REPORT OF COMMITTEE ON MAINTENANCE

B C TINEY, *Chairman*

TREATMENT OF ICY PAVEMENTS

SYNOPSIS

The reduction of traffic hazards caused by slippery roadways is one of the important problems demanding the attention of maintenance engineers at the present time and it is essential that a solution be found The formation of ice on the pavement surfaces constitutes one of the worst and most difficult conditions to combat It has been the practice of highway maintenance engineers of certain northern states to use calcium or sodium chloride for treatment of icy pavements These materials are usually added to sand or cinders and the mixture spread upon the travelled surface They serve to lower the freezing point and embed the abrasive particles in the ice, thus rendering the surface non-skid Considerable diversity of opinion, however, has existed concerning the most effective manner in which these chlorides should be used, whether or not they damage the surface of concrete pavements, and their relative ability to melt ice

Progress reports of methods in practice for treatment of icy pavements and investigations using concrete specimens of 28 days and six months of age have been presented in the Tenth, Eleventh and Twelfth Annual Proceedings of the Highway Research Board This report reviews the previous reports and presents the results of tests on concrete specimens one year of age, together with the recommendations of the Committee

For studying the values of calcium chloride and sodium chloride for the treatment of icy pavements a program of research on the following factors was outlined:

(1) Melting power of calcium chloride and sodium chloride at various low temperatures

(2) Minimum amount of each salt necessary to embed abrasive material in ice at various low temperatures

(3) Effects of calcium chloride and sodium chloride on the surfaces of concretes subjected to repeated freezings and thawings

(4) The value of pretreatment of the surface with various coverings to protect the concrete from possible scaling when these salts are used for thawing ice

Research in accordance with the above outline was conducted by the State Highway Department of Michigan and by the Engineer Department of the District of Columbia

Concrete blocks of approximately 100 square inches area were prepared with raised edges so that solutions of chlorides could be held on the surface Series of different consistencies of concrete, of different degrees of finish, and of different ages, using various concentrations of solution at various degrees of low temperature were included in the tests

Cement mortar specimens (2 x 4 inch cylinders) were prepared in two consistencies and two finishes. These cylinders were immersed to one-half their depth in solutions of sodium and calcium chloride

Both the block and cylinder specimens were subjected to 30 cycles of freezing and thawing.

In the report of the Michigan Department the data have been evaluated and graphs presented which show the results of the tests Figures 1 and 2 show clearly the relative effects of sodium and calcium chloride

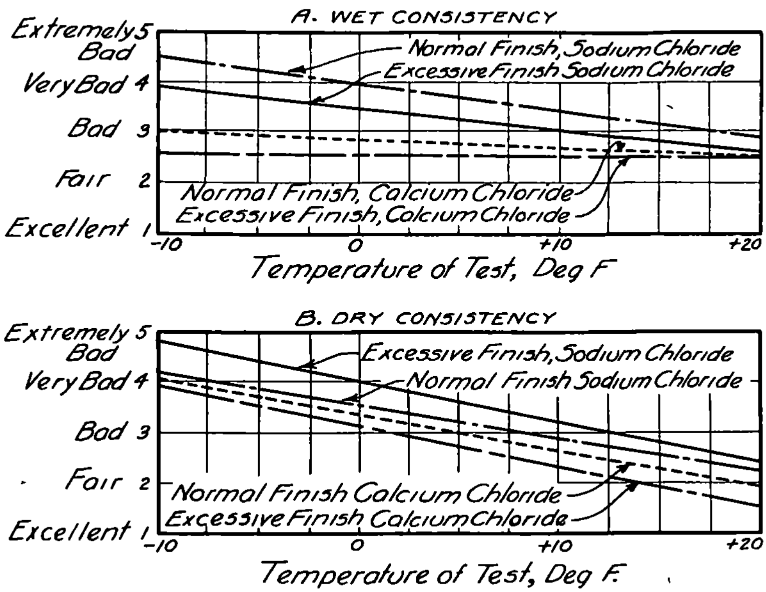

Figure 1. Surface Condition Rating of Specimens at End of 28 Days. Averages of Three Application Rates.

