Icing of Bridge Cables – State-of-the-Art - Review

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Abstract

Cable icing can result in additional dead load and increase an impact surface for wind loads. But most importantly, ice chunks, under some meteorological conditions, can fall down from cables onto the roadway causing a major damage to the traffic on the bridge. The purpose of this paper is to present a general overview of the investigations that have been made to protect bridge cable from damage caused from ice accretion. That includes understanding of icing fundamentals caused by freezing precipitation and in-cloud icing. Also, results of experimental wind tunnel tests, which have been performed on horizontal, vertical and inclined cylinders will be discussed. Finally, different de-icing and anti-icing techniques, such as active removal systems (mechanical, thermal) and passive methods -based on natural forces as well as monitoring systems are being reviewed.

Keywords: Cable-stayed bridges; ice accretion; cable icing; anti-and de-icing techniques; cable vibration; wind tunnel tests, snow and ice control.

1 Introduction

The influence of ice accretion has been studied mainly in the fields of power lines, aviation, and wind turbines but less work is available in the area of bridge engineering. However, in recent years, the relevance of ice accretion on the bridge cables has been recognized and is becoming a major concern for major bridges. As witnessed on the Veterans Glass City Skyway Bridge (Toledo, Ohio) in 2007, 2008, 2009, 2011 and 2015, the Great Belt Bridge (Denmark) in 2010, the Port Mann Bridge (Vancouver, Canada) in 2012 and Penobscot Narrow Bridge (US) in 2013, ice accretion on cables can have severe consequences for human safety and cause economical loss. Closure or traffic restrictions on the bridge were required for all above mentioned cases. Furthermore, ice accretion on bridge cables can cause unanticipated vibration behaviour due to altered in cross-sectional area, making cables aerodynamically unstable, thus shortening their lifetime. The resultant damage may be difficult to inspect, because of the waterproof coating, which can lead to uncertainty regarding the fatigue life. That is the reason why many engineers are trying to find a solution to prevent ice accretion on bridge cables.

2 Ice Accretion

Ice accretion occurs under a high level of ambient air humidity, combined with temperatures slightly below zero Celsius degree and mild wind speed. It can take place, when water either freezes in the atmosphere before it sticks to exposed objects in the air flow, or if when it freezes after getting in contact with a cold surface. Precise prediction of ice formation is very difficult to obtain due to many atmospheric conditions and material parameters. In addition, the development of ice

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