OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT

February 20, 1967

To: E. A. Finney, Director
Research Laboratory Division

From: H. L. Patterson

Subject: Investigation of Concrete Pavement Cracking on the Southbound I 75 Fisher Freeway (Sta. 987+00 to 990+00, Construction Project BI 82194E, C4). Research Project 66 B-81. Research Report No. R-623.

In a letter to W. W. McLaughlin dated October 17, 1966, D. L. Wickham, Assistant to the Chief Construction Engineer, requested that four cores be taken from the southbound I 75 pavement south of the Rouge River Bridge, between Stations 987+00 and 990+00. A number of unexplained cracks had occurred in the center 24-ft section of this 48-ft roadway, poured June 18, 1966. These included one long longitudinal crack at the centerline and several transverse cracks. Figure 1 gives a general plan of the area involved.

Exact coring locations were to be determined by A. J. Sypitkowski, Project Engineer. The cores were to be delivered to the Research Laboratory for determination of air content, cement content, and ultimate compressive strength.

Mr. Sypitkowski stated that the sawcut down the centerline of the middle two lanes was made on June 20, and that no cracking had taken place at that time. In fact, cracking was not noticed until late September. He also said that the unreinforced cross-over pavement, temporarily connecting the freeway to Fort Street, was not poured until July 14 and 15.

Analysis of Field and Laboratory Concrete Specimens

Mr. Sypitkowski selected eight locations for cores--seven from the cracked area and the eighth from the previous day's pour. This eighth core was included as a control core, as a basis for comparison with the other seven. For further control, he sent the Research Laboratory sample bags of portland cement, sand, and slag coarse aggregate used in the pavement concrete, along with the required mix proportions. To assist further in the investigation, a diagram of the roadway was included, showing the crack patterns and locations where cores were cut.

This diagram, with additions, is shown in Figure 2. Of the seven cores, two were taken through cracked areas, and one broke in two during drilling. Thus, four cores (in addition to the control core) were suitable for testing. Figure 3 shows Cores II and V cut through cracks.

Tests on the cores show that all four taken between Sta. 987+54.5 and 988+55 passed minimum requirements for compression and entrained air, but proved inferior to the control core in compression. The cement content was about the same for all cores tested, including the control core, averaging 6.5 sacks of cement per cubic yard of concrete.

From the samples of portland cement, sand, and slag coarse aggregate, three concrete cylinders were cast according to the mix proportions used for the pavement. The mix contained the design quantity of 5.5 sacks per cubic yard of concrete. Two were tested in compression after curing 8 days, then were pulverized, and sent to the Spectro-Chemistry Unit for a cement analysis. The third was moist cured for 28 days and then tested for air entrainment and compression. It was tested in a moist condition and barely passed minimum compression requirements. Results of these tests on cylinders are also included in Table 1. Cement content analysis of two cylinders averaged 5 sacks of cement per cubic yard of concrete.

The values obtained by chemical analysis for both the cores and cylinders were based on duplicate determinations on two different samplings of the thoroughly mixed powder from the ground concrete. This method is reportedly accurate to within $\pm$ 1/2 sack of cement per cubic yard of concrete. The high value of 6.5 sacks per cubic yard for the pavement cores is probably influenced by the age of concrete and inherent errors due to the slag coarse aggregate. Because of this material, the calcium oxide or silica methods of ASTM C85 could not be used and an alternate sulfate method was developed and used for this purpose.

In summary, laboratory test data on cores and materials supplied by the Project Engineer generally indicate that the concrete in the questionable area satisfied specification requirements for compressive strength, cement content, and entrained air. Unfortunately, only one core was taken from the uncracked control area, preventing realistic comparison of relative concrete strength at an age of 5 months. Field beam data, where available, also indicate adequate flexural strength for all pavement pours in June and July. However, no beams were made on June 18 from the area in question. Test beams were made on June 17, 20, 27, 29, and July 15. The 7-day strengths ranged from 590 to 811 psi with an average of 692, and 14-day tests ranged from 711 to 886 with an average of 789.

Inspections of Cracked Pavement Site

During the course of the laboratory study and at the suggestion of Mr. Wickham, the site was visited on two occasions. The first was on October 26, 1966, at which time the two cracked center lanes (poured 6-18-66) were observed. Corresponding transverse cracks were also noted in the two outside lanes (Fig. 2), which were poured later (June 27 and 29). The second visit was on November 15. The pavement in the center two lanes had been replaced. The crack pattern in the two outside lanes was measured, however, to complete the record of all original cracks in this area (Fig. 2). Appearance of the southbound roadway after this repair is shown in Figure 4.

