Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
SPR-UAF-92-21		

4. Title and Subtitle	5. Reporting Date
High Capacity Intersection Thaw System	February 1995
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
John Zarling	INE/TRC 94.13

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Institute of Northern Engineering University of Alaska Fairbanks Fairbanks, AK 99775-5900	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered.
Alaska Dept. of Transportation and Public Facilities Engineering and Operations Standards 3 Mile Building 3132 Channel Drive Juneau, Alaska 99801-7898	Final
	14. Sponsoring Agency Code

15. Supplementary Notes

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Design guidelines are presented for the two most commonly used deicing systems: electric heating cable and hydronic using pipes embedded in the pavement. Manufacturers of these systems have considerable design and installation experience with private sector applications and should be consulted prior to designing either of these types of systems.

A numerical finite element heat transfer analysis was carried out to determine the effects of pipe spacing, depth and temperature and insulation depth below the piping system of pavement surface temperature. Based on this analysis, a model deicing system was constructed and actual melting rates were measured.

Several high capacity intersections were identified in the Anchorage area as potential sites for a thermal deicing system. Heating requirements have been estimated for Anchorage, and several installed sidewalk snow melting systems are described. Recent design and construction experience by the Oregon Department of Transportation is reported for both electric and hydronic bridge deicing systems. Their cost data along with the heating requirements and energy prices and consumption for an Anchorage deicing system can be used for estimates of installation and operating costs.

17. Key Words	18. Distribution Statement
High capacity intersection, thermal deicing.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified	unclassified	122	

Alaska Cooperative
Transportation and Public Facilities
Research Program

Final Report

High Capacity Intersection Thaw System

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This report covers the first year's work performed in order to evaluate the potential applications of high capacity roadway intersection thawing systems for the Anchorage area. A survey of "lower 48" Departments of Transportation located in the northern tier states was conducted to determine their use of thermal deicing systems. Manufacturers of thermal deicing systems were also surveyed. Results of these surveys as well as a literature search on deicing systems using the TRIS data base have been compiled and reported.

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Table of Contents

List of Figures

List of Tables

Introduction

This project consists of a preliminary theoretical evaluation of pavement heating systems for deicing purposes at high traffic capacity intersections during wintertime in south central Alaska. Safety improvement is the primary objective for using roadway deicing systems to achieve reduced stopping distances and increased tire traction. Side benefits would include decreased acceleration and deceleration times, resulting in more efficient traffic flow and reduced costs associated with vehicle accidents and repair and sanding.

There are several short and long term gains if intersection thermal deicing systems prove feasible. Because vehicles are able to decelerate and accelerate more quickly through intersections, the following potential benefits exist:

1. Less energy used idling while waiting for passage through intersections,
2. Less air pollution due to reduced time for passage through intersections,
3. Reduced maintenance costs by eliminating sanding and spring clean-up of intersections,
4. Reduced travel time, which increases the efficiency of commerce, and
5. Reduced vehicle accident rates due to deiced intersections.

These benefits eventually must be weighed against the installation and operating cost of an intersection deicing system.

Because of high traffic volumes in the south central region of Alaska and its more moderate weather conditions, a greater potential exists for implementing such a system. Therefore, identifying sites in the Anchorage area was one of the goals in the first year's effort. The second goal was to investigate a number of design options for pavement deicing systems. These options include electric and hydronic systems.

The emphasis for this stage of the study was to address the two aforementioned objectives. The first step was a literature review of reports and publications detailing the design of pavement

deicing systems used in the past. An overview of this information is presented in the next section. This review of state-of-the practice plus the references given in the Bibliography and Appendix should enable a design engineer to quickly access the options available for roadway thermal deicing systems. The second step was to conduct a survey of "lower 48" DOT's to assess their use of thermal deicing systems. A similar survey of vendors and designers of pavement thawing systems was conducted as the third step. Site identification of possible high traffic volume intersections was the fourth step. The fifth step was a thermal analysis and an experiment to develop some "rules of thumb" that can be applied to the design and selection of thermal deicing systems. Finally, energy requirements and costs for a deicing system located in the Anchorage area were determined. Overall life cycle costs can be estimated based on the above operating costs combined with Oregon Department of Transportation's installation costs.

Typical Energy Sources and an Overview of Deicing Systems

Energy sources for intersection deicing systems range from high grade energy in the form of electricity, natural gas or fuel oil, or steam, and finally to low grade forms of energy such as waste heat. Electricity has the advantage of being readily available, but the cost per watt-hour or BTU is the highest. Natural gas in the Anchorage area is relatively low in cost and could be used as an energy source to heat an antifreeze solution for a hydronic deicing system.

Electric Systems

Snow melting with electricity as an energy source uses insulated electric cable embedded into or below the paving materials. Mineral insulated heating cables consist of a die drawn seamless copper or stainless steel alloy sheath surrounding copper or copper alloy conductors with the annular space filled with magnesium oxide. The outer metal sheath is usually protected from corrosion by a high density polyethylene jacket extruded over the cable. An alternative to the resistive line conductors is to use resistive elements to bridge the space between to two line conductors. Metallic elements are solid or stranded conductors spirally wound around a nonconducting fibrous material core. In some designs the magnesium oxide is replaced with a conducting element such as a polymer with a given amount of resistance. The polymers have a resistance that is a function of temperature, providing a self-regulating characteristic. These polymer-type heating cables' output decreases with increasing temperature. When energized, the resistive element will produce the specified amount of heat. Both types are covered with a protective exterior layer of insulation such as silicone rubber or polyvinyl chloride.

Cable spacing depends primarily on the heat conducting ability of the material in which it is to be placed. Concrete has a higher thermal conductivity than asphalt, permitting a larger cable spacing. Spacing for optimum performance usually lies within the following limits: 6-inch to 12-inch spacing for concrete and 4-inch to 9-inch spacing for asphalt.

The following details must be determined, and specifications set accordingly, when designing an electric system: heated area size, watts per square foot, voltage available, and approximate cable length. Mats or cables must not be damaged by compaction equipment during installation. Expansion joints must be considered, and all wiring must conform with the National Electric Code. Ground fault interrupts should be used to provide for personnel safety.

Raychem (1991) recommends the following steps for a successful installation:

(1) Determine required cable spacing. Most systems use 12-inch spacing in concrete at a minimum depth of 1-1/2 inches. Actual spacing is dependent on weather conditions and performance expectations for the melting/deicing system.

(2) Create a drawing showing placement of heating cable, electrical supply and control components.

(3) Calculate the required power requirements based on the area of coverage and cable spacing.

(4) Determine the voltage and circuit breaker needs. Most electrical deicing systems operate on 208 V to 277 V power.

(5) Write specifications. Vendors of heat tracing cable usually have available model specifications for their individual systems.

(6) Install the system according to the manufacturers specifications. (7) Test the system during and after installation to ensure expected performance.

Self regulating heating cable responds to the local pavement temperature, increasing output when the pavement temperature drops and decreasing output when it rises. Self regulating heating cable cannot overheat and destroy itself, even if overlapped and therefore does not require the use of overlimit thermostats.

The 12-inch spacing standard using Raychem ElectroMelt EM2-XR cable is adequate for the majority of applications. This spacing will keep pavement temperatures above freezing at temperatures down to 5°F and a wind speed of 10 miles per hour or less. This spacing would also prevent snow accumulation 97% of the time. For more severe conditions, non concrete pavements, ramps and walkways with air below, cable not embedded in concrete from four to

six inches thick, and concrete without steel reinforcing, the Raychem design manual should be consulted. Table 1 below presents Raychem's recommendations for cable spacing required to keep the surface above 32°F for ambient temperatures below 5°F and wind speeds in excess of 10 mph.

Table 1: Raychem's Reccomendations for Cable Spacing

Ambient Temperatures (°F) for Ice-Free Surfaces

Heating-cable spacing (in inches)	**Average Wind Speed during freezing period**			
	5 mph	**10 mph**	**15 mph**	**20 mph**
6	-40	-25	-10	0
8	-40	-10	0	10
10	-25	0	10	15
12	-15	5	15	20

The effective power (energy delivered to the surface) of a snow melting system is used to warm the fallen snow to the melting temperature, supply heat to melt the snow, and provide for the evaporation and make up for the convection and radiation losses from the surface.

Circuits must be sized not only to handle the steady state power requirements of the heating cable but also the start-up amperage requirements. The start-up amperage quickly drops off as the cable increases in temperature and the power requirements decrease. Proper grounding of the cable is a must.

Hydronic Systems

Hydronic system design includes the selection of the heat transfer fluid circulating through the system, the fluid heater, pumps to circulate the fluid, pipe system type and layout, and controls. Thermal stresses in the concrete or asphalt are also a consideration.

A variety of fluids for transferring heat are available. These range from glycols, to heat transfer oils, to brines such as sodium chloride, calcium chloride, or potassium acetate. Although

makes them somewhat undesirable. Glycols (ethylene and propylene) are most often used in snow melting systems because of their moderate cost, high specific heat, and with inhibitors, the ease of corrosion control. The disadvantage of glycols is that their viscosities becomes high at low temperatures and care must be exercised to prevent leakage — especially for ethylene glycol due to its toxicity. Heat transfer oils are relatively expensive and have low specific heats, and their corrosion potential is low. Potassium acetate, manufactured by Vanguard Plastics in McPherson, Kansas, is being used as a heat transfer fluid in ground source heat pump systems because of its low viscosity and nontoxicity; it should be a strong candidate for hydronic thawing systems. Cost of GS4 (potasium acetate) range from $12.63 per gallon in 55 gallon drums to $9.36 per gallon in 4,400 gallon bulk truck loads, FOB Seattle, Washington.

Piping system types placed within the pavement are metal or plastic. Corrosion can cause rapid failure of steel or iron pipe if proper precautions are not taken. Plastic pipe is more popular because of its lower cost and higher corrosion resistance. Precaution is necessary so that the fluid temperatures required will not damage the plastic. Polybutylene, polyolefin and polyethylene are the most frequently used materials.

Pump selection depends on the flow rate required, the system's pressure and suction head requirements, the corrosion potential of the fluid, and the viscosity of the fluid at start up. Pumps and controls need to be protected from the environment and vandalism. A utility building or pit is recommended.

The fluid heating equipment in most hydronic systems are gas or oil fired boilers if on-site generation is required, or electric boilers or steam converters if off-site generation. In some applications, diesel or gas engine waste heat is used. Air elimination or venting and expansion tanks are required in well designed systems.

Wirsbo (1989) is a major producer of high density polyethylene tubing for hydronic deicing systems. They have installed over 30 million square feet of heated surface area around the world, including roadway intersection deicing systems in Scandinavia. Wirsbo recommends fluid

world, including roadway intersection deicing systems in Scandinavia. Wirsbo recommends fluid temperatures of 90°F to 120°F. This makes it possible to easily use waste heat as an energy source. The basic design principle applied to the piping loop layout is to maintain loop lengths within 2-1/2%. This eliminates the need for balancing valves, and the loops can be connected to a single manifold. Complex systems may require multiple manifolds. For highway construction, Wirsbo suggests that the tubing be placed at the bottom of the asphalt. This company has a technical department that will assist in all phases of a deicing project including design layout, specifications, engineering, compilation of material lists, fixed price quotation, and installation supervision.

Adlam (1950) presents a summary of a design procedure that can be used as a guide for design of a hydronic ice and snow melting system. The steps he lists are as follows:

1. Determine the snowfall rate for the site chosen.

2. Determine the water equivalent of this snowfall rate.

3. Using the equations given in a later section or in Table 2, estimate the total heat load, q_o, and antifreeze fluid temperature.

4. Determine pipe type, size and spacing. Adlam (1950) provides charts for pipe spacing based on different pipe and surface (asphalt and concrete) types.

5. Layout coils, connect piping and boiler location.

6. Select concentration of antifreeze to prevent freezing during off cycles.

7. Estimate the amount of antifreeze required.

8. Calculate the maximum total load on boiler and select boiler. The start-up load should be considered. Review all materials for compatability against corrosion.

9. Calculate the pipe friction.

10. Select pump to satisfy flow and head loss requirements.

11. Review pipe expansion considerations.

12. Decide on control strategy.

Table 2 given below is from Chapman (1952) and can be used as a guide for estimating the total heat transfer rate and the temperature of the antifreeze circulated through the hydronic piping coils as a function of snowfall rate, outdoor temperature and local wind speed. The ASHRAE procedure for estimating the total heat flux will also be presented. Using this method, the individual components contributing to the total heat flux can be claculated.

Table 2: Heating Requirements (BTU/hr-ft^2) and Antifreeze Temperatures as a Function of Snow Fall Rates, Wind Speeds and Ambient Temperatures.

Snowfall (inches of water, equiv.)		Air Temperature											
		0			10			20			30		
		Wind Velocity											
		5	10	15	5	10	15	5	10	15	5	10	15
.08	q_o	151	206	260	128	169	210	103	129	156	76	87	97
	T	108	135	163	97	118	138	85	98	111	71	76	81
0.16	q_o	218	273	327	193	234	275	166	192	219	136	147	157
	T	142	169	197	129	150	170	117	130	143	101	106	111
0.24	q_o	293	347	402	265	306	347	236	262	289	204	214	224
	T	179	207	234	166	186	207	151	164	177	135	140	145

Heat Pipes and Thermosyphons

A heat pipe consists of a sealed pipe filled with a working fluid having both liquid and vapor phases present. An internal wick installed in the sealed pipe causes the liquid to flow by capillary action along the entire length of the pipe. When heat is added at one end of the pipe the liquid vaporizes and flows as a gas to the cooled end where it condenses and returns to the heated end via the wick. This continuous evaporation and condensation of the working fluid gives rise to very high heat transfer rates, which are characteristic of heat pipes. If the wick is eliminated the heat pipe becomes a thermosyphon. In this case, gravitational force must return the liquid to the heated end and therefore the device will only work if the evaporator section is lower than the condenser section.

The use of ground-coupled thermosyphons to heat pavements was initially proposed by Tippmann (1965). The initial field tests of thermosyphon based pavement heating systems was conducted at the Turner-Fairbanks Highway Research Station in 1972. These successful tests were followed by the installation of 1,213 thermosyphons in a West Virginia highway ramp in 1975 (Nydahl et al., 1987). An earth coupled system was also tested by the New Jersey Department of Transportation in 1969.

These efforts led to the installation of thermosyphons in four highway structures, as reported by Nydahl et al. (1987a, 1987b). Water source thermosyphons were used to heat bridge decks in order to prevent surface icing, in Colorado and Wyoming. The first bridge deck demonstration was along the Interstate 70 route in the geothermally active Glenwood Canyon area of Colorado. The water source for these tests was 77°F geothermal water at flow rates of about 35 gpm. The thermosyphons reduced snow cover on the heated portions of the roadway by 96%, compared to the unheated portion during the 10 month winter season. The hot water flooded evaporator sections between six and eight feet in length; the embedded condenser sections were about 16 feet in length. The Wyoming Highway Department tested a thermosyphon system that heated a quarter of a bridge deck using 47°F well water as the energy source. Despite the low water temperature, the thermosyphon system significantly reduced the icing on the bridge deck compared to the unheated section. The estimated heat transfer rate approached 35 BTU/hr-ft^2 during a melting event.

Two earth-coupled thermosyphon systems were installed in the Cheyenne, Wyoming area in 1984 to heat highway ramps (Nydahl et al., 1987). These 7% grade ramps were over 10,000 square feet in size and were coupled to the ground with 177 thermosyphons. The evaporator sections of these units were 100 feet in length and attached to a common manifold. The condenser sections had a total length of 120 feet.

A small field test on a bridge deck was conducted at Sybille Canyon in southeastern Wyoming in 1976 (Nydahl et al., 1987). Twelve 80-foot long thermosyphons heated 96 square

feet of bridge deck. This system reduced the periods of freezing on the bridge deck by 72% and 57% during two consecutive winter seasons.

In 1980 the Wyoming Highway Department and FHWA contracted for design, construction and operation of a thermosyphon based bridge deck deicing system, Nydahl et al (1987) with the University of Wyoming. The ground heated bridge, 80 feet wide and 60 feet long, was constructed over Spring Creek in Laramie, Wyoming. Fifteen thermosyphons with 100-foot long vertical evaporator sections were installed at each corner of the bridge. The condenser sections for this installation consisted of four parallel pipes 3 inches on center with lengths alternating between 40 and 20 feet so that the outer vehicle lanes were preferentially heated. The condensers were placed about 2 inches below the surface of the pavement and heated approximately 80 square feet of area. This system caused the elimination of icing on the preferentially heated lanes. Measurements indicated a 18F° temperature increase at the surface of the pavement.

Fujikura, Ltd., a Japanese company, has developed a flexible heat pipe in lengths of up to 100 meters. Their heat pipes have been installed under roadways in Sapporo, Japan as a deicing system. Either hot water boilers or geothermal energy served as a heat source for these systems. It is doubtful that ground heat in Alaska would be a practical source given the relatively low soil temperatures. However, heat pipes and thermosyphons exhibit a thermal transformer effect: a long evaporator section receiving a thermal energy at a low density can deliver energy at a high density through a short condenser section.

Literature Search

A literature search was carried out at the Rasmuson Library on the University of Alaska Fairbanks campus. In addition to the holdings of this library, a number of data bases were also searched using key words such as deicing, pavement thawing, and ice and snow control. The data base that provided that largest number of citations was TRIS (Transportation Research

Information System) maintained by the Federal Highway Administration. Appendix A contains an annotated bibliography from the TRIS search.

Survey of "Lower 48" DOT's

A directory of state DOT's was used to identify 28 chief engineers within northern tier and mountainous states of the U.S.A. Letters with a faxable return form were sent to these individuals to determine the use of thermal deicing systems within their states. See Appendix B for copies of the letter and form. Of the 28 letters sent, thirteen replies were received and summaries are given below.

California Department of Transportation
No thermal deicing systems being used

Iowa Department of Transportation
No thermal deicing systems being used

Maine Department of Transportation
No thermal deicing systems being used

Minnesota Department of Transportation
No thermal deicing systems being used

Montana Department of Transportation
No thermal deicing systems being used

Nebraska Department of Transportation
One thermal deicing system in use
City of Lincoln near the University of Nebraska on the Tenth Street Viaduct has a heated pedestrian overpass.

Contact: Roger Figard, City Engineer
(402) 441-7548

Lyman Freemon, Bridge Engineer
(402) 479-4701

New York Department of Transportation
No thermal deicing systems being used

Ohio Department of Transportation
No thermal deicing systems being used

Oregon Department of Transportation
Four thermal deicing systems in use or under construction
City of Klamath Falls, Oregon uses geothermal energy for a system that been in use for several years.

Contact: Rachael Thurston
(503) 731-8303
Portland, OR

Highland Zoo Bridge, Portland, Oregon
electric cable system
North Fork Silver Creek Bridge, Salem Oregon
hydronic piping system
I84 and UPR overpasses, Hood River, Oregon
electric cable and hydronic piping system

Contact: Oregon Department of Transportation Bridge Section
Frank Nelson, (503) 986-3324
Curt Cryer, (503) 986-3333
Merridith Mercer, (503) 986-3332

South Dakota Department of Transportation
No thermal deicing systems being used

Utah Department of Transportation
No thermal deicing systems being used

Vermont Department of Transportation
No thermal deicing systems being used

Wyoming Department of Transportation
Three bridges are being deiced using thermal systems
Bridge over North Sybille Creek
Wyo 34 MP 25.72 Albany Co.
Bridge over Spring Creek
I-80 Bus. MP 330.64 Albany Co.
Union Pacific Railroad Overpass
I-80 MP 9.37 Laramie Co.

Contact: David Pope, State Bridge Engineer
(307) 777-4427

Survey of "Lower 48" Deicing System Manufacturers and Designers

The Thomas Register was used to identify 37 companies that advertised their product or service for the manufacture or design of deicing systems. These companies were written, requesting information as to the type of product and the locations of their installations. Below is a list of the firms who are presently offering either products or services related to thermal deicing systems.

Environmental Technology Inc.
1302 High Street
South Bend, Indiana
46601
(219) 233-1202

This company has been making snow and ice detectors for about 25 years. Their systems provide control for two types of heating systems: electric resistance heaters and hydronic systems.

Heatway
Radiant Floors and Snow Melting
3131 W. Chesnut Expressway
Springfield, MO
65802
1-800-255-1996

This company offers deicing systems using hydronic systems with standard boilers for a heat source. The piping system consists of single or double pipe hose which is manifolded into a piping grid. Their products have been used in the U.S.A. and Canada.

Hume Snow Melting Systems
4403 Ferniee Avenue
Royal Oak, Michigan
48073
(313) 549-2830

This company has been in business over 25 years and has installed hydronic deicing systems throughout the U.S.A. and Canada. They use polyolefin pipe and glycol fluids. This company also offers snow and ice detectors to provide automatic control of their system.

Snow Technologies Inc.
12587 Farmington Road
Livonia, Michigan 48150
(313) 427-6691

This company provides engineering design and supply of hydronic snow melting systems. Polyethylene homopolymer plastic pipe is used.

ThermalEase
Radiant Floor Heating Systems
P. O. Box 11787
Baindridge Island, WA 98110
(206) 842-9552
(206) 842-9562 FAX

This company offers PEX and polybutylene pipe for snow melting systems.

Bio Thermal Unlimited, Inc.
P. O. Box 191
48 Canal St.
Ellenville, N.Y. 12428
(914) 647-6700
(914) 647-6828 FAX

This company offers Bio-Flex, a reinforced hose for floor heating and snow melting systems. They also sell a cross-linked polyethlene tubing, Bio-Pex for snow melting applications.

ElectroMelt System
Raychem Corporation
300 Constitution Drive
Menlo Park, California 94025-1164
(800) 542-8936

This company has developed a self regulating heating-cable. A design guide is available for their product. They recommend the placement of their electric heat trace in concrete.

Meltaway Hydronic Surface Heating
Wirsbo Co.
5925 148th St. West
Apple Valley, Minnesota 55124
(612) 891-2000

Wirsbo Co. is a subsidiary of the parent Wirsbo Co. of Sweden. They installed their first system in 1969. Since then they have installed more than 30 million feet of tubing covering an area of 25 million square feet. This company has designed and installed a roadway deicing system for an intersection with a 6% slope. Their hydronic system uses a cross linked high density polyethylene tubing with glycol fluids.

In early 1994, the International Conference of Winter Cities was held in Anchorage. At this symposium several Japanese industries exhibited a number of winter technologies and products. A listing of companies whose products are applicable to roadway deicing is presented below.

Hokkaido Electric Power Co., Inc.
2, Higashi, Odori, Chuo-ku, Sapporo 060 Japan
81-11-251-1111
81-11-882-3790 FAX

This company has conducted research and development on snow-melting systems for roads. They have installed both heat pump and electric cable melting systems. The heat pump system uses waste heat from a subway station as a source of energy to heat over 3,000 square feet of roadway surface. Heat pump coefficient of performance is 3.2 which reduces the electrical energy usage by two thirds compared to a electric resistance system.

Fujikura Ltd.
5-1, Kiba 1-chome, Koto-ku
Tokyo 135, Japan
81-3-5606-1174
81-3-5606-1514 FAX

This company produces heat pipes for snow melting and deicing. They have installed road heating and parking lot heating systems. The source of energy for the heat pipes has been either a hot water boiler or geothermal energy. This company also has offices in the USA (Fujikura

America, Inc., 1400-100 Galleria Parkway, NW, Atlanta, GA 30339, Tel. (404) 956-7200 and (404) 984-3380 FAX).

Densei Inc.
2-1, Techno Park 1-chome,
Shimo-Nopporo, Atsubetsu-ku
Sapporo 004, Japan
81-11-809-2055
81-11-809-2183 FAX

This company produces snowfall detectors and road heating control systems.

Patine' Corporation
N.J.K. Building, 2-6-1 Sugamo, Toshima-ku
Tokyo, Japan
81-3-3915-9111
81-3-3949-1171 FAX

This company offers snow-melting systems and controls.

Hokkaido Gas Co., Ltd.
373, Higashi 5-chome, Kita 4-jo
Chuo-ku, Sapporo 060 Japan
81-11-231-9511
81-11-222-6696

This company has done research and development on roadway deicing systems using gas as an energy source for a hot water boiler.

Site Selection in the Anchorage Bowl

A discussion concerning possible deicing sites occurred with Mike Tooley of the Anchorage International Airport Road office of DOT&PF. Mr. Tooley suggested four possible intersections for consideration as a potential site for a deicing system. These intersections are the following:

1. Lake Otis and 36th St.

This intersection consists of two lanes of traffic in all directions with an additional left turn lane for each direction as well. A downhill deceleration to a stop exists for east bound traffic on 36th St.

2. Old Seward Highway and Dimond

This intersection is one of the highest traffic volume intersections in Anchorage. The Old Seward Highway has two lanes of traffic in each direction with the additional of left turn lanes in both the north and south directions. Dimond Blvd has six lanes including two left turn lanes east bound into the intersection. West bound into the intersection is five lanes including two left turn lanes. There are three lanes west bound on Dimond from the intersection.

3. Lake Otis and Tudor Road

This intersection has two lanes leaving the intersection in all directions. Four lanes including two left turn lanes exist for flow of traffic into the intersection on Lake Otis. The two additional lanes are for left turns. Tudor has four lanes into the intersection from the east allowing two lanes for left turns. East bound traffic on Tudor has only three lanes into the intersection with one lane for left hand turns.

4. New Seward Highway and 36th St.

This is one of the highest traffic volume intersections in Anchorage. Five lanes of traffic enter this intersection from the north and the south on the New Seward Highway. A right hand turn lane from the south onto 36th St. exists. Three lanes of traffic leave this intersection in the same directions. This provides two lanes for left hand turns in either direction. Thirty-sixth St. has five lanes of traffic entering the intersection from the west. Two lanes of traffic leave this intersection in the east-west direction along 36th St.

Oregon Bridges and Costs

The Oregon Department of Transportation has three bridges with heated bridge decks that are presently in design or construction phase. O-DOT is performing the designs in order to maintain control over the design and implementation functions (Cryer, 1994).

The Highland Zoo Bridge on the west side of Portland is near the final stages of construction. The 150-foot long bridge has two 18-foot wide traffic lanes and a 6-foot wide sidewalk. The asphalt approaches (60 feet by 36 feet) and ramps (210 feet by 26 feet) will be heated as well. The contractor is in the final phase of construction and only needs to place a 3-inch micra-silica overlay to complete the project (December, 1994). Electric resistance heating cable is being used to heat the bridge deck, approaches and ramps. The heating cable is manufactured by Delta Therm Inc. at a cost of $3.00 per ft. The incremental cost for the installation of the bridge deck deicing system is estimated at $18 per square foot. Electric power rates at about $0.06/kwh in the Pacific Northwest are relatively low as compared to the rest of the nation making electric resistance heating a practical alternative. The total area being electrically heated for the Zoo bridge is 13,620 square feet at an estimated total installed cost of $240,000 for a per square foot cost of $17.60.

The North Fork Silver Creek Bridge in Silver Falls Park east of Salem is being replaced. The new 105-foot long bridge will have two traffic lanes with a total width of 40 feet. Impact panels are 20-foot long on the approaches to the bridge. White cross-linked polyethylene 1/2-inch diameter PEX tube manufactured by the Wirsbo Corporation is being used for heating the

This is one of the highest traffic volume intersections in Anchorage. Five lanes of traffic enter this intersection from the north and the south on the New Seward Highway. A right hand turn lane from the south onto 36th St. exists. Three lanes of traffic leave this intersection in the same directions. This provides two lanes for left hand turns in either direction. Thirty-sixth St. has five lanes of traffic entering the intersection from the west. Two lanes of traffic leave this intersection in the east-west direction along 36th St.

Oregon Bridges and Costs

The Oregon Department of Transportation has three bridges with heated bridge decks that are presently in design or construction phase. O-DOT is performing the designs in order to maintain control over the design and implementation functions (Cryer, 1994).

The Highland Zoo Bridge on the west side of Portland is near the final stages of construction. The 150-foot long bridge has two 18-foot wide traffic lanes and a 6-foot wide sidewalk. The asphalt approaches (60 feet by 36 feet) and ramps (210 feet by 26 feet) will be heated as well. The contractor is in the final phase of construction and only needs to place a 3-inch micra-silica overlay to complete the project (December, 1994). Electric resistance heating cable is being used to heat the bridge deck, approaches and ramps. The heating cable is manufactured by Delta Therm Inc. at a cost of $3.00 per ft. The incremental cost for the installation of the bridge deck deicing system is estimated at $18 per square foot. Electric power rates at about $0.06/kwh in the Pacific Northwest are relatively low as compared to the rest of the nation making electric resistance heating a practical alternative. The total area being electrically heated for the Zoo bridge is 13,620 square feet at a total installed cost of $240,000 for a per square foot cost of $17.60.

The North Fork Silver Creek Bridge in Silver Falls Park east of Salem is being replaced. The new 105-foot long bridge will have two traffic lanes with a total width of 40 feet. Impact panels are 20-foot long on the approaches to the bridge. White cross-linked polyethylene 1/2-inch diameter PEX tube manufactured by the Wirsbo Corporation is being used for heating the

bridge deck and impact panels. Proprolyene glycol at 35% aqueous is the heat transfer fluid being used in the piping systems. Heat is being supplied by a water to water heat pump. The low temperature side of the heat pump is being supplied with well water as an energy source. The area being heated is 5,800 square feet at an estimated total cost of $373,000 which is a per square foot cost of $55.70.

The third system of bridges is in Hood River, Oregon near the Columbia River Gorge. The North 2nd. Street Bridge overpass is a combined electric and hydronic system. The combined system is being installed so real side by side comparisons can be made of the two types of deicing systems. The bridge is 206 feet long with four lanes of traffic. One twenty-foot long impact panel forms the approach to the bridge on the north end with no impact panel on the south end. An 8-foot and a 6-foot side walk parallel the 32-foot wide double lanes, yielding a total width of 78 feet. The inner lanes, middle 23 feet, are electric resistance cable heated, and the outer lanes and side walks are hydronically heated, 26-foot and 23-foot wide sections respectively. The sources of energy for the hydronic system are a gas fired hot water boiler on the east side and ground water with heat pump on the west side. The South Bridge over-passing the Union Pacific Railroad has two side walks and two travel lanes with a total area of 13,100 square feet. It is 310 feet long with 6-foot wide side walks and 12-foot wide lanes with 6-foot wide shoulders and is electrically heated. The total area of both bridges that is electrically heated is 17,800 square feet at an estimated cost of $436,000 which yields a $24.48 per square foot cost. The total area of the I-84 bridge crossing that is being mechanically heated is 11,700 square feet. The total and per square foot costs are estimated to be $453,000 and $38.72, respectively.

Heat Transfer Aspects of Thermal Deicing Systems

The design of roadway thawing systems must consider snow and water covered surfaces. When a snow flake lands on a heated surface it must first be warmed from the ambient air temperature to the melting temperature of water or 32°F. Then it is melted by the addition of the heat of fusion of water, 144 BTU/lb. During the process of warming and melting, the snow acts as an insulator. Next, the water is warmed to the equilibrium temperature of the pavement

surface. From the time of melting, the wet surface is undergoing evaporation that requires the heat of vaporization of water, 1060 BTU/lb. In addition, convective and radiative heat transfer is taking place from the pavement surface. Six heat transfer processes have been identified with respect to the operation of a snow melting system: sensible heat transfer to the snow, heat of fusion to melt snow, heat of evaporation to dry surface, heat transfer by convection, heat transfer by radiation, and sensible heating of melt water. If the rate of snow fall is S inches per hour, then the heat load to raise the snow to the melting temperature and melt this snow is

$$CS(32°F-T_{air})/12+LS/12$$

C is the volumetric specific heat of the snow, which is the product of the mass specific heat, 0.5 BTU/lb-F°, and its density. L is the volumetric latent heat of the snow which is the product of the latent heat of fusion of water, 144 BTU/lb, and the snow density. The heat load is expressed in BTU/hr-ft^2. The thermal energy required to evaporate this quantity of moisture is HV/12. H is the volumetric heat of vaporization which is the product of h_{fg}, the enthalpy of vaporization, and the density of the snow. Surface heat losses are both convective and radiative. The magnitude of the convective transfer is mainly controlled by wind speed and is affected by the speed of passing vehicles. Newton's Law of Cooling can be used to express this local heat transfer rate, q_c, as

$$q_c = h(T_s - T_{air})$$

where h is the convective heat transfer coefficient and T_s and T_{air} are the temperatures of the surface and air respectively. For radiation, the roadway surface only "sees" the sky which is likely cloud covered. Under this type of weather condition, the radiative temperature of the sky is usually assumed equivalent to air temperature. The radiative heat transfer rate, q_r, can then be expressed as

$$q_r = \sigma\varepsilon_s(T_s^4 - T_{air}^4)$$

where ε_s and σ are the surface emissivity and Stefan-Boltzmann's constant, respectively.

There is also downward heat conduction from the thawing/melting system to the ground below. The use of insulation will mitigate the magnitude of this loss.

ASHRAE (1991) provides the following simplified design equations for making estimates of most of the heat transfer components in BTU/hr-ft^2 described above. The sensible heat required to warm the snow to 32°F is

$$q_s = 2.6S(32°F - T_{air})$$

where S is the rate of snowfall in inches of water equivalent per hour and T_{air} is the ambient air temperature. The heat of fusion to melt the snow is

$$q_m = 746S$$

The combined heat transfer rate by convection and radiation is

$$q_{cr} = 11.4(0.0201V + 0.055)(T_f - T_{air})$$

where V is the wind speed in miles per hour and T_f is the water film temperature usually taken as 33°F. The heat transfer rate by evaporation is

$$q_e = h_{fg}(0.0201V + 0.055)(0.185 + P_{av})$$

where P_{av} is the ambient air vapor pressure of water in inches of mercury.

The above four defined heat transfer rates (convection and radiation have been combined into one term and the sensible heating of the melt water has been neglected as small) can be summed to arrive at an estimate of the total heat transfer rate, q_o, at the slab surface,

$$q_o = q_s + q_m + A_r(q_e + q_{cr})$$

where A_r is the ratio of snow-free area to the total heated surface area and is therefore a dimensionless quantity.

This heating requirement must be increased for bottom and edge losses which depend on the depth of the heating system below the pavement surface, the size and length to width ratio of the heated area, and the use and amount of insulation. Back and edge losses can be up to 30% to 50% of q_o, depending on type of construction.

ASHRAE (1991) defines three classes of snow melting systems. Roadway deicing systems are in Class III, which includes toll plazas of highways and bridges, and aprons and loading areas of airports. Because Class III systems require a snow free surface, A_r is set equal to one in the above equation for q_o. Other design assumptions recommended by ASHRAE include using 0°F for T_{air} and 15 mph for V. The value for snowfall rate (S) should be obtained from the Local Climatological summary for the site or estimated from known values for cities with similar climates. For wet climates such as Juneau, a maximum rate of 0.15 water per hour is suggested.

Chapman (1952) derived an equation for estimating the fluid temperature (T_m) required to provide a heat output of q_o. The equation is based on construction of either 3/4-inch or 1-inch diameter pipes placed 12 inches on center at a depth of 3 inches below the surface in a concrete pavement.

$$T_m = 0.5q_o + T_f$$

Most of the components defining the heat load on the thawing system are dependent on weather conditions at the site. Weather data for Anchorage is available on floppy disk from the Alaska State Climate Center, Environment and Natural Resources Institute at the University of Alaska Anchorage. Daily averaged weather data for 38 years of record that include daily maximum and minimum temperatures, precipitation, snowfall, snow depth, and water equivalent

have been stored. These data can be scanned to identify major snow storm events. The hourly data for these major snow storm events are required to delineate hourly snow fall rates, wind speeds and air temperatures. This will require an analysis of the archival data from the National Weather Service at NOAA. Annual averages or maximum values for all parameters should not be used because it is unlikely they will occur as either averages or maximums simultaneously. It will be necessary to perform a frequency analysis over a several year period to arrive at meaningful values for design purposes.

Numerical and Experimental Analysis and Results

The objective of the numerical and experimental portion of this study was to investigate the thermal effects of pipe spacing, insulation thickness, pipe depth, and fluid temperature on surface temperature of the pavement for a hydronic deicing system. Following the numerical modelling, a physical model of a deicing system was built to simulate a roadway deicing system. Measurements of surface temperature were made and compared with the simulated results.

Numerical Analysis

The TDHC finite element program (Goering and Zarling, 1985) was used to investigate the effects of pipe temperature and spacing as well as insulation thickness on surface temperatures. A surface heat flux equivalent to melting snow falling at a rate of 2 inches per hour having a density of 6 pounds per cubic foot was used. Extruded polystyrene insulation was assumed placed below the thaw pipes in the gravel aggregate in all cases. In all cases, the heating system was assumed to be turned on only at the start of snowfall.

The input parameters used for the numerical thermal analysis are presented below.

A. Snow melting surface: Asphalt concrete

B. Design conditions

   1. Snowfall: 2 inches per hour, specific gravity of 0.1

2. Ambient temperature: 20°F

3. Fluid temperature: 140°F

C. Hydronic fluid type: 50% ethylene glycol and water

1. 140°F

a. Viscosity	1.3 cP
b. Specific heat	0.84 Btu/lb-F°
c. Thermal conductivity	0.24 Btu/hr-ft-F°

2. 180°F

a. Viscosity	0.9 cP
b. Specific heat	0.86 Btu/lb-F°
c. Thermal conductivity	0.18 Btu/hr-ft-F°

D. Pipe type: Type K 1-inch diameter rigid copper tubing

E. Materials

1. Asphalt concrete

a. Dry density		130 lb/ft^3
b. Moisture content	4%	
c. Initial temperature		20°F

2. Gravel A

a. Dry density		138 lb/ft^3
b. Moisture content	4%	
c. Initial temperature		22°F

3. Gravel B

a. Dry density		125 lb/ft^3
b. Moisture content	8%	
c. Initial temperature		34°F

4. Silt

a. Dry density		90 lb/ft^3
b. Moisture content	25%	

c. Initial temperature 34°F

5. Extruded polystyrene insulation

The thermal properties of the five above materials used in the modelling are given in Table 3.

The basic geometry analyzed using the TDHC finite element program is shown in Fig. 1. The geometric variables and subregions include the surface layer of asphalt concrete, gravel fill material, underlying silt, and pipe spacing and depth.

A finite element mesh of the region was created using the GRIDGEN program as shown in Figure 2. The copper tubing was not included in this mesh because its thermal conductivity is much larger than the other elements, and therefore, its thermal resistance can be considered negligible. The GRIDGEN program created two data files: (a) an input file for plotting the mesh, and (b) an input file containing the geometric and thermal property data for the TDHC finite element simulation program.

A total of 13 different geometries were developed and analyzed using the TDHC finite element program. Table 4 lists the various cases.

Numerical Results

Temperature versus time plots were produced to compare the thermal characteristics of each system listed in Table 4. Figure 3 presents the results for the first six systems listed in Table 4. Trial 1, the initial system design, with an average fluid temperature of 140°F, was not included because of lack of data. Trials 2 through 4 are represented by the three lines plotted at the bottom of the graph. Trial 2 data is the initial system design with 180°F circulated glycol. In Trial 3, the pipe distance below the surface was reduced to 18 inches with pipes placed 18 inches on center with 2 inches of insulation and a fluid temperature of 180°F. Both of these trials produced very poor results. It took 12 hours to raise the surface temperature only several degrees. In an effort to remedy this, the pipes were moved to 12 inches on center in Trial 4.

Table 3: Thermal properties used in finite element analysis of roadway deicing system.

Thermal Properties of Roadway Deicing System						
Material	Conductivity Btu/ft hr °F		Specific Heat Btu/ft^3 °F		Latent Heat Btu/ft^3	Initial Temp.[5] (°F)
	Frozen	Unfrozen	Frozen	Unfrozen		
Asphalt Concrete	0.84	0.84	24.7	27.30	744	20
Gravel A	1.359	1.555	25.88	28.29	696	22
Extruded Polystyrene (20°F)	0.02	0.02	1.296	1.296	0	28
Gravel B	1.693	1.53	26.25	31.25	1440	34
Silt	1.009	0.7	26.55	37.80	3240	34
Copper Tubing (@150°F)	230.6	230.6	51.2	51.20	0	-

Table 4: Characteristics of systems analyzed using finite element analysis

Systems analyzed Using TDHC					
Trial Number	Pipe Spacing to center (inches)	Pipe Distance below Surface (inches)	Insulation Thickness (inches)	Average Fluid Temperature (°F)	Initial Gravel Temperature (°F)
1	18	24	2	140	22.0
2	18	24	2	180	22.0
3	18	18	2	180	22.0
4	12	24	2	180	22.0
5	12	9	2	180	22.0
6	9	9	2	180	22.0
7	6	9	4	180	32.1
8	9	9	4	180	22.0
9	9	9	4	180	32.1
10	6	5	4	180	32.1
11	6	5	4	180	22.0
12	6	5	4	140	32.1
13	6	3.5	4	140	22.0

Figure 1

Initial System Design

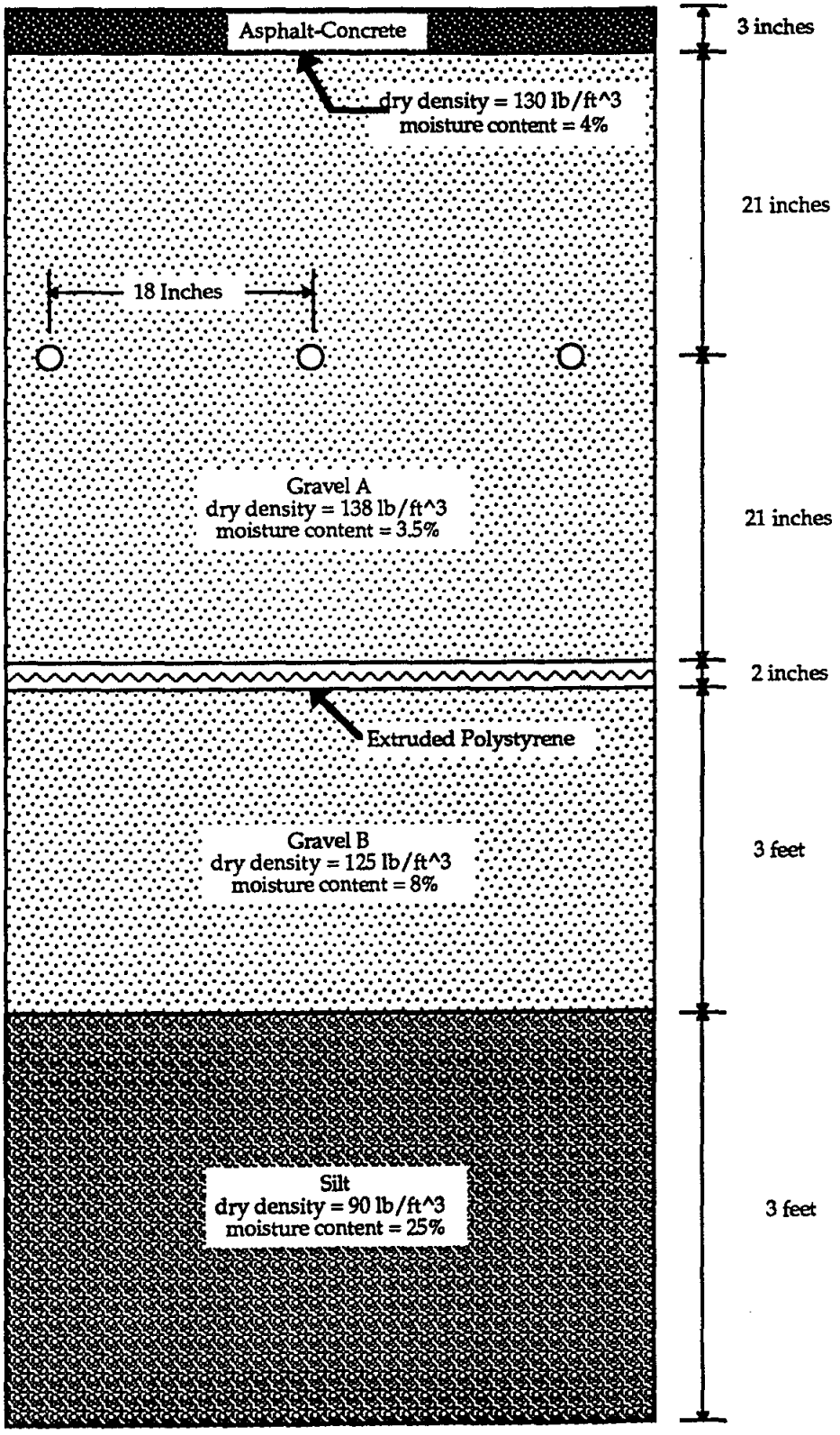


Figure 2: Finite Element Mesh

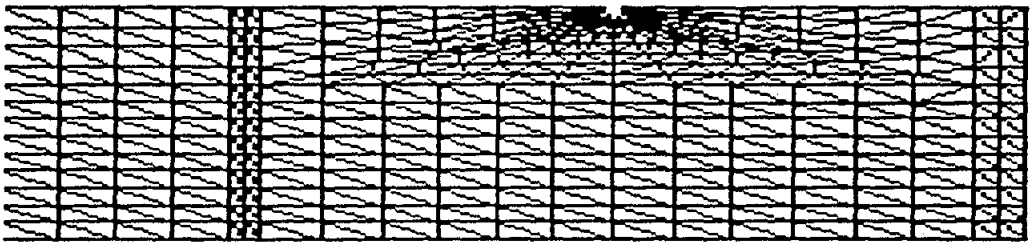
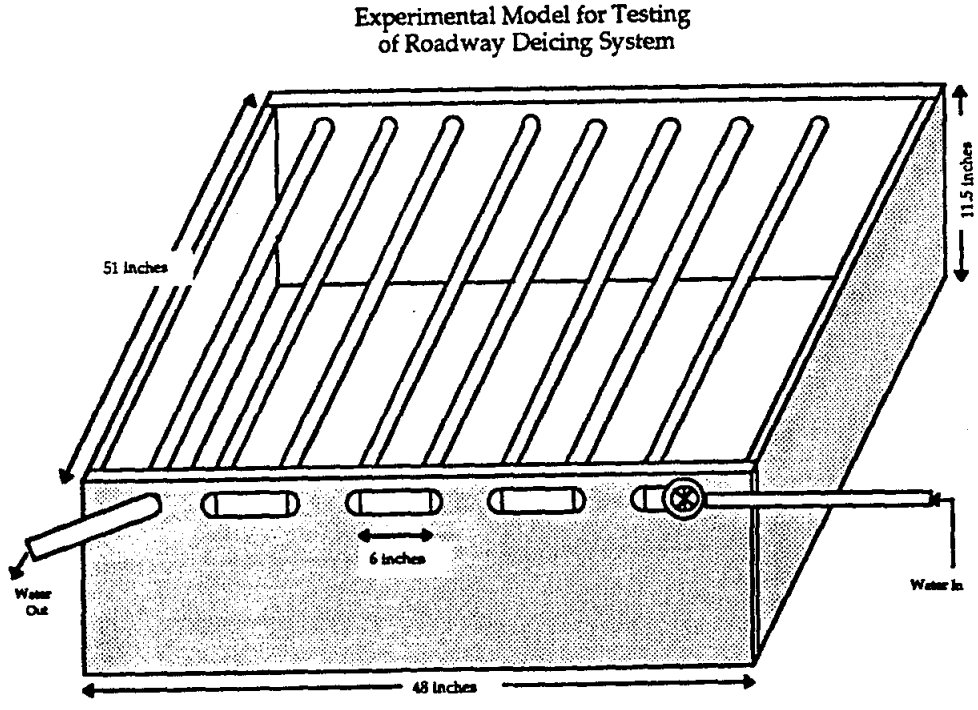


Figure 3: Model tested for experimental data.



