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Introduction

This is a progress report of work done on the Webber Creek Bridge by the Concrete Section of the Materials and Research Department. Included is a description of tests and measurements made at the site and data obtained in the laboratory.

The work involved was done under two Project Work Order Numbers, R-61259 and R-52057. The first was used for work primarily associated with the bridge at the time of placement of the concrete. The second, R-52057, is a lab work project for analyzing volume change of concrete as affected by various factors. The slab curling measurements and shrinkage bar measurements have been charged against this number.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A PROGRESS REPORT OF CONCRETE TESTING ON THE WEBBER CREEK BRIDGE

MAY 1963

63-09

State of California
Department of Public Works
Division of Highways

MATERIALS AND RESEARCH DEPARTMENT

May 1, 1963

Project Work Order
R 52057, R 61259
Webber Creek Bridge

Mr. J. E. McMahon
Bridge Engineer
Division of Highways
Sacramento, California

Attention: Mr. John J. Kozak

Dear Sir:

Submitted for your consideration is:

A PROGRESS REPORT OF

CONCRETE TESTING ON THE

WEBBER CREEK BRIDGE

Study made by . . . . Technical Section
Under General Direction of . . . . D. L. Spellman
Field Work Supervised by . . . . J. H. Woodstrom
Report Prepared by . . . . J. H. Coan

Yours very truly,

F. N. Hveem
Materials & Research Engineer

cc:LRGillis
ASHart

Table of Contents

INTRODUCTION

This is a progress report of work done on the Webber Creek Bridge by the Concrete Section of the Materials and Research Department. Included is a description of tests and measurements made at the site and data obtained in the laboratory.

The work involved was done under two Project Work Order Numbers, R-61259 and R-52057. The first was used for work primarily associated with the bridge at the time of placement of the concrete. The second, R-52057, is a lab work project for analyzing volume change of concrete as affected by various factors. The slab curling measurements and shrinkage bar measurements have been charged against this number.

SCOPE

Four concrete mixes with cement and aggregate combinations selected to produce four levels of volume change were used to pave the decks of the four spans of each bridge (i.e.: the eastbound and the westbound), over Webber Creek. Figure 1 in the Appendix shows the location of the mix combinations. Materials used in the various concretes were tested and stockpiled in May, 1962, well in advance of construction. Construction was scheduled for June and July but was delayed until September and October because of industry strikes. Materials were dry batched at a local readymix plant and transported to the construction site in paving type batch trucks, a distance of about 1-1/2 miles. Mixing was done in a single drum paving type mixer in 1-1/2 cubic yard batches. Typical mix design for all cement-aggregate combinations contained the following proportions per cubic yard of concrete:

1-1/2" x 3/4"	1260 pounds
3/4" x #4	810 "
Sand	1300 "
Cement	564 "
Water	258 "

Consistency of concrete placed in the decks was controlled generally to have a slump of from 3" to 5" as measured with the Kelly Ball. Consistency of concrete used for test specimens was measured with a slump cone. Six compressive strength test specimens, 6x12-inch cylinders, were cast during the placement of concrete in each span. From concrete placed in each span of the deck, the following shrinkage specimens were also fabricated:

9 - 3x3x11-in. prisms (concrete wet sieved on 1-in. screen)

6 - 4x5x18-in. prisms

At the time of concrete placement of each span of the right bridge, a 12'x12'x9" slab was cast of concrete corresponding to the mix combination used in the bridge. The slabs were located approximately 1/2-mile west of the bridge. Concrete used for these slabs was mixed in a transit mix truck employing approximately 100 mixing revolutions prior to discharge. The volume of the batch was approximately 4 cubic yards. Slump was adjusted to 1-1/2" to 2-1/2".

Reinforced beams, 7-1/4"x12"x10', containing strain gages were cast in conjunction with Spans 1, 3 and 4 of the left bridge and Span 1 of the right bridge. These were cured under wet mats at the jobsite for approximately 10 days and then transported to the University of California at Berkeley, for testing by the University representative.

Climatological data including wind velocities, evaporation rate, and temperature were recorded during each day concrete was placed and is shown in Table 2.

