BUILDING RESILIENCE: The Roofing Perspective

A Report from the EPDM Roofing Association
June 2020 Edition

ERA
EPDM ROOFING ASSOCIATION

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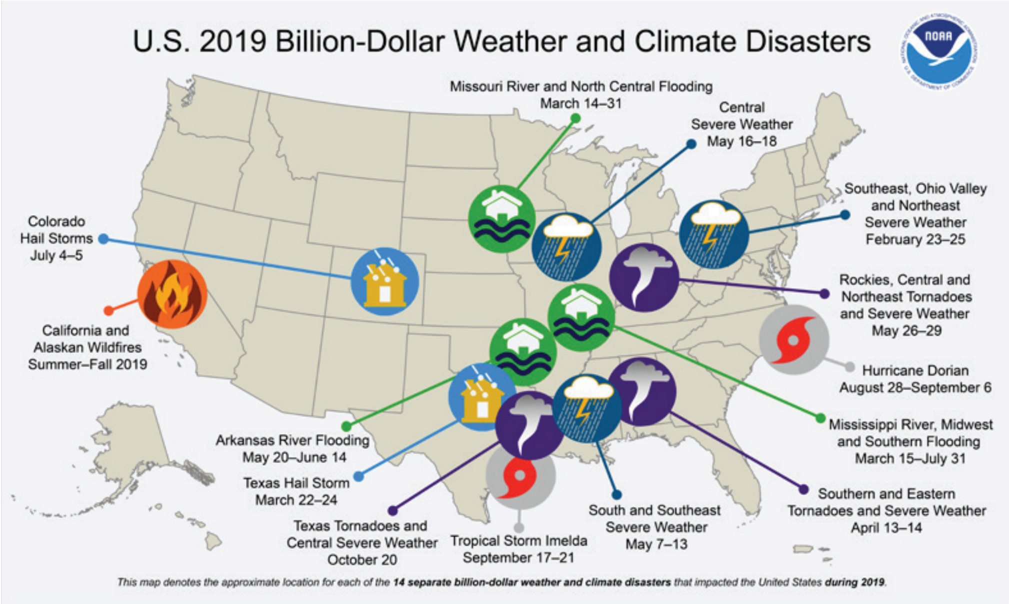
FOREWORD

June 1, 2020

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 pro-actively provided to the marketplace. Now more than ever, as our economy faces unprecedented challenges, ERA is committed to providing essential information about our products, and the value they provide to create resilient structures.

For the past two decades, 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. These extreme weather events are assaulting the built environment with record-setting 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



2019 is the fifth consecutive year (2015-2019) in which 10 or more billion-dollar weather and climate disaster events have impacted the United States. Over the last 40 years (1980-2019), the years with 10 or more separate billion-dollar disaster events include 1998, 2008, 2011-2012, and 2015-2019.

a building is a first line of defense, any discussion of resilience must include careful consideration of roofing systems. Given the importance of this issue, and the critical role that roofing plays in a resilient building, ERA has produced this second annual report on Building Resilience. Like its predecessor, 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."

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.

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, in 2019 there were 14 "weather and climate disaster events", each causing at least $1 billion in damage and collectively causing the deaths of 44 people. These included wildfires, two "tropical cyclones", three inland floods, and eight severe storms. NOAA statistics also detail the increasing frequency of these events: during the last four decades, the annual average was 6.5 disaster events. During the last five years, between 2015 and 2019, the annual average rose to 13.8 events. Among the most damaging weather events during 2019:

- In February a wide-ranging storm system delivered tornadoes and flooding in the south, primarily in Mississippi, Alabama and Tennessee. Moving north, it caused extensive high-wind damage across the Ohio Valley and throughout the northeast from West Virginia to Massachusetts. This storm system also produced heavy rain and caused major flooding in the Ohio, Mississippi and Tennessee River valleys.

"Resilience is the backbone of emergency management."

