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MICHIGAN
STATE HIGHWAY DEPARTMENT
Charles M. Ziegler
State Highway Commissioner

EFFECT OF FOREIGN MATERIAL ON QUALITY OF CONCRETE ON PROJECT F 45-15,C2

by

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and
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Research Project 48 B-22

Research Laboratory
Testing and Research Division
Report No. 114
June 10, 1948

EFFECT OF FOREIGN MATERIAL ON QUALITY OF CONCRETE ON PROJECT F 43-18,02

At the request of the construction section of the Reed Division an investigation has been made to determine the effect of a foreign material on the physical properties of the concrete pavement which inadvertently became incorporated with the cement for a limited period during paving operations on Project F 43-18,02. This report explains and presents in detail the findings from the various studies included in the investigation.

Project History

The pavement in question is located on US-10 west of Reed City and was built by the Pierson Contracting Company during the summer of 1947. On July 12, during the pouring of concrete between Stations approximately 62+80 and 60+25, the contractor encountered unusual pouring conditions. The concrete developed a flash set which continued to get worse until mixing operations had to be discontinued and the mixer cleaned. Upon examination by highway and contractor personnel it was discovered that the cement was contaminated with a white material, its identity at the time being unknown. This white material was traced to hopper car PM 20133, which was used to deliver cement to the project. Subsequent inquiry on the part of the contractor with the Pere Marquette Railroad Company revealed that the above car, prior to cement loading, was in the service of the Semet-Solvay Company and contained soda ash. See letter to this effect from the Pierson Contracting Company, Figure 1.

Effect of Alkali Salts on Setting Cement

According to Lea and Desch [2] both caustic soda (NaOH) and sodium carbonate (Na_2CO_3) strongly accelerate the setting of cements, the addition of

(1) F. M. Lea and C. H. Desch, "The Chemistry of Cement and Concrete," Edward Arnold and Co., London, (1940).

PIERSON CONTRACTING COMPANY

SAGINAW, MICHIGAN

WILMER PIERSON, PRESIDENT
WILMER G. PIERSON, VICE-PRES.
JOHN S. PIERSON, SEC'Y-TREAS.

609 EDDY BLDG.
PHONE 3-8981

April 26, 1948

Mr. C. C. Rhodes
Room 3, Olds Hall
Michigan State College
East Lansing, Michigan

Re: State proj F 67-39 C3
Reed City

Dear Sir:

With regard to the carload of contaminated cement used on subject project last July 12, we are quoting below from an internal memorandum of the Huron Portland Cement Company:

" Detroit, Michigan
July 15, 1947

To: Mr. C. L. Laude (Gen Sales Mgr)

From: Mr. L. C. Hamilton (Traffic mgr)

With further reference to my memorandum of July 14, 1947 regarding hopper car PM 20133 which is in service between Muskegon and Reed City for the Pierson Contracting Company and found to be contaminated with some foreign chemical, you are informed that we have been advised by the Pere Marquette Railroad that prior to cement loading this car was in the Sement-Solvay service and contained soda ash."

We trust that this information will prove helpful to you.

