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INTERCHANGE

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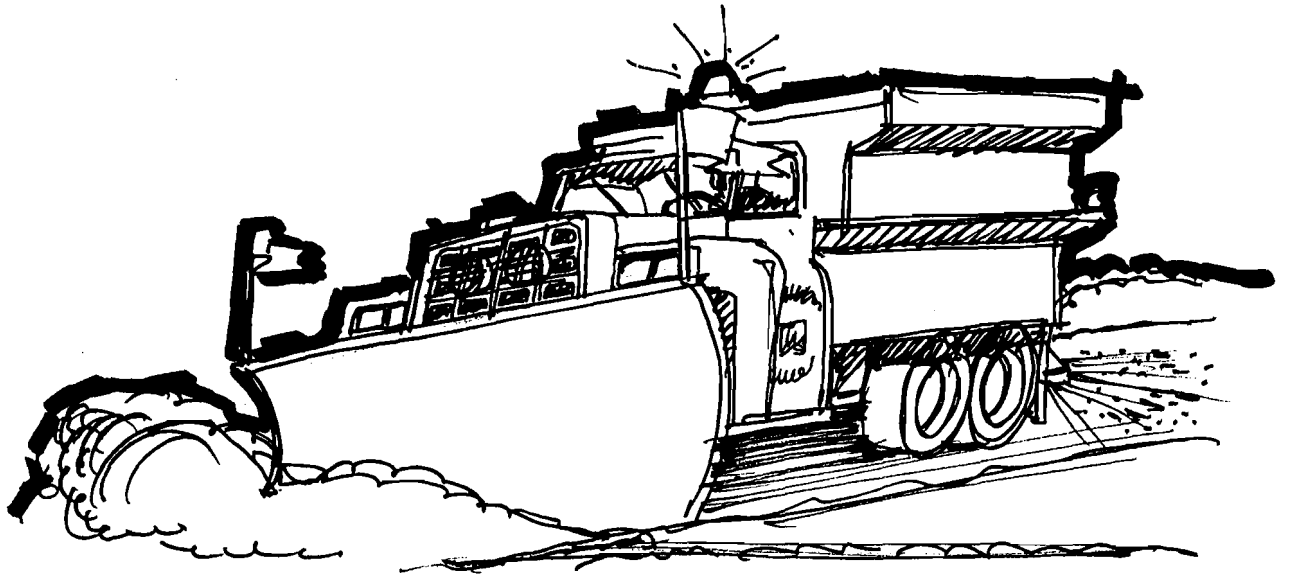
SAFETY RESTORATION DURING SNOW REMOVAL - GUIDELINES



History of the Problem

Snow and ice have been concerns to the driving public for many years. Significant resources are spent each year by state, county, and municipal governments on snow and ice control programs. In 1984, for example, these governments spent over $1 billion on snow and ice control programs. This money was spent in the interests of public safety and in an effort to maintain free flowing traffic.

Once a highway is reopened to traffic after a storm, maintenance crews must perform post-snowstorm cleanup work. Cleanup includes removing accumulated snow adjacent to the shoulder; clearing snow to provide adequate sight distance in curves and intersections; clearing snow from drainage structures; loading and hauling snow from bridges, cuts, gore areas, narrow medians, and other areas where storage is not appropriate; and cleaning snow from guardrail, longitudinal barriers, and impact attenuators.

Safety is compromised when the safety functions of appurtenances such as bridge rails, safety-shaped barriers, guardrail, and crash cushions are degraded by heavy accumulations of snow and ice. Accidents are also generated when snow accumulation reduces sight distance or visibility at intersections, curves, and on-ramps.

Scope and Objectives of the Research

The objectives of this research were to:

*Determine the extent to which highway safety problems are created or increased when highway safety features are compromised by snow removal and storage practices.

*Identify locations where emergency snow removal practices or inattention during post-snowstorm cleanup operations may create a safety hazard.

*As appropriate, determine how best to reduce or eliminate safety hazards through better use of highway

department's existing manpower and equipment.

*Develop recommendations which will enable maintenance engineers or to prioritize their post-snowstorm cleanup operations so to as minimize the hazards to the traveling public.

Hazards and Remedies

Hazards and remedies are presented in three groups and according to their order of importance: most serious, serious, and important.

1. Most Serious Hazards

Superelevated and Sharp Curves

Snow or ice accumulation on the high side shoulder of superelevated ramps and superelevated curves, especially those without reverse shoulder slopes, received the highest ranking. Snow piled in the middle of sharp curves reducing sight distance (visibility) of approaching vehicles is a related hazard. Snow stored on the high side of curves is subject to melting and refreezing, creating sheets or patches of ice on the once-cleared road surface. "Freezeback" usually occurs when afternoon sun melts piled snow, allowing moisture to run back across the previously cleared driving surface and to freeze in the cold of early evening. Superelevated curves, ramps, and bridge decks that have a straight cross section from curb to curb are especially affected by refrozen snow-melt.

