DEPARTMENT OF MAINTENANCE

Calcium Chloride-Salt Snow and Ice Control Test, Winter 1960-61

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The Connecticut State Highway Department, for many years has endeavored to maintain bare pavements throughout the winter. It is extremely difficult and in some areas impossible to accomplish the desired results using sand-salt mixture or salt alone.

A further consideration was the conservation of sand. In many areas of Connecticut, sand deposits have been depleted or zoned out of existence, resulting in the necessity of importing sand. The resulting increase in the cost of sand tends to make chemical control of snow and ice more attractive from an economic point of view.

The results obtained by the use of calcium chloride-salt mixtures on the New York Thruway were cited to gain permission to conduct a test of chemical control of snow and ice on a section of Conn. 15 in the towns of Willington, Ashford, and Union during the winter of 1960-61. This report covers the test in considerable detail.

As pointed out in the report, mechanical failures and unfamiliarity with procedures resulted in higher costs than would normally be expected. Nevertheless, the cost appears to be substantially the same as standard methods of snow and ice control.

• THE CONNECTICUT State Highway Department is constantly seeking to improve its techniques and methods in snow and ice control. The successful use of calcium chloride-salt mixtures by the New York Thruway Authority and the Massachusetts Department of Public Works prompted the Connecticut Highway Department to conduct controlled tests on a section of its highway system during the winter of 1960-1961.

In addition to improving service to the public, it is necessary to give serious consideration to the increasing cost of abrasives and their increasing scarcity. In many areas of the State, deposits of sand have been depleted or zoned out of existence.

LOCATION

The test section, on Conn. 15 (the Wilbur Cross Highway, a 4-lane divided highway) in the towns of Willington, Ashford, and Union, started at the east junction of US 44 and ran easterly to the Massachusetts State line, a distance equal to 27.8 mi of 2-lane road. The control section (also on Conn. 15) was in the towns of Tolland, Vernon, South Windsor,

and Manchester and started at the east junction of US 44 and extended westerly to the Tolland Turnpike overpass, a distance equal to 29.1 mi of 2-lane road.

The test section is considerably higher in elevation than the control section and contains more and longer grades. Because of the difference in elevation, temperatures are generally lower in the test section.

PROCEDURES

Storage facilities at the highway maintenance garage in the town of Union were limited. Two carloads of bulk flake calcium chloride were stored in a salt shed from which all salt had been removed. Two more carloads were piled on the ground and covered with sand and polyethylene sheeting. Figure 1 shows calcium chloride storage early in the season. Unfortunately, children living in the vicinity of the storage area punched holes in the covering and some dampening and lumping of the calcium chloride resulted.

All the salt was stored outside and covered with tarpaulins and polyethylene sheeting.

The general procedure was to have available enough of the calcium chloride-salt mixture for one storm, about 30 to 35 tons. Sometimes it was necessary to mix additional amounts during the storm.

The mixing was done at the storage area on a dry bituminous surface. A front-end loader was used. Two buckets of salt were put down, then a bucket of calcium chloride, then two more buckets of salt and another bucket of calcium chloride. This was then thoroughly mixed by the front-end loader. The process was repeated until the required amount of the mixture had been prepared. The material was stored on a bituminous surface at the storage area and covered with polyethylene sheeting until needed for storm use.

The front-end loader was used for loading the mixture into Good Roads spreaders. These spreaders can be easily installed or removed

Figure 1. Calcium chloride storage shed with surplus stored outside.

from a regular dump truck body. Normally they would remain on the truck during the winter season. Figure 2 shows the spreader being loaded.

At the end of the storm season what remained in the separate stockpiles of calcium chloride and salt was covered with sand and polyethylene sheeting. A recent inspection showed that the materials stood up very well. A slight crust had formed on both the calcium chloride and the salt but it crumbled easily on handling.

Figure 3 shows the calcium chloride storage shed buttoned up between storms after the outside storage pile had been used.

Except where otherwise indicated the test mixture proportions were one part calcium chloride to two parts salt by volume.

