Snow and Ice Removal from Road Surfaces by Electrical Heating

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One of the biggest problems in efficient and economical operation of road systems is the removal of snow and ice from driving surfaces, especially in the critical areas of a facility where operation of the usual snow removal machinery is not practical. One method is the use of electric heat. An experiment was started in 1961 to melt snow and ice automatically on the on- and off-ramps of the F. G. Gardiner Expressway in Metropolitan Toronto, Canada. The experiment, conducted to establish technical and economical feasibility before larger financial commitments were made, was carried out on site under actual traffic conditions. Electric heat was generated by iron wire mesh mats embedded under the pavement surface using between 20 and 30 v. Electricity was turned on and off automatically by temperature and weather detection instruments. Manual means were also provided to save on power when possible.

Each year the area of the experiment was progressively increased as technical and economic data accumulated. In the last year of operation, during the winter of 1963-1964, two complete ramps, one off and one on, were operating under traffic conditions and were kept under constant observation.

Between 30 and 40 w/sq ft of area is required to keep the driving surface free of snow and ice in the Toronto area which averages approximately 55 in. of snow per winter. Capital cost, for a good complete installation, is assessed at $3.40/sq ft. Operation costs $0.32/sq ft of heated area per winter. Both costs may be considerably reduced in the future. The method is practical, but due to its high costs should be used judiciously.

• IN RECENT YEARS, much attention has been focused on the necessity of removing snow and ice from freeways, highways, and expressways because these facilities must move vehicular traffic in large numbers, at high speeds, and with the greatest possible safety. Some points or areas in these roads do not lend themselves to the conventional means of clearing snow and ice by plowing and salting and, therefore, other methods, preferably automatic, must be found.

One of these methods consists of placing electric heating elements in the roadway immediately under the driving surface and energizing them, as required, to keep the roadway surface clear of snow and ice. This is the subject of an experiment which was begun in 1961 on the F. G. Gardiner Expressway, in Metropolitan Toronto, by Metropolitan Roads Department, with a view to using this method on all the on- and off-ramps of the elevated sections of the expressway. The purposes of the experiment were as follows:

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1. To prove the practicability of this method;
2. To decide the best type of heating element to be used;
3. To define design and construction details;
4. To determine the minimum number of watts per square foot of pavement required to melt the snow; and
5. To obtain sufficient operating data on load characteristics to allow the electrical authority to establish a power rate for this type of load.

After an initial test for one year, the test area was enlarged considerably for further observations.

After three winters of operation it can be said that this method of melting snow and ice does work, but both its capital and operating costs are quite high. It is felt, however, that all of these costs can be reduced and to this end future efforts will be directed. If these costs can be substantially reduced, this method could then be used more extensively to cover danger areas of any road system where electric power is available.

This paper describes the experiment, its purpose, history, design, construction, operation, results obtained and the conclusions.

HISTORY

The history of this experiment dates from 1958 when shortly after the opening of the first section of the F. G. Gardiner Expressway, which is at ground level, the operational features of the future elevated structure were reviewed. One outstanding feature was the problem of keeping the access ramps free from snow and ice during the winter months so that the capacity of the facility could meet the rush-hour traffic demands.

The basic idea was to find some means of melting snow and ice on the ramps without using salting trucks and snowplows. If this machinery leaves the main deck of an elevated expressway, it has great difficulty getting back on again due to heavy and often snarled-up traffic on the adjoining streets.

In view of this, Lakeshore Expressway Consultants investigated various methods that could be used for melting snow on the ramps, including:

1. Electric heating by embedding wire mesh or some sort of heating element into the roadway pavement;
2. Radiant heating with pipes embedded into the road slab using gas, oil, or electrical boilers to heat the fluids circulating through the coils; and
3. Natural gas fired infrared heaters installed on poles above the roadway.

Radiant heating was eliminated because of the high capital cost of installation and possible damage from the plumbing embedded in the concrete deck due to leaking, freezing, temperature stresses, etc. Infrared heating was eliminated because technically the system is not yet perfected. Infrared heaters will operate well in protected areas but not so well in wind-swept areas. The heat ray seems to be carried away by the wind before it hits the surface. However, this method has possibilities; if technical difficulties can be overcome it could be very effective and cheap to operate.

Electric heating was chosen because it offered the best compromise to the somewhat conflicting requirements of an ideal snow removal system. The method was attractive for the following reasons:

1. Power is readily available in the Toronto area;
2. The system is comparatively easy to control and monitor;
3. It offers ready application of heat to the areas requiring it;
4. Heat output is uniform over the entire heating element;
5. Maintenance is low in cost; and
6. Very little structural work is involved in the installation.

TYPE OF HEATING ELEMENT

Two main forms of installation are suitable for electrical road heating systems, the uninsulated iron wire mesh grid energized at low voltages and insulated cables (generally of the mineral-insulated type) which can be operated at voltages as high as 600 v.

