A STUDY OF CALCIUM CHLORIDE AS USED IN ICE AND SNOW REMOVAL

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INTRODUCTION

Importance.

Millions of dollars are spent for automobiles, buses, and trucks. Millions of people are using streets and highways. It is to the best interests of the automotive industry, and to the country at large that these cars and trucks be able to use our highways safely as many days of the year as possible. For this reason the problem of keeping the streets free from the hazardous condition created by ice storms is a vitally important subject.

History.

The problem of ice control corresponds very much with that of snow removal. Prior to 1916, there was no organized attempt made to keep the highways open or the streets cleaned. In 1916 the roads were opened for a few cars to get through and a few cities cleaned their streets. From then until 1925 all work was local and haphazardly done. The study of snow removal and ice control came in 1925. Then research projects were started in all sections of the snow belt to keep the roads safe for traffic during the winter months. At the present time all cities in the snow belt are steadily increasing their appropriations for maintenance of their streets during the winter months.

The change of the motor car to a commercial vehicle, has placed upon all cities the responsibility of maintaining the thoroughfares in such condition that the vehicle can operate with reasonable ease and speed during all seasons of the year, with equal safety to property and life.

This has made it necessary for the cities to provide a means of controlling the icy condition of their streets. In order to do this they sought some economical and efficient method of procedure. Calcium chloride was found to be the most efficient at low cost. Hence it is very widely used in ice control at the present time.

Calcium chloride is a white deliquescent salt which, when exposed to the atmosphere, has the property of retaining moisture almost indefinitely. It is produced in three forms--flake, solid and liquid. The flake form is most commonly used because of its ease of handling. Liquid and solid forms are sometimes used by large operators where the necessary facilities are available. Flake calcium chloride contains 77-[illegible]%, the solid 73-7[illegible]%, and the liquid 34-[illegible]% anhydrous calcium chloride, the balance being practically all water of crystallization.

Uses.

Calcium chloride is used in many ways in the highway field. It is used in curing concrete, keeping roads free from dust in the summer, and prevents all kinds of materials from freezing. The feature which makes calcium chloride so desirable as a means of keeping materials from freezing gives rise to the question of adopting it for the use in ice control, which has already taken place.

Other Investigations.

Many investigations have been conducted on calcium chloride as a curing agent and some good points have been settled. Nevertheless very little has been done in regard to the proper use of it in ice control. There is however at the present time several major investigations taking place. The Michigan State Highway Department is working along this line. Professor H. T. Barnes of McGill University has conducted more research along this line than any one individual. He is working on a compound now which he believes will be acceptable to all.

Some municipalities have conducted their own tests but these have been very short and incomplete. They have in many instances however formed the governing policy of the city which sometimes has been caused by the wrong interpretation of the results.

Some research has been conducted on calcium chloride in regards to whether or not it causes scaling. In these tests some good conclusions have been drawn.

Every phase of the problem must be gone into thoroughly. To do this requires searching investigations of every variety to obtain all the details that may have an important bearing on the solution of the problem.

Scope of this Investigation.

In this investigation it is the authors hope to find the best method of using calcium chloride effectively as well as economically. To be able to find some information in regard to its undesirable feature of causing scaling and corrosion.

[illegible]

In attempting to find the prevailing practice, objections and effectiveness of calcium chloride in the control of ice, a question-naire was sent out to 2[illegible] of the cities in the snow belt. The results are as follows:

New York City.

They do not use calcium chloride in any form on their city streets for snow or ice removal. They had conducted tests on it however and they were unsatisfactory. The temperature being too high at the time each test was conducted.

Toronto, Canada.

They do not use it in general practice. They had however conducted experiments with it. It was mixed dry with 1[illegible] pounds of calcium chloride to two cubic yards of cinders. No effect had been noticed to the surface of the pavements from the use of calcium chloride. In removing the ice they claimed it had very little effect except when the temperature was around 3[illegible] degrees F. The most effective way of combating icy conditions they say was by spreading cinders over the icy portions of the pavements. They had also conducted experiments with calcium chloride for snow removal and found the solution to be weakened to such an extent that it became use-

less.

