



Using Mechanical Ice Breakers to Improve Snow and Ice Removal Operations

Requested by
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The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field. The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this publication are for clarity only.

Table of Contents

Executive Summary	2
Background	2
Summary of Findings	3
Gaps in Findings.....	10
Next Steps	10
Detailed Findings	11
Related Research and Resources.....	11
Consultation with State and International DOTs.....	12
Case Studies	14
Contacts	15

Executive Summary

Background

Caltrans is charged with the responsibility of maintaining throughout the winter season more than 9,000 lane miles of winter routes with a target level of service of bare roadway. Snow buildup on these roads generally rests on top of the pavement and can be cleared away with a pass of a plow blade or blower. However, under certain weather and traffic conditions, hardpack snow and ice bonds to the pavement surface, impeding its removal by standard means. This hardened ice layer acts to deflect conventional plow blades up and over this layer, failing to break the pavement bond. Several Caltrans districts have shut down routes due to ice conditions that develop during severe winter storms. As mitigation, brine is often sprayed on the highway before a snowstorm as a means to inhibit ice from bonding with the pavement surface. Once an ice pack forms on the highway, granular salt and brine is traditionally applied to the surface of the ice to soften and facilitate its removal with standard plow blades. Caltrans currently spends approximately \$2.5 million on deicing and anti-icing each year. Caltrans is aggressively pursuing a plan for reducing or eliminating the use of salt as a primary deicing agent on specified routes and substituting with environmentally safe methods of ice prevention or removal. To accomplish this, innovative new winter operation techniques must be explored which will reduce Caltrans reliance on salt usage while at the same time either retaining or improving the current level of service. In Caltrans District 3 at the Agriculture Inspection Station on Interstate 80, the inspectors have complained about residual dust from sanding operations—mechanical means of ice removal may help mitigate this. Some cities throughout the world do not allow use of abrasives and salts on the roadway; this may represent a future trend, further motivating mechanical ice removal. Use of mechanical ice removal techniques should have a positive environmental impact including reduced usage of salt, brine, and abrasives, and improved air quality, leading to sustainable winter operations. At the request of the Caltrans Division of Maintenance, this Preliminary Investigation (PI) is being conducted to assess how innovative new mechanical ice breaker technologies could potentially evolve into effective new tools for Caltrans ice prevention or removal operations.

The cost of road closures on Interstate 80 due to severe winter weather are estimated to be in the hundreds of thousands of dollars per day. Mechanical ice breakers could potentially reduce the duration or completely prevent closures. As such, the cost of ice breaker equipment could be recouped fairly quickly.

The latest innovative methods for mechanically removing ice buildup on roadways are as follows, in no particular order:

- Penetrating drum attachments
- Multi-blade plow technology
- Utilization of special purpose ice cutting blades
- Establishment of the optimum ice cutting blade angles
- Underbody truck scraper attachments

Caltrans winter operations personnel have most certainly had exposure to some of these tools. This PI will explore each of these technologies individually in greater detail and additionally, how some of these products can be combined to greater effect. The goal of this study is to develop a

general perspective of the state-of-the-art in mechanical ice breaking equipment to assist Caltrans with the identification and adoption of the tools most capable of providing the greatest benefit. This study will focus on a literature search and review of current practices of other State DOTs (Departments of Transportation) regarding the utilization of mechanical ice breaking devices for their winter operations.

Summary of Findings

An extensive body of work exists regarding the utilization of mechanical ice breaking technologies which have been specifically developed to effectively cut through ice pack bonded to highway pavement surfaces. The ideal performance objective is the ability to mechanically scrape down to bare pavement with little or no damage to pavement and without waiting for a salt treatment to soften a layer of bonded ice before effective removal can be achieved. Attaining this capability implicitly delivers an associated reduction in highway salt usage and more quickly provides motorists with the higher level of service and safety bare pavement provides. The diversity of ice breaking technologies under development does not appear to be converging on a single best solution, but instead is increasingly becoming tailored to the distinctive needs and weather conditions of the individual State DOTs. The list of mechanical ice breaking technologies, which have been DOT-proven as efficient at cutting through ice pack on the highway, are categorized and ordered based on their apparent adaptability to the existing Caltrans winter operations fleet.

Compatible Technologies

Segmented flexible blade

The benefit of utilizing flexible mounting blade edges (see Figure 1) is to reduce salt use by improving the clearing capability of plows in a single pass. Segmented flexible blades are naturally better at following the roadway contour and producing a cleaner scraped surface than conventional rigid edges. Evaluation is ongoing, but reports from DOTs utilizing this technology have reported a reduction in the formation of ice pack buildup on the highway, doubling of blade life, and reduced noise. Iowa DOT has developed a segmented flexible blade they call the Milo FlexEdge for use on their standard truck moldboards mounted by means of an adapter strip. The 1 foot long segmented blade sections are mounted with rubber washers and are more adept at following the roadway contour, thereby delivering outstanding clearing capability with reduced noise. Iowa DOT fabricated a prototype internally, but was seeking industry interest to have their blade design commercialized. Several DOTs including Minnesota, North Dakota, Ohio, Illinois, and New Hampshire use one of the already commercially available segmented flexible blade systems. These systems are noticeably more complicated than the Milo FlexEdge system. Detailed specifications of the commercially available systems can be obtained at the following websites:

