
493-656	2.0
Over 656	2.5

The elapsed time between depositing the concrete on the floor and final screeding may not exceed 10 minutes unless otherwise authorized by the Engineer.

720.04 CONSTRUCTION REQUIREMENTS.

(a) Proportioning.

LBS. OF CEMENT PER CU. YD., MIN	625
LBS. OF WATER PER LB. OF CEMENT, MAX	0.38
PERCENT OF AIR BY VOLUME	6.0 ± 2**

**As Determined by KT-19 (Rollometer). A regularly calibrated air meter may be used for production with random verification by the rollometer.

Use a ratio of the coarse aggregate to the fine aggregate of 50:50 by weight.

Designate a target slump within the range of 2 to 5 in. A tolerance of 25% or 3/4 inch, whichever is larger, will apply to the target slump.

A water-reducing or plasticizing admixture for improving workability may be required, and may be used when approved by the Engineer. Use admixtures in accordance with Section 402 and Special Provision 9OP-130, latest revision. Adjust the designated slump accordingly.

Adjust the yield cement factor (ycf) for higher air within specification limits, as allowed in the Standard Specifications.

Delay the commencement of tests from 4 to 4 1/2 min. after the sample has been taken from a continuous mixer. If a batch type mixer is used, take the tests at the point of placement and commence immediately.

(b) Portland Cement Grout.

This material is a 1:1 by weight mixture of Portland cement and mortar sand (FA-M), water reducing or plasticizing add mixture if necessary, and sufficient water to produce a water to cementitious ratio of 0.60, grout should be a Heavy Cream consistency.

The consistency of the grout slurry is such that it can be applied with a stiff brush or broom to the concrete in a thin, even coating that will not run or puddle in low spots.

For application to vertical joints between adjacent lanes and at the curbs, the grout may be thinned to paint consistency.

When hydrodemolition is used as the method of machine preparation, apply the grout by a hydraulic and compressed air sprayer. Apply the grout in a thin even coat at a minimum nozzle pressure of 60 psi. and at a minimum rate equal to the wearing surface placement.

(c) Preparation of Surface.

1. Old, Existing Concrete Decks. Prior to application of grout in preparation for replacement of new concrete, make a final cleanup sand or shot blasting followed by an air blast to remove all loose disintegrated concrete, dirt, oil, laitance, and curing material from patches and other foreign material from the surf ace of the prepared deck and bottom 3 in. of hubquard. The old existing concrete deck should not be presaturated before the grout and concrete wearing surface is placed. Remove all free water. The deck should be surface dry to allow some absorption of the grout.

2. New Concrete Decks. Prior to applying grout in preparation for placement of new concrete, sand or shot blast the surface followed by an air blast to remove all dirt, oil and other foreign material, as well as any unsound concrete, laitance, and curing material from the surface, the bottom 3 in. of hubguard, and edges against which new concrete is to be placed. Protect metal floor drains and areas of the curb or railing above the proposed surface from the sand blast. It is desired that the surface be roughened by the sand blast to provide satisfactory bond with the surfacing concrete. Do not presaturate the existing concrete before the grout and new concrete is placed. Remove all free water. The prepared surface should be surface dry to allow some absorption of the grout. Check the finish machine clearance above the prepared surf ace before concrete is placed to ensure the thickness is as specified on the Plans.

(d) Placing and Finishing Concrete. Environmental conditions during placement are critical to the quality of concrete in bridge decks. Of particular importance is the evaporation rate. Placing of concrete will not be allowed when conditions on the bridge deck are such that the evaporation rate (as determined in the American Concrete Institute Manual of Concrete Practice 305R, Chapter 2) is estimated to equal or exceed 0.2 lbs. per square foot per hour, or is predicted to exceed that rate during the course of the placement. Prior to placing of concrete, temperature and humidity will be measured on the bridge deck. Wind speed may be measured on the deck or estimated using information from the nearest weather station. Concrete temperatures may be those actually measured from the previous day's run, or from test batches, or may be estimated from aggregate, cement and water temperatures. With this information, use Figure 2.1.5 from the above reference (copy attached) to estimate the evaporation rate. When the general area evaporation rate is estimated to be above 0.2 lbs per square foot per hour, the Contractor may proceed by using measures such as fogging, wind breaks, cooling the concrete, etc. to create and maintain environmental conditions on the bridge deck which are satisfactory for concrete placement. A finishing machine meeting the requirements stipulated under Equipment above will be required. Place and fasten the screed rails in position to insure finishing the concrete to the required profile. Place the supporting rails upon which the finishing machine travels outside the area to be concreted. A hold-down device shot into concrete will not be permitted unless the concrete is to be subsequently overlaid. Hold-down devices of other types leaving holes in exposed areas will be approved provided the holes remaining are grouted full. Methods for anchoring and supporting the rails and the concrete placing procedure require approval by the Engineer.

Locate longitudinal joints along lane lines or as approved by the Engineer. Keep the joints clear of wheel paths as much as practical.

Produce and place the concrete within the specified limits in as continuous and uniform of an operation as practical. After the surface has been cleaned and immediately before placing concrete, scrub or spray a thin coating of bonding grout into the dry prepared surface. Exercise care to ensure that all parts receive a thorough even coating, and that no excess grout is permitted to collect in pockets. Limit the rate of progress in applying grout so that the grout does not become dry before it is covered with new concrete. If the grout is-allowed to dry out- place a header and cease placement. No further concreting will be allowed until the old grout has been removed and the surface again cleaned by sand blasting.

Manipulate, mechanically strike off, and mechanically consolidate new concrete to a minimum of 98 percent of the vibrated unit weight and screed to final grade. Hand tamping is required in irregular areas or along the curb where the finishing screed does not reach to assist in consolidation and bonding of the concrete. For overlays of less than 2 inches perform hand tamping with a 6 in. x 6 in. metal plate device, for overlays of 2 inches and greater perform hand tamping with a hand held vibrator. The Engineer will use an approved nuclear density measuring device to monitor in-place density. Hand floating operations may be required to produce a tight, uniform surface. Take every reasonable precaution to secure a smooth riding bridge deck. Correct surface variations exceeding 1/8 in. in 10 ft. by use of an approved profiling device, by replacing the bridge deck wearing surface, or other methods approved by the Engineer.

To preclude plastic shrinkage cracking of the wearing surface concrete, treatment with a precure material is required immediately after strike off of the surface. If measures to create an environment for concrete placement have been taken, continue these measures throughout the finishing operation.

When a tight, uniform surface has been achieved, give the surface a suitable texture by transverse grooving with a finned float having a single row of fins. Make the grooving approximately 3/16 in. in width, on 3/4 in. centers, with a groove depth of approximately 1/8-in. Do this operation at such time and in such manner that the desired texture will be achieved while minimizing displacement of the larger aggregate particles. For bridges having drains, the transverse grooving should terminate approximately 2 ft. in from the gutter line at the base of the curb. This area adjacent to the curbs should be given a light broom finish longitudinally.

Finish the exposed edges of the end spans of bridges which form a part of the road surface with an edger having a 1/4 in. radius.

(e) curing.

Apply Type 1-D liquid membrane forming curing compound immediately behind the tininq float. The final cure will be with wet burlap covered with white polyethylene sheeting.

If fogging of the wearing surface has been used during placement and finishing, continue until the wet burlap can be placed. If it has not been used to this point, it must begin during completion of the finishing operation. Maintain a damp surface until the wet burlap cure begins.

Place the burlap as soon as possible without damaging the surface. Keep the burlap wet 100 per cent of the time during the cure period. The use of soaker hoses or occasional spraying is required. Continue the wet burlap cure for a period of seven days.

In warm weather, for the first twenty-four hours of the seven-day curing period, white polyethylene sheeting may not be used in direct sunshine during the day. However, it may be used at night in lieu of keeping personnel and equipment on the job site to keep the burlap wet. If polyethylene sheeting is used over the burlap during the first twenty-four hours, it must not be placed prior to one hour before sunset, and must be removed within one hour after sunrise. After the first twenty-four hours, the polyethylene sheeting may be left in place continuously, day and night, for the remainder of the curing period.

Perform cold weather curing as outlined in the standard specifications.

No traffic is permitted on a finished surf ace course for seven days after placement. At temperatures below 55° F, the Engineer may require a longer waiting time.

(f) Weather Limitations.

1. Concreting in Hot Weather. See Standard Specifications concerning hot weather concreting.

2. Concreting in cold Weather. Except by specific written authorization, discontinue concreting operations when a descending air temperature in the shade and away from artificial heat falls below 45° F. Do not start or resume operations until an ascending air temperature reaches 40° F., or if night time temperatures are expected to fall below 35° F.

(g) Limitations of operations.

At least 1 day prior to the placement, make a trial placement to gain experience with all aspects of this construction. This requirement may be waived by the Engineer if the Contractor and concrete producer can show significant similar experience with wearing surface concrete.

When a new deck is involved, do not commence work on the wearing surface until the lower course meets the time requirements of Section 701 of the Standard Specifications, unless specified otherwise.

Do not place concrete adjacent to a surface course less than 36 hours old; however, this restriction does not apply to a continuation of placement in a lane or strip beyond a transverse joint in the same lane or strip.

In areas where there is no traffic, preparation of the area may be started in a lane or strip adjacent to a newly placed surface the day following its placement. If this work is started before the end of the seven-day curing period, the work will be restricted as follows:

Sawing or other operations may interfere with the curing process in the immediate work area for the minimum practical time only. Resume the curing promptly upon completion of the work. Keep the exposed areas damp until such time as curing media is replaced. Use no power driven tools heavier than a 15 lb. chipping hammer.

(h) Construction Joints.

Seal all vertical construction joints in the wearing surface and the vertical joint between the wearing surface and the curb by sandblasting and then painting the joints with an approved concrete masonry coating when the wet burlap and polyethylene sheeting is removed.

(i) Placement of Conterline Form and Headers.

If these forms cannot be held in place in a manner preventing movement during consolidating and finishing, the following procedure is required. Before new concrete is placed against hardened concrete from previous placements, saw the older concrete back six (6) inches and chip it away before new concrete is placed.

(j) Correction of Unbonded Areas.

If newly overlain areas are discovered to be unbonded by tapping or chaining during construction of the project, outline the concrete from such areas by sawing, remove it with small air tools (15 lbs maximum), and replace it at no additional compensation.

(k) Material for Bridge Deck wearing Surface.