Their main objection to the use of calcium chloride was that the average temperature was too low to allow calcium chloride to be effective.

St. Paul, Minnesota.

In St. Paul they use it both mixed dry with cinders and spray solution of it on piles of cinders and used it that way. Their objections to it are that it causes [illegible] when a solution of water and calcium chloride freezes it is much harder to remove than the ice itself.

Toledo, Ohio.

They use it in a mixture with sand, 50% sand and 50% calcium chloride.

They have no objection to it and believe that it is very effective.

Boston, Massachusetts.

They do not use calcium chloride for snow removal but do use it mixed with sand in ice control. They mix one drum of flake calcium chloride to five tons of sand. They also have used it dry on their pavements.

They have no objection to calcium chloride at all.

Des Moines, Iowa.

They have used it on different occasions but do not make a practice of it. It was used dry and only when the ice was thin. It had been used also in snow removal but this proved ineffective. Their only objection to its use was that it was too expensive.

Pittsburgh, Pennsylvania.

The only way they use it is alone. The results have been very satisfactory and they have no objections to it at all.

Fort Wayne, Indiana.

They have used calcium chloride and have no objections to it. At present they heat sand at an asphalt plant at 350 degrees F. and spread it in a thin layer on the ice.

Buffalo, New York.

Here they mixed it dry with sand and obtained satisfactory results. They have no objections to its use and have demands from automobile clubs to place it on their streets.

Flint, Michigan.

They use a saturated solution of calcium chloride and sand. It is mixed in a regular concrete mixer. They find it very effective. Their only objection is that it is easily tracked into stores in the down town area.

Syracuse, New York.

Here they use 300 pounds to 1[illegible] cubic yards of sand. The effect is very satisfactory and they have no objections at all as to its harmful effect.

Pontiac, Michigan.

They use 100 pounds of calcium chloride to 1 cubic yard of sand. They have used this mixture for [illegible] years and they have noticed no ill effect to the pavements. They claim that if they would not have calcium chloride they would have to use three times as much sand to accomplish the same purpose. Their only objection to its use is that it is expensive.

Rochester, New York.

They use it mixed dry and in solution. In mixing it dry they use it in a proportion of 7-1. In solution for spraying they mix 1[illegible]0 pounds of calcium chloride with 1[illegible] gallons of water. They have been using it for the last few years and have found that it does not injure the pavements in any way. No objections have been raised to the use of calcium chloride on their streets; in fact, they receive requests for more extensive use of the material and [illegible] comment from the newspapers and the auto club.

New Jersey.

It is recommended to use 150 calcium chloride to 1 cubic yard of coarse gravel sand, mixed with a calcium chloride drill. This is claimed by them to be the most effective way to use it.

Rhode Island.

It is recommended to use 150 lbs. to 1 cubic yard of sand mixed dry. It is also recommended to spray a solution and put it on sand cinders to keep them from freezing in the water.

Minnesota.

It is recommended for use on the highways of Minnesota, "A combination of sand, slag or cinders with calcium chloride in 35 % solution has been proved practical, the solution being prepared by mixing 100 lbs. of calcium chloride with 13 gallons of water to produce 19 gallons of mixture and applied in sufficient quantities to saturate the piles aggregate."

Calcium chloride is in wide use today in ice control which is very evident from the various units that use it. There is no set practice as to its use however. Some use it as high as 50 % sand and others use as little as 150 pounds of calcium chloride to one cubic yard of aggregate.

In Minnesota they are farther advanced than in other states as to its use. The whole trouble lies in the fact that if it has been tried one year and found successful it is in use and if not successful the use of it is prohibited.

The results of the question-naire proved definitely that there was no set standard and that there was very little objection to its use as far as scaling and corrosion were concerned.

SCALING

Scale is the formation of a cleavage plane between the thin layer of material on the surface and the balance of the pavement. The upper part of the cleavage plane, or what is ordinarily termed scale, may become noticeable or be removed by two causes. One, on account of the difference in time of set between it and the main slab. Second, by constant moving traffic. Any pavement in which this cleavage plane is formed is bound to give up the scale as traffic is permitted upon it if it doesn't before.