upon 28-day concrete of various consistencies and types of finish Figures 3 and 4 show this same comparison, but on specimens six months of age, taken from the results reported by the Engineer Department of the District of Columbia Figure 5 shows the relative effects of these chlorides on concrete specimens one year of age; taken from Michigan Department investigation

The program of tests carried out by the Engineer Department of the District of Columbia included some specimens covered with a 40 per cent solution of sodium silicate and some covered with 85–100 penetration asphalt previous to the application of the chloride solutions, as well as specimens having applications of various concentrations of chlorides and subjected to various temperatures Also specimens were included on which was applied a calcium chloride solution of such concentration that freezing did not occur

CONCLUSIONS

The relative ice-melting power of the two chlorides constitutes a measure of their ability to embed sand In these tests sodium chloride

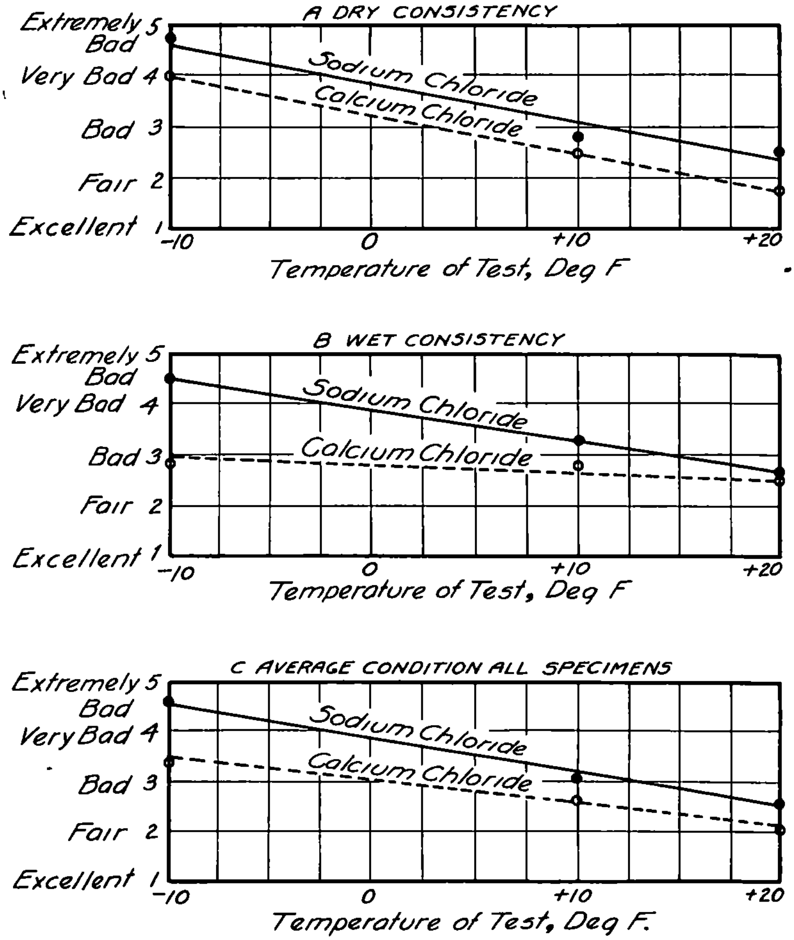

Figure 2 Surface Condition Rating of Specimens at End of 28 Days. Averages of Three Application Rates, Two Finishes, Two Consistencies

had the greater melting power and therefore the greater potential sand embedment property at temperatures above approximately plus 10°F Between plus 10°F and minus 6 5°F the differences in melting power are slight Below minus 6 5°F , approximately the eutectic point of sodium chloride, this salt has no melting or sand embedment power, whereas calcium chloride continues to be active down to its eutectic point, minus 58 5°F. Table I shows the relative melting capacities of