MATERIALS

Aggregate:

Aggregates from the Pleasanton area and from the Bear River near Auburn were stockpiled at the batch plant and were sampled for testing well in advance of their use. The results of the tests are shown in Table 1. Both materials met the California 1960 Standard Specifications for concrete aggregates in all respects. All coarse aggregates were sieved on a No. 4 screen immediately prior to batching, and material passing this size was wasted. It was noted that under these conditions a substantial amount of fine material was separated from the coarse aggregate before it entered the batching bin and the condition resulted in a substantial improvement in the cleanness of the coarse aggregate.

Cement:

The Calaveras Cement Company at San Andreas provided both the Type I "high alkali" and the Type II "low alkali" cements used in the project. It was intended that the so-called "high alkali" cement would contain at least 1% alkali, calculated as equivalent sodium oxide. The alkali content was about 0.9% but provided a large enough difference in the two cements to serve the purpose. Typical chemical analysis and physical tests are shown in Table 2. Both cements were delivered in bulk to the batch plant and were maintained in separate silos until fed to the weigh hopper by a screw conveyor. Division of Highways specifications for all concrete work calls for Type II cement containing not more than 0.60% by weight of alkalies calculated as Na_2O, with no limit on the amount of C_3S. The Type II cement used met specifications in all respects and had an average alkali content of about 0.5%.

CLIMATOLOGICAL DATA

Measurements were recorded at half-hour intervals to indicate weather and temperature conditions on each of the eight days concrete was placed in the decks. Evaporation rates were measured with a recording type atmometer. Placement of concrete was made during morning hours from approximately 7 AM to 11 AM or 12 noon, and weather changes were relatively uniform from start to finish. Therefore, Table 3 shows ranges of conditions rather than hour by hour changes. Conditions as far as weather is concerned, would be considered close to ideal for concreting.

TEST DATA

Specimens for testing in the laboratory were fabricated near the midpoint of each placement period. Fabrication was done in accordance with ASTM procedures. Shrinkage bars were cured under wet mats for 24 hours, at the jobsite, then in the laboratory curing room for the remainder of the curing period. Table 4 shows data relating to shrinkage, compressive strength and modulus of elasticity of concrete made with the various cement and aggregate combinations.

At the request of the Bridge Department, tests to determine the thermal coefficient of expansion of concrete containing the Pleasanton aggregate and Type I cement were made on two of the 4x5x18-inch specimens cast during the placement of concrete in Span 2, left bridge. The bars had been dried for 28 days and were soaked for 4 days prior to testing. Concrete was kept in water during testing except while being measured. The thermal coefficient was determined to be 5.2×10^{-6} in/in per degree F.

AUXILLIARY SLABS

Auxilliary non-reinforced 12'x12'x9" slabs were placed in conjunction with the placing of each deck span of the right bridge for each combination of aggregate and cement, making four slabs in all. The center and four corners of each slab were provided with a means of measuring minute elevation changes with reference to the base on which the slab was placed. Thermocouples were cast in the concrete near the top and near the bottom of one slab. Curling measurements have been made at a time of day when the top and bottom temperatures were approximately the same in order to reduce the thermal effect to a minimum. The temperature differential between the top and bottom of the slabs at the time of measurement were not in excess of 2 degrees F. Variations in elevation of the center and the four corners of each slab were used to compute differences between the average elevation of the four corners, and the center of the slab. Figure 2 shows the results plotted against time. It can be seen that maximum curling occurred in the slab containing Pleasanton aggregate and Type I, high alkali cement, and the least curling occurred in the slab containing Bear River aggregate and Type II, low-alkali cement. The other two combinations fell in between these two extremes in the same order as predicted by preliminary tests.

It is interesting to note that when the upward curling of the slab corners was reversed by rain and wet weather, the two slabs that curled the most flattened until their corners were as low or lower relative to the center as were the corners of the other two slabs. It is evident that concrete having various degrees of drying shrinkage was actually produced in the bridge decks, and though the concrete was placed late in the year under ideal conditions, there is at least a possibility that there will be differences in performance of the different deck spans.

