AN EVALUATION OF THE USE OF LIQUID CALCIUM CHLORIDE TO IMPROVE DEICING AND SNOW REMOVAL

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ABSTRACT

The Iowa method of spraying liquid calcium chloride onto sodium chloride applied in snow and ice removal operations was evaluated on four sections of highway in the Staunton District. From the relatively sparse data accumulated over three winters, it was concluded that the slight advantage gained through use of the method was offset by the additional cost and trouble entailed. However, it was noted that the prewetted salt adhered to glare ice better than did the unwetted salt, and it is recommended that the mixing tanks used in the evaluation be left in place to supply liquid calcium chloride for use on salts applied to glare ice.

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INTRODUCTION

The Virginia Department of Highways and Transportation's bare pavement policy states that, in the event of snow, the Department will make every effort to provide a surface free of snow and ice on all interstate and arterial roads and many of the primary roads, so that traffic can proceed in safety without the use of chains except during periods of heavy falling snow or drifting. To adhere to this policy, road crews must begin work as soon as snow begins to fall and must apply salts to the roadway and plow the snow as needed. To accomplish this work the Department annually allocates about $14 million, with the understanding that if this fund is depleted additional money will be taken from other maintenance allocations. On the other hand, if the funds are not used in any given year, they are reallocated to other maintenance activities. Obviously, any reduction in the amount of chemicals used for snow and ice removal without a sacrifice in the level of service to the public would be of great benefit, since the funds saved could be redirected to maintenance of the state's roads.

Therefore, when it was learned that Iowa had in some cases been able to reduce its use of rock salt during snow by about 40% by spraying a solution of water and flake calcium chloride onto the salt just before it was applied to the roadway,[1] the Research Council, in conjunction with the Staunton District, initiated a program to determine if similar savings could be realized in Virginia.[2] In addition to the savings, Iowa reported a reduction in the time required for the salt to react with snow and ice, especially at very low temperatures.

OBJECTIVES

The specific objectives of the project were to determine—

1. if in Virginia the Iowa method would reduce the reaction time between salt and snow and ice; and

2. whether a significant reduction in the use of salt could be realized.

DESIGN OF EXPERIMENT

A pilot study was planned in which the liquid calcium chloride would be tried at four locations: Route 220 in Bath County, Route 64 in Alleghany County, Route 81 in Augusta County, and Route 64 on Afton Mountain in Augusta County. To mix the calcium chloride solution, 1,000-gallon fiberglass tanks with self-contained agitators were installed on the lots at the Department's Mint Springs, Fishersville, Covington, and Warm Springs Maintenance Area Headquarters. To apply the solution, four trucks were equipped with a small tank and pump and the necessary connections, valves, and spray nozzles mounted in a manner to assure a thorough coating on the rock salt as it left the conveyor belt.

Arrangements were made for two trucks to work each section of roadway included in the study; one to apply the wetted salt and the other to apply dry rock salt. The two trucks would work the section from opposite directions. The effects of the applications would then be compared and pertinent data recorded by inspectors from the Staunton District who were to be present each time the snow or ice removal operations were in progress.

Upon ordering the kits of tank, pump, valves, and nozzles for attachment to the trucks it was learned that the company which had supplied them had gone out of business. Therefore, the equipment had to be fabricated by the Staunton Shop. This, of course, required the equipment personnel to research what was needed and to determine sources of the components. The normal delays in back ordering were also experienced, and after a prototype was built adjustments in the design had to be made.

The first solution mixed was not satisfactory; the water used contained silt and the four pounds of calcium chloride per gallon added to it, as recommended by Iowa, would not stay in solution. Subsequent mixing with cleaner water and 2.5 pounds of calcium chloride per gallon of water worked quite well and was adopted as the solution to use in the experiment. The 2.5-pound solution had a freezing point of -10°F, which it was felt was satisfactory for use under the climatic conditions prevailing in Virginia.

