WA-RD 113.1

CMA RESEARCH PROJECT

WASH. DEPT. OF TRANSPORTATION

CMA RESEARCH

IN WASHINGTON STATE

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The authors wish to acknowledge the cooperation of Maintenance Superintendents Howard Riebe, Spokane, and Harry Krug, Cle Elum, and their capable crews. These valued employees willingly accepted the challenge of experimenting with a previously unproven deicing chemical under the most adverse conditions experienced within the Washington state highway network. Without the willingness of these frontline crews, this project could not have been successfully completed.

Additional acknowledgement is due to the contribution of the writing skills of Jan Froehlich.

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ABSTRACT

As part of the pooled fund research project, the Washington State Department of Transportation was selected to field-test approximately 100 tons of Calcium Magnesium Acetate (CMA) to evaluate its potential as a deicing chemical with direct comparison to salt (Sodium Chloride) and Urea. Evaluation included all aspects of storage, handling, use, and performance. CMA was applied whenever necessary at each test site, using the same application rates as presently used for salt. Typical equipment consisted of front dump trucks with the spinner ahead of the rear axle, and rear discharge hopper trucks. All equipment was used without modification.

The use of CMA at the beginning of a storm reduced the amount of bonding of snow to the roadway surface. This effect of keeping the roadway surface bare for longer periods of time reduced the cost of snow fighting. This was accomplished with chemical application rate of 125 lbs. per lane mile.

The addition of sand to CMA reduced the problems of dust, caking and uneven distribution. The sand provided moisture and weight to the application resulting in a smoother, more even distribution. CMA spread above was excessively dusty creating problems in the spreading and distribution. CMA is slower to react on compact snow and ice than salt or Urea. This delay in reaction time was not considered a handicap in the overall snow fighting procedure.

The conclusion was that CMA shows promise as a deicing-melting chemical. The problems of dust, light-weight and brittleness need further work and may be significantly alleviated by development of a hydrated compound.

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I. SUMMARY

The Washington State Department of Transportation field-tested Calcium Magnesium Acetate (CMA) in a wide range of weather conditions and temperatures, using standard equipment.

Although slower acting than salt or Urea by about 20 minutes, CMA does break the bond of compact snow or ice with the roadway surface. It is most effective at temperatures above 25° F., which is consistent with results for salt and Urea.

CMA and sand mixed provided approximately the same results as a similar salt/sand mixture. The sand helps hold the chemical on the roadway until melting action begins.

When applied to roadway frost, CMA appeared to cause a steady draw of moisture, requiring additional applications. By comparison, salt seemed to melt the frost and allow drying during warmer periods of the day.

The CMA tested was lightweight, which created difficulties in application. The material would blow off a full load, creating a minor visibility problem. The lack of weight also contributed to uneven distribution as the load was reduced through application. CMA would cake on the truck bed and in the spinner assembly whenever moisture interacted with the dust. The excessive dust also created problems in handling.

CMA applied at the beginning of a snowstorm provided the most exciting results. The application of a small quantity (125 lbs/lane mile) of CMA at the beginning of a moderate (1.5" per hour) snowstorm maintained a compact-free roadway. The CMA was applied at 26° F. in moderate traffic. Salt was applied to the opposite lanes at a rate 6 times that of CMA, and required continuous plowing to keep the roadway free of slush. If this performance is verified through additional tests, it could greatly reduce the cost of snow and ice control.

The conclusion was that CMA shows promise as a deicing-melting chemical. The problems of dust, light-weight and brittleness need further work and may be significantly alleviated by development of a hydrated compound.

COMMENTS FROM THE SUPERINTENDENTS OF THE TWO TEST AREAS

The Maintenance Superintendents of the two test areas submitted the following comments about their use of CMA as an alternative deicer:

1. CMA reacted well with snow or ice with temperatures ranging from mid 20's to 32° F.

2. CMA reacted slower than Urea.

3. Very dusty to handle--men had to use face masks.

4. Created dusty conditions when applying. Spinner seemed to break it up causing dust problems.

5. Single biggest problem was the drawing of frost in areas of previous applications. Caused continuous use of chemical. Areas that would normally dry out during daylight hours would stay wet and ice up in late afternoon or early morning.