- VBL Valley Blades - PolarFlex
<http://www.valleyblades.com/polarflex/>
- Joma Articulating Blade System
<http://winterequipment.com/winter-joma-articulating-blade-system>

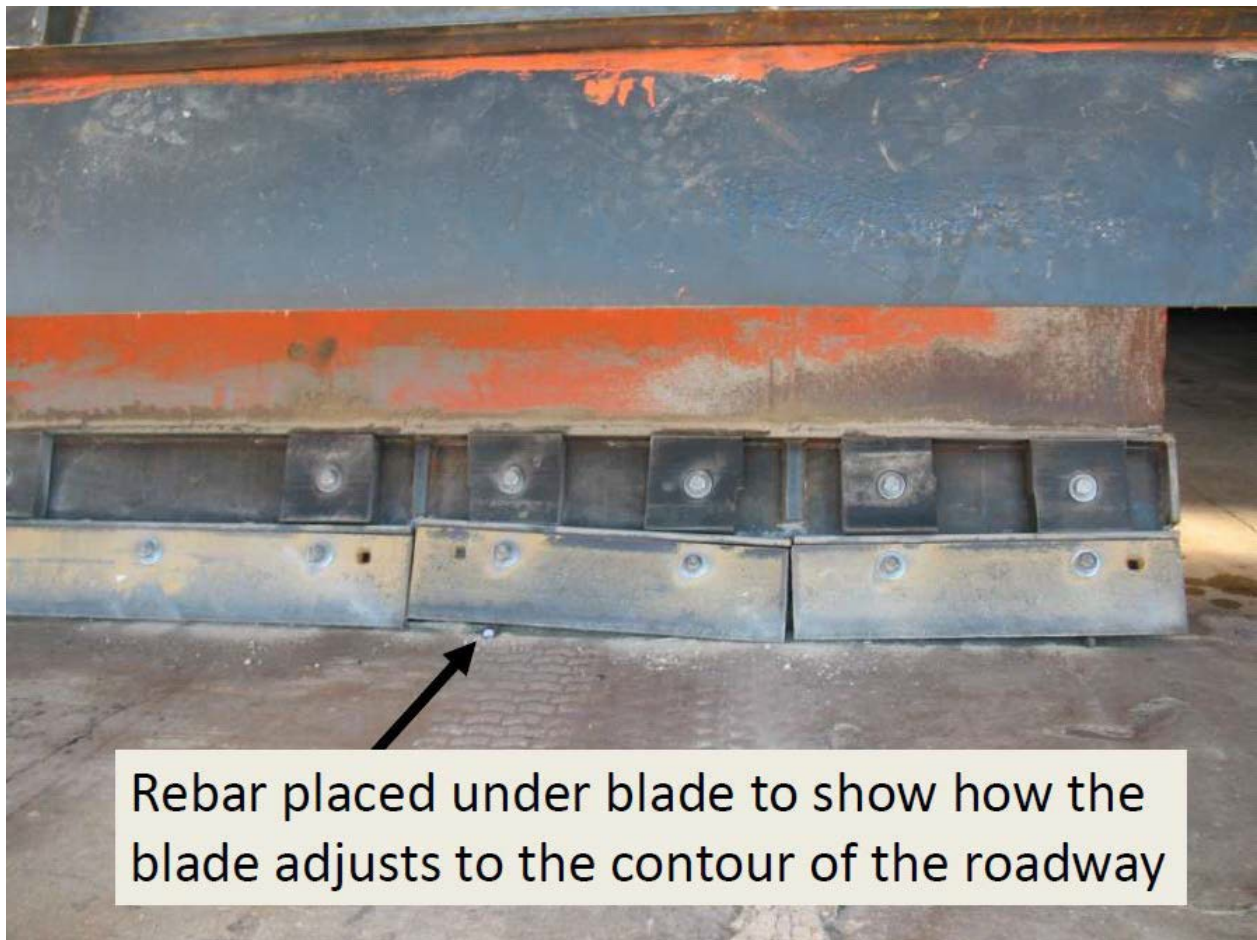


Fig 1. Segmented flexible blade¹

Serrated expendable cutting edges

These reversible, self-sharpening, consumable blades are readily available for plow trucks, graders, and wheel loader plow attachments. Versions of these blades vary from a single edge to various grooved profiles optimized for different levels of ice cutting capability. The Olofsfors Sharq P300 HD blade for graders and plow trucks contains grooves designed to cut down through compacted snow to break the pavement bond without pavement damage. Another product from Olofsfors, the Sharq Viking provides penetration in all ice conditions. It has an edge profile with long, thin, hard teeth that cut grooves through the thickest section of ice pack, effectively fracturing the pavement bond. Serrated ice cutting blades are often mounted in offset pairs to produce a flat single-pass cut. Olofsfors provides mounting boards that adapt to common moldboards for use with all Sharq-Edges products. The company website lists several types of ice cutting blades designed for a variety of applications:

