AGING AND FAILING INFRASTRUCTURE SYSTEMS: HIGHWAY BRIDGES

September 14, 2015 1100 EDT.

PREPARED BY: OFFICE OF CYBER AND INFRASTRUCTURE ANALYSIS

SCOPE

The Department of Homeland Security Office of Cyber and Infrastructure Analysis (DHS/OCIA) produces Critical Infrastructure Security and Resilience Notes in response to changes in the infrastructure community's risk environment from terrorist activities, natural hazards, and other events. This product summarizes the findings related to highway bridges that were identified in the National Risk Estimate on Aging and Failing Critical Infrastructure Systems released by DHS/OCIA in December 2014.[1] This Critical Infrastructure Security and Resilience Note supports DHS leadership; other Federal, State, and local agencies; and private sector decision makers.

KEY FINDINGS

- **In the United States, most highway bridges are designed for a life of approximately 50 years; many newer bridges are designed for a life of 75 years or more. The life of a bridge can be extended past its designed lifespan with inspections, maintenance, and preservation measures.**
- **Bridge conditions have steadily improved in recent years, but funding for roads, highways, and highway bridges may be inadequate to maintain or improve current capacities. An estimated $8 billion increase in annual spending is needed to eliminate the Nation's bridge upgrade backlog.**
- **More than 63,000 highway bridges are classified as structurally deficient, but very few bridge failures involve loss of life. As bridge conditions worsen, restrictions are put in place or bridges are taken out of service.**

OVERVIEW

For this National Risk Estimate, OCIA gathered subject matter experts to highlight the current state of critical infrastructure and identify trends and physical characteristics of infrastructure that increase the risk of failure. The study also identifies market, regulatory, and policy factors that affect infrastructure risk.

There are approximately 600,000 highway bridges in the United States. These bridges are owned primarily by State and local governments; States own 48 percent, and local governments own 51 percent. The Federal Government owns only 1 percent of bridges located on Federal land.[2]

---

[1] For more information regarding the methodology and findings of this study, please see "Aging and Failing Critical Infrastructure Systems National Risk Estimate, OCIA", December 2014, https://hsin.dhs.gov/ci/iir/OCIA/OCIA%20Products%20DocLib%20HSIN/OCIA%20-%20Aging%20and%20Failing%20Critical%20Infrastructure%20Systems.pdf.

[2] U.S. Congressional Research Service, Highway Bridges: Conditions and the Federal/State Role, RL34127, August 10, 2007, by Robert S. Kirk and William J. Mallet, accessed April 4, 2013.

The average age of bridges in the United States is 42 years. Most have a lifespan of approximately 50 years, although many newer bridges are being designed to last 75 years or longer.[3] Most of the Nation's 600,000 bridges will have outlived their designed lifespan within the next 10 to 40 years. With inspections, maintenance, and repairs, the lifespan of a bridge, can be extended, but eventually repairs become too costly, and a bridge must be closed and replaced.

In 2013, the American Society of Civil Engineers assigned a grade of C+, on a scale from A to F, to the Nation's bridges. It estimated that an annual investment of $20.5 billion is needed to repair and maintain highway bridge infrastructure, an $8 billion increase from current spending levels.[4]

RISK OF FAILURE

The Federal Highway Administration (FHWA) maintains the National Bridge Inspection Program, aimed at ensuring bridge safety, and maintains the National Bridge Inventory (NBI), which includes information on bridge conditions.[5,6] Bridges identified as structurally deficient may have decks, superstructures, or substructures determined to be in poor condition. Bridges identified as functionally obsolete do not meet current design standards and may be too narrow, have insufficient load-carrying capabilities, or do not meet other standards. These ratings are used to determine whether a highway bridge is eligible for the Highway Bridge Replacement and Rehabilitation Program.[7] The condition of bridges has steadily improved in recent years, but as of December 2013, NBI reported that 63,000 bridges were still identified as structurally deficient, and an additional 84,000 were functionally obsolete.[8]

Structurally deficient and functionally obsolete bridges are not inherently unsafe, but may require additional maintenance or restrictions on speed, vehicle size and load, and the number of vehicles permitted.[9] These restrictions can increase traffic or require some vehicles to use different routes, increasing travel time and distance, and increasing fuel consumption. If structurally deficient and functionally obsolete bridges become unsafe, they are taken out of service, with economic consequences.

As bridges age, their likelihood for failure increases because the most common causes of bridge failure, erosion and scouring, are time-dependent.[10,11] Other time-dependent causes of failure are material fatigue and corrosion. Commercial vehicles traveling over bridges can induce material fatigue. Rates of corrosion can increase in salt water or acidic soils.[12,13] Extreme weather and natural disasters, such as hurricanes, floods, droughts, earthquakes, tornados, and other natural events can also damage bridges. Bridges suffering from scour, fatigue, or corrosion are more likely to be affected by extreme weather and natural disasters.