TABLE 1

Summary of Tests, Webber Creek Bridge Deck Aggregates

Test	Calif. Test Method Number	Pleasanton			Bear River		
		1-1/2"x3/4"	3/4"x#4	Fine Aggr.	1-1/2"x3/4"	3/4"x#4	Fine Aggr.
Sand Equivalent	217			82			98
Cleanness Value	227	81	89		94	97	
Sodium sulfate soundness	214	2.6	3.1	2.6	1.0	0.8	0.6
Organic Impurities	213			Satis.			Satis.
LA Rattler, 500 R, % Loss	211	23.6			36.0		
Mortar Strength Ratio	515			121			130
Specific Gravity	207	2.67	2.70	2.64	2.61	2.62	2.60
Absorption	207	1.0	1.2	1.4	0.6	0.4	0.8
Grading, % Passing:	202						
2"					100		
1-1/2"		100			94	100	
1"		46	100		22	99	
3/4"		8	92		2	86	
3/8"		0	21		0	29	
No. 4			2	100		2	100
" 8			0	84		1	77
" 16				54			59
" 30				32			42
" 50				16			19
" 100				7			5
" 200				4			2

TABLE 2

Summary of Tests, Webber Creek Bridge Deck Cements

Type of Cement	Chemical Determinations						Physical Properties							
	C_4AF, %	C_3A, %	$CaSO_4$, %	C_3S, %	C_2S, %	Equiv. Na_2O, %	Compr. Strength 3-day psi	Compr. Strength, 7-day psi	Fineness Cm^2/gm	Autoclave Expans. %	Initial Set, Hrs.	Final Set, Hours	Mortar Expansion	Mortar Contraction
Type I Avg. of 4 tests	9	13	3	63	12	.88	2650	4000	3950	.350	2.75	4.40	.0065	.0592
Type II Avg. of 3 tests	9	8	3	51	26	.46	2300	3275	3300	.025	3.10	5.15	.0033	.0373
ASTM Specs. Type I Type II		8 Max.		(a)		.60[b]	1200 1000 Min.	2100 1800 Min.	2800 2800 Min.	.80 .80 Max.	1.00 1.00 Min.	10.00 10.00 Max.	.010[b] Max.	.048[b] Max.

(a) C_3S plus C_3A 58% maximum. This specification waived by California Division of Highways.

(b) California specification only.

TABLE 3

Climatological Data, Webber Creek Bridge

	Range of Climatological Conditions During Placement					
	Date Cast, 1962	Wind Velocity Miles/Hr.	Relative Humidity Percent	Evaporation Rate, Mls/Hour	Air Temperature °F	Concrete Temperature °F
Span 1, Left Br.	9-4	0-6	55-24	1-17	57°-95°	74°-80°
Span 2, Left Br.	9-6	0-3	56-29	1-16	60°-93°	74°-81°
Span 3, Left Br.	9-13	0-4	69-35	3-12	50°-80°	69°-76°
Span 4, Left Br.	9-11	0-10	58-29	4-14	56°-87°	68°-76°
Span 1, Right Br.	10-4	0-5	62-46	1-6	56°-72°	65°-74°
Span 2, Right Br.	10-8	0-6	50-43	4-7	55°-74°	62°-70°
Span 3, Right Br.	10-15	2-10	48-45	0-8	60°-64°	60°-61°
Span 4, Right Br.	10-10	2-10	76-65*	0-0	60°-66°	68°-70°