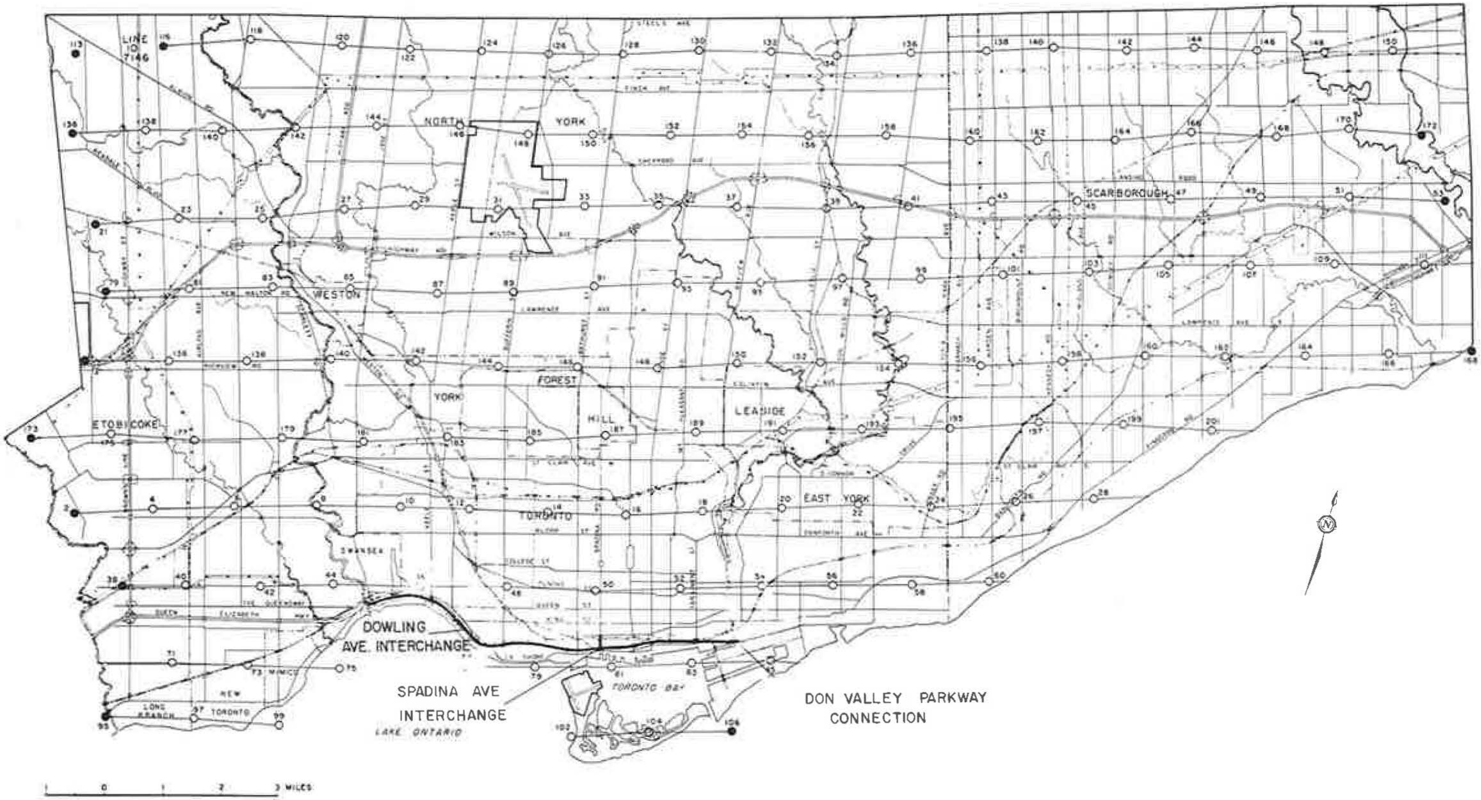

Figure 1. Partial map of Metropolitan Toronto showing F. G. Gardiner Expressway.

At the time of this installation, mineral-insulated cable was considered unsuitable because relatively little was known of its ability to withstand corrosion. Also, such a system would have to be operated at higher voltages to be economical and it was thought desirable to limit voltage for safety reasons. At that time, mineral-insulated cable had not received the wide acceptance in Canada that it enjoyed in Europe. Subsequently, however, several installations with mineral-insulated cable have been made in Canada and appear to be operating satisfactorily.

LOCATION

Figure 1 shows the general layout of the F. G. Gardiner Expressway. The solid lines indicate the portions which are completed or are under construction; the dotted lines indicate proposed extensions. From the Dowling Interchange to Leslie St., approximately 9 mi, the Expressway is on elevated structure. This study is concerned with the ramps within this area.

The original idea of using some automatic means of snow melting was sparked by the two ramps connecting the F. G. Gardiner Expressway with the Don Valley Parkway (Fig. 1). These ramps are 25 to 50 ft in the air and designed for a speed of 60 mph with 4 to 6 percent grades and 6 to 7° horizontal curves. It was realized that the presence of a little ice on the pavement surface of the ramps could be the cause of serious accidents; therefore, some means had to be found of insuring against slippery conditions, particularly on these two ramps connecting the two major expressways.

In March 1961 when the study of snow melting schemes began, the on-ramp of the Expressway at Spadina Ave. was under construction. It was decided then to use this ramp, which is 782 ft long, 17 ft wide and has a 6 percent grade, for a feasibility study before any large financial commitments were made. In other words, the result of an experiment on this ramp would form the basis for future decisions.

ORGANIZATIONS INVOLVED

After the basic design studies for this experiment were made by the consultants, a meeting was held between the Metropolitan Toronto Department of Roads, the consultants, the Toronto Hydro-Electric System, and representatives of the Hydro-Electric Power Commission of Ontario. Each organization agreed to perform the phases of the experiment most suited to their organization, with the consultants acting as designers and supervisors of the test and all expenditure being borne by the Metropolitan Toronto Department of Roads.

PHASE I

General Description of Test Installation

The first test installation was on a 65-ft section of the on-ramp of the westbound Expressway at Spadina Ave. Four separate heating elements of different wire thicknesses and spacings, lengths, and wattages were installed as shown in Figure 2. The heating elements consisted of galvanized welded steel mesh. Before placing it in the pavement, tests were carried out on samples of each mesh to determine their resistance and calculate the length of each type of wire mesh required to give a specific wattage per square foot of deck.

The installation of these heating elements was carried out as follows:

1. The concrete ramp surface was waterproofed in the usual manner;
2. A base course of asphaltic concrete 1½ in. thick was laid and rolled;
3. The heating elements were placed on this base course and all necessary feeder cables were connected;
4. A wearing surface course of asphaltic concrete 1½ in. thick was laid on top of the heating elements;
5. Thermocouples and other measuring instruments were installed at various levels and locations in the pavement to determine amperages, temperature gradients through the section of the deck, etc.

Figure 2. Test installation.

Figure 3 shows a plan and cross-section of the first installation.

A transformer station to supply power to these elements was installed under the main elevated structure adjacent to the two ramps. The transformer station stepped down the voltage from 13,800 to 4160/2400 and power was carried at 2,400 v to heating transformers hung at the top of the ramp piers and just underneath the road deck.

The heating transformers were rated at 100 kva and stepped down from 2,400 v to 20 and 30 v. Short cable connections were run from the heating transformers through a sleeve in the roaddeck to the bus bars of the heating elements. The heating transformers were equipped with ten taps to give secondary voltages of from 20 to 30 v at 1-volt intervals. These taps were provided to allow variation of the watts per square foot on different elements and to compensate for varying lengths of heating elements between the expansion joints in the road deck.