Investigation of Subsoil Conditions

Soil boring records show a thick stratum of very soft silty clay which underlays several square miles of this area. It was suspected that the dewatering and subsequent consolidation of this stratum might be causing subsidence at various locations throughout the area. However, after consulting the Soils Division, this possibility was ruled out.

It was also suspected that poorly consolidated backfill over sewer lines of the storm drainage system might have been responsible for cracking in this area. However, this was discounted after investigation disclosed that no longitudinal sewer ran under the southbound roadway. The only transverse sewer was a 12-in. line connecting catch basins together at Station 987+65, which is 12 ft from the closest transverse crack.

Conclusion

Since laboratory tests show that the concrete in this cracked area satisfies all requirements for compressive strength, cement content, and entrained air, it can be concluded that the cracks are not due to faulty or low strength concrete.

The Soils Division suggested another possible explanation for settlement in this area. The cracked pavement is at the location where topsoil had been stockpiled. If all topsoil was not removed before roadway construction, possible consolidation of the remaining topsoil might have caused settlement and cracking.

In Figure 1, the cracks in the southbound pavement occur where the crossover roadway connects the northbound and southbound I 75 freeway lanes to Fort Street. It is probable that construction vehicles crossing over this area in

August and September, combined with subgrade settlement, have caused this cracking. During the November inspection, large dump trucks were using the southbound freeway and cross-over to Fort Street.