To prevent melted snow from refreezing on superelevated ramps or curves, snow should be plowed to the low side of the roadway during emergency snow removal unless it is possible to push or wing over the high side edge of the shoulder line or ditch. At the inside of curves, snow should not be stored snow where it will reduce visibility of approaching vehicles. Where snow has been stored on the high side of curves, it should be removed and sand applied to wet spots to increase friction between tires and the road surface. Packed snow may have to be removed with a grader or front-end loader.

Bridge Parapets, Rails, and Curb Areas

Snow or ice accumulation at bridge parapets, rails, and curbed areas is a most serious hazard. An associated but less serious hazard occurs when snow plows cast snow from overhead bridges onto adjacent roadway, railroad tracks, or properties below.

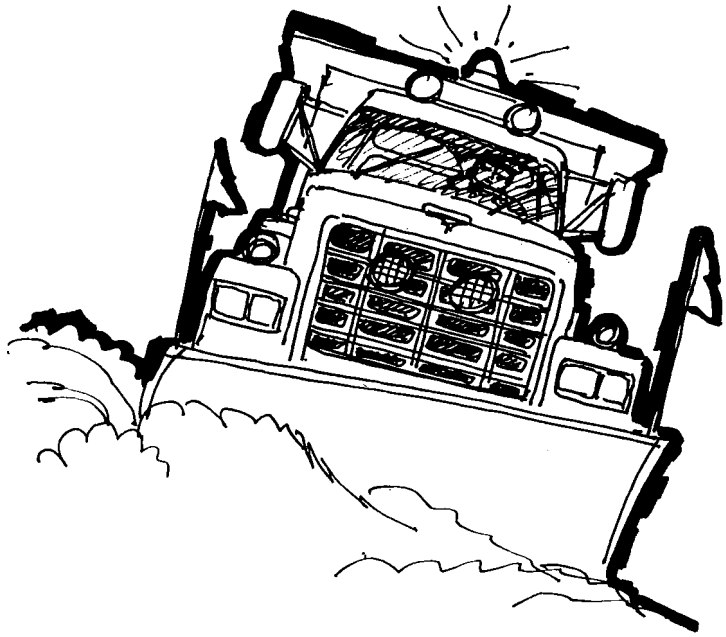
During emergency snow removal on bridges, snow often gets plowed against parapets and rails. Hard-packed snow piled at two-thirds the height of the bridge parapet or rail changes its shape and creates the potential for vehicle ramping. The most critical areas on a bridge are the parapet, rail, or curb along the north side of an east west-oriented bridge. Because that side is always shaded, melting is inhibited. Safety-shaped bridge parapets, regular bridge parapets,and open-pipe bridge rails are subject to vehicle ramping which can result in fatal injuries.

Plowing in tandem can be used to clear an entire bridge deck, including railings. Plowing in tandem is most safely accomplished under well-lit conditions and when traffic is light.

Snow and ice on a bridge parapet, rail, or curb should be removed completely. Otherwise, when the temperature rises and melting occurs, moisture from the remaining snow may run back across the pavement and create "freeze-back" conditions.

Plows and Other Snow Removal Equipment

The difference in operating speed between snow removal vehicles and traffic vehicles and the poor visibility created by blowing snow create the potential for serious collisions. Collisions usually involve vehicles running into the rear of snow plows or vehicles striking the plow when passing. Faster moving, impatient, or indifferent motorists often tailgate or try to pass plows. Sometimes while completing their passing maneuver, they misjudge the snow plow's speed and hook their rear bumper onto the plow blade. Head-on accidents have also occurred when snow plows are near the center line facing oncoming traffic.



Snow plow operators complain about motorist driving habits during snow removal operations. Because motorists generally do not understand snow plowing operations, they frequently misjudge the width, length, and speed of the snow plowing vehicle. Once the roadway is open to traffic during snow plowing, travel speeds will increase to their normal level, increasing the severity of a collision with the slower moving plow.

To reduce the potential of traffic vehicles colliding with snow removal vehicles, strobe or other high-intensity lighting devices visible to motorists in front and rear, even through blowing snow, are recommended.

Motorists need to be better informed about the difficulties in driving, handling, and maneuvering snow removal vehicles and other equipment. Public service announcements educating motorists on how to drive during winter conditions using the theme of "Give'em Room" have been used, but the success of these programs is not yet known.

Intersections and Interchanges

Obscured motorist visibility due to snow piled at intersections and interchanges is the fourth most serious ranked hazard. Snow piled near intersections can affect a motorist's ability to see oncoming vehicles at intersecting roads. These piles of snow also block an oncoming motorist's view of cars at intersections.