This phenomenon of scaling, quite commonly attributed by many highway engineers to the effect of calcium chloride applications during curing, has been found in various test sections throughout the country to occur as seriously on sections where calcium chloride was not used. In place of finding this scaling to be the cause of any method of curing, various investigations show that excess tamping to be the common cause, especially if any noticeable percentage of inert materials are present in the aggregates.

Calcium chloride alone does not cause scaling in curing and hence I believe that after the pavement is properly cured there will be no ill effects. Various cities and [illegible] towns [illegible] have used it for a a period of four or five years and have noticed no ill effect from it. From this I conclude that calcium chloride as used in snow removal and ice control will have no harmful effects to the surface of the concrete.

CORROSION

There is no doubt at all as to Calcium chloride causing corrosion when exposed to air. The main objection to this comes from the automobile manufacturers, who claim that its effects are very harmful to the chromium plating that is applied to automobile accessories. In this regard several authorities claim that if real chromium plating were applied this action would not take place. At any rate there is not sufficient literature on the subject at the present time to know definitely what really takes place.

Surface applications applied to concrete in the curing process have no corrosive action at all on the reinforcement in the concrete slabs. This has been proven definitely by many research laboratories throughout the country.

In regard to the amount of corrosion, information was found to the effect that a dilute solution of calcium chloride caused more corrosion when exposed to air than a concentrated solution. In these experiments as a standard of comparison distilled water was used. These tests showed that there was a great deal more corrosion from these solutions of calcium chloride than distilled water.

The manufacturers of calcium chloride are attempting to find a chemical which when added to calcium chloride will retard this excessive corrosive action. When they accomplish this there will be no objection at all to its use.

All the material found indicated that there has been very little investigation along this line. Until such investigations are worked out the extent to which it is harmful can not be determined.

[illegible]

Fine Sand and Calcium Chloride Mixed Dry.

This was mixed by shovels in proportion ranging from one shovel of calcium chloride to four shovels of sand to one shovel of this salt to twelve shovels of sand. These mixtures were spread on several intersections by shovel. They were applied to both packed snow and ice.

The results from these applications were not satisfactory. In the case of packed snow it made it mealy and slushy and on ice it merely served as an anchor for the sand in certain spots where the calcium chloride was concentrated and in others failed to have any effect at all. In those spots that did not have considerable calcium chloride on them it gave the same appearance as if just sand were used. In this test it was noticed that by applying the aggregate by shovel that in certain spots it was effective and where there was little calcium chloride there was no good done at all. It was decided to use a calcium chloride drill for further applications to give a better uniformity of application. This method of application was tried.

The packed snow reacted the same with this application and in several instances where the snow had ice beneath it, the ice was not affected. Showing that the strength of the calcium chloride had been weakened to such an extent that it was useless by the time the layer of ice was reached.

