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THE OPERATION OF AN ELECTRICAL HEATING SYSTEM FOR BRIDGE DECKS

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ABSTRACT

The 9th-Street interchange with I 64 in Louisville, Kentucky, was designed and constructed with an automated electrical heating system for snow and ice removal. This report summarizes the operation of the heating system during the first four years. The system was capable of keeping the interchange free of ice and snow accumulation. The average daily slab temperature fell below 0°C (32°F) only on a few occasions. The average cost of electrical power for heating the interchange was $883 per day.

INTRODUCTION

The presence of snow or ice on highways, especially at bridges and interchanges, often results in hazardous driving conditions. Conventional snow and ice removal may prove inadequate due to the time lag between ice and snow accumulation and plowing and(or) salting operations. Also, deterioration of concrete in bridge decks is often attributed to the use of deicing chemicals. A number of nonchemical methods of preventing freezing have been investigated. One solution for the control of such conditons is a heating system for bridge decks and pavements capable of melting any snow or ice that might accumulate on the roadway.

The 9th-Street interchange in Louisville, Kentucky, is subject to extreme conditions due to the use of maximum interstate grades and superelevations, the height of the ramps, and the location near the Ohio River (Figure 1). The major portions of the ramps are elevated, exposing both the top and bottom surfaces of the ramps to wind currents. An automated heating system, with manual override switches, was deemed necessary for this location. The design, construction, and initial operation of the system was described in a report to the Second International Symposium on Snow Removal and Ice Control Research in 1978 *(1)*.

The heating system is operated at a low level of heat when the slab temperature goes above a certain set point. As the temperature drops, slab temperature sensors cause the voltage regulator to increase the voltage into the system. As the temperature increases, the voltage level is reduced. However, various weather parameters, such as barometric pressure, rain, snow, humidity, and others, are programmed into the system so that the system actually operates on the probability of snow and ice rather than the detection of snow and ice. An illustration is given in Figure 2. The slab temperature establishes a base-line condition. As the temperature drops, more heat input goes into the slab. The basic straight-line situation is then changed by the weather factor signal modifiers, represented by the cross-hatched areas between the curves. If weather conditions remain ideal, even though the temperature goes very low, a minimum of heating would be required, as shown by the lower portion of the cross-hatched area If weather conditions are unfavorable, more heat would be required as shown by the upper portion of the cross-hatched area.

OPERATIONAL DATA

The 9th-Street interchange was opened to traffic on December 3, 1976. The initial operating season extended through April 16, 1977. The system was also operated during three additional seasons: November 9, 1977, to March 30, 1978; November 16, 1978, to March 29, 1979; and November 13, 1979, to March 31, 1980. These periods included some extreme cold-weather and snow conditions for the Kentucky area. The heating system was in operation at various levels throughout these periods.

Monthly weather statistics are summarized in Table 1. Figures 3 and 4 compare the average daily slab temperature to the average daily air temperature as recorded at the 9th-Street interchange during the 1976-77 winter season. The position of the thermocouple used to determine the average slab temperature was at the surface of one of the bridge ramps. Visual observations indicated that both deck and pavement sections were kept free of snow and ice accumulation. Figures 5 and 6 show heated and unheated pavements during a period of snow accumulation. Both pictures were taken of the same snowfall. The official ground cover for that day was 127 mm (5 inches) of snow. Figure 7 is an aerial view of the entire interchange taken on February 2, 1978. The photo clearly shows the difference between heated and unheated sections during severe cold and snow accumulation.

Power usages and costs for the heating system are listed in Table 2. The cost for heating the interchange during the 1976-77 winter was \$8.50 per m^2 (\$0.79 per square foot) or \$911 per day. For the 1977-78 season, these costs were \$10.33 per m^2 (\$0.96 per square foot) or \$1,089 per day; for 1978-79, \$8.07 per m^2 (\$0.75 per square foot) or \$876 per day; for 1979-80, \$6.03 per m^2 (\$0.56 per square foot) or \$650 per day. These costs do not include labor charges for operators who monitor the interchange throughout the season. An agreement with the electrical subcontractor for maintenance of the system has been estimated to be \$50,000 per year.

