Ice Hazard Mitigation and Monitoring on the Veterans’ Glass City Skyway Bridge

Presenters: T. Audet, L. Istefan, D. Nims

Authors: A. Abdelaal\textsuperscript{1}, D. Nims\textsuperscript{1}, L. Istefan\textsuperscript{2}, T. Audet\textsuperscript{2}, A. Helmicki\textsuperscript{3}, V. Hunt\textsuperscript{3}, T-S. Ng\textsuperscript{1}, K. Jones\textsuperscript{4}, C. Ryerson\textsuperscript{4}, M. Byanjankar\textsuperscript{1}

\textsuperscript{1}. University of Toledo, 2. Ohio Department of Transportation, 3. University of Cincinnati, 4. US Army Cold Regions Research and Engineering Laboratory.
February 2011 Icing Video

https://youtu.be/GBgtrocmDNk
Outline

• Icing problem
  • Veterans’ Glass City Skyway Bridge and Icing

• Search for a solution
  • Anti/de-icing technologies and selection
  • University of Toledo testing facilities
  • Coating testing indoor and outdoor
  • Other Anti-/de-icing Techniques

• Operations Perspective
  • What operations needs to help them make decisions to minimize risk
  • When ice is forecast, accumulated or shedding

• Icing event management
  • Real time monitoring system(Dashboard) and sensor development
  • Sensor development
    • UT Ice presence and state sensor
    • UT Optical ice thickness sensor
  • Icing modelling

• Summary of status for this winter
Icing problem

Cable stayed bridges in the United States and lower tier of Canada and map of footprints of damaging ice storms (1946-2014)
Veterans’ Glass City Skyway Bridge

- Veterans’ Glass City Skyway (VGCS) is a large single pylon cable stayed bridge in Toledo, Ohio, USA with a main span of 375m.
- Stay sheaths are brushed stainless steel.
- Three lanes of traffic in each direction with an average daily traffic count of 50,000.
- Owned and operated by the Ohio Department of Transportation (ODOT) and opened to traffic in 2007.
Icing problem on the VGCS

February 2011

Ice accumulation on the east side of VGCS stays (2011)

Event Timeline

- Ice accumulated on the stays on Sunday evening
- Nearly released Tuesday afternoon. Temp below freezing, bright sun.
- Finally, released Thursday am when overcast was a bit lighter and the temp went above 32°

Large piece of ice blowing over the edge of the bridge.

Ice shed from the stays (2011)
Ice Falling from the Stays Requires Actions by Operations

- To protect the safety of the public and ODOT personnel
- To maintain the best safe traffic flow on the bridge
- To minimize the need for ODOT personnel to be in harm’s way
- The actions are needed in at three times in an icing event
  - Ice is being forecasted
  - Ice has collected on the stays and is persisting
  - Ice fall has begun or is imminent
Needed tools

• Information needed:
  • Temperatures / forecast
  • Timing
  • Length
  • One stop visual aid
  • Storage location for weather activities and ice accumulations
Ice on the Stays Requires Actions by Operations

• Procedures – Once ice is present on cables:
  • One or two lanes closed
  • Monitored conditions
  • Traffic control devices remained on the bridge
  • Maintenance personnel made visual observations
Ice on the Stays Requires Actions by Operations

- Procedures to address safety:
  - Lane closures
  - Detours
  - Public Information
  - Weather monitoring
  - Economic Impact
Veterans’ Glass City Skyway Bridge and icing

<table>
<thead>
<tr>
<th>Ice Event</th>
<th>Ice Accretion</th>
<th>Ice Shedding Trigger</th>
<th>Ice Persistence (Days)</th>
<th>No. of Lanes Closed</th>
<th>Damaged Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2007</td>
<td>Freezing rain, fog</td>
<td>Rain with temperature above freezing</td>
<td>2</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>Mar 2008</td>
<td>Snow, rain, fog</td>
<td>Sun with temperature above freezing</td>
<td>1</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>Dec 2008</td>
<td>Snow, fog; freezing rain, fog</td>
<td>Rain, gusty winds and temperatures above freezing</td>
<td>7</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Jan 2009</td>
<td>Freezing rain, fog</td>
<td>Gusty winds, temperature above freezing</td>
<td>10</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>Feb 2011</td>
<td>Freezing rain, clear</td>
<td>Light wind, overcast, and temperature above freezing</td>
<td>4</td>
<td>All</td>
<td>No</td>
</tr>
<tr>
<td>Jan 2015</td>
<td>Freezing rain, snow</td>
<td>Gusty winds and overcast, remaining ice sublimated/melted following day when air temperature was above freezing</td>
<td>4</td>
<td>All</td>
<td>No</td>
</tr>
</tbody>
</table>
Active & Passive Anti/De-icing technologies

• Initially, it was hoped that an off the shelf active or passive technology would be identified that resolved the icing issue.