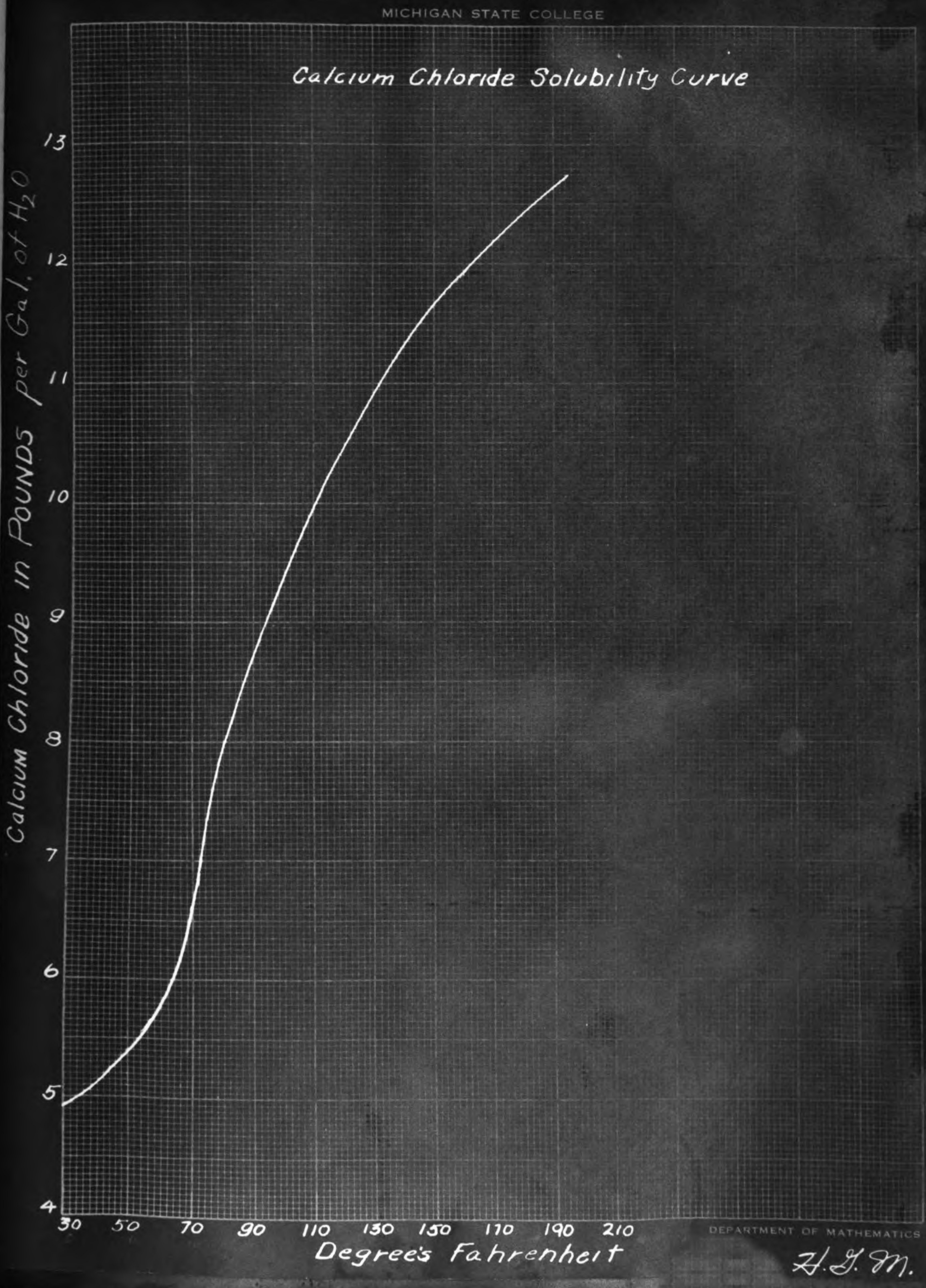
This application on ice was effective. The melting caused by the calcium chloride formed a solution around the sand particles which melted their way into the ice and formed a good resisting surface. The main fault of this test was that the sand was too fine which did not make the surface rough enough to resist slipping. It was decided that in further tests in sand to use a coarse gravel sand.

During all of these tests on sand the temperature did not go below 20 degrees F. This gave us very little idea of what would happen at lower temperatures.

Spraying the aggregate with a solution of calcium chloride.

1. Method of determining the solution to use?

The number of pounds of calcium to a gallon of water in the spraying solution was next determined. Others who had used it in solution suggested 3 to 5 pounds per gallon and to use a 30-35% solution, which amounted to the same thing. A chart of the properties of calcium chloride obtained from a chemical company


MICHIGAN STATE COLLEGE
Calcium Chloride Solubility Curve
Calcium Chloride in POUNDS per Gal. of H_2O
13
12
11
10
9
8
7
6
5
4
30
50
70
90
110
130
150
170
190
210
Degrees Fahrenheit
DEPARTMENT OF MATHEMATICS
H.G.M.

