



City of Charleston

PRESERVATION  
ESTD SOCIETY 1920  
of CHARLESTON



# RESILIENCE GUIDANCE FOR CHARLESTON

JULY 2024

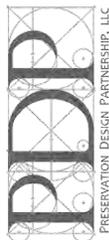


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[www.charleston-sc.gov](http://www.charleston-sc.gov)



Unless otherwise noted, all components of the *Resilience Guidance for Charleston* including all text, graphic design, photography and illustrations unless noted otherwise were prepared by Dominique M. Hawkins, FAIA, LEED AP, and Jennifer Wolfe, AICP.

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Center cover photograph: PSC Survey, Brandon Hall



# R RESILIENCE GUIDANCE: PREAMBLE

## CHARLESTON'S ENVIRONMENTAL THREATS

Charleston has four primary environmental threats that impact buildings, properties, and citizens. These icons are used throughout the publication to identify resilience improvements associated with these threats:



Flood



Wind



Earthquake



Heat

Properties with a backlog of maintenance are more vulnerable to environmental threats and damage.



Good Maintenance

This publication was spearheaded by the Preservation Society of Charleston in an effort to increase the resilience of the city's built environment and to promote the safety of its citizens from environmental threats. The project began with a series of conversations with City representatives, local leaders, and citizens to better understand Charleston's most pressing resilience issues.

Three focus areas emerged from these conversations as desired project outcomes:

- A detailed explanation of the requirements for flood mitigation projects;
- Clarification of the City permitting, BAR, and DRB review processes; and
- Identification of lower-cost, implementable improvements to increase resilience.

This document primarily addresses the third bullet, which is considered by the Preservation Society of Charleston and the City of Charleston to be the highest priority need. To that end, the information herein is designed to serve the greatest number of property owners and tenants, not just designated historic buildings.

Multiple actions can increase the overall resilience of the "Holy City" and empower its residents to protect themselves and their properties from environmental threats. ***This publication provides guidance to implement improvements, as well as a broader understanding of best practices, to assist in conversations with contractors, architects, and engineers. The options presented range from routine maintenance measures to projects that can reduce the severity of flood, heat, wind, and earthquake damage.***



PRESERVATION  
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of CHARLESTON

Dear Residents,

Charleston's built environment is extraordinary because of its improbable perseverance in a challenging climate. It has contended with the forces of water, wind, heat, and even seismic shifts for generations. It is no wonder that historic preservation is so firmly embedded in our city's culture: Each building still standing here is a testament to this legacy of stewardship.

To survive the next century and beyond, taking care of our city will require new ways of thinking. The impetus for this publication is our mission to support the long-term preservation of Charleston's built environment and enhance livability for all of its residents. True to our reputation as a grassroots organization, it is the outcome of a meticulous study of Charleston's unique vulnerabilities to a changing climate and robust community engagement.



We aim for this publication to serve the greatest number of residents and not just owners of historic homes. Charlestonians have established and maintained one of the most distinct built environments in the world, often against great odds. Professionals in the building trades should not have a monopoly on how to care for them. Caring for your home by learning to perform basic maintenance and enhancements is an act of civil service.

For more complex projects beyond the capacity of the ordinary homeowner, this guidance can help broker informed conversation with contractors, architects and engineers. There is great joy in taking the small steps it takes to create resilient properties and to do your part to protect the Charleston we know and love.

Many are to thank for their extraordinary contributions to this volume. The project was spearheaded by PSC staff member Erin Mehard. The National Trust for Historic Preservation, City of Charleston, Ceres Foundation, Edwin and Ellen Harley, and Jim and Augustine Smith all provided critical financial support. Our network of peer reviewers throughout Charleston were some of the most knowledgeable professionals in the field. And, of course, the authors Dominique Hawkins and Jenny Wolfe at PDP. Their work here, I believe, will stand the test of time and serve as an indispensable resource for Charleston's residents.

Sincerely,

A handwritten signature in black ink that reads "Brian R. Turner". The signature is fluid and cursive.

Brian R. Turner  
President & CEO, Preservation Society of Charleston

## RESILIENCE GUIDANCE CONTENTS

This *Resilience Guidance for Charleston* addresses a variety of issues that owners and tenants of smaller properties may confront in the process of maintaining and incrementally improving their properties. These sections can be used to guide routine maintenance, address a noted problem, or improve the resilience potential of a larger project such as a roof replacement.

### TOPIC SECTION CONTENTS

Each topic section contains:

- Description of how the four environmental threats of flooding, high winds, earthquakes, and extreme heat can impact the site or building component
- Listing of “Key Tips” for upgrades – many of which are do-it-yourself and maintenance projects – and their potential resilience benefits
- Checklists that include information on the relative cost and expertise level for each recommendation, including several no-cost or low-cost items that can be implemented independently by property owners or tenants
- Identification of best practices for properties subject to the Board of Architectural Review (BAR) or Design Review Board (DRB)
- Identification of issues to consider when the property is located in the Special Flood Hazard Area (SFHA)
- Resources for additional information
- Identification of codes and requirements that may influence project design

Information is cross-referenced between the topic sections to make it easier to locate the relevant material.

### R1 RESILIENCE GUIDANCE: OVERVIEW

Introduces maintenance as an overall strategy to improve resilience to climate threats including water and flooding, wind, earthquakes, and extreme heat, and provides information about the permit review process.

### R2 RESILIENCE GUIDANCE: LANDSCAPE

Landscape improvements can be relatively low-impact and inexpensive to implement, with resilience benefits of water absorption on-site and the cooling impacts of increasing shade.

### R3 RESILIENCE GUIDANCE: ROOF SYSTEM

Maintaining or modifying the roof system can reduce water intrusion, damage from high winds, and interior heat gain while providing an opportunity for solar collection.

### R4 RESILIENCE GUIDANCE: EXTERIOR WOOD

Supplementing connections on wood structures can reduce the impacts of high winds and earthquakes, while care is needed to minimize deterioration from rot and potential pest infestation.

### R5 RESILIENCE GUIDANCE: EXTERIOR MASONRY

Stone, brick, and other structural masonry units rely on mortar to bond individual units together, while reinforcing bars give concrete tensile strength, both of which can be compromised by water exposure.

### R6 RESILIENCE GUIDANCE: WINDOWS AND DOORS

Building openings are more vulnerable to environmental impacts and can be reinforced or modified to reduce the impacts of high winds and regulate indoor air temperatures.

### R7 RESILIENCE GUIDANCE: BUILDING SYSTEMS

Building systems are vulnerable to floodwater, and efficient appliances and equipment can reduce dependence on power and fuel and their associated costs.

### R8 RESILIENCE GUIDANCE: BUILDING INTERIOR

Interior improvements can reduce flood- and earthquake-related structural damage and contents loss, and help regulate temperatures to reduce heat gain.





## City of Charleston

Dear Residents of the City of Charleston,

I am pleased to introduce to you the Resilience Guidance for Charleston, a vital initiative in partnership with the Preservation Society of Charleston and our city staff. This comprehensive document aims to empower you, our valued residents, with the knowledge and tools to enhance the resilience and sustainability of your homes.



In Charleston, we face unique environmental challenges, from flooding and high winds to earthquakes and extreme heat. The Resilience Guidance for Charleston addresses these threats head-on, providing practical solutions that range from DIY projects to essential questions for engaging contractors. It is designed to be approachable and budget-conscious, ensuring that every resident can take meaningful steps towards safeguarding their property.

This guidance is structured into seven informative chapters, each focusing on key aspects of home resilience: landscaping improvements, roof systems, exterior wood elements, exterior masonry, windows and doors, building systems, and building interiors. Within each chapter, you will find a handy checklist to assist you in evaluating and improving the resilience of your home.

By implementing the recommendations outlined in this document, you will not only protect your investment but also contribute to the overall resilience of our community. Together, we can fortify Charleston against environmental challenges and ensure a safer, more sustainable future for generations to come.

I encourage each of you to explore the Resilience Guidance for Charleston and embark on this journey towards a more resilient home. Your proactive efforts will make a significant difference, and I am confident that, with your dedication, we can strengthen our city's ability to thrive amidst adversity.

Sincerely,

William S. Cogswell, Jr.  
Mayor, City of Charleston





The impacts of the 1938 tornado devastated the Fiddler's Green community near what is now the Hagood and Lockwood Avenue area. (National Weather Service, [weather.gov](http://weather.gov))

# R1 RESILIENCE GUIDANCE: OVERVIEW

## VULNERABILITY

*Vulnerability is the susceptibility of human settlements to the harmful impacts of natural hazards.*

This susceptibility has implications at the individual, household, and community levels, and potentially harmful outcomes such as injuries, deaths, damage to housing and infrastructure, and destruction of businesses and livelihoods. It is therefore important to capture both the physical/exposure and social/human dimensions.

(FEMA)

## RESILIENCE

*Resilience is the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions.*

(FEMA)

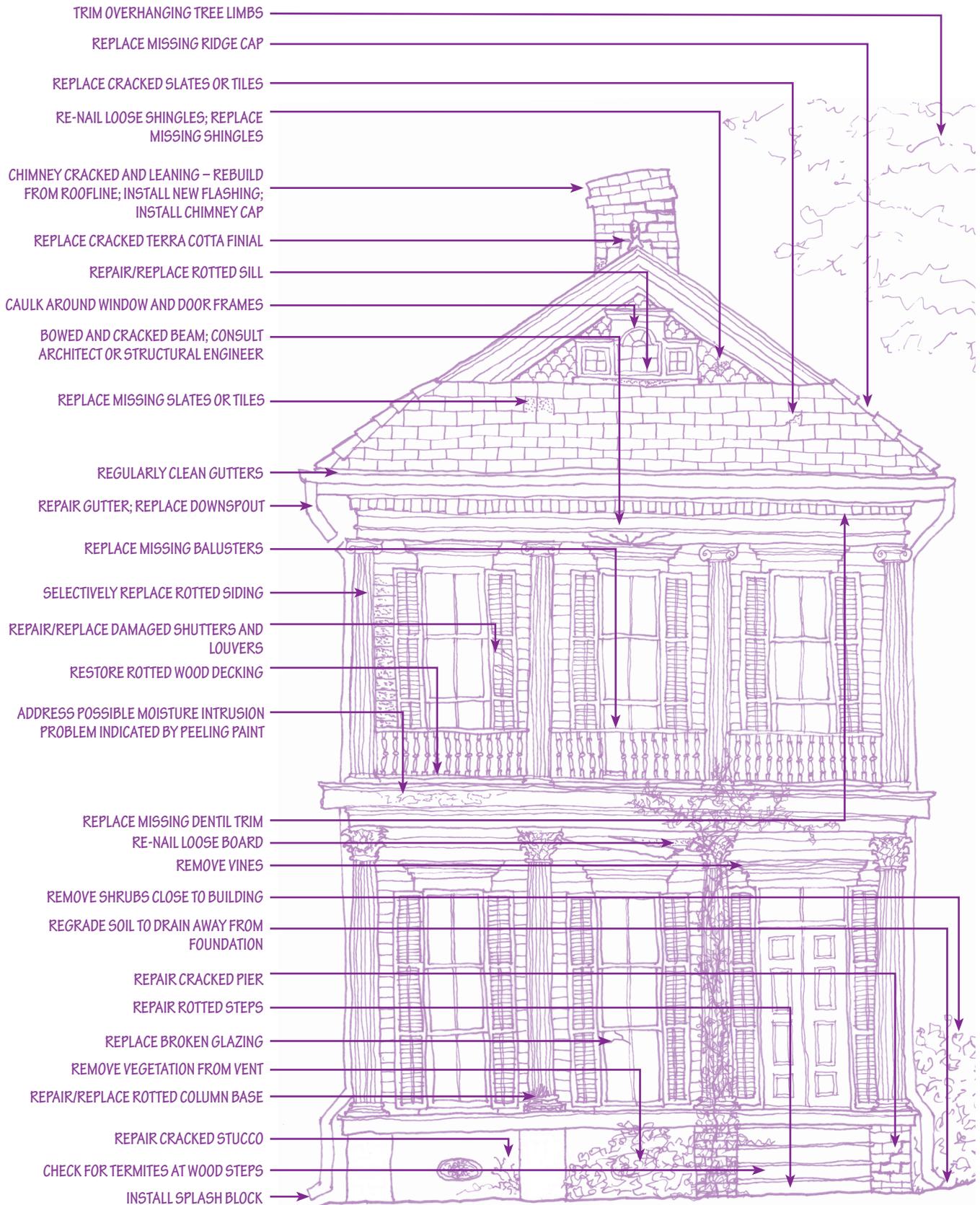
*The goal of this Resilience Guidance for property owners and tenants is to provide enough information for them to make improvements to enhance resilience in place, and to aid recovery until resources allow for the implementation of a more comprehensive strategy.*

Climate change, sea level rise, tropical storms, hurricanes, and earthquakes serve as the backdrop to the *Resilience Guidance for Charleston*. The title is intended to describe adaptation measures for these collective environmental forces. Specific vulnerabilities in Charleston include flooding, extreme heat, damaging winds, and earthquakes that are potential sources of building damage and risks to life safety. The *Resilience Guidance* sections offer resilience improvement strategies to reduce the impacts of these vulnerabilities. Properties, buildings, and settings in and out of historic districts are included to provide a resource for all of Charleston's existing buildings.

The organization of the *Resilience Guidance* is divided into specific building or site components, like exterior wood or landscape. A checklist in each topic section provides readers with a tool to quickly identify areas of improvement, relative costs, and level of professional resources that may be needed. Information is also included to successfully navigate the local permit approval process for small-scale projects. Recommendations may not reduce flood, wind, or earthquake insurance premiums, or be sufficient to meet building codes. However, they are intended to provide guidance on accessible, effective strategies for regular maintenance and enhancements that can improve a property's resilience. **Large and more complex projects, such as elevating a building to mitigate flood risk, are not included.** Other reference materials and local officials can provide specific resources for these actions.



## TYPICAL WOOD FRAME BUILDINGS: GENERAL MAINTENANCE ACTIVITIES



## MAINTENANCE: FOUNDATION OF RESILIENCE

Regular maintenance helps preserve buildings, structures, and properties; protects real estate values; and keeps Charleston an attractive place to live, work, and visit. Lack of regular upkeep can reduce property values and damage the building, resulting in accelerated deterioration of a building or property elements and features. Small openings or unpainted surfaces can allow moisture penetration and eventually rot building materials.

Sustained maintenance is imperative to protect a building structure from flooding, high winds, and earthquakes; and can also reduce potential costly repairs. Historic building materials have a longer service life if maintained, but can be more costly or difficult to replace. *Maintenance is the foundation of resilience planning for a property.*

Property owners and tenants are encouraged to inspect buildings and properties regularly to identify potential problems. Ideally, property inspections will take place twice each year, in the spring and fall. The spring inspection will identify issues that can be addressed in advance of hurricane season, while the fall inspection will allow for storm damage-related repairs and lead-time for larger projects. Regular maintenance items include painting, cleaning gutters and downspouts, and inspecting the roof. The individual topic sections in this *Resilience Guidance* document provide a road map of key issues for different areas of a property and options for improvements.



Wood located on or next to a brick or a concrete foundation or pier is more likely to absorb moisture and rot, as well as attract pests and termites. Open joints provide a path for stormwater and floodwater.

### BOARD OF ARCHITECTURAL REVIEW (BAR)

One of the essential goals of BAR is to protect and preserve historic properties for the benefit of future generations. This includes all exterior historic materials found within a local designated historic district. *To preserve the authenticity of Charleston, particularly in locally designated historic districts, the BAR strongly encourages the retention of historic materials or replacement in-kind whenever work on a property is considered.* Therefore, recommended repairs are focused on specific areas of deterioration in order to maintain a building's stability and weather resistance, rather than wholesale replacement of a historic building material. Careful attention to detail might be required as part of the effort, and regular maintenance with timely repairs can minimize large repair costs associated with ongoing deterioration. (Refer to *Special District Permitting, sidebar page R1.5.*)

## MAINTENANCE MANUAL

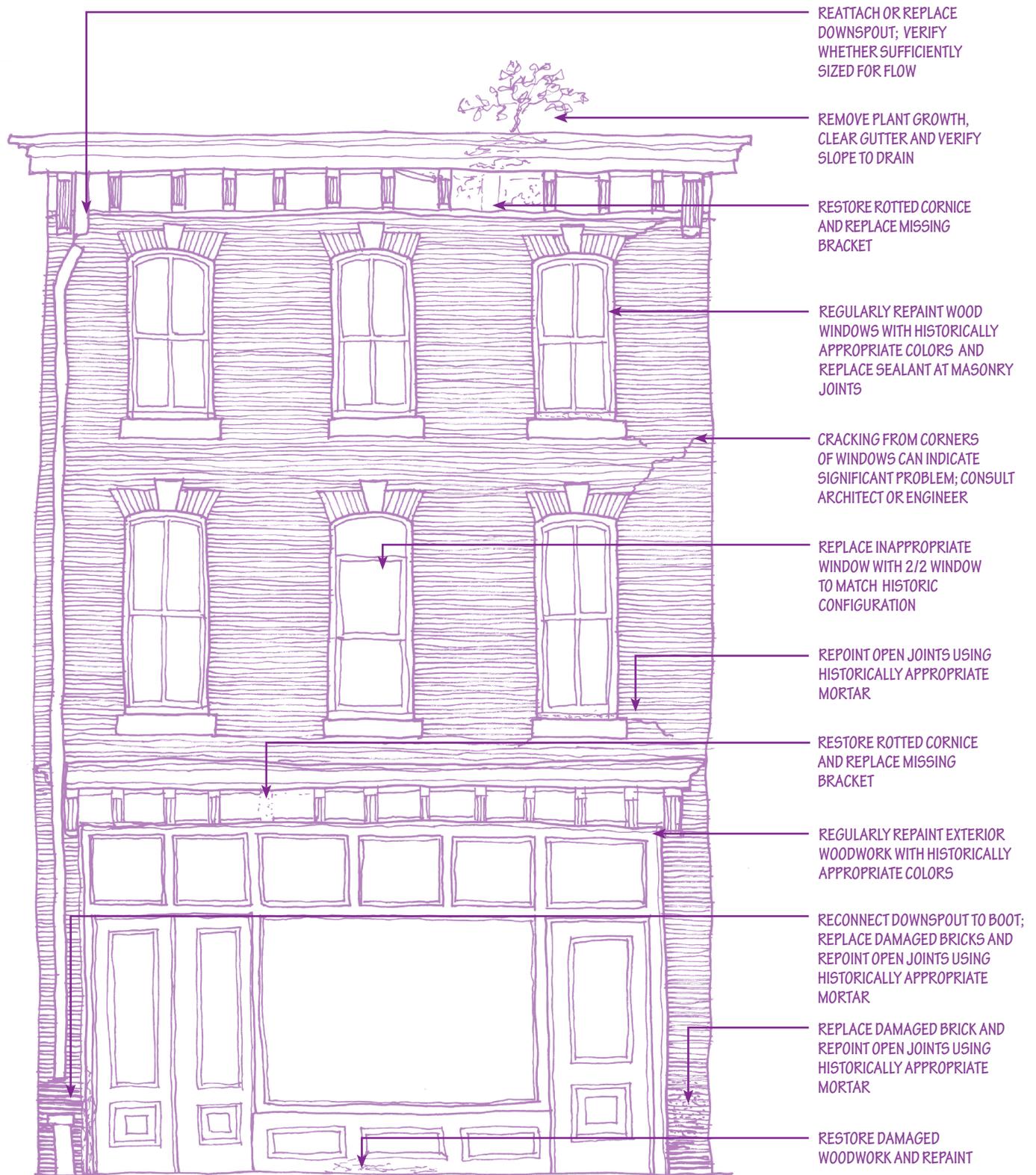
Property owners will find it helpful to develop a maintenance manual to track conditions over time, problems, maintenance tasks, and contractors who perform work. The information in the manual generally falls into four categories:

- **General information** should include the names and telephone numbers for emergency services and repairs, warranties, and basic information on specific building equipment, such as maintenance manuals
- **Property documentation** should include historical, construction, alteration, and legal information that is specific to the property's past conditions, including construction drawings, products used, and construction photographs, if available
- **Inspection and maintenance records** should include the preventive maintenance work completed by the owner and contractors; lists of items to be inspected, and how often inspections occur (i.e., annual heating and cooling system reviews); and information on particular repair and upkeep techniques of particular components, materials, and equipment, with receipts specifying work performed
- **Property review documentation** should include dated photographs of the overall building and site, as well as detailed areas of problems that can be used to track whether conditions are worsening over time

The manual can be organized as an electronic document and/or a three-ring binder so it can be easily supplemented over time. In addition to informing physical changes, the maintenance manual may also be valuable when negotiating policies or claims with insurance brokers and should be safely stored.



TYPICAL MASONRY OR STOREFRONT BUILDINGS: GENERAL MAINTENANCE ACTIVITIES





## COMPLEX PERMIT APPLICATION REVIEW

Projects that include any type of structural work, from reframing doorways to elevating a building, will require engineering plans. At a minimum, most properties within Special Districts (such as BAR, DRB, or Special Flood Hazard Areas) will require a building permit or a professional certification to be performed by outside experts, such as contractors or design professionals. Applicants for these more complex projects can contact the Permit Center or request assistance with the permitting process from their outside professionals.

## WORK BY PROPERTY OWNERS

Property owners are allowed to complete their own permitted work if the building is a single-family structure or duplex and is the primary residence of the owner. In these cases, the property cannot be rented or sold for two years. **Prior to beginning work, please consult with the City's Permit Center team for requirements and anticipate additional requirements for properties located in the SFHA, a BAR, or DRB district.** Some maintenance work, including painting, may require a permit. (Refer to *Special District Permitting, sidebar page R1.5.*)

- **Residential Properties:** Residential property owners must file an exemption form and disclosure statement with the Charleston or Berkeley County Register of Deeds office before submitting a permit application with the City of Charleston. City staff will make this determination based on the scope of work when the project valuation is \$5,000 or more. All permit conditions must be followed as required.
- **Commercial Properties:** Commercial projects with a valuation equal to or greater than \$10,000 must be performed by contractors licensed through the SC Department of Labor, Licensing, and Regulation (SCLLR).