The main power transformer was provided with a special tap on the low voltage side to give 1,620 v which when used would cut the watts per square foot of the heating installation by approximately one-half. The load at this lower voltage is referred to as the base load, and the load at the higher voltage as the snow load.

Two electrically operated oil switches were installed in the transformer station inclosure to switch the heating installation to base load, snow load, and off. A thermostat controlled the operation of the switch for the base load and was set to turn it on when the air temperature dropped below 38 F.

Operation of Initial Test

This installation was tested from Dec. 29, 1961, to March 19, 1962. Instrumentation of the test consisted of recording continuously the temperature of 24 different locations in the asphalt and concrete road deck, recording the voltage fluctuation by a recording voltmeter connected to one of the elements, and recording periodic readings

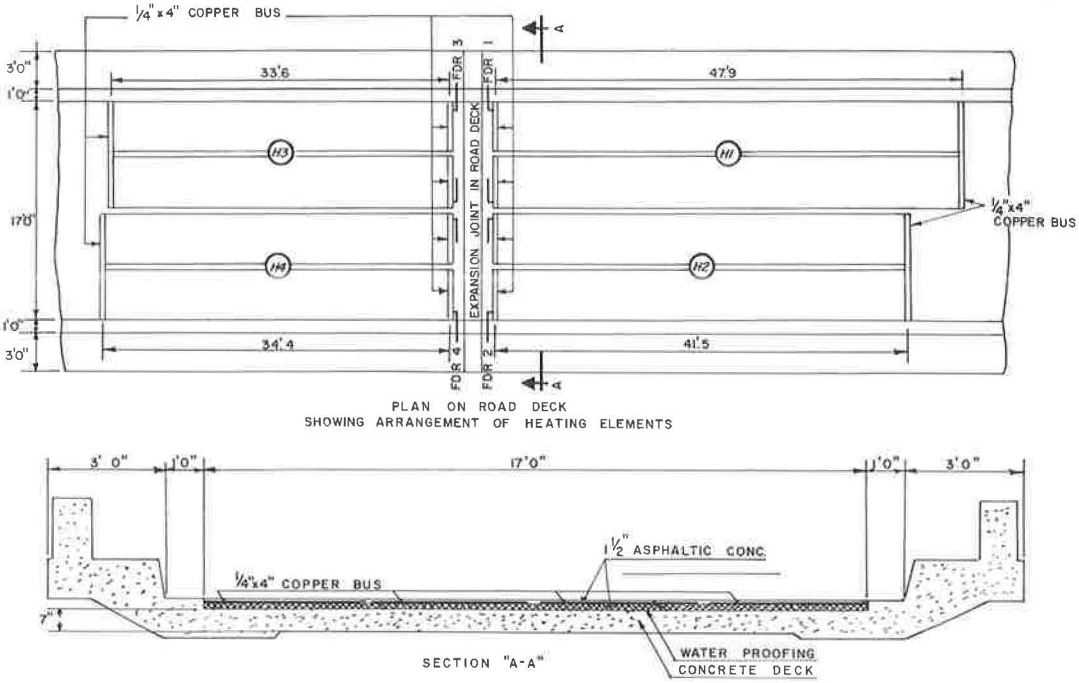

Figure 3. Plan and cross-section of first test installation showing arrangement of heating elements.

TABLE 1

DATA FROM INITIAL TESTS

Heating Element	Mesh		Length (ft)	Area (sq ft)	Resistance (ohms)	Appl. Voltage	Current (amp)	Power (kw)	Power Factor	Watts/Sq Ft
	Wire Gage	Spacing (in.)								
H1	No. 8	6 × 6	47.9	407	0.0335	30.9	643	18.48	0.931	45.5
H2	No. 8	6 × 6	41.5	353	0.0290	31.2	740	21.6	0.938	61.4
In series:										
H3	No. 8	6 × 6	33.6	286	0.0235	15.1	451	6.13	0.896	19.5
H4	No. 10	4 × 4	34.4	293	0.0253	14.7	451	6.09	0.918	20.8
In parallel:										
H3	No. 8	6 × 6	33.6	286	0.0235	28.1	926	23.2	0.889	81.0
H4	No. 10	4 × 4	34.4	293	0.0253	29.6	971	26.8	0.932	91.5

of voltage, current and wattage to determine the impedance and power factor. Some of the test data are given in Tables 1 and 2.

As expected, the higher rated elements were more effective during snow, as also was reduced mesh spacing. Due to the exposed nature of the elevated structure, it was found that wind has a considerable effect on the surface temperature of the deck. A relatively high wind at low ambient temperatures resulted in much lower deck temperatures as compared with those with a negligible wind.

To determine the effect of power cutoff under fault or peak load control conditions, a series of tests was carried out for various periods of time without power. Power was cut off for $\frac{1}{2}$-, 1- and 2-hr periods and resulting temperature drops were recorded. It was found that both high and low heats could be cut off for periods up to 1 hr during peak loads on the Hydro-Electric System, without great loss of melting capacity (Fig. 4).