When approved by the District Engineer on repair of existing bridges, this pay item will be used to compensate the Contractor for the additional wearing surface material that will be required to fill the areas greater than the thickness of wearing surface shown on the Plans. The Contractor is responsible for maintaining adequate quality control of the demolition process to minimize deviations from the plan grades.

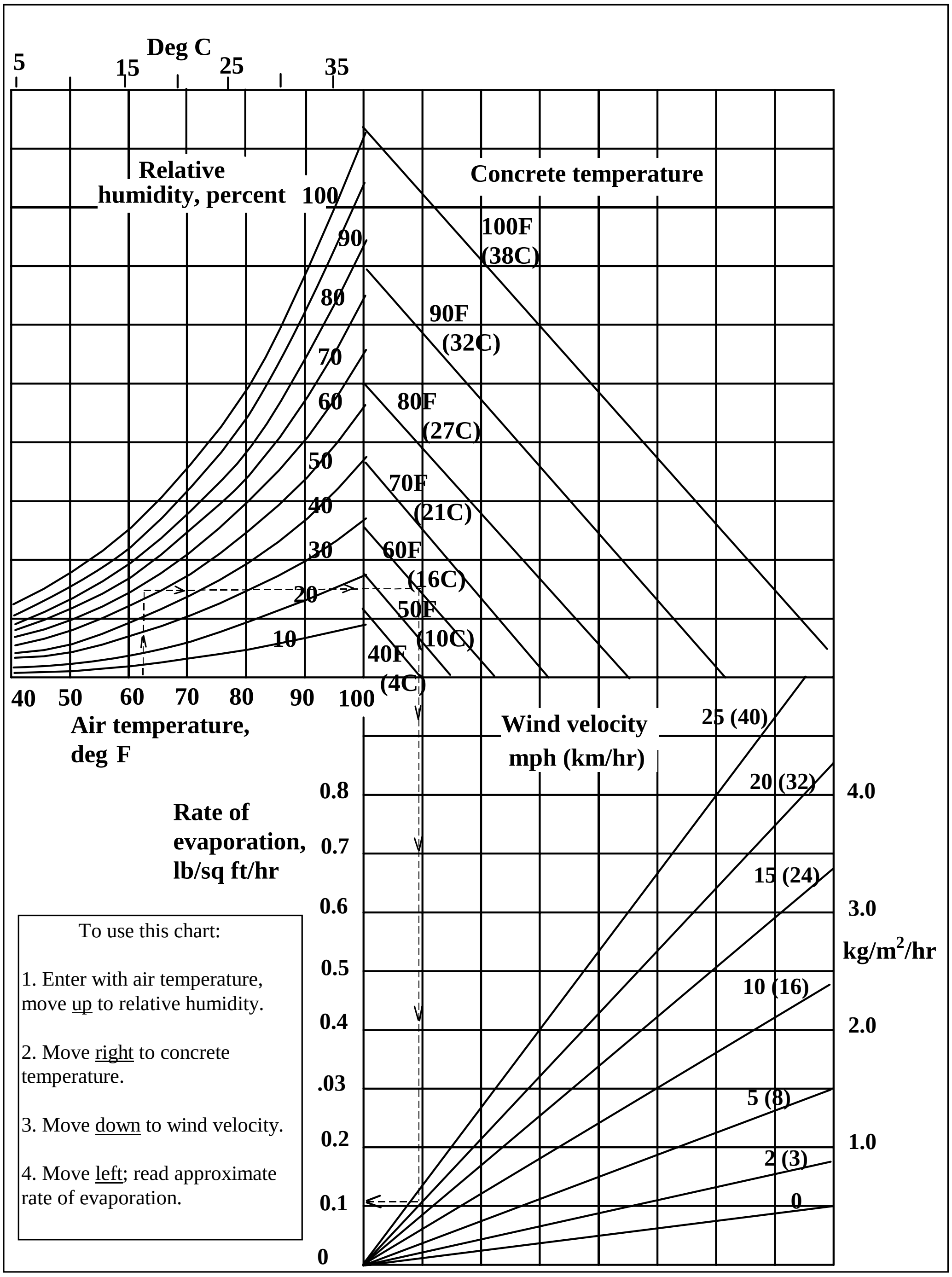
The Engineer will keep a running account of the volume of wearing surf ace material that is produced and delivered to the deck. When approved, the Contractor will be paid, at the set price per cubic yard, for all wearing surface material in excess of 110 percent of the theoretical volume to cover the deck area with the thickness of wearing surface shown on the Plans.

720.05 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.

Bridge Deck Wearing Surface will be measured by the square yard, to the nearest 0.1 sq. yd., complete in place. Quantity for which payment will be made may be the quantities shown on the Plans provided the project is constructed as shown on the Plans. Material for Bridge Deck Wearing Surface will be measured by the cubic yard, to the nearest 0.1 cu. yd.

Payment for "Bridge Deck Wearing Surface" at the Contract unit price, and "Material for Bridge Deck Wearing Surface" at the Contract set unit price (when approved by the District Engineer), will be full compensation for the specified work.

08-25-95 M&R (DAM)



Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. When the evaporation rate exceeds 0.2 lb/ft^2/hr (1.0 kg/ m^2/hr), measures shall be taken to prevent excessive moisture loss from the surface of unhardened concrete; when the rate exceeds 0.1 lb/ft^2/hr (0.5 kg/m^2/hr) such measures may be needed. When excessive moisture loss is not prevented, plastic cracking is likely to occur.

KANSAS DEPARTMENT OF TRANSPORTATION SPECIAL PROVISION TO THE STANDARD SPECIFICATIONS EDITION OF 1990

NOTE: This special provision is generally written in the imperative mood. The subject, "the Contractor" is implied. Also implied in this language are "shall", "shall be”, or similar words and phrases.
The word "will" generally pertains to decisions or actions of the Kansas Department of Transportation.

SECTION 700
SILICA FUME OVERLAY

Create a now subsection in Section 700, Structures, titled "Silica Fume overlays.

1.0 DESCRIPTION.

Furnish materials for, and construct a wearing course of silica fume modified portland cement concrete on the prepared surface of reinforced concrete bridge decks. Place the overlay according to the grades, thickness’ and cross-sections shown on the Plans.

BID ITEMS	UNIT
Silica Fume Overlay	Square Yard
Material for Silica Fume Overlay	Cubic Yard (Set Price)

*Denotes Thickness

2.0 MATERIALS.

(a) Portland Cement.
Portland Cement, Section 2001, except only Type II or Type I/II is permitted.
Fly Ash modified concrete will not permitted.

(b) Coarse Aggregate.
Standard Specifications 1102.02(a); delete articles (1) through (2.1) incl. and replace with the following:

1. Description. This specification covers the quality, size and other requirements of coarse aggregate for use in silica fume overlay. Use naturally occurring crushed stone aggregates conforming to the following requirements.

2. Quality.

(2.1) Soundness, minimum	0.95
(2.2) Wear, maximum	40%
(2.3) Acid Insoluble Residue, minimum	55%

3. Gradation.

SIEVE SIZE	PERCENTAGE RETAINED
¾”	0
½”	0-10
3/8”	15-50
#4	85-100

(c) Fine Aggregates.

Standard Specifications, Type FA-A.

(d) Fine Aggregates for Grout.

Standard Specifications, Section 1102 Type FA-M. In lieu of using FA-M it will be permissible to furnish aggregate complying with the grading requirements of FA-A, provided the plus No. 4 material is removed.

(e) Water.

Standard Specifications, Section 2401.

(f) Curing Materials.

Standard Specifications, Section 1400 and/or as specified in 3.0 (f) of this specification.

(g) Admixtures.

1. Air Entraining Admixture. Standard Specifications, Section 1400.
2. Water Reducing Admixture. ASTM C494, Type F or G. Standard Specifications, Section 1400.

(h) Precure / Finishing Aid Material.

This material is a pigmented, water based material as described in ACI 345R, capable of producing a monomolecular film over freshly placed concrete, which serves to retard evaporation from the surface. Use "Aquafilm" by Conspec, "Confilm" by Master Builders, "Euco-Bar" by Euclid Chemical or an approved equal. For review and approval of proposed equals, submit complete technical data and material safety data sheets to the Bureau of Materials and Research.

Prepare and use the material in strict accordance with the manufacturer's, instructions. Precure will be accepted on the basis of a brand name.

(i) Silica Fume.
Standard Specifications, Section 1400 (90P-158, latest revision).

3.0 CONSTRUCTION REQUIREMENTS.

(a) Equipment.
Equipment is subject to approval of the Engineer and must comply with the following:

1. Surface Preparation Equipment.
Use sand-blasting and/or water jetting equipment capable of removing rust, oil, dirt, loose disintegrated concrete and concrete laitance from the existing surface of the bridge deck. Wet sand blasting may be used only with permission of the Engineer.
2. Proportioning and Mixing Equipment.
Section 401 of the Standard Specifications.
3. Placing and Finishing Equipment.
Include adequate hand tools for placement of plastic concrete and for working down to approximately the correct level for striking-off with the finishing screed. Use a finishing machine consisting of a mechanical strike-off capable of providing a uniform Thickness of concrete slightly above finish grade in front of an oscillating screed or screeds. The finishing machine will be inspected and approved by the Engineer before work is started on each project.
Use at least one oscillating screed capable of consolidating the concrete by vibration to 100 percent of the vibrated unit weight with the following features:

-Identical vibrators installed such that at least one vibrator is provided for each 5 ft. of screed length.
-Bottom face at least 5 in. wide with a turned up or rounded leading edge.
-Effective weight of at least seventy-five pounds for each square foot of bottom face area.
-Positive control of vertical position, the angle of tilt, and the shape of the crown.
-Design together with appurtenant equipment such that positive machine screeding of the plastic concrete will be obtained as close as practical to the face of the existing curb line.

-Length sufficient to uniformly strike-off and consolidate the width of the lane to be paved.
-Forward and reverse motion under positive control.
-Supporting rails which are fully adjustable (not shimmed) to obtain the correct profile, unless otherwise approved by the Engineer. Provide supports which are sufficiently rigid that they do not deflect under the weight of the machine. Anchor the supporting rails to provide horizontal and vertical stability.
-Equipped to travel on the completed lane when placing concrete in a lane abutting a previously completed lane.

Manufacturer's specifications and/or certification may be used as verification of the finishing machine requirements.

4. Fogging equipment. Fogging will be accomplished using high pressure equipment that generates at least 1200 psi at 2.2 gpm, or with low pressure equipment having nozzles capable of supplying a maximum flow rate of 1.6 gpm. In either case, the fog spray is produced from nozzles, which atomize the droplets, and are capable of keeping a large surface area damp without depositing noticeable water. Use during placement and initial curing.

