BUILDING RESILIENCE: The Roofing Perspective

An Annual Report from the EPDM Roofing Association

ERA

EPDM ROOFING ASSOCIATION

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FOREWORD

November 1, 2018

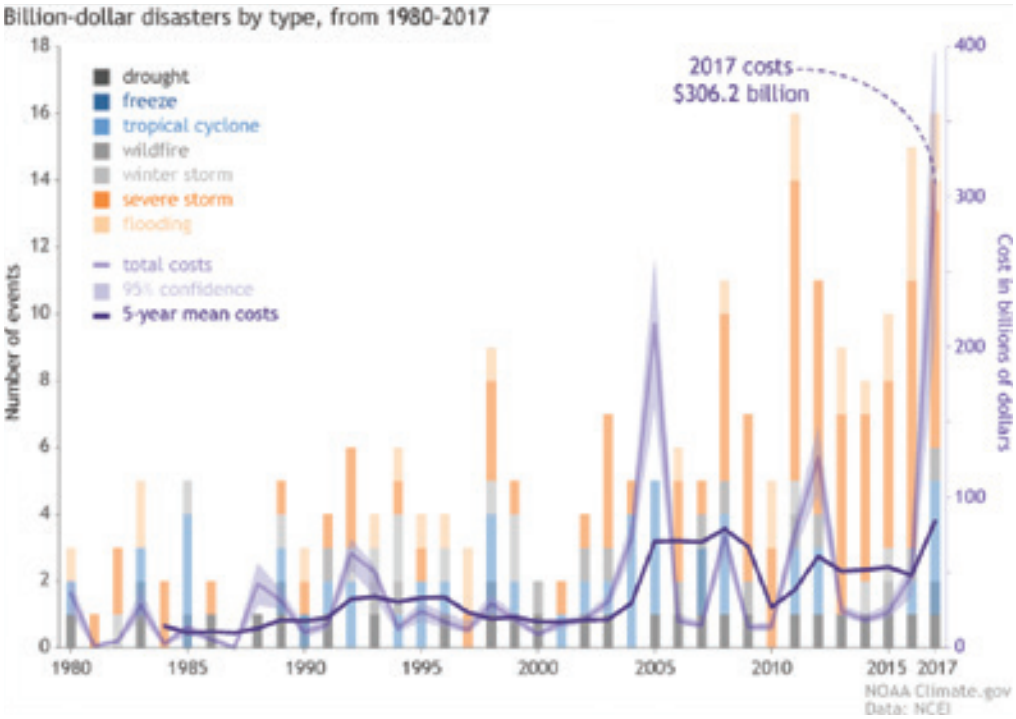
The EPDM Roofing Association (ERA) is dedicated to delivering science-based technical and research support, providing dependable roofing solutions and communicating the longstanding attributes of EPDM roofing materials to the construction industry. Carlisle Construction Materials and Firestone Building Products formed ERA in 2002, and were joined in 2012 by Johns Manville, together mounting an effort to ensure that accurate information about the value of EPDM was proactively provided to the marketplace.

Over the past 15 years, while EPDM membrane formulations have remained relatively constant, ERA members have consistently delivered product innovations to the roofing community. Self-adhering components have increased roof system quality, highly puncture resistant 90 mil EPDM membranes have been introduced offering the thickest layer of waterproof protection available, and white EPDM has been introduced for use where appropriate.

During the same period that these advances were developed and introduced, long-standing issues surrounding the roofing industry have intensified, and new issues have emerged. The association currently finds itself devoting significant time and resources to ensure that government bodies do not take away choice from building owners, facility managers, architects and designers. As part of this effort, ERA provides code and regulation setting bodies with science-based information to ensure that any changes in the regulatory environment are based on fact and a full understanding of the consequences.

ERA is now committing significant resources to an issue of growing importance that impacts almost every consideration of the roofing industry. While there may be debate about the cause, global statistics confirm the increasing frequency of more extreme weather: intense tornado outbreaks, record setting heat, catastrophic wildfires, heavy downpours, longer droughts and more frequent hurricanes.

Even as this report is being prepared, parts of the Eastern United States are recovering from the record rainfall,



The number (left vertical axis), type (colors), and annual cost (right vertical axis) of U.S. billion-dollar disasters from 1980-2017. (lines) The orange colors were chosen to emphasize the rising contribution of two event types to the total annual costs: severe storms and inland flooding. NOAA Climate.gov animation, based on NCEI data from Adam Smith.

historic flooding and catastrophic storm surge of Hurricane Florence and Hurricane Michael. These extreme weather events are assaulting the built environment with new strength and intensity, creating an urgent need for more resilient structures. Historic weather patterns can no longer be a guide for building codes and standards, since the past is not a reliable guide for what can be expected from future threats. Since the roof of a building is a first line of defense, any discussion of resilience must include careful consideration of roofing systems.

Given the importance of this emerging issue, and the critical role that roofing plays in a resilient building, ERA has produced this first annual report on Building Resilience. This document is meant to be a resource for the roofing industry, and for the thought leaders who impact the trajectory of roofing science.

Our goal is to ensure that anyone interested in creating or investing in a resilient roof has access to up-to-date information about best practices to be followed, as well as an understanding of the benefits of EPDM in creating a resilient roofing system. We want to be your partners in building the resilient future of the roofing industry.

Building Resilience: Defining the Path Forward

The discussion about the need for resilience is taking place in a wide variety of settings such as non-profit organizations, industry associations, academic and research institutions, code and standard setting organizations, Federal agencies, and state and local governments. Despite general agreement on certain aspects of resilience, each of these groups has unique goals and a unique point of view.

This has led to a proliferation of working definitions of resilience. For instance:

	The Department of Homeland Security defines resilience as, "...the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies. Whether it is resilience towards acts of terrorism, cyber attacks, pandemics, and catastrophic natural disasters, our national preparedness is the shared responsibility of all levels of government, the private and nonprofit sectors, and individual citizens."
	Both the International Code Council (ICC) and the US Green Building Council (USGBC) define resilience as the "ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."
RESILIENT DESIGN INSTITUTE	The Resilient Design Institute, self-described on its website as "a solutions-based organization that will offer practical guidance for making our buildings, communities, and systems more resilient in the face of global climate change", states that resilience is "the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance. It is the capacity to bounce back after a disturbance or interruption. From Katrina to Sandy, California drought to Mississippi flooding, resilience is both response and action." This organization differentiates among "building scale" resilience, "community scale" resilience, and "regional and ecosystem scale" resilience.
National Institute of BUILDING SCIENCES	The National Institute of Building Sciences (NIBS) states that: "Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."