6. It did not react as fast as Urea with the snow bottom which caused excessive chemical movement by traffic.

7. We felt 400-600 lbs. per lane mile was not adequate to get the same results as we were getting with 400-600 lbs. of Urea.

8. Appears to work best when applied with sand. The sand helps hold the chemical until melting action begins.

9. Temperatures below 24° F. greatly reduces the melting effects of CMA.

10. No corrosive effects of CMA have been noticed on any of the equipment used during the testing.

11. As a traction device, it was very noticeable that CMA prevented any ice floor from developing, while this was not the case with salt in this same storm.

12. CMA, when applied to compact snow and ice, generally stayed where contact was made, while salt slid off the lane surface.

13. Salt proved more effective in the dissipation of snow and ice in plow berms.

II. CONCLUSIONS AND RECOMMENDATIONS

While CMA has a slower reaction time on compact snow and ice than either salt or Urea, we did not find this unacceptable. The overall effect of a 20 minute delay in reaction was not deemed to be critical in a continuous snow fighting operation.

A mixture of 1 part CMA and 5 parts sand, stored in the open, proved sufficient to retain deicing properties and keep the stockpile from freezing. Mixtures lower than 1 part CMA to 5 parts sand should be investigated. If deicing was still maintained, a 1 to 10 mixture would be more cost effective.

Additional research should be directed toward developing a CMA product that will be more dense and dust free. The present product is extremely dusty, which created problems in both handling and spreading.

Future testing should pursue the application of limited amounts of CMA (125 to 200 lbs. per lane mile), at the onset of a snow storm in areas where sand is undesired. The savings to be realized from decreased plowing, sanding, and sand cleanup would influence overall costs and might significantly narrow the break-even point between CMA and salt.

III. DISCUSSION

Physical Setting of Study

Tests were conducted in three separate areas in Washington State:

1. Interstate 90 through the Cascade Mountains from the Snoqualmie Pass Summit at M.P. 52.4 to the western terminus of the Denny Creek Viaduct at M.P. 50.4. Salt had never been used on the 3,300 foot long viaduct and this area was used for test comparison with Urea.

2. Another section of interstate 90 in the Snoqualmie Pass vicinity, M.P. 56.3 to M.P. 57.0, was used for a side-by-side comparison with salt. CMA was applied to the westbound lanes and salt to the eastbound lanes, both with and without abrasives.

   The State of Washington is influenced by a Pacific marine flow which resulted in 479 inches of snowfall in the Snoqualmie Pas area during the winter.

3. The Spokane Viaduct section of Interstate 90, M.P. 279.5 to M.P. 285.6, was used for a comparison of salt vs. CMA without abrasives under drier, colder conditions than are typical at Snoqualmie Pass.

Skid tests, evaluating both CMA and Urea, were conducted at the Washington State Patrol Academy test track on asphalt concrete pavement, and on Portland Cement concrete on Interstate 5, M.P. 111 to 112, northbound.

Testing Conditions

During the first quarter of the 1983 test period (ending March 31, 1983), our test areas received below average snowfall, and chemical de-icers were not necessary. However, conditions for the fourth quarter of the 1983 test period (October 1, 1983 through December 31, 1983) provided opportunities for testing CMA in a wide range of conditions and temperatures. Weather during this period included freezing rain, heavy wet snow, dry blowing snow, compact snow and ice, and beginning storm conditions.

The Snoqualmie Pass test area is equipped with eight surface systems sensors that are capable of continuously monitoring and recording air and surface temperatures on the Denny Creek Viaduct. Avalanche crews monitor and record meteorological data at Snoqualmie Pass on an around-the-clock basis. Our drivers recorded the time and rate of application of each load of deicing chemicals; this information was compared to the sensor records to determine the volume of chemicals required to produce satisfactory results at various temperatures.

Materials and Methods

A storage test was included in which CMA was stored in 200-pound quantities for each of five separate test methods: covered and uncovered in both bagged and bulk form, and mixed in a ratio of 5 parts sand to 1 part CMA, by volume. All Urea and salt storage was in bulk form in enclosed sheds.

Equipment consisted of front dump trucks with the spinner ahead of the axle, and rear discharge hopper trucks. The equipment was not modified for CMA. We used equal distribution rates for salt, CMA, and Urea. It was not deemed important to adjust the application rate of any individual chemical to achieve an equal melt rate. The specific gravity of salt is 2.17, Urea is 1.33, and CMA is 0.83.

