EARLY SCALING OF CONCRETE PAVEMENT
US 41 Marquette Bypass (Construction Project U 52042E, C8)

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In accordance with C. S. Lundberg's request to J. C. Brehler of July 23, 1964, the Research Laboratory Division has tested concrete cores from the eastbound and westbound lanes of the Marquette Bypass, to determine the cause of variable but extensive scaling of portions of that pavement. The scaling in question is located at the western end of the project, on pours of November 8, 11, and 12, 1963 (Stas. 1101+37 to 1202+00); the rest of the project was poured between August 19 and September 4, 1963. Cores received for testing at the Research Laboratory on July 20, 1964, included 25 specimens from the November pours, and two (here designated Control Cores I and II) from the August pours. In addition, top slices of six more cores from the August pours were received from the Testing Laboratory Division on September 16, 1964, for further checking of air contents.

A detailed field survey of the entire project was performed on September 15, 1964, and established that all scaling was confined to the pours of November 8, 11, and 12, as illustrated in the survey diagram showing extent and degree of scaling (Fig. 1). Figs. 2 and 3 illustrate typical scaled areas on both roadways, as encountered during the survey.

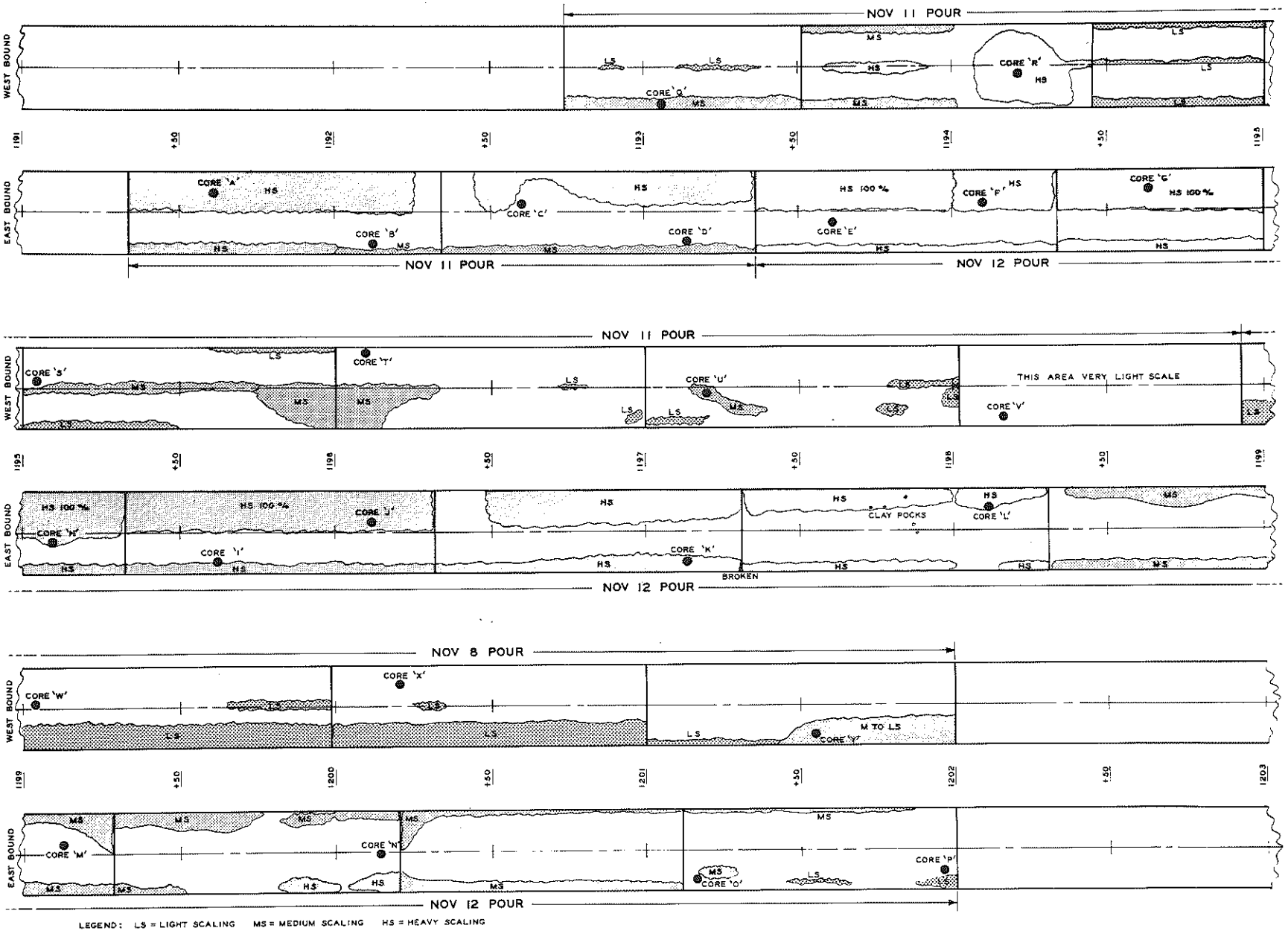

Figure 1. Schematic drawing of US 41 concrete poured in November 1963 (Sta. 1191+40 to 1202+00), showing locations of 25 special cores "A" through "Y", and extent and degree of scaling (based on condition survey of September 15, 1964).