In interchange on-ramp areas, piles of snow can hide merging vehicles and vehicles stopped at crossroad intersections. There is a point on the on-ramp where entering vehicles are hidden from and cannot see mainline vehicles. High-speed accidents resulting in severe injuries can occur when these intersecting vehicles collide.

First priority post-snowstorm cleanup areas are unsignalized four-lane intersections, merging areas at on ramps, off-ramp intersections, and two-lane unsignalized intersections.

Many signalized intersections are changed to flashing operation late at night, thereby operating as unsignalized intersections. Intersections with flashing signals should be cleared of piled snow with the same priority as unsignalized intersections.

Figure 1 shows post-snowstorm cleanup priorities at intersections and interchanges as practiced in Minnesota DOT District 9. The solid portions of the diagrams are the areas susceptible to motorists visibility problems with piled snow.

2. Serious Hazards

The following five hazards were ranked as serious: snow or ice accumulation on guardrail; improper alignment of snow plows; stalled or abandoned vehicles impeding snow removal operations; lack of snow storage area at narrow medians, shoulders, and gores; and snow or ice on concrete safety-shaped barriers. These hazards, although serious, should be treated after the hazards rated most serious are remedied.

Guardrail

Snow or ice accumulation along guardrails are a result of drifting snow or plowing operations, and is more of a hazard on freeways than on regular roadways because of the greater length of guardrail, higher traffic volumes, and higher vehicle speeds on freeways. Unsafe conditions include snow drifting on a clear road, possible melting and refreezing of snow, and reduced effectiveness of the guardrail section due to piled snow.

To prevent snow accumulation around guardrails, roadways should be plowed out to the guardrail as soon as possible after roads have been reopened to traffic. To prevent drifting, snow should also be cleared from the shoulder inside guardrail sections. This helps snow plow operators to locate guardrails even when the rails are completely covered with snow.

Snow Plow Alignment

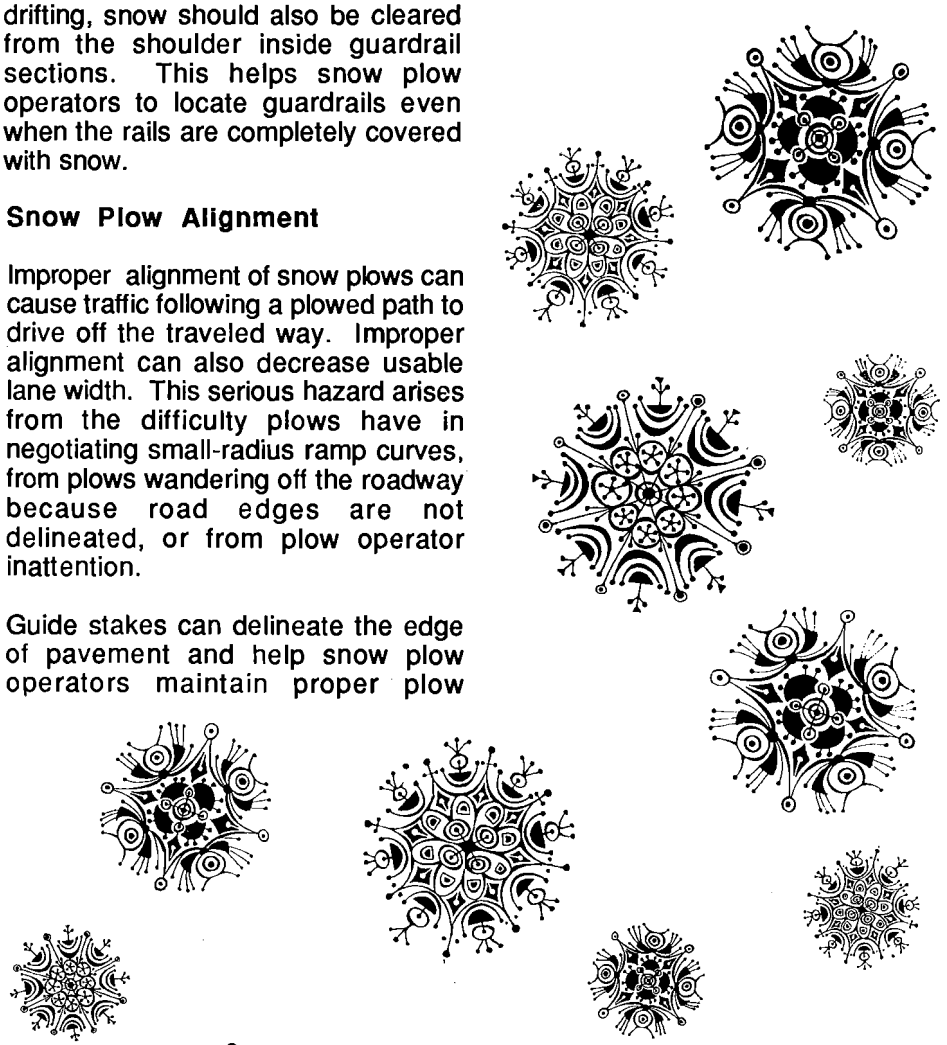
Improper alignment of snow plows can cause traffic following a plowed path to drive off the traveled way. Improper alignment can also decrease usable lane width. This serious hazard arises from the difficulty plows have in negotiating small-radius ramp curves, from plows wandering off the roadway because road edges are not delineated, or from plow operator inattention.