## HIRING OUTSIDE PROFESSIONALS

Some projects are beyond the capacity of a property owner. When searching for a contractor or design professional, read online reviews; request permits for successfully completed projects in the area; and ask neighbors, colleagues, and friends, to develop a prospective list of professionals. Price should be considered in addition to the following criteria:

- Active Business License, City of Charleston
- Active SC LLR Contractor, Architecture, or Professional Engineering license ([www.llr.sc.gov](http://www.llr.sc.gov))
- Familiarity with resilience mitigation to improve a property's ability to withstand a severe storm or natural disaster
- Familiarity with the BAR and DRB process and requirements, as applicable
- References for similar projects completed on time and on budget
- Surety bonding for contractors completing more complex projects
- General Liability and Workers Compensation Insurance, as well as Professional Liability Insurance (architect and engineer)
- Communication expectations before and during work
- Qualifications and anticipated presence of site supervisor or architect/engineer managing the project



When buildings are elevated in a SFHA, there are unique requirements related to the location of mechanical systems and ductwork.

## SUBMITTING THE CORRECT BUILDING INSPECTIONS PERMIT APPLICATION

A Building Inspection Permit is required for almost all types of work. A completed permit application, with an accurate description of the proposed scope of work, must be submitted for all projects. There are two building permit applications applicable to the *Resilience Guidance* recommendations; chose the appropriate application based upon the building use.

### Residential Existing Building Alterations/Additions Application

Used for existing one- and two-family dwelling buildings (detached, duplexes, and townhomes, three stories or less with a separate exit) and accessory buildings and structures; and accessory buildings and structures such as garages, sheds, pool houses, and accessory dwelling units at existing residences.

### Commercial and Multi-Family Application

Used for all commercial buildings and accessory structures. This includes all mixed-occupancy residential buildings with three or more dwelling units, or more than three stories, regardless of the size limited to the project scope.

## FLOOD OR FLOODING

The City of Charleston defines flood or flooding as a temporary rise in the level of water which results in the inundation of areas not ordinarily covered by water.

*Floods occur naturally and can happen almost anywhere. They may not even be near a body of water, although river and coastal flooding are two of the most common types.*

(FEMA)

## NATURAL FLOOD HAZARDS

Three natural sources of flooding should be considered when assessing the property's vulnerability and developing a response strategy.

- **Coastal (tidal or surge):** Storm surge, tidal shifts, waves, and sea level can all influence coastal flooding
- **Rainfall (pluvial):** Heavy rainfalls resulting in flooding can be the remnants of anticipated storms such as hurricanes, tropical storms, or high-wind seasonal storms (known as compound flooding); or an unpredictable intense rainfall, known as a flash flood or rain bomb
- **Riverine (fluvial):** Added volumes of water cause rivers to rise and flow faster and culverts to be overwhelmed

## OTHER FLOOD HAZARDS

Property owners and tenants should also be aware of other flood risks like:

- Interior flooding from storm drains, floor drains, sewers, septic systems, water supply piping, and damaged or faulty appliances
- Dam failure
- Groundwater flooding or rising water tables that can loosen soils and weaken structural integrity
- Buried or hidden urban waterways



Flooding in the West Side. (Photo from PSC Survey, Brandon Hall)

## FLOODING AND SEA LEVEL RISE



*There are three sources of flooding: coastal, rainfall, and riverine. Each can cause significant damage, but when an area plagued by coastal flooding is struck by a flash flood from a tropical storm, the effects can be compounded.* Coastal flooding may also be informally referred to as sunny-day flooding, nuisance, or persistent flooding – appropriate words to describe increasing occurrences due to sea level rise. On its own, coastal flooding can result in traffic problems, road closures, overwhelmed storm drains, and occasional infrastructure damage that often cause public inconvenience and business interruptions. Increased water tables can create groundwater flooding, causing soils to become spongy or soggy. This is particularly true along the banks of waterways and low-lying marshland areas and areas with high or increasing water tables.

Occasional flood events usually have a specific cause, typically a weather event that occurs from natural sources like a storm, heavy precipitation, and king tides. *Low-lying and flood-prone areas adjacent to or near waterways, called floodplains, are more vulnerable to these weather events even if they are normally dry.* The Federal Emergency Management Agency (FEMA) identifies floodplains on maps to indicate areas of potential flooding. (Refer to [msc.fema.gov/portal/home](https://msc.fema.gov/portal/home) for detailed maps.) While there may be advance warning for severe weather events, other flood hazards may be sudden and result in unpredictable flooding. (Refer to *Other Flood Hazards sidebar at left.*)

## RECOGNIZING FLOOD VULNERABILITIES

The City recognizes that “all properties in the City of Charleston are in a flood zone, but not all properties are in the Special Flood Hazard Area (SFHA).” (Refer to [msc.fema.gov/portal/home](https://msc.fema.gov/portal/home) for detailed maps.) *Any existing property in Charleston may experience flooding. Property owners and tenants are encouraged to obtain flood insurance, regardless of location, ownership, or lender requirements.* Charleston is also increasingly vulnerable due to the impact of climate change and sea level rise. The *2020 City of Charleston All Hazards Vulnerability and Risk Assessment* anticipates three feet of sea level rise between 2030 and 2100, making 15,000 properties inaccessible due to tidal flooding.





Trees can be toppled or uprooted during severe wind or rain events that can damage buildings and block access roads. (SC Emergency Management Division)



Wind damage to roofs can cause significant interior damage if water leaks occur.

## WIND AND TORNADES



Severe storms can include sustained, damaging wind speeds and carry debris that can impact any part of a building. The intensity of hurricanes and tropical storms are increasing over historical trends due to warmer atmospheric and sea surface temperatures from climate change. (Refer to *Vulnerable Cities: Coastal Flood Risk*, [climatecentral.org](http://climatecentral.org).) While there is usually advance warning of a tropical event, a tornado can often develop too quickly for adequate response time, unless it is associated with other storm events. Most occurrences of tornadoes do coincide with tropical events, which happened in September 2004 and 2017, when Tropical Storm Frances and Hurricane Irma, respectively, spawned tornadoes across South Carolina (SC State Climatology Office).

While flood vulnerability is typically associated with a building's proximity to water, buildings throughout Charleston are potentially vulnerable to wind damage. Secondary damage from high winds include downed trees that fall on buildings or power lines. This can start fires or block roadways, hindering emergency vehicle access.

Wind damage can cause failure to the following building components:

- Roofs
- Chimneys
- Window and door openings
- Structural systems
- Siding materials
- Appendages, such as chimneys, porches, and carports
- Overhead electrical service

There are several improvements that a property owner can implement to reduce the potential damage from high winds, including trimming trees, protecting windows, and improving structural reinforcing. The *Resilience Guidance* topic sections provide recommendations and strategies to reduce potential damage.

### WIND DESIGN

The City of Charleston is located in a coastal high-wind zone. New buildings and structures must be designed to withstand 150 mph wind design speeds, based on current code requirements. To ensure compliance, the Building Inspections Division requires signed and sealed plans by a SC licensed structural engineer or architect for modifications and alterations to an existing building structural system including:

- Partial or complete removal of interior or exterior building walls
- New outdoor structures, such as: sheds, pergolas, decks, screened porches
- New building components such as windows, doors, skylights, and garage doors (refer to *Historic Preservation Considerations, for historic windows and doors, page R6.11*)

**EARTHQUAKE VULNERABILITY**

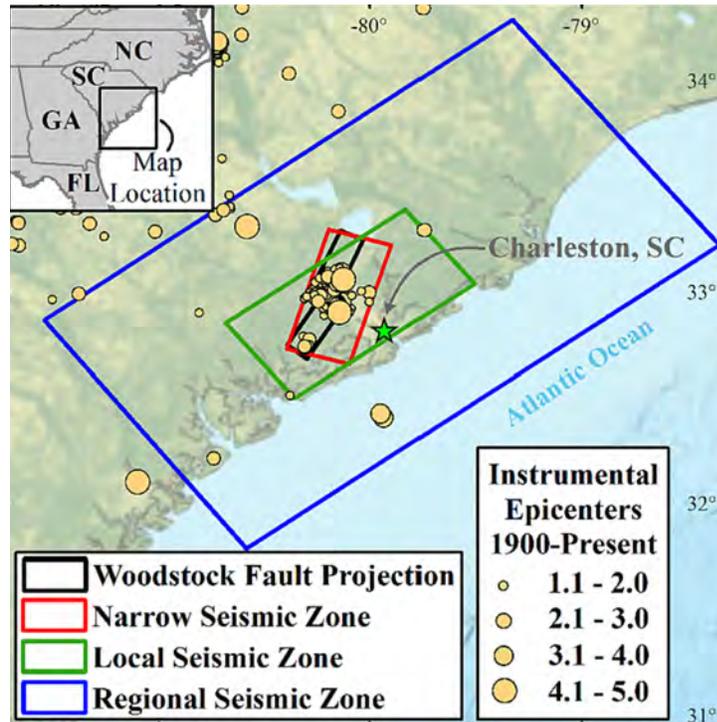
Earthquakes are not an uncommon occurrence in South Carolina. The majority of earthquakes worldwide occur at plate boundaries when plates stick and then jump past each other. The cause of earthquakes in South Carolina is not so clear; the quakes are located within a plate rather than at a plate boundary. In South Carolina, approximately 70 percent of the earthquakes occur in the Coastal Plain, and most are located around three areas west and north of Charleston: Ravenel-Adams Run-Hollywood, Middleton Place – Summerville, and Bowman. *Geologically, Charleston lies in one of the most seismically active areas in the Eastern United States.* This seismic cluster is known as the Middleton Place – Summerville Seismic Zone (MPSSZ).

(Charleston Regional Hazard Mitigation Plan)

**LIQUEFACTION**

When loose soil is shaken by an earthquake, it will compact just like the shaking of a canister of flour. If the spaces between the grains are filled with water, when the soil compacts in the few seconds of an earthquake, the water gets squeezed out from the soil but cannot flow away instantaneously. *During that time, the soil can no longer support structures above, causing buildings to shift and sometimes sink.* This action is similar to when you wiggle your toes on the wet sand on a beach, making your feet sink into the sand.

(FEMA P-530)



Woodstock Fault projection (Durá-Gómez and Talwani, 2009a, Durá-Gómez and Talwani, 2009b) and the zonal weighting scheme assigned to the Charleston Seismic Zone in the most recent U.S. National Seismic Hazard Model Project (NSHMP) maps (Petersen et al., 2014, Petersen et al., 2020).

**EARTHQUAKES**



A deadly earthquake struck the Charleston area in 1886, claiming lives and leaving many buildings in ruins across the city. Since that time, there have been continued reports of earthquakes, particularly northwest of Charleston, although none as damaging. South Carolina is located within a single tectonic plate. Rather than multiple plates shifting and rumbling against each other, like the types of earthquakes experienced on the West Coast, there are no individual plates in this region. (Refer to *Earthquake Vulnerability, sidebar at left.*)

However, Charleston’s loose, wet soil conditions can amplify the impacts of an earthquake through a process known as liquefaction. Liquefaction can turn normally solid ground into a quicksand-like state, with the potential for significant harm to residents and damage to buildings and structures. (Refer to *Liquefaction, sidebar at left.*) Property owners and residents should become aware of the serious threat potential of an earthquake, even though the historical earthquake is known as a 1-in-500-year event.

Earthquakes are unpredictable and can cause severe damage within minutes or less, including these factors:

- Unreinforced masonry structures are at greater risk of damage
- Falling debris can impact an otherwise unaffected building
- Items hung or stacked against walls can topple from minor shaking
- Utilities can be damaged, such as water and gas pipes, causing flood or fires

All property owners and tenants should take actions to safeguard the contents of their home or business building, and consider advanced mitigation options.



The southern exposure of this building around 4pm shows the porch with welcomed shade. Landscaping and building design can affect indoor air temperatures and solar panels provide an alternate energy source, all increasing the property's resilience.

## EXTREME HEAT



Extreme heat is associated with climate change, causing a particular threat for people's health and well-being in buildings with high internal temperatures. The average temperature in Charleston County was 74.7 degrees Fahrenheit between 1961 and 1990, while the projected average temperature for 2050 is 76–81 degrees. The anticipated number of days exceeding 90 degrees almost doubles in the same time frame. (Refer to [U.S. Climate Resiliency Toolkit, climate.gov](#).) Temperature and humidity data collected from a variety of surface temperatures, outdoor workers, and transportation routes in Charleston helped identify the city's most concentrated hot areas, or heat islands. The findings demonstrate the benefits of tree canopies and the careful selection of building and pavement materials and colors, and can serve as a guide to residents for their own properties. (Refer to [Charleston Extreme Heat Initiatives, sidebar at right.](#))



The southern exposures of several houses around 5pm see little relief from natural landscaping. Interior blinds can help reduce thermal energy radiating through the windows.

## CHARLESTON EXTREME HEAT INITIATIVES OVERVIEW

One of the studies outlined in Charleston's [Extreme Heat Initiatives](#) found a 40-degree differential on and around different materials outdoors on the very same day in the same place. Gravel, manicured grass, and plantings were on the low end of the temperature measurements; with asphalt, brick, and artificial turf on the higher end. Researchers also found a 19-degree difference between a clay tile roof and an asphalt shingle roof on neighboring buildings at Charleston's Gadsden Green public housing complex. Even a lighter hue of asphalt shingle was measured to be almost 10 degrees cooler than a darker color.

(Post and Courier editorial, August 9, 2023)

## SOCIAL INEQUITIES OF CLIMATE CHANGE

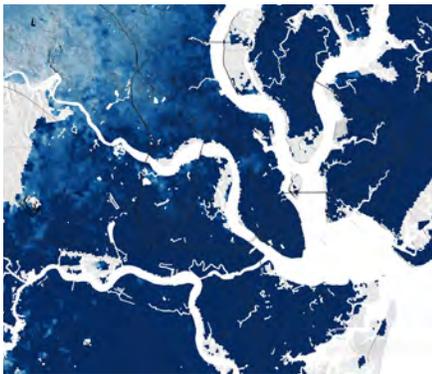
Studies are continuing to find that vulnerable populations are disproportionately impacted by climate change. Their neighborhoods tend to be:

- Prone to increased flooding that causes repetitive financial hardships from repairs
- On a regional scale, located on the frontline of contaminated groundwater from factories and plants
- Under-maintained and have failing infrastructure
- Located in heat island areas with less green space and tree canopies

Charleston's neighborhoods with the highest overall social vulnerability are spread across the city. In the Downtown/Peninsula, Inner West Ashley, and Cainho areas there are notable impacts to public housing and food stamp retailers. (Refer to [City of Charleston All Hazards Vulnerability and Risk Assessment, 2020.](#))



Lightning struck the steeple of the Second Presbyterian Church of Charleston in 2020, resulting in a localized fire. ([www.2ndpc.org/blog/2020/4/20](http://www.2ndpc.org/blog/2020/4/20))



Charleston is one of the fastest sinking cities (about 4 mm/year) in the eastern U.S., with a portion of that thought to be the result of human activities, including groundwater pumping. (NASA Earth Observatory Image, [earthobservatory.nasa.gov/images/152452/americas-sinking-east-coast](http://earthobservatory.nasa.gov/images/152452/americas-sinking-east-coast))

### FLOOD-RELATED EROSION

The collapse or subsidence of land along the shore of a lake or other body of water as a result of undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as a flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding. (NFIP)

## SECONDARY THREATS

### FIRE AND LIGHTNING

Fires can occur in the aftermath of a flood or earthquake when fuel containers are damaged or downed electrical lines come in contact with floodwater. Floodwaters, damaged bridges and access roads, and debris can hinder fire-fighting access and efforts, allowing the fire to continue to spread. Lightning can also cause fires, and while often associated with heavy rain events, some strikes are up to 10 miles away from active rainfall.

- Warm temperatures and water will produce thunderstorms and generate lightning
- Lightning is one of the most hazardous and life threatening impacts of a storm event and is difficult to forecast

### SHIFTING LANDSCAPES: SUBSIDENCE AND EROSION

Many areas of Charleston, both on and off the peninsula, have coastal edges that were built on top of artificial fill material that compacts differently than adjacent soils. This means that ground surfaces are more likely to shift at different rates, since filled areas have an increased rate of subsidence. Some aspects of shifting landscapes are man-made, such as coastal erosion from boat traffic and historical development of natural areas, but climate change is likely exacerbating the phenomenon.

#### SUBSIDENCE

Land areas near shorelines are slowly sinking – a gradual process known as subsidence. With subsidence, the negative impacts of rising seas and storm events are increasing. Subsidence is largely attributed to climate change, however, it is also attributed to man-made influences from groundwater extraction. (Refer to *Geophysical Research Letters*, by Pei-Chin Wu, Meng (Matt) Wei, [agupubs.onlinelibrary.wiley.com](http://agupubs.onlinelibrary.wiley.com).)

The Charleston Aquifer supplies almost all of the groundwater for Charleston County, and two-thirds of the water for the tri-county area of Berkeley, Charleston, and Dorchester counties. Subsidence can also compromise natural shoreline protection elements – such as marshes, beaches, mangrove stands, coral reefs, and oyster beds – reducing their effectiveness. Invasive species, pollutants, and development can also contribute to increased rates of shoreline loss. Waterfront property owners can encourage the growth and preservation of natural shoreline protection by understanding its function and limiting activities that are harmful. (Refer to *Natural Shoreline Protection*, page R2.12)

#### EROSION

Shorelines along waterbodies can gradually erode from the action of slow consistent waves or currents over hundreds or thousands of years. However, more significant and noticeable erosion is occurring at an accelerated rate from increasingly severe storms and sea level rise. Erosion can impact coastal waterfront properties, historic maritime resources and military infrastructure, and archaeological resources. (Refer to *Flood-Related Erosion*, sidebar at left.)



## HURRICANE AND FLOOD PREPAREDNESS FOR RESILIENCE

### PRE-STORM ACTIVITIES

- ❑ **Protective materials:** Collect sandbags, plywood, plastic sheathing, lumber, tools, and flashlights on site
- ❑ **Clean-up materials:** Collect sump pumps, wet-vacuums, bleach, cleaning supplies, rubber gloves, protective clothing, fans
- ❑ **Business operations:** Cancel appointments, reservations, deliveries
- ❑ **Recovery plan:** Identify licensed contractors, electricians, plumbers, clean-up crews, service providers, and telecommunication companies
- ❑ **Regular training:** Train staff/occupants for flood preparation, including installing flood shields/ barriers and wind protection
- ❑ **Important contacts / providers / suppliers / staff:** Telephone numbers and account numbers
- ❑ **Business interruption insurance:** Obtain insurance
- ❑ **Evacuation plan:** Prepare plan
- ❑ **Continuity of operations:** Prepare plan

### STORM PREPARATION

#### PROPERTY

- ❑ **Tree limbs:** Trim overhanging tree limbs that might crash through a roof or take down electric lines
- ❑ **Site debris:** Clear debris that might become waterborne or airborne, clog storm drains, provide fuel for a fire, or damage buildings
- ❑ **Site drains / gutters / downspouts / floor drains:** Clear for water flow
- ❑ **Oil / propane tanks:** Secure barbecue grills and close at main valve
- ❑ **Outdoor furnishings:** Relocate to interior or secure

- ❑ **Document property:** Inventory and photograph property, equipment, furnishings
- ❑ **Swimming pools:** Partially drain

#### EXTERIOR BUILDING

- ❑ **Roof hatches / skylights / ventilators:** Secure and brace
- ❑ **Roof vents:** Install temporary protection
- ❑ **Shutters:** Secure or install plywood, mylar, or temporary coverings to building wall, not to window/door frames
- ❑ **Windows / doors:** Secure and brace windows and doors
- ❑ **Temporary barriers / shields:** Install sandbags or metal panels at flood vulnerable openings

#### INTERIOR BUILDING

- ❑ **Furnishings:** Remove breakable items from walls and cabinets; elevate vulnerable items; roll up rugs; close window treatments including interior blinds, drapes and interior shutters; and be mindful that roof and window damage can occur if flooding is associated with a storm event when considering where to temporarily relocate items
- ❑ **Utilities:** Turn off electricity at panel/ gas to equipment, water heater, stoves, oven, dryer
- ❑ **Personal preparation:** Collect medications, hygiene materials, clothing, valuable papers, important contacts
- ❑ **Important documents / computer equipment / files:** Collect insurance policies, deeds, leases, photo albums, and business records and place in a waterproof, fireproof and portable container (maintain duplicates off site)

### AFTER THE STORM

#### SAFETY

- ❑ **Electricity:** Avoid floodwater unless electricity is turned off at circuit breaker; allow system and equipment to dry out, take caution to not cause electrical overload when restarting
- ❑ **Utilities:** Contact power and gas service providers for emergencies, service resumption, or meter inspection if in contact with floodwater
- ❑ **Unsafe buildings / conditions:** Report to local building official
- ❑ **Stabilize building:** Tarp damaged roof and stabilize structure
- ❑ **Secure:** Prevent building intruders

#### ASSESS AND RECORD DAMAGE

- ❑ **Document losses:** Inventory and photograph property, equipment, furnishings damage
- ❑ **Insurance company:** File claims and save invoices and receipts

#### CLEANING UP AND DRYING OUT

- ❑ **Remove water:** Use sump pump and wet vacuum
- ❑ **Building materials:** Remove and discard damaged carpets, baseboards, drywall, and insulation
- ❑ **Furnishings:** Discard if not cleanable
- ❑ **Ventilation:** Open windows, operate fans to dry out materials, remove baseboard and cornice to ventilate wall cavities and minimize mold
- ❑ **Clean / disinfect:** Use bleach and water solution, particularly kitchen surfaces, equipment, utensils
- ❑ **Permit:** Obtain building permit prior to repair, demolition, or construction
- ❑ **Health department:** Contact for business inspection

This material is funded by the Preservation Society of Charleston on behalf of the City of Charleston.  
[www.charleston-sc.gov](http://www.charleston-sc.gov)

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Hampton Park, Library of Congress (ca. 1910-1920)

# R2 RESILIENCE GUIDANCE: LANDSCAPE

## LANDSCAPE IMPROVEMENT GOALS

*Capturing rain on site is a primary defense that can slow flooding by allowing it to be naturally absorbed into the ground. This is important because streets can become flooded, local storm drains overwhelmed, and water can spill onto a neighbor's property causing additional damage.*

## MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (Refer to *Resilience Guidance: Permit Review*, page R1.5.) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

*Landscape projects can significantly improve flood resilience. The most important goal is to capture stormwater on site, which can reduce water racing into streets and storm drains.* Landscape improvements can be relatively low impact, inexpensive to implement, and completed as do-it-yourself projects by property owners or tenants over time. Many detailed ideas and resources can be found in the *Charleston Rainproof* program. (Refer to [charleston-sc.gov/rainproof](http://charleston-sc.gov/rainproof).)