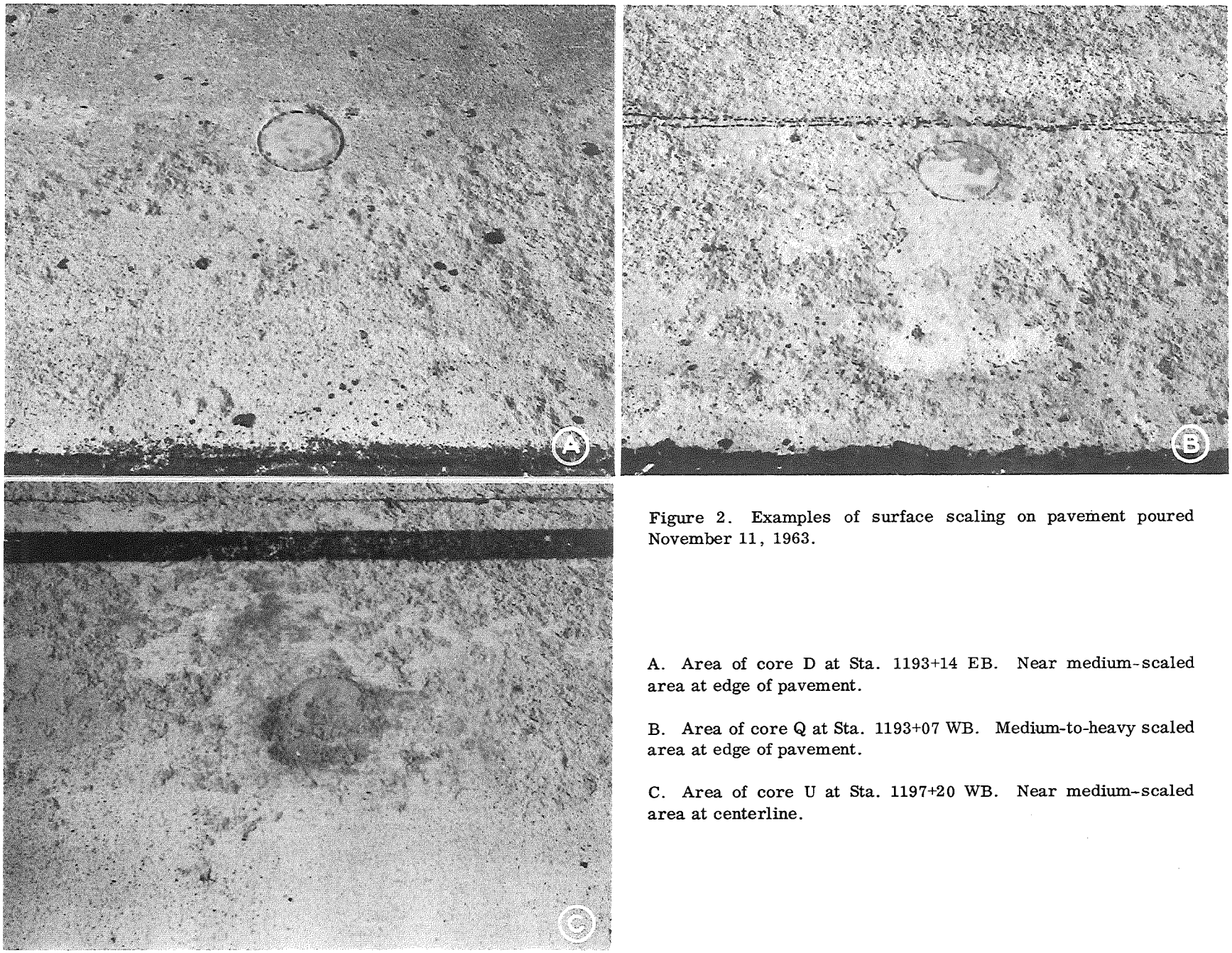

Figure 2. Examples of surface scaling on pavement poured November 11, 1963.

