pennsylvania
DEPARTMENT OF TRANSPORTATION

Research Project # 2001-055
Evaluation of DensiCrete on a Superstructure

Final Report
November 2009

Prepared By:
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Evaluations and Research Section
Engineering Technology and Information Division
Bureau of Construction and Materials

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-PA- 2009-019-RP 2001-055	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Evaluation of DensiCrete on a Superstructure		**5. Report Date** November 2009 **6. Performing Organization Code**
7. Author(s) Marcella Jo Lucas		**8. Performing Organization Report No.** RP # 2001-055
9. Performing Organization Name and Address Pennsylvania Department of Transportation Bureau of Construction and Materials – ETI Division Materials Testing Laboratory DGS Annex Complex 81 Lab Lane, Harrisburg, Pa 17110-2543		**10. Work Unit No.** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address Pennsylvania Department of Transportation Bureau of Planning and Research – Research Division P.O. Box 3555, Harrisburg, Pa 17105-3555 Federal Highway Administration 228 Walnut Street, Room 508, Harrisburg, Pa 17101-1720		**13. Type of Report and Period Covered** Final Report July 2001 – June 2008 **14. Sponsoring Agency Code**

15. Supplementary Notes

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Organization: Pennsylvania Department of Transportation
Bureau of Construction and Materials

16. Abstract

This report details the evaluation of the penetrating sealer DensiCrete, a silicate in water material that was applied to three Portland cement concrete bridge decks in Erie County, Pennsylvania.

The field observations and testing were to determine if this penetrating sealer would be acceptable as an alternate to boiled linseed oil, if the DensiCrete material deters chloride ion penetration, and increases the concrete strength.

The test results from this research project were inconclusive.

17. Key Words Penetrating Sealer Silicates in Water Portland Cement Concrete Bridge Decks Chloride Ion Content		**18. Distribution Statement** No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.	
19. Security Classif. (of this report) None	**20. Security Classif. (of this page)** None	**21. No. of Pages** 20	**22. Price**

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

DISCLAIMER

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions and efforts of Engineering District 1-0, William Koller, P. E. Bridge Engineer, George Backo, Erie County Assistant Maintenance Manager, and all the Erie County maintenance forces. Without their help this report would not have been possible.

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METRIC CONVERSION FACTORS		
Convert From	**To**	**Multiply By**
Length		
Foot	Meter (M)	0.3048
Inch	Millimeter (mm)	25.4
Yard	Meter (M)	0.9144
Mile (Statute)	Kilometer(KM)	1.609
Area		
Square Foot	Square Meter (M^2)	0.0929
Square Inch	Square Centimeter (CM^2)	6.451
Square Yard	Square Meter(M^2)	0.8361
Volume		
Cubic Foot	Cubic Meter (M^3)	0.02832
Gallon (U.S. Liquid)	Cubic Meter (M^3)	0.003785
Gallon (CAN. Liquid)	Cubic Meter (M^3)	0.004646
Ounce (U.S. Liquid)	Cubic Centimeter (CM^3)	29.57
Mass		
Ounce-Mass (AVDP)	Gram(G)	28.35
Pound-Mass (ADVP)	Kilogram (KG)	0.4536
Ton (Metric)	Kilogram (KG)	1,000
Ton (Short, 2,000 LBM)	Kilogram (KG)	907.2
Density		
Pound-Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	16.02
Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	0.5933
Pound-Mass/Gallon (U.S.)	Kilogram/Cubic Meter (KG/M^3)	119.8
Pound-Mass/Gallon (CAN)	Kilogram/Cubic Meter (KG/M^3)	99.78
Temperature		
Degree Celsius (C)	Kelvin (K)	$T_K = (T_C + 273.15)$
Degree Fahrenheit (F)	Kelvin (K)	$T_K = (T_F + 459.67)/1.8$
Degree Fahrenheit (F)	Degree Celsius (C)	$T_C = (T_F – 32)/1.8$
Illumination		
Foot-Candles	Lux (LX)	10.76
Foot-Lamberts	Candela/Meter sq. (CD/M^2)	3.426
Force and Pressure or Stress		
Pound-Force	Newton (N)	4.45
Pound-Force/sq. in.	Kilopascals (KPA)	6.89

EXECUTIVE SUMMARY

This research project evaluated the application of DensiCrete on three structures in Erie County, Engineering District 1-0. DensiCrete is a sodium silicate material called a "Silicate in Water" that is used as a penetrating sealer on Portland Cement Concrete.