Guide stakes can delineate the edge of pavement and help snow plow operators maintain proper plow alignment. Within interchanges, guide stakes should be installed at 50-ft intervals. Guide stakes can be spaced farther apart (200 ft) between interchanges and on rural routes. To avoid annual installation and removal costs, some states prefer to leave guide stakes installed year-round.

Stalled or Abandoned Vehicles

Stalled or abandoned vehicles impeding proper emergency snow removal or post-snowstorm cleanup operations are also a serious ranked hazard. Severe snowstorms occurring at rush hour in urban areas create the worst problems because of higher traffic volumes. In rural areas, stalled vehicles can force highway agencies to close roads. Blowing snow is a particular problem in areas where high winds cause drifting. Tractor-trailer trucks that have run off the roadway present the biggest problem because they are difficult to remove.

To help prevent the problem of stalled



vehicles during heavy snow, public service announcements should be used to warn people to stay home or to exit the road and sit out the storm. Commercial tow trucks pressed into use for the removal of stranded vehicles should be part of a plan to support snow removal operations. Tow trucks can be called into service by the local police agency.

Narrow Medians, Shoulders, and Gore Areas

Lack of snow storage areas at narrow medians, shoulders, and gore areas is another serious ranked hazard, especially when snowfall has been heavy or when storms have occurred in close succession. When piled snow melts it can run off and refreeze, causing localized icing. Piled snow also can obscure vision. It can even collapse onto the roadway during snow melt.

On multilane highways, to prevent snow accumulation in narrow medians where there is less than twenty feet (6.1m) of storage width or concrete median barriers, the snow should be plowed across the roadway to the right; otherwise, snow will have to be loaded into trucks and hauled away. Wing plows should be used to create extra storage area on shoulders. In gore areas a motor grader or front-end loader should be used to remove snow. In gore areas, sand and salt on bare pavement can act like ballbearings causing vehicles to skid and strike signs and other appurtenances. Power sweepers are needed to clean gore areas.

Safety-Shaped Barrier

Snow and ice piled against roadside or median concrete safety shaped barriers, especially in areas of frequent and heavy snowfall, is another serious hazard. Urban areas are the most critical. As with bridge parapets and rails, snow piled at two thirds the height of the barrier changes it shape and creates a vehicle ramping hazard. The hazard is compounded in areas where vehicles can strike barriers at angles greater than 15 degrees, such as on the inside of curves and in wide medians. The side of the barrier facing the sun may be clear of snow, but the shaded northern face, which is hidden from the sun, often contains packed snow. Normal plowing procedures will remove snow from the lower face of a safety-shaped barrier but will not remove the packed snow that forms a ramp on the upper face. A raised plow blade may be able to pull snow from the upper face of safety-shaped barriers.