*In addition to absorbing stormwater, adding shade trees as landscape improvements reduces heat on a property.* Mature, wind-resilient shade trees located on the south and west sides of a building can reduce the intensity of the sun on the roof and walls, and reduce indoor temperatures.

Other actions, like collecting compost and planting native species, are sustainable and resilient habits that can collectively improve the natural environment.

Some of the key projects to increase water storage on site include:

- Reducing hardscape or paved areas that do not absorb water
- Changing the grading pattern to control stormwater
- Installing stormwater collection systems
- Increasing shade trees and native plants
- Collecting compost and reducing chemical fertilizers
- Protecting natural shorelines from erosion





Identifying problem areas can help the design of solutions to guide water flow. The quantity of roadway stormwater runoff reaching the lawn is reduced by absorption through the gravel bed. The larger stones contain the gravel to minimize spread. Installing a smaller gravel bed may be a task that can be completed by property owner. Specialty equipment can be rented or a contractor hired for larger areas.



Water is pooling under this building. Prolonged exposure to standing water can compromise the mortar at the cast stone piers, making the building more vulnerable to damage from flooding and earthquakes. Ways to divert the water away from the foundation should be evaluated.

## UNDERSTANDING PROPERTY DYNAMICS

For the most successful, resilient landscape, three components of a site should be understood when considering changes: water movement, soil type, and sun patterns.

### WATER MOVEMENT

Floodwater can behave very differently than a heavy rainfall on a site. Knowing where puddles form, and how floodwater or stormwater flows across, off, or onto a property from neighbors or the right-of-way can indicate where change is needed to improve drainage. It is also valuable to understand the compound impact of water movement on a site when a significant rainfall event occurs at the same time as a coastal flood.

**One of the flood resilience goals is to retain as much of the stormwater that falls onto a property as possible, rather than allowing it to flow into the street, stormwater system, or onto neighboring properties.** If this is done collectively within a neighborhood, the volume of water that flows into the street and overwhelms the stormwater system would be reduced, lessening flood severity in the area.

**Retaining stormwater on-site can be accomplished by allowing the stormwater to be captured and absorbed into the ground whenever possible, while also minimizing the risks to existing buildings.** Several options for stormwater collection are presented in this section. This is easier to accomplish on larger parcels with a lot of land. When that is not possible, stormwater can be temporarily captured and retained in rain barrels or cisterns, and released when the ground is able to absorb more water, or used as a water source for a garden. (Refer to *Rain Barrels and Cisterns*, page R2.7.) For areas with a high water table, a specially-designed stormwater retention basin may be necessary to hold enough water in an area that is easily saturated.



Capturing stormwater on a property, but away from building foundations, prevents it from flowing onto a street. Ideally, standing water should drain within 48 hours.



The lower grade causes water to pool along the side of this house. Regular standing water prevents grass from growing in the area.

### SOIL OBSERVATION AND TESTING

Simple tests can be performed without professional training to determine drainage, or percolation, rate. This is an important step before making any big decisions about stormwater improvements to a property.

#### Observations of Healthy Soil

- Water is not standing on the ground surface hours after a rainfall
- Digging a hole 2-3 feet into the ground is relatively easy
- Plants and earthworms are thriving

#### Soil Testing

- Test for drainage by digging a hole 12 inches deep and 12 inches wide and fill the hole with water. Take hourly observations of the water level below the ground surface. Sandy soils will drain at about 4 inches an hour, while 1 inch or less per hour indicates a problem with compaction or other issues.
- Home pH tests can be used. However, a county cooperative research center can conduct a soil sample for a nominal fee, providing information on the pH levels, nutrients and organic matter, and recommendations. *(Refer to Clemson University Agricultural Service Laboratory or the nearest extension office.)*

Based on the results, various actions on the following pages may be needed to improve drainage on the property. (University of Maryland Extension, [www.extension.umd.edu](http://www.extension.umd.edu))



Soil can be spiked, or small plugs removed, using an aerator to improve air and water flow. Aerating also improves the health of the soil, making it easier to grow grass or groundcover. A hand-held aerator can be used for smaller areas, or a machine rented for large lawns.

### SOIL TYPE

Soil type is important for water infiltration. Soil maps are readily available and can help with the design and performance of infiltration mechanisms and rates. Soil testing can also be performed to observe drainage rates and to determine the types of plants that will thrive. *(Refer to Soil Observation and Testing sidebar, at left.)*

### SUN PATTERNS

Just like there are patterns in the way water behaves on a property, there are also patterns for the sun. These patterns vary during the course of each day and seasonally. Identifying areas that are shady or sunny can aid in selecting plants and trees that will thrive. It may also guide decisions on where to plant trees to improve shading for a garden or building, potentially reducing heat gain.

#### KEY TIPS:

- Photograph and document a property during or immediately after a coastal storm and/or heavy rainfall to understand how water flows and where puddles form
- Perform soil observations and tests to identify materials and determine drainage rate at different areas
- Understand seasonal and daily sun patterns, including sunny spots and where shade may be needed in the heat of the summer

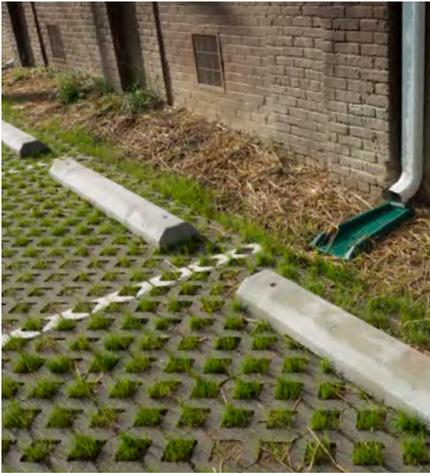


Creeping thyme plants are burned out from the hot afternoon sun.



Pachysandra at the base of a tree protects the trunk while mowing and helps maintain soil moisture.





Open concrete pavers allow grass to grow in this parking area, which helps absorb more stormwater.



Portions of this parking lot have been curbed to allow for planting areas that increase the capacity for stormwater.



Pavers are available with edge spacers that form open, pervious joints when laid, allowing water to flow through into the ground.

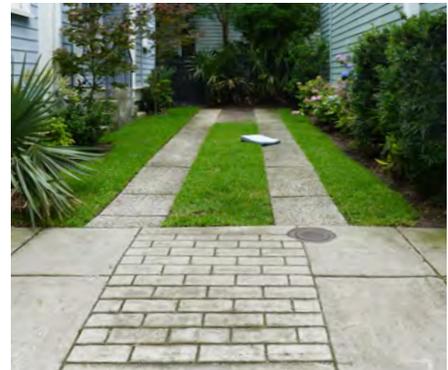
## HARDSCAPE AND IMPERVIOUS SURFACES

Alternatives to solid, paved walkways, driveways, patios, and parking lots are beneficial to increase the water storage capacity on a site. Solid paved areas, in addition to covered areas of a property such as buildings and swimming pools, are referred to as impervious surfaces because they limit the ability for stormwater to be absorbed into the ground naturally. Impervious areas cause rainfall to behave as water runoff, overwhelming the local stormwater system and increasing the likelihood of neighborhood flooding.

The level of stormwater absorption into the ground can be enhanced by including more trees and plantings that absorb water naturally. (Refer to [Trees, page R2.9](#), and [Ground Covers and Native Plantings, page R2.10](#).) Additionally, if soils are heavily compacted, they can become effectively impermeable. (Refer to [Soil Observation and Testing, sidebar page R2.3](#).) The process of reducing impervious surfaces and increasing stormwater capture on a property can be accomplished over time, and can be part of an overall landscape design strategy.

### KEY TIPS:

- Convert solid concrete or asphalt driveways and pads to pavers or loose material that allow water to drain (loose materials should have containment edging and can become airborne projectiles in heavy winds)
- Replace regular pavers with permeable pavers or install spaced pavers to allow groundcover to grow in joints
- Perform a drainage test in various locations of the yard to record how long it takes water to drain (refer to [Soil Observation and Testing, sidebar page R2.3](#))
- Use an aerator tool to loosen compacted soils
- For severely compacted soils, till the soil (using a hand or power tool) and amend the soil with compost or other organic material, such as peat moss or vermiculite
- Avoid driving on yard surfaces, which can increase compaction and reduce water absorption and plant growth



Driveways can be limited to tire paths or paved with pervious materials to increase the ability for stormwater to be captured on site.



**Hardscapes** are the non-living features – such as compacted gravel, stone pavers, retaining walls and fences – that prevent stormwater absorption.



Connected ditches (**bioswales**) collect stormwater from roadways and properties, allowing it to absorb into the ground. Water tolerant plantings can be added, similar to a rain garden. (Refer to Rain Gardens, page R2.6.)

#### PERMIT REQUIREMENTS

All development, including excavation and placement of fill, will require a permit under applicable federal, state, and local laws, ordinances, and regulations. Fill or erosion control structures such as a retaining wall may also have civil implications if floodwater, flow intensity, and/or direction is worsened for neighboring properties. Contact the Permit Center for additional information.

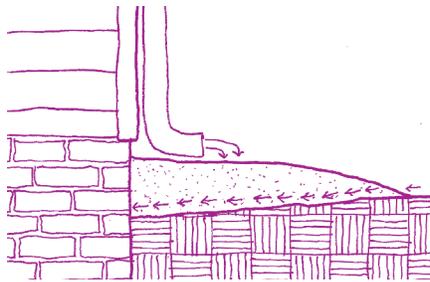
#### DEFINITIONS

**Berms:** Berms are built up mounds in straight or curved shapes about five times as wide as they are tall. They can direct stormwater and provide an opportunity to add vertical interest to the landscape.

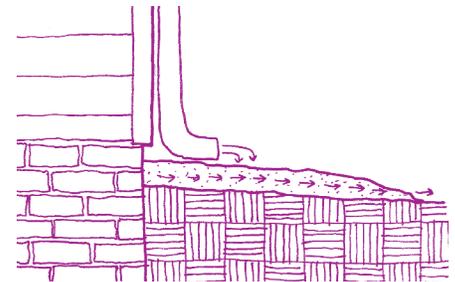
**(Bio)Swales:** Swales are shallow channels that are about four times as wide as they are deep. Swales can be built to direct stormwater away from building foundations, or toward areas that promote natural infiltration, like waterways, dry wells, and rain gardens. (Refer to Rain Gardens, page R2.6.)



**Grading** refers to leveling an area or changing the slope to control water flow. A retaining wall maintains soil height above the street level, which is lower along the sidewalk.



**Bad:** Water flows through the ground cover layer to the soil surface that drains toward the foundation.



**Good:** Water flows through the ground cover to the soil surface that drains away from the foundation.

## SITE GRADING

During and after rain events is the best time to visually survey water movement patterns and where water is collecting on a property. Look for puddles in the yard or driveway indicating depressions in the ground surface; dirt left on vertical surfaces from water splashing against a building foundation or landscape walls; and debris piles of pine needles, leaves, mulch, or other materials that the water picked up and deposited. Minor pooling sites can be filled or planted to elevate the low spots. However, if there are property-wide issues, more significant change may be needed requiring the assistance of a landscaper, and heavy equipment to build berms and swales to manage the movement and direction of stormwater.

#### KEY TIPS:

Please note that the site and building flood mitigation options listed below may not be feasible or successfully resolve flooding issues at a property. Intensifying storms and sea level rise may soon render mitigation options ineffective, diminishing their long-term cost effectiveness.

- Observe water flow paths and areas that are collecting water during heavy rains
- Use a combination of sand, soil, and plant material to fill in small depressions
- Prioritize grading around the building foundation to avoid water from flowing toward a building or crawlspace
- Consider building a berm and/or a swale if there is a significant amount of water collecting or flowing through the property





Rain gardens located along paved areas can collect roadway stormwater.

## RAIN GARDENS

When stormwater is allowed to absorb naturally on-site, the water is filtered through the soil; which can reduce contaminants from going into natural waterways. **Natural or man-made depressions in the ground are opportunities to create a rain garden, serving both a functional and decorative purpose.** Rain gardens are designed to pool water in a defined location. In contrast, a bioswale is engineered to funnel water to a drainage system. (Refer to Definitions, sidebar page R2.5.) Either feature can be designed and built by a property owner, although special rental equipment may be beneficial for a large-scale project. Landscape architects, community cooperative extension offices (often at universities), and expert gardeners can help design a solution for the property's unique conditions. (Refer to *A Guide to Rain Gardens by Clemson Cooperative Extension.*)

### KEY TIPS:

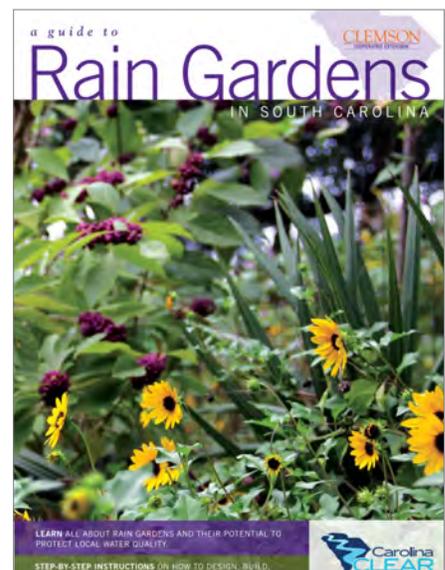
- Perform a soil drainage test to determine whether the selected site has good drainage (refer to *Soil Observation and Testing, sidebar page R2.3*)
- Monitor areas that collect water and/or where water travels naturally in the yard (refer to *Site Grading, page R2.5*)
- Direct rain downspout extensions and/or cistern or rain barrel overflows to a rain garden or a swale (refer to *Definitions, sidebar page R2.5*)
- Use native plants and plants that are best suited to the unique conditions of the rain garden's location (sun, shade, saturation, salt tolerance) (refer to *Ground Covers and Native Plantings, page R2.10*)
- Limit any use of fertilizers and herbicides (refer to *Ground Covers and Native Planting, page R2.10*)
- Monitor weeds and erosion to ensure continued health
- Locate rain gardens at least 10 feet from building foundations
- Keep rain gardens at least 25 feet away from septic system drain fields
- Avoid areas where the water table is less than 18 inches deep
- Plan a rain garden that is 8 to 10 feet long in the direction of water flow
- Call #811 in S.C. before you dig to avoid buried cables and pipes



River stone-lined, dry creek beds are a type of garden that will only be wet immediately after a rain event.



Hybrid rain barrels can capture stormwater and support plantings or small gardens in paved area.



Clemson has a detailed rain garden publication. ([clemson.edu/extension](http://clemson.edu/extension))



Rain barrels can be used as an irrigation source. (NC Cooperative Extension, [www.ces.ncu.edu](http://www.ces.ncu.edu))

### RAINWATER COLLECTION SYSTEMS

Harvesting rainwater can have several benefits. Become familiar with how the system works to help determine if and how it can work best on your property. Components of a rainwater collection system include:

- **Catchment area:** A location that collects or sheds water, like a downspout or an open corner at roof valley
- **Conveyance system:** The means to transport the water from a gutter, piping, or just a section of the roof that can pour rainwater into the storage tank
- **Filtration screen:** A screen added at the point where water enters the gutter and the tank to prevent most debris from collecting and clogging the system (periodic cleaning will be necessary)
- **Storage tank:** Acquire ready-made rain barrels or cisterns, converted 50-55 gallon food-grade containers, or a rectangular 275-gallon tote
- **Water distribution:** A spigot or pipe allows collected water to be distributed with a garden hose or by filling a watering can (pressure will be dependent on the volume)

(University of Florida Institute of Food and Agricultural Science, [www.sfyl.ifas.ufl.edu](http://www.sfyl.ifas.ufl.edu))

## RAIN BARRELS AND CISTERNS

Rainwater that falls onto a roof can be collected in rain barrels to water gardens or be slowly released when the ground is no longer saturated following a storm. (Refer to *Rain Gardens*, page R2.6.) Cisterns, larger stormwater collectors, can be installed above or below ground and even in large crawlspaces.

### KEY TIPS:

- Choose a rain barrel that is at least 42 gallons and has a screened collection area, outgoing spigot at the bottom, and overflow features
- Contact Charleston Rainproof for discount programs ([www.charleston-sc.gov](http://www.charleston-sc.gov))
- Add pumps and connect multiple barrels to increase ease of use
- Install covers and screens to minimize clogging and mosquitos, and follow regular maintenance tips
- Elevate rain barrels to increase water pressure from the bottom hose spigot
- Install above-ground rain barrels and cisterns in a manner that is not obvious from the street or a neighboring property, using fencing or plant screening, such as a shrub or a trellis, to conceal it as necessary
- Use harvested water for plants, filling fountains and ponds, rinsing outdoor tools, keeping compost moist, and pet washing
- Do not use captured water for drinking or food preparation unless specific filtration systems are installed and the water is tested by the county



Plantings can conceal rain barrels.



Cisterns provide larger storage capacity.



The roof downspout discharges into a rain barrel.



Historic brick cisterns (Preservation Society of Charleston)





A French drain collects and moves water away from the foundation to reduce building water damage. (LSU Ag Center)



A solid downspout drain can divert water to a an absorption area or rain barrel.



Participation in the local Adopt-a-Drain program helps reduce flooding, protects waterways, and reduces litter.

## DRAINS

Drains collect stormwater into pipes and direct it to a different area, such as a rain garden on-site, or into the municipal stormwater system. Drainage pipes are sloped in the desired direction of the water flow. However, during a flood event, rising water can back up through the piping, eventually coming up through the drains.

There are several types of drains. A French drain may be recommended to manage shallow groundwater by capturing water and redirecting it from a problem area, like along a building foundation, to a desired location such as a rain garden. A pipe with perforations at the top is laid in a sloped, gravel-filled trench, which uses gravity to move the water along the drain. These systems can be completely underground and covered with plantings, or a walkable, permeable surface. (Refer to *Hardscape and Impervious Surfaces*, page R2.4.)

Site drains are located in low-lying portions of a site or at paved surfaces such as parking lots. Conveyance drainage piping, which includes downspout extensions, direct stormwater to a desired location. Unlike French drains, site drains and conveyance drainage piping rely on solid piping that should be of sufficient size to prevent backups during severe storms and rain bombs.

### KEY TIPS:

- Avoid routing the drain to paved surfaces, city stormwater utilities, or neighboring properties to encourage more water absorption on-site
- Record property elevations to determine any grade changes that may be necessary when digging the trench for a drain system
- Add valves to drain pipes to manage the direction of water flow in flood-prone areas
- Follow detailed installation guides; clean and maintain the system regularly to ensure peak performance
- Consider multipurpose solutions like gravel covered walkways or patios over French drains (loose materials should have containment edging)
- Install drainage pipes with sufficient capacity to manage severe stormwater
- Regularly clear site drains and street drains (refer to *Adopt-a-Drain Program*, sidebar at right, and *Plumbing*, page R7.6)

### ADOPT-A-DRAIN

The City's Adopt-a-Drain program allows local residents and organizations to "adopt" storm drains to help protect nearby drains from unwanted debris, pollutants, or blockages.

This program helps to ensure neighborhood drainage systems work as efficiently as possible by keeping the surface drains clear of debris blockages, and simultaneously protects water quality.

Participation in the program:

- Helps reduce or prevent flooding
- Helps protect waterways from pollution
- Helps keep a neighborhood clean and free of litter

([www.charleston-sc.gov/1984/Adopt-A-Drain](http://www.charleston-sc.gov/1984/Adopt-A-Drain))

### PROTECTING STORM DRAINS

Per Section 27-40 through 27-43 of the City's Code of Ordinances, **it is illegal to dump anything into any stream channel, pond, basin, or other part of the City's stormwater drainage system.** Dumping of materials into Charleston's waters or drains pollutes the water, clogs storm drains, and leads to flooding. To report illegal dumping and illicit discharges, please contact the Citizen Services Desk at (843) 724-7311.



Crape Myrtle

Eastern Redbud

Eastern Red Cedar

East Palatka Holly

Magnolia (Little Gem)

Fringetree

There are several small-to-medium native trees that are recommended for Charleston’s environmental conditions. When selecting a location and tree, consider the shape, height, and growth rate to determine potential conflicts with adjacent buildings, utility lines, existing trees, and paved areas. (South Carolina Master Gardener - Clemson Extension Program)



The Carolina Palmetto is the state tree.

## TREES

Trees can have a significantly positive environmental impact. Tree leaves and branches can slow down rainwater, while roots can reduce erosion and absorb and store a massive amount of rainwater. Shade trees can reduce the temperature in their surrounding area; and, if shading a building, they reduce the impact of the sun’s rays, lowering interior temperatures.

In addition to shade, trees cool temperatures by transpiration. **Transpiration is a process in which trees and vegetation absorb water through their roots and cool surroundings by releasing water vapor into the air through their leaves. Trees and vegetation also provide cooling through evaporation of rainfall collecting on leaves and soil.** (U.S. EPA)

### KEY TIPS:

- Maintain existing trees by regularly observing their health and removing decaying limbs that may damage buildings or power lines during high winds
- Consider tree maintenance requirements such as pruning and raking
- Consider the wind resistance of trunks and branches
- Follow a professional’s advice for selecting, siting, and planting a tree
- Select trees that are suited for Charleston’s Zone 9A climate conditions
- Consider the shape, height, and growth rate to determine potential conflicts with adjacent buildings, utility lines, trees, and paved areas
- Allow for the roots to spread at least 2- to 3-times the mature width to promote a strong root system that can withstand strong winds
- To enhance shade, choose high, wide-crowned trees with deciduous leaves
- Provide 2-4 inches of mulch at the base of the tree to the extent of the dripline, leaving an inch clear around the trunk, to maintain soil moisture
- Wind resistant trees include hollies, crape myrtles, magnolias, bald cypress, Florida and Japanese maples, bottlebrushes, river birches, redbuds, fringe trees, and palms

### DID YOU KNOW?

- Trees are more than 50% water
- A mature oak tree can absorb 40,000 gallons of water each year
- A standard deciduous tree can intercept 500-760 gallons each year
- A standard evergreen tree can intercept 4,000 gallons each year (Penn State Extension)



## GROUND COVERS AND NATIVE PLANTINGS

Native plantings are adapted to survive and evolve in place, making them suitable to existing soil, water, and sunlight conditions. Often, native plantings don't require additional irrigation, fertilizer, or pesticides to keep them alive because they are hardy where they naturally grow. (Refer to *Composting and Natural Fertilizers*, page R2.11.) In addition, native plants attract more wildlife, promoting a healthier biodiversity.