In 2001, the manufacturer Wicktek, Inc., of Farmington, PA requested that DensiCrete be approved for a different construction application than it was already approved for in Publication 35, Bulletin 15 Approved Construction Materials. The manufacturer wanted the product evaluated for approval with Publication 408 PennDOT Specifications: Section 1019 "Protective Coatings for Reinforced Concrete Surfaces".

The three structures used in this research project had the DensiCrete material applied to half of the bridge deck. The other half of the bridge deck had boiled linseed oil applied or nothing applied. Surface surveys and concrete tests were done on these bridge decks. The concrete samples collected were to measure and compare the chloride ion penetration, the visual absorption, and the compressive strength of the test sections. Only chloride ion testing was performed on all six test sections.

The test results from this research project were inconclusive; the Department will continue to monitor and test the application of the DensiCrete material when requested by the Engineering Districts.

DensiCrete shall maintain its current approval in Publication 35, Bulletin 15 Approved Construction Materials, under the Miscellaneous Section, "Penetrating Sealers to Reduce Chloride Penetration of Concrete" in the "Silicates in Water" category.

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BACKGROUND

DensiCrete, formerly PermaCrete, is a watery opaque sodium silicate material. When used on concrete, this material should seal, waterproof, and protect the surface from unwanted intrusions. This material has been approved by the Pennsylvania Department of Transportation (PennDOT) for listing in Publication 35, Bulletin 15 Approved Construction Materials since 1996. The listing is under the Miscellaneous Section, "Penetrating Sealers to Reduce Chloride Penetration of Concrete" in the "Silicates in Water" category. This approval has allowed DensiCrete to be used as a penetrating sealer on cement concrete surfaces that have no vehicular or pedestrian traffic.

In 2001, the manufacturer Wicktek, Inc., Farmington, PA requested that DensiCrete be approved for use in lieu of boiled linseed oil for bridge superstructure application as stated in Publication 408/2000 PennDOT Specifications: Section 1019 "Protective Coatings for Reinforced Concrete Surfaces"; which referenced Section 503 "Protective Coatings for Cement Concrete Pavements" for the boiled linseed oil application. Since this request would change how and where the DensiCrete material would be used, PennDOT would consider this approval of the DensiCrete material as an experimental product evaluation.

For the evaluation, PennDOT with input from Wicktek, Inc. developed this research project to test DensiCrete on several structures. The research project was to assess the DensiCrete properties to prevent chloride ion penetration and strengthen the concrete while maintaining a safe driving surface. Based on these field observations, the Department would learn if this penetrating sealer would be acceptable as an alternate to boiled linseed oil, if the DensiCrete material deters chloride ion penetration, and if DensiCrete increases the concrete strength.

For the rest of this report the DensiCrete material may be referred to as the experimental product.

PROJECT SUMMARY

Two locations were selected for this research project; both in Engineering District 1-0, Erie County. This area of Pennsylvania gets lake effect snowfall from October through March. Choosing locations were snow and ice removal occur for most of the year gives the experimental product the opportunity to prove its performance in extreme field conditions. See Figure 1 and Figure 2 for the research project locations.

The first location was a structure on SR 5 over Sixteen Mile Creek. This structure was built in 2001, the same year as the research project. The prime contractor for this location was Shingledecker's Welding of Franklin, PA. The experimental product and the comparison product were applied by the prime contractor during the construction project.

The second location was twin structures on SR 79 over SR 3006 (Traffic Route 6N). At the time of the experimental product placement the northbound structure was three years old and the southbound structure was four years old. Wicktek, Inc. subcontracted Premiere Systems, Meadville, PA to apply the experimental product. Nothing was applied to the comparison areas, these areas were left untreated.

Both SR 79 structures had been retrofitted with anti-icing systems. The systems automatically apply a salt brine solution, when sensors dictate that weather conditions are approaching freezing conditions. This substantially increases the amount of chloride exposure for these bridge decks.