OFFICE OF TESTING AND RESEARCH

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HLP:jcb

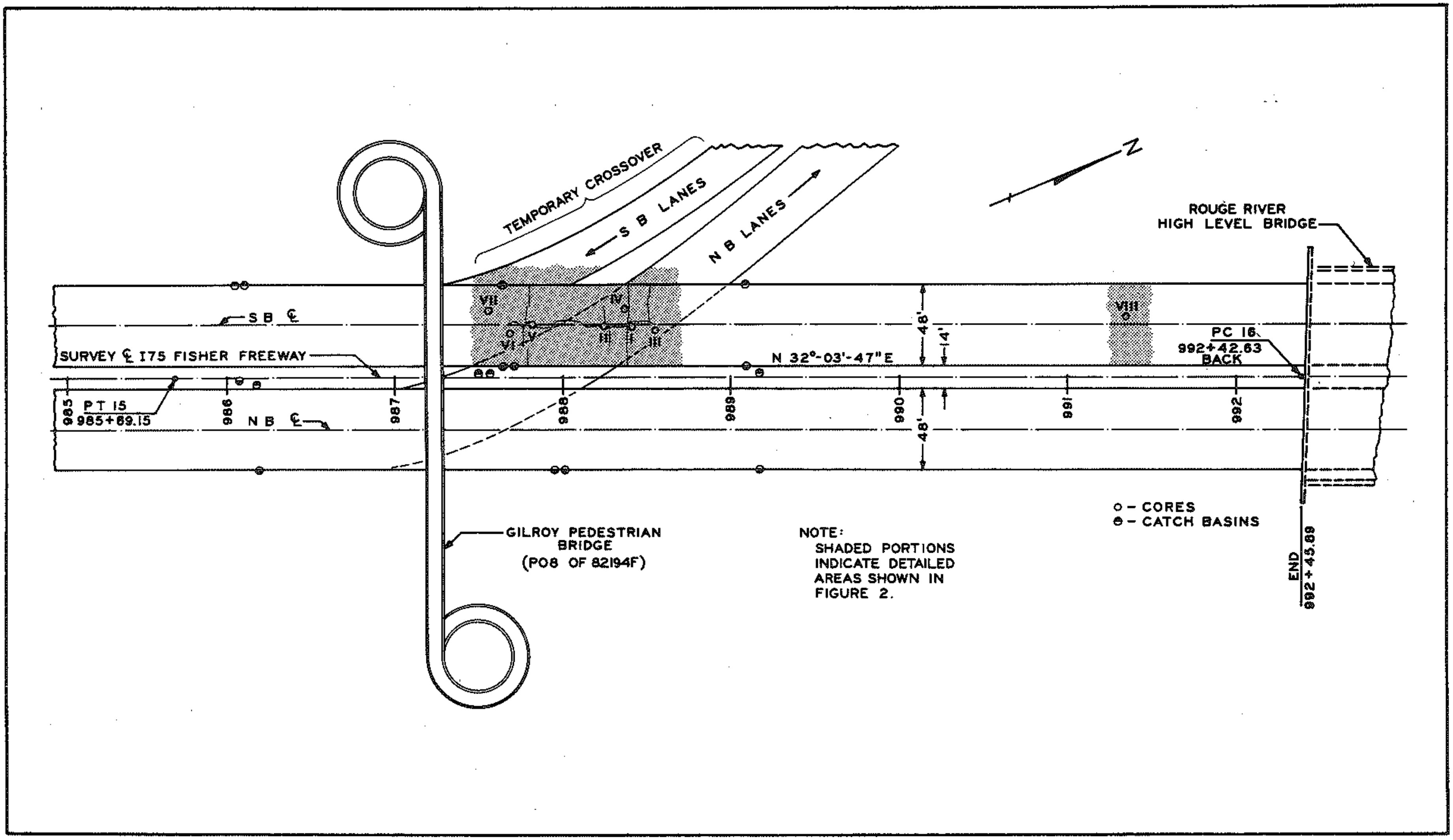
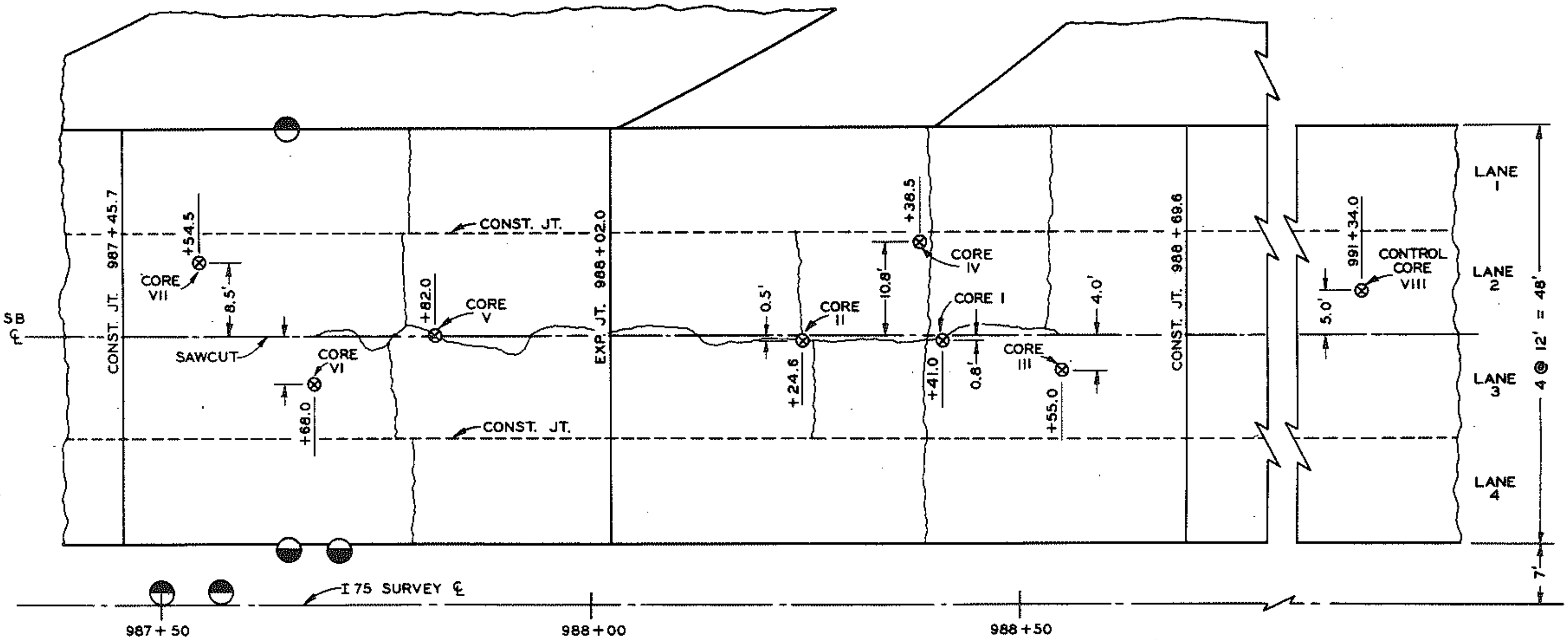


Figure 1. General location plan of cracked pavement.