The Carolina Yards Plant Database can help you identify appropriate plants for different conditions (i.e., salt-tolerant species, low water requirement, etc.). Other resources include many of Charleston's public parks, such as Colonial Lake that has a native garden with labeled plants. **Home gardeners can support wildlife and contribute to the restoration and support of local ecosystems by planting more native species, reducing chemicals used to treat garden problems, and implementing environmentally-friendly practices like leaving the leaves.** (Clemson Cooperative Extension, Home and Garden Information Center, *Native Plants for Wildlife: Resources for Home Gardeners.*)

### KEY TIPS:

- Replace portions of grass lawns with native ground covers to reduce mowing, fertilizing, and watering needs
- Understand the soil and conditions before purchasing new plants (refer to *Soil Observation and Testing*, sidebar page R2.3)
- Plant shade-tolerant ground covers near tree trunk bases to avoid root damage from mowing
- Selectively weed lawns to avoid pulling native plants like spiderwort, a type of native iris
- Reference Carolina Native Plant Society for information on native plant sales and other resources for native plants
- Avoid introducing invasive species and remove those that are present over time



Charleston's parks can provide great inspirations for plant materials. Native plants provide soil stabilization, better storage for water, and stormwater infiltration. In contrast, conventional turf grass acts as an impervious surface since the grass's short roots are compacted over time.



Spiderwort adapts to many environments but performs well in sunny and moist gardens.

### INVASIVE SPECIES TO AVOID

Invasive plants can harm the environment and human health. (SC Forestry Commission)

- Bradford pear tree
- Kudzu
- Chinese tallow
- Japanese honeysuckle
- Chinaberry
- Golden bamboo
- Mimosa tree
- Chinese, European, and Japanese privets

### RECOMMENDED GROUND COVERS AND NATIVE PLANTS

The Clemson Home and Garden Center recommends the ground covers appropriate for Charleston's environment. Consult their website for information regarding plant size and preferred sun and soil conditions. ([hgic.clemson.edu](http://hgic.clemson.edu)) (N - native, ST - salt tolerant. While plants may indicate salt tolerance, regular inundation or extended inundation with salt water may damage some plants. Consult with a professional to determine the right balance for the property's characteristics.)

- |                              |                           |                           |
|------------------------------|---------------------------|---------------------------|
| • Beach Wormwood (ST)        | • Phlox (some N)          | • Mondo Grass             |
| • Willowleaf Cotoneaster     | • Barrenwort              | • Lavender Cotton (ST)    |
| • Carolina Jessamine (N, ST) | • Green and Gold (N)      | • Sweet Box               |
| • Confederate Jasmine (ST)   | • Fern (some N)           | • Purple Heart (ST)       |
| • Carpet Bugle, Ajuga        | • Lamb's Ears             | • St. John's-Wort (N)     |
| • Plumbago (ST)              | • Lantana (ST)            | • Inland Sea Oats (N, ST) |
| • Cheddar Pink (ST)          | • Lily-of-the-Valley (ST) | • Sweetgrass (ST)         |
| • Juniper (some N ST)        | • Creeping Rosemary (ST)  | • Pachysandra             |

### TEMPORARY FLOOD BARRIERS

Temporary barrier systems include sand bags, water-filled rubber tubes, or structural wall systems installed immediately before a flood event. Empty rubber tubes are laid on the ground and filled with water, providing up to two feet of protection depending on the contour of the land and whether joints between sections are properly sealed. Temporary structural wall systems typically require installation into pre-mounted ground anchors and can provide protection to higher elevations. **Both of these options rely on available, trained personnel to establish a continuous perimeter barrier and do not necessarily include a secondary drainage system to evacuate water seepage and rainwater collected within the barrier.** The National Flood Barrier Testing and Certification Program tests and certifies flood barrier products used for floodproofing. ([www.floodsciencecenter.org](http://www.floodsciencecenter.org)) These options are labor intensive efforts and are not a long-term solution to all types of flooding, since increasing water tables can keep pushing water from the ground to the surface.



Temporary barriers can reduce flood risk for a short duration if installed prior to an event. (Courtesy of Glenn Keyes)



Low retaining walls can be used to manage a change in slope, control water flow, and collect stormwater to allow it to percolate.

### WALLS AND FENCES

Another way to control or impede water flow across a property is a landscape wall or a fence. Retaining walls can be used to stabilize inclines, enclose a water retention basin, or reinforce a landscape berm. In some cases, wood or metal fences can accumulate soil and debris, which can create unintended trenches or berms. To prevent future problems, regular observation and maintenance of these features is important for a property-wide stormwater and resilience plan.

#### KEY TIPS:

- Check for deterioration; repair, and/or replace components as needed
- Remove rust from metal fences and prime and repaint every 5-8 years
- Anticipate repainting or staining wood fences every 5-8 years
- Secure all vertical, horizontal, and gate connections to prevent fence elements from becoming airborne or waterborne projectiles

### COMPOSTING AND NATURAL FERTILIZERS

Compost collection allows organic materials to decompose, creating an excellent natural fertilizer that can improve soil nutrients and stormwater capacity. The compost materials can be cultivated and used on site, or households can participate in Charleston's residential composting program, which has multiple free drop-off locations.

#### KEY TIPS:

- Fertilize only as needed to maintain the health of lawns and landscape plants, using fertilizers that have a minimum of 50% slow-release nitrogen
- Establish a 10- to 30-foot "no fertilizer, no pesticide" zone along the shoreline
- Compost in a bin or level spot in a yard, about three- to five-feet square, and collect yard trimmings, fruit and vegetable scraps, crushed eggshells, coffee grounds and filters, and tea bags (staples removed)
- Stir compost with a pitchfork or stick every few weeks to circulate air, speed up the "cooking" process, and distribute moisture evenly



#### DID YOU KNOW?

- Approximately one quarter of all collected garbage in the Charleston region are food scraps
- Composting reduces garbage truck trips and landfill space
- Compost reduces the need for chemical fertilizer and is healthier for plants and wildlife

(City of Charleston, Charleston Composts Program)



## SHORELINE PERMITTING

*Activities that disturb beachfront and wetlands should not be undertaken without first obtaining permits from the South Carolina Department of Health and Environmental Control (SCDHEC) Office of Ocean and Coastal Resource Management.* Any disturbance of freshwater wetlands requires a permit from the U.S. Army Corps of Engineers and certification from SCDHEC's Office of Ocean and Coastal Resource Management.



Seawalls require many levels of environmental and social consideration.



Stone and rock rip-rap can help stabilize the shoreline.



Cordgrasses help stabilize shorelines and reduce wave erosion further inland.

## SHORELINE PROTECTION

Most of Charleston's shorelines are publicly owned, but some private properties abut marshy shorelines that ebb and flow with the tide. During flood events, water levels will typically rise and are sometimes compounded by wave action, storm surge, or high-velocity water flow threatening adjacent properties. A range of shoreline protection measures can provide protection for individual properties. A combination of techniques may be used, generally falling into two categories based on their construction method: either "hard," or "armored" adaptations; and/or whether they are "soft," "natural," or "landscape" adaptations that emulate natural processes.

### STRUCTURAL SHORELINES

Structural protective measures can be constructed parallel to a shoreline or property line to fortify it against potential flood-related damage. However, their ability to halt all types of shoreline erosion is not guaranteed and their construction could create erosion issues in adjacent unprotected areas.

- **Seawalls** are vertical walls constructed along a shoreline to provide protection from waves on one side and retain earth on the other, possibly extending above existing grade. They are constructed to reflect incoming wave energy back out towards the water.
- **Bulkheads**, like seawalls, are vertical walls that extend along a shoreline. However, their primary function is to retain soil, not to withstand forceful wave action.
- **Revetments and rip-rap** are fortified slopes or banks constructed of boulders or chunks of concrete that disperse wave energy from currents or light waves. They can prevent erosion and improve the structural stability of soil slopes.

### NATURAL SHORELINE PROTECTION

Natural shoreline protection methods are also known as non-structural or "soft" measures, and are based on emulating the natural ecosystem of an area for a flood-resilient design. For helpful resources, contact the South Carolina Department of Natural Resources (SCDNR) or local natural estuarine resource staff, university partners, or water conservation district staff.

- **Wetland restoration** reestablishes wetlands that have been removed or reduced over time with vegetation that has the ability to filter and store water, and promote ground absorption.
- **Living shoreline** efforts include creating oyster reefs and sustaining cordgrass plantings to reduce wave action and filter pollutants.
- **Floodplain restoration** involves increasing surface areas to distribute water and to increase storage adjacent to a water body or channel that is subject to flooding during a heavy rain or flood event.

Most projects are undertaken by a government entity and implemented at a community scale. However, projects on individual properties can supplement these efforts. To be eligible for a living shoreline, a parcel or lot must be defined as waterfront property in SC Code of Regulations 30-1.D(54) and will require an individual critical area permit from SCDNR.



**BAR**

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- *Hardscaping*
- *Elevation Design Guidelines*

**HISTORIC PRESERVATION CONSIDERATIONS**

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. This may include hardscaping, cisterns, walls, fences, or other built/permanent type features. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly. Information is provided below for best practices toward maintaining the historic character of a property when changes are made to outdoor spaces and landscapes.

**IMPERVIOUS SURFACES**

- Minimize impervious surfaces in prominently visible areas
- Consider use of historically appropriate paving options that allow stormwater filtration such brick pavers, structured landscape parking pavers, and crushed shells or stones

**LANDSCAPE OPTIONS**

- Utilize landscape elements such as swales and berms in a natural slope and incorporate native and salt resistant plantings
- If retaining walls are necessary, use concrete blocks finished with paint or stucco or traditional bricks that are fitting within the historic character
- Plant shade trees in areas that do not compromise historic features
- Install rain barrels in an inconspicuous manner at the base of downspouts, and screen with shrubs or fencing to minimize visibility
- Construct and maintain fences with traditional designs and materials
- Remove plant and algae growth from historic materials

**SHORELINE PROTECTION**

- Consider the potential visual impact of bulkheads and the property’s relationship with the water when selecting materials

**LANDSCAPE IMPROVEMENT CHECKLIST**

The Landscape Improvement Checklist on the following pages identifies maintenance tips, plant and paving material recommendations, and related potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person’s abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building’s resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

LANDSCAPE IMPROVEMENT CHECKLIST

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	<b>RESILIENCE BENEFIT</b>	<b>COST</b>	<b>DO-IT-YOURSELF</b>	<b>CONTRACTOR MAY BE REQUIRED</b>	<b>ARCHITECT OR ENGINEER MAY BE REQUIRED</b>	<b>“OFF-THE-SHELF” SOLUTION AVAILABLE</b>
<b>UNDERSTANDING PROPERTY DYNAMICS</b> <span style="float: right;">Page R2.2</span>						
<input type="checkbox"/> Perform soil observations and tests		¢	●	●		●
<b>HARDSCAPES AND IMPERVIOUS SURFACES</b> <span style="float: right;">Page R2.4</span>						
<input type="checkbox"/> Reduce or replace solid paved surfaces with pavers or loose material to allow drainage		\$\$\$-\$\$\$	●	●		
<input type="checkbox"/> Replace solid pavers with permeable pavers or re-install pavers in a spaced pattern allowing for drainage and/or groundcover		¢-\$\$\$	●	●		
<input type="checkbox"/> Use an aerator to loosen compacted soils, till severely compacted soil and add compost or organic material like peat moss or vermiculite		¢-\$	●	●		
<b>SITE GRADING</b> <span style="float: right;">Page R2.5</span>						
<input type="checkbox"/> Fill in small depressions in yard		¢	●			●
<input type="checkbox"/> Build a berm and/or a swale		¢-\$\$	●	●	●	
<b>RAIN GARDENS</b> <span style="float: right;">Page R2.6</span>						
<input type="checkbox"/> Direct stormwater to a rain garden from downspouts, rain barrels, and cistern overflows		¢	●			●
<input type="checkbox"/> Add native plants best-suited to the unique conditions of the rain garden or swale		¢-\$	●			
<input type="checkbox"/> Limit use of fertilizers and herbicides		¢	●			●
<b>RAIN BARRELS AND CISTERNS</b> <span style="float: right;">Page R2.7</span>						
<input type="checkbox"/> Install rain barrels or cisterns to maximum benefit		¢-\$	●			●
<input type="checkbox"/> Use fencing or plant screening to conceal visible barrels or cisterns		¢-\$	●			●
<input type="checkbox"/> Periodically test water for watering plants, filling fountains and ponds, rinsing outdoor tools, keeping compost moist, and pet washing		¢	●			
<b>DRAINS</b> <span style="float: right;">Page R2.8</span>						
<input type="checkbox"/> Install drain(s) directed toward an on-site absorption area		¢-\$\$	●	●		●
<input type="checkbox"/> Add valves to manage the direction of water flow in flood-prone areas		¢-\$	●	●		
<input type="checkbox"/> Clean drains regularly, especially before a storm, and participate in the Adopt-a-Drain program		¢	●			

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>TREES</b> <span style="float: right;">Page R2.9</span>						
<input type="checkbox"/> Remove decaying tree limbs		¢-\$	●	●		
<input type="checkbox"/> Plant wind-resistant, wide-crowned trees with deciduous leaves to maximize shade, allowing wide root system spread		\$	●	●		
<input type="checkbox"/> Maintain 2-4 inches of mulch at the base of the tree to the extent of the dripline		¢-\$	●			
<b>GROUND COVERS AND NATIVE PLANTINGS</b> <span style="float: right;">Page R2.10</span>						
<input type="checkbox"/> Replace portions of grass lawn areas with native ground covers		\$\$-\$	●			
<input type="checkbox"/> Plant shade-tolerant ground cover around tree bases		¢-\$	●			
<input type="checkbox"/> Maintain and plant native garden species		¢	●			
<b>WALLS AND FENCES</b> <span style="float: right;">Page R2.11</span>						
<input type="checkbox"/> Remove accumulated debris or soil that interrupts stormwater flow		¢	●			
<input type="checkbox"/> Maintain routine re-coatings on wood and metal finishes		¢-\$	●	●		
<input type="checkbox"/> Secure all fence connections to prevent elements from becoming airborne/waterborne projectiles		¢-\$	●	●		
<input type="checkbox"/> Purchase or prepare temporary stormwater barriers		\$\$-\$	●			●
<b>COMPOSTING AND NATURAL FERTILIZERS</b> <span style="float: right;">Page R2.11</span>						
<input type="checkbox"/> Fertilize only as needed using a minimum of 50% slow-release nitrogen fertilizers		¢-\$	●			●
<input type="checkbox"/> Establish a 10- to 30-foot "no fertilizer, no pesticide" zone along the shoreline		¢-\$	●			
<input type="checkbox"/> Collect yard trimmings and food scraps for composting		¢	●			●
<input type="checkbox"/> Participate in Charleston's compost drop-off or compost in a bin or on a level spot in the yard		¢-\$	●			
<b>SHORELINE PROTECTION</b> <span style="float: right;">Page R2.12</span>						
<input type="checkbox"/> Plan and design hard armoring projects that do not negatively harm other properties		\$\$-\$	●	●	●	
<input type="checkbox"/> Maintain natural grasses and encourage living shoreline growth		\$\$-\$	●	●	●	

## LANDSCAPE RESOURCES

### American Society of Landscape Architecture

Resilience Beyond Rhetoric in Urban Landscape Planning and Design, Nina-Marie Lister, Hon. ASLA, in Nature and Cities, Lincoln Institute of Land Policy, 2016  
Sustainable Residential Design: Improving Water Management and Applying Ecological Design  
[asla.org/flooding](http://asla.org/flooding)

### Charleston Soil and Water Conservation District

[www.charlestonsoilwaterconservationdistrict.com](http://www.charlestonsoilwaterconservationdistrict.com)

### City of Charleston

Adopt-a-Drain, Charleston Rainproof, [www.charleston-sc.gov](http://www.charleston-sc.gov)

### Clemson Home and Garden Information Center (HGIC)

A Guide to Rain Gardens  
Creating an Environmentally Friendly Landscape  
Carolina Yards: Plant Database  
Native Plants for Wildlife: Resources for Home Gardeners  
[hgic.clemson.edu](http://hgic.clemson.edu)

### Louisiana State University Agricultural Center

Installing and Maintaining a French Drain, [lsuagcenter.com](http://lsuagcenter.com)

### Lowcountry Master Gardener Association

Preferred Trees for the Low Country, [lowcountrymga.org](http://lowcountrymga.org)

### National Flood Barrier Testing and Certification Program

[www.floodsciencecenter.org](http://www.floodsciencecenter.org)

### North Carolina Cooperative Extension

Rain Barrels, [ces.ncu.edu](http://ces.ncu.edu)

### South Carolina Department of Health and Environmental Control (SCDHEC)

Runoff Diversion Measures, [scdhec.gov](http://scdhec.gov)

### South Carolina Department of Natural Resources (SCDNR)

Summary of Living Shoreline Research and ACE Basin National Estuarine Research Reserve, [dnr.scgov](http://dnr.scgov)

### South Carolina Forestry Commission

Urban Tree Species Guide for South Carolina and Invasive Species, [scfc.gov](http://scfc.gov)

### The Nature Conservancy

Building Coastal Resilience, [nature.org](http://nature.org)

### University of Florida Food and Agricultural Science

Rainwater Collection Systems, [sfyl.ifas.ufl.edu](http://sfyl.ifas.ufl.edu)

### U.S. Environmental Protection Agency

Coastal Adaptation Toolkit and EPA Green Streets Design Manual  
Composting at Home  
Using Trees and Vegetation to Reduce Heat Islands  
[epa.gov](http://epa.gov)



## REGULATIONS TO REVIEW

- City of Charleston Buffer Ordinance
- City of Charleston BAR policies as applicable
- City of Charleston Tree Protection Ordinance
- City of Charleston Stormwater Management Utility and Land Use ordinances
- City of Charleston Flood Hazard Prevention and Control Ordinance
- SC Department of Natural Resources and Department of Health and Environmental Control

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

**City of Charleston Permit Center**  
2 George Street, Ground Floor  
Charleston, SC 29401  
843.577.5550  
[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)

This material is funded by the Preservation Society of Charleston on behalf of the City of Charleston.  
[www.charleston-sc.gov](http://www.charleston-sc.gov)

PRESERVATION  
ESTD SOCIETY 1920  
of CHARLESTON

Prepared by:  
Preservation Design Partnership, LLC  
Philadelphia, Pennsylvania  
[www.pdparchitects.com](http://www.pdparchitects.com)



A view across Charleston rooftops near the time of the Civil War. ([www.loc.gov](http://www.loc.gov))

# R3

## RESILIENCE GUIDANCE: ROOF SYSTEM

### ROOF IMPROVEMENT GOALS

*Regular roof maintenance is an important factor in the long-term protection of all buildings and structures. A poorly maintained roof has a higher likelihood of major damage from water intrusion, wind, or a seismic event.*

### MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (*Refer to Resilience Guidance: Permit Review, page R1.5.*) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

*The roof system provides the first line of defense against weather events, since it is the primary protection from rain, wind, and the sun's heat.* It is a vital part of the building's outer envelope. While it is easy to think of a roof as a single surface material, roofs are made up of a number of components that must work together to protect the building and its occupants. The outer-most surface is the covering, which is usually shingles, tiles, or metal. Below this layer is a barrier called an underlayment; the next layer is panels of decking, typically plywood. Flashing is tucked into the edges and around chimneys, dormers, and other venting elements. The structural system that supports the roof is typically wood joists, beams, and sometimes trusses.

*Each roof component will wear at different rates over time, and the deterioration can be accelerated by water seepage, sun exposure, or pests.* Furthermore, if there is existing deterioration weakening these components, storms can cause more extreme damage. Regular maintenance and small improvements can work together to reduce damage and climate threats.

Maintaining the roof or improving a roof's water barriers can reduce:

- Potential leaks from stormwater
- Structural damage from high winds and earthquakes
- Heat gain at the interior of a building

Learning how to protect properties from climate threats by identifying existing roof vulnerabilities and addressing problems through small, incremental improvements can improve resilience. Conditions will vary based upon the original construction and current condition, and may require multiple approaches.





*This roof needs shingle replacement and evaluation for structural repair. Overhead trees limbs should be trimmed so they are not touching the roof.*

### ROOF MAINTENANCE TO IMPROVE RESILIENCE

There are a number of ways roof maintenance can improve resilience.

- **Weather-tightness:** Weather-tight roofing preserves a building and provides shelter from stormwater, wind, and the sun's heat. Small holes are pathways for stormwater entry into a building, potentially resulting in damage to finishes, wood rot, and mold growth.
- **Structural soundness:** A structurally-sound roof can resist wind uplift and windborne debris impact. Well-secured components are less likely to become airborne or topple in an earthquake, and can prevent water intrusion.
- **Heat absorption:** Sunlight hitting a roof surface can significantly increase temperatures inside the building. In locations without trees to shade the roof surface, the color and/or reflectivity of a roof can reduce indoor air temperatures. *(Refer to Trees, page R2.9.)*

#### KEY TIPS:

- Inspect roofing components every six months to allow time for repairs prior to hurricane season
- Look at the roof from the ground and ask friendly neighbors to allow access to their yards for a better vantage point and/or use a drone if available
- Tree limbs should be trimmed to avoid contact with the roof surface
- Complete maintenance issues, hire a worker or a contractor, or retain an architect or engineer for more complex projects
- Do not delay action, since problems identified sooner can be less costly to repair and may prevent more extensive deterioration
- Gutters and downspouts should be cleared of leaves and debris at least twice a year, and observed during a rainstorm to make sure they are functioning properly and not overflowing *(refer to Gutters and Downspouts, page R3.4)*
- Flat roofs or low-sloped roofs should be inspected immediately following a rainfall to see if there is standing water

#### PROPERTY INSURANCE

In addition to increasing resilience, some improvements may allow owners to reduce their property insurance premiums. To be eligible for these reductions, certification from an architect or engineer indicating that improvements meet specific wind resistance requirements may be required.



*Leaves need to be cleared from the roof and gutters. A professional service may be needed to access the roof safely.*



Individual shingles are missing and others are in a deteriorated condition.



Metal hangers can be used to secure dislodged slates or replace individual slates.



Lightning rods look like spikes sticking up from the roof surface.