5. General. Provide an overall combination of labor and equipment with the capability of proportioning, mixing, placing and finishing new concrete at the following minimum rates except when noted otherwise on the Plans:

TOTAL SURFACE AREA PER BRIDGE (SQ. YD)	MINIMUM REQUIREMENT (C. Y. / HR.)
0-328	1.0
329-492	1.5
493-656	2.0
Over 656	2.5

The elapsed time between depositing the concrete on the floor and final screeding may not exceed 10 minutes unless otherwise authorized by the Engineer.

(b) Proportioning.

LBS. OF CEMENT PER CU. YD., MIN	595
LBS. OF SILICA FUME PER CU. YD., MIN	30
LBS. OF WATER PER LB. OF (CEMENT + SILICA FUME) MAX	0.40
PERCENT OF AIR BY VOLUME	6.0 ± 2**

** As Determined by KT-19 (Rollometer). A regularly calibrated air meter may be used for production with random verification by the rollometer.

Use a ratio of the coarse aggregate to the fine aggregate of 50:50 by weight.

A water-reducing admixture for improving workability may be required, and may be used when approved by-the Engineer. On placements involving long hauls from the plant, minor redosing (involving a small percentage of the total) may be allowed when approved by the Engineer, providing mixing revolutions are available.

Designate a target slump within the range of 2 to 5 in. A tolerance of 1 in. will apply to the target slump.

Adjust the yield cement factor (ycf) for higher air within specification limits, as allowed in the Standard specifications.

Delay the commencement of tests from 4 to 4 1/2 min. after the sample has been taken from a continuous mixer. If a batch type mixer is used, take the tests at the point of placement and commence immediately.

(c) Portland Cement Grout.

This material is a 1:1 by weight mixture of portland cement and fine aggregate, the design percentage of silica fume, high range water reducer as necessary, and sufficient water to produce a water to cementitious ratio of 0.60.

The consistency of the grout slurry is such that it can be applied with a stiff brush or k)room to the previously placed concrete in a thin, even coating that will not run or puddle in low spots.

For application to vertical joints between adjacent lanes and at the curbs, this grout may tie thinned to paint consistency.

(d) Preparation of Surface.

1. Old, Existing Concrete Decks. Prior to application of grout in preparation for replacement of new concrete, make a final cleanup sand blasting followed by an air blast to remove all loose disintegrated concrete, dirt, oil, laitance, and curing material from patches and other foreign material from the surface of the prepared deck and bottom 3 in. of hubguard. The old existing concrete deck should not be presaturated before the grout and concrete overlay is placed. Remove all free water. The deck should be surface dry to allow some absorption of the grout.

2. New Concrete Decks. Prior to applying grout in preparation for placement of new concrete, sand blast the surface followed by an air blast to remove all dirt, oil and other foreign material, as well as any unsound concrete, laitance, and curing material from the surface, the bottom 3 in. of hubguard, and

edges against which new concrete is to be placed. Protect metal floor drains and areas of the curb or railing above the proposed surface from the sand blast. It is desired that the surface be roughened by the sand blast to provide satisfactory bond with the surfacing concrete. Do not presaturate the existing concrete before the grout and new concrete is placed. Remove all free water. The prepared surface should be surface dry to allow some absorption of the grout.

Check the finish machine clearance above the prepared surface before concrete is placed to ensure the thickness is as specified on the Plans.

(e) Placing and Finishing Concrete.

Environmental conditions during placement are critical to the quality of silica fume concrete of particular importance is the evaporation rate. Placing of silica fume concrete will not be allowed when conditions on the bridge deck are such that the evaporation rate (as determined in the American Concrete Institute Manual of Concrete Practice 305R, Chapter 2) is estimated to equal or exceed 0.2 lbs. per square foot per hour, or is predicted to exceed that rate during the course of the placement. Prior to placing of concrete, temperature and humidity will be measured on the bridge deck. Wind speed may be measured on the deck or estimated using information from the nearest weather station. Concrete temperatures may be those actually measured from the previous day's run, or from test batches, or may be estimated from aggregate, cement and water temperatures. With this information, use Figure 2.1.5 from the above reference (copy attached) to estimate the evaporation rate. When general area evaporation conditions are estimated to be above 0.2 lbs. per square foot per hour, the Contractor may proceed by using measures such as fogging, wind breaks, cooling the concrete, etc. to create and maintain environmental conditions on the bridge deck which are satisfactory for silica fume concrete placement.

A finishing machine meeting the requirements stipulated under equipment above will be required. Place and fasten the screed rails in position to insure finishing the concrete to the required profile. Place the supporting rails upon which the finishing machine travels outside the area to be concreted. A hold-down device shot into concrete will not be permitted unless the concrete is to be subsequently overlaid. Hold-down devices of other types leaving holes in exposed areas will be approved provided the holes remaining are grouted full. Methods for anchoring and supporting the rails and the concrete placing procedure require approval by the Engineer.

Locate longitudinal joints in accordance with details shown on the Plans or as approved by the Engineer. Keep the joints clear of wheel paths as much as practical.

Produce and place the concrete within the specified limits in as continuous and uniform of an operation as practical. After the surface has been cleaned and immediately before placing concrete, scrub a thin coating of bonding grout into the dry prepared surface. Exercise care to ensure that all parts receive a thorough even coating, and that no excess grout is permitted to collect in pockets. Limit the rate of progress in applying grout so that the grout does not become dry before it is covered with new concrete. If the grout is allowed to dry out, place a header and cease placement. No further concreting will be allowed until the old grout has been removed and the surface again cleaned by sand blasting.

Manipulate, mechanically strike of f, and mechanically consolidate new concrete to a minimum of 98 percent of the vibrated unit weight and screed to final grade. Hand tamping with a 6 in. x 6 in. metal plate device is required in irregular areas or along the curb where the finishing screed does not reach to assist in consolidation and bonding of the concrete. The Engineer will use an approved nuclear density measuring device to monitor in-place density. Hand floating operations may be required to produce a tight, uniform surface.

Take every reasonable precaution to secure a smooth riding bridge deck. Correct surface variations exceeding 1/8 in. in 10 ft. unless directed otherwise by the Engineer.

To preclude plastic shrinkage cracking to which the silica fume concrete is prone, treatment with a fog bar and precure material are required immediately after strike off of the surface. If fogging has not been required during placement, start it at this point and continue throughout the finishing operation.

When a tight, uniform surface has been achieved, give the surface a suitable texture by transverse grooving with a finned float having a single row of fins. Make the grooving approximately 3/16 in. in width, on 3/4 in. centers, with a groove depth of approximately 1/8 in. Do this operation at such time and in such manner that the desired texture will be achieved while minimizing displacement of the larger aggregate particles. For bridges having drains, the transverse grooving should terminate approximately 2 ft. in from the gutter line at the base of the curb. This area adjacent to the curbs should be given a light broom finish longitudinally.

Finish the exposed edges of the end spans of bridges, which form a part of the road surface with an edger having a 1/4 in. radius.

(f) curing.

Apply Type 1-D liquid membrane forming curing compound immediately behind the tining float. The final cure will be with wet burlap covered with white polyethylene sheeting.

Continue fogging the entire placement to maintain a damp surface until the wet burlap can be applied.

Place the burlap as soon as it can be without damaging the surface. Keep it wet 100 per cent of the time during the cure period. The use of soaker hoses or occasional spraying is required. Continue the wet burlap cure for a period of seven days.

In warm weather, for the first twenty-four hours of the seven day curing period, white polyethylene sheeting may not be used in direct sunshine during the day. However, it may be used at night in lieu of keeping personnel and equipment on the job site to keep the burlap wet. If polyethylene sheeting is used over the burlap during the first twenty-four hours, it must not be placed prior to one hour before sunset, and must be removed within one hour after sunrise. After the first twenty-four hours, the polyethylene sheeting may be left in place continuously, day and night, for the remainder of the curing period.

Perform cold weather curing as outlined in the standard specifications.

No traffic is permitted on a finished surface course for seven days after placement. At temperatures below 55° F, the Engineer may require a longer waiting time.

(g) Weather Limitations.

1. Concreting in Hot Weather. See Standard Specifications concerning hot weather concreting.

2. Concreting in Cold Weather. Except by specific written authorization, discontinue concreting operations when a descending air temperature in the shade and away from artificial heat falls below 45° F. Do not start or resume operations until an ascending air temperature reaches 40° F, or if night time temperatures are expected to fall below 35° F.

(h) Limitations of Operations.

Provide a technical representative of the silica fume manufacturer on the job site during the initial placement of the concrete at no additional cost to the Department. The representative is to provide technical expertise to the Contractor, concrete producer, and the Engineer regarding batching, transport, placement, and curing of silica fume concrete. This requirement will be waived for experienced contractors. Submit your request along with a list of silica fume concrete overlay projects completed to the Engineer.

At least 1 day prior to the placement, make a trial placement to gain experience with all aspects of this construction. This requirement may be waived by the Engineer if the

Contractor and concrete producer can show significant similar experience with silica fume concrete.

When a new deck is involved, do not commence work on the wearing surface until the lower course meets the time requirements of Section 701 of the Standard Specifications, unless specified otherwise.

Do not place concrete adjacent to a surface course less than 36 hours old; however, this restriction does not apply to a continuation of placement in a lane or strip beyond a transverse joint in the same lane or strip.

In areas where there is no traffic, preparation of the area may be started in a lane or strip adjacent to newly placed surface the day following its placement. If this work is started before the end of the seven-day curing period, the work will be restricted as follows:

Sawing or other operations may interfere with the curing process in the immediate work area for the minimum practical time only. Resume the curing promptly upon completion of the work. Keep the exposed areas damp until such time as curing media is replaced. Use no power driven tools heavier than a 15 lb. chipping hammer.

(i) Construction Joints.

Seal all vertical construction joints in the overlay and the vertical joint between the overlay and the curbs by sandblasting and then painting the joints with an approved two part cement based acrylic polymer grout when the wet burlap and polyethylene sheeting is removed.

(j) Placement of Centerline Form and Headers.

If these forms cannot be held in place in a manner preventing movement during consolidating and finishing, the following procedure is required. Before new concrete is placed against hardened concrete from previous placements, saw the older concrete six (6) inches and chip it away before new concrete is placed.

(k) Correction of Unbonded Areas.

