Trials of Calcium Magnesium Acetate Deicer on Highways in Ontario

DAVID G. MANNING AND MAX S. PERCHANOK

Field trials of calcium magnesium acetate (CMA) have been undertaken at two locations in the province of Ontario. During the winters of 1986–1987 and 1987–1988, CMA was applied to a section of freeway and adjacent sections of service road near Beamsville. Under the prevailing conditions (which could be characterized as temperatures rarely below −5°C during periods of precipitation, relatively light snowfall, and heavy traffic volumes), CMA was found to be comparable to salt in achieving bare pavement, though more CMA was used than salt. CMA was found to be relatively more effective in longer storms. During the winters of 1989–1990 and 1990–1991, CMA, from the same commercial supplier as in the earlier tests, was applied to a section of two-lane highway near Owen Sound. The test site experienced heavy snow, frequent snow squalls, cold temperatures, and light traffic volumes. Maintenance quality standards achieved with salt were achieved only 50 percent of the time with CMA. The performance of CMA was much more sensitive to temperature, humidity, time of application, and traffic volume than was salt. Wetting the CMA or the CMA-sand mixture with a CMA solution improved performance, especially in dry, cold periods or windy conditions. It was concluded that, even if budget considerations were ignored, replacing salt with CMA in most parts of Ontario would result in a significant reduction in the level of service currently provided. A steel bin with augers for loading and unloading was found to be an effective method of storing and handling the CMA.

The Ontario Ministry of Transportation (MTO) is responsible for clearing snow and ice from highways under its jurisdiction. This is carried out by plowing, sometimes in combination with sanding or chemical deicing, in accordance with the ministry's maintenance quality standards (*1*). Rock salt (sodium chloride) is the standard deicer because it is effective under most winter weather conditions experienced in the province and is inexpensive relative to other available deicers.

The use of sodium chloride as a deicer has several harmful environmental effects; they include increasing the rate of corrosion in automobiles and highway infrastructure materials, damaging sensitive vegetation along the roadside, and contributing salt to highway runoff (*2–4*). MTO has responded by minimizing the quantities of salt used and by searching for effective and economic alternatives, with a preference for chemicals that contain neither sodium nor chloride ions (*5*).

Calcium magnesium acetate (CMA) was identified in the late 1970s as a possible alternative to salt (*6*) and has been the subject of many studies on its production, health and environmental effects, and performance (*3,4,7*). It has been evaluated under field conditions by MTO at two sites. During the winters of 1986–1987 and 1987–1988, it was tested near Beamsville, and during the winters of 1989–1990 and 1990–1991 it was applied to a section of highway near Owen Sound, Ontario.

Ontario Ministry of Transportation, Research and Development Branch, 1201 Wilson Avenue, Room 331, Central Building, Downsview, Ontario, Canada M3M 1J8.

SUMMARY OF BEAMSVILLE TRIALS

The results of the evaluation near Beamsville have been reported in detail (*8*). They are summarized here because the differences in performance at the two test sites are important to understanding the conditions under which CMA performs effectively.

At the Beamsville test site CMA was applied to a 2.4-km section of four-lane freeway [38,500 annual average daily traffic (AADT)] and adjacent two-lane service roads (less than 500 AADT). Contiguous 7-km sections of the freeway and service roads were maintained using salt and served as control sections. All the roads had a bituminous surface. The CMA was produced commercially. At the beginning of a storm, CMA and salt were applied to the appropriate sections at approximately the same time; subsequent applications were made to meet the quality standards, but it was not attempted to make the same number of applications to the CMA and salt sections because the chemicals performed differently under various storm conditions. The specified application rate for salt was 130 kg/two-lane-km (equivalent to 230 lb/lane-mi). Application rates for CMA were 182 to 221 kg/two-lane-km (1.4 to 1.7 times the standard salt application), an application ratio of 1.7 being the theoretical quantity of CMA necessary to provide equal deicing performance.

Fifteen storms were recorded during the first winter and 20 during the second. Most of the storms occurred when the temperature was between 0 and −5°C, which is typical of winter conditions in the Niagara Peninsula. The storms ranged from a few hours to 3 days long; most lasted less than 1 day.

The findings were as follows:

- The storage and handling characteristics of CMA were comparable to those of salt.
- The use of CMA did not require changes in equipment and only small changes in procedure. The tendency of CMA to stick to equipment and loading areas was a minor inconvenience. Patrol staff readily accepted the CMA.
- The times it took to achieve bare pavement in the CMA and salt sections on the freeway were similar and, with one exception, within 45 min of each other.