Based on these definitions as well as definitions offered by other comparable organizations, it is important to note that:

- While resilient systems usually incorporate durability, energy efficiency and sustainability, resilience has a broader meaning than any of these terms when applied to the built environment. Buildings that house critical services and are also essential to the recovery of a community, such as hospitals and fire and police stations, must be able to withstand the initial force of a cataclysmic event and return to full-functioning as quickly as possible.
- Resilient systems help to protect a structure against both stresses and shocks, stresses being defined as long-term changes such as rising temperatures or sea levels, and shocks defined as individual destructive events, such as a hurricane, earthquake or typhoon.
- Resilience is being discussed as an attribute of individual buildings, as well as a function of entire communities, cities and regions.
- Resilience usually is discussed in the context of natural events such as hurricanes, tornadoes, earthquakes, wildfire, extreme heat or cold, but it can also be seen as an essential protection against acts of terrorism, cyberattacks or pandemics.
- Resilience is not a uniquely coastal issue. A recent Congressional briefing by the Environmental and Energy Study Institute (EESI) that focused on urban resilience showed that cities from Flagstaff to Pittsburgh are looking at ways to harden their community infrastructures against flooding, earthquakes, fire, tornadoes and other natural disasters.

Taking into account the above variables in a discussion of resilience, for the sake of consistency in this document, resilience will refer to individual buildings and will use the working definition supplied by the Department of Homeland Security: “the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies.” We will focus on the critical role of the roof system in creating a resilient structure, since the roof can often be the first line of defense against cataclysmic weather. While it may be possible to be sheltered by a roof without fully intact walls, if the roof fails, the entire structure, as well as its occupants, are in jeopardy. Additionally, while many architects and roof designers oppose placing mechanical equipment on the roof, there is no doubt that this is increasingly become a reality in resilient structures. And, finally, in certain situations, the roof must be sturdy enough to support evacuation activities, should that be necessary during or immediately after a weather crisis.

Building Resilience: The Year in Resilience

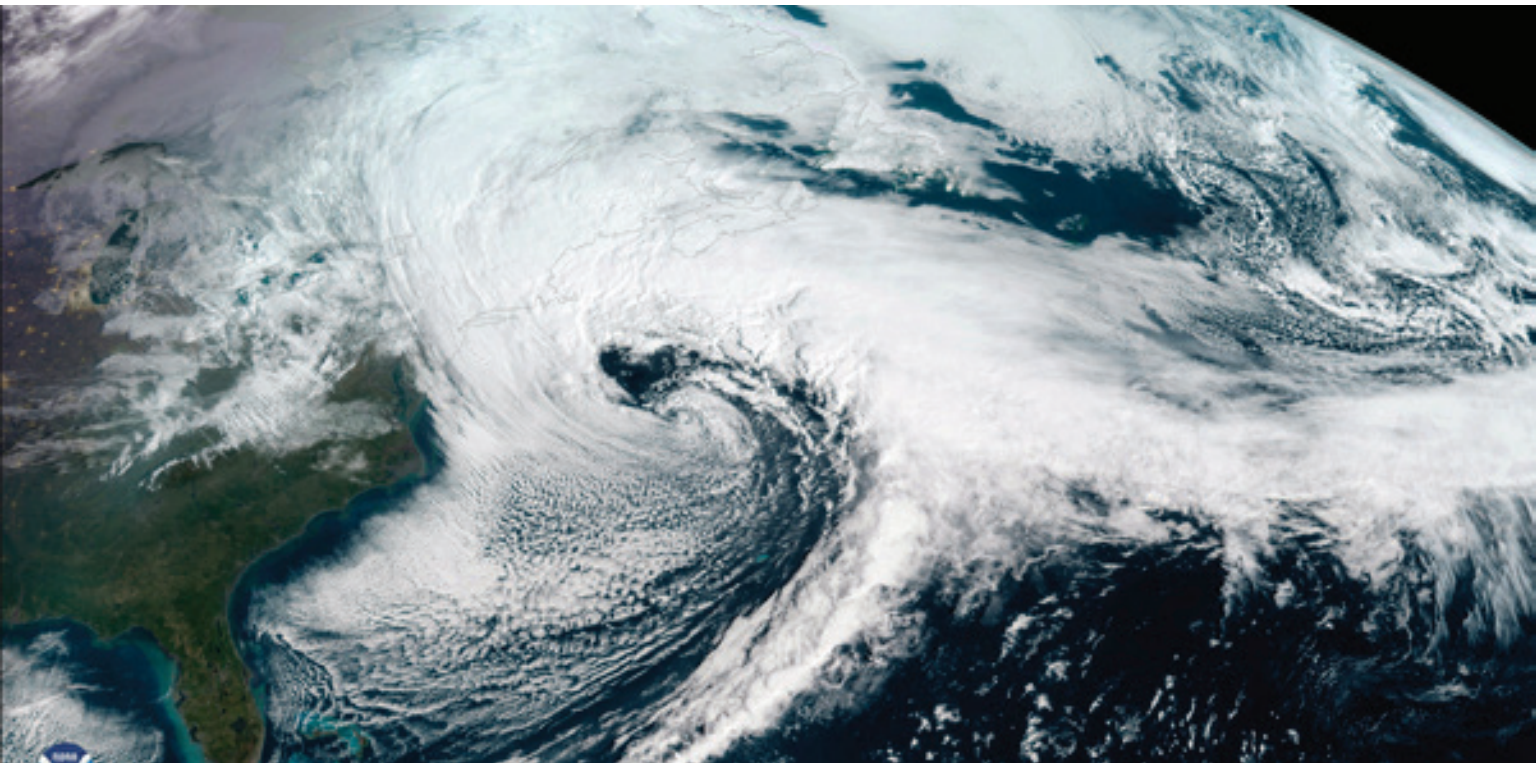
Weather Events

According to NOAA's National Centers for Environmental Information, to date in 2018 there have been six "climate and weather disaster events", each causing at least $1 billion in damage and collectively causing the deaths of 36 people:

- In January, a Nor'easter caused damage across the northeastern states, as well as in South Carolina, Tennessee, Virginia, North Carolina and Georgia. Current estimates are that the storm caused $1.1 billion in damage, and 22 deaths. This storm also introduced the terms "bombogenesis" and "extratropical cyclone" to the public's weather vocabulary. Put in more conventional terms, it was one of the most powerful winter storms ever observed on the East Coast, delivering winds up to 75 miles per hour, and coating states as far south as South Carolina with snow. Boston experienced record-setting high tides, turning its downtown streets into waterways.