Very truly yours,

Pierson Contracting Company

John S. Pierson
Sec'y-Treasurer

Figure 1

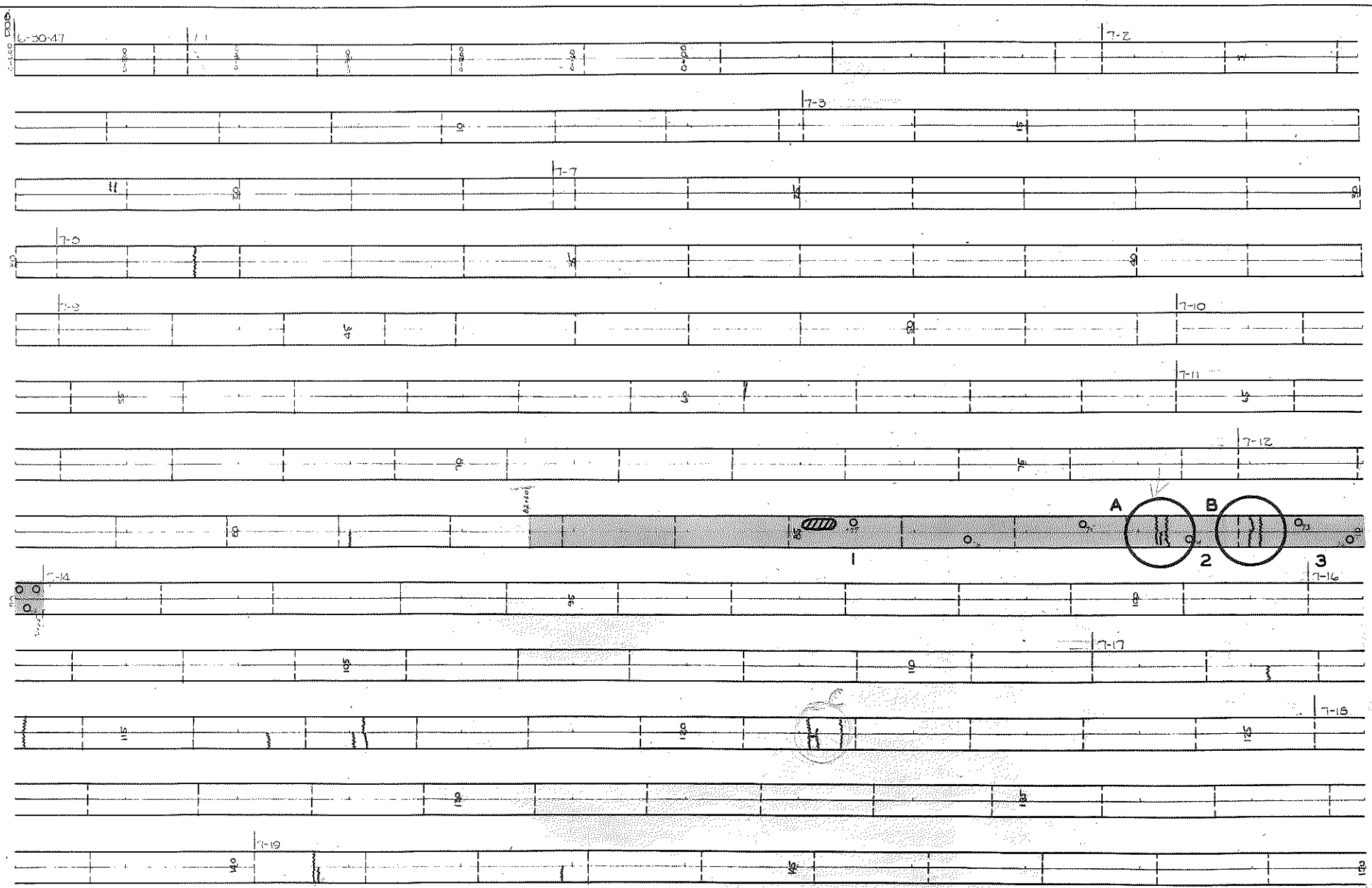
1 to 2 per cent of these materials reducing the time of initial set to a few minutes.

Physical Properties of the Hardened Concrete

Two condition surveys have been made on this project, one in September 1947 and the other in March 1948. Concrete cores were also obtained from designated locations in the affected areas for laboratory examination.

Results From Condition Surveys: The physical condition of the pavement with respect to cracking revealed by both surveys is illustrated in Figure 2. In the 1947 survey, cracking was noted in the affected area at Stations 88+20 and 89+10. At that time the pavement was not discolored. The survey in 1948 revealed the same amount of cracking, but the pavement had become badly discolored in those two areas. See Figures 3 and 4. In addition, scaling has taken place over a small area at Station 88+20. These areas are shown in Figures 4 and 5. Exudation of white material was also noted at a few localized areas as shown in Figure 6, and some discoloration has appeared at Station 88+40 (Figure 7). From a visual examination the most seriously damaged pavement is in the vicinity of Stations 88+20 and 89+00, designated areas A and B in Figure 2. However, other weakened areas may develop with time.

Results From Core Studies: Nine cores were taken from the affected section of pavement. Their location and identification are shown in Figure 2. The results of laboratory tests for strength and durability in freezing and thawing are given in Table 1. The core strengths tie in very well with the general performance of the pavement. The strength values of cores 88, 75, 74 and 77 are relatively low and they were taken from the three slabs most seriously affected.