The rate of application of the calcium chloride-salt mixture varied from 400 to 1,200 lb per mi of 2-lane roadway with 800 lb being the rate most frequently used. The mixture was spread in the center of the traveled way except on banked curves where it was spread on the high side.

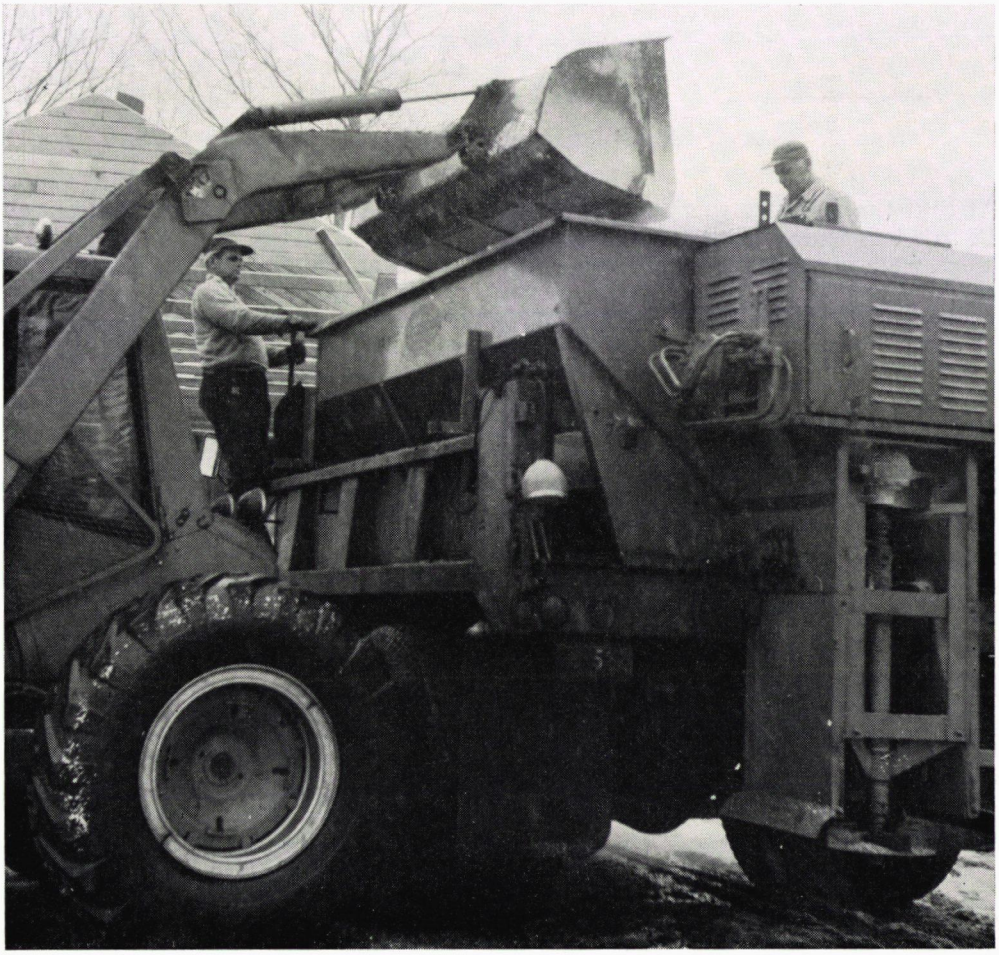

Figure 2. Loading demountable sander with mixture.

Figure 3. Calcium chloride storage shed closed by tarpaulin between storms.

At first the mixture was spread from 12 to 14 ft wide. However, as experience was gained, this was gradually reduced to a width of 3 to 5 ft. This proved to be the most effective width of spread.

In the control section, salt was spread from 3 to 4 ft wide in the center of the traveled way. The rate of application varied from 500 to 1,200 lb per mi of 2-lane roadway depending on the temperature and the amount of precipitation, with 1,000 lb being the rate most frequently used.

The calcium chloride-salt mixture was applied one or more times in the test section during 17 storms. In the control section, straight salt was applied one or more times in 15 storms and treated sand (1 part salt to 8 parts sand) was used in two storms when temperatures were high and precipitation was light.

