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Federal Highway Administration

Resilience and Durability to Extreme Weather Pilot Project: Navy Bridge Inspection Program

Resilience and Durability Pilot Projects 2018 – 2020
The Federal Highway Administration (FHWA) partnered with eleven pilot project teams to assess and deploy resilience solutions. This case study is part of a series that summarizes the pilot projects and highlights transportation system resilience efforts at other agencies across the country. For more information, visit https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/extweatherpilot.cfm.

Summary
The Navy Bridge Inspection Program (NBIP), part of the Naval Facilities Engineering Command Engineering and Expeditionary Warfare Center, assessed vulnerability and associated risk of its East and Gulf coast bridges to impacts of sea level rise and storm surge.

Key Takeaways

- Using FHWA's Assessment and Adaptation Framework as a guide, the NBIP was able to identify which bridges warrant adaptation measures against sea level rise and storm surge.
- The study resulted in NBIP modifying its bridge inspection reporting to propose site-specific adaptation options.
- NBIP's research and coordination with public works groups will encourage stronger consideration of extreme weather impacts on bridges.

Objectives

The primary objective of the NBIP study was to better inform partners and influence decision-making to build a more resilient United States Navy (USN). In addition, the study aimed to enhance communication between the USN and installations' public works groups. A goal is that the individual military installations within the study, that own the structures and are responsible for their maintenance and repair, will incorporate the results into project planning, asset management, and ongoing resiliency endeavors. More broadly, NBIP considered the study as an initial view into the vulnerability and risk of the USN and United States Marine Corps (USMC) bridge inventory which can serve as a model for future similar studies of other stressors and assets.

Scope

NBIP's study focused on sea level rise and storm surge as extreme weather stressors on East and Gulf Coast bridges within the USN and USMC transportation systems (Figure 1). These two stressors are of particular concern to USN and USMC since many of their installations are in coastal areas and are regularly exposed to extreme weather events. Waves and wave load stressors were beyond the scope of the study. NBIP used available data to study 67 roadway bridges over water, including six culverts that met the National Bridge Inspection Standards definition to be considered bridges due to their length. Thirty-five out of the 67 bridges were considered exposed and thus included in the vulnerability assessment and risk analysis (Figure 2).

Approach

NBIP closely followed the FHWA Vulnerability Assessment and Adaptation Framework to conduct an indicator-based vulnerability assessment using available data. NBIP developed a tool to analyze the data, the NBIP Tool, using the FHWA's Vulnerability Assessment Scoring Tool (VAST) as a basis.

Selecting Indicators

The indicator selection process involved many iterations of review in order to generate a final list that is comprehensive in depicting the assets' complete vulnerabilities as related to each stressor. NBIP reviewed indicators used by past pilot vulnerability studies, suggested indicators within FHWA's VAST Tool, and available data within the USN. The selected indicators were broken up into three categories: exposure, sensitivity, and adaptive capacity.

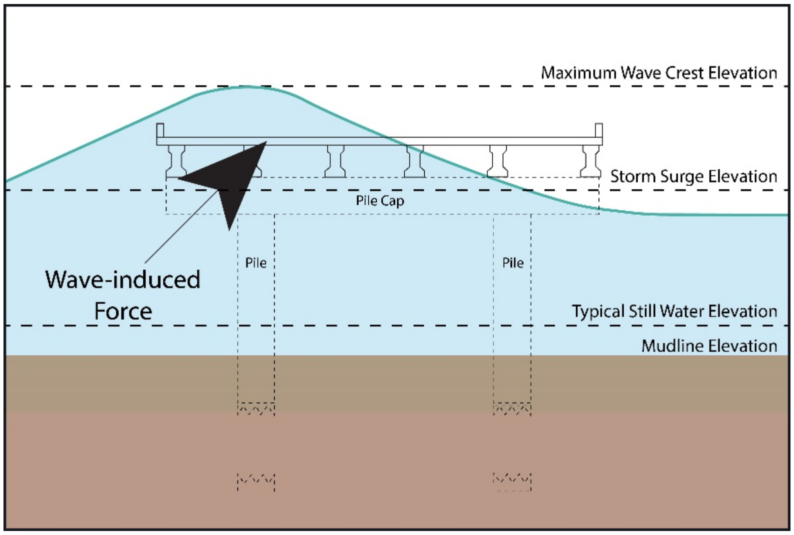

Figure 1. Schematic of wave-induced uplift and lateral loads on a bridge deck resulting from storm surge. Source: FHWA.