Test Procedures

The specific test areas were well defined for control and comparison. They were selected by the local maintenance superintendents for ease of access and application control without sacrifice to either the test program or the primary mission of keeping the highway open to traffic. Applications were performed whenever necessary.

Deicing chemical tests were documented as to application rates, handling techniques, problems encountered in application, air and surface temperatures, rate of penetration (visual comparison), length of melting condition, and general results. In an attempt to standardize the reporting and the data analysis, we used slightly modified versions of forms suggested by the Michigan Department of Transportation. These forms were reviewed and accepted by field personnel.

Storage testing was monitored on a monthly basis through September, 1983 when our storage test site was inadvertently buried with a load of bulk salt.

Each test was documented by the drivers, supervisors, and an observer. The reporting sequence allowed an immediate report from the driver relating any problems in the delivery of CMA, a 15 to 30-minute delay report from the supervisor as to reaction time of the chemicals, and a one-hour delay report from the observer detailing the roadway surface condition.

Applications rates varied, depending on weather conditions. At the Spokane site, application rates ranged from 125 pounds per lane mile applied at the start of a dry snowfall at 26°F with very slight winds, to 400 pounds per lane mile on compact snow with 15 mph winds at 28°F. In the Snoqualmie Pass area, application rates varied from 200 to 750 pounds per lane mile.

The final test application used 15 tons of CMA and sand in the Snoqualmie Pass vicinity, mixed at a rate of 1 to 5.

Skid testing was done with a full-scale tire according to ASTM E274-79, using water and various concentrations of CMA and Urea as a lubricant at 40 mph on asphalt concrete pavement and portland cement concrete surfaces.

Results and Discussion

CMA appeared to be more hygroscopic than salt, although a crust would form resulting in less actual leaching during storage than is typical for salt. CMA cannot be stored in the open under polyvinyl, as the film deteriorates either from weather or from reaction to the acetic acid. Our storage test area was inadvertently violated by a bulk shipment of salt, which terminated our long-term storage tests after 8 months. Results to the time of termination indicated that both bagged and bulk storage of CMA can be accomplished at a reasonable cost.

The mixing of CMA and sand (1 part CMA to 5 parts sand) while preparing stockpiles proved effective in protecting stockpiles from freezing. The CMA/sand mixture also retained enough chemicals to work as a deicer. This mix results in a greater percentage of the material being applied where it is needed and staying there. It also reduces chemical and vehicle use compared to separate applications, while not contributing to an increase in chloride damage.

CMA was, generally about 20 minutes slower to react than either salt or Urea, but it did provide the same final reaction of breaking any bonding of the compact snow or ice with the pavement surface.

We tested CMA in weather conditions ranging from freezing fog to heavy snow. This included freezing rain, which dropped as rain but froze when it came in contact with the frozen roadway surface. When CMA was applied, the moisture from the rain assisted the CMA to work at a surface temperature of 19° F. and break the bond of ice with the roadway surface. The rain is assumed to have assisted this action, which occurred at a temperature below the normal range for this deicer. CMA is most effective above 25° F.

At the Spokane site, application of CMA at the start of a dry snowstorm resulted in a significant decrease of compacting and far less effort in maintaining a bare pavement, as compared to salt, during a 10-inch snow fall over a six-hour period. Some observers independently noted that if CMA is applied at a rather low rate (under 200 pounds/lane mile) at the beginning of a storm, it will be unlikely that compact snow and ice will form.

Regarding skid testing results, we compared CMA and Urea using formulations similar to the Pennsylvania Transportation Institute (P.T.I.) tests. The P.T.I. concluded that saturated solutions of CMA did not lower the friction numbers but that Urea did lower the skid numbers substantially. Our two-year field experience with Urea did not agree with the P.T.I. report, and our skid test results agreed with our field experience. Only the first test of Urea showed any significant decrease in the friction number when compared to the friction numbers using water. All the other tests showed some slight differences but each was within the limits of test reproducibility for skid numbers. Our laboratory personnel and personnel from P.T.I. were unable to determine why different results occurred from duplicate procedures.

