Research Report
UKTRP-86-26

SHRINKAGE COMPENSATING DECK CONCRETE
(KY 1974 Bridge over Tates Creek Road)

by

David Q. Hunsucker
Research Engineer Associate

November 1986

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(KY 1974 Bridge over Tates Creek Road)

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David Q. Hunsucker
Research Engineer Associate

Kentucky Transportation Research Program
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet

and

Federal Highway Administration
US Department of Transportation

November 1986

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16. Abstract

This report summarizes the construction activities on an experimental bridge deck utilizing shrinkage compensating concrete. The experimental concrete is characterized in terms of freeze/thaw durability, compressive strength, and elastic moduli.

17. Key Words	18. Distribution Statement
Shrinkage Compensating Concrete Freeze/thaw Durability Compressive Strength Elastic Modulus	Unlimited with approval of the Kentucky Transportation Cabinet

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PROJECT LOCATION

Shrinkage compensating concrete is made with an expansive cement in which the expansion, if restrained, induces compressive stresses that approximately offset tensile stresses induced by drying shrinkage. The objectives of this study were to evaluate the construction and performance of the Shrinkage Compensating Bridge Deck Concrete, Class S, and to compare the performance to conventional bridge deck concrete, Class AA.

The bridge under study is located on KY 1974 (Tates Creek Road) over West Hickman Creek in Lexington, Fayette County, Kentucky. The subcontractor for the bridge was R. R. Dawson Bridge Company. The experimental shrinkage compensating concrete was batched at the W. T. Congleton Company.

EXPERIMENTAL MATERIALS

A trial mix was batched at the W. T. Congleton Company ready-mix plant to determine the optimum amount of water to be used in the mix. The reason for this determination was the fact that the concrete had to be transported for approximately thirty minutes before reaching the job site, and loss of slump was of concern. Materials to produce 1 cubic yard were as follows:

Cement..............620.0 lbs
Water................41.6 lbs
Fine Aggregate.....1095.0 lbs
Coarse Aggregate...1685.0 lbs
Air Entrainment
Admixture.............6.5 ozs

Immediately after mixing, the slump was 5-3/4 inches and the air content was 5.0 percent. After 30 minutes, the slump was 4-1/2 inches and the air content was 5.0 percent. The final concrete mix design obtained from the Division of Materials is reported in Appendix I.

CONSTRUCTION

Site investigations were made prior to placement of the experimental concrete (see Figure 1). Figures 2 and 3 show the tied reinforcing steel in the deck. Equipment observed at the site included a Bucyrus-Erie 30-B Series Crane with drop buckets to place the concrete. A Bidwell vibrating screed concrete finishing machine was used to finish the deck (see Figures 4 and 5).

The shrinkage compensating deck concrete was placed in the eastbound lanes on Wednesday, March 26, and in the westbound lanes on Friday, March 28, 1986. Interviews with Kentucky Department of Highways personnel revealed that the experimental concrete on the eastbound deck was difficult to finish. The stiff wind blowing that day evaporated much of the free water necessary for a good finish. The bridge also was on a skew and the tyning machine was not, and the experimental concrete was sticky. Results were much better on the westbound deck. The amount of free water necessary for a good finish was adequate and workers seemed to have gained experience from the previous pour.

The experimental shrinkage compensating concrete has been characterized in terms of freeze/thaw durability, compressive strength, and elastic modulus. Results of freeze/thaw testing are contained in Appendix II. The average durability factor (based on 350 cycles) for four prisms was 56. The average percent expansion was 0.071 for the set. The average durability factor and percent expansion fall below the requirements for Class AA concrete.

Compressive strength and elastic modulus tests were performed at 28 days. Results are contained in Appendix III. The average compressive strength for two cylinders was 3,080 psi and the average elastic modulus was 3.16 million psi. Section 601.05 of the Kentucky Standard Specifications for Road and Bridge Construction states that a Class AA concrete shall have a 28-day compressive strength of 4,000 psi.

Due to the fact that 28-day compressive strengths were low, a request was made by the District 7 Engineer for Construction for the Division of Materials to core the deck. Results of this activity are contained in Appendix IV. The