The Research Project Locations:

S-#23879

BMS #25-0005-0940-1218
SR 5, Segment 0940 Offset 1218
Erie County
Engineering District 1-0

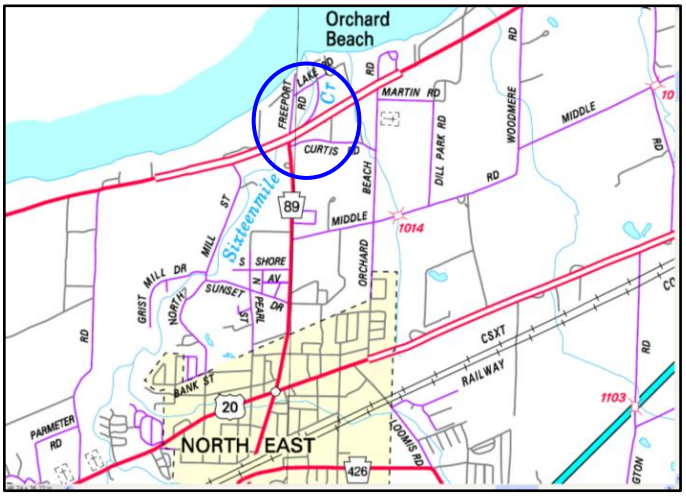

Figure 1, SR 5 Project Location

S-#21983

BMS# 25-0079-1654-0711
SR 79, Segment 1654 Offset 0860 NB
Erie County
Engineering District 1-0

S-#21983

BMS# 25-0079-1655-0652
SR 79, Segment 1655 Offset 0801 SB
Erie County
Engineering District 1-0

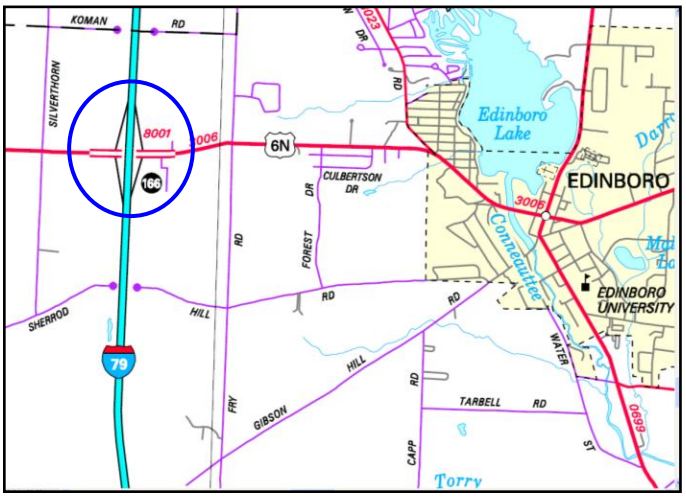

Figure 2, SR 79 Project Locations

PRODUCT PLACEMENT

The procedure used to place the experimental product (DensiCrete) was as follows:

- Power wash the bridge deck with water to clean the surface of any debris
- Let bridge deck surface dry
- Use a garden sprayer (2 gallon size) to apply the first coat of material in a block-by-block pattern
- Let the bridge deck surface dry between coats
- Apply a second coat in the same pattern and/or third coat, if needed to meet application rate

The procedure used to place the comparison product (boiled linseed oil) was as follows:

- Dry and clean the bridge deck of any dirt, debris, oil, and grease
- Pressure spray the material to ensure complete coverage of the bridge deck
- Let the bridge deck surface dry for 24 hours between coats
- Apply second coat to meet application rate

SR 5

At the SR 5 location the experimental product was applied to the bridge deck on September 27, 2001.

The manufacture Wicktek, Inc. sub-contracted the field application to Premiere Systems. The representative from Premiere Systems demonstrated the experimental product placement for the construction contractor Shingledecker's Welding of Franklin, PA. The construction contractor then applied 55 gallons of the experimental product to the westbound bridge deck lanes and parapet.

The bridge deck was 50'-7½" long and 110'-3¾" wide (out-to-out). The dimension of the experimental area was 17'-9" wide (normal to the centerline) by 44'-6" long based on a 60 degree skew. The total area was 2,701 SF.

SR 79 Northbound

At the SR 79 Northbound location the experimental product was applied to the north half of the super-structure. The overall bridge deck measured 106'-2" long and 43'-6" wide. The experimental product area was both lanes and shoulders of the north end of the structure with the dimensions being 53'-2" long by 43'-6" wide.

The manufacture Wicktek, Inc. sub-contracted the field application at this location to Premiere Systems. Engineering District 1-0 Erie County maintenance forces supplied the traffic control and water truck for this application.

A minimum of 21 gallons of material was proposed for placement on the bridge deck surface. Actual placement was about 30-32½ gallons of material for this location. The experimental product application rate was not measured. Using the spray setting on sprayer, the experimental material was applied to an

area until the surface was saturated and the material created a puddle. The DensiCrete material should cure in 28 days.

The experimental product was applied to the driving lane and shoulder on July 17, 2002, then to the passing lane and shoulder on July 18, 2002. Table 1, Experimental Product Placement on SR 79 Northbound, summarizes the experimental product placement on those days.