Insulation thickness is maintained at 2 inches, fluid temperature is 180°F and the pipes are located 24 inches below the surface. There was a slight increase in surface temperature, however it is obvious from the plot this system is still inadequate.

Next the pipes were placed 9 inches below the surface for Trials 5, 6, and 8. Trial 5 has the pipe spacing at 12 inches on center, 2 inches of insulation and a fluid temperature of 180°F. The results plotted from Trial 5 show an improvement in the response of the system. The pipes are placed 9 inches on center in Trial 6 with the other parameters remaining the same. This placement resulted in only a small change in the heating time. Trial 8 was identical to Trial 6 except the insulation thickness was increased to 4 inches. This change in thickness resulted in little change on the heating time.

Because 4 to 5 hours were necessary for the surface temperature to reach 32°F, it was thought that too much energy was being used to thaw the gravel around the pipes, so the gravel temperature was increased to 32.1°F for the next four trials, Fig. 4. In trial 7, the pipes are placed 6 inches on center and 9 inches below the surface with 4 inches of insulation and a fluid temperature of 180°F. In Trial 9 the pipes are 9 inches on center with the other parameters identical to Trial 7. In these trials, it can be seen that having an initial temperature of 32.1°F did increase the rate of temperature change. It should be noted that moving the pipes closer together made only a slight increase in the rate of temperature change. For these trials it took between 3 and 4 hours to bring the surface temperature to 32°F. Trials 10 and 12 are represented by the lines at the top of the graph. In these trials the pipe is positioned 5 inches below the surface. Both trials have a pipe spacing of 6 inches on center and an insulation thickness of 4 inches. Trial 10 has an average fluid temperature of 180°F and Trial 11 has an average fluid temperature of 140°F. In these trials the surface temperature reached 32°F in 1 to 2 hours. The difference in rate of temperature change from Trial 10 to Trial 12 was a result of the difference in fluid temperatures. There was approximately a 10°F difference in steady-state surface temperatures. The time required for each trial to reach 32°F differed by only about 10 minutes.

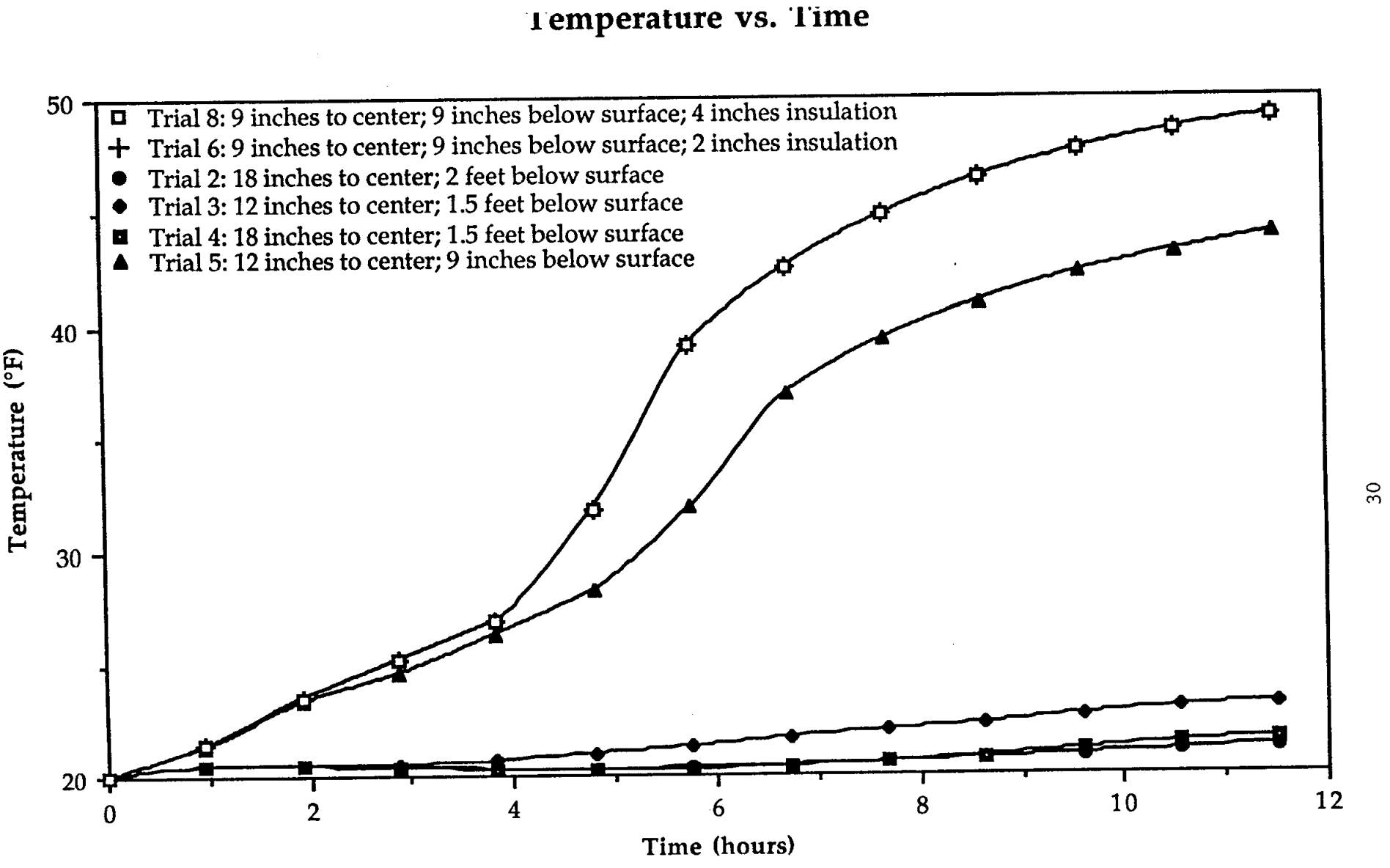


Figure 4. Initial gravel temperature is 22°F; average fluid temperature is 180°F.

Figure 5 compares Trials 10 and 11. Trial 11 has pipe spacing of 6 inches on center and 5 inches below the surface, with 4 inches of insulation and an average fluid temperature of 180°F. These characteristics are the same as those for Trial 10, except the later has an initial gravel temperature of 32.1°F. Trial 11 has an initial gravel temperature of 22°F. Figure 6 shows that when the pipes are close to the surface, that having the gravel already thawed or not makes practically no difference at all in the performance of the system. This is due to the minimal moisture content of the gravel. At 3.5% moisture content, the soil is practically dry and there is essentially no water to freeze or thaw.

Figure 6 shows the results of the final trial, Trial 13. This was chosen as the optimum system. Pipe spacing is 6 inches center to center and 6 inches below the surface. Insulation is 4 inches thick and placed 21 inches below the surface (see Figure 7). The average fluid temperature is 140°F. With this system, the surface directly above the pipes reached 32°F in approximately 45 minutes (surface temperature A). Also shown is a plot of the surface temperature midway between two pipes (surface temperature B). At this location, it takes the surface approximately 72 minutes to reach 32°F.

Experimental Test

An apparatus was built to simulate a thawing system. The test apparatus, shown in Fig. 8, was approximately 4' X 4' X 1' in size. Two inches of extruded polystyrene insulation was placed in the bottom of the box. Type K, 3/4-inch diameter, rigid copper tubing on 6-inch centers was installed 3 inches below the top of the box. The box was then filled with wet sand to simulate NFS fill and asphalt concrete. Approximately, 1 inch of snow was finally spread over the surface.

Condensate water at 128°F at the UAF power plant was used as the heat source. Ambient, surface and fluid temperatures were recorded every five minutes over the test period. Pictures were also taken to record the melt patterns. The ambient temperate at the beginning of the test was 34°F and increased to 43°F over the 90 minute test period.

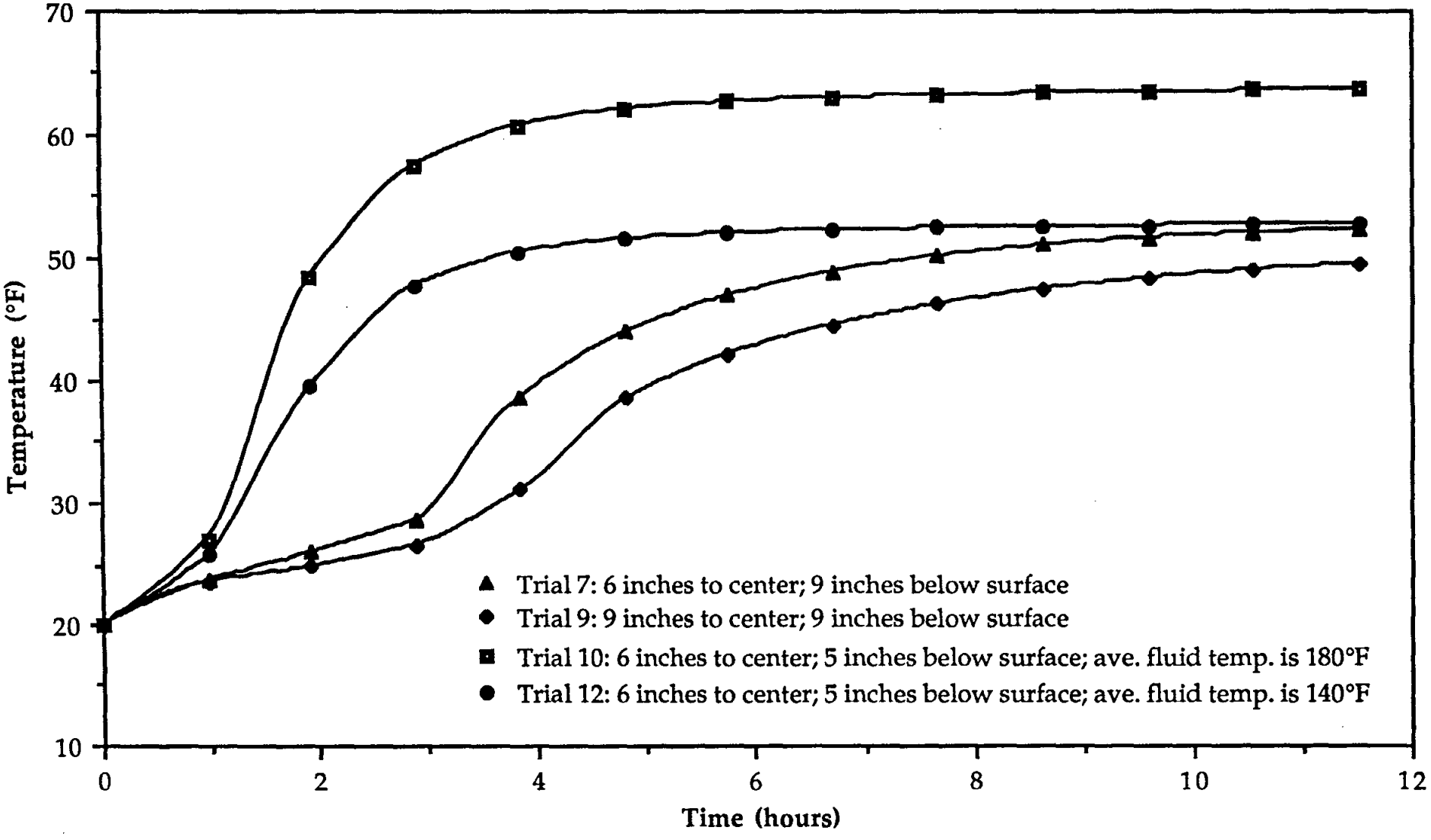


Figure 5. Initial gravel temperature is 32.1°F; insulation is 4 inches thick.

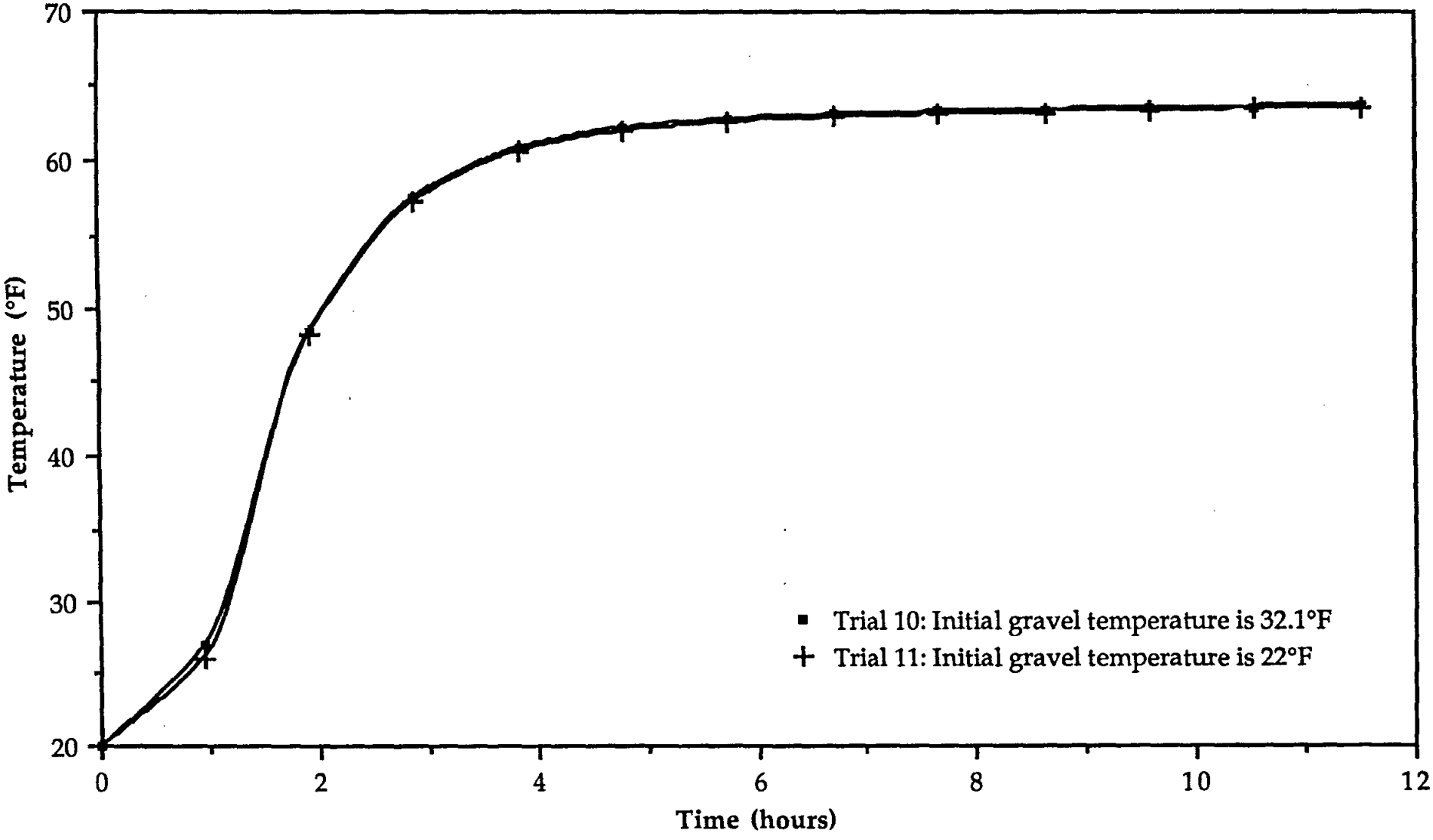


Figure 6. Average fluid temp. is 180°F; pipe is 6 inches to center; pipe is 5 inches below surface.

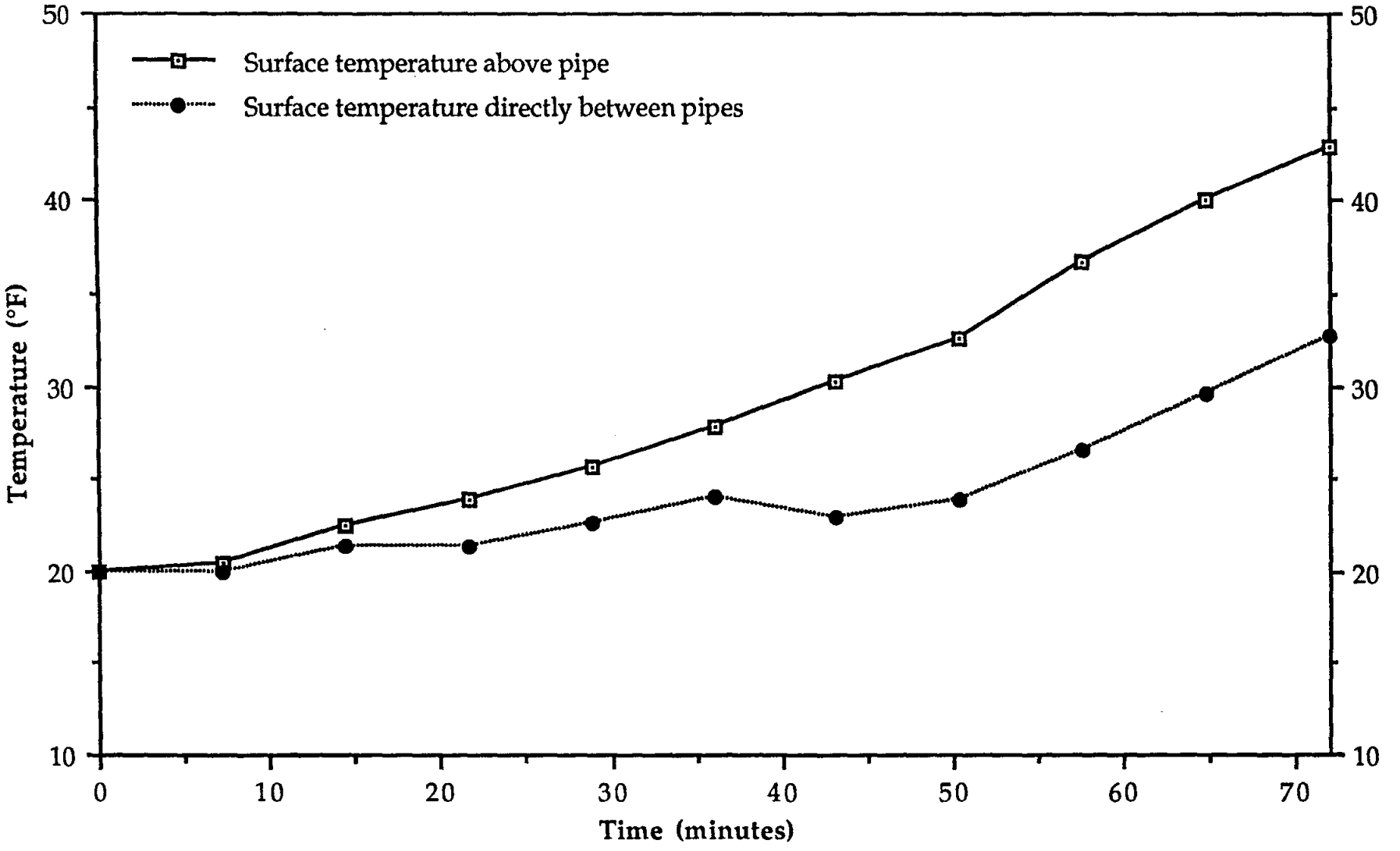


Figure 7. Optimum system. Fluid temperature is 140°F; pipe spacing is 6 inches to center; pipe is 3 inches below surface.

Optimum Deicing System

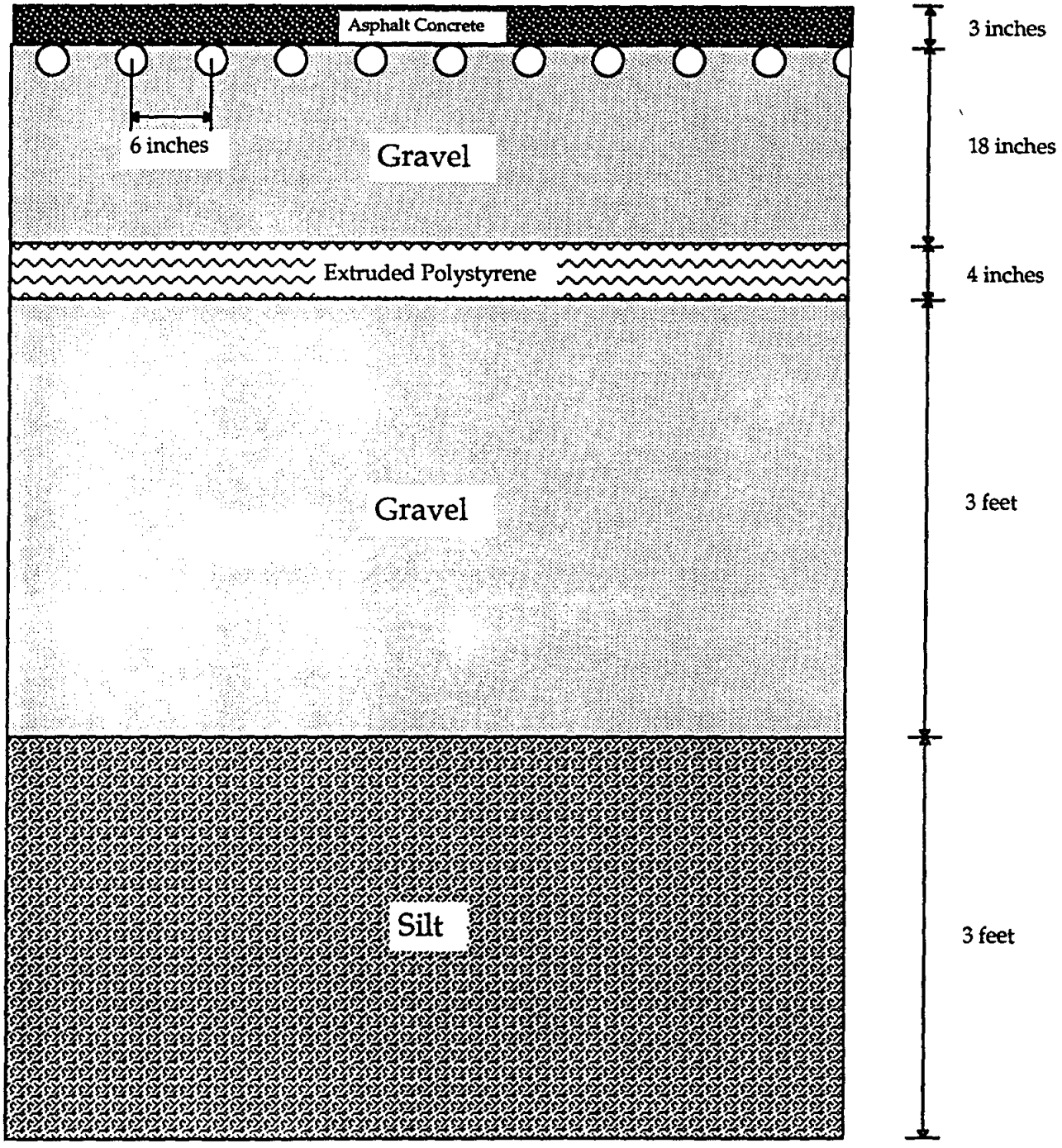


Figure 8. Optimum Deicing System as determined by finite element analysis.

Experimental Results

The results of the experimental run produced the expected melting patterns. Over the 90 minute period, the surface temperature directly above the pipes changed from 32°F to 45°F. The surface temperature midway between the pipes varied from 32°F and 34°F during this period of time. The snow above the pipes was the first to melt. When all the snow had melted at a measuring point, the surface temperature then immediately increased as the surface dried. Figure 9 shows a plot of the thermocouple temperature measurements of the surface response as a function of time.

Anchorage Energy Costs

The two most viable primary energy sources for a pavement deicing system in Anchorage are electrical power and natural gas. Municipal Light and Power (ML&P) has a current electrical rate (rate 23 -- dedicated transformer) for commercial users (over 20kw peak demand) of $.0466 per kwh with a $173 per month connect charge and a peak demand charge of $10.25 per kw per month. If a peak demand of 80 kw and a consumption of 6,000 kwh is assumed, the actual cost would be $1,272 per month or $.212 per kwh. Greater monthly consumption will reduce the per kwh cost (12,000 kwh consumption yields $.129 per kwh). Enstar Natural Gas of Anchorage has a $7.50 per month connect charge with a $.32 per CCF gas cost. A CCF, or 100 cubic feet of natural gas, contains 100,000 BTU. The same energy consumption as described for the electrical case would be $95 (or $183 at double the consumption) at a 75% boiler efficiency. Based on these data, the use of natural gas as an energy source seems to be clearly the most attractive. If a site is chosen in the vicinity of any waste heat source, this option should certainly be pursed.

Anchorage Weather Data

Seven consecutive years of Anchorage International Airport weather records were reviewed for the months of November, December, January and February for snowfall events, NOAA

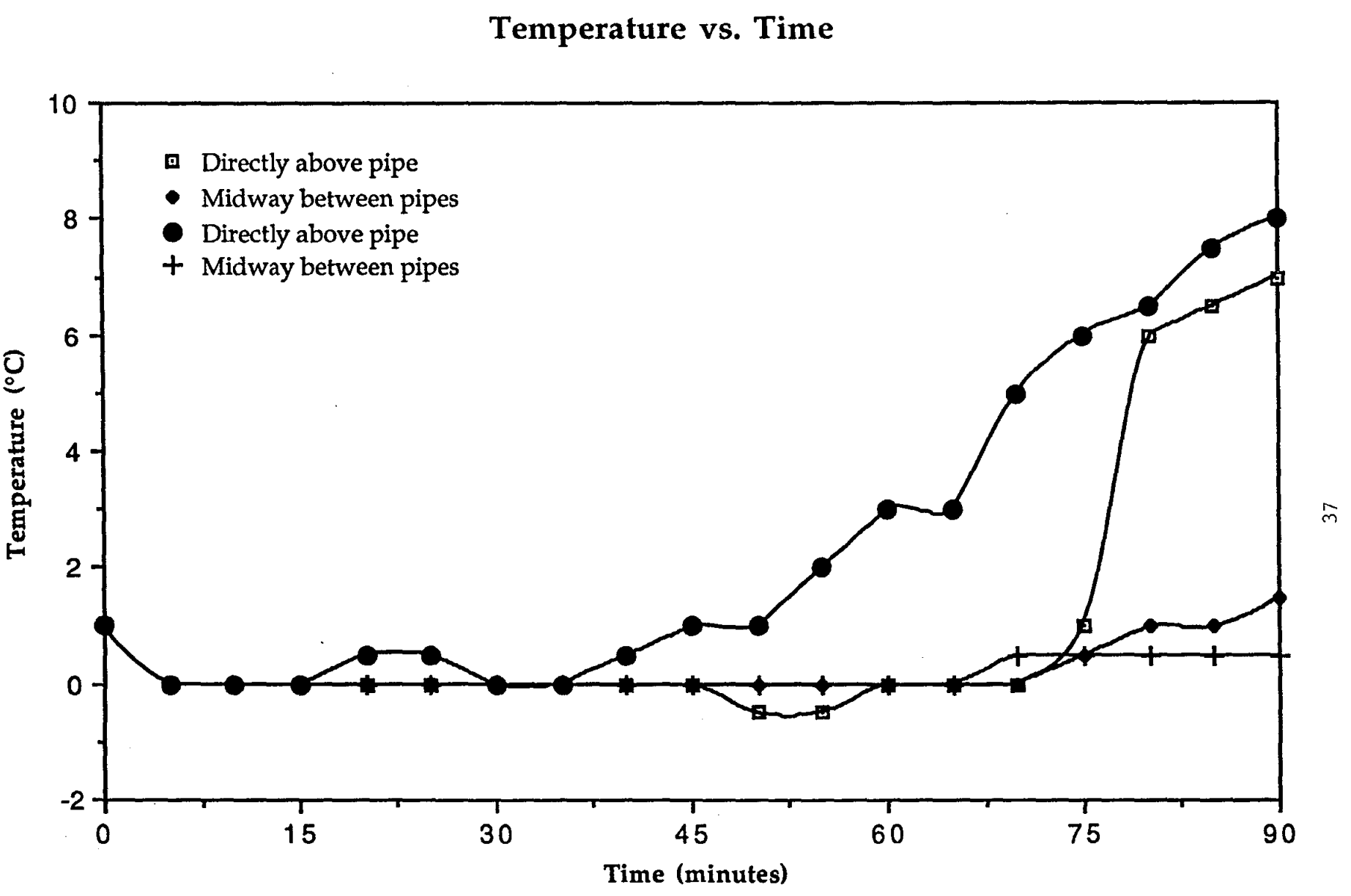


Figure 9. Temperature vs. Time plot of data from experimental test run.

(1987-1994). Table 5 provides an analysis of these data. Measurable snowfall amounts were required to list the days as having snow. There are many additional days of trace amounts of snow that have not been included in the table. Also listed in the table are the maximum snowfall event for the month along with the water equipment and temperature for that day. It is noted that snowfall amounts and water contents vary in the Anchorage bowl. Other weather recording stations data records should be reviewed if the site for a deicing system is close to one of these stations. Weather data are available for Eagle River, Elmendorf Air Force Base, Ft. Richardson Army Base, Alaska Pacific University, and Anchorage Hillside.

Table 5: Airport International Airport Snowfall Event Data

Year	No. Days Snow	Max. Daily Snow (in.)	Water Equiv.(in.)	Temp. (°F)
		November		
1987	12	7.4	.50	27
1988	12	4.7	.40	26
1989	9	3.2	.19	23
1990	6	5.8	.69	25
1991	7	5.1	.52	17
1992	11	3.3	.38	34
1993	9	4.1	.20	27
		December		
1987	17	5.6	.32	27
1988	14	3.2	.24	22
1989	12	6	.52	29
1990	14	5.7	.78	31
1991	10	5.1	.27	19
1992	18	6.8	.58	25
1993	10	1.9	.06	28

Year	No. Days Snow	Max. Daily Snow (in.)	Water Equiv.(in.)	Temp. (°F)
		January		
1988	6	2.3	.25	25
1989	8	3.6	.10	32
1990	15	4.8	.29	15
1991	4	4.4	.35	13
1992	14	7.1	.46	20
1993	9	1.9	.20	27
1994	8	3.8	.27	22
		February		
1987	6	2.2	.06	30
1988	9	3.6	.13	22
1989	5	1.2	.12	26
1990	11	5.4	.34	18
1991	8	1.8	.08	14
1992	9	8.3	.47	31

Based on the above data, a design snowfall rate of one inch per hour is suggested with a calculated water content equivalent of 0.08 inches per hour. Note, this assumption also suggests that the December 1992 snow storm, for example, lasted less than eight hours. Higher snowfall rates are likely possible, however, the cost of a pavement deicing system to keep the pavement free of snow is directly related to the snowfall rate chosen. The mean daily temperature during these fourteen snowfall events is 24°F. On average, there are 10 days during these months with measurable snowfall. The average temperature for Anchorage International Airport during December and January is 13°F with a mean wind speed of 6 mph. Hourly weather data would have to be analyzed to get the actual snowfall rates for the above events. ASHRAE (1991) recommends a complete frequency analysis of weather data to achieve greater accuracy in the occurrence of snowfall rates with the associated wind speeds and temperatures.

Anchorage Snow Melting Systems

There are several snow melting systems already installed in the Anchorage area (Toomey, 1994) (see Appendix C). These include sidewalk systems at the Allstate Insurance Co. building at Tudor and Patterson and the City Hall. The City Hall system uses waste heat from the building boilers to heat an antifreeze that is circulated below the sidewalk in plastic tubing. The added cost was reported to be $20,000 for the snow melting system on the $12 million renovation project raising on-going costs by 2%. Other buildings that have sidewalk deicing systems include the military processing station on C Street, the Veterans Administration at the Alaska Regional Hospital and the Health Services Building under construction near the new Native Hospital. Koonce and Pfeffer Inc. have been the architects on these projects (Pfeffer, 1995).

The Veteran Affairs building was one of the first buildings in Anchorage to have a sidewalk snow melting system designed and installed, Heusser (1995). The tubing for this system constructed in the early 1980s is polybutylene with all joints above ground. Like all the subsequent systems that Heusser & Co. designed, it was sized for a 100 BTU/hr-ft^2 snow melting load. Heusser uses the design guidelines published by Bell and Gossett (1966), which range linearly from 60 BTU/hr-ft^2 for 0.5 inches of snowfall per hour to 180 BTU/hr-ft^2 for 1.5 inches of snowfall per hour. The system operates continuously whenever the outdoor temperature is below 32°F. Keeping the pavement above freezing (heated) tends to prevent run-off during actual snow melting events as most of the snow melts and evaporates.

The Health and Human Services Building adjacent to the New Native Hospital has about 1,900 square feet of sidewalk being heated hydronically. Wirsbo 5/8-inch diameter PEX tubing and Entran 1-inch diameter tubing is being used. This system is connected to a 300,000 BTU/hr boiler. The control for the system consists of an outdoor thermostat that turns the system on whenever the outdoor air temperature drops below freezing. The snow melting system was designed at Heusser's standard 100 BTU/hr-ft^2.

The Anchorage City Hall has Wirsbo PEX tubing at 5/8-inch diameter and 1-inch diameter placed on 6-inch and 12-inch centers, respectively. The area being heated is about 3,700 square feet. Controls and design melting load are identical to the Health and Human Services Building. Estimates for the cost of these hydronic systems are $1 per foot of tubing plus $2 per foot of pipe for installation. If the tubing is installed on one foot centers, then the installed cost of the tubing is $3 per square foot. These costs do not include the boiler or controls.

Installation of these systems generally involves using nylon wire ties to tie the tubing to concrete reinforcing wire mesh to hold the tubing in place. Then a 2-inch to 3-inch thick concrete slab is poured over the mesh and tubing. No tubing joints are allowed under the slab. The tubing is laid out so all runs are nearly equal in length, and the system is designed to be a reversed return layout to equalize head loss for each system loop. A three way mixing valve is used to maintain a constant loop supply temperature from the boiler. Balancing valve and shut valves are installed for each loop.

Additional advantages identified for sidewalk snow melting systems have been reduced risk of slip and fall cases, and reduced building interior maintenance as most of the snow and moisture is not tracked indoors by the public as they cross the heated walk-way sections prior to entering the building interior.

Anchorage Energy Requirements

The following calculations are based on ASHRAE (1991) and have been previously outlined in this report. Data for these calculations are from the previous section. Heat transfer due to sensible heating of snow:

$$q_s = 2.6S(32 - T_a) = 2.6(0.08)(32 - 24) = 3 \text{ BTU/hr-ft}^2$$

Heat transfer due to melting of snow:

$$q_m = 746S = 746(0.08) = 60 \text{ BTU/hr-ft}^2$$

Heat of evaporation from wet pavement surface:

$$q_e = h_{fg}(0.0201V + 0.055)(0.185\text{-}P_{av})$$

$$= 1075[0.0201(6) + 0.055](0.185\text{-}.12) = 12 \text{ BTU/hr-ft}^2$$

Heat transfer due to convection and radiation from pavement:

$$q_{cr} = 11.4(0.0210V + 0.055)(T_f - T_a)$$

$$= 11.4[0.0201(6) + 0.055](33 - 24) = 31 \text{ BTU/hr-ft}^2$$

Total heat transfer rate, q_o, at the slab surface is the sum of the above heat transfer rates or 106 BTU/hr-ft^2. Heat transfer due to back and edge losses

$$q_b = .25q_o = .25(106) = 26 \text{ BTU/hr-ft}^2$$

Summing the above two values provides an estimate of the per square foot energy requirement of 132 BTU/hr-ft^2 (38 watts/ft^2) based on the Anchorage Internation Airport weather data.

Anchorage System Operating Cost

At 38 watts per square foot, an area of 2,100 square feet could be heated with an 80 kw electrical load. If the system is operated for 11 days at 24 hours per day and at 75% of peak, 15,800 kwh of electrical energy would be consumed in one month. The cost per month of this energy is $1,730. A system to heat an intersection would require an area at least ten times this large at a monthly energy cost of $17,300.

Natural gas hydronic heating is significantly lower in operating cost. To heat 2,100 square feet at 132 BTU/hr-ft^2 for 10 days with a boiler efficiency of 75% would cost $281 per month. An area ten times this size would have a monthly cost of $3,810. Electricity would be required to operatre the boiler and circulation pumps at an estimated cost of $60 per month.

If the deicing system is maintained in the idle mode between snowfall events, greater energy costs are going to be experienced. However, the design heat load can be reduced, and idling the system allows quicker melting response when a snowfall event occurs.

Conclusion

This report covers the first year's work performed to evaluate the potential application of high capacity roadway intersection thawing systems for the Anchorage area. A survey of "lower 48" Departments of Transportation located in the northern tier states was conducted to determine their use of thermal deicing systems. It was determined that the Oregon Department of Transportation has recently designed and constructed three bridge systems using either electrical or hydronic heating systems. Their construction cost estimates ranged from $18 to $25 per square foot for electric systems and $39 to $56 per square foot for hydronic systems. A survey of manufacturers of thermal deicing systems was also completed. Results of these surveys as well as a literature search on deicing systems using the TRIS data base have been compiled and included in this report.

Design guidelines are presented for the most commonly used deicing systems: electric heating cable and hydronic using pipes embedded in the pavement. Manufacturers of these systems have considerable design and installation experience for private sector systems and should be consulted if either of these systems is being considered. A thermal analysis of pipe spacing, depth, and insulation placement below the heat distribution pipes was carried out. Based on the numerical finite element results, a test section was built and melting rate tests were conducted. Results of the numerical and experimental efforts have been presented and discussed.

Several high capacity intersections were identified in the Anchorage area as potential sites for thermal deicing systems: Dimond Blvd. and the Old Seward Highway, Lake Otis Dr. and Tudor Rd., Lake Otis Dr. and 36th St., and the New Seward Highway and 36th St. Heating requirements have also been estimated to be about 130 BTU per hour per square foot for Anchorage based published weather data taken from the Internation Airport records covering a seven-year period for the months of December and January. This value compares favorably with the 100 BTU per hour per square foot value that has been used for sidewalk snow melting systems. Recent design and construction experience by the Oregon Department of Transportation

are reported for both electric and hydronic bridge deicing systems. Their cost data along with energy requirements and prices for the Anchorage area can be used to make estimates of Anchorage installation and operating costs.

For example, a deicing system covering an area of 21,000 square feet has an estimated operating cost of $17,300 per month using electicity and $2,900 per month using natural gas if it is operated 10 days per month.

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APPENDIX A

DIALOG File 63: TRIS _ 70-92/JUL

619691 DA
DURABILITY OF SILICA FUME CONCRETES FOR HIGH-STRENGTH PRECAST PRESTRESSED CONCRETE BRIDGE GIRDERS IN ALBERTA . PROCEEDINGS OF THE 1989 ANNUAL CONFERENCE OF THE ROADS AND TRANSPORTATION ASSOCIATION OF CANADA, CALGARY, ALBERTA, SEPTEMBER 17-21, 1989
Johnson, DC
Roads and Transportation Association of Canada 1765 St Laurent Boulevard Ottawa Ontario K1G 3V4 Canada 1-895102-04-9
1989 pp B55-B75 12 Ref.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Roads and Transportation Association of Canada 1765 St Laurent Boulevard Ottawa Ontario K1G 3V4 Canada
Durability tests used in this study include the following: 20-hour and 28-day compressive strength, 28-day flexural strength, resistance to freezing and thawing, scaling in the presence of deicing salt, and chloride permeability. The determination of air void parameters and their relationship to the durability of laboratory test specimens and the performance of selected in-service bridge elements is an integral part of the work. The results illustrate the difficulties in relating air void parameters to performance both in the field and in the laboratory. In the field, scaling does not correlate well with air content, spacing factor and specific surface (ASTM C457) in both the Alberta study and a larger similar study in the U.S. In the laboratory, the entrainment of air void systems in superplasticized silica fume concretes that comply with currently accepted criteria is shown to present no real difficulty with the particular admixtures employed. Howver, the results of durability tests show that scaling in particular may occur even when the air void system meets these criteria, that accelerated curing may increase scaling and chloride permeability, and that silica fume enhances resistance to scaling as well as impermeability to chloride. (Author/TRRL)
DESCRIPTORS: AIR VOIDS CONTENT; CANADA; CEMENT AND CONCRETE CHLORIDES; CONCRETE BRIDGES; CONCRETES; CONFERENCES; DURABILITY; GIRDERS; HIGH STRENGTH CONCRETES; PRECAST CONCRETE ; PRESTRESSED CONCRETE; SCALING; SILICA FUME

470384 DA
CORRELATIONS BETWEEN ROAD-SALT-USE AND WINTER INTENSITY. THIRD INTERNATIONAL ROAD WEATHER CONFERENCE, TAMPERE, FINLAND, 24TH FEBRUARY 1986
Speth, O
Finnish Meteorological Institute Vuorikatu 24 Helsinki Finland 951-697-253-5
1986 n.p.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Finnish Meteorological Institute Vuorikatu 24 Helsinki Finland
The actual guidelines for today's road winter maintenance requires a high degree of traffic safety and also the need to avoid any harm to the environment by cutting down the use of thawing agents as much as possible. The paper shows the investigations, done so far, to find a correlation between salt use and meteorological parameters, whereby the solution of the problem is approached by a thorough analysis of everyday practice of winter maintenance in various road authority stations in the state of bavaria. Moreover a statistical evaluation of data collected in all road authority stations over a long period of time is still under way. (TRRL)
DESCRIPTORS: DEICING SALT; HIGHWAY MAINTENANCE; MAINTENANCE, GENERAL; STATISTICAL ANALYSIS; WINTER

470332 DA
REPAIR OF CONCRETE STRUCTURES EXPOSED TO THE INFLUENCE OF FROST AND DEICING SALT, USING A THIN LAYER OF MORTAR MIXED WITH SYNTHETIC RESIN. PROCEEDINGS - SYMPOSIUM ON RESEARCH ON THE USE OF MODERN ACHIEVEMENTS IN YUGOSLAV CIVIL ENGINEERING IN THE FIELD OF MATERIALS AND STRUCTURES. VOLUMES 1, 2, 3 AND 4
Umek, S
Jugoslovensko Drustvo za Ispitivanje I Istrazivanj Kneza Milosa 9-13 Beograd Serbia Yugoslavia
Oct 1986 pp 293-307 5 Ref. Slovenian
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Jugoslovensko Drustvo za Ispitivanje I Istrazivanj Kneza Milosa 9-13 Beograd Serbia Yugoslavia
The paper discusses cement mortars improved with different kinds and quantities of polymer latex used in thin layers for concrete protection. It presents test results of such protective systems with regard to surface effects of freezing and thawing cycles and the influence of deicing salt. The investigations were performed on a road after a five-year period of exposure to weathering and deicing salt. (TRRL)
DESCRIPTORS: CEMENT AND CONCRETE; CEMENT MORTARS; CONCRETE STRUCTURES; CORROSION PREVENTION; DEICING SALT; FREEZING THAWING EFFECTS; FROST PROTECTION; GENERAL MATERIALS; LATEX; POLYMERS; REPAIRS; STRUCTURES DESIGN AND PERFORMANCE; SYNTHETIC RESINS; WEATHERING

470233 DA
INFLUENCE OF THE SALINITY OF ICE ON ITS THAWING TIME
Gervais, J-P; Maheux, D
Transport and Road Research Laboratory
TRRL Translation Jan 1988 6p
REPORT NO: T 3428
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Transport and Road Research Laboratory Old Wokingham Road Crowthorne RG11 6AU Berkshire England
This study reviews the opinions put forward by the personnel responsible for the winter maintenance of the road network. These opinions can be summarized as follows: "Following a first application of deicing salts, it can happen that the saline solution (snow or thawing ice and salt) thus formed is too weak and that it freezes after a drop in temperature. It is then more difficult to thaw this ice containing a frozen salt solution." To comment on the above, two aspects
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

especially must be taken into account: the chemical action of the saline solution and the action of the deicing salts on the pavement. Those two aspects are studied and discussed. (TRRL)

DESCRIPTORS: CHEMICAL REACTIONS; DEICING SALT; FREEZING THAWING EFFECTS; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; TEMPERATURE

455837 DA

THE EFFECT OF DEICING SALT ON AGGREGATE DURABILITY

Dubberke, W; Marks, VJ (Iowa Department of Transportation)

Transportation Research Board

Transportation Research Record N1031 1985 pp 27-34 8 Fig. 11 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

Since 1962, the Iowa DOT has been using the methods of rapid freezing in air and thawing in water to evaluate coarse aggregate durability in concrete. Earlier research had shown that the aggregate pore system was a major factor in susceptibility to D-cracking rapid deterioration. There are cases in which service records indicate that on heavily salted primary roads, concrete containing certain aggregates show rapid deterioration while the same aggregates show relatively good performance on secondary roads with limited use of deicing salt. A fivecycle salt treatment of the coarse aggregate before durability testing has yielded durability factors that correlate with aggregate service records on heavily salted primary pavements. X-ray fluorescence analyses have shown that sulfur contents correlate well with aggregate durabilities with higher sulfur contents that produce poor durability. Trial additives affecting the salt treatment durabilities would indicate that one factor in the rapid deterioration mechanism is an adverse chemical reaction. The objective of the current research is to develop a simple method of determining aggregate susceptibility to salt-related deterioration. This method of evaluation includes analyses of both the pore system and chemical composition. This paper appeared in Transportation Research Record N1031, Geotechnical Engineering Research.