If newly overlain areas are discovered to be unbonded by tapping or chaining during construction of the project, outline the concrete from such areas by sawing, remove it with small air tools (15 lbs maximum), and replace it at no additional compensation.

(1) Material for Silica Fume Overlay.

When approved by the District Engineer on repair of existing bridges, this pay item will be used to compensate the Contractor for the additional overlay material that will be required to fill the areas greater than the thickness of overlay shown on the Plans. The Contractor is responsible for maintaining adequate quality control of the demolition process to minimize deviations from the plan grades. Approval of this item will be based on an original grade survey of the deck prior to demolition. Overruns caused by poor workmanship will not be approved.

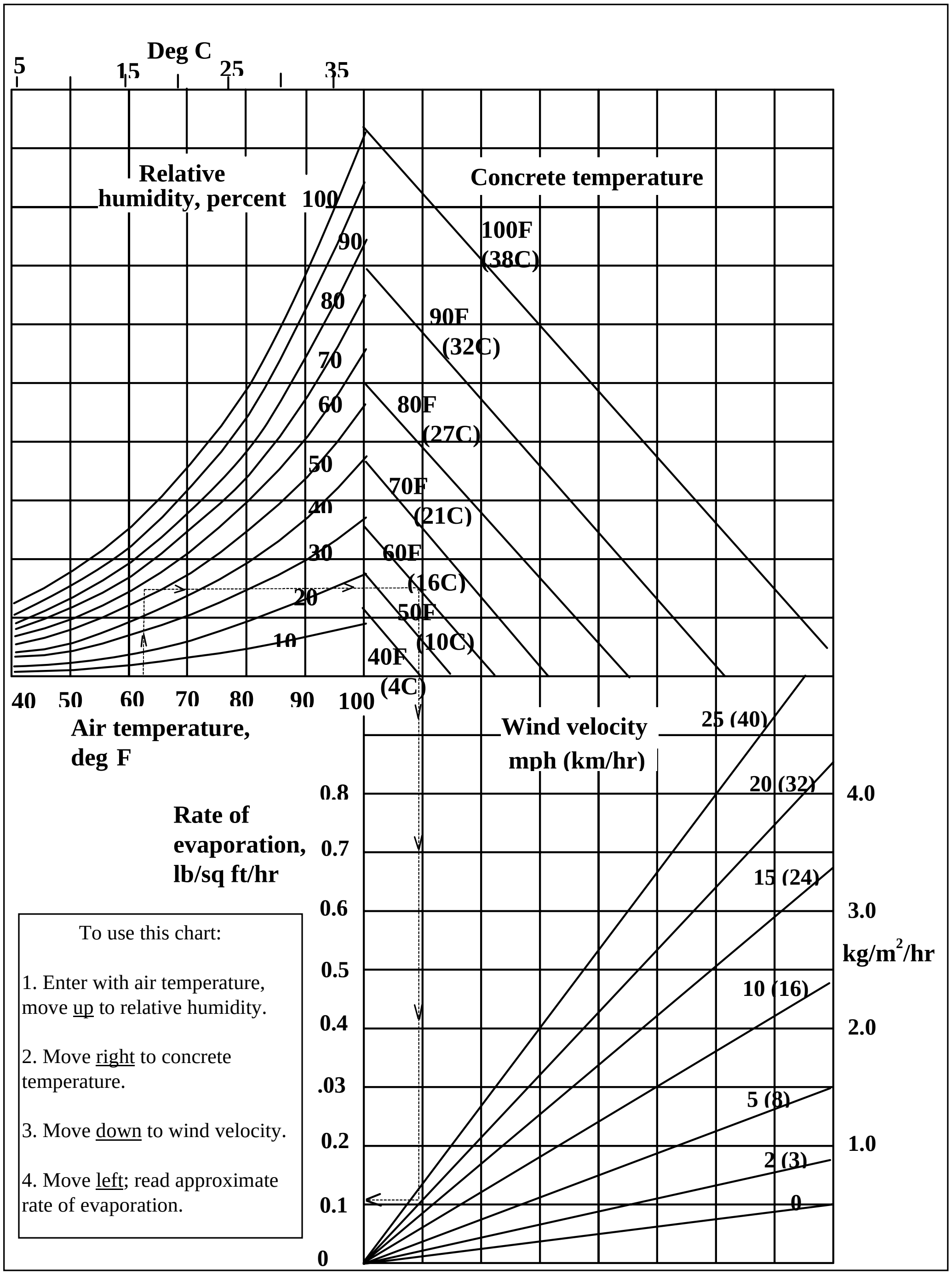
The Engineer will keep a running account of the volume of overlay material that is produced and delivered to the deck. When approved, the Contractor will be paid, at the set price per cubic yard, for all overlay material in excess of 110 percent of the theoretical volume to cover the deck area with the thickness of overlay shown on the Plans.

4.0 METHOD OF MEASURMENT AND BASIS OF PAYMENT.

Silica Fume overlay will be measured by the square yard, to the nearest 0.1 sq. yd., complete in place. Quantity for which payment will be made may be the quantities shown on the Plans provided the project is constructed as shown on the Plans. Material for Silica Fume Overlay will be measured by the cubic yard, to the nearest 0.1 cu. yd.

Payment for "Silica Fume Overlay" at the Contract unit price, and "Material for Silica Fume Overlay" at the Contract set unit price (when approved by the 'District Engineer), will be full compensation for the specified work.

03-13-95 M&R (JLC)



Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. When the evaporation rate exceeds 0.2 lb/ft^2/hr (1.0 kg/ m^2/hr), measures shall be taken to prevent excessive moisture loss from the surface of unhardened concrete; when the rate exceeds 0.1 lb/ft^2/hr (0.5 kg/m^2/hr) such measures may be needed. When excessive moisture loss is not prevented, plastic cracking is likely to occur.

SECTION 1400
SILICA FUME

Create a now subsection in Section 1400, Concrete Admixtures and Curing Materials, titled Silica fume.

1.0 DESCRIPTION.

This specification covers silica fume, or micro-silica, which is suitable for use as an admixture for portland cement concrete. Silica fume is a by-product resulting from the reduction of high-purity quartz with coal in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys.

2.0 REQUIREMENTS.

Provide material with the following properties:

1. SiO2 min. %	85
2. S03 max. %	3.0
3. Loss on Ignition, max. %	6.0
4. Other Ingredients, including High range water reducer, max. %	7.0
5. Moisture content of dry silica fume, max. %	3.0
6. Available alkalies as Na2O, max. %	1.50
7. Strength Activity Index, ASTM C 311, with portland cement at 7d and 28d, min. % of control	85

3.0 PREQUALIFICATION.

(1) Sources of silica fume must be prequalified. Submit certified analyses of the quality control tests completed during the six-month period immediately prior to the prequalification request. Certified analyses are defined as the range of test results of the properties specified above on representative materials tested by a laboratory which is regularly inspected and certified by the Cement and Concrete Reference Laboratory (CCRL) include mill certifications for the raw material.

(2) Forward the certified analyses to the Chief of Materials and Research. If the material satisfies all requirements, the source will be placed on a prequalified list.

(3) Verification samples will be taken by each District at the rate of one per year for each silica fume producer supplying material to that District's projects.

(4) Semi-annual results of the producers quality control testing as defined above, are required to be forwarded to the Bureau of Materials and Research to maintain status on the prequalified list. Sources will remain on the prequalified list so long as verification samples and semi-annual test results meet all requirements, and indicate acceptable quality control.

4.0 BASIS OF ACCEPTANCE.

(a) Prequalification as required by 3.0.
(b) A Type C certification in accordance with Section 2600.

03-13-95 M&R (JLC)

042100000 Silica Fume LBS 9OP-158 PRC17

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 1990 EDITION

SILICA FUME WITH STEEL FIBERS OVERLAY

NOTE: SILICA FUME WITH STEEL FIBER OVER-LAY FOR THIS PROJECT IS SUBJECT TO SPECIAL PROVISION 90P-158 (LATEST REVISION) WITH THE FOLLOWING ADDITIONS AND/OR DELETIONS:

Special Provision 90P-158 (latest revision), subsection 1.0., Description, delete this subsection and replace with the following:

1.0 DESCRIPTION.

Furnish materials for, and construct a wearing course of silica fume and steel fiber modified Portland cement concrete on the prepared surface of reinforced concrete bridge decks. Place the overlay according to grades, thicknesses and cross-sections shown on the Plans.

BID ITEMS	**UNIT**
Silica Fume with Steel Fibers Overlay (*)	Square Yard
Material for Silica Fume with Steel Fibers Overlay	Cubic Yard (Set Price)

*Denotes Thickness

Special Provision 90P-158 (latest revision), Add the following as new subsection 2.0 (j), Steel Fibers.

(j) Steel Fibers.

Furnish Steel Fibers conforming to the following requirements. Fibers will be accepted on the basis of a Type D certification and visual identification by the Field Engineer.

(1) 100 percent low carbon steel fibers specifically manufactured as concrete reinforcement.

(2) Hooked end fibers with a nominal minimum length of 2 in. and a nominal minimum diameter of 0.02 in.

(3) Aspect ratio of 100 or less.

(4) Minimum tensile strength of 150 ksi.

(5) Collated and glued together side by side with water soluble glue which will dissolve upon introduction of the fibers into the concrete mix.

(6) Meet or exceed the requirements of ASTM A 820.

(7) Fiber reinforcement and any admixtures used must be compatible. Use of any admixtures in the concrete mix or changes to the specified mix must be approved by the Bureau of Materials and Research of the Kansas Department of Transportation.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (a), Equipment, Part 2.

The mixer must be capable of allowing the addition of the fibers at the proper time and in the proper amounts as specified by the Fiber manufacturer's Representative or the Engineer.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (b), Proportioning.

LBS. OF FIBERS PER CU. YD. (percent of fibers by volume 0.64)	85

The volume of the fibers may be changed as suggested by the fiber manufacturer with the approval of the Bureau of Materials and Research of the Kansas Department of Transportation.

Contractors are reminded that steel fibers will stiffen the concrete mix. A water-reducing admixture will probably be necessary to maintain the workability of the mix.

Measure the slump after the addition of the fibers.

Mix and incorporate the fibers into the concrete in accordance with the fiber manufacturer's recommendations and the Bureau of Materials and Research Engineer's instructions.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (e), Placing and Finishing Concrete.

Remove all fiber clumps (or balls) from the concrete mix previous to the finishing operation.

Perform grooving at such a time and in such a manner as to minimize the displacement of the steel fiber, and prevent protrusion of the steel fiber from the deck surface.