- Olofsfors - Sharq_ <http://www.sharqedges.com/>

¹ Illowa peer Exchange, Davenport Maintenance Garage, Iowa DOT, <http://www.iowadot.gov/maintenance/pdf/1WelcomePlows.pdf>

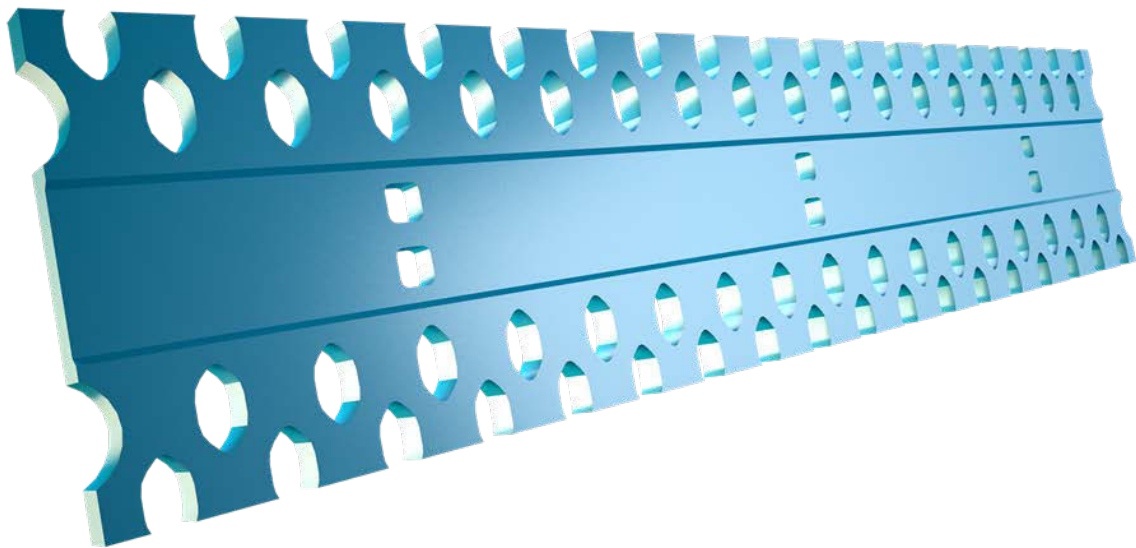
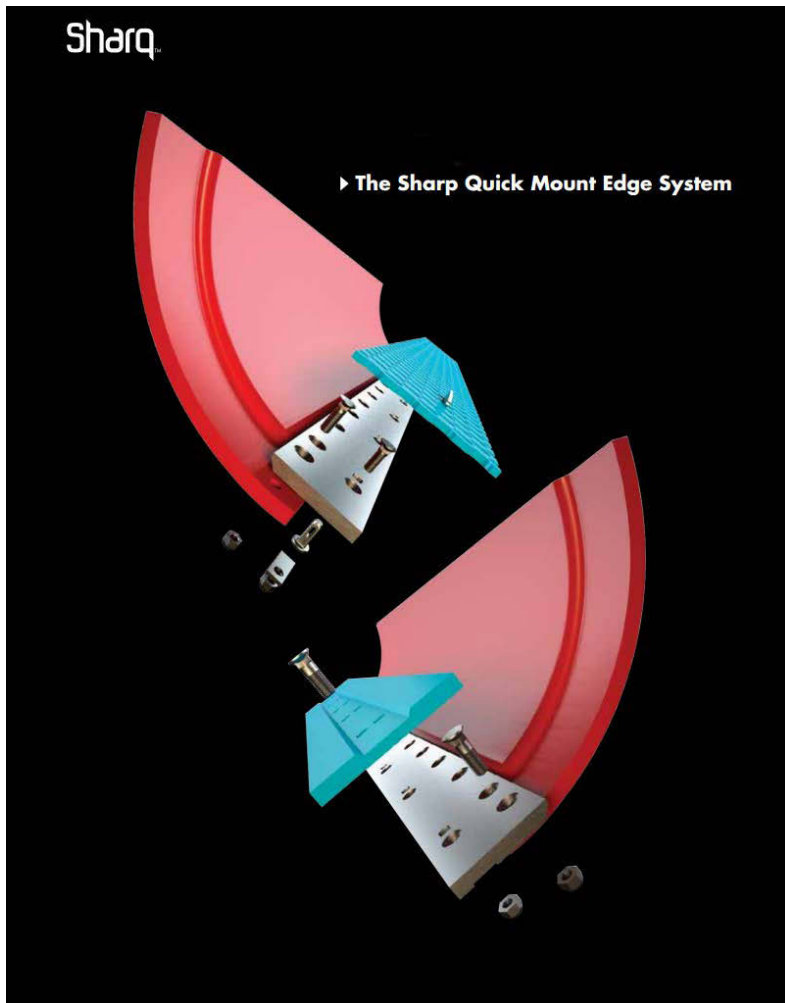