"Resilience is the backbone of emergency management."

— FEMA Strategic Plan, 2018-2022



A picture of the third Nor'easter in 10 days to impact New England in early 2018.

- A second series of Nor'easters battered the Atlantic Coast from Maryland to Maine during the first three days of March, killing an additional nine people and causing $2.2 billion in damage. Water levels in Boston reached the third highest on record. The NOAA website gives an explanation for this increased flooding: "Regardless of whether these storms are getting stronger, they are occurring over an ocean that is fuller than it used to be. This all makes it easier for storms to push enough water onshore to cause flooding."
- From March 18 to 21st, the Southeastern United States was hit with a series of severe hail storms and tornadoes, causing 1.4 billion dollars damage. An EF-3 tornado, with winds up to 140 miles per hour, caused extensive damage in and around Jacksonville, Alabama primarily on the campus of Jacksonville State University.
- Over a four-day period in early May, a series of storms devastated parts of the Central and Northeastern states. Tornadoes, high winds, and hail caused $1 billion dollars damage. In mid-May, severe storms again crossed the Central States, followed by a derecho event across the Northeastern states that caused widespread high wind damage.
- On May 28th, a massive storm released more than nine inches of rain in two hours, the equivalent of one month's average rainfall, on historic Ellicott City in Maryland. This caused catastrophic flooding, sending more than 10 feet of rapidly moving water down Main Street in Ellicott City. While this was not a NOAA-ranked "billion dollar" event, two years earlier, the same location experienced historic flooding, and the area had not completed repairs from that event.

> "If we incorporate a reasonable range of projections in our plans now, we will be able to save ourselves a lot of money. And if we don't do that, I think there will be economic harm because our infrastructure will be rebuilt and then it will fail again."
>
> — Judge Alice Hill, Research Fellow, Hoover Institution, Stanford University and former Special Assistant to President Barack Obama and Senior Director for Resilience for the National Security Council

Policy Response

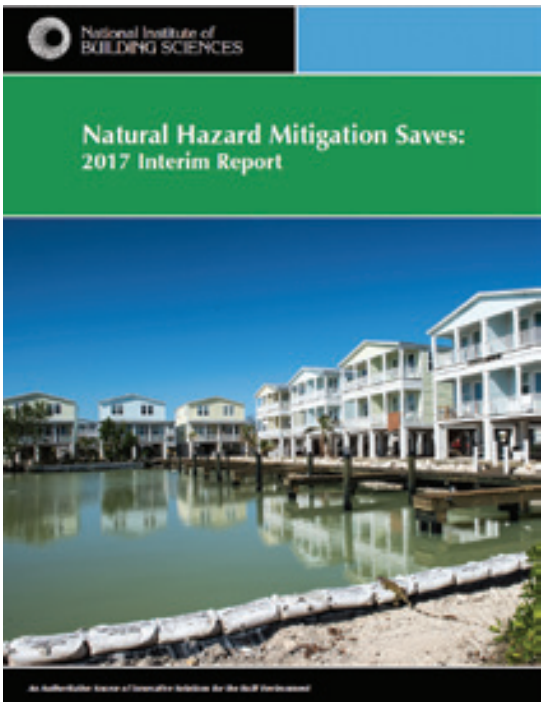
While natural forces continued their unabated pressure during 2018 on the built environment, discussion of the most effective response to this onslaught intensified and began to center around mitigation. This new focus examined the value of proactively investing in resilient structures in anticipation of devastating weather events, rather than waiting until extensive damage required expensive repair. Two especially influential reports were released that focused on mitigation:

National Institute of Building Sciences' Natural Hazard Mitigation Saves: 2017 Interim Report

The National Institute of Building Sciences released its *Natural Hazard Mitigation Saves: 2017 Interim Report*, updating and expanding its previous landmark report on mitigation published in 2005. Working from data provided by the Federal Emergency Management Agency (FEMA), the 2005 report found that every $1 of natural hazard mitigation funded by the FEMA between 1993 and 2003 saved the American people an average of $4 in future losses. That one to four ratio of investment to returns was widely quoted at the time that the report was published, and has been cited repeatedly during the past decade as interest in resilience grown. The newer report demonstrated an even higher net benefit of Federal mitigation investments than previously understood.

Based on updated data and a wider array of Federal programs examined, Federally funded mitigation grants, on average, can save the nation $6 in future disaster costs for every $1 spent on hazard mitigation. This is up from the 2005 study's finding that $1 spent on mitigation results in $4 in savings. (Grant programs from 1993-2016.)

The report also demonstrates for the first time that, on average, investments made by local communities and homeowners in hazard mitigation measures that exceed standard building codes can save the nation $4 for every $1 spent. This equates to $15.5 billion in savings from one year of building new construction beyond current code requirements.



> "Mitigation represents a sound financial investment."
>
> — MMC of NIBS

FEMA National Mitigation Investment Strategy (draft)

Also in early January, FEMA released its draft *National Mitigation Investment Strategy* to provide a "national approach to investments in mitigation activities and risk management across the United States". This document was released for public comment, and the final strategy report is expected to be released in November.

According to the FEMA draft, their final investment strategy will be grounded in three fundamental principles: (1) catalyze private and non-profit sector mitigation investments and innovation; (2) improve collaboration between the Federal government and state, local, tribal and territorial governments, respecting local expertise in mitigation investing; and (3) make data- and risk-informed decisions that include lifetime costs and risks. The investment strategy's overarching goal, according to FEMA, is to improve the coordination and effectiveness of "mitigation investments," defined as risk management actions taken to avoid, reduce, or transfer risks from natural hazards, including severe weather.