Table 1, Experimental Product Placement on SR 79 Northbound

SR 79 Northbound Structure							
Day	Area	Procedure	Time		Temperature Readings		
			Start	Finish	Time	Surface (º F)	Air (º F)
July 17, 2002	Driving Lane and Shoulder	Power Washing	10:07 am	11:13 am	10:06 am	94º	81º
		First Coat	11:15 am	11:55 am	11:15 am	—	89º
		Second Coat	12:00 pm	12:40 pm	12:08 pm	100º	106º
		Stop Work	12:43 pm	—	12:43 pm	115º	110º
July 18, 2002	Passing Lane and Shoulder	Power Washing	8:00 am	8:40 am	8:48 am	79º	81º
		First Coat	9:00 am	10:02 am	9:48 am	88º	91º
		Drying Time	10:02 am	10:18 am	—	—	—
		Second Coat	10:18 am	10:58 am	10:58 am	88º	90º
		Drying Time	10:58 am	11:20 am	—	—	—
		Stop Work	11:20 am	—	—	—	—

On both days the representative followed the same procedure, power washing the bridge deck surface using at least 400 gallons of water on each side. The experimental product was placed in a block by block pattern, so that when finished the beginning shoulder area was dry enough to start the second coat. During the second coat, placement temperatures reached or were above DensiCrete's specification requirement of 90 ºF, so the manufacture decided not to apply a third coat. This completed the experimental application on the SR 79 northbound structure.

Photo 1, DensiCrete Application on SR 79 Northbound

SR 79 Southbound

At the SR 79 Southbound location the experimental product was applied to the south half of the super-structure. The overall bridge deck measured 106'-2" long and 43'-6" wide. The experimental product was placed on the full width of the south end of the structure with the dimensions being 53'-2" x 43'-6".

The manufacture Wicktek, Inc. had sub-contracted the field application at this location to Premiere Systems. Engineering District 1-0, Erie County maintenance forces supplied the traffic control and water truck for this application.

A minimum of 21 gallons of material was proposed for placement on the bridge deck surface. Actual placement was about 30-32½ gallons of material for this location. The experimental product application rate was not measured. Using the spray setting on sprayer, the experimental material was applied to an area until the surface was saturated and the material created a puddle. The DensiCrete material should cure in 28 days.

The experimental product was applied to the driving lane and shoulder on Monday, July 22, 2002 then to the passing lane and shoulder on Tuesday, July 23, 2002. The experimental product placement is summarized in Table 2, Experimental Product Placement on SR 79 Southbound.

On the first day the representative followed the product placement procedure; power washing the bridge deck surface using at least 300 gallons of water for both sides. The water drained from the experimental area into the comparison area inlets. Since the quantity of experimental product was less than the water used, none of the DensiCrete drained into the comparison area. The experimental product was placed in a block by block pattern. When both the surface and air temperatures were above 90º at 11:25 am, the representative decided to stop work.

On the second day, since the southbound passing and shoulder area were power washed yesterday, the representative did a cursory walk through to see if the bridge deck surface was acceptable for the experimental product placement. The representative decided to go ahead with the application without any further cleaning. Three-fourths of the first coat on the southbound lane had been completed when it

started to rain. The work was halted until the bridge deck surface was dry enough to continue the application again. The representative reapplied the first coat of the experimental product to the passing lane and shoulder, and then the second coat was applied. This completed the experimental application on the SR 79 southbound structure.

Table 2, Experimental Product Placement on SR 79 Southbound

SR 79 Southbound Structure							
Day	Area	Procedure	Time		Temperature Readings		
			Start	Finish	Time	Surface (º F)	Air (º F)
July 22, 2002	Driving Lane and Shoulder	Power Washing	7:55 am	8:30 am	8:15 am	83º	81º
		First Coat	8:40 am	9:20 am	9:15 am	89º	88º
		Second Coat	9:25 am	10:15 am	10:15 am	87º	92º
		Drying Time	10:15 am	10:35 am	—	—	—
		Switched Lanes	10:35 am	10:50 am	—	—	—
	Passing Lane and Shoulder	Power Washing	10:55 am	11:25 am	11:25 am	91º	95º
		Stop Work	11:25 am	—	—	—	—
July 23, 2002	Passing Lane and Shoulder	First Coat	8:00 am	8:20 am	8:00 am	76º	75º
		Stop Work	8:20 am	10:20 am	8:40 am	Rain	Rain
		Drying Time	10:20 am	11:15 am	11:10 am	77º	74º
		First Coat	11:20 am	12:15 pm	12:10 am	80º	75º
		Second Coat	12:20 pm	1:00 pm	1:00 pm	89º	86º
		Drying Time	1:00 pm	1:30 pm	—	—	—
		Stop Work	1:30 pm	—	—	—	—

