EFFECT OF USING ADVANCED WINTER MAINTENANCE TECHNOLOGIES ON ACCIDENT RATES IN THE REGION OF OTTAWA-CARLETON

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1. Abstract

Winter maintenance of a road network is sizable challenge for any road authority, meeting this challenge requires a systematic approach as a well as being innovative and ever-improving the agency’s maintenance operation.

Increasing budgetary limitations, requirement to streamline municipal services, heightened awareness of environmental issues, and the availability of new technologies are but only few reasons that prompted the Right-of-way branch at the Infrastructure Division, at the Environment and Transportation department of the Regional Municipality of Ottawa-Carleton to seriously consider advanced technologies in roadway winter maintenance to achieve its mandated service requirements. Advanced technologies were introduced into the Region toward the end of 1996.

While several technologies have been introduced into the winter maintenance, this paper will be concerned with Road Weather Information System (RWIS), mobile pavement temperature sensors, pre-wetting and anti-icing techniques. A description of the technology introduces as well as an explanation of the thought process and the rational behind the introduction of each technology.

Finally, the impact of technological advancement within the winter maintenance operation at the Region of Ottawa-Carleton is examined from the point of view of vehicle accident rates relating to winter conditions before and after the implementation of the above-mentioned technologies.

2. Introduction

Road authorities are always challenged with maintaining a safe, reliable road network for the movement of people and goods. The challenge is even greater when the road are in an area with active winter weather, that generate hazardous road conditions such as snow and ice-covered roads, or reduced visibility due to drifting or blowing snow. That challenge is a recurring one with the arrival of the winter season every year.

To meet the challenge of safe and accessible roads during inclement weather conditions road authorities have been establishing systems, policies and procedures, as well, equipment manufactures have been developing and making equipment to suite these challenges. It can be safely claimed that snow and ice control forms the largest single item of any winter maintenance operation’s budget.

With concerns of winter maintenance expenditures, come concerns for safety, the environment, animal and plant life, along with technological advancements the traditional winter maintenance operation is changing. Through this paper some of the traditional approaches; technologies available for the operation and their general impact will be touched upon.

While several technologies and operational innovations and improvements have been introduced into the winter maintenance section at the former RMOC, it is not possible to cover it all in a desirable detailed level in one paper. Therefore, this paper will be concerned most with the introduction of the Road Weather Information System, mobile pavement temperature sensors, pre-wetting and anti-icing techniques.

Moreover, while there are many indicators that can be studies for impact of technological advancement in the field, this paper will be concerned with one aspect, which is the vehicle accident (crash) rate relating to winter conditions in the former Region of Ottawa-Carleton, which since January 1st 2001 has been part of the new City of Ottawa.

3. Winter Maintenance Operation

The concept of traditional snow and ice control (snow fighting) is to wait until the snow fall starts, and some accumulation has occurred, and then mobilize equipment and resources to remove the snow from the road surface. Road salt is usually applied to prevent the remaining film of snow and/or liquid form freezing and forming a layer of ice, known to be dangerous to vehicles and drivers on the road.

Each operation has an objective; the objective of a roadway winter maintenance operation may be defined to be "Maintain adequate road access for safe passage of traffic in a timely and cost-effective manner". However, a more simplified operational objective for roadway winter maintenance providers would be “to use the Right material, in the Right amount, at the Right time, in the Right place”. Such an objective will form basis for a more cost-effective and efficient operations, not to mention a more safe, and environmentally conscious one.

Winter maintenance operations include snow and ice control measures such as snow plowing, snow removal, salting (de-icing) and sanding. The mechanical movement of snow through plowing and removal are reactive in nature and they are strictly physical treatment of snow and ice condition of the road. As well the application of sand is mechanical, where the purpose would be to increase friction between the vehicle and the road by increasing traction with the pavement through the application of sand.

On the other hand, the application of salt, or any other material with similar characteristics, is chemical treatment of the snow and ice covered road. The purpose of adding such chemicals is to depress the freezing point of the resultant solution on the road surface to be less of that of the pavement temperature. And not allow ice to form where the chemical, known also as deicers, have been applied. Further precipitation of snow will dilute the formed solution on the road, which would require the re-application of the material to renew the concentration of the chemical and maintain its effectiveness to depress the freezing point.

Another division can be seen in winter maintenance operation is the timing of treatment. The mechanical treatments are generally reactionary, and they are applied after the snow and ice had accumulated on the road. However, the application of deicing materials can be reactionary or it can be proactive.