A. Area of core D at Sta. 1193+14 EB. Near medium-scaled area at edge of pavement.

B. Area of core Q at Sta. 1193+07 WB. Medium-to-heavy scaled area at edge of pavement.

C. Area of core U at Sta. 1197+20 WB. Near medium-scaled area at centerline.

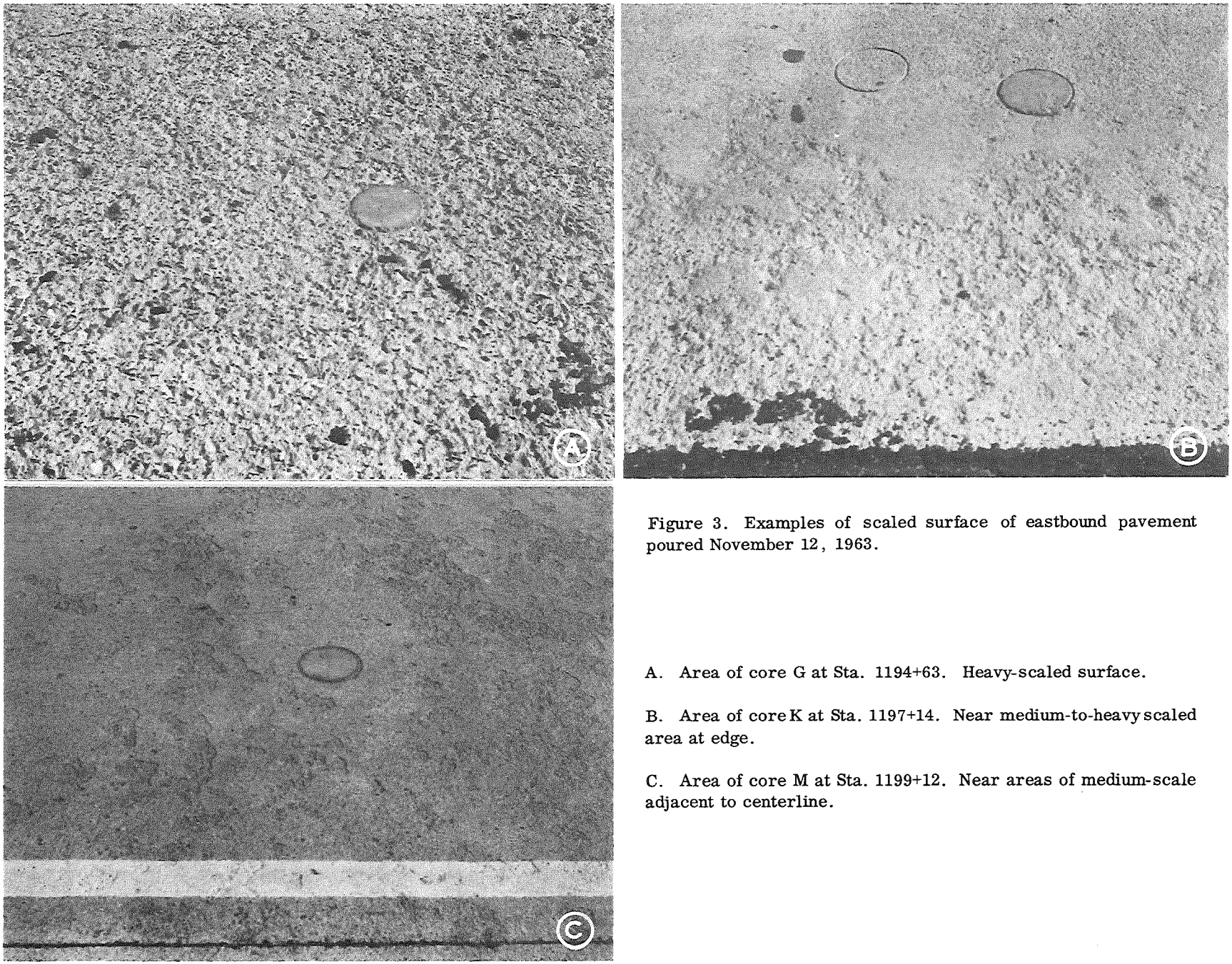

Figure 3. Examples of scaled surface of eastbound pavement poured November 12, 1963.

A. Area of core G at Sta. 1194+63. Heavy-scaled surface.

B. Area of core K at Sta. 1197+14. Near medium-to-heavy scaled area at edge.

C. Area of core M at Sta. 1199+12. Near areas of medium-scale adjacent to centerline.

Table 1 summarizes results for all 33 cores received for testing, and Fig. 4 shows three examples of the surface scaling observed on these cores. The tabulated results indicate a concrete pavement of average or normal strength, but variable air content.

The air content as determined by the linear traverse method ranged from 1.9 to 5.0 percent, with several cores near the lower of these values. These linear traverse results generally run 0.5 to 1.0 percent lower than corresponding values obtained using the pressure meter on fresh concrete. This means that a number of the areas cored had air contents in the 3-percent range, which of course is below the minimum 4-percent specified. Construction records were examined and Table 2 contains a summary of all air checks run in the field on the east- and west-bound lanes. These values, except for the 3.3-percent value on the first day of pouring (August 19), indicate good air content for the points tested. However, many of the tests were with the Chace meter, subject to more inaccuracies than the low-pressure meter. No air checks were made on November 12, and only Chace tests were run on November 8 and 11. Field air check tests on these last two dates were 5.7 and 5.5, respectively.

These scaling characteristics might be attributed to the frequently low air content of the concrete in the case of the November pours, but this explanation would not be valid in all cases. The November 8 pour,

TABLE 1
SUMMARY OF CORE TESTS