DESCRIPTORS: CHEMICAL REACTIONS; COARSE AGGREGATES; CORRELATIONS; D CRACKING; DEICING SALT; DURABILITY; EXPLORATION CLASSIFICATION (SOILS); MINERAL AGGREGATES; SOIL SCIENCE; SULFUR; SUSCEPTIBILITY; X RAY FLUORESCENCE

378086 DA

FROST AND DEICING SALT DAMAGE TO CONCRETE PAVEMENTS

Bakker, RFM; Hendriks, CF; Merkuur, TC

Vereniging Het Nederlandsche Wegencongres

Wegen VOL. 56 NO. 3 Mar 1982 pp 86-94 4 Fig. 1 Tab. 13 Phot. 10 Ref. Dutch

SUBFILE: TRRL; IRRD; HRIS

In order to study scaling of concrete caused by frost and/or deicing salt, experimental sections of road were constructed with various combinations of portland cement or blast furnace cement; gravel or crushed gravel and percentages of cement. After a month and after nine years, freezing-thawing tests were carried out. Also after nine years the sections were visually inspected. It is concluded that the slight scaling of the concrete with blast furnace cement has had no influence on the behaviour of the pavement. From recent skidding resistance tests it is concluded that the skidding resistance is only slightly decreased. (TRRL)

DESCRIPTORS: BLAST FURNACES; CEMENT; CEMENT AND CONCRETE; CEMENTS; CONCRETE; CONCRETES; DEICING SALT; EXPERIMENTAL ROAD FREEZE THAW TESTS; FREEZING THAWING CYCLE; FROST; FROST DAMAGE ; GRAVEL; GRAVELS; PAVEMENT DESIGN AND PERFORMANCE; PORTLAND CEMENTS; RIGID PAVEMENT; SALT (DEICING); SCALING; SKID RESISTANCE; SKIDDING RESISTANCE; SLAG; SPALLING

300201 DA

DEVELOPMENT, CONSTRUCTION AND PRACTICAL OPERATION OF AN ICE WARNING PROJECT ON STATE HIGHWAY 28

Tenggestad,

Leidsche Drukkerij BV

Otar VOL. 64 NO. 1 Jan 1979 pp 16-23 4 Fig. 8 Phot. 11 Ref. Dutch

SUBFILE: TRRL; IRRD; HRIS

The aim of the computerised ice warning system is to predict slipperiness at least one hour in advance. In connection with ice warning the main factors to be measured are: (1) the temperature variation of the road surface; (2) the presence or expected presence of moisture on the road surface; (3) the presence of salt on the road surface. In ten sub-stations of the first ice warning project in the Netherlands the following items are measured: (1) the temperature of the road surface in the wheel tracks of two lanes; (2) the humidity of the road in the wheel tracks of two lanes; (3) air temperature; (4) relative humidity. The data are relayed to a central computer of which the main tasks are: (1) to collect all measured results from the sub-stations every five minutes; (2) to conduct forecasts of measurement values; (3) to issue warnings. Recommendations for improvement are made and financial aspects are discussed. It is pointed out that the full benefit is obtained from an ice warning system only if the operator makes skillful and efficient use of the collected information. /TRRL/

DESCRIPTORS: BLACK ICE; COMPUTER PROGRAMS; COST BENEFIT ANALYSIS; DIGITAL COMPUTER; FORECAST; FREEZING THAWING CYCLE; HUMIDITY; ICE CONTROL; MOISTURE CONDITIONS; MOISTURE CONTENT; NETHERLANDS; OPERATIONS AND TRAFFIC FLOW; ROAD SURFACES; SALT (DEICING); SENSOR; SURFACING; TEMPERATURE; TEMPERATURE MEASUREMENT; VARIATIONS; WARNING SYSTEMS; WHEEL PATH; WINTER MAINTENANCE

DIALOG File 63: TRIS _ 70-92/JUL

291070 DA
FREEZING AND THAWING DETERIORATION OF CONCRETE PAVEMENTS
Melick, MJS; Merkuur, TC (State Road Laboratory, Netherland Provincial Waterstaat, Noord-Brabant)
Vereniging Het Nederlands Wegencongres
Wegen VOL. 46 NO. 3 Mar 1972 pp 77-82 4 Fig. 3 Tab. 2 Phot. 6 Ref. Dutch
SUBFILE: TRRL; IRRD; HRIS
Freezing and thawing deterioration (scaling) occurs rather frequently on new concrete roads as a result of the intensive use of deicing salts. In the past it has been established that scaling took place also when organic or inorganic chemicals were applied as in the case of pure sand. The scaling mechanism has therefore probably a more physical than chemical character. In the literature, scaling is principally attributed to a prolonged or premature finishing of the concrete surface. It is generally stated that the use of an air entrainer highly increases the resistance of concrete to freezing and thawing. By order of the Department of Public Works in the Province Noord-Brabant, 14 experimental road sections were constructed with variations in the composition of the concrete and the type of cement. At the State Road Laboratory cores drilled out of the pavement sections were submitted to 40 freezing and thawing cycles (-7 degrees C and +20 degrees C respectively). During the tests common salt was spread on the top surface which was covered with A 3 mm layer of ice. The rate of deterioration of the concrete surface was determined by weighting the concrete fragments that became detached and by photographing the surface. At the end of the tests the penetration depth of the common salt in all cylinders was determined. The investigations showed that: concrete with an air entrainer added has a greater resistance to deterioration than concrete without such an admixture. The detachment of the upper layer (0.1 mm) is more serious in the case of concrete prepared with blast furnace cement than with concrete prepared with portland cement. This process takes place during the first five cycles. A distinct deterioration was recorded from the cylinders made of a concrete mixture without air entrainer. At the end of the test period (after 40 cycles) the deterioration of the cores prepared with portland cement was more marked than the deterioration observed from the cores prepared with blast furnace cement. Visual observations of the experimental road sections will show how far the scaling which will appear in the future can be accurately predicted from the results of laboratory tests. /TRRL/
DESCRIPTORS: AIR ENTRAINED CONCRETE; CONCRETE PAVEMENTS; DEICERS; DETERIORATION; FREEZE THAW DURABILITY; LABORATORY TESTS; MAINTENANCE, GENERAL; MIX DESIGN; SCALING; TEST SECTIONS

218989 DA
WINTER DAMAGE TO ROAD PAVEMENTS
Oecd, Paris /France/; /Road Research Group
May 1972 99 pp
SUBFILE: HRIS
this report considers the ways in which winter damage to road pavements could be reduced mainly from the point of view of pavement design, construction and maintenance. Details of the various factors involved, i.e. Gritting materials, de-icing chemicals, snow clearing machines, studded tires and snow chains are given. Types, causes and the process of damage to both bituminous and cement concrete pavements (excluding the effect of freezing-thawing cycles) are described. Measuring and test methods used to determine pavement damage and/or wear both in the laboratory and on actual roads are examined. /author/
DESCRIPTORS: BITUMINOUS PAVEMENTS; CONCRETE PAVEMENTS; DEICING; GRITS; MAINTENANCE, GENERAL; PAVEMENT DISTRESS; SNOWPLOWS; STUDDED TIRES; WEAR

218319 DA
CHEMICAL DE-ICING AGENTS USED TO COMBAT SLIPPERY ROADS
Carlier, A
Wegen /Netherlands/ 1965 Vol 39, No 10, PP 261-271, 5 PHOT
SUBFILE: TRRL; IRRD; HRIS
A NEW METHOD IS DISCUSSED OF RECORDING THE RESULTS OF PRACTICAL TESTS WHICH WOULD ENABLE THE USE OF VARIOUS THAWING AGENTS TO BE COMPARED, AND WOULD PROVIDE DATA ON THE TECHNICAL AND ECONOMIC SIGNIFICANCE OF SODIUM CHLORINE AND CALCIUM CHLORIDE MIXTURES, THE REQUIREMENTS OF SCATTERING MACHINES, THE STORAGE OF DE-ICING AGENTS AND THEIR EFFECTS ON VEHICLES AND ROAD SURFACES. CONCLUSIONS REACHED WITH THE USE OF THIS METHOD WERE AS FOLLOWS: THE ACCIDENT RATE DECREASES WHEN EITHER OF THE TWO DE-ICING AGENST IS USED; NO DAMAGE IS CAUSED TO WELL DESIGNED CONCRETE ROADS OR DENSE ASPHALTIC CONCRETE SURFACINGS. /FG/RRL/
DESCRIPTORS: ACCIDENT RATES; ASPHALTIC CONCRETE; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; CHLORINE COMPOUNDS; CONCRETE PAVEMENTS; MAINTENANCE, GENERAL; METHODS; PAVEMENT DISTRESS; RECORDING; ROAD SURFACES; SLIPPERINESS; SODIUM COMPOUNDS; STORAGE; TEST RESULTS; VEHICLES

183481 DA
AIR-ENTRAINED CONCRETE AS READY-MIXED CONCRETE
Kaltenboeck, H
Bauverlag GmbH
Bauwirtschaft VOL. 29 NO. 25 Jun 1975 pp 857-866 10 Fig. 1 Tab. 11 Ref. German
SUBFILE: TRRL; IRRD; HRIS
In order to withstand the effects of frost and road salts, concrete for various uses especially in road construction, is produced using air-entraining additives. It was established from tests on ready-mixed air-entrained concrete that large differences in air-content exist by the time the concrete is placed due to: minute differences in composition, moisture content of the aggregates and in mixing time and standing time in the truck-mixer. From comprehensive test programmes, the conditions at the mixing plant were investigated which affect

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DIALOG File 63: TRIS _ 70-92/JUL

the proportion (determined microscopically or in an air content apparatus) of total air content and artificially produced air content and in addition the changes in distance factor. The requirements of a ready-mixed concrete batching plant to deliver to site wholly uniform air-entrained concrete are listed. /TRRL/

DESCRIPTORS: AIR CONTENT; AIR ENTRAINED CONCRETE; CEMENT AND CONCRETE; CONSTRUCTION; DEICING SALT; FREEZING THAWING CYCLE; FROST; MANUFACTURE; MIX DESIGN; MIXING TIME; MOISTURE CONTENT QUALITY; READY MIXED CONCRETE; ROAD CONSTRUCTION

DIALOG File 63: TRIS _ 70-92/JUL

622952 PR
ICE DETECTION SYSTEM/I-295 BRIDGE
PERFORMING ORG: Virginia Department of Transportation 1221 East Broad Street Richmond Virginia 23219
CONTRACT NO: Contract
PROJECT START DATE: 9002
PROJECT TERMINATION DATE: ND
SUBFILE: HRIS
The objectives of this study are to ascertain (1) the performance of the ice detection and climatological data systems; (2) the effects on the lead wires from the sensors to the processing units from weathering, chemicals, and other factors; and (3) the usefulness and the cost-effectiveness of the data in maintaining a safe roadway for the traveling public during the winter months.
DESCRIPTORS: CHEMICALS; COST EFFECTIVENESS; ICE DETECTION; MAINTENANCE, GENERAL; PERFORMANCE; RESEARCH PROJECT; WINTER MAINTENANCE

615488 PR
ICE DETECTION AND HIGHWAY INFORMATION SYSTEMS
SPONSORING ORG: Kansas Department of Transportation
PERFORMING ORG: Kansas Department of Transportation State Office Building, 2300 Van Buren Street Topeka Kansas 66612
CONTRACT NO: DTFH71-89-513-KS-13; In-House
PROJECT START DATE: 8901
PROJECT TERMINATION DATE: ND
SUBFILE: HRIS
Evaluate the usefulness and cost effectiveness of the Kansas City area ice detection and highway weather information system and to compare the system to the current weather forecast system. (Surface systems, inc. Vs. Weather Corporation of America)
DESCRIPTORS: HIGHWAY INFORMATION SYSTEMS; HIGHWAY SAFETY; ICE CONTROL; ICE DETECTION; ICE PREVENTION; RESEARCH PROJECT; SAFETY

501927 DA
AUTOMATIC ICY ROAD SIGN STUDY
Colorado Dept. of Highways
1966 24p
REPORT NO: HS-000 844
SUBFILE: HSL
Evaluation of test results on the ability of a control device to detect, and automatically indicate when icy road conditions exist.
DESCRIPTORS: AUTOMATION; ICE DETECTORS; ICE WARNING SIGNS; ICY ROAD CONDITIONS

501922 DA
PAVEMENT ICING WARNING SYSTEMS. LABORATORY EVALUATION OF ECONOLITE AND NELSON PROTOTYPE DEVICES
Bourget , L.
California Div. of Highways, Sacramento
1967 14p
REPORT NO: HS-000 849
SUBFILE: HSL
AVAILABLE FROM: NTIS
Ice warning detector system designed with sensors intended for flush imbedment in roadway pavements.
DESCRIPTORS: ELECTRONIC MONITORING SYSTEMS; ICE DETECTORS; ICY ROAD CONDITIONS; PAVEMENTS; SENSORS

501094 DA
HIGHWAY, BRIDGE, AND AIRPORT RUNWAY DETECTION SYSTEM PREDICTS FROST AND ICE CONDITIONS BEFORE THEY OCCUR
Ciemochowski , MF
Holley Carburetor Co.
8p
REPORT NO: HS-001 813
SUBFILE: HSL
System incorporates humidity sensing for anticipating frost that leads to ice formations, and separate sensors for sensing ice formations resulting from precipitation.
DESCRIPTORS: FROST; ICE DETECTORS; ICE FORMATION; ICY ROAD CONDITIONS; RUNWAYS

319500 DA
USE OF SAR SYSTEMS FOR ICEBERG DETECTION AND CHARACTERIZATION
Lawson, RW; Shuchman, RA; Rawson, RF; Worsfold, RD (Environmental Research Institute)
Intl Symp on Remote Sensing of the Environment Manila Philippines
VOL. 2 1978 Proceeding pp 1127-47
SUBFILE: MRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
During February and March 1977, a synthetic aperture radar (SAR) program was conducted on the east coast of Canada using a 3 cm and 23 cm dual polarization SAR system. Data obtained from this program have been used to demonstrate the capability of SAR for the detection and identification of icebergs. Results from the analysis and interpretation of the 3 cm and 23 cm SAR imagery are presented. These results include imagery and quantitative measurements, demonstrating the detectability of icebergs in a variety of sea ice clutter backgrounds. Using imagery having resolution of 3 meters by 3 meters, it is possible to estimate iceberg by using the detail of the iceberg shadow. The information obtained from this program can be used for the design of future operational SAR systems for iceberg detection and characterization. From the 12th International Symposium on Remote Sensing of the Environment, Manila, 20 April 1978.
DESCRIPTORS: DETECTION SYSTEMS; ICE CHARACTERISTICS; ICE DETECTION; ICEBERGS; NAVIGATION, COMMUNICATIONS, AND DETECTION ; RADAR IMAGES; RADAR SYSTEMS

DIALOG File 63: TRIS _ 70-92/JUL

198333 DA
AN OPERATIONAL RESEARCH INVESTIGATION OF THE ICE-DETECTION CAPABILITY AND UTILITY OF THE SURFACE CONDITION ANALYZER (SCAN) SYSTEM AND ITS APPLICABILITY TO NAVY-WIDE USE
Mack, EJ; Anderson, RJ; Bock, DH; Niziol, TA; Reif, HG
Calspan Corporation P.O. Box 235 Buffalo New York 14221
Mar 1979 Final Rpt. 181 p.
REPORT NO: CALSPAN-6283-M-1
CONTRACT NO: N00014-78-C-0284; Contract
SUBFILE: NTIS; ATRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
During 1978, Calspan Corporation conducted an independent research investigation of the basic principles and operational performance of the Surface Condition Analyzer system (SCAN)TM in the detection of icing conditions on runway surfaces and its applicability to Navy-wide use. The results and conclusions derived from this investigation were formulated from data and information garnered from the following sources: site visits and interviews at civil and Naval airfields where SCAN is installed; visits and discussions at the manufacturer's plant; strip-chart records of actual SCAN-output signals, correlated with visual inspection of runway and sensor surfaces, runway traction, and display terminal readouts, obtained during a two-week operational performance study at Keflavik NAS; study of the manufacturer's drawings and schematics; review of the literature on snow and ice removal and control (SIRC) operations and economic analyses of these procedures as impacted by SCAN; and climatological analyses. The principal conclusion was that, while SCAN will not supplant routine personal inspection of runways, SCAN's ability to provide, on occasion, advance warning of hazardous icing conditions coupled with its surface temperature information (used for more effective chemical application) makes it well worth the investment costs. (Author)
DESCRIPTORS: AIRPORTS; AVIATION SAFETY; CLIMATE; DETECTORS; EFFECTIVENESS; EFFICIENCY; HYDROPLANING; ICE; ICE DETECTORS; ICE FORMATION INDICATORS; METEOROLOGY; NAVAL AIR STATIONS; OPERATIONS RESEARCH; PERFORMANCE ENGINEERING; PERFORMANCE EVALUATION; RUNWAYS; SCAN SURFACE CONDITION ANALYZER SYSTEM; SURFACE TEMPERATURE; WARNING SYSTEMS

191710 DA
THE DEVELOPMENT OF A MICROWAVE RADIOMETER FOR USE AS A HIGHWAY ICE DETECTOR
Lockheed Missiles and Space Co. Inc., Sunnyvale, Berinsky, S; Hong, HK; Lee, TH; Schrader, WT
Sep 1978 152p
REPORT NO: FHWA/RD-78/203
CONTRACT NO: DOT-FH-11-9328; Contract
SUBFILE: NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The program objective was to develop a system capable of detecting snow, ice, frost, or slush over a highway bridge deck area greater than 4 x 2 feet (1.2 x 0.6 m) and generate a valid alarm signal to warn motorists of a hazard. The detection system selected was a microwave radiometer operating at 10 GHz which continuously samples a reference noise source and internal amplifier noise to provide measurement corrections of radiated power received from the road surface being observed. Principal radiometer components are: rectangular horn antenna; sensitive receiver; and signal processor/alarm unit. The successive program phases were: (1) design optimization and system tradeoffs; (2) breadboard model laboratory and field tests; and (3) prototype model design, fabrication and test. Test results on asphalt and concrete roadway simulators, as well as actual asphalt roads, correlated with previously published radiometric temperatures for similar surfaces. The following road conditions were detectable: dry/warm; dry/cold; wet; slush; ice layer (0.1 cm minimum); and snow layer (1 cm minimum). All road hazard detection objectives were met except for frost detection. Descriptions of recommended additional effort are presented, including detailed evaluation of the prototype model; advanced alarm logic; self-test techniques; and a scanning antenna to cover increased road areas.
DESCRIPTORS: BRIDGE DECKS; HAZARDS; HIGHWAYS; ICE; ICE DETECTORS; ICE FORMATION INDICATORS; MICROWAVE EQUIPMENT; MOTOR VEHICLE OPERATORS; RADIOMETERS; SLUSH; SNOW; WARNING SYSTEMS

175634 DA
ICE AND FOG: DETECTION AND WARNING SYSTEMS (A BIBLIOGRAPHY WITH ABSTRACTS)
Habercom, GE, Jr
National Technical Information Service; 5285 Port Royal Road; Springfield; Virginia; 22161
Mar 1978 155 pp
SUBFILE: NTIS; HRIS; MRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Sea ice, aircraft ice, bridge ice, and fog formation detecting methods are reviewed in these Government-sponsored research reports. Remote aerial sensing and ground based detection systems are among the methods investigated. (This updated bibliography contains 150 abstracts, 32 of which are new entries to the previous edition.) Supersedes NTIS/PS-77/0188, NTIS/PS-76/0096 and NTIS/PS-75/231.
DESCRIPTORS: ABSTRACTS; AERIAL RECONNAISSANCE; BIBLIOGRAPHIES; BIBLIOGRAPHIES (ICE AND FOG DETECTION); DETECTING DEVICES; DETECTION; FOG; FOG DETECTION; ICE; ICE DETECTION; INFRARED DETECTION; OPTICAL DETECTION; POLLUTION ABATEMENT AND CONTROL; REMOTE SENSING; SAFETY; WARNING SYSTEMS

DIALOG File 63: TRIS _ 70-92/JUL

172116 DA
ARCTIC SEA-ICE CONDITIONS IN EARLY SPRING VIEWED BY SATELLITE
Ahlnas, K; Wendler, G (Alaska University)
Arctic and Alpine Research VOL. 9 NO. 1 pp 61-72 24 Ref.
SUBFILE: MRIS
AVAILABLE FROM: Colorado University, Boulder Institute of Arctic & Alphine Research, c/o K. Salzburg Boulder Colorado 80309
A detailed analysis was made of satellite imagery, mainly from the NOAA-VHRR (National Oceanic and Atmospheric Administration-Very High Resolution Radiometer) in the visible and infrared range, to produce maps of mean monthly ice concentration of the western Arctic Ocean for March 1973 and March 1974. Using multidaily coverage of the saetllite, a total of 2552 data points divided into 47 subsections of the Arctic Ocean were analyzed. In both years an average of 75% of usable observations were obtained; the cloudy observations constituted 25%. The highest ice concentrations found in the Beaufort Sea and East Siberian Sea were 85% and 81%, respectively for March 1973. For March 1974, the ice concentration was on an average 10% higher due to a greater frequency of onshore wind components as reduced from 5-day means of surface pressure differences between selected coastal stations of the Beaufort Sea. Areas of low ice concentration were found in parts of the northern Bering Sea, along the northwest coast of Alaska and northwest of Wrangel Island in both years. In 1973 low ice concentrations were also observed north of the New Siberian Islands and west of Banks Island.
DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ARCTIC ENVIRONMENT; ARCTIC MAPS; ICE DETECTION; ICE FORMATION; ICE MAPPING; SATELLITE IMAGERY

167793 DA
SEA ICE-75. SUMMARY REPORT
Blomquist, A
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
28 pp 15 Ref.
REPORT NO: Research Rpt. 16:9
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report summarizes results and conclusions from the project "Sea Ice 75"--A field experiment aimed at evaluating the capability of remote sensing techniques for surveillance and mapping of sea ice in the Bay of Bothnia. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.
DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE DETECTION; ICE MAPPING; REMOTE SENSING

167792 DA
SEA ICE-75. RADAR ALTIMETER RESULTS
Axelsson, S
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
27 pp 9 Ref.
REPORT NO: Research Rpt. 16:7
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report describes the results obtained at a field test on sea-ice mapping by radar altimetry. The experiment was carried out in the Gulf of Bothnia, March 1975. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.
DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE DETECTION; ICE MAPPING; RADAR SYSTEMS; REMOTE SENSING

167791 DA
SEA ICE-75. IR-SCANNER RESULTS
Fagerlund, E; Lundholm, G
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
19 pp 6 Ref.
REPORT NO: Research Rpt. 16:6
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The field experiment in the Gulf of Bothnia has shown that thermal infrared sensing can be used to differentiate ice from water and new ice from old, thicker ice. Special features, such as rafting patterns, ridges and cracks, are correlated to thermal variations and can be detected and identified in the thermal image. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.
DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE DETECTION; ICE MAPPING; ICE RIDGES; INFRARED DETECTION; REMOTE SENSING

167790 DA
SEA ICE-75. FLAR, ODAR SHIP'S RADAR
Hagman, T; Nilsson, J
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
32 pp 2 Ref.
REPORT NO: Research Rpt. 16:6
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report describes results from a field test on sea ice
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

mapping by radar in the Gulf of Bothnia, March 1975. Three different types of radar were used: forward looking Airborne Search Radar (FLAR), Omnidirectional Helicopterborne Search Radar (ODAR) and Shipborne Radars of the Icebreaker "TOR". Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE DETECTION; ICE MAPPING; RADAR SYSTEMS; REMOTE SENSING

167789 DA

SEA ICE-75. ICE DETECTION BY SLAR

Morra, RHJ; Deloor, GP

Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway

31 pp 7 Ref.

REPORT NO: Research Rpt. 16:3

SUBFILE: MRIS; NSFI

AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway

The theoretical background, types of side looking airborne radar (SLAR) systems with their specifications, properties and limitations are described. The "slar" images are interpreted; these were obtained during survey flights over the Bothnia Gulf. Actual interpretation is based on a comparison with aerial photographs, taken during the same period. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE DETECTION; ICE MAPPING; ICE SURVEYS; RADAR SYSTEMS; SIDE LOOKING RADAR

167788 DA

SEA-ICE 75. GROUND TRUTH REPORT

Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway

68 pp 6 Ref.

REPORT NO: Research Rpt. 16:2

SUBFILE: MRIS; NSFI

AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway

A remote sensing project over sea ice was carried out between March 10 and 20, 1975. Several sensors, microwave, visual and infrared, were tested. Simultaneously an extensive ground truth work was carried out. This report gives information on all ground truth data including the satellite and air photo information. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; DATA ACQUISITION; ICE DETECTION; ICE MAPPING; INFRARED DETECTION; REMOTE SENSING; SATELLITE SYSTEMS

167786 DA

SEA ICE-75. ANALYSIS OF "SLAR" DATA

Parashar, S

Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway

Res. Rpt. 46 pp 32 Ref.

REPORT NO: Research Rpt. 16:4

SUBFILE: MRIS; NSFI

AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway

The purpose of this report is to present results, obtained from the analysis of "slar" (side-looking airborne radar) data. This experiment was conducted in the Bay of Bothnia during March, 1975. In an effort to help explain and understand some of the results, included are sections on the formation of sea ice and its relevant characteristics, the nature of radar return from sea ice, and sea ice parameters of interest. Research Report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ICE CHARACTERISTICS; ICE DETECTION; ICE FORMATION; ICE MAPPING; RADAR SYSTEMS; REMOTE SENSING; SIDE LOOKING RADAR

048093 DA

EVALUATE THE APPLICATION OF ERTS-A DATA FOR DETECTING AND MAPPING SEA ICE

Barnes, JC

Environmental Research and Technology Incorporated; 429 Marrett Road; Lexington; Massachusetts; 2173

N4 May 1973 Prog Rpt 9 pp

REPORT NO: ERT-P-408-5

CONTRACT NO: NAS5-21802; Contract

SUBFILE: NTIS; MRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151

The author has identified the following significant results. Generally good agreement has been observed between the location of ice edges and ice concentrations as indicated on aerial observation charts and as mapped from ERTS-1 imagery. Moreover, ice surface features reported to be ridges and thaw holes are readily detected in the ERTS-1 imagery. Reported hummocks, puddles, frozen puddles, and rafted ice are not as readily detected in the imagery, although brightness variations on some ice surfaces can be distinguished, thereby suggesting their presence. In the ERTS-1 imagery, although dark new ice and nilas are difficult to detect, other younger forms of ice can be mapped and can usually be distinguished from older ice because of their lower, more uniform reflectance. A preliminary examination of the initial sample of ERTS-1 imagery collected during the spring, during the season of maximum ice extent, indicates several ice features of interest. Compact pack ice can be distinguished from

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DIALOG File 63: TRIS _ 70-92/JUL

coastal fast ice, and many leads can be mapped, even in the mid-Beaufort Sea. Several leads have distinct variation in reflectance. (Author)

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ARCTIC REGIONS; ICE DETECTION; ICE HUMMOCKS; ICE IDENTIFICATION; ICE MAPPING; ICE RIDGE DISTRIBUTION; MULTISPECTRAL BAND SCANNERS; NASA; PACK ICE; RETURN BEAM VIDICONS; SEA ICE

025704 DA

ON THE DETERMINATION OF THE EXTENSION OF SEA ICE IN ARCTIC WATERS BY MEANS OF SATELLITE PICTURES

(Meteorological Institute, Oslo)

POAC Conference; Schumacher, NJ

SUBFILE: MRIS

AVAILABLE FROM: Technical University of Norway Conference Chairman Trondheim Norway

For about one year satellite pictures received at the Meteorological Institute, Oslo, have been used to prepare charts showing the extension of the sea ice in the Norwegian Sea, the Svalbard area and the Barents Sea. The charts have been mailed to different users. In addition, the positions of the main ice edge are transmitted daily from Jan Mayen Radio and Bjornoya Radio. Usually, satellite pictures give a fairly reliable foundation for the determination of the ice edge, but the method suffers from obvious deficiencies. Firstly, persistent cloud cover may prevent observations for days from the same area. Secondly, details less than some 5 km squared cannot be detected on day light pictures, and on infrared pictures, even details of twice that size will usually be invisible. Thirdly, the temperature of the sea ice surface is occasionally not much different to that of the sea, with the result that no contrast at all can be found on infrared pictures between areas covered by sea ice and areas of open water. This may easily bring about an underestimation of the extent of the ice and is a serious source of error, even more so since infrared satellite pictures are the only data available from the polar seas during the winter half year. Therefore, there will always be a need for additional information from lower levels. Abstract of paper delivered at the First International Conference on "Port and Ocean Engineering under Arctic Conditions" held at Trondheim, Norway, August 23-30, 1971

DESCRIPTORS: ARCTIC AND COLD WEATHER OPERATIONS; ARCTIC REGIONS; ICE CHARTS; ICE DETECTION; INFRARED DETECTION; REMOTE MONITORING

DIALOG File 63: TRIS _ 70-92/JUL

621988 DA
CALCIUM MAGNESIUM ACETATE (CMA) DEICER - AN EFFECTIVE ALTERNATIVE FOR SALT-SENSITIVE AREAS. IN: 1991 TAC ANNUAL CONFERENCE, PROCEEDINGS. VOLUME 1. SEPTEMBER 15-16, 1991, WINNIPEG, MANITOBA, CANADA
Fritzsche, CJ
Transportation Association of Canada 2323 St Laurent Boulevard Ottawa Ontario K1G 4K6 Canada 1-895102-28-6
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Association of Canada 2323 St Laurent Boulevard Ottawa Ontario K1G 4K6 Canada
In this paper the environmental impact of traditional deicing chemicals is compared with that of calcium magnesium acetate (CMA), a deicer developed by the US Federal Highway Administration (FHWA) to address the infrastructure and environmental degradation associated with the use of traditional deicing chemicals. Case studies are presented that demonstrate the effective incorporation of CMA into winter maintenance operations to provide safe winter highways in environmentally sensitive areas.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; DEICERS; ENVIRONMENTAL DESIGN; ENVIRONMENTAL IMPACT; MAINTENANCE, GENERAL; WINTERIZATION

621977 DA
CMA USE ON THE ZILWAUKEE BRIDGE. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Miller, WL
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
The Zilwaukee Bridge, a post-tensioned, precast, segmental concrete box structure is located on I-75 just north of Saginaw, Michigan. Its substructure consists of double column piers that are supported on steel H piles driven some 80 feet to bear on bedrock. Calcium magnesium acetate (CMA) has been utilized for snow and ice control on the bridge. Observations on the use of CMA are noted and it was concluded that CMA is effective when used properly, however, the use of CMA on Michigan's entire trunkline system would exhaust the entire maintenance budget for material alone. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: BRIDGES; CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; COSTS; DEICING; ENERGY AND ENVIRONMENT; MAINTENANCE, GENERAL; MICHIGAN; SNOW & ICE CONTROL; WINTERIZATION

621975 DA
REMEDIATING HIGHWAY DEICING SALT CONTAMINATION OF PUBLIC AND PRIVATE WATER SUPPLIES IN MASSACHUSETTS. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Pollock, SJ
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
The Massachusetts Department of Public Works (MDPW) maintains 12,315 lane miles of highway (1989-90). The total amount of salt applied per winter by MDPW during this period averaged 201,519 tons. The storage, handling and application of this quantity of highway deicing salt statewide resulted in salt contamination of many public and private water supplies. The purpose of this report is to document the effectiveness of preventive and remedial actions that are used by MDPW to alleviate salt contamination of water supplies. Two of these are: (1) reduced salting on state highways; and (2) using a salt substitute such as calcium magnesium acetate. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; ENVIRONMENTAL EFFECTS ; MAINTENANCE, GENERAL; MASSACHUSETTS; SODIUM CHLORIDES; STATE HIGHWAYS; STATE TRANSPORTATION DEPARTMENT; WATER SUPPLY

621974 DA
COMPARATIVE STUDY OF CHEMICAL DEICERS: UNDERCUTTING AND DISBONDMENT. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Kirchner, HW
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs. Apps.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
Research has revealed significant differences in the penetration and melt volume capabilities of several deicing chemicals over a range of selected temperature and time intervals. The goal of this paper is to show that these same differences exist with undercutting and disbondment characteristics of those same deicing chemicals. Five chemical deicers are reported in this study. The materials included are: (1) Calcium chloride pellets (CaCl2), (2) Sodium chloride (rock salt)-two suppliers, (3) Potassium chloride (KCl), (4) Pelletized urea, and (5) Calcium magnesium acetate (CMA). The product information on these deicers is presented in the appendix. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at

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DIALOG File 63: TRIS _ 70-92/JUL

Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CALCIUM CHLORIDES; CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; DEICERS; DEICING; ENERGY AND ENVIRONMENT; ICE CONTROL; MAINTENANCE, GENERAL; PELLETS; POTASSIUM CHLORIDE

621970 DA
BENEFITS AND COSTS IN THE USE OF SALT TO DEICE HIGHWAYS. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Hanneman, RL
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
This paper discusses the benefits and drawbacks to the continued use of salts for deicing highways. Practically speaking, the author states that no viable alternative to the practice of deicing has been found. Calcium magnesium acetate has not replaced salt as a deicer because a greater quantity of CMA is required to melt ice. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; COST COMPARISONS; DEICERS; DEICING SALT; ENERGY AND ENVIRONMENT; MAINTENANCE, GENERAL; SALT, SODIUM CHLORIDE; SNOW & ICE CONTROL

621968 DA
NEW SALT BASED HIGHWAY DEICERS WITH IMPROVED ANTI-CORROSIVE PROPERTIES. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Ireland, DT
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. 1 Fig. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
The physical deterioration of high traffic areas like the interstate system, bridges, and the exposed steel related to the roadways has exemplified the need for the development of an economical and effective deicing compound that is anti-corrosive in nature. The findings presented in this report are the result of laboratory tests conducted at the Cargill Research Center in Minnetonka, Minnesota. The goal of the product development process was to develop an enhanced-salt deicer that exhibits the positive attributes of salt, but also provides anti-corrosive and anti-scaling properties, which should result in longer roadway, infrastructure, and vehicular life. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CHEMICAL DEICING AGENTS; CORROSION PREVENTION; DEICERS; DEICING SALT; ENERGY AND ENVIRONMENT; LABORATORY TESTS; MAINTENANCE, GENERAL; STEEL STRUCTURES

621967 DA
CORROSION AND ALTERNATE DEICERS. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
McCrum, RL
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. 1 Tab. Refs.
SUBFILE: HRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
Michigan's corrosion evaluation of alternate deicers started in the early 1980s with accelerated laboratory testing and, given some of the concerns about how well the laboratory environment can simulate the real world, has gradually advanced to more realistic field testing. While accelerated laboratory testing can give quicker answers, correct answers are of primary importance given the high cost of an alternate deicer. Speciments were selected to represent most of Michigan's currently used highway structural metal applications with special attention going to those most directly exposed to highway deicing salts. While painted bridge steels, bar reinforcement for concrete, aluminum alloys, galvanizing, guardrail materials, and a few galvanic couples were also tested, the results for only the following groups of metals are discussed in detail here. (1) Bridge Steels: ASTM A572, A588, A588 previously exposed to NaCl environment, and A36 for both open and "sheltered" (tensile specimens) exposures. (2) Prestressing Strand: ASTM A416 Grade 270. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CHEMICAL DEICING AGENTS; CORROSION TESTS; CORROSIVE ENVIRONMENTS; DEICING SALT; ENVIRONMENTAL DESIGN; GUARDRAILS; LABORATORY TESTS; MICHIGAN; SALT, SODIUM CHLORIDE STEEL STRUCTURES; STRUCTURAL MATERIALS; STRUCTURES DESIGN AND PERFORMANCE

621966 DA
A COMPARISON OF CONVENTIONAL AND ALTERNATIVE DEICERS: AN ENVIRONMENTAL IMPACT PERSPECTIVE. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Moran, VM; Abron, LA; Weinberger, LW
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South
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DIALOG File 63: TRIS _ 70-92/JUL

Main Street, P.O. Drawer 519 Chelsea Michigan 48118
The known impacts on the surrounding plant and animal life of sodium chloride have caused researchers to study several alternate deicing chemicals, their feasibility, and the possible risks they pose to the environment. The primary objectives of this study are to present, through a review of literature and previous studies, the known risks to the environment of using sodium chloride as a deicing agent and to examine alternative deicing chemicals with an emphasis on reducing the negative impacts of deicers on the environment. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CHEMICAL DEICING AGENTS; DEICERS; DEICING SALT ENERGY AND ENVIRONMENT; ENVIRONMENTAL DESIGN; ENVIRONMENTAL IMPACT; GROUNDWATER; SODIUM CHLORIDES; WATER POLLUTION

621965 DA
THE ENVIRONMENTAL IMPACT OF DEICERS IN AIRPORT STORMWATER RUNOFF. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Sills, RD; Blakeslee, PA
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
Airports have long been recognized as facilities associated with noise pollution and potential groundwater contamination due to fuel releases. Airports have also received increasing scrutiny directed toward the potential environmental impacts resulting from the wintertime use of deicing chemicals and their subsequent occurrence in stormwater runoff. Due to this growing concern, the Michigan Department of Natural Resources, Surface Water Quality Division, in 1990, conducted an investigation into the practice of aircraft and runway deicing. This entailed a literature review, information gathering from airport representatives, deicer applicators and deicer formulators, and field studies to investigate potential environmental impacts of the practice. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: AIRPORT RUNWAYS; CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; ENVIRONMENTAL DESIGN; ENVIRONMENTAL IMPACT; GROUNDWATER; RUNOFF; STORM WATER DRAINAGE; WATER POLLUTION

621959 DA
ENVIRONMENTAL IMPACT AND TOXICOLOGICAL CHARACTERISTICS OF CALCIUM MAGNESIUM ACETATE. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
McFarland, BL; O'Reilly, KT
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
Whenever a new chemical is proposed for wide-scale use, it becomes important to determine the potential effects on humans and the environment. Sodium and calcium chlorides have been widely used as effective highway deicers for many years. But their use has not been without some cost to the environment in terms of impacts on roadside vegetation, streams and lakes, and soils and sediments. Concerns over these negative impacts prompted studies into alternate deicers which led to the recommendation of calcium magnesium acetate (CMA) as the best alternative to road salt due to its potential for large-scale production and extremely low levels of toxicity on terrestrial and aquatic organisms. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; ENVIRONMENTAL DESIGN ENVIRONMENTAL IMPACT; SODIUM CHLORIDES

621957 DA
DEICING CHEMICAL USE ON THE MICHIGAN STATE HIGHWAY SYSTEM. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Gales, JE; Van der Meulen, J
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
This report updates a 1984 paper prepared by the Legislative Science Office (now the Science and Technology Division, Legislative Service Bureau) entitled, Salt and Road Deicing on the Michigan State Highway System. Ongoing interest in reducing the amount of salt used for deicing roads in winter as well as advances in the manufacture of salt alternatives have necessitated tis update. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; MAINTENANCE, GENERAL; MICHIGAN; STATE HIGHWAYS; STATE TRANSPORTATION DEPARTMENT

616503 DA
VERGLIMIT DE-ICING CHEMICAL ASPHALT ADDITIVE. SR 309- 02M LEHIGH COUNTY. CONSTRUCTION REPORT
Sheftick, DE
Pennsylvania Department of Transportation Bureau of Bridge
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

and Roadway Technology, T&S Bldg, Rm 1009 Harrisburg Pennsylvania 17120; Pennsylvania Department of Transportation Office of Research & Special Studies, T&S Bldg, Rm 905 Harrisburg Pennsylvania 17120; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Jun 1991 56p 2 Fig. 6 Tab. 5 Phot. 7 Ref. 4 App.

REPORT NO: FHWA-PA-86-041+83-39; Res Proj 83-39D

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

In 1988, the Pennsylvania Department of Transportation (PennDOT) constructed an ice retardant bituminous concrete overlay on SR 309, Section 02M in Lehigh County. The chemical additive Verglimit was added to the bituminous concrete mix at a rate of five percent of the total mix weight to produce the ice retardant mix. Only minor mix design and construction modifications were necessary to produce this ice retardant mix. The asphalt content of the Verglimit modified mix was increased by 0.1% as compared to the control mix of a standard ID-2 wearing course. The weight percent of aggregate retained on the #200 up through the #4 sized sieves was reduced by 8.8 to 9.9% to compensate for the addition of Verglimit particles into the mix. Construction modifications included: restricting the amount of water added to the roller during initial compaction operations; spreading mortar sand onto the overlay surface and rolling it into the surface during final compaction operations; and flushing the finished pavement with water from a high pressure distributor truck to prevent slippery surface conditions due to bleeding of the Verglimit additive. Although post construction bleeding of the pavement was noticed, skid tests performed five and eight days after construction indicated that the overlay had adequate friction resistance. Skid resistance values ranged from 46 to 77. The performance of the Verglimit overlay has been identical to that of the standard mix ID-2 overlay placed on this project. Maximum rut depths were measured at 3/8-in. in both the Verglimit and standard mix sections. No conclusions as to the deicing effectiveness of Verglimit can be made since the project was never monitored during any snowfalls or freezing precipitation events.

DESCRIPTORS: ASPHALT CONTENT; ASPHALTIC CONCRETE; BITUMINOUS MATERIALS AND MIXES; BLEEDING; CHEMICAL DEICING AGENTS; CONSTRUCTION; FRICTIONAL RESISTANCE; MIX DESIGN; OVERLAY COURSE; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT PERFORMANCE POST CONSTRUCTION; RUT DEPTH; SKID RESISTANCE; VERGLIMIT; WEARING COURSE

616494 DA

VERGLIMIT DE-ICING CHEMICAL ASPHALT ADDITIVE. FINAL REPORT

Sheftick, DE

Pennsylvania Department of Transportation Bureau of Bridge and Roadway Technology, T&S Bldg, Rm 1009 Harrisburg Pennsylvania 17120; Pennsylvania Department of Transportation Office of Research & Special Studies, T&S Bldg, Rm 905 Harrisburg Pennsylvania 17120; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Jun 1991 42p 1 Fig. 3 Tab. 4 Phot. 10 Ref. 4 App.

REPORT NO: Res Proj 83-39

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The Pennsylvania Department of Transportation has used the chemical additive Verglimit in ID-2 wearing courses on three experimental overlay projects from 1985 to 1988. This report discusses the use of Verglimit by other states, its material properties and addition rate, mixing operations, construction and post construction, project accident records, and cost. It was concluded that, due to its cost and limited effectiveness, Verglimit should only be placed on highway sections with substantial numbers of ice or snow related accidents attributable to persistent early icing or sections which cannot be reached quickly by maintenance crews in times of hazardous driving conditions.

DESCRIPTORS: ACCIDENT RECORDS; ASPHALTIC CONCRETE; BITUMINOUS MATERIALS AND MIXES; CHEMICAL DEICING AGENTS; CONSTRUCTION; COSTS; EFFECTIVENESS; MATERIAL PROPERTIES; MIXING PROCEDURES; OVERLAY COURSE; PAVEMENT DESIGN AND PERFORMANCE; POST CONSTRUCTION; VERGLIMIT; WEARING COURSE

602672 DA

COMPARATIVE STUDY OF UNDERCUTTING AND DISBONDMENT CHARACTERISTICS OF CHEMICAL DEICERS

McElroy, AD; Blackburn, RR; Kirchner, HW

Transportation Research Board

Transportation Research Record N1268 1990 pp 173-180 3 Fig. 5 Tab. 6 Phot. 1 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

A laboratory study was conducted to determine the undercutting and disbondment characteristic of 10 chemical deicers. The materials included six discrete deicing chemicals and four blends: calcium chloride pellets, calcium chloride flakes, two sodium chloride products, potassium chloride, pelletized urea, sodium chloride with a small amount of carboxymethocellulose, a blend of sodium chloride and potassium chloride sprayed with urea, a blend of sodium chloride and urea, and calcium magnesium acetate. In the undercutting tests, deicer particles were distributed on 6- x 9- x 2-in. concrete slabs covered with a 1/8-in. layer of ice. Tests were conducted at temperatures ranging from 0 deg F to 25 deg F in 5 deg F increments. Results were photographed and subsequently measured with a computerized stylus. The disbondment test apparatus measured and recorded the horizontal and vertical forces required to remove ice from a concrete specimen as it was drawn beneath a stationary blade. Each deicer was applied to the 1/8-in. ice samples and allowed to undercut for 30 min before disbondment forces were recorded. The tests showed that at least a 95% complete undercutting is necessary for ice removal by mechanical

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DIALOG File 63: TRIS _ 70-92/JUL

disbondment forces of 2.8 lb per inch of blade width. This paper appears in Transportation Research Record No. 1268, Highway Maintenance Operations and Research 1990.
DESCRIPTORS: BLENDS; CALCIUM CHLORIDES; CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; COMPARISONS; DEICERS; GENERAL MATERIALS; ICE CONTROL; LABORATORY TESTS; PERFORMANCE POTASSIUM CHLORIDE; SODIUM CHLORIDES; UREA

602593 DA
HIGHWAY SNOW CONTROL RESEARCH IN JAPAN
Itagaki, K
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755
Sep 1990 65p Figs. 4 Tab. Phots. Refs. 4 App.
REPORT NO: Special Report 90-33
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The wide range of Japanese efforts to control snow and ice on highways is reviewed. Many studies parallel U.S. and European research, but extensive basic studies of applications of modern high technology are noted as well. The studies are grouped into the following categories: (1) Basic studies; (2) Snow-removal equipment; (3) Road heating; (4) Chemicals and snow melters; (5) Snow-protection facilities; (6) Trafficability, friction, and adhesion; (7) Sociological and economic impact; (8) Statutory measures and regulations; and (9) Collective measures.
DESCRIPTORS: ADHESION; ADMINISTRATION; CHEMICAL DEICING AGENTS; CONSTRUCTION AND MAINTENANCE EQUIPMENT; ECONOMIC IMPACT; EQUIPMENT; FRICTION; HEATING; JAPAN; LAWS; MAINTENANCE, GENERAL; REGULATIONS; REVIEWS; SNOW & ICE CONTROL ; SNOW MELTERS; SNOW PROTECTION FACILITIES; SNOWPLOWS; SOCIOLOGICAL ASPECTS; TRAFFICABILITY

602578 DA
TRANSPORTATION FORUM: DE-ICING CHEMICALS FOR WINTER MAINTENANCE, SEPTEMBER 29, 1988, HALIFAX, NOVA SCOTIA
Roads and Transportation Association of Canada
Transportation Forum 1990 64p
REPORT NO: No. 2
SUBFILE: HRIS
AVAILABLE FROM: Roads and Transportation Association of Canada 1765 St Laurent Boulevard Ottawa Ontario K1G 3V4 Canada
This document represents the second issue of RTAC's revised "Transportation Forum". The objective of the journal is to present papers from RTAC-sponsored seminars, symposia and workshops. This second issue presents the papers delivered on September 29, 1988, at a seminar on "De-Icing Chemicals for Winter Maintenance," held in conjunction with RTAC's annual conference in Halifax, Nova Scotia. The seminar focused on the effects of de-icing salts on the environment, recent field testing of alternatives to traditional rock salt, and the practical aspects of winter road maintenance. The seminar concluded with a speakers' group discussion which addressed: means of coping with winter budget constraints, operational properties of the ideal de-icer, and the actions required to reduce the environmental effects of de-icing chemicals.
DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; CONFERENCES; CONSTRAINTS; DEICERS; ENVIRONMENTAL EFFECTS; FIELD TESTS; FUNDING; GENERAL MATERIALS; HIGHWAY MAINTENANCE; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; WINTER

601463 DA
SALT SUBSTITUTE DEICER BROCHURE
South Dakota Department of Transportation Transportation Building Pierre South Dakota 57501
1990 31p 5 Fig. 2 Tab. 9 Phot. 1 App.
REPORT NO: No. 94
SUBFILE: HRIS
AVAILABLE FROM: South Dakota Department of Transportation Transportation Building Pierre South Dakota 57501
The use of chloride salts (sodium and calcium) as deicing chemicals results in nearly $3 billion of damage annually to automobiles, bridges, parking ramps and pavements in the United States. In South Dakota, the annual cost of salt-related bridge restoration alone exceeds $6 million. Joint research by the South Dakota Department of Transportation and the South Dakota School of Mines and Technology resulted in development of a new product which shows promise as an effective deicer while avoiding the damaging effects of chloride salts. The manufacturing process reacts two low-cost items, sodium carbonate and waste wood products, to produce both an effective deicing chemical and a quality woodpulp. Laboratory and market research indicates these products can be produced at a cost that is at least competitive with the cost of similar products now on the market. This brochure contains eight sections: (I) Overview; (II) The Results of South Dakota's Investigation; (III) South Dakota's Chemical Process; (IV) South Dakota's Salt Substitute; (V) South Dakota's Pulp; (VI) Need for Further Testing; (VII) South Dakota Has Commissioned a Market Survey by a Nationally Recognized Company; and (VIII) Your Opportunity.
DESCRIPTORS: BROCHURES; CHEMICAL DEICING AGENTS; COST EFFECTIVENESS; EFFECTIVENESS; GENERAL MATERIALS; MAINTENANCE, GENERAL; MARKET RESEARCH; RESEARCH AND DEVELOPMENT; SODIUM CARBONATE; WOOD PULP

600936 DA
EVALUATION PROCEDURES FOR DEICING CHEMICALS. INTERIM REPORT
Chappelow, CC
Strategic Highway Research Program National Research Council, 818 Connecticut Ave, NW, Ste 400 Washington D.C. 20006
Jun 1990 v.p. 2 App.
REPORT NO: SHRP-W/IR-90-001; SHRP H-205
SUBFILE: HRIS

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DIALOG File 63: TRIS _ 70-92/JUL

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

This program consists of two phases. The first phase has been directed towards the development of a preliminary set of evaluation procedures based on the thermodynamic and corrosion characteristics of promising categories of potential deicer chemicals. The second phase is directed toward the development and modification of chemical deicer test methods, and the development and evaluation of improved sodium chloride. This interim report presents the research activities and findings of the phase I investigations.