PROPERTIES OF DOW CALCIUM CHLORIDE SOLUTIONS

Specific Gravity at 60/60°F.	°Be' at 60°F. (A.S.)	% Actual Calcium Chloride	Freezing Point °F.	Lbs. Dow 73-75% Solid $CaCl_2$		Lbs. Dow 77-80% Flake $CaCl_2$	
				Per Gal. Sol.	Per CuFt Sol.	Per Gal. Sol.	PerCuFt Sol.
1.01	1.4	1.1	+31.1	.13	.9	.13	.9
1.02	2.8	2.3	+30.2	.26	2.0	.25	1.8
1.03	4.2	3.5	+29.1	.40	3.0	.38	2.8
1.04	5.6	4.7	+28.0	.55	4.1	.51	3.8
1.05	6.9	5.8	+27.0	.69	5.2	.65	4.9
1.06	8.2	7.0	+25.9	.84	6.3	.78	5.9
1.07	9.5	8.1	+24.6	.98	7.4	.92	6.9
1.08	10.7	9.2	+23.4	1.13	8.4	1.06	7.9
1.09	12.0	10.4	+21.7	1.27	9.5	1.19	8.9
1.10	13.2	11.4	+20.3	1.42	10.6	1.33	9.9
1.11	14.4	12.5	+18.5	1.56	11.7	1.46	10.9
1.12	15.5	13.5	+16.5	1.70	12.8	1.59	11.9
1.13	16.7	14.6	+14.4	1.85	13.9	1.73	13.0
1.14	17.8	15.6	+12.0	2.00	15.0	1.87	14.0
1.15	18.9	16.6	+ 9.7	2.15	16.1	2.01	15.0
1.16	20.0	17.6	+ 7.0	2.30	17.2	2.15	16.1
1.17	21.1	18.6	+ 4.1	2.45	18.3	2.29	17.2
1.18	22.1	19.5	+ 1.4	2.60	19.4	2.43	18.2
1.19	23.2	20.5	− 2.2	2.75	20.6	2.58	19.3
1.20	24.2	21.5	− 5.8	2.90	21.7	2.72	20.3
1.21	25.2	22.4	− 9.4	3.05	22.8	2.86	21.4
1.22	26.2	23.3	−13.2	3.20	24.0	3.00	22.5
1.23	27.1	24.2	−17.1	3.35	25.1	3.14	23.5
1.24	28.1	25.1	−21.3	3.51	26.2	3.29	24.6
1.25	29.0	26.0	−25.8	3.67	27.4	3.43	25.7
1.26	29.9	26.9	−30.8	3.83	28.6	3.58	26.8
1.27	30.8	27.8	−36.4	3.98	29.8	3.73	27.9
1.28	31.7	28.7	−44.1	4.14	31.0	3.88	29.0
1.29	32.6	29.6	−59.8	4.31	32.2	4.03	30.2
1.30	33.5	30.5	−41.8	4.47	33.4	4.19	31.3
1.31	34.3	31.3	−29.2	4.63	34.6	4.34	32.4
1.32	35.2	32.2	−16.6	4.80	35.9	4.50	33.6
1.33	36.0	33.1	− 5.8	4.97	37.2	4.65	34.8
1.34	36.8	34.0	+ 4.1	5.14	38.4	4.81	36.0
1.35	37.6	34.9	+13.3	5.31	39.7	4.97	37.2
1.36	38.4	35.7	+21.6	5.48	41.0	5.14	38.4
1.37	39.2	36.6	+29.7	5.66	42.3	5.30	39.6
1.38	39.9	37.4	+37.0	5.83	43.6	5.46	40.8
1.39	40.7	38.3	+44.4	6.01	44.9	5.63	42.1
1.40	41.4	39.1	+50.4	6.18	46.2	5.79	43.3
1.41	42.2	40.0	+55.8	6.36	47.6	5.96	44.6
1.42	42.9	40.8	+60.6	6.54	48.9	6.13	45.8
1.43	43.6	41.7	+64.9	6.72	50.3	6.29	47.1
1.44	44.3	42.5	+68.0	6.90	51.6	6.46	48.4
1.45	45.0	43.3	+70.9	7.09	53.0	6.64	49.7
1.46	45.7	44.2	+73.6	7.28	54.5	6.82	51.0
1.47	46.4	45.1	+75.7	7.48	56.0	7.01	52.4

revealed that a four pound per gallon solution had the lowest freezing point so this was selected.

As a means of spraying the solution on the piles of aggregate an ordinary hand pump was used.