LANE NO.	STATION		POURED
	START	END	
1	987+00	992+46	6-29-66
2, 3	978+25	988+70	6-18-66
2, 3	988+70	992+46	6-17-66
4	977+88	992+46	6-27-66

Figure 2. Detail plan of cracked pavement.

Figure 3 (right). Cores II and V (not tested), showing full depth cracks.

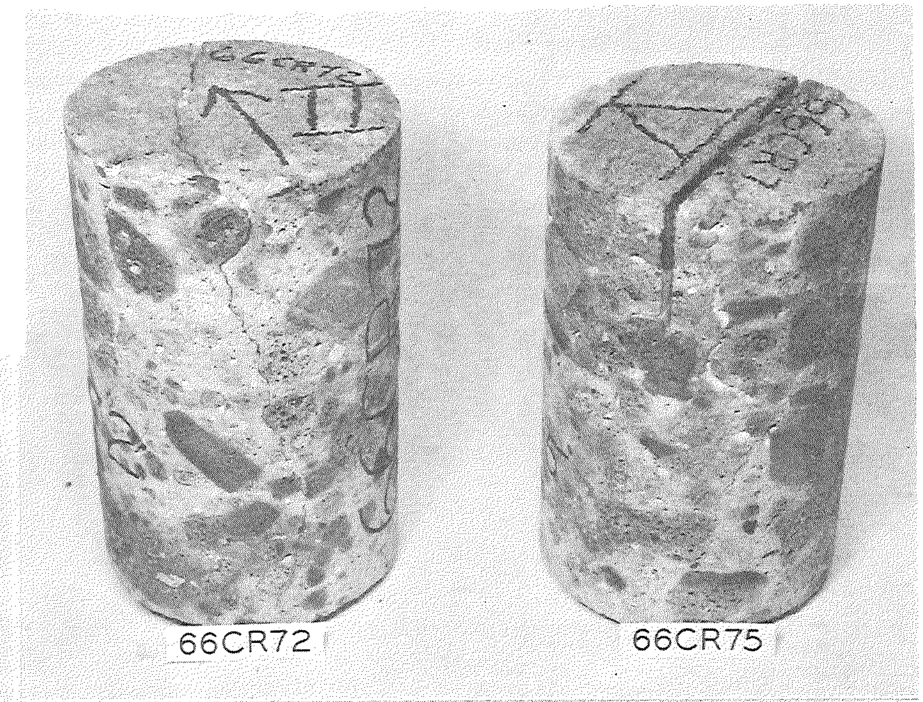


Figure 4 (below). General view of area looking south (November 15, 1966).

TABLE 1
SUMMARY OF TEST RESULTS

FIELD TEST CORES

Sample No.	Core No.	Station	Location Relative to SB Roadway ℄	Core Height, in.	Depth to Longitudinal Steel, in.	Appearance	Compressive Strength, psi*	Air Content, percent**
66 CR-71	I	988+41.0	0.8' R.	10.2	5.6	No Cracks, Core Broken	--	--
66 CR-72	II	988+24.6	0.5' R.	10.2	4.4	Long. & Trans. Full-Depth Crack	--	--
66 CR-73	III	988+55.0	4.0' R.	10.2	5.4	No Cracks	3,690	4.6
66 CR-74	IV	988+38.5	10.8' L.	10.1	3.7	No Cracks	4,340	5.5
66 CR-75	V	987+82.0	℄	9.7	4.0	Long. Full-Depth Crack	--	--
66 CR-76	VI	987+68.0	5.5' R.	10.2	4.4	No Cracks	4,500	--
66 CR-77	VII	987+54.5	8.5' L.	10.2	4.3	No Cracks	3,710	4.8
						Average	4,060	
Control Core								
66 CR-78	VIII	991+34.0	5.0' L.	10.1	5.2	No Cracks	5,070	5.3

LABORATORY TEST CYLINDERS

Cylinder No.	Moist Compressive Strength, psi		Air Content, percent**
	8 Days	28 Days	
1	2,660	--	--
2	2,350	--	--
3	--	3,500	6.4

* Corrected to L/D = 2.0 (age about 5 months).
** Linear traverse method on top 1/2 in.