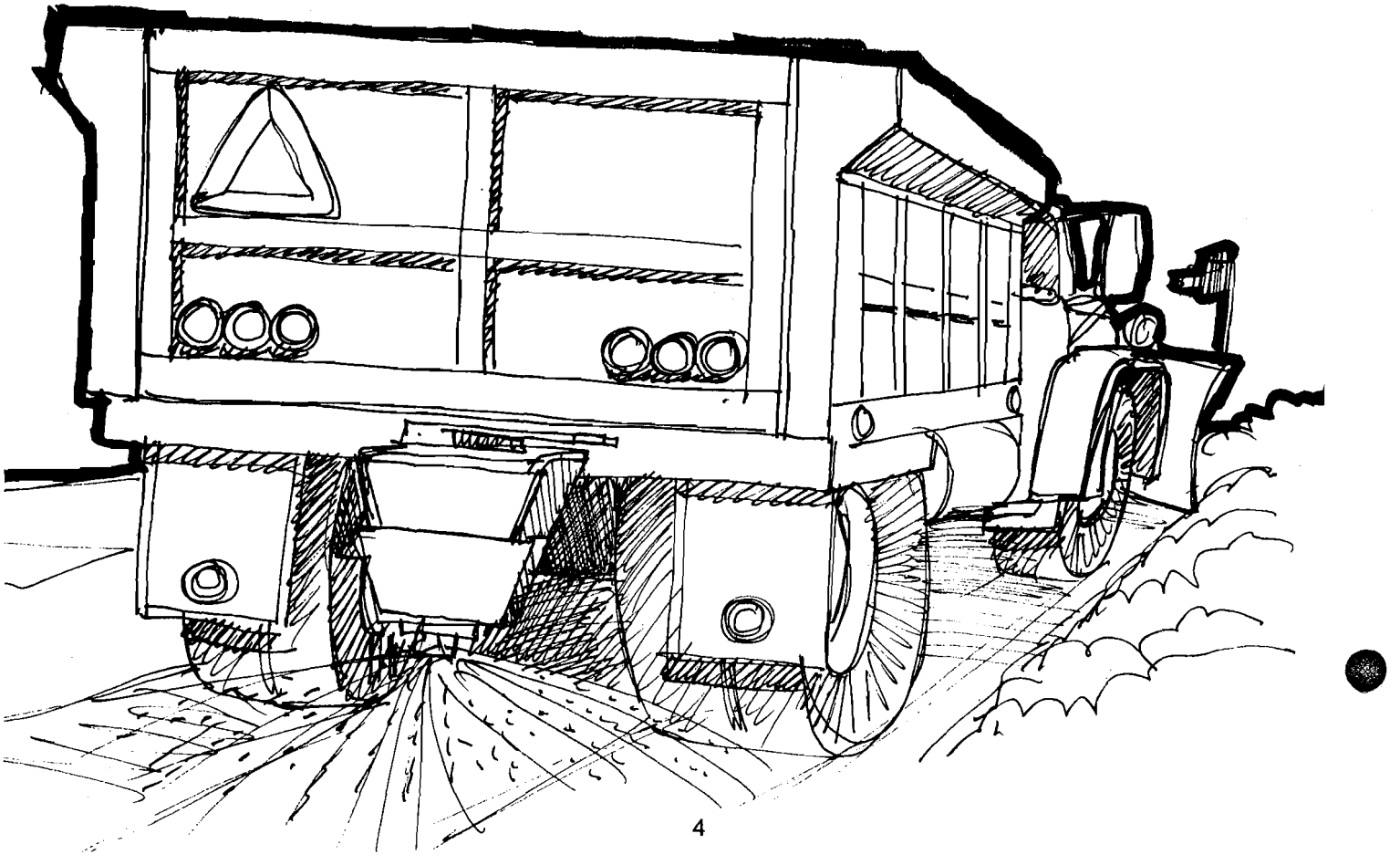
Freezing rain on top of an existing snow ramp creates a frozen surface that is especially hazardous.

3. Important Hazards

Several snow and ice accumulation hazards ranked as important are also present during post snowstorm cleanup operations. These hazards, which do not require immediate attention except where obvious problems exist, are snow covered drains, culverts, and channels; snow or ice windrows; shallow cut areas; at-grade railroad crossings; pavement obstructions such as curbed and raised areas; obscured highway signs; and snow-covered impact attenuators.

Drains, Culverts, and Channels

The accumulation of snow, ice or debris at drains, culverts, and channels when snow-melt backs up



onto the pavement and creates pools of water which can refreeze. Heavy rains that freeze before an impending snowstorm increase the hazard.

Arrows painted on barriers, parapets, or pavement indicating the location of drains will aid in locating drains when they are covered by snow. The New York Thruway Authority marks drain locations and even gives the distance from the edgeline to the drain.

When plowing bridges, drains should be checked to see that they are clear. Clogged drains can be treated with salt but may require hand-cleaning.

Drainage problems at culverts are common in areas with a deep frost depth where ice remains in the culvert. In the spring, melting snow and rain can build up on the roadway and refreeze into slippery spots. Ice can be melted using a steam generator.