— FEMA Strategic Plan, 2018-2022

Hurricane Dorian approaches the United States east coast, September, 2019

- In March, a severe hailstorm struck the Dallas area, damaging homes, businesses and vehicles. The same storm delivered extensive hail damage in Oklahoma.
- In May, a four-day tornado outbreak impacted states across the Rockies, as well and states in the Central and Northeast. This outbreak produced 190 tornadoes, damaging hail, and thunderstorms. An EF-4 tornado produced heavy damaged near Dayton, Ohio.
- Devastating wildfires ripped through parts of California and Alaska throughout the summer and fall, not ending until early November. In an effort to lessen the impact of the fires, a key California electrical utility provider turned off power to millions of homes and businesses several times during days with forecasted high winds and extremely dry conditions. While this step was somewhat successful, it also caused billions of dollars in losses. Alaska also suffered a near-historic wildfire season with more than two million acres burned.
- The remnants of tropical storm Imelda dumped up the three feet of rain over a wide swath of Texas between Houston and Beaumont. Thousand of homes, businesses and vehicles were impacted by floodwater. This historically extreme rainfall and the resulting flooding has become a regular occurrence across Southeast Texas during the last five years.
- In early September, Hurricane Dorian, a Category 1 storm, made landfall on the Outer Banks of North Carolina after devastating the northern Bahamas. The storm surge inundated coastal communities throughout the Outer Banks and isolated residents who did not evacuate. The storm also spawned tornadoes, devastating homes and businesses. Just prior to landfall, Dorian clocked wind speeds of 185 miles per hour, tying a record that had remained unchallenged for eight decades.
- In late October, tornadoes, some with intensity up to EF-3 and winds of 140 miles per hour, swept through highly developed sections of northern Dallas. In addition to damaging homes and businesses, they leveled significant public infrastructure.

Policy Response

While natural forces continued their unabated pressure during 2019 on the built environment, discussion of the most effective response to this onslaught intensified and centered on 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.

The National Institute of Building Sciences (NIBS) has been a leader in supplying hard evidence that mitigation saves money, improves safety, and keeps property loss to a minimum. Its most recent report, released in April of this year, represents the most comprehensive benefit-cost analysis of their research to date, focusing on “the strengthening of existing buildings to prepare for hazards like floods, high winds, fires, and earthquakes.” The chart below provides details of the benefit-cost ratio for mitigation efforts to guard against the damage of floods, hurricanes, winds, earthquakes and fire.

National Institute of BUILDING SCIENCES	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

National Institute of Building Sciences’ Natural Hazard Mitigation Saves: 2018 Interim Report

More than a decade after releasing its original report on mitigation in 2005, the National Institute of Building Sciences began a multi-year study on natural hazard mitigation. Since then, the Institute has released a series of reports as it completes its findings. In January 2019, the Institute issued the Natural Hazard Mitigation Saves: 2018 Interim Report. The report details the significant savings that result from implementing mitigation strategies in terms of safety, and the prevention of property loss and disruption of day-to-day life.

The report is a compilation of the project team’s results to this point and includes the findings from the 2017 Interim Report, released in January 2018, and a second report, Natural Hazard Mitigation Saves: Utilities and Transportation Infrastructure, released in October 2018. (See below for summary of 2017 Report.)

For this part of the ongoing study, the Institute’s project team looked at the benefits of designing buildings to meet the 2018 International Residential Code (IRC) and 2018 International Building Code (IBC)—the model building codes developed by the International Code Council (ICC)—versus

“Mitigation represents a sound financial investment.”

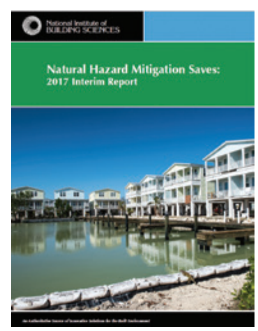
— MMC of NIBS

> "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

the prior generation of codes represented by 1990-era design and National Flood Insurance Program (NFIP) requirements. The project team found a national benefit of $11 for every $1 invested.

Based on the project team's estimates, communities that consistently meet the latest editions of commonly adopted code requirements, culminating in the 2018 IRC and IBC, have added 30,000 new jobs to the construction-materials industry and an approximate .3% increase in utilization of domestically produced construction materials for each year of new construction (over what would have been if buildings were designed as they were in 1990).

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.