The cost of operating the heating system is dependent on several factors. The weather greatly determines the power required to heat the pavement. January of 1977, for example, had the lowest average temperature for any month dating back to 1872. The 721 mm (28.4 inches) of snow in January 1978 made it the snowiest January since 1918 for the Louisville area. Manual settings of the signal modifiers and the slab set point may also affect the amount of heat input to the slab. The voltage-raise timers affect the power demand by controlling the time allowed the voltage regulator for increasing or decreasing the heat input to the slab. The opinion of the operator, in judging weather conditions and the probability of snow or ice, determines the settings for these instruments.

REFERENCES

1. Havens, J. H.; Azevedo, W. V.; Rahal, A. S.; and Deen, R. C.; *Heating Bridge Decks by Electrical Resistance,* **Proceedings,** Second International Symposium on Snow Removal and Ice Control Research, Special Report 185, Transportation Research Board, 1979.

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TABLE 1. MONTHLY WEATHER SUMMARIES

YEAR	MONTH	TEMPERATURES (°C) HIGH	LOW	AVERAGE	LARGEST SNOWFALL DEPTH (MM)	DATE	GREATEST ACCUMULATION DEPTH (MM)	DATE	TOTAL SNOW-FALL (MM)
1976	DECEMBER	18	-17	1	23	29TH	25	29TH	28
1977	JANUARY	6	-25	-7	198	9-10TH	229	11TH	498
	FEBRUARY	24	-15	3	10	19-20TH	51	3RD	20
	MARCH	28	-6	11	3	22ND	TRACE	22ND	3
	APRIL	30	1	16	20	4-5TH	TRACE	6TH	20
1977	DECEMBER	16	-15	1	48	6TH	50	6TH	55
1978	JANUARY	15	-18	-5	358	16-17TH	482	20TH	721
	FEBRUARY	4	-17	-4	48	18TH	254	2ND	139
	MARCH	28	-16	5	162	2-3RD	152	3RD	238
	APRIL	30	1	14	TRACE	16TH	TRACE	16TH	TRACE
1978	DECEMBER	18	-8	4	TRACE	25TH	TRACE	25TH	TRACE
1979	JANUARY	12	-17	-4	70	27-28TH	76	10TH	215
	FEBRUARY	17	-16	-2	119	18TH	127	9TH	276
	MARCH	24	-7	9	17	24-25TH	25	25TH	22
	APRIL	27	-1	12	TRACE	6TH	TRACE	6TH	TRACE
1979	DECEMBER	20	-10	4	TRACE	17TH	TRACE	17TH	TRACE
1980	JANUARY	13	-11	8	172	30-31ST	177	31ST	271
	FEBRUARY	17	-16	-1	50	5-6TH	152	1ST	91
	MARCH	18	-17	5	99	1ST	101	2ND	99
	APRIL	30	0	12	TRACE	15TH	TRACE	15TH	TRACE

NOTE: 1 IN. = 25.4MM; C = (F - 32)/1.8

TABLE 2. POWER USAGE AND COSTS

PERIOD	NUMBER OF DAYS	KWH	AVERAGE KWH/DAY	COST	AVERAGE COST/DAY
12- 9-76 - 1-10-77	32	2,011,200	62,850	$50,765.62	$1,586.43
1-11-77 - 2- 8-77	29	2,505,600	86,400	63,484.30	2,189.11
2- 9-77 - 3-10-77	30	648,000	21,600	16,618.09	553.94
3-11-77 - 4- 8-77	29	230,400	7,945	5,952.84	205.27
4- 9-77 - 5-10-77	31	28,800	929	797.36	25.72
12- 9-76 - 4-16-77*	151	5,424,000	35,921	137,618.21	911.38
12- 9-77 - 1-11-78	34	1,584,000	46,588	$49,388.15	$1,452.59
1-12-78 - 2- 9-78	29	2,347,200	80,938	77,839.46	2,684.12
2-10-78 - 3-13-78	32	878,400	27,450	31,688.75	990.27
3-14-78 - 4-11-78	29	86,400	2,979	6,663.04	229.76
4-12-78 - 5-11-78	29	28,800	993	1,056.42	36.43
11- 9-77 - 3-30-78*	153	4,924,800	32,188	166,635.82	1,089.12
12-10-78 - 1-10-79	31	1,190,400	38,400	$38,671.51	$1,247.47
1-11-79 - 2- 9-79	29	1,694,400	58,428	55,816.33	1,924.70
2-10-79 - 3-12-79	31	878,400	28,335	29,093.95	938.51
3-13-79 - 4-10-79	29	172,800	5,959	5,920.00	204.14
4-11-79 - 5-10-79	29	28,800	993	958.10	33.04
11-16-78 - 3-29-79*	149	3,964,800	26,609	130,459.89	875.57
12-11-79 - 1-10-80	31	542,400	17,497	$22,194.33	$ 715.95
1-11-80 - 2-11-80	32	993,600	31,050	40,732.41	1,272.89
2-12-80 - 3-11-80	29	681,600	23,503	27,895.82	961.92
3-12-80 - 4-10-80	30	129,600	4,320	5,920.00	197.33
4-11-80 - 5- 9-80	28	19,200	685	779.38	27.84
11-13-79 - 3-31-80*	150	2,366,400	15,776	97,521.94	650.15