Given the potential impact of this report (FEMA National Mitigation Investment Strategy (draft)) on the built environment, as well as on the industries that work to incorporate resilient strategies, ERA submitted feedback to FEMA. ERA commended FEMA for its issuance of the draft strategy, and expressed confidence that all the suggested recommended goals are desirable as risk management strategies to be implemented at the private and public sector levels. However, given ERA's experience with building performance, the association focused its comments on two of the specific recommended strategies in the published draft:

Recommendation 6.1: Federal departments and agencies should ensure up-to-date building standards are used for Federal building projects and could incentivize SLTTs receiving Federal aid for building projects to adopt and enforce, at a minimum, the most current version of model building codes.

The ERA response stated, "There's no question that a review of hurricane and related weather catastrophic events reflect that the better the building quality and the better the building codes, the better the performance of the community. While there has been substantial improvement in many states across the country, adoption and compliance pose significant hurdles for overall performance in disaster events. The urgency of this cannot be overstated. Part of this effort to upgrade the building codes and consequently overall resilience must focus on the quality of materials, installation, and inspection of final construction to ensure compliance by local authorities.

The experience of the roofing industry in its inspection of many disasters over the years have confirmed that a well installed, inspected, and well-maintained roof, is a linchpin of overall building resilience. ERA believes that Federal funding to the states to allow for the kind of technical assistance that enhances code quality and state and local compliance programs necessary to achieve physical and community resilience should be provided."

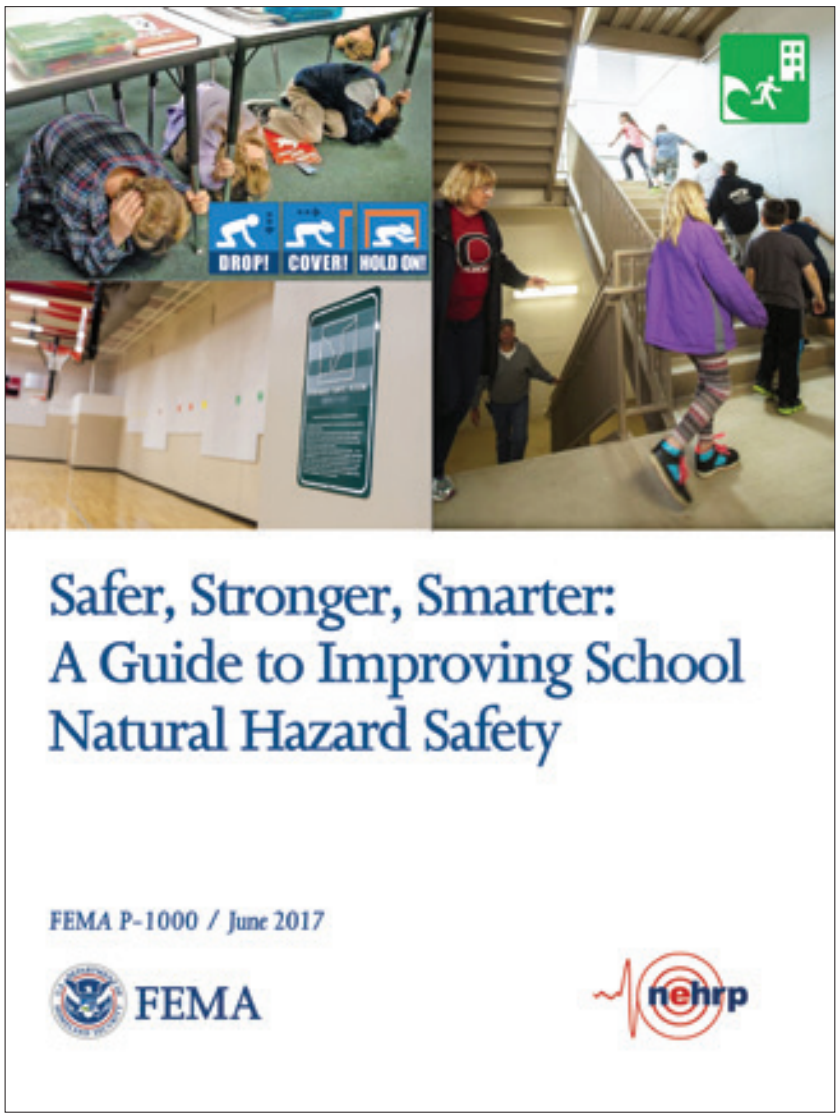
Recommendation 6.3: Public sector entities should focus more on rebuilding better as well as rebuilding quickly following damage caused by natural disasters.

From the ERA response, "As important as recommendation 6.1 is, this recommendation to achieve rebuilding better buildings quickly following damage caused by natural disasters is even more important. As FEMA Deputy Director Roy White has pointed out in several presentations focused on resilience, it makes no sense for the agency to fund rebuilding of a destroyed facility to standards that existed when the original building was constructed with the likelihood that it would not be able to withstand another weather perturbation beyond historic norms. Consequently, FEMA and HUD need to have authority and appropriations to ensure that rebuilding is done with an eye toward future, not historic climate conditions. This is in recognition that the original basis for many buildings that then are destroyed has been dramatically changed by recently evolving weather patterns. In addition, as the FEMA and NIBS study recently demonstrated, there is a payback to the government of a 6 to 1 ratio for investing in rebuilding to a more resilient standard."

As the Federal agency charged with helping people "before, during and after disasters", FEMA issued two other influential reports that impact the government's approach to building resilience:

FEMA SCHOOL SAFETY REPORT: "Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety"

A June, 2017 FEMA report sounded the alarm that many of the nation's fifty million school children are at risk because of aging school buildings, or buildings that do not meet basic resilience standards to withstand a natural disaster, or are located in a flood plane. The FEMA report, "Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety" points out that "... many of our nation's school buildings are older unreinforced masonry structures that are vulnerable to severe damage and collapse in the next earthquake, or are of lighter frame construction that is vulnerable to other types of natural hazards such as a tornado, hurricane, high winds, or flash flooding."



In fact, as of 2014, according to FEMA, the average public school building was 44 years old. And while some of these schools have undergone major renovation, "the original construction of numerous school buildings predates many of the modern building code requirements protecting occupants from natural hazards such as earthquakes, floods, high winds, and tsunamis". In other words, millions of school children are being educated in buildings that are using 20th century construction standards to meet 21st century hazards. And those 21st Century hazards are becoming more of a threat. As the FEMA report unequivocally states, "Over the last several decades, the United States has experienced an escalation in the number of damaging natural hazard events and corresponding costs resulting from that damage."

