A3C09: Committee on Winter Maintenance
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Winter Highway Maintenance
A Look Forward

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The field of winter maintenance has advanced significantly in the United States during the past two decades. This advance began at least partly as a result of the Strategic Highway Research Program (SHRP). SHRP began in the mid-1980s and featured a number of projects directly related to winter maintenance.

From the work of SHRP grew the realization that U.S. technology in the field of winter maintenance lagged behind the technology used overseas. This realization led to two international scanning tours. The first, in 1994, visited Japan and several countries in Europe. The second, in 1998, visited additional European countries. These visits led to a renaissance of technology in the area of winter maintenance in the United States.

The new technology is concentrated in a few technical areas, which may be referred to as the "low-hanging fruit." These areas promise the most benefit for the smallest investment (of both funds and human resources, in terms of training and technology transfer). In this paper, our aim is to discuss the areas in which significant advances have been made and in which there is potential to make significant new advances. The areas to be considered are

- Weather forecasting;
- Anti-icing strategies;
- Novel tools, equipment, and techniques; and
- Training, education, and technology transfer.

WEATHER FORECASTING

Perhaps foremost in the areas of technology advancement is the whole field of weather forecasting. This area was revolutionized with the advent of Road Weather Information Systems (RWISs). These systems provide agencies with site-specific weather information that, in turn, provides a forecast for the state of the road surface. RWISs were not widely used in the United States a decade ago. Now, most state agencies have some sort of RWIS, and many maintenance garages have satellite terminals that provide real-time weather information at a level of detail that was unimaginable 10 years ago.

Nor is this advancement complete. The intended audience for much of the weather information now developed in national models is not the winter maintenance community. Forecasts often deal with weather at an elevation of 10 meters above ground, which can be crucial, but work is now under way to develop forecasts specifically aimed at ground-level weather. Progress toward this goal should dramatically improve the value and accuracy of road-condition forecasts.

The technology behind the sensors that are used in RWIS stations is relatively mature. The sensors have been refined so that they are now reliable and accurate. A novel trend today is toward using snow-plowing trucks as mobile sensor platforms. In recent years, the concept of mounting infrared thermometers on trucks to provide real-time pavement temperatures to operators has been implemented in several locales.

Such sensors still pose challenges. They measure the emissivity of the surface at which they are pointed, and thus will give different temperature readings for surfaces of different colors, even when those surfaces are at the same temperature. The necessary ruggedness of this delicate sensor, which must be placed in a hostile and unforgiving environment, is another concern. Nonetheless, the responses of operators of trucks equipped with these sensors have been very positive.

The temperature readings and RWIS forecasts are not an end in themselves but merely tools in the winter maintenance toolbox. The information must be provided to the end user, and significant work is currently being done in this area. One of the more novel uses of this information is to control variable-message speed limit signs under adverse winter weather conditions. Experiments using this technology are being conducted in Nevada and in Finland, and results to date suggest considerable success.

Future developments in this area probably will follow the information path that the applications suggest. It is important to get information about road and weather conditions to maintenance workers and road users as quickly as possible. Several methods are being considered for transferring information. Some metropolitan areas (e.g., the Twin Cities in Minnesota) are sharing video images with local TV stations to provide real-time information about road and traffic conditions. Other agencies (e.g., Montgomery County, Maryland) have web pages that contain relevant and timely information about winter weather conditions.

Major challenges that remain to be addressed in this area include

- Bringing forecasts down to road level,
- Developing reliable mobile sensor systems,
- Using the data collected in real-time control applications, and
- Sharing the information swiftly and effectively with all possible end users.

ANTI-ICING STRATEGIES

One of the major changes to come from the SHRP studies was the implementation of anti-icing as a strategy for winter maintenance. The typical approach to dealing with snow and ice on the road has been to wait until a certain amount of snow has fallen (usually 1 to 2 inches) and then go out and treat the road by plowing and applying deicing chemicals. This reactive approach often gives rise to road conditions that are less than optimal at the onset of a storm, because snow-melting chemicals must “burn through” already fallen precipitation to reach the road surface.