DESCRIPTORS: CHEMICAL DEICING AGENTS; CORROSION; CORROSION RESISTANCE; CORROSIVE ENVIRONMENTS; DEICING; DEICING SALT; MAINTENANCE, GENERAL; THERMODYNAMICS; WINTER; WINTER SERVICE

496092 PR

ICE-PAVEMENT BOND PREVENTION SURFACE MODIFICATION

INVESTIGATORS: Baum, B

SPONSORING ORG: Strategic Highway Research Program

PERFORMING ORG: Springborn Material Sciences, Incorporated 1 Springborn Center Enfield Connecticut 06082-4899

CONTRACT NO: SHRP-H-202; Contract

PROJECT START DATE: 8904

PROJECT TERMINATION DATE: ND

SUBFILE: HRIS

This contract will design, test, and demonstrate practical methods and equipment for prevention of ice bonding. Tasks include; 1) Investigate methods for concentrating a deicing chemical or chemicals on or near the surface of pavements, which will effectively reduce snow/ice adhesion at low temperatures. The methods developed should be cost-effective with respect to manufacture, application and service life, and be nontoxic and noncorrosive. 2) Develop a method of physically modifying pavement to prevent formation or bonding of ice. The modified pavement should be economical, long-lived, effective over a wide range of climatic and traffic conditions, relatively easy to apply and maintain, and have an adequate coefficent of friction between rubber tires and pavement. The field testing and evaluation of long-term pavement performance conducted as a part of this study will require close coordination with SHRP's long-term pavement performance (LTPP) program.

DESCRIPTORS: ADHESION; CHEMICAL DEICING AGENTS; COST EFFECTIVENESS; DEICERS; FRICTIONAL COEFFICIENT; GENERAL MATERIALS; ICE PREVENTION; LONG TERM; LOW TEMPERATURES; MAINTENANCE, GENERAL; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT PERFORMANCE; PAVEMENT SKIDDING CHARACTERISTICS; RESEARCH PROJECT; SNOW; SNOW MELTERS

496073 PR

ICE-PAVEMENT BOND PREVENTION SURFACE MODIFICATION

INVESTIGATORS: Baum, B

SPONSORING ORG: Strategic Highway Research Program

PERFORMING ORG: Springborn Material Sciences, Incorporated 1 Springborn Center Enfield Connecticut 06082-4899

CONTRACT NO: SHRP H-202; Contract

PROJECT START DATE: 8904

PROJECT TERMINATION DATE: ND

SUBFILE: HRIS

The object of this research is to investigate methods for concentrating a deicing chemical(s) on or near the surface of pavements, which will effectively reduce snow/ice adhesion at low temperatures. The methods developed should be cost-effective with respect to manufacturing, application and service life, and be nontoxic and noncorrosive. In addition, develop a method of physically modifying pavement to prevent formation or bonding of ice. The modified pavement should be economical, long-lived, effective over a wide range of climatic and traffic conditions, relatively easy to apply and maintain, and have an adequate coefficient of friction between rubber tires and pavement.

DESCRIPTORS: ADHESION; CHEMICAL DEICING AGENTS; COST EFFECTIVENESS; DEICERS; FRICTIONAL COEFFICIENT; ICE PREVENTION ; LOW TEMPERATURES; MAINTENANCE, GENERAL; PAVEMENT SKIDDING CHARACTERISTICS; RESEARCH PROJECT; SNOW & ICE CONTROL; SNOW MELTERS

485527 DA

VERGLIMIT DEICING CHEMICAL ASPHALT ADDITIVE. CONSTRUCTION REPORT

Highlands, KL

Pennsylvania Department of Transportation Bureau of Bridge and Roadway Technology, T&S Bldg, Rm 1009 Harrisburg Pennsylvania 17120; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Dec 1988 44p 2 Fig. 3 Tab. 8 Phot. 2 App.

REPORT NO: FHWA-PA-88-007+83-39; RP 83-39C

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

This project was constructed by the Pennsylvania Department of Transportation (PennDOT) in Schuylkill County on SR 924-01M near the town of Shenandoah. The purpose of this project is to evaluate the mixing, placement, post-construction performance, and cost-effectiveness of the Verglimit deicing chemical additive in an asphalt overlay and compare it to an overlay consisting of PennDOT's standard ID-2 wearing course. This report details the mixing, placement, and post-construction procedures performed to construct the overlays. Problems were encountered with the Verglimit on this project. The most serious problem was the creation of a "wet" pavement surface following construction. This "wetness" or "bleeding" on the Verglimit surface temporarily reduced the skid resistance of the Verglimit pavement. Several accidents occurred on the Verglimit overlay during the week immediately following its placement. There are several factors discussed in this report which might explain the bleeding of this Verglimit overlay. One major factor considered to be a cause is the excess amount of Verglimit flakes which were crushed during construction

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DIALOG File 63: TRIS _ 70-92/JUL

compaction. The Verglimit overlay on this project cost approximately three times that of PennDOT's standard ID-2 overlay.

DESCRIPTORS: ACCIDENTS; BITUMINOUS OVERLAYS; BLEEDING; CHEMICAL DEICING AGENTS; CONSTRUCTION; CONSTRUCTION METHODS; COST EFFECTIVENESS; GENERAL MATERIALS; MAINTENANCE, GENERAL; PAVEMENT DESIGN AND PERFORMANCE; PERFORMANCE EVALUATION; SAFETY; SKID RESISTANCE; SNOW & ICE CONTROL; VERGLIMIT

479288 DA

CHEMICALLY BREAKING THE BOND BETWEEN ICE AND ROAD SURFACES. FINAL REPORT

Trost, SE; Heng, FJ; Cussler, EL

Minnesota University, Minneapolis Department of Chemical Engineering and Materials Science Minneapolis Minnesota 55455 Minnesota Department of Transportation Transportation Building, Rm B-9, John Ireland Boulevard St Paul Minnesota 55155

Jan 1987 23p 5 Fig. 1 Tab. Refs.

REPORT NO: MN/RC-87/6; U of M, TOC #18

CONTRACT NO: 62869; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The rates for breaking the bond between ice and road surfaces have been measured as a function of the temperature, the type of road surface, and the chemical application. Surfaces of asphalt, concrete, and brick gave indistinguishable results. Chemicals used included sodium chloride, calcium chloride, urea, and calcium magnesium acetate (CMA). The results are analyzed in terms of the maximum areas undercut and the rates at which the areas are undercut. The areas for all chemicals can be correlated with arguments based on freezing point depression. The rates seem consistent with mass transfer correlations.

DESCRIPTORS: BONDING; CALCIUM CHLORIDES; CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; FREEZING POINT DEPRESSION; ICE; MAINTENANCE, GENERAL; PAVEMENTS; SODIUM CHLORIDES; TEMPERATURE; UREA

477352 DA

PROGRAM TO REDUCE DEICING CHEMICAL USAGE

Lord, BN

Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike McLean Virginia 22101

1988 13p Refs.

SUBFILE: HRIS

AVAILABLE FROM: Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike, HNR-20 McLean Virginia 22101

Our Nation's transportation system has become the veins and arteries of the lifeblood of our national economy. Rapid, reliable movement of people, goods, and services to supply raw materials and the work force to produce and deliver are critical to the health and welfare of our society. This capability must be year-round. In our northern States, this requires the maintenance of clear open roads and streets throughout the winter. Over the years (since about 1948), our dependency on deicing chemicals has been increased to provide "bare pavement" for safe and efficient winter transportation. Concern about the effects of sodium chloride (salt) on our environment and water quality and on automobile and highway bridge deck corrosion also increased with this chemical usage. Beginning in the late 1960's and culminating today with an $8 million research effort in the Strategic Highway Research Program (SHRP), the highway community--industry, government, and academia--has undertaken measures to minimize our dependency on chemicals.

DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; CORROSION; DEICERS; ENVIRONMENTAL EFFECTS; GENERAL MATERIALS; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; SODIUM CHLORIDES; STRATEGIC HIGHWAY RESEARCH PROGRAM

473194 DA

EFFECT OF CALCUIM MAGNESUIM ACETATE (CMA) ON PAVEMENTS AND MOTOR VEHICLES. FINAL REPORT

Slick, DS

DAEDALEAN, Incorporated 15110 Frederick Road Woodbine Maryland 21797; Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike McLean Virginia 22101

Apr 1987 206p 13 Fig. 53 Tab.

REPORT NO: FHWA/RD-87/037; FCP 33C3-062

CONTRACT NO: DTFH61-84-C-00029; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The corrosion and/or deterioration of highway-related and automotive-related materials by chloride-containing deicing chemicals has become a major economical problem in the United States. The Federal Highway Administration has proposed the use of calcium magnesium acetate (CMA) as an alternative to these chloride-containing chemicals (specifically, sodium chloride). This report describes the comparative effects of CMA and sodium chloride on various highway-related and automotive-related materials. The results of various exposure techniques, followed by extensive additional testing, indicate that CMA is much less deleterious to highway-related and automotive-related materials than sodium chloride.

DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; COMPARISONS; CORROSION; DETERIORATION; ECONOMIC IMPACT ; GENERAL MATERIALS; MOTOR VEHICLES; PAVEMENTS; SODIUM CHLORIDES; TESTING

471956 DA

VERGLIMIT DE-ICING CHEMICAL ASPHALT ADDITIVE. CONSTRUCTION REPORT

Morian, DA; Arellano, JL

Pennsylvania Department of Transportation Engineering

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

District 1-O, 1140 Liberty Street Franklin Pennsylvania 16323 Pennsylvania Department of Transportation Office of Research & Special Studies, T&S Bldg, Rm 905 Harrisburg Pennsylvania 17120; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590

Mar 1987 32p 11 Fig. 1 Tab. 3 App.

REPORT NO: FHWA-PA-86-041+83-39; Res Proj 83-39

CONTRACT NO: 83-39; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The purpose of this project was to determine the effectiveness and feasibility of using the Verglimit de-icing chemical asphalt additive to minimize pavement icing problems. The Verglimit additive consists of calcium chloride flakes encapsulated in linseed oil. It was introduced into the bituminous mix at 5% of the aggregate by weight. This project consisted of a 1 1/2-inch Verglimit-modified ID-2 wearing overlay on a 2-inch binder course. No problems were encountered during construction. Normal paving techniques were followed except that a light spray of kerosene was used on the rollers instead of water because water strips the linseed oil from the calcium chloride flakes. The calcium chloride content of the Verglimit was 75% by weight. The average density of six cores of the Verglimit-modified ID-2 was 99.6%. Skid tests taken in March 1987 indicate the skid resistance of the Verglimit-modified ID-2 is only slightly lower than that of the adjacent sections. The cost of the Verglimit-modified ID-2 material is three times that of standard ID-2 material. However, a reduction in application of de-icing agents (250 lbs/lane mile, 1985-86) and increased safety may justify this cost.

DESCRIPTORS: ADDITIVES; BITUMINOUS MATERIALS AND MIXES; BITUMINOUS MIXTURES; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; COSTS; DENSITY; EFFECTIVENESS; FEASIBILITY; GENERAL MATERIALS; ICE CONTROL; LINSEED OIL; SKID RESISTANCE

469147 DA

FORMATES AS ALTERNATIVE DEICERS

Palmer, DA

Transportation Research Board

Transportation Research Record N1127 1987 pp 34-36 1 Fig. 10 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The cost of deicing the nation's road system is roughly 20 times greater than the cost of the salt that is spread. This is due to chloride corrosion, which hits the vehicle fleet hardest. Next hardest hit are the nation's bridges, whose life has been reduced from about 20 to 5 years. Because corrosion inhibitors have proven ineffective, attention has turned to alternative chemical deicers. Though most current government support is dedicated to evaluation of calcium magnesium acetate (CMA), this chemical compound has many technical and economic drawbacks. In fact, CMA might continue to be too expensive to generate much use. At less than half the cost, it may be possible to produce sodium, calcium, or dolomitic lime formates. They can probably be made directly from carbon monoxide, rather than using formic acid. Sodium formate is much less toxic than initially thought. Further, it can probably be spread as a very concentrated solution or even as a slurry. The freezing-point curve of sodium formate is similar to that of sodium chloride down to about -14 deg C. It has now been demonstrated experimentally that sodium formate does not spall cured concrete. This paper appeared in Transportation Research Record No. 1127, Innovation, Winter Maintenance, and Roadside Management.

DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; COSTS; DEICING; FORMATES; GENERAL MATERIALS; MAINTENANCE, GENERAL; PERFORMANCE; SODIUM FORMATE

394940 DA

ROADSIDE DEICING CHEMICAL ACCUMULATION AFTER 10 YEARS

Hsu, MT (Maine Department of Transportation)

Transportation Research Record N969 1984 pp 36-40 1 Fig. 6 Tab. 16 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

Soil and plant samples were collected along the northbound lane of I-95 between Alton and Howland, Maine, from sites identical to those used in a similar study in 1972-1973. The sodium and chloride content of the samples was determined; the values were averaged and treated statistically. The mean values were then compared with values obtained in 1972-1973. The following conclusions could be drawn. Sodium ion concentration exhibited a general cumulative trend due to application of road salt, sodium chloride (NaCl). However, accumulation was far below exchangeable sodium levels that are considered damaging. The chloride ions leached out of the soil fairly rapidly and had no pronounced accumulative effect. The effect of deicing salt on the sodium and chloride content of hemlock needle tissues was insignificant. The NaCl content of accumulated snow, which is caused by snow plow and blow action during the application of the road salt in the winter season, diminished as the distance from the highway increased. The alkalinity (or acidity) of soil appeared to have a direct relationship with the sodium content of the soil. The present study is generally applicable to areas adjacent to four-lane divided Interstate highways in the northeastern United States. This paper appeared in Transportation Research Record Number 969, Wetlands and Roadside Management.

DESCRIPTORS: ACID SOILS; ALKALINE SOILS; CHEMICAL DEICING AGENTS; DIVIDED HIGHWAY; ENVIRONMENTAL DESIGN; FOUR LANE HIGHWAYS; ROADSIDE; SODIUM CHLORIDES; SOILS; VEGETATION

DIALOG File 63: TRIS _ 70-92/JUL

387368 DA
AMERICA'S HIGHWAYS. ACCELERATING THE SEARCH FOR INNOVATION
Transportation Research Board
Transportation Research Board Special Report N202 1984 169p Figs. Tabs. Refs.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
This study outlines a strategy for screening potential highway research areas to identify the most promising for a national program and there by identifies six priority areas where a concerted research effont can produce major innovations that will increase the productivity and safety of the nation's highway system: asphalt, long-termpavement performance, maintenance cost-effectiveness protection of concrete bridge components, cement and concrete in highway pavements and structures, and chemical control of snow and ice on highways.
DESCRIPTORS: ASPHALTS; CHEMICAL DEICING AGENTS; CONCRETE BRIDGES; COST EFFECTIVENESS; FUTURE RESEARCH; HIGHWAY MAINTENANCE; HIGHWAY RESEARCH; LONG TERM; PAVEMENT PERFORMANCE ; PRIORITIES; SNOW & ICE CONTROL

387367 DA
AMERICA'S HIGHWAYS. ACCELERATING THE SEARCH FOR INNOVATION. EXECUTIVE SUMMARY
Transportation Research Board
Transportation Research Board Special Report N202 1984 12p 2 Tab.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
This study outlines a strategy for screening potential highway research areas to identify the most promising for a national program and thereby identifies six priority areas where a concerted research effort can produce major innovations that will increase the productivity and safety of the nation's highway system: asphalt, long-term pavement performance, maintenance cost-effectiveness, protection of concrete bridge components, cement and concrete in highway pavements and structures, and chemical control of snow and ice on highways.
DESCRIPTORS: ADMINISTRATION; ASPHALTS; CHEMICAL DEICING AGENTS; CONCRETE BRIDGES; COST EFFECTIVENESS; FACILITIES DESIGN; FUTURE RESEARCH; HIGHWAY MAINTENANCE; HIGHWAY RESEARCH ; LONG TERM; MAINTENANCE, GENERAL; PAVEMENT PERFORMANCE; PRIORITIES; SNOW & ICE CONTROL

291133 DA
ICE DETECTIONS FOR RUNWAYS AND ROADS
Building and Contract Journals Limited
Highways and Road Construction VOL. 41 NO. 1763 1973 pp 20-21 1 Fig.
SUBFILE: TRRL; IRRD; HRIS
This article describes an ice detection unit the "icelert", designed for use on airfields and other paved areas; it gives sufficient warning to allow the runway to be treated with anti-icer chemical before ice actually forms. Furthermore when the chemicals become too diluted to be effective or when the temperature of the surface falls to a level at which the existing solution would freeze, another warning is given, the unit consists of three probes each of which carries a pair of electrodes, a control box, and a decoder and display unit. The ice detector has been used with a fair degree of success on RAF airfields in Germany and has been installed on a limited number of airfields in the United Kingdom. /TRRL/
DESCRIPTORS: AIRPORT RUNWAYS; CHEMICAL DEICING AGENTS; DETECTING DEVICES; ELECTRODES; ICE; MAINTENANCE, GENERAL; PAVEMENTS; PROBES; WARNING SYSTEMS

265454 DA
LIQUID GLYCOL AND FORMANIDE UREA BASED ICE CONTROL CHEMICALS
Rice, RR
Air Force Civil Engineering Center; Tyndall AFB; Florida; 32401
Jul 1974 Intrm Rpt. 54 pp Figs. 4 Tab. 13 Ref. 3 App.
REPORT NO: AFCEC-TR-74-4
SUBFILE: HRIS
This document reports on field effectiveness evaluations of commercial and military specification liquid ice control chemicals as runway and taxiway anti-icing and deicing agents. The formulations tested were approved as being non-deleterious to aircraft metals and plastics. The chemicals evaluated were determined to be less effective as deicers than urea for temperatures above 15 deg F, and more effective below. Deicing effectiveness was variable. Chemical effectiveness as anti-icers was more predictable. The chemicals proved effective in preventing ice formulation up to a water: chemical dilution ratio of 8:1. Based on investigations requested and/or sponsored by the Controlling Office, the chemicals should not be applied to non-air entrained portland cement concretes, nor should they be used without consideration of their effects on the environment. Results reported by other investigators indicate that care should be exercised to insure against excessive traction losses due to the application of liquid ice control chemicals.
DESCRIPTORS: AIRCRAFT EQUIPMENT; CHEMICAL DEICING AGENTS; DEICERS; ICE CONTROL; MAINTENANCE, GENERAL; NONAIR ENTRAINED CONCRETE; RUNWAYS; TAXIWAYS; TRACTION; UREA

262656 DA
DEICING CHEMICALS: RED FLAG FOR ECOLOGY OR GREEN FOR SAFETY?
Pattison, PL (Public Works)
Rural and Urban Roads VOL. 11 NO. 6 Jun 1973 pp 31-33
SUBFILE: HRIS
The technical and sometimes emotional problems of using deicing chemicals in a community can often wipe out reasonable solutions and literally place those communities on the "horns

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

of a dilemma." Resident and official alike become frustrated and wonder what the best course is to follow in the best interest of all. However, the burden falls on the shoulders of the community official who must act with the best of his ability. He will perform well and still find must act with the best of his ability. He will perform well and still find some residents-- or other governmental agencies--criticizing his techniques. The matter turns into a viselike squeeze. In the following article, Public Works Superintendent Philip L. Pattison of the Town of Canton, Massachusetts, spells out the problems and some of the views he had developed toward them for guiding him to solutions. /Editor's Forward/

DESCRIPTORS: CHEMICAL DEICING AGENTS; COMMUNITY VALUES; DEICERS; ECOLOGY; HIGHWAY SAFETY; MAINTENANCE, GENERAL; SNOW & ICE CONTROL

262089 DA

RECOMMENDED PROCEDURES FOR CHEMICAL APPLICATIONS FOR SNOW AND ICE CONTROL

Public Works VOL. 105 NO. 1 Jan 1974 p 50

SUBFILE: HRIS

Three basic methods of spreading deicing chemicals are outlined. They are, the window application for rural and residential roads, steeply crowned roadways and two-lane main thoroughfares; a fixed width spreader for single lane applications on residential streets; and the spinner type method which is adaptable for all uses. Recommendations are made concerning the rate of application, the calibration of spreaders and the timing of the application. Possible environmental damage should be considered by each municipality and it is recommended that each municipality maintain records of chemical usage for each occasion when chemical treatment is required.

DESCRIPTORS: CALIBRATIONS; CHEMICAL DEICING AGENTS; MAINTENANCE, GENERAL; METHODS; RECOMMENDATIONS; RESIDENTIAL AREAS; RURAL HIGHWAYS; SNOW & ICE CONTROL; SPREADERS; TIMING; WINDROWS

260727 DA

A SEARCH: NEW TECHNOLOGY FOR PAVEMENT SNOW AND ICE CONTROL

Murray, DM; Eigerman, MR

ABT Associates, Incorporated; 55 Wheeler Street; Cambridge Massachusetts; 02138

Dec 1972 62 pp Figs. Tabs. 65 Ref.

REPORT NO: EPA-R2-72-125

CONTRACT NO: 68-01-0706; Contract

SUBFILE: HSRI; HRIS

A study was undertaken to search for new approaches to the problem of snow removal and ice control in vehicular and pedestrian usage areas. Proven techniques of technology transfer were applied for the purpose of identifying technologies that have not yet been utilized for deicing purposes. Contacts with specialists and a "brainstorming session" were used to determine strategies for searches of computerized data banks. Although several approaches were indentified, none are immediately usable. Results of the study indicate that: (1) more information is needed on salt damage to the environment, paved areas, highway structures, and vehicles in order to perform accurate cost-benefit analyses of alternative approaches. 2. More complete knowledge is needed on the effects of alternate chemical deicers. 3. Pavement heating is an expensive means of removing snow and ice but can be justified in special cases for safety or environmental reasons. 4. Two mechanical devices, snow plow with compressed air and a brush and blower system require further testing and development. 5. Research is required to identify a hydrophobic substance which can be applied to pavement to reduce ice adhesion. A brief cost estimate of the various approaches has been included. /HSRI/

DESCRIPTORS: BENEFIT COST ANALYSIS; CHEMICAL DEICING AGENTS DEICERS; ENVIRONMENTAL EFFECTS; HYDROPHOBIC PROPERTIES; MAINTENANCE, GENERAL; PAVEMENT DISTRESS; SALTS; SNOW & ICE CONTROL; SNOW REMOVAL; SNOWPLOWS; TECHNOLOGY TRANSFER

260520 DA

THE EFFECTS OF ROAD TRAFFIC ON SOIL, PLANTS AND WATER

Thiemann, KH

Verlag Paul Parey

Zeitschrift Fuer Kultartechaik und Flurbereinigung VOL. 13 NO. 2 1972 pp 90-108 5 Tab.

SUBFILE: TRRL; IRRD; HRIS

A section of the motorway between Hamburg and Kassel was studied in order to determine the effect of fuel and oil deposits and de-icing salt washed off the road on to the surrounding land. Snow, water, soil and plant samples were taken up to a distance of 100 m from the road. The evaluation showed that the detrimental effects of de-icing salt on plant growth and soil properties are limited to an area between 5 and 10 m from the carriageway, whereas those of fuel and oil deposits only have a detrimental effect on the land immediately next to the road. /TRRL/

DESCRIPTORS: CHEMICAL DEICING AGENTS; EXHAUST GASES; FUELS; OILS; PLANTS /BOTANY/; SALTS; SOIL SCIENCE; SOILS; TRAFFIC; VEGETATION; WATER

234189 DA

POLLUTION ASPECTS ASSOCIATED WITH CHEMICAL DEICING

Schraufnagel, FH

Highway Research Record, Hwy Res Board 1967 No 193, pp 22-33, 4 TAB, 38 REF

SUBFILE: HRIS

chemical deicers may range from urea to rock salt. About the only requirements are that the substance be soluble in and lower the freezing point of water. Chlorides are discussed in applications to streets and highways, water supplies, and sewage and waste. Nitrogen and phosphorus deicers are not satisfactory from the standpoint of future surface water quality. However, a noncorrosive mixture has been patented for

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DIALOG File 63: TRIS _ 70-92/JUL

the chemical removal of ice and snow at airports. A few other deicers are discussed.
DESCRIPTORS: CHEMICAL DEICING AGENTS; CHLORIDES; HIGHWAYS; MECHANICS (EARTH MASS); POLLUTION; ROCK SALT; SEWAGE DISPOSAL UREA; WASTE DISPOSAL; WATER SUPPLY

219056 DA
SAVE SALT: SAVE THE ENVIRONMENT
Better Roads Mar 1973 pp 28-9 6 Phot
SUBFILE: HRIS
motivated by a desire to reduce both costs and damage to the environment, the maintenance department of the Illinois tollroad system has experimented with salt-application control through careful adjustments of the spinner baffles and with the use of liquid calcium chloride as an additive to salt to improve the melting action of the latter. Two sections of the tollway system were chosen for the experiment. Although the relatively mild winter renders the data tentative, preliminary results indicate a 20% saving in the amount of salt used per lane mile. Experiments with various baffle settings, feed systems, storage, and truck modifications are described briefly.
DESCRIPTORS: APPLICATIONS; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; DEICERS; DEICING; LIQUIDS; MAINTENANCE, GENERAL; RATE; SALT /SODIUM CHLORIDE/; WETTING

219049 DA
AUTOMATED DE-ICING SYSTEM
American Highways Jul 1972
SUBFILE: HRIS
during the winter of 1972--73 the New York dot will field test a new method of snow and ice control on a four-lane upstate bridge. An electronic sensing device continuously monitors temperature and humidity at the pavement level. When the readings indicate that snow is falling or ice is forming, the sensor activates a series of nozzles that spray a special fluid, called "isolv," onto the deck. The fluid is more effective than salt, does not corrode metal or degrade cement, and works at much lower temperatures than salt. Since it tends to soak into the pavement surface, "isolv" prevents further icing for several hours after application. The system is connected to traffic signals at either end of the bridge so that traffic is halted during the 30-second application period. The liquid, which contains no phosphates, is believed to have no environmental side effects.
DESCRIPTORS: BRIDGE DECKS; CHEMICAL DEICING AGENTS; DEICERS DETECTION; ELECTRONIC DEVICES; ICE; MAINTENANCE, GENERAL; SNOW ; SNOW & ICE CONTROL

219048 DA
ANALYSIS AND CURRENT STATUS OF ROAD DEICING
Envir Assn of Ostego & Del Cnties; 1973
Feb 1973 14 pp 3 Tab Refs
SUBFILE: HRIS
the results of a study on the effects of salt on highway safety and the environment are discussed. Tables are included which give cost data for deicers and accident data. Various conclusions are reached, the most important being that there is sufficient reasonable doubt at this time concerning the use of deicing salts, both with regard to their effect on the environment and their effectiveness for the purpose for which they are intended, that there should be no further expansion of the use thereof until more information is available.
DESCRIPTORS: ABRASIVES; ACCIDENT REPORTS; BENEFIT COST ANALYSIS; CHEMICAL DEICING AGENTS; DATA ACQUISITION; DEICERS; ECONOMICS; ENVIRONMENTAL EFFECTS; HIGHWAY DRAINAGE; MAINTENANCE, GENERAL; SALT /SODIUM CHLORIDE/

218997 DA
LIQUID CALCIUM CHLORIDE BOOSTS SALT'S EFFECTIVENESS
Better Roads Jul 1972 pp 22-3 3 Phot
SUBFILE: HRIS
the trend toward increasing quantities of deicing chemicals per hour per storm has been arrested. Assessment of the limitations of salt has led to the conclusion that it has developed a system using liquid calcium chloride as A salt treatment that was field-tested on the toledo-- Cleveland section of the Ohio turnpike during the winter of 1970-71 and then expanded during the winter of 1971-72 to other roads in Ohio, Iowa, and Illinois. In the melting action of salt, concentrated brine forms and resists further dilution under subfreezing temperatures. The strong brine quickly crystallizes. In contrast, a small amount of liquid calcium chloride added to a tone of salt dilutes both chloride brines, bringing them to a state incapable of further melting. As a result, only a minimum of salt recrystallization occurs. Test results have shown that appliction rates of salt per mile have been sharply reduced, while superior effectiveness has been achieved. A brief presentation is made of the system's chemistry, economics, dispensing equipment, application procedures, and storage.
DESCRIPTORS: ADDITIVES; APPLICATIONS; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; DEICERS; LIQUIDS; MAINTENANCE, GENERAL; RATE; SALTS

218875 DA
OBSERVED CHARACTERISTICS OF CHEMICAL DEICERS DURING THE WINTER 1970-1971
Conn Dept Transp, Bureau of Highways; Kasinskas, MM
Jun 1971 Item 19, 20 PP, 2 FIG, 1 TAB, 6 PHOT, 6 REF
SUBFILE: HRIS
to observe the relative effectiveness of chemical deicers, three different amounts of sodium chloride were compared with the same amounts of sodium chloride with an added uniform amount of a 50% propylene glycol and water solution. Laboratory tests were conducted to measure the effectiveness of different concentrations of the glycol-water solution. The
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

results indicate that a 40 percent propylene glycol solution is the minimum concentration to be considered. While there was poor control over amounts of sodium chloride actually applied, the glycol-salt combination demonstrated the faster melting characteristics. This was further supported by the results of two additional limited field tests. What effect different concentration would have on the speed of melting, and the differences among individual commercial deicers, is still unkown. There is a need to determine for each producct the degree of toxicity, corrosiveness, and harmful effects due to chemical interaction with anticaking compounds added to the sodium chloride.

DESCRIPTORS: CHEMICAL DEICING AGENTS; DEICERS; GLYCOLS; MAINTENANCE, GENERAL; SALT /SODIUM CHLORIDE/; SNOW & ICE CONTROL

218793 DA

CALCIUM CHLORIDE-SALT SNOW AND ICE CONTROL TEST, WINTER 960-61

Busse, W; Usher, M

Highway Research Board Proceedings 1962 Vol 41, P 321-332, 4 FIG, 2 TAB, 1APP

SUBFILE: HRIS

the Connecticut state highway department has for many years endeavored to maintain bare pavements throughout the winter. It is extremely difficult and in some areas impossible to accomplish the desired results using a sand-salt mixture or salt alone. A further consideration was the conservation of sand. In many areas of Connecticut, sand deposits habe been depleted or zoned out of existence, resulting in the necessity of importing sand. The resulting increase in the cost of sand tends to make chemical control of snow and ice more attractive from an economic point of view. The results obtained by the use of calcium chloride-salt mixtures on the New York Thruway were cited to gain permission to conduct a test of chemical control of snow and ice on a section of Conn. 15 in the towns of willington, ashford, and union during the winter of 1960-61. This report covers the test in considerable detail. Mechanical failures and unfamiliarity with procedures resulted in higher costs than would normally be expected. Nevertheless, the cost appears to be substantially the same as standard methods of snow and ice control. /author/

DESCRIPTORS: CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; COSTS; DEICERS; EFFECTIVENESS; FIELD TESTS; MAINTENANCE, GENERAL; SALTS

218689 DA

SNOW AND ICE CONTROL IN CALIFORNIA

Forbes, CE; Stewart, CF; Spellman, DL

Highway Research Board Special Reports

SUBFILE: HRIS

THE PRESENT OPERATIONS FOR SNOW REMOVAL AND ICE CONTROL IN CALIFORNIA ARE DESCRIBED WHERE PROBLEMS RESULT FROM A VARIETY OF FACTORS SUCH AS COMPLEX WEATHER CONDITIONS, VAST DIFFERENCES IN ELEVATION, WIDE TEMPERATURE RANGES, AND CHANGING TRAFFIC PATTERNS. A DISCUSSION OF A RESEARCH PROJECT INITIATED TO STUDY BRIDGE DECK HEATING AND MOTORIST AND MAINTENANCE WARNING SYSTEMS TO MINIMIZE THE HAZARDS OF FROSTING IS INCLUDED. ALSO DISCUSSED IS A STUDY TO FIND A DE-ICING CHEMICAL FOR USE AS AN ALTERNATIVE TO THE CHLORIDE SALTS. A COMPARATIVE TEST WAS ESTABLISHED TO MEASURE THE RATE AS WELL AS THE QUANTITY OF ICE THAT COULD BE MELTED AT VARIOUS TEMPERATURES. ALSO CONSIDERED WAS THE EFFECT OF THE CHEMICALS ON THE FRICTION FACTOR OF CONCRETE; THE CORROSIVITY TO STEEL, CONCRETE, AND OTHER MATERIALS; THE ENVIRONMENT, INCLUDING STREAMS, DOMESTIC WATER SUPPLIES, FISH, AND PLANT AND ANIMAL LIFE; AND MAINTENANCE PERSONNEL WHO WILL DISTRIBUTE THE CHEMICALS ON THE ROADWAY. /AUTHOR/

DESCRIPTORS: BRIDGE DECKS; CHEMICAL DEICING AGENTS; CONCRETES; CORROSION; ELEVATION; ENVIRONMENT; HEATING; MAINTENANCE PERSONNEL; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; SNOW REMOVAL; STEELS; TEMPERATURE; TRAFFIC FLOW PATTERN; WARNING SYSTEMS; WEATHER

218319 DA

CHEMICAL DE-ICING AGENTS USED TO COMBAT SLIPPERY ROADS

Carlier, A

Wegen /Netherlands/ 1965 Vol 39, No 10, PP 261-271, 5 PHOT

SUBFILE: TRRL; IRRD; HRIS

A NEW METHOD IS DISCUSSED OF RECORDING THE RESULTS OF PRACTICAL TESTS WHICH WOULD ENABLE THE USE OF VARIOUS THAWING AGENTS TO BE COMPARED, AND WOULD PROVIDE DATA ON THE TECHNICAL AND ECONOMIC SIGNIFICANCE OF SODIUM CHLORINE AND CALCIUM CHLORIDE MIXTURES, THE REQUIREMENTS OF SCATTERING MACHINES, THE STORAGE OF DE-ICING AGENTS AND THEIR EFFECTS ON VEHICLES AND ROAD SURFACES. CONCLUSIONS REACHED WITH THE USE OF THIS METHOD WERE AS FOLLOWS: THE ACCIDENT RATE DECREASES WHEN EITHER OF THE TWO DE-ICING AGENST IS USED; NO DAMAGE IS CAUSED TO WELL DESIGNED CONCRETE ROADS OR DENSE ASPHALTIC CONCRETE SURFACINGS. /FG/RRL/

DESCRIPTORS: ACCIDENT RATES; ASPHALTIC CONCRETE; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; CHLORINE COMPOUNDS; CONCRETE PAVEMENTS; MAINTENANCE, GENERAL; METHODS; PAVEMENT DISTRESS; RECORDING; ROAD SURFACES; SLIPPERINESS; SODIUM COMPOUNDS; STORAGE; TEST RESULTS; VEHICLES

217982 DA

CHEMICAL DEICING OF AIRCRAFT RUNWAYS

Conrardy, WP

Highway Research Record, Hwy Res Board 1964 No61, Pp19-35, 18FIG, 4TAB, 5REF

SUBFILE: HRIS

although snow accumulations can be adequately removed from airfield pavements by a variety of mechanical means, safe removal of thin layers of ice, which cause difficulty with respect to aircraft braking action, is still inadequate. In addition to the usual requirements that ice control chemicals cause minimum damage to the pavement to which applied, the U.

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DIALOG File 63: TRIS _ 70-92/JUL

S. Air force has imposed some quite rigid requirements with respect to stress corrosion. The very-high-strength aluminum and low-alloy steels used in advanced aircraft systems are particularly susceptible to catastrophic stress corrosion cracking, a mode of failure greatly accelerated when the structures involved are contaminated by such conventional ice control agents as sodium chloride and calcium chloride. This paper discusses an evaluation of several candidate deicing formulations with respect to their increasing the stress corrosion susceptibility of high-strength metals. Specimen preparation , conditions for exposure, methods of applying stress, data for a number of deicing materials are presented. /author/

DESCRIPTORS: AIRCRAFT; AIRPORT RUNWAYS; ALUMINUM; BRAKING; CHEMICAL DEICING AGENTS; CONTAMINATION; CORROSION; CORROSION PREVENTION; EVALUATION; ICE CONTROL; LOW ALLOY STEELS; MAINTENANCE, GENERAL; PAVEMENT DISTRESS; SNOW REMOVAL; STRESS CORROSION

217981 DA
REHABILITATION OF DETERIORATED BRIDGE SLABS
West, AL
Highway Research Record, Hwy Res Board 1964 No61, Pp36-42, 4FIG, 2TAB
SUBFILE: HRIS

a review is presented of the methods utilized by the central maintenance engineering division of the port of New York authority to rehabilitate concrete bridge decks, improve riding surfaces and provide maximum protection against effects of deicing chemicals and the elements. /author/

DESCRIPTORS: CHEMICAL DEICING AGENTS; CONCRETE BRIDGE DECKS DETERIORATED CONCRETE; ELEMENTS; IMPROVEMENT; MAINTENANCE, GENERAL; METHODS; PROTECTION; REHABILITATION; RIDING QUALITY; SLABS

216055 DA
CORROSION INHIBITORS INVESTIGATION
Craik, DW; Schilling, RH
Manitoba University, Winnipeg /Canada/
Dec 1966 21 Pp, 12 FIG, 2 TAB, 2 REF, 2 APP
SUBFILE: RTAC; HRIS

CORROSIVE EFFECTS OF THE WINNIPEG DE-ICING AND SURFACE CONTROL TECHNIQUE ON VEHICLES, PAVING MATERIALS AND OTHER AFFECTED MATERIALS WERE STUDIED. CHEMICAL ADDITIVES TO THE SALT, INHIBITORS, WERE USED TO REDUCE THE ELECTROLYTIC EFFECT OF MELTED ICE, AND THE EFFECT OF THE RESULTING CONCENTRATION CELL PRODUCED OR TO PASSIVATE A STEEL SURFACE. THE COST OF INHIBITION WAS LESS THAN $4.00 PER TON OF SALT AND APPEARED ACCEPTABLE IF CORROSION PROTECTION WAS AFFORDED. THE THREE INHIBITORS USED WERE CARGUARD, A PRE- TREATED ROCKSALT, A COMMERCIAL GRADE SODIUM HEXAMETAPHOSPHATE, AND AN INHIBITOR OF THE INTERNATIONAL SALT COMPANY. PRELIMINARY TESTS WERE PERFORMED TO DETERMINE THE EFFECTS OF CHEMICAL ADDITIONS TO SAND AS RELATED TO BRAKING DISTANCES OF VEHICLES ON A HARD PACK SNOW SURFACE. THE CORROSION RATES OF VEHICLES WERE COMPARED FOR THE WINTER SEASONS OF 1964/65 AND 1965/66. REFERENCES' DE-ICING CHEMICAL CORROSION INVESTIGATION. MANITOBA UNIVERSITY, SEPTEMBER 1965.

DESCRIPTORS: CHEMICAL DEICING AGENTS; CORROSION; CORROSION PREVENTION; DEICERS; ECONOMICS; GENERAL MATERIALS; INHIBITORS PAVEMENTS; PHOSPHATES; ROCK SALT; SODIUM COMPOUNDS; VEHICLES

215097 DA
CONSTRUCTION PRACTICES FOR PLACING, FINISHING AND CURING CONCRETE PAVEMENT
Barbee, JF
Highway Research Board Bulletin 1960 No 265, pp 17-26, 15 FIG
SUBFILE: HRIS

a portaind cement pavement must be so constructed that it will (1) provide a smooth-riding surface, (2) be durable to natural weathering and to chemicals disseminated for snow and ice control, and (3) be capable of sustaining the traffic that it is intended to carry. The methods required to achieve the three goals are explained in detail. Needless to say, the quality of a concrete pavement is a direct reflection of the quality of the workmanship that produces it.

DESCRIPTORS: CHEMICAL ATTACK; CHEMICAL DEICING AGENTS; COLD WEATHER CONCRETING; CONCRETE PAVEMENT CONSTRUCTION; CONSTRUCTION; HIGHWAY CONSTRUCTION; PORTLAND CEMENTS; RESISTANCE; WEATHERING; WHEEL LOAD

158070 DA
SURVEY OF ALTERNATIVES TO THE USE OF CHLORIDES FOR HIGHWAY DEICING
Zenewitz, JA
Federal Highway Administration; Office of Research and Development; Washington; D.C.; 20590
May 1977 Final Rpt. 25 pp
REPORT NO: FHWA-RD-77- 52
SUBFILE: HRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

This review was initiated to ascertain the state-of-the-art of highway deicing and to furnish information and suggestions for use in planning and initiating research in this problem area. This concise report summarizes the results of the review. Information concerning the various alternatives to chlorides for highway deicing, chemical and physical, which have been or are being used satisfactorily or unsatisfactorily by State Highway Agencies, contacted Canadian provinces, responsive European countries, and contacted federal agencies and private institutions is contained herein. In addition, throughout the report, pertinent information from cited references as well as personal evaluations, suggestions and recommendations are given.