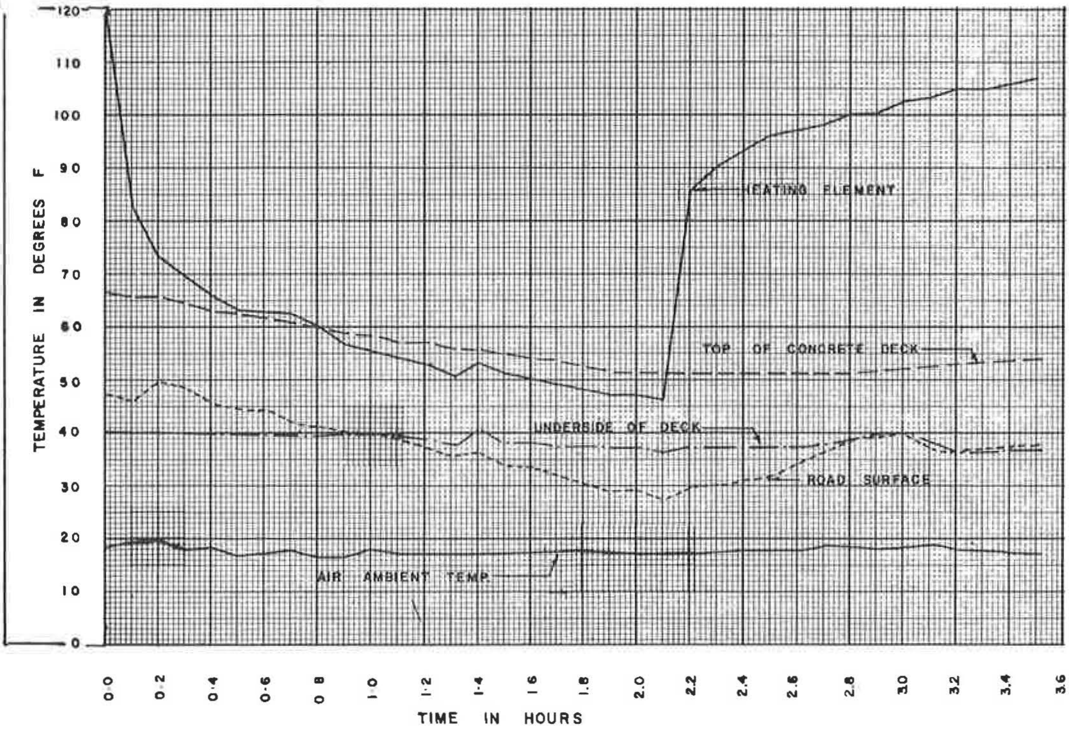

Figure 4. Curve showing temperature during 2-hr power cut-off, Element H1.

TABLE 2

HEAT LOSS FROM UNDERSIDE OF DECK

Element	Ambient Air Temp. (°F)	Heat Loss to Underside of Deck (%)
H1	5	16.35
H2	5	14.18
H3	5	19.10
H4	5	18.30
H1	34.5	15.70
H3	34.5	19.50
H4	34.5	19.70

Figure 5 shows the temperature gradients measured vertically through the road deck for the ambient air temperature shown. The results indicate there is quite a considerable heat loss from both the upper and underside of the deck. The loss from the underside, of course, does no useful work during snow, whereas both contribute to the cost of the power during the time the elements are energized. This suggested the use of insulation on the underside of the slab which has not yet been tried in this experiment.

The time required to increase the road deck temperature is shown in Figure 6. It will be seen that with an ambient air temperature of approximately 8 F about 2 hr were required to raise the temperature of the pavement surface from 15 to 40 F, the temperature at which snow melts readily.

PHASE II

The results during the winter of 1961-1962 of the initial installation previously described were encouraging enough to enlarge the experimental area by paving and equipping the whole of the on-ramp, approximately 782 ft long by 17 ft wide, and all the off-ramp, 995 ft by 17 ft, at Spadina Ave. the following summer. Figure 7 shows the test elements in service on a cold day during the winter of 1961-1962.

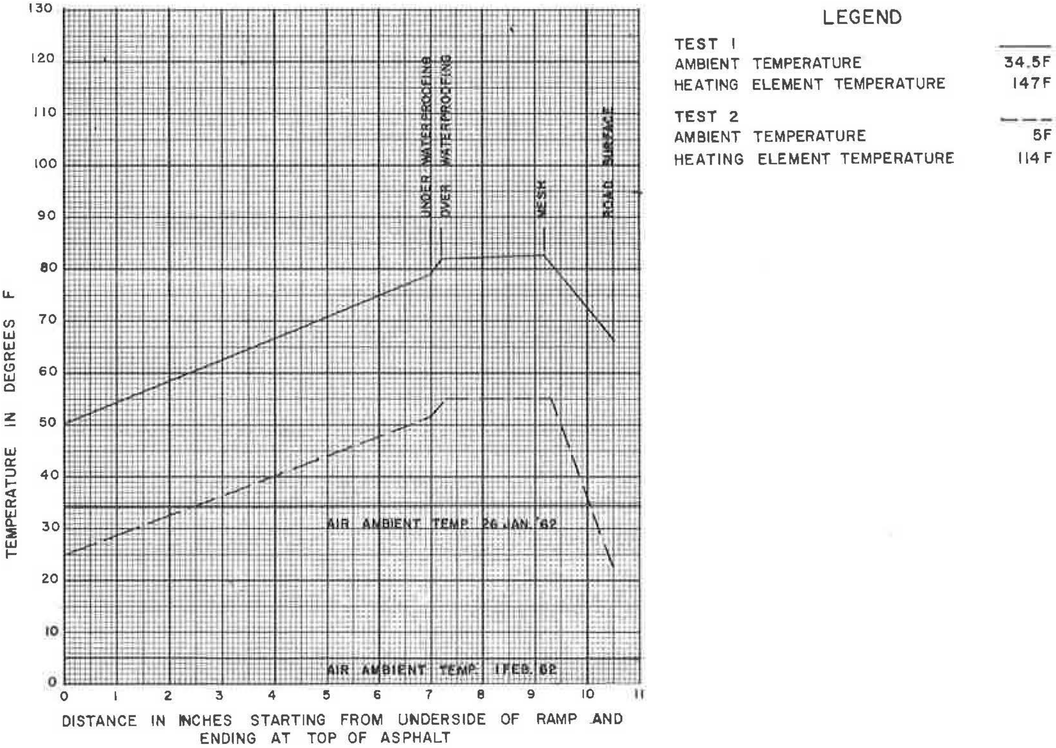

Figure 5. Temperature gradient through road deck, element H1.

During the winter of 1962-1963 the whole of the on-ramp and a 65-ft section of the off-ramp were energized and operating under traffic conditions. In this second phase of the installation, changes were made in the asphalt mixes, types of wire mesh, and in the techniques of construction used. These variations were made from lessons learned in the first phase on the 65-ft section of the on-ramp as mentioned above.

During the first phase it was learned, for example, that the asphaltic concrete covering the mesh was not strong enough in some places to hold down the heating element. This was due to the springiness of the steel and to heat softening the asphalt. The wire mesh popped out in some areas and had to be recovered by patching.