### LIGHTNING PROTECTION

Lightning commonly accompanies severe storms. Metal roof buildings and those that are far from neighbors are more vulnerable. If a building is struck by lightning, the current is carried throughout the structure, creating a surge that can damage plugged-in appliances and electronics or start a fire. Lightning protection systems include rods that attract lightning and safely carry it into the ground through conductors.



A roof may have one pitch or multiple pitches. All roof valleys, ridges, chimney or window joints, and eaves require proper flashing to prevent stormwater leaks.

### SLOPED ROOFING

Sloped roofs are typically covered by overlapping rectangular shingles made from slate, tile, metal, or asphalt. Metal sloped roofs can be standing seam or formed sheet metal. The overlapping individual shingles or metal panels direct stormwater to the bottom edge of the roof, known as the eave, where it is collected in a gutter and flows down to the ground in downspouts. *(Refer to Roof Soffits and Overhangs, page R3.6, and Gutters and Downspouts, page R3.4.) If shingles are damaged or worn, or metal is punctured or rusted, stormwater can find a path through the outer surface resulting in a roof leak.* Leaks may or may not be visible in the attic or ceiling spaces until the damage is severe. Another condition to note is the presence of moss, mold, or algae growing on the shingle surface. This can be a sign that shingles are becoming thinner as they wear down from age and are developing holes and absorbing water. Weakened shingles can detach and slide down the roof slope, and gaps at the bottom of shingles can allow strong winds to pull shingles off of the roof.

#### KEY TIPS:

- Refasten or replace nails that are popping up with secure fasteners
- Replace deteriorated or missing individual shingles, with in-kind material
- Repair isolated metal punctures or rust, preferably with in-kind material
- Refasten or solder slipping metal sheets, panels, open seams, or joints
- Consider roof replacement when over 20% of shingles are split, cracked, missing, or deteriorated, or 20% of the metal roof sections are rusted or punctured; this will also require replacement flashing *(refer to Roof Joint Protection, page R3.7, and Roof Replacement, page R3.10)*
- Use nails or foam insulation when replacing clay or concrete tile roofs to minimize edge uplift from strong winds
- Remove moss, mold, or algae from roof surface; clean and treat surface to prevent future growth
- Use a licensed contractor to make any repairs or remediate asbestos shingles, which are a hazardous material

## FLAT ROOFING

Roofs with a shallow slope are referred to as flat roofs. A watertight surface and membrane is gently sloped toward a drain using tapered insulation installed under the roof surface material. Membrane materials include built-up roofing, single-ply roofing, modified bitumen roofing, and metal roofing. Flat metal roofs found on historic porches are made of small, rectangular pieces of copper, seamed and soldered together. **To prevent leaks, the membrane or metal flat roofing must be continuous and without splits, punctures, or surface cracking.**

### KEY TIPS:

- Repair or reseal seams, splits, punctures, or surface cracking as soon as possible
- Apply a light-colored or reflective coating to reduce interior heat gain
- Avoid installing gravel, which can become airborne projectiles in heavy winds
- Build up roof insulation under the roof surface if there are puddles or ponding, and patch membrane or metal roof surface
- Consider roof replacement when over 20% of the surface is deteriorated; this will also require replacement flashing and tapered insulation to allow drainage and keep the interior cooler (refer to [Roof Joint Protection, page R3.7](#), and [Roof Replacement, page R3.10](#))
- Consider installing solar collectors that can provide energy and can shade the roof surface, using certified installers (refer to [Solar Collectors, page R3.8](#))



Rubber roofing can crack, eventually forming leaks. Significant cracking of this roof suggests replacement might be prudent. Selecting a lighter color can reduce heat absorption.



A system of gutters and downspouts can direct rainwater away from the building if kept clear of debris.

## GUTTERS AND DOWNSPOUTS

Gutters and downspouts that are in good repair and clear of clogs can reduce water damage to building walls, foundations, and piers. They are located near or along the bottom edge of a roof slope to collect rainwater from the roof surface. If buildings were not designed with gutters, they can be added. In addition to collecting stormwater, gutters can collect leaves and debris, causing them to become clogged and ineffective, resulting in stormwater overflowing the edge. Downspouts are generally surface-mounted to building walls to transport stormwater from the gutter to the ground or to an underground drainage system via a cast iron boot. Stormwater discharged onto the ground should be directed away from building foundations, piers, and crawlspaces to minimize masonry damage. (Refer to [Site Grading, page R2.5](#), and [Managing Moisture, page R5.3](#).) Gutters and downspouts can be damaged by flying debris or pulled away from the building in strong winds.

### KEY TIPS:

- Regularly clear gutters and downspouts of leaves and debris that might cause a clog
- Maintain fasteners and verify they are secured to the building
- Ensure that gutters are sloped towards the downspout
- Install a system to deposit stormwater into an on-site mechanism, such as a rain barrel
- Direct stormwater away from the building with a splash block or downspout extension to prevent water from pooling next to the foundation (refer to [Site Grading, page R2.5](#))

## CHIMNEYS

Chimneys can be weak spots during a storm if water seeps through unprotected caps or open joints. A damaged chimney is also more vulnerable to toppling in high winds and earthquakes. Toppled chimneys or chimney parts can crash through the roof and cause major water damage and potentially damage the roof structure.

Tall, skinny chimneys and those that are leaning or have open joints are more prone to toppling. Regular maintenance can prevent mortar loss between bricks or stucco deterioration that is important to stabilize a chimney. *(Refer to section R5: Exterior Masonry.)*

### KEY TIPS:

- Re-secure or replace chimney cap to reduce air loss and potential vermin
- Parge or coat chimney top so water does not seep into bricks from above
- Repoint damaged or weathered mortar joints between bricks
- Replace damaged bricks and stucco
- Brace tall, skinny, or leaning chimneys
- Rebuild severely damaged chimney above the roof line, preferably in-kind
- Reline crumbling chimney flue
- Replace damaged metal flashing at base of chimney: metal flashing can provide a longer-term repair; caulk or roof tar can provide a quick, temporary repair *(refer to Roof Joint Protection, page R3.7)*
- Inspect/repair or install crickets (sloped metal flashing) behind the chimney



*Mortar joints between bricks may need to be repaired to prevent weak spots and potential structural failure. Stepped flashing is found at the base of the chimney along the roof slope.*



*Projecting features may need reinforced tie-downs and seals.*

## ROOF PROJECTIONS

Roof projections include historic features that extend above a roofline, such as dormer windows and cupolas, as well as modern interventions like plumbing vents, skylights, roof hatches, television dishes, antenna, mechanical equipment, solar panels, and lightning rods. *(Refer to Lightning Protection, sidebar page R3.3.)* Features projecting through and above a roof pose the potential for roof leaks and damage from high winds that can dislodge components, or they can be damaged by windborne debris impact.

### KEY TIPS:

- Remove abandoned rooftop projections that are not historic features, like old television antennae or satellite dishes, to reduce the number of roof penetrations and attachment locations; patch roof and fastener locations with a compatible material to ensure long-term durability
- Securely anchor roof projections from wind uplift and prevent them from becoming airborne in high winds
- Replace damaged metal flashing at base of projections: metal flashing can provide a longer-term repair; caulk or roof tar can provide a quick, temporary repair *(refer to Roof Joint Protection, page R3.7)*
- Replace older skylights and roof hatches with hurricane-rated skylights and hatches that can withstand high winds



## ATTIC VENTS

Attic vents can be located on a roof, on a ridge vent or hatch vent, or on a projecting eave or gable end. *(Refer to Roof Soffits and Overhangs, below.)* Attic vents allow trapped hot air to escape, reducing interior temperatures in summer months. While vents allow air to escape, they also provide a path for hurricane-strength winds to enter an attic, which can cause structural damage to the roof framing. Hurricane-rated attic vents can provide the highest level of protection, but it is also possible to temporarily protect vent openings with plywood panels in advance of a high-wind storm.

### KEY TIPS:

- Prepare gable-end vent protection, such as pre-cut plywood panels, for installation in advance of a storm
- Replace existing attic vents with hurricane-rated vents, preferably to match existing appearance and building style
- Reinforce gable ends over four feet in height to reduce the possibility of collapse in high winds *(refer to Hurricane-Rated Connectors, page R3.9, and Wood Cladding, page R4.3)*
- Reinforce roof structure with hurricane-rated connectors



Any openings, including attic vents, will need temporary storm protection.



The roof eave projects beyond the building wall below. Eaves can be open, with exposed rafter tails, or boxed with vented spaces (as in this example).



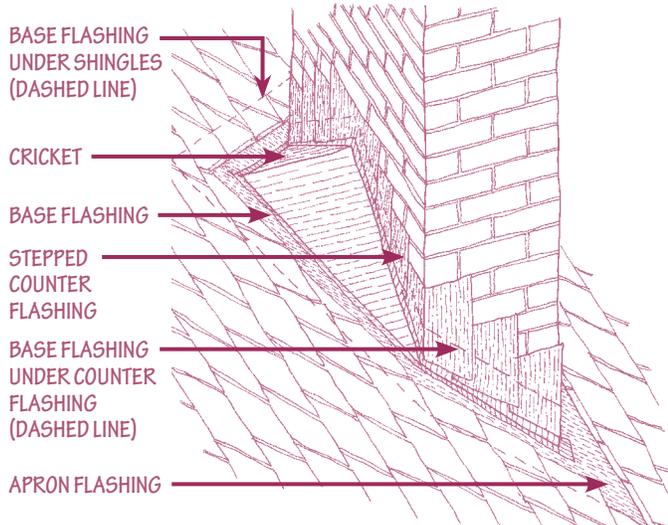
Overhangs on most buildings extend up to 16-inches from the building wall.

## ROOF SOFFITS AND OVERHANGS

The underside of a roof may have extended eaves or an enclosed soffit. Deep overhangs provide shade to reduce a building's interior heat gain. However, if the connections are insufficient or deteriorated, strong winds can separate the eaves from the roof and the building through uplift, damaging the structure and potentially creating a path for stormwater to enter the building.

### KEY TIPS:

- Ensure there is a strong connection between the roof structure or overhang to the main building structure
- Reinforce the structure of roof soffits and overhangs with hurricane-rated connectors *(refer to Hurricane-Rated Connectors, page R3.9)*



Flashing is composed of many pieces of sheet metal that are layered to prevent water from entering between joints. The specific types and configuration should be customized to the unique conditions of each roof.

#### ROOF FLASHING TYPES

Metal flashing is the best long-term protection for openings and joints on a roof. Tar and caulk are temporary solutions that should only be used until metal flashing can be installed.

- **Ridge Flashing:** Installed as a cap at the high edge of two roof slopes
- **Valley Flashing:** Located at the intersection between two roof slopes to direct water to gutter
- **Drip Edge Flashing:** Installed along the roof eave to direct water into gutters and protect roof edges
- **Vent Pipe Flashing:** Installed around vent pipes, often with upward slope under shingles and downward slope exposed
- **Chimney Flashing:** Typically made up of base flashing and counter flashing; may include a cricket at upper slope and base flashing; or apron flashing at downward slope
- **Base Flashing:** Installed under roof shingles and over underlayment where vertical walls intersect the roof surface
- **Step Flashing:** “L-shaped” flashing bent under shingles and extending up an intersecting wall surface
- **Counter Flashing:** Covers the top edge of base flashing or step flashing; top edge should be installed in a cut masonry joint, known as a reglet
- **Apron Flashing:** Base flashing located along the roof at the base of a wall or vertical intersections of chimneys, skylights, and dormers



Dormer windows have flashing at the top edge, along the roof slope, and below the window.

#### ROOF JOINT PROTECTION

Roof joints can occur at roof edges, chimneys, and roof projections. Roof joints tend to be protected with roof tar, caulk, and/or flashing, which are thin pieces of metal installed to prevent stormwater from entering a structure through a joint. Roof tar and caulk should be considered a short-term protective measure that will require regular removal and re-application.

Metal flashing is often found in sloped roofing layered under shingles at valleys, and bent to extend up chimneys or other roof projections. The top leg of the metal flashing may be protected by roof tar, sealant, or an additional piece of metal flashing known as counter flashing, which provides longer term protection than roof tar or caulk.

#### KEY TIPS:

- Re-secure loose sections of flashing
- Replace missing or deteriorated flashing
- Replace damaged or missing tar or caulk at the top of base flashing
- Aluminum flashing, which is the least expensive metal flashing, is prone to deterioration (discolored spotting and small holes)
- Copper flashing, one of the costliest options, tends to be one of the most durable
- Replacing the base flashing that is located below or between shingles may be difficult or impossible without removing large areas of shingles or roofing; installing flashing with a similar or longer lifespan than replacement roofing at the outset is recommended





The visibility of solar panels can be reduced if the color is close to the roof surface color. Verify that attachments are appropriate for the roof materials and securely fastened to reduce the likelihood of uplift in severe winds.



Solar roof tiles can more closely mimic shingle patterns.

## SOLAR COLLECTORS

Solar collectors provide a renewable energy source that can reduce electricity costs for a property owner to power air conditioning, heating, hot water, and electricity. Solar water heaters supply hot water for building use, reducing fuel or electricity needed to power a traditional hot water heater.

Solar panels are usually panels mounted a few inches above a roof surface, but films or tiles applied directly to the roof surface are emerging as an alternative. *(Refer to Historic Preservation Considerations, page R3.11, for guidance related to historic buildings.)* In addition to producing electricity, solar panels have the added benefit of shading roof surfaces. A qualified structural engineer will need to be consulted to design an installation to meet the required load, wind load, and uplift requirements.

### KEY TIPS:

- Install solar panels on a well-maintained roofs
- Install a solar water heater on a well-maintained roof to produce hot water, securely fastening tank to roof framing to prevent toppling
- Maintain connectors to prevent uplift in high winds
- Confirm with installer that the attachment connectors are appropriate for the roof surface; traditional standing seam, slate, and tile roof surfaces require specialized attachments, and consultation with an independent expert, like an architect, or a second opinion may be warranted prior to installation *(refer to Historic Preservation Considerations, page R3.11, for guidance related to historic buildings)*
- Install battery storage for solar panels to provide service during a power outage

### SOLAR PANEL TAX CREDITS

Tax credits can reduce the cost of solar panels for property owners. The federal Energy Star website has information about efficient products, rebates, and tax credits for solar panels. *(Refer to [www.energystar.gov](http://www.energystar.gov).)* In addition, contact the South Carolina Energy Office for information if installing solar panels. *(Refer to [www.solar.sc.gov](http://www.solar.sc.gov).)*



Exposed roof framing in the attic can have pest and moisture problems.



Loose insulation should be measured to monitor depth. (energy.gov)

## ATTIC

Inspecting the attic can help identify problems with a roof system. Water staining, a dark patch, or white bloom can be signs of a leak. Cracked, sagging, or missing framing members can identify a structural problem. Dampness or mildew can indicate poor ventilation. Addressing attic vulnerabilities can improve the life of a roof and reduce indoor air temperatures.

### KEY TIPS:

- If the attic is accessible, review condition at least once a year, particularly around projections like chimneys, which are prone to joint leaks
- Repair roof leaks
- Install insulation on the attic floor to reduce heat and air conditioning loss below (refer to *Insulation Matrix*, page R8.6)
- Install a whole-house attic fan in un-insulated buildings; note potential for humidity and mold issues for insulated buildings (refer to *Heating and Air Conditioning*, page R7.4)
- Replace damaged or insufficient roof structure
- Reinforce roof structure with hurricane-rated connectors
- Reinforce gable ends over four feet in height to reduce possibility of collapse in high winds (refer to *Hurricane-Rated Connectors*, below)
- Evaluate options for a spray polyurethane foam (SPF) to the underside of the roof deck at the joints between plywood panels, and on both sides of framing members (rafters) (refer to *Historic Preservation Considerations*, page R3.11, and *Insulation Matrix*, page R8.6)

## HURRICANE-RATED CONNECTORS

Many buildings in Charleston have wood framing for the roof and floors even if the walls are masonry. Wood-framed portions of a structure are more likely to be damaged by the effects of a significant storm. In some historic buildings, the connections between wood elements are nailed together, older buildings may have pegged or mortised joints. **The movement of a building in high winds or earthquakes may loosen connection joints and compromise its structural integrity, increasing the potential for damage from strong, sustained winds or wind gusts.** Adding hurricane-rated connections between structural elements can help a building resist wind forces and keep a building intact during hurricanes and other extreme storms. (Refer to *Wood Cladding*, page R.4.) At the roof level, hurricane-rated connectors should span across roof ridges and attach rafters to the walls and framing below. **To provide access to complete this work, roof replacement may be required and an architect or engineer should be consulted for guidance.** (Refer to *Historic Preservation Considerations*, page R3.11.)

### METAL CONNECTORS

The type of metal used for the connectors should be based upon the building's location and conditions. Galvanized metal straps, connectors, nails, and screws are less likely to rust than steel. However, in areas exposed to saltwater or spray, stainless steel connectors may be warranted. They are more expensive, but the cost of removing wall surfaces to replace rusted or corroded connectors should be considered.



A structural engineer or architect should select and design the hurricane-rated connector layout best suited for the building conditions. The installation requires access to structural elements, like masonry walls and wood framing, necessitating removal of interior finishes.





Light-colored roofing material can help reduce interior air temperatures.

### REPAIR VERSUS REPLACEMENT FOR HISTORIC BUILDINGS

One of the attractions of Charleston is the physical aesthetic and economic value of older and historic properties that will benefit future generations. *To preserve the authenticity of Charleston's heritage, the City strongly encourages the retention of historic materials or repair/replacement in-kind whenever work on a property is considered.* For those properties that are designated historic or within a regulated district, these practices are enforced by the BAR. (Refer to Board of Architectural Review (BAR), sidebar page R1.3.)

Recommended repairs are focused on specific areas of deterioration in order to maintain the stability and weather resistance of a building, rather than wholesale replacement of a historic building material. Careful attention to detail might be required as part of the effort. Regular maintenance with timely repairs can minimize large repair costs associated with ongoing deterioration.

### ROOF REPLACEMENT

All materials deteriorate over time, and at some point it will be necessary to replace the roof surface. The useful life of a roof will vary based upon the materials and installation details. A full roof replacement provides an opportunity to significantly improve resilience as noted below.

- **Water Intrusion:** An adhesive roof membrane can be installed on sheathing as a secondary water barrier or a sprayed-on sealer applied; joint-tape systems can be applied between sheathing members; and flashing can be replaced at all penetrations and transitions (refer to *Insulation Matrix*, page R8.6, and *Roof Joint Protection*, page R3.7)
- **Wind:** Roof, eave, and gable-end framing can be enhanced and secured; hurricane straps can be added to the roof structure; sheathing can be securely fastened to the framing; hurricane-rated skylights and hatches can be installed (refer to *Hurricane-Rated Connectors*, page R3.9, and *Roof Projections*, page R3.5)
- **Earthquake:** Chimneys can be repointed and secured (refer to *Chimneys*, page R3.5)
- **Heat:** Attic or roof insulation can be installed; light colored or solar-reflective roofing can be installed; solar panels may be considered to offset energy usage (refer to *Solar Collectors*, page R3.8)

Property owners are encouraged to consider the long-term benefits of resilience upgrades and how that can reduce continued, costly repairs over time. Consultation with an architect or qualified contractor early in the design process can help a property owner understand current vulnerabilities and the range of resilience options appropriate for the unique conditions of a roof system.



### BAR

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- *Roofing*
- *Solar Panels*
- *Materials and Demolition*
- *Hurricane Protection Panels*

## HISTORIC PRESERVATION CONSIDERATIONS

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly. Information provided below indicates best practices toward maintaining the historic character of a property when changes are made to the roof or roof features.