FIELD EVALUATION

The bridge decks at the three structures were divided into two test sections with a total of six test sections. At each field view, traffic control was provided by Erie County maintenance forces. These field views were to document the bridge deck surface conditions and to collect samples from each test section. Visual observations of the bridge decks were photographed and any distresses were noted. Collected samples were taken to PennDOT's Bureau of Construction and Materials, Materials Testing Lab for processing and analysis.

Surface Conditions

SR 5, no surface distress or cracking during the research project study.

SR 79 Northbound, the experimental product area on the shoulder, a 3'-6" long by 7'-6" wide area had a stained area that during the experimental product placement the power washing could not remove. This stain was visible throughout the research project. Samples were not collected in this area.

SR 79 Southbound, no surface distress or cracking during the research project study.

Samples Collected

The concrete samples collected were to measure and compare the chloride ion penetration, the visual absorption, and the compressive strength of the test sections.

For chloride ion penetration testing, samples were taken in the comparison area (boiled linseed oil or untreated) and the experimental area of all three structures.

When this research project started the SR 5 structure was being built. The DensiCrete and the boiled linseed oil were applied within days of each other after the bridge deck curing was removed. The chloride ion content baseline for the test sections on this bridge deck were considered zero. After application the SR 5 structure was tested at 1 year, 3 years and 7 years.

The SR 79 structures had baseline samples taken in September 2001 and June 2002 before the DensiCrete application. After the application, chloride ion samples were taken on the SR 79 northbound structure at 1 year, 3 years and 6 years and on the SR 79 southbound structure at 1 year, 3 years and 5 years.

The following steps, which are based on Pennsylvania Test Method No. 414, were used for collecting the chloride ion tests from each test section.

- Cleaned the Hilti drill, ¾ inch drill bits, blow out bulbs, brushes, and stainless steel spoons with Alconox and distilled water in preparation for the chloride ion sampling.
- Measured and marked the comparison area and the experimental product area test sections on each structure's bridge deck.
- Randomly selected, using a modified version of PTM No. 1, and marked the five sample locations per test section (comparison, boiled linseed oil, DensiCrete).

- At the five locations, samples were taken at ½ inch, 1 inch, and 2 inch depths, totaling fifteen per test section. The same process was done for each depth.
- Samples were taken by drilling the appropriate depth at each location using a Hilti drill fitted with a ¾ inch drill bit and a collection tin with a 1 inch hole in the bottom. The depth of the hole was checked using a wooden ruler.
- Most of the concrete dust collected on the perimeter of the collection tin. The remaining dust was collected either by scooping the material out of the hole with a small stainless steel spoon or by using a blow out bulb to collect the remaining pulverized concrete onto the collection tin.

Photo 2, Collecting Chloride Ion Sampling

- The pulverized concrete material was placed in a labeled sample tin for that location and depth. Five grams of pulverized material was collected for each depth. Each sample tin was processed for the chloride ion content.
- Between sample locations and increments the equipment was wiped clean to avoid cross-contamination
- The resulting holes were filled with a fast drying epoxy or a quikcrete material. When the material was set, maintenance removed the traffic control.

The chloride ion samples were processed using lab test Concrete: "Determining Chloride Concentration Procedure" PA 616. Results were reported in pounds per cubic yard.

For the visual absorption and the compressive strength tests concrete cores were to be extracted from the comparison area and the experimental area of all three structures. Cores were not taken at the SR 5 location for either area, the spacing of the reinforcement bars bottom and top mats overlapped to closely to extract a 4 inch core without also removing rebar. A core with rebar would not give acceptable results for these tests. At the SR 79 structures baseline cores were taken in September 2001 for absorption and compressive strength. The comparison cores were taken in July 2003, one year after the DensiCrete application, these results are not available.

Skid Resistance testing in accordance with ASTM E 274 was to be done after the material had been placed and had sufficient cure time. When the testing was requested, the Bureau of Maintenance and Operations responded that the test sections were not long enough for the test to be performed. The test sections were not tested for skid resistance.

CONCLUSIONS

The chloride ion test results for this research project did not show that the DensiCrete material was better or worse at preventing chloride ion penetration than the boiled linseed oil or the untreated comparison areas.