FEMA

FEMA National Mitigation Investment Strategy

In August, 2019, FEMA released its *National Mitigation Investment Strategy* or NMIS. NMIS is a single national strategy for advancing mitigation investment to reduce risks posed by natural hazards (for example, sea level rise, droughts, floods, hurricanes, tornados, wildfires, earthquakes) and increasing the nation's resilience to natural hazards.

The draft of this document was released for public comment in January, 2018, and ERA provided detailed feedback on two proposed regulations (see sidebar).

The Investment Strategy's objective is to identify and measure the effectiveness of mitigation investments, and inform decisions on when and where to make investments. The Investment Strategy encourages the whole community— including individuals—to invest in mitigation, pre- and post-disaster, by adopting the Investment Strategy's three shared goals.

Those goals are to show how mitigation investments reduce risk; coordinate mitigation investments to reduce risk; an make mitigation investment a standard practice.

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."

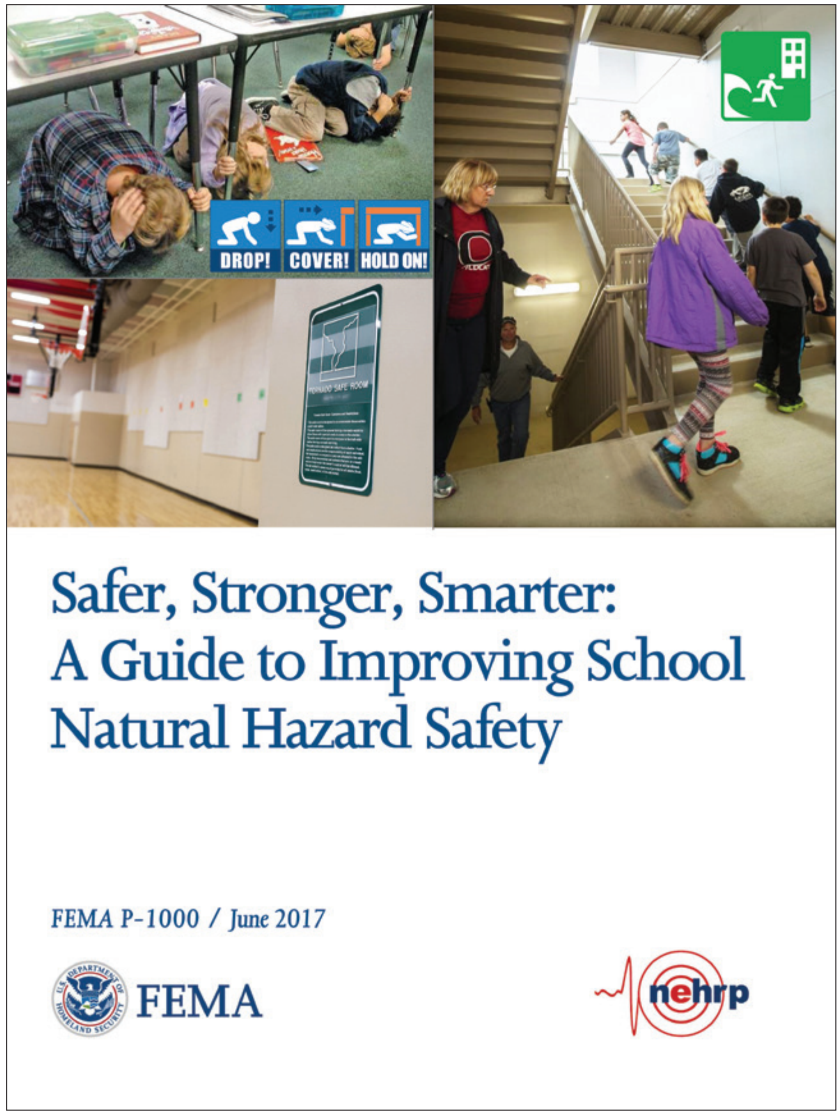
Recommendation 6.3: Public sector entities should focus more on rebuilding better as well as rebuilding quickly following damage caused by natural disasters.

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.”

Legislative Initiatives

The Disaster Recovery Reform Act (DRRA)

In October, 2018, President Trump signed into law the Disaster Recovery Reform Act, or DRRA. The landmark legislation shifted the focus of Federal disaster funding from rescue and relief following cataclysmic weather events, to mitigation and resilience in anticipation of them.

