

SNOW AND VERMONT'S HIGHWAY SYSTEM

By Byron Blanchard¹ and Sheldon Miller²

In Vermont, as in most of the Northeast, each year there comes a day toward the end of October when the wind, with an unpleasant edge, whips a sullen low overcast along the crests of the hardwood ridges. From this ominous sky, with a soft sibilant sound, the first few crystals of snow sift downward to rasp on the dead leaves and grass, or perish as spots of moisture on the fast waning warmth of street or sidewalk. With the appearance of these harbingers of the long cold season ahead, two events occur.

The winter sports enthusiasts and fuel salesmen cheer exultantly. But those poor souls, the motorists, to whom each flake pertends constant hardship till the Ides of March, utter an anguished moan and fervent prayer that nature restrain her bounty in at least this one respect.

Today these souls may take some heart from the efforts expended in their behalf by Vermont's Highway Department, not only by maintaining a system of highways as free from ice and snow as possible, but also by building roadways that take advantage of natural phenomena to minimize the maintenance required.

In this last respect, Vermont's Department of Highways does not lay claim to an extensive or original program of highway design strictly from the standpoint of reducing winter maintenance. There are too many other design problems which must receive consideration. Rather, there is a growing consciousness that frequently what constitutes good design practice for some other reason is also good for snow removal, or may be made so by some minor modification.

There are several cases in point. Normally a roadway on shallow fill, that is, about five feet in depth, represents the optimum section for highway design. Such a condition drains well, provides a stable foundation on the original ground and is economical to build. It also has the advantage of elevating the pavement into the untempered sweep of the wind. This not only encourages much of the falling powder snow to be blown off the surface, but exposes the remaining packed or plowed snow to the continual erosive and evaporative effects of the wind.

1. District Highway Engineer, Vermont State Department of Highways.
2. Engineer, Vermont State Department of Highways.

Snow drifts result from a decrease in wind velocity and occur in much the same manner as sedimentation in a stream. Observations by Department personnel indicate that slopes of one on four or flatter cause less change in wind velocity and consequently have less tendency to cause deposition or drift formation than steeper slopes. For this reason roadways in shallow excavation or fill are built with these flatter slopes whenever feasible. Even considerable cuts, normally excavated to a one-on-two slope, may have slopes flattened if the extra earth material can be utilized elsewhere on the project and the cost of additional right-of-way is not prohibitive. This treatment has the added benefit of allowing the sun's rays, even with their lowered incidence during the winter, to reach parts of a highway that would otherwise be in shadow from the steeper slopes. Flatter slopes also are aesthetically more pleasing and provide greater vehicle safety during emergency use.

The dry, lightweight powder snows which fall during periods of comparatively low temperatures are more susceptible to these general practices than the heavy wet snows associated with temperatures near the freezing mark.

Snow that is removed from the roadway by plowing can continue to be a problem as it builds up in windrows along the roadside. Here it interferes with sight distance and on the high side of banked curves it can be a source of daytime melt which runs across the pavement and causes a hazardous condition when it freezes after sundown.

Again, the fill section allows the snow to be plowed entirely clear of the roadway, largely eliminating the snowbanks. In a cut section the flattening of side slopes provides a wider ditch in which the snow may be piled. In deep rock cuts which normally have a 4 on 1, or nearly vertical face, the ditch may be deliberately widened to about 8 feet to provide room for plowed snow and to prevent loose material on the ledge face from falling into the roadway. On the high side of banked curves a two-foot wide reverse slope is designed to conduct melt away from the pavement.

Landscaping now plays a part in keeping highways clear in the winter with the planting of evergreens as permanent living snow fences in some locations. These trees are planted in staggered rows about 100 feet from the roadway on the side toward the prevailing wind. The height, density, and spacing of the plantings all play a part in the size and shape of the drift formed. Mr. W. Gordon Hunter, Landscape Architect for the Maine State Highway Department describes the width of drifts as 15 to 20 times the barrier height. This fact reflects the need for an abnormally wide right-of-way when drift control by this method is desired.

The problem of route location itself frequently includes consideration of the desirability of being on southerly slopes to take advantage of as much exposure to the sun as possible.

Perhaps the most recent and novel experiment by the Department amounts to putting long winter underwear on bridges. Currently bridge decks have, because of their complete exposure, a decided tendency to cool much more quickly than the adjoining sections of highway. With air temperatures at or slightly below freezing, snow can accumulate or icing occur several hours sooner on a bridge than on the rest of a road. This creates an exceedingly hazardous condition which might not be rectified until the roadway itself required the attention of the maintenance crew.