Given these challenges, FEMA offers extensive specifics on upgrading school structures to improve safety and notes the critical importance of roofing systems to protect the integrity of a school building. It warns that a roof that is damaged in a hurricane "will result in significant interior damage due to water leakage" and any roofing system that is "extremely susceptible to wind damage . . . should be mitigated as soon as budget permits."

The FEMA 2018-2022 Strategic Plan (Draft)

In March, FEMA released a draft of its five-year strategic plan with three dominant goals: Build a Culture of Preparedness; Ready the Nation for Catastrophic Disasters; and Reduce the Complexity of FEMA. Writing about the first goal, the FEMA plan said, "Resilience is the backbone of emergency management. The Nation's ability to weather storms and disasters without experiencing loss significantly reduces our risk. The most successful way to achieve disaster resiliency is through preparedness, including mitigation."

2018 2022

Strategic Plan

Helping People. Together.

FEMA Mission: **Helping people before, during, and after disasters.**

STRATEGIC GOALS

I. BUILD A CULTURE OF PREPAREDNESS

OBJECTIVES

- 1.1 Incentivize investments that reduce risk, including pre-disaster mitigation, and reduce disaster costs at all levels
- 1.2 Close the insurance gap
- 1.3 Help people prepare for disasters
- 1.4 Better learn from past disasters, improve continuously, and innovate

II. READY THE NATION FOR CATASTROPHIC DISASTERS

- 2.1 Organize the "BEST" (Build, Empower, Sustain, and Train) scalable and capable incident workforce
- 2.2 Enhance intergovernmental coordination through FEMA Integration Teams
- 2.3 Posture FEMA and the whole community to provide life-saving and life-sustaining commodities, equipment, and personnel from all available sources
- 2.4 Improve continuity and resilient communications capabilities

III. REDUCE THE COMPLEXITY OF FEMA

- 3.1 Streamline the disaster survivor and grantee experience
- 3.2 Mature the National Disaster Recovery Framework
- 3.3 Develop innovative systems and business processes that enable FEMA's employees to rapidly and effectively deliver the agency's mission
- 3.4 Strengthen grants management, increase transparency, and improve data analytics

FEMA Vision:
A prepared and resilient Nation.

FEMA

Legislative Initiatives

FEMA Legislation:

- The Disaster Recovery Reform Act (DRRA) is included in HR 4, a bill that reauthorizes the Federal Aviation Administration for the next five years. The components of the DRRA included in HR 4 increase the Federal investment in pre-disaster mitigation, increase reimbursement caps for state and local governments on a range of disaster costs, and allow state and local governments to administer housing assistance grants. President Trump signed the DRRA into law as part of the Federal Aviation Administration Reauthorization Act of 2018 on October 5.
- In August, ERA joined with 45 other leading industry groups to support the inclusion of enhanced building codes and greater Federal funding for resilient construction in the pending legislation. In part, the letter said, "The EPDM Roofing Association (ERA), the leading trade association representing the manufacturers of EPDM single-ply roofing products and their suppliers, has joined with 45 other influential industry groups to urge the Senate to include building code upgrades in the pending Disaster Recovery Reform Act (DRRA). "This bill is focused on supporting mitigation activities, so it is essential to include the adoption of modern model building codes as part of the legislative package," said Jared Blum, Executive Director of ERA. "If passed, it would promote the construction of resilient, energy-efficient buildings that can withstand frequent cataclysmic natural events, and quickly recover from their impact."
- While much of the legislative action was focused on preventing futures losses, the massive losses sustained during 2017 required increased spending. To aid in recovery of these extreme weather events there were three supplemental appropriations bills that were enacted in response to Administration requests made in September, October, and November 2017. These provided $120 billion in budget authority for disaster assistance for Hurricanes Harvey, Irma, and Maria, and calendar year 2017 wildfires and canceled $16 billion in debt held by the National Flood Insurance Fund.

Building Resilience: Creating the Resilient Roof

> "The roof is your first line of defense against anything Mother Nature inflicts... and during a bad storm your roof endures fierce pressure from wind, rain, and flying debris."
>
> — IBHS President and CEO Julie Rochman

The roofing industry is focusing on two key aspects of creating a resilient roof: durable components, the building blocks of resilience, and a robust design.

Durable components are characterized by:

- Outstanding weathering characteristics in all climates (UV resistance, and the ability to withstand extreme heat and cold)
- Ease of maintenance and repair
- Excellent impact resistance
- Ability to withstand moderate movement cycles without fatigue
- Good fire resistance (low combustibility) and basic chemical resistance

A robust design that will enhance the resiliency of a roofing system should incorporate:

- Redundancy in the form of a back up system and/or waterproofing layer
- The ability to resist extreme weather events, climate change or change in building use
- Excellent wind uplift resistance, but most importantly multiple cycling to the limits of its adhesion
- Easily repaired with common tools and readily accessible material

Testing for Resilience: Identifying Durable Components

The Insurance Institute for Business and Home Safety (IBHS) Research Center is an independent, nonprofit, scientific research and communications organization supported solely by property insurers and reinsurers. IBHS' building safety research leads to real-world solutions for home and business owners, helping to create more resilient communities. The mission of the organization is to conduct objective, scientific research to identify and promote the most effective ways to strengthen homes, businesses and communities against natural disasters and other causes of loss.

Insurance Institute for Business & Home Safety®

The IBHS research facility, which opened in 2010, evaluates various residential and commercial construction materials and systems. The lab is the only lab in the world that can unleash the power of highly realistic windstorms, wind-driven rain, hailstorms and wildfire ember storms on full-scale one- and two-story residential and commercial buildings in a controlled, repeatable fashion.

The mission of IBHS is to reduce the social and economic effects of natural disasters. And much of its research has focused, at least in part, on the resilience of roofs.

Hail research at IBHS is conducted in the Laboratory Building for Small Tests, a compact structure with equipment appropriate to replicate large hailstones and hurl them at roof samples. More than 75 percent of the cities in the United States experience at least one hailstorm a year, and the risk extends across the country to all areas east of the Rockies. Annually, hail losses reach more than 1 billion dollars. The IBHS has identified the factors that contribute to the extent of hailstorm damage, with the impact resistance of roofing materials being one of the most critical factors, along with hailstone size, density and hardness.

