OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

May 9, 1975

To: L. T. Oehler
Engineer of Research

From: C. V. Iansiti
H. L. Patterson

Subject: Cement Content of Low Strength, Type 1P, Concrete.
Research Project 74 TI-256. Research Report No. R-961.

In a letter to your office, dated November 18, 1974, D. L. Wickham, Construction Staff Engineer, requested we conduct an investigation into the low strength concrete from Job Number I 82292-04743A. All core samples have confirmed the low beam strength, both in flexure and compression, as shown in Table 1 and in concrete test results dated November 12, 1974. Cement content analysis was specifically requested by Mr. Wickham.

The project location is Ann Arbor Rd at I 275, and consists of ramp and road widening on Ann Arbor Rd poured on September 3 and 4, 1974. All paving was of the "formed" type and utilized the same 1P concrete as was used on the southern third of the I 275 mainline project. The experimental Dundee 1P slip-form concrete was modified by the addition of water, to obtain a 3-in. slump for formed paving. The Inspector's Report of September 3 mentioned a "large underrun," which amounted to 3 percent. Reports for September 4 and 11 both indicated overruns (1.3 and 4.3 percent).

Laboratory work required the preparation of control samples for strength testing, and control concrete analysis samples. Materials for use in the control samples were obtained from the same source as the materials used in the project, and the cement was Dundee 1P (1973-74) stock on hand in this laboratory. The control concrete was proportioned from the I 275 mainline mix design charts, and from it were poured six, 4 by 8-in. cylinders. Three of the cylinders were tested in compression after a seven-day moist room cure, and then crushed and pulverized for chemical analysis along with samples of the subject cores. The remaining three control cylinders were tested in compression after 28 days of moist room curing (Table 2).

The cement content analysis, based on soluble silica and conducted in accordance with ASTM Designation C 85-66 "Cement Content of Hardened Portland Cement Concrete," indicated no apparent deficiency in cement content (Table 3).

A close examination of the Project Inspector's Report (Form 1174 and 1174A) of September 3 would suggest that the mentioned underrun could have resulted from one of two different possibilities: first, a recording error in the number of sacks of cement that were used; or second, a cumulative

error made in the assessment of the actual mix volume. The possibility of the cumulative error was realized when the 3.7 percent moisture measurement for the coarse aggregate was observed on the September 3 Plant Report. Although it rained on September 2 (0.41 in. at Detroit Metro Airport and 0.11 in. at Ypsilanti), it is seldom that a gravel coarse aggregate would ever have a moisture content over 2 percent as its relatively large particle size is not conducive to adsorbing moisture. An error in this measurement would increase the volume of coarse aggregate, which in turn would cause a harsh mix and increase the water requirements. In addition, more water was added to increase the slump of this slip-form mix to a value of three in. More volume was also added by the entrained air which averaged 7.6 percent, or 1.1 percentage points over the design level. Calculations show that cumulatively, these contributing factors add about 3.4 percent to the designed volume which is close to the described magnitude of the underrun.

Facts that tend to support the first possibility are as follows: a concrete overrun occurred on September 4 despite a recorded coarse aggregate moisture value (4.2 percent) which was greater than that of September 3; cores cut from concrete poured on both September 3 and 4 showed that all had a length in excess of 9 in., the design depth, (see Table 1); and the concrete poured on September 4 also had a high level of entrained air (7.5 percent). These latter facts, therefore, suggest that the underrun was a result of a recording error in the amount of cement used.

A major problem at the batch plant is obtaining a truly representative moisture sample of each aggregate, particularly after a rain. This is most difficult with the fine aggregate where the moisture content throughout the pile can vary greatly. Another related problem with measuring the moisture content of an aggregate sample is getting the sample from the heating pan back to the scale pan without losing part of the sample; a large soil test spoon is very helpful in accomplishing this task. The Project Engineer should periodically have independent measurements made to check the Plant Inspector's work.

Even though the suspected coarse aggregate moisture error and other cumulative factors of additional volume may not have been responsible for the underrun, they perhaps are responsible for the low strength of the cores. High water-cement ratios from wet mixes plus high air levels could produce strength levels such as in Table 1.

TESTING AND RESEARCH DIVISION

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TABLE 1
COMPRESSIVE STRENGTH VALUES FOR CORE SAMPLES
TAKEN FROM ANN ARBOR RD AT I 275

Laboratory Number	Core Depth	Station Number	Pour Date	Compressive Strength,* psi
74 CC 516	9.5	90+70	9-4-74	3190
74 CC 517	9.1	89+19	9-4-74	3090
74 CC 518	10.3	91+35	9-3-74	2620
74 CC 519	9.4	107+87	9-3-74	2940
74 CC 520	9.2	107+04	9-3-74	3500
74 CC 521	9.5	108+70	9-3-74	2280
74 CC 522	9.6	89+30	9-11-74	2520

* Cores tested November 6, 1974 after 48 hr in moist room. Cores drilled from pavement on October 29 and 30, 1974.

TABLE 2
COMPRESSIVE STRENGTH VALUES OF LABORATORY
PREPARED CONTROL SAMPLE CYLINDERS

Cylinder Number	Moist Room Cure	Compressive Strength, psi
1	7 days	2615
2	7 days	2706
3	7 days	2659
4	28 days	3518
5	28 days	3614
6	28 days	3423

TABLE 3
CEMENT CONTENT ANALYSIS
(Results are Accurate to Within 1/2 sack/cu yd)

Sample Number	Cement Content, sacks/cu yd
Control No. 1	5.8
Control No. 3	6.0
74 CC 516	5.9
74 CC 517	5.8
74 CC 519	6.1