Any movement (handling, breaking bags, loading trucks, and spreading) of CMA created excessive dust. Crews had to wear masks during manual handling operations. Bulk delivery and loading would significantly reduce this problem.

Dust resulting from CMA being applied to the roadway through the spinner may constitute a hazard to passing vehicles due to decreased visibility in some wind conditions. Roadway dust was significantly reduced by mixing CMA and sand together in the same load.

Winds in the mountain pass sometimes blew the CMA off the roadway surface before any melting action could occur. An application of sand immediately following the CMA application provided a partial remedy to this problem.

Because it is lightweight, CMA blows off the load in transport. When the load gets low, CMA does not flow smoothly through the flight chain. This results in an uneven distribution toward the end of a load. We believe that minor modifications to the chain will take care of this problem if a more dense form of CMA cannot be developed.

CMA tended to cake on the dump bodies and in the chute and spinner assemblies. This was especially true on wet equipment or if a partial load of CMA was left in a truck after a run. Cleaning the trucks was difficult, as the material had to be chipped off. Using all the truckload each time out generally eliminated clogging problems.

Maintenance crews occasionally used CMA in areas other than the designated test sites when a chemical deicer was required. This usage accelerated the crews' awareness of the effects of CMA under various conditions and indicated their acceptance of CMA as an alternative deicer.

In conclusion, we believe CMA shows promise of a viable deicing or melting chemical. We would be willing, and able, to justify some extra cost and effort that associated with salt in view of the high costs of corrosive damage done to bridge decks and auto bodies.

The current problems of excess dust, light-weight, and brittleness are, to some extent, associated with the chemical makeup. Formulation of a hydrated compound of CMA may significantly alleviate these problems. It is worth pursuing.

The final pages of the report provide capsule accounts of each application of CMA made during this research project.

CMA RESEARCH PROJECT

STORM	TEST	TEMP	SURFACE	NO. OF POUNDS PER LANE MILE CMA	SALT	UREA	RESULTS	COMMENTS
1	1	29	Compact	375	375		CMA slower	CMA was slower to break bond than salt, created less moisture, but did break bond about 10 minutes later.
2	1	31	Compact Blowing Snow			650	Slush	Snow bottom was broken and with sand provided good traction. UREA still working after 9 hours.
	1	29	Compact Blowing Snow	750	750	750	Bottom broken	Good traction after 30 minutes. CMA test section is higher elevation than UREA. Sand/salt worked 15 minutes faster than either CMA or UREA.
2	2	29	Compact Poor Traction Blowing Snow	650		650	Good traction	Compact was broken. CMA worked faster than UREA, but did not maintain good traction for as long a period in snow storm.
3	1	29	Compact	625		625	Bottom breaking in 30 Min. CMA 15 min. in UREA	CMA did not respond as fast as UREA, but gave good traction after 30 minutes.
4	1	29	Blowing Snow Thin Ice	525		525	After	In 30 minutes UREA broke bond. CMA did not allow bond to form from blowing snow.
5	1	26	Compact Snow & Ice	375	1800			1,800 lbs. of sand and salt/mile, 375 lbs. of CMA/mile. CMA was patchy, salt and sand cleared roadway. Light weight of CMA made very patchy application rate.
6	1	24	Thin Ice	130			Whipped off by traffic.	Heavy traffic whipped CMA off, same effect as salt and UREA.
7	1	26	Freezing Rain	571			CMA slower	Mixed with sand in truck, spread evenly and gave good results. Slower than salt/sand but gave good traction.
7	2	28	Freezing Rain	400	400		1 hr. for reaction	Suggestion that on freezing rain a lighter application more frequently may be better. Video-tape on this one.
8 8	2 3	19 24	Blowing Snow	250 250				No compact formed. Bond of snow never materialized. Opposite lane developed compact. (No other chemical used).

STORM	TEST	TEMP	SURFACE	NO. OF POUNDS PER LANE MILE			RESULTS	COMMENTS
				CMA	SALT	UREA		
9	1	30	Compact Snow	1000			Good	CMA & Sand 1-5 broke bottom.
10	1	31	Compact Snow	400			Good	Strip melting bottom was broken.
11	1	31	Wet Snow	400		400	Fair	Slower to work than UREA.
12	1	31	Compact Snow and Ice	1000	1000		Good	Same as salt when mixed 1-5 with sand.