For the exposure indicator, the study drew on the Department of Defense's environmental research programs: Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program. These programs produced data for sea level rise, storm surge, and combined scenarios specific to individual military installations. Sixty stressor scenarios were evaluated, including combinations of lowest, low, medium, high, and highest sea level rise for years 2035, 2065, and 2100 with 5-year, 20-year, 50-year, and 100-year events.

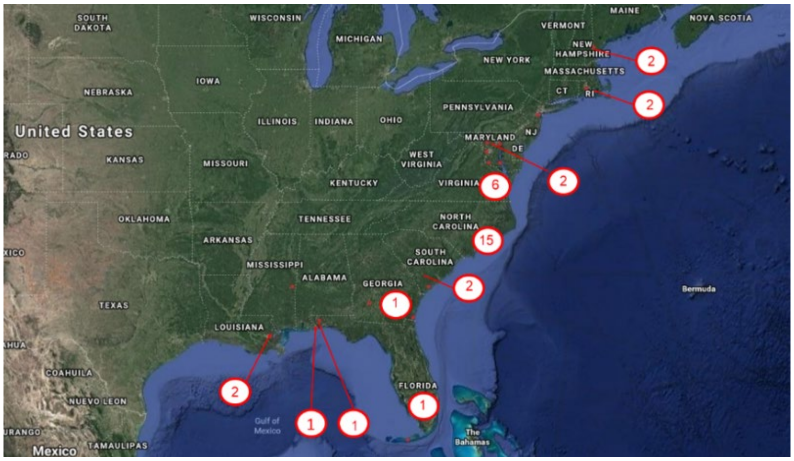

Figure 2. Locations of 35 exposed bridges evaluated as part of the vulnerability assessment and risk analysis. Source: NBIP.

For the sensitivity and adaptive capacity components of the vulnerability assessment, NBIP consulted several stakeholders – including Naval Facilities Engineering Command (NAVFAC) Engineering and Expeditionary Warfare Center (EXWC); Ocean Engineering, NAVFAC Headquarters; and Sustainability and Land Use Planning, NAVFAC Headquarters – to determine the indicators that most accurately represent the vulnerabilities of the bridge assets within this scope. The data for the sensitivity indicators were derived from sources such as bridge inspection reports and bridge plans and drawings. The data for the adaptive capacity indicators were derived from sources such as bridge inspection reports and internal data record systems. Reasonable assumptions were made and documented when data were not present.

Managing Data

The data were managed in a spreadsheet, which evolved into the NBIP Tool. NBIP scored and weighted indicators using the NBIP Tool in order to generate a final vulnerability assessment score for each bridge within the study. To determine value ranges and weighting of the indicators, NBIP reviewed past studies and recommendations from the FHWA VAST Tool. NBIP also relied on its engineering experience and familiarity with the bridges within the scope. In addition, the stakeholders reviewed the NBIP's scoring and weighting.

Risk Analysis

After performing the vulnerability assessment, NBIP evaluated risk. This was done using the Mission Dependency Index (MDI), or the consequences if a bridge is impacted, and comparing it with the vulnerability results, or the probability of a bridge being impacted. In this way, risk is a function of consequences and probability of impact. NBIP plotted the bridges' vulnerability scores against their MDI values for the best conditions and the worst conditions of the effects of combined sea level rise and storm surge. Mission independent bridges with low vulnerability scores are considered to be at low risk while mission critical bridges with high vulnerability scores are considered to be at critical risk.

Decision-Making

NBIP holds a unique role in being able to directly recommend maintenance and repairs to installations' public works groups on a regular basis through cyclical bridge inspections; however, the decision to implement these recommendations ultimately rests with these groups as the bridge owners. In order to influence decision-making, NBIP held several presentations and meetings with stakeholders and is continuing to promote this research in ongoing conversations. The NBIP has also modified its approach to bridge inspection reporting to incorporate this research and has proposed site specific adaptation options for all vulnerable and at-risk bridges. These adaptation options are detailed in bridge summary sheets, to be used in discussions with installations' public works groups.

