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Resiliency planning: prioritizing the vulnerability of coastal bridges to flooding and scour

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Abstract

Bridge owners are faced with the daunting task of maintaining or replacing aging infrastructure over the next century. Added to this challenge are climate change projections such as rising sea levels. A major concern to bridge owners is the need to strengthen the resiliency of their bridges while utilizing a limited amount of financial resources. This paper will offer a methodology for prioritizing the vulnerability to flooding and scour for a state department of transportation's bridge inventory. Through the use of geographic information system (GIS) software, data is mined from the National Bridge Inventory (NBI) - making this methodology applicable to any state agency in the country. The New York City metropolitan region will be presented as a case study.

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Keywords: resiliency; vulnerability; prioritization; sea level rise; flooding; scour; bridges; geographic information systems; national bridge inventory; finance; policy; risk management; data mining

1. Introduction

According to the American Society of Civil Engineers (ASCE), one in nine bridges are rated as structurally deficient in the United States (ASCE, 2013). The Federal Highway Administration (FHWA) estimates that $20.5 billion will need to be invested annually to address these deficiencies. This is a challenge for federal, state and local bridge owners since only $12.8 billion is currently being spent, leaving a shortfall of $8 billion.

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Now added to this challenge is the reality of climate change projections. The Intergovernmental Panel on Climate Change (IPCC), a leader in collaborative climate change research, issued its fifth assessment report in 2014. Many governments, including New York City, are comparing the IPCC's latest global scale climate projection models to their local scale models in order to make decisions on how to best mitigate and become resilient to climate change impacts. In response, the New York City Panel on Climate Change (NPCC) released their 2015 report, Building the Knowledge Base for Climate Resiliency. This report focuses the need to increase the resiliency of many systems, including infrastructure, around New York City and the larger metropolitan region. It also includes local climate projections through 2100. Key findings include sea level rise projections. Sea level rise in New York City is projected to continue to "exceed the global average" and could possibly "reach as high as 6 feet by 2100" (NPCC, 2015). This alone would increase the frequency of the current 100-year flood by the 2080s. The 100-year flood is defined as a flooding event with a 1% probably of occurrence each year. This is of particular concern to civil engineers as the 100-year flood is used as a benchmark when designing bridges for flooding and scour. Scour is the erosive action of water on soil which may undermine the foundation of a bridge.

The objective of this research was to develop a methodology for prioritizing the vulnerability to flooding and scour for a state department of transportation's bridge inventory. The National Bridge Inventory (NBI) database was the source from which the prioritization criteria were developed. It is the author's hope that this criteria could be used as a decision making tool to assist bridge owners in determining which bridges are likely to be the most vulnerable to climate change projections. These bridges can then be given the highest priority towards a more thorough risk assessment and resiliency planning. By focusing on the highest priority bridges first, funding could be spent more efficiently.

The New York coastal area was chosen as the case study because of the region's sensitivity to changes in sea level (see Fig. 1). The criteria developed using the NBI database was customized for the New York coastal geographic region, and this could be done for any coastal area. The methodology and results of the prioritization criteria are presented and discussed in this paper specifically for the New York coastal area.

Fig. 1. New York coastal region study area.