To alleviate this condition, the underside of several spans of the dual roadway bridge carrying Interstate I 89 over the Winooski River in Montpelier have been sprayed with a polyurethane foam insulation 1/2 to 3/4 of an inch thick. It is intended that this insulation will retard heat loss from the bridge deck enough to keep driving conditions on the structure similar to those on the adjacent highway. The installation is instrumented with recording thermocouples both on the insulated and uninsulated sections for purposes of comparison. (It was hoped that a deck temperature retard of five or more degrees from the ambient air temperature would be obtained but apparently two degrees is about the maximum produced so far. Of course, in the few months that the installation has been operating, the meteorological conditions have only been significant a very few times. The spans over water, curiously, show a greater tendency to behave than those over land but again the difference is not great enough to be of importance yet.)

Although it's unlikely that even our cleverest efforts in improved design will soon eliminate the need for winter maintenance crews, it is a fact that modern highways are safer, more pleasant to drive, and more economical to maintain through the winter months, when adequate design consideration is given to the presence and behavior of snow.

WINTER MAINTENANCE OPERATIONS IN VERMONT

Winter maintenance of highways in Vermont also has advanced enormously since the days of the horse-drawn plow. No longer will Vermonters accept as a matter of fact the occasional suspension of highway traffic that winter storms used to bring. Instead, throughout the state, people expect the main roads, at least, to be completely passable at all times. Many an individual lives some distance from his place of work. Loss of time means loss of money. He demands bare pavements. Vermont's burgeoning ski industry, which brings needed cash to the state's economy, demands bare pavements. Even the citizen whose concern is convenience rather than cash or necessity demands bare pavements. These demands are being met with increasing efficiency by Vermont's Highway Department financed by appropriations from the State Legislature and using methods that are mostly uniform throughout the state.

For operational purposes the state is divided into twelve maintenance districts, each district having from 150 to 240 miles of state highways. All district operations are in charge of the District Highway Engineer. Next in line are an Assistant District Engineer, one General Foreman, and from three to four Highway Foremen. Under the foremen are patrolmen, highway maintenance men and laborers. All district personnel below the assistant engineer are permanent employees and paid on an hourly basis with no time-and-a-half for overtime.

A typical district is District Number 11 which borders on Canada from Alburg at the New York State Line, east to Richford. It comprises Franklin County and those islands in Lake Champlain which are known as Grand Isle County. There are 192 miles of state highway in this district.

The district office and main garage are located in St. Albans, while a sub-garage is maintained in the Village of Enosburg Falls.

The district snow equipment consists of 17 trucks, 3 graders and 5 frontend loaders. All trucks are equipped with one-way plows with attachments for automatic sanders and salters. Nine trucks and 3 graders are equipped with hydraulic wings.

Salt in bulk is stored in sheds whose total capacity is approximately 1300 tons. Sand mixed with salt is stockpiled in the open at strategic locations. Both salt and sand are loaded into trucks by means of front end loaders.

Each fall the District Engineer draws up a plowing, sanding and salting schedule in which each truck is assigned a specific section of highway for snow operations.

By November 1, all salt sheds are full, stockpiles of sand mixed with salt are ready, and most of the trucks are equipped with snowplow, sander, and salter attachments. Most of the automatic sanders and salters are operated by chain drive from a gear mounted on the hub of the rear wheel of the truck. This drive is engaged or disengaged by a lever in the truck cab, thus one man is able to drive the truck and to start and stop the flow of sand or salt as it is needed.

During November, maintenance crews erect approximately 15 miles of snowfence at locations where heavy drifting occurs. District 11 is frequently subject to high winds during the winter months, and the snowfence makes it easier to keep the roads open during the big storms.

In District 11, a night watch is set up and each man gets this duty approximately once in every ten days. It is his responsibility to alert the general foreman or in some cases to call out the crews directly when snow begins during the night.

When an inch of snow has accumulated, salt is applied in a small windrow along the center line of the pavement at a rate of 400 to 800 pounds per mile. The salt melts the snow and forms a brine that keeps the snow from packing and building up on the pavement. When the snowfall reaches 2 inches, trucks start plowing and continue as long as the storm lasts. When the storm lets up, more salt is applied to clear all the snow from the pavement. Trucks also spread sand on hills and curves while plowing to keep traffic moving.