FEMA is working on the development and implementation of the Building Resilient Infrastructure and Communities (BRIC) program, which will be t he dominant program to distribute funds authorized by the DRRA. The BRIC program will be funded as a six percent set aside from estimated disaster grant expenditures. AS of summer 2019, FEMA had provided a brief overview of the BRIC program development and facilitated an open conversation with stakeholders through a chat platform. After incorporating feedback from those interested parties, FEMA is expected to share final details of the program later in 2020.

Prior to the passage of the DRRA legislation, mitigation activities were usually bundled with disaster relief funds, limited primarily to planning purposes, or earmarked for recovery from specific events, such as earthquakes or floods. Just as important, Federal funds earmarked for mitigation could be used to repair damaged buildings only to their prior standards, but not improve them to better withstand the impact of future storms. Under the DRRA legislation passed in 2018, funds can be used to strengthen the built environment to heightened standards of resilience, so that buildings can protect people and property during future storms, and readily return to normal function in the wake of a disaster. In other words, buildings repaired in the wake of a storm can be built to standards that will not doom them to experience comparable damage in future storms.

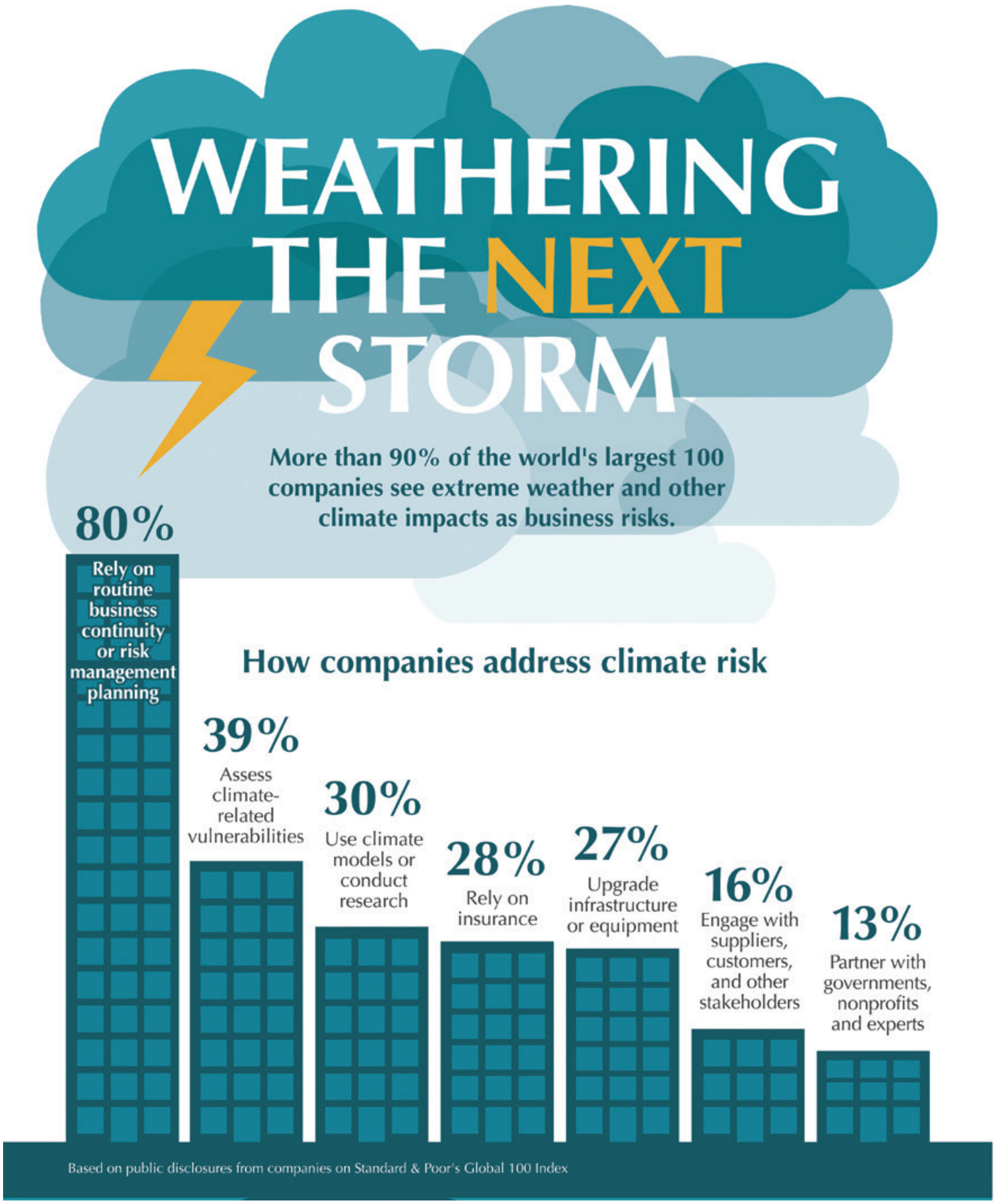
The PREPARE Act

Additional legislative efforts are underway to intensify and bring order to the Federal focus on mitigation. The PREPARE Act, which has bipartisan support from Reps. Matt Cartwright (D-Pa.) and Daniel Webster (R-Fla.), authorizes the creation of an interagency council to provide recommendations to all relevant Federal agencies about the best means of planning and preparing for extreme weather incidents. Additionally, this new interagency council would serve as a clearinghouse to provide state and local stakeholders with the best information available and best practices to help them formulate emergency preparation plans tailored to their local needs.