*ACTUAL DATES OF OPERATION

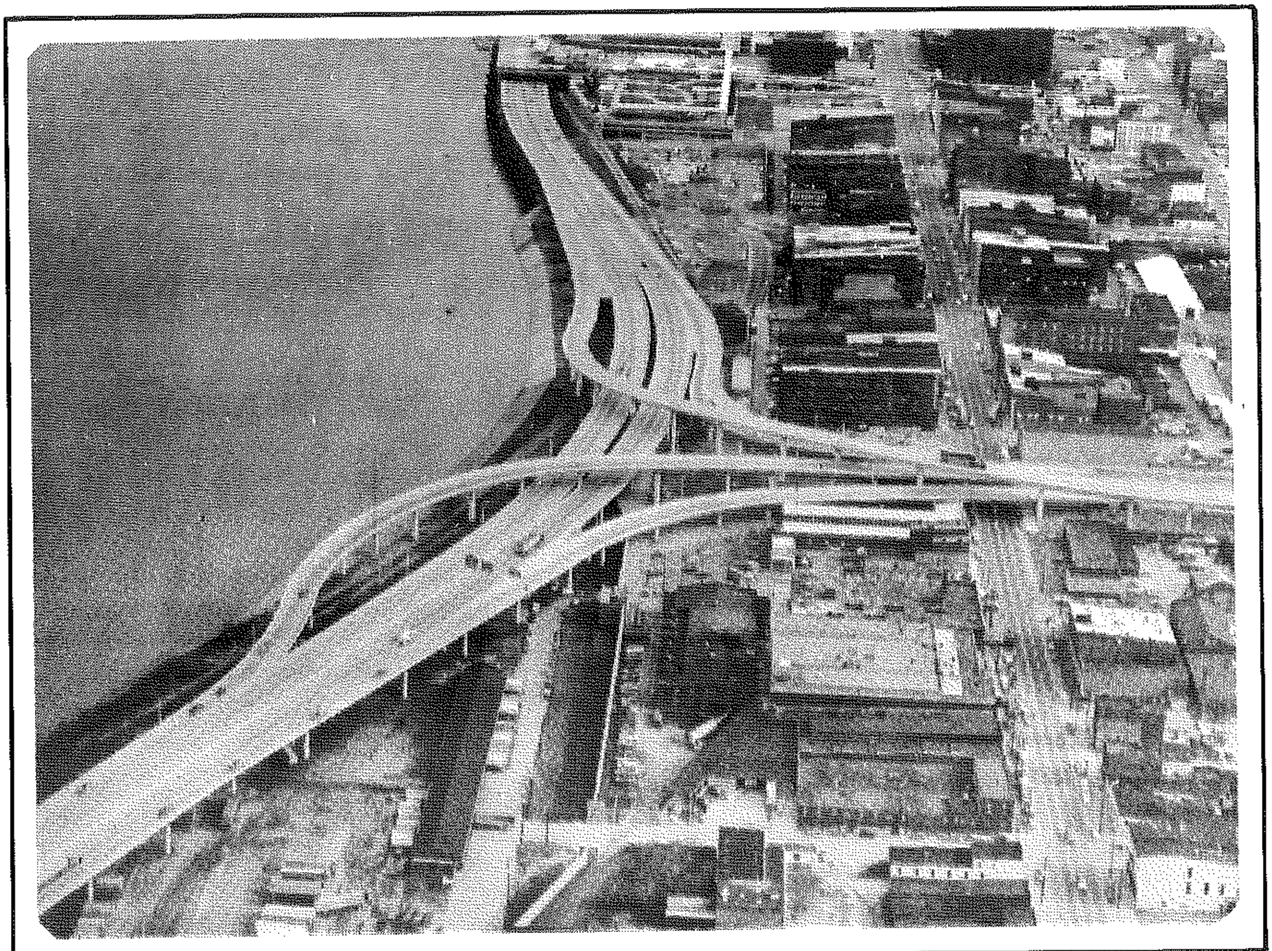

Figure 1. 9th-Street Interchange, Looking Upstream.