Figure 1: The Construction Site

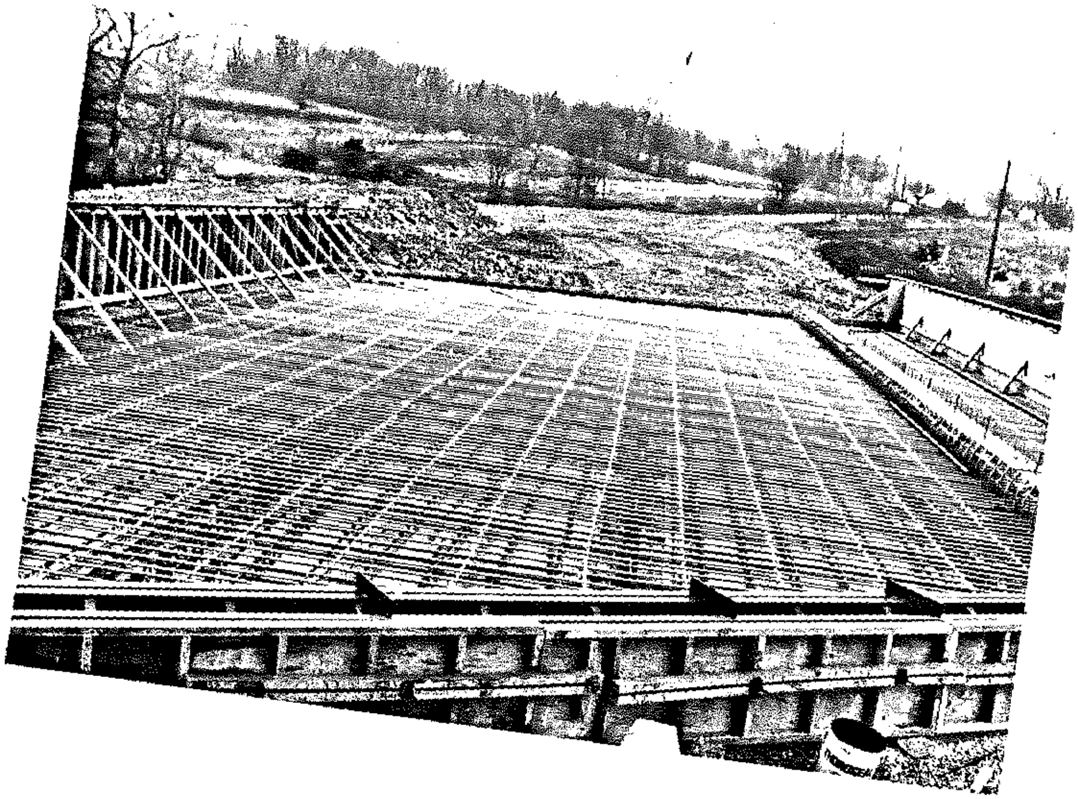


Figure 2: The Reinforcing Steel

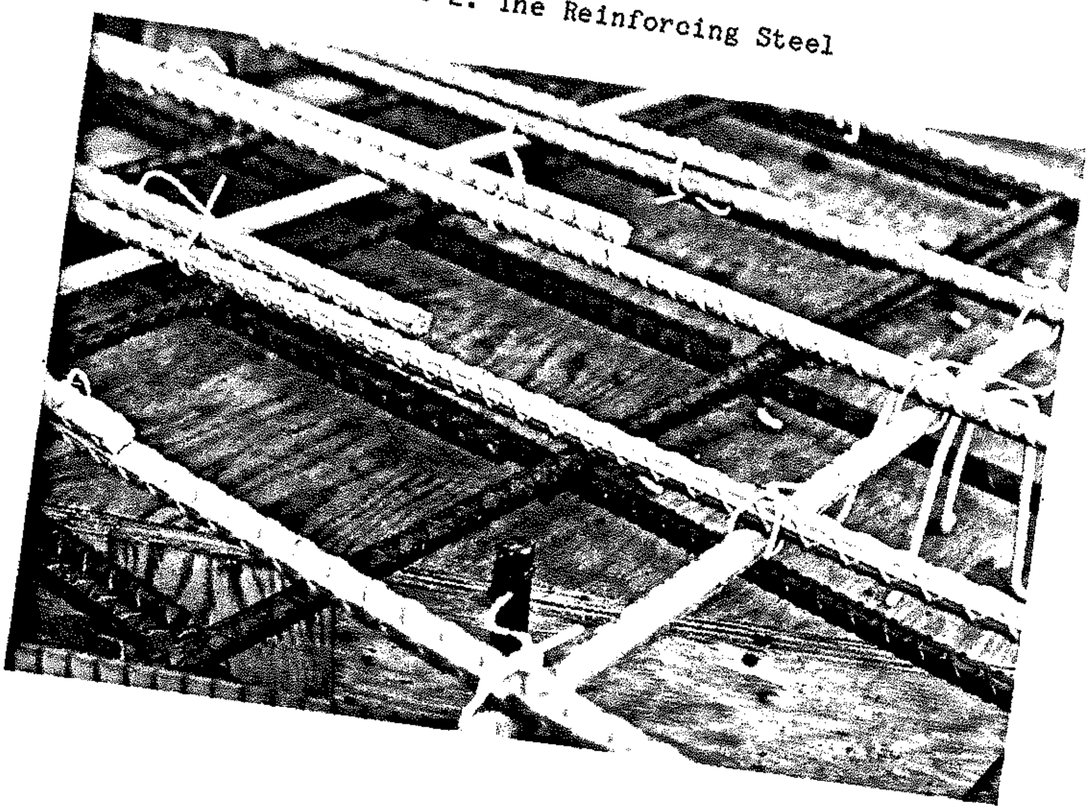


Figure 3: The Tied Reinforcing Steel

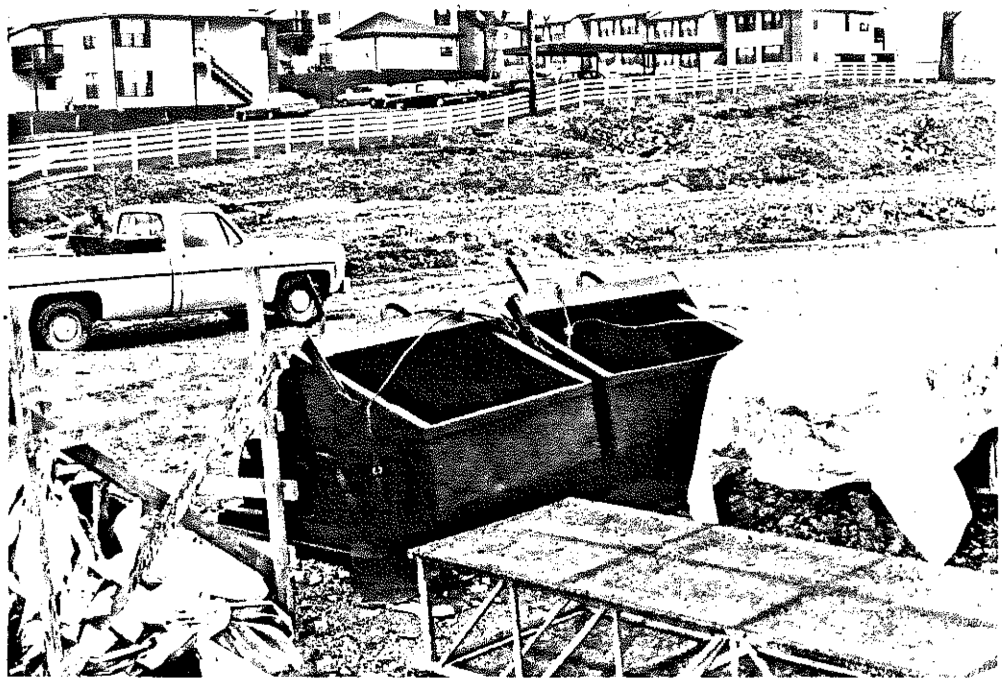


Figure 4: The Drop Buckets

Figure 5: Bid-Well Concrete Finisher

average compressive strength for westbound-lane cores at 52 days was 3,720 psi. The average for eastbound-lane cores at 54 days was 4,270 psi.

Additional cores were obtained by the Division of Materials at 96 days and 98 days for the westbound and eastbound lanes, respectively. Results are contained in Appendix IV. The average compressive strength for the westbound-lane cores was 4,040 psi and the average for the eastbound-lane cores was 4,115 psi. The Division of Materials recommended the concrete be considered acceptable.

PERFORMANCE MONITORING

Visual inspections for cracks have been made. The initial inspection was made on April 2, 1986. Slick areas were observed in the eastbound deck. High wind during the placement operation may have caused moisture loss. During the finishing operation, slick spots developed in the drier areas (see Figures 6 and 7). There were no cracks observed during that inspection.

Visual inspections continued through the months of April, May, and June, and no cracking was observed. On July 11, 1986, cracking was observed in the eastbound deck near the northeast corner. The cracks were generally radial and extended from the west end of the bridge to the north barrier wall. Five cracks were observed (see Figures 8, 9, and 10).

The inspection of August 25, 1986, did not reveal additional deck cracking. However, cracking was observed on the western abutment and around the drain in the abutment wall (see Figures 11 and 12).

Two bridges of similar design and constructed using conventional Class AA concrete also have been inspected for crack patterns. One comparison bridge is located in Scott County, Kentucky, on KY 227 over Lecomptes Run. The bridge was let to contract in November 1981. The bridge was inspected in June 1985. Three small longitudinal cracks were observed. Each crack was about 3 feet in length.