2. Method of spraying.

The solution made up was 80 pounds of calcium chloride to 20 gallons of water. This amount was thought sufficient to saturate 2 cubic yards of the aggregate. This solution was mixed and sprayed on the aggregate until it was believed that it was saturated. The pile was then turned over by shovel and completing the operation by drenching with the solution. This process was repeated until the solution was used up.

Coarse Gravel Sand Sprayed with the Solution.

The first application was applied to a stretch of road, which contained both gravel and pavement, in a residential district. This stretch was about 300 ft. long. It was applied with a regular calcium chloride drill. At the time of application the ice was about ½ inch thick.

The method proved very satisfactory and made the street safe for traffic. The saturated sand only concentrated into the ice far enough to firmly imbed the particles. At night when the temperature went down to 20 degrees F. these particles were imbedded very firmly in the ice forming a very rough surface which resisted skidding. The ice was melted very little but the results revealed that it was possible to make the surface safe for traffic without the necessity of removing the ice completely, which would have been far too expensive an undertaking in this case. This stretch of road was made safe for traffic for two days in which the temperature ranged from 20-30 degrees F.

Second Test on Coarse Gravel Sand Treated with Solution.

In the second test on this aggregate, which was made up and applied in the same way, it was placed at stop street intersections.

The same effect was noticed in these tests. The traffic did not seem to remove the sand particles. At spots where cars had stopped quickly the surface of the ice had been cleared of the sand, which could not be avoided. At nearly all of the intersections treated, the surface was safe enough so that a good driver could stop with very little difficulty from skidding.

3rd Test on Sand

In this test the effects could not be ascertained

due to the fact that considerable thawing took place within one hour after the sand had been applied.

Cinders Sprayed With the Solution.

Cinders were placed on a stretch of hilly road, where the traffic was purely residential. This stretch was about [illegible]00 ft. long, required one yard of cinders, and was applied very carefully by shovel.

This was very effective in removing the icy condition of this hill. When first inspected, which was one hour after it had been placed, considerable melting had taken place and the ice hazard had been completely removed. The street in the immediate vicinity was still very slippery.

The ice was about ½ inch thick when the cinders were placed on it at [illegible]:30 A.M. The day was mild and some thawing took place but at 5 P.M. the ice was completely removed from the traffic lane whereas the rest of the street still had considerable ice on it.

In other applications this same day at stop street intersections similar results were obtained. The cinders were more effective than the sand in this respect.

Cinders were also applied to two hills on streets of a maximum grade. The sections treated

on the north side of the hills where the icy conditions remained longer than in other places in the city. The ice was about ½ inch thick and the cinders were applied with shovels.

In both places the cinders melted their way into the ice and when crushed by traffic formed a mat of cinders which resisted skidding.

The cinders absorbed more of the solution and hence were better than sand for combating the ice problem. This being the reason for the increased efficiency of cinders over sand.

Coke Breeze Sprayed With the Solution.

The coke breeze was applied to one bad hill and on one intersection. There was considerable traffic in both places. When used the ice was about 1/2 inch thick.

They were put on in the morning following a sleet storm and in the afternoon and evening there was another sleet storm.

These sections were inspected about every two hours during the second sleet storm and again the morning following. The streets in the city were extremely hazardous throughout this twenty-four hours, but at the section treated there was no ice at all. The pavement was absolutely safe for traffic at all times. The coke breeze was crushed in the traffic lanes and spread the solution over a wider area.

The reason I believe that coke breeze proved so effective is because of its extremely porous quality which made it able to absorb more of the solution than the other two.

COST

Taking into consideration the following unit cost:

Calcium chloride	at $24.00 per ton
Labor	at $[illegible].50 per hour
Trucks	at $1.50 per hour
Coke Breeze	at $[illegible].50 per cubic yd.
Sand	at $1.25 per cubic yd.
Cinders	at $1.00 per cubic yd.

And considering one cubic yard of material to be effective over [illegible]20 square yards, the cost of application per square yard was calculated.

The cost for cinders was [illegible].[illegible] cents, for sand 2.7 cents and for coke breeze [illegible].[illegible] cents per sq. yard.