In several of the storms, when the temperature was very low, a mixture of one part calcium chloride to one part salt was applied to those areas in the test section that did not clear up fast enough with the one to two mixture.

Normal plowing operations when necessary were carried on in both sections during each storm, and hills and curves were sanded from time to time if they became slippery.

Figure 4 shows the condition of the pavement in the test section during test 3, 1½ hr after spreading at the rate of 800 lb per mi. The off-ramp has had only normal application of treated sand.

OBSERVATIONS

Table 1 was compiled from reports submitted by the foremen of both the test and control sections at the end of each storm and shows that the test section was in better condition during 8 storms. The control section was better during 2 storms and both sections were the same during 7 storms. The test section was clear of snow and ice sooner in 4 storms, the control section in 1 storm and both sections were cleared at about the same time during 12 storms, although, in general, temperatures

were lower and snowfall heavier in the test section.

Total snowfall for all 17 storms was approximately 87.5 in. for the test section and 80.0 in. for the control section. The average temperature in the test section was 26.1 F and in the control section 29.7 F. Duration of the 17 storms was 209.75 hr for the test section, and 209.25 hr for the control section. Total amount of sand used was 730 cu yd in the test and 632 cu yd in the control section. Over-all cost was $24,238.49 in the test section and $21,823.67 in the control. This does not include sand cleanup.

The cost for rock salt was about $13 a ton and that of bulk calcium chloride about $36 a ton. This brought the mixture cost to approximately $19 a ton.

Because one of the objectives in testing the calcium chloride-salt mixture was to reduce the amount of sand used, the greater use of sand in the test section needs an explanation. The shed for the storage of salt was not completed until almost the end of the season. The salt got wet several times and when mixed with the calcium chloride caused the mixture to become lumpy and clog the spreaders.

During storms 7, 14, and 17 considerable difficulty in starting equipment and caking of the mixture was encountered. As a result it was necessary to use substantial amounts of sand, making the chemicals less effective when applied. If the sand used during these three storms is deducted from the total amounts used in each section, it then appears that the test section used 340 cu yd and the control section 514 cu yd of sand. Comparison of the amounts of sand used during the individual storms indicates less sand was generally used in the test section than in the control section. An attempt was made to determine what the probable costs, including spring cleanup, would be if treated sand, straight salt, or calcium chloride-salt were used. Because no detailed costs are available for previous years it was decided such speculative costs would not be significant.

Those who have been closely involved in maintenance operations are

Figure 4. Southbound roadway at Conn. 198, 1½ hr after application of mixture.