In contrast to the traditional strategy, anti-icing requires that an agency place chemicals on the road surface just before the start of precipitation. These chemicals prevent the formation of a bond between snow and pavement. As a result, snow plowing is easier and more effective, and effects are immediate. Anti-icing strategies can potentially provide a much-improved level of service to road users, but many challenges remain to be met before this goal can be achieved.

Primary among these challenges is the ability to determine when anti-icing treatment should begin. Clearly, such knowledge derives from improved weather forecasting. To effectively treat a stretch of road in an anti-icing mode, maintenance professionals need accurate forecast information about the start of the storm. In general, anti-icing should not begin much more than four hours before a storm starts (unless it is for frost treatment, which is a very different situation).

Additionally, anti-icing makes use of liquid chemicals as well as solid (pellet or granular) chemicals. The advantages of liquids are that they spread across the road more evenly and do not bounce off or get swept off the roadway during or after application. However, the choice between liquid and solid chemical application is difficult and can, under certain circumstances, be highly dependent on conditions.

The extensive and novel use of liquid chemicals has posed several challenges that are in the process of being met. These challenges include making and storing sufficient quantities of the chemicals to provide service throughout a storm event.

The usual application rate of liquid anti-icing chemicals is 25–50 gallons per lane mile (i.e., per mile, per lane), and spray devices can cover three lanes simultaneously. Thus, one single pass on a three-lane highway may deliver of up to 150 gallons per lane mile, and a route of 30 lane miles might require up to 4,500 gallons of chemical. This amount is not easily stored on a regular tandem-axle dump truck. To address this concern, both Missouri and Iowa have developed spray trucks based on tanker trucks. The trucks were deployed during the 1998–99 season and have performed well to date.

The major challenge in the area of anti-icing is implementing a radically new strategy across an entire agency, rather than in one or two locations, where it is enthusiastically received. Some states are already implementing anti-icing in whole parts of their system. One example is Iowa, which implemented anti-icing strategies on all interstate routes during the 1998–99 winter.

Issues that must be addressed in meeting this challenge include

- Obtaining accurate and timely information about the onset of storms;
- Defining new and improved techniques for the manufacture, storage, and use of liquid anti-icing chemicals;
- Developing specialized equipment capable of delivering liquid chemicals over long routes; and
- Implementing appropriate methods for the wide-scale deployment of anti-icing techniques for all sizes and types of agencies.

NOVEL TOOLS, EQUIPMENT, AND TECHNIQUES

Much new equipment has appeared in the area of winter maintenance during recent years. A major study to investigate the effectiveness of these new pieces of equipment is the Concept Vehicle Project, undertaken by Iowa, Minnesota, and Michigan. Each of the three states has built and equipped a truck to test novel equipment in field conditions. Equipment tested includes friction-measuring devices, Global Positioning System (GPS) locators, engine power boosters, and special chemical application systems.

As might be expected, not all of the equipment has performed well under all circumstances. However, most equipment has shown promising results, and some has been well-received. The use of vehicle-mounted thermometers, for example, has been considerable, despite concerns about their reliability and accuracy. Operators welcome the devices because they provide valuable information about road conditions. The benefits that the equipment provides far outweigh the difficulties it poses.

One challenge that develops as more equipment is added to trucks is ensuring that operators do not become overloaded by all the information supplied to them. Several approaches are being considered to address this problem, such as using automation to control a range of activities that have previously been handled by the truck operator. By using fuzzy logic and other "smart" programming techniques, very effective control systems can be developed.

The GPS also is being tested in an extensive study in Virginia. The possibility of knowing where all trucks are at a point in time—as well as where they have been, and what they have done—is of enormous value to dispatchers and others who must deal with the public during a storm. It also raises the possibility of being able to adjust winter maintenance activities during a storm in response to data from the field.

Making the act of winter maintenance more manageable falls under the developing concept of "total storm management." It offers the possibility of much more flexible approaches to winter service and thus much more efficient use of resources.

The major challenges that remain to be addressed in this area include

- Testing and refining new equipment for use on snow-plowing trucks,
- Automating equipment control on snow-plowing trucks to reduce operator burdens,
- Improving cab ergonomics to reduce operator fatigue,
- Finding ways to use GPS and other similar systems to provide more information about truck fleet deployment, and
- Developing the equipment and techniques to provide managers and operators the ability to conduct total storm management.