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STORM	TEST	TEMP	SURFACE	NO. OF POUNDS PER LANE MILE CMA	SALT	UREA	RESULTS	COMMENTS
1	1	22	Dry Blowing Snow	222			Bad	Plugged chute on truck would not allow distribution. Salt/sand was applied on same area because of accidents.
2	1	22	Blowing Snow	200	400		None	CMA did not break the bond in dry compact. Salt was applied in same area after 4 hours. Trouble with distribution again.
3	1	25	Compact Snow	333	333		30 minutes	Penetration to roadway surface in 30 minutes. Problems with application from chute, less moisture evident in CMA lanes than salt lanes.
4	1	25	Compact Snow	666	666		Good	Pavement cleared in 1 hour--2 lanes. Less moisture than salt lanes. Driver thought results were better than salt lanes.
5	1	26	Compact Snow	600			Good	Not much traffic, but penetration to surface in 1½ hours.
6	1	27	Blowing Snow	200	500		Fine	No compact formed on CMA lanes. Crews liked the salt application better because of slush being removed easily. However, nothing formed on CMA lanes, therefore, no plowing was required.
7	1	30	Black Ice	125			30 minutes	Removed black ice in 30 minutes.
8	1	30	Ice	416	500		Good	Same results as salt, no differences noted. Moisture on road from previous snow was freezing. Both CMA and salt broke the surface bond satisfactorily.
9	1	32	Wet Snow				Bad	CMA plugged the equipment.
10	1	14	Dry Snow	200			None	No results. Test was for lower limits. 14° F. is below limit of CMA, UREA and salt.
11	1	23	Dry Snow	400	400		Slower	CMA was blowing off roadway and trapping snow at side of lanes.

TOTAL CHEMICAL USED

HYAK		
SALT	400 tons	Freezing rain, 8 storms required bulk of this.
UREA	200 tons	Denny Creek Bridge and selected spots.
CMA	60 tons	Test area and selected spot use.
SPOKANE		
SALT	230 tons	
UREA	15 tons	
CMA	38 tons	In test -vs- salt