DESCRIPTORS: CHEMICAL DEICING AGENTS; CHLORIDES; EVALUATION GENERAL MATERIALS; HIGHWAYS; MAINTENANCE, GENERAL;

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

RECOMMENDATIONS; STATE OF THE ART STUDIES; SUBSTITUTES

130613 DA
SNOW AND ICE CONTROL; MATERIALS STORAGE AND HANDLING
Patton, RW; Harris, HW; Shepherd, WS; VanVynck, J; Powers, G ; Niles, JH; Gould, JS; Johnson, L; Wheadon, R; Dunn, W; Welch, B; Miller, AS; Sellon, LD (Colorado Department of Highways; Montana Department of Highways; Wyoming State Highway Department; Utah State Department of Transportation)
Federal Highway Administration; Office of Research and Development, Implementation Division; Washington; D.C.; 20590
Sep 1975 21 pp 3 Fig. 1 Ref.
REPORT NO: FHWA-RD-75-524
SUBFILE: HRIS
AVAILABLE FROM: Federal Highway Administration Implementation Division, Office of Development, HDV-22 Washington D.C. 20590
This Report details the results of an in-depth review of the various costs involved in the procurement, specifications, processing and storage of abrasives and chemicals used for snow and ice control. The study was conducted in early 1975 by teams of engineers from four States; Colorado, Montana, Utah and Wyoming. The study was successful and the estimate savings among the four states from the implementation of only one of the recommendations (automatic mixing) is $220,000 in one year. The study costs of $60,000 compare favorably to the estimated minimum savings to the public of $5,000,000 annually if implemented Nationwide. The techniques of Value Engineering were proven effective in the analysis of maintenance activities even in States with Operational Maintenance Management Systems. /Author/
DESCRIPTORS: ABRASIVES; CHEMICAL DEICING AGENTS; COSTS; MAINTENANCE, GENERAL; PROCESSING; PROCUREMENT; SAVINGS; SNOW & ICE CONTROL; SPECIFICATIONS; STORAGE

128554 DA
PHASE TRANSITIONS OF ADSORBATES: VI, EFFECT OF DEICING AGENTS ON THE FREEZING OF CEMENT PASTE
Litvan, GG (National Research Council of Canada)
American Ceramic Society Journal VOL. 58 NO. 1-2 Feb 1975 pp 26-30 10 Fig. 15 Ref.
SUBFILE: HRIS
Changes in the dimensions and heat content of hydrated cement specimens were determined as a function of temperature and concentration of deicing agent in cooling-warming cycles between plus 15 and minus 70 C. The concentration of the polar deicer (NaCl) solution varied from 0 to 26% and that of the nonpolar (urea) solution from 0 to 40%. The w/c ratios were 0.4, 0.6, and 0.8 plain and 0.5 air-entrained. Experiments were also conducted to clarify the effect of cooling rate and sample size. The observations can be explained by the mechanism previously proposed for phase transitions of absorbates. In the presence of salts, freezing and melting of liquid exuded from the pores on cooling proceed according to thermograms except at extreme concentrations. The detrimental effect of deices is attributed mainly to the high degree of saturation, a consequence of the low vapor pressure of the solutions. A beneficial aspect is the widening of the temperature range in which transitions occur. These opposing effects result in the worst conditions at a low deicer concentration (5% NaCl) and optimum conditions at a moderately high concentration (13% NaCl). Since the effect of deicers is physical, it should be common to all chemicals. Air entrainment, although beneficial in most circumstances, can be detrimental. The best protection against "salt scaling" appears to be reduction of porosity./AUTHOR/
DESCRIPTORS: AIR ENTRAINMENT; CEMENT AND CONCRETE; CEMENT PASTE; CHEMICAL DEICING AGENTS; CONCENTRATION; CONCRETES; DETERIORATION; EXPERIMENTS; FREEZING; FROST ACTION; PHASE TRANSITION; POROSITY; SCALING; SODIUM CHLORIDES; TEMPERATURE; UREA

098985 DA
MANUAL FOR DEICING CHEMICALS: STORAGE AND HANDLING
Richardson, DL; Campbell, CP; Carroll, RJ; Hellstrom, DI; Metzger, JB; O'Brien, PJ
Little (Arthur D), Incorporated; 25 Acorn Park; Cambridge; Massachusetts; 02140
Jul 1974 7207-7406 99 pp
REPORT NO: EPA-670/2-74-033
CONTRACT NO: EPA-68-03-0154; Contract
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This report contains the results of a study conducted for the U.S. Environmental Protection Agency to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Based on the best current practices for highway maintenance as observed during two years of study, parctical guidelines are presented for good practice in the storage and handling of deicing chemicals. Covered storage of salt and other deicing chemicals is strongly recommended; permanent structures for this purpose are preferable. Guidelines are given for site selection and for design foundations, paved working area, and site drainage. Existing storage facilities are presented that represent a range of costs, designs, construction materials and storage capacities. For the handling of salt and other deicing chemicals, general precautions and good housekeeping practices are defined. Environmental responsibilities are discussed for personnel who administer and supervise highway maintenance. /FHWA/
DESCRIPTORS: CHEMICAL DEICING AGENTS; DEICERS; ENVIRONMENTAL EFFECTS; GENERAL MATERIALS; GUIDELINES; MAINTENANCE, GENERAL; MATERIALS HANDLING; SALTS; SNOW & ICE CONTROL; STORAGE

DIALOG File 63: TRIS _ 70-92/JUL

097770 DA
WINTER MAINTENANCE. THE ACTION OF CHEMICAL SOLVENTS ON HIGHWAY STRUCTURES
Aghilone, G; Casacci, L; Chiostri, M
Societa Autostrade
Autostrade VOL. 16 NO. 6 Jun 1974 pp 3-5 Italian
SUBFILE: TRRL; IRRD; HRIS
The action of de-icing chemicals on the steel, concrete and reinforced concrete of highway structures is briefly reviewed and it is concluded that the extent of the contribution of these de-icing salts to the damage and deterioration of the structures can be sufficiently determined; it was ascertained that where the de-icing chemicals are not used, the damage is appreciably less. Measures recommended to ensure the maximum resistance of structures to the effects of de-icing chemicals include: A basic design well able to withstand minimum values; slab thicknesses never less than 20 cm; concrete thickness covering reinforcement never less than 2 cm; bonded tendons for prestressed reinforced concrete in preference to sheathed cables; maximum accessibility to bearing and support areas for inspection and maintenance; and protection with high quality resins (epoxy, polyurethane etc). /TRRL/
DESCRIPTORS: CALCIUM CHLORIDE; CHEMICAL DEICING AGENTS; CONCRETES; DAMAGE; DETERIORATION; ENGINEERING STRUCTURE; EPOXY RESINS; INSPECTION; MAINTENANCE, GENERAL; POLYURETHANE RESINS PROTECTION; REINFORCED CONCRETE; SALT (CHEMICAL); SALT (DEICING); SNOW & ICE CONTROL; SODIUM CHLORIDE; STEELS; THICKNESS; WINTER MAINTENANCE

096208 DA
DEICING SALTS, THEIR USE AND EFFECTS
Materials Performance VOL. 14 NO. 4 Apr 1975 pp 9-14 1 Fig. 2 Tab. 65 Ref.
SUBFILE: HRIS
The use of deicing salt in the United States reached an all time high of 9.6 million tons for the winter of 1970-71. Despite the concern of environmentalists, the use of deicing salts is increasing because of the public demand and need of bare pavements for rapid travel and safe highways during the winter. Economic losses to individuals and businesses could amount to billions of dollars per year if there were an inability to move traffic during the winter season. Alternatives to the use of sodium or calcium chloride include potassium chloride, aluminum chloride, lithium chloride, ammonium sulfate, ammonium nitrate, urea, urea-calcium formate, alcohols, and the use of heated pavements. Investigation of these alternatives revealed that they were not feasible for various reasons, including safety, performance, and costs. Further investigation of deicing salts revealed the corrosion of motor vehicles may be in direct proportion to the amount of deicing salt used, and that underground installations may undergo accelerated corrosion from salt brine seepage through the soil and through structural openings. The treatment of deicing salts with corrosion inhibitors was found to be ineffective, but other preventive measures are suggested for the control of automobile and underground corrosion.
DESCRIPTORS: ALCOHOLS; AUTOMOBILES; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; CORROSION; CORROSION PREVENTION; COSTS; DEICERS; ECONOMICS; GENERAL MATERIALS; HEATING; PERFORMANCE; SAFETY; SALTS; SNOW & ICE CONTROL; SODIUM CHLORIDES; UNDERGROUND STRUCTURES

090719 DA
MANUAL FOR DEICING CHEMICALS: APPLICATION PRACTICES
Richardson, DL; Terry, RC; Metzger, J; Carroll, RJ
Little (Arthur D), Incorporated; 25 Acorn Park; Cambridge; Cincinnati; Massachusetts; Ohio; 02140
Dec 1974 Final Rpt. 164 p. Figs. Tabs. Phots. 10 Ref.
CONTRACT NO: EPA-68-03-0154; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This report contains the results of a study to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Practical guidelines are presented for the use of deicing chemicals. (1) Supervisory aspects of proper chemical usage are defined, including organization and personnel training. (2) Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage. (3) The backbone of winter road maintenance is equipment. General requirements and major equipment classes are described. Methods are given for accurate spreader calibrations. (4) Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies. (5) Legal requirements for and constraints on snow and ice control are described. See also report dated Jul 74, PB-236 152.
DESCRIPTORS: CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; COLD WEATHER OPERATIONS; DEICERS; DEICING; ENVIRONMENTAL PROTECTION; FEDERAL GOVERNMENT; HANDLING EQUIPMENT; HIGHWAYS; LEGISLATION; MAINTENANCE; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; MANAGEMENT PLANNING; MANUALS; MATERIALS HANDLING; PERSONNEL; PERSONNEL TRAINING; PUBLIC SUPPORT; REGULATIONS; SANDS; SNOW & ICE CONTROL; SNOW VEHICLES; SODIUM CHLORIDE; STATE GOVERNMENT; WATER POLLUTION; WATER POLLUTION ABATEMENT; WEATHER FORECASTING

DIALOG File 63: TRIS _ 70-92/JUL

622097 DA
DEVELOPMENT AND EXPERIMENT OF A WATER SPRINKLING MODEL WITH VARIABLE FLOW FOR SNOW MELTING ON RAILWAY TRACKS
Sawase, K; Kojima, T
Railway Technical Research
Railway Technical Research Inst, Quarterly Reports VOL. 32 NO. 4 Dec 1991 pp 251-257 8 Fig. 1 Tab. 3 Ref.
SUBFILE: RRIS; UMTRIS
AVAILABLE FROM: Ken-yusha, Incorporated Hikaricho 1-45-6, Kokubunji Tokyo Japan
For use in a snow-melting system for railway tracks, it is necessary from an economic point of view to manufacture a water sprinkler with variable flow rate in response to snowfall intensity and atmospheric temperature. A newly-developed sprinkler was constructed and operated to control the water flow rate by water pressure, using either a module valve or an inverter pump installed in the pipeline. Experiments confirmed that a snow-melting system equipped with the proposed sprinkler is technically and economically promising because of energy conservation.
DESCRIPTORS: RAIL TRANSPORTATION; RAILROAD TRACK; SNOW MELTERS; SNOW REMOVAL; SPRINKLING; TRACK MAINTENANCE; TRACK MAINTENANCE PLANNING

622085 DA
DETERMINING FEASIBILITY OF WEST VIRGINIA OIL AND GAS FIELD BRINES AS HIGHWAY DEICING AGENTS. PHASE 3. FINAL REPORT
Eck, RW; Sack, WA
West Virginia University Department of Civil Engineering Morgantown West Virginia 26506-6101
May 1991 188p
SUBFILE: HRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The research described in the report represents the third and final phase of a comprehensive research project to determine the feasibility of West Virginia oil and gas field brines as highway deicing agents. Phase 3 focused on expanding the limited brine quality information collected in Phase 1 to include brine availability information (both quality and quantity) statewide. A principal objective was to develop a microcomputer-based brine availability database based on existing information and analysis conducted as part of the current effort. Seventy brine samples were analyzed from 23 counties; based on meeting acceptable criteria, 32 of these samples were found to be suitable. A ranking system was developed for brine spreading and brine addition to abrasive materials. Brine quality and quantity information was included in the database, which is capable of generating a number of different reports. According to the database, almost 568,000 gallons per year of suitable brine were identifies. A number of brine usage scenarios were identified and evaaluated. The most promising scenario was treating a staandard abrasive hopper spreader with brine as a substitute for conventional rock salt.
DESCRIPTORS: ANALYSIS; BRINES; DATA BASE DESIGNS; DEICING; INFORMATION SYSTEMS; MAINTENANCE, GENERAL; QUALITY; SNOW & ICE CONTROL; SNOW MELTERS; WEST VIRGINIA

619546 DA
DEVELOPMENT AND EXPERIMENT OF A WATER SPRINKLING MODEL WITH VARIABLE FLOW FOR SNOW MELTING ON RAILWAY TRACKS
Sawase, K; Kojima, T
Railway Technical Research
Railway Technical Research Inst, Quarterly Reports VOL. 32 NO. 4 Dec 1991 pp 251-257 8 Fig. 1 Tab. 3 Ref.
SUBFILE: RRIS; UMTRIS
AVAILABLE FROM: Ken-yusha, Incorporated Hikaricho 1-45-6, Kokubunji Tokyo Japan
For use in a snow-melting system for railway tracks, it is necessary from an economic point of view to manufacture a water sprinkler with variable flow rate in response to snowfall intensity and atmospheric temperature. A newly-developed sprinkler was constructed and operated to control the water flow rate by water pressure, using either a module valve or an inverter pump installed in the pipeline. Experiments confirmed that a snow-melting system equipped with the proposed sprinkler is technically and economically promising because of energy conservation.
DESCRIPTORS: RAIL TRANSPORTATION; RAILROAD TRACK; SNOW MELTERS; SNOW REMOVAL; SPRINKLING; TRACK MAINTENANCE; TRACK MAINTENANCE PLANNING

619535 DA
DETERMINING FEASIBILITY OF WEST VIRGINIA OIL AND GAS FIELD BRINES AS HIGHWAY DEICING AGENTS. PHASE 3. FINAL REPORT
Eck, RW; Sack, WA
West Virginia University Department of Civil Engineering Morgantown West Virginia 26506-6101
May 1991 188p
SUBFILE: HRIS; NTIS
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DIALOG File 63: TRIS _ 70-92/JUL

gallons per year of suitable brine were identifies. A number of brine usage scenarios were identified and evaaluated. The most promising scenario was treating a staandard abrasive hopper spreader with brine as a substitute for conventional rock salt.

DESCRIPTORS: AVAILABILITY; BRINES; DATA BASE; DEICERS; DEICING; INFORMATION SYSTEMS; MAINTENANCE, GENERAL; QUALITY; SNOW & ICE CONTROL; SNOW MELTERS; WEST VIRGINIA

618578 DA
ALTERNATIVE TECHNOLOGIES FOR DEICING HIGHWAYS
Foster, B
National Conference of State Legislatures
State Legislative Report VOL. 15 NO. 10 Apr 1990 18p Refs. Apps.
SUBFILE: HRIS
AVAILABLE FROM: National Conference of State Legislatures 1560 Broadway, Suite 700 Denver Colorado 80202
This report describes the reasons salt is widely used for keeping highways ice- and snow-free, and the various alternatives to salt use that are available. It also discusses the history of calcium magnesium acetate (CMA); other deicers such as sand; corrosion inhibited salts; and other alternative deicers.
DESCRIPTORS: ADMINISTRATION; CALCIUM MAGNESIUM ACETATE; DEICERS; ENVIRONMENTAL EFFECTS; ICE CONTROL; MAINTENANCE, GENERAL; SAFETY; SALTS; SANDING; SNOW & ICE CONTROL; SNOW MELTERS

604195 DA
DEVELOPMENT OF A FIXED DISTANCE SNOW-MELTING SPRINKLER OPERATING AT VARIOUS WATER FLOW RATES
Sawase, K
Railway Technical Research
Railway Technical Research Inst, Quarterly Reports VOL. 31 NO. 3 Sep 1990 pp 153-159 12 Fig. 2 Tab. 3 Ref.
SUBFILE: UMTRIS
AVAILABLE FROM: Ken-yusha, Incorporated Hikaricho 1-45-6, Kokubunji Tokyo Japan
A new snow-melting sprinkler has been developed that can maintain a fixed spraying distance with varying water flow rates depending on the water pressures. This study was conducted to evaluate the performance of the new sprinkler for melting snow along railway tracks. The heat loss in flying water droplets and their relation to sprinkler performance was theoretically investigated. The size of water droplets at various water flow rates was measured photographically, and they were 5-6 mm diameter at an initial speed of 11.5-16.0m/s. The temperature drop of the water droplet was about 0.2 degrees C/m in flight through air at 0 degrees C. In this sprinkler the sprinkled water distribution is kept uniform regardless of the water flow rate.
DESCRIPTORS: FLOW RATE; RAILROAD TRACK; SNOW MELTERS; SPRINKLERS; TEMPERATURE CONTROL; WATER DISTRIBUTION; WATER FLOW

602593 DA
HIGHWAY SNOW CONTROL RESEARCH IN JAPAN
Itagaki, K
Cold Regions Research and Engineering Laboratory Department of the Army, P.O. Box 282 Hanover New Hampshire 03755
Sep 1990 65p Figs. 4 Tab. Phots. Refs. 4 App.
REPORT NO: Special Report 90-33
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The wide range of Japanese efforts to control snow and ice on highways is reviewed. Many studies parallel U.S. and European research, but extensive basic studies of applications of modern high technology are noted as well. The studies are grouped into the following categories: (1) Basic studies; (2) Snow-removal equipment; (3) Road heating; (4) Chemicals and snow melters; (5) Snow-protection facilities; (6) Trafficability, friction, and adhesion; (7) Sociological and economic impact; (8) Statutory measures and regulations; and (9) Collective measures.
DESCRIPTORS: ADHESION; ADMINISTRATION; CHEMICAL DEICING AGENTS; CONSTRUCTION AND MAINTENANCE EQUIPMENT; ECONOMIC IMPACT; EQUIPMENT; FRICTION; HEATING; JAPAN; LAWS; MAINTENANCE, GENERAL; REGULATIONS; REVIEWS; SNOW & ICE CONTROL ; SNOW MELTERS; SNOW PROTECTION FACILITIES; SNOWPLOWS; SOCIOLOGICAL ASPECTS; TRAFFICABILITY

496681 DA
SYSTEM MELTS AWAY SNOW AND DOUBT
Public Works Journal Corporation
Public Works VOL. 121 NO. 8 Jul 1990 pp 46-47 2 Phot.
SUBFILE: HRIS
AVAILABLE FROM: Public Works Journal Corporation 200 South Broad Street Ridgewood New Jersey 07451
Holland, Michigan, installed a snow melt system during its renovation of the downtown area in 1988. The network of Meltaway tubing (a flexible cross-linked polyethylene tubing from Wirsbo Company, Apple Valley, Minnesota) circulates 90 deg F water from the city's power plant to keep downtown sidewalks and the main thoroughfare virtually snow free all winter. Operating costs are running well under the original budget. The system has since been expanded to include two parking lots that were not in the original five-block plan, and the city is considering expanding the system further.
DESCRIPTORS: HEATED WATER; MAINTENANCE, GENERAL; OPERATING COSTS; SNOW & ICE CONTROL; SNOW MELT SYSTEMS; TUBING

496092 PR
ICE-PAVEMENT BOND PREVENTION SURFACE MODIFICATION
INVESTIGATORS: Baum, B
SPONSORING ORG: Strategic Highway Research Program
PERFORMING ORG: Springborn Material Sciences, Incorporated 1 Springborn Center Enfield Connecticut 06082-4899
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

CONTRACT NO: SHRP-H-202; Contract
PROJECT START DATE: 8904
PROJECT TERMINATION DATE: ND
SUBFILE: HRIS
This contract will design, test, and demonstrate practical methods and equipment for prevention of ice bonding. Tasks include; 1) Investigate methods for concentrating a deicing chemical or chemicals on or near the surface of pavements, which will effectively reduce snow/ice adhesion at low temperatures. The methods developed should be cost-effective with respect to manufacture, application and service life, and be nontoxic and noncorrosive. 2) Develop a method of physically modifying pavement to prevent formation or bonding of ice. The modified pavement should be economical, long-lived, effective over a wide range of climatic and traffic conditions, relatively easy to apply and maintain, and have an adequate coefficent of friction between rubber tires and pavement. The field testing and evaluation of long-term pavement performance conducted as a part of this study will require close coordination with SHRP's long-term pavement performance (LTPP) program.
DESCRIPTORS: ADHESION; CHEMICAL DEICING AGENTS; COST EFFECTIVENESS; DEICERS; FRICTIONAL COEFFICIENT; GENERAL MATERIALS; ICE PREVENTION; LONG TERM; LOW TEMPERATURES; MAINTENANCE, GENERAL; PAVEMENT DESIGN AND PERFORMANCE; PAVEMENT PERFORMANCE; PAVEMENT SKIDDING CHARACTERISTICS; RESEARCH PROJECT; SNOW; SNOW MELTERS

496073 PR
ICE-PAVEMENT BOND PREVENTION SURFACE MODIFICATION
INVESTIGATORS: Baum, B
SPONSORING ORG: Strategic Highway Research Program
PERFORMING ORG: Springborn Material Sciences, Incorporated 1 Springborn Center Enfield Connecticut 06082-4899
CONTRACT NO: SHRP H-202; Contract
PROJECT START DATE: 8904
PROJECT TERMINATION DATE: ND
SUBFILE: HRIS
The object of this research is to investigate methods for concentrating a deicing chemical(s) on or near the surface of pavements, which will effectively reduce snow/ice adhesion at low temperatures. The methods developed should be cost-effective with respect to manufacturing, application and service life, and be nontoxic and noncorrosive. In addition, develop a method of physically modifying pavement to prevent formation or bonding of ice. The modified pavement should be economical, long-lived, effective over a wide range of climatic and traffic conditions, relatively easy to apply and maintain, and have an adequate coefficient of friction between rubber tires and pavement.
DESCRIPTORS: ADHESION; CHEMICAL DEICING AGENTS; COST EFFECTIVENESS; DEICERS; FRICTIONAL COEFFICIENT; ICE PREVENTION ; LOW TEMPERATURES; MAINTENANCE, GENERAL; PAVEMENT SKIDDING CHARACTERISTICS; RESEARCH PROJECT; SNOW & ICE CONTROL; SNOW MELTERS

486602 DA
SNOW-MELTING SYSTEM USING RIVER WATER HEATED BY GROUNDWATER
Sawase, K
Japanese National Railways
Railway Technical Research Inst, Quarterly Reports VOL. 30 NO. 2 May 1989 pp 82-88 8 Fig. 3 Tab. 1 Phot. 2 Ref.
SUBFILE: RRIS
AVAILABLE FROM: Ken-yusha, Incorporated Hikaricho 1-45-6, Kokubunji Tokyo Japan
In order to melt rapidly the snow deposit into a drain for snow-removal using heated river water and to discharge it after removal from railroad track by the snow-plough train, 1 deg C river water was heated to 9 deg C by heat-exchange with 17 deg C well water pumped up from a 164 m deep well. The merit of a snow-melting system using the well water as heat source is that it can be returned to the ground depth from which it is taken. This system has the ability of disposing 6.0 cm/h of snow-fall, or 63 cm/day of snow deposit under winter weather conditions.
DESCRIPTORS: GROUNDWATER; HEATING; MAINTENANCE, GENERAL; RAILROAD TRACK; RIVERS; SNOW MELTERS; SNOW REMOVAL; WINTER

392625 DA
SALT AND SPREADERS: DYNAMIC DUO BATTLES SNOW AND ICE
Public Works Journal Corporation
Public Works VOL. 115 NO. 9 Sep 1984 pp 114-115
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
Road salt and the spreaders that apply it are critical elements in the control of snow and ice. Some advice is given on the following aspects: the proper maintenance of salt spreaders; spreader calibration; salt application guidelines; and the obtaining and storage of salt.
DESCRIPTORS: CALIBRATIONS; CONSTRUCTION AND MAINTENANCE EQUIPMENT; DEICING SALT; MAINTENANCE; MAINTENANCE, GENERAL; PROCUREMENT; ROADS AND STREETS; SNOW AND ICE CONTROL; SNOW MELTING SYSTEMS; SPREADERS; STORAGE

382618 DA
SPECIFICATION GUIDE FOR SNOW REMOVAL VEHICLES FOR RAIL TRANSIT SYSTEMS
King, C; Baker, J
Kusko (Alexander) Incorporated 161 Highland Avenue Needham Heights Massachusetts 02194; Urban Mass Transportation Administration 400 7th Street, SW Washington D.C. 20590
Nov 1983 Final Rpt. 174p
REPORT NO: UMTA-MA-06-0025-83-8; DOT-TSC-UMTA-83-22
CONTRACT NO: DTRS-57-81-C-00010; Contract
SUBFILE: UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
During the Winter of 1977-1978, a major snow storm shut down
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

the Boston transit system for almost a week and the Winter of 1978-1979 produced similar snow conditions that paralyzed the Chicago transit system and disabled more than half of their rail fleet. As a result of these disruptions and breakdowns, the snow Belt Transit operators became increasingly aware of the need for special measures that must be taken in order to maintain rail operation during severe winter conditions. This need was highlighted at the American Public Transit Association's conference in the Spring of 1979 at which time a Snow and Ice emergency Task Force was formed. This task force determined that a high capacity special purpose snow removal vehicle was needed by the industry, designed for removing the heaviest accumulation from a rail transit system's right-of-way. This Specification Guide is intended as a guide for Snow Belt rail transit operators to use in the preparation of technical specifications for the procurement of snow removal vehicles. It is not intended to be a procurement document. This Guide has been developed to provide the purchaser with a choice as to the type of vehicle and options that will best satisfy site-specific needs. Since the operating constraints of commuter rail are no more restrictive than those for rapid transit, commuter rail operators are encouraged to use this document in the development of their own technical specifications for snow removal vehicles. Only existing, proven design concepts are considered here in the interest of lower costs, shorter delivery times, and avoidance of costly prototype developments for each transit system. The three types of snow removal vehicles described in this Specification Guide are: 1) rail-mounted "jet" blower; 2) rail-mounted rotary blower; and 3) rail/highway rotary blower.

DESCRIPTORS: BLOWERS; COMMUTER RAILROADS; RAPID TRANSIT SYSTEMS; SNOW MELTERS; SNOW REMOVAL; SNOWPLOWS; SPECIFICATIONS ; UMTA SECTION 6; VEHICLE DESIGN

265567 DA

GROUND SURFACE HEATING

Wahlman, E (H Thearells Ingenioresbyraa)

Svenska Vag-Och Vattenbyggaren Riksforband

Vag-Och Vattenbyggaren N2 1973 pp 160-162 2 Fig. 1 Phot. Swedish

SUBFILE: TRRL; IRRD; HRIS

AVAILABLE FROM: National Swedish Road & Traffic Research Institute Drottning Kristinas Vag 41 S-11428 Stockholm Sweden

Surface heating of streets and pedestrian precincts has been practised in Sweden for about 10 years. Heating by means of embedded plastic pipes with circulating warm water is the method generally practised. The heating coils are installed about 100mm under the surface. The surface temperature must not be lower than 0 degrees C and a certain temperature above this is necessary for melting of the snow. The heating systems are connected to the return pipes of a local heating plant. The water temperature in these return pipes is 45 degrees C to 70 degrees C, which is quite sufficient for the surface heating. The temperature regulation and control are automatically maintained by a system of thermostats, cooler-heaters, pumps and valves. A temperature regulation system is exemplified in the article and the problems associated with it are discussed. A discussion on the advantages of ground surface heating in general and a brief cost analysis are also included.

DESCRIPTORS: ADMINISTRATION; CONSTRUCTION AND MAINTENANCE EQUIPMENT; GROUND HEAT; HEAT PIPES; HEATING EQUIPMENT; PEDESTRIAN STREETS; PLASTIC MATERIALS; SNOW MELTERS; SURFACE TEMPERATURE; TEMPERATURE CONTROL; THERMOSTATS

219465 DA

MORE MELTING, LESS HAULING, FEWER DUMP SITES

Rural and Urban Roads VOL. 10 NO. 7 Jul 1972 pp 60-1 2 Phot

SUBFILE: HRIS

three snow melters - two mobile and one stationary - used by Minneapolis to reduce the number of trucks required for hauling snow and the number of dump sites required are economical in both labor and time savings.

DESCRIPTORS: CONSTRUCTION AND MAINTENANCE EQUIPMENT; ECONOMICS; SNOW MELTERS

190813 DA

WETTED SALT PROCESS FOR IMPROVED SNOW AND ICE CONTROL

Public Technology, Incorporated; 1140 Connecticut Avenue, NW; Washington; D.C.; 20036; 20550

28 p.

REPORT NO: NSF/RA-770580

CONTRACT NO: NSF-C834; Contract

SUBFILE: NTIS; HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The document is intended for local and state officials who desire to broaden and enhance their awareness of the wetted salt process. The development history and expected benefits are briefly described, along with an outline of the basically simple implementation requirements. The process of using liquid calcium chloride to wet road salt before spreading it on streets, roads, and highways can improve its deicing action and reduce the amount of salt that is required. The process should be useful in the operations of any jurisdiction which has a need to clear ice and hard-packed snow from streets and highways when ambient temperatures range from 20 to 25 degrees Fahrenheit and lower. The wetted salt process is proving to be attractive in terms of both improved deicing action and the relative cost of deicing operations. The report deals with practical experience and highlights the important issues in deicing operations, including effectiveness, costs, and environmental conditions. An economic analysis and sample worksheets are presented to assist a local evaluation of the wetted salt process. The entire volume reflects recent experience and cost values taken from the reports of local government which have implemented the process.

DESCRIPTORS: CALCIUM CHLORIDES; COST EFFECTIVENESS; DEICERS DEICING; DEICING SALT; ECONOMIC ANALYSIS; ENVIRONMENTAL IMPACT

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DIALOG File 63: TRIS _ 70-92/JUL

; ICE CONTROL; LIQUIDS; LOCAL GOVERNMENT; MAINTENANCE, GENERAL ; PAVEMENTS; ROAD SALT; SNOW MELTERS; SNOW REMOVAL; SOLUTIONS WETTED SALT PROCESS

173932 DA
PAVEMENT HEATING--EXECUTIVE SUMMARY
Winters, F; Sasor, SR
New Jersey Department of Transportation; Division of Research and Development, 1035 Parkway Avenue; Trenton; New Jersey; 08625
Feb 1977 Final Rpt. 28 pp 2 Fig. 1 Tab. 1 Phot.
REPORT NO: FHWA-NJ-77-003A
SUBFILE: HRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
In order to evaluate a roadway heating system which utilized the energy stored in the earth for snow melting, a 3200 square foot experimental heated pavement was constructed in Trenton, New Jersey. Heat was extracted from the earth by means of a grid of pipes buried 3 to 13 ft. below ground and transferred via an ethylene glycol-water solution to pipes embedded in a test pavement. For purposes of comparison, a section of pavement heated by electrical resistance wires was also included as part of the installation. Results of operation have indicated that the best snow melting has taken place on sections of portland cement concrete containing 3/4" and 1-1/4" wrought iron pipe spaced on 6" centers and embedded at a depth of 2 inches. These sections produced an average heat dissipation rate of approximately 100 BTU's per square foot of surface area per hour when 2 linear feet of pipe buried in the earth were coupled to 1 linear foot of pipe embedded in the test pavement. Snow melting rates were usually between 1/4 inch and 1/2 inch per hour. During the Summers of 1970 and 1971 the system was operated for the purpose of transferring heat from the warm pavement to the earth where it could be stored for use during the winters. Heat was successfully transferred; however, due to the loss of heat to the surrounding earth and the atmosphere during the fall, no significant storage of heat was achieved by the start of the snow season. The thermal insulation used with the pipes buried 3 to 13 feet in the earth was not effective in reducing heat loss during the fall. Though this installation was shown to be more economical to operate than an electrically heated pavement, the total cost was higher when construction cost was considered. /Author/
DESCRIPTORS: COSTS; ELECTRICAL RESISTANCE; ENERGY; HEAT PIPES; HEAT TRANSFER; MAINTENANCE, GENERAL; PAVEMENTS; PORTLAND CEMENT CONCRETES; SNOW MELTERS; STORAGE; THERMAL INSULATION

173931 DA
PAVEMENT HEATING, 1969-1975--FINAL REPORT
Winters, F; Sasor, SR
New Jersey Department of Transportation; Division of Research and Development, 1035 Parkway Avenue; Trenton; New Jersey; 08625
Feb 1977 Final Rpt. 196 pp 16 Fig. 5 Tab. 8 Phot. 8 App.
REPORT NO: FHWA-NJ-77-003
SUBFILE: HRIS
AVAILABLE FROM: New Jersey Department of Transportation Division of Research and Development, 1035 Parkway Avenue Trenton New Jersey 08625
In order to evaluate a roadway heating system which utilized the energy stored in the earth for snow melting, a 3200 square foot experimental heated pavement was constructed in Trenton, New Jersey. Heat was extracted from the earth by means of a grid of pipes 3 to 13 ft. below ground and transferred via an ethylene glycol-water solution to pipes embedded in a test pavement. For purposes of comparison, a section of pavement heated by electrical resistance wires was also included as part of the installation. Results of operation have indicated that the best snow melting has taken place on sections of portland cement concrete containing 3/4" and 1-1/4" wrought iron pipe spaced on 6" centers and embedded at a depth of 2 inches. These sections produced an average heat dissipation rate of approximately 100 BTU's per square foot of surface area per hour when 2 linear feet of pipe buried in the earth were coupled to 1 linear foot of pipe embedded in the test pavement. Snow melting rates were usually between 1/4 inch and 1/2 inch per hour. During the Summers of 1970 and 1971 the system was operated for the purpose of transferring heat from the warm pavement to the earth where it could be stored for use during the winters. Heat was successfully transferred; however, due to the loss of heat to the surrounding earth and the atmosphere during the fall, no significant storage of heat was achieved by the start of the snow season. The thermal insulation used with the pipes buried 3 to 13 feet in the earth was not effective in reducing heat loss during the fall. Though this installation was shown to be more economical to operate than an electrically heated pavement, the total cost was higher when construction cost was considered. /Author/
DESCRIPTORS: COSTS; ELECTRICAL RESISTANCE; ENERGY; HEAT PIPES; HEAT TRANSFER; MAINTENANCE, GENERAL; PAVEMENTS; PORTLAND CEMENT CONCRETES; SNOW MELTERS; STORAGE; THERMAL INSULATION

169548 DA
SNOW STUDIES. VOLUME 2. 1975-OCTOBER 1977 (A BIBLIOGRAPHY WITH ABSTRACTS)
Brown, RJ
National Technical Information Service; 5285 Port Royal Road; Springfield; Virginia; 22161
Nov 1977 190 pp
SUBFILE: NTIS; HRIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The bibliography covers research on snow cover, snowmelt, snowdrifts, snow removal, trafficability, snow rescue and survival, physical and mechanical properties, as well as
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

detection by remote sensing. Applications include construction of roads, runways, buildings, pipe lines, etc., in cold, remote, arctic or subarctic regions. (This updated bibliography contains 185 abstracts, 59 of which are new entries to the previous edition.) Supersedes NTIS/PS-76/0809, NTIS/PS-75/719, and NTIS/PS-75/042. See also Volume 1, 1964-74, NTIS/PS-76/0808.

DESCRIPTORS: ABSTRACTS; ARCTIC REGIONS; BIBLIOGRAPHIES; CHEMICAL PROPERTIES; COLD WEATHER CONSTRUCTION; COLD WEATHER OPERATIONS; CONSTRUCTION; FROZEN SOILS; MECHANICAL PROPERTIES PHYSICAL PROPERTIES; REMOTE SENSING; RIGHT OF WAY; SENSORS; SNOW; SNOW COVER; SNOW MELTERS; SNOW REMOVAL; SNOWDRIFTS; SNOWMELT; STRUCTURES; SURVIVAL; THICKNESS; TRAFFICABILITY

144200 DA

SNOW MELTERS

Trecan Limited 4540 Dixie Road Mississauga Ontario L4W 1N2 Canada

Report 8 pp Phots.

SUBFILE: RTAC; HRIS

This report discusses Snow Melters as a method of snow removal. The snow melting units are specifically designed for shopping centers, multi-level garages, industrial areas, municipal road networks, etc. As well as a discussion of the melters effectiveness, this report shows different models and authorized dealers.

DESCRIPTORS: INDUSTRIAL AREAS; MAINTENANCE, GENERAL; MULTISTORY STRUCTURES; ROAD NETWORK; SHOPPING CENTERS; SLATES SNOW MELTERS

139579 DA

DESIGN HEAT REQUIREMENTS FOR EMBEDDED SNOW-MELTING SYSTEMS IN COLD CLIMATES

Williams, GP (National Research Council of Canada)

Transportation Research Record N576 pp 20-32 8 Fig. 20 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Record 15 Transportation Research Board 2101 Constitution Av enue, NW

Methods of calculating design heat requirements of embedded snow-melting systems are assessed, particularly for those operating in cold climates. Formulas for estimating design heat requirements developed from snow-melting tests carried out during three winters at Ottawa, Canada, are compared with those recommended in the Guide and Data Book of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), the only comprehensive guidelines available in North America. The relation between convective coefficients and wind speed at an exposed site compares reasonably well with that recommended by ASHRAE, provide adjustments are made for the size of the heated area, the exposure to wind, and the height at which wind speeds are measured. Evaporative coefficients recommended by ASHRAE also need to be adjusted for the size of heated area and the exposure to wind. Radiative coefficients need to be adjusted for cloud conditions. The design heat requirements for systems operating in cold climates are determined by the maximum rate of surface heat loss from bare, wet pavements for weather conditions that will probably prevail immediately after snowstorms. Design heat requirements calculated for an exposed site at Ottawa by using the heat transfer coefficients obtained are 170 Btu/square foot-hour (536 W/m square). This agrees quite well with current practice in this region. Two case histories of snow-melting tests are presented to illustrate that the use of insulation will practically eliminate ground heat loss and the need to allow for it in design calculations. /Author/

DESCRIPTORS: CASE HISTORIES; COLD WEATHER OPERATIONS; COMPUTATIONS; CONVECTION; DESIGN; EVAPORATION; HEAT; HEAT LOSS ; HEAT TRANSFER; PAVEMENT DESIGN AND PERFORMANCE; SNOW MELTERS ; STRUCTURES DESIGN AND PERFORMANCE; WIND; WIND VELOCITY

DIALOG File 63: TRIS _ 70-92/JUL

623036 DA
NEVADA TAKES CLOSE LOOK AT CMA EFFICACY
Nelson, RJ
Scranton Gillette Communications, Incorporated
Roads and Bridges VOL. 30 NO. 6 Jun 1992 pp 32-34
SUBFILE: HRIS
AVAILABLE FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
The article describes the actual in-field performance of CMA (calcium magnesium acetate) vs road salt performance as documented by the Nevada Department of Transportation and Caltrans (California Department of Transportation). The Univresity of Nevada performed data collection to determine and document the effectiveness of CMA relative to NDOT's standard practices using salt. The test section which consisted of 12.5 miles of 2-lane highway on SRs 28 and 431, and the details of the testing are summarized. It was found that although CMA did work as snow and ice control deicing chemical, the timing of the initial application of CMA was critical. The spherical shape and low density of the CMA was a drawback, and it would create an 'oatmeal mush' which had to be removed mechanically. These and other findings are noted.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; COMPARISONS; DEICERS ; DEICING SALT; MAINTENANCE, GENERAL; PERFORMANCE; SNOW & ICE CONTROL

623035 DA
NASC SNOWFIGHTERS ARM FOR WINTER BATTLE
Flynn, L
Scranton Gillette Communications, Incorporated
Roads and Bridges VOL. 30 NO. 6 Jun 1992 pp 26-30
SUBFILE: HRIS
AVAILABLE FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
The presentations at the American Public Works Association's 32nd annual North American Snow Conference in St. Paul, Minnesota, April 12-15 are discussed. It is noted that emerging technology from advanced weather forecasting systems to improved snow plowing equipment and removal methods is giving snowfighters a greater, more varied arsenal with which to combat snow and ice on U.S. roads. The 4-day conference featured sessions on reducing road salt, deicing chemicals, weather forecasting, use of salt spreading and plowing equipment, and training. The use of alternative deicers and techniques such as anti-icing through the preapplication of deicers, was covered in conjunction with discussions of the proper use of salt. Groundwater contamination from road salt was covered, as well as the safe storage of road salt using conveyor belts and storage bends for loading and unloading, and the application of quick cleanup techniques of excess salt around storage facilites. Computerized electronic spreader control systems, and the compatibility of the system with equipment were also discussed.
DESCRIPTORS: CONFERENCES; DEICERS; DEICING SALT; GROUNDWATER ; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; PERSONNEL TRAINING; SNOW & ICE CONTROL; SNOWPLOWS; STORAGE; WATER POLLUTION; WEATHER FORECASTING

621973 DA
PERSISTENCE OF REDUCED SNOW TO PAVEMENT SHEAR STRENGTH FOR TWO AGGREGATE MATERIALS TREATED WITH CMA AND NACL. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Adams, EE; Alger, RG; Chekan, JP; Williams, FD; Valverde, R
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
The primary objective of this laboratory testing program was to examine the residual anti-icing effects of road salt (sodium chloride) and calcium magnesium acetate (CMA) on two aggregates commonly used in road construction. The road salt was the same as that used by the Houghton County Road Commission and the calcium magnesium acetate was the granular formulation marketed by Chevron Chemical Company under the trade name Ice-B-Gon (TM). The specific aggregates selected for examination were limestone and granite. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; DEICING; ENERGY AND ENVIRONMENT; GRANITES; LABORATORY TESTS; LIMESTONES; MAINTENANCE, GENERAL; SALT, SODIUM CHLORIDE; SNOW & ICE CONTROL; SODIUM CHLORIDES

621971 DA
ENVIRONMENTAL COSTS OF ROAD SALTING. IN: CHEMICAL DEICERS AND THE ENVIRONMENT
Vitaliano, DF
Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8
1992 v.p. Figs. Tabs. Refs.
SUBFILE: HRIS; UMTRIS
AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118
Among the costs imposed on society-at-large by the extensive use of deicing salt is the damage to roadside vegetation and the elevation of sodium levels in drinking water. This paper lays out the appropriate conceptual framework for placing a dollar value on these costs, based on the economic principles of cost-benefit analysis. The model is empirically estimated with data relating to New York state. The results indicate that the typical overnight camper values roadside tree damage in New York's Adirondack Park at $1.55 per year. With respect to drinking water, road salting is found to elevate sodium levels in the sample of communities analyzed, but no significant relationship to hypertensive deaths is discovered. The latter is attributed to the low levels of sodium in the

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DIALOG File 63: TRIS _ 70-92/JUL

communities sampled. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: DEICING SALT; DRINKING WATER; ENERGY AND ENVIRONMENT; ENVIRONMENTAL EFFECTS; MAINTENANCE, GENERAL; NEW YORK STATE; SALT, SODIUM CHLORIDE; SODIUM CHLORIDES

621969 DA

AN OVERVIEW OF THE NATIONAL RESEARCH COUNCIL STUDY OF THE COMPARATIVE COSTS OF USING ROCK SALT AND CMA FOR HIGHWAY DEICING. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Menzies, TR

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. 1 Ref.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

Sodium chloride, or common road salt, is by far the most popular chemical deicer, because it is inexpensive to purchase, readily available, and easy to handle, store, and apply. In 1980 the Federal Highway Administration (FHWA) identified calcium magnesium acetate (CMA) as a possible replacement for salt. A special committee of the National Research Council has been convened to carry out the study. An important goal of the committee is to characterize and quantify, to the fullest extent possible, all of the many indirect costs of highway salting, including damage to motor vehicles, infrastructure, and the natural environment. The purpose of this paper is to identify the various issues that the committee is addressing while trying to characterize and quantify salt's costs. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: CALCIUM MAGNESIUM ACETETE; CORROSION; CORROSIVE PROBLEMS; ENERGY AND ENVIRONMENT; ICE CONTROL; MAINTENANCE, GENERAL; ROCK SALT; SALT, SODIUM CHLORIDE; SODIUM CHLORIDES

621963 DA

GROUNDWATER PATHWAYS FOR CHLORIDE POLLUTION OF LAKES. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Bowser, CJ

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. Figs. 1 Tab. Refs.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

The purpose of this paper is to acquaint the reader with some of the evidence for road salt contamination in groundwater systems in Wisconsin, and to demonstrate how these pathways are significant vectors of salt and other potential contaminants to lake systems. The focus is on two areas in Wisconsin, the first relatively pristine and the second urbanized, and the critical similarities and dissimilarities between the two. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: CHLORIDES; DEICING SALT; ENERGY AND ENVIRONMENT ; ENVIRONMENTAL DESIGN; GROUNDWATER; LAKES; URBANIZATION; WATER POLLUTION; WISCONSIN

621961 DA

EFFECTS OF ROAD DEICING SALT ON AQUATIC INVERTEBRATES IN FOUR ADIRONDACK STREAMS. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Demers, CL

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. Figs. Refs.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

The damage done to road surfaces, bridges, vehicles, and buildings by road deicing salt has been studied extensively. The environmental impact of deicing salt has also been well documented; however, the effects on aquatic organisms have received less attention. Most studies involving aquatic organisms have been in laboratory settings and have dealt primarily with lentic environments. This study examined the effects of elevated chloride levels on the aquatic macroinvertebrates inhabiting four small Adirondack streams. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: AQUATIC LIFE; CHLORIDES; DEICING; DEICING SALT ENERGY AND ENVIRONMENT; ENVIRONMENTAL EFFECTS; ENVIRONMENTAL IMPACT; MOUNTAINS; STREAM POLLUTION; STREAMS

621959 DA

ENVIRONMENTAL IMPACT AND TOXICOLOGICAL CHARACTERISTICS OF CALCIUM MAGNESIUM ACETATE. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

McFarland, BL; O'Reilly, KT

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. Figs. Tabs. Refs.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

Whenever a new chemical is proposed for wide-scale use, it becomes important to determine the potential effects on humans and the environment. Sodium and calcium chlorides have been widely used as effective highway deicers for many years. But

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

their use has not been without some cost to the environment in terms of impacts on roadside vegetation, streams and lakes, and soils and sediments. Concerns over these negative impacts prompted studies into alternate deicers which led to the recommendation of calcium magnesium acetate (CMA) as the best alternative to road salt due to its potential for large-scale production and extremely low levels of toxicity on terrestrial and aquatic organisms. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; ENVIRONMENTAL DESIGN ENVIRONMENTAL IMPACT; SODIUM CHLORIDES

621958 DA

THE MICHIGAN ENVIRONMENTAL ROAD SAFETY ACT. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Van Regenmorter, W

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

This paper presents an introduction to and the actual bill introduced by Michigan State Senator William Van Regenmorter which requires studies by state agencies comparing salt with potential replacements. The studies are emphasizing corrosion, toxicity and environmental damage. Cost is a major consideration when looking at potential replacements for salt such as calcium magnesium acetate. Therefore, the bill requires that these studies examine the long-term costs of salt and any replacements, factoring in the costs of environmental damage. If the studies show that a replacement is effective, less toxic, less corrosive, safer for the environment and cost-effective over the long term, salt would be replaced. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: CORROSION; ENERGY AND ENVIRONMENT; ENVIRONMENTAL IMPACT; MICHIGAN; SALT, SODIUM CHLORIDE

621957 DA

DEICING CHEMICAL USE ON THE MICHIGAN STATE HIGHWAY SYSTEM. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Gales, JE; Van der Meulen, J

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. Figs. Tabs. Refs.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

Science Office (now the Science and Technology Division, Legislative Service Bureau) entitled, Salt and Road Deicing on the Michigan State Highway System. Ongoing interest in reducing the amount of salt used for deicing roads in winter as well as advances in the manufacture of salt alternatives have necessitated tis update. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: CHEMICAL DEICING AGENTS; DEICERS; ENERGY AND ENVIRONMENT; MAINTENANCE, GENERAL; MICHIGAN; STATE HIGHWAYS; STATE TRANSPORTATION DEPARTMENT

621955 DA

ENVIRONMENTAL IMPACT OF ROAD SALTING. IN: CHEMICAL DEICERS AND THE ENVIRONMENT

Jones, PH; Jeffrey, BA

Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118 0-87371-705-8

1992 v.p. Tabs. Refs. Apps.

SUBFILE: HRIS; UMTRIS

AVAILABLE FROM: Lewis Publishers, Incorporated 121 South Main Street, P.O. Drawer 519 Chelsea Michigan 48118

Based on a survey of current knowledge of the environmental impacts associated with the application of sodium chloride to roads, this report provides a theoretical basis for the preparation of Ontario Ministry of Transportation and Communication's (MTC) Environmental Assessment Reports. Road salt is the major chemical pollutant involved in MTC undertaking, and Ministry planners are frequently required to assess the environmental impacts of its application. This book is an outgrowth of the Alternative Deicing Technologies and the Environment Conference convened at Michigan State University on March 25-26, 1991. The editor is Frank M. D'Itri.

DESCRIPTORS: ENERGY AND ENVIRONMENT; ENVIRONMENTAL EFFECTS; ENVIRONMENTAL IMPACT; ONTARIO, CANADA; POLLUTION; SALT, SODIUM CHLORIDE

615014 DA

DEICERS USERS RATE BEST

Better Roads VOL. 61 NO. 8 Aug 1991 pp 28-29

SUBFILE: HRIS

AVAILABLE FROM: Better Roads P.O. Box 558 Park Ridge Illinois 60068

This article presents the results of a recent Better Roads' survey of about 200 agencies on deicing products. Freezgard + PCI or Cargill's CG-90 rated best, with liquid calcium chloride rating well, and salt placing third. Includes selected comments by survey respondents, and a rating chart of the six main deicers.