For the visual absorption and the compressive strength tests, concrete cores were not collected for all test sections, making the comparison of these test results unacceptable.

Since the bridge decks were not long enough for skid resistance tests, this research project was not able to determine the safety of the DensiCrete material on a superstructure. However, this material has been used in other locations and tested by other state DOT's with no safety concerns reported.

The test results from this research were inconclusive; the Department will continue to monitor and test the application of the DensiCrete material when requested by the Engineering Districts.

RECOMMENDATIONS

When this research project started in 2001, DensiCrete was seeking approval for use on bridge superstructures. Since then the Department has changed 408 PennDOT Specification, Section 1019 "Protective Coatings for Reinforced Concrete Surfaces" to include a part (d) Penetrating Sealers (For Bridge Superstructure). Based on this specification change and DensiCrete's current PennDOT approval, it is recommended that DensiCrete shall maintain approval in Publication 35, Bulletin 15 Approved Construction Materials, under the Miscellaneous Section, "Penetrating Sealers to Reduce Chloride Penetration of Concrete" in the "Silicates in Water" category.

REFERENCES

"Concrete: Determining Chloride Concentration Procedure" (PA 616), Pennsylvania Department of Transportation, Bureau of Construction and Materials, Harrisburg, Pa.

"Obtaining Samples of Pulverized Concrete for Chloride Analysis", (PTM 414), Pennsylvania Department of Transportation, Bureau of Construction and Materials, Harrisburg, Pa., July 1995

"Probability Sampling", (PTM 1), Pennsylvania Department of Transportation, Bureau of Construction and Materials, Harrisburg, Pa., July 1995