IBHS has found that unsupported roofing materials perform poorly and ballasted low-slope roofs perform especially well in hailstorms because they disperse energy. IBHS recommends that builders use systems that have impact resistance approval, including their own Fortified standard. Additionally, IBHS leadership stresses that resilient roofing systems in new and retrofitted construction can make good financial sense. According to Julie Rochman of IBHS, “We are really going to continue focusing on moving our culture from one that is focused on post-disaster response and recovery to pre-disaster investment and loss-mitigation … we’re going to be very focused on getting the roofs right in this country.”

Installation of a Resilient Roof

With any roofing material, the proper application of the membrane is as important to the satisfactory performance of the roofing system as the materials themselves. Meticulous application processes are especially important if a roofing system is resilient when threatened by extreme weather events.

The first and most basic decision to be made before application begins is, “How will the roofing membrane be secured to the layers that support it?” Here, for instance, there are three options for EPDM: mechanically attached, adhered, and ballasted. Mechanically fastened roofs secure the membrane to the roof with fasteners and plates, which vary depending on the roof deck material. In any adhered roofing system, the membrane is bonded to the layer below with adhesive. And ballasted roofing systems rely on the weight of aggregate – usually stones or pavers, or a combination of both - to hold the membrane in place and resist uplift.

Each approach has benefits:

- In an adhered system, the roofing membrane is glued to the surface beneath it, using specially formulated adhesives. Adhered systems are suitable for flat roofs, contoured roofs, roofs with an irregular shape and any roof with limited load bearing capacity because they are lightweight and flexible. In addition, adhered roof systems also have a high wind uplift performance rating, which makes them a good choice to enhance the resilience of a structure.
- Mechanically attached roofs are secured to the insulation and roof deck below with fasteners, usually screws, concrete nails or augers, varying with the material used in the deck. This can be the fastest, and least expensive, method of installation especially on steel or wood decks.
- Ballasted roofing systems use a layer of stones or pavers to anchor the roofing membrane in place. The stones are substantial enough and applied in a thick enough layer to hold the membrane in place even during high winds. The installation of a ballasted roof is fairly straightforward and relatively quick if contractors have the right equipment to handle moving ballast. These systems have the additional advantage of being able to be installed during almost any kind of weather, and offer cooling energy savings for warmer southern markets without reflecting heat energy back up into the atmosphere like reflective roofing.

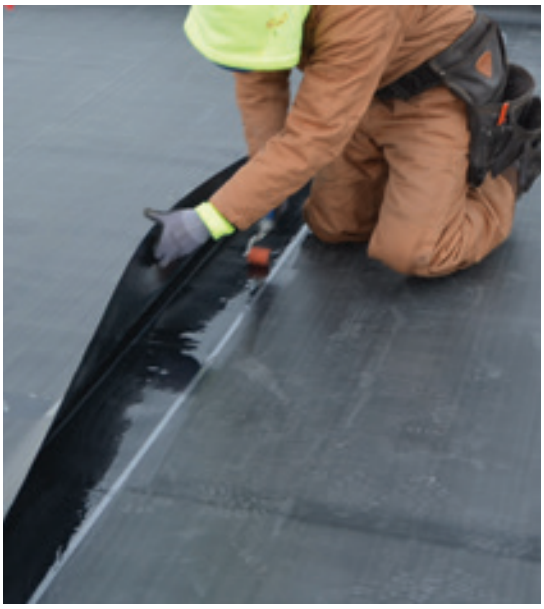
Fully Adhered Roof System

Mechanically Fastened Roof System

Ballasted Roof System

Regardless of the choice of roofing system, there are critical aspects of roofing installation which require special attention to ensure resilience in the roofing system:

- Application of a roofing membrane should be carefully planned so that it can be completed in one phase, lasting over as short a period as possible. One of the greatest hazards of roof construction is the application of a roofing system in "phases," where a partially completed roof system is left exposed to the weather for a period of time, even overnight, and the remainder of the roofing system is installed at a later time. Moisture is the enemy of any roofing system, so it's important to ensure that the substrate board, roof insulation, and cover board used are dry while installation is under way.
- One of the most vulnerable points of a roof is where the low-slope roof terminates at the exterior wall. Most low-slope and flat roofs are designed so that the membrane terminates under the edge flashing system. A best practice is to take the flashing up and over the roof edge and down onto the exterior wall, or to tie it into the air barrier.
- Securing the roof metal edge flashing is critical to keeping the roof cover intact during high winds and should be done so in compliance with ANSI-SPRI RP1. Loose flashing will allow wind and rain to get driven underneath the roof cover where the wind action will add to uplift pressure on the roof system. High winds can peel back loose metal fascia and tear away the entire edge flashing system. The roof cover system also can peel away from the edge if the flashing fails. This is a common failure point that can result in partial or total loss of a roof cover system. In addition, water entry due to loose flashing can create moisture problems within the roof cover system and inside the building.
- In addition to the point where the membrane terminates with the exterior walls, any penetrations of the roof surface, such as pipes, vents, skylights, heating and air conditioning equipment and drains, create potential opportunities for water to seep into the roofing system and damage the building interior. Creating a strong and effective waterproof seal on these roof penetrations is essential to maintaining the integrity of a roof. These weak points should be covered with flashings and other commercially available devices such as molded rubber pipe boots, elevated curbs or pitch pans and caulked as needed to create a tight seal and protect the area from moisture intrusion.



Repairs

One of the most important aspects of maintaining your roof and ensuring that it remains resilient is to perform at least annual inspections of the roof. Frequent inspection and scheduled maintenance, as required under manufacturers warrantees, can save the time and money that can be involved with emergency repairs.

Walk the roof after each storm, in the spring and in the late fall prior to the onset of winter, looking for anything that might be a problem such as debris, clogged roof drains, physical damage from vandalism, excessive roof traffic or wind-blown debris that could create a tear, puncture or hole in the membrane. Check coping caps to make sure that they are not disengaged from cleats, loose or missing. And any "soft spots" on the roof could be an indication of moisture-contaminated insulation. Check for any de-bonding or loose lap and flashing seams in the field of the roof or around roof curbs and penetrations. Obviously, after a storm, clear debris from the roof as quickly as possible and check for any rips or punctures in the membrane. And, if any service companies have accessed the roof, ensure that they have not left even small items like small screws or metal shavings that could damage the membrane.

EPDM in a Resilient Roofing System

The attributes of EPDM membrane make it a uniquely valuable component of a resilient of a roofing system. EPDM is a cross-linked **thermoset material** with an inherit ability to recover and return to its original shape and performance after a severe weather event.