DATA GATHERING

The winters of 1974-'75, '75-'76, and '76-'77 produced little snow in the test areas, even though the temperatures during the winter of 1976-77 were quite severe. The low incidence of snowstorms resulted in very sparse data.

The first data were recorded on February 2, 1975, on Interstate 81; additional data were obtained on February 4 for both I-64 on Afton Mountain and I-81; and on March 10 on Afton Mountain. Thus for the winter of 1974-75, data were collected on only four days.

Data were even less sparse in the winter of 1975-76, as there was input from only three operations: for December 21, 1975, on I-64 on Afton Mountain, and from both Afton Mountain and I-81 on March 9, 1976.

The winter of 1976-77 produced more data than were gotten from the previous two years, but still no great amount. Operations were conducted three times on each of the four sites. Thus data were obtained for only 19 operations, which is a very limited amount of data when the many variables associated with a snowstorm are considered. These variables include the temperature, chill factor, humidity, snow properties, and equipment operation.

FINDINGS

Table 1 summarizes the data collected by the inspectors. As can be seen there were only four storms during which the recorded temperature was below 20°F. A low temperature of 12°F was recorded during two storms and the next low temperature was 18°F. The mean temperature at the beginning of the storms was 25°F and at the end of the storms it was 24°F. With the spread of the data there are, of course, no significant differences in these two mean values. The temperatures recorded during this study are typical of temperatures during snowstorms in Virginia; i.e., the temperatures usually expected during snow are in the mid 20's. In addition, the humidity in Virginia is usually on the high side. The average relative humidities in Roanoke, which is the closest recording station to the test areas, for the months of November, December, January, February, and March were 68% for 1974-75; 58% for 1975-76; and 56% for 1976-77. The combination of a relatively high temperature and humidity is conducive to effective results when using sodium chloride for snow removal. The action of rock salt as a dissipater of snow would probably be greater by wetting at a lower temperature and relative humidity.

Twelve of the storms resulted in a snow accumulation of three inches or greater. The lightest snow was a quarter inch, while the deepest was ten inches. The storms ranged in length from less than two hours to twenty-four hours, with the mean length being between eleven and twelve hours.

TABLE 1

SUMMARY—LIQUID CALCIUM CHLORIDE EXPERIMENT

Date	Route	Temp. Deg. F Begin—End	Storm Length, hr.	Snow Depth, in.	Salt Rate With CaCl, #/mile	Salt Rate, #/L.Mile	Improved Results	Equip Malf.	Application Prior To Plowing, hr.
Winter of 1974-75 Augusta County									
2/2/75	81	29 -32	8.5	3.00			Equal		
2/4/75	64	22 -24	13.5	10.00	760	760	Equal	Yes	2.75
2/4/75	81	25 -22	13.5	8.00			Equal	Yes	2.25
3/10/75	64	24 -30	10	4.00	450	450	Yes		2.00
Winter of 1975-76 Augusta County									
12/21/75	64	26 -27	5.5	1.00	800	800			4.50
3/9/76	64	26 -20	21.5	9.00	533	533	Yes		3.00
3/9/76	81	26 -24	18	6.50	584	584	No		3.50
Winter of 1976-77 Augusta, Bath, Alleghany Counties									
11/11/76	64[a]	32 -26	24	8.00	500	500	Yes		2.50
12/26/76	220	29 -22	19	5.00	400	400	Yes	Yes	2.00
12/26/76	64[a]	20 -12	11	4.00	500	500	Equal		1.75
1/4/77	220	18 -12	3	1.00	400	400	Yes		No plowing
1/5/77	64[a]	30 -32	14	6.00	500	500	Equal		2.00
1/6/77	64	24 -21	8	2.00	500	700	No		1.75
1/6/77	81	24 -28	10	2.00	515	580	Equal		
1/9/77	220	26 -18	11.5	4.50	400	500	Equal		2.00
1/9/77	64	20 -18	10	3.00	350	700	Equal		2.00
1/9/77	81	20 -22	11	2.50[b]	450	450	No		2.25
1/24/77	64	28 -29	1.75	0.75	440	700	Equal		No plowing
1/24/77	81	26 -29	2	0.25	440		No	Yes	No plowing
MEAN		25 -24	11.4	4.20					2.40

[a] I-64 in Alleghany County near Covington

[b] plus freezing rain

On eleven occasions the amounts of salt used with and without calcium chloride were the same, while different quantities were used on three occasions. The records were not complete for the remaining three storms.