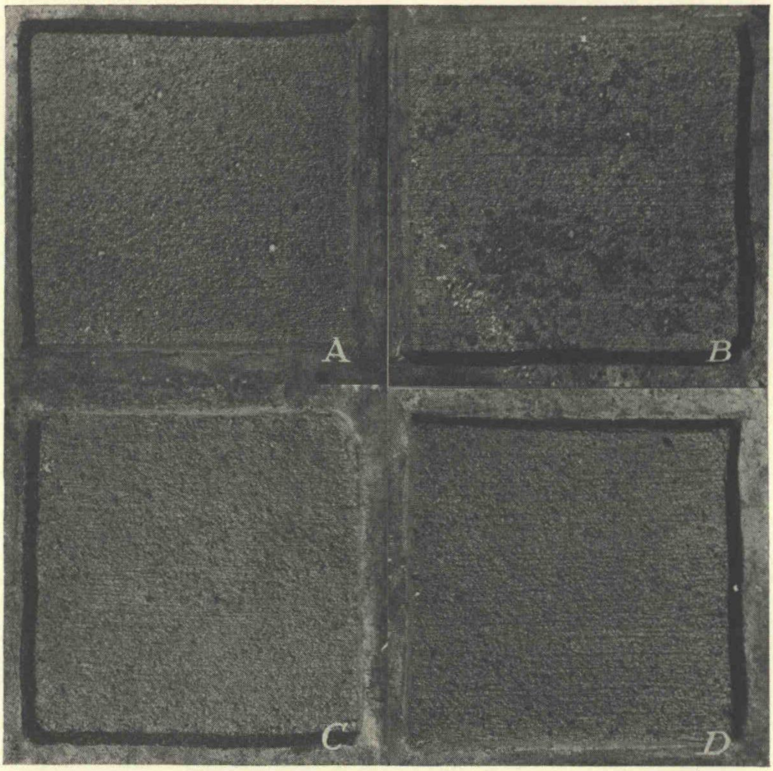

Figure 3. Effects of Calcium Chloride and Sodium Chloride Treatments on Surface of Concrete.

A. Four per cent calcium chloride on plain concrete (slight disintegration).
B. Four per cent sodium chloride on plain concrete (marked disintegration).
C. Eight per cent calcium chloride on plain concrete (slight disintegration).
D. Eight per cent sodium chloride on plain concrete (slight disintegration).

TABLE I

COMPARISON OF MELTING CAPACITIES OF CALCIUM AND SODIUM CHLORIDE

Laboratory Tests

Temperature Deg. F.	Pounds of Ice Melted Per Pound of Chemical	
	77–80 per cent Flake Calcium Chloride	Pure Sodium Chloride
−30°F.	2.9	—
−20	3.2	—
−10	3.5	—
−6.5	3.7	3.2
0	4.0	3.7
5	4.4	4.1
10	4.8	4.9
15	5.5	6.3
20	6.8	8.6
25	10.4	14.4
30	31.1	46.3

calcium and sodium chloride at various temperatures obtained in these tests.

Disintegration of concrete which may occur in connection with the treatment of icy pavements with chlorides, is not due to the action of the chlorides, but rather to the repeated freezing and thawing action produced by the treatment.