REGIONS OF INCREASED RISK

Hurricanes, flooding, seismic events, and other natural disasters can cause bridge failures, and bridges in regions prone to severe weather and natural disasters have a higher risk of failure. The American Association of State Highway and Transportation Officials (AASHTO) provides guidance on the design requirements for bridges in

---

3 Transportation for America, The Fix We're In For: The State of Our Nation's Bridges, Washington, D.C.: Transportation for America, 2011.
4 American Society of Civil Engineers, "2013 Report Card for America's Infrastructure," http://www.infrastructurereportcard.org/, accessed April 25, 2013.
5 Moss, Gary, "Impacts of 'MAP-21' on the National Bridge Inspection Program," Presented at the August 7, 2014, Tribal Government Coordination Meeting, Federal Highway Administration, http://flh.fhwa.dot.gov/programs/ttp/bridges/documents/NBIS-For-Tribally-Owned-Bridges.pptx, accessed October 21, 2014.
6 Federal Highway Administration, "Tables of Frequently Requested NBI Information," http://www.fhwa.dot.gov/bridge/britab.cfm, accessed October 21, 2014.
7 Federal Highway Administration, "Additional Guidance on 23 CFR 650 D," http://www.fhwa.dot.gov/bridge/0650dsup.cfm, accessed April 29, 2014.
8 Federal Highway Administration, "Deficient Bridges by State and Highway System," http://www.fhwa.dot.gov/bridge/deficient.cfm, accessed April 22, 2014.
9 LePatner, Barry B., "The Basics," http://saveourbridges.com/basics.html, accessed April 4, 2013.
10 Scour is the water-induced erosion of the soil surrounding bridge foundations.
11 Federal Highway Administration, "Idaho Transportation Department Office Manual Plans of Action for Scour Critical Bridges," http://www.fhwa.dot.gov/engineering/hydraulics/pubs/idpoa.cfm#2, accessed April 22, 2014.
12 National Aeronautics and Space Administration, "Fundamentals of Corrosion and Corrosion Control," http://corrosion.ksc.nasa.gov/corr_fundamentals.htm, accessed December 26, 2013.
13 Corrosion occurs when a material degrades as a result of a reaction with its environment.

regions prone to extreme weather and natural disasters.[14,15] Bridges crossing waterways face a higher likelihood of failure from scouring, washout, buildup of ice or debris, and barge accidents.

Pennsylvania has the highest percentage (23 percent) of structurally deficient bridges; Rhode Island, Iowa, and South Dakota each has at least 20 percent of their bridges identified as structurally deficient. Florida and Nevada (at less than 2.2 percent) each has the lowest percentage of structurally deficient bridges.[16] The high percentage of structurally deficient bridges in Pennsylvania is likely due in part to weather conditions and the amount of salt used on roads to prevent ice buildup. Despite high percentages of structurally deficient bridges, strong maintenance programs mitigate the risk of failure.

Washington, D.C., has the highest percentage (63 percent) of functionally obsolete bridges; Hawaii, Massachusetts, Rhode Island, and Puerto Rico each has at least 30 percent of their bridges identified as functionally obsolete. Minnesota and South Dakota (at less than 5 percent) each has the lowest percentage of functionally obsolete bridges.[17]

DEPENDENCIES AND INTERDEPENDENCIES

Most sectors are dependent on highway bridges to conduct daily operations such as delivery of products to end users. During their daily commutes, individuals rely on bridges as access points to urban areas. Some bridges are the only source of access into areas. The failure of a bridge can directly affect the Energy and Communications Sectors, as power lines, fiber optic cables, and other utility lines can be colocated underneath a bridge.

MARKET, REGULATORY, AND POLICY FACTORS

The Federal fuel taxes on gasoline and diesel motor fuels, which feed into the National Highway Trust Fund for highway projects, have stood at 18.4 cents and 24.4 cents per gallon, respectively, since 1993. These taxes would need to be raised to 29 cents and 39 cents per gallon to have the same purchasing power in today's dollars.[18] As a result, the trust fund ran out of money and had to be rescued in 2008, 2009, and 2010, at a total cost to taxpayers of $34.5 billion.[19] Without improvements, the trust fund will not be able to meet its obligations beginning in fiscal year 2015. Additionally, revenues from fuel taxes are decreasing due to the increase in fuel-efficient and electric vehicles.[20]

The National Bridge Inspection Standards require highway bridge inspections every 24 months, although some exceptions exist for more or less frequency. Inspectors examine every element of a bridge. They identify and document changes in the deterioration and strength of these elements to determine the potential for failure. Inspectors use visual observation and technologies such as x-rays, strain gauges, and other methods to identify the condition of all bridge elements on their failure points. Fracture-critical bridges—steel bridges without structural support redundancies that are subject to catastrophic failure—require a higher level of inspection and maintenance due to their lack of support redundancies.