TRAINING, EDUCATION, AND TECHNOLOGY TRANSFER

The recent emergence of new technology brings with it significant challenges in training workers to use new equipment and techniques. Considerable effort has been expended in the area of training, and more is under way. Perhaps the most significant approach used to date is the "train the trainer" technique, whereby operators and other end users of new technologies are trained, then dispatched to train their peers. This approach has worked well and probably will be continued and expanded.

Technology transfer has been significantly enhanced by use of computers. A simple but effective step in this regard was the establishment of an e-mail–based Listserv in 1997. This Listserv (the snow and ice mailing list snow-ice@list.uiowa.edu) has several hundred subscribers from around the world and provides a forum for the discussion of topics related to winter maintenance. Users state that it is a quick and easy way to find expertise in almost any area of winter maintenance or to find that your area of interest is one in which little or nothing is known.

The Internet provides some useful tools. The American Association of State Highway and Transportation Officials Lead States program has developed an anti-icing website (http://leadstates.tamu.edu/) that includes a database of publications, personnel, and field experience. The Federal Highway Administration also maintains a website (http://www.ota.fhwa.dot.gov/icing) that contains useful information. In addition, many agencies maintain websites to inform the public of winter weather situations and associated road conditions.

The value of a website as a tool lies primarily in the timeliness of the posted information. It is surprisingly time-consuming to gather and post information on the Internet, and the effort should not be underestimated. Nonetheless, the web clearly has a role to play in technology transfer. The challenges in this regard are whether people will expend the effort needed to make websites work by keeping them current and providing useful information.

With regard to education, maintenance issues are typically slighted (compared with design issues) in college curricula. However, in addition to short courses and seminars that have long been offered, graduate level engineering classes are being developed (and offered via the web) in the field of winter highway maintenance. This development suggests that the importance of maintenance is beginning to be acknowledged in the field of engineering and is a promising development.

The primary challenges to be addressed in this area include

- Encouraging the use of existing communication and technology transfer among the winter service community,
- Developing and implementing new means of communication to educate and train the community more effectively,
- Finding new and effective means of communicating winter information to the road-using public, and
- Bringing winter service methods and technology into the educational field through coursework and other methods.

MAJOR FUTURE CHALLENGES

In addition to the challenges already identified, a few challenges will face the winter maintenance community in coming years:

- Changing the current concept of winter maintenance to one of “winter service”;
- Defining appropriate benchmarks for winter service activities, so that full-blown quality approaches may be used in keeping roads clear during winter storms;
- Developing effective and timely methods for informing the general public about road conditions during winter storms; and
- Determining appropriate areas for long-term, high-risk, high-return research to allow winter service to continue to develop into the next millennium.

Winter service is a process whereby agencies serve the public by maintaining a safe road system under winter weather conditions. This challenge has many aspects to it, which include developing service benchmarks and improving public information.

Developing benchmarks for measuring performance in a given situation will require creating a way to measure the severity of a storm in terms of how difficult it is to keep roads clear and serviced during that storm.

If the public is kept aware of and informed about a winter storm and about the progress made in dealing with its effects, then clean-up activities may be easier. Although such aspects are not typical engineering concerns, they are very real issues that the winter maintenance community must consider and address.

Identifying long-range research is important because no studies under way have 10- to 20-year time frames for payback. Most of the developments discussed here have been closer to development and implementation than to pure research. The reason for this short-term focus in the winter maintenance field is that there is so much low-hanging fruit to be picked. Much of the work during the past 5 years—and most likely in the next 5—will center on implementing existing technology or making small (but important) enhancements to it.

The solutions currently being pursued are evolutionary changes in current methods, and they will bring improvements to a point. At some stage, revolutionary change will be needed to advance, and it will take place only if people are undertaking high-risk research. This process may need to be jump-started by way of a workshop at which novel concepts are brainstormed and prioritized for eventual funding and research.

CONCLUSIONS

The field of winter maintenance has progressed significantly during the past 10 years, and the state of the art suggests that a similar level of advancement could be seen over the next 5 to 10 years. More sophisticated techniques and equipment allow a much more flexible, efficient, and effective approach to dealing with winter weather. The future is very bright and filled with a broad range of challenges.