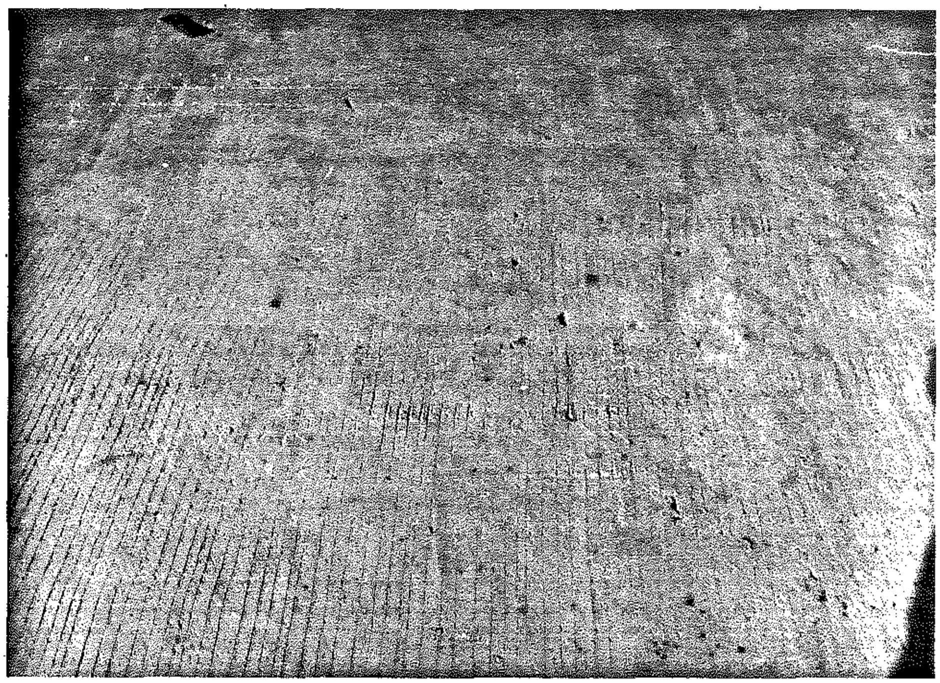


Figure 6: Slick Spot in the Finish

Figure 7: A Good Finish

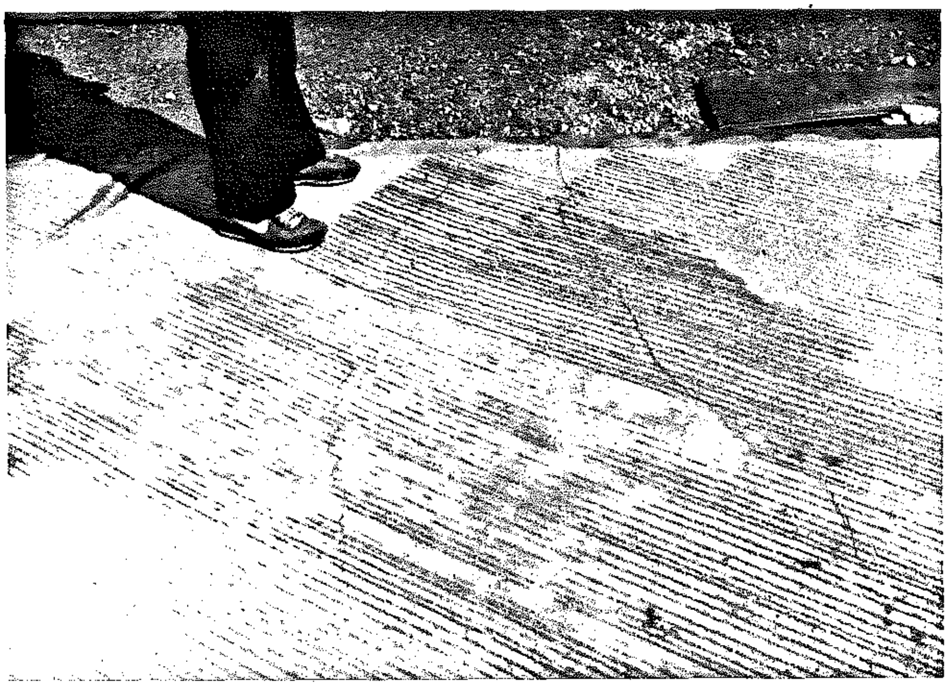


Figure 8: Cracks Observed

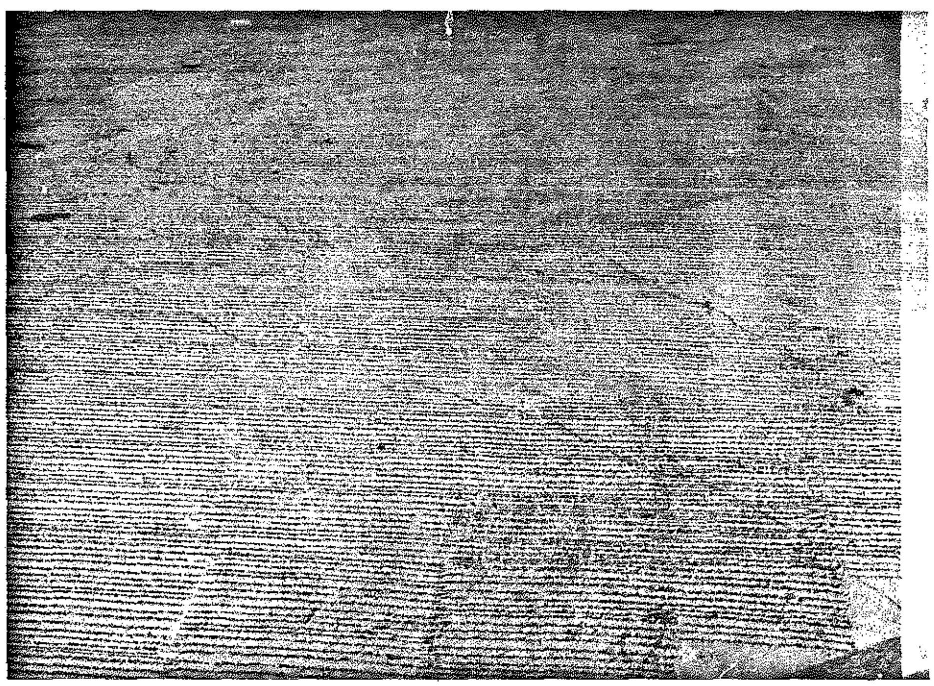


Figure 9: Deck Cracking

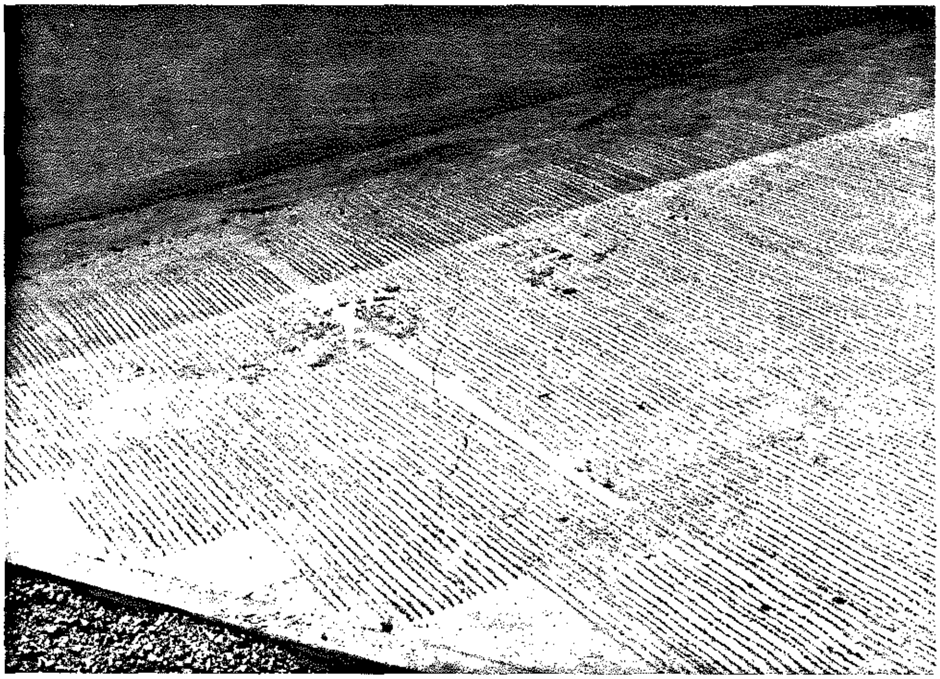


Figure 10: Corner Cracking

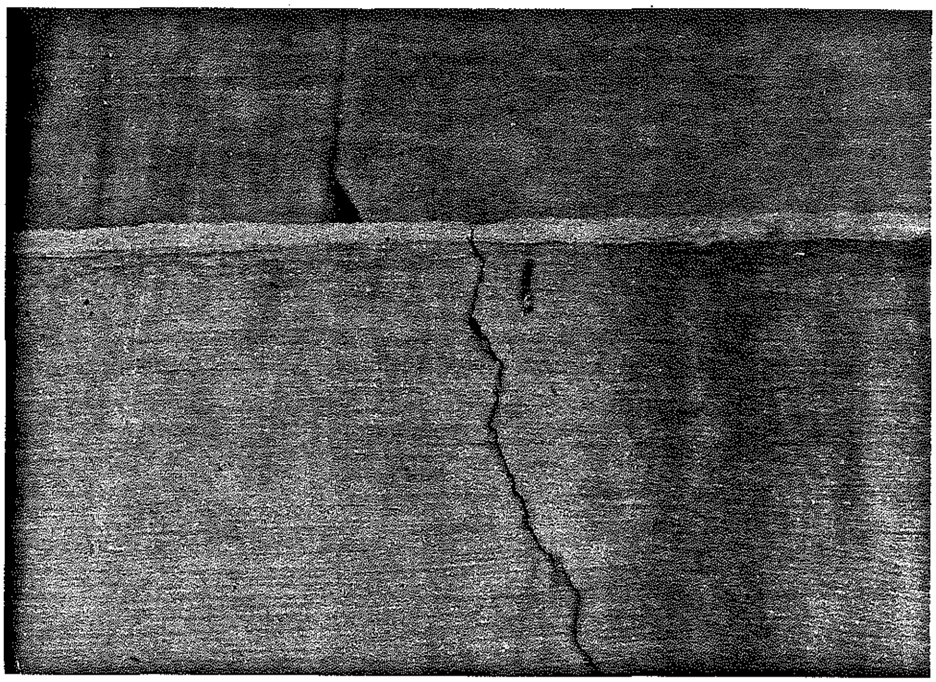


Figure 11: Crack in Abutment Wall

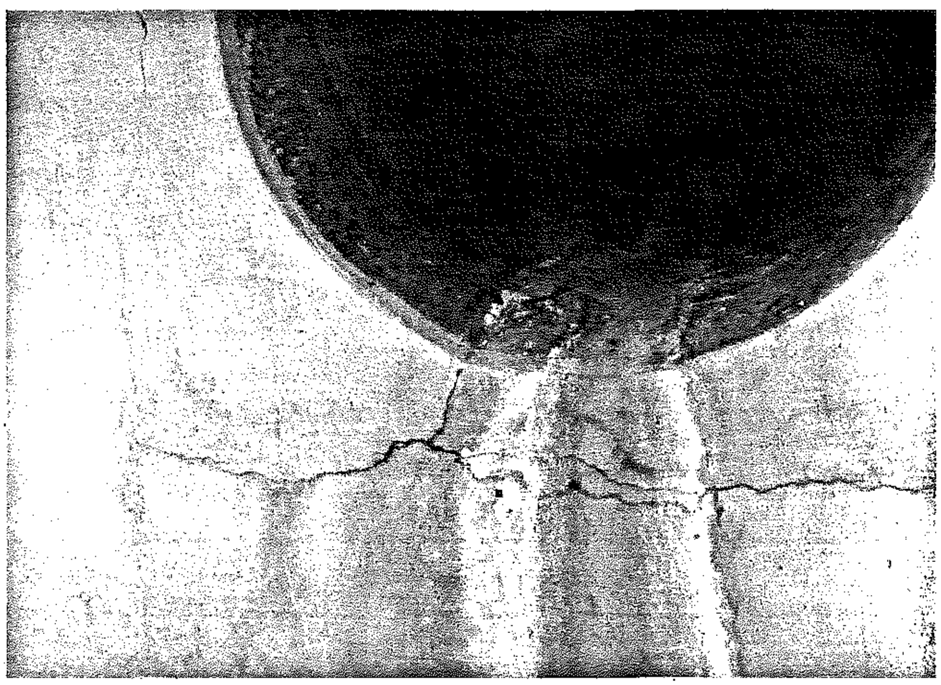


Figure 12: Cracking Around the Drain

The second comparison bridge is located in Jefferson County, Kentucky, on the Old Sheperdsville Road over Buechel Branch. The bridge was let to contract in December 1983. The bridge was inspected in June 1985. Corner cracking was observed on both ends of the northbound lanes. Cracking also was observed near drains in the northbound lanes.

Monitoring of the experimental and control bridge decks will continue. Interim reports will be issued detailing performance of the bridge decks. A final report will be issued at the end of the study period.

Appendix I

TD 64-305
Rev. 1/78

KENTUCKY DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
DIVISION OF MATERIALS

COUNTY Fayette Co. Date 3-28-86

PROJECT NO. FSP-034-1974-06-08-21-B

Concrete Producer Conveleston Plant Location Lex.

Class of Concrete CL "S" Max. Water-Gals./Bag 6.30 Min. Cem. Factor-Bags/Cu. Yd. 6.6

Lbs. of Cement/Cu. Yd. 620 Cement Brand Southwestern Cement Sample No.

Type "A" or "D" Admix. Brand & Amount Used ______ Ozs./Cu. Yd.

Air Entraining Admix. Brand & Amount Used ______ 6 Ozs./Cu. Yd.

Data For 6.6 Bag Batch	Fine Aggregate Data			Coarse Aggregate Data		
Design Dry Wts./Bag (S.S.D.)	Source Harrison-Sand-Gravel			Source Lex. Quarry		
Fine 183 lbs.	Bulk Sp. Gr. (S.S.D.) 2.65			Bulk Sp. Gr. (S.S.D.) 2.71		
Coarse 271 lbs.	Absorption 0.70 %			Absorption 1.80 %		
	Percent by Volume 40			Percent by Volume 60		
Time of Day	8:00					
Design Dry Weights (S.S.D.) (1)	1208			1789		
Design Air Content % (2)	5.5			5.5		
Percent Aggregate Deducted for Air (3)	8.12			8.12		
Design Dry Wts. Adj. for Air (S.S.D.) (4)	1110			1644		
Free Moisture Content % (5)	4.1			0.5		

	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.
Actual Damp Weights (10)	1156	1652				
Actual Dry Weights (S.S.D.) (9)	1110	1644				
Moisture Correction (lbs. of water) (11)	46	8				
Total Moisture Correction (lbs. of water) (12)	54					
Water Added at the Mixer (lbs.) (7)	293 (35.1)					
Total Water Used (lbs.) (13)	347					
Maximum Allowable Free Water (lbs.) (6)	347					
Actual Water Underrun (lbs.) (14)	0					
Total Water Per Bag of Cement (gals.) (15)	6.30					

(8)
Adj. Water Underrun (lbs.)

Adj. Water Underrun (lbs.)		Sp. Gr.				Aggr. Ratio		
0	x	2.65	(F.A.) =	0	lbs. F.A. x	40	% =	0 lbs. F.A.
