OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT
JOHN C. MACKIE, COMMISSIONER

August 20, 1963

To: W. W. McLaughlin
Testing and Research

From: E. A. Finney

Subject: Investigation of Defective Concrete in Bridge Deck Pour, B01 of 63081D, C6, Southbound I 696 over the Rouge River. Research Project R-63 B-71. Report No. 434.

Transmitted herewith are five copies of Report No. 434 by M. G. Brown on the above subject.

Although an overdose of retarder must be considered the primary cause of the shrinkage cracks observed in Pour B, it is evident from the data presented in this report that there were other possible contributory causes, such as weather (extremely high temperatures), time of day when poured, air content of the concrete, and brand of cement used. The excessively long setting time delayed placing the curing cover at the proper time to prevent drying of the surface.

Regardless of where the responsibility may be placed the affected concrete should be removed and replaced as ordered by the Bridge Construction Division.

OFFICE OF TESTING AND RESEARCH

E. A. Finney, Director
Research Laboratory Division

EAF:CCR:cgc

Attachments

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To: E. A. Finney, Director
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Subject: Investigation of Defective Concrete in Bridge Deck Pour, B01 of 63081D, C6, Southbound I 696 over the Rouge River. Research Project R-63 B-71. Report No. 434.

The following is a summary of a field inspection and laboratory studies on cores and related mixes of the subject structure. This is in accordance with W. W. McLaughlin's letter request to you dated July 23, 1963.

As you recall from your inspection of July 25 the defective area, containing numerous deep shrinkage cracks, is approximately the western half of pour B, span 1, of the subject structure which was finished around 10:30 AM on July 2, 1963. Pour D, span 1, is a smaller pour on the south side of the same span and was finished about 1:00 PM on the same day. Both pours were placed from west to east. Pour B contained about 41.5 cu yd of concrete and supposedly contained 3 ounces of Plastiment retarder per sack of cement. Pour D contained about 24.0 cu yd and was designed to contain 2 ounces of Plastiment per sack of cement. The west part of pour B did not set up properly and large shrinkage cracks began to appear the afternoon of July 2 when the air temperature reached 92 F and the concrete about 95 F. Because of the over retardation pour B was not covered until 8:00 AM the next morning. Time of initial set was estimated to be about 26 hours. Pour D had normal setting properties and was covered later on July 2. There were three 4-in. cores drilled in pour B and two in the west end of pour D for comparison on July 11, 1963. Three additional cores were drilled in the cracked area of pour B on a later date. Six of these cores were transmitted to the Research Laboratory for study.

R. H. Merrill and W. L. Frederick of the Research Laboratory made an inspection of the subject pours on July 24 and obtained samples of Plastiment from Cooper Supply Co. and the Koenig Ready Mix Plant. Cooper Supply furnished the concrete for the subject pour on July 2. They noted that many of the shrinkage cracks at core locations extended to a depth of 4 to 6 inches. They were shown a test beam from pour B which had a 7 day modulus of rupture of 680 psi. Laboratory infra-red analysis on the two Plastiment samples indicated they were the same and also matched a Bureau of Public Roads reference curve.

The attached Table I contains a summary of laboratory tests performed on six of the eight cores drilled from pours B and D. Numbers 3 and 6 were retained by the Office of Testing and Research. Table II contains a summary of laboratory time of set tests run on mortar mixes using the same materials and proportions used on July 2. The Proctor needle method, ASTM C 403, was used and no coarse aggregate was contained in the mixes. Dundee type iA cement from the subject project was used with three Plastiment concentrations and also without any retarders. Two mixes were made with Huron type 1A cement to compare retarder effects with another cement brand.

In summary, it is apparent from the chemical tests that the Plastiment content of the four cores tested was quite erratic and considerably greater than the 3 ounce per sack figure in three instances. The apparently high Plastiment content of control core 5 may be due to the fact it is in a transition area of decreasing retarder content at the beginning of pour D. This indicates the automatic dispenser for retarder was not working properly. The air content ran on the high side in three of the cores from the defective area (pour B). After 102 cycles of rapid freeze-thaw in air and water, ASTM C 291, there has been only a slight weight gain in core numbers 4 and 8 from the good and bad pours, respectively. The laboratory time of set tests indicate that about a double dosage, 6 ounces of Plastiment per sack of Dundee cement, would have produced approximately the effect in set delay observed in pour B on July 2 and 3. This would be allowing for differences in laboratory temperature, 75 F, and the high of 94 F coupled with low humidity and drying effects of the sun in the field. The laboratory test also indicate that the Dundee type 1A cement is much more sensitive to a double normal dosage of Plastiment than is Huron type 1A cement.

Even though the air and strength properties of cores from within the defective portion of pour B appear to be within reasonable limits it is recommended that this portion containing the deep shrinkage cracks be removed and replaced with specification concrete. The strength, air content, and Plastiment dosage are not known for the east portion of pour B and most of pour D. To establish a complete pattern of retarder dosage it would be necessary to obtain cores from these areas and test them. It should be noted that the unusual drying conditions of high temperature and low humidity encountered on this project on greatly retarded and plastic concrete may be experienced on structures using the new Dow Corning DC 777 silicone retarder. It may be necessary to cover these abnormally retarded mixes with polyethylene film or other approved light weight materials before the normally accepted application time. If such a procedure had been followed on pour B of the subject structure possibly the deep shrinkage cracks would not have occurred.

OFFICE OF TESTING AND RESEARCH

M. G. Brown, Supervisor
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MGB:cgc

TABLE I
CORE TEST SUMMARY
B01 of 63081D, C6, SB I 696 over Rouge River

Core Number	Location	Compressive Strength, psi[a]	Air Content, percent[b]	Freeze-Thaw Weight Change, percent[c]	Retarder Content, oz/sack[d]
Pour B, north side Span 1, 28' 4" x 48' 6"					
1	9' 3" from west end	4060 (10)	4.3	----	2-3
2	21' 9" from west end	3730 (22)	7.3	----	5
7	in defective area (west half)	3860 (22)	6.8	----	6-9
8	in defective area (west half)	--------	7.7	+0.6	---
Pour D, south side Span 1, 16' 4" x 48' 6"					
4	2' from west end	--------	3.9	+0.7	---
5	3' from west end	2455 (10)	3.7	----	6

NOTE: (a) Corrected to standard height to diameter ratio of 2:1. Number in parentheses ( ) indicates age in days.
(b) Linear traverse method on top 1/2 in.
(c) After 102 cycles of rapid freeze-thaw in air-water, ASTM C 291.
(d) Retarder content on pulverized cores estimated by chemical colorimetric method compared to lab mixes of 3 and 6 oz per sack concentrations.

TABLE II
TIME OF SET TESTS
LABORATORY MORTAR MIXES
Proctor Needle Method, ASTM C 403

Plastiment Content, oz/sack of cement	Initial Set, hrs to 500 psi needle pressure	Final Set, hrs to 4000 psi needle pressure
Dundee, type 1A cement		
0	5-1/2	7
3	8-1/4	17
6	29-1/2	44
6 (duplicate test)	33	47
12	65 (approx.)	123 (approx.)
Huron, type 1A cement		
3	7-1/4	13-1/4
6	10	20-1/2

NOTE: Time of set tests measured on mortar of same materials and proportions used on July 2, 1963 with no coarse aggregate and in 75 F laboratory air.