Highway 2 Bridge over Peace River at Dunvegan, AB An Integrated Work Zone and Road Condition Solution

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Abstract
This paper outlines one aspect of how Alberta Transportation (AT) approached the construction and continuing maintenance dilemma for the Highway 2 Bridge over the Peace River at Dunvegan, Alberta.

A two year construction project to replace the deck on the 750 meter long Dunvegan suspension bridge will begin in spring of 2008. The work zone includes a four kilometer, steep slope approach which is a regular route for heavily loaded resource trucks carrying timber, and oil, and gas production equipment. In addition to the steep slope, the traffic, which includes frequent oversize trucks, will be reduced to a single lane during construction for crossing the structure. To accommodate the work zone, warning signs need to be provided at the top of each slope and traffic control is needed on each approach adjacent to the bridge.

Additionally, AT was concerned about the potential for icing on the Dunvegan Bridge. As part of the bridge rehabilitation contract, AT reviewed a range of alternative winter countermeasures including: Road Weather Information Systems (RWIS) / video cameras, Dynamic Message Signs (DMS) and Fixed Automated Anti-icing Spray Technology (FAAST). The countermeasures were evaluated in terms of overall benefit and their ability to facilitate safe travel during adverse winter conditions in addition to potential improvements in maintenance efficiency, productivity and reductions in environmental impacts.

An on-site RWIS activated Traveller Information System involving DMS and video cameras was ultimately selected for deployment at the site. To reduce the overall costs, installation of four permanent portable DMS will be accelerated such that they can be used during the term of the two-year construction project. The same DMS signs will be available and appropriately configured at the outset allowing them to be used by AT operations staff in the future for a variety of traffic management activities. When the DMS are used in conjunction with the proposed on site advanced RWIS and video cameras, the integrated ITS system will be employed to assist maintenance crews by notifying them automatically of pending icing conditions allowing them to validate conditions with the video cameras, mobilize their own forces and pass on relevant conditions to the en-route travelers, supporting general traveller information, traffic management and incident management at the site.

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1. INTRODUCTION

Alberta Transportation (AT) retained consulting engineering design services for the rehabilitation of the Dunvegan Bridge on Highway 2, crossing the Peace River, between Grande Prairie and Peace River, Alberta. The work includes designs for a replacement deck, and a curbing and guide rail for the bridge and approaches. There is a history of frequent icing conditions which result in adverse winter driving conditions at this location which presents a mobility and safety concern for AT. Mark F. Pinet & Associates Limited (MFPA) was retained to study and prepare a functional design for the installation of a Fixed Automated Anti-Icing System (FAAST) to be included in the bridge rehabilitation.

After an initial review, it was determined that the cost of a full FAAST system was not justified by the collision or mobility concerns. MFPA was then requested to review the option of installing Road Weather Information System (RWIS) in conjunction with several Dynamic Message Signs (DMS) to provide motorists information on construction and potential weather related safety issues.

1.1. Project Rationale

AT believes that response times and maintenance levels of service of this location may be significantly improved by implementing a program which involves the remote sensing of ice and frost. The remote sensing would then trigger an appropriate winter maintenance response from the maintenance contractor the automated application of environmentally friendly liquid anti-icing chemicals in advance of freezing.

In 2003, AT commissioned the development of the Intelligent Transportation System (ITS) Blueprint for Advanced Traveller Information and Traffic Management Systems for the Highway 2 Corridor, as shown in **Figure 1**. The blueprint addressed the overall need for RWIS on the National Highway System (NHS), including a high-level warrant review for FAAST deployment on selected high risk structures.