Special Provision 90P-158 (latest revision), subsection 3.0 (h), Limitations of Operations, delete paragraph 2 and replace with the following.

Provide a technical representative of the fiber manufacturer on the job site during the initial placement at no additional cost to the Department. The representative is to provide technical expertise to the Contractor, concrete producer, and the Engineer regarding batching, transport, placement and curing of the steel fiber concrete. This requirement will not be waived.

At least 1 day prior to the construction of the bridge deck wearing surface, make a 4 cu. yd. trial concrete mix which is uniform and meets all of the specifications. Batch and place the trial mix using the same equipment and procedures which will be used during construction.

Special Provision 90P-158 (latest revision), Change the title of subsection 3.0 (l), Material for Silica Fume Overlay, to Material for Silica Fume with Steel Fibers Overlay.

Special Provision 90P-158 (latest revision), subsection 4.0, Method of Measurement and Basis of Payment, Delete this subsection and replace with the following:

Silica Fume with Steel Fibers Overlay will be measured by the square yard, to the nearest 0.1 sq. yd., complete in place. Quantity for which payment will be made may be the quantities shown on the Plans provided the project is constructed as shown on the Plans. Material for Silica Fume with Steel Fibers Overlay will be measured by the cubic yard, to the nearest 0.1 cu. yd.

Payment for "Silica Fume with Steel Fibers Overlay" at the Contract unit price, and "Material for Silica Fume with Steel Fibers Overlay" at the Contract set unit price (when approved by the District Engineer), will be full compensation for the specified work.

8-15-95 M&R (RU) (DAM)

90P423901 STEEL FIBERS (SILICA FUME) LBS 90P-4239 CRTD

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 1990 EDITION

NOTE: This special provision is generally written in the imperative mood. The subject, "the *Contractor*" is implied. Also implied in this language are "*shall*", "*shall be*", or similar words and phrases. The word "*will*" generally pertains to decisions or actions of the Kansas Department of Transportation.

BRIDGE DECK WEARING SURFACE - TYPE 1P CEMENT

Special Provision 90P-95 (latest revision) applies except:

Delete Paragraph **720.02 (a) Portland Cement**, and replace with the following:

(a) 1P Portland Pozzolan Cement.

Type 1P Cement, Section 2001, only Type 1P Cement will be permitted. Fly Ash modified concrete will not be permitted.

09-06-95 M&R (DAM)

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 1990 EDITION

SILICA FUME WITH POLYPROPYLENE FIBERS OVERLAY

Special Provision 90P-158 (latest revision) applies except:

Delete subsection 1.0, Description, and replace with the following:

1.0 DESCRIPTION.

Furnish materials for, and construct a wearing course of Silica Fume and Polypropylene Fiber modified Portland cement concrete on the prepared surface of reinforced concrete bridge decks. Place the overlay according to grades, thicknesses and cross-sections shown on the Plans.

BID ITEMS	UNIT
Silica Fume with Polypropylene Fibers Overlay (*)	Square Yard
Material for Silica Fume with Polypropylene Fibers	Cubic Yard (Set Price) Overlay

*Denotes Thickness

Special Provision 90P-158 (latest revision), Add the following as new subsection 2.0 (j), Polypropylene Fibers.

(j) Polypropylene Fibers. Furnish Polypropylene Fibers conforming to the following requirements. Fibers will be accepted on the basis of a Type D certification and visual identification by the Field Engineer.

(1) 100 percent virgin polypropylene, specifically manufactured as concrete reinforcement.

(2) Fibrillated, rough textured, and interconnected.

(3) Contain no reprocessed olifin materials.

(4) Minimum tensile strength of 80 ksi.

(5) Graded with a maximum nominal length of 2".

(6) Fiber reinforcement and any admixtures used must be compatible. Use of any admixtures in the concrete mix or changes to the specified mix must be approved by the Bureau of Materials and Research of the Kansas Department of Transportation.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (a), Equipment, Part 2.

The mixer must be capable of allowing the addition of the fibers at the proper time and in the proper amounts as specified by the Fiber Manufacturer or the Engineer.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (b), Proportioning.

LBS. OF FIBERS PER CU. YD. (percent of fibers by volume 0.2)	3

The volume of the fibers may be changed as suggested by the Fiber Manufacturer with the approval of the Bureau of Materials and Research of the Kansas Department of Transportation.

Measure the slump after the addition of the fibers.

Mix and incorporate the fibers into the concrete in accordance with the Fiber Manufacturer's recommendations.

Special Provision 90P-158 (latest revision), Add the following to subsection 3.0 (e), Placing and Finishing Concrete.

Remove all fiber clumps (or balls) from the concrete mix previous to the finishing operation.

Perform grooving at such a time and in such a manner as to minimize the displacement of the polypropylene fiber.

Special Provision 90P-158 (latest revision), Change the title of subsection 3.0 (l), Material for Silica Fume Overlay, to Material for Silica Fume with Polypropylene Fibers Overlay.

Special Provision 90P-158 (latest revision), subsection 4.0, Method of Measurement and Basis of Payment, Delete this subsection and replace with the following:

Silica Fume with Polypropylene Fibers Overlay will be measured by the square yard, to the nearest 0.1 sq. yd., complete in place. Quantity for which payment will be made may be the quantities shown on the Plans provided the project is constructed as shown on the Plans. Material for Silica Fume with Polypropylene Fibers Overlay will be measured by the cubic yard, to the nearest 0.1 cu. yd.

Payment for "Silica Fume with Polypropylene Fibers Overlay" at the Contract unit price, and "Material for Silica Fume with Polypropylene Fibers Overlay" at the Contract set unit price (when approved by the District Engineer), will be full compensation for the specified work.

09-27-95 M&R(RU) (DAM)

Greenwood County Bridge #60 Mix Designs

Bridge #60

Design Mix 4P975S2A
Name Concrete Bridge Wear Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.40	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1438 lbs	3757.32 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1438 lbs	139.16 ft^3 design 148.04 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 252 lbs	CYF = 4.383444
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.143719
Silica Fume (Admix)	Master Builders Inc.	3.20	2.20	cemt2: 20 lbs	

Air Entraining Agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2B
Name Concrete Bridge Wear Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.39	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1446 lbs	3767.31 yd^3 139.53 ft^3 design
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1446 lbs	148.44 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 246 lbs	CYF = 4.371820
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.143338
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air Entraining Agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2C
Name Concrete Bridge Wear Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.38	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1454 lbs	3777.30 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1454 lbs	139.90 ft^3 design 148.83 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 239 lbs	CYF = 4.360257
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.142959
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2D
Name Concrete Bridge Wear Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.37	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/gravel	50.00	2.55	Agg1 1462 lbs	3787.29 yd^3
FA-A natural sand	Ritchie Sand (087)	50.00	2.61	Agg2 1462 lbs	140.27 ft^3 design 149.22 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 239 lbs	CYF = 4.337315
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.142582
Silica Fume (Admix)	Master Builders Inc.	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2E
Name Concrete Bridge Wearing Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.36	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1470 lbs	3797.27 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1470 lbs	140.64 ft^3 design 149.62 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 227 lbs	CYF = 4.337315
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.142207
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2F
Water Source City of Severy
Name Concrete Bridge Wearing Surface
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.35	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1478 lbs	3807.27 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1478 lbs	141.01 ft^3 design 150.01 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 221 lbs	CYF = 4.325934
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.141834
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2G
Name Concrete Bridge Wearing Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.34	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/gravel	50.00	2.55	Agg1 1486 lbs	3817.26 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1486 lbs	141.38 ft^3 design 150.40 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 214 lbs	CYF = 4.314613
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.141463
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Bridge #60

Design Mix 4P975S2H
Name Concrete Bridge Wearing Surface
Water Source City of Severy
Date 5/7/1997

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.33	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/gravel	50.00	2.55	Agg1 1495 lbs	3827.25 yd^3
FA-A Natural Sand	Ritchie Sand (087)	50.00	2.61	Agg2 1495 lbs	141.75 ft^3 design 150.79 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 208 lbs	CYF = 4.303351
Cement TY-1P BLK/BAG	Ash Grove (Chanute)	96.80	2.92	cemt1: 610 lbs	Admix Factor = 0.141093
Silica Fume (Admix)	Master Builders Inc	3.20	2.20	cemt2: 20 lbs	

Air entraining agent 6 oz/yd^3

Greenwood County Bridge #61 Mix Designs

Bridge #61

Design Mix 4P597S1A
Name Concrete Bridge Wearing Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.38	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1456 lbs	3781.89 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1456 lbs	140.07 ft^3 design 149.01 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	water: 239 lbs	CYF = 4.497751
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	cemt1: 630 lbs	

Air entraining agent 6.00 oz/yd^3

Bridge #61

Design Mix 4P597S1B
Name Concrete Bridge Wearing Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.37	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1464 lbs	3791.61 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1464 lbs	140.43 ft^3 design 149.40 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 233 lbs	CYF = 4.486221
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6 oz/yd^3

Bridge #61

Design Mix 4P597S1C
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.36	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1472 lbs	3801.60 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1472 lbs	140.80 ft^3 design 149.79 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 227 lbs	CYF = 4.474432
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6.00 oz/yd^3

Bridge #61

Design Mix 4P597S1D
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.35	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1481 lbs	3811.59 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1481 lbs	141.17 ft^3 design 150.18 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 221 lbs	CYF = 4.462705
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6.00 oz/yd^3

Bridge #61

Design Mix 4P597S1E
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.34	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1489 lbs	3821.58 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1489 lbs	141.54 ft^3 design 150.58 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 214 lbs	CYF = 4.451039
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6 oz/yd^3

Bridge #61

Design Mix 4P597S1F
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.33	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1497 lbs	3831.57 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1497 lbs	141.91 ft^3 design 150.97 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 208 lbs	CYF = 4.439433
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6 oz/yd^3

Bridge #61

Design Mix 4P597S1G
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.32	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1505 lbs	3841.56 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1505 lbs	142.28 ft^3 design 151.36 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 202 lbs	CYF = 4.427889
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6 oz/yd^3

Bridge #61

Design Mix 4P597S1H
Name Concrete Bridge Wear Surface
Water Source City of Severy

W/C max	W/C design	Design slump	Min. CF	Design CF	% Air
0.38	0.31	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	50.00	2.55	Agg1 1513 lbs	3851.55 yd^3
FA-A Natural Sand	Ritchie Sand	50.00	2.61	Agg2 1513 lbs	142.65 ft^3 design 151.75 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 195 lbs	CYF = 4.416404
Cement TY-1P BLK	Ash Frove (Chanute)	100.00	2.92	Cemt1: 630 lbs	

