Case Study # 3

Accident Reduction on the 401/416 Ramp using Fixed Automated Spray Technology (FAST)

Overview

Facts:

Location: Hwy. 401 ramp to Hwy. 416, near Prescott, Ontario

Average Annual Snow Fall: ~199cm

Average Winter Temperature: -5.2ºC (December to March)

Total Length of Bridge (serviced): 165 metres long, 11.2 metres wide,

Level of Service Standard: Bare pavement

A number of weather-related accidents occurred during the first winter following the construction of the Highway 401/416 interchange ramp near Prescott, Ontario. The Ministry of Transportation of Ontario (MTO) had been investigating different methods of improving highway safety during winter storms and saw an opportunity to significantly reduce the potential for icing on the ramp. In the fall of 2000, MTO installed Fixed Automated Spray Technology (FAST) along with an Advanced Road Weather Information System (ARWIS), which work together to apply anti-icing chemical in advance of an icing condition. Since the installation of these systems, no winter-related accidents have occurred at this location.

Background

Research and experience has shown that early pro-active treatment of road or bridge surfaces with an anti-icing chemical or an abrasive can significantly reduce accidents caused by the loss of traction on icy driving surfaces.

A technology now exists to provide a pro-active and timely application of anti-icing chemicals before icing conditions develop. The technology is known as FAST, which is an acronym for Fixed Automated Spray Technology. A FAST system continuously monitors conditions on a bridge or roadway surface and sprays anti-icing chemical onto the driving surface just in advance of icing conditions. The system continues to spray until sufficient chemical has been applied to address the freezing condition. The benefits of the automatic features of the system include: an immediate response time, enhanced roadway safety, reduced chemical wastage and reduced salt damage to the structure.

The construction of the elevated ramp from Highway 401 to Highway 416 was completed in September 1999. Due to its proximity to the St Lawrence River, the deck of the ramp is exposed to winds that have high moisture content. As is the

case with many bridges, the deck tends to freeze before the rest of the adjacent highway sections. Often motorists traveling eastbound and exiting onto the ramp were travelling from unfrozen to frozen conditions at highway speeds. In the year prior to installation of the FAST system, 14 winter-related accidents were recorded on the ramp. Since the maintenance yard servicing this ramp was some distance away, winter maintenance crews had no way of knowing when icing conditions were occurring on the ramp without first going to the site. The Ministry wanted to improve its response time for icing situations and eliminate unnecessary trips to the site. The Ministry had been researching the feasibility of using FAST in Ontario for a number of years and, given the climate, the collision experience and the remoteness of the site, chose this location for a demonstration project.

Source: MTO

Description of Winter Maintenance Practices

FAST

Fixed **A**utomated **S**pray **T**echnology was originally developed in Europe to handle winter conditions such as those that exist on the Highway 401/416 ramp. The technology is relatively new to North America. Although the design concepts are relatively simple, the technology that makes it work is complex. The system requires state-of-the-art weather and pavement sensing systems and some artificial intelligence in the form of a computer algorithm that determines when to activate the spray system. The system design is relatively straightforward except for the location of the spray heads. To effectively cover the road surface, the design has to take into consideration the span, cross section and crossfall of the bridge and how the tracking/spreading characteristics of vehicles can help distribute the anti-icing chemical.

The anti-icing chemical is sprayed from spray heads flush-mounted in the pavement. The Ministry chose to retrofit the spray head into the deck over the alternative of surface mounting them on the parapet wall of the ramp. The chemical is sprayed at a low angle so passing vehicles are not affected by their operation. The chemical is stored in a pump house located close to the ramp that also houses the computer, the mechanical/hydraulic hardware and the electronics of the system. The piping and wiring were surface mounted outside the parapet wall or under the deck to maintain the aesthetic of the original design.

Two systems are used to detect the potential icing condition and activate the spray system. Adjacent to the ramp is an Advance Roadway Weather

Information System (ARWIS), which monitors the conditions of the air flowing around the ramp, feeding information on air temperature, wind speed and direction, relative humidity, and estimated dew point to the system computer. A second detection system is installed in the pavement on the ramp. This system relays information to the computer on the temperature of the pavement, the presence of moisture and whether there is anti-icing chemical on the surface of the pavement.