States and localities own 99 percent of bridges. The FHWA works with AASHTO and Federal, State, and local bridge owners to carry out safety and repair programs. Even though the NBI provides standards for inspections and regulations, States are not subject to common standards for repair criteria. Some States have increased efficiency in their inspection programs through the integration of electronic databases and software applications.[21]

---

14 American Association of State Highway and Transportation Officials, AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, with 2012 Interim Revisions, Washington, D.C.: AASHTO, 2011.
15 American Association of State Highway and Transportation Officials, Guide Specifications for Bridges Vulnerable to Coastal Storms, Washington, D.C.: AASHTO, 2008.
16 Federal Highway Administration, "Deficient Bridges by State and Highway System," http://www.fhwa.dot.gov/bridge/deficient.cfm, accessed April 22, 2014.
17 *Ibid.*
18 Federal Highway Administration, "Financing Federal-Aid Highways," http://www.fhwa.dot.gov/reports/fifahiwy/ffahappm.htm, accessed January 3, 2014.
19 Cawley, Kim P., "Testimony on the Status of the Highway Trust Fund," Congressional Budget Office, July 23, 2013.
20 Virginia Department of Transportation, "Vehicle Miles Traveled (VMT) Tax: An Alternative to the Gas Tax for Generating Highway Revenue," http://vtrc.virginiadot.org/rsb/rsb19.pdf, accessed April 28, 2014.
21 Federal Highway Administration, "Transportation Asset Management Case Studies Bridge Management Experiences of California, Florida, and South Dakota," http://www.fhwa.dot.gov/infrastructure/asstmgmt/bmcs702.cfm, accessed April, 24 2014.

States use a variety of measures when reporting the status of their bridges related to the NBI inspection criteria, making data aggregation and analysis difficult.[22]

MITIGATION INITIATIVES

The Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law on July 6, 2012, and was the first multiyear transportation authorization enacted since 2005.[23] MAP-21 increased funding for highways and established new development and management programs, including maintenance and inspection. MAP-21 provides funds for transportation infrastructure, and it transforms current policy frameworks.

Some States have proposed implementing a Vehicle Miles Traveled (VMT) tax to replace fuel taxes. With VMT taxes, vehicle weight could be used to more accurately calculate the impact a vehicle has on road conditions. The State of Oregon is establishing a VMT program that will go into effect July 1, 2015, for up to 5,000 volunteer cars and light trucks. The volunteers will instead be charged 1.5 cents per mile—in lieu of the fuel tax—and issued a fuel tax refund.[24]

Individual States have initiatives to mitigate risks associated with natural disasters. A 2009 study on seismic vulnerability conducted by the Oregon Department of Transportation discusses implementing new inspection criteria and retrofitting to increase mitigation of seismic activity in the region.[25] The Minnesota Department of Transportation conducted a flood mitigation study in 2011 and plans to replace or repair certain bridges in areas susceptible to flooding.[26]

22 Federal Highway Administration, "Bridge Management Practices in Idaho, Michigan, and Virginia," http://www.fhwa.dot.gov/asset/hif12029/hif12029.pdf, accessed April 24, 2014.
23 Federal Highway Administration, "Moving Ahead for Progress," https://www.fhwa.dot.gov/map21/, accessed April 23, 2014.
24 Oregon Department of Transportation, "Road Usage Charge Program," http://www.oregon.gov/ODOT/HWY/RUFPP/Pages/ruc_overview.aspx, accessed January 7, 2014.
25 Oregon Department of Transportation, "Seismic Vulnerability of Oregon State Highway Bridges: Mitigation Strategies to Reduce Major Mobility Risks," http://www.oregon.gov/ODOT/TD/TP_RES/docs/reports/2009/2009_seismic_vulnerability.pdf, accessed April 28, 2014.
26 Minnesota Department of Transportation, "Minnesota River Flood Mitigation Study," http://www.dot.state.mn.us/floodmitigation/docs/mn-river-study.pdf, accessed October 30, 2014.

OMB Control No.: 1670-0027
Expiration Date: 10/31/2017

Homeland Security

National Protection and Programs Directorate

NPPD Customer Feedback Survey

Product Title:

1. Please select the partner type that best describes your organization. Select One

2. Overall, how satisfied are you with the usefulness of this product?

- ○ Very Satisfied
- ○ Somewhat Satisfied
- ○ Neither Satisfied Nor Dissatisfied
- ○ Somewhat Dissatisfied
- ○ Very Dissatisfied

3. How did you use this product in support of your mission?

- ☐ Integrated into one of my own organization's information or analytic products
- ☐ Used contents to improve my own organization's security or resiliency efforts or plans
  If so, which efforts?
- ☐ Shared contents with government partners
  If so, which partners?
- ☐ Shared contents with private sector partners
  If so, which partners?
- ☐ Other (please specify)

4. Please rank this product's relevance to your mission. ***(Please portion mark comments.)***

- ○ Critical
- ○ Very important
- ○ Somewhat important
- ○ Not important
- ○ N/A

5. Please rate your satisfaction with each of the following:

	Very Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Very Dissatisfied	N/A
Timeliness of product or support	○	○	○	○	○
Relevance to your information needs	○	○	○	○	○

6. How could this product or service be improved to increase its value to your mission? ***(Please portion mark comments.)***

To help us understand more about your organization so we can better tailor future products, please provide (OPTIONAL):

Name:
Organization:
Contact Number:
Position:
State:
Email:

Submit Feedback

[Privacy Act Statement]

[Paperwork Reduction Act Compliance Statement]