To prevent popping, smaller gage wire mesh (No. 10 instead of No. 8) with wires more closely spaced was used. The closer spacing of wires also gave more uniform heat to the pavement surface. All of the on-ramp was equipped with No. 10 gage galvanized wire mesh with 2- by 2-in. spacings and all of the off-ramp with No. 10 bare iron wire mesh having longitudinal wires spaced at 2 in. and lateral wires at 6 in. Since iron wire is softer and less springy than galvanized wire, it is less liable to pop. To further insure against popping, wire mesh in the off-ramp was embedded in mastic asphalt instead of asphaltic concrete. Mastic asphalt has a higher melting point and much greater holding power than asphaltic concrete.

Asphaltic concrete is hot-laid plant-mixed pavement composed of 5 to 7 percent residual asphalt mixed with graded aggregates. Mastic asphalt is a mixture of Trinidad natural asphalt, residual asphalt and fine aggregates hot mixed in special paddle machines. Abbreviated specifications for both are included in the Appendix.

There was also some trouble with bus-bar plates. When the traffic went over them they moved and broke up the pavement. To prevent this they either had to be securely anchored into the concrete deck without touching the reinforcing steel or they had to be embedded into mastic asphalt. The use of mastic asphalt was adopted. A typical rec-

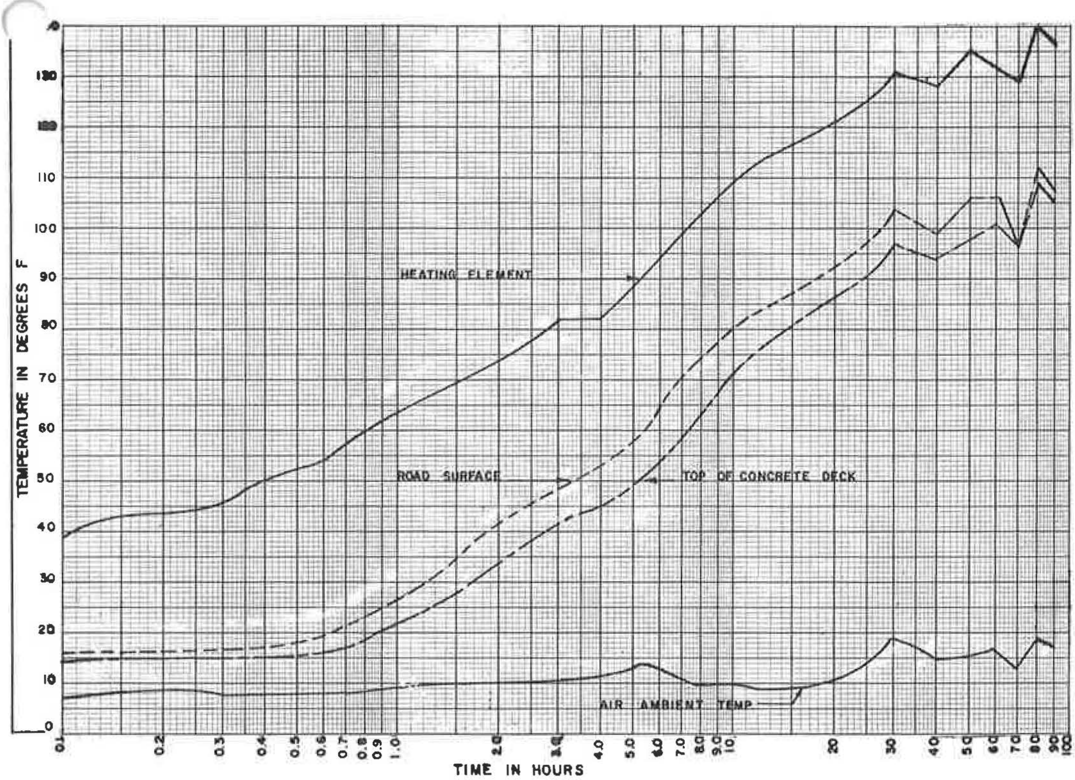

Figure 6. Temperature rise in road deck, Element H4.

commended cross-section is shown in Figure 8. Figure 9 shows a picture of Phase II installation using mastic asphalt.

During this phase a snow detection unit was installed to automatically turn on and off the snow load. It is located in the transformer station with the snow detector heads mounted on the expressway structure above. The snow detector turns the snow load on when snow begins to fall if the air temperature is below 38 F and turns the load off when snow stops.

PHASE III

Final Installation

The final test made during the winter of 1963-1964 consisted of energizing and operating all of the on- and off-ramps at Spadina Ave. Installation was as described in Phase II. The initial installation included ten heating transformers. Nine more were added to provide enough capacity for the whole area of the two ramps. The high-voltage power transformer installed in Phase I had sufficient capacity (1, 500 kva) and required no enlargement.

In addition, a relay was provided in the oil switch control unit to allow Toronto Hydro-Electric System to connect in their peak load control circuit, which is an overriding control and allows them to shut off both base and snow melting loads as required. This peak load control was connected so that it could be remotely operated from the Toronto Hydro-Control Centre, which is manned 24 hr a day, 7 days a week.

GENERAL OPERATION OF EXPERIMENT

During the winter of 1962-1963 the total recorded snowfall in the Toronto area was only 35 in., as compared with the average of 55 in. for this area. In addition, there