	Specimen Identification		Station	Roadway	Pour Date	Core Height, in.	Steel Depth, in.	Compressive Strength, psi*	Air Content, percent**	Upper Surface Scaling
	Lab. No.	Code								
August Concrete	64 CR-42	Control I	1208+89	EB	8-19-63	9.7	5.7	4906	4.8	none
	64 CR-52	Control II	1214+96	WB	8-28-63	9.1	5.2	4719	4.6	none
	64 CR-65	1599	1205+11	EB	8-19-63	9.1	5.7	----	3.4	none
	64 CR-66	1598	1214+50	EB	8-20-63	9.3	5.5	----	4.5	none
	64 CR-67	1596	1234+05	EB	8-21-63	9.1	4.7	----	5.0	none
	64 CR-68	1595	1245+23	EB	8-22-63	9.2	5.1	----	4.3	none
	64 CR-69	1594	1255+86	EB	8-23-63	8.8	5.3	----	4.0	none
	64 CR-70	1593	1266+66	EB	8-26-63	9.1	5.7	----	4.2	none
November Concrete	64 CR-49	W	1199+04	WB	11-8-63	9.1	5.4	5667	---	none(a)
	64 CR-50	X	1200+21	WB	11-8-63	9.1	5.5	----	2.9	none(a)
	64 CR-51	Y	1201+55	WB	11-8-63	9.0	4.3	4756	2.6	none
	64 CR-26	A	1191+62	EB	11-11-63	9.4	4.6	----	4.1	heavy
	64 CR-27	B	1192+12	EB	11-11-63	9.1	5.0	4766	---	light
	64 CR-28	C	1192+60	EB	11-11-63	9.9	3.9	----	4.9	light
	64 CR-29	D	1193+14	EB	11-11-63	9.3	4.5	4538	---	light
	64 CR-43	Q	1193+07	WB	11-11-63	9.1	5.1	5429	1.9	heavy
	64 CR-44	R	1194+22	WB	11-11-63	9.3	4.3	----	2.1	medium(a)
	64 CR-45	S	1195+05	WB	11-11-63	9.0	5.1	5910	---	none(a)
	64 CR-46	T	1196+10	WB	11-11-63	8.9	4.6	4402	---	medium
	64 CR-47	U	1197+20	WB	11-11-63	9.5	4.2	----	2.3	medium(a)
	64 CR-48	V	1198+16	WB	11-11-63	9.1	5.0	4964	---	light
	64 CR-30	E	1193+62	EB	11-12-63	8.3	4.1	----	4.9	none
	64 CR-31	F	1194+10	EB	11-12-63	9.9	4.7	5405	---	heavy(a)
	64 CR-32	G	1194+63	EB	11-12-63	9.0	4.2	----	2.7	heavy
	64 CR-33	H	1195+10	EB	11-12-63	8.8	4.9	5357	---	light
	64 CR-34	I	1195+62	EB	11-12-63	8.8	3.7	5227	---	medium(a)
	64 CR-35	J	1196+12	EB	11-12-63	9.6	4.3	----	3.5	medium(a)
	64 CR-36	K	1197+14	EB	11-12-63	9.2	4.5	4774	---	light
	64 CR-37	L	1198+11	EB	11-12-63	9.4	5.4	4358	---	light
	64 CR-38	M	1199+12	EB	11-12-63	8.6	3.9	5141	---	none
	64 CR-39	N	1200+13	EB	11-12-63	9.1	4.5	----	2.7	light(a)
	64 CR-40	O	1201+16	EB	11-12-63	8.6	2.5	5341	---	medium
	64 CR-41	P	1201+96	EB	11-12-63	9.4	4.6	4621	---	light