The data sheets indicated that the calcium chloride distributing system malfunctioned only four times, but in a meeting with the inspectors who recorded the data the authors were advised that malfunctions occurred much more frequently, and that the four occasions recorded were ones in which the equipment either stopped working altogether or was very difficult to repair.

The time between salt applications and plowing ranged from 1.75 hours to 4.50 hours, with the mean being 2.40 hours. On three occasions the snow was so light that plowing was not required.

The effectiveness of the liquid calcium chloride was determined subjectively; i.e., the inspector decided if the wetted salt melted ice or snow any better than did the untreated salt. Of the 19 operations observed, in 9 cases the two types of application were rated as equal; 4 times the salt treated with liquid was rated inferior; 5 times it was thought to have performed more effectively; and in 1 case the inspector did not evaluate the results. In only 5 cases was less of the prewetted as opposed to the untreated salt used. The results were rated equal in 4 of those cases, which would indicate a potential savings of salt by prewetting. If in these 4 cases it is considered that wetting the salt did provide an advantage, and this number of instances was added to the 5 cases in which the prewetted salt performed better when equal amounts of salt were used, then in 9 cases out of 19, or a little less than 50% of the cases, wetting of the salt provided better results. This finding is tempered by the fact that all of the inspectors reported that these advantages were slight and did not justify the trouble of providing the additional equipment required to wet the salt. It will also be recalled that the additional equipment frequently malfunctioned. In light of the above, it was the overwhelming consensus of everyone involved in the experiment that the slight advantage realized on some occasions did not justify adopting the prewetting scheme.

However, on several occasions when glare ice was present the maintenance crews noticed that the dry salt did not remain on the ice but bounced and rolled off the pavement onto the shoulder. They found if they wet the salt in the truck body with liquid calcium chloride it adhered to the ice quite well. Consequently the four maintenance areas that have the 1,000-gallon mixing tanks have asked that they be left in place for mixing the liquid calcium chloride for use on the salt applied to glare ice.

SUMMARY

The findings from the experiment are summarized below.

1. The equipment installed on the trucks to dispense the liquid calcium chloride malfunctioned frequently and required a great deal of maintenance at the very time continued use of the salt spreading trucks was critical.

2. About 50% of the time the wetted salt seemed to perform better than the nonwetted salt, but the advantage was slight and did not justify the added cost and trouble.

3. The humidity and temperature during Virginia snowstorms normally are high enough to ensure effective action when unwetted sodium chloride is applied to the roadway.

4. While the addition of liquid calcium chloride through the dispensers on the salt trucks was not found to provide an improvement in snow removal that would justify the adoption of such a system, the practice of wetting the salt in the truck body with liquid calcium chloride for use on glare ice was found to be feasible.

RECOMMENDATIONS

In light of the above findings, it is recommended that—

1. the use of liquid calcium chloride dispensing units on salt trucks not be adopted; and

2. the four 1,000-gallon mixing tanks be kept in use to mix liquid calcium chloride to wet sodium chloride in the truck bodies for treatment of glare ice.

REFERENCES

1. Huisman, Charles L., "Implementation Package for Use of Liquid Calcium Chloride to Improve Deicing and Snow Removal Operations," Federal Highway Administration, Washington, D. C., April 1973.

2. Creech, M. F., J. B. Dungan and D. C. Mahone, "Working Plan—An Evaluation of the Iowa Method for Use of Liquid Calcium Chloride in Deicing and Snow Removal," Virginia Highway Research Council, Charlottesville, Virginia, November 1973.