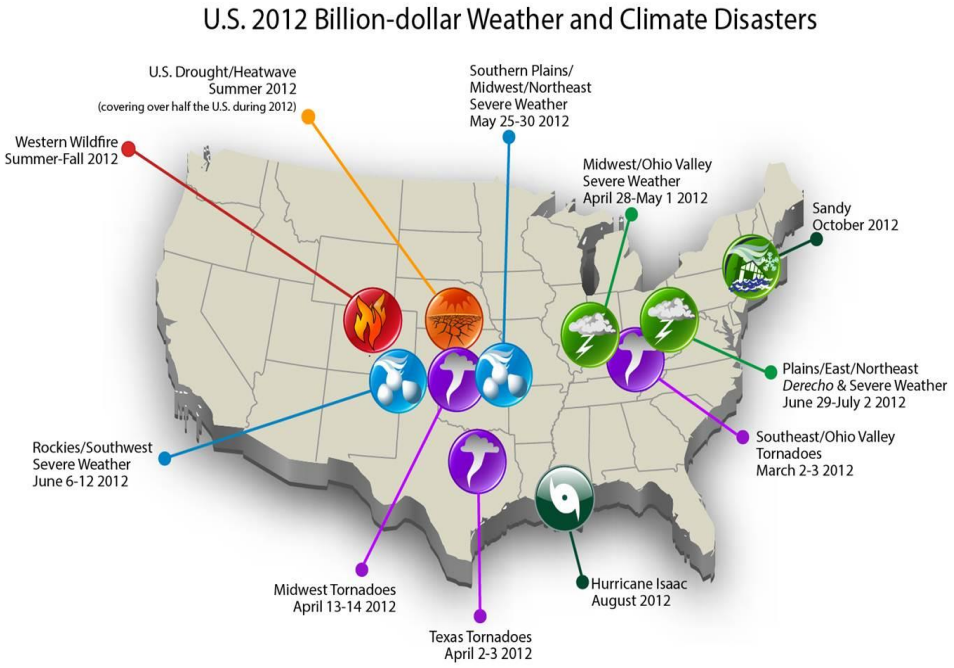
AASHTO
EXTREME WEATHER & THE TRANSPORTATION SYSTEM

How Do Extreme Weather Events Impact Materials?

Extreme weather events affect nearly every state in the U.S. In 2012, for example, a total of 133 disaster events[i] occurred resulting in about $881 billion in damages[ii] (see NOAA NCDC graphic[iii] at right). Events ranged from hurricanes, droughts, heat waves, severe local storms, non-tropical floods, and winter storms, to wildfires and freezes. In addition, many parts of the country have witnessed gradual shifts in average temperatures and rainfall patterns over the past several decades. These changes stress transportation systems in many ways, including effects on materials, such as pavement deterioration, slope instability, scour, changes to materials expansion and contraction, and more. There is strong evidence 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.



How Can Materials Engineers Prepare for Extreme Weather Events?

Although transportation agency experiences will vary by state and topic, below is a "Top 10" list of suggestions for materials engineers to better prepare for extreme weather and shifting climate trends.

1. **Identify and Review Climate Assumptions:** Identify the climate and weather-related assumptions in materials design and engineering, and review whether those assumptions should be updated to incorporate recent trends or future projections.
2. **Monitor Tends:** Develop and track performance metrics related to weather (e.g., number and severity of weather events, pavement condition, maintenance needs) improve decision-making over time, given a better to understanding of how weather variables are changing and how materials are responding.
3. **Identify and Consult Geographic Analogs:** Exchange knowledge with peers in locations whose current "normal" weather conditions are similar to the "new normal" expected in your location.
4. **Coordinate:** Improve coordination and communication between maintenance staff and materials engineers to improve understanding of how materials are responding in the field.
5. **Consider Lifecycle Costs:** Consider lifetime project costs and benefits—and including fresh assumptions of weather risk—in the materials design process.
6. **Be Flexible:** For locations or assets particularly vulnerable to extreme weather impacts and that carry high consequences of asset failure, incorporate flexible or adaptive design concepts into project design.
7. **Revisit Manuals:** Review and revise design manuals as needed to incorporate changing conditions—for example, consider whether it's best to use historic-based information or a forecasting process.
8. **Materials Selection and Design:** Incorporate extreme weather event trends in design processes. For example, prepare for higher-than-normal weather events by "hardening" infrastructure, or incorporate flexible or adaptive design concepts into project design.
9. **Asset Management:** Use risk-based asset management systems to track relevant information on materials and extreme weather vulnerabilities to inform decision-making over time.
10. **Use "Smart" Technology**: For critical assets or in areas of potential vulnerability, consider including sensor technology to monitor and warn of serious stresses (water or temperatures) impacting assets in real time.

Center for Environmental Excellence

Materials Resources for Extreme Weather Preparedness

PUBLICATIONS

- **Climate Change, Extreme Weather Events and the Highway System** (NCHRP Report 750, Volume 2, 2014). This 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.
- **FHWA Climate Change and Extreme Weather Vulnerability Assessment Framework** (FHWA, December 2012). This document is a guide for transportation agencies interested in assessing their vulnerability to climate change and extreme weather events. The accompanying "Virtual Framework" is a web resource with step-by-step guidance and tools for transportation agencies.
- **Engineering Assessments of Climate Change Impacts and Adaptation Measures** (U.S. DOT, August 2014). Report discusses engineering assessments and adaptation options for a range of facilities and climate stressors in Mobile, AL. Includes lessons learned from applying an 11-step climate assessment process.
- **Response to Extreme Weather Impacts on Transportation Systems** (NCHRP Synthesis 454, May 2014). Report examines eight recent cases of extreme weather in the U.S. from the perspectives of transportation operations, maintenance, design, construction, planning, communications, interagency coordination, and data and knowledge management.
- **The Infrastructure and Climate Network (ICNet) Climate Change Impacts on Future Pavement Performance and Maintenance Costs** (ICNet, October 2013). Presentation through ICNet's webinar series on ongoing research about the impacts of climate change on pavement and strategies to adapt pavement design procedures.

FEDERAL GUIDANCE AND RULES

- **FHWA Order 5520 – Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events** (Dec. 15, 2014). Directive establishes FHWA policy that FHWA programs, policies, and activities integrate consideration of climate change and extreme weather event impacts and adaptation into planning, operations, policies, and programs.
- **Eligibility of Activities To Adapt To Climate Change and Extreme Weather Events Under the Federal-Aid and Federal Lands Highway Program** (Sept. 24, 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.
- **MAP-21, Section 1315 – USDOT Final Rule on Categorical Exclusions (CE) for Emergency Repair Projects** (Feb. 19, 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.

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/
- **Center for Climate and Energy Solutions:** Interactive map depicting extreme weather events, 1990-2013. www.c2es.org/science-impacts/maps/extreme-weather

OTHER RESOURCES

AASHTO's Resilient and Sustainable Transportation Systems (RSTS) 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/technical_assistance_program.aspx)

For questions or for more information, please contact Shannon Eggleston, Program Director for the Environment at SEggleston@aashto.org.

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[i] "Disaster events" in this context have been defined as 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