APPENDIX A TEST SECTION LOCATIONS

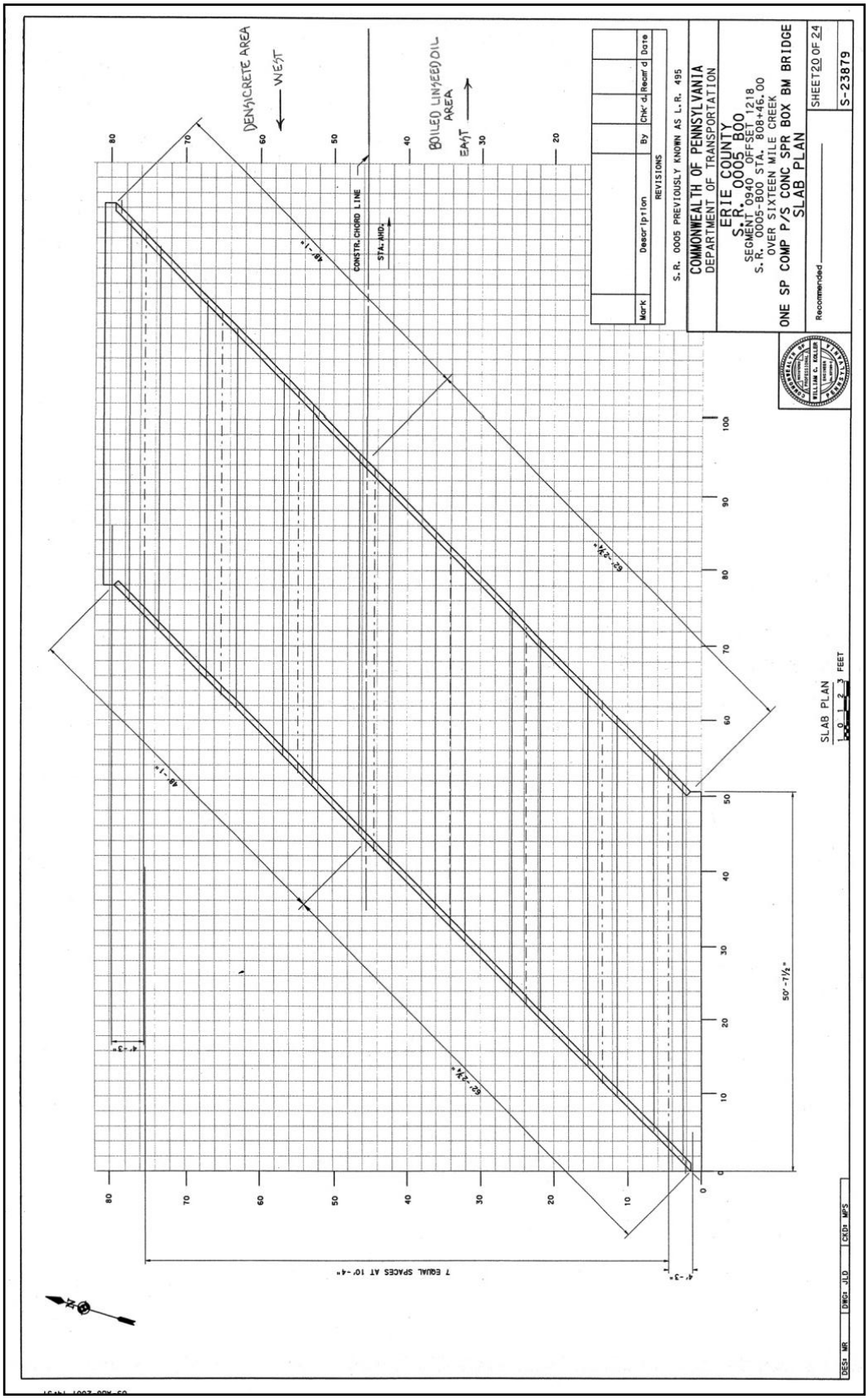

Figure 3, SR 5 Test Section Locations

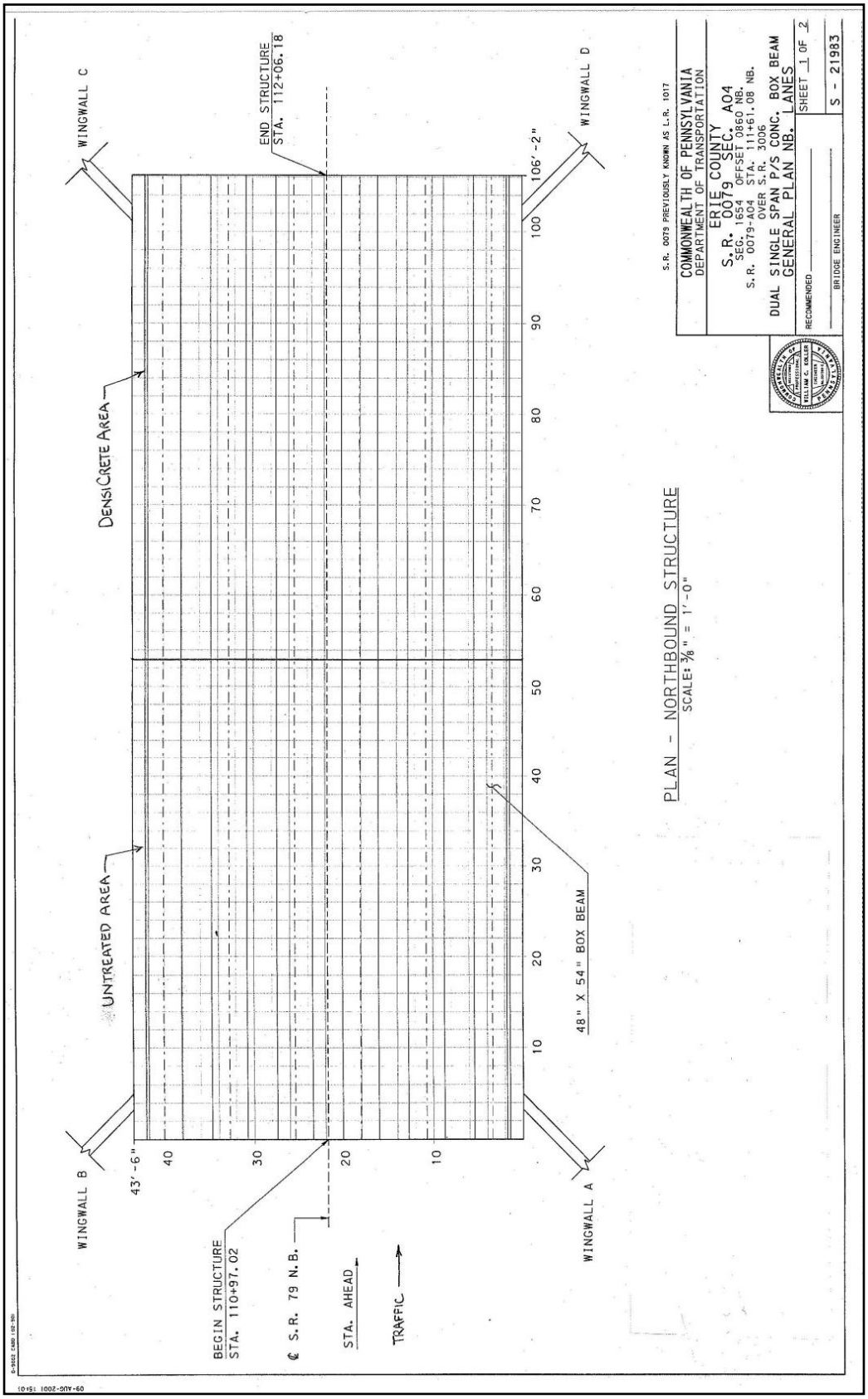