Being proactive with roadway winter maintenance operation means that a major shift in mentality, as well as having the proper tools, and address the main issues and key factor that have the largest impact on the operation. A reactive approach would be centred on breaking the bond that had already formed between the pavement and snow; that technique is known as “de-icing operation”.

However, a proactive approach would be centered on preventing the ice-pavement bond from forming rather than break the bond later with properly more material and effort, that technique is known as “anti-icing operation”. As well, a proactive approach will allow for the adoption of an In-time service delivery model and a well-integrated maintenance operation.

4. Advanced Winter Maintenance Operation

An advanced roadway winter maintenance operation is one that utilizes different tools while adopting technologies at varying scales to achieve a well-integrated, efficient, and cost-effective maintenance operation.

Establishing key factors in one’s operation will allow for proper planning and adoptions of the proper tools within the operation. One of the key elements that were missing in winter maintenance is pavement surface temperature. It is in fact the temperature that affects the chemical and its application, not air temperature, since the contact is occurring at the road surface. Pavement temperature is a key factor in the decision on type and application of materials used for snow and ice control.

Therefore, the need to monitor pavement temperature for the purpose of snow and ice control material application is established. Several technologies are available to allow a road authority to monitor pavement temperature. Among these technologies are infrared temperature sensors, hand-held or vehicle-mounted. More elaborate systems such as Road Weather Information Systems (RWIS) helps to monitor road condition, live or near live. In addition, the information collected via the RWIS can be used in developing fairly accurate road condition forecasting.

Such systems are referred to as "Decision Support" systems. They allow for less guesswork and more informed decisions for winter maintenance operations. Decision support systems may include pavement temperature monitors, RWIS, Road condition forecasting, route optimization, and other technologies that serve similar purposes. All of which has to be sublimated with proper training, as it is vital to the success of operation; training should include the various levels of the organizations, form supervisory staff and spreader operators to the politicians, contractors, and the media.

5. Mobile Infrared Temperature Sensors

Hand-held infrared thermometers were introduces on experimental basis to the road supervisors at the Regional Municipality of Ottawa-Carleton (RMOC) in the winter of 1995. Immediately they have been proved to a popular tool, as the road supervisor with occasionally measure the road temperature, and then evaluate the trend of cooling and anticipate the cross over to freezing, at which point they have to mobilize spreading equipment. By the following winter the first vehicle-mounted temperature sensor was installed, the following winter all supervisory vehicle were equipped with the temperature sensor, which allows the measurement of air temperature, the hand-help measure pavement only, as well give a continues reading on the in-dash meter from within the comfort of the vehicle interior.

Infrared thermometer and temperature sensors are generally accurate within two-degree. A training session as to the limitation of such tool and its usage within the context of the winter maintenance operation accompanies the installation of such sensors.

6. Road Weather Information System (RWIS)

A Road Weather Information System (RWIS) was introduced at the Regional Municipality of Ottawa-Carleton (RMOC) towards the end of 1996. The system is a network of micro-weather stations complete with air temperature, humidity, wind speed and direction, and precipitation sensors. Added to that are sensors embedded within the pavement surface capable of measuring pavement temperature, detect wetness, ice, presence of salt and deicing chemicals. Other temperature sensors are also installed at two depth levels below the pavement surface for measuring the subsurface and the sub-grade temperatures. The site Remote processing Unit (RPU) collects the reading form all the attached sensors and sub-stations, if any are linked, and hand the information over to a central server that automatically called and downloads the information from the stations at the different location, and through the proper software make them available on the Local Area Network for maintenance staff and supervisors.

At the time of writing this paper there are ten (10) RWIS stations at different levels of complexity, each coving a representative area up to a 40 km radius, plans are under way for expansion of the system to include more station for finer coverage of the new City of Ottawa by the road weather information system. Figure [1] illustrates the locations of RWIS stations and sub-stations across the former RMOC, and now the new City of Ottawa.