- In short storms the quantity of CMA used tended to be much higher than that of salt, whereas CMA was relatively more effective in longer storms. A residual effect from one storm to the next was observed in the CMA section, particularly during the first winter.
- The ratio of the total quantities of CMA and salt used on the freeway test sections was 1.2 in 1986–1987 and 1.4 in 1987–1988.
- The application rate for CMA of 1.7 times that of salt appeared excessive and an application ratio of 1.4 appeared insufficient, but the optimum ratio was not determined.

SCOPE AND METHODOLOGY OF OWEN SOUND TRIALS

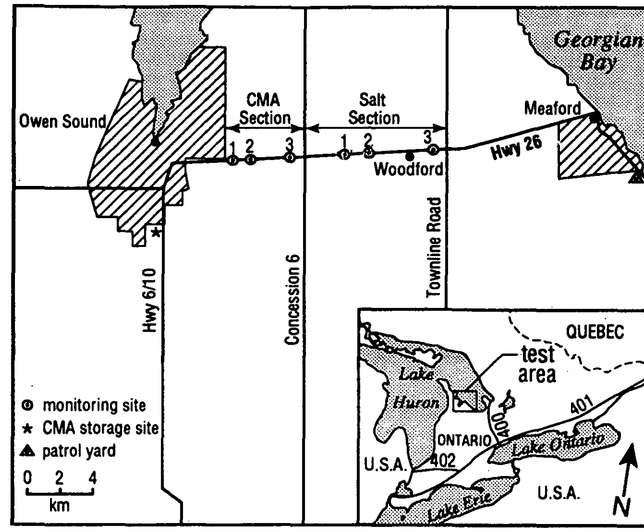
The results of the Beamsville trials were generally favorable toward the use of CMA, but it was recognized that the test conditions of relatively mild temperatures, light snow, and heavy traffic were not typical of conditions throughout most of the province. Additional testing was therefore undertaken under conditions of colder temperatures, heavier snowfall, and lower traffic volumes more representative of rural Ontario. The primary purpose of the trials was to determine whether CMA could be used as the sole deicer in the province if availability and cost were not limiting factors. A secondary objective was to improve storage and handling procedures to reduce the wastage experienced at Beamsville. Trials were undertaken during the winters of 1989–1990 and 1990–1991. CMA from the same commercial supplier used earlier was compared with salt using several criteria, including quantities used, storage, handling and spreading characteristics, time required to initiate deicing, drying and persistence effects, slipperiness, and effect on vehicles.

The trials were conducted on Highway 26 between the eastern limit of Owen Sound and the western limit of Meaford. Highway 26 is a two-lane road with a bituminous wearing surface and winter average daily traffic of 2,400 vehicles. The test area is east of Lake Huron and south of Georgian Bay and is subject to frequent snow squalls and prolonged periods of cold nighttime temperatures. The mean winter snowfall is 2.8 m, with an average of 24 days a year of blowing snow, average daily maximum temperatures in January and February of −2.4°C, and average daily minimum temperatures of −10°C (*9–11*)

In each year of the trials, two sections of Highway 26 were designated for testing: the CMA test section and the salt test section. Except for isolated incidents during the first winter, only the specified deicer, applied either neat or mixed with sand, was used in its designated section. The location of the test sections used during 1989–1990 is shown in Figure 1. For 1990–1991, both the CMA and the salt sections were extended (*12*).

Within each section, observations and measurements were made at specific test sites. The locations of the observation sites were selected to represent the range of road weather conditions experienced while still permitting a valid comparison between the sites in each test section.

Four independent sources (spreader operator, plow operator, patrol supervisor, and observers hired to collect data at the observation sites) maintained records of materials used and the time of application. In addition, in 1990–1991 plow and spreader times were checked against a time-lapse video record at one of the observation sites. Traffic volumes and weather conditions were also recorded.



CMA section
1) level, open site with moderate snowfall and heavy drifting
2) inclined, forested site with passing lane, moderate snowfall and light drifting
3) level, open site with moderate snowfall and heavy drifting

Salt section
1) level, open site with moderate snowfall and heavy drifting
2) level, open site with moderate snowfall and heavy drifting
3) inclined, forested site with moderate snowfall and light drifting

FIGURE 1 Test sections and observation sites, 1989–1990.

Storage and Handling

Storage and handling includes transferring the deicing material from the supplier's delivery truck into temporary storage at the MTO patrol yard and either transferring it from storage into a spreader truck or mixing it with winter sand to prevent stockpile freezing.

CMA was stored and handled during the Beamsville trials using the same equipment as for salt. It was dumped from delivery trucks onto a paved apron outside a salt shed and moved into and out of the shed using a front-end loader. Several problems were encountered, including dusting, spillage, and sticking to the loader tires and apron in wet conditions.