- EPDM has been used in numerous projects in various geographic areas from the hottest climate in the Middle East to the freezing temperatures in Antarctica and Siberia.
- After decades of exposures to extreme environmental conditions, EPDM membrane continues to exhibit a great ability to retain the physical properties and performances of ASTM specification standards.
- EPDM is the only commercially available membrane that performs in an unreinforced state making it very forgiving to large amounts of movement without damage and potentially more cycles before fatiguing
- EPDM is very dimensionally stable when exposed to significant changes in temperature.
- EPDM has excellent hail resistance as it remains flexible and pliable so that it can absorb the impact from hail without fracturing. Other materials have a tendency to become more brittle with age and therefore more prone to hail damage.
- EPDM has excellent resistance to biological growth

EPDM is resistant to extreme UV exposure and heat.

- EPDM passed 41,580 KJ/m2 in the Xenon Arc testing chamber (which is 4 times the ASTM standard) with no sign of cracking or surface degradation @ 0.7 W/m2 irradiance @ 80 degrees Celsius.
- EPDM far exceeded the test protocol ASTM D573 which requires materials to pass 4 weeks @ 240 degrees Fahrenheit. EPDM black or white membranes passed 68 weeks at these high temperatures.
- Exposed EPDM roof systems have been in service now for 50 plus years with little or no surface degradation.

EPDM is versatile.

- EPDM can be configured in many roofing assemblies, including below grade and between-slab applications.
- EPDM is compatible with a broad range of construction materials/interfaces/conditions, making it a good choice for areas that may encounter unique challenges
- EPDM can be exposed to moisture and intense sunlight or totally immersed in salty water.
- EPDM can be formulated in dark or light color for energy efficiency in either heating or cooling dominated climates.

EPDM can easily be installed, repaired and restored following simple procedures without the use of sophisticated, complicated equipment.

- EPDM can be repaired during power outages.
- EPDM can be repaired with relatively unskilled labor.

Building Resilience: Additional Resources

Community Resilience Planning

The increasing frequency of extreme weather events and the resulting disruption impacts socio-economics, energy and homeland security. Due to Federal funding, these disruptions impact everyone, whether located in a specific geographic area where the events occur or not.

The National Institute of Standards and Technology (NIST) Community Resilience Planning Guide

The NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems (Guide) provides a practical and flexible approach to help all communities improve their resilience by setting priorities and allocating resources to manage risks for their prevailing hazards.

NIST Special Publication 1190GB-12 - Guide Brief 12 – Short-Term Implementation Tasks: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190GB-12.pdf

NIST's resilience research focuses on the impact of multiple hazards on buildings and communities and on post-disaster studies that can provide the technical basis for improved standards, codes, and practices used in the design, construction, operation, and maintenance of buildings and infrastructure systems.

This Guide Brief offers suggestions for short-term implementation tasks, as well as short-term activities, that support continual engagement during the overall planning process.

AIA

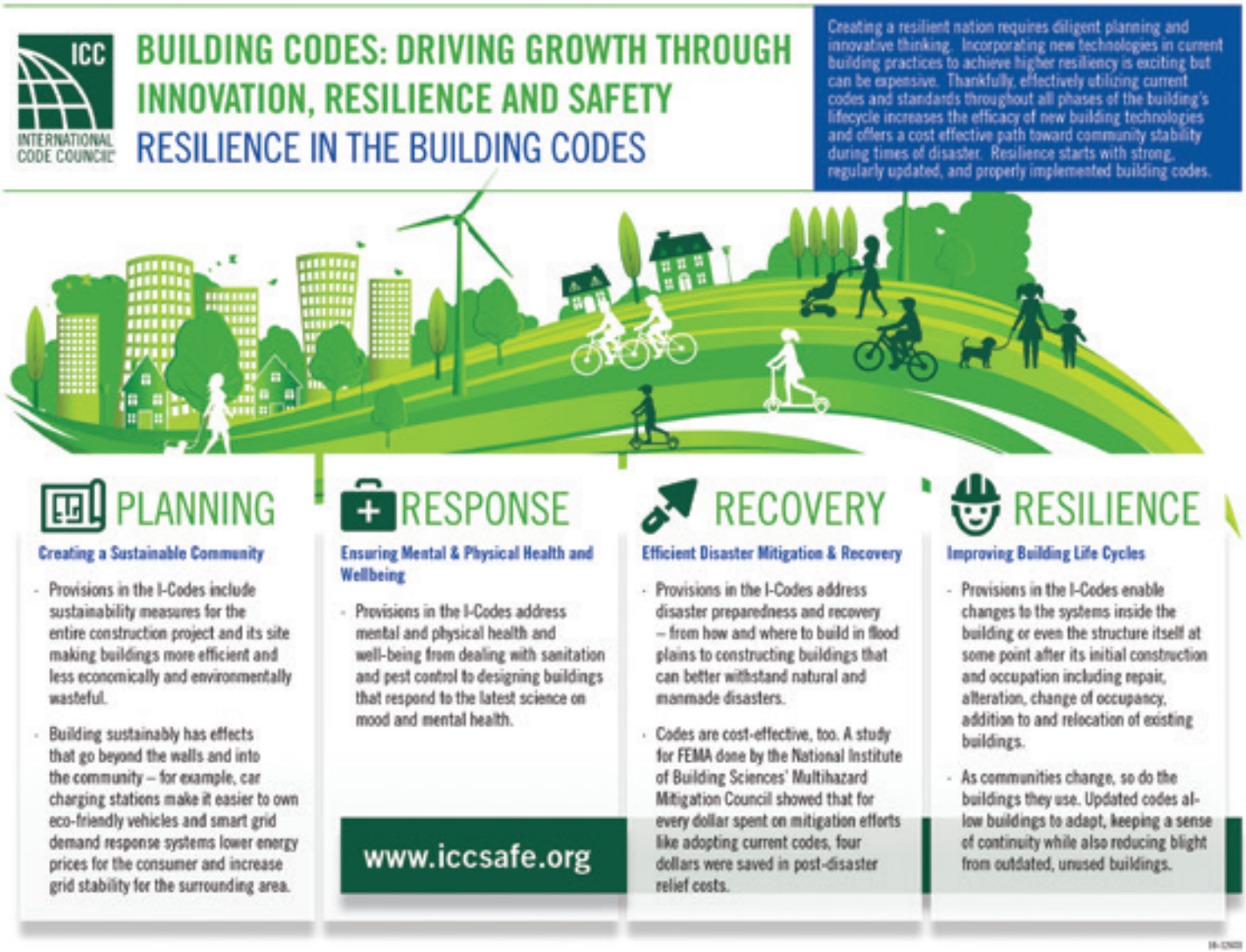
The AIA website offers extensive resources on the subject of resilience. This includes a special focus on its Disaster Assistance Program which "supports a nationwide network of architects who help communities prepare for, respond to, and recover from disasters." Additionally, the program provides training, support, and resources for architects through local, state, and national AIA chapters.