DESCRIPTORS: CALCIUM CHLORIDES; DEICERS; DEICING; DEICING SALT; MAINTENANCE, GENERAL; ROAD MAINTENANCE; SALT, SODIUM

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DIALOG File 63: TRIS _ 70-92/JUL

CHLORIDE; SNOW & ICE CONTROL; SURVEYS, DATA COLLECTION

611912 DA
HIGHWAY OPERATIONS: PROGRESS AND PRODUCTS UPDATE
Smith, KH; Harriott, DM; Cox, B; Hibbs, J; Minsk, D; Shah, SC
Strategic Highway Research Program National Research Council, 818 Connecticut Ave, NW, Ste 400 Washington D.C. 20006
Jul 1991 54p 8 Fig. 7 Tab. 1 App.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Library 2101 Constitution Avenue, NW Washington D.C. 20418
This report describes the Strategic Highway Research Program's (SHRP's) projects in the Highway Operations area. The introduction explains the structure and overall objectives of SHRP's Highway Operations Program. The main body of the report is divided into two sections: one covering the Maintenance Research, and the other covering the Snow and Ice Control Research. Projects under Maintenance Research include preventive maintenance (H-101), innovative materials (H-105/H-106), innovative repair equipment (H-105/H-107), pavement condition measurement (H-103/H-104), and worker protection (H-108/H-109). Projects under Snow and Ice Control Research are snowplows (H-206), snow fences (H-206), road weather information systems (H-207), pretreatment (H-208), and deicing chemicals (H-205). The fourth section of this report discusses the Research Implementation project (H-110).
DESCRIPTORS: DEICERS; HIGHWAY MAINTENANCE; HIGHWAY OPERATIONS; IMPLEMENTATION; INFORMATION SYSTEMS; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; MATERIALS; MEASURING; OCCUPATIONAL SAFETY; PAVEMENT CONDITION; PRETREATMENTS; PREVENTIVE MAINTENANCE; RESEARCH; SNOW & ICE CONTROL; SNOW FENCE; SNOWPLOWS; STRATEGIC HIGHWAY RESEARCH PROGRAM; WEATHER

610888 DA
OKLAHOMA DOT USES CMA IN FREEZING RAIN
Public Works Journal Corporation
Public Works VOL. 122 NO. 8 Jul 1991 pp 55-56 1 Phot.
SUBFILE: HRIS
AVAILABLE FROM: Public Works Journal Corporation 200 South Broad Street Ridgewood New Jersey 07451
This article describes the use of calcium magnesium acetate (CMA) for deicing. The Oklahoma Department of Transportation (ODOT) during the winter of 1990-1991 found that CMA/sand mixes applied early in winter storms provided ice free roads longer than salt/sand mixes. Describes storage of CMA; properties of CMA as opposed to salt; and when to apply CMA.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; DEICERS; DEICING SALT; ICE CONTROL; MAINTENANCE, GENERAL; OKLAHOMA; SALT, SODIUM CHLORIDE; SNOW REMOVAL; STATE TRANSPORTATION DEPARTMENT ; WINTER DRIVING

610825 DA
CMA HAS UNIQUE ROLE IN DEICING STRATEGY
Fritzsche, CJ
Scranton Gillette Communications, Incorporated
Roads and Bridges VOL. 29 NO. 6 Jun 1991 p 43
SUBFILE: HRIS
AVAILABLE FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
The article describes a 4-year observation of calcium magnesium acetate deicers that shows that the product is a viable alternative to salt in some situations, if used correctly. When mixed with snow, CMA becomes hydrated, gaining water as it dissolves. This action inhibits snow particles adhering to each other or to the road. This snow remains light and dry compared to the heavier, slushy snow created by the salt's briming action. CMA stops working at about 10 deg F, while salt stops at 20 deg F. The lower free-water content of CMA-treated snow explains how CMA helps prevent refreezing and pack formation at lower temperatures. The reasons why CMA performs well in the field but is judged marginal in laboratory tests are discussed. The storage and handling requirements of CMA are discussed.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; DEICERS; DEICING SALT; GENERAL MATERIALS; MAINTENANCE, GENERAL; PERFORMANCE

602578 DA
TRANSPORTATION FORUM: DE-ICING CHEMICALS FOR WINTER MAINTENANCE, SEPTEMBER 29, 1988, HALIFAX, NOVA SCOTIA
Roads and Transportation Association of Canada
Transportation Forum 1990 64p
REPORT NO: No. 2
SUBFILE: HRIS
AVAILABLE FROM: Roads and Transportation Association of Canada 1765 St Laurent Boulevard Ottawa Ontario K1G 3V4 Canada
This document represents the second issue of RTAC's revised "Transportation Forum". The objective of the journal is to present papers from RTAC-sponsored seminars, symposia and workshops. This second issue presents the papers delivered on September 29, 1988, at a seminar on "De-Icing Chemicals for Winter Maintenance," held in conjunction with RTAC's annual conference in Halifax, Nova Scotia. The seminar focused on the effects of de-icing salts on the environment, recent field testing of alternatives to traditional rock salt, and the practical aspects of winter road maintenance. The seminar concluded with a speakers' group discussion which addressed: means of coping with winter budget constraints, operational properties of the ideal de-icer, and the actions required to reduce the environmental effects of de-icing chemicals.
DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; CONFERENCES; CONSTRAINTS; DEICERS; ENVIRONMENTAL EFFECTS; FIELD TESTS; FUNDING; GENERAL MATERIALS; HIGHWAY MAINTENANCE; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; WINTER

DIALOG File 63: TRIS _ 70-92/JUL

495780 DA
TESTS WITH PRE-WETTED SALT IN THE WINTERS 1980/81-1983/84
Gustafson, K
National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden
1985 53p Swedish
REPORT NO: HS-039 676
SUBFILE: HSL
AVAILABLE FROM: National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden
Tests are in progress in Sweden to reduce the usage of salt on winter roads. One method to decrease the salt amount is to pre-wet the salt with CaCl2- or NaCl-solution. The salt then, has faster reaction with less wastage outside the road and as a whole a reduction of salt. Spreaders with pre-wetting equipment have been tested. The pre-wetting takes place on the spinner plate when spreading the salt. The three first winters the pre-wetting was performed with CaCl2-solution, but due to its great aggressivness on concrete, a change was made to NaCl-solution. The pre-wetting method compared to conventional spreading has been evaluated by National Road Administration and VTI during the 4 winters the tests have been performed. The tests have been concentrated on the measurements of friction and the salt amount on the road in connection with deicing measures. In this comprehensive report the results of the investigations are given.
DESCRIPTORS: CALCIUM CHLORIDES; DEICERS; FRICTION; HIGHWAY SAFETY; PREWETTING; RESEARCH; SALTS; SODIUM CHLORIDES

495495 DA
FIELD DEICING COMPARISON OF CALCIUM MAGNESIUM ACETATE AND SALT DURING 1987-1988 IN WISCONSIN
Smith, RL, Jr
Transportation Research Board
Transportation Research Record N1246 1989 pp 39-48 1 Fig. 6 Tab. 1 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
During the 1987-1988 winter maintenance season, calcium magnesium acetate (CMA) and CMA-coated sand were applied to the northern half of a 7.5-mile section of four-lane freeway, US-14, located just south of Madison, Wisconsin. Road salt (sodium chloride) was applied to the southern half of the section for comparison purposes. The moderately severe winter, with 52.4 inches of snow during the application period, provided a good basis for comparison of the two deicers. In order to achieve "bare pavement" on US-14, 48% more tons of CMA and CMA-coated sand than salt were applied, based on lane-mile adjusted driver estimates of material used. About 1% less total "effective" or pure CMA (i.e., excluding the weight of the sand) was required compared with salt. The CMA application required 70% more miles and 143% more hours compared with salt; however, some part of the additional CMA application effort can be attributed to the dedication of a truck to the CMA section while the salt truck had other highway sections to cover. Deicer performance measures were provided by subjective truck driver ratings and by objective field observations. As used in Wisconsin, CMA had distinct disadvantages in handling and transport and somewhat poorer deicing performance than salt, but CMA did provide at least a minimum level of deicing performance. Given the lower level of use of CMA-coated sand and satisfactory performance in all but the coldest conditions, additional research on the economic feasibility of more extensive use of CMA-coated sand may be warranted. Reductions in the cost of CMA-coated sand may be possible by producing the CMA locally and using locally available sand. This paper appears in Transportation Research Record No. 1246, Winter Maintenance, Roadside Management, and Rating Routine Maintenance Activities.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CALCIUM MAGNESIUM ACETATE COATED SAND; COMPARISONS; COSTS; DEICERS; EFFECTIVENESS; FIELD OBSERVATION; FIELD TESTS; FUTURE RESEARCH ; HANDLING; MAINTENANCE, GENERAL; PERFORMANCE; QUANTITY; SODIUM CHLORIDES; SUBJECTIVE ANALYSIS; TIME FACTOR

495493 DA
COMPARATIVE FIELD STUDY OF THE OPERATIONAL CHARACTERISTICS OF CALCIUM MAGNESIUM ACETATE AND ROCK SALT
Manning, DG; Crowder, LW
Transportation Research Board
Transportation Research Record N1246 1989 pp 18-26 2 Fig. 6 Tab. 10 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
A field study was undertaken during the winters of 1986-1987 and 1987-1988 to compare the performance of calcium magnesium acetate (CMA) and rock salt as deicing chemicals. The study included determination of the deicing effectiveness and the handling and storage characteristics of the two chemicals. The CMA was applied to a section of freeway and the adjacent sections of service roads near Beamsville, Ontario. Salt was applied to the adjoining freeway and service roads, which served as the control sections. The CMA and salt were applied at specified rates, and the frequency was dictated by the road conditions. The condition of the test sections was recorded by independent monitors at 1-hr intervals during all winter storms. The 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, and there was a residual effect from one storm to another. The storage and handling characteristics of CMA were similar to those of salt. Modifications to equipment were not required, and spreading procedures were changed only slightly. The corrosion of the CMA spreader unit was substantially less than that of the salt spreader unit. This paper appears in Transportation Research Record No. 1246, Winter Maintenance, Roadside Management, and Rating Routine Maintenance Activities.

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DIALOG File 63: TRIS _ 70-92/JUL

DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; COMPARISONS; CORROSION; DEICERS; EFFECTIVENESS; FIELD STUDIES; HANDLING; MAINTENANCE, GENERAL; PERFORMANCE; ROCK SALT; SPREADERS; STORAGE

495492 DA
TIME, TEMPERATURE, AND RELATIVE HUMIDITY IN DEICING OF HIGHWAYS USING SODIUM CHLORIDE OR MAGNESIUM CHLORIDE WITH A METAL CORROSION INHIBITOR
Goyal, G; Lin, J; McCarthy, JL
Transportation Research Board
Transportation Research Record N1246 1989 pp 9-17 7 Fig. 5 Tab. 14 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
The ice-melting effectiveness of sodium chloride (SC), "Qwiksalt (registered trademark) plus PCI (registered trademark) Granular Reduced Corrosion Road Deicer" (Qwiksalt or QS) and "Freezgard (registered trademark) plus PCI (registered trademark) Liquid Reduced Corrosion Road Deicer" (Freezgard or FG) with respect to the removal of ice from highways was studied by laboratory experimentation. QS is a solid consisting of a mixture of SC, magnesium chloride, water, and a lignin-based biodegradable corrosion inhibitor called PCI corrosion control polymer. FG is a concentrated aqueous solution of magnesium chloride and PCI. The rate of melting of ice by salts was investigated by two variants of a "blotter" method in which the aqueous saline solution generated by the melting of ice and dissolving of salt is absorbed onto a tared blotter paper and weighed. The effects of several different conditions of relative humidity, temperature, treatment time, and extent of application of the deicers were studied. Results are reported as grams of saline solution generated per square meter of ice surface and also as estimated net pounds of water generated per lane-mile (63,360 sq ft). Some preliminary experiments were conducted to estimate the effectiveness of the preparations with respect to penetration of ice and debonding of the ice-concrete interface. Relative to SC, Qwiksalt generates brine more rapidly during treatment times up to 30 min. Differences are observed especially under conditions of low temperature and low relative humidity, for example, at -18 deg C and about 5 to 20% relative humidity. Freezgard forms brine very rapidly, although less extensively than QS or SC. These new deicers should find many important applications. This paper appears in Transportation Research Record No. 1246, Winter Maintenance, Roadside Management, and Rating Routine Maintenance Activities.
DESCRIPTORS: CORROSION; DEBONDING; DEICERS; EFFECTIVENESS; HUMIDITY; ICE; INHIBITORS; LABORATORY TESTS; MAGNESIUM CHLORIDE; MAINTENANCE, GENERAL; MELTING; RATE; SODIUM CHLORIDES; TEMPERATURE; TEST RESULTS; TIME

495261 DA
EDGELINE WIDTHS AND TRAFFIC ACCIDENTS
Lum, HS; Hughes, WE
Federal Highway Administration
Public Roads VOL. 54 NO. 1 Jun 1990 pp 153-159 Tabs. 13 Ref.
SUBFILE: HRIS
AVAILABLE FROM: Government Printing Office Superintendent of Documents Washington D.C. 20402-9325
A study was made to determine whether the more expensive wide edgelines are cost beneficial in terms of reducing edgeline-related accidents. A separate and liminted evaluation was also conducted to determine the effects of 4-in and 8-in edgelines on drivers' performance in an uncontrolled environment. Within the curve, the measure of performance was the frequency of encroachment (i.e., tires touching or going over) either the centerline, edgeline, or both. It was found that 8-in edgelines are not cost effective for installation on 2-lane rural roads in those areas where there is frequent heavy snowfall and the use of deicing materials and abrasives tends to deteriorate edgelines, or where pavement widths are less than or equal to 22 feet. They are also not cost-effective where roads have paved shoulders over 6 ft wide. It is noted that 8-in edgelines may be appropriate as a safety improvement when applied at spot locations such as isolated horizontal curves and approaches to narrow bridges.
DESCRIPTORS: BRIDGE APPROACHES; COST EFFECTIVENESS; DEICERS DRIVER PERFORMANCE; EDGE STRIPING; HORIZONTAL CURVES; OPERATIONS AND TRAFFIC FLOW; TRAFFIC ACCIDENTS; TRAFFIC MARKINGS; TWO LANE HIGHWAYS; WIDTHS

494843 DA
THE PLANE TRUTH ABOUT SNOW REMOVAL
Communication Channels, Incorporated
American City and County VOL. 104 NO. 4 Apr 1990 pp 52-56
SUBFILE: HRIS
AVAILABLE FROM: Communication Channels, Incorporated American City and County, P.O. Box 28968 Atlanta Georgia 30358-9990
Keeping airport runways free of snow is a matter of time and money not only to the municipality, but also to the airline. The article describes how special techniques and equipment are used at various airports, and notes several deicing products now on the market that meet the federal environmental guidelines for removing snow from runways. Maintenance activities at the Greater Pittsburg International Airport are noted, as well as those at the Omaha Airport Authority, and Albuquerque, New Mexico. An airport runway deicer consisting of calcium magnesium acetate is noted, as well as an anticorrosive deicer consisting of a mixture of road salt and a corrosion inhibitor. A line of heavy snow-moving equipment is also described.
DESCRIPTORS: AIRPORT RUNWAYS; CORROSION PREVENTION; DEICERS MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; SNOW REMOVAL

DIALOG File 63: TRIS _ 70-92/JUL

487237 DA
ALTERNATIVES TO SODIUM CHLORIDE AS A SNOW AND ICE CONTROL AGENT ---PROCEEDINGS OF THE 23RD ANNUAL MEETING OF THE CANADIAN TRANSPORTATION RESEARCH FORUM, MINAKI LODGE, ONTARIO, CANADA, 24-27 MAY 1988
Miner, WM; Simmonds, J
CANADIAN TRANSPORTATION RESEARCH FORUM C/O MR. C. DICKSON, NATIONAL TRANSPORTATION AGENCY Ottawa Ontario Canada
1988 77-87
SUBFILE: HRIS; TRRL; IRRD
Based on a study by the city of Ottawa, this paper identifies the alternatives being explored for snow and ice control, assesses these alternatives, recommends the most promising chemical alternatives and presents the costs and benefits of using these alternatives relative to road salt. Also included are the preliminary results of field trials performed with the recommended chemical deicers comparing them to road salt. The report identifies calcium magnesium acetate and sodium formate as the most promising alternatives, in terms of comparable deicing performance with significantly lower environmental effects. The major drawback to these two chemicals is their prohibitive high cost, although considerable savings would accrue through their use from reduced automobile corrosion and structural deterioration. Further controlled field trials are recommended before either chemical is put into widespread use. For the covering abstract of the conference see IRRD 807127.
DESCRIPTORS: ACETATE; ALTERNATE; CALCIUM; CONFERENCE; CORROSION; COST BENEFIT ANALYSIS; ENVIRONMENT; MAGNESIUM; SALT (DEICING)

485198 DA
SHRP SNOW, ICE CONTRACTS MAY AID SNOWFIGHTERS
Minsk, D
Scranton Gillette Communications, Incorporated
Roads and Bridges VOL. 27 NO. 6 Jun 1989 pp 47-48
SUBFILE: HRIS
AVAILABLE FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
It is described how the SHRP (Strategic Highway Research Program) is sponsoring the investigation of the structure and formation of the ice-pavement bond, as a means of developing an effective material or technique to prevent the bond from forming or to reduce its strength, with a minimum use of chemicals of any kind. A computer simulation of the freezing of water on a pavement has been developed and is being extended to cover many other aspects of freezing. Other research is focused on the surface energetics of pavement surfaces and on shear tests on a variety of ice-covered surfaces. Deicing chemicals that will eliminate or reduce snow/ice adhesion, and the encapsulation of noncorrosive chemicals is also being investigated. SHRP studies will also address the reduction of the amount of snow or ice on the pavement, and improved storm communication systems. Designs for displacement plows, and the blowing of snow is also being candidate deicing chemicals that may be introduced by industry.
DESCRIPTORS: CHEMICALS; COMMUNICATION SYSTEMS; DEICERS; EVALUATION; FREEZING; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; PAVEMENTS; RESEARCH; ROAD SURFACES; SNOW & ICE CONTROL; STRATEGIC HIGHWAY RESEARCH PROGRAM

485197 DA
SNOW BUDGETS STABLE, PR EFFORTS UP, SURVEY SHOWS
Kuennen, T
Scranton Gillette Communications, Incorporated
Roads and Bridges VOL. 27 NO. 6 Jun 1989 pp 40-46
SUBFILE: HRIS
AVAILABLE FROM: Scranton Gillette Communications, Incorporated 380 Northwest Highway Des Plaines Illinois 60016
The results are reported of a survey of snow and ice control techniques which had a 45% response rate. More than 80% of the roads had snow and ice control, and most snow and ice control budgets would remain the same. The successful snowfighting program would depend on 3 aspects: public agency, news media and driving public. The public relations aspect of snow and ice control are discussed. Preseason training is discussed, as well as the use of deicers. Salt with abrasive was by far the most popular category of deicers, although the use of abrasives posed cleanup problems. Comments are made on litigation related to salt use, and increaed funds for ice control. A significant increase was noted in calcium chloride use. The use of contractors for snow control, and snow and ice control equipment are briefly described.
DESCRIPTORS: ABRASIVES; CALCIUM CHLORIDES; DEICING SALT; FINANCE; LITIGATION; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; PERSONNEL TRAINING; PUBLIC RELATIONS; SNOW & ICE CONTROL; SURVEYS, DATA COLLECTION

477352 DA
PROGRAM TO REDUCE DEICING CHEMICAL USAGE
Lord, BN
Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike McLean Virginia 22101
1988 13p Refs.
SUBFILE: HRIS
AVAILABLE FROM: Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike, HNR-20 McLean Virginia 22101
Our Nation's transportation system has become the veins and arteries of the lifeblood of our national economy. Rapid, reliable movement of people, goods, and services to supply raw materials and the work force to produce and deliver are critical to the health and welfare of our society. This capability must be year-round. In our northern States, this requires the maintenance of clear open roads and streets throughout the winter. Over the years (since about 1948), our dependency on deicing chemicals has been increased to provide
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

"bare pavement" for safe and efficient winter transportation. Concern about the effects of sodium chloride (salt) on our environment and water quality and on automobile and highway bridge deck corrosion also increased with this chemical usage. Beginning in the late 1960's and culminating today with an $8 million research effort in the Strategic Highway Research Program (SHRP), the highway community--industry, government, and academia--has undertaken measures to minimize our dependency on chemicals.

DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; CORROSION; DEICERS; ENVIRONMENTAL EFFECTS; GENERAL MATERIALS; MAINTENANCE, GENERAL; SNOW & ICE CONTROL; SODIUM CHLORIDES; STRATEGIC HIGHWAY RESEARCH PROGRAM

472105 DA

PREFERRED DRYING METHODS OF CALCIUM MAGNESIUM ACETATE SOLUTIONS. FINAL REPORT

Solash, J

Energy & Minerals Research Company 964 E. Swedesford Road, P.O. Box 389 Exton Pennsylvania 19341; Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike McLean Virginia 22101

Nov 1986 67p

REPORT NO: FHWA/RD-87/045; FCP 33C2-032

CONTRACT NO: DTFH61-85-C-00078; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Sodium chloride is currently used to remove ice from roads. While cheap, sodium chloride is corrosive and contaminates groundwater and streams. The Department of Transportation under the aegis of the Federal Highway Administration (FHWA) began a search for a sodium chloride substitute. Calcium magnesium acetate (CMA) has been identified as an excellent candidate deicing material. The objectives of this project were to examine the best way to prepare dry CMA from CMA solutions and to determine the ice melting ability of CMA. An optimum process for producing solid CMA would then be recommended. Energy & Minerals Research Company (EMR) examined approximately 19 different drying methods for CMA solutions. In addition, they attempted to recrystallize CMA using organic liquids. Several drying methods were finally selected for initial evaluation. Small quantities of CMA were produced, and the product properties were evaluated. Two methods were then selected for further evaluation. Larger quantities were produced and further evaluated. This report contains the data generated during the course of this study and the conclusions based on this data.

DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; DEICERS; DRYING; GENERAL MATERIALS; MAINTENANCE, GENERAL; PREPARATION; PRODUCTION METHODS

469147 DA

FORMATES AS ALTERNATIVE DEICERS

Palmer, DA

Transportation Research Board

Transportation Research Record N1127 1987 pp 34-36 1 Fig. 10 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The cost of deicing the nation's road system is roughly 20 times greater than the cost of the salt that is spread. This is due to chloride corrosion, which hits the vehicle fleet hardest. Next hardest hit are the nation's bridges, whose life has been reduced from about 20 to 5 years. Because corrosion inhibitors have proven ineffective, attention has turned to alternative chemical deicers. Though most current government support is dedicated to evaluation of calcium magnesium acetate (CMA), this chemical compound has many technical and economic drawbacks. In fact, CMA might continue to be too expensive to generate much use. At less than half the cost, it may be possible to produce sodium, calcium, or dolomitic lime formates. They can probably be made directly from carbon monoxide, rather than using formic acid. Sodium formate is much less toxic than initially thought. Further, it can probably be spread as a very concentrated solution or even as a slurry. The freezing-point curve of sodium formate is similar to that of sodium chloride down to about -14 deg C. It has now been demonstrated experimentally that sodium formate does not spall cured concrete. This paper appeared in Transportation Research Record No. 1127, Innovation, Winter Maintenance, and Roadside Management.

DESCRIPTORS: ALTERNATIVES; CHEMICAL DEICING AGENTS; COSTS; DEICING; FORMATES; GENERAL MATERIALS; MAINTENANCE, GENERAL; PERFORMANCE; SODIUM FORMATE

465521 DA

CHEMISTRY OF DEICING ROADS: PENETRATING ICE

Trost, SE; Heng, FJ; Cussler, EL

American Society of Civil Engineers

Journal of Transportation Engineering VOL. 114 NO. 2 Mar 1988 pp 221-231 Figs. Tabs. Refs. Apps.

REPORT NO: ASCE Paper 22299

SUBFILE: HRIS

AVAILABLE FROM: American Society of Civil Engineers 345 East 47th Street New York New York 10017

Experimental measurements of the rates at which sodium chloride, calcium chloride, urea, and calcium magnesium acetate (CMA) penetrate ice are consistent with a theory developed to predict this rate. These measurements and theory complement earlier studies of the rate at which ice can be debonded from road pavement. The mass transfer coefficients found from the penetration measurements are similar to those found from spinning ice disks, but are much less than those found for debonding. Possible reasons for this discrepancy and

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

the steps that limit road deicing are discussed.
DESCRIPTORS: CALCIUM CHLORIDES; CALCIUM MAGNESIUM ACETATE; CHEMICALS; DEBONDING; DEICERS; FORECASTING; MAINTENANCE, GENERAL; PENETRATION; RATE; SODIUM CHLORIDES; UREA

463340 DA
COSTS TO THE PUBLIC DUE TO USE OF CORROSIVE DEICING CHEMICALS AND A COMPARISON TO ALTERNATE WINTER ROAD MAINTENANCE PROCEDURES
Nottingham, D; Schoettle, S; Gunderson, W
Alaska Department of Transp and Public Facilities Div. of Planning & Programming, Res. Sect., ,301 Peger Road Fairbanks Alaska 99701; Department of Transportation Office of the Secy. of Transportation, 400 7th Street, SW Washington D.C. 20590
Dec 1983 35p Tabs. Refs. 3 App.
SUBFILE: HRIS
AVAILABLE FROM: Department of Transportation Office of the Secy. of Transportation, 400 7th Street, SW Washington D.C. 20590
The results are reported of a study which quantified salt related damage to vehicles and bridges in the Anchorage area, and examined possible means of reducing the use of salt. The total program cost includes direct and initial costs and indirect costs of loss of vehicle value and damage to bridge decks. Two avenues for reducing the total costs of the present Anchorage deicing program were examined: (1) utilizing heated storage buildings for stockpiling sand and (2) replacing salt with non-corrosive deicing chemicals. Certain prioritized actions are noted as being required for the orderly accomplishment of reducing indirect cost based on the total costs concept: (1) build sand storage facilities to maintain sand stockpiles (This could eliminate about 85% of total salt usage statewide.); (2) examine alternate deicing agents; (3) calibrate distribution equipment and optimize deicing chemical application rate for effectiveness; (4) train maintenance personnel; and (5) develop standard maintenance policies which outline procedures for various weather conditions.
DESCRIPTORS: APPLICATIONS; BRIDGE DECKS; CHEMICALS; CORROSION; COSTS; DAMAGE; DEICERS; DEICING SALT; EQUIPMENT; HIGHWAY MAINTENANCE; MAINTENANCE, GENERAL; SANDS; STORAGE; VEHICLES; WEATHER

461956 DA
ICE-MELTING CHARACTERISTICS OF CALCIUM MAGNESIUM ACETATE - EXECUTIVE SUMMARY. FINAL REPORT
Schenk, RU
Bjorksten Research Laboratories, Incorporated P.O. Box 9444 Madison Wisconsin 53715; Federal Highway Administration Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike McLean Virginia 22101
Jan 1986 12p
REPORT NO: FHWA/RD-86/180; FCP 33C3-012
CONTRACT NO: DOT-FH-61-83-C-00041; Contract
SUBFILE: HRIS
Port Royal Road Springfield Virginia 22161
Pertinent chemical and physical properties of calcium magnesium acetate (CMA) were determined. Included were comparisons of ratios of calcium to magnesium varying from 100% CaAc2 to 100% MgAc2. The objective was to determine the optimum composition of CMA for road deicing. In a 12-month study involving wetting/drying tests with 11 ratios of Ca/Mg and five pH's, it was found that CMA at pH's above 7.0 and at any Ca/Mg ratio produced no more harm to portland cement concrete than did NaCl. In addition, with compositions containing Mg at levels equal to or greater than Ca, the damage to concrete was significantly reduced. The lowest eutectic temperature (freezing point) was determined to occur with CMA 3/7 (3 mole fractions Ca to 7 mole fractions Mg). At higher Mg concentrations there is evidence that MgAc2.8H2O was formed. This hydrated salt has very low solubility at low temperatures. The anhydrous and minimally hydrated calcium acetate and magnesium acetate have significant heats of solution, with MgAc2 having the higher heat of solution - similar to CaCl2. The optimum pH for CMA was determined to be at least pH 7, with pH 9 the likely upper limit due to precipitation of Mg(OH)2. The optimum Ca/Mg ratio was determined to be 3Ca/7Mg +/- 1 unit.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICAL PROPERTIES DAMAGE; DEICERS; GENERAL MATERIALS; PH VALUE; PHYSICAL PROPERTIES; PORTLAND CEMENT CONCRETES; SOLUBILITY

461840 DA
NATURAL MATERIALS FIGHT ROAD CORROSION
Better Roads VOL. 56 NO. 12 Dec 1986 p 48
SUBFILE: HRIS
AVAILABLE FROM: Better Roads P.O. Box 558 Park Ridge Illinois 60068
A product is described which combines magnesium chloride ice control agent, and a corrosion-control polymer based on lignosulfonate derived from lignin (natural tree binder). This combination provides effective ice control and at the same time reduces the corrosion of autos, bridges, and road supports. The PCI polymer reduces the corrosion action of the salt. Tests showed that Great Salt Lake Minerals & Chemicals' Freezgard with PCI gave lower corrosion rates on mild steel coupons when compared with other common road deicing materials. Minnesota Department of Transportation's tests showed an 84% reduction in corrosion when Freezgard and PCI was used. Freezgard with PCI is an effective deicer even in temperatures as low as -32 deg F compared with conventional road salt, which begins to lose its effectiveness at temperatures below 20 deg F.
DESCRIPTORS: AUTOMOBILES; BRIDGES; CALCIUM MAGNESIUM ACETATE ; CORROSION PREVENTION; DEICERS; EFFECTIVENESS; FREEZING; HIGHWAYS; ICE CONTROL; LIGNOSULFONATE; MAGNESIUM COMPOUNDS; MAINTENANCE, GENERAL; POLYMERS; SALTS

DIALOG File 63: TRIS _ 70-92/JUL

461839 DA
SALT-SUBSTITUTE TEST GETS UNDERWAY
Better Roads VOL. 56 NO. 12 Dec 1986 p 43
SUBFILE: HRIS
AVAILABLE FROM: Better Roads P.O. Box 558 Park Ridge Illinois 60068
A new granular form of calcium magnesium acetate (CMA) is being tested by the Federal Highway Administration along a 7-mile length of U.S. Highway 14 in Wisconsin. Road salt, granular CMA, and sand coated with CMA are being applied, and a side by side comparison is being made of the effectiveness of each substance. The granular CMA looks like rock salt and handles like it. It is noted that, to date, CMA appears to be the most promising non-salt chemical deicing agent which is both effective and environmentally acceptable. CMA is less corrosive, non-toxic, and degrades in the environment slowly. The calcium and magnesium in CMA are precipitated as carbonates and can actually be beneficial additives to the soil.
DESCRIPTORS: CALCIUM MAGNESIUM ACETATE; CHEMICALS; DEICERS; ENVIRONMENTAL IMPACT; GRANULAR MATERIALS; MAINTENANCE, GENERAL ; SALT, SODIUM CHLORIDE; TESTING

457514 DA
PILOT PLANT STUDIES AND PROCESS DESIGN FOR THE PRODUCTION OF CALCIUM-MAGNESIUM ACETATE. FINAL REPORT
Ostermann, RD; Economides, MJ
Alaska University, Fairbanks Department of Petroleum Engineering Fairbanks Alaska 99775-1260; Alaska Department of Transp and Public Facilities 2301 Peger Road Fairbanks Alaska 99701
Nov 1985 73p Figs. Tabs. 9 Ref.
REPORT NO: AK-RD-86-24
SUBFILE: HRIS
AVAILABLE FROM: Alaska University, Fairbanks Department of Petroleum Engineering Fairbanks Alaska 99775-1260
Chloride salts are commonly used as deicing chemicals in many northern states. These chemicals are corrosive to automobiles, bridge decks and other public structures, and cause considerable damage to plants found near salted roadways. Calcium Magnesium Acetate (CMA) offers potential as an alternative deicing chemical. CMA is a generic term applied to the reaction product of acetic acid and limestone. It is non-corrosive and has no known potential to cause environmental damage. During 1982-1984, over 12,000 gallons of saturated CMA solution were produced by researchers in the Petroleum Engineering Department of the University of Alaska - Fairbanks. The raw materials were acetic acid, hydrated lime and native limestone. The product CMA solution was used in road tests in Fairbanks as well as for environmental studies. The results of these pilot plant studies are presented in this report. A process design for the production of 12,000 GPD of CMA from native limestone based on the results of the pilot plant studies is presented. For a grass-roots operation located in Fairbanks, the total capitol cost is estimated at $215,000, including site and structure costs. Using current prices for acetic acid, limestone and hydrated lime, product price of $413 per ton (dry CMA equivalent) is required for a 15% annual rate of return. It should be noted that raw materials costs amount to over 85% of the annual operating costs with capitol cost amortization amounting to only 2% of the product cost. The process economics are thus relatively insensitive to changes in capitol costs due to process design changes. Moreover, acetic acid cost alone accounts for 70% of the product price. The key to reducing the price of CMA lies in obtaining inexpensive acetic acid.
DESCRIPTORS: ACETIC ACID; CALCIUM MAGNESIUM ACETATE; CONSTRUCTION AND MAINTENANCE EQUIPMENT; DEICERS; GENERAL MATERIALS; HYDRATED LIME; LIMESTONES; MAINTENANCE, GENERAL; MANUFACTURING; PLANT LAYOUT

450843 DA
SEARCH CONTINUES FOR ALTERNATIVE DEICING CHEMICALS
Better Roads VOL. 55 NO. 6 Jun 1985 pp 44-45
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
Routine use of a nonchloride deicer remains limited to a few specialized situations. Cost, rather than effectiveness, seems to be the central issue. Recent work by the Federal Highway Administration has fostered interest in calcium magnesium acetate (CMA). In many states, work is underway to produce CMA economically, to evaluate its effectiveness and to determine its corrosive effects. Basically, CMA is produced by a reaction of dolomatic lime with acetic acid. There are several ways to achieve this reaction, however, and much research is centered on cost-effective production methods.
DESCRIPTORS: ACETIC ACID; CALCIUM MAGNESIUM ACETATE; CHEMICAL REACTIONS; CHEMICALS; COST EFFECTIVENESS; DEICERS; DEICING CHEMICALS; DOLOMITIC QUICKLIME; MAINTENANCE, GENERAL; ROADS AND STREETS; SNOW AND ICE CONTROL

426609 DA
COMPARATIVE STUDY OF CHEMICAL DEICERS
MCELROY, AD
NATIONAL RESEARCH COUNCIL TRANSPORTATION RESEARCH WASHINGTON DC
1988 ENGLISH
SUBFILE: UCITS; TLIB
BY A.D. MCELROY ... OTHER PHYS. DESCRIPTION: 13 ILLUSTRATED COVER TITLE PAPER PRESENTED AT THE 1988 ANNUAL MEETING OF THE TRANSPORTATION RESEARCH BOARD, WASHINGTON, D.C PAPER NO. 870500 ADDL CORP. AUTHOR INFO: NATIONAL RESEARCH COUNCIL U.S.. TRANSPORTATION RESEARCH BOARD NATIONAL RESEARCH COUNCIL TRANSPORTATION RESEARCH BOARD
DESCRIPTORS: DEICING CHEMICALS; EVALUATION; ROADS; SNOW AND ICE CONTROL

DIALOG File 63: TRIS _ 70-92/JUL

389527 DA
WASHING - AN AID TO STEEL BRIDGE MAINTENANCE
Nash, GFJ (Constructional Steel R&d Organisation)
Specialist and Professional Press
Surveyor VOL. 163 NO. 4791 May 1984 pp 14-15 1 Fig.
SUBFILE: TRRL; IRRD; HRIS
The use of de-icing salts is altering local environments alongside motorways and trunk roads, affecting the maintenance needs of steel and concrete overbridges. Sodium chloride solution is corrosive with corrosion rates doubling for each 10 deg C increase in temperature. The salt is hygroscopic and UK relative humidity levels result in the surface being coated with a sodium chloride solution almost continuously in the winter and during the night in summer. Increased summer temperatures ensure that corrosion continues at the same rate throughout the year. Evidence suggests that washing in a marine environment reduces corrosion and paint failure. Hence washing bridges at the end of winter could halt corrosion for eight or nine months of the year. Washing is less disruptive to traffic than painting and cost benefits could be achieved if it were found that painting had to be carried out less frequently as the result of annual washing. The author suggests that more needs to be known of the levels of salt, deposits on steel and concrete overbridges, and trials should be conducted to determine the long-term effects of washing steel and concrete overbridges. (TRRL)
DESCRIPTORS: BRIDGE; CONCRETE; CONCRETE BRIDGES; CORROSION; CORROSION PREVENTION; DEICERS; DEICING SALT; MAINTENANCE; MAINTENANCE, GENERAL; METAL BRIDGE; SODIUM CHLORIDE; STEEL BRIDGES; TEMPERATURE; WASHING

387518 DA
EXPERIMENTS WITH UNSALTED ROADS DURING THE WINTER 1982/83. EFFECTS ON ROAD CONDITIONS AND CONSEQUENCES FOR ROAD USERS AND ROAD MAINTENANCE AUTHORITIES
Bjoerketun, U; Karlsson, J-AA; Oeberg, G
National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden 0347-6049
N363 1984 Monograph 63p 17 Fig. 10 Tab. Phot. 9 Ref. Apps. Swedish
SUBFILE: TRRL; IRRD; HRIS
Experiments with some unsalted roads started in 1980 in Sweden and have continued. This report describes the result of studies during the winter 1982/83 regarding road conditions, friction, traffic counts, vehicle stops, resources used by maintenance authorities and intense monitoring of National Road 55. If similar sections with different anti-skid measures (salting and not salting respectively) are compared, the occurrence of icy/snow road conditions is 10-15% greater on the unsalted roads. The experiments also showed that the cost of winter road maintenance may vary greatly between different road sections. The main factors contributing to this difference are: climate, topography, volume and type of traffic, technique and different assessment of the effects of the measures applied. Photography and film evaluation was used sanding and ice grading are given and it is noted that different types of road pavement can demonstrate large difference in friction under externally similar conditions. (TRRL)
DESCRIPTORS: ANTISKID TREATMENT; BLACK ICE; CLIMATE; CONTINUOUS; COST; DEICERS; EVALUATION (ASSESSMENT); FRICTION; HIGHWAY MAINTENANCE; MAINTENANCE COSTS; MAINTENANCE, GENERAL; MANAGEMENT; PERSONNEL; REDUCTION (DECREASE); ROAD CONDITIONS; ROAD USER; SALT (DEICING); SANDING; SNOW; SNOW CLEARANCE; SNOW REMOVAL; SURVEILLANCE; SWEDEN; TOPOGRAPHY; TRAFFIC COUNT; TRAFFIC FLOW; TRAFFIC VOLUME; WINTER; WINTER MAINTENANCE

387325 DA
FEDERAL HIGHWAY ADMINISTRATION RESEARCH ON CALCIUM MAGNESIUM ACETATE - AN ALTERNATIVE DEICER
Chollar, BH
Federal Highway Administration, Office of R&D
Public Roads VOL. 47 NO. 4 Mar 1984 pp 113-118 3 Ref.
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
The importance of snow and ice control on highways and the advantages of a clear pavement cannot be overstated. In addition to greatly reducing highway accidents and fatalities, keeping the roads clear has benefited the American economy by allowing the movement of people and goods. The Federal Highway Administration (FHWA) and State highway and transportation departments are investigating the complete laboratory and field deicing, environmental, and economic effects of using calcium magnesium acetate (CMA), the most logical alternative to salt presently available. FHWA-sponsored research to identify alternative deicers shows that CMA is potentially less polluting and corrosive than salt.
DESCRIPTORS: APPLICATIONS; CALCIUM COMPOUNDS; CALCIUM MAGNESIUM ACETATE; DEICERS; ECONOMIC IMPACT; ENVIRONMENTAL STUDIES; GENERAL MATERIALS; HIGHWAY SYSTEMS; ICE PROBLEMS; MAINTENANCE; MAINTENANCE, GENERAL; PAVEMENTS

385849 DA
DETERIORATION RATES OF CONCRETE BRIDGE DECKS
Cady, PD; Weyers, RE (Pennsylvania State University, University Park)
American Society of Civil Engineers
Journal of Transportation Engineering VOL. 110 NO. 1 Jan 1984 pp 34-44 10 Ref.
SUBFILE: EIT; HRIS
AVAILABLE FROM: Engineering Societies Library 345 East 47th Street New York New York 10017
Procedures are developed for estimating the parameters required for life-cycle costing of the elements of maintenance and rehabilitation of concrete bridge decks subject to the deteriorative effects of deicing chemicals. The included elements are the age and extent of deterioration at which

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

annual maintenance can be expected to begin, the rate of increase in annual maintenance, and the age at which rehabilitation is required. The information presented is primarily of use in formulating repair/rehabilitation/replacement policy.

DESCRIPTORS: BRIDGES, CONCRETE; BRIDGES, HIGHWAY; CONCRETE; CONCRETE BRIDGE DECKS; DECKS; DEICERS; DEICING CHEMICALS; DETERIORATION; DISINTEGRATION; LIFE CYCLE COSTING /LCC/; MAINTENANCE; MAINTENANCE, GENERAL; POLICY; REHABILITATION; REPAIRS; REPLACEMENTS; ROADS AND STREETS; SNOW AND ICE CONTROL ; STRUCTURES DESIGN AND PERFORMANCE

382960 DA

IMPLEMENTATION OF RESEARCH

Betsold, R (Federal Highway Administration)

Purdue University

Engineering Bulletin of Purdue University N153 1982 pp 46-52 1 Fig.

SUBFILE: HRIS

AVAILABLE FROM: Purdue University West Lafayette Indiana 47907

The author reviews some recent FHWA research projects that could be of use to state, county and city highway officials. These include measurements of 140 low-volume intersections showing that yield signs produce much lower user costs than stop signs, the development of a self-restoring barrier guardrail to handle the smaller cars and larger trucks now on the road, the refining of computer programs for traffic simulation and control, the use of calcium magnesium acetate as a substitute for deicing salt, the testing of polymer concrete for use in maintenance, and the development of a epoxy thermoplastic pavement marking materials that is for more durable than conventional traffic point. This paper was presented at the 68th Annual Road School, Purdue University, March 9-11, 1982.

DESCRIPTORS: ADMINISTRATION; CALCIUM MAGNESIUM ACETATE; COMPUTER PROGRAMS; COST COMPARISONS; DEICERS; EPOXY; GUARDRAILS; HIGHWAY RESEARCH; HIGHWAY USER COSTS; IMPLEMENTATION; INTERSECTIONS; POLYMER CONCRETE; STOP SIGNS; THERMOPLASTICS; TRAFFIC MARKING MATERIALS; TRAFFIC SIMULATION MODELS; VEHICLE SIZE; YIELD SIGNS

373171 DA

PROCESS DEVELOPMENT FOR PRODUCTION OF CALCIUM MAGNESIUM ACETATE (CMA)

Marynowski, CW; Jones, JL; Boughton, RL; Tuse, D; Cortopassi, JH; Gwinn, JE

SRI International 333 Ravenswood Avenue Menlo Park California 94025 3747-1; Federal Highway Administration Office of Research and Development, 400 7th Street, SW Washington D.C. 20590

Mar 1983 Intrm Rpt. 72p

REPORT NO: FHWA-RD-82-145

CONTRACT NO: DTFH61-81-C-00122; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

SRI International screened alternative processes and alternative biomass feedstocks to identify a preferred process and feedstock for commercial production of calcium magnesium acetate (CMA), a candidate chemical for noncorrosive, environmentally acceptable selective replacement of sodium chloride for highway and bridge deicing. The process identified as having the greatest economic potential was one that used the anaerobic, thermophilic bacterium, Clostridium thermoaceticum to ferment biomass-derived sugars to acetic acid, and reacted the acetic acid with dolomitic lime to make CMA. Corn grain was identified to be the most favorable biomass feedstock in the tonnages projected to be required; high-glucose corn syrup was a slightly less favorable choice. Preliminary process designs were prepared and detailed economic analyses were carried out for three alternative CMA processes: (1) from corn grain by hydrolysis and fermentation, (2) from high glucose syrup by fermentation, and (3) from purchased synthetic acetic acid. Cost sensitivity analyses were included for the effects of: (1) plant size, (2) feedstock costs, (3) plant facilities investment, and (4) plant on-stream time. For the base case, the estimated selling price (plant gate) of CMA was 18-19 cents/lb (40-42 cents/kg), or about 7-8 times the current cost of road salt. The experimental effort to develop the process to permit scale-up to a pilot plant was hampered by delays in obtaining a seed culture of C. thermoaceticum and by subsequent indications that the seed culture received probably contained the spores of another organism. Recommendations are made for further work judged necessary to attain the performance of the process assumed for the base economic analysis. (FHWA)

DESCRIPTORS: ACETATES; ACETIC ACID; BIOMASS; CALCIUM COMPOUNDS; CHEMICAL PROCESSES; COSTS; DEICERS; DOLOMITIC QUICKLIME; FEEDSTOCK; GENERAL MATERIALS; MAGNESIUM COMPOUNDS; MAINTENANCE, GENERAL; MANUFACTURING

337205 DA

SIX-YEAR GROWTH OF TREES AND SHRUBS ALONG MINNESOTA ROADS ESPECIALLY AS AFFECTED BY DEICING SALTS

Buschena, C; Sucoff, E

Minnesota Local Road Research Board, St. Paul.; Federal Highway Administration, St. Paul, MN. Minnesota Div.; Minnesota Dept. of Transportation, St. Paul.

May 1980 36-SUPPL 39p

REPORT NO: LRRB-INVESTIGATION-6; FHWA/MN-80/7

SUBFILE: NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Deicing salt, chiefly sodium cloride, has been identified as an important cause of damage to roadside vegetation. A 1973 investigation along Minnesota roadways attempted to quantify the extent of the damage to roadside vegetation by deicing salt. The 1973 study concluded that there was 'no reason to

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DIALOG File 63: TRIS _ 70-92/JUL

expect widespread increases in salt damage' providing salt usage remained the same. The objectives of this study was to verify these conclusions and to inventory tree growth along Minnesota roads through a re-measurement of the permanent plot system established for this purpose in 1973. Also pub. as Minnesota Agricultural Experiment Station, St. Paul Miscellaneous Report no. 1760. Sponsored in part by Minnesota Dept. of Transportation, St. Paul. Prepared in cooperation with Minnesota Univ., St. Paul. Coll. of Forestry. Color illustrations reproduced in black and white.

DESCRIPTORS: DAMAGE; DEICERS; HEIGHT; HIGHWAYS; MEASUREMENT MINNESOTA; MORTALITY; PLANT GROWTH; ROADSIDES; SHRUBS; SODIUM CHLORIDE; TOLERANCES PHYSIOLOGY; TREES PLANTS

337185 DA

VINTERVAEGSALTETS MILJOEPAVERKAN (THE ENVIRONMENTAL IMPACT OF HIGHWAY DEICING)

Baeckman, L

Statens Vaeg- och Trafikinstitut, Linkoeping (Sweden).

1980 116p

REPORT NO: VTI-197

SUBFILE: NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The environmental impact of highway deicing has been studied at a number of study sites. The impact was demonstrated by damage to vegetation and by high salt concentrations in soil, groundwater and vegetation. However, there is no simple relationship between the amount of salt spread on the roads and the rate of environmental impact. The determining factors for the environmental impact are the prevailing geological and hydrological conditions. Damage to vegetation, especially to conifers, is very common along roads where salt is spread. The amount of woody vegetation damaged by road salt is, however, relatively small as there is only a narrow strip along the roads which is affected. Chloride analyses from a number of public groundwater supplies near roads were studied. The chloride levels are usually very low and only in a few supplies are the levels rising. The salt concentration in a surface water supply near a highway was also studied. The sodium and the chloride levels are very low, which indicates that highway deicing has little effect on surface water. In the United States there is, contrary to Sweden, a great concern about road salt contamination of water supplies. This could partly be due to the great amount of salt spread in the USA, but also to the fact that in the USA it is generally held that relatively small amounts of sodium are health-endangering. In Sweden there is no limit value for sodium in drinking-water. Text in Swedish; summary in Swedish and English. Also pub. as ISSN-0347-6030.

DESCRIPTORS: DEICERS; DEICING; ENVIRONMENTAL IMPACTS; FOREIGN TECHNOLOGY; GROUND WATER; HIGHWAYS; SODIUM CHLORIDE; VEGETATION; WATER POLLUTION

334200 DA

ALTERNATIVES TO SODIUM CHLORIDE FOR HIGHWAY DEICING (ABRIDGMENT)

Dunn, SA; Schenk, RU (Bjorksten Research Laboratories, Incorporated)

Transportation Research Board

Transportation Research Record N776 1980 pp 12-15 30 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

A search has been made for road deicing chemicals to replace sodium chloride (NaCl). The impetus for this search stems from the numerous drawbacks associated with the current extensive use of NaCl as a road deicer. All classes of chemical compounds were reviewed. Deletions were made on the basis of such pertinent criteria as water solubility and freezing-point lowering, corrosion, toxicity, flammability, relative cost or cost potential, and effect on soils, plants, and water supplies. Low molecular weight and high solubility were primary qualifications. Waste products were considered as possible raw-material sources. Two candidate deicers have been selected that, if used, would result in total costs of about one-half those associated with the use of NaCl. Both materials can be made from waste cellulose. Neither is corrosive. One of them, methanol, reacts almost immediately on contact with snow and ice but is less persistent than the other candidate or than NaCl. The other candidate, calcium magnesium acetate (CMA), acts at about the same rate as NaCI in the temperature range of common activity and shows about the same persistence. In strong contrast to NaCl, CMA is a corrosion inhibitor, is beneficial to most soils, and has no potential to harm drinking supplies. This paper appeared in Transportation Research Record No. 776, Guideway Snow and Ice Control and Roadside Maintenance.

DESCRIPTORS: ACETATES; ALTERNATIVES; CALCIUM COMPOUNDS; CORROSION; DEICING SALT; ENVIRONMENTAL DESIGN; ENVIRONMENTAL IMPACT; FLAMMABILITY; MAGNESIUM COMPOUNDS; MAINTENANCE, GENERAL; METHANOL; SODIUM CHLORIDES; TOXICITY

315057 DA

ALTERNATE HIGHWAY DEICING CHEMICALS. EXECUTIVE SUMMARY

Dunn, SA; Dunn, A; Schenk, RU

Bjorksten Research Laboratories, Incorporated P.O. Box 9444 Madison Wisconsin 53715; Federal Highway Administration Office of Research and Development, 400 7th Street, SW Washington D.C. 20590

Mar 1980 Final Rpt. 17 p.