TABLE 1
CALCIUM CHLORIDE-SALT TEST, CONN. 15, WINTER OF 1960-61

Test No.	Date	Test Section [1]								Control Section [2]							Section		
		Duration of Storm (hr)	Total Snowfall (in.)	Avg. Temp. During Storm (°F)	Calcium Chloride Used (tons)	Salt Used (tons)	Sand Used (cu yd)	Total Cost ($)	Cost per Mile ($)	Duration of Storm (hr)	Total Snowfall (in.)	Avg. Temp. During Storm (°F)	Salt Used (tons)	Sand Used (cu yd)	Total Cost ($)	Cost per Mile ($)	In Better Condition During Storm	Cleared Sooner	
																		Section	Hr
1	12-11-60	16½	16	13	7.5	25	—	1,966.27	70.78	25	15	18	6	12	1,726.62	59.29	Test	—	—
2	12-16-60	18	2	31	10	25	—	1,123.32	40.44	20	2.5	31.5	36	40	1,091.28	37.48	Test	—	—
3	12-19-60	5½	1	26	14	42	20	1,284.18	44.43	6½	1	26	33	17	853.16	29.30	—	—	—
4	12-21-60	3½	1.5	29	9	27	—	1,047.72	37.71	4	1	34	12	25	693.76	23.82	—	—	—
5	12-29-60	16½	3.5	24	28	84	55	1,749.92	62.99	13½	3	26	30	71	2,037.50	69.97	Test	Test	3½
6	1- 1-61	6	3	30	7	21	30	1,573.60	56.65	6½	2.5	34	12	40	1,123.04	38.57	—	—	—
7	1-15-61	24½	12	26	12.4	30.8	275	1,807.10	65.05	25	10	31.5	44	60	2,184.96	75.03	Test	Control	1½
8	1-19-61	18	14	11	9	27	50	2,559.60	92.14	20	13	19	12	40	2,152.36	73.91	Test	Test	1
9	1-26-61	12	3	12	7	21	5	1,176.49	42.35	10½	2.5	18	3	39	1,296.38	44.52	Test	Test	1
10	2- 3-61	25	14	24.5	15	45	55	3,044.33	109.59	21	15	28	24	30	2,277.82	78.22	Test	Test	½
11	2-14-61	3½	0.5	33	2	6	20	388.04	13.97	4	0.5	37	—	20	293.68	10.09	—	—	—
12	3- 1-61	12¾	3	32	9	25	20	1,231.10	44.32	9½	1	34	30	30	1,070.05	36.75	—	—	—
13	3- 8-61	14½	3	29.5	9	21	35	1,540.58	55.46	15¼	3	32.5	36	50	1,586.27	54.47	Test	—	—
14	3- 9-61	6½	0.5	29	2.5	7	60	541.13	19.48	2	0.5	32	—	18	214.50	7.37	—	—	—
15	3-13-61	16½	5.5	34	10	27	35	1,509.75	54.35	14½	5	35	48	40	1,601.40	54.99	Control	—	—
16	3-19-61	7	2	29	8	21	15	985.41	35.47	7	2	33	24	60	1,067.79	36.67	—	—	—
17	3-19-61	3½	3	31	3	10	55	759.95	27.36	5	2.5	35	6	40	553.10	18.99	Control	—	—
Total	—	209¾	87.5	—	162.4	464.8	730	24,238.49	—	209¼	80.0	—	356	632	21,823.67	—	—	—	—
Avg.	—	12.34	5.15	26.12	9.55	27.34	42.94	1,425.79	51.32	12.31	4.71	29.68	20.94	37.18	1,283.75	44.08	—	—	—

[1] Conn. 15, from east junction of US 44, easterly to Massachusetts State Line (27.78 mi of two-lane road).
[2] Conn. 15, from east junction of US 44, westerly to the Tolland Turnpike Overpass at Buckland (29.12 mi of two-lane road).

well aware that there is no substitute for experience. It must be remembered that the crews in the control section have had 15 years experience in the use of treated sand and straight salt. On the other hand, the crews in the test section were totally unfamiliar with the storage, mixing, and use of the calcium chloride-salt mixture. As might be expected, mistakes were made. However, knowledge gained from these mistakes should help to reduce costs in the future.

Both the foreman and general foreman in the test section were somewhat skeptical of the use of the mixture, particularly the possible reduction in the use of sand. This attitude was completely reversed at the end of the snow season. The general foreman's and the foreman's reports are contained in the Appendix. The crew that worked on the test section can now pass on to other crews the experience gained in the use of the mixture during the 1960-61 season.

During the 17 storms of the test period the average temperature was above freezing in only 2 storms in the test section, but in 8 storms in the control section. There were 3 storms when the average temperature was below 20 F in both sections.

Neither calcium chloride nor salt was used during the first storm on December 11 and 12. On the day after the storm there were approximately 8.5 mi of hard-packed snow, 2 to 4 in. thick, covering or partially covering one or both lanes in the test section. Although the temperature did not go above 6 F, all the packed snow was removed with the calcium chloride-salt mixture and snowplows in a period of 6.5 hr (10:30 AM to 5:00 PM). In the control section even though the temperature rose to 12 F, it took as long to clear 6.5 mi of highway covered with the same thickness of hard-packed snow. However, in addition to salt and snowplows, graders were also used. The test section was in safer condition throughout the storm, although the cost per mile was greater.