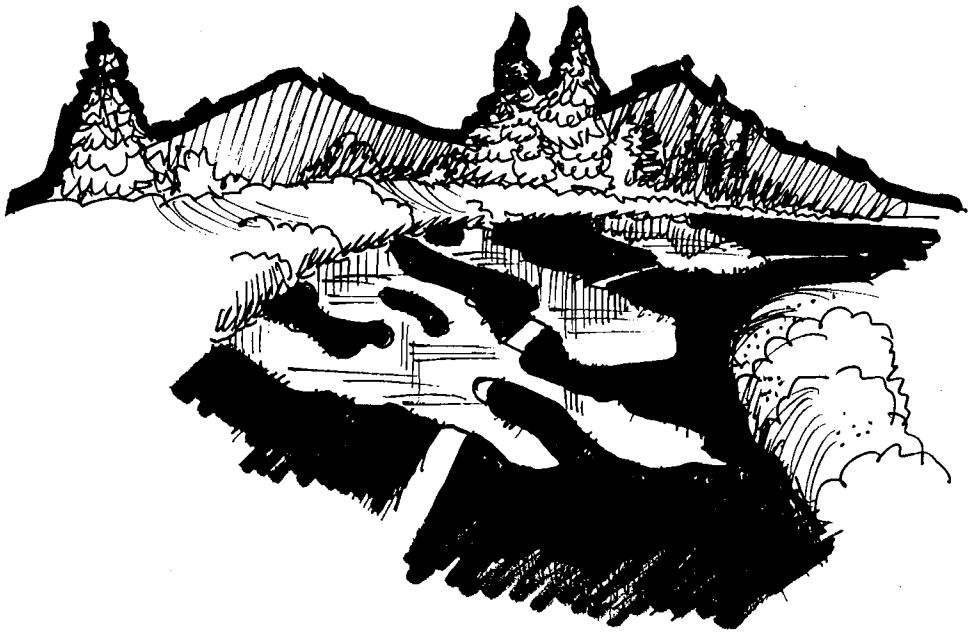
Channels and ditches blocked with plowed snow can cause snow-melt to run onto the pavement. Drainage channels that have a history of snow and water backup should be cleared of drifted or accumulated snow in anticipation of thawing weather. A backhoe or hydraulic excavator such as a "Grad-All" can be used. A dump truck may be needed to haul snow.

Snow or ice windrows along the edge of pavement prevent water from running off the pavement, especially in hilly areas. Openings should be made in the windrow to permit drainage of water from the road.

Snow or Ice Windrows

Snow or ice windrow buildup at entrance and exit ramps and at intersections is another important hazard which presents an unexpected obstacle to motorists. The hazard, created when a windrow blocks a motorist's path, is usually a temporary condition during plowing operations. Windrows can be prevented from forming by adjusting plow speed and mold board angle to obtain sufficient snow cast.

To remove windrows, plows operating singly should start plowing from the left and continues around the interchange until snow and windrows have been moved all the way to the right.



If more than one plow is used, plowing activities should be coordinated so that the second plow is in tandem behind the first on both the mainline and ramps.

Shallow Cut Areas

Snow or ice accumulation in shallow cut areas is another important ranked hazard. Lack of snow storage area causes snow to blow and drift across the roadway, Blowing snow impedes vision and snow drifts can be struck by motorists. Blowing and drifting are aggravated by successive snowstorms that occur over a short period of time. Roads built perpendicular to the usual wind direction also have definite drifting problems.

Remedies include installing snow fences, winging back and benching snow drifts, using a blower when a shallow cut is full of snow, and loading and hauling away snow. A backup vehicle is needed to alert approaching motorists that roadside cleanup is in process.

At-Grade Railroad Crossings

Snow or ice pushed onto at-grade railroad crossings is another important hazard which affects roads other than freeways. Once snow, ice, or aggregate gets into flanges or rails, it is difficult to remove and can cause train derailments.

High-volume urban traffic carries snow slush and debris onto tracks. To alleviate the hazard, the plow should be emptied along the shoulder in advance of an at-grade railroad crossing.

Approaches to crossings should be treated to prevent slippery conditions, but chemicals must not be spread on the track area itself. Plow operators must use extreme care when working around railroad tracks because the extra length of their vehicle and the noise of their operation can prevent their hearing an approaching train. Adjusting the angle of the plow so that it is not parallel to that of the railroad track will prevent the plowing of snow from overhead bridges onto railroad tracks.

Pavement Obstructions

Pavement obstructions such as raised islands, rumble strips, curbs, delineators, buttons, joint, and covers that may inhibit snow and ice removal are important hazards but they do not pose much of a problem from either safety or cleanup standpoints. In general, these hazards should receive priority treatment only at locations where there have been safety or cleanup problems in the past.

Such obstructions, especially at channelized areas, can prevent complete snow and ice removal. Snow from these obstructions should be removed before it has a chance to melt, spread, and refreeze onto adjacent pavement.

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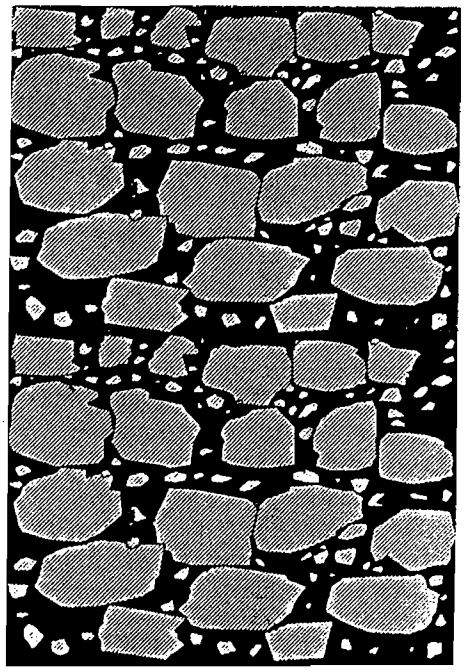
STONE MATRIX ASPHALT (SMA) COMES TO U.S. INSTALLED BY FOUR STATES THIS YEAR