STORAGE

Figure (1) Bagged CMA stored at Snoqualmie Pass test area

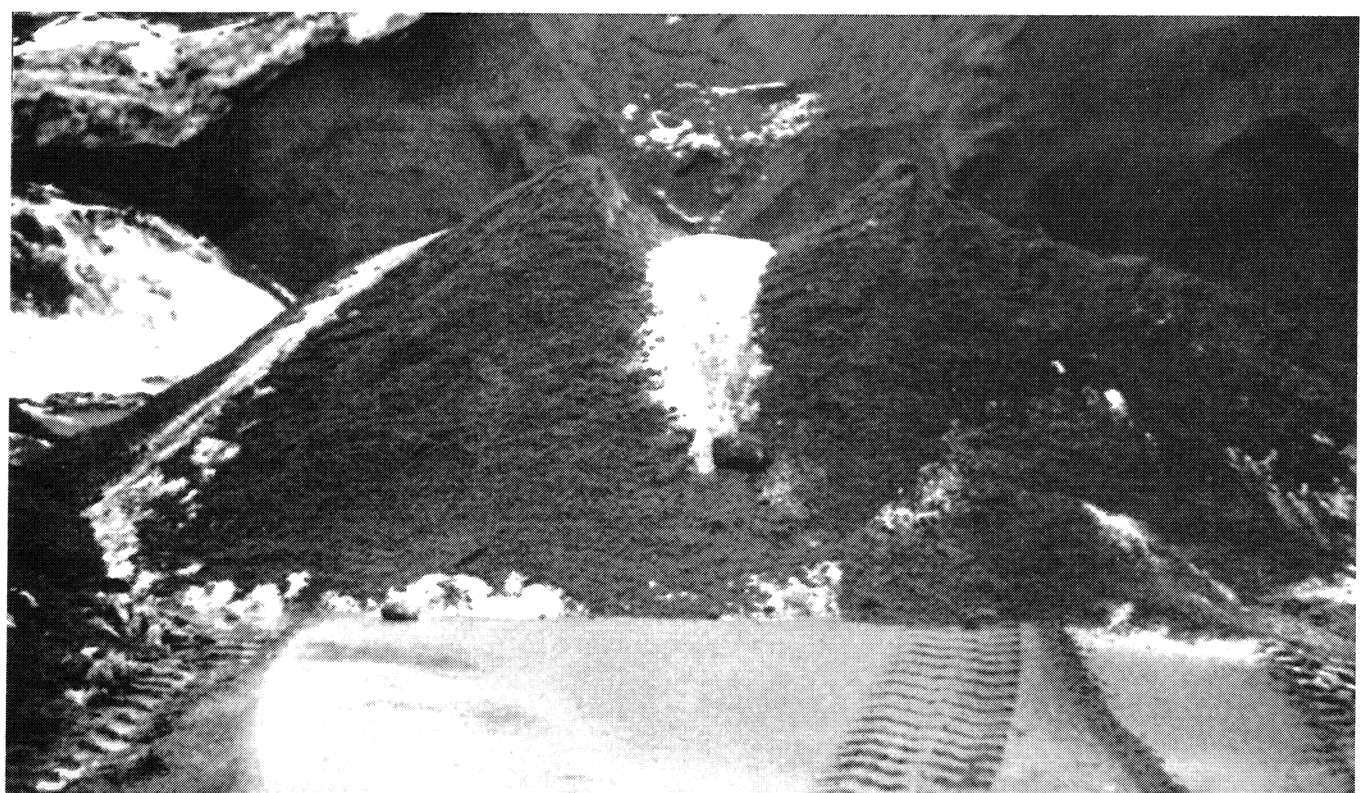

Figure (2) CMA mixed with sand at Snoqualmie Pass test area

EQUIPMENT

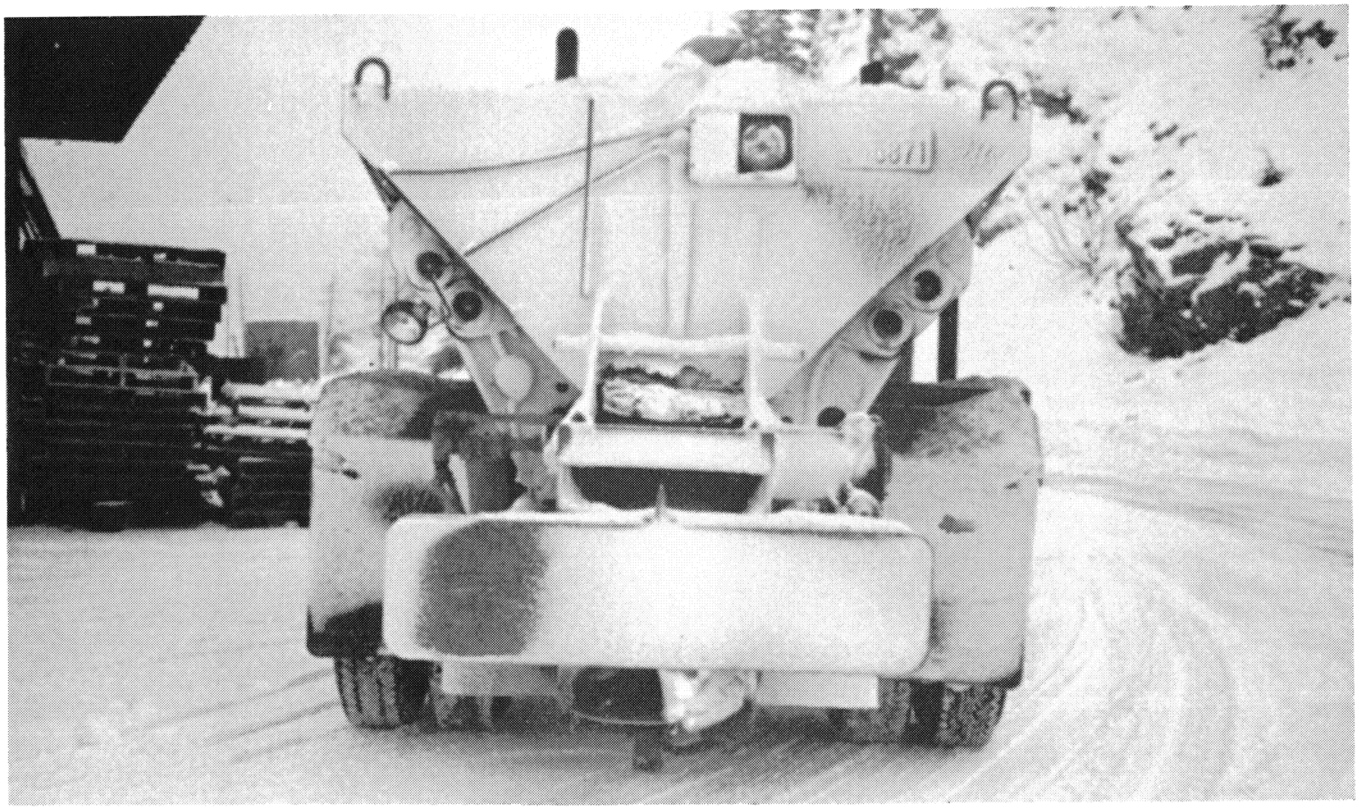