AREAS A - B MOST SERIOUSLY DAMAGED, (SEE PHOTOGRAPHS)

▨ SECTION CONTAMINATED

O LOCATION OF CORES

CONDITION SURVEY #2 (9-30-47)
Research Project F43-16, C2 & 61-39, C3
US-10 West of Reed City
Sheet 1 of 2 Sta 0-600 Ft. to 150+00

Figure 2

Sheet 1 of 2

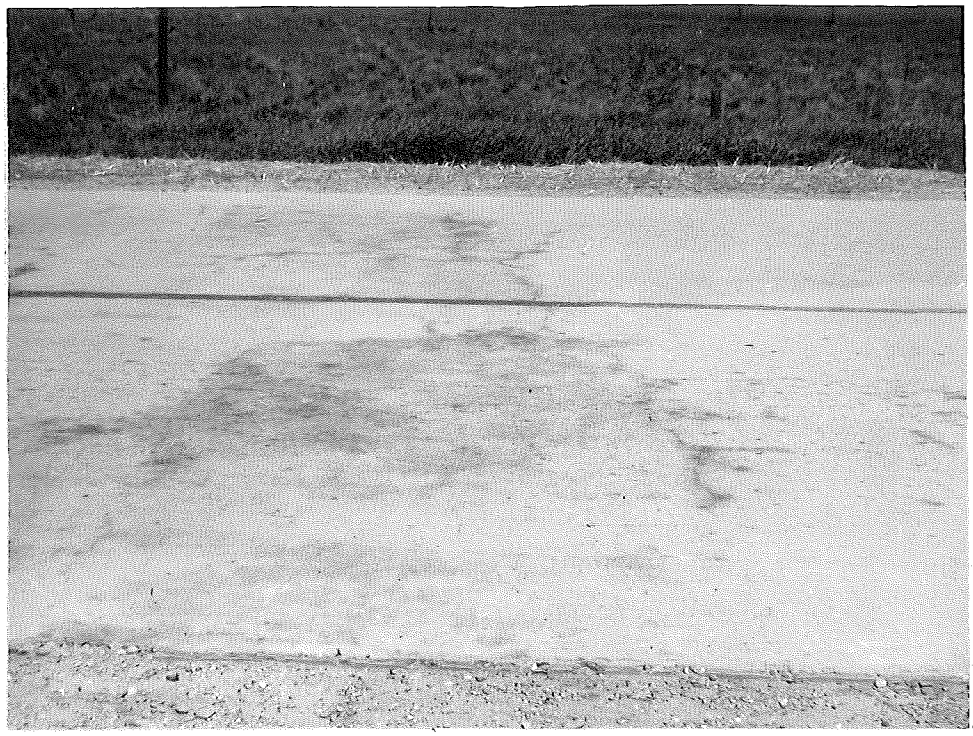


Figure 3. Appearance of pavement from Station 89+00 to 88+10. Note discoloration and hair checking of concrete.

Figure 4. Appearance of pavement between Station 86+20 to 86+25. Concrete discolored and scaled in north lane only. Cracking extended across entire pavement.

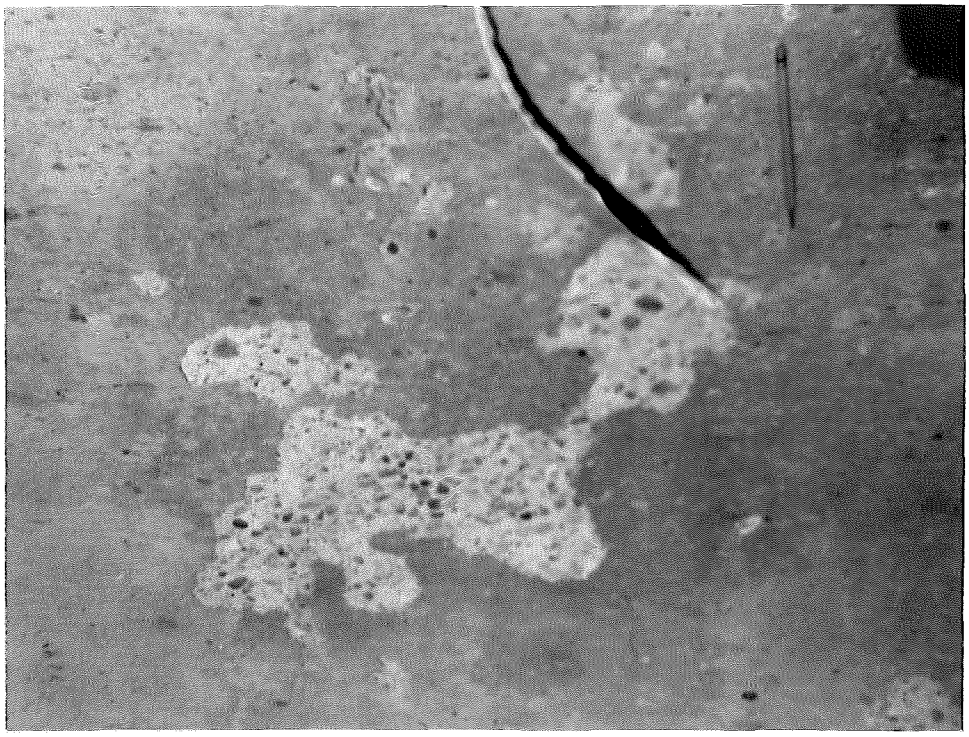


Figure 5. View of scaled area at Station 88+20.