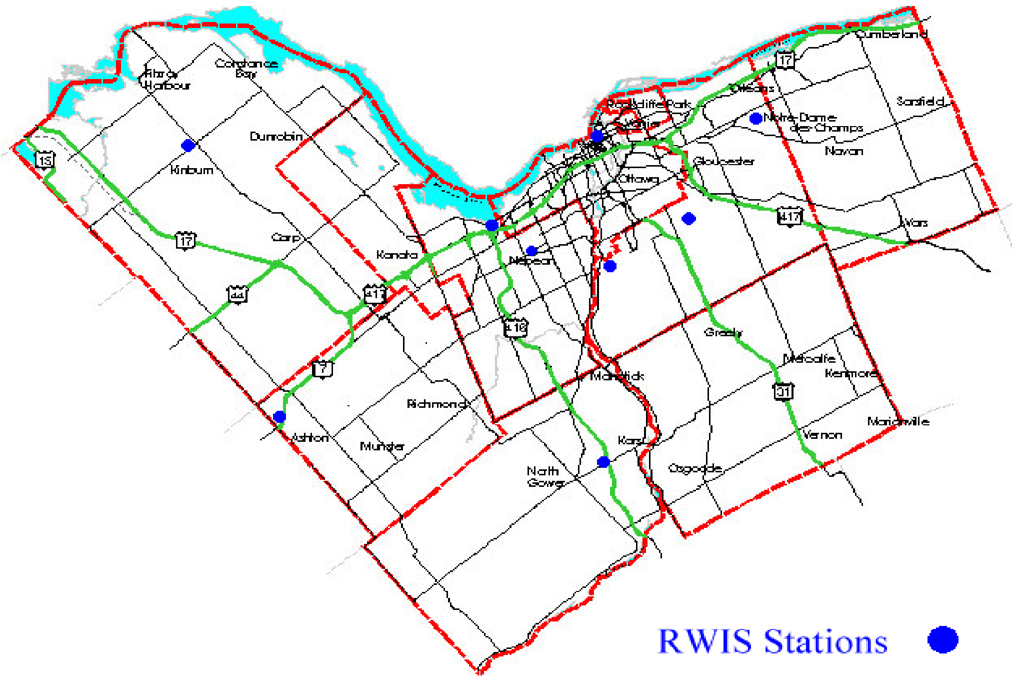

Figure [1] Locations of RWIS Stations within the new City of Ottawa

7. Pavement Condition Forecasting

Using the information collected by the RWIS collection of stations and sensors, the Canadian national weather service, Environment Canada, at their Ottawa Regional Office, and through a special service agreement with the RMOC, has been providing a 24-hour forecast, every 12 hours, for pavement condition during the winter months. The forecasts include condition forecasting for pavement surface temperature, road condition forecast (dry, wet, black ice, etc.). The service also includes providing precipitation forecast for the next 48 hours, (See Figure [2] & [3]), as well as phone support and consultation.

The pavement condition forecast is then used by road maintenance staff to plan their snow and ice control activities, such as call-in of operators, type of material to be loaded (sand, salt, mix). The road condition forecast is also critical in identifying the right conditions for employing techniques such as pre-wetting, anti-icing, or liquid deicer application. The pavement condition forecast is used in conjunction with the pavement temperature forecast, actual pavement temperature reading from the RWIS, hand-held and vehicle-mounted pavement temperature sensors. Not to mention staff training and experience.