* Corrected to standard L/D ratio of 2.0.

** Linear traverse method, testing upper 1/2 to 3/4 in. (ASTM C 457-60T).

(a) Core also had neat cement or mortar deposit on bottom.

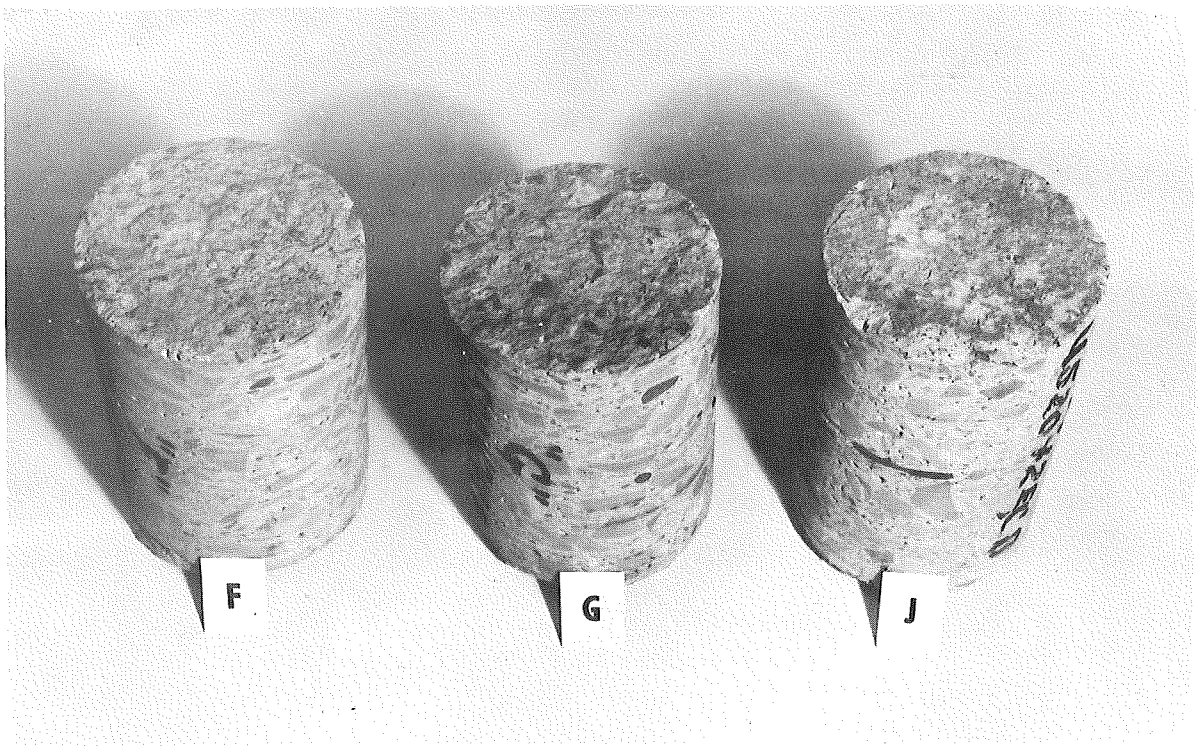