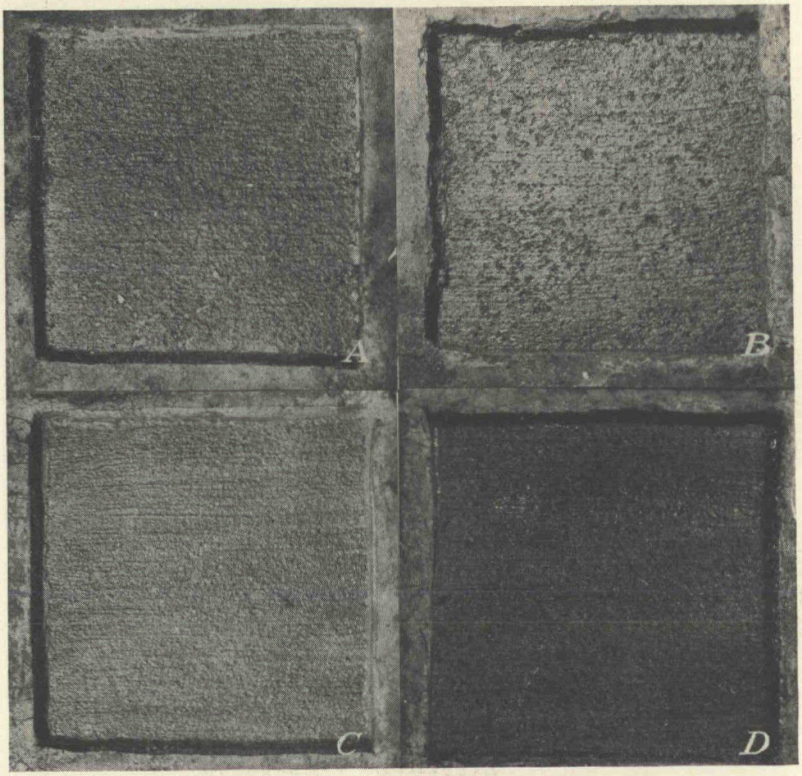

Figure 4. Effects of Treatments with Chlorides and Boiling Water upon Concrete Surface.

A. Twelve per cent calcium chloride on plain concrete (slight disintegration).

B. Twelve per cent sodium chloride on plain concrete (slight disintegration).

C. Thirty per cent calcium chloride on plain concrete (no disintegration).

D. Block from which an ice coating (plain water) was removed by the application of boiling water (slight disintegration).

Both sodium and calcium chloride, applied to the surface of concrete, increase the pitting and scaling which may occur from repeated freezing and thawing. The use of sodium chloride is more detrimental than the use of calcium chloride.

Mortar cylinders partially immersed in solutions of calcium and sodium chloride, and subjected to repeated freezing and thawing, showed damage to the mortar bond The sodium chloride was more detrimental than the calcium chloride since the specimens immersed in solutions of the former developed large longitudinal cracks with minor spider-web cracks, and in many cases the entire cylinders disintegrated Cylinders immersed in calcium chloride solutions developed only surface scaling

Coating of the concrete with oil, asphalt, or sodium silicate previous to making the tests did not prove of value in protecting the concrete against pitting or scaling of the surface

One of the most important factors controlling the severity of pitting and scaling is the amount of chert, shale, or soft stone that exists near the surface of the concrete It is evident from a detailed study of the specimens that the presence of such material near the surface would almost invariably result in deep pitting and removal of surface mortar

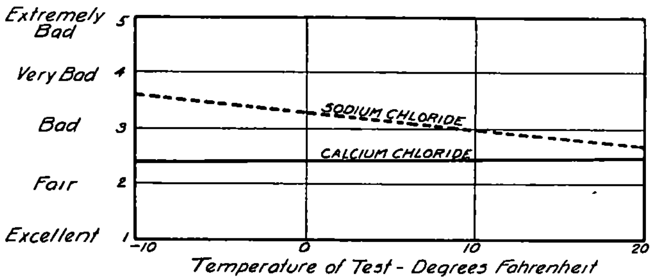

Figure 5. Surface Condition Rating of Specimens at Conclusion of Test Age One Year. Average Condition of All Specimens Three Application Rates, Two Consistencies, Two Finishes

It should be noted that the results from these tests were due to 30 cycles of freezing and thawing and the solutions of chlorides were the maximum amounts which might be used In practice, a considerable amount of the chloride would be absorbed or adsorbed by the abrasive and much of it would be dissipated by traffic Such results as are shown by these tests would be found only where concentrations of the solutions and abrasives were permitted to remain on the surface of the concrete and where conditions were such that repeated freezing and thawing would occur The tests do indicate, however, the importance of the proper supervision and care which should be exercised in using this method of treatment of icy pavements

Field observations of concrete pavements indicate that

There are comparatively few cases where pavement scaling can be attributed to the use of calcium chloride in the treatment of ice

Many pavements where calcium chloride has been used over a period of years in the treatment of ice, show no indications of scaling.