The computer is programmed with software that monitors all of the sensor inputs. If sensors indicate the presence of moisture, a freezing road surface and insufficient chemical present, the system is activated and sprays the pavement with anti-icing chemical. The system will re-spray if the chemical sensors report insufficient chemical in the surface water solution to prevent freezing.

The chemical is purchased and delivered to the site and the refill interval is determined by the amount of chemical used and the storage capacity. The amount used will vary from season to season depending on the severity of the winter. Usage will vary from site to site as well according to local climate.

It is important to understand that FAST systems do not eliminate the need for plowing and that accumulate snow still must be plowed with traditional technology. The anti-icing chemical will prevent the snow from bonding to the ramp surface to make plowing more efficient. The flush mounted spray heads are unaffected by the plows and, if buried in a snow windrow, the spray has sufficient pressure to blow through the snow. If the deck sensors do not detect the chemical after a spray cycle, the system will reactivate assuming some sort of blockage.

Anti-icing Chemical

The manufacturers of the FAST systems design them to operate with a variety of anti-icing chemicals. The Ministry selected potassium acetate to use in the system on the Highway 401/416 ramp.

Potassium acetate is a de-icing/anti-icing liquid chemical used for highways and airport runways because of its low freeze point and the reduced risk it poses to the environment and aircraft. Potassium acetate is most effective when applied uniformly to surfaces before freezing precipitation. Re-application may be necessary if snow and ice begin to bond to the surface. According to the manufacturer, the advantages of potassium acetate over other chemicals are:

- High performance;
- Excellent anti-icing and de-icing characteristics;
- Long lasting; requiring fewer applications;
- Safe for steel and concrete structures;
- Nonflammable;
- Non-toxic to vegetation and animals;
- Low freezing point (-60ºC);
- Low Biological Oxygen Demand (BOD) in water.

The system was installed in September 2000 and the commissioning of the final components was completed in mid-October 2000. The FAST system coverage is 1784.5 m^2 on the bridge and 190 m^2 on the approach to the bridge for a total of 1974.5 m^2. The treatment of the approaches is necessary to reduce contamination due to tracking of sodium chloride from the adjacent highways.

Costs

The following outlines the estimated cost for a complete system provided and fully installed at the subject site based on a conceptual design by the vendor. Since this was a demonstration project, the costs were less than those that would be incurred for a normal installation. Subsequent projects are likely to be priced higher.

Design, Construction, Project Management & Commissioning

The total final cost for the facility including the design, construction, project management and commissioning of the ARWIS system, the spray system and the chemical storage facilities was approximately $300,000 or $153/$m^2$.

Annual Operating Costs

The annual operating cost includes the chemical costs, monthly monitoring/reporting, site inspections, maintenance and utility costs. The variable costs (chemicals and utilities) will depend on the severity and nature of the winter. For example, over a 3-year period, the annual chemical cost ranged from $12,000 to $15,000. The annual operating costs are approximately $30,000.

Benefits

There is no direct cost reduction benefit for the Ministry since FAST systems are far more expensive to implement than the traditional spreader truck and de-icing technology. However, there are significant societal and environmental benefits. The following outlines the estimated benefit of installing the FAST system at this location. The benefits presented below were not actually observed, but rather

have been predicted based on assumptions developed by Environment Canada for its Compendium of Cost Benefit Indicators[1].

Collision Avoidance

The collision avoidance during the first year of operation, based on the previous year's experience, was 14 and no other winter related collisions have occurred since completion.

A Traffic Safety Report (MTO, 2000) estimated that of all accidents, 0.31% result in fatalities, 23.8% result in injuries and 62.6 % result in damages (Note: because of the geometry of a bridge, it is assumed that all accidents will result in damage). The estimated cost for these accidents is: $1,600,000 for a fatality, $28,600 for an injury, $5,700 for damages.