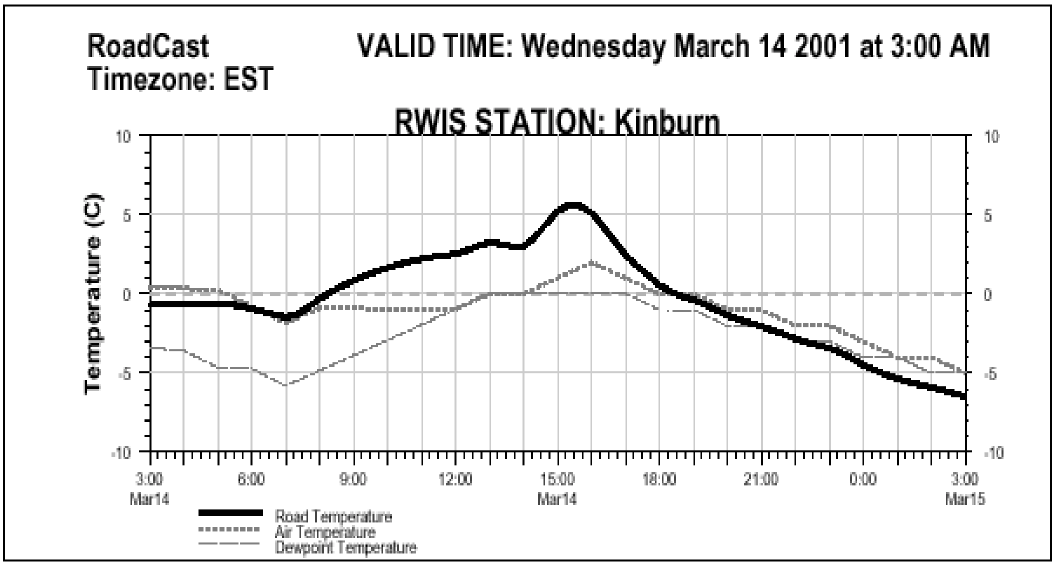

Figure [2] Samples From Road Temperature Forecast by Environment Canada

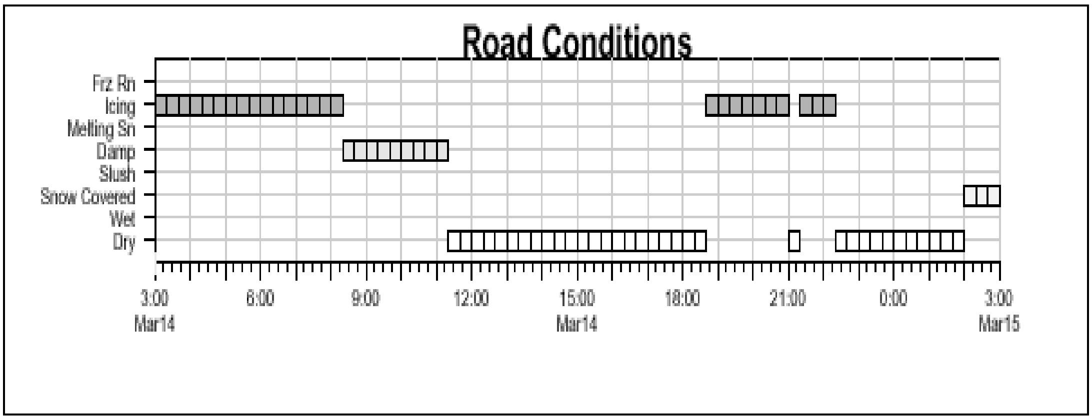

Figure [3] Samples From Road Condition Forecast by Environment Canada

8. Pre-wetting, Anti-icing and Liquid Solutions

When considering chemicals for de-icing operations, the characteristics of the chemical should be considered and a good understanding must be developed as to capabilities and limitation of such chemicals. Not only that to establish what is the optimum working temperature for this chemical, but also to establish the proper working application rates.

An integral part of understanding snow and ice control is the realization that dry material (salt) does not melt snow and ice, it has to be in a liquid state before it has any effect. Thus working with liquid deicers may have merits. Liquids have a shorter response time for decreasing the freezing point of the snow on the road than an application of dry material. That opens the door for the use of pre-wetting and anti-icing as winter maintenance operations tools.

Pre-wetting involves applying a liquid film on a deicer solid before spreading on the road surface. Which can be done in many ways with different chemicals, some maintenance practitioners even pre-wet sand for road application. However, the most successful method so far is an on-board pre-wetting system. With such a system the liquid is applied at a precise ratio to the solids as they hit the spinner disk of the spreader.

The use of liquids in pre-wetting and anti-icing will increase material retention on the road, as well as shorten the time for the effect to take place. As well as reduce the total amount of material used for the same level of effectiveness. It should be noted that concentration of the liquid solution used in the pre-wetting process should be taken into consideration giving factors such as the prevailing weather conditions (rate of precipitation), level of service to be applied, and materials used.

The Region of Ottawa-Carleton has adopted pre-wetting since 1995 in a phased fashion. Crushed Road Salt (Sodium Chloride) is used as a deicer, and pre-wetted with a sodium chloride solution saturated at 23% concentration. As well the anti-icing trails has been conducted using a 23% concentrated sodium chloride solution, mixed on site with special brine mixers.

9. Accidents Analysis

The goal here is to evaluate the impact of the new technologies introduced into winter maintenance operations at the RMOC in 1996 on the number of vehicle collisions (accidents) in the area. Some of the technologies introduced at the start of the winter season in 1996 were RWIS, Infrared thermometers, and pre-wetting.

For the purposes of this analysis, accidents data were collected for winter seasons from 1994 to 2000 (with the exception of 1998 data which was not available). The data obtained were then divided into two groups. The first group represents the data prior to 1997 (prior to the implementation of the new technologies), while the second group represents data inclusive of 1997 and beyond, (after implementation of the new technologies).

Subsequently, a “t” test was used to determine whether the change in winter weather related accidents (before and after January 1997) were statistically significant. Table [1] represents the number of accidents, before January 1997, for a given month divided by 0.01 of the number of registered vehicles for that year (i.e. number of accidents per 100 registered vehicles). On the other hand Table [2] represents the accident winter data after January 1997.