During the Owen Sound trials, CMA was stored in a 90-m^3 steel bin of the type normally used to store grain. The bin was located at a sub-yard at Owen Sound during the 1989–1990 trials and at a sub-yard near Woodford during the 1990–1991 trials. Material was transferred from highway transport trucks into the bin and from the bin into spreader trucks using electrically driven augers (Figure 2).

Method and Criteria of Application

Key measures of the effectiveness of a deicer are the quantity of the material used and the time required to effect ice melting

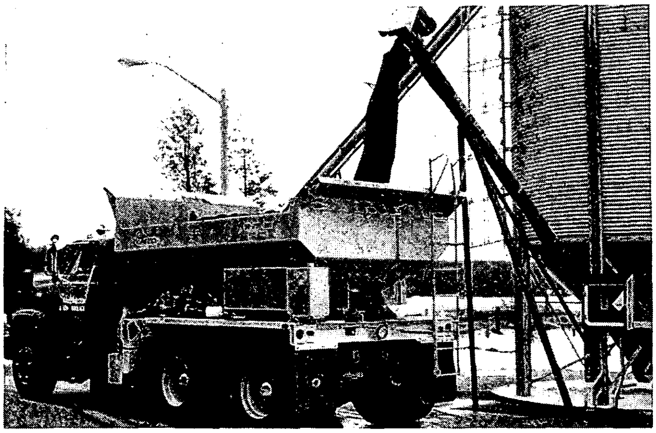


FIGURE 2 CMA storage bin and loading procedure.

or disbonding under given weather and traffic conditions. Detailed records were made of the timing, spread rate, and total quantities of CMA, salt, and sand applied at each test site during each storm.

CMA was dropped over a fixed or slowly rotating spinner to effect spreading across the road surface. This method was used instead of the conventional method of deicer application, a windrow down the centerline, because previous trials showed that CMA did not dissolve and spread as a solution. Instead, it formed a slush that remained where pellets were applied until it was removed by plowing or tire action.

The timing and rate of application differed in the 2 years of testing. In 1989–1990 the application rate for CMA was 195 kg/two-lane-km, or 1.5 times the standard salt application rate. The first applications of CMA and salt in each storm were made at the same times to permit direct comparisons of the deicing effectiveness of CMA and salt. Subsequent applications during a storm were made independently as warranted by road conditions. However, road weather conditions were not sufficiently similar in the salt and CMA test sections to warrant direct comparison, and procedures were changed after the first year of trials.

In 1990–1991, the timing of CMA applications was scheduled so as to optimize effectiveness and was not related to the timing of applications in the salt section. The application rate was also adjusted by the patrol supervisor between 195 and 247 kg/two-lane-km, depending on road and weather conditions.

Several of the 1990–1991 applications included spraying a 25 percent solution of CMA in water on the CMA pellets and winter sand immediately before spreading to determine whether blow-off could be reduced. The prewetting apparatus consisted of a commercial weed sprayer mounted on the spreader. The spray apparatus incorporated a heater and antifreeze system to prevent freezing and maintain a low viscosity of the solution during storage. The solution was applied at a pressure of 224 kPa, through a flat-tip nozzle that sprayed a fine mist on the CMA pellets or sand grains on the spinner. The resulting application rate was 1.9 L/min, or approximately 3.75 L/two-lane-km, depending on vehicle speed. The sprayer could be turned on and off by the truck operator while the vehicle was in motion.

Spread Width and Blow-Off

Blow-off occurs when deicer or sand particles are blown off the road by wind or turbulence created by passing vehicles. Blow-off is most common when particles are bouncing along the road immediately after discharge from the spinner.

Spreading characteristics were documented qualitatively as the spreader truck passed the observation sites and by videotaping the spreading operations from a trailing vehicle. Blow-off was documented at the observation sites by mapping the spread width and density under different wind and pavement wetness conditions.

Effectiveness of Ice Melting and Disbonding

Deicers act by one of two processes: one is by dissolving with a body of ice or snow and thus simply melting the mass of material from the top down; the other is by penetrating the main body of material and then dissolving a thin layer between the snow or ice and the pavement. The second process breaks the ice-pavement bond and is more efficient in terms of quantities of deicer used and vehicle safety. Less deicer is used because only a small mass of material needs to be melted, and it results in safer driving conditions because the surface is not covered with a layer of deicer solution.

Although it is difficult to measure the two processes in the field, the dominant process can be inferred by observation. If the bond-breaking process is dominant, the snow or ice will be cast from the road by vehicle tires or plowing to expose bare pavement that is wet with deicer solution. If melting at the surface occurs and enough deicer is applied, the snow or ice will gradually turn to slush and then dissolve. Providing it does not refreeze, the solution is cast aside by traffic or gradually drains or evaporates from the pavement, eventually leaving a bare and dry surface.