### ROOFING MATERIAL

- Repair or replace in-kind and localize repairs rather than full replacement
- Match the shape and pattern of the historic material when repairing or replacing the roofing material
- Select compatible flashing material and fasteners with a lifespan and material similar to the new roofing

### GUTTER AND DOWNSPOUTS

- Retain the original gutter and downspout system and appearance
- Replace gutters with new material of similar size, shape texture, and pattern if replacement with original material is not possible
- Install plain half-round, painted K-style or ogee gutters if none exist
- Paint downspouts to match the adjacent wall color

### CHIMNEYS

- Retain and properly maintain historic chimneys, chimney caps, and detailing even in instances where the interior of the chimney has been removed
- Install a minimally visible, dark-colored, projecting chimney damper or cap
- Install flue extensions that are clay tile, unpainted galvanized metal, or painted black

### ROOF PROJECTIONS

- Replace existing or install a new skylight or roof hatch with components that are relatively flat, minimally visible, and sympathetic to and compatible with the existing roof materials

### ATTIC VENTS

- Select hurricane-rated attic vents appropriate to the building style

### JOINT PROTECTION

- Install any new or replacement flashing with a life span longer than, or equal to, the life span of the roof material
- Install flashing compatible with all roof materials

### ATTIC

- Application of spray foam on historic attic framing should be done with caution; install foam so that the application is reversible
- Obscuring historic framing and sheathing with foam hinders the ability for visual damage inspections
- Spray foam applied throughout an attic can create a micro-climate that promotes moisture and condensation, resulting in deterioration of framing



## HISTORIC PRESERVATION CONSIDERATIONS (CONTINUED)

### SOLAR COLLECTORS

- Locate on rear roof slopes, behind architectural features or parapets, or other locations of limited visibility such as accessory buildings
- Ensure that significant, character-defining features are not removed, damaged, altered, or obstructed
- Limit the fastening system to areas that will least impact fragile historic roofing materials
- Consider custom details to limit physical and visual impacts to the historic structure
- Consider installation alternatives, such as positioning panels on auxiliary structures, free-standing installations, and locating panels on secondary roof forms, all with restricted visibility from the public right of way
- Select solar collectors that are low-profile, or no more than 8” above the roof surface, and can be installed at a pitch consistent with the existing roof
- Paint conduits and attachment mechanisms to be compatible with the existing material, including roof, siding, etc.
- Install solar collectors in a manner that is reversible
- Confirm with installer that the attachment connectors are appropriate for the roof surface; traditional standing seam, slate, and tile roof surfaces require specialized attachments, and consultation with an independent expert, like an architect, or a second opinion may be warranted
- Locate battery storage in a minimally visible location



### ROOF REPLACEMENT

- Select replacement roofing material that is compatible with the appearance of historic roofing

### ROOF SYSTEM IMPROVEMENT CHECKLIST

The Roof System Improvement Checklist on the following pages identifies maintenance information and other related potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person’s abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building’s resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

ROOF SYSTEM IMPROVEMENT CHECKLIST

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>ROOF MAINTENANCE TO IMPROVE RESILIENCE</b>						Page R3.2
<input type="checkbox"/> Trim overhanging tree limbs		¢-\$	●	●		
<input type="checkbox"/> Clear gutters and downspouts at least twice a year; inspect during a rainstorm		¢-\$	●	●		
<input type="checkbox"/> Contact an architect or engineer to review/repair structural problem like a sagging or bowing roof		\$\$\$\$		●	●	
<b>SLOPED ROOFING</b>						Page R3.3
<input type="checkbox"/> Refasten or replace nails that are popping up with secure fasteners		\$\$-\$	●	●		
<input type="checkbox"/> Replace deteriorated or missing individual shingles; repair isolated metal punctures or rusting		\$\$-\$	●	●		
<input type="checkbox"/> Refasten or solder slipping metal sheet, panel, open seam, or joint		\$		●		
<input type="checkbox"/> Remove moss, mold, or algae from roof surface; clean and treat surface to prevent future growth		¢-\$	●			●
<b>FLAT ROOFING</b>						Page R3.4
<input type="checkbox"/> Repair or reseal seams, splits, punctures, or surface cracking as soon as possible		\$\$-\$		●		
<input type="checkbox"/> Apply light-colored or reflective coating		\$	●	●		●
<input type="checkbox"/> Avoid installing gravel that can become airborne		¢-\$		●		
<input type="checkbox"/> Build up roof insulation under the roof surface and slope to drain		\$\$		●		
<b>GUTTERS AND DOWNSPOUTS</b>						Page R3.4
<input type="checkbox"/> Clear gutters and downspouts of debris		¢-\$	●	●		
<input type="checkbox"/> Maintain fasteners and verify they are secured to the building and gutters are sloped toward the downspout		¢-\$	●	●		
<input type="checkbox"/> Install a system to deposit stormwater into an on-site mechanism, such as a rain barrel		¢	●			●
<input type="checkbox"/> Direct stormwater away from the building with a splash block or downspout extension		¢	●			●

# RESILIENCE GUIDANCE: ROOF SYSTEM

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>CHIMNEYS</b> <span style="float: right;">Page R3.5</span>						
<input type="checkbox"/> Re-secure or replace chimney cap		¢-\$	●	●		●
<input type="checkbox"/> Parge or coat top of chimney		¢-\$	●	●		
<input type="checkbox"/> Repoint damaged or weathered mortar		\$-\$-\$		●		
<input type="checkbox"/> Replace damaged bricks and stucco		\$-\$-\$		●		
<input type="checkbox"/> Brace tall, skinny, or leaning chimneys		\$-\$-\$	●	●		
<input type="checkbox"/> Rebuild severely damaged chimney		\$-\$-\$		●	●	
<input type="checkbox"/> Reline crumbling chimney flue		\$-\$-\$		●		
<input type="checkbox"/> Replace damaged/missing metal flashing		¢-\$	●	●		
<b>ROOF PROJECTIONS</b> <span style="float: right;">Page R3.5</span>						
<input type="checkbox"/> Remove abandoned rooftop projections and patch roof and fastener locations		¢-\$	●	●		
<input type="checkbox"/> Securely anchor roof projections		¢-\$	●	●		
<input type="checkbox"/> Replace damaged metal flashing		\$-\$-\$	●	●		
<input type="checkbox"/> Replace older skylights and roof hatches with hurricane-rated skylights and hatches		\$-\$-\$		●	●	
<b>ATTIC VENTS</b> <span style="float: right;">Page R3.6</span>						
<input type="checkbox"/> Prepare gable-end vent protection, such as pre-cut panels, for installation in advance of a storm		¢	●			
<input type="checkbox"/> Replace existing attic vents with hurricane-rated vents		\$	●	●		●
<input type="checkbox"/> Reinforce gable ends over four feet in height to reduce possibility of collapse in high winds		\$-\$	●	●		
<input type="checkbox"/> Reinforce roof structure with hurricane-rated connectors		\$-\$-\$		●	●	
<b>ROOF SOFFITS AND OVERHANGS</b> <span style="float: right;">Page R3.6</span>						
<input type="checkbox"/> Secure roof structure or overhang to main building structure		\$-\$-\$-\$		●	●	
<input type="checkbox"/> Reinforce roof soffits and overhangs with hurricane-rated connectors		\$-\$-\$-\$		●	●	

<b>ACTION / PROJECT</b>  <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>ROOF JOINT PROTECTION</b> <span style="float: right;">Page R3.7</span>						
<input type="checkbox"/> Re-secure loose sections of flashing		\$\$\$	●	●		
<input type="checkbox"/> Replace missing or deteriorated flashing		\$\$\$	●	●		
<input type="checkbox"/> Temporarily seal gaps at top of base flashing with roof tar or caulk		¢-\$	●	●		
<input type="checkbox"/> Replace flashing and counter flashing		\$\$\$\$		●	●	
<b>SOLAR COLLECTORS</b> <span style="float: right;">Page R3.8</span>						
<input type="checkbox"/> Install solar panels on a well-maintained roofs		\$\$\$		●		
<input type="checkbox"/> Install a solar water heater on a well-maintained roof, securely fasten		\$\$		●		
<input type="checkbox"/> Maintain connectors		¢-\$	●	●		
<input type="checkbox"/> Confirm attachment connectors are appropriate for the roof surface		\$			●	
<b>ATTIC</b> <span style="float: right;">Page R3.9</span>						
<input type="checkbox"/> Repair roof leaks		\$\$\$	●	●		
<input type="checkbox"/> Install insulation on attic floor		\$\$\$	●	●		●
<input type="checkbox"/> Install a whole-house attic fan in un-insulated buildings		\$\$\$	●	●		●
<input type="checkbox"/> Replace damaged or insufficient roof structure		\$\$\$\$		●	●	
<input type="checkbox"/> Install structural hurricane-rated connectors		\$\$\$\$		●	●	
<input type="checkbox"/> Reinforce gable ends over four feet in height		\$\$		●	●	
<input type="checkbox"/> Evaluate appropriateness of spray polyurethane foam (SPF)		\$\$\$		●	●	
<b>HURRICANE-RATED CONNECTORS</b> <span style="float: right;">Page R3.9</span>						
<input type="checkbox"/> Install structural hurricane-rated connectors		\$\$\$		●		
<b>ROOF REPLACEMENT</b> <span style="float: right;">Page R3.10</span>						
<input type="checkbox"/> Replace roof in-kind		\$\$\$		●		
<input type="checkbox"/> Replace roof with resilience upgrades		\$\$\$		●	●	

## ROOF SYSTEM RESOURCES

### City of Charleston

BAR Policy Statements  
Climate Adaptation Planning + Analytics (CAPA) Heat Watch, 2021  
Homeowner Rehabilitation  
Sustainability Checklist  
[charleston-sc.gov](http://charleston-sc.gov)

### Federal Emergency Management Agency (FEMA)

Building Codes Toolkit for Homeowners and Occupants, FEMA P-2325  
Wind Retrofit Guide for Residential Buildings, FEMA P-804  
[fema.gov](http://fema.gov)

### National Park Service

Preservation Brief 4: Roofing for Historic Buildings  
Preservation Brief 41: The Seismic Rehabilitation of Historic Buildings  
Preservation Brief 50: Lightning Protection for Historic Structures  
[nps.gov](http://nps.gov)

### U.S. Department of Energy

Building American Solution Center Gutters and Downspouts  
Cool Roofs  
Cooling with a Whole House Fan  
Homeowner's Guide to Going Solar  
[energy.gov](http://energy.gov)

### U.S. Department of Environmental Protection

EnergyStar Attic Air Sealing Project  
[energystar.gov](http://energystar.gov)



### REGULATIONS TO REVIEW

- International Existing Building Code
- South Carolina Building Code
- South Carolina Residential Code
- City of Charleston Code of Ordinances (Zoning, BAR, DRB)
- City of Charleston Climate and Geographic Design Criteria

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

**City of Charleston Permit Center**  
2 George Street, Ground Floor  
Charleston, SC 29401  
843.577.5550  
[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)



Wood is a traditional building material that can be repaired and strengthened over time to withstand weather events. (www.loc.gov)

# R4 RESILIENCE GUIDANCE: EXTERIOR WOOD

## EXTERIOR WOOD IMPROVEMENT GOALS

*Wood is a naturally resilient material if maintained regularly. Framing elements can absorb low levels of vibrations and wind pressure and can dry out from rain and flood events. The key to good maintenance is routine painting and localized treatment of any signs of deterioration.*

## MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (Refer to Resilience Guidance: Permit Review, page R1.5.) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

Wood is a relatively available, adaptable, and economical building material that can be used for structural framing. Most of Charleston's small-scale buildings have exterior wood elements. In masonry buildings, exterior wood elements may be limited to windows and doors. However, many of Charleston's most notable as well as humble buildings include wood cladding, trim, decorative features, and porches or piazzas. Some of the resilient features and vulnerabilities of wood elements are identified below.

- **Cladding:** Wood cladding includes horizontal siding or shingles mounted to a wall. Cladding can direct water to shed off and away from the building and deflect wind and water. Gaps in cladding can allow stormwater and air to enter wall cavities, and the exterior color can affect the amount of heat absorbed into the building.
- **Trim:** Wood trim is used to cover seams and gaps preventing stormwater and air infiltration. It can also be a decorative element that adds to the building style.
- **Porches and Piazzas:** Based on the location, a porch or a piazza can protect an entrance area from water, shade windows and walls, and provide an outdoor area shielded from the sun and rain. However, they are also vulnerable to uplift in severe winds and toppling in earthquakes.

***One of the best ways to improve resilience for wood elements is regular maintenance.*** Wood building elements are vulnerable to deterioration from water exposure, fungus, mold, and insects. Deterioration can impact the stability of the wood element as well as the tightness of nail and screw connections. ***Regular small or incremental repairs can greatly extend the life a wood element and improve the overall resilience of a building.***





All wood surface elements and details should be securely fastened, regularly repainted, and monitored for rot to increase resistance to natural hazards.

## GENERAL MAINTENANCE OF EXTERIOR WOOD

Exterior woodwork adds important details that can distinguish one building from another, and should be preserved regardless of the building age or style. Care should be taken when looking for potential problems with wood elements since the extent and cause of damage may not be immediately apparent. **Severe problems may have an unattractive appearance. Peeling paint or missing details can be cosmetic, or a sign of a more significant problem, like rot.** Wood-destroying organisms like termites may be less noticeable and will require more detailed inspections and treatment. Masking any of these conditions can result in more expansive and expensive future repairs.

Old-growth wood, like heart pine and cypress found in historic buildings, is more resilient than treated pine or new growth cypress. Depending on rain, wind, and sun exposure, new-growth woods and siding materials may need routine treatment to extend their life cycle. Selective repair or replacement of damaged parts and a regular maintenance program will improve resilience.

### KEY TIPS:

- Conduct semi-annual inspections of all exterior wood elements to verify condition and determine maintenance needs; signs of deterioration include peeling paint and veins of dirt near the ground indicating termite activity
- Clean exterior surfaces annually in warm weather with a garden hose, household detergent, and a bristle brush
- Maintain exterior woodwork on a regular basis, repainting every 5-8 years
- Engage a pest management service to minimize termite and pest infestations
- Repair smaller areas of damage before deterioration spreads
- Selectively replace deteriorated elements when they are beyond repair, matching the original whenever possible



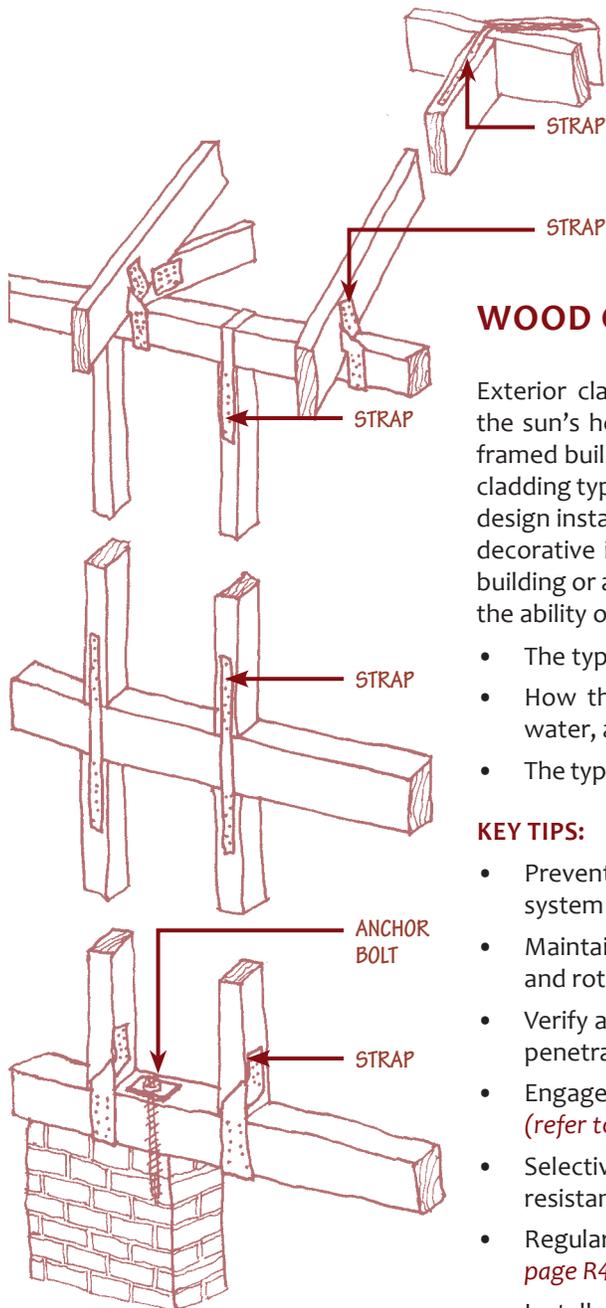
Removal of original siding should be limited because old-growth wood is dense and more decay resistant.



Paint can deteriorate over time or be an indicator of underlying problems that show as wrinkling, peeling, blistering, cracking or crazing, or alligatoring.



Wood that is in contact with the ground, situated close to plants, or in areas prone to splashing water are particularly vulnerable to rot and must be regularly cleaned and painted.



## PEST MANAGEMENT SERVICES

Termite management should be handled by a qualified company. They can regularly check the property and be available when infestation treatment is required, such as the application of boric acid or termite shields. Pest management companies can also address other pests including carpenter ants and bees, as well as nesting animals.

## WOOD CLADDING

Exterior cladding acts as the exterior skin of a building, repelling water and the sun's heat. The exterior cladding can also increase the rigidity of a wood-framed building, improving its ability to withstand earthquake vibrations. Wood cladding types include clapboard, weatherboard, tongue and groove, or a shiplap design installed as individual, overlapping boards. Less frequently, square cut or decorative individual wood shingles were used as cladding, either on an entire building or as a decorative feature on a prominent gable end. Factors influencing the ability of wood cladding to serve as a resilient "skin" include:

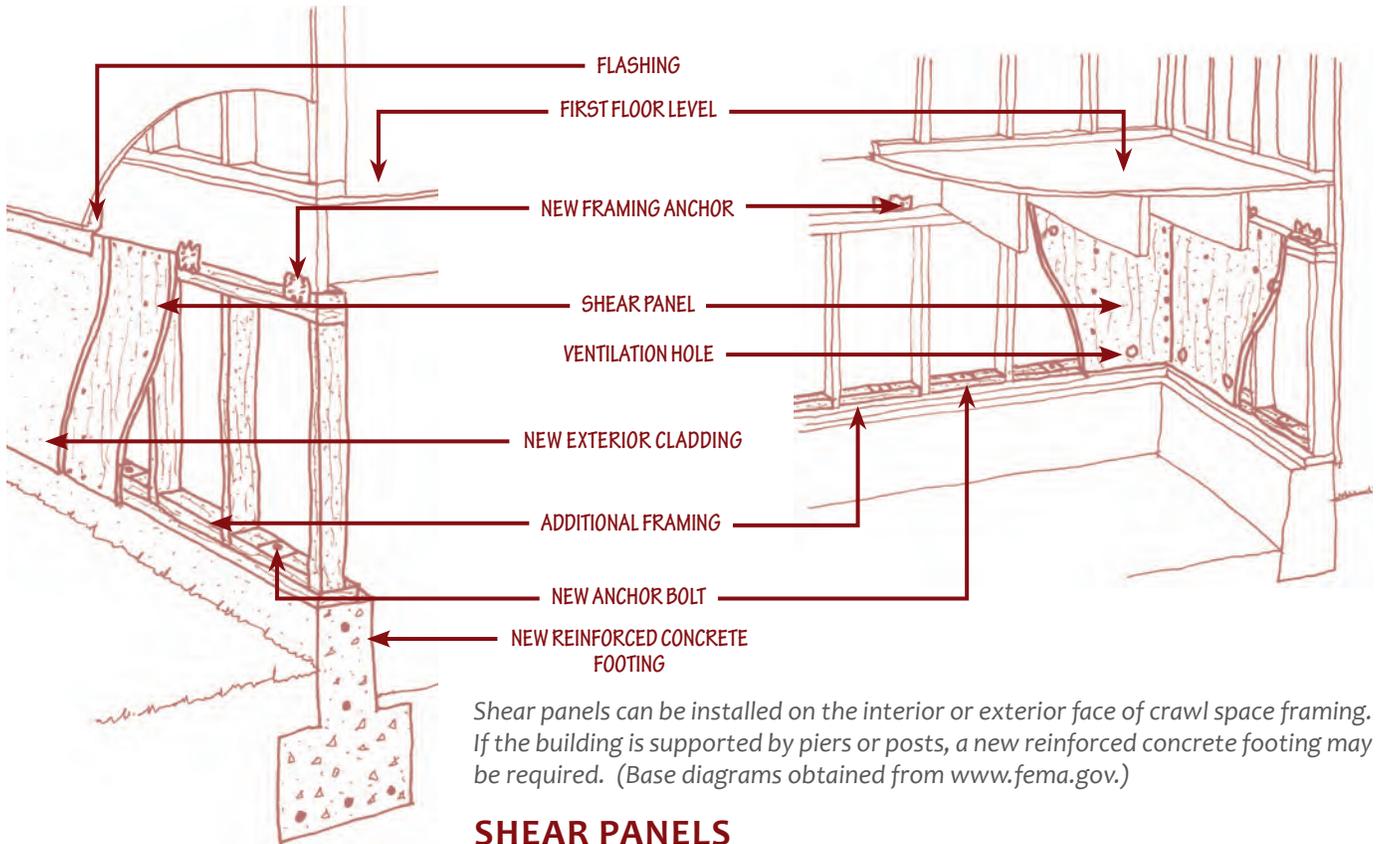
- The type and condition of the wood and wood substitute
- How the walls and its parts are assembled, whether the assembly sheds water, and the tightness of the joints
- The type and condition of fasteners, such as nails, screws, hangers, and straps

### KEY TIPS:

- Prevent gaps or openings that can allow stormwater or wind to enter to wall system
- Maintain and make repairs to cladding as needed to reduce deterioration and rot that ultimately requires replacement of large areas of exterior siding
- Verify all layers of siding are secured to limit damage from strong winds and penetration from wind-driven rain
- Engage a pest management service to minimize termite and pest infestations (*refer to Pest Management Services, sidebar above*)
- Selectively replace flood-damaged cladding with visually similar water resistant or composite materials (*refer to FEMA Technical Bulletin 2*)
- Regularly repaint cladding to protect outside surface (*refer to Exterior Paint, page R4.7*)
- Install anchor bolts, cross braces, and hurricane straps to improve hurricane and earthquake resilience if there is access to the wall framing (*refer to diagram at left and Shear Panels, page R4.4*)
- Install tension anchors from masonry walls to roof and floor framing
- Obtain a pressure test and/or an infrared test to identify areas that can be improved to reduce interior heat loss or gain
- Upgrade or install new wall insulation with appropriate breathable membrane; avoid moisture barriers that may promote rot (*refer to Insulation Matrix, page R8.6*)
- If the exterior siding is removed at non-historic buildings consider air barriers as well as impact and water-resistant materials like fiber-cement products

If the framing is exposed, it can be reinforced with hurricane straps to increase the resistance to wind uplift. Exposed framing also provides the opportunity to add exterior plywood shear panels to improve rigidity in addition to building insulation and an air barrier to improve heat loss or gain.





## SHEAR PANELS



Shear panels can be installed on outside walls when siding is being replaced.

Shear panels and walls can greatly improve the resilience of a wood-framed structure by resisting racking from earthquakes and high winds. Wood-framed structures are very susceptible to seismic damage. Many wood-framed buildings are constructed using nails as fasteners. The back and forth shaking of a structure can weaken connections and cause a structure to rack (tilt) or portions of a structure to collapse. A shear panel, typically made from plywood or similar rigid material, can be fastened to the interior or exterior face of wood-framed wall studs. The shear panels act as a diaphragm, making a framed wall perform more like a solid structural element than a series of individual studs. The flat surface of the shear wall can also reduce the amount of airflow through wood siding and provide a continuous surface on which to install an air barrier.

### KEY TIPS:

- If the exterior siding is removed, install shear panels to the outside walls to increase building rigidity (*refer to Historic Preservation Considerations, page R4.8*)
- Install shear panels to the exterior or interior face of exterior wood studs in crawlspaces and between wood porch or piazza supports to increase building rigidity; a continuous concrete foundation and flood openings may be required if the building is in the Special Flood Hazard Area (*refer to Flood Openings, page R5.8*)
- Install shear panels on the interior of garage walls, particularly if there is living space above the garage; additional support will be required around garage door opening (*refer to Garage Door Wind Protection, sidebar page R6.9*)



Trim pieces may appear as monolithic, solid features, however they are usually made up of many pieces.

## WOOD TRIM

Running trim details can be found at transitions between materials or where they change direction, such as the roof lines or eaves, window and door frames, and corner boards. Decorative trim can serve similar functional purposes, while adding character to the building. Deteriorating wood trim provides a pathway for stormwater and wind to penetrate into exterior walls, eventually causing damage to structural elements. Trim details may have sufficient weight to cause damage or physical harm if they are dislodged.

### KEY TIPS:

- Maintain the protective paint or stain finish (*refer to Exterior Paint, page R4.7*)
- Maintain caulk joints between different materials and changes in direction to prevent stormwater and air infiltration (*refer to Weatherstripping and Caulk, page R6.8*)
- Refasten trim pieces as needed and address repairs with wood filler, epoxy consolidation, or Dutchman (*refer to Wood Rot Repair, page R4.7*)
- Ensure any newly added trim is securely anchored to the building structure



Connections for carports, attached or detached, should be evaluated for improvements to reduce wind damage.