Using the 14 accidents recorded in the first year, we can calculate the first year societal benefits in total dollars:

Fatalities: 0 x $1,600,000 = …….. ……... $0

Injuries: 3 x $28,600 = …….. $85,800

Damages: 14 x $5,700 = …… ……. $79,800

Total: $165,000

Reduced Liability

With legal judgements against road authorities increasing, the current liability exposure for owners of highways systems can be in the millions of dollars for a single claim. It is difficult to estimate savings from the reduction of liability.

Environmental Benefits

Anti-icing with potassium acetate has reduced the chloride release by 100 percent over that which would have occurred with traditional methods using salt. Using the MTO application rates for road salt (130kg/2-lane km), the ramp would receive between 1 and 2 tonnes of salt per year depending on the severity and nature of the weather. The chloride reduction from eliminating salt use is in the range of 600 to 1200 kg per year[2]. It is difficult to quantify the resultant environmental benefits from this reduction in chloride use.

[1] Winter Road Maintenance Activities and the Use of Road Salts in Canada: A Compendium of Costs and Benefits Indicators - Environment Canada, Regulatory and Economic Analysis Branch, 2002.

[2] A kilogram of road salt (NaCl) produces a chloride (Cl–) load of 0.6066 kilograms.

Reduced Corrosion[3]

Potassium Acetate is less corrosive than sodium chloride. This feature will increase the life span of the ramp through reduced corrosion of the concrete and steel in the deck. As a result, fewer maintenance interventions can be anticipated during the life cycle of the structure.

It has been estimated that 1.5%[1] of existing bridge surfaces need to be repaired annually because of road salt damage. The cost to carry out spot repairs on the bridges is estimated to be $763 per m^2. If no salt damage occurs until 15 years after the build date and then it occurs at 1.5% per year until the 30-year full rehabilitation date, the salt damage repair cost can be estimated to be $317,000 in 2004 dollars. Annualized over the 30-year period, the saving is approximately $10,666 per year.

The 30-year estimate is based on the life span of the bridges built in the 1970's. The life span and rehabilitation dates of the structures being constructed today are unknown. Current concrete, concrete reinforcement and asphalt technology has moved forward and is more resistant to road salt damage than previously.

Reduced Travel Delays

The ramp cross-section has one lane and two widened paved shoulders. Any severe collision on the structure would require a full closure detouring traffic to alternate routes adding to motorists' delays and travel times. Since the average annual daily traffic is 3000 vehicles we can assume that the hourly daily traffic is approximately 175 vehicles[4] . If we assume that each accident will delay traffic for an average of 3 hours, then each accident can result in 524 person-hours of delay. Based on a cost of $27/hr/worker for lost wages due to lateness the cost of delay is $14,148 per accident. Using the 14 accidents recorded in the first year we can estimate the benefit to be $198,072.

Cost/Benefit Assessment

The following table summarizes the monetized costs and benefits discussed previously. The benefit to cost ratio is approximately 1.13 : 1 for these monetized costs and benefits. The investment in the FAST system at the Highway 401/416 ramp was paid back in one year. The benefits listed below are understated because they do not include numbers for environmental benefits or reduced liability. Therefore, the benefit/cost ratio is also understated.

[3] The corrosion reduction has been annualized over the 30-year life of the bridge.
[4] Assumes that most of the traffic occurs during the 17 hour period from 6 a.m. to 11 p.m.

Costs	
Design, Construction, Commissioning	$300,000
Operating	$30,000
Total Costs	$330,000

Benefits	
Collision Avoidance	$165,600
Reduced Corrosion	$10,666
Reduced Travel Delays	$198,072
Total Benefits	$374,338

Conclusions

The installation of the FAST system resulted in a 100% reduction in accidents on the Highway 401/416 ramp. It also eliminated the use of road salts containing chlorides at this location, which results in benefits to the environment and increases the life of the ramp. The benefit/cost analysis shows that the investment was recovered in the first year of operation. Recognizing these benefits, the Ministry of Transportation of Ontario has proceeded with plans to install similar systems elsewhere in the province.

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This Case Study is part of a series on Road Salt Management.