A standardized format was used to map the pavement conditions at the observation sites and record the weather conditions. Parameters included the type, thickness, and lateral extent of snow, ice, or deicer solution on the pavement; road surface temperature; and meteorological conditions. Road conditions were classified as icy, snowpacked, snow-covered, slushy, bare and wet, bare and damp, bare and dry, residue, or frost. The order of the conditions listed is important because a change within the range "icy" to "bare and dry" was interpreted as an improvement in road condition.

During the 1990–1991 trials, several additions were made to the procedures and an automated data collection system was installed at one observation site. At all sites in the CMA section, thermocouples were installed in the pavement to measure road-surface temperature, and thermometers were mounted on roadside posts to measure air temperature.

At the automated data collection site, road weather data were recorded at 30-min intervals and the road-surface condition was recorded on videotape at 4-sec intervals.

The pavement was marked with paint lines that, when imaged in the video system as shown in Figure 3, provided a calibrated record of the rate of deicing during every CMA application. A luminaire was installed at this site to allow nighttime videotape recording.

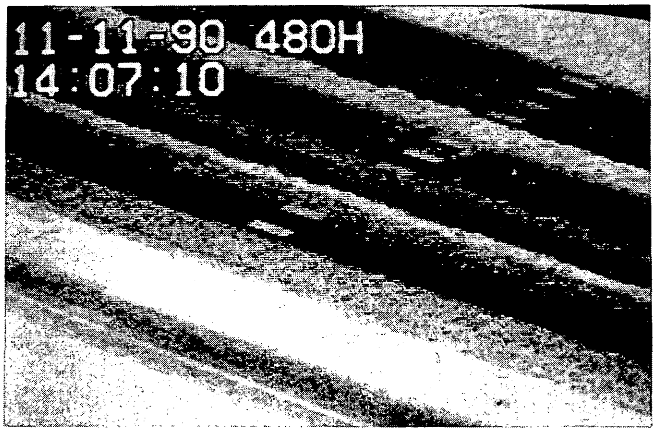


FIGURE 3 Videotape of road conditions, November 11, 1990, at 2:07 p.m.

Hourly traffic volume in each direction was measured during the first test season using a microwave detector mounted on a hydropole at the Woodford sub-yard, the midpoint of the test area (Figure 1). During 1990–1991, traffic was measured using an electromagnetic loop detector installed in the pavement surface at the same location.

RESULTS AND ANALYSIS OF OWEN SOUND TRIALS

Storage and Handling

Initially, difficulties were experienced in loading the spreader from the storage bin because of overload of the electric motor on the auger during start-up. The problem was rectified by reducing the diameter of the auger flights that extended into the storage bin, thus reducing the loading rate (to approximately 500 kg/min), and by emptying the auger before it was switched off. Excessive dusting was also observed; it was controlled by attaching a flexible nozzle to the end of the auger.

The presence of the dust raised concerns that the CMA pellets could be abraded by the augers. Samples were taken when the CMA was unloaded from the highway transport truck into the storage bin, and when it was loaded into the spreader truck, to determine whether attrition occurred in passing through the loading and unloading augers. Comparison of the size distributions of the two samples indicated that the amount of attrition was very small (*12*).

Liquid CMA, used only during 1990–1991, was delivered in 205-L steel drums and pumped into a reservoir on the spreader truck as needed. Bacterial slime was observed floating on the liquid in the steel drums upon opening, after delivery from the supplier. This was anticipated because of the metabolism of acetate by bacteria and was removed by skimming.

CMA was mixed with winter sand to prevent stockpile freezing. A rate of 5 percent by mass (which is the standard ratio for salt) was used in 1989–1990 and 2 percent by mass in 1990–1991. When 5 percent CMA was used, the pellets became soft and sticky as moisture was absorbed from the sand, leaving the dry sand susceptible to blow-off. The use of 2 percent CMA was found to be sufficient to prevent the stockpile from freezing, and it did not result in a noticeable drying of the sand.

Application Experience

During both winters, CMA was observed to stick to the sides of the spreader bin, which at times prevented it from falling onto the spreader conveyor. This problem occurred whenever CMA was loaded into a wet spreader. The problem was solved partially by parking the spreader truck in a garage or sand storage dome and by scraping and washing off any material remaining in the spreader bin immediately after use.

Slush splashing from the road caused the CMA to cake on the spinner to the extent that the spinner had to be scraped and washed between applications.

CMA pellets were observed to bounce more than salt upon hitting the pavement, unless the road was moist or snow-covered. They were also blown off the road by wind and by air currents from trucks following the spreader.