REPORT NO: FHWA-RD-79-109

CONTRACT NO: DOT-FH-11-9100; Contract

SUBFILE: HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

A search has been made for road deicing chemicals to replace sodium chloride (AaCi). The impetus for this search stems from

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DIALOG File 63: TRIS _ 70-92/JUL

the numerous drawbacks associated with the prevalent use of MaCl as a road deicer. All types of chemical compounds were reviewed. Selections were made on the basis of criteria such as water solubility and freezing point lowering, corrosion, toxicity, relative cost or cost potential, effect on soils and plants and water supplies, flammability, concrete compatibility, traction, friction, highway performance, etc. Information was sought first in the literature, then supplemented or verified in the laboratory as needed. Two candidate deicers were found to be as effective as sodium chloride. One, methoanol, reacts almost immediately upon contact with snow and ice but is less persistent than NaCl. The other candidate, calcim magnesium acetate (CMA), acts at about the same rate as NaCl in the temperature range of common activity and shows about the same persistence. It gives rise to about the same descreases in coefficients of braking traction and skidding friction as NaCl. In strong contrast to NaCl, CMA is a corrosion inhibitor, is beneficial to most soils and has no potential for harming drinking supplies. The unpurified CMA derived from solid wastes, primarily cellulose, gives improved traction and reduces production costs. The methodology for CMA production, cost evaluated above, is unsophisticated 19th Century technology. Application of modern technology may further lower production costs. (FHWA)

DESCRIPTORS: ACETATES; CALCIUM COMPOUNDS; CORROSION; DEICING SALT; INHIBITORS; MAGNESIUM COMPOUNDS; MAINTENANCE, GENERAL; METHANOL; SKID RESISTANCE; SUBSTITUTES; TOXICITY; TRACTION

291070 DA

FREEZING AND THAWING DETERIORATION OF CONCRETE PAVEMENTS

Melick, MJS; Merkuur, TC (State Road Laboratory, Netherland Provincial Waterstaat, Noord-Brabant)

Vereniging Het Nederlands Wegencongres

Wegen VOL. 46 NO. 3 Mar 1972 pp 77-82 4 Fig. 3 Tab. 2 Phot. 6 Ref. Dutch

SUBFILE: TRRL; IRRD; HRIS

Freezing and thawing deterioration (scaling) occurs rather frequently on new concrete roads as a result of the intensive use of deicing salts. In the past it has been established that scaling took place also when organic or inorganic chemicals were applied as in the case of pure sand. The scaling mechanism has therefore probably a more physical than chemical character. In the literature, scaling is principally attributed to a prolonged or premature finishing of the concrete surface. It is generally stated that the use of an air entrainer highly increases the resistance of concrete to freezing and thawing. By order of the Department of Public Works in the Province Noord-Brabant, 14 experimental road sections were constructed with variations in the composition of the concrete and the type of cement. At the State Road Laboratory cores drilled out of the pavement sections were submitted to 40 freezing and thawing cycles (-7 degrees C and +20 degrees C respectively). During the tests common salt was spread on the top surface which was covered with A 3 mm layer of ice. The rate of deterioration of the concrete surface was determined by weighting the concrete fragments that became detached and by photographing the surface. At the end of the tests the penetration depth of the common salt in all cylinders was determined. The investigations showed that: concrete with an air entrainer added has a greater resistance to deterioration than concrete without such an admixture. The detachment of the upper layer (0.1 mm) is more serious in the case of concrete prepared with blast furnace cement than with concrete prepared with portland cement. This process takes place during the first five cycles. A distinct deterioration was recorded from the cylinders made of a concrete mixture without air entrainer. At the end of the test period (after 40 cycles) the deterioration of the cores prepared with portland cement was more marked than the deterioration observed from the cores prepared with blast furnace cement. Visual observations of the experimental road sections will show how far the scaling which will appear in the future can be accurately predicted from the results of laboratory tests. /TRRL/

DESCRIPTORS: AIR ENTRAINED CONCRETE; CONCRETE PAVEMENTS; DEICERS; DETERIORATION; FREEZE THAW DURABILITY; LABORATORY TESTS; MAINTENANCE, GENERAL; MIX DESIGN; SCALING; TEST SECTIONS

265712 DA

CONCRETE PAVEMENTS, FRANCE

Plisson, M

Permanent International Association of Road Congr; 43 Avenue du President Wilson; 75-paris 16; France

pp 23 Figs. Phots.

REPORT NO: Book III-5

SUBFILE: HRIS

The results are presented of trials performed on unreinforced concrete carriage ways with sawn joints without dowels and laid by a slip form paver of a treated base. The mechanical behavior was studied with the aid of various measuring instruments and by different methods of loading and sounding permitting the application of variable stresses. Laboratory tests on the wearing properties of different concrete mixes used in road construction were carried out with the aid of a ball bearing shaker. The results of these tests will then be related to the wearing properties on actual carriageways which are subjected to studded tires. The chemical corrosion aspect and the temperature impact aspect of the action of deicing salts were also studied. Anti-skid treatment of fresh concrete (when laying) and hardened concrete (by grooving) was also investigated. Transverse brushing was found to improve the coefficient of friction in the former case. Presented at the XIVth World Road Congress, Prague, Czechoslovakia, 1971.

DESCRIPTORS: CONCRETE PAVEMENT DESIGN; CORROSIVE PROBLEMS; DEICERS; LABORATORY TESTS; LOADING; MEASUREMENTS; MECHANICAL PROPERTIES; PAVEMENT DESIGN AND PERFORMANCE; SAWED JOINT; SKID RESISTANCE; SOUNDING; STRESSES; STRUCTURES DESIGN AND PERFORMANCE; TEMPERATURE; WEAR

DIALOG File 63: TRIS _ 70-92/JUL

262868 DA
THE DEVELOPMENT OF A CORROSION INHIBITOR FOR ADDITION TO ROAD DE-ICING SALT
Transport and Road Research Laboratory; Bishop, RR
29 pp 14 Fig. 5 Tab. 15 Ref.
REPORT NO: TRRL Rept. No. LR489
SUBFILE: NSC; HRIS
A corrosion inhibitor for use as an additive to highway de-icing salt has been developed. Laboratory experiments have been used as screening tests and the more promising materials have been evaluated in trials on cars. The corrosive action of salt on mild steel is almost constant over a concentration range of 10 to 0.05 percent of salt in solution. The protection given by inhibitors diminishes markedly as they become diluted and they are only effective in reducing corrosion if their initial addition is of the order of 7 percent of salt. This has been demonstrated both in laboratory tests and in field trails. The use of this proportion of hibitor would increase the expenditure on de-icing salt by about 25 M pound sterling. Even though the cost of vehicle corrosion from salt exceeds this considerably, it seems unlikely that such an increase in public expenditure on salting could be justified unless almost complete protection from corrosion could be offered. A cheaper way of employing the inhibitor, as part of an automatic car washing process is being examined. /Author/
DESCRIPTORS: CORROSION PREVENTION; COST COMPARISONS; DEICERS ; DEICING SALT; HIGHWAY MAINTENANCE; INHIBITORS; MAINTENANCE, GENERAL; SALTS; WASHING

238032 DA
DISPOSAL OF SODIUM IONS IN SOIL
Hutchinson, FE
Maine State Highway Commission; /Materials & Res Div
Sep 1971 Tp 71-10c, 23 PP, 1 FIG, 14 TAB
SUBFILE: HRIS
limestone and gypsum were surface applied to three sites along Maine highways where sodium levels had been raised appreciably by road salting for deicing purposes during previous winters. Both materials were applied at rates equivalent to 2, 4, 8, and 16 milli-equivalents of calcium per 100 grams of soil. Soil samples from the plots were analyzed 6, 12, and 18 months following treatment to determine the effectiveness of calcium ions in replacing sodium ions held by the soil particles. Calcium levels in the soil at all sites were significantly increased by limestone application, but the sodium levels remained unchanged. Magnesium levels tended to decrease with increased rate of liming, while potassium and ph values remained relatively constant. Gypsum treatments significantly increased the calcium levels in the soils, although less than limestone. At the 6-inch depth, sodium levels were significantly reduced by the treatment, which gave 16 milli-equivalents of calcium (14 tons gypsum/acre) at sites where the original sodium concentration was 734 and 397 ppm. Magnesium, potassium, and ph values were generally unchanged by gypsum treatment. Gypsum applied at a rate equivalent to 14 tons per acre to the site which originally contained 734 ppm of sodium resulted in a 31% reduction 18 months after treatments were applied. /author/
DESCRIPTORS: CALCIUM; CHEMICAL ANALYSIS; DEICERS; DEMINERALIZATION; ENVIRONMENTAL EFFECTS; GYPSUM; ION EXCHANGE TESTS; IONS; LIMESTONES; MAGNESIUM; PH VALUE; POTASSIUM; SODIUM; SOIL SCIENCE; SOILS

223826 DA
VEHICLE CORROSION CAUSED BY DEICING SALTS, EVALUATION OF THE EFFECTS OF REGULAR VS. INHIBITED SALT ON MOTOR VEHICLES
American Public Works Association; 1970
1970 85 pp Refs Rept No APWA-SR-34
SUBFILE: HRIS; HSL
the test roads in Minnesota were treated with sand, rock salt, and a commercial inhibited salt. Three automobiles were regularly driven on each of three roads during three winters and two spring-summer-fall seasons under controlled conditions. The vehicles were completely disassembled at the conclusion of the field operation to permit a detailed inspection of all parts. These evaluations indicated that up to 50% of vehicle corrosion can be attributed to the action of deicing salt and that the inhibitor used can reduce corrosion somewhat for bright metal parts, but it does not provide protection for major parts of auto body steel. /hsl/
DESCRIPTORS: CORROSION; CORROSION PREVENTION; DEICERS; HUMAN FACTORS; ROCK SALT; SALTS; SANDS; STEEL STRUCTURES; VEHICLES

219527 DA
SPECIFICATION FOR WINTER GRITTERS FOR ROADS
British Standards Institution
N 16 Dec 1972 19 pp 2 Fig 3 Tab
SUBFILE: TRRL; IRRD; HRIS
STANDARDS APPLYING TO ALL TYPES OF WINTER SPREADERS (EXCEPT MANUAL SPREADERS), USED FOR DISTRIBUTING MATERIALS, INCLUDING SALT, ON ROADS, ARE DESCRIBED. MACHINES ARE CLASSIFIED, AND THE ESSENTIAL REQUIREMENTS FOR THE CONSTRUCTION AND PERFORMANCE OF EACH CLASS ARE SPECIFIED. A PROTOTYPE PERFORMANCE TEST USING TWO SPECIFIED MATERIALS IS INCLUDED FOR EACH CLASS, WITH PROVISION FOR TESTING, ISSUE OF CERTIFICATE AND MARKING.
DESCRIPTORS: CONSTRUCTION AND MAINTENANCE EQUIPMENT; DEICERS ; DEICING; MAINTENANCE EQUIPMENT; SPREADERS; STANDARDS

219189 DA
DO DE-ICING SALTS CONSTITUTE A HEALTH HAZARD?
Bauverlag GmbH
Bauwirtschaft VOL. 25 Nn6 1971 pp 1525-6 1 Fig
SUBFILE: TRRL; IRRD; HRIS
ARGUMENTS PRESENTED AT THE 14TH WORLD ROAD CONGRESS, IN PRAGUE IN THE AUTUMN OF 1971, ON THE EFFECT OF A MIXTURE OF DEICING SALTS AND FUEL OIL ON GROUND WATER, DRINKING WATER AND

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DIALOG File 63: TRIS _ 70-92/JUL

VEHICLE CORROSION ARE OUTLINED. /TRRL/
DESCRIPTORS: CORROSION; DEICERS; DRINKING WATER; FUEL OILS; GROUNDWATER; MAINTENANCE, GENERAL; VEHICLES; WATER POLLUTION

219098 DA
ROAD SALT USE AND THE ENVIRONMENT
Walker, WH; Wood, FO
Highway Research Record, Hwy Res Board N425 pp 67-76 4 Fig 16 Ref
SUBFILE: HRIS
at the present time, salt use cannot be seriously restricted; it is far too essential in snow and ice control, and there are no readily available substitutes. Alternative materials generally are prohibitive in cost and may have much worse environmental effects than salt. However, as more salt is required for winter maintenance of streets and highways, there have been localized incidences of water pollution, mostly in the vicinity of large, poorly located or improperly covered salt piles. Such pollution must be kept to a minimum in the future if maximum benefits from deicing salts are to be maintained. One of the first steps taken should be to inspect existing and proposed salt storage sites to determine the pollution potential of each site and to devise means of pollution prevention or elimination if the inspections prove such actions to be necessary. Concurrently, research and development of more efficient, economical, and dependable salt handling and salt spreading equipment should be expedited. It is also advised that concerted efforts should be directed toward correcting wasteful and improper salt handling or application practices of major salt users such as highway maintenance departments.
DESCRIPTORS: DEICERS; DEICING; ENVIRONMENTAL EFFECTS; EQUIPMENT; MAINTENANCE, GENERAL; POLLUTION; RESEARCH AND DEVELOPMENT; SALT /SODIUM CHLORIDE/; SNOW & ICE CONTROL; SPREADING; STORAGE

219097 DA
DE-ICING CHEMICALS AND ABRASIVES: STATE OF THE ART
Keyser, JH
Highway Research Record, Hwy Res Board N425 pp 36-51 12 Fig 4 Tab 140 Ref
SUBFILE: HRIS
the state of the art of deicing chemicals and abrasives for winter road maintenance is summarized through a discussion of the following: properties of deicing chemicals; abrasives; factors influencing the melting rate of snow and ice; and the rate of application of deicing chemicals. Tables and figures are presented which show: (1) the increase in the coefficient of sliding friction as ice is being melted by the action of sodium chloride and calcium chloride; (2) the decrease in stopping distance of an automobile by sanding the pavement surface and by completely melting the ice or snow (wet surface); and (3) the suitability of the various types of chemicals and abrasives. Essentially, the abrasive will provide immediate traction and increase skid resistance, whereas chemicals will principally act to control snow and ice conditions by (a) preventing the formation of ice films, (b) weakening the bond between the snow and the road surface, (C) melting the fresh snow as it falls, and (D) melting compacted snow that remains after plowing.
DESCRIPTORS: ABRASIVES; CALCIUM CHLORIDES; DEICERS; MAINTENANCE, GENERAL; SALT /SODIUM CHLORIDE/; SKID RESISTANCE SLIDING FRICTION; SNOW & ICE CONTROL; STATE OF THE ART STUDIES ; STOPPING DISTANCES; TRACTION

219074 DA
VEHICLE CORROSION DUE TO THE USE OF CHEMICALS IN WINTER MAINTENANCE AND THE EFFECT OF CORROSION INHIBITORS
Norwegian Road Research Lab; Thurmann-moe, T; Ruud, OE
N44 Jan 1973 p 15-29 7 Fig 4 Tab
SUBFILE: HRIS
in an investigation of vehicle corrosion attributed to the use of deicing chemicals, the effects of various chemicals and also of corrosion inhibitors was studied in several independent tests. Five different intermittent inversion tests (drip-dry tests) series running for a period of 1-3 months, were performed as outdoor laboratory projects (3 in winter; 1 in summer; and 1 in autumn). Two similiar series of tests were performed in the laboratory. Field trials conducted on three road sections (unsalted section; salted section; and salt and corrosion inhibitor section) invdlved the testing of vehicles with racks attached by steel plates. Results of the laboratory tests indicate that 70 to 80 percent of the corrosion is attributable to salt while field tests indicate the figure to be between 56 and 66 percent. Although the corrosion is more than twice as high with salting than without, the total contribution of salt is expected to be lower when annual estimates are considered. Tests designed to find a non-corrosive deicing chemical revealed no viable alternative to salt. Of thirteen corrosion inhibitors studied, one insoluble product was found to be promisiing. The inhibitors, however, had negative side effects and are very expensive. The main conclusions drawn from the investigations are listed.
DESCRIPTORS: CHEMICALS; COLD WEATHER OPERATIONS; CORROSION; CORROSION PREVENTION; CORROSION TESTS; DEICERS; FIELD TESTS; INHIBITORS; LABORATORY TESTS; MAINTENANCE, GENERAL; RUST CONTROL; SALTS

219048 DA
ANALYSIS AND CURRENT STATUS OF ROAD DEICING
Envir Assn of Ostego & Del Cnties; 1973
Feb 1973 14 pp 3 Tab Refs
SUBFILE: HRIS
the results of a study on the effects of salt on highway safety and the environment are discussed. Tables are included which give cost data for deicers and accident data. Various conclusions are reached, the most important being that there is sufficient reasonable doubt at this time concerning the use

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DIALOG File 63: TRIS _ 70-92/JUL

of deicing salts, both with regard to their effect on the environment and their effectiveness for the purpose for which they are intended, that there should be no further expansion of the use thereof until more information is available.
DESCRIPTORS: ABRASIVES; ACCIDENT REPORTS; BENEFIT COST ANALYSIS; CHEMICAL DEICING AGENTS; DATA ACQUISITION; DEICERS; ECONOMICS; ENVIRONMENTAL EFFECTS; HIGHWAY DRAINAGE; MAINTENANCE, GENERAL; SALT /SODIUM CHLORIDE/

218997 DA
LIQUID CALCIUM CHLORIDE BOOSTS SALT'S EFFECTIVENESS
Better Roads Jul 1972 pp 22-3 3 Phot
SUBFILE: HRIS
the trend toward increasing quantities of deicing chemicals per hour per storm has been arrested. Assessment of the limitations of salt has led to the conclusion that it has developed a system using liquid calcium chloride as A salt treatment that was field-tested on the toledo-- Cleveland section of the Ohio turnpike during the winter of 1970-71 and then expanded during the winter of 1971-72 to other roads in Ohio, Iowa, and Illinois. In the melting action of salt, concentrated brine forms and resists further dilution under subfreezing temperatures. The strong brine quickly crystallizes. In contrast, a small amount of liquid calcium chloride added to a tone of salt dilutes both chloride brines, bringing them to a state incapable of further melting. As a result, only a minimum of salt recrystallization occurs. Test results have shown that appliction rates of salt per mile have been sharply reduced, while superior effectiveness has been achieved. A brief presentation is made of the system's chemistry, economics, dispensing equipment, application procedures, and storage.
DESCRIPTORS: ADDITIVES; APPLICATIONS; CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; DEICERS; LIQUIDS; MAINTENANCE, GENERAL; RATE; SALTS

218985 DA
DE-ICING SALTS AND THE ENVIRONMENT
Habitat Sch of Environment; Mcconnell, H
Feb 1972 50 pp 1 Fig 5 Tab 88 Ref 3 APP
SUBFILE: HRIS
between 1947 and the end of 1970 the use of deicing salts increased about 18 times. Increasingly there has been a trend away from a sand--salt mix toward use of salt only, primarily because of the popularity of the "bare pavement maintenance" policy. The improvement in public safety and convenience is accompained, however, by detrimental side effects: deterioration of concrete highway structures, corrosion of automobiles and shoe leather, chloride contamination of ground and surface water supplies, damage to roadside vegetation, and toxicity to fish and wildlife of excessive chloride. Also, the relative safety of salted vs. Unsalted roads is still undetermined. Many states are concerned about these side effects, but Massachusetts appears to be the most active in confronting them. Most of the information available to the public has been supplied by organizations promoting the sale of deicing salts, although the u.s. Environmental Protection Agency has published a review of the existing literature. The present report is another such review, treating the following topics: the chemistry and application of deicing salts, damage to public works, automobile corrosion, water pollution, effects on vegetation and wildlife, the effectiveness of salting, alternatives, and the economics of salting.
DESCRIPTORS: BIBLIOGRAPHIES; DAMAGE; DEICERS; ENVIRONMENTAL EFFECTS; MAINTENANCE, GENERAL; REVIEWS; SALTS

218845 DA
STREET SALTING, URBAN WATER QUALITY WORKSHOP - PROCEEDINGS
Hawkins, RH
Syracuse University; /State U Coll of Forestry
Jul 1971 94 Pp, Figs, TABS
SUBFILE: HRIS
contents: deicing: a public works director's dilemma, adrian g. Clary; salt- the universal de-icing agent, frank o. Wood; environmental impact of highway deicing, edmund J. Struzeski, jr.; the effect of highway salt on water quality in selected main rivers, f.e. Hutchinson; road salt as an urban tracer, w. S. Broecker, B. Schwartz, n. Sloan, p. Ancona; runoff of deicing salt: effect on irondequoit bay, r. C. Rubeck, w. H. Diment, b. L. Deck, a. L. Baldwin, s. D. Lipton; effects of road salt on a Vermont stream, samuel H. Kunkle; street salting & water quality in meadowbrook, syracuse, New York, r.h. Hawkins; road salt as a polluting element, r.w. Sharp; lake stratification caused by runoff from street de-icing, j.h. Judd; salt-assisted accidents- a question of relative safety, f.s. Adams; salt at its source: livingston and Wyoming counties, New York, particia de La vergne.
DESCRIPTORS: ACCIDENTS; DEICERS; DEICING; ENVIRONMENTAL EFFECTS; LAKES; MAINTENANCE, GENERAL; RIVERS; RUNOFF; SALT /SODIUM CHLORIDE/; SALTS; STRATIFICATION; STREAM POLLUTION; WATER POLLUTION

218720 DA
ACCUMULATION OF ROAD SALT IONS IN SOILS ALONG MAINE HIGHWAYS
Maine Farm Research; Hutchinson, FE
Oct 1966 3 Pp, Fig, TABS
SUBFILE: HRIS
analyses conducted in Maine since 1965 show that ions of sodium and chloride tend, with number of years of deicing-salt application, to increase in absolute quantity and in the distance from the roadway where they can be found. For example, a section of the Maine turnpike that had been salted for only two years had sodium concentrations of AS Much as 300 micrograms per gram of soil only at distances of 2--7 feet from the roadwide and no concentration as high as 100 micrograms beyond 20 feet, while by contrast a section salted for 17 years had concentrations of 500--600 micrograms at the near distance and 280-400 micrograms at distances from 20--50

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DIALOG File 63: TRIS _ 70-92/JUL

feet. These data compare with A reading of 50 micrograms along unsalted roadways. It appears that most of the ions are retained in the soil and do not pass off into waterways. The main deleterious effects of sodium and chloride accumulations in soil are on maintenance of scenic vegetation along the roadway and on soil structure, the soil becoming less permeable and creating drainage problems.

DESCRIPTORS: CHLORIDES; CONTAMINATION; DEICERS; ENVIRONMENTAL DESIGN; FRANGIPANI; HIGHWAY DRAINAGE; IONS; MAINTENANCE, GENERAL; PLANTS /BOTANY/; SALT /SODIUM CHLORIDE/ SODIUM; SOIL PERMEABILITY; SOIL SCIENCE; SOIL STRUCTURE; SOILS ; STREAM POLLUTION; TOXICITY

218586 DA

NEW DEVELOPMENTS IN WINTER MAINTENANCE

Dickinson, WE

Intl Bridge Tunnel & Turnpike Assoc Oct 1969

REPORT NO: pp 24-27

SUBFILE: HRIS

THE SALT INDUSTRY HAS DEVELOPED WHAT IS CONSIDERED TO BE AN IDEAL BLEND OF SALT FOR ROAD DEICING, I.E. A BLEND OF COARSE PARTICLES FOR BORING ACTION THROUGH ICE TO PAVEMENT BELOW AND SUFFICIENT FINE SALT TO PROVIDE INSTANT TRACTION AND RAPID MELTING ACTION. THE MATERIAL IS 75% COARSE-CRUSHED ROCK SALT AND 25% FINE; BOTH THE COARSE-CRUSHED AND THE BLEND MEET ASTM SPECIFICATIONS. A SUMMARY OF TESTS OF THE EFFECTIVENESS OF THE BLEND IS PRESENTED. FIELD TESTS WERE CONDUCTED AT STEVENS POINT, WISCONSIN; GENESEE COUNTY, NEW YORK; CHICAGO, ILLINOIS; AND CINCINNATI, OHIO; TESTS WERE ALSO CONDUCTED BY THE STATE HIGHWAY DEPARTMENTS OF KENTUCKY, MINNESOTA AND OHIO. THE DEMONSTRATIONS HAVE SHOWN THAT THE HIGHWAY TEST SALT PROVIDES TRACTION EQUIVALENT TO SAND OR CINDERS AND THAT IT COSTS 1/3 THAT OF ABRASIVES. LABORATORY TESTS, USING AN ANTI-SKID DYNAMOMETER TO MEASURE THE CO- EFFICIENT OF FRICTION, SHOWED THAT AT LOW TEMPERATURES SAND HAD LITTLE EFFECT OVER GLARE ICE AND THAT CINDERS WERE ONLY SLIGHTLY BETTER THAN SAND. AT AN AIR TEMPERATURE OF 25 DEGREES F, THE COEFFICIENT FOR COARSE-CRUSHED ROCK SALT IMMEDIATELY AFTER APPLICATION WAS GREATER THAN THAT FOR EITHER SAND OR CINDERS. AT 15 DEGREES F, THE INITIAL COEFFICIENT WAS GREATER THAN SAND BUT LESS THAN CINDERS. THE SALT BLEND PRODUCES A HIGHER COEFFICIENT OF FRICTION THAN COARSE-CRUSHED ROCKS SALT ALONE. FURTHER FIELD TESTS ARE BEING CONDUCTED TO COMPARE THE BLEND WITH COARSE-CRUSHED GRADE. HOWEVER, THE NEW MATERIAL IS REGARDED AS WELL SUITED TO PRESENT WINTER MAINTENANCE NEEDS.

DESCRIPTORS: ABRASIVES; CINDERS; COARSE MATERIALS; COEFFICIENT OF FRICTION; DEICERS; DEICING; DYNAMOMETERS; FINENESS; ICE; MAINTENANCE, GENERAL; MIXTURES; ROCK SALT; SALTS; SANDS; SNOW & ICE CONTROL

218364 DA

MEMORANDUM CONCERNING WEAR AND TEAR OF BITUMINOUS ROAD SURFACINGS IN WINTER /IN GERMAN/

Forschung Fur Das Strassenwesen /Ger/

1970 15 pp 4 Phot

SUBFILE: TRRL; IRRD; HRIS

THE PAPER REVIEWS THE WEAR AND TEAR TO BITUMINOUS ROAD SURFACES BY DEICING SALTS, WINTER TIRES, SNOW CHAINS, SPIKED TIRES, AND ANTI-SKID MATERIALS SPREAD ON THE ROADS. IN THE COURSE OF A WINTER, SPIKES CAUSE WEAR OF AS MUCH AS 5 MM ON ASPHALTIC CONCRETE AND 3.5 MM ON MASTIC ASPHALT. RECOMMENDATIONS ARE MADE FOR MEASURES TO REDUCE WEAR IN WINTER, ESPECIALLY IN RESPECT OF THE COMPOSITION AND LAYING OF THE MIX. /TRRL/

DESCRIPTORS: BITUMINOUS SURFACING; CHAINS; DEICERS; MAINTENANCE, GENERAL; PAVEMENT DISTRESS; STUDDED TIRES; SURFACING; WEAR

218167 DA

THE EFFECT OF ROCK SALT UPON ROADSIDE SUGAR MAPLES IN CONNECTICUT

Button, EF; Peaslee, DE

Highway Research Record, Hwy Res Board 1967 No 161, Pp121-131, 5 FIG, 8 TAB, 10 REF

SUBFILE: HRIS

increasing traffic and public demand for ice-free roads has led to increased employment of rock salt and calcium chloride for efficient and economical deicing of roads. These rates of salt application, however, are now suspected of damaging roadside vegetation. Measurements on two groups of sugar maples were made to assess the influence of salt on the trees and on tissue concentrations of chloride, calcium, potassium, magnesium, and phosphorous and of sodium. The studies reported have established that tissue concentrations of sodium and chloride increase with increasing exposure to roadside drainage and that exposed trees generally exhibit more severe symptoms of declining vigor and contain lower concentrations of some essential nutrients in their tissue. Concentrations of sodium and chloride in the sap suggested chloride uptake by maples is normally slight, but may increase markedly at times, possibly reflecting exposure to runoff of brine in late winter or early spring.

DESCRIPTORS: CALCIUM CHLORIDES; CONCENTRATION; DEICERS; DRAINAGE; ENVIRONMENTAL DESIGN; MAINTENANCE, GENERAL; MAPLE WOOD; MEASUREMENTS; ROADSIDE; ROCK SALT; RUNOFF; TREE DAMAGE; TREES /PLANTS/

217171 DA

CORROSIVE EFFECTS OF DEICING SALTS ON AUTOMOBILES

Palmer, JD

Materials Protection Nov 1971 Vol 10, No 11, PP 38-43, 5 FIG, 7 TAB, 7 REF

SUBFILE: HRIS

long-term tests with standard autombobiles were made by three organizations---the American public works association, the national association of corrosion engineers, and the salt institute---to study the effects of deicing salts under commuter-driving conditions in u.s. And Canadian cities that

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

experience hard winters. Two tests covered three winters; the other, two. All cars were driven all year long. Procedures and results from each test are described and discussed. Two of the tests represent a departure from previous experiments in that complete reliance was placed on data from electrical resistance probes rather than on weight loss coupons. The probe element is not similar to underbody areas in that it does not tend to develop heavy deposits of road soils and corrosion products; hence it is more responsive to short-term variations in conditions. Direct conversion of electrical resistance probe readings to corrosion rate is not desirable unless a careful, direct correlation has been established with coupons or body metal corrosion rates. Three major findings emerged from the tests: (1) with certain qualifications, deicing salt inhibitors are not effective; (2) atmospheric corrosion rates in urban and suburban locations were nearly identical; and (3) the effects of deicing salt can be appreciably reduced by exposure to unsalted conditions for a period of eight months or less. The significance of these findings is dicussed, and recommendations affecting maintenance operations are made.

DESCRIPTORS: AIR POLLUTION; AUTOMOBILES; CITIES; CORROSION; DEICERS; ELECTRICAL RESISTANCE; GENERAL MATERIALS; INHIBITORS MAINTENANCE, GENERAL; SALT /SODIUM CHLORIDE/; SALTS; SUBURBS

214300 DA

NBS FINDS WAY TO REDUCE U.S. HIGHWAY REPAIR COSTS

Dimensions Nbs /US/ VOL. 57 NO. 7 Jul 1973 pp 168-9 1 Fig 1 Tab 1 Phot

SUBFILE: HRIS

Epoxy coatings applied as powders by an electrostatic spray technique provide the best protection (both chemical and mechanical) for steel reinforcing bars which corrode in contact with the chloride ions contained in such road deicing chemicals as sodium chloride and calcium chloride. Epoxy coatings offer better film integrities, fewer film defects and greater flexibility than liquid epoxies. An investigation team selected and applied 47 commercially available organic coating systems, evaluated their protective qualities in a portland-cement concrete-chloride environment and studied the mechanical characteristics of the coated bars in bridge decks. The bond strength between coated rebars and concrete was carefully determined. The evaluatiory program is tabulated. On the basis of these studies, it was concluded that correctly formulated and applied epoxy of 7 mil thickness has adequate flexibility and protective value for use on concrete reinforcing bars. The FHWA is encouraging its implementation division and state highway departments to design and build bridge decks embodying the test findings. The use of these epoxy coatings will help reduce the annual repair costs necessitated by the premature deterioration of concrete highway bridge deckings.

DESCRIPTORS: BARS; BRIDGE DECKS; CEMENT AND CONCRETE; COATINGS; CORROSION PREVENTION; COSTS; DEICERS; DETERIORATION EPOXY; HIGHWAY BRIDGES; MAINTENANCE COSTS; MAINTENANCE, GENERAL; PROTECTION; REBARS; REINFORCING STEEL; REPAIRS

205244 DA

MANAGEMENT OF FOREST STANDS ON HIGHWAY RIGHT-OF-WAYS

Young, HE

Maine University; /Life Sci & Agr Exp Station

VOL. 20 NO. 12 Feb 1973 9 pp 8 Fig

SUBFILE: HRIS

this paper is presented in an effort to encourage the incorporation of ecologically sound forest management into design, construction, and maintenance of highways, and so, reduce pollution, provide an additional source of raw material, and reduce maintenance costs by the continuous sale of forest products from forest stands on the highway right-of-ways. The clearing of vegetation for major highways exposes faces on the edges to detrimental wind, light, moisture and soil temperature changes. Land fill areas cause similar changes. Thinning and pruning of forest trees by landscape architects, effects of the use of deicing salts, heavy equipment, and changes in drainage patterns caused by highway construction are reviewed. Some general forest ecology concepts are listed. Guidelines for forest management of highway right-of-way are presented. Care must be exercised in road location to insure that it does not pass through A natural area of public interest. The design of each segment of a new highway to minimize changes in natural drainage is an important aspect of highway construction. The inclusion of foresters in the staffs of state highway departments and their involvement in the planning, design, construction, and maintenance of highways and the planning, supervision and usage of forest products is urged.

DESCRIPTORS: CHEMICALS; DEICERS; DRAINAGE; ECOLOGY; ENVIRONMENTAL DESIGN; FORESTS; HIGHWAY CONSTRUCTION; HIGHWAY DESIGN; HIGHWAY MAINTENANCE; LANDSCAPE DESIGN; MANAGEMENT; RIGHT OF WAY; TREES /PLANTS/

193889 DA

ALTERNATIVE HIGHWAY DEICING CHEMICALS

Dunn, SA; Schenk, RU (Bjorksten Research Laboratories, Incorporated)

Transportation Research Board Special Report N185 pp 261-269 1 Fig. 3 Tab. 25 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

A search has been made for road deicing chemicals to replace sodium chloride (NaCl). The impetus for this search stems from the numerous drawbacks associated with the current extensive use of NaCl as a road deicer. All classes of chemical compounds were reviewed. Deletions from the sum total were made on the basis of pertinent criteria such as water solubility and freezing point lowering, corrosion, toxicity, relative cost or cost potential, effect on soils and plants, on water supplies, flammability, etc. Low molecular weight and high solubility were primary qualifications. Waste products were considered as possible raw material sources. Two

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DIALOG File 63: TRIS _ 70-92/JUL

candidate deicers have been selected which, if used, might result in total costs about one-half those associated with the use of NaCl. Both materials can operate at temperatures below that at which NaCl becomes ineffective. Both can be made from waste cellulose. Neither is corrosive. One of them, methanol, reacts almost immediately upon contact with snow and ice but is less persistent than the other candidate or than NaCl. The other candidate, calcium magnesium acetate (CMA) acts at about the same rate as NaCl in the temperature range of common activity and shows about the same persistence. By strong contrast with NaCl, CMA is a corrosion inhibitor, is beneficial to most soils and has no potential for harming drinking supplies. /Authors/ This Paper appeared in TRB Special Report 185, Snow Removal and Ice Control Research.

DESCRIPTORS: CHEMICAL COMPOUNDS; CORROSION; COSTS; DEICING SALT; ENVIRONMENTAL IMPACT; FLAMMABILITY; FREEZING; GENERAL MATERIALS; MAINTENANCE, GENERAL; MOLECULAR WEIGHT; PLANTS /BOTANY/; SODIUM CHLORIDES; SOILS; SUBSTITUTES; TEMPERATURE; TOXICITY; WATER

190813 DA

WETTED SALT PROCESS FOR IMPROVED SNOW AND ICE CONTROL

Public Technology, Incorporated; 1140 Connecticut Avenue, NW; Washington; D.C.; 20036; 20550

28 p.

REPORT NO: NSF/RA-770580

CONTRACT NO: NSF-C834; Contract

SUBFILE: NTIS; HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The document is intended for local and state officials who desire to broaden and enhance their awareness of the wetted salt process. The development history and expected benefits are briefly described, along with an outline of the basically simple implementation requirements. The process of using liquid calcium chloride to wet road salt before spreading it on streets, roads, and highways can improve its deicing action and reduce the amount of salt that is required. The process should be useful in the operations of any jurisdiction which has a need to clear ice and hard-packed snow from streets and highways when ambient temperatures range from 20 to 25 degrees Fahrenheit and lower. The wetted salt process is proving to be attractive in terms of both improved deicing action and the relative cost of deicing operations. The report deals with practical experience and highlights the important issues in deicing operations, including effectiveness, costs, and environmental conditions. An economic analysis and sample worksheets are presented to assist a local evaluation of the wetted salt process. The entire volume reflects recent experience and cost values taken from the reports of local government which have implemented the process.

DESCRIPTORS: CALCIUM CHLORIDES; COST EFFECTIVENESS; DEICERS DEICING; DEICING SALT; ECONOMIC ANALYSIS; ENVIRONMENTAL IMPACT ; ICE CONTROL; LIQUIDS; LOCAL GOVERNMENT; MAINTENANCE, GENERAL ; PAVEMENTS; ROAD SALT; SNOW MELTERS; SNOW REMOVAL; SOLUTIONS WETTED SALT PROCESS

190726 DA

ROADS AND RUNWAYS: SNOW REMOVAL AND DEICING TECHNIQUES (A BIBLIOGRAPHY WITH ABSTRACTS)

Brown, RJ

National Technical Information Service; 5285 Port Royal Road; Springfield; Virginia; 22161

Dec 1978 210 p.

SUBFILE: NTIS; HRIS; RRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The bibliography covers research reports on materials, maintenance, costs, corrosion inhibition, pollution, and the planning applied to snow and ice removal. Applications cover bridges and railroads as well as highways and runways. (This updated bibliography contains 203 abstracts, 26 of which are new entries to the previous edition.)

DESCRIPTORS: ABSTRACTS; BIBLIOGRAPHIES; CHEMICAL COMPOUNDS; CORROSION; CORROSION PREVENTION; COST ANALYSIS; DEGRADATION; DEICERS; DEICING; HANDLING EQUIPMENT; HIGHWAY BRIDGES; HIGHWAYS; ICE CONTROL; ICE PREVENTION; MAINTENANCE; MAINTENANCE COSTS; MAINTENANCE, GENERAL; MELTING; PLANNING; RAILROADS; ROADS; RUNWAYS; SNOW REMOVAL; SNOWPLOWS; WATER POLLUTION

185979 DA

THE USE OF DEICING SALTS IN MINNESOTA: A REVIEW OF SNOW AND ICE REMOVAL MANAGEMENT PRACTICES, SALT USE EFFECTS, AND ALTERNATIVES

Reagan, PL

Minnesota Legislature Science & Technology Project; Capitol Square Building, Cedar at 10th; Saint Paul; Washington; Minnesota; D.C.; 55105; 20550

Apr 1978 220 p.

REPORT NO: NSF/RA-780177

CONTRACT NO: NSF-ISP76-02379; Grant

SUBFILE: NTIS; HRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

This study was undertaken with the objective of replacing or significantly reducing the negative effects of salt on vehicles and the environment. Reducing salt use and improving salt storage practices can help mitigate these factors. A survey was conducted to evaluate snow and ice removal practices on state, county and municipal levels, and results indicated that management practices for snow and ice removal were lax in most instances. Recommendations are made for improved management practices that would considerably reduce salt use, and alternative chemicals are suggested. The report also offers recommendations for salt application guidelines, salt management and control practices, environmental studies and accident prevention techniques.

DESCRIPTORS: BRIDGE DECKS; CALCIUM CHLORIDES; CORROSION; CORROSION ENVIRONMENTS; DEICERS; DEICING; DEICING SALT; DEICING SALTS; ENVIRONMENTAL EFFECTS; GUIDELINES; INORGANIC

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DIALOG File 63: TRIS _ 70-92/JUL

SALTS; MAINTENANCE MANAGEMENT; MAINTENANCE, GENERAL; MINNESOTA ; MOTOR VEHICLES; ROADS; SNOW & ICE CONTROL; SNOW REMOVAL; SODIUM CHLORIDE

181848 DA
SNOW AND ICE CONTROL: ROAD SALT USE IN MINNESOTA. WORKSHOP PROCEEDINGS, HELD AT ST. PAUL, MINNESOTA ON SEPTEMBER 13, 1977
Minnesota Legislative Science and Technology Proj; Capitol Square Building, Cedar at 10th; Saint Paul; Washington; Minnesota; D.C.; 55105; 20550
Sep 1977 164 p.
REPORT NO: NSF-RA-770523-770523
CONTRACT NO: NSF-ISP76-02379; Grant
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The Snow and Ice Control Workshop was held in response to a Proposal that the Committees on Transportation and Environment and Natural Resources establish a special subcommittee to examine the feasibility of salt use by the Department of Transportation and other road authorities throughout the state of Minnesota for the purpose of snow and ice control on roads and streets. It was also proposed that the subcommittee undertake a study with the objective of finding substitute deicing materials that would reduce the negative effects of salt on vehicles and the environment. This publication includes the presentations of each of the speakers who participated in the workshop. Section one contains the three papers dealing with the current use of road salt in Minnesota. Section two follows with papers concerning corrosion and its structural consequences. Section three deals with environmental problems. The final section deals with alternative snow and ice control methods.
DESCRIPTORS: CORROSION; DEICERS; DEICING SALT; DETERIORATION ; ENVIRONMENTAL IMPACT; ENVIRONMENTAL IMPACTS; FEASIBILITY; HIGHWAYS; ICE CONTROL; INORGANIC SALTS; MAINTENANCE; MAINTENANCE, GENERAL; MEETINGS; MINNESOTA; MUNICIPALITIES; ROADS; SNOW & ICE CONTROL; SNOW REMOVAL; STREETS; STRUCTURES; SUBSTITUTES; TRAFFIC SAFETY; VEGETATION; VEHICLES

179184 DA
EFFECT OF DEICING AGENTS AND SULPHATE SOLUTIONS ON CONCRETE AGGREGATE
Gillott, JE (Calgary University, Canada)
Geological Society
Quarterly Journal of Engineering Geology VOL. 11 NO. 2 1978 pp 177-192 1 Fig. 2 Tab. 8 Phot. 45 Ref.
SUBFILE: TRRL; IRRD; HRIS
Concrete durability is adversely affected by deicing agents and sulphate solutions. Sodium chloride and calcium chloride are the commonly used deicing agents - salts thrown on roads and other pavements to help ice melt in winter. Sulphates are common in soils and clays in Britain, Europe, the Middle East, western North America and elsewhere, while chlorides and sulphates are also present in sea-water. Scanning electron micrographs of limestones (used quite commonly as aggregate in concrete) show that the surfaces of limestones scale and disintegrate when soaked in solutions of sodium chloride, calcium chloride and magnesium sulphate. The morphology of both calcite and dolomite is changed, but calcite is attacked most rapidly, the progress of the reactions being observed to be controlled by cleavages and grain boundaries; the morphological results depend on the angle between the plane of weakness and the surface. Some limestones show dimensional change during continuous soaking in salt solutions at constant temperature. The adverse effect on concrete durability of deicers and sulphate solutions may thus result from attack on limestone aggregate as well as on cement paste.(a) /TRRL/
DESCRIPTORS: CALCITES; CALCIUM CHLORIDE; CALCIUM CHLORIDES; CEMENT AND CONCRETE; CONCRETE; CONCRETE AGGREGATES; CONCRETE DURABILITY; DEICING SALT; DETERIORATION; DOLOMITE; LIMESTONE; LIMESTONES; MAINTENANCE, GENERAL; MORPHOLOGY; SALT (DEICING); SHAPE; SODIUM CHLORIDES; SULFATES; SULPHATE; TEST

175790 DA
INFLUENCE OF ROAD SALTING ON THE NUTRIENT AND HEAVY METAL LEVELS IN STREAM WATER
Gosz, JR
New Mexico State University, Las Cruces; Water Resources Research Institute; University Park; Albuquerque; Washington; New Mexico; D.C.; 88003; 87131; 20242
Dec 1977 45p
REPORT NO: WRRI-093; OWRT-A-057-NMEX(1)
CONTRACT NO: DI-14-34-0001-7066; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This study evaluated the influence of road salt on levels of nutrients, heavy metals, and sediment in streams as modified by topography. As a result of an extremely low snow pack, salt inputs and stream discharge were low. This reduced losses of nutrients and salt from the below road areas; however, the losses which did occur were strongly linked to the road salting practice. All study areas showed an accumulation of road salt because of the low discharge. The addition of massive quantities of sodium caused the release of other cations and significantly altered soil structure. The breakdown of soil structure appeared to be the major reason for large losses of sediment and heavy metals from the below road areas. Steep slopes and a large road area to below road area ratio appear most influential in altering in water quality. Prepared in cooperation with New Mexico Univ., Albuquerque. Dept. of Biology.
DESCRIPTORS: CALCIUM; CHLORINE; CONCENTRATION COMPOSITION; DEICERS; DEICING SALT; DISCHARGE; EVALUATION; FACILITIES DESIGN; FOREST LAND; HEAVY METALS; HIGHWAY DRAINAGE; INORGANIC SALTS; ION EXCHANGING; LOSSES; MAGNESIUM; METALS; NEW MEXICO; NUTRIENT CONTENT; POTASSIUM; PRECIPITATION METEOROLOGY; ROADS SEDIMENT CONCENTRATION; SEDIMENTS; SLOPE VALUE; SLOPES; SNOW

(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

REMOVAL; SODIUM; SOIL STRUCTURE; STREAM POLLUTION; STREAMS; SULFATES; WATER QUALITY; WATERSHEDS

156438 DA
THE PROBLEMS OF WINTER TRAFFICABILITY AT ROAD JUNCTIONS
Sotto, E
Casa Editrice la Fiaccola
Rivista della Strada VOL. 45 NO. 424 Nov 1976 Analytic pp 1057-62 1 Fig. Italian
SUBFILE: TRRL; IRRD; HRIS
The basic objectives of winter maintenance with regard to intersections are described as follows: preventive action to preserve the condition of the pavement and maintain good adhesion, following the use of deicing chemicals; ensuring the maximum possible braking distance in the prevailing visibility and road surface conditions; and returning the intersection to full trafficability within a given time, which must be compatible with that envisaged for the entire itinerary. These objectives should be achieved with a minimum of interruption to traffic, avoidance of polishing or damage to the road surface (from snow ploughs etc), and a minimum lateral residue of snow. Some operative procedures are suggested, for normal and free-flow intersections and motorway junctions in suburban areas. /TRRL/
DESCRIPTORS: BRAKING; DEICERS; HIGHWAY DAMAGE; HIGHWAY MAINTENANCE; JUNCTION; JUNCTIONS; MAINTENANCE, GENERAL; PREVENTIVE MAINTENANCE; SNOW CLEARANCE; SNOW CLEARANCE EQUIPMENT; SNOW REMOVAL; SUBURBS; TRAFFICABILITY; WINTER MAINTENANCE; WINTER SERVICE

154124 DA
DEVELOPMENT OF A HYDROPHOBIC SUBSTANCE TO MITIGATE PAVEMENT ICE ADHESION
Ahlborn, GH; Poehlmann, HCJ
Ball Brothers Research Corporation; P.O. Box 1062; Boulder Edison; Cincinnati; Colorado; New Jersey; Ohio; 80302; 08817
Dec 1976 218 pp
REPORT NO: EPA/600/2-76/242
CONTRACT NO: EPA-68-03-0359; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The specific problem to which this report is addressed is the development of a hydrophobic substance to mitigate the adhesion of ice to pavement as an alternative to deicing chemicals. The factors involved in evaluating this concept are the following: Economics; safety; environmental impact; coating effectiveness; potential pavement damage. As a result of this program, two coating formulations (exact formulae are given in Chapter 5 of this report), have been identified as showing considerable promise as semi-permanent, hydrophobic, road coatings with reduced ice adhesion. They are: A modified (no pigment) Federal Specification TT-P-115D traffic paint containing a room-temperature-curing silicone rubber (Dow Corning DC732) as a release agent; and a silicone resin waterproofing compound (Dow Corning DRI-SIL-73) combined with the same silicone rubber as above. One major achievement in this program was the discovery of a method for stabilizing the highly reactive silicone rubber in a fluid solution for spraying. Sponsored in part by Municipal Environmental Research Lab., Edison, N.J. Storm and Combined Sewer Section.
DESCRIPTORS: ADHESION; BRIDGE DECKS; COATINGS; DEICERS; DEVELOPMENT; ECONOMIC ANALYSIS; ECONOMICS; ENVIRONMENTAL IMPACT; GENERAL MATERIALS; HIGHWAYS; HYDROPHOBIC PROPERTIES; ICE; MAINTENANCE, GENERAL; PAVEMENTS; PERFORMANCE TESTS; RUBBER; SAFETY; SILICONE COATINGS; SILICONE RESINS; SILICONES STABILIZATION; TRAFFIC PAINTS; WATER POLLUTION ABATEMENT; WATERPROOF COATINGS; WATERPROOFING MATERIALS; WEAR