Fig 2. Serrated expendable cutting edges (courtesy Olofsfors – Sharq)

Adaptable Technologies

Multiple-blade plows

DOTs from the states of Iowa, Indiana, Wisconsin, and Minnesota have partnered in the development of multiple-blade plow technology² as illustrated in Figure 3. Initially, four major plow manufacturers built different versions of multiple-blade plows for testing customized primarily by state (Figure 4). Iowa tested the Flink³ plow, Minnesota tested the Henderson⁴ plow, Ohio tested the Henke⁵ reversible multi-blade plow, and Wisconsin tested the Monroe⁶ plow. Pennsylvania DOT uses a triple-blade reversible plow as well. In general, each state DOT favors a slightly different configuration related mainly to their specific winter road conditions; however, most include some type of controllable scarifier ice cutting blade section trailing a flexible snow-clearing front blade. Multi-blade systems appear to utilize standard mounts, but additional truck hydraulic circuits and controls would be necessary to control the added blades and functionality.

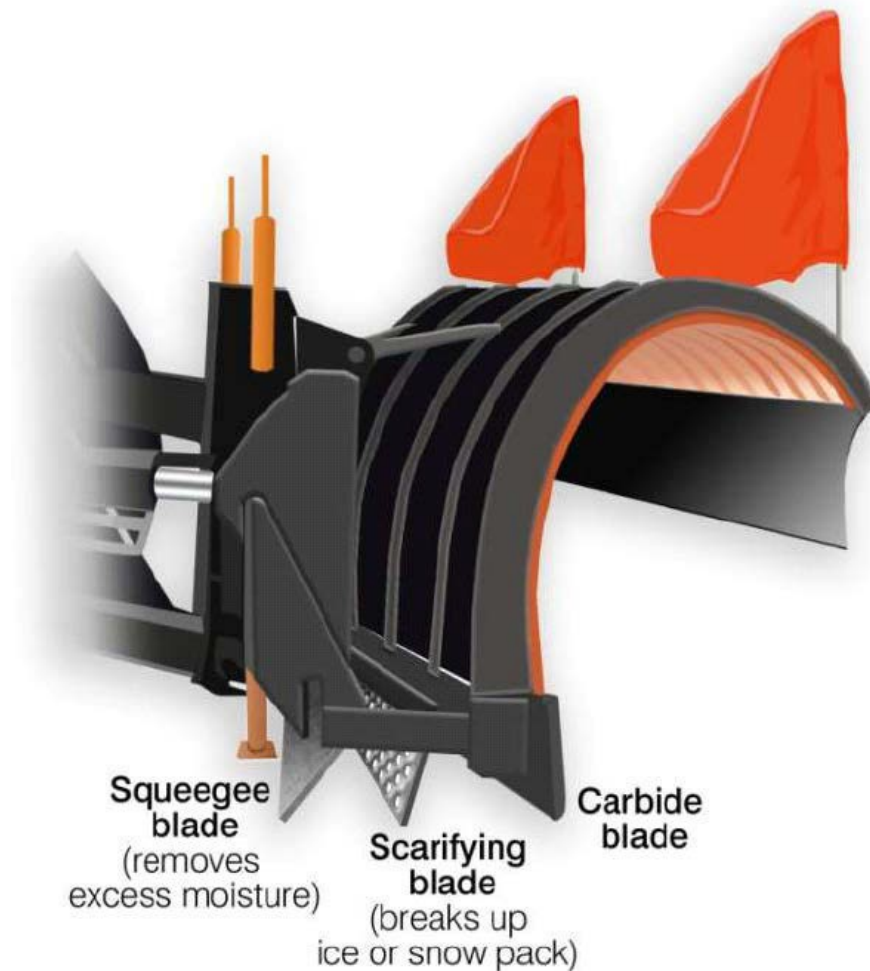


Fig 3. Multi-blade plow (courtesy Iowa DOT)

² CTC & Associates LLC, "Multiple-Blade Snowplow Project Final Report," December, 2010