In storm 8 (January 19-21, 1961) the snowfall in the test section was 14 in. and in the control it was 13 in. The average temperatures were 11 F and 19 F, respectively. The traveled way in the test section cleared approximately 6.5 hr earlier than that in the control. The test section was in better condition during the storm and during the cleanup. Only calcium chloride-salt mixture and snowplows were used except for several small areas where a grader was used for a short time. In the control section, in addition to salt and snowplows, graders were used nearly all day January 21 and until 10:30 PM that night. The test section cost more per mile, however, it was safer during the storm and cleared 6½ hr ahead of the control section.

In storm 9 the snowfall was approximately 3 in. in the test section and 2.5 in. in the control. Average temperatures were 12 F and 18 F, respectively. The test section cleared approximately one hour sooner than the control and was in better condition during the storm. The cost of snow removal and sanding was approximately 10 percent less in the test section.

In storm 16 the snowfall and duration of the storm were the same. The temperature was 4 F higher in the control section. Both sections were substantially the same during the storm and cleared up at the same time. The test section used 15 cu yd of sand and the control 60 cu yd. Here also the cost per mile for snow removal and sanding was lower on the test section.

During the three storms when the average temperature was below 20 F in both sections the calcium chloride-salt mixture worked much better than straight salt. Also during storm 16, when the average temperature in

the test section was 29 F and that in the control section 33 F, the use of the mixture was more economical.

It has been the practice in Connecticut to include the cost of spring cleanup in the total cost of snow and ice control.

The original plan for the experiment contemplated detailed costs for this operation. Because scheduled cleanup in the control section would only include shoulders, gutters, and catch basins and the test section would include these items plus two or three years' accumulation of sand back of the shoulder as well as other areas, a fair comparison could not be made.

The Highway Department has expanded its program to include 8 test and 8 control sections in various areas of the State during the winter of 1961-62. It is anticipated that cleanup cost can be included in subsequent reports. Fortunately, the test section is an area where special maintenance costs have been tabulated as part of a Bureau of Public Roads maintenance cost study. The control section was not a part of this study. Table 2 gives data for the test section for the winters of 1959-60 and 1960-61. The control section was not part of this study.

In the winter of 1960-61 when the calcium chloride-salt mixture test began, although the snowfall was more than 80 percent greater than that of the previous winter and the temperatures somewhat lower, the cost for snow and ice removal was only slightly more than 3 percent greater. This increase could be partially accounted for by annual increments in wages and possibly increases in the costs for materials and equipment.

Caution should be used in drawing any conclusions from Table 2. Depth of snowfall and temperature are only two factors of many that influence cost. For example, the storm of test 1 had 16 in. of snow, had 13 F average temperature in the test section, and cost $70.78 per mi for control. The storm of test 2 had 2 in. of snow, had 31 F average temperature, and cost $40.44 per mi for control. On the basis of snowfall and temperature alone one might expect a cost of $9 or $10 per mi for test 2.

CONCLUSIONS

Based on the results of this test, the following conclusions appear valid:

TABLE 2

TEST SECTION, WINTERS OF 1959-60 AND 1960-61 [1]

Period	Snowfall		Avg. Temp.		Sand Used		Salt Used		Calcium Chloride Used		Total Cost Snow Removal and Sanding	
	In.[2]	%	°F [2]	%	Cu Yd	%	Tons	%	Tons	%	Dollars	%
Winter 1959-60	48.32	—	29.99	—	2,904	—	614.5	—	—	—	38,651.59	—
Winter 1960-61	87.5	—	27.41	—	1,697	—	464.8	—	162.4	—	39,912.77	—
Excess:												
Winter 1959-60 over winter 1960-61	—	—	2.58	9.42	1,207	71.13	149.7	32.2	—	—	—	—
Winter 1960-61 over winter 1959-60	39.18	81.05	—	—	—	—	—	—	162.4	100	1,261.16	3.26

[1] 24 storms each winter.

[2] Data obtained from Bradley Field Weather Station. It was assumed snowfall and average temperature ratios were same in test section and at Bradley Field.