Stone Matrix Asphalt (SMA) and its promise as a paving surface in the United States is a current topic this year. SMA mixtures were developed and used in Europe over twenty years ago to provide increased resistance to (a) rutting under heavy traffic, and (b) wear from studded tires. The members of the 1990 European Asphalt Study Tour, consisting of government and industry representatives from the United States were impressed by the performance of SMA mixtures in Europe. NCAT Director Dr. Ray Brown, with a group of state DOT and FHWA engineers, also visited Europe this year to become acquainted with SMA technology.

The FHWA in cooperation with state DOTs and industry representatives has already initiated a series of field trials this year. SMA mixes were placed in Wisconsin and Georgia in July and September, in Michigan in August and in Missouri in September. The primary objective of these field trials is to determine SMA's construction feasibility and its performance as an alternate pavement surface to conventional dense-graded hot mix asphalt (HMA).

The concentration of coarse aggregate (retained above a 2mm or No.8 sieve) in the gap-graded SMA is generally 70 to 80 percent. When compacted, the angular coarse aggregate particles form a structural skeleton (matrix) which, unlike a dense-graded HMA, has particle-to-particle contact. Increased internal friction and shear resistance results from this skeleton or matrix. High quality crushed aggregates must be used. The space between the coarse aggregate particles is filled with mastic consisting of asphalt cement binder, fine crushed sand, and filler. Since SMA contains high asphalt content it is necessary to add a fiber or a polymer stabilizer to retain a thick binder film around the coarse aggregate particles without any drain-down. It is very important to design and control the amount of mastic, which should be just enough to hold the aggregate particles together but not so much as to push the coarse aggregate apart. A very high level of field quality control (especially proportioning of the ingredients as per design) must be used. A 50-blow Marshall mix design is generally used in Europe and has been used in the U.S. so far. The German specification requires an air void content of 2.0 to 4.0 percent. Typically, 6 percent or less air voids are expected in the compacted mat. Steel rollers (10 to 12 tons) in a static mode are most commonly used. Vibratory rollers are not generally used because of the potential to crush the aggregate. Pneumatic-tired rollers tend to pick up the SMA mat.



STONE MASTIC ASPHALT

The table gives the location of SMA project sites in Wisconsin, Georgia, Michigan, and Missouri, and the mix composition used at each site. The aggregate gradations (especially passing No.8 sieve) are very similar. German specifications recognize 5mm (0.20"), 8mm (0.31") and 11mm (0.43") top size aggregate mixtures. However, 11mm is most common in Germany and throughout Europe. This is equivalent to about 1/2 inch nominal maximum size aggregate. Top sizes of 16mm (0.62") and even 20mm (0.79") have also been used in Europe.

Batch facilities are typically used in Europe for the production of SMA and dense graded HMA. Fiber, if used, is added directly to the mixer and dry cement. Batch facilities were used for SMA production in three states, but in Michigan a drum mix facility was used in addition to a batch facility.

NCAT is involved in the mix design and evaluation of these field trials. A status report on the design and performance of SMA sections will be prepared by NCAT by the end of this year.

This article is reproduced with permission from "Asphalt Technology News" Fall 1991 issue. Asphalt Technology News is published by the National Center for Asphalt Technology (NCAT) of Auburn University. We have annotated the current Massachusetts specifications for Top Course and Modified Top Course. You will notice that at #4, #9, and #8 sieve sizes, the SMA has less passing which means there are more large particles in the mix design.

SMA Gradation Compared to Current MA Practice

PROPERTY	WISCONSIN I-94 (WAUKESHA COUNTY)	GEORGIA I-85 (JACKSON COUNTY) COARSE	GEORGIA I-85 (JACKSON COUNTY) FINE	MICHIGAN ROUTE M-52 (INGHAM COUNTY)	MISSOURI I-70 (EAST OF I-270 INTER-CHANGE)	MASSACHUSETTS SPECIFICATIONS TOP COURSE	MASSACHUSETTS SPECIFICATIONS MODIFIED TOP COURSE
Percentage of Aggregate Passing Gradation							
GRADATION							
3/4"	100	100		100	100		95-100
1/2"	94	62	100	94	96	95-100	75-90
3/8"	70	42	78	73	76	80-100	60-75
4	28	26	36	36	34	50-76	40-60
8	20	20	23	25	20	37-54	32-44
16	16	16	18	19	16	26-40	24-34
30	14	15	17	16	13	17-29	16-26
50	13	14	15	14	13	10-21	8-18
100	12	12	13	12	12	5-16	4-13
200	11	10	10	10	10	2-7	2-7
%	5.7	5.8	5.9	6.5	6.5	5.5-7.0	5.5-6.5
%	none	8*	8*	0.3**	0.5***&0.3**		
%	7^	5^^	5^^	none	none		
	85-100	AC-30	AC-30	AC-20	AC-20		