³ <http://www.flinkco.com/>

⁴ <http://www.hendersonproducts.com/plowsf.html>

⁵ <http://henkemfg.com/>

⁶ <http://www.monroetruck.com/Products.aspx?category=153>

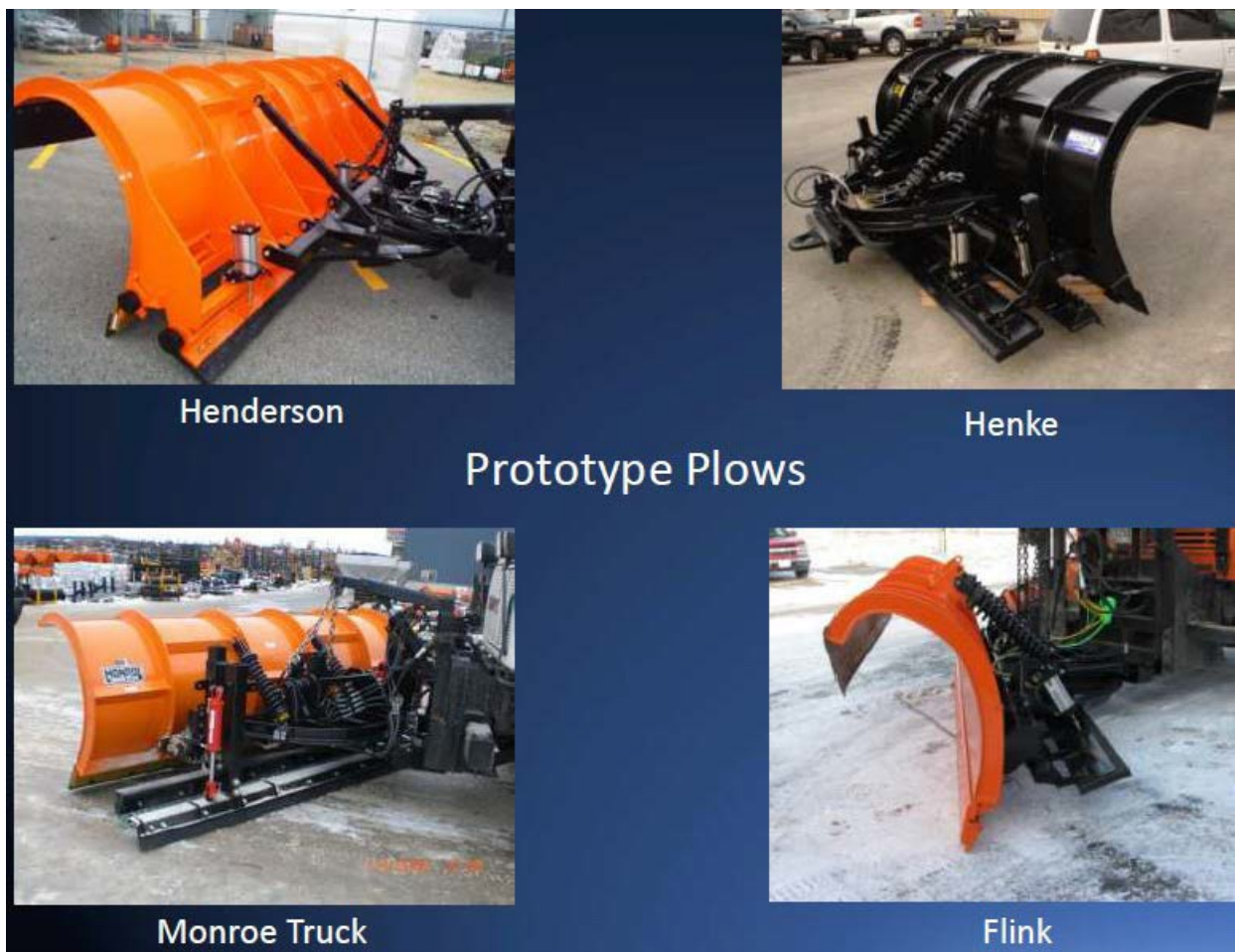


Fig 4. Multi-blade prototype plow designs for the four participating DOTs (courtesy Iowa DOT)

Optimizing blade scraping effectiveness

The University of Iowa conducted a detailed study to determine the optimal ice scraping blade parameters. A test device measured scraping performance under authentic winter conditions. Test results indicated that an ice cutting edge produces maximum scraping effectiveness with a 15 degree blade rake angle and a 23,000 lb blade down force. Front moldboards on plow trucks are customarily optimized for snow removal. A Strategic Highway Research Program-funded study places the optimal blade rake angle for snow removal at 40 degrees to minimize the snow packing effect⁷. Caltrans front moldboards have a blade rake angle set at approximately 25 degrees with a 2,000 lb floating weight blade down force. Therefore, to efficiently mechanically scrape ice, many state DOTs add an underbody ice scraper plow attachment with the specific ice cutting blade geometry to their conventional snowplow trucks.

Underbody scrapers

Many state DOTs, especially Michigan, Indiana, and Wisconsin, prefer to use underbody scrapers (see Figure 5) as opposed to the scarifying sections typically utilized in multi-plow configurations. Underbody plows can provide greater down force, but limiting or controlling the hydraulic down pressure is generally recommended. Underbody scrapers typically make use of

⁷ K.M. Pell, "An Improved Displacement Snowplow," SHRP-H-673, May, 1994

the 0 to 15 degree blade rake angle and high down pressures proven to produce optimal ice scraping effectiveness. Underbody truck plows are similar to graders, which Caltrans already utilizes in snow and ice clearing operations; however, the truck application is far more mobile on the highway. Research has been conducted in controlling the blade angle and down pressure automatically through the use of a computerized control system⁸. By calculating the current horizontal force, these systems are able to automatically adjust blade angle and down pressure when horizontal force drops below a specified value. The Quick Edge underbody plow cutting edge system was developed for the Minnesota DOT to simplify the task of routine blade replacement⁹. Augmenting a conventional snowplow with an underbody scraper attachment might offer superior ice scraping capability when needed in the existing Caltrans snowplow truck fleet. However, Caltrans has tested this previously, and operators do not like how the underbody scraper changes the vehicle dynamics. The scraper makes the truck hard to control and unpredictable in the mountains.