Key Results & Findings

Vulnerability Assessment

The results of the vulnerability assessment showed that out of 67 bridges, five bridges were too far inland to be considered exposed. An additional 27 bridges were not tidally influenced, and were also not considered to be exposed. The remaining 35 bridges were evaluated and scored poorly in nearly all of the 60 stressor scenarios. Of these stressor scenarios, the NBIP highlighted the best conditions (year 2035, lowest estimated sea level rise, 5-year storm event) and worst conditions (year 2100, highest estimated sea level rise, 100-year event) to show that regardless of scenario, these bridges should be considered for adaptation options and that inaction is not recommended. The vulnerability assessment results are summarized in Table 1.

Table 1. Summary of vulnerability results.

Best Conditions		Worst Conditions	
Score	# of Bridges	Score	# of Bridges
High	8	High	19
Medium	26	Medium	16
Low	1	Low	0

Risk Analysis

The risk analysis results showed that for all 60 stressor scenarios, zero bridges are at low risk (Table 2). Installations' public works groups can use these results as criteria for project prioritization as part of risk mitigation strategies.

Table 2. Summary of risk results.

Best Conditions		Worst Conditions	
Score	# of Bridges	Score	# of Bridges
Critical Risk	2	Critical Risk	5
Very High Risk	3	Very High Risk	3
High Risk	12	High Risk	15
Moderate Risk	18	Moderate Risk	12
Low Risk	0	Low Risk	0

Lessons Learned

The study's scope presented both challenges and benefits, as it was relatively small in terms of the number of assets evaluated, but relatively large in terms of regions encompassed. While it was difficult to consider assets in varied locations, NBIP has been directly involved in the inspection of every structure within the study, which allowed for familiarity and in-depth perspective of each bridge. NBIP is also the data manager for most USN and USMC bridge asset information and is required to maintain bridge records. Transportation practitioners undertaking future transportation vulnerability assessment projects are encouraged to reach out to the bridge inspection group within their agency responsible for managing bridge assets for their experiential knowledge and access to data.

Additionally, NBIP regularly liaises with installations' public works groups for the coordination of each bridge inspection. Since NBIP is in communication with public works personnel and offers in-briefs and exit-briefs for key personnel at the installations, this has allowed NBIP to build close relationships with those who are responsible for the bridge assets. NBIP encourages practitioners undertaking vulnerability assessment projects to reach out to local public works groups and build these relationships to gain their support and assistance. Lastly, NBIP encountered challenges with data gathering. It took time to investigate the best exposure data to use, due to the varied geography within the scope and lack of experience in performing similar studies. Additionally, NBIP revised the indicators several times. This was done as new discussions took place within NBIP and with stakeholders, as well as when a data set was found to be insufficient in capturing a vulnerability. Some data sets also had gaps. For these issues, NBIP made reasonable assumptions and documented them.

Next Steps

NBIP has identified next steps as a result of the study:

- Conduct additional research on bridges with considerable vulnerability or risk to more accurately implement extreme weather adaptation options for a more site specific response.
- Potentially assess a larger number of bridges within NBIP's inventory and include other stressors.
- Make the NBIP Tool available to other EXWC groups.
- Purchase a handheld LiDAR system to scan each bridge within the NBIP inventory that requires inspection.
- Maintain the data within the NBIP Tool by updating it as new information is reported on the bridges.
- Discuss the study results with military installations' public works groups and support them in guidance on how best to address the concerns outlined herein.
- Continue to pursue avenues to influence decision-making and ensure impact of this research.
- Modify reporting requirements and talking points with installations' public works groups during regularly scheduled bridge inspections to incorporate the results of this study.

For More Information

Resources

NBIP Final Pilot Report: https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/

NAVFAC Installation Adaptation & Resilience Climate Change Planning Handbook: https://www.fedcenter.gov/DocuDocum/index.cfm?id=31041

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