The Committee believes that the importance of safeguarding life and property on icy pavements far outweighs the minor damage that may be done to the pavements

RECOMMENDATIONS

After careful consideration of the results of these investigations, the Committee makes the following recommendations —

Use If the treatment is to be applied to cement concrete pavements, the use of calcium chloride is recommended.

In the case of pavements other than cement concrete the Committee has had no information that either calcium or sodium chloride will promote disintegration by freezing and thawing and therefore either of the chemicals may be used, excepting that calcium chloride is preferable at temperatures lower than 6 5°F below zero

Abrasive Materials Cinders are preferable, although coarse sand may be used since it is more generally available

Preparation of Stock Piles In treating stock piles to prevent freezing, 25 to 50 pounds of calcium chloride or sodium chloride for each cubic yard of abrasive should be spread over the piles either dry or in solution

Application At the time of application, the material should be treated with an additional fifty pounds of flake calcium chloride or sodium chloride per cubic yard The treated abrasive should be applied at the rate of 1½ to 2 pounds per square yard of pavement surface Mechanical spreading is preferable to hand work

The use of either chemical, without abrasives, for the purpose of removing ice is not recommended for general practice, excepting in cities where abrasives tend to clog drainage systems In such cases it is desirable to remove the resulting slush from the pavement

There is definite information that the presence of sand or cinders on the pavement surface, after the ice has melted, will cause damage to the pavement by grinding action under the wheels of vehicles It is therefore important not to apply an excess of sand or cinders and to remove any accumulations of such abrasives from the bottoms of grades or other locations where they may collect

DISCUSSION

ON

TREATMENT OF ICY PAVEMENTS

MR G A RAHN, *Pennsylvania Highway Department* The basic theory of embedding a gritty material in the ice, in order to provide tractive resistance for vehicular traffic, is sound

I note that the report recommends the use of flake calcium chloride, and does not mention calcium chloride solutions All of our work in Pennsylvania has been done by impregnating the cinders with a 35 per cent solution Due consideration was given to the various methods used with this material in conjunction with cinders, and in the final analysis it was felt that if the individual particles of the cinders could carry a certain portion of the salt, this would be much more efficient than a dry mixture of the flake and cinders, which at its best would tend to segregate

Our method consists of pouring the 35 per cent solution over the cinder pile immediately before use If a crust is formed this will disintegrate under the action of the solution The impregnated cinders are spread in a manner similar to dry cinders This will form a mat upon the icy surface, and an immediate reaction is noted, the particles being embedded to a depth of $\frac{1}{16}$ to $\frac{1}{8}$ inch, dependent on the density of the ice With untreated cinders it will require a patrol to spread them morning and evening, while the treated cinders remained efficient for as many as 14 days It is estimated that this makes a saving of between 65 and 70 per cent of the cost of cindering This method of treatment is not economical on ice which will only lay for a day or two, but is economical in sections where the icy condition is continuous over a considerable length of time

Flake calcium chloride has been found economical in the removal of ice from gutters, and will lower the cost of this operation approximately 50 per cent

Economics also enters into this problem from the standpoint that cinders are difficult to obtain, due to the shutdown and curtailed operation of industrial plants at the present time Even prior to the time which we are now passing through, it was ofttimes difficult to obtain cinders in the quantity necessary to carry on this work I think we all agree that cinder is the ideal material to use, and in the search for a substitute the inherent qualities of this material should be kept in mind In other words, my opinion is that the material should be black, gritty, and free from very fine particles.

Black, from the psychological standpoint that this material can be seen by the motorist, and will be conducive to a feeling of safety, which would be lacking in a light colored material I recall several instances in Pennsylvania when we received reports that certain hills had not been cindered Upon investigation we found a light colored granulated slag had been placed on the pavement, and due to its color it blended with the color of the ice, and in some cases had blown away This gives rise to another point, the material used should stay put A black material also absorbs heat, which aids in embedding the particle in the ice

Gritty, from the standpoint that it will be more readily embedded, gives tractive resistance and is not so easily removed under the action of traffic, as rounded material

Free from fines from the standpoint that an excess of fine material will produce a greasy condition which will tend to increase skidding rather than prevent it

The problem of making highways safe for traveling during all seasons of the year is one which cannot be passed by Winter travel, especially in the northern states, is hazardous at its best We should lend our best efforts in reducing this hazard to a minimum

Dr C D Looker, *International Salt Company* I believe all of us agree that 30 cycles of freezing, thawing and drying out on successive days is a condition which is much more severe than is ever encountered in actual practice The drying out of a pavement after a sleet or snow storm is a much slower process By the time the ice has all melted and the road surface has dried, most of the chloride has been carried to the side of the road.