Table [1] Accident Data Before 1997

	Number of accidents per 100 registered vehicle		
	1994	**1995**	**1996**
January	0.567361	0.350881	0.396182
February	0.399726	0.345883	0.328212
March	0.283291	0.272498	0.254688
November	0.36308	0.41243	0.33694
December	0.392708	0.473452	0.371057

Table [2] Accident Data Before January 1997

	Number of accidents per 100 registered vehicle		
	1997	**1999**	**2000**
January	0.357179	0.314333	0.311697
February	0.276593	0.200294	0.241553
March	0.277633	0.25224	0.189991
November	0.328584	0.282199	0.293812
December	0.318706	0.282924	0.367207

Applying the “t” test to the data shown in Tables [1] and [2] gave the indication that a reduction is present in the amount of vehicle accidents over that period of time. This simple analysis shows encouraging results with reduced numbers for accidents for the winter months. Nevertheless, vehicle accident data are but only one type of indicator for the impact of the new technology implementation. Figure [4] illustrates graphically the change of the number of accident vehicles per 100-registered vehicle through time.

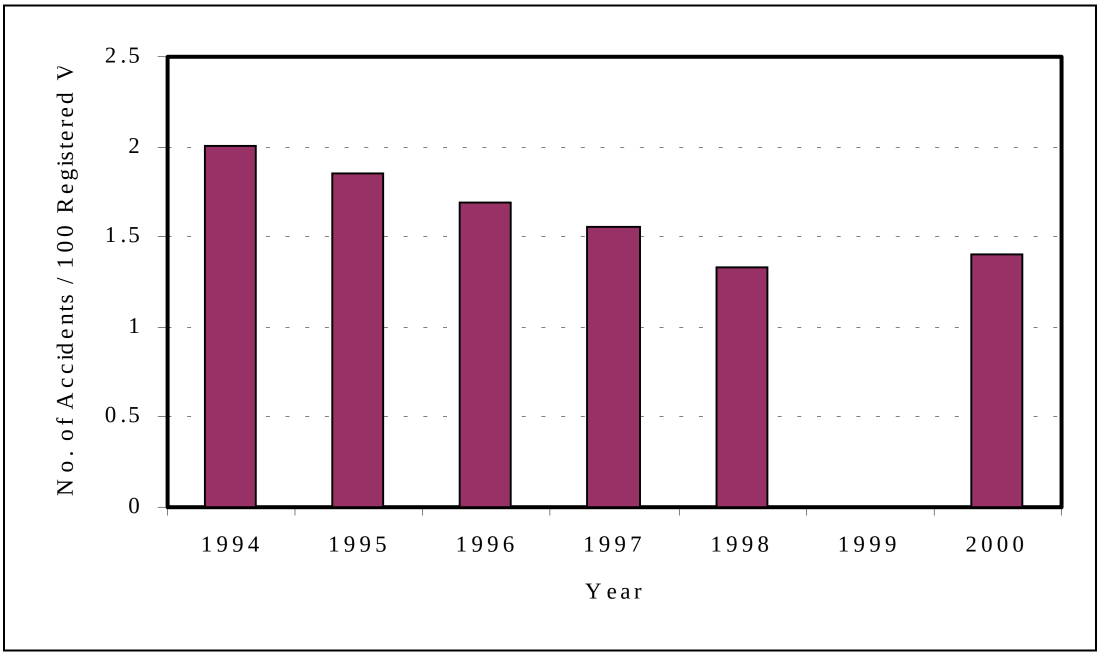

Figure [4] Chart showing accident data for period of analysis

10. Summary and Conclusions

This paper presented some of the new technologies that have been implemented within the former Region of Ottawa-Carleton, and continues within the new City of Ottawa, during last 5 years. The purpose of introducing these technologies, in part, was to increase the efficiency of winter maintenance operations while meeting the required mandate for the level of service at minimum coast.

In order to evaluate the effectiveness of the new technologies a statistical analysis was conducted on data for vehicle accidents, available before and after applying these technologies, in an effort to show the effect on road safety. Based on the analysis above, it can be concluded that the improved winter maintenance operation is having a positive impact on road safety within the city of Ottawa. However, although the numbers show a noticeable reduction in the number of collisions after the implementation of the advanced technologies within winter maintenance operations, it should be noted the other variables might have played a role, which also may vary in their level of impact. Such as new traffic control devices, media awareness campaigns, improved vehicle designs, level of enforcement, etc. all of which came into effect after January 1997.

To achieve an all-encompassing analysis, more accident year-data is required, and a measure of the intensity of the impact of other factors. It is recommended that this investigation be carried out in further details and more information as they become available over the next few years.