KEY:
* Mineral Fiber by wt. of AC
** Cellulose Fiber by wt. of mix
***Mineral Fiber by wt. of mix
^ Vestoplast-S
^^Novophalt

continued from page 5

Obscured Highway Signs

In areas of heavy snow fall and drifting compounded by high winds, snow obscuring highway signs is another important hazard, Snow thrown by plows can also adhere to signs. An unsafe condition exists when motorists cannot see a sign legend, especially warning and regulatory signs.

Signposts can be struck to shake the snow loose. Fortunately, snow adhering to signs usually melts and slides off when the sun comes out. Where drifting covers signs, the area should be dug back to clear the signs, especially those in critical areas.

Impact Attenuators

Still another important hazard is snow or ice accumulation on impact attenuators. The attenuator may become jammed with snow or ice from emergency snow removal operations. An out-of-control vehicle can climb snow covered attenuators and strike the object behind the attenuator. Impact attenuators operate well under winter conditions, but care should be taken to see that snow and ice accumulation does not hinder operations. If attenuators are used at hazardous or high accident locations, higher priority treatments should be applied.

To avoid cracking sand barrels during snow cleanup, the snow should be removed carefully with a plow or other equipment. When filling sand barrels, a 20 to 25 percent mixture of salt should be added to the sand to prevent it from freezing.

This article is condensed from "Safety Restoration During Snow Removal Guidelines" which was published in February 1991 by US Dept. of Transportation, Federal Highway Administration. The study was based on literature review, telephone interviews, data collection and analysis and state visits. State visits were made to Colorado, Montana, New York, Ohio and Wisconsin during the winters of 1985-86 and 1986-87. Anyone interested in obtaining a copy of the complete report call or write to:
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SHULDINER SITS ON PRESIDENTIAL JURY

Paul Shuldiner, Professor of Civil Engineering, has been appointed to the Presidential Design Awards Jury of the National Endowment for the Arts. The jury met in December to select those federally sponsored projects which are to receive the 1992 Presidential Design Awards. Award recipients in the 1988 competition included: the Vietnam Veterans Memorial in Washington, D.C.; NASA's International Ultraviolet Explorer Program; Boston's Southwest Corridor Transportation Project; and the Sunshine Skyway Bridge spanning Tampa Bay.

IN THIS ISSUE

VIDEO LENDING LIBRARY: NEW ACQUISITIONS

OPEN ROADS: A Look at Freeway Incident Management PA-141

This 20-minute video program presents--in clear, non-technical language--the current state-of-the-practice of freeway incident management, and is intended for viewing by top-level management, elected officials, citizen groups, and other interested parties.

Through an effective mix of animation, special effects, on-camera interviews, and real-world video footage, this video program dramatically depicts the severity of the incident problem, then offers effective and practical solutions. In so doing, it touches upon a broad range of proven, successful incident management strategies--including many simple, low-cost procedures that can be readily adopted.

THE IDEA STORE VIDEO-Edition 6 PA-140

This is a video featuring ideas on wildflowers, adopt-a-highway, light cages for warning lights, fabricated posts, Roads Scholar 1 & 2, signs, brainstorming, and safety packet.

EFFECTIVE SNOW FENCES MO-184

Part 1- This is a 10-minute video describing the benefits of snow fences. The benefits include eliminating the need to remove snow, increasing visibility, and reducing pavement management costs.

Part 2- Shows how snow fences work, by reducing windspeed, capacity and height design, and proper placement.

This is an excellent tape for anyone using snow fences or who has a drifting problem.

The Baystate Roads Program, which publishes *Mass Interchange* each quarter, is a Technology Transfer (T2) Center created under the Federal Highway Administration's (FHWA) Rural Technical Assistance Program (RTAP). FHWA is joined by the Massachusetts Department of Public Works, the Department of Civil Engineering at the University of Massachusetts/Amherst, and local public works departments in an effort to share and apply the best in transportation technologies.

In addition to publishing *Mass Interchange*, the Baystate Roads Program facilitates information exchange by conducting workshops, providing reports and publications and videotapes on request, and offering one-to-one technical assistance on specific roadway issues. Because the program relies on input from many sources, inquires, articles, and ideas are encouraged.

To contact the Baystate Roads Program, please call Silvio Baruzzi at (413) 545-2604.

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