Figure (3) Hopper/Sander

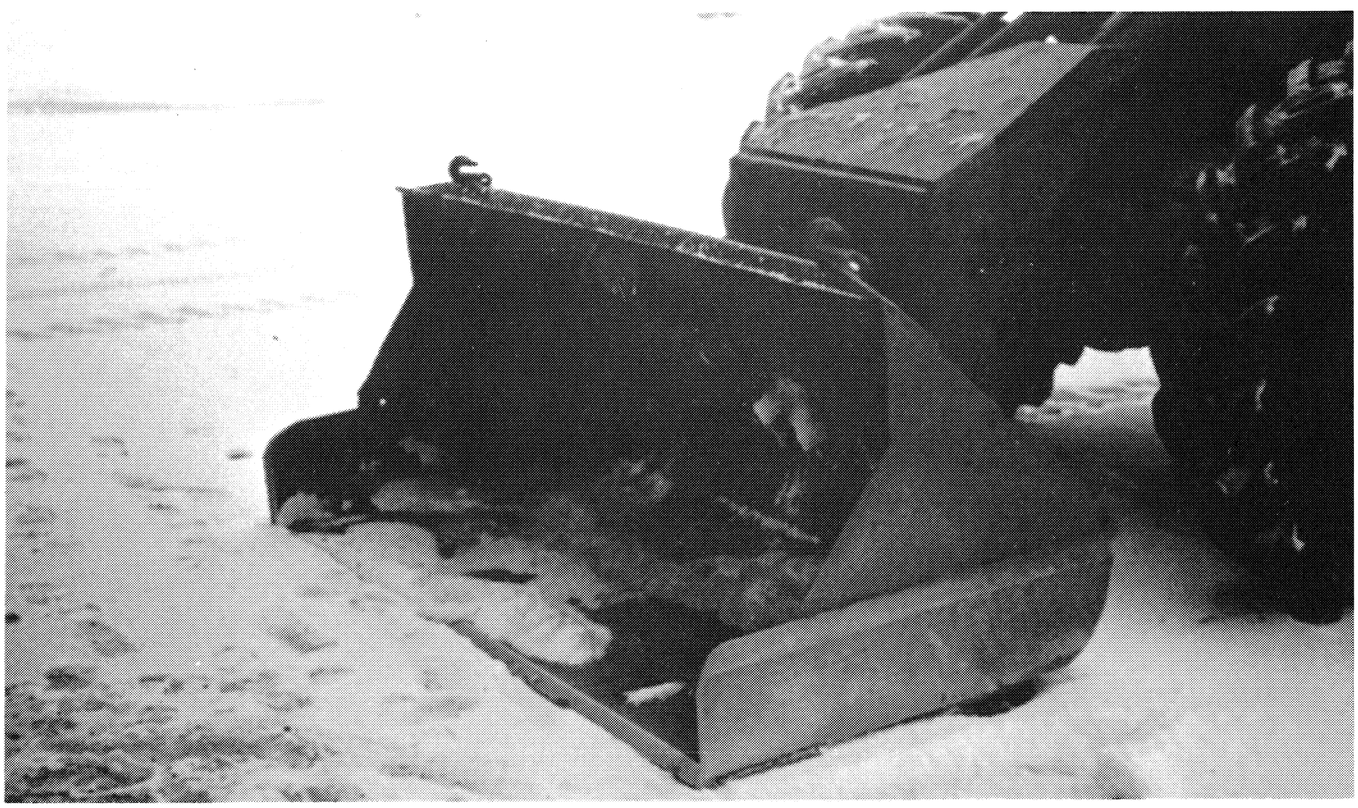

Figure (4) Loader

HANDLING

Figure (5)   Bagged CMA being emptied into loader bucket

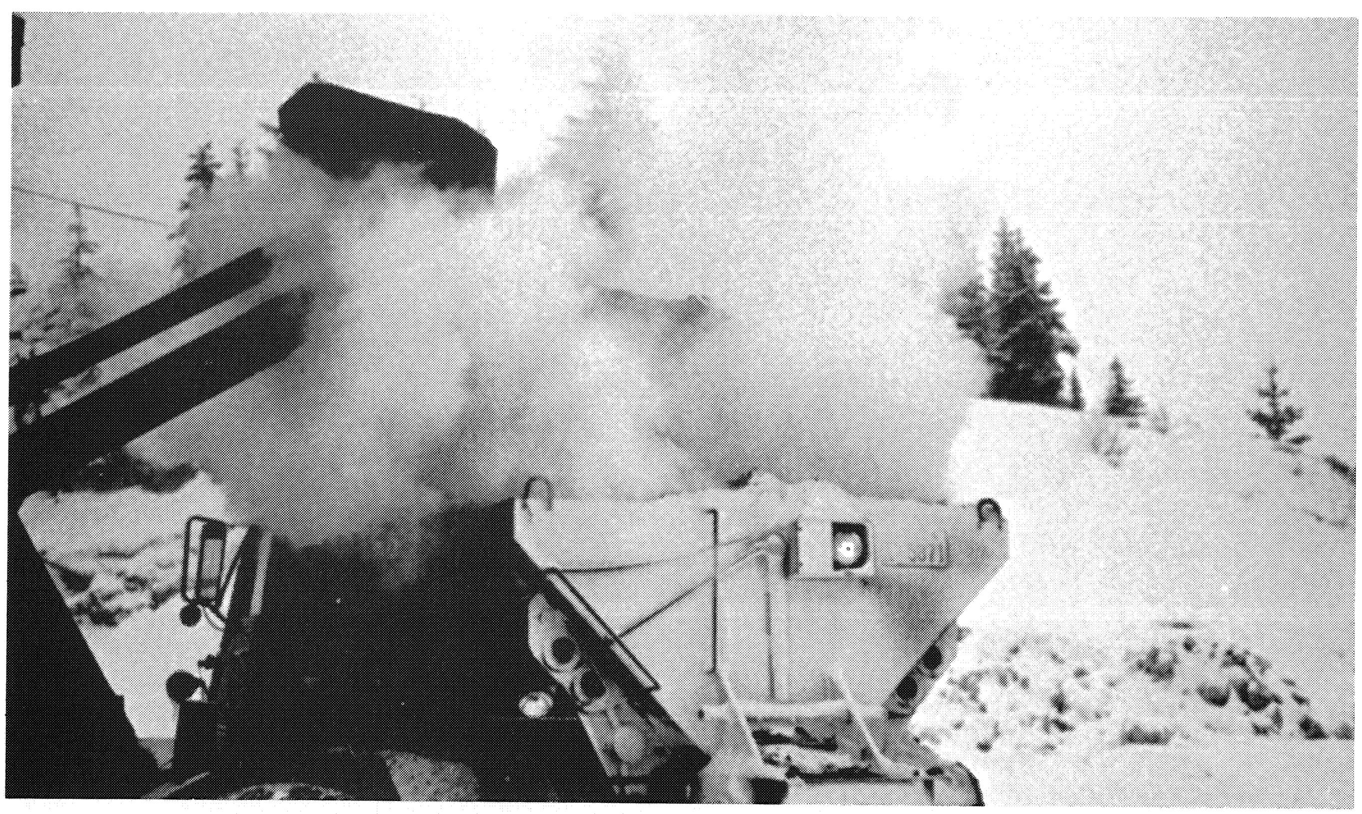

Figure (6)   Loader being emptied into hopper spreader prior to application. Dust cloud is result of breakup of CMA [illegible]

RESULTS

Figure (7) and (8) Interstate 90 forty minutes after CMA application at 29 degrees