		2.71	(C.A.) =	0	lbs. C.A. x	60	% =	0 lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =	lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =	lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =	lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =	lbs. C.A.

Test Results at Jobsite

Slump 4¾ - 6
Air Content 4.5 - 6.5 %
Concrete Temp.
Cylinder Ident. Nos. 1-16-A, B, BX, C

Test Results at Plant

Slump 6-7"
Air Content 4.5 - 4.7%
Concrete Temp.

cc: Central Lab, ADEC, DME, Project file

R Miller
(Concrete Plant Inspector)

KENTUCKY DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
DIVISION OF MATERIALS

TD 64-305
Rev. 1/78

COUNTY Fayette Co. Date 3-28-86

PROJECT NO. FSP-034-1974-06-08-21-B

Concrete Producer Covington Plant Location Lex.

Class of Concrete Cl. "S" Max. Water-Gals./Bag 6.30 Min. Cem. Factor-Bags/Cu. Yd. 6.6

Lbs. of Cement/Cu. Yd. 620 Cement Brand Southwestern Cement Sample No.

Type "A" or "D" Admix. Brand & Amount Used ______ Ozs./Cu. Yd.

Air Entraining Admix. Brand & Amount Used ______ 6 Ozs./Cu. Yd.

Data For 6.6 Bag Batch	Fine Aggregate Data	Coarse Aggregate Data
Design Dry Wts./Bag (S.S.D.)	Source Harrison-Sand-Gravel	Source Lex. Quarry
Fine 183 lbs.	Bulk Sp. Gr. (S.S.D.) 2.65	Bulk Sp. Gr. (S.S.D.) 2.71
Coarse 271 lbs.	Absorption 0.70 %	Absorption 1.80 %
	Percent by Volume 40	Percent by Volume 60

		Fine			Coarse		
Time of Day		8:00					
Design Dry Weights (S.S.D.)	(1)	1208			1789		
Design Air Content %	(2)	5.5			5.5		
Percent Aggregate Deducted for Air	(3)	8.12			8.12		
Design Dry Wts. Adj. for Air (S.S.D.)	(4)	1110			1644		
Free Moisture Content %	(5)	4.1			0.5		

		Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.
Actual Damp Weights	(10)	1156	1652				
Actual Dry Weights (S.S.D.)	(9)	1110	1644				
Moisture Correction (lbs. of water)	(11)	46	8				
Total Moisture Correction (lbs. of water)	(12)	54					
Water Added at the Mixer (lbs.)	(7)	293 (35.1)					
Total Water Used (lbs.)	(13)	347					
Maximum Allowable Free Water (lbs.)	(6)	347					
Actual Water Underrun (lbs.)	(14)	0					
Total Water Per Bag of Cement (gals.)	(15)	6.30					

(8)

Adj. Water Underrun (lbs.)		Sp. Gr.				Aggr. Ratio			
0	x	2.65	(F.A.) =	0	lbs. F.A. x	40	% =	0	lbs. F.A.
		2.71	(C.A.) =	0	lbs. C.A. x	60	% =	0	lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =		lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =		lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =		lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =		lbs. C.A.

Test Results at Jobsite

Slump 4¾ - 6

Air Content 4.5 - 6.5 %

Concrete Temp.

Cylinder Ident. Nos. 1-16-A,B,BX,C

Test Results at Plant

Slump 6-7"

Air Content 4.5 - 4.7%

Concrete Temp.

R Miller
(Concrete Plant Inspector)

cc: Central Lab, ADEC, DME, Project file

KENTUCKY DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
DIVISION OF MATERIALS

TD 64-305
Rev. 1/78

COUNTY FAYETTE CO. Date 3-26-86

PROJECT NO. FSP-034-1974-06-08-020-C

Concrete Producer CONGLETON Plant Location LEX.