In eight tests, CMA pellets were prewetted with a 25 percent CMA solution to determine whether a liquid coating would help the CMA adhere to the road surface. The use of the spray improved the adhesion of the CMA to the road surface and reduced the spread width (*12*). In very windy conditions, sand was spread on top of the CMA to hold it onto the road. This required a second pass of the spreader truck, but, since only one vehicle was available, almost 1 hr had elapsed, which limited the effectiveness of the technique.

Quantities Applied

Statistics summarizing the deicer applications in the CMA and salt test sections are shown in Table 1. During the first test season from November 4, 1989, to April 4, 1990, CMA or CMA-sand mix was applied 181 times in the CMA test section. Data from the CMA and salt test sections in 1989–1990 exclude eight events in which salt was applied in the CMA section and 17 events in which salt-sand mix was applied in the CMA test section. Reasons for using salt in the CMA test section are as follows:

- The storage facility had run out of CMA or CMA-sand mix;
- The spreader dedicated to CMA had mechanical problems;
- Salt was deemed necessary to remove an icing condition; and
- Because of spreader availability, salt-sand application permitted a faster response during critical icing conditions.

During the 1990–1991 test season (from November 7, 1990, to April 15, 1991), CMA or CMA-sand was applied 221 times. No salt was used in the CMA section. Records for this season did not distinguish between full, spot, or multiple applications during the same spreader call-out in the salt section; therefore, they were not included in the top section of Table 1.

Information directly comparing the number of applications and quantities of CMA and salt used must be interpreted with

TABLE 1 Summary of Material Use

	1989-1990	1990-1991
Number of Material Applications[a,b]		
CMA	59	77
CMA-sand mix	122	142
Salt	65	-
Salt-sand mix	133	-
Ratio		
CMA:salt	0.91	-
CMA-sand:salt-sand	0.92	-
Mass Applied (kg/two-lane-km)[a,c,d]		
CMA	18,750	14,615
CMA-sand mix	117,329	192,308
Salt	18,048	29,771
Salt-sand mix	99,095	108,153
Ratio		
CMA:salt	1.04	0.49
CMA-sand:salt-sand	1.18	1.78
CMA-sand:CMA	6.2	13.1
Salt-sand:salt	5.5	3.6

[a]Excludes storms in which salt or salt-sand mix was applied in CMA section.
[b]Excludes spot applications.
[c]Averaged over test section.
[d]Includes spot applications.
- Data not available.

care. First, direct comparison requires that traffic and weather conditions in the CMA and salt test sections be similar, and this was not always the case. Patrol and monitor personnel observed that weather conditions frequently differed over short distances within the test areas as a result of snow squalls from Georgian Bay.

Second, no attempt was made to use neat CMA when salt was in use and a CMA-sand mixture when a salt-sand mixture was in use. A simple comparison of the number of deicer applications and total quantities applied suggests that CMA was more effective, or remained effective longer, than salt. However, the much greater quantity of sand used in the CMA section means that there were times when salt was effective but CMA was not, and sand had to be applied to provide traction only in the CMA section. In summary, the seasonal application data suggest that CMA was less effective than salt.

Effectiveness of CMA and Salt

General Characteristics

Observations were made of the comparative deicing characteristics of salt and CMA.

In the case of salt, one of two processes was observed, depending on road weather conditions. Under relatively warm temperatures and light snowfall, salt created a solution with the snow almost immediately upon application, and the solution drained off the road. Under more severe conditions when a snowpack had formed on the pavement, salt penetrated the snowpack, usually within a period of 30 min, to disbond the snowpack from the pavement and facilitate plowing. This occurred at temperatures down to approximately −12°C.

Deicing processes associated with CMA differed from those observed with salt. They were sensitive to precipitation, air temperature conditions, humidity, the type of material on the road, and traffic. Under relatively warm temperatures (above about −6°C) and light snow conditions with little traffic, CMA quickly penetrated the thin snow cover, but it did not go into a solution with the surrounding snow once it reached the pavement surface. Instead, it remained in solid form on the pavement within the original pit melted in the snow.

When CMA was applied on snow cover or snowpack with light to moderate snowfall, air temperatures above −6°C, and traffic present, pellets in the wheel tracks dissolved slowly in the snow to form a slush, but not a liquid. Tire action gradually caused the slush to accumulate between the wheel tracks, until it was removed by plowing.

Under conditions of heavy snowfall and temperatures close to the freezing point, the CMA pellets did not dissolve quickly enough to melt the accumulating snow, and they were covered by the snow. When the snow stopped falling, the CMA began to dissolve with it to form slush, which was then plowed from the road.