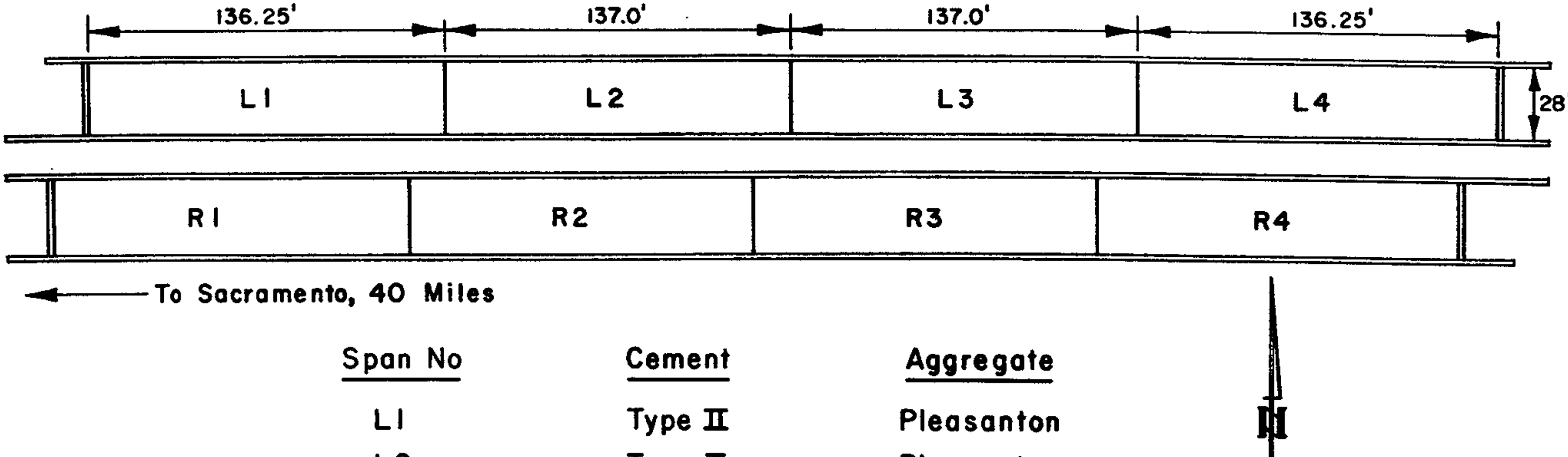
*Rain started after pour completed.

TABLE 4

Summary of Webber Creek Bridge Test Data on
Drying Shrinkage, Compressive Strength and Modulus of Elasticity

Drying Shrinkage, %								
3x3x11-1/4" Bars (Wet Screened through 1"), Average of 9			4x5x18" Bars 1-1/2" Max. Aggregate Average of 6		Compressive Str. Average of 3 6x12" Cylinders, P.S.I.		Mod. E at 1000 psi Average of 3 6x12" Cylinders, P.S.I. x 10^6	
Pleasanton Aggregate - Type I Cement								
Span	2L	1R	2L	1R	2L	1R	2L	1R
7-day	.041	.041	.025	.024				
14 "	.059	.056	.036	.037	3890	4870	3.60	4.05
28 "	.077	.075	.051	.052	4440	5250	4.17	4.36
56 "	.094	.089	.073	.068				
Unit Weight of Fresh Concrete					152.1	152.5		
Slump, Inches					4	3		
Pleasanton Aggregate - Type II Cement								
Span	1L	2R	1L	2R	1L	2R	1L	2R
7-day	.029	.031	.020	.021				
14 "	.043	.044	.028	.031	3880	4100	3.36	4.18
28 "	.059	.063	.041	.044	4840	5080	3.99	4.57
56 "	.075	.079	.060	.059				
Unit Weight of Fresh Concrete					150.4	152.9		
Slump, Inches					3	3		
Bear River Aggregate - Type I Cement								
Span	3L	3R	3L	3R	3L	3R	3L	3R
7-day	.017	.018	.008	.011				
14 "	.024	.026	.013	.018	4190	4660	4.90	5.03
28 "	.031	.035	.019	.022	5000	5160	5.52	5.47
56 "	.038	.042	.026	.029				
Unit Weight of Fresh Concrete					151.0	150.2		
Slump, Inches					3	3		
Bear River Aggregate - Type II Cement								
Span	4L	4R	4L	4R	4L	4R	4L	4R
7-day	.012	.015	.009	.006				
14 "	.017	.022	.013	.011	4320	5150	4.93	5.46
28 "	.023	.029	.017	.016	5660	6230	5.55	6.27
56 "	.031	.038	.023	.023				
Unit Weight of Fresh Concrete					150.8	150.8		
Slump, Inches					3	3		

Figure 1



Span No	Cement	Aggregate
L1	Type II	Pleasanton
L2	Type I	Pleasanton
L3	Type I	Bear River
L4	Type II	Bear River
R1	Type I	Pleasanton
R2	Type II	Pleasanton
R3	Type I	Bear River
R4	Type II	Bear River

WEBBER CREEK BRIDGE, Br #25-05

CEMENT AND AGGREGATE COMBINATIONS

Figure 2

CURL OF 12' x 12' SLABS

PLACERVILLE LOCATION, WEBBER CREEK