Practically all of the reports of injury to concrete have referred to railroad switches and ice cream stands where large amounts of salt (Sodium Chloride) had been used If calcium chloride had been used in like manner, the report proves that the concrete would, also, have been injured Sodium chloride is being used, correctly, either alone or in combination with sand or cinders by highway departments, transportation companies and cities without injury to concrete or other road surfaces.

Low Temperatures In the United States, except perhaps in the extreme north, there is very little occasion for treating pavements with sand or cinders which have been impregnated with chloride when the temperature is lower than minus 6 degrees Fahrenheit Table 1 and calculations from published works (Comptes Rendus 148, 550, 1909 and J Am Chem Soc 40, 1204, 1918) show that there is practically no difference in the melting power of sodium chloride and 77–80 per cent calcium chloride between 10 degrees F. and minus 6 degrees F

Neither chemical has appreciable sand embedment power at low temperatures As the temperature rises and the amount of traffic increases, sodium chloride will prove the more effective When the price of these two chemicals is considered, the savings are apparent when sodium chloride is used

Preparation of Stock Piles In order to make a mixture equivalent to the 35 per cent calcium chloride solution which has been recommended, dissolve 50 pounds of sodium chloride in 18 gallons of water This makes about 20 gallons of saturated brine Mix as much of this solution with the cinders as they will take up Spread 30 to 50 pounds of sodium chloride over each cubic yard of material before it is applied to the road at the rate of 1 5 to 2 pounds per square yard of surface Fine rock salt is best adapted to this purpose It may be easily dissolved if suspended in water near the top of the container in an open mesh bag or a basket made of screen wire

For those who do not care to use cinders or sand, a very thin layer of sodium chloride may be spread on the ice by means of a mechanical spreader

In the absence of field experiments to show that sodium chloride, when properly used, will not injure cement concrete pavements more than calcium chloride, the use of sodium chloride will prove economical and efficient on the thousands of miles of asphalt, tar-bound macadam, water-bound macadam, brick and gravel roads to make them safe for traffic

It is hoped that consideration will be given to the continuation of this research by some field work in which the effects of sodium chloride on concrete, when properly applied, be observed under actual traffic and highway conditions

REPORT OF SUBCOMMITTEE ON MAINTENANCE OF CONCRETE PAVEMENT CRACKS AND EXPANSION JOINTS

W H ROOT, *Subcommittee Chairman*

Maintenance Engineer, Iowa Highway Commission

SYNOPSIS

This report is a record of the conditions of application and results secured with various fillers on three experimental road sections in Iowa In 1931 five asphalts, three tars, one asphalt cut back and one asphalt emulsion were tried on one road In 1932 materials similar to the more successful asphalts and tars used in 1931 and a heavier cut back asphalt were used on two other roads

The cut back and the emulsion used in 1931 gave some trouble in application and neither appeared to solidify rapidly enough to be considered satisfactory for use under traffic The heavier emulsion gave satisfaction although it was difficult to apply

The asphalts with penetration around 100 at 25°C and fairly soft tars with a float test around 112 gave good results

The results of similar experiments in California and Connecticut are to be reported later

In 1931 this subcommittee of the Maintenance Committee of the Highway Research Board presented a statement of the results which are desired to be attained by the maintenance of expansion joints and cracks in concrete pavements This statement was as follows·

1 By the proper maintenance of cracks and joints in concrete pavements we hope to prolong the life of such pavements by
   a Reducing the spalling and breaking down of the concrete adjacent to the crack or joint, and
   b Deferring the blowing up of the pavement, due to compression failures and reducing the number of such failures