Development of an Automated Ice Sensing System to Assist the Operators of a Cable Stayed Bridge in Making Decisions

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Summary: Atmospheric icing is a significant challenge that affects structures including bridges in many countries. The shedding of ice that accumulates over cable stayed bridges is hazardous for the travelling public in addition to the economic loss and inconvenience for the motorists. Currently there are 32 cable stayed bridges located in the United States and lower tier of Canada situated in or near areas that historically had damaging ice storms. The main focus of this study is the Veterans' Glass City Skyway (VGCS) which is a large single pylon cable stayed bridge in Toledo, Ohio, USA owned and operated by the Ohio Department of Transportation (ODOT). Since its opening in July 2007, six major icing events have occurred on the VGCS which required lane closures or shut down of the bridge. In some instances ice with the potential to cause damage persisted on the stays for several days before releasing suddenly. The main cause for five of the six events was freezing rain.

To mitigate the icing hazard, three courses of action were considered: active - which requires power and operator action, passive - which remains permanently in place such as coatings, and administrative - which requires closure of lanes or the bridge to separate the travellers from potential falling ice. Both active and passive procedures involve anti/de-icing technologies. A broad investigation was conducted to review all known anti/de-icing technologies. The evaluation criteria were efficiency, cost, and environmental friendliness. Three technologies were selected for testing which included icephobic coatings, chemicals, and internal heating. None of the reviewed or tested active or passive anti/de-icing technologies worked economically or efficiently. Consequently, an administrative management strategy was taken.

This approach requires determining the thickness and condition of the ice on the stays to calculate when lane closures are appropriate. An automated real time monitoring system was created in order to identify the ice condition on the stays. The system identifies whether the conditions are right for icing and whether ice is accumulating or if accumulated ice has the potential to shed soon. The system uses data collected from Road Weather Information System (RWIS) stations, local airports, and sensors mounted on the bridge to determine if ice is accumulating or if accumulated ice has the potential to fall soon.

Existing commercial sensors are not capable of capturing all the essential information about the icing conditions so two new sensors, an ice presence and state sensor, and an ice thickness sensor, were developed and tested at an icing experiment station on full scale stay specimens. These new sensors compliment commercial sensors mounted on the bridge.

A monitoring system has been developed and tested on the bridge by academic researchers working with the ODOT operators since 2011. It is now refined to the point where it is being transferred to ODOT for use as an operational tool during the winter of 2015-2016.

Useable Findings: Icing affects bridges over a wide area of the US and lower Canada. Active or passive systems are generally not effective in mitigating the icing hazard on bridges. Accurate real time information on the condition of the ice accumulating on the bridge stays can help the operators assess if lanes should be closed.

Conclusion: Information on ice condition can come from a number of sources and requires experience to interpret. An automated ice monitoring system with appropriate regional, local and bridge mounted sensors and experience based algorithms can accurately capture icing events. An operator friendly interface on the monitor can provide bridge operators with real time information about icing conditions and assist them in making lane closure decisions.