To accomplish the same result by mixing calcium chloride dry the cost was approximately 7 cents per square yard. This additional cost comes from the excess calcium chloride that is used. The spraying solution requires only .[illegible]0 pound per cubic yard of aggregate whereas mixing it dry requires anywhere from 100 to 200 pounds of calcium chloride. This additional cost would be justified if the results obtained from mixing it dry proved more effective, but this however is not true.

CONCLUSION

As stated in the opening pages of this report it was the author's hope to find the most effective way of combating the ice problem. It was also stated that an attempt would be made to find the most economical method as well.

Materials.

The materials found the best to use were those of a porous nature. This would include sand, cinders, and coke breeze. The ability of such materials to absorb a solution of calcium chloride is the characteristic that makes them desirable for this work.

Method Of Using Calcium Chloride.

The method of spraying a solution of the chloride on the aggregate was found to be the most effective as well as economical way to use it.

Method Of Applying The Aggregate.

The most effective method of applying the saturated aggregate was by a regular calcium chloride drill. This gave a uniform distribution over the entire area treated, insuring that all sections would be taken care of.

Advantage Of Saturated Aggregate to A Dry Mixture.

The ice does not have to be completely removed to make the pavement safe for traffic. In many instances this would be too expensive an undertaking. The main object in ice control is to make the surface of the ice resist slipping. This can be done easier with a saturated aggregate than with a dry mixture. A saturated particle of the aggregate when it comes in contact with the ice uses the absorbed solution to melt the ice around the particle thus embedding it in the ice. This forms the protective mat on the ice to resist skidding. In the case of a dry mixture the calcium chloride and aggregate are not in close enough contact through out the mixture to do the work equally as well. Thus in the dry mixture a great deal of the calcium chloride is wasted.

Calcium Chloride as Used in Snow and Ice Removal.

In snow and ice removal calcium chloride may be used but in removing snow it is unsatisfactory. It melts the snow and forms slush. In some places the flakes melt their way down through the snow leaving a hard crust on top. This makes the snow very difficult to handle. If there is snow fall on top of a layer of ice and calcium chloride is applied, the snow on top is not removed.

If there is snow fall on top of an icy street and calcium chloride is applied the snow will become mealy but the ice underneath will be still intact. This does not help in putting the street in a safe condition for travel and if anything the snow will become mealy but the ice will not be affected. This is caused by the calcium chloride content of the mixture becoming so weakened by the time that it comes in contact with the ice that it is useless. This does not make the surface safer but makes it more hazardous.

Calcium chloride is better than sodium chloride in snow removal however. In a test conducted before a snow storm some calcium chloride and sodium chloride were placed on some pieces of concrete. The depth of melting above the concrete blocks were noticed the day following the storm. The temperature at all times was below freezing. The amount of slush above the block with calcium chloride on it was approximately 1 [illegible] inches, while above the block with a like amount of sodium chloride there was [illegible] inch of slush.

In complete ice removal when the ice is thick, calcium chloride applied to the surface will cause the layer of ice to break up into blocks and make it easier to handle.

Detremental Effects of Calcium Chloride.

Calcium chloride does not cause scaling by itself. It does however cause corrosion, but the extent to which it corrodes does not make it extremely harmful. The good derived from its use easily offsets this harmful feature.

Limitations and Suggestions.

It is regretted that this work was not started earlier in the winter because of the fact that more periods of icy conditions would have been available.

The temperature did not go below 1[illegible] degrees F. in any of these tests that were conducted. Therefore no conclusions could be drawn as to the effectiveness of calcium chloride at lower temperatures.

The weather during the winter was extremely mild with frequent thaws after an ice storm. The result of this was that the time one application would be effective could not be determined with any certainty.

It was also hoped to be able to apply a solution on a pavement before a storm and notice the effects. This was not possible due to lack of the necessary equipment.

For further investigation into this vitally important subject I would suggest that first; starting the investigation earlier in the winter to take ad-

nature of all icy conditions. Second, conduct an extended investigation into the use of a calcium chloride solution alone. Third, paint a section of pavement and notice if the ice is more easily removed from that section than a section not painted. In other words notice the effect of color on melting ice. Fourth, observe the action of calcium chloride solution at low temperatures. Fifth, investigate the melting conditions on different surfaces of pavements such as brick, asphalt and wooden.

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by

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