## WOOD PORCHES AND PIAZZAS

Porches and piazzas tend to be constructed with wood elements, whether the building is a masonry or wood-framed structure. Traditionally, they were designed to resist gravity loads, and not uplift or lateral loads. Since they project from the main structure, they are more vulnerable to damage from high winds and earthquakes, as are carports and raised decks. However, they provide beneficial shade and stormwater protection. Maintaining, fortifying, or constructing a new porch or piazza can increase the resilience of the main building structure. (*Refer to Historic Preservation Considerations, page R4.8.*)

### KEY TIPS:

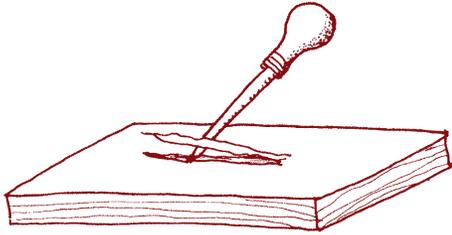
- Maintain steps, columns, posts, railings, and roofs to increase the longevity of the porch or piazza
- Maintain fasteners to prevent components from dislodging in high winds
- Ensure that any nearby plants or attached planters are not draining water toward the porch or contributing to biological growth on wood surfaces
- Avoid using the space as a storage area where items are subject to open winds and rain
- Maintain gutters and downspout systems to direct heavy rain away from the porch or piazza (*refer to Gutters and Downspouts, page R3.4*)
- Confirm decking, roofing, and horizontal rails are angled to shed water
- Install new porches or piazzas on south and west sides of a building in a manner that shades walls, windows, and doors
- Install hurricane-rated fasteners to tie columns and posts to the roof and foundation structures to strengthen their resistance against wind uplift and lateral earthquake forces (*refer to diagram, page R4.3*)
- Retain an architect or engineer to determine whether additional lateral support bracing is needed for wide openings



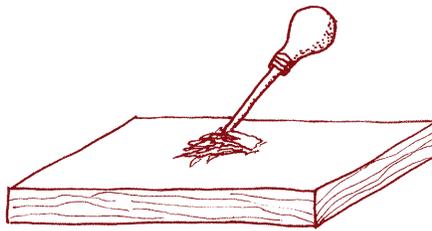
This traditional iron post connection could be replaced with a hurricane-rated connector.

## WOOD ROT

Evaluating wood splinters can help determine if wood is healthy or rotted.



Less penetration and long splinters are an indication of healthy wood.



Greater penetration and short splinters are possible indication of rot.

### DECAY RESISTANT WOOD

When making large repairs or constructing new features consider using a decay-resistant wood:

- Mahogany
- Redwood
- Air-dried, pressure-treated, southern yellow pine; select grade for installation location, C and BRT (Better) for exposed siding and trim (proper preparation is required for paint to adhere)

### WOOD ROT MATRIX

ROT SOURCE	OBSERVATIONS	REMEDIES
<b>Groundwater</b>	Soil is moist or water is pooling near building elements that is transferring moisture to other parts of the building	<ul style="list-style-type: none"> <li>❑ Eliminate direct contact between wood and soil</li> <li>❑ Change site grading to direct water away from the building</li> <li>❑ Remove or trim back vegetation close to the building</li> <li>❑ Install a damp-proof barrier to stop rising damp</li> </ul>
<b>Precipitation (rain)</b>	Heavy rains, wind driven rain, and flooding can push water into small openings and trap moisture in wall cavities	<ul style="list-style-type: none"> <li>❑ Ensure that small openings and crevices are sealed with caulk and the surface is entirely painted</li> <li>❑ Clear out gutters and ensure they are properly sized</li> <li>❑ Direct rainwater away from the building to avoid splashing</li> </ul>
<b>Leaky Plumbing</b>	Cracked pipes or slow leaks develop around water sources and appliances	<ul style="list-style-type: none"> <li>❑ Seal any cracks in grout and tiles on floors and around tubs, sinks, washing machines, and dishwashers</li> <li>❑ Routinely inspect for leaks where plumbing is accessible behind the walls, around washing machines, and dishwashers</li> </ul>
<b>Condensation</b>	Warm moist air comes in to contact with a cold surface that is below the dew point temperature, causing excess moisture to change to water droplets on a cold surface	<ul style="list-style-type: none"> <li>❑ Install exhaust fans in kitchens, bathrooms, and laundries</li> <li>❑ Insulate water pipes to avoid shocks from temperatures</li> <li>❑ Place a layer of plastic sheathing on the ground in the crawlspace to limit condensation on wood sills and joists</li> <li>❑ Install insulation at exterior walls without a vapor barrier (<i>refer to Insulation Matrix, page R8.6</i>)</li> <li>❑ Paint interior walls</li> <li>❑ Install a dehumidifier</li> <li>❑ Ensure that condensation from window or wall air conditioning units is not dripping onto wood or pooling near building walls and windows</li> <li>❑ Insulate all internal HVAC coolant lines and drain lines</li> <li>❑ Ensure HVAC units are well sealed and do not excessively leak air</li> <li>❑ Maintain air conditioning at design set temperature</li> </ul>
<b>Termites</b>	Swarms are rarely observed but residual evidence of their colony include detached wings, excrement, mud tubes, or cartons (nests)	<ul style="list-style-type: none"> <li>❑ Contract with a qualified pest control company to:                             <ul style="list-style-type: none"> <li>• Apply a termiticide as a soil treatment</li> <li>• Install termite bait stations</li> <li>• Perform a complete fumigation (tenting)</li> <li>• Treat infested trees</li> </ul> </li> </ul>



Deteriorated and rotted wood can be carved out.



Epoxy has been applied to match the profile of the existing trim.



After painting, the repaired area is difficult to distinguish from the wood.

## WOOD ROT REPAIR

If a portion of an exterior element is deteriorated beyond repair, it is often possible to replace only the deteriorated sections and not the entire component or unit.

**Applying and maintaining a good coat of paint after repairs to add a layer of protection to limits moisture infiltration and damage from the sun, pests, and other forms of deterioration.** (Refer to Exterior Paint, below.)

### WOOD ROT REPAIR TYPES

There are two traditional means to repair wood elements:

- **Epoxy consolidation:** Insertion of penetrating liquid epoxy into porous wood, generally by injection through small, drilled holes. As the epoxy dries it hardens and strengthens the deteriorated wood.
- **Dutchman:** In-kind replacement of deteriorated portion of wood, not necessarily the entire element.



Painting is a continuous maintenance need for exterior wood surfaces.

## EXTERIOR PAINT

Paint is one of the best ways to protect exterior materials from the elements, particularly wood without natural or chemical preservatives. Exterior paint provides a layer of protection to a building by adding a barrier that limits moisture infiltration, damage from the sun, pest infestation, and other forms of deterioration. To a lesser degree, it also provides a “skin” that reduces air flow into a building when combined with sealant in gaps and openings. (Refer to Weatherstripping and Caulk, page R6.8.)

### KEY TIPS:

- Repaint exterior woodwork every 5-8 years to reduce damage from water, the sun, and pests
- Wash painted surfaces annually to remove dirt and mildew, extending the life of the paint and improving the appearance (refer to General Maintenance of Exterior Wood, page R4.2)
- Consult with a paint specialist to select the appropriate paint for the conditions: oil paint, often found on older buildings, tends to adhere better to problem surfaces; several layers of latex paint can form an unintended impermeable moisture barrier and its surface tension can pull underlying paint layers from substrate
- For the best long-term results, prepare surface and apply primer and paint in accordance with paint manufacturer’s recommendations
- Repair deteriorated areas and underlying causes prior to repainting
- Select light-colored paint for exterior wall surfaces to reflect the sun’s heat, reducing interior heat gain

### LEAD PAINT

Paint dust from older buildings may contain lead. Recommendations when disturbing paint surfaces:

- Keep children and pets away
- Wear a ventilator
- Avoid open food and beverage containers
- Thoroughly clean exposed skin and launder work clothes





A few buildings in the historic district feature wrought or cast iron detailing in balconies or galleries, that should be retained and preserved to the extent possible. (Refer to NPS Preservation Brief 27: The Maintenance and Repair of Architectural Cast Iron for additional resources.)

## HISTORIC PRESERVATION CONSIDERATIONS

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly and use Preservation Briefs for guidance. (Refer to Resources, page R4.12.) Information is provided below for best practices toward maintaining the historic character of a property when changes are made to exterior wood elements.

### GENERAL MAINTENANCE

- Retain and maintain existing exterior woodwork including siding, shingles, trim, and ornament
- Stucco, brick, and stone veneer should not be applied on buildings that traditionally had wood siding

### REPAIR OR REPLACEMENT

- Replace only the original elements that cannot be repaired using elements of the same material, size, profile, and other visual characteristics; wholesale replacement of historic siding or trim is discouraged and rarely warranted
- Replace missing or deteriorated materials with salvaged materials or similar new materials
- Retain balustrades, adding a secondary rail if required for code purposes
- When replacing siding it might be necessary to install temporary bracing to prevent racking of the structure in high winds or an earthquake
- Changes in siding materials and characteristics should correspond with natural breaks in buildings such as corner boards

### BAR

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- Use of Mechanical Tools
- Piazza Enclosures
- Historic Materials Demolition
- Elevation Design Guidelines



Devastation was widespread when Hurricane Hugo made landfall nearby. Some property owners may choose to pursue larger mitigation projects that could impact piazzas or porches and historic building access points. (SC Department of Natural Resources)

## HISTORIC PRESERVATION CONSIDERATIONS (CONTINUED)

### PAINT

- Paint wood in a color and finish to complement the architectural characteristics
- Use caution around paint dust from an old building as it may contain lead (refer to *Lead Paint*, sidebar page R4.7)

### FLOOD, HURRICANE, OR SEISMIC RETROFITS

- Strengthen soffits, overhangs, and vents at the connections between the roof and wall framing in a manner that minimizes visibility
- Design exterior reinforcements, when necessary, to avoid obscuring the historic material or decorative details
- Paint any new exterior vents, soffits, and reinforcement materials to blend with adjacent wall or trim colors
- Install hurricane-rated straps on to the tops and bottoms of vertical posts and columns; consult an architect or engineer for specific guidance (historic columns and posts do not always have fasteners at the top and bottom)
- Anchor the bottoms of columns and posts to the ground with masonry or concrete footers
- Extend stairs in building elevation projects in a manner that maintains historic alignments and relationship with the entrance door to the extent possible
- Align extended piers with vertical elements such as porch columns or posts and corners of stair landings
- Install screening to visually minimize porch piers, stair supports, and ramps
- Install railings that are compatible with the historic building type and style
- Minimize visual impacts of accessible elevators or lifts

## EXTERIOR WOOD IMPROVEMENT CHECKLIST

The Exterior Wood Improvement Checklist on the following pages identifies maintenance information and related potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person's abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building's resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

EXTERIOR WOOD IMPROVEMENT CHECKLIST

<p><b>ACTION / PROJECT</b></p> <p><i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i></p>	<p>RESILIENCE BENEFIT</p>	<p>COST</p>	<p>DO-IT-YOURSELF</p>	<p>CONTRACTOR MAY BE REQUIRED</p>	<p>ARCHITECT OR ENGINEER MAY BE REQUIRED</p>	<p>“OFF-THE-SHELF” SOLUTION AVAILABLE</p>
<p><b>GENERAL MAINTENANCE OF EXTERIOR WOOD</b> <span style="float: right;">Page R4.2</span></p>						
<p><input type="checkbox"/> Clean exterior surfaces annually in warm weather with a garden hose, household detergent, and a bristle brush</p>		<p>¢-\$</p>	<p>●</p>	<p>●</p>		
<p><input type="checkbox"/> Maintain exterior woodwork on a regular basis</p>		<p>\$-\$\$</p>	<p>●</p>	<p>●</p>		
<p><input type="checkbox"/> Repair smaller areas of deterioration before deterioration spreads</p>		<p>¢-\$\$</p>	<p>●</p>	<p>●</p>		
<p><input type="checkbox"/> Selectively replace deteriorated elements when they are beyond repair, matching the original whenever possible</p>		<p>¢-\$\$</p>	<p>●</p>	<p>●</p>	<p>●</p>	
<p><b>WOOD CLADDING</b> <span style="float: right;">Page R4.3</span></p>						
<p><input type="checkbox"/> Prevent gaps or openings that can allow stormwater or wind to enter</p>		<p>\$-\$\$</p>	<p>●</p>	<p>●</p>		
<p><input type="checkbox"/> Maintain and make repairs to reduce loss from deterioration and rot</p>		<p>\$-\$\$\$</p>	<p>●</p>	<p>●</p>		
<p><input type="checkbox"/> Secure all layers of siding that may have been added over time</p>		<p>\$-\$\$</p>	<p>●</p>			
<p><input type="checkbox"/> Engage a pest management service</p>		<p>\$</p>		<p>●</p>		
<p><input type="checkbox"/> Selectively replace flood-damaged cladding with visually similar water resistant or composite materials at non-historic buildings</p>		<p>\$-\$\$</p>		<p>●</p>		
<p><input type="checkbox"/> Install anchor bolts, cross braces, and hurricane straps</p>		<p>\$\$-\$\$\$</p>		<p>●</p>	<p>●</p>	
<p><input type="checkbox"/> Install tension anchors from masonry walls to roof and floor framing</p>		<p>\$\$-\$\$\$</p>		<p>●</p>	<p>●</p>	
<p><input type="checkbox"/> Obtain a pressure test and/or an infrared test to identify areas needing improvements</p>		<p>\$</p>		<p>●</p>		
<p><input type="checkbox"/> Upgrade or install new wall insulation with appropriate breathable air barrier</p>		<p>\$\$-\$\$\$</p>	<p>●</p>	<p>●</p>	<p>●</p>	
<p><input type="checkbox"/> If the exterior siding is removed of a non-historic building, consider impact and water resistant materials</p>		<p>\$-\$\$\$</p>		<p>●</p>	<p>●</p>	

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	<b>RESILIENCE BENEFIT</b>	<b>COST</b>	<b>DO-IT-YOURSELF</b>	<b>CONTRACTOR MAY BE REQUIRED</b>	<b>ARCHITECT OR ENGINEER MAY BE REQUIRED</b>	<b>"OFF-THE-SHELF" SOLUTION AVAILABLE</b>
<b>SHEAR PANELS</b> <span style="float: right;">Page R4.4</span>						
<input type="checkbox"/> If the exterior siding requires removal, install shear panels to exterior wall framing		\$-\$\$\$		●	●	
<input type="checkbox"/> Install shear panels at inside face of exterior wood studs, in crawlspaces, and between porch or piazza supports		\$-\$\$\$	●	●	●	
<input type="checkbox"/> Install shear panels inside garage walls		\$-\$\$\$	●	●	●	
<b>WOOD TRIM</b> <span style="float: right;">Page R4.5</span>						
<input type="checkbox"/> Maintain caulk joints between different materials and at material edges		¢-\$\$	●			●
<input type="checkbox"/> Refasten loose or dislodged trim pieces		¢-\$\$	●	●		
<input type="checkbox"/> Ensure any newly added trim is securely fastened to the building		¢-\$\$	●	●		
<b>WOOD PORCHES AND PIAZZAS</b> <span style="float: right;">Page R4.5</span>						
<input type="checkbox"/> Maintain fasteners and steps, columns, posts, railings, roofs that are exposed to the weather		¢-\$	●	●		
<input type="checkbox"/> Ensure that any nearby plants are not causing water damage or biological growth		¢	●			
<input type="checkbox"/> Maintain gutters and downspout systems and direct stormwater away from building foundation		¢-\$	●	●		
<input type="checkbox"/> Construct or alter decking, roofing, and horizontal rails at an angle to shed water		\$-\$\$\$	●	●	●	
<input type="checkbox"/> Install new porches or piazzas on south and west sides of a building to maximize shade		\$\$-\$\$\$		●	●	
<input type="checkbox"/> Install hurricane-rated fasteners to tie down the roof and secure columns and posts to foundations to improve resilience to high winds and earthquakes		\$\$-\$\$\$		●	●	
<input type="checkbox"/> Consider additional bracing or shear walls for porches that span wide spaces		\$\$-\$\$\$		●	●	
<b>EXTERIOR PAINT</b> <span style="float: right;">Page R4.7</span>						
<input type="checkbox"/> Repaint exterior wood every 5-8 years		\$-\$\$\$	●			
<input type="checkbox"/> Repair deteriorated areas and underlying problems prior to repainting		\$-\$\$\$	●	●		
<input type="checkbox"/> Select light-colored paint for exterior wall surfaces to minimize heat gain		\$-\$\$\$	●			

## EXTERIOR WOODWORK RESOURCES

### Federal Emergency Management Administration (FEMA)

Earthquake Safety at Home, FEMA P-530

Flood Damage-Resistant Materials Requirements, Technical Bulletin 2

Wind Retrofit Guide for Residential Buildings, FEMA P-804

[fema.gov](https://www.fema.gov)

### Historic England

Repairing Walls of an Older Home

[historicengland.org.uk](https://www.historicengland.org.uk)

### National Park Service

Preservation Brief 10: Exterior Paint Problems

Preservation Brief 11: Rehabilitating Historic Storefronts

Preservation Brief 16: The Use of Substitute Materials on Historic Exteriors

Preservation Brief 27: The Maintenance and Repair of Architectural Cast Iron

Preservation Brief 41: The Seismic Rehabilitation of Historic Buildings

Preservation Brief 45: Preserving Historic Wood Porches

[nps.gov](https://www.nps.gov)

### Old House Journal

Epoxies for Wood Repair

7 Insulation Tips to Save Money and Energy

[oldhouseonline.com/repairs-and-how-to](https://www.oldhouseonline.com/repairs-and-how-to)

### U.S. Department of Energy

Adding Insulation to an Existing Home

Finding and Selecting an Energy Assessor

[energy.gov](https://www.energy.gov)

### U.S. Department of Environmental Protection

Lead Abatement, Inspection and Risk Assessment

Lead Renovation, Repair and Painting Program

[epa.gov](https://www.epa.gov)



### REGULATIONS TO REVIEW

- International Existing Building Code
- ASCE 24-14 Flood Resistant Design and Construction
- South Carolina Building Code
- South Carolina Residential Code
- City of Charleston Code of Ordinances
- City of Charleston Flood Hazard Prevention and Control Ordinance

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

**City of Charleston Permit Center**  
2 George Street, Ground Floor  
Charleston, SC 29401  
843.577.5550  
[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)



Brick masonry is a traditional building type that relies on the structural integrity of each brick and mortar layer. (www.loc.gov)

# R5

## RESILIENCE GUIDANCE: EXTERIOR MASONRY

### EXTERIOR MASONRY IMPROVEMENT GOALS

Masonry is often part of the structural system of older buildings and maintenance is critical to prevent significant problems. Severe storms will find weak points allowing wind and water to cause more damage. Brick and other unreinforced masonry is vulnerable to earthquakes and potential collapse.

### MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (Refer to Resilience Guidance: Permit Review, page R1.5.) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

Masonry includes any type of stone, brick, or concrete-formed material. **Functionally, the primary role of masonry is to transfer building loads to the ground, either through masonry walls acting as the principal load-bearing system or through masonry piers supporting wood-framed structures. Masonry also protects a building from fire; acts as a building's skin shedding water, deflecting sunlight and wind; and provides thermal mass that can regulate interior temperatures.** Masonry and stucco can also be an important design feature, complementing the building's style.

As a critical structural component, masonry must address several forces listed below to be resilient.

- **Gravity:** Transferring the weight of the building and its contents to the ground.
- **Lateral pressure:** Horizontal forces that press into the side of walls, foundations, or piers. Lateral forces can be caused by severe winds or the weight of floodwater or saturated soil.
- **Lateral impacts or forces:** Significant horizontal forces such as shaking from an earthquake, storm surge, or impacts from waterborne debris like a floating tree trunk can knock a building or an appendage, such as a porch or piazza, off its foundation.
- **Buoyancy:** Water pressure below a building or a foundation that can lift and crack a floor slab or a dislodge a porch from its foundation.

**Resilience can be improved by maintaining masonry or working with a design professional to supplement a masonry system.**



## MASONRY AS BUILDING COMPONENTS

There are a variety of masonry types used in building construction with different properties, which, when combined with the condition, impact resiliency.

- **Unit Masonry:** Stone, brick, and stacked concrete block rely on mortar between the units to form a solid structure. If the mortar bonds are damaged or missing, the wall or pier is weakened and more likely to fail in a flood, severe winds, or an earthquake.
- **Monolithic Masonry:** Poured concrete or concrete block filled with poured concrete tends to act as a single, solid unit, and when supplemented by steel reinforcing bars, can resist lateral loads from floodwaters, severe winds, and earthquakes. However, voids or cracks in the concrete can expose the metal reinforcing to water, leading to rust and further deterioration of the concrete. Additionally, concrete can be a very porous material, which if uncoated, absorbs water (like standing floodwater) very easily.
- **Impacts on Resiliency:** The strength and water absorption rate can vary dramatically between different types of stone, brick, and concrete. Older, handmade brick usually is softer and is likely to absorb more water than newer, machine-made brick, and requires special care when installing mortar, stucco, or masonry coatings. Similarly, limestone is relatively soft, making it easier to carve than granite, but its open pores are more likely to absorb water.
- **Installation:** The way materials were installed, masonry thicknesses, bonding pattern, foundation depths, and connections to other materials like wood framing will impact resiliency. Thinner masonry walls are more vulnerable to lateral forces than thicker walls.

*Due to the critical structural role of masonry, the forces it must withstand, and the factors that can impact its ability to perform sufficiently, the types of resiliency repairs that can be performed by property owners are limited. Property owners should consult with an architect, engineer, or a building inspector if there are any concerns, or conditions that suggest a structure may be compromised.*

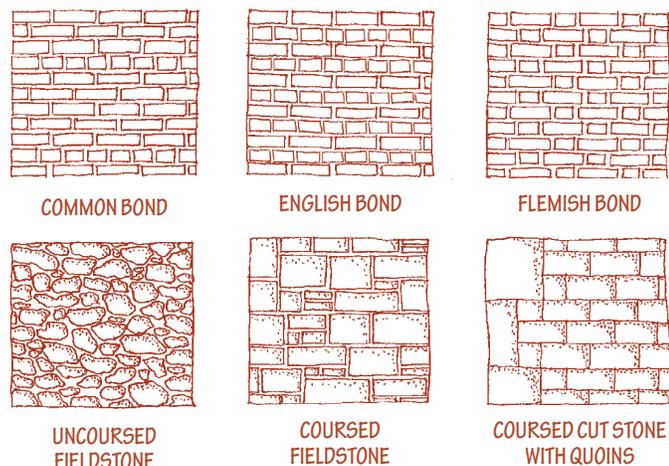


The metal reinforcing bars were installed very close to the outside face of the concrete. Water exposure through small cracks has caused the bars to rust and expand, spalling the concrete surface.