Fig 5. Underbody scraper (courtesy Meiren Engineering)

The following are examples of commercially available underbody scraper attachments:

- Monroe Underbody Scraper_
<http://www.monroetruck.com/Products.aspx?category=190>

⁸ G. Kochumman, C. Novotny, and A. Kruger, "Development of a Computer Controlled Underbody Plow," Technical Report No. 448, IIHR Hydroscience & Engineering, University of Iowa, January, 2006.

⁹ M. Etheridge and C. Shankwitz, "Quick Edge: Rapid Underbody Plow Cutting Edge Changing System," Technical Report No. MN/RC-2006-19, Minnesota Department of Transportation.

- Henke UBS Underbody Scraper
<http://henkemfg.com/truck/ubs-underbody-scraper/>

Developable Technologies

Penetration drum

A literature search did not produce any published research studies or systematic analysis of penetration drum-style devices, other than personal testimonials and sales literature. An unselected National Cooperative Highway Research Program (NCHRP) research problem submitted in 2012 titled “Sustainable Snow Removal System” briefly touched on the use of a mechanical device as part of the system. Alaska appears to be the only state DOT with experience utilizing a truck-mounted penetration drum to remove ice from highways. Alaska started with the Raiko attachment custom-mounted to a plow truck. No down pressure is applied by the front plow mount and no pavement damage has been observed. Initial highway testing of the ice breaking ability of the Raiko attachment was mixed, but favorable. In the same time frame, the Alaska DOT designed and built their own wheel loader-mounted prototype penetration drum attachment. It is based on a gang of standard carbide tipped planer drums mounted on an articulating frame.



Fig 6. Raiko Wheel Loader Attachment with Plow



Fig 7. Underbody Plow Truck with a Raiko Attachment in Operation (Alaska DOT)

Adding a trailing plow behind the penetration drum is a common enhancement. Raiko offers an integrated, small trailing plow option on their wheel loader version. In Figure 6, a serrated ice cutting blade can clearly be seen attached to the moldboard of this device. The Raiko equipped plow truck in Alaska is utilizing an underbody plow attachment as can be seen in Figure 7. A trailing plow blade is clearly useful in clearing away pulverized ice tailings and, by utilizing specialized ice cutting blades, could ostensibly augment ice scraping effectiveness.

- The commercially-available penetration drum device designed specifically for wheel loader duty is the Snow Lion Machine by Harbin Technology Development Co: <http://www.xsqdf.com/>
- The commercially-available penetration drum device for either wheel loader or grader duty is the Arctic Shark by Ultramech: <http://ultramech.com/products.html>
- The Raiko Icebreaker [sic] penetration drum device can be deployed on wheel loaders, graders, and plow trucks: <http://www.sah-ko.fi/raikomachines/jalleenmyyja-eng.html>

- The Lukewei Ice Breaking machine was designed especially for use on trucks: <http://en.lukewei.com/content/?107.html>

Gaps in Findings

We could find no guidance at the National or State level regarding utilization of penetration drum ice breaker devices for winter operations.

Next Steps

The Caltrans Division of Maintenance and Division of Equipment have a comprehensive understanding of snow fighting operations and a lengthy history of innovative equipment development and testing. Caltrans has knowledge, and in many cases, direct experience with many of the mechanical ice breaking technologies discussed. As such, Caltrans should first assess this knowledge and experience and use it as a foundation for future development. In addition, it may be prudent for Caltrans to identify key parameters essential to meeting their specific needs, for example:

- Characterization and scope of the ice pack problem on Caltrans highways. Caltrans has a good record of ice events, including ice-related closures in Districts 5, 7, and 11.
- The Caltrans specific requirements and performance specifications of effective mechanical ice breaking operations
- Caltrans expected areas of operation in the state and unique requirements
- Compatibilities to existing Caltrans procedures and fleet equipment
- Caltrans specific safety and legal/liability issues.

Information from additional studies and engineering analysis that might be helpful in evaluating the appropriateness of technologies suitable for Caltrans-specific application are as follows:

- Any comparison, testing, evaluation, and successful deployment strategies between the various different types of penetration drum devices
- Evaluations on synergistic benefits of utilizing specialized ice cutting blade technologies in a trailing plow configuration with a penetration drum attachment
- Ascertain if any study or test data proves the effectiveness of flexible plow blade systems in preventing ice pack formation on highways
- Cost benefit analysis of expendable type special purpose ice cutting blades when utilized as an auxiliary tool in association with a conventional snowplow truck or penetration device.

The Caltrans Division of Maintenance and Division of Equipment might consider the following steps when pursuing the addition of mechanical ice breaking capabilities to their snow fighting toolbox:

- Follow up with Alaska DOT to obtain additional information on their continued use and testing of ice breaker technology. Alaska appears to be the only DOT to test the Raiko penetration drum attachment and provided favorable reviews, but Alaska DOT also

undertook the effort to build a custom penetration drum attachment. Whether these projects occurred simultaneously or one device led to the development of the other may have a significant impact on how Caltrans views and chooses to utilize this technology.