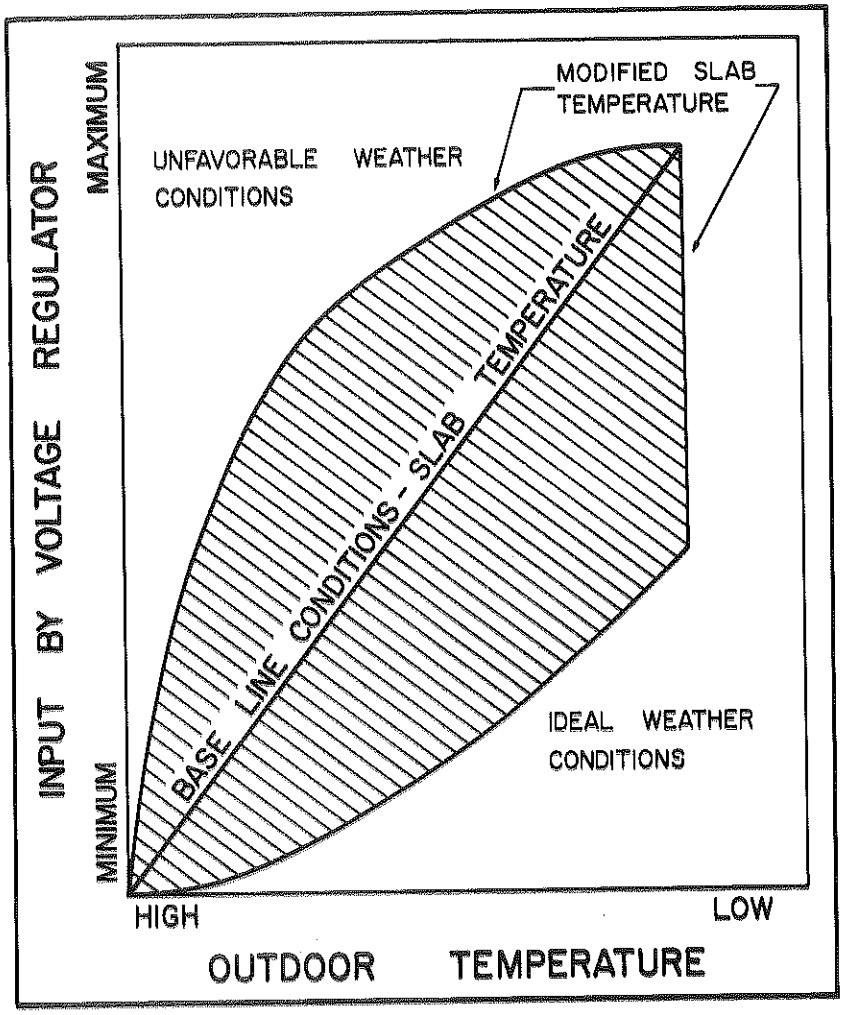

Figure 2. Modified Slab Temperature Conditions.