The legislation proposes to draw members from the Departments of Defense, Transportation, Energy, Homeland Security, Justice, Housing and Urban Development and ten other agencies. It will also include "senior Federal officials" with relevant policy expertise and policy responsibilities. This wide-ranging list gives an indication of the need for improved coordination of mitigation activities, as well as the currently dispersed responsibilities for disaster relief that are spread throughout the Federal Government. The sponsors of the bill emphasize that this is a "zero-cost" effort. In other words, their proposal draws on existing resources in the Federal Government and reorganizes them to facilitate better communications among agencies involved in mitigation activities.

ERA has endorsed the PREPARE ACT, along with more than 100 organizations, including the American Institute of Architects, the International Code Council, The Pew Charitable Trusts and the U.S. Green Building Council.

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.”

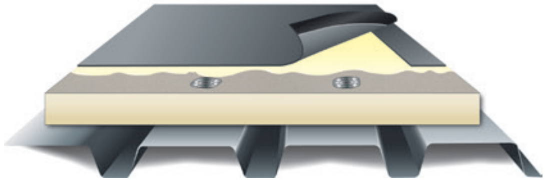
Installation of a Resilient Roof

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.

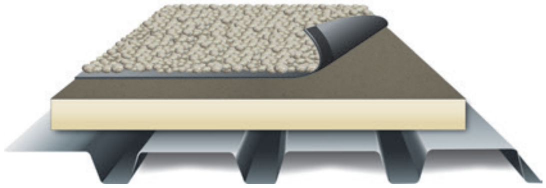
The first and most basic decision to be made before application begins is, "How will the roofing membrane be secured to the layers that support it?" Here, for instance, there are three options for EPDM: mechanically attached, adhered, and ballasted. Mechanically fastened roofs secure the membrane to 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

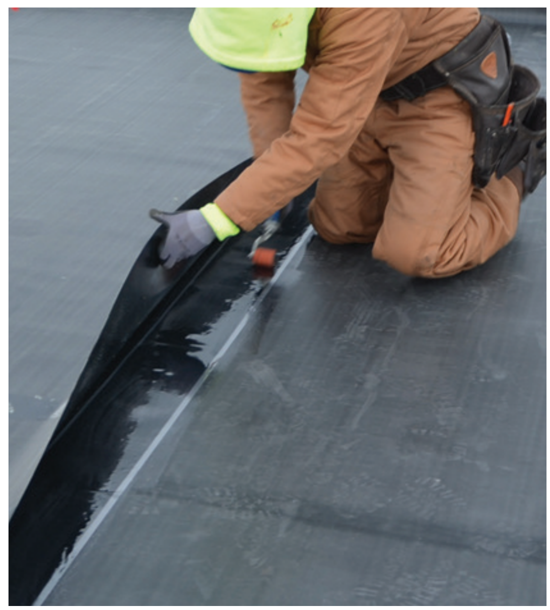

Mechanically Fastened Roof System


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.