At temperatures below −6°C and with traffic present, CMA dissolved very slowly with snow on the road to form a slush. Slush began to form after about 30 min, depending on traffic volume, and continued to form over 2 hr or more. Again, CMA pellets remained undissolved outside the wheel tracks for hours or days after application.

After the end of a storm, and after the slush and snow were plowed from the pavement surface, a moist residue of CMA remained on the pavement for some hours or days. It gave the pavement a shiny, damp appearance although liquid was not visible. Blowing snow was observed to stick more readily to such pavements than to dry pavement in the salt section, although the snow did not become bonded to the pavement and was readily plowed off. It did necessitate more frequent plowing, however.

Prewetting the CMA pellets with a 25 percent solution of CMA in water increased the rate of reaction significantly. In several tests at temperatures above −6°C, the prewetted CMA dissolved snow in the wheel tracks at approximately the same rate as salt. At colder temperatures, prewetted CMA dissolved more quickly than dry CMA, but much more slowly than salt.

Ice Melting Effectiveness

The effectiveness of deicing was quantified in 1989–1990 by tabulating the frequency with which road surface conditions improved within 2 hr. In 1990–1991, a 30-min criterion for effectiveness was used in addition to the 2-hr criterion. The 30-min criterion corresponds approximately to standards achieved by rock salt at temperatures above −12°C and was chosen because MTO operating instructions require plowing to begin approximately 30 min after salt is applied (*1*). The effectiveness over 30 min is thus an indirect method of comparing the effectiveness of CMA with that of salt.

In both years, an effective application was defined as one in which the pavement condition improved by at least one category (as defined by the classification system used) within the prescribed time period. It should be noted that the application of the pavement condition classification was not identical in the first and second year of trials. In the first year, condition refers to the predominant condition across the driving lane at the test site. In the 1990–1991 analyses that follow, pavement condition refers to the condition of the outer wheel track zone at the test site.

Other qualifications of the analysis relate to initial condition, completeness of monitoring records, and material applied. Data were excluded if the initial condition was bare and dry, bare and damp, or bare and wet, if the frequency of monitoring was less than once in 2 hr (1989–1990) or once in 15 min (1990–1991), or if sand was applied during the monitoring period.

The duration of deicing is defined as beginning at the time of material application and ending at the observation just before plowing or the next material application.

In all cases, CMA was applied only in conditions under which rock salt would be expected to perform effectively. As shown in Table 2 using the 2-hr criterion for effectiveness, CMA was successful in 74 percent of the applications in 1989–1990 and 80 percent of the applications in 1990–1991 (excluding applications of prewet CMA). These success rates are significantly lower than the rate expected from salt, especially considering that the 2-hr criterion is much less stringent than would be considered acceptable for salt.

Table 2 shows trends of decreasing effectiveness with decreasing air temperature and increasing effectiveness with increasing traffic, and suggests that these variables act together to influence deicing. This trend would be expected for any chemical deicer.

The performance of CMA was revealed by analyzing the results from 1989–1990 of applying CMA to a snowpacked condition. All of the applications were successful in improving the road condition by at least one classification at temperatures above −6°C, some were successful between −12 and −6°C, and none was successful below −12°C. In total, 44 percent of the applications on a snowpacked surface were successful, with 12 percent resulting in slight improvement to snow-covered condition, 7 percent in moderate improvement to bare tracks, 3 percent to slushy, and 22 percent to bare and wet.

TABLE 2 Success Rate of CMA Using 2-hr Criterion

	Successful Applications (%)	
	1989-1990	1990-1991
All data	74	80
By air temperature		
-4.9°C or higher	100	100
-5 to -7.9°C	84	86
-8 to -10.9°C	44	80
-11°C or lower	20	80
By traffic count		
0 to 9 vph	61	88
40 to 79 vph	80	100
80 to 119 vph	82	91
120 or more vph	100	87

NOTE: Success is defined as improvement in pavement condition by at least one category within 2 hr after application of CMA.
vph = vehicles per hour

A more-detailed analysis of deicer effectiveness was conducted on the data from 1990–1991, which were collected on shorter intervals. These data were used to construct cumulative frequency curves of deicing effectiveness. The curves show the relationship between elapsed time since deicer application and the success rate or effectiveness of deicing.