The AIA also offers a Disaster Resilience Handbook, and coordinates its AIA Resilience Network. The Resilience Network focuses on topics of disaster assistance, hazard mitigation, climate adaptation and resilience by creating a forum for knowledge sharing, networking, news and events and opportunities for external and internal project participation.

Resilience in Building Codes

ICC Actions:

One pathway to influence greater resilience in buildings is through the International Building Code Council (ICC) and respective jurisdictions. The building codes frame resilience in the built environment in four ways: (1) efficient disaster mitigation and recovery, (2) ensuring occupant mental and physical health and wellbeing, (3) improving building life cycles, and (4) creating a sustainable community. The challenge ICC faces is the political will to improve resilience at a jurisdiction level. To answer this challenge ICC recognizes the need for a "whole community" approach and is a member of the Resilient Nation Partnership Network as well as the Alliance for National & Community Resilience.



Resilient Cities

There are a number of "City- focused" Resilience programs that guide cities and communities through the process of building resilience.

The National League of Cities (NLC) recommends:

Preparedness: National Flood Insurance Program should be reauthorized, affordable, and solvent

Mitigation: Cities and property owners should be encouraged to retrofit existing structures

Relief: Continued disaster emergency assistance provided to states and communities in the path of Harvey, Irma, Western wildfires, and flooding events nationwide

Recovery: Rebuilding should consider future climate risk and vulnerabilities

Design and redesign systems: Adaption strategies to better absorb disruption

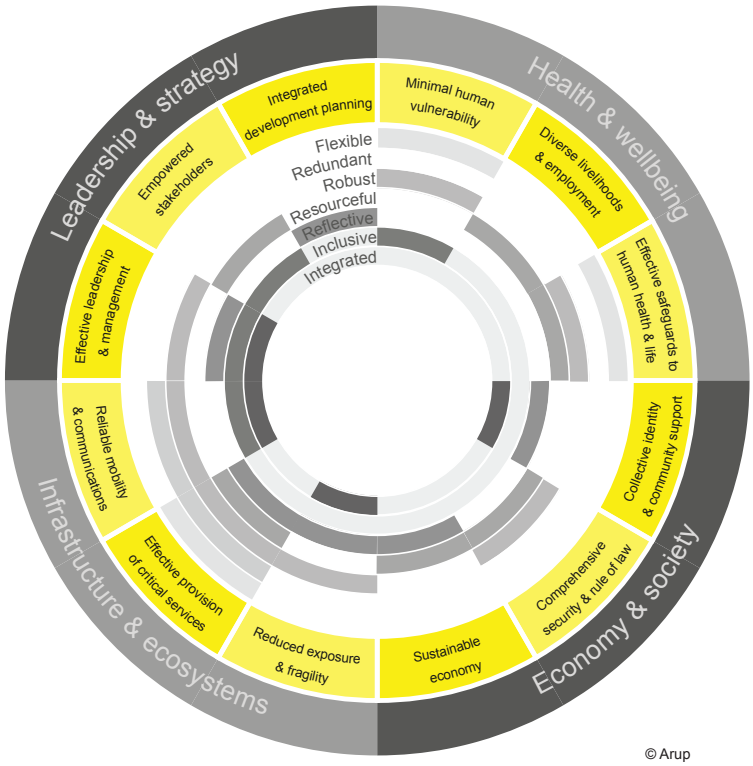
100 Resilient Cities

City Action: Seeking to build an urban resilience marketplace through a network of global industry leaders and innovators from the private and non-profit sectors to match our diverse network of cities.

Resilience solutions: delivering new collaborative services and tools

Engagement of Local Leaders: resilience champions and experts, and galvanize support among stakeholders and residents

Global Influence: Seeking to influence global thought leaders, policy makers and financial pathways to incentivize resilience building



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The City Resilience Index (CRI) is an initiative led by Arup with the support of the Rockefeller Foundation to develop a comprehensive set of indicators, variables and metrics that allow cities to understand, baseline and subsequently measure local resilience over time.

Industry Promotion of Resilience

The High Performance Building Coalition (http://hpbccc.squarespace.com):

The High Performance Building Coalition is a coalition of approximately 200 organizations that provides guidance and support to the High Performance Building Caucus of the U.S. Congress. We support legislation and policies that protect life and property, promote innovative building technologies, enhance U.S. economic competitiveness, increase energy and water efficiency in the built-environment, advance sustainable and resilient communities, and support the development of private sector standards, codes and guidelines that address these concerns.

ERA Resilience Engagement

ERA, as a member, supports efforts in resilience by the Business Council for Sustainable Energy (BCSE) and the Environmental and Energy Study Institute (EESI) with recommended provisions that represent a national focus on pre-disaster mitigation and response measures that will ensure the United States will be better prepared for disasters by both coordinating Federal agency actions and advancing building technologies solutions that are functionally reliable and to withstand extreme weather impacts.

EESI and the National Association of Energy Officials (NASEO) are driving public/private resilient buildings (new and retrofit) strategies to withstand extreme weather and other hazards. The idea is for inclusive participation by Federal, state and local governments, working in partnership with standard-setting and private sector organizations to meet the needs for increased focus on pre-disaster resilience solutions.

> "I would argue that the roof must be the most resilient portion of the building envelope. My definition of resilient is the ability of the building or building component to withstand disasters and to be returned into service rapidly after such an event occurred. If a roof system is lost during a disaster, the entire contents of the building will likely be ruined and therefore the time required to put the building back into service is very long."
>
> — Andre Desjarlais, Program Manager for the Building Envelope Systems Research Program, Oak Ridge National Laboratory

Thank you to the Hutchinson Design Group for providing photos for this report.

EPDM ROOFING ASSOCIATION

www.epdmtheresilientroof.org