# International Collaboration Improves Earthquake and Tsunami Hazard Mitigation in the United States

U.S. Department of Transportation
**Federal Highway Administration**

Office of International Programs

**The Office of International Programs works to access, promote, and disseminate global best practices and technical innovations to ensure a safe and efficient United States highway transportation system.**

## ORIGINS

The Federal Highway Administration (FHWA) Office of International Programs has supported knowledge-building and effective practices in transportation in the United States and other countries. One example is the United States-Japan Bridge Engineering Workshops. These workshops have helped the United States share information on ductile structural designs with Japan. In turn, Japan has shared information and data on performance of their bridges following earthquake and tsunami events. Japan and the United States have also engaged in several cooperative research programs on topics such as experimental verification of seismic performance of bridges and experimental/numerical modeling of tsunami effects.[1]

Products to come from this collaboration include three 2021 Oregon Department of Transportation reports for the Transportation Pooled Fund study TPF-5(307), "Validation of Tsunami Design Guidelines for Coastal Bridges," partnering with FHWA and the States of Alaska, California, Hawaii, Oregon, and Washington.[2] A draft design guide was adopted by the American Association of State Highway and Transportation Officials (AASHTO).[3] Relationships built during the United States-Japan workshops were leveraged to create the Transportation Pooled Fund Study, TPF-5(307). This study produced probabilistic tsunami hazard maps for highway bridges for five western States, a methodology for developing site-specific tsunami hazard information, and loading calculations for bridges subject to tsunami effects. The reports cite findings from the 2011 Tohoku Earthquake in Japan, which provided critical information on how bridges performed under the impact of the tsunami wave. The reports also cite papers from Proceedings of the 29th and 30th United States-Japan Bridge Engineering Workshops, Study on Tsunami Wave Force Acting on a Bridge Superstructure, Hybrid Testing of a Prestressed Girder Bridge to Resist Wave Forces, and Effect of Fluid-Structure Interaction on Connection Forces in Bridges Due to Tsunami Loads.

**FIGURE 1.** UTATSU OHASHI BRIDGE LOCATED ALONG JAPAN'S NORTHEAST SHORE WAS SEVERELY DAMAGED, INCLUDING SUPERSTRUCTURES WASHED OUT BY THE TSUNAMI WAVE FROM THE 2011 EARTHQUAKE.
**SOURCE:** FHWA/PWRI[4]

FHWA also conducted additional experimental and numerical research at its Turner-Fairbank Highway Research Center partnering with Argonne National Laboratory, to develop methodologies to estimate potential scour effects following tsunamis. A milestone of the United States Tsunami strategy is the publication of the AASHTO Guide Specifications for Bridges Subject to Tsunami Effects.

[1]Nelda Bravo, Phil Yen, and Agnes Vélez (2015), Partners Across The Pacific, FHWAHRT-15-004, Public Roads, Vol. 78 No. 6, May/June 2015 (**https://highways.dot.gov/public-roads/mayjune-2015/partners-across-pacific**).

[2]**https://www.oregon.gov/odot/Programs/ResearchDocuments/TsunamiFinal.pdf**, **https://www.oregon.gov/odot/Programs/ResearchDocuments/Tsunami_Part1_Final.pdf** and **https://www.oregon.gov/odot/Programs/ResearchDocuments/Tsunami_Part2_Final.pdf**

[3]American Association of State Highway and Transportation Officials (AASHTO) (2022), Guide Specifications for Bridges Subject to Tsunami Effects, First Ed., January 2022.

[4]Tetsurou Kuwabara and W. Phillip Yen (2011), U.S.-Japan Joint Reconnaissance of Bridge Damage due to 2011 Great East Japan Earthquake, (**https://www.pwri.go.jp/eng/ujnr/tohokueq.htm**).

# International Collaboration Improves Earthquake and Tsunami Hazard Mitigation in the United States

## CAUSES AND EXAMPLES OF TSUNAMIS

Tsunamis are long-period waves caused by an underwater disturbance such as a volcanic eruption, earthquake, or landslide. It is commonly miscalled a "tidal wave."[5]

- The Boxing Day Tsunami of December 26, 2004 in the Indian Ocean was one of the worst natural disasters of the past century. The tsunami waves reached up to 100 feet high on land, and killed over 220,000 people, destroying entire cities and villages.[6]
- The 2011 Great East Japan (Tohoku) Earthquake triggered massive tsunami waves, which pushed seawater as far as 6 miles (9.7 kilometers) inland.[7] The waves reached up to 130 feet[8] and more than 300 bridges were washed away by the tsunami (see Figure 1).[9]

## COMMUNITY RESILIENCE FOLLOWING EARTHQUAKES AND TSUNAMIS

### U.S. Strategy

- Lifeline Objectives:
  - Provide for public safety in the event;
  - Provide transportation facilities critical to life support functions;
  - Reduce the economic impact to the extent reasonable; and
  - Provide emergency response following the event.
- Lifeline Resiliency Requirements:
  - Post-event functionality;
  - Seismic and tsunami design for Recovery and Critical bridges; and
  - Assessment of geotechnical hazards such as liquefaction, lateral spread, landslide, etc.[10]

### Japan Strategy[11]

- Tohoku area (practical example following the 2011 Tohoku Earthquake and Tsunami)
  - Rehabilitation of affected areas; and
  - Opening of emergency transportation network to traffic.