Air entraining agent 6 oz/yd^3

Greenwood County Bridge #62 Mix Designs

Bridge #62

Design Mix 4P597S3A
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.40	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1444 lbs	3859.65 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1444 lbs	142.95 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 89 lbs	152.08 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 252 lbs	Cement Factor = 4.183281
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.223854
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3B
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.39	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1452 lbs	3870.18 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1452 lbs	143.34 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 90 lbs	152.48 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 246 lbs	Cement Factor = 4.171899
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.223245
Silica Fume (Admix)	Master Builders Inc	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3C
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.38	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1460 lbs	3880.44 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1460 lbs	143.72 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 90 lbs	152.89 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 239 lbs	Cement Factor = 4.160868
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.222655
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3D
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.37	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1468 lbs	3890.70 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1468 lbs	144.10 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 91 lbs	153.30 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 233 lbs	Cement Factor = 4.149896
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.222068
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3E
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.36	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1476 lbs	3900.96 yd^3 144.48 ft^3 design
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1476 lbs	153.70 ft^3
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 91 lbs	air free

Material	Supplier	% Blend	Sp. Gr.	Water: 227 lbs	Cement Factor = 4.138981
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.221484
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3F
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.35	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1484 lbs	3911.22 yd3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1484 lbs	144.86 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 92 lbs	154.11 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 221 lbs	Cement Factor = 4.128124
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.220903
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3G
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.34	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1492 lbs	3921.48 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1492 lbs	145.24 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 92 lbs	154.51 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 214 lbs	Cement Factor = 4.117323
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.220325
Silica Fume (Admix)	Master Builders Inc.	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

Bridge #62

Design Mix 4P597S3H
Name Silica Fume Overlay
Water Source City of Severy

W/C max.	W/C design	Design slump	Min. CF	Design CF	% air
0.40	0.33	3.00	625	630	6.0

Material	Supplier	% Blend	Sp. Gr.	Weight/Volume	Total Weight
CA-7 Chat	Bingham Sand/Gravel	48.50	2.55	Agg1 1501 lbs	3931.74 yd^3
FA-A Natural Sand	Ritchie Sand	48.50	2.61	Agg2 1501 lbs	145.62 ft^3 design
Steel Fiber/PCC	Dramix Steel	3.00	7.85	Agg3 93 lbs	154.92 ft^3 air free

Material	Supplier	% Blend	Sp. Gr.	Water: 208 lbs	Cement Factor = 4.106579
Cement TY-2 Bulk	Lafarge (Fredonia)	94.90	3.19	cemt1: 598 lbs	Silica Factor = 0.219750
Silica Fume (Admix)	Master Builders Inc	5.10	2.20	cemt2: 32 lbs	

Air entraining agent 8 oz/yd^3

APPENDIX C - CONCRETE FIELD MEASUREMENTS

CONCRETE FIELD MEASUREMENTS
Bridge #60
Greenwood County, KS

Overlay Placement Date: May 12, 1997 – North Half (westbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate lb/f^2/hr
7:30 AM	55	60	36	5	0.07
9:20 AM	65	68	32	5	0.09
10:30 AM	68	66	29	5	0.08

Overlay Mix Properties

Test #	Mix Temp. °F	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	67	38	1.75	3.6	144	632
2	72	43	2.25	3.4	143	629

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (143.54 lb/ft^3 rodded)
1601+95	148.6*	103.5*
1602+78	145.2	101.2
1603+60	141.7	98.7

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #60
Greenwood County, KS

Overlay Placement Date: May 14, 1997 – South Half (eastbound)

Climatic Conditions

Time	Air Temp °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate $lb/f^2/hr$
7:45 AM	61	65	36	5	0.08
10:50 AM	70	65	31	5	0.07
11:30 AM	75	68	29	10	0.12

Overlay Mix Properties

Test #	Mix Temp. °F	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	65	45	4.0	3.1	144	630

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (143.71 lb/ft^3 rodded)
1602+00	140.7*	97.9*
1602+80	142.8	99.4
1603+50	142.7	99.3

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #60
Greenwood County, KS

Overlay Placement Date: May 12, 1997 – North Half (westbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate lb/f^2/hr
7:30 AM	55	60	36	5	0.07
9:20 AM	65	68	32	5	0.09
10:30 AM	68	66	29	5	0.08

Overlay Mix Properties

Test #	Mix Temp. °F	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	67	38	1.75	3.6	144	632
2	72	43	2.25	3.4	143	629

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (143.54 lb/ft^3 rodded)
1601+95	148.6*	103.5*
1602+78	145.2	101.2
1603+60	141.7	98.7

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #60
Greenwood County, KS

Overlay Placement Date: May 14, 1997 – South Half (eastbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate $lb/f^2/hr$
7:45 AM	61	65	36	5	0.08
10:50 AM	70	65	31	5	0.07
11:30 AM	75	68	29	10	0.12

Overlay Mix Properties

Test #	Mix Temp. °F	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	65	45	4.0	3.1	144	630

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (143.71 lb/ft^3 rodded)
1602+00	140.7*	97.9*
1602+80	142.8	99.4
1603+50	142.7	99.3

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #61
Greenwood County, KS

Overlay Placement Date: May 22, 1997 – South Half (eastbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate lb/f^2/hr
7:30 AM	58	60	49	1	0.03
10:30 AM	68	72	38	5	0.09
12:00 PM	74	75	39	5	0.10

Overlay Mix Properties

Test #	Mix Temp. °F	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement lb/yd^3
1	72	2.5	3.3	144	648

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (144.11 lb/ft^3 rodded)
1714+20	146.3*	101.6*
1713+30	153.0	106.2
1712+40	152.6	105.9

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #61
Greenwood County, KS

Overlay Placement Date: May 29, 1997 – North Half (westbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate $lb/f^2/hr$
7:40 AM	68	70	46	0	0.03
9:40 AM	70	75	43	0	0.04
10:20 AM	77	79	29	0	0.05

Overlay Mix Properties

Test #	Mix Temp. °F	AEA oz/cy	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement lb/yd^3
1	75	12	3.5	4.3	143	642
2	73	24	7.0	5.7	140	628

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight ($141.14\ lb/ft^3$ rodded)
1714+20	139.1*	98.5*
1713+20	139.1	98.6
1712+50	138.2	97.9

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #62
Greenwood County, KS

Overlay Placement Date: June 23, 1997 – North Half (westbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate lb/f^2/hr
5:45 AM	72	75	68	0	0.03
8:00 AM	80	85	62	0	0.04
9:12 AM	78	85	70	5	0.09

Overlay Mix Properties

Test #	Mix Temp. °F	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	80	6.5	4.7	147	646
2	90	5.25	4.8	146	642
3	90	3.75	3.9	146	645

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (146.20 lb/ft^3 rodded)
1748+10	144.0*	98.5*
1748+90	144.7	99.0
1749+50	143.3	98.0

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #62
Greenwood County, KS

Overlay Placement Date June 25, 1997 – South Half (eastbound)

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate lb/f^2/hr
5:30 AM	75	80	76	0	0.03
7:50 AM	78	90	76	0	0.05
8:45 AM	80	90	78	0	0.07

Overlay Mix Properties

Test #	Mix Temp. °F	AEA oz/cy	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3	Cement + Silica Fume lb/yd^3
1	80	30	48	5.0	4.1	147	648
2		35	60		6.8		
3	90	33	54	2.5	4.6	145	640
4		33	51	2.5	4.6		

Wet Density Test
(Troxler 3430 Nuclear Density Test Instrument)

Station	Wet Density lb/ft^3	% of Rodded Unit Weight (146.18 lb/ft^3 rodded)
1748+10	144.1*	98.6*
1748+90	142.3	97.3

* Transverse Profile Average

CONCRETE FIELD MEASUREMENTS
Bridge #445
Sedgwick County, KS

Overlay Placement Date: May 20, 1997 – Entire Bridge

Climatic Conditions

Time	Air Temp. °F	Concrete Temperature °F	Humidity %	Wind Speed mph	Evaporation Rate $lb/f^2/hr$
7:20 AM	53	66	71	4	0.05
8:50 AM	62	68	52	6	0.09
10:00 AM	63	71	47	7	0.10

Overlay Mix Properties

Test #	Mix Temp. °F	AEA oz/cy	Plasticizer oz/yd^3	Slump inches	Air Content %	Unit Weight lb/ft^3
1	N/A			1.5	5.2	142
2	N/A	7	63	1.0	5.5	142
3	N/A	7	63	1.5	5.2	142

Report of Inspection of Aggregate Type: CA-7
Project: 96-37 K3293-05
County: Greenwood
Bridge No.60, 61 and 62

Contractor: Beachner Const. Co. Inc.
Produced by: Bingham Sand/Gravel Co.
Type of Construction: Bridge Deck Overlay

Shipping Point: Severy ,KS
From Plant at: Ottawa ,KS
Specification No.: Special Provision 90P-95-R3

Test No.: 1
Identification Specifications: 90P-95-R3

					Sieve Analysis		Square Mesh			Percent		Retained		
2"	1.5"	1"	.75"	.5"	.375"	4	8	16	30	40	50	100	200	% loss in wash test
0	0	0	0	0/10	15/50	85/100	0	0	0	0	0	0	0	
0	0	0	0	5.5	24.3	99.1	99.7	99.8	99.9		99.9	99.9	99.97	0.03

Total Accepted: 250 Cu. Yd.

Report of Inspection of Aggregate Type: FA-A
Project: 96-37 K3293-05
County: Greenwood
Bridge No. 60, 61 and 62

Contractor: Beachner Const. Co. Inc.
Produced by: Ritchie Sand Co.
Type of Construction: Br. Deck Overlay

Shipping Point: Severy ,KS
From Plant at: S35T26SR01W (Sedgwick Co.)
Specification No.: 1990 Std. Spec., Sec.1102

Test No.: 1
Identification Specifications: Sec. 1102

					Sieve Analysis		Square Mesh		Percent		Retained			
2"	1.5"	1"	.75"	.5"	.375"	4	8	16	30	40	50	100	200	G.F.	% loss in wash test
0	0	0	0	0	0	0/5	0/24	15/50	40/75		70/90	90/100	0	See Spec.	<2
0	0	0	0	0	0	0	3.8	23.1	54.5		86.5	98.8	99.8	2.67	0.2

Total Accepted: 250 Cu. Yd.