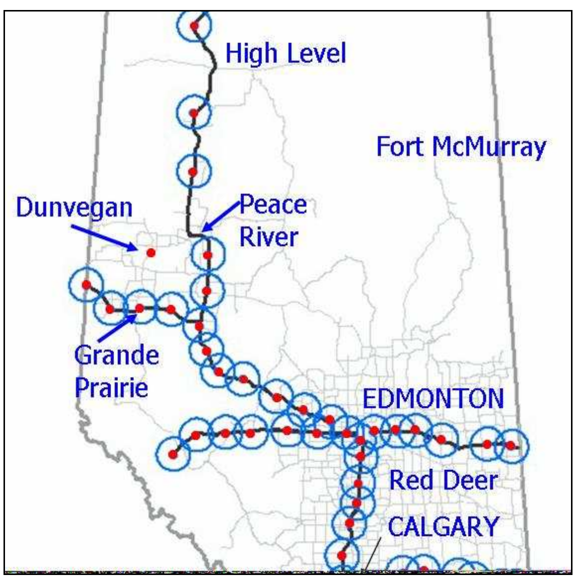

Figure 1 - Proposed Alberta National Highway System RWIS Sites

1.2. Need for Winter Countermeasure

In the aforementioned ITS study, part of the scope was to address the overall RWIS in place on the National Highway System, within Alberta. ITS and FAAST systems (between Calgary and Edmonton) were also evaluated. During interviews and on review of survey responses from AT staff and municipalities, it was identified that, in some instances, bridges were subject to higher winter collision rates.

Unfortunately, since the selected segment of Highway 2 at Dunvegan does not fall within the NHS definition, this particular location was not assessed for either an RWIS or FAAST system. However, the site has been reassessed as part of the 2006-2007 study.

The RWIS network proposed in the original study was designed to respond to contractor and AT contract administrators' requirement for information related to the atmospheric and pavement conditions throughout the network. The RWIS system would supply them with real-time information and forecasts of pavement conditions. This would facilitate the deployment of staff and equipment to the sites using the most appropriate anti-icing and abrasive materials. The forecast of conditions would be generated using the best available observations and employ computerized forecasting techniques. However, the condition detection and forecasting was designed to be representative of general conditions, in a specific time period and a specific geographic region. Given the variability of weather, site specific variations from forecasted conditions would be inevitable. These variations could pose a problem for maintainers and drivers.

When conditions deteriorate in a localized area, such as at a specific structure or road segment, they often result in severe collisions. Motorists exhibit a propensity to drive according to the generally observed pavement conditions. However, bridges are regularly several degrees colder than adjacent road sections. The problem is magnified when structures are located on curves or on downgrades where motorists rely on friction to navigate or slow down their vehicles. Again, this is generally not a problem until moisture is present and the surface temperature drops below the freeze point. Response times for maintainers at these locations, without the benefit of forecasting, could be from 30 minutes to several hours; which is more than sufficient time for a collision to occur. RWIS provide a mechanism for maintainers to detect and respond, in a pro-active manner, to changes in road conditions.

2. Background

2.1. Study Area

The Dunvegan Bridge is situated 500 km northwest of Edmonton, 90 km north of Grande Prairie, and approximately 120 km southwest of Peace River on Highway 2 as shown in **Figure 2**. The land adjacent to the crossing is undeveloped with the exception of the Dunvegan Provincial Park and Historic Site which sits on the north bank of the Peace River straddling the highway.

The bridge crossing is located in a deep portion of the river valley where the difference in elevation from the water surface to the top of the adjacent plateaus is approximately 600 metres. Highway 2 traverses the valley walls over a distance of approximately 4000 metres resulting in steep average gradients of 7-8%. The topography around the bridge creates a microclimate resulting in local weather events, more concentrated and directional wind patterns, and higher humidity levels than the adjacent plateaus.

Figure 2 - Site Location

2.2. Bridge Design

The structure was originally built in 1960 to replace a ferry crossing. The deck was upgraded in 1978. Under the current contract with AE, the deck replacement design was to be completed in 2007 with construction undertaken in 2008 and 2009. The life of the replaced deck is projected to be in excess of 50 years.

Figure 3 - Dunvegan Bridge Looking Northeast from the South Bank

2.3. Traffic Operations

The north approach is posted at 100 km/h but, due to the steep approach grades, vehicles have been observed entering the bridge at a higher speed. It is postulated that this is an attempt by drivers to maintain momentum for the steep bridge and south approach climb beyond.

The south approach is posted at 75 km/h. It was observed during a site visit that trucks moving from south to north would often cross the centerline on their approach to the bridge. It is postulated that this manoeuvre was an attempt to meet the posted approach speed by cutting the corner of the tight radius approach curve.