- Characterize the specific challenges Caltrans faces regarding highway ice pack and establish benchmarks for the desired benefits and outcome. Identify where and when to deploy mechanical ice breakers for maximum benefit.
- Conduct engineering analysis on the suitability and effectiveness of the prevailing technologies as related to Caltrans specific needs
- Develop core concept strategies and configurations which apply, adapt, and/or combine mechanical ice breaking technologies to achieve the Caltrans desired outcome
- Present core strategies to Caltrans stakeholders for discussion
- Conduct detailed development of the preferred concept as designated by Caltrans stakeholders
- Submit detailed design to stakeholders for further development
- Procure commercial system if one meets Caltrans specific needs. If not, fabricate and develop design
- Conduct Caltrans field testing and evaluation
- Create cost benefit analysis.

Detailed Findings

Related Research and Resources

Mechanical Ice Scraping Studies

SHRP Report SHRP-H-346: Improved Cutting Edges for Ice Removal,

Wilfrid A. Nixon, August 1993.

Iowa Institute of Hydraulic Research, College of Engineering, University of Iowa.

Citation at <http://trid.trb.org/view.aspx?id=380787>

Measurement of Ice Scraping Forces on Snow-Plow Underbody Blades,

Wilfrid A. Nixon and James Potter, February 1997.

Iowa Department of Transportation Project HR 372 Final Report,

Iowa Institute of Hydraulic Research, College of Engineering, University of Iowa.

http://publications.iowa.gov/16268/1/IADOT_hr372_Measure_Ice_Scraping_Plow_Underbody_Blades_1997.pdf

Development of a Computer Controlled Underbody Plow,

Wilfrid A. Nixon, George Kochumman, Carrie Novotny, and Anton Kruger, January 2006.

Iowa Highway Research Board Project TR412,

Hydroscience & Engineering, College of Engineering, University of Iowa.

<http://www.iowadot.gov/research/reports/Year/2006/fullreports/tr412.pdf>

Flexible Blade System Studies

Evaluation of Snow Plow Blade Systems, Final Evaluation,

Andy Mastel, December 2011.

North Dakota Department of Transportation - Materials and Research Division,
Experimental Study MR 2010-03.

Citation at <http://trid.trb.org/view.aspx?id=1138477>

Snow Plow Cutting Edges for Improved Plowing Performance, Reduced Blade Wear and Reduced Surface Impacts,

Author: EVS, February 2011.

Minnesota Department of Transportation, Transportation Research Synthesis TRS1101.

<http://www.dot.state.mn.us/research/TRS/2010/TRS1101.pdf>

Underbody Plow Studies

Quick Edge: Rapid Underbody Plow Cutting Edge Changing System,

Michael Etheridge and Craig Shankwitz, July 2006.

Minnesota Department of Transportation, Research Section, Report Number MN/RC-2006-19.

http://conservancy.umn.edu/bitstream/handle/11299/151692/Mn_DOT2006-19.pdf?sequence=1&isAllowed=y

Multiple State Consortium Development of Multi-Blade Plows

Multiple-Blade Snowplow Project Final Report,

Authors: CTC & Associates LLC, December 2010.

<http://www.iowadot.gov/research/pdf/tpf218.pdf>

Consultation with State and International DOTs

A brief survey of the current practices was sent by Caltrans Division of Research, Innovation and System Information (DRISI) to selected State DOTs and other organizations based on the list provided by the Caltrans Winter Operation Coordinator.

The following survey questions were sent out by Caltrans DRISI to several State DOTs and other organizations:

1. What mechanical deicing technologies are out there in addition to the Snow Lion, the Arctic Shark, and the Raiko Icebreaker [sic]?
2. What is the cost to buy?
3. What is the cost to operate?
4. Do you know of other organizations that are using this technology?
5. How long have you utilized these device(s)?
6. Do you have any policy and or SOP for their use?
7. What are your observations? Can you tell us what works or doesn't work?
8. Can you provide a lesson learned of your operation utilizing these devices?

The following agencies responded to survey:

Alaska

Contacts: Shannon Conger, Administrative Officer I, Alaska DOT, 907-465-3903,
shannon.conger@alaska.gov

Mike Coffey, Chief, Statewide Maintenance and Operations, Alaska DOT, 907-465-3904,
mike.coffey@alaska.gov