Sand FAM Grout

Sieve Size	Spec.	Actual Wt.	Percent
4	0	0	0.00%
8	0-30	13	0.45%
16		177	6.11%
30	20-50	867	29.91%
50	50-75	2153	74.27%
100	90-100	2833	97.72%
200		2886	99.55%

Original Dry Weight : 2899g

Rock CA-7

Sieve Size	Spec.	Actual Wt.	Percent
.75"	0	0	0.00%
.5"	0-10	224	5.51%
.375"	15-50	989	24.31%
4	85-100	4032	99.12%
8		4058	99.75%
16		4061	99.83%
30		4063	99.88%
50		4065	99.93%
100		4066	99.95%
200		4067	99.97%

Original Dry Weight : 4068g

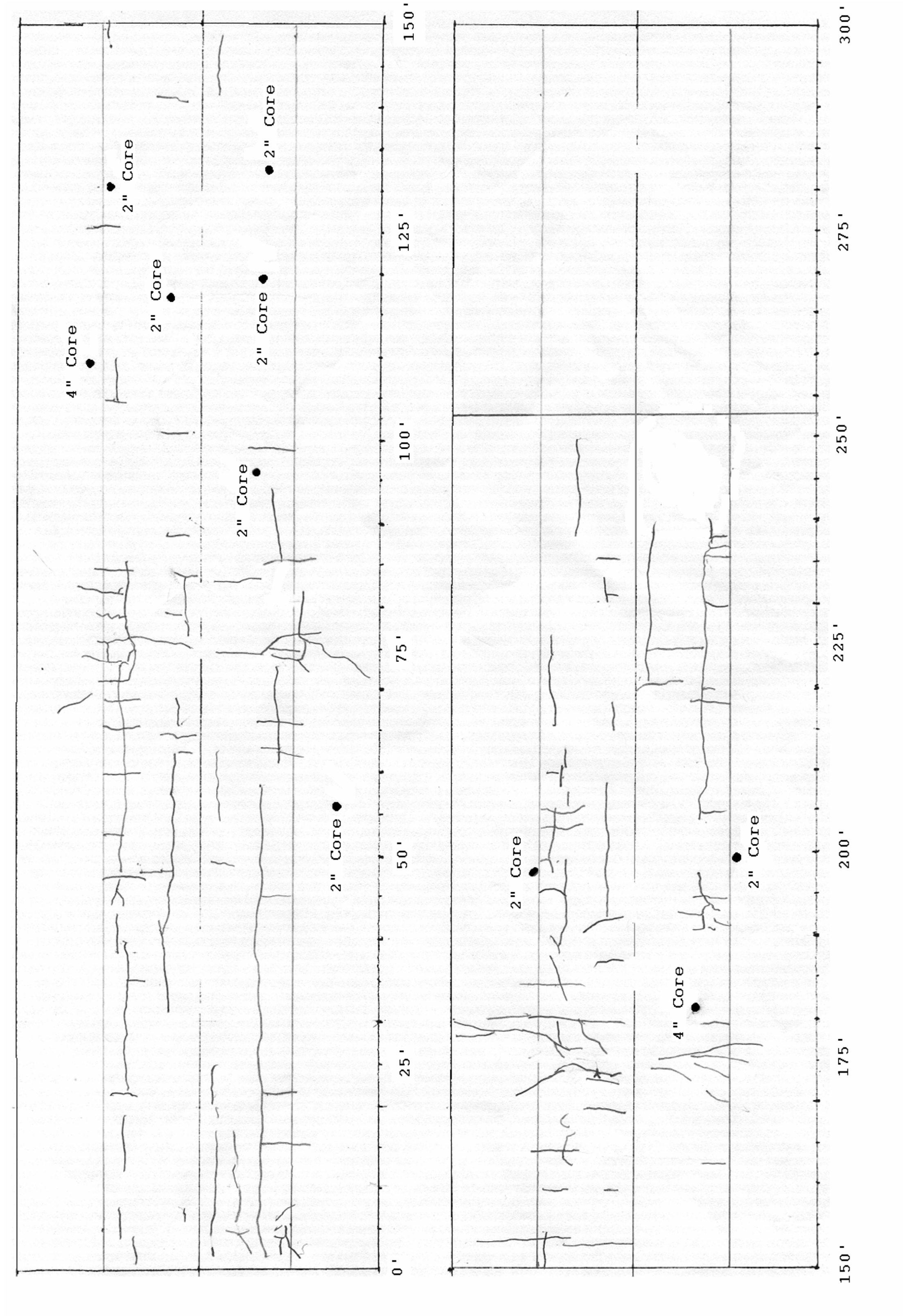
Sand FA-A

Sieve Size	Spec.	Actual Wt.	Percent
4	0-5	0	0.00%
8	0-24	96	3.77%
16	15-50	587	23.08%
30	40-75	1386	54.50%
50	70-90	2200	86.51%
100	90-100	2513	98.82%
200		2533	99.80%