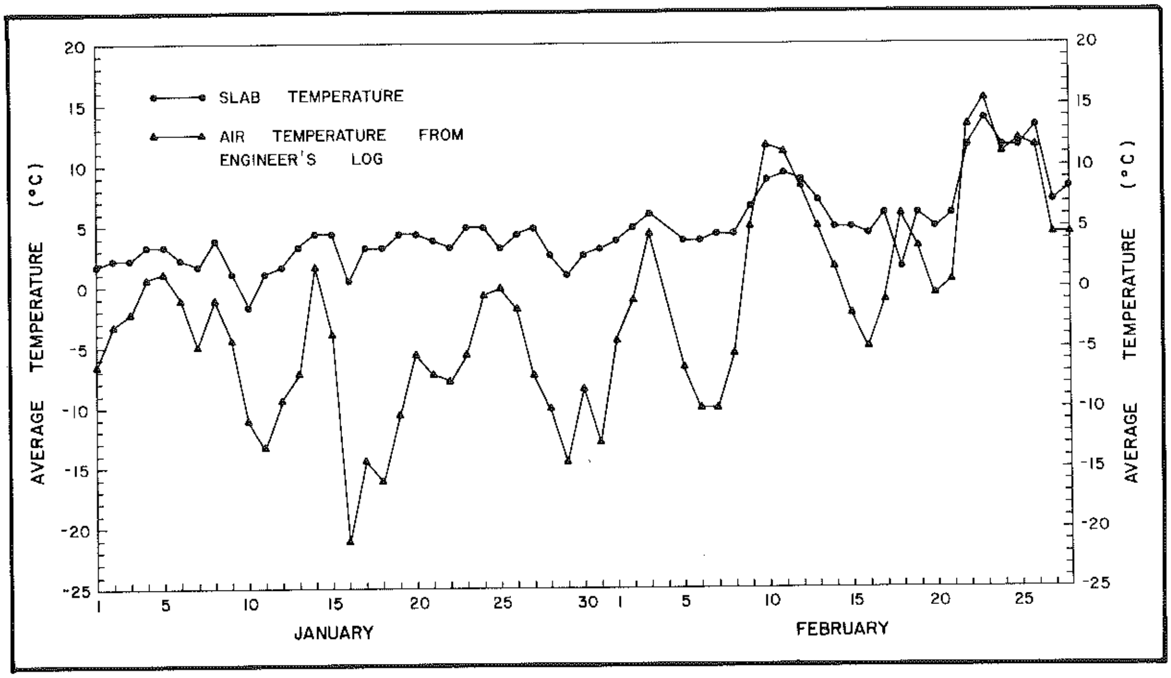

Figure 3. Average Temperature Versus Time (January and February, 1977).