BUILDING CODES: DRIVING GROWTH THROUGH INNOVATION, RESILIENCE AND SAFETY

RESILIENCE IN THE BUILDING CODES

Creating a resilient nation requires diligent planning and innovative thinking. Incorporating new technologies in current building practices to achieve higher resiliency is exciting but can be expensive. Thankfully, effectively utilizing current codes and standards throughout all phases of the building's lifecycle increases the efficacy of new building technologies and offers a cost effective path toward community stability during times of disaster. Resilience starts with strong, regularly updated, and properly implemented building codes.

PLANNING

Creating a Sustainable Community

- Provisions in the I-Codes include sustainability measures for the entire construction project and its site making buildings more efficient and less economically and environmentally wasteful.
- Building sustainably has effects that go beyond the walls and into the community – for example, car charging stations make it easier to own eco-friendly vehicles and smart grid demand response systems lower energy prices for the consumer and increase grid stability for the surrounding area.

RESPONSE

Ensuring Mental & Physical Health and Wellbeing

- Provisions in the I-Codes address mental and physical health and well-being from dealing with sanitation and pest control to designing buildings that respond to the latest science on mood and mental health.

www.iccsafe.org

RECOVERY

Efficient Disaster Mitigation & Recovery

- Provisions in the I-Codes address disaster preparedness and recovery – from how and where to build in flood plains to constructing buildings that can better withstand natural and manmade disasters.
- Codes are cost-effective, too. A study for FEMA done by the National Institute of Building Sciences' Multihazard Mitigation Council showed that for every dollar spent on mitigation efforts like adopting current codes, four dollars were saved in post-disaster relief costs.

RESILIENCE

Improving Building Life Cycles

- Provisions in the I-Codes enable changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation including repair, alteration, change of occupancy, addition to and relocation of existing buildings.
- As communities change, so do the buildings they use. Updated codes allow buildings to adapt, keeping a sense of continuity while also reducing blight from outdated, unused buildings.

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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

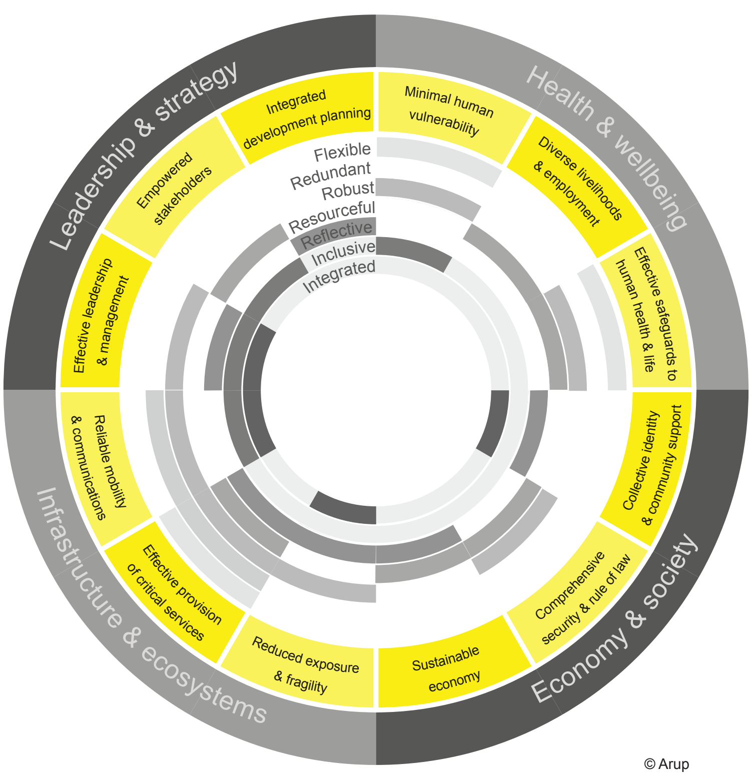
100 Resilient Cities

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

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