Class of Concrete CL. "S" Max. Water-Gals./Bag 6.130 Min. Cem. Factor-Bags/Cu. Yd. 6.6

Lbs. of Cement/Cu. Yd. 620. Cement Brand SOUTH WESTERN Cement Sample No. C-1

Type "A" or "D" Admix. Brand & Amount Used ______ Ozs./Cu. Yd.

Air Entraining Admix. Brand & Amount Used ______ 6 Ozs./Cu. Yd.

Data For 6.6 Bag Batch
Design Dry Wts./Bag (S.S.D.)
Fine 183 lbs.
Coarse 271 lbs.

Fine Aggregate Data
Source HARRISON SAND-GRAVEL
Bulk Sp. Gr. (S.S.D.) 2.65
Absorption 0.70 %
Percent by Volume 40

Coarse Aggregate Data
Source LEX. QUARRY
Bulk Sp. Gr. (S.S.D.) 2.71
Absorption 1.80 %
Percent by Volume 60

	Fine			Coarse		
Time of Day	9:30					
Design Dry Weights (S.S.D.) (1)	1208			1789		
Design Air Content % (2)	5.5			5.5		
Percent Aggregate Deducted for Air (3)	8.12			8.12		
Design Dry Wts. Adj. for Air (S.S.D.) (4)	1110			1644		
Free Moisture Content % (5)	3.9			0.5		

	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.
Actual Damp Weights (10)	1153	1652				
Actual Dry Weights (S.S.D.) (9)	1110	1644				
Moisture Correction (lbs. of water) (11)	43	8				
Total Moisture Correction (lbs. of water) (12)	51					
Water Added at the Mixer (lbs.) (7)	296					
Total Water Used (lbs.) (13)	347					
Maximum Allowable Free Water (lbs.) (6)	347					
Actual Water Underrun (lbs.) (14)	0					
Total Water Per Bag of Cement (gals.) (15)	6.300					

(8)
Adj. Water Underrun (lbs.) — Sp. Gr. — Aggr. Ratio

0 x 2.65 (F.A.) = 0 lbs. F.A. x 40 % = 0 lbs. F.A.
2.71 (C.A.) = 0 lbs. C.A. x 60 % = 0 lbs. C.A.

______ x ______ (F.A.) = ______ lbs. F.A. x ______ % = ______ lbs. F.A.
______ (C.A.) = ______ lbs. C.A. x ______ % = ______ lbs. C.A.

______ x ______ (F.A.) = ______ lbs. F.A. x ______ % = ______ lbs. F.A.
______ (C.A.) = ______ lbs. C.A. x ______ % = ______ lbs. C.A.

Test Results at Jobsite
Slump 6"
Air Content 5.5%
Concrete Temp.
Cylinder Ident. Nos. 15-A,B,C, BX

Test Results at Plant
Slump 6"-7"
Air Content 5.8 - 6.2 %
Concrete Temp.

R. Miller
(Concrete Plant Inspector)

cc: Central Lab, ADEC, DME, Project file

KENTUCKY DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
DIVISION OF MATERIALS

TD 64-305
Rev. 1/78

COUNTY FAYETTE CO. Date 3-26-86
PROJECT NO. FSP-034-1974-06-08-020-C
Concrete Producer CONGLETON Plant Location LEX.
Class of Concrete CL. "S" Max. Water-Gals./Bag 6.[illegible]30 Min. Cem. Factor-Bags/Cu. Yd. 6.6
Lbs. of Cement/Cu. Yd. 620. Cement Brand SOUTH WESTERN Cement Sample No. C-1
Type "A" or "D" Admix. Brand & Amount Used [illegible] Ozs./Cu. Yd.
Air Entraining Admix. Brand & Amount Used 6 Ozs./Cu. Yd.

Data For 6.6 Bag Batch
Design Dry Wts./Bag (S.S.D.)
Fine 183 lbs.
Coarse 271 lbs.

Fine Aggregate Data
Source HARRISON SAND-GRAVEL
Bulk Sp. Gr. (S.S.D.) 2.65
Absorption 0.70 %
Percent by Volume 40

Coarse Aggregate Data
Source LEX. QUARRY
Bulk Sp. Gr. (S.S.D.) 2.71
Absorption 1.80 %
Percent by Volume 60

	Fine			Coarse		
Time of Day	9:30					
Design Dry Weights (S.S.D.) (1)	1208			1789		
Design Air Content % (2)	5.5			5.5		
Percent Aggregate Deducted for Air (3)	8.12			8.12		
Design Dry Wts. Adj. for Air (S.S.D.) (4)	1110			1644		
Free Moisture Content % (5)	3.9			0.5		

	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.	Fine Aggr.	Coarse Aggr.
Actual Damp Weights (10)	1153	1652				
Actual Dry Weights (S.S.D.) (9)	1110	1644				
Moisture Correction (lbs. of water) (11)	43	8				
Total Moisture Correction (lbs. of water) (12)	51					
Water Added at the Mixer (lbs.) (7)	296					
Total Water Used (lbs.) (13)	347					
Maximum Allowable Free Water (lbs.) (6)	347					
Actual Water Underrun (lbs.) (14)	0					
Total Water Per Bag of Cement (gals.) (15)	6.300					

(8)

Adj. Water Underrun (lbs.)		Sp. Gr.				Aggr. Ratio			
0	x	2.65	(F.A.) =	0	lbs. F.A. x	40	% =	0	lbs. F.A.
		2.71	(C.A.) =	0	lbs. C.A. x	60	% =	0	lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =		lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =		lbs. C.A.
	x		(F.A.) =		lbs. F.A. x		% =		lbs. F.A.
			(C.A.) =		lbs. C.A. x		% =		lbs. C.A.

Test Results at Jobsite
Slump 6"
Air Content 5.5%
Concrete Temp.
Cylinder Ident. Nos. 15-A,B,C, BX

Test Results at Plant
Slump 6"-7"
Air Content 5.8 - 6.2 %
Concrete Temp.

[signature]
(Concrete Plant Inspector)

cc: Central Lab, ADEC, DME, Project file

Appendix II

KENTUCKY TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

College of Engineering
Transportation Research Building
533 South Limestone
Lexington, Kentucky 40506-0043
Telephone: 606-257-4513

June 23, 1986

H.5.53

Mr. Jim Stone, PE
Division of Materials
Kentucky Department of Highways
Frankfort, Kentucky 40622

Dear Mr. Stone,

Enclosed for your review and information are results of recent freeze/thaw testing of Type S Concrete prisms. Specifics regarding these activities are presented in Mr. Hunsucker's memorandum. If you need additional information, please contact this office.

Sincerely,
Robert C Deen by RDH

Robert C. Deen
Director

RCD:dh
Enclosure

cc. G.W. Sharpe
D.L. Allen

KENTUCKY TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

College of Engineering
Transportation Research Building
533 South Limestone
Lexington, Kentucky 40506-0043
Telephone: 606-257-4513

MEMORANDUM

H.5.53

TO: Robert C. Deen
Director

FROM: David Hunsucker DH
Research Engineer Associate

DATE: June 23, 1986

SUBJECT: Test Results -- Expansion Data for Type S Concrete Prisms Exposed to Freezing and Thawing

Four concrete length change prisms were delivered to this facility on April 23rd, 1986, for exposure to 350 cycles of rapid freezing and thawing. Freeze/thaw testing was in accordance with ASTM C-666, Procedure B, Freezing in Air and Thawing in Water. One freeze/thaw cycle is approximately three hours in duration with temperature variations of 0±3°F to 40±3°F (-17.8°C to 4.4°C). Periodic readings were made to determine changes in the relative dynamic modulus of elasticity (sonic modulus) and changes in the length and weight of each prism.

ASTM C-666 states that specimens be soaked in saturated lime water from the time of their removal from the molds until the time freezing and thawing begins. Upon receiving the concrete prisms, they were introduced into saturated lime water at 70 F. On Thursday, April 24th, the prisms were placed in the freeze/thaw unit and allowed to soak at 40°F for 4 hours. Initial readings were then taken for length, weight and sonic modulus of each prism.

ASTM C-666 states that a concrete prism should withstand 300 cycles of rapid freezing and thawing before the relative dynamic modulus (sonic modulus) of elasticity reaches 60 percent of the initial modulus. Speciman TPS-4 failed to meet this specification.

Kentucky Specifications require that a prism withstand 350 cycles of rapid freezing and thawing before the relative dynamic modulus (sonic modulus) of elasticity reaches 60 percent of the initial modulus. Speciman TPS-1 failed to meet this specification.