141079 DA
SNOW AND ICE CONTROL CONNDOT RESEARCH, OPERATIONS AND POLICY
Button, EF; Kasinskas, MM
Connecticut Department of Transportation; 24 Wolcott Hill Road, P.O. Drawer A; Wethersfield; Connecticut; 06109
Dec 1975 21 pp 33 Ref. 1 App.
SUBFILE: HRIS
The need for the use of deicing chemicals is discussed, research in snow and ice control is reviewed, research (local, national and international) on the ecological effects of the use of deicing chemicals is described, and Conn DOT policy for snow and ice control to minimize ecological damage is presented. Policies reflecting necessary background research, as well as programs initiated to improve needed storage and handling operations are also presented. ConnDOT research in snow and ice control involved studies using calcium chloride-salt mixtures, urea, and sodium chloride brine solutions. Research on ecological effects of deicing chemicals focussed on the potential injury to soils and vegetation. Winter maintenance policy for expressways and 2-lane roads are stated, and policies relating to storage, claims associated with damage due to salt are discussed.
DESCRIPTORS: CALCIUM CHLORIDES; CLAIMS; COLD WEATHER OPERATIONS; DAMAGES; DEICERS; ENVIRONMENTAL EFFECTS; EXPRESSWAYS; HANDLING; MAINTENANCE OPERATIONS; MAINTENANCE, GENERAL; POLICY; RESEARCH; SALINE WATER; SNOW & ICE CONTROL; SODIUM CHLORIDES; SOILS; STORAGE; TWO LANE HIGHWAYS; UREA; VEGETATION

137300 DA
EFFECT OF DEICING SALTS ON WOODY VEGETATION ALONG MINNESOTA ROADS
Sucoff, E
Minnesota Agricultural Experiment Station; St. Paul; St Paul; Minnesota; 55155; 55101
Final Rpt. 51 pp
REPORT NO: Technical Bull-303; Forestry Ser-20
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

Port Royal Road Springfield Virginia 22161
Information was collected on amounts of deicing salts used and methods of application. Planting practices and investment were also surveyed. Techniques are presented for the recognition of soil-salt and spray-salt damage using visual symptoms and chemical analysis of leaves and soils. Proof was obtained that salt causes much of the twig dieback in hardwoods and needle browning in pines observed along certain Minnesota roadways. The locations are defined where salt-spray and soil-salt damage are likely to be high, moderate, or low. Species are rated for their sensitivity to soil-salts and winter spray-salts. A brief history of salt damage in Minnesota is presented, and the seriousness of current damage is evaluated in terms of mortality, reduced growth and disfigurement, and increased maintenance costs. Seven ways to reduce salt damage are presented including a planting guide to match species to site. Future prospects are estimated for salt damage in Minnesota. A permanent plot system is described that will monitor build up in plant and soil sodium and chloride as well as changes in the vegetation caused by salt damage. Also pub. as Minnesota Dept. of Highways, St. Paul. Investigation No. 636.
DESCRIPTORS: ASSESSMENTS; CHEMICAL ANALYSIS; DAMAGE; DEICERS ; DEICING SALT; DISCOLORATION; GROWTH; INORGANIC SALTS; MAINTENANCE, GENERAL; MINNESOTA; MONITORING; PLANT GROWTH; ROADS; ROADSIDE; ROADSIDE VEGETATION; SHRUBS; SODIUM CHLORIDE SOIL ANALYSIS; SOILS; TABLES DATA; TOLERANCES PHYSIOLOGY; TOXIC TOLERANCES; TREE DAMAGE; TREES PLANTS; VEGETATION

097417 DA
PCC PAVEMENTS FOR LOW-VOLUME ROADS AND CITY STREETS
NCHRP Synthesis of Highway Practice N27 31 pp 19 Fig. 22 Ref. 2 App.
CONTRACT NO: HR 20-5; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
In an effort to provide information that may be utilized in decision-making by interested individuals (highway officials, design and construction engineers and others), detailed information is offered on planning, designing and constructing portland cement concrete pavements for light traffic conditions. The accumulated experience of 20 years of highway agencies in several states and cities was utilized in developing this report. The data indicate that PCC pavement has a good probability of maintaining extremely low maintenance costs and a satisfactory level of service over a long period. The planning of the paving project is detailed and the importance is emphasized of a realiable forecast of traffic that will use the road over its projected service life. Subgrade conditions, exposure elements affecting performance, materials availability, and utilities in the pavement area are considered as well as equipment and construction expertise, pavement design life, costs, serviceability, performance, project size and funding. The physical characteristics required for acceptable performance of any pavement are listed, and aspects such as data development for design, geometric design and control of other design features are considered. Mixture proportions and thickness design are also discussed. Plans to handle local traffic during construction are important. Observations are made regarding subgrade preparation, materials handling, placing, vibrating and finishing. Various aspects of surface maintenance are discussed, as well as deicing chemicals, drainage and enforcement of load limits. A check list is provided as an aid to determine if the use of concrete pavement can offer the best long-range solution. Suggestions are made for reducing costs and upgrading quality. Research needs are identified. Report on National Cooperative Highway Research Program, Synthesis of Highway Practice. (Library of Congress Catalog Card No. 75-13909)
DESCRIPTORS: CITY STREETS; CONSTRUCTION MATERIALS; DECISION MAKING; DEICERS; DRAINAGE; FUND ALLOCATIONS; HIGHWAY PLANNING LEVEL OF SERVICE; LOW VOLUME ROADS; MAINTENANCE COSTS; MATERIALS HANDLING; PAVEMENT CONSTRUCTION; PAVEMENT DESIGN; PAVEMENT DESIGN AND PERFORMANCE; PERFORMANCE; PORTLAND CEMENT CONCRETES; PROJECT PLANNING; SUBGRADES; TRAFFIC FORECASTING; WEIGHT LIMITS

096787 DA
CHANGES IN CHEMICAL COMPOUNDS IN GROUND SURROUNDING THE HIGHWAY
Andersson, A; Mattssor, L
Institution for Lantbrukets Hydrotekoik
Grundfoerbaetting N4 1972 7 pp 2 Fig. 3 Tab. 8 Ref. Swedish
SUBFILE: TRRL; IRRD; HRIS
AVAILABLE FROM: National Swedish Road & Traffic Research Institute Drottning Kristinas Vag 41 S-11428 Stockholm Sweden
The concentration of heavy metals, mercury, manganese, copper, silver, zinc, cadmium, lead, molybdenum and tungsten, and the effect of salt (nacl) used as de-icing agent, on salt content and salt balance, were examined along a main road over ground level with the road and used as pasture. The road carries approx. 8500 vehicles/day. The soil is sand rich in humus in the top 5 cm. Samples were taken from the top 5 cm at distances of 2 M up to 64 M, and down to 50 cm in 5 cm increments at some intermediate points. It is shown that hg and mn contents are independent of distance from the road but co-vary with humus content. Other heavy metals are distance dependent, with increases nearer the road. Nacl is applied at the rate of approx. 5.6 tons/km per winter. There is a 15-fold increase in salt concentration within splash distance. There is a change in ion balance; since na and cl ions are both mobile, this occurs to a depth of 50 cm. Heavy metals and salt are found in larger quantities inside a 5-10 M strip next to the road. /TRRL/
DESCRIPTORS: AIR POLLUTION; CHEMICAL COMPOUNDS; DEICERS; HEAVY; HIGHWAY; HIGHWAYS; HUMUS; MAINTENANCE, GENERAL; METAL; METALS; POLLUTION; SALT (CHEMICAL); SALT (DEICING); SALT /SODIUM CHLORIDE/; SAND; SOIL; SOIL SAMPLING; VEHICLE;
(cont. next page)

DIALOG File 63: TRIS _ 70-92/JUL

VICINITY

090719 DA
MANUAL FOR DEICING CHEMICALS: APPLICATION PRACTICES
Richardson, DL; Terry, RC; Metzger, J; Carroll, RJ
Little (Arthur D), Incorporated; 25 Acorn Park; Cambridge; Cincinnati; Massachusetts; Ohio; 02140
Dec 1974 Final Rpt. 164 p. Figs. Tabs. Phots. 10 Ref.
CONTRACT NO: EPA-68-03-0154; Contract
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This report contains the results of a study to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Practical guidelines are presented for the use of deicing chemicals. (1) Supervisory aspects of proper chemical usage are defined, including organization and personnel training. (2) Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage. (3) The backbone of winter road maintenance is equipment. General requirements and major equipment classes are described. Methods are given for accurate spreader calibrations. (4) Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies. (5) Legal requirements for and constraints on snow and ice control are described. See also report dated Jul 74, PB-236 152.
DESCRIPTORS: CALCIUM CHLORIDES; CHEMICAL DEICING AGENTS; COLD WEATHER OPERATIONS; DEICERS; DEICING; ENVIRONMENTAL PROTECTION; FEDERAL GOVERNMENT; HANDLING EQUIPMENT; HIGHWAYS; LEGISLATION; MAINTENANCE; MAINTENANCE EQUIPMENT; MAINTENANCE, GENERAL; MANAGEMENT PLANNING; MANUALS; MATERIALS HANDLING; PERSONNEL; PERSONNEL TRAINING; PUBLIC SUPPORT; REGULATIONS; SANDS; SNOW & ICE CONTROL; SNOW VEHICLES; SODIUM CHLORIDE; STATE GOVERNMENT; WATER POLLUTION; WATER POLLUTION ABATEMENT; WEATHER FORECASTING

620562 DA
ICE-DETECTION SYSTEM EVALUATION. FINAL REPORT
Woodham, D
Colorado Department of Transportation 4201 East Arkansas Avenue Denver Colorado 80222; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
Aug 1991 40p 3 Fig. 9 Phot. 3 Ref. 3 App.
REPORT NO: CDOT-DTD-R-91-10
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This evaluation consisted of interviews with SCAN ice-detection system users and evaluations of the manpower and material savings associated with the use of the system as well as the possible influences the system may have on accidents which occur during winter conditions. It appears that salt/sand usage and overtime costs have been reduced by the use of the SCAN system. Anecdotal information suggests that there have been fewer winter accidents at one instrumented site. The system provides relevant information to maintenance decision makers. The overall effectiveness of the system is dependent on how users accept and will use the information.

606750 DA
BATTLING THE ELEMENTS
MacInnes, A
Reed Business Publishing Limited
Surveyor VOL. 174 NO. 5013 Jul 1990 pp 22-23
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Reed Business Publishing Limited Carew House, Quadrant House, The Quadrant Sutton Surrey SM2 5AD England
In this article, winter maintenance strategies of Highland Regional Council are outlined. In the highland region of Scotland, there is 760 km of trunk road and 6678 km of other roads. Modernisation of the winter maintenance fleet began in 1978, following a blizzard which blanketed the area leaving vehicles stranded in snowdrifts. Re-equipping took place over a six year period. The region now has strategically placed, a fleet of 18 snowblowers, and the major snowploughs on the trunk and strategic road network are dedicated winter vehicles. The bulk of the 90 gritter fleet comprises ex-army Bedford lorries. A fleet of 30 mini-tractors is available to clear snow and apply salt to pavements and pedestrian areas. All vehicles involved in winter maintenance are fitted with radio communications, and emergency survival kit. Snow gates have been installed at locations where problems occur with drifting snow. Each of the eight operational areas uses the ice detection system ICE-ALERT, which provides 24 hour road temperature prediction graphics. The regional council also issues a Highland Roadline card giving contact telephone numbers and details of the winter maintenance policy and priorities.

605139 DA
E-470: TOLL ROAD OF THE FUTURE. AVI TECHNOLOGY
American Road & Transportation Builders Assn
Transportation Builder VOL. 3 NO. 1 Feb 1991 pp 12-13
SUBFILE: HRIS
AVAILABLE FROM: Transportation Builder 501 School Street, SW Washington D.C. 20024
The E-470 toll road, a public/private venture, under construction in Denver, Colorado, will use innovative technology, particularly, an unique automatic vehicle identification system of toll collection with dedicated lanes for AVI patrons. This means that patrons maintain highway speed, delays are minimized and traffic incident management is controlled. Initial installation will include 14 lanes and 6,000 individual vehicle tags. At the toll lane, the high security tags are read by a stationary remote recognition reader which houses the low power RF antenna. The plaza

computer interfaces with an off-site host computer responsible for all account maintenance. The system which operates on extremely low power radio frequency, is more than 99.5% accurate. E-470's other high technological systems include pavement ice detectors, call boxes and surveillance cameras, and variable message signs.

578646 DA
THE USE OF IMAGE ANALYSIS FOR BLACK ICE DETECTION
CHEN, Y
RECHERCHE-TRANSPORTS-SECURITE ENGLI Sep 1991 PP 19-30 ENGLISH
REPORT NO: SHISSUEN7
SUBFILE: UCITS; TLIB
YI CHEN ILLUSTRATED INCLUDES BIBLIOGRAPHICAL REFERENCES

576097 DA
ICE-DETECTION SYSTEM EVALUATION
WOODHAM, D
COLORADO DEPT OF HIGHWAYS DENVER COLO
Aug 1991 FINAL REPO ENGLISH
REPORT NO: CDOT-DTD-R-91-10
SUBFILE: UCITS; TLIB
DAVE WOODHAM ADDL PLACE OF PUBLCATION: ADDL PUBLISHER: AVAILABLE THROUGH
THE NATIONAL TECHNICAL INFORMATION SERVICE OTHER PHYS. DESCRIPTION: 21 ILLUSTRATED COVER TITLE IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION AUGUST, 1991 INCLUDES BIBLIOGRAPHICAL REFERENCES LEAF 21 ADDL CORP. AUTHOR INFO: COLORADO. DEPT. OF HIGHWAYS

568251 DA
ICE DETECTION AND ROAD WEATHER INFORMATION SYSTEMS: A STATE OF THE ART REPORT
RIDLEY, RC
ONTARIO MINISTRY OF TRANSPORTATION AND DOWNSVIEW ONT
Aug 1987 ENGLISH
REPORT NO: TDS-87-01
SUBFILE: UCITS; TLIB
R.C. RIDLEY AUGUST 1987 INCLUDES BIBLIOGRAPHICAL REFERENCES TDS-87-01 ADDL CORP. AUTHOR INFO: ONTARIO. MINISTRY OF TRANSPORTATION AND COMMUNICATIONS. RESEARCH AND DEVELOPMENT BRANCH ONTARIO MINISTRY OF TRANSPORTATION AND COMMUNICATIONS RESEARCH AND DEVELOPMENT BRANCH

526230 DA
THE DEVELOPMENT OF A MICROWAVE RADIOMETER FOR USE AS A HIGHWAY ICE DETECTOR. FINAL REPORT
Berinsky, S.; Hong, H. K.; Lee, T. H.; Schrader , W. T.
Lockheed Missiles and Space Co., Inc., P.O. Box 504, Sunnyvale, Calif. 94086
1978 92 645 155p
REPORT NO: FHWA-RD-78-203; PB-2; HS-026 718
CONTRACT NO: DOT-FH-11-9328; Contract
SUBFILE: HSL
AVAILABLE FROM: NTIS
A program was designed to develop a system capable of detecting snow, ice, frost, or slush over a highway bridge deck area greater than 4 x 2 feet (1.2 x 0.6 m) and generate a valid alarm signal to warn motorists of a hazard. The detection system selected was a microwave radiometer operating at 10 GHz which continously samples a reference noise source and internal amplifier noise to provide measurement corrections of radiated power

received from the road surface being observed. The principal radiometer components are a rectangular horn antenna, a sensitive receiver, and a signal processor/alarm unit. The successive program phases were: design optimization and system tradeoffs; breadboard model laboratory and field tests; and prototype model design, fabrication and test. Test results on asphalt and concrete roadway simulators, as well as actual asphalt roads, correlated with previously published radiometric temperatures for similar surfaces. The following road conditions were detectable: dry/warm; dry/cold; wet; slush; ice layer (0.1 cm. minimum); and snow layer (1 cm. minimum). All road hazard detection objectives were met except for frost detection. Descriptions of recommended additional effort are presented, including detailed evaluation of the prototype model; advanced alarm logic; self-test techniques; and a scanning antenna to cover increased road areas. Rept. for Sep 1977-Aug 1978.

493724 DA
SIMPLIFIED SOFTWARE CLINCHES LATEST ICE DETECTION ORDERS
Harverson, D
D.R. Publications Limited
Highways VOL. 59 NO. 1959 Mar 1990 pp 22, 24 2 Fig. 1 Phot.
SUBFILE: HRIS
AVAILABLE FROM: D.R. Publications Limited Faversham House, 111 St James Road Croydon Surrey CR9 2TH England

Two highway authorities recently selected the Edinburgh firm Findlay Irvine to install ice warning systems, citing software as having influenced their decisions. The new software is menu-driven and very user-supportive. Switching between different displays, from one out-station to another and from current to historical data, is all carried out by use of the cursor. The most interesting displays are still the forecast graphs received from the Meteorological Office with the actual road surface temperature superimposed. There is a continuing debate on whether the forecaster should be asked for a pessimistic as well as a realistic forecast. The greatest problem faced by any forecaster seems still to be the accurate prediction of cloud cover, which has a dramatic effect on road surface temperatures and thus is relevant to the evaluation of thermal mapping as a night-by-night tool for identifying when and where to grit. To operate this tool, the forecaster must specify not just the minimum night temperature for a particular station but the weather condition over a sizeable area in which this station lies. The ice warning system then uses the appropriate "thermal footprint" to project the minimum night temperature over the highway network within that area. An instrument which may prove of use in the calibration of thermal maps is the Thermocheck, the latest addition to the Findlay Irvine ICELERT family. This is a simple, temperature only out-station with memory for a year's data. Since the cost of Thermocheck is approximately one-tenth that of a conventional out-station, Thermochecks can be deployed relatively liberally. Stored data can be downloaded into a Microscribe or a Husky and thence into a PC. Current readings can also be collected by any passing vehicle (up to 70 mph) equipped with the appropriate receiver/display. Highway authorities are using GripTesters for friction testing roads made slippery not by ice but by wear and warm weather. The GripTesters users' group is converting GripNumbers to SCRIM readings.

491665 DA
HIGHWAY METEOROLOGY AND WINTER MAINTENANCE OPERATIONS
Runacres, AME; Colville-Symons, AH; Symons, LJ
Telford (Thomas) Limited
Municipal Engineer VOL. 6 NO. 3 Jun 1989 171-84 20 Ref.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Telford (Thomas) Limited Thomas Telford House, 1 Heron Quay London E14 9XF England

This paper reviews the development of technological aids in highway

meteorology and discusses their application to winter maintenance. The subjects considered include ice detection systems and a resume of their use in Great Britain and abroad is given together with information on the systems chosen by different authorities. Mention is made of thermal mapping, with particular reference to experience in Wales. Weather radar and its application are also described. The cost-effectiveness of weather radar, the extent and characteristics of the network and its potential for use are discussed. Possible future developments in the field are outlined, as well as the problems encountered in the implementation of these new technologies into existing highway winter maintenance programmes. (Author/TRRL)

488132 DA
FIELD EVALUATION SITE FOR GROUND ICE DETECTION. PART I - CONSTRUCTION DETAILS OF AN ARTIFICIAL ICE MASS.
Gruol, V; Kawasaki, KJ; Osterkamp, TE
Alaska University Geophysical Institute Fairbanks Alaska 99701; Alaska Department of Transp and Public Facilities Pouch Z Juneau Alaska 99811; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
Nov 1981 30p
REPORT NO: FHWA-AK-RD-82-13
CONTRACT NO: F16152; HP&R
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

An artificial ice mass of known size, shape and depth was fabricated during the winter of 1981-82 near Fairbanks, Alaska. This report primarily concerns itself with the details associated with the construction of the ice mass. However, some initial electromagnetic ground resistivity and subsurface radar site surveys are also included.

483525 DA
PREDICTION NIPS ICY ROADS DANGER IN THE BUD
Thornes, J
SURVEYOR VOL. 168 NO. 4929 Jan 1987 18-9
SUBFILE: HRIS; TRRL; IRRD

The traditional form of road danger warning predicting icy roads has recently been replaced by computerised ice predictions for specific road locations in the shape of the national ice prediction system (nips). In autumn 1986, all 14 weather centres in the UK installed microcomputers (IBM xt 286s) and communications software as specified by Department of Transport specification mce 2020e, June 1986. This has been provided by thermal mapping international and will enable the microcomputers to have two-way communications with ice detection systems installed in counties and regions. Conformance to dtp specification means that any sensor manufacturer's ice detection system can be used and accuracy maintained. 34 counties or regions will have undertaken thermal mapping by the end of winter 1986/7, 25 counties or regions will have sensors installed by then and 34 are taking the ice prediction part of the "open road" package being offered by the meteorological office in winter 1986/7. The system installed in cheshire and being installed in hereford and worcester is explained in detail as an example. The meteorological office has developed its own road temperature prediction model which is in use at most weather centres. This will be compared with the thornes/trrl model at the Manchester centre. Initial results indicate that the meteorological model is better at predicting maximum road temperatures and the timing of freezing, whilst the thornes/trrl model is better at predicting the minimum road surface temperatures. A combination has been suggested. Other organizations making or about to make systems and devices available to the dtp specification mce 2020e are findlay, irvine Ltd; vaisala Ltd; surface systems Ltd (scan); boschung; and malling control of Denmark.

482730 DA
NEW ICE DETECTION SYSTEM
Lustenberger, M
Vibro-Metro S.A. Fribourg Switzerland
Jan 1988 19p
SUBFILE: ATRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
A concept for detecting ice on aircraft, based on a vibrating diaphragm was developed. Ice accretion on the surface increases the diaphragm stiffness causing the natural frequency to increase sharply. The diaphragm is forced into oscillation by a piezoelectric material, which is proportional to the accreted ice thickness. Flight and ice tunnel test confirm the measurement principle for a variety of icing conditions. In Dfvir, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems, p 619-638. Order as N88-280001/1/WTS.

470390 DA
DESIGNING, COMMISSIONING AND INSTALLING AN ICE DETECTION SYSTEM IN WALES - PROBLEMS AND SOLUTION. THIRD INTERNATIONAL ROAD WEATHER CONFERENCE, TAMPERE, FINLAND, 24TH FEBRUARY 1986
Symons, L; Perry, A; Symons, A
Finnish Meteorological Institute Vuorikatu 24 Helsinki Finland 951-697-253-5
1986 n.p.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Finnish Meteorological Institute Vuorikatu 24 Helsinki Finland
In the United Kingdom, the forecasting of road weather to warn local authorities of the need to apply salt has long been the preserve of the meteorological office with, even in recent years, only a very limited development of any form of competition. There has, however, been considerable criticism of the level of accuracy of standard road danger warnings. With the installation of a small number of ice detector systems in various part of Great Britain, the meteorological office has shown an enthusiastic response to the potential revealed by road temperature sensors as part of a more sophisticated model for predicting road temperatures. Prediction of precipitation patterns has been much improved with the development of weather radar, the whole of Wales now being covered by the radars. For other weather data, however, the meteorological office is well aware that it lacks adequate synoptic stations and even weather reporting climatological stations in the interior of Wales. (TRRL)

466647 DA
REPORT ON ICE WARNING SYSTEMS
County Surveyors' Society County Surveyor's Department, County Hall Taunton Somerset United Kingdom
Jun 1985 25p 8 Fig. 1 Tab. 5 Ref.
REPORT NO: Rept No 5/2
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: County Surveyors' Society County Surveyor's Department, County Hall Taunton Somerset United Kingdom
This report presents data on: the history of equipment and current working practice, cost/benefit of ice detectors, thermal mapping prior to installation of ice warning systems, improvement of road danger warning by using an accurate prediction model (Thornes TRRL prediction model), use of weather radar and meteosat, and specifications (standards of installation of sensor sites, current manufacturers and comparative survey, standards of testing and maintenance equipment, sample layout). Some recommendations are put forward. (TRRL)

393278 DA
ICE DETECTION SYSTEM FOR ROADS COULD SAVE MONEY AND LIVES
Edwards, BD (Eagle International Equipment Limited)
Municipal Engineering Publications, Limited
Municipal and Public Services Journal VOL. 92 NO. 42 Oct 1984 p 1626 1 Phot.
SUBFILE: TRRL; IRRD; HRIS
In order that local authorities can realise savings in the cost of providing protection against icy road conditions, with no loss of level of protection provided, accurate information concerning local conditions is essential. Continuous monitoring requires accurate information on surface and atmospheric conditions as can be provided by the Eagle scan ice-detection system. The system uses road surface sensors covering air temperature, humidity and precipitation, plus wind speed and direction sensors where necessary. Installed by Devon County Council, at 31 locations throughout the county, savings of some 100000 pounds sterling are claimed for deicing operations during the winter of 1983-84. Reduced accident rates and ecological benefits can result from the use of ice detection systems. (TRRL)

378793 DA
FIELD EVALUATION SITE FOR GROUND ICE DETECTION
Kawasaki, K; Gruol, V; Osterkamp, TE; Jurick, RW
Geophysical Institute Alaska University, Fairbanks Fairbanks Alaska 99701 ; Alaska Department of Transp and Public Facilities Pouch Z Juneau Alaska 99811; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
Mar 1983 Final Rpt. 27p 10 Fig. 2 Tab. Refs.
REPORT NO: FHWA-AK-RD-83-27
CONTRACT NO: F36152; HP&R
SUBFILE: HRIS
An artificial ice mass has been constructed for the purpose of testing various geophysical methods of ground ice detection. Details of its construction may be found in the State of Alaska, Department of Transportation and Public Facilities Report No. FHWA-AK-RD-82-13 (Gruol, et al., 1981). In this final report, the construction details are summarized and additional information on the site is given, including a description of soil types, temperature measurements and results from some measurements made on the ice mass with geophysical exploration devices. This background information on the artificial ice mass will provide a guide for its use as a known target embedded in a known background for the purpose of testing other geophysical methods of exploring for permafrost or different versions of methods that have already been investigated. (Author)

319500 DA
USE OF SAR SYSTEMS FOR ICEBERG DETECTION AND CHARACTERIZATION
Lawson, RW; Shuchman, RA; Rawson, RF; Worsfold, RD (Environmental Research Institute)
Intl Symp on Remote Sensing of the Environment Manila Philippines
VOL. 2 1978 Proceeding pp 1127-47.
SUBFILE: MRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
During February and March 1977, a synthetic aperture radar (SAR) program was conducted on the east coast of Canada using a 3 cm and 23 cm dual polarization SAR system. Data obtained from this program have been used to demonstrate the capability of SAR for the detection and identification of icebergs. Results from the analysis and interpretation of the 3 cm and 23 cm SAR imagery are presented. These results include imagery and

quantitative measurements, demonstrating the detectability of icebergs in a variety of sea ice clutter backgrounds. Using imagery having resolution of 3 meters by 3 meters, it is possible to estimate iceberg by using the detail of the iceberg shadow. The information obtained from this program can be used for the design of future operational SAR systems for iceberg detection and characterization. From the 12th International Symposium on Remote Sensing of the Environment, Manila, 20 April 1978.

318786 DA
HIGHWAY TRAFFIC DETECTORS AND DETECTION. 1964-JUNE, 1980 (A BIBLIOGRAPHY WITH ABSTRACTS)
Kenton, E
National Technical Information Service, Springfield, VA.
Jul 1980 167p
SUBFILE: NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Reports are cited on the development, calibration, testing, and operation of motor vehicle detectors and the detection of traffic incidents on highways and roads. Research is included on freeway surveillance, closed circuit television, electronic reconnaissance, magnetic measuring devices, traffic flow monitors, and sensor configurations. Investigations of snow and ice detection on bridges are noted. Other topics are radar sensors, automatic control equipment, communication, diamond interchange traffic, headway monitoring, critical intersections, overheight truck load detection, and the placement of detectors. (This updated bibliography contains 160 abstracts, 23 of which are new entries to the previous edition.)

198487 DA
HIGHWAY TRAFFIC DETECTORS AND DETECTION (A BIBLIOGRAPHY WITH ABSTRACTS)
Kenton, E
National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Jul 1979 143 p.
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Reports are cited on the development, calibration, testing, and operation of motor vehicle detectors and the detection of traffic incidents on highways and roads. Research is included on freeway surveillance, closed circuit television, electronic reconnaissance, magnetic measuring devices, traffic flow monitors, and sensor configurations. Investigations of snow and ice detection on bridges are noted. Other topics are radar sensors, automatic control equipment, communication, diamond interchange traffic, headway monitoring, critical intersections, overheight truck load detection, and the placement of detectors.

198333 DA
AN OPERATIONAL RESEARCH INVESTIGATION OF THE ICE-DETECTION CAPABILITY AND UTILITY OF THE SURFACE CONDITION ANALYZER (SCAN) SYSTEM AND ITS APPLICABILITY TO NAVY-WIDE USE
Mack, EJ; Anderson, RJ; Bock, DH; Niziol, TA; Reif, HG
Calspan Corporation P.O. Box 235 Buffalo New York 14221
Mar 1979 Final Rpt. 181 p.
REPORT NO: CALSPAN-6283-M-1
CONTRACT NO: N00014-78-C-0284; Contract
SUBFILE: NTIS; ATRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

During 1978, Calspan Corporation conducted an independent research investigation of the basic principles and operational performance of the Surface Condition Analyzer system (SCAN)TM in the detection of icing conditions on runway surfaces and its applicability to Navy-wide use. The results and conclusions derived from this investigation were formulated from data and information garnered from the following sources: site visits and interviews at civil and Naval airfields where SCAN is installed; visits and discussions at the manufacturer's plant; strip-chart records of actual SCAN-output signals, correlated with visual inspection of runway and sensor surfaces, runway traction, and display terminal readouts, obtained during a two-week operational performance study at Keflavik NAS; study of the manufacturer's drawings and schematics; review of the literature on snow and ice removal and control (SIRC) operations and economic analyses of these procedures as impacted by SCAN; and climatological analyses. The principal conclusion was that, while SCAN will not supplant routine personal inspection of runways, SCAN's ability to provide, on occasion, advance warning of hazardous icing conditions coupled with its surface temperature information (used for more effective chemical application) makes it well worth the investment costs. (Author)

193881 DA
PRESENT STATUS OF THE BRIDGE ICE DETECTION PROGRAM AT FHWA
Leifer, JC (Federal Highway Administration)
Transportation Research Board Special Report N185 pp 215-219 10 Fig.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
This paper discusses the need for an effective ice detection system for bridges, and outlines an early evaluation program that has led to the selection of a spot ice detector for further testing. This small detector is installed flush with the surface of a pavement and, with its associated electronics package, is capable of transmitting surface conditions to a remote location over a telephone or radio link. The advantages of an area ice detector are discussed and results to date in the development of a microwave radiometer for detection of surface condition are presented. /Author/ This Paper appeared in TRB Special Report 185, Snow Removal and Ice Control Research.

193855 DA
PRELIMINARY ASSESSMENT OF AN ICE ACCRETION SYSTEM
Tattelman, P (Air Force Geophysics Laboratory)
Transportation Research Board Special Report N185 pp 53-56 5 Fig. 1 Tab.
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
Climatic chamber tests of an off-the-shelf ice detection system manufactured by Rosemount Engineering Company were conducted at the Armament Development and Test Center, Eglin AFB, Florida. The purpose of the tests was to determine the feasibility of taking objective observations of ice accretion near the earth's surface. Data was collected for a variety of wind, temperature, and precipitation conditions which simulate natural icing. This paper presents the preliminary results of the tests. /Author/ This paper appeared in TRB Special Report 185, Snow Removal and Ice Control Research.

191710 DA
THE DEVELOPMENT OF A MICROWAVE RADIOMETER FOR USE AS A HIGHWAY ICE DETECTOR
Lockheed Missiles and Space Co. Inc., Sunnyvale, Berinsky, S; Hong, HK; Lee, TH; Schrader, WT

Sep 1978 152p
REPORT NO: FHWA/RD-78/203
CONTRACT NO: DOT-FH-11-9328; Contract
SUBFILE: NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
The program objective was to develop a system capable of detecting snow, ice, frost, or slush over a highway bridge deck area greater than 4 x 2 feet (1.2 x 0.6 m) and generate a valid alarm signal to warn motorists of a hazard. The detection system selected was a microwave radiometer operating at 10 GHz which continuously samples a reference noise source and internal amplifier noise to provide measurement corrections of radiated power received from the road surface being observed. Principal radiometer components are: rectangular horn antenna; sensitive receiver; and signal processor/alarm unit. The successive program phases were: (1) design optimization and system tradeoffs; (2) breadboard model laboratory and field tests; and (3) prototype model design, fabrication and test. Test results on asphalt and concrete roadway simulators, as well as actual asphalt roads, correlated with previously published radiometric temperatures for similar surfaces. The following road conditions were detectable: dry/warm; dry/cold; wet; slush; ice layer (0.1 cm minimum); and snow layer (1 cm minimum). All road hazard detection objectives were met except for frost detection. Descriptions of recommended additional effort are presented, including detailed evaluation of the prototype model; advanced alarm logic; self-test techniques; and a scanning antenna to cover increased road areas.

175634 DA
ICE AND FOG: DETECTION AND WARNING SYSTEMS (A BIBLIOGRAPHY WITH ABSTRACTS)
Habercom, GE, Jr
National Technical Information Service; 5285 Port Royal Road; Springfield; Virginia; 22161
Mar 1978 155 pp
SUBFILE: NTIS; HRIS; MRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Sea ice, aircraft ice, bridge ice, and fog formation detecting methods are reviewed in these Government-sponsored research reports. Remote aerial sensing and ground based detection systems are among the methods investigated. (This updated bibliography contains 150 abstracts, 32 of which are new entries to the previous edition.) Supersedes NTIS/PS-77/0188, NTIS/PS-76/0096 and NTIS/PS-75/231.

172116 DA
ARCTIC SEA-ICE CONDITIONS IN EARLY SPRING VIEWED BY SATELLITE
Ahlnas, K; Wendler, G (Alaska University)
Arctic and Alpine Research VOL. 9 NO. 1 pp 61-72 24 Ref.
SUBFILE: MRIS
AVAILABLE FROM: Colorado University, Boulder Institute of Arctic & Alphine Research, c/o K. Salzburg Boulder Colorado 80309
A detailed analysis was made of satellite imagery, mainly from the NOAA-VHRR (National Oceanic and Atmospheric Administration-Very High Resolution Radiometer) in the visible and infrared range, to produce maps of mean monthly ice concentration of the western Arctic Ocean for March 1973 and March 1974. Using multidaily coverage of the saetllite, a total of 2552 data points divided into 47 subsections of the Arctic Ocean were analyzed. In both years an average of 75% of usable observations were obtained; the cloudy observations constituted 25%. The highest ice concentrations found in the Beaufort Sea and East Siberian Sea were 85% and 81%, respectively for March 1973. For March 1974, the ice concentration was on an average 10% higher due to a greater frequency of onshore wind

components as reduced from 5-day means of surface pressure differences between selected coastal stations of the Beaufort Sea. Areas of low ice concentration were found in parts of the northern Bering Sea, along the northwest coast of Alaska and northwest of Wrangel Island in both years. In 1973 low ice concentrations were also observed north of the New Siberian Islands and west of Banks Island.

170442 DA
HIGHWAY ICE DECTECTION
Brinkman, CP (Federal Highway Administration)
Transportation Engineering VOL. 47 NO. 11 Nov 1977 pp 34-36 1 Fig. 2 Phot. 6 Ref.
SUBFILE: HRIS
Ice detectors for activating a sign must be able to detect all icing events with high reliability and a low false alarm rate. Ice detectors do not always "see" the same icing condition the motorist does. Several reasons were noted for the apparent difficulty in maintaining an accurate detecting system. In pavement detection heads are often recessed to prevent damage by snowplows. As a result, water or ice may accumulate in the depression. The detector heads are made of a material different from that of the road and therefore can possess different thermal properties. Finally, the highwy environment is harsh. Water, deicing chemicals, snowplow blades, chains and heavy trucks all abuse the inpavement detector heads. To date, no ice detector has solved all of the above problems.

167793 DA
SEA ICE-75. SUMMARY REPORT
Blomquist, A
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
28 pp 15 Ref.
REPORT NO: Research Rpt. 16:9
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report summarizes results and conclusions from the project "Sea Ice 75"--A field experiment aimed at evaluating the capability of remote sensing techniques for surveillance and mapping of sea ice in the Bay of Bothnia. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167792 DA
SEA ICE-75. RADAR ALTIMETER RESULTS
Axelsson, S
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
27 pp 9 Ref.
REPORT NO: Research Rpt. 16:7
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report describes the results obtained at a field test on sea-ice mapping by radar altimetry. The experiment was carried out in the Gulf of Bothnia, March 1975. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167791 DA
SEA ICE-75. IR-SCANNER RESULTS
Fagerlund, E; Lundholm, G
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
19 pp 6 Ref.
REPORT NO: Research Rpt. 16:6
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The field experiment in the Gulf of Bothnia has shown that thermal infrared sensing can be used to differentiate ice from water and new ice from old, thicker ice. Special features, such as rafting patterns, ridges and cracks, are correlated to thermal variations and can be detected and identified in the thermal image. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167790 DA
SEA ICE-75. FLAR, ODAR SHIP'S RADAR
Hagman, T; Nilsson, J
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
32 pp 2 Ref.
REPORT NO: Research Rpt. 16:6
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The report describes results from a field test on sea ice mapping by radar in the Gulf of Bothnia, March 1975. Three different types of radar were used: forward looking Airborne Search Radar (FLAR), Omnidirectional Helicopterborne Search Radar (ODAR) and Shipborne Radars of the Icebreaker "TOR". Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167789 DA
SEA ICE-75. ICE DETECTION BY SLAR
Morra, RHJ; Deloor, GP
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
31 pp 7 Ref.
REPORT NO: Research Rpt. 16:3
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The theoretical background, types of side looking airborne radar (SLAR) systems with their specifications, properties and limitations are described. The "slar" images are interpreted; these were obtained during survey flights over the Bothnia Gulf. Actual interpretation is based on a comparison with aerial photographs, taken during the same period. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167788 DA
SEA-ICE 75. GROUND TRUTH REPORT
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
68 pp 6 Ref.

REPORT NO: Research Rpt. 16:2
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
A remote sensing project over sea ice was carried out between March 10 and 20, 1975. Several sensors, microwave, visual and infrared, were tested. Simultaneously an extensive ground truth work was carried out. This report gives information on all ground truth data including the satellite and air photo information. Research report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

167786 DA
SEA ICE-75. ANALYSIS OF "SLAR" DATA
Parashar, S
Ship Research Institute of Norway; Technical University of Norway; 7034 Trondheim-NTH; Norway
Res. Rpt. 46 pp 32 Ref.
REPORT NO: Research Rpt. 16:4
SUBFILE: MRIS; NSFI
AVAILABLE FROM: Ship Research Institute of Norway Technical University of Norway 7034 Trondheim-NTH Norway
The purpose of this report is to present results, obtained from the analysis of "slar" (side-looking airborne radar) data. This experiment was conducted in the Bay of Bothnia during March, 1975. In an effort to help explain and understand some of the results, included are sections on the formation of sea ice and its relevant characteristics, the nature of radar return from sea ice, and sea ice parameters of interest. Research Report completed with the cooperation of the Winter Navigation Research Board, Swedish Administration of Shipping and Navigation and the Finnish Board of Navigation.

159183 DA
HIGHWAY TRAFFIC DETECTORS AND DETECTION (A BIBLIOGRAPHY WITH ABSTRACTS)
Adams, GH
National Technical Information Service; 5285 Port Royal Road; Springfield; Virginia; 22161
Jun 1977 122 pp
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Reports are cited on the development, calibration, testing, and operation of motor vehicle detectors and detection of traffic incidents on highways and roads. Research is included on freeway surveillance, closed circuit television, electronic reconnaissance, magnetic measuring devices, traffic flow monitors, sensor configurations, and photodetectors. Investigations of snow and ice detection on bridges are noted. Other topics are radar sensors, automatic control equipment, communication, diamond interchange traffic, headway monitoring, critical intersections, overheight truck load detection, and the placement of detectors. Except for a few general studies, highway ramp control and automatic urban traffic control systems are documented in other bibliographies. (Contains 117 abstracts.)

144309 DA
SNOW AND ICE DETECTION AND WARNING SYSTEMS
MacWhinney, RC; Lovell, EC; Ruden, RJ
MB Associates; Bollinger Canyon Road, P.O. Box 196; San Ramon; California; 94582
Aug 1975 Final Rpt. 171 pp 66 Fig. 17 Tab. 3 Ref. 3 App.
REPORT NO: FHWA-RD-76- 25

CONTRACT NO: DOT-FH-11-8127; Contract
SUBFILE: HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
This report summarizes the activity of a 2-year program to evaluate commercially available ice and snow detection and warning systems. The objectives were to select and operationally evaluate a number of promising detector systems and to prepare a data base of motorist behavior in adverse conditions for use in a motorist warning system study to be conducted during the second year of the study. Three detector systems were selected for evaluation. A bridge in the High Sierra Mountains near Truckee, California, was selected for the test site and fully instrumented with the detectors, as well as speed and weather measurement stations. A computerized, fully automatic data acquisition system was used to provide 24-hour-per-day recording of all sensor and detector information. Three optimally placed speed traps provided an approach speed profile for each of some 50,000 vehicles, automatically classified as car or truck that approached the bridge. Data recordings was made across a wide spectrum of environmental conditions. Although motorist behavior was found to be significantly altered by varying weather conditions, the manually operated motorist warning system also produced significant alterations in behavior. Sponsored by the Federal Highway Administration.

139578 DA
DEVELOPMENT OF A FROST AND ICE DETECTION SYSTEM FOR HIGHWAY BRIDGES
Fox, NK (Iowa State Highway Commission)
Transportation Research Record N576 pp 17-19
SUBFILE: HRIS
AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418
A frost and ice detection system for bridge decks based on the detection of the heat of fusion of ice is being used experimentally in Iowa. Observation of the operation of 5 installations during the 1971-72 winter revealed that 57 alarms were genuine and 9 were false and that on 7 occasions the units failed to detect frost, ice, or snow.

127285 DA
NEW AIDS IN WINTER TRAFFIC CONTROL
Bell, GH (Wyoming State Highway Department)
Public Works VOL. 106 NO. 8 Aug 1975 pp 58-60 6 Phot.
SUBFILE: HRIS
New devices to alert motorists to hazardous conditions are discussed. The devices used on Interstate 90 in Wyoming, are: weather wire; wind velocity instruments; pavement ice detectors; visual range monitors; "micro" or spot weather forecasts; variable message signs; and lower power AM radio. The weather wire transmits forecasts as well as existing conditions. Wind speed measurements are being correlated with accident data. Pavement ice detectors are placed in locations such as tunnels and bridges. The sensors transmit information to the control box, which then activates a warning sign. Visual range monitors use probes, computers and anemometers to determine sight distance in bad weather. Use of spot (Micro) weather forecasts has been valuable in scheduling manpower and in anticipating storms. Variable message signs allow display of several hazardous conditions by remote control. Low power AM radio, still in the planning stages, consists of continuous broadcasts of road and travel information. Signs inform motorists as to the frequency to which they should tune their car radios.

094637 DA
ICE SENSORS AND INFORMATION SIGNING

Nelson, TI
Oklahoma Department of Highways; Jim Thorp Building; Oklahoma City; Washington; Oklahoma; D.C.; 73105; 20590
Oct 1975 Final Rpt. 12 pp
SUBFILE: NTIS; HRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161
Two commercially available ice detector systems together with informational signs were installed on a long bridge structure over a wide waterway. The systems were monitored for three winter seasons in order to evaluate their sensitivity and efficiency. Prepared in cooperation with Federal Highway Administration, Washington, D.C.

APPENDIX B

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UNIVERSITY OF ALASKA FAIRBANKS

School of Engineering
Institute of Northern Engineering
539 Duckering Building
Fairbanks, Alaska 99775-0660

Fax: (907) 474-6087

June 10, 1993

Robert L. Humphrey
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010

RE: Thermal (Nonchemical) Deicing Systems

Dear Mr. Humphrey:

The Transportation Research Center at the University of Alaska Fairbanks has undertaken a feasibility study for Alaska's Department of Transportation and Public Facilities on deicing systems for high capacity intersections. As part of the research effort we want to identify thermal, nonchemical (snow melting) deicing systems used in the "lower 48". We realize that the use of this type of system is limited to special applications such as bridge decks, ramps to buildings, etc.

If you are aware of any snow melting systems available in your state, we would appreciate your sending their locations and points of contact by FAX or using the enclosed self-addressed, stamped envelope. When this project is finished, a copy of the final report will be send to you.

Our next step, after collecting an inventory of systems in the "lower 48", is to interview the maintenance personnel responsible for the systems. We will be requesting information on their type, cost, problems, effectiveness, etc. From these data, we hope to develop design guidelines in addition to what we have found in the literature.

Thank you in advance for your help.

Sincerely,

John P. Zarling
Professor, Mechanical Engineering
Director, Institute of Northern Engineering

None in Iowa

Points of Contact and Locations of Snow/Ice Melting Systems (Nonchemical)

1. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

2. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

3. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

4. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

5. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

6. Name_____
   Address_____
   City/State/Zip_____
   Phone/FAX_____

APPENDIX C

It's simple, it's cheap — it works

Heated sidewalks keep snow at bay at City Hall

By SHEILA TOOMEY
Daily News reporter

As snow piled up in downtown Anchorage on Monday, the sidewalks around City Hall remained an island of slightly damp concrete in an ocean of drifts.

The new heated sidewalks work.

Installed last year during extensive building renovations, the City Hall sidewalks are warmed by waste heat coming off the building's two huge boilers. The waste heat warms a fluid similar to antifreeze, which is circulated through plastic tubing that was embedded in the sidewalks before the concrete was poured.

"It's real simple," said architect Mark Pfeffer, whose firm directed the renovation.

It's also relatively cheap, costing about $20,000 in a $12 million project and raising

Please see Page B-2, SIDEWALKS

ANNE RAUP / Anchorage Daily News

Heated pipes underneath the sidewalks in front of City Hall keep the walks free of snow.

Continued from Page B-1

on-going gas costs by perhaps 2 percent, he said.

The system keeps the sidewalks at about 34 degrees, warm enough to melt every flake and to keep the resulting moisture from freezing.

A similar system has been operating for eight years at the Allstate Insurance Co. building at Tudor and Patterson, Pfeffer said. The military processing station on C street, the Veterans Administration at Alaska Regional Hospital, the health services building under construction near the new Native hospital and Pfeffer's driveway also have the no-shovel system, he said.

Although not having to shovel seems attractive enough by itself, Pfeffer said heated sidewalks save money by eliminating the need for salt and saving carpets from snowy, salty shoes.

Alas, the technology is not yet optimal for use at private residences, he said. First of all, you need a boiler. And most home boilers aren't big enough to keep a driveway heated enough to handle 20-inch snowfalls. Pfeffer has to plow out his driveway, just like the rest of us. He uses the heating system to keep it clear once the snow stops.