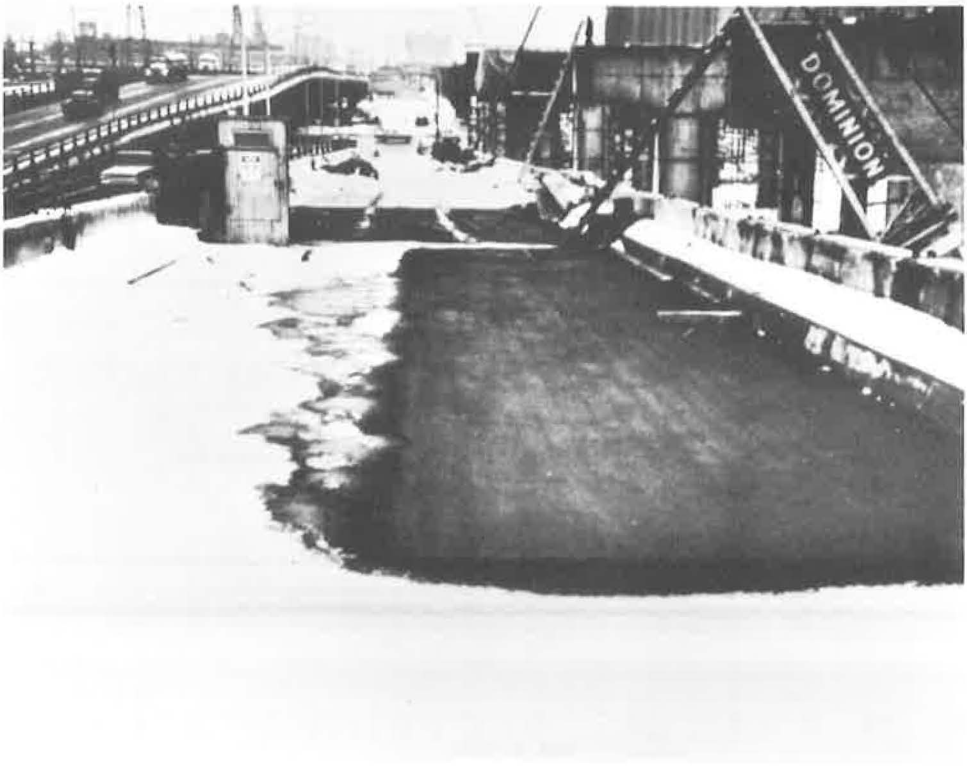

Figure 7. Test elements in service on a cold day during winter of 1961-1962, showin elements H1, H3, and H4 energized and snow lying on area of element H2 which was no energized at the time.

were no heavy snowfalls or snowfalls of prolonged duration experienced during that winter. However, it was possible to determine that a minimum of 30 w/sq ft total snow melting load is required to keep the ramps safe for traffic and that at the entrance to each ramp it was desirable to have at least 40 w/sq ft melting load applied to the road surface to take care of snow carried over by cars entering the ramps.

After examining the test results of a full-scale installation during a complete winter's operation which gave a more accurate assessment of the power consumption, it was found that some power savings could be made by arranging to turn off the base load during fine weather. Although the base load wattage is approximately equal to snow load wattage, in an average winter the base load, used continuously, would be in operation between 15 and 20 times longer than the snow load which is on only during a snowfall. Under such conditions, base load power consumption in kilowatt-hours is as high as 20 times that of the snow load. For example, for a 65- by 17-ft area of the ramp, base load power consumption for 121 days was 53,800 kw-hr and the snow load was 3,210 kw-hr. Therefore, any effort toward reducing the base load which will not result in increasing the peak demand can reduce operating costs tremendously. This effort alone, in the winter of 1963-1964, resulted in reducing power costs from $0.45 to $0.32/sq ft of heated surface. There is no doubt that further substantial reductions can be made by judicial use of weather forecasts, particularly if the Hydro-Electric System's present demand rate, which does not seem to be justified, is eliminated.

Another factor considered in further reducing power costs is installation of rigid insulation over the underside surface of the road slab to prevent heat losses. This would cost approximately $0.20/sq ft of slab. So far it has not been used in this experiment.

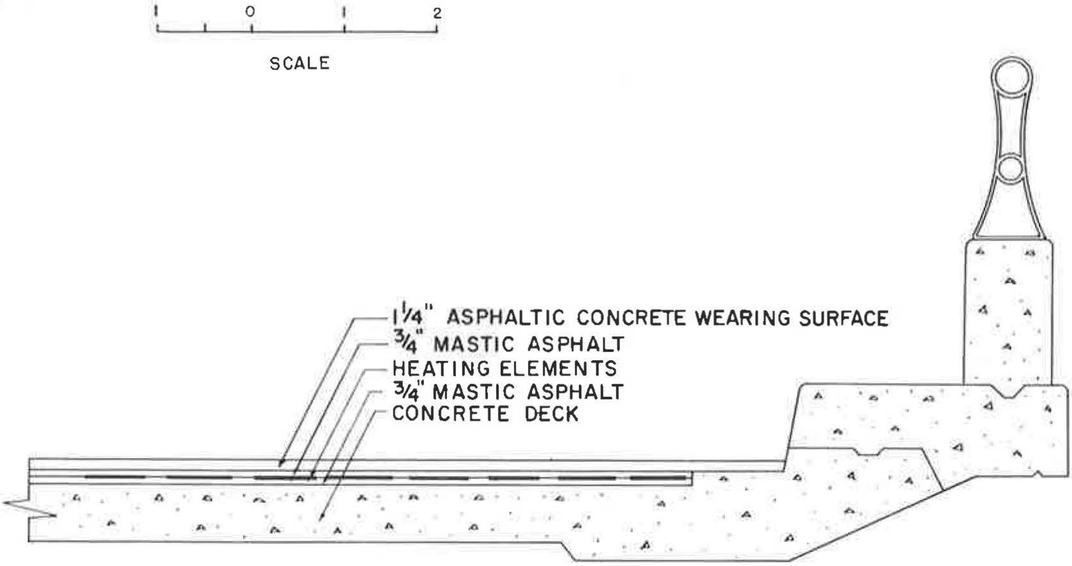

Figure 8. Typical cross-section, test installation of electric heating on ramps using mastic asphalt.

The ramp heating total installation, Phase III, lasted for 153 days, commencing on Nov. 22, 1963, and ceasing on April 22, 1964. During that period snowfalls varying from a trace to 9 in. fell on 96 separate occasions in 61 days. Peak ad cutoff affected snow melting on 29 occasions. The actual snowfall during this period was 51.7 in. There were no particular difficulties with melting the snow and, from this point of view, the installation has been successful. However, the cost of operating the system has, as expected, been fairly high.