• Broad investigation was conducted to review all the identified anti/de-icing technologies

• Selection of the tested technologies was based on efficiency, cost, and environmental friendliness of each technique

• Three technologies selected
  • icephobic coatings
  • chemicals
  • internal heating
Summary anti/de-icing techniques tested

• None of the tested active or passive anti/de-icing technologies worked efficiently.

• Therefore, administrative management strategy were considered to be applied.

• Administrative management strategy includes:
  • Develop real time monitoring system (Dashboard)
  • New sensor development.
  • Model the icing event (Ice accumulation and shedding modelling)
Real time monitoring system (Dashboard)

• Automated real time monitoring system built to observe the conditions on the bridge

• Dashboard shows data from the sensors on the bridge (stay temperature, ice accumulation, precipitation, solar radiation) and from local airports and Road Weather Information System (RWIS) stations

• Developed algorithm based on the weather data on the bridge and in surrounding area that identifies ice accumulation, ice shedding, and clear conditions
Real time monitoring system (Dashboard)

Section that describes state of ice on the stays

Section that describes reporting status of sensors
Real time monitoring system (Dashboard)
UT Ice presence and state sensor

• No sensor exist to measure the ice conditions on the sheaths or the thickness of the ice.

• Two new sensors developed: ice presence and state sensor and ice thickness sensor

Ice Experiment on March 23rd and 24th 2015

Ice Accumulation on the stay

Ice start to shed from the stay

Ice shed from the stay

Piece of the ice shed from stay
## Icing modelling (expected)

<table>
<thead>
<tr>
<th>Time Stamp</th>
<th>Ice accumulation</th>
<th>Max ice thickness on stay (mm)</th>
<th>Ice profile</th>
<th>Ice shedding</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/5/2015 3:10:00</td>
<td>no</td>
<td>------</td>
<td></td>
<td>No</td>
<td>--------</td>
</tr>
<tr>
<td>10/5/2015 4:10:00</td>
<td>Yes</td>
<td>$\approx$ 2 mm</td>
<td></td>
<td>--</td>
<td>--------</td>
</tr>
<tr>
<td>10/5/2015 5:10:00</td>
<td>Yes</td>
<td>$\approx$ 10 mm</td>
<td></td>
<td>--</td>
<td>--------</td>
</tr>
<tr>
<td>10/5/2015 6:10:00</td>
<td>------</td>
<td>$\approx$ 10 mm</td>
<td></td>
<td>yes</td>
<td>$\approx$ 4 hours</td>
</tr>
<tr>
<td>10/5/2015 7:10:00</td>
<td>------</td>
<td>$\approx$ 8 mm</td>
<td></td>
<td>yes</td>
<td>$\approx$ 3.5 hours</td>
</tr>
</tbody>
</table>
Summary of status for the 2015-2016 winter

• The dashboard has been operational for several winters hosted on the servers at the University of Cincinnati. This winter it is being hosted on the ODOT servers and mirrored on the UC servers. It’s operation will be in ODOT’s hands next year.

• The UT sensors have been tested in the lab and at UT’s icing experiment station. This year a set of sensors are being deployed on the VGCS. Ideally, these will make getting regular ice condition info on the stays possible without requiring ODOT crews to visit the bridge. If successful, these sensors will be built into the dashboard algorithms for the 2016-2017 winter.

• At the end of this winter, we may have some feedback from operations to improve the dashboard or sensors.
Conclusion

• Icing on bridge superstructures is a widespread problem.
• Generally, there is no practical active or passive fix for ice on stays.
• ODOT is pursuing an icing event management strategy
• Sensors on the bridge and in the surrounding area coupled with an efficient algorithm can integrate the sensor data in a way that assists the operators in making event management decisions.
• Such a system has been tested on the VCGS and, with an improved sensor array, is being transferred to ODOT servers this winter.
Acknowledgements

• To develop a viable ice management tool that is used requires input from researchers and the operators. The following ODOT employees have provided invaluable assistance and taught the researchers a great deal about operations
  • Mike Gramza
  • Matt Harvey
  • Lori Middleborough
  • Tom Powell
  • Lisa Wires

• Richard Martinko and Christine Lonsway of the University of Toledo – University of Toledo Transportation Center have provided continuous administrative support and editorial assistance.
Thank you

Questions?