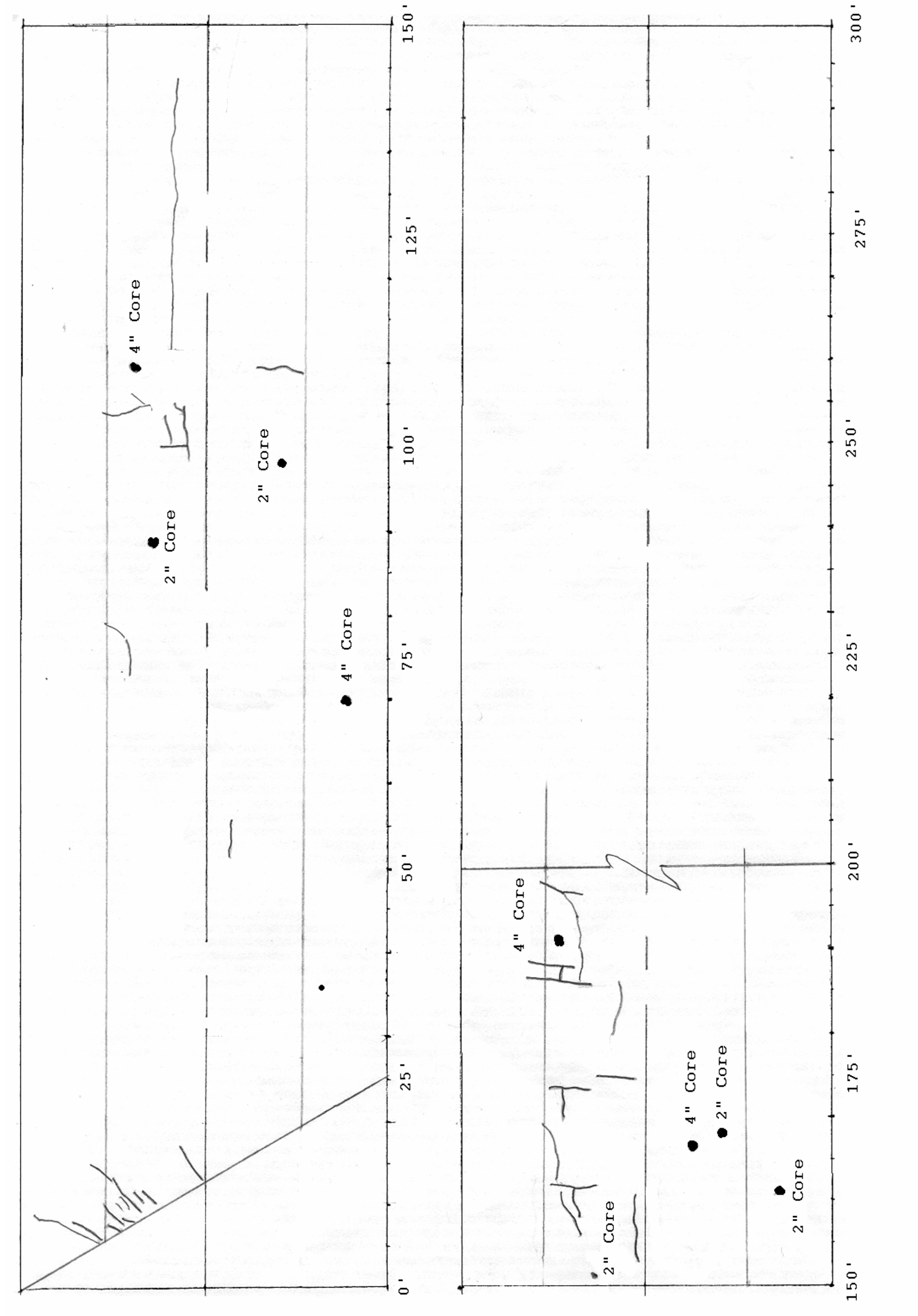
Original Dry Weight : 2538g

APPENDIX D - BRIDGE DECK CRACK SURVEYS

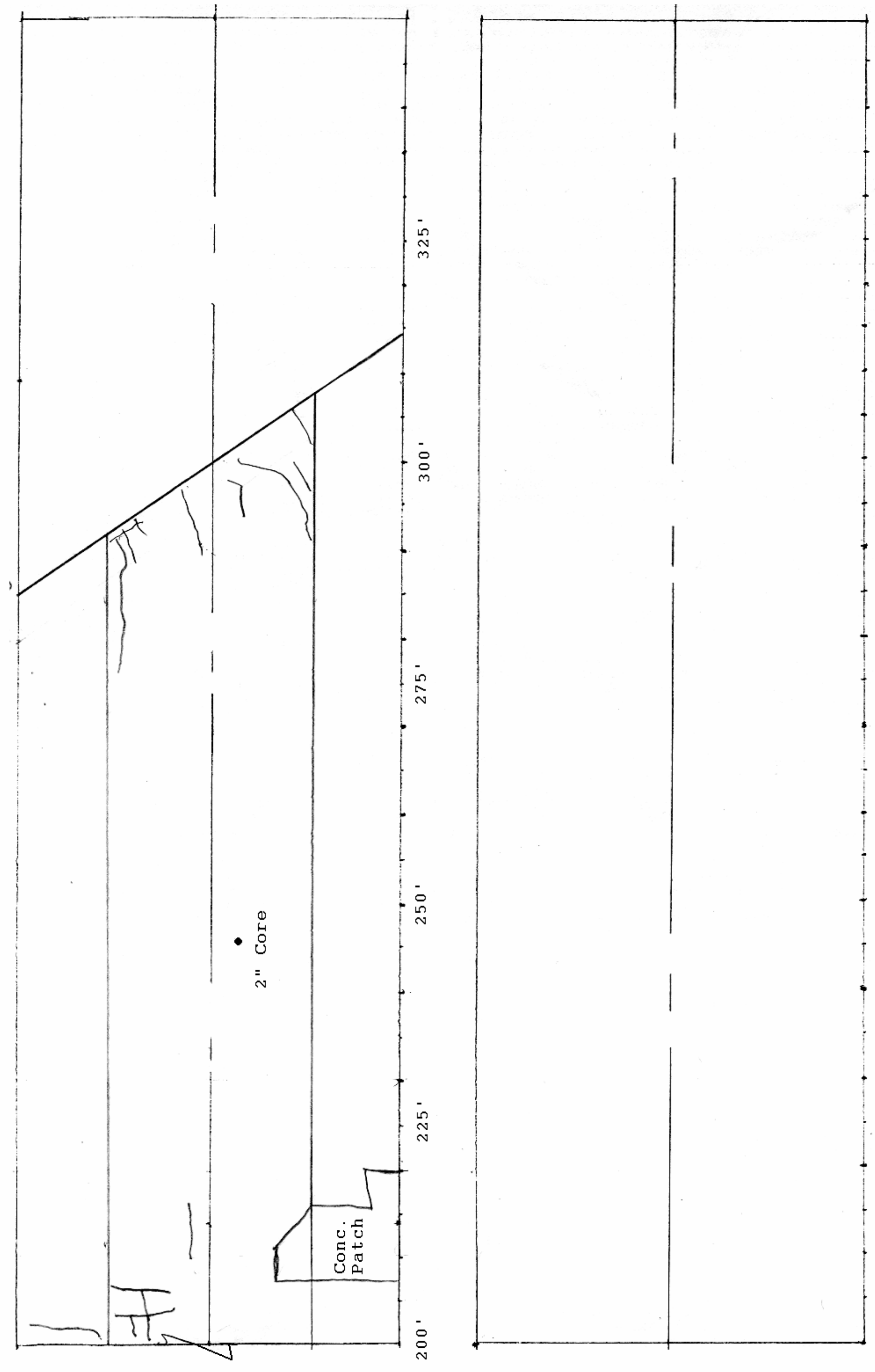
Bridge #60 Crack Map



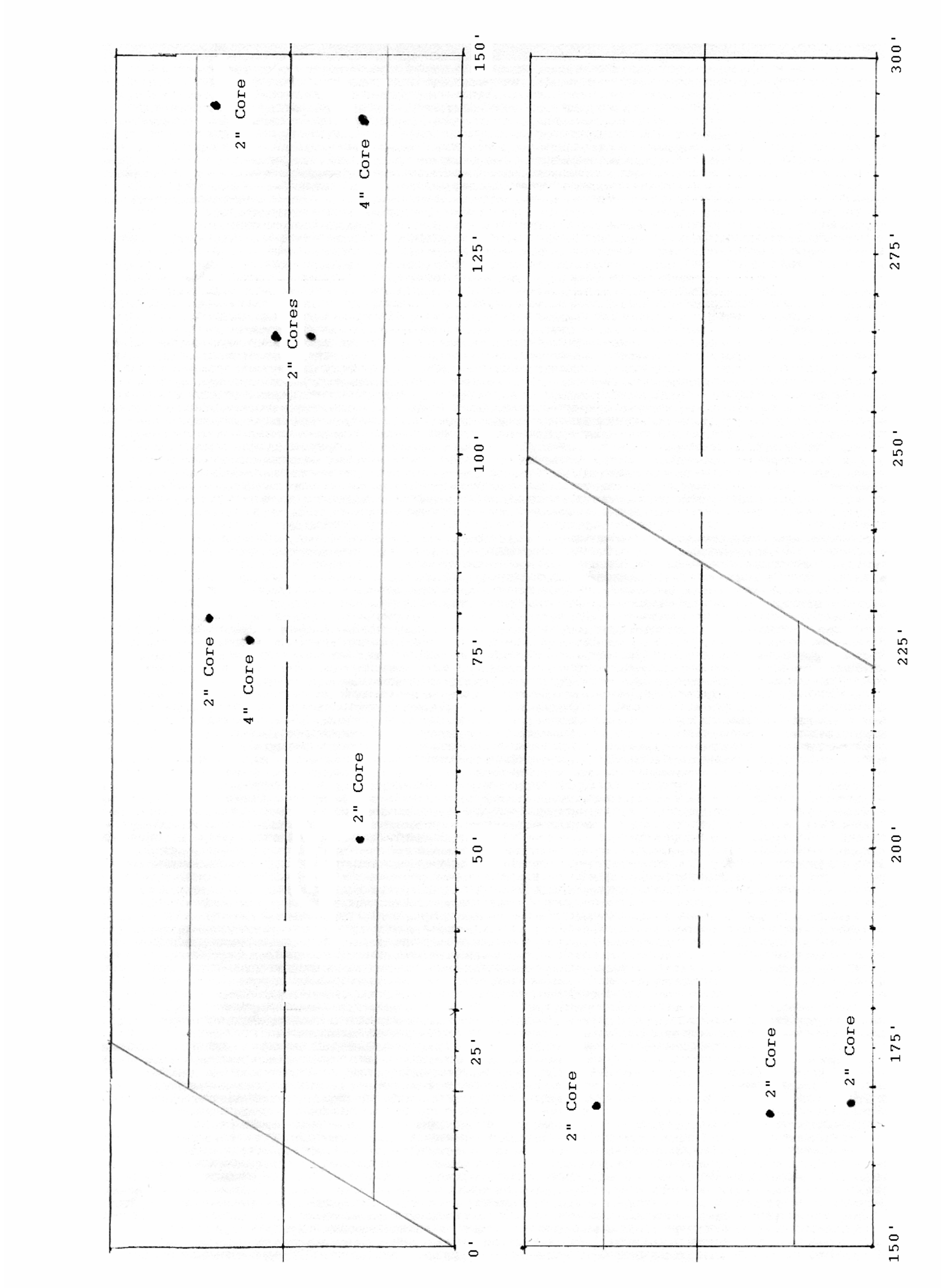
Bridge #61 Crack Map



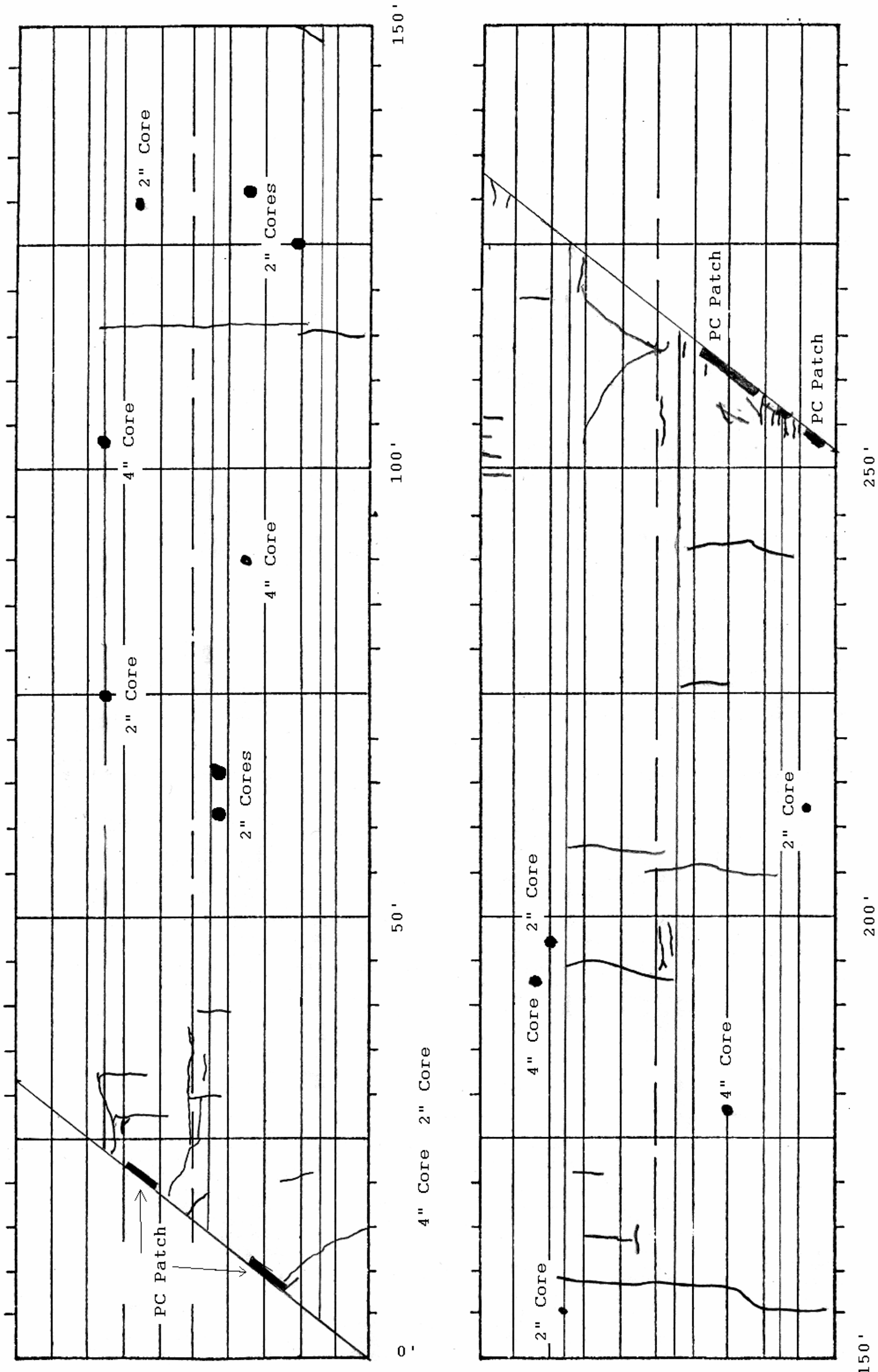
Bridge #61 continued



Bridge #62 Crack Map



Bridge #445



150'
2" Core
2" Cores
4" Core
100'
4" Core
2" Core
2" Cores
50'
4" Core 2" Core
PC Patch
0'
PC Patch
PC Patch
250'
2" Core
200'
2" Core
4" Core
4" Core
2" Core
150'

DEPARTMENT OF TRANSPORTATION

KANSAS