Figure 6. Excretion of white material in localized areas. Station 89+05.

Figure 7. Discoloration in north lane, Station 85+40. Concrete not cracked or checked in dark areas.

TABLE 1

SUMMARY OF LABORATORY TESTS OF PAVEMENT CORES

Station	Core No.	Core Section	Average Thickness	Bulk Sp. Gr.	Comp. Str. psi(1)	Entrained Air(2)	Durability in Freeze-Thaw Test at Cycle Indicated (3) 10	20	30	40	50	Wt. Loss 50 cycles, per cent
90+23 L	69	Top	1.97	2.18			1	1	1	2	2	0.7
		Bottom	1.52	2.42			0	2	2	3	3	11.5
		Middle			3640	3.2						
90+13 R	70	Top	1.47	2.36			0	1	1	2	2	4.1
		Bottom	1.67	2.42			0	0	0	1	1	1.9
		Middle			4100	4.3						
90+03 L	71	Top	1.91	2.35			0	1	1	2	2	0.3
		Bottom	1.56	2.41			0	0	0	1	1	1.4
		Middle			4005	5.1						
89+93 R	72	Top	1.59	2.36			0	2	2	3	3	2.8
		Bottom	1.98	2.36			0	0	1	1	1	1.2
		Middle			4250	---						
89+43 L	73	Top	1.81	2.43			0	1	2	3	3	8.5
		Bottom	2.46	2.42			0	0	1	1	1	1.1
		Middle			3540	---						
88+43 R	74	Top	1.76	2.46			1	1	1	3	3	4.5
		Bottom	2.31	2.41			2	2	2	3	3	3.6
		Middle			2985	---						
87+43 L	75	Top	1.90	2.40			0	0	0	1	1	0.4
		Bottom	1.85	2.42			0	1	1	1	1	0.4
		Middle			4515	---						
86+43 R	76	Top	1.73	2.38			0	0	0	1	1	0.6
		Bottom	1.92	2.40			0	0	0	0	1	1.6
		Middle			4120	---						
85+43 L	77	Top	1.90	2.38			0	0	0	1	1	0.1
		Bottom	1.96	2.41			0	0	0	0	0	1.5
		Middle			3840	---						
(4)	146	Top	1.90	2.39			0	0	0	1	1	0.3
		Bottom	1.69	2.47			0	0	0	1	1	0.6
		Middle			4825	---						
(4)	147	Top	1.66	2.43			0	0	0	1	1	0.3
		Bottom	1.59	2.42			0	0	0	0	0	0.5
		Middle			4490	2.6						

(1) Compressive strength of cores corrected to conform to a cylinder whose height is twice its diameter.
(2) Camera Lucida method.
(3) Symbols denote: 0, no appreciable attack; 1, very slight attack; 2, moderate attack; 3, heavy attack.
(4) Adjacent to but outside of affected area.

The cores were cut transversely into three sections. The middle section, four inches long, was used for compressive strength tests. The remaining top and bottom sections were subjected to freeze and thaw tests in a solution of 10 per cent calcium chloride. The chloride solution was employed to accelerate the test. The freeze-thaw data presented in Table 1 show that the sections of cores 69, 72 and 74 have the lowest resistance to freezing and thawing action, which is in order since these cores had the lowest strength values. Although core 77 had a low strength value its freeze-thaw rating compares favorably with those of the remaining cores.

Conclusions

From the available facts at the time of this writing, it may be concluded that the slabs of concrete pavement most seriously damaged from the presence of the soda ash are those designated 2 and 3 in Figure 2. Their respective stationings are 87+80 to 88+90, and 88+80 to 89+95. However, the slab designated 1, between Stations 84+90 and 85+30, has started to show discoloration and the core strength was below average. It is possible that in this slab the effect of the soda ash may develop at a later date. This may also be true for other concrete adjacent to the areas most seriously affected.