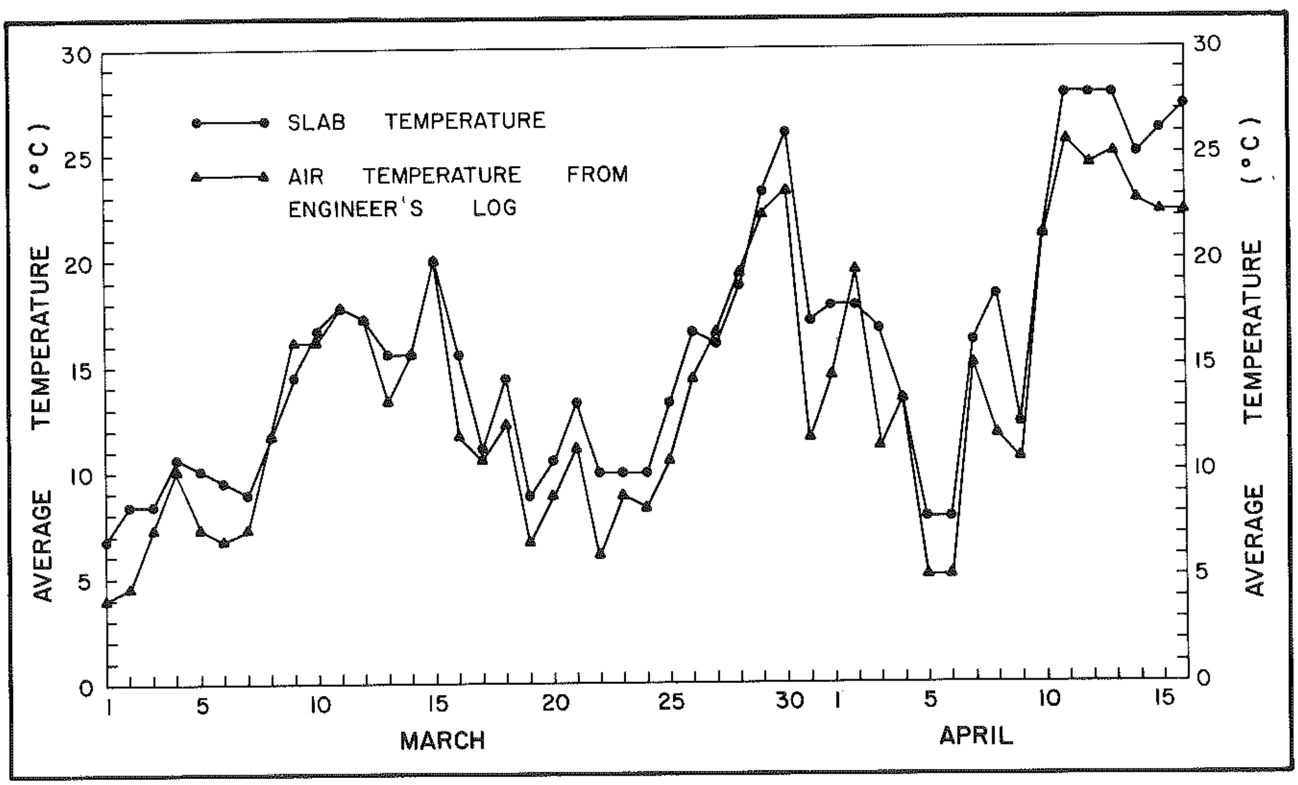

Figure 4. Average Temperature Versus Time (March and April, 1977).

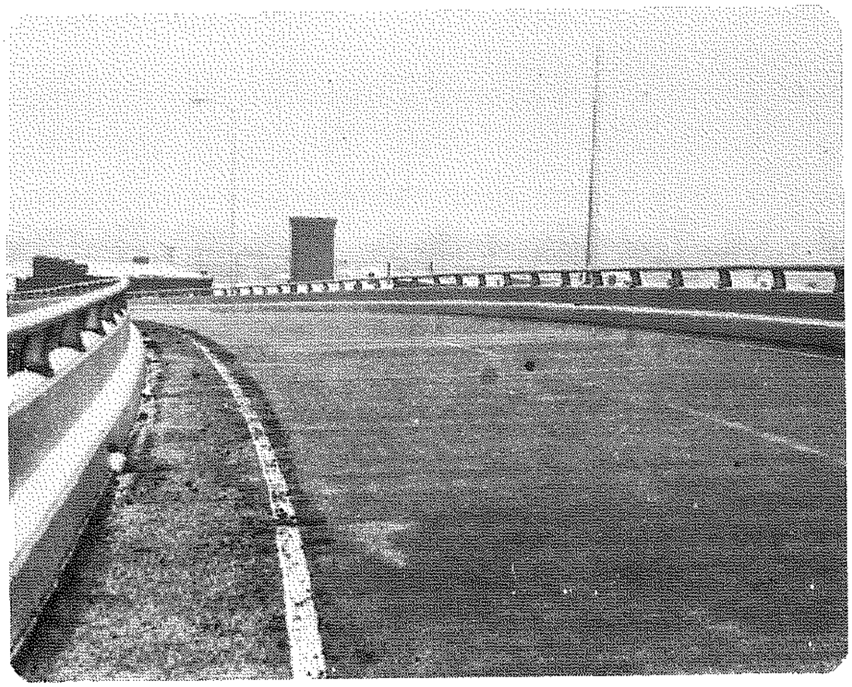

Figure 5. Heated Pavement (January 14, 1977).