A value of 0.035 percent expansion for the concrete prisms has been recommended by the Division of Materials. The percent expansion is the ratio of the change in length to the initial length expressed as a percentage. All Type S specimens exceeded the 0.035 percent expansion limit.

All expansions were positive and freeze/thaw testing was continuous.

If there are and questions regarding the data, please contact our office at your convenience.

DATE	CYCLE NUMBER	No. OF CYCLES (N)	STANDARD BAR(S)	TPS - 1					TPS - 2				
				WEIGHT (W_c)	READING (n)	LENGTH [redacted]	PERCENT EXPANSION [redacted]	$Pc = \frac{WcNc^2}{WiNi^2} \times 100$	WEIGHT (Wc)	READING (n)	LENGTH [redacted]	PERCENT EXPANSION [redacted]	$Pc = \frac{Wc(Nc)^2}{Wi\ (Ni)^2} \times 100$
4/24	179	0	2200	16.5	1630	16.4984	—	100%	16.3	1630	16.4988	—	100%
4/25	184	5	2200	16.5	1560	16.4985	0.0006	91.6	16.3	1560	16.4998	0.0061	91.6
4/29	210	31	2200	16.5	1510	16.4987	0.0018	85.8	16.3	1530	16.5003	0.0091	88.1
5/2	229	50	2200	16.5	1500	16.4990	0.0036	84.7	16.3	1510	16.5008	0.0121	85.8
5/7	258	79	2200	16.5	1480	16.4992	0.0048	82.4	16.3	1490	16.5020	0.0194	83.6
5/12	291	112	2200	16.5	1470	16.5000	0.0097	81.3	16.3	1470	16.5033	0.0273	81.3
5/16	316	137	2200	16.5	1420	16.5009	0.0152	75.9	16.3	1470	16.5022	0.0206	81.3
5/21	350	171	2200	16.5	1380	16.5023	0.0236	71.7	16.3	1390	16.5044	0.0339	72.7
5/23	7	178	2200	16.5	1380	16.5031	0.0285	71.7	16.3	1410	16.5013	0.0152	74.8
5/27	35	206	2200	16.5	1350	16.5023	0.0236	68.6	16.3	1460	16.5022	0.0206	80.2
5/30	55	226	2200	16.5	1330	16.5050	0.0400	66.6	16.3	1340	16.5036	0.0291	67.6
6/3	82	253	2200	16.5	1330	16.5063	0.0479	66.6	16.3	1350	16.5060	0.0436	68.6
6/9	123	294	2200	16.5	1300	16.5075	0.0552	63.6	16.3	1320	16.5068	0.0485	65.6
6/13	150	321	2200	16.5	1280	16.5089	0.0636	61.7	16.4	1300	16.5081	0.0564	64.0
6/18	182	353	2200	16.5	1220	16.5093	0.0661	56.0	16.4	1270	16.5086	0.0594	61.1
				60% AT 330 CYCLES									
				DURABILITY FACTOR = 56					DURABILITY FACTOR = 61				

DATE	CYCLE NUMBER	No. OF CYCLES (N)	STANDARD BAR(S)	TPS - 3					TPS - 4				
				WEIGHT (W_c)	READING (n)	LENGTH [redacted]	PERCENT EXPANSION [redacted]	$Pc = \frac{WcNc^2}{WiNi^2} \times 100$	WEIGHT (Wc)	READING (n)	LENGTH [redacted]	PERCENT EXPANSION [redacted]	$Pc = \frac{Wc(Nc)^2}{Wi\ (Ni)^2} \times 100$
4/24	179	0	2200	16.1	1580	16.5744	–	100%	16.1	1560	16.5624	–	100%
4/25	184	5	2200	16.1	1530	16.5745	0.0006	93.8	16.1	1470	16.5612	-0.0072	88.8
4/29	210	31	2200	16.1	1500	16.5761	0.0103	90.1	16.1	1400	16.5634	0.0060	80.5
5/2	229	50	2200	16.1	1470	16.5770	0.0157	86.6	16.1	1380	16.5644	0.0121	78.3
5/7	258	79	2200	16.1	1470	16.5787	0.0259	86.6	16.1	1330	16.5664	0.0242	72.7
5/12	291	112	2200	16.1	1470	16.5786	0.0253	86.6	16.1	1320	16.5685	0.0368	71.6
5/16	316	137	2200	16.1	1470	16.5801	0.0344	86.6	16.1	1290	16.5686	0.0374	68.4
5/21	350	171	2200	16.1	1370	16.5814	0.0422	75.2	16.1	1270	16.5716	0.0555	66.3
5/23	7	178	2200	16.1	1390	16.5819	0.0453	77.4	16.1	1270	16.5722	0.0592	66.3
5/27	35	206	2200	16.1	1380	16.5825	0.0489	76.3	16.1	1230	16.5721	0.0586	62.2
5/30	55	226	2200	16.1	1340	16.5839	0.0573	71.9	16.1	1240	16.5742	0.0712	63.2
6/3	82	253	2200	16.1	1340	16.5836	0.0555	71.9	16.1	1200	16.5745	0.0731	59.2
6/9	123	294	2200	16.2	1320	16.5850	0.0640	70.2	16.1	1190	16.5760	0.0821	58.2
6/13	150	321	2200	16.2	1290	16.5866	0.0736	67.1					
6/18	182	353	2200	16.2	1280	16.5872	0.0772	66.0					
				DURABILITY FACTOR = 66					60% AT 248 CYCLES DURABILITY FACTOR = 42				

Appendix III

KENTUCKY TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

College of Engineering
Transportation Research Building
533 South Limestone
Lexington, Kentucky 40506-0043
Telephone: 606-257-4513

H. 5. 53

Mr. Jim Stone
Division of Materials
Kentucky Department of Highways
Frankfort, Kentucky 40622

Dear Mr. Stone:

Subject: Experimental Bridge Deck Using Shrinkage Compensating Bridge Deck Concrete
Fayette County
Tates Creek Pike (KY 1974)
Bridge over West Hickman Creek
Item No. 7-201.0

Enclosed for your review are results of the 28-day compressive strength test data for the concrete cylinders made from the March 28th, 1986, placement of the subject bridge deck. The cylinders were cured and broken in accordance with ASTM C-39 Standards. The average 28-day maximum compressive strength for the cylinders was 3083 psi with a unit weight of 140.4 pcf.

In the Special Note for Shrinkage Compensating Bridge Deck Concrete, Class S, issued 10-15-84, it is stated that the concrete mixture shall conform to all requirements for Class AA concrete. Table 1 in Section 601.05 of the Standard Specifications for Road and Bridge Construction states that a Class AA concrete shall have a 28-day compressive strength of 4000 psi.

How do our results compare to your results for the Class S concrete? Is there sufficient questions concerning the quality of the concrete to warrant coring of the bridge deck to verify strength of the mixture?

Please inform me of your decision and forward a copy of your compressive strength data at your convenience.

Sincerely,

Robert C. Deen by D.Q.H.