The cumulative frequency of elapsed time between deicer application and road condition improvement is shown in Figure 4 for all CMA applications during 1990–1991. When time is not limited, the success rate was 80 percent (curve for dry CMA). When elapsed time is limited to 1 hr, the success rate was 68 percent; and when elapsed time is limited to 30 min, the success rate was 45 percent. The success rate after 30 min indicates that, if CMA were substituted for salt in the MTO winter maintenance program, successful deicing would be achieved in fewer than half of the conditions tested. Figure 4 indicates that prewetting resulted in a slight improvement in performance. However, prewetting was usually carried out under cold, snowpacked, and often windy conditions, all of which reduce the effectiveness of a deicer. If prewetted CMA had been compared with dry CMA under similar conditions, it is expected that the improvement in performance would be greater than indicated by Figure 4.

Additional information about the performance of CMA is presented in Figure 5, which shows the influence of air temperature on the effectiveness and rate of deicing. As expected, the success rate increases with the duration of deicing for all temperature ranges and with temperature for most durations. Unexpected results for elapsed times of less than 30 min suggest that other factors influence the initiation of deicing immediately after the material has been spread. Applying the 30-min elapsed time criterion resulted in a success rate of 35 to 45 percent in the temperature range above −8°C and 10 percent in the range below −8°C. The average time required for deicing (i.e., the 50th percentile of success) was 40 min at 0 to −4.9°C, 50 min at −5 to −7°C, and more than 140 min at temperatures below −8°C.

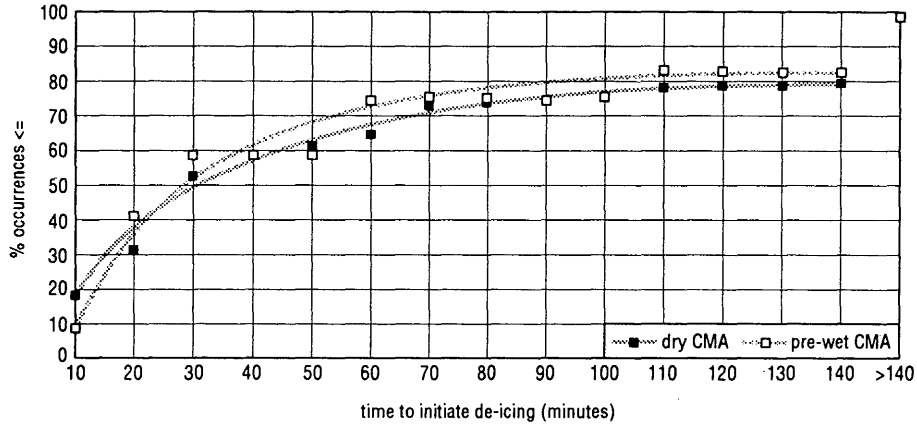


FIGURE 4 Effectiveness of dry and prewet CMA, 1990–1991.

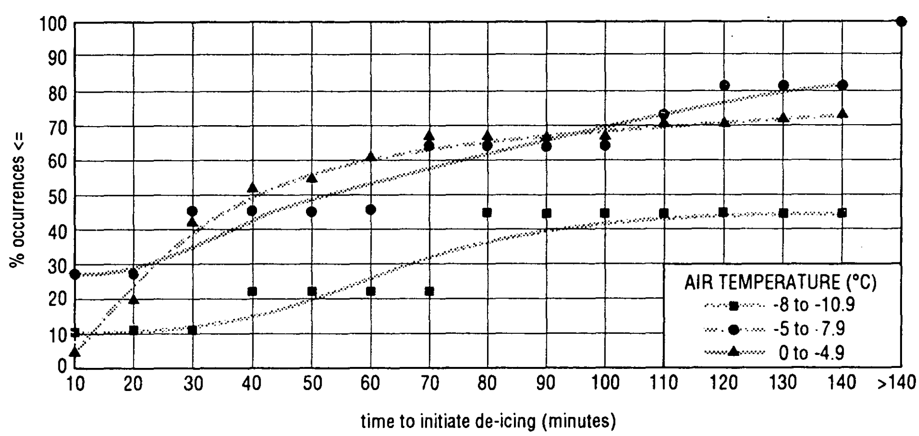


FIGURE 5 Effectiveness of dry CMA by air temperature, 1990–1991.

The influence of vehicle traffic on effectiveness and rate of deicing was similar to that of temperature. Applying the 30-min elapsed time criterion, the success rate was 30 percent for vehicle counts below 80 per hour and 55 percent for counts above 80. The average time required for deicing was 30 min at vehicle counts of 80 per hour or higher, 50 min at 40 to 79 vehicles per hour, and 60 min at 39 or fewer vehicles per hour.