Figure 4, SR 79 Northbound Test Section Locations

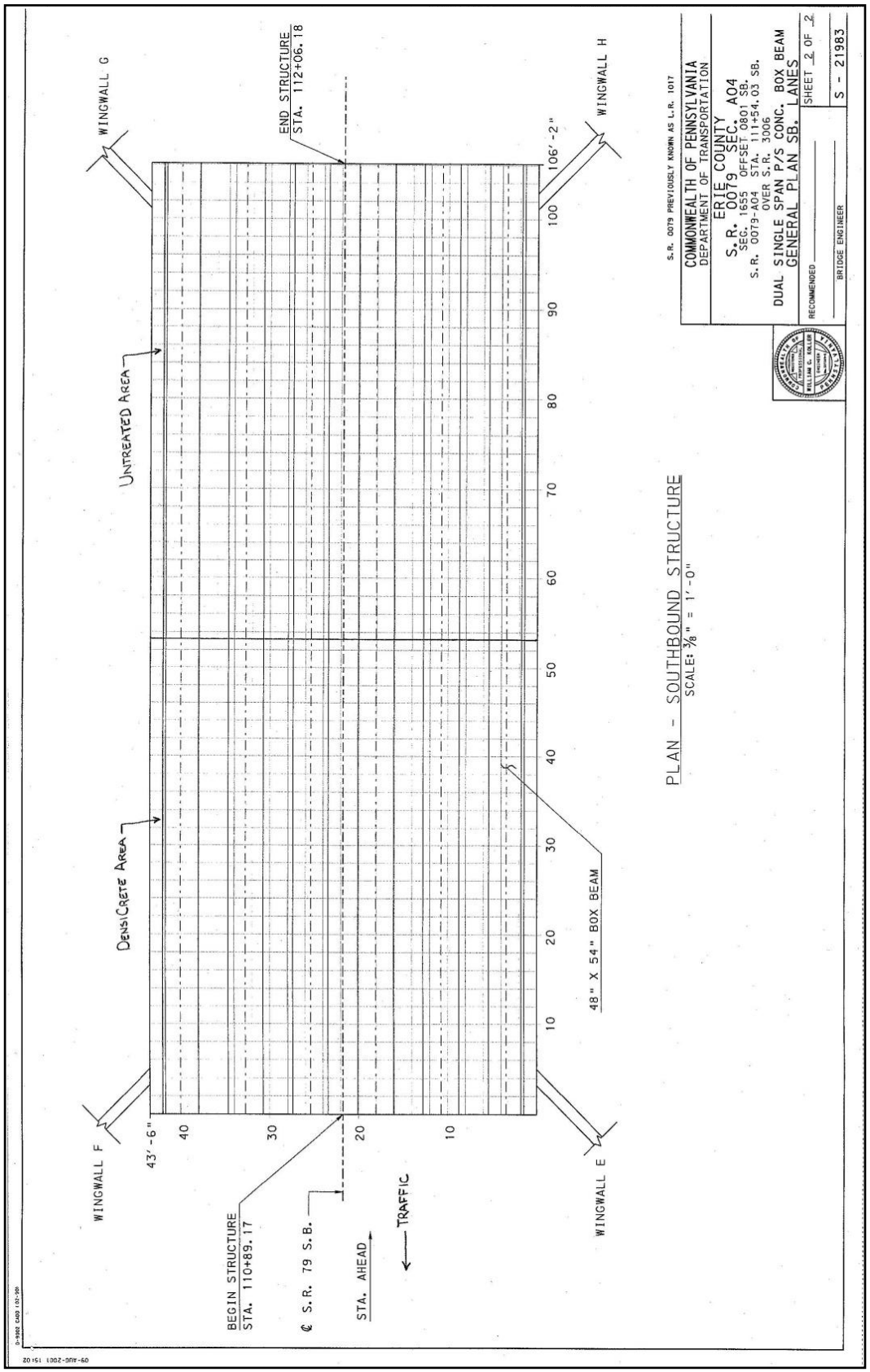

Figure 5, SR 79 Southbound Test Section Locations