When temperatures get down to 15° and below, it becomes necessary to mix chloride with the salt. The chloride absorbs moisture and gives off heat in melting which triggers the action of the salt and starts a brine within ten minutes. At this low temperature salt alone may not begin melting action for thirty to forty-five minutes.

During periods of snowfall accompanied by high winds, salting operations are suspended because salt will cause blowing snow to stick rather than blow off.

The use of a wing with a plow speeds up plowing operations as one round trip clears the full width of the pavement. After the storm the wing is used to push the snow off the shoulder to provide room for snow from the next storm.

Vermont's portion of the National System of Interstate Highways reflects the simplified winter maintenance resulting, in part, from improved highway designs. These dual highways represent twice as much roadway to maintain per mile compared to an ordinary highway, and they are maintained at a cost approximately twice that of a two-lane road.

Slightly different maintenance techniques are used such as:

1. Tandem plowing, one plow throwing right and one left or sometimes 2 throwing right and 1 left. This clears the entire pavement in one pass. Plows travel about thirty miles per hour.
2. Salt and chloride are applied by automatic spreader in a band eight to ten feet wide instead of being dumped in a narrow strip along the center line to be spread subsequently by two way traffic as is the practice on regular highways. Incidentally, lack of traffic in the passing lane to distribute the salt frequently necessitates an extra application.

These practices or modifications of them will be used on District 11's approximately 26 miles of Interstate Highway now under construction.

During the 1961-62 winter season the district used 3000 tons of salt, 100 tons of chloride, and 4000 cubic yards of sand. The total cost was \$138,000.00, an average of \$719.00 per mile.

The total quantities of material used in the state were 42,000 tons of salt, 1500 tons of chloride, and over 200,000 cubic yards of sand. The total cost for the state was approximately \$1,280,000.00 for state highways alone.

Including proportional allowances for city and village streets and other town highways, each inch of snow that falls on our state costs Vermont's citizens approximately \$85,000. In a state where annual snowfalls range between 55 and 120 inches, justification is easily found for studies in the control of snow.

Vermont is proud of its reputation for keeping its highways open during all types of winter storms and for maintaining bare pavement throughout the winter season. Most of the credit must go to the winter maintenance crews who often work the clock around without sleep during severe storms.

Undoubtedly, as the world's highway transportation continues to mushroom, new materials and techniques will be developed and applied until we approach the day when we may travel with as little regard for the elements in January as in June, and the October concern over those first flakes of the season will fade into the past along with the horse and snow roller.

"SNOW AND VERMONT'S HIGHWAY SYSTEM"

Discussion by George E. Kirk, Jr., Hydraulic Engineer
U. S. Bureau of Public Roads

The authors have presented a very informative paper on how the Vermont State Highway Department handles the problem of snow removal from highways, covering the aspects of design and techniques used.

Just how important is this aspect of snow and ice control from a dollar standpoint? Comparison of cost figures between states is a difficult matter because of variable conditions and the lack of uniformity in the items reported, but the minimum cost of snow and ice control was \$988 per mile among the states reporting to the Region One Office, U.S. Bureau of Public Roads, for the 1961-62 winter season. This figure is quoted not as an authoritative minimum which the State Highway Departments should strive to meet or be below, but to present to the Conference a concept of the immensity of this snow and ice control problem.

The importance of improved snow removal resulting from good design practices is being recognized in such publications as the American Association of State Highway Officials', termed AASHO, "Landscape Design Guide Standards" prepared by the Committee on Roadside Development. Their preliminary draft contains several references to improved snow and ice control through increased width of median to reduce snow drifting, planting to retard snow drifting (mentioned in the paper), and selective thinning to reduce shade-induced icing hazards on the roadway.

The paper mentions that snow and ice control on the Interstate highways with twice as much roadway will cost approximately twice that of a two-lane road. If the Interstate is maintained to a comparable degree of the two-lane road, we would expect the cost to be materially less than double the two-lane road. This would be due to the flatter grades, wider shoulders, and greater ditch capacity for storing snow. Snow removal equipment travels faster on the Interstate. The faster speeds clean more mileage and tends to throw snow farther out of the way. The faster speeds and more rapid cleaning also reduce packing by traffic. The wider shoulders also help prevent snow melt from flowing back onto the pavement and becoming an ice hazard.

The paper gave us totals of salts and abrasives used in Vermont during the 1961-62 winter season: 42,000 tons of salt (meaning sodium chloride), 1500 tons of chloride (meaning calcium chloride), and 200,000 c. yds. of sand. It would be interesting to know the trend of these totals; that is, are they tending to increase stabilize, or decrease for comparable conditions.