Robert C. Deen
Director

Enclosure
cc. B. L. Wheat; S. J. Amato
D. Hunsucker; D. Allen; G. Sharpe

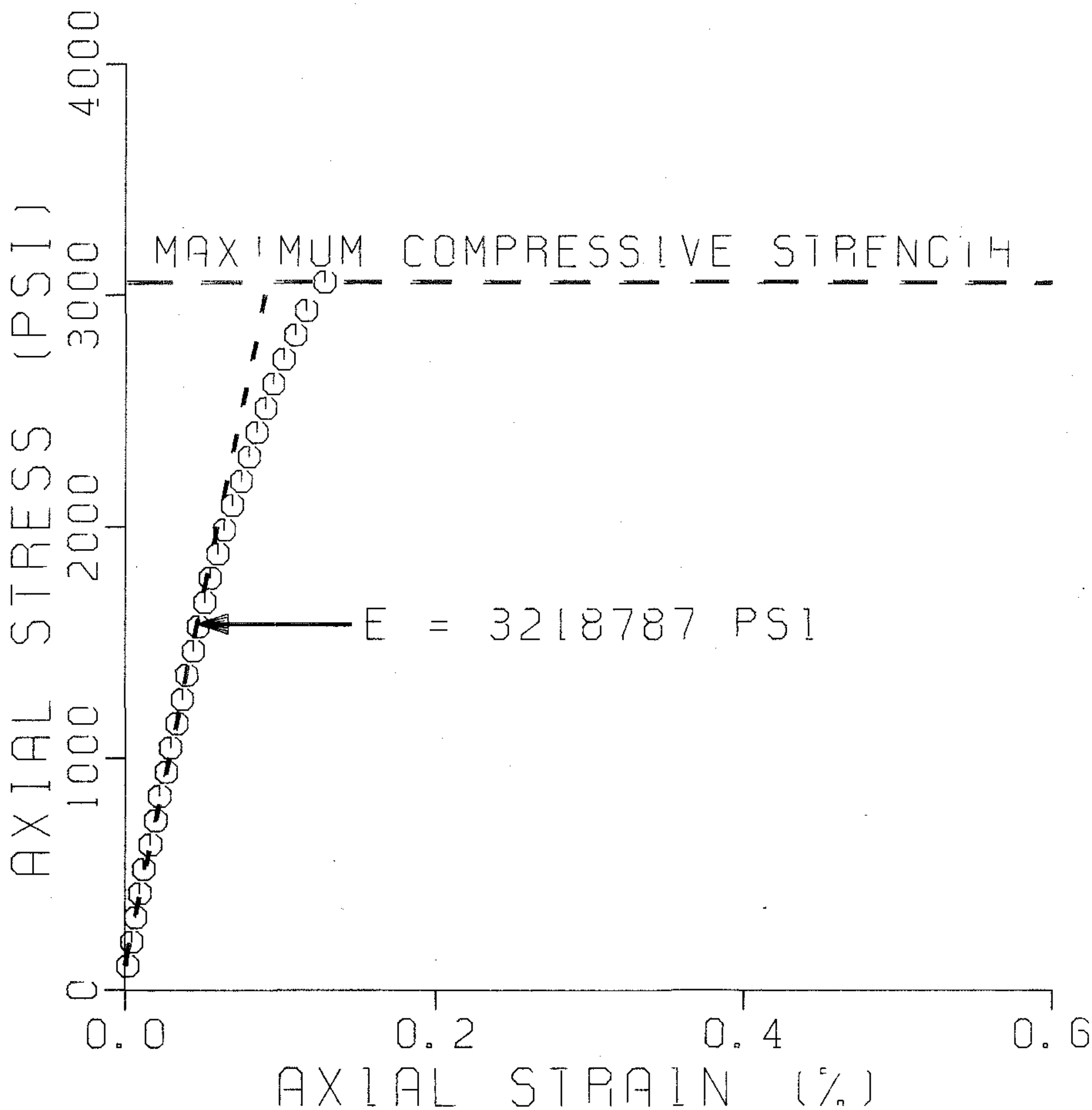
TABULAR VALUES OF STRESS-STRAIN, INCLUDING AVERAGES

SAMPLE I AXIAL STRAIN (%)	SAMPLE I AXIAL STRESS (PSI)	SAMPLE II AXIAL STRAIN (%)	SAMPLE II AXIAL STRESS (PSI)	AVERAGE VALUES AXIAL STRAIN (%)	AVERAGE VALUES AXIAL STRESS (PSI)
0.00	104.79	0.00	105.31	0.00	105.05
0.00	209.58	0.00	210.62	0.00	210.10
0.01	314.37	0.01	315.94	0.01	315.15
0.01	419.16	0.01	421.25	0.01	420.20
0.01	523.95	0.01	526.56	0.01	525.25
0.02	628.74	0.02	631.87	0.02	630.30
0.02	733.53	0.02	737.18	0.02	735.35
0.02	838.31	0.02	842.50	0.02	840.41
0.03	943.10	0.03	947.81	0.03	945.46
0.03	1047.89	0.03	1053.12	0.03	1050.51
0.03	1152.68	0.03	1158.43	0.03	1155.56
0.04	1257.47	0.04	1263.74	0.04	1260.61
0.04	1362.26	0.04	1369.06	0.04	1365.66
0.04	1467.05	0.05	1474.37	0.04	1470.71
0.05	1571.84	0.05	1579.68	0.05	1575.76
0.05	1676.63	0.05	1684.99	0.05	1680.81
0.05	1781.42	0.06	1790.30	0.06	1785.86
0.06	1886.21	0.06	1895.62	0.06	1890.91
0.06	1991.00	0.07	2000.93	0.07	1995.96
0.07	2095.79	0.07	2106.24	0.07	2101.01
0.07	2200.58	0.08	2211.55	0.08	2206.06
0.08	2305.37	0.08	2316.86	0.08	2311.11
0.08	2410.16	0.09	2422.18	0.09	2416.16
0.09	2514.94	0.10	2527.49	0.09	2521.21
0.09	2619.73	0.10	2632.80	0.10	2626.27
0.10	2724.52	0.11	2738.11	0.11	2731.32
0.11	2829.31	0.12	2843.42	0.11	2836.37
0.12	2934.10	0.13	2948.74	0.12	2941.42
0.13	3056.36	0.15	3110.21	0.14	3083.28

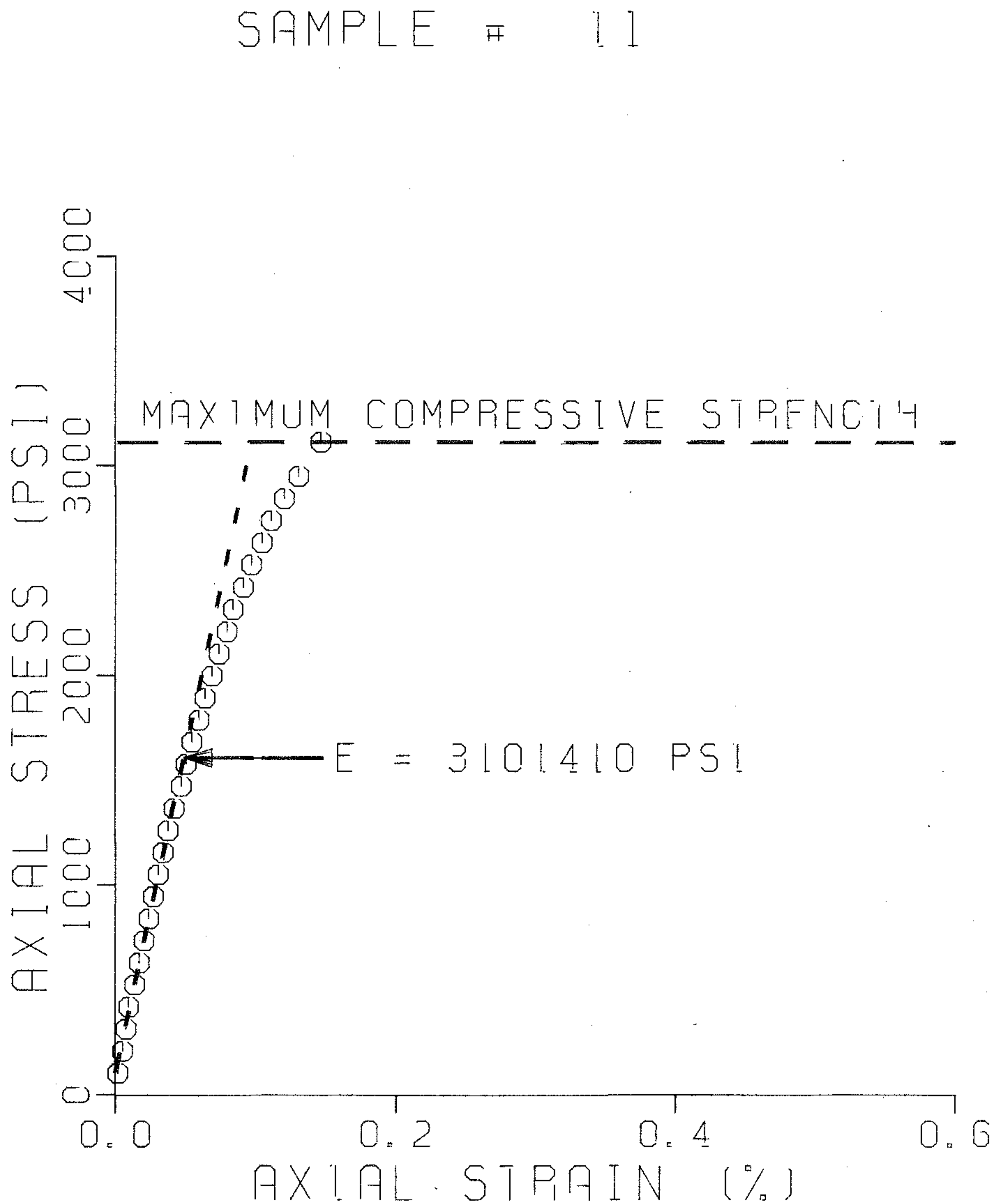
SUMMARY OF RESULTS OF STRESS TESTS

SAMPLE NUMBER	MAXIMUM COMPRESSIVE STRESS (PSI)	ELASTIC MODULUS (PSI)	UNIT WEIGHT (PCF)
I	3056.36	3218787.00	139.77
II	3110.21	3101410.00	140.98
AVERAGE	3083.28	3160098.00	140.37