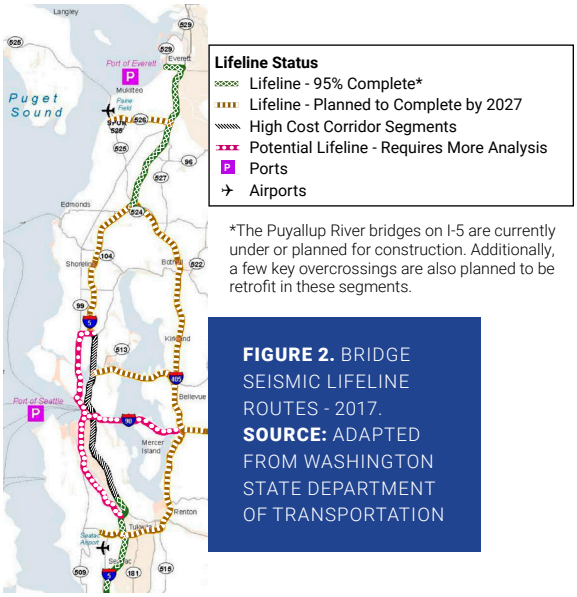


**FIGURE 2.** BRIDGE SEISMIC LIFELINE ROUTES - 2017. **SOURCE:** ADAPTED FROM WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

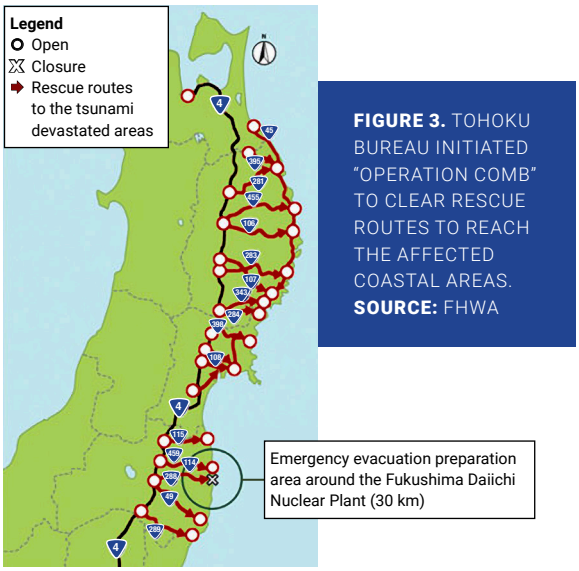


**FIGURE 3.** TOHOKU BUREAU INITIATED "OPERATION COMB" TO CLEAR RESCUE ROUTES TO REACH THE AFFECTED COASTAL AREAS. **SOURCE:** FHWA

[5]FHWA, Hydraulic Engineering Circular No. 25, Publication No. FHWA-HIF-19-059, January 2020 and American Association of State Highway and Transportation Officials (AASHTO) (2022), Guide Specifications for Bridges Subject to Tsunami Effects, First Ed., January 2022.

[6]FHWA, Hydraulic Engineering Circular No. 25, Publication No. FHWA-HIF-19-059, January 2020.

[7]Nelda Bravo, Phil Yen, and Agnes Vélez (2015), Partners Across The Pacific, FHWA-HRT-15-004, Public Roads, Vol. 78 No. 6, May/June 2015 (**https://highways.dot.gov/public-roads/mayjune-2015/partners-across-pacific**).

[8]FHWA, Hydraulic Engineering Circular No. 25, Publication No. FHWA-HIF-19-059, January 2020.

[9]Kazuhiko Kawashima, Kenji Kosa, Yoshikazu Takahashi, Mitsuyoshi Akiyama, and Hiroshi Matsuzaki (2011), Ground Motion and Tsunami Induced Damage of Bridges during 2011 Great East Japan Earthquake, Proc. 27th US-Japan Bridge Engineering Workshop, November 7-9, 2011, (**https://www.pwri.go.jp/eng/ujnr/tc/g/pdf/27/27-1-2_Kawashima.pdf**).

[10]Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification, Oregon Department of Transportation, May 15, 2012 (**https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf**).

[11]FHWA-NILIM (2021), 2021 U.S.-Japan Bridge Engineering Workshop.


www.international.fhwa.dot.gov

1200 New Jersey Avenue, SE
8th Floor, E83-462
Washington, DC 20590

Office: 202-366-9636
Fax: 202-366-3590

U.S. Department of Transportation
Federal Highway Administration