



Extreme Weather Events and Potential Impacts on Bridges and Structures

Extreme weather events affect nearly every state in the U.S. In 2012, a total of 133 disaster eventsⁱ occurred resulting in about \$881 billion in damagesⁱⁱ (see NOAA NCDC graphicⁱⁱⁱ at right). Events ranged from hurricanes, droughts, heat waves, severe local storms, non-tropical floods, and winter storms, to wildfires and freezes. There is strong evidence^{iv} that events related to heat, heavy precipitation, and coastal flooding will grow in frequency and severity in coming decades and we will likely continue to experience droughts and tropical storms. Changes in the frequency or intensity of extreme weather events also influence changes in design inputs and considerations for engineers. For example, how does one look at infrastructure design differently provided changes in weather-related stressors like increased wind or storm exposure and associated wave impacts, temperatures, precipitation, and freeze-thaw cycles? And, how does one assess the risk to existing infrastructure from increased incidence of extreme weather events?

U.S. 2012 Billion-dollar Weather and Climate Disasters



How Can Bridge and Structural Engineers Prepare for Extreme Weather Events?

Although DOT considerations will vary by state and topic, below is a “Top 10” list of suggestions for bridge and structural engineers to better prepare for extreme weather.

- Potential Overall Effects of Extreme Weather on Bridge Design:** Consider effects (individually and combined) of extreme temperatures and precipitation events on scour, pier and abutment protection, thermal expansion joints, bearings, superstructure elements, and bridge deck elevation and profile.
- Accelerated Bridge Construction Techniques for Easier Bridge Replacement and Repairs:** Research accelerated bridge construction techniques that allow for rapid replacement and repairs when needed.
- Pre-Positioning of Materials & Equipment:** Develop strategies for responding to bridge disruptions due to weather-related events, including pre-positioning replacement materials in vulnerable areas.
- Rapid Response Measures:** Develop a plan (e.g., scour plan of action, etc.) for reacting to structure damage or loss recognizing that access to that facility may be limited by potential damage. Develop closure and detour plans for facilities identified at risk.
- Risk Reduction Strategies:** Structures in areas with a low waterway opening to drainage area ratio in urbanized areas, or in areas with more dramatic topography, have a higher propensity for potential damage from high water volumes or velocities. Identify existing structure locations vulnerable to extreme weather risks, and develop appropriate strategies to minimize such risks.
- Early Warning Indicators:** Incorporate “early warning indicators” for potential extreme weather-related risks into bridge management systems. Examples include establishing a target rainfall intensity value within the facility watershed requiring monitoring and the use of gauging and Road Weather Information Systems (RWIS) to monitor upstream stream flow conditions.
- Workforce Protection:** Protect workers from extreme temperatures and weather during bridge construction.
- Risk Assessment for Bridge Approaches:** Consider effects to, and maintenance strategies for, impacts in these facilities with little/no current program of monitoring.
- Dialogue on Actions Having the Potential of Increasing Risk:** Participate in development of community strategies and upstream or downstream flood control measures that consider potential negative effect on structures.
- Challenges to Adaptation of Bridges:** Identify barriers to undertaking adaptive measures, such as the clearing of debris below structures and legal liabilities created by expanding waterway openings (which can contribute to downstream flooding).



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



Bridge and Structures Resources for Extreme Weather Preparedness

PUBLICATIONS

- **Climate Change, Extreme Weather Events and the Highway System** (NCHRP 750, Vol. 2, 2014). Report presents guidance for practitioners on adaptation strategies to likely impacts of climate change in the planning, design, construction, operation, and maintenance of infrastructure assets in the U.S.
- **Expedited Procurement Procedures for Emergency Construction Services** (NCHRP 438, 2012). Report explores procurement procedures utilized by states in coordination with Federal agencies to repair and reopen roadways in emergency situations.

GUIDANCE AND RULES

- **AASHTO Guide Specifications for Bridges Vulnerable to Coastal Storms** (2008). Guide covers new concepts not included in previous design provisions with comprehensive specifications for the design of bridges vulnerable to coastal storms.
- **AASHTO Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges** (2009). This 2nd edition incorporates lessons learned from use of the original 1991 Vessel Collision Guide Specification, additional research and clarification of risk procedure elements applicable in extreme weather events.
- **AASHTO LRFD Bridge Design Specifications** (2012). Comprehensive specifications employing the Load and Resistance Factor Design methodology and covers “Extreme Event Limit States” to ensure structural survival of a bridge during extreme events.
- **Eligibility of Activities To Adapt To Climate Change and Extreme Weather Events Under the Federal-Aid and Federal Lands Highway Program** (September 2012). Memo clarifies activities eligible for FHWA funding, including vulnerability assessments, design and construction of projects or features to protect assets from damage associated with climate change.
- **FHWA Hydraulic Design Series No.2 – Highway Hydrology** (2002). This 2nd edition includes new sections on wetlands hydrology, snowmelt hydrology and special topics including but not limited to GIS approaches and applications.
- **MAP-21, Section 1315 – USDOT Final Rule on Categorical Exclusions (CE) for Emergency Repair Projects** (February 2013). Rule revises the existing CE for emergency repair projects under Moving Ahead for Progress in the 21st Century Act (MAP-21).
- **MAP-21, Section 1511 – Special Permits During Periods of National Emergency Implementation Guidance, Revised** (June 2013). Section provides policy direction on special permits for divisible loads and guidance describing the program’s purpose, permit requirements, and ineligible activities.
- **USACE Coastal Engineering Manual** (2012). Guidance includes tools and procedures to plan, design, construct, and maintain coastal projects. Update covers guidance on conducting studies for coastal flooding, shore protection, and navigation projects.
- **USDOT Hydraulic Engineering Circular No. 25, Vol. 2** (publication anticipated fall 2014). Volume 2 provides technical guidance for incorporating extreme events into coastal highway design focusing on sea level rise, storm surge, and wave action.

WEBSITES

- **AASHTO Transportation and Climate Change Resource Center:** Extreme Weather Symposium, 2013. Materials on recent extreme weather events, costs, and how DOTs can manage them. climatechange.transportation.org/symposium/
- **FHWA Climate Change Adaptation Website:** www.fhwa.dot.gov/environment/climate_change/adaptation/
- **Federal Emergency Management Agency (FEMA) Map Service Center:** <https://msc.fema.gov>
- **C2ES:** Interactive map depicting extreme weather events, 1990-2012. www.c2es.org/science-impacts/maps/extreme-weather

OTHER RESOURCES

AASHTO’s Sustainable Transportation: Energy, Infrastructure, and Climate Solutions (STEICS) Technical Assistance Program provides timely information, tools, and technical assistance to State DOTs to manage challenging issues associated with extreme weather events. (http://climatechange.transportation.org/about/steering_committee.aspx)

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ⁱ “Disaster events” include tropical cyclones (e.g., hurricanes), droughts/heatwaves, severe local storms, non-tropical floods, winter storms, wildfires, and freezes.

ⁱⁱ Smith and Katz, Natural Hazards, June 2013, Volume 67, Issue 2, pp. 387-410.

ⁱⁱⁱ Source: NOAA NCDC at www.ncdc.noaa.gov/billions/summary-stats

^{iv} Walsh, J. et al., 2014: Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.