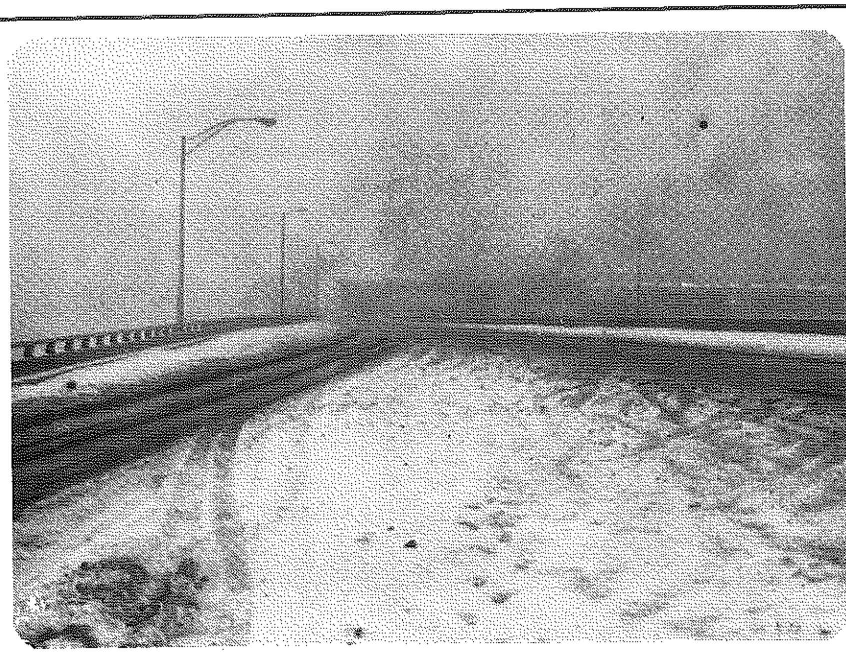

Figure 6. Unheated Pavement (January 14, 1977).

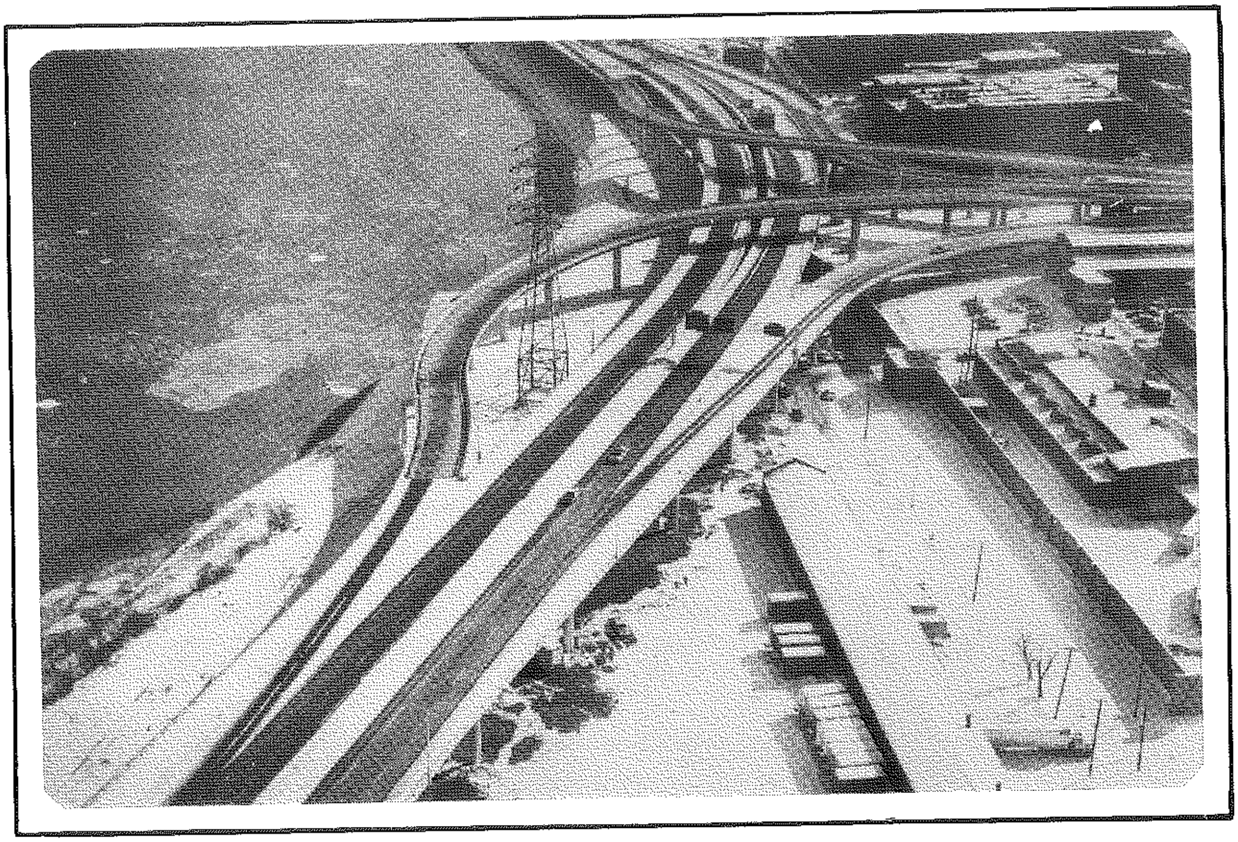

Figure 7. Aerial View of the 9th-Street Interchange on February 2, 1978, Showing the Distinct Difference between Heated and Unheated Sections.