1. The calcium chloride-salt mixture works faster at all temperatures. At 20 to 25 F the mixture starts to work in 5 to 10 min. Straight salt takes 30 to 45 min.
2. The mixture works at lower temperatures than salt.
3. The mixture keeps roads safer during storms.
4. The use of the mixture reduces the amount of sanding and plowing.
5. The mixture is more expensive than straight salt.
6. Mixing and handling costs are greater. Of course, this applies to the salt-sand mixture also.
7. An additional storage shed is required at each storage area.
8. The use of the mixture initially requires closer supervision.
9. Dampness in the spreader motors presents a greater problem when the mixture is used.
10. Depth of snowfall and temperature are only factors in the cost of snow and ice control.
11. Substantial reduction can be achieved in the amount of abrasives used.

RECOMMENDATIONS

Despite the additional cost, the use of the calcium chloride-salt mixture appears to be justified. This cost differential may have been due to lack of experience in the use of the mixture and more severe storm conditions in the test section. However, the superior performance of the mixture at all temperatures has been effectively demonstrated.

A test and control section should be established in each of the four maintenance districts for the winter of 1961-62. These sections should be in substantially the same condition at the start of the test in order to compare cleanup costs.

Construction of separate sheds for calcium chloride and salt would protect both materials from becoming wet. Protection of the ignition systems of spreader motors can be effectively maintained by adopting a procedure followed by the New York Thruway Authority. Equipment is washed with hot water after storm use. Then ignition wires and spark plugs are sprayed with a silicone lubricant preservative.

Based on the results obtained on the test section during 1960-61 the Connecticut State Highway Department will expand the test to include two test and two control sections in each of the four districts during the winter of 1961-62.

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APPENDIX

OBSERVATIONS ON USE OF SALT AND CALCIUM CHLORIDE DURING THE WINTER OF 1960-61

WILLIAM BUSSE, *Foreman, Connecticut Highway Department.*—Use of the salt and calcium chloride mixture on the road is advantageous if used correctly at the right time, in this writer's opinion.

Last winter, mistakes were made in applying it, for example, it was applied when it was snowing very hard and, even though some action resulted, this is not advisable, as the road cannot be kept bare. On the other hand, regardless of the amount of snow coming down it is advisable to get one coat of the mixture on the entire road immediately, as it does help in the final cleanup. It was best also to touch up the hills at intervals during the storm, this cut down tremendously on the amount of sand required.

After the big storms of Dec. 12, 1960, and Jan. 20, 1961, when the road was completely plowed off, a mixture of the chemicals would bare the road completely in 2 to 3 hr even with the temperature around zero.

Storage of chemicals is, or was, a major concern. It must be stored properly and under cover if possible. Too much should not be mixed in advance—just enough to cover the entire road. Material that is stored out-of-doors should be well covered with dry sand and a cover of waterproof paper. The salt used in the mixture should also be kept dry as there was considerable trouble with this until a salt shed was acquired. If salt or calcium chloride tends to get lumpy an even distribution of the chemicals cannot be attained as they will not feed evenly through the jets; this also would call for a second application where one should have done the job properly.

The mixing of the chemicals should be done with care. Improperly mixed materials will result in rapid action when the calcium chloride is concentrated and slow action where there is more salt. Correct blending takes a little longer, but it pays off. Because no two storms are alike, mixing too much in advance is expensive. A mixture suitable for one condition might not be right for the next storm. Remixing for proper proportioning or making up a new mixture wastes both time and money.

Considerable difficulty with spreader motors resulted from the use of the mixture; they were continually getting wet. A motor shut off for a period of time would have to be dried out before it would start, even though all motors were properly cared for before and after the storm.

The center strip has a much better appearance this year, and there is less sand on shoulders because of the use of the mixture.

There were no tie-ups on the hills, because the mixture was used, sparingly, and plows kept the snow closely plowed down.

No special equipment had to be used to remove hard packed snow. At one time a grader could have been used, but before it was available, an application of the mixture and plowing did the job.

Having used clear salt in previous years and having used a calcium chloride-salt mixture this year, there is no comparison if the mixture is correctly used. It will give quick action, where clear salt will not, and it will make the road safe for travel much sooner.