A report from Cass County, Michigan, indicates that costs might be decreased through application of a sodium chloride-calcium chloride mixture at about a 3 to 1 ratio. Of course, some State Highway Departments prefer not to use calcium chloride unless extremely low temperatures dictate its use. The reason is that calcium chloride, besides being more expensive than salt, is deliquescent and maintains a wet condition until completely dissolved, whereas sodium chloride will recrystallize and blow away after the snow is melted.

Although not mentioned in the paper, most State Highway Departments find radio communication indispensable to the operation of snow removal. Through the use of radio control, one man can efficiently inspect and dispatch men and equipment in his section of concern to the most critical areas. This eliminates unnecessary travel by the larger and slower moving equipment. It also allows one section to aid another more severely hit section through contact of the respective men in charge. It further allows a greater flexibility through radio contact with State Police.

The authors comment on the field testing of underside of bridges insulation as a means of retarding the rapid heat loss from the structures during falling temperatures. If successful, the material will eliminate the hazard of premature icing of bridge decks compared to the approach roads as well as reduce the number of freeze-thaw cycles. This in turn will increase the life of the deck material, particularly concrete, not only from the lesser freeze-thaw cycles, but the accompanying reduction in use of ice control salts.

The importance of the overall problem of snow and ice removal has been given high priority by the recently organized National Cooperative Highway Research Program. Of the six research problem areas presented to and accepted by the Board for the first year's program, area number 6 is "Study of Highway Structure Protection in Relation to the Removal of Snow and Ice from Structures." The insulation technique, mentioned in the paper, shows that research in this area is already underway.

The authors should be commended for presenting a stimulating and interesting paper which indicates a practical understanding of the problems involved in snow and ice control.

Discussion by J. V. Arpin, City of Montreal

On reading Messieurs Blanchard's and Miller's opening paragraph on Snow and Vermont's Highway System, I am sure that the Great Byron himself would not have produced more pleasing literature!

I insist that the men in charge of winter street maintenance in a large city where precipitation is heavy, be included in the group of poor souls that moan.

On highways, when good design takes advantage of wind action and snow disposal in cuts, the winter maintenance problem is one of equipment and its adequate use.

From a safety point of view, rural and urban roads must be kept to bare pavement with chlorides and abrasives playing the leading role.

Take a little more than one third of Vermont's Highways, tie them up in bows and you have a pattern of Montreal's streets. Throw-in over 375,000 cars, 1,400,000 people, sprinkle from four to fifteen inches of snow and try plowing at 30 miles an hour.

During a storm, in a large city, the two ogres: Traffic and Parking show their ugly heads and yell out loud: "Vous ne passerez pas" You shall not pass!

Unlike highways where the shoulders are free, city streets are lined with sidewalks having a strip of land between them and the curb, where poles, posts, trees and hydrants are planted to form a real stockade.

For efficient snow removal, it is essential that such trees and utilities be placed back of the sidewalk and it would be wise for street designers to keep this in mind.

On highways, parking is non-existent. On city streets, parking will increase snow removal costs by as much as 25%.

Montreal's 850 miles of streets represent one third of Vermont's highways and we use nine times its number of equipment.

During a heavy storm, we put to work approximately 2,700 pieces of equipment, not including the 1,000 trucks used for hauling snow. One third is City owned, another third is rented on an hourly basis and the balance is supplied by contractors who have three year contracts to plow the pavement only or to plow both pavement and sidewalks, to load and haul the snow.

Such an array of snow clearing equipment requires close supervision, clear operating schedules and most of all a constant watch with adequate means of communication. Flexibility is a must to take care of changing conditions.

Our most serious problem is no doubt snow disposal. Vacant land close to operations will soon be non-existent and our access to the St. Lawrence river is limited to two dumps. When the river freezes up, we must dump the snow on the wharfs and blow it onto the ice.

On our land dumps 70 heavy tractors push the snow into mountain like heaps which must be bulldozed in the spring to clear the view.

We have tried-out this winter two types of snow melters which have given a good show but their respective capacities of 75 and 125 tons are still far from the output of a snow blower (400 tons).

In an effort to keep the wharf edge clear of ice, we have tried-out some ice eroding equipment. Unfortunately, these machines arrived after the ice had set in and their full benefit could not be ascertained.

Both highway maintenance engineers and city street maintenance engineers must be dedicated men who constantly realize that the motorist is dependent upon them for road safety and comfort. This responsibility must be shared with the entire organization if each and everyone is to feel that he is part of a team.