Figure 4. Examples of scaled core tops from November 12 pour (eastbound roadway).

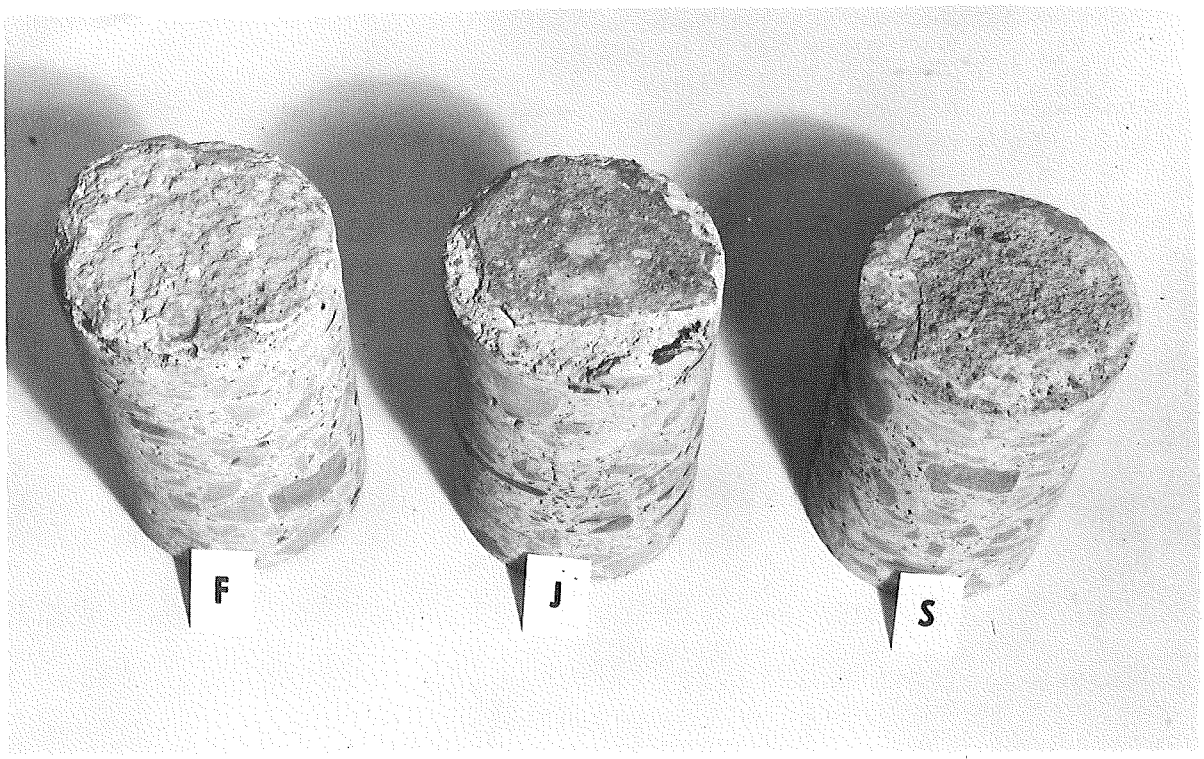

Figure 5. Examples of bottom deposit of neat cement or mortar on cores from pours of November 11 and 12 (east and westbound lanes).