MUNROE USHER, *General Foreman, Connecticut Highway Department.*—The Chemical Test Section begins at the junction of US 44 in Tolland and extends northeasterly to the Massachusetts State Line, a distance of 14.0 mi of divided highway. A mixture of calcium chloride with salt was used for snow and ice control, and abrasives (sand) were applied when the mixture was not available, or heavy snowfall and cold temperatures were not favorable for the use of chemicals.

The effectiveness of this mixture (about 3 parts salt to 1 part calcium chloride by weight, or 2 parts salt to 1 part calcium chloride by volume) was far superior to straight salt in all cases when the temperature was below 28 F. Above this temperature

the mixture was more rapid in action but the salt acted so quickly the traffic experienced no difficulty with either one. The mixture was applied at the rate of 800 to a 1,000 lb per mi (one side of the highway), using three jet spreaders which would cover the entire section without reloading. With this equipment the entire section could be treated in about 30 min, and at temperatures of 20 to 25 F the pavement would be completely bare in about 30 min. If snow or ice cover was very thin in spots, the pavement would be bare of snow or ice in 5 or 10 min. If snow or ice cover was heavy and temperature lower, an additional application was necessary in a few cases. With this quick and positive action no sanding was necessary.

Obtaining a bare pavement in this experimental section was very important as the route is heavily used by trailers and is generally on a grade; and the section between Conn. 32 and Conn. 89 is subject to about a 500 ft change in elevation in a distance of 7.7 mi, so that eastbound trailers are slowed down to the extent that anything except bare pavement can cause a poorly loaded vehicle to stall and cause a tie-up.

Before an application, it is important to have the road well plowed, as the calcium chloride apparently triggers the salt into instant action and the effectiveness is expended quickly, whereas salt will lie in the snow inactive until favorable moisture conditions prevail.

Several times during the last winter trucks were borrowed from this section for use on other roads. This was not possible before, as with any snow or ice on the pavement the heavy trailer traffic was so critical, that sanding operations were constant and all equipment was needed.

The amount of sand used on the experimental section was about one-fourth that used during the previous winter. Sand was used during cold, hard snow storms when traffic was generally having little difficulty because of the dryness and consistency of the snow.

After one severe and very cold snow storm, on both the experimental section and the control section, each had a layer of cold, hard-packed snow on most grades, where the slow moving truck traffic had packed the snow in spite of the temperature of around 10 F. The mixture was applied on the experimental section and salt on a few test sections within the control section. The mixture worked to the extent that within a few hours the pavement was plowed bare. Where the salt was applied it lay inactive on the packed snow until traffic whipped it off onto the shoulders. Graders were used on the control section until it was bare, about 12 hr later than the experimental section. During this comparison the temperature was about 3 F lower on the test section.

The mixture was prepared about one storm ahead of its use and generally at the 3:1 ratio by weight described previously, as experience proved this to be generally the most effective mix. A lower ratio of calcium, possibly 4:1, would work at temperatures above 27 F, but the saving in material costs would be offset by the extra work and the additional space required to store and handle the two mixes. Further, the hilly and northern parts of the State are usually too cold for the lighter mix, except perhaps, at the beginning and end of the snow and ice season.

The control section used for comparison was a section of the same route, commencing at the junction of Tolland Turnpike, in Manchester, and extending northeasterly to the beginning of the experimental section at the junction of US 44 in Tolland.

Comparison of the snow and ice removal costs between the two sections, can be of only limited value for the following reasons: Temperature differences of 2 to 4 degrees colder on

the Union section frequently necessitated longer and more expensive operations. During each of the past three winters there were five instances when partial or full operations for snow and ice work were required on the experimental section, when no work, or merely skeleton forces, were needed on the control section.

Greater care of the rear-end motors must be exercised when spreading, or after using the calcium chloride mixture. Apparently the fine dust given off by the calcium chloride will penetrate all motors and ignition parts and as soon as moisture is available, it is absorbed and causes ignition shorts. A thorough washing and drying, and a more frequent starting of the rear-end motor during periods of non-use practically eliminated this trouble.

The extra difficulties caused by the calcium chloride are so minor and the improvement in pavement conditions so great that giving up the use of the mix is not recommended even if the savings in spring cleanup operations were not considered.