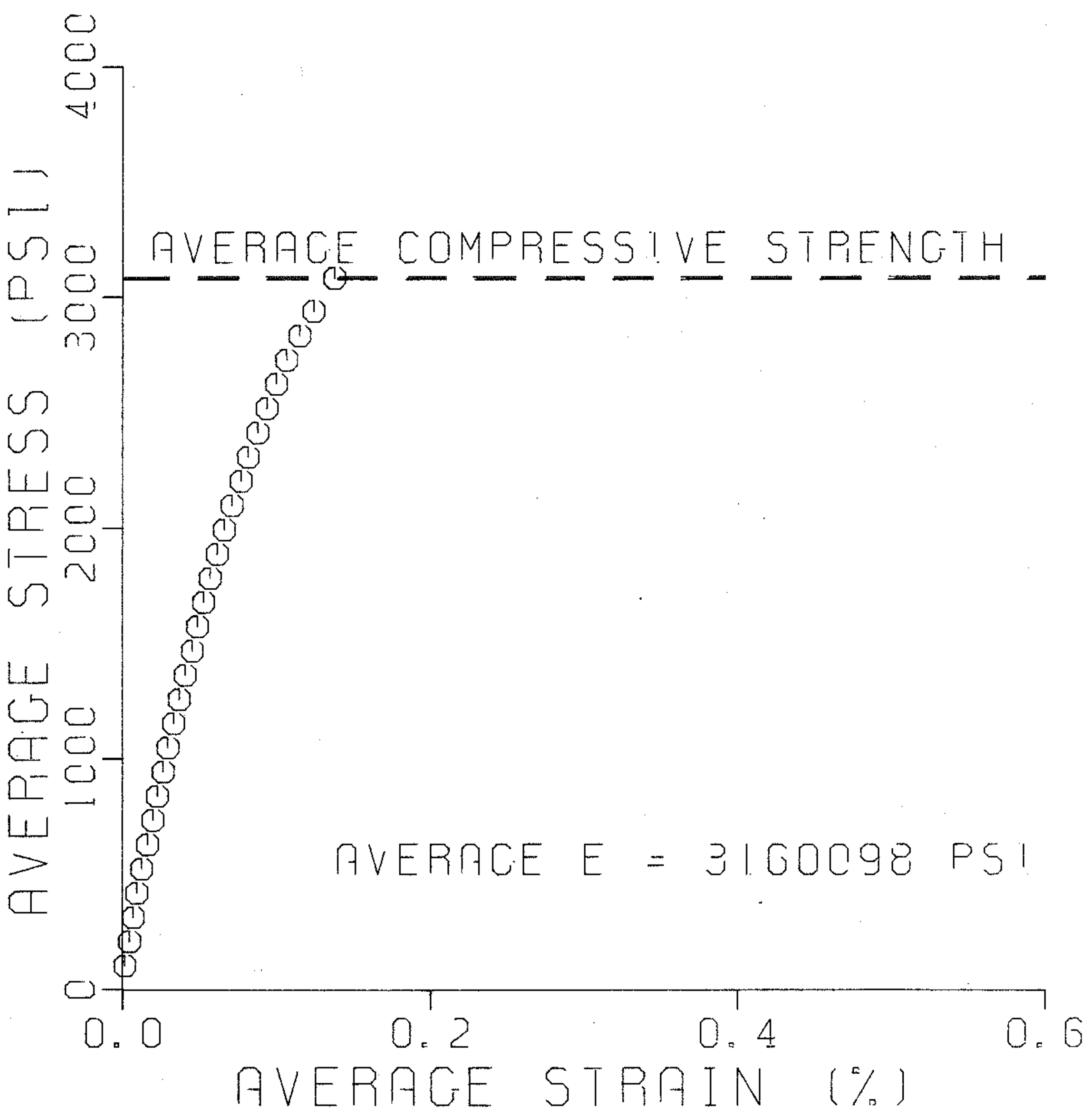
SAMPLE # 1



MAXIMUM COMPRESSIVE STRENGTH
E = 3218787 PSI
AXIAL STRESS (PSI)
0
1000
2000
3000
4000
0.0
0.2
0.4
0.6
AXIAL STRAIN (%)


SAMPLE # 11
MAXIMUM COMPRESSIVE STRENGTH
E = 3101410 PSI
AXIAL STRESS (PSI)
4000
3000
2000
1000
0
0.0
0.2
0.4
0.6
AXIAL STRAIN (%)

AVERAGE VALUES



Appendix IV

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

C. LESLIE DAWSON
SECRETARY

MARTHA LAYNE COLLINS
GOVERNOR

M E M O R A N D U M

TO: Bill Mullins, District Engineer for Construction
District 7, Lexington

FROM: John McChord, Director
Division of Materials

BY: Jim Warfield JW
Cement Section

DATE: May 19, 1986

SUBJECT: Fayette County M8615(3)
FSP 034 1974 008.198 21 B 324

As requested, eight (8) cores were taken from the above mentioned project to determine the strength quality of in-place class "S" concrete. The results are as follows:

Core	Location	Wt/Ft^3	PSI	Age
1	90+62.05, 22' RT	143.3	3435	52 Days
2	90+35.05, 25' RT	143.7	4660	52 Days
3	90+7.05, 13' RT	142.2	3150	52 Days
4	90+26.05, 9' RT	141.0	3635	52 Days
5	90+49.05, 4' LT	142.0	3600	54 Days
6	90+30.05, 20'LT	145.7	4625	54 Days
7	89+93.05, 24'LT	144.2	4305	54 Days
8	90+00.55, 2' LT	144.0	4545	54 Days

If further information is desired, please advise.

JMc/JW/ad
cc: ✓Construction
✓David Hunsucker, Research
David Treadway, R.E.
L. Epley
J. Stone
File

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

C. LESLIE DAWSON
SECRETARY

MARTHA LAYNE COLLINS
GOVERNOR

M E M O R A N D U M

TO: Bill Mullins, District Engineer
for Construction
District 7 - Lexington

FROM: John McChord, Director
Division of Materials

BY: Jim Warfield, Supervisor JW
Cement Lab & Core Drill Units

DATE: July 7, 1986

SUBJECT: Fayette County M 8615 (3)
FSP 034 1974 008.198 21 B 324

Additional cores were taken to further investigate the strength quality of in-place Class "S" concrete. See memo dated May 19, 1986. The results are as follows:

CORE	LOCATION	WT./FT.^{3}	PSI	AGE
1A	90+62, 21' Rt.	142.5	3640	96 Days
1B	90+62, 23' Rt.	143.6	4350	96 Days
3A	90+07, 12' Rt.	140.6	3535	96 Days
3B	90+07, 14' Rt.	142.5	4400	96 Days
4A	90+26, 8' Rt.	141.6	4120	96 Days
4B	90+26, 10' Rt.	141.3	4195	96 Days
5A	90+49, 3' Lt.	143.3	4190	98 Days
5B	90+49, 5' Lt.	141.8	4045	98 Days

The average strength of cores 1A and 1B is 3995 PSI, and the average strength of cores 3A and 3B is 3970. Using the criteria of Section 105.04, we recommend that this concrete be considered acceptable on the basis of being in reasonably close conformity to the specification requirement of 4000 PSI.

Bill Mullins
Page -2-
July 7, 1986

If further information is desired, please advise.

JMc:JW:lw
cc: Construction
✓David Hunsucker, Research
David Treadway, R.E.
L. Epley
J. Stone
file