1. SOA's experience is with the Raiko and Arctic Shark. We modified the Raiko hardware to enable us to mount on one of our plow trucks. No down pressure with a front plow mount so no pavement damage has been observed.
2. Raiko \$44K
Arctic Shark, Loader Mtd [Mounted] \$40K
Arctic Shark, Skid Steer Mtd [Mounted] \$21K
3. Very little; however Alaska has had milder winters than normal since we first got them.
4. No.
5. Since 2014
6. We do not. At this point we are working to find the parameters where they work best, what temperature, ice conditions, etc. We have found that the Raiko (mounted on a plow truck) seems to achieve the best results when we operate it in the 15-17 MPH range when ice buildup is significant.
7. These devices are not a 'magic bullet' in removing ice but can be very effective tools in the right application. They provide almost instant profile on glare, thick (1/4" or more) ice. Using this machine also provides a path for liquid deicers to reach the pavement and break the ice bond. We have also used the Raiko to remove hard pack snow that has bonded to the pavement after repeated snow events. We have used the Arctic Shark Skid Steer mounted device for sidewalks and paths with fair results.
8. These are good tools to have in the toolbox if freezing rain events are common. We estimate that one ice breaker has the same results on road surfaces as 6 motor graders equipped with serrated disposable cutting edges. Caution: When any of the ice breakers is engaged with the road surface turning movements must be kept to a minimum. The implements appear to be designed to move in a straight line. **Caution:** should be used when crossing railroads and bridge expansion joints.

Pennsylvania

Contacts: Daryl R. St. Clair, Maintenance Technical Leadership Division, Pennsylvania DOT,
717-214-1883, DSTCLAIR@pa.gov

"We manage to a Level of Service as to not allow ice to build up. If there ended up being thick ice we would follow a process as to restrict vehicles or close the road. There may be back roads where we use a grader".

Charles Goodhart, Director (retired), Bureau of Maintenance & Operations, Pennsylvania DOT,
charlesgoodhart407@comcast.net

"The ice removal equipment you found on the internet certainly will remove ice and snow but would undoubtedly damage the pavement markings, paint lines, raised pavement markings, pavement surface, etc. My premise was that we need to move snow removal and ice control to

be more sustainable, efficient, cost effective, etc. and reduce our carbon footprint at the same time. Winter services is a complex operation with a lot of parts. The objective of the research would be to compile all the various sundry modules of removing snow and ice from pavements, ascertain where the gaps or improvement prospects are, map out what needs to be developed, linked or adapted and create a sustainable systematic approach whose benefits can be measured and that optimizes the use of chemicals, optimizes the energy it takes to perform winter services, reduces highway accidents/fatalities, reduces tort liability risk, maintains or increases the level of winter service, increases the life of pavement markings-RPMs-paint lines, diminishes the damage to pavement surfaces and lessens deleterious impacts to the environment, highways, bridges, appurtenances and equipment.”

Ontario Ministry of Transportation, Canada

Contacts: Max Perchanok, Research Coordinator, Ontario Ministry of Transportation, / Chai, Winter Maintenance Committee, TRB, 416-235-4680, Max.Perchanok@ontario.ca

“No experience with these in Ontario, Canada. We apply course sand abrasives to improve traction when snow can’t be removed by plowing and salting.

Our lowest class, low volume roads in the north are maintained by plowing and sanding most of the winter and only cleared of snow in the spring or during a warm break in the winter. The next class up is restored from packed snow to center bare or wheel track bare by plowing and then applying salt at the centerline. The concentrated salt at the centerline cuts a channel through packed snow and eventually spreads outward, and with plowing the snow is cleared from the center out to the edges. It’s easier on the pavement than Transformer teeth”.

Case Studies

Alaska DOT - Raiko Icebreaker [sic] Testimonial:

The following excerpt was taken from published in the Feb 18, 2014 issue of American City and County Magazine titled “Snowbusters, Municipal methods for combating winter weather,” by Derek Prall.

- o <http://americancityandcounty.com/fleets/snowbusters>

According to Dan Schacher, the state of Alaska Department of Transportation’s maintenance supervisor in Fairbanks. “It’s definitely a tool we’re looking forward to using more,” he said as the Raiko Icebreaker device made it initial passes on Johansen Expressway, Airport Way and other high priority road.

Alaska DOT and Public Facilities Chief of Statewide Maintenance and Operations, Mike Coffey, says the ice breaker, purchased last fall, was part of a pilot program, and to his knowledge is the first of its kind in the U.S.

“It’s simple in design,” says Coffey, “It’s a big drum with teeth that you can attach to a snowplow, a loader or a grader.”

Coffey says he was searching for a solution for the heavy icepack that covers Fairbanks’ roads during the winter. “Traditional methods of scraping it with plows

wasn't [sic] really working," Coffey says. So instead of sticking to the time-consuming, ineffective method, he researched ways to break up the icepack, and, after browsing through YouTube videos of different techniques from around the globe, settled on the Finnish ice breaker from Raiko.

"[The ice breaker] isn't a silver bullet," says Coffey, "but after two or three passes, it does make a significant difference."

The benefits are noticeable. Coffey says multiple residents have told him they can tell a difference between roads that have been plowed using the ice breaker and those that haven't.

"It's been so successful I just bought two more," Coffey says, adding each ice breaker costs around \$40,000.

The US Department of Interior, National Park Service Office, and the Alaska Region Office awarded Yukon Equipment, INC. a contract to purchase a Raiko Icebreaker T15 model on May 28, 2015.

- o <https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=6e25f24684aaa198570f3dd7c59779c0&cvview=0>

Contacts

The following individuals were contacted to gather information for this investigation.

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