TABLE 2
SUMMARY OF FIELD AIR CHECKS
ON FRESH CONCRETE

	Date	Station	Air Content, percent*	Testing Agent**
Eastbound	8-19-63	1202+50	5.0	C
	8-19-63	1208+00	3.3	T&R
	8-19-63	1209+50	5.4	T&R
	8-20-63	1221+50	5.0	T&R
	8-21-63	1231+00	7.0	C
	8-22-63	1243+00	7.0	C
	8-23-63	1259+00	5.0	C
	8-26-63	1270+00	5.5	C
	8-27-63	1279+00	7.2	C
Westbound	11-11-63	1194+00	5.5	C
	11- 8-63	1201+50	5.7	C
	8-28-63	1215+50	5.6	T&R
	8-30-63	1238+00	5.1	C
	8-31-63	1246+00	8.0	C
	9- 3-63	1255+50	5.6	T&R
	9- 4-63	1272+00	7.0	C

* For all but first two checks in this column, contractor was using 3/4 oz of Protex air-entraining agent per sack of cement.

** C - Test by Construction personnel using Chace meter on small mortar sample.

T&R - Tested by Testing and Research personnel using pressure meter on 0.2 cu ft of fresh concrete.

TABLE 3
SUMMARY OF WEATHER DATA
Marquette FAA Airport
November 1963

Date	Air Temperature, F		Precipitation, in.	
	Low	High	Total	Snow **
7	40	49	.13	---
8*	37	48	---	---
9	37	45	.19	---
10	34	43	trace	---
11*	32	38	trace	---
12*	31	35	.31	0.1
13	33	35	.21	trace
14	29	36	.12	0.5
15	29	39	---	---
16	30	52	---	---
17	38	48	---	---
18	27	45	---	---
19	26	53	---	---
20	32	43	trace	---
21	41	43	.01	---
22	32	54	.35	trace
23	17	32	.06	1.0
24	8	25	trace	trace
25	11	35	.03	0.3
26	31	37	trace	---
27	29	38	---	---
28	29	38	.01	0.4
29	20	29	.03	1.1
30	11	27	.21	2.8

* Concrete pouring dates.

** Ten inches of snow is assumed equivalent to one inch of water.

although low in air content, shows little or no scaling at the three stations cored, while the November 11 and 12 pours show considerable scaling, in some cases located in areas with higher air contents. The strength data indicate that the concrete is undoubtedly of the correct proportioning (as had been stated in the Daily Reports of Concrete Proportioning).

One factor that might have contributed to the scaled condition of the November 11 and 12 pours, perhaps to a major degree, is possible frost damage to the green concrete as indicated by prevailing air temperatures during pouring and curing. Temperature and precipitation data from November 7 to 30 are given in Table 3. Low Temperatures recorded at the Marquette FAA Airport were from 31 to 38 F on November 11 and 12, and much lower subsequently to a minimum of 8 F recorded on November 24. It is evident that the minimum air temperature was 32 F or less on seven of the nine days from November 11 to 19. Further, Weather Bureau data in Table 3 show a total snowfall of 1.3 in. between November 22 and 25, and 4.3 in. between November 28 and 30. No doubt, the pavement had been opened by late November and consequently could have received salt applications during these periods, aggravating the scaling situation.

Daily Concrete Reports indicate that the November 8, 11, and 12 pours contained slightly less than 1 lb of flake calcium chloride per sack of cement. The November 8 pour was cured using sprayed white mem-

brane (Permite) without straw, although on November 11 and 12, 12 in. of straw was used as protection over curing membrane. Temperature data indicate the likelihood that the grade could have been frozen during pouring on November 11 and 12, and that the slab top could have been damaged during the subsequent low temperatures. This would be especially likely if the straw cover had blown off the pavement. Fresh concrete temperatures are unavailable, but were probably low since materials were not heated.

Visual inspection also showed that some core bottoms had a thin film of neat cement or mortar deposit, possibly caused by a frozen and impervious base course or by dumped wash material from the paver. Fig. 5 shows three examples of this bottom deposit. A few cores exhibited large voids as examples of poor consolidation. Core T was very poor and had large voids at the bottom.

In summary, the variable scaling found on the pavement surfaces poured last November 8, 11, and 12 may be due to one or more of the following factors:

1. Variable and low air content in some of the areas cored.
2. Freezing temperatures beginning November 11, which lowered fresh concrete temperatures, retarded the curing rate, and possibly caused early surface frost damage.
3. Possible early and heavy application of salt before adequate curing had been attained.