There is no doubt that the system works. The heated ramps were much safer for traffic. Figure 7 shows clearly that energized areas are clear of snow and ice. Figure 10 shows the driving surface quite free of ice or snow during a storm in the winter of 1963-1964 when the snowfall was 9 in. in a few hours. Actually during this storm the temperature was low enouth to prevent road salt from melting the snow on other sections of the Expressway. In cases of heavy snowfalls, accompanied by unusually low temperatures where salt alone will not melt the snow, it was found that salt with even a little heat from the heating elements will do the job. This may be of particular significance in northern regions where temperatures are very low during snow storms.

Melt water has never been a problem. Most of the time it evaporates as soon as the snow hits the pavement. Only during very heavy snow storms has some water been seen to collect into the gutters and run down to the catch basin or to the foot of the ramp where the area is salted.

ELECTRIC POWER COSTS

Electrical rates used during the experiment were as follows:

1. Demand charge—$1.38/kw/mo of billing demand; and
2. Energy charge—$0.021/kw-hr for the equivalent of the first 50-hr monthly use of the billing demand, $0.014/kw-hr for the equivalent of the next 50-hr monthly use of the billing demand, and $0.038/kw-hr for the remaining consumption.

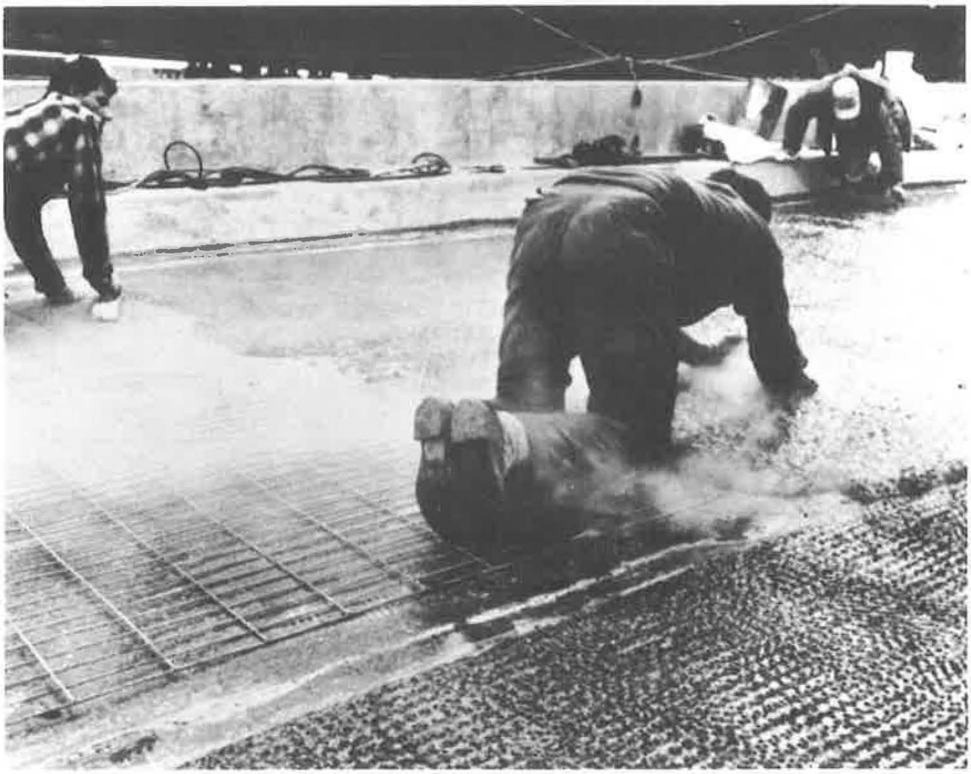

Figure 9. Laying of mastic asphalt with lower right hand area prepared for installation of wire mesh heating elements.

There were discounts of 10 percent for taking a 13.2-kv supply and carrying out our own transformation, 15 percent for the supply being subject to the System's off-peak control, and a 10 percent prompt payment discount.

FACTORS AFFECTING ECONOMY OF OPERATION

As in all heating installations there are a number of factors affecting costs. For conventional heating systems, such as in buildings, these factors are fairly well recognized, but in snow melting systems there is a very little such information available. Therefore, it is thought worthwhile to discuss some of the more important factors here and to make some suggestions for dealing with them.

The following appear to merit the most careful consideration:

1. Proper design and construction;
2. Power demand and power rate structure;
3. Weather and weather forecasts;
4. Ambient air temperature;
5. Slab heating time;
6. Slab cooling time; and
7. Careful operation by trained personnel.

Many factors dealing with design and construction of snow melting systems have already been dealt with in the paper, including type of heating element, its distance below the surface of pavement, the embedment material and insulation.

It can very easily be shown that, if the electrical rate structure includes a demand charge, this can be the most costly of all the items being considered. This is not new, of course; every industrialist knows the value of keeping his demand down, and

gure 10. Heated ramp during heavy snow storm in winter of 1963-1964 showing perimental area, Phase II (off-ramp) complete melting of snow in heated area; filled approach road, where no heating elements installed, kept free of ice due to heat dragged by tires from heated area.

there are many ways of achieving this. To illustrate its importance in this experiment, the cost of operation under 1963-1964 conditions is estimated on three peak demand bases, full load (1,100 kw), half load (550 kw) and one-fifth load (220 kw). The annual costs based on our existing rates for power would be \$0.50, \$0.26 and \$0.141/sq ft of heated ramp surface, respectively.

There is obviously an incentive to reduce the peak demand or alternatively renegotiate a new rate structure without a penalizing demand charge. Due to the heat storage capacity of the slab, the use of an off-peak power rate for this purpose is possible. For example, assuming power rates of 10, 8 and 6 mills, ramp heating costs would be \$0.27, \$0.21 and \$0.16/sq ft, respectively. If suitable rates cannot be negotiated, demand limitors should be installed.

The third factor, weather, we cannot alter, but we can do something about reducing the unnecessary use of power to keep the surface warm when there is no likelihood of snow. This can be achieved by careful collection and interpretation of all available weather forecast information as indicated previously.

Concrete slabs are slow to heat and weather forecasts are not completely reliable; therefore, these points must be kept in mind to avoid inadequate heat in the slab when it is needed. Therefore, a two-heat level system is provided, the base load heat and the snow melting heat. The slab can be kept at a sufficient temperature in anticipation of snow by means of the base load; slab temperature can be increased as weather conditions dictate by the use of the snow load which is controlled automatically by snow and temperature conditions.