Other Characteristics

Drying of Pavement Previous studies suggested that CMA dries very slowly after reacting with snow or ice on the pavement. This could have both desirable and adverse effects on driving conditions. Desirable effects include initiation of deicing during subsequent storms, which might prevent bonding of packed snow or ice to the pavement and reduce the total quantity of CMA used. Adverse effects include adhesion of blowing snow to the pavement and reduction of skid resistance due to a liquid film. Both adhesion of blowing snow and initiation of deicing (anti-icing) were observed in the present study. Pavement drying time in the CMA section was documented from the video records taken in 1990–1991. Where drying was undisturbed by additional precipitation, the pavement typically took several days to dry. Comparative data were not collected in the salt section, but experience shows pavement to which salt has been applied dries within a day.

Effects on Vehicles To observe corrosion of the machinery, visual comparisons were made of the CMA and salt spreaders used during the trials. No corrosion was visible on the CMA spreaders after either season of operation, but corrosion was evident on the salt spreaders.

A transparent, sticky film was observed to accumulate on monitor vehicles that were used primarily within the CMA test section. The film was difficult to wash off with soap and water.

A few reports were received stating that vehicles that regularly traveled the CMA test section had unusually squeaky door hinges and underbody moving parts. This was also noted on the vehicle used by monitors.

CONCLUSIONS

Over four winters, MTO has studied the effectiveness of CMA as a highway deicer. Trials near Beamsville showed that it has effectiveness similar to salt under freeway traffic conditions and when temperatures are from 0 to −5°C and snow is light.

Trial near Owen Sound showed that the effectiveness of CMA decreases noticeably when traffic is light, temperatures are below −5°C, and there is moderate snowfall or drifting. Such conditions are typical of rural highways in Ontario.

In the Owen Sound trials, maintenance quality standards that are typically achieved using salt were achieved only 50 percent of the time with CMA even though a much higher application rate was used. If the standards were revised to permit a 1-hr period for a deicer to act before the road was plowed, the rate of effectiveness would have been 68 percent, and for a 2-hr period the rate would have been 74 to 80 percent. These rates could be increased by approximately 10 percent if the CMA were prewetted.

CMA can be an effective replacement for salt under a limited range of conditions. However, its widespread adoption as a replacement for salt would result in significant reductions in the level of service for snow and ice removal currently provided by MTO, even if the winter maintenance budget allowed for unlimited use of the material.

REFERENCES

1. Operating Instructions; Winter Maintenance Standards. *Maintenance Manual*, Vol. 4, Series M-700. Highway Engineering Division, Ontario Ministry of Transportation and Communications, Downsview, Ontario, Canada, 1981.
2. P. H. Jones, B. A. Jeffrey, P. K. Watler, and H. Hutchon. *Environmental Impact of Road Salting—State of the Art*. Report RR 237. Ontario Ministry of Transportation and Communications, Downsview, Ontario, Canada, 1986.
3. *Special Report 235: Highway Deicing: Comparing Salt and Calcium Magnesium Acetate*. TRB, National Research Council, Washington, D.C., 1992.
4. M. Perchanok, D. G. Manning, and J. J. Armstrong. *Highway Deicers: Standards, Practice and Research in the Province of Ontario*. Report MAT-90-13. Research and Development Branch, Ontario Ministry of Transportation, Downsview, Ontario, Canada, 1991.
5. D. G. Manning. *Issues Relating to the Use of De-Icing Chemicals*. Report MAT-90-04. Ontario Ministry of Transportation, Downsview, Ontario, Canada, 1990.
6. S. A. Dunn and R.U. Schenk. *Alternative Highway Deicing Chemicals*. Report FHWA-RD-79-109. FHWA, U.S. Department of Transportation, 1980.
7. *Chemical Deicers and the Environment* (F. M. D'Itri, ed.). Lewis Publishers, Boca Raton, Fla., 1992.
8. D. G. Manning and L.W. Crowder. Comparative Field Study of the Operational Characteristics of Calcium Magnesium Acetate and Rock Salt. In *Transportation Research Record 1246*, TRB, National Research Council, Washington, D.C., 1989, pp. 18–26.
9. D. M. Brown, G. A. McKay, and L. J. Chapman. *The Climate of Southern Ontario*. Climatological Studies Number 5. Atmospheric Environment Service, Environment Canada, Toronto, 1980.
10. *Canadian Climate Normals, 1951–1980; Temperature and Precipitation, Ontario*. Atmospheric Environment Service, Environment Canada, Toronto, 1980.
11. *Canadian Climate Normals, 1951–1980; Volume 9, Days with Blowing Snow*. Atmospheric Environment Service, Environment Canada, Toronto, 1984.
12. M. S. Perchanok and R. Raven. *The Effectiveness of Calcium Magnesium Acetate Deicer Under Severe Operating Conditions, Winter 1989/90 and 1990/91*. Report MAT-91-02. Ontario Ministry of Transportation, Downsview, Ontario, Canada, 1992.