2.4. Collision Statistics

Collision statistics were provided for four years between 1998 and 2002. The values suggest a relatively high collision rate. Most collisions occurred in the winter. Of the collisions, three were confirmed to be fatal by RCMP accident reports, the Area Maintenance Contract Inspector (MCI), and the Maintenance Contractor Foreman. On a site visit in February 2006 there was evidence of a recent collision in the northeast quadrant on the slope adjacent to the parking area.

2.5. Traffic Volumes

The present volume of traffic at the bridge is reported by AT at 2640 Average Annual Daily Traffic (AADT) with passenger vehicles accounting for 80.7%, tractor-trailers accounting for 9.4%, single unit trucks accounting for 6.0%, and others accounting for 3.9%. There was no information available on the projected increase of traffic for this section of the highway.

2.6. Winter Maintenance Practices

Travellers, both private and public, including emergency services and visitors, rely on the Province's snow and ice control services to maintain the transportation network in a safe and passable condition throughout the winter.

Winter maintenance for the Dunvegan Bridge is conducted by a private contractor under contract to AT. The contractor plows, salts, and applies mixed abrasives, depending on the observed weather event and conditions. The maintenance yard is based approximately 30 kilometres south of the site. It was reported that once a weather event is detected, and for the duration of the event, the MCI stations one of the contractor's trucks at the site with the sole responsibility of treating the bridge and the adjacent slopes.

AT contracts with a private meteorological service to provide them with forecasts for an area which covers the Dunvegan Bridge.

2.7. Construction Practices

AT provided a map showing the locations of their advanced flagman locations. These locations roughly correspond to the crest of the river valley. In addition to the advanced stations, they would also provide traffic control immediately adjacent to the work area.

3. Countermeasures

3.1. RWIS Solutions

RWIS field equipment is divided between the atmospheric and the pavement sensors. The atmospheric sensors are mounted on a tall tower and collect air temperature, relative humidity, precipitation, wind speed, and wind direction information. The pavement sensor suite collects pavement surface temperature and condition information and monitors subsurface temperatures.

RWIS form the basic building block for a range of scalable advanced winter maintenance solutions. RWIS can be used as part of a trigger site, a hot spot site, an advanced node site, or as part of an automated anti-icing approach. The Dunvegan Bridge icing issues and needs fits nicely with in the range of solutions which include advanced RWIS and FAAST.

An advanced RWIS site consists of an RWIS tower with atmospheric sensors and an active pavement sensor which provides the ability to predict freeze point and pavement conditions. The advanced RWIS site is able to monitor conditions at the site, determine which conditions are critical, and determine what appropriate actions should be taken in response to the critical conditions. The advanced RWIS site can also advise another device of the conditions so it can provide an appropriate response.

3.2. FAAST

FAAST is the combined use of RWIS and spray anti-icing systems. It has been available in Europe for more than 25 years, but only recently for North American road and highway applications.

Based upon collision statistics, the research, and the experience with other agencies, AT believed there was a potential for problems at the Dunvegan Bridge. Response times for de-icing, at critical locations, can be significantly improved by implementing a program which involves the remote sensing of ice and frost used in conjunction with the automated application of liquid anti-icing chemicals immediately prior to freezing. Because the application is applied when, and where as needed, significantly less chemical can be applied to maintain the same level of service obtained with traditional methods. The reduced volume, and choice of anti-icing chemical, reduces corrosion and environmental consequences.

Potassium acetate is the anti-icing agent of choice for FAAST systems. Potassium acetate does not contain damaging chloride based molecules and reduces adverse impacts on the environment and corrosion of bridge components.

3.3. Dynamic Message Signs

DMS technology can be deployed as a single standalone unit or as part of a larger Traveller Information System (TIS). When deployed as part of a TIS, DMS units can be controlled and operated by a control center or automatically by a local artificial intelligence.

DMS which are deployed as part of a larger TIS have Center-to-Field communication. These DMS can be controlled both remotely and locally by human operators. In some TIS deployments, DMS have Field-to-Field communications. In these instances, the DMS can be controlled remotely by a field device with artificial intelligence, such as RWIS or FAAST. DMS with Field-to-Field communication are used for displaying time critical information, such as pavement conditions, at permanent locations.

The DMS at the Dunvegan Bridge will be installed immediately before the bridge and further back up the approach slopes as shown in **Figure 4**.