Concrete slabs are slow to lose heat. Advantage can be taken of this flywheel effec by reducing the power or by cutting it off altogether for a limited period up to 2 hr, depending on ambient temperatures to obtain low off-peak hourly rates. The heat inertia of the ramps is probably the greatest single operational factor in economics of snow melting. This heat inertia could be increased by insulating the underside of the slab. It should be possible to ascertain in advance the time required to bring up the slab temperature and with accurate weather forecasts, adequate time usually could be provided to heat the slab. The charts included in this paper illustrate this.

To effect the maximum reduction in kilowatt-hours, the lowest ambient temperature at which the thermostat controlling base load operation can be set to give adequate time for the snow melting load to be effective, without increasing the peak demand, should be established.

Careful operation with properly trained personnel is of paramount importance to correlate all available information on weather forecasts, ambient temperatures, slab temperatures, rates of heating and cooling of the slab and to decide on the amount of power required and time when it should be turned on and off. Actually this is not too difficult after a short training period and the operation becomes more efficient as experience is gained.

COSTS

General costs per square foot of a typical installation using approximate figures are as follows:

1. Installation using asphaltic concrete as embedment medium and including the wire mesh, bus-bar plates, etc., as shown in Figure 3, but not including electrical = $0.90
2. Using mastic asphalt as an embedment medium as shown in Figures 8 and 9 = $1.50
3. Electrical costs including transformers, switch-gear, wiring, installation, etc. = $1.90
4. Total overall costs using asphaltic concrete as embedment medium = $2.80
5. Total overall costs using mastic asphalt as embedment medium = $3.40

FINAL RESULTS AND CONCLUSIONS

The early tests and the operation of a full-scale system over the winters of 1962-1963 and 1963-1964 have shown the efficiency of this form of snow removal for road surfaces. The control of the snow melting system, its coordination with the available power source, the power costs, and the monitoring of the complete operation have shortcomings and limitations in this particular installation which can be improved.

Metal wire mesh used in this experiment has proven to be a good heating element. Its advantages include safety of low voltage and low capital cost. In addition, it acts as reinforcement to the pavement when and if it is not used as heating element and it continues to carry current in case of accidental breaks in longitudinal wires by the flow path provided by the lateral wires.

Mastic asphalt or an equivalent material with strong holding power and long life is required for embedment of the wire mesh.

The estimation of operating costs is difficult, subject as this is to the vagaries of the weather and other conditions which cannot be predicted with any accuracy. Close control of all other variables will, however, keep costs reasonably low and not as far different from the cost of conventional sanding and salting while having the advantage of greater availability of the heated road surface.

A penalizing maximum demand rate structure will always be a problem for road heating by electricity. If the utility concerned insists on imposing it, its cost can and should be reduced by the provision in the heating circuit of suitable load demand reducers.

It is hoped that the time and effort which have been put into this installation will not go unrewarded, and that the decisions and changes which are being made will result in more effective use of the power with consequent reduction in operating costs, coupled with greater reliability and availability.

In conclusion it may be said that with proper design, construction, operation and suitable power rates, this system of melting snow and ice by electricity can become very popular and useful if applied judiciously.

Appendix

SPECIFICATIONS

Hot-Laid Asphalt Wearing Course, Type H.L.-1

Type H.L.-1 surface course consists of crushed traprock, sand and mineral filler uniformly mixed with asphalt cement. The pavement mixture contains 5.0 to 7.0 percent by weight of asphalt cement conforming to Specification Designation 85/100 penetration. The coarse aggregate consists of crushed traprock or gravel having strong uncoated particles of uniform quality throughout. Fine aggregate consists of sand or screenings composed of clean hard durable particles free from clay, loam, shale, cementation or other objectionable material.

Grading requirements for coarse aggregate, fine aggregate and the mixtures are given in Table 3.

Mineral filler consists of thoroughly dry limestone or other mineral dust which, when tested by means of Tyler sieves, meets the following requirements:

Passing No. 28 mesh sieve, 100 percent; and
Passing No. 200 mesh sieve, not less than 80 percent.

Hot Mastic Asphalt Paving for Electrically Heated Roadways

The hot mastic asphalt used on ramps is a blend of natural Trinidad Lake asphalt and residual refined asphalts. To this is added limestone flour, ¼-in. granite chips, and sometimes a small amount of concrete sand.

The matrix or asphaltic cement is blended as follows:

Trinidad Lake asphalt, 50 percent; and
Residual asphalt 60/70 penetration, 50 percent (penetration at 25 C = 23).

Wherever possible, Venezuelan grade of residual asphalt is recommended. The proportion of natural lake asphalt may vary according to climatic conditions or type of heating used.

The proportions of the total mix generally fall close to the following specifications:

Asphalt cement	16.5 percent
Limestone dust	43.5 percent
¼-in. traprock	40.0 percent
Total	100.0 percent

TABLE 3

GRADATION REQUIREMENTS

Material	Passing Sieve (% by dry wt)[a]									
	½ In.	⅜ In.	¼ In.	No. 4	No. 8	No. 14	No. 28	No. 48	No. 100	No. 200
Coarse agg.	≥ 100	50-70	20-35	≤ 10	-	-	-	-	-	-
Fine agg.	100	100	100	95-100	85-100	55-90	35-70	15-40	5-15	0-7
Mixture	100	72-88	56-74	45-60	36-60	25-55	16-43	7-24	2-9	0-4

[a] Tested by Tyler sieve, square openings.

The hardness index figure should read between 40 and 60 at 25 C/100 kg when tested in accordance with Canadian Government Specification Board, Specification No. 56-GP-6, 4.2.3.

It should be noted that only 54 percent of natural lake asphalt is actually bitumen. Therefore, an asphalt cement content yields only 12.70 percent asphalt content.

The limestone dust used in mastic asphalt paving must be a high-grade calcium carbonate (see Metropolitan Toronto Roads Department Specification No. MT.750-02-d).

The mastic asphalt should be mixed in properly designated, mechanically agitated mastic mixers, the blades of which should never be allowed to wear down and allow more than 1/4 in. between stirrer tip and mixer side. Failure to observe this factor accounts for most of the poor mastic laid.