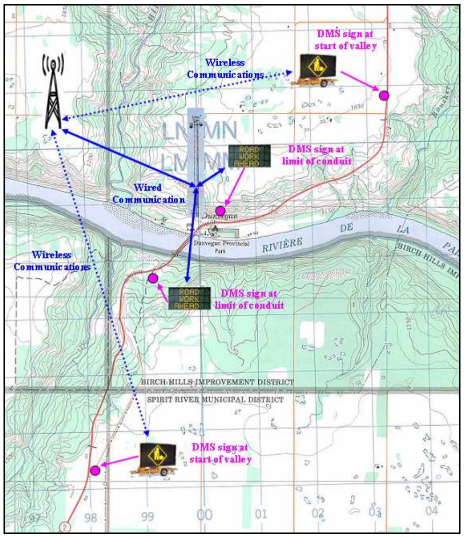

Figure 4 - Locations of DMS signs

The main advantage of installing adjacent to the bridge structure is to provide a short term reminder to motorists prior to crossing the bridge. The advantage of signs further back along the approaches are to notify drivers prior to driving down into the river valley while their vehicle speeds are high. This gives them adequate time to slow down. The message sign must be far enough back from the river so that it is not affected by fog and other visibility limiting events that may be localised to the river. The locations would coincide with the traditional location for flagmen as described in **Section 2.7.**

4. Assessment

4.1. Warrant Analysis

Structures have statistically been more susceptible to dangerous winter conditions than other roadway elements. They are subjected to a greater frequency of collisions since their conditions differ from the adjacent roadway and usually are colder than the adjacent approaches. This phenomenon may be exacerbated as a result of their proximity to open water and other features (dams, etc.) which can keep water open all year round. Motorists often encounter these structures while driving in accordance with the prevailing “terra firma” roadway conditions, rather than with regard to specific bridge conditions. Collisions are frequently the result of the failure to acknowledge and react in an appropriate manner given that the bridge freezes before the road.

The Dunvegan Bridge was reviewed to establish relative warrants for increased levels of technology and winter maintenance. Using collision statistics, existing problem locations are relatively easy to identify and prioritize. A warrant model was undertaken by MFPA to assess the warrants and determine the relative priority for installation. Factors considered included:

- Collisions
- Level of Service (LOS)
- Horizontal Alignment
- Bridge Approach Profile
- Proximity to Open Water
- Traffic Volumes
- Design Speed
- Bridge Type
- Bridge Length

4.2. Cost/Benefit

The benefit to cost ratio was calculated based on a service life of 15 years and an annual discount rate of 6%. The Canadian Guide to In-service Road Safety Reviews (January 2004) states that "a benefit to cost ratio greater than 1.0 over the effective project life represents an attractive project." In the case of the FAAST system on the Dunvegan Bridge, the benefit to cost ratio was 0.95 indicating that an immediate installation is not justified. However, AT should review the warrants of a FAAST system continuously until the benefit to cost ratio either drops well below or exceeds 1.0.

5. Preferred Alternative

An on-site RWIS activated Traveller Information System involving DMS and video cameras were ultimately selected for deployment at the site. To reduce the overall costs, installation of four permanent portable DMS will be accelerated such that they can be used during the term of the two-year construction project. The same DMS signs will be available and appropriately configured at the outset allowing them to be used by AT operations staff in the future for a variety of traffic management activities. When the DMS are used in conjunction with the proposed on site advanced RWIS and video cameras, the integrated ITS system will be employed to assist maintenance crews by notifying them automatically of pending icing conditions allowing them to validate conditions with the video cameras, mobilize their own forces and pass on relevant conditions to the en-route travelers, supporting general traveller information, traffic management and incident management at the site.

Specifications and drawings for the advanced RWIS were provided by MFPA to AT's RWIS service provider to allow for installation of an advanced active RWIS sensor and an interface controller allowing the RWIS to notify the MCI of potentially hazardous conditions requiring maintenance. The controller also has the capacity to automatically activate the DMS, warning drivers of potentially hazardous winter driving conditions.

All RWIS equipment was configured to facilitate the future incorporation into a retrofit FAST system once the warrants have been met to justify the full installation.