### CHIMNEYS

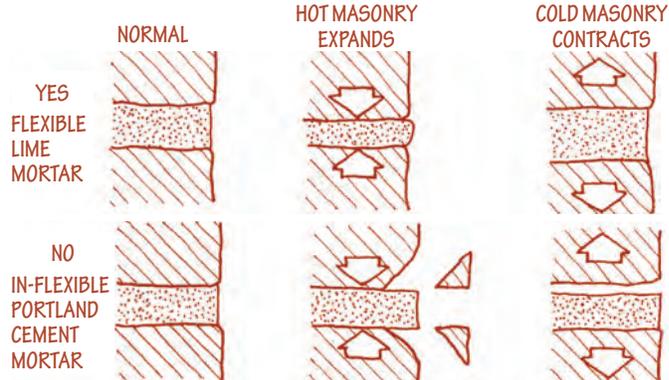
Chimneys should be maintained to minimize moisture absorption. They can also be braced to protect against severe winds and earthquakes. (Refer to Chimneys, page R3.5.)

### TYPICAL COURSING PATTERNS



Unit masonry is made up of stacked material joined by mortar. The size, arrangement, and bonding pattern of the bricks or stones can impact the strength of masonry walls and piers and its ability to withstand severe impacts.

### MORTAR DO'S AND DON'T'S



Maintaining the mortar in unit masonry is critical to bonding the individual bricks, stones, or concrete blocks together. Portland cement-based mortar, typically sold in pre-mixed bags in big-box hardware stores, is too hard for older bricks and some types of stones. Using it can damage the masonry and cause the bonds to break, reducing the structural stability and providing a pathway for floodwater. (Refer to Mortar, page R5.4.)



Avoid locating downspout discharges near masonry walls and foundations.



Buildings should be stabilized and secured while awaiting rehabilitation.

## MANAGING MOISTURE



The algae along the foundation suggests significant moisture in the wall. Possible sources can be pooling adjacent to the wall, rising damp, or rainwater splashing from the sidewalk.

Regular moisture saturation of masonry can eventually result in structural issues that can compromise its resiliency. Water saturation can cause mortar to lose its bond or wash out of the joints in unit masonry, and it can cause concrete reinforcing to rust and expand, cracking off chunks of the surface. **While professional assistance from an architect or engineer is likely needed to address structural issues related to masonry, property owners can minimize damage to masonry by reducing moisture infiltration and the resulting deterioration.**

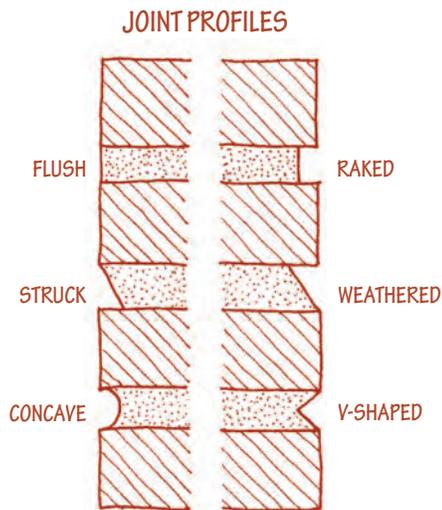
One of the keys in successfully managing masonry moisture damage is understanding the source. While rainwater entering an open joint is an obvious source, it is more likely that greater damage will be caused from an overflowing gutter or downspout, or stormwater pooling next to a building foundation and then sucked up into the masonry like a straw. Other sources of moisture include rising damp, water wicking up through masonry foundations from underground, or rainwater splashing up onto masonry from adjacent hard surfaces.

### KEY TIPS:

- Review areas for sources of potential moisture intrusion, particularly during or immediately after a storm
- Verify that gutters and downspouts are clear and directing water away from the building (*refer to Gutters and Downspouts, page R3.4*)
- Install splash blocks or downspout extensions to direct water away from building walls or foundations
- Remove or thin vegetation close to a building and conduct regular inspections for algae and/or mold behind vegetation
- Re-grade area adjacent to foundation to direct groundwater away from building if there are noticeable puddles or ponding during a rain storm (*refer to Site Grading, page R2.5*)
- Remove any vines and scrub surface with a stiff natural-bristle brush to remove dried roots, allowing air to circulate and the sun to dry the wall
- Clean moss, or algae, and efflorescence from masonry surfaces with low pressure water, gentle detergent, and natural bristle brushing; a non-toxic biocide can be used for more significant discoloration as needed



The loss of a stucco coating from a masonry wall can allow water to be absorbed by the underlying masonry, advancing deterioration of the brick and mortar joints.



When repointing, joint profiles, in addition to color and texture, should match the existing for a blended appearance.



Deteriorated surfaces and mortar are more likely to absorb moisture.



There is a wide range of stone types, colors, and coursing patterns. Regular maintenance of mortar joints is critical.



Many older buildings use unreinforced masonry construction, which is more vulnerable to seismic events.

## MORTAR

Historically, mortar was generally composed of a few ingredients: sand, lime, and water, and possibly additives such as animal hair or oyster shells. The mortar mix was selected to be softer than the adjacent masonry, allowing movement in the wall to damage the mortar rather than crack the brick or stone. Repointing is needed as the mortar wears over time. Eventually, a small amount of Portland cement was added into the mix to improve the workability and setting time. **Over time, the amount of Portland cement in mortar was increased, and it became more available in bagged mixes sold at hardware stores. However, modern Portland cement mixes tend to be too hard for most historic bricks and softer stone, causing damage when used for repairs or repointing.** (Refer to *Mortar Do's and Don't's*, page R5.2.) Soft and crumbling mortar or open joints/broken joint bonds are indications that the mortar is failing, and, if untreated, may cause building damage.

### KEY TIPS:

- Selectively repoint with compatible mortar (lime-based mortar for older brick) using joint profiles and mortar mixture to match the existing to minimize recurrences
- Consider full repointing with compatible mortar if deterioration is substantial
- Carefully remove deteriorated mortar to minimize adjacent masonry damage

## WALLS AND PIERS

Traditionally constructed of brick or stone and bonded by mortar, these elements carry the weight of interior walls, floors, and roofs. With structural masonry, they carry the weight of walls, floors, and roofs.

Signs of potential masonry problems include spalling, chipping, flaking, cracking, or crumbling of surfaces; loose or missing stones or bricks; pitted surface from sandblasting or pressure washing; or stucco removal.

### KEY TIPS:

- Replace incompatible mortar and match original mortar (refer to *Mortar*, at left)
- Patch missing or deteriorated stone and brick with compatible materials if area is isolated
- Consider substantial repairs or replacement with in-kind materials when deterioration is substantial
- Address damaged masonry surfaces to reduce moisture absorption
- Install diagonal bracing inside parapet walls
- Install tension anchors from masonry walls to roof and floor framing
- Periodically review adjacent materials and interior finishes for signs of moisture damage



Concrete blocks are structural masonry units typically covered in stucco or a masonry veneer, or painted. Reinforced blocks have poured concrete and steel rods connecting the individual units and is an approved foundation material for building elevations.

## CONCRETE MASONRY UNITS

Like bricks, concrete masonry units (CMUs), also known as concrete blocks, and cast stone units are formed structural elements. While concrete blocks are plain, cast stone units will often have specialty textures, shapes, or colors to mimic stones. Similar to stone and brick, cracks or pitted surfaces are signs of potential problems.

### KEY TIPS:

- Repair surface cracks, which can absorb moisture and increase exposure of reinforcing bars to moisture and corrosion
- Maintain stucco coating, if present, as a barrier to moisture entry



These cast stone blocks are made of concrete and formed to appear like stone.



Stucco-clad concrete retaining walls may serve as planting areas and/or stormwater barriers. (Refer to Walls and Fences, page R2.11.)



Surface cracking in concrete or masonry can provide an pathway for water to enter a wall.

## CONCRETE

Poured concrete walls and slabs may appear to be waterproof but concrete is a very porous material that can absorb water, particularly when exposed to water for extended periods, like during a flood. In addition, concrete may be vulnerable to seepage at transitions between structural members or between installation “pours.” The structural capacity of concrete to resist lateral and buoyancy forces is influenced by the thickness of the concrete, the size and condition of the reinforcing, the manner in which the building was constructed, and its condition.

### KEY TIPS:

- Repair surface cracks quickly to reduce the exposure of reinforcing bars to moisture and corrosion
- Apply an exterior wall sealer that will not discolor concrete to flood-vulnerable surfaces; apply a small test area and view after drying prior to applying to entire surface; and consult a professional as needed
- Install an under-slab sealer prior to installing a new slab on grade

## TERRA COTTA

Exterior terra cotta is typically a decorative element on a building. Similar to brick, terra cotta is made from clay that can be molded into a variety of shapes with different colors of glaze applied. The glaze acts as a protective layer to prevent moisture absorption. Terra cotta is usually attached to the wall with either mortar or metal anchors. When located along a building cornice, as is common, terra cotta is more exposed to the elements. Because it can be highly decorative, the formed, profiled shapes can hold water. Open joints, cracks in the glaze, or damaged sections of terra cotta material provide an opportunity for moisture absorption. The loss of mortar or the rusting of anchors could allow individual units to become airborne in high winds or detach in an earthquake.

### KEY TIPS:

- Verify terra cotta units are well anchored to building
- Clean surfaces with gentle detergents and water pressure
- Maintain mortar joints (*refer to Mortar, page R5.4*)
- Repair or renew deteriorated glazes
- Address small cracks and spalls with masonry coating and, if more severe, consider a replacement unit



Terra cotta is made of clay, cast in molds similar to brick, in a variety of decorative shapes and colors. Decorative terra cotta is usually non-structural.

## BRICK OR STONE VENEERS

Decorative masonry finishes can be applied as an outer layer over structural walls and can also imitate traditional materials. These include brick and stone veneers that are either a single layer of a material, or thin slices of the solid materials attached to the backup structure with mortar or metal anchors. Veneers were applied over an original exterior material that was deteriorating, or used to cover a design that was out of favor. Problem areas can be recognized from cracks in the surfaces, bulges, or peeling away from the wall.

### KEY TIPS:

- Verify brick and stone veneer is well-attached to wall to prevent it from becoming airborne, waterborne, or detaching during an earthquake
- Install anchors or grout to reattach veneer separating from backup structure
- Maintain mortar joints to prevent water entry and detachment of units
- Patch missing or deteriorated stone and brick with compatible materials if area is isolated
- Consider substantial repairs or replacement with in-kind materials when deterioration is substantial after completing necessary substrate repairs



Terra cotta can flake or spall allowing water and wind to penetrate into structural components.



Marble or granite veneers are often applied at the apron under storefront windows on commercial buildings.



A full-width brick veneer has been installed on this new poured concrete pier at a building elevation to mimic the original appearance.



Stucco is a versatile material that can be coated with a color or have a scored finish coat to resemble masonry. It also serves as a protective coating for the underlying masonry or wood structure.

## STUCCO

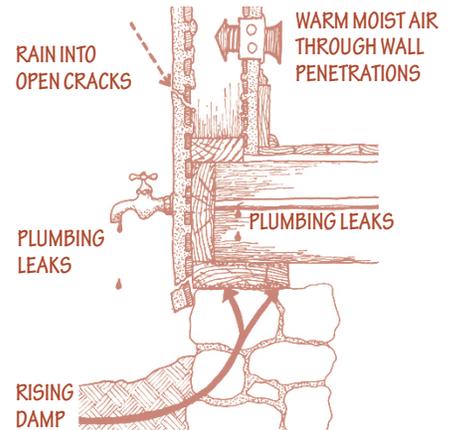
Stucco is made of similar materials to mortar and was traditionally applied in three coats: scratch, brown, and finish coats. This relatively inexpensive material can provide a more finished appearance to brick, stone, or wood-framed buildings. Stucco acts as a weather repellent coating, protecting the building from the elements including rain, sunlight, and wind; and can moderately increase fire resistance. Stucco can also provide an insulating layer to a wall by reducing the passage of air through small gaps.

### KEY TIPS:

- Consider patching with compatible stucco if the area of deterioration is isolated, typically a lime-based stucco for older buildings
- Consider replacement if deterioration is substantial
- Verify keying of stucco to mortar joints, lath or underlying substrate: if wall area moves when pushed, stucco is not bonded and should be secured or replaced with compatible material to avoid potential surface collapse
- Check adjacent materials for moisture trapped behind stucco surface



Moisture trapped in the wall is causing the acrylic paint to fail. Complete paint removal and application of a breathable coating may be required.



Stucco can be applied to masonry and wood-framed buildings. Moisture from a variety of sources can impact the condition of stucco as well as the underlying wood structure.



Some newer applications of stucco are intended to look like stone veneer. They are smeared on masonry and not keyed to joints or lath. Un-keyed stucco cracks easily and can peel away from the wall.

## MASONRY COATINGS

When a masonry surface is located in a vulnerable location or has been damaged by sandblasting or other means, it may not be able to withstand water exposure. In these cases, a breathable masonry coating or stucco may need to be applied to the surface. Lime wash is an example of a traditional masonry coating. Similar types of coatings are available today in a variety of colors. There are a number of newer coatings available, but many can trap moisture in a wall, causing deterioration.

### KEY TIPS:

- Consult the coating manufacturer’s information to complete required repairs and preparation prior to installing a coating
- Apply a “breathable” coating that will prevent moisture from entering, preferably a lime-based coating that allows vapor to escape and avoid coatings that trap moisture like acyclic paint ([Refer to Exterior Masonry Resources, page R5.12, Preservation Brief 1](#))
- Verify coating will not have a shiny appearance or discolor over time



Flood vents may be installed new, or in existing openings in a foundation if they meet design and spacing requirements.

## FLOOD OPENINGS

Floodwater can become trapped in crawlspaces and basements, placing lateral pressure on walls. Flood vents provide a way for floodwater to enter and exit interior spaces in a way that reduces lateral pressure. In existing buildings, crawlspace openings may also function as flood vents or manufactured flood vents can be installed. **Flood vents must be of sufficient size, number, and location to be able to quickly equalize interior and exterior water levels.** Any modification to, or covering of, flood openings such as louvers, screens, netting, or shrubs adjacent to foundations should be installed in a manner that does not impede the free flow of floodwater.

### KEY TIPS:

- Clear both sides of flood vents to ensure free flow of water in and out
- Install the recommended quantity of flood vents with the bottom within 12” of the ground to meet FEMA size and location requirements
- Consult an architect or engineer to verify flood vents function as required

### FEMA FLOOD OPENING REQUIREMENTS

There are specific criteria for flood vents for improvements that require local regulatory compliance. Per FEMA, every enclosed area is required to have at least two flood openings on exterior walls and additional openings based on the area that is enclosed. Flood openings should be installed in at least two sides of each enclosed area to decrease the chance that all openings will be blocked by floating debris and to allow for more even transfer of floodwater and decreased pressure.

## ARCHITECT OR ENGINEER CONSULTATION

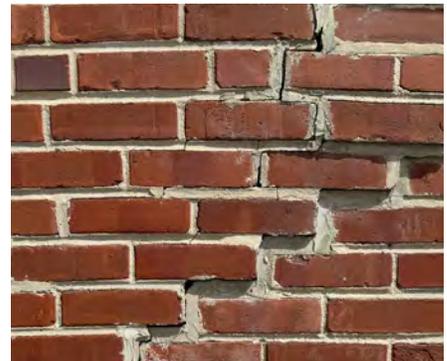
Architects and structural engineers can provide specific guidance on how to address severe problems with masonry that impact its structural capacity. They can also make recommendations regarding the best way to retrofit a building for flood, wind, and earthquake resilience based upon its unique characteristics and conditions. During a consultation, they can make recommendations for projects that can be completed by a property owner as well as identify projects that might reduce hazards and insurance premium costs.

Some of the structural issues that would benefit from a consultation include:

- Multiple vertical and/or diagonal cracks
- Wide vertical and/or diagonal cracks
- Cracks that split individual bricks or stones
- Bows or bulges in wall plane or partial collapse of a wall
- Leaning walls or chimneys that may indicate differential or uneven foundation settlement or significant structural problems
- Concrete structure missing large chunks or reinforcing bars exposed and/or rusting

### KEY TIPS:

- Consult with a design professional for severe structural issues
- Consult with a design professional to identify building resiliency improvements



Consult with an architect or engineer for severe cracks or partial collapse of masonry walls.

## BAR

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- *Use of Mechanical Tools*
- *Piazza Enclosures*
- *Historic Materials Demolition*
- *Elevation Design Guidelines*

## HISTORIC PRESERVATION CONSIDERATIONS

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly. Information provided below are best practices toward maintaining the historic character when making resiliency upgrades to masonry buildings.

### GENERAL MASONRY MAINTENANCE

- Remove algae, moss, vines and other vegetation from masonry and stucco with the gentlest means possible
- Remove or trim adjacent shrubs

- Avoid removing historic stucco from masonry surfaces, creating or maintaining the appearance of delaminated stucco, or exposing brick or unpainted concrete masonry units for decorative or aesthetic purposes

### MORTAR AND STUCCO

- Complete masonry and stucco work in fair weather
- Repoint mortar or stucco of the same hardness or softer than the original mortar or stucco; do not use premixed mortar or stucco
- Match the appearance, color, texture, pattern, joint size, and tooling of the historic mortar and stucco
- Repoint mortar in a single layer no greater than 3/8" deep at a time to minimize the potential for cracking
- Avoid widening or extending the existing mortar joints or overlapping the new mortar over the masonry surface
- Avoid destructive power tools and modern chemical additives
- Avoid installing stucco over brick, stone, or wood-framed buildings that were not intended to be stuccoed

### REPLACEMENT MASONRY

- Replace masonry that matches the historic in type, color, texture, size, shape, bonding pattern, and compressive strength; do not use modern masonry made to look old
- Replace masonry toothed into the existing to continue adjacent pattern

## EXTERIOR MASONRY IMPROVEMENT CHECKLIST

The Exterior Masonry Improvement Checklist on the following pages identifies maintenance information and related potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person's abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building's resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**"Off-the-Shelf" Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.



EXTERIOR MASONRY IMPROVEMENT CHECKLIST

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>MANAGING MOISTURE</b> <span style="float: right;">Page R5.3</span>						
<input type="checkbox"/> Verify that gutters and downspouts are clear and directing water away from the building, install splash blocks or downspout extensions if needed		¢-\$	●			●
<input type="checkbox"/> Manage vegetation close to a building and inspect for algae and/or mold behind vegetation		¢	●			
<input type="checkbox"/> Re-grade area adjacent to foundation		\$-\$-\$	●	●		
<input type="checkbox"/> Clean with low pressure water, gentle detergent, and natural bristle brushing; apply a non-toxic biocide as needed		¢-\$	●			●
<b>MORTAR</b> <span style="float: right;">Page R5.4</span>						
<input type="checkbox"/> Selectively repoint using compatible mortar		\$-\$-\$	●	●	●	
<input type="checkbox"/> Consider replacement if deterioration is substantial		\$-\$-\$-\$		●	●	
<b>WALLS AND PIERS</b> <span style="float: right;">Page R5.4</span>						
<input type="checkbox"/> Patch missing stone and brick with compatible materials		\$-\$-\$-\$	●	●		
<input type="checkbox"/> Consider replacement if deterioration is substantial		\$-\$-\$-\$		●	●	
<input type="checkbox"/> Install diagonal bracing inside parapet walls		\$\$		●	●	
<input type="checkbox"/> Install tension anchors from masonry walls to roof and floor framing		\$\$-\$-\$-\$		●	●	
<b>CONCRETE MASONRY UNITS</b> <span style="float: right;">Page R5.5</span>						
<input type="checkbox"/> Repair surface cracks		\$-\$-\$	●	●		●
<input type="checkbox"/> Maintain stucco coating, if present, as a barrier to moisture entry		\$-\$-\$	●	●		●
<b>CONCRETE</b> <span style="float: right;">Page R5.5</span>						
<input type="checkbox"/> Repair surface cracks quickly		\$-\$-\$	●	●	●	●
<input type="checkbox"/> Apply wall sealer that will not discolor		\$-\$-\$	●	●	●	●
<input type="checkbox"/> Install an under-slab sealer at new slab-on-grade		\$\$-\$-\$-\$	●	●	●	

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>TERRA COTTA</b> <span style="float: right;">Page R5.6</span>						
<input type="checkbox"/> Clean surfaces		¢-\$\$	●	●		
<input type="checkbox"/> Maintain mortar joints and repair or renew deteriorated glazes		\$-\$\$		●	●	
<input type="checkbox"/> Address small cracks and spalls with masonry coating; if more severe consider a replacement unit		\$\$-\$\$\$		●	●	
<b>BRICK OR STONE VENEERS</b> <span style="float: right;">Page R5.6</span>						
<input type="checkbox"/> Verify veneer is well-attached to wall		¢-\$	●	●		
<input type="checkbox"/> Repair or reattach veneer		\$-\$\$\$		●		
<b>STUCCO</b> <span style="float: right;">Page R5.7</span>						
<input type="checkbox"/> Patch or replace with compatible stucco		\$-\$\$\$		●	●	
<input type="checkbox"/> Consider replacement for significant damage		\$-\$\$\$		●	●	
<input type="checkbox"/> Verify keying of stucco to substrate		\$-\$\$\$		●	●	
<input type="checkbox"/> Check for moisture trapped behind stucco		¢-\$		●		
<b>MASONRY COATINGS</b> <span style="float: right;">Page R5.7</span>						
<input type="checkbox"/> Complete required repairs and preparation prior to installing coating		¢-\$\$\$	●	●		
<input type="checkbox"/> Apply a "breathable" coating		\$-\$\$\$	●	●		●
<input type="checkbox"/> Select flat-finish coating that won't discolor		\$-\$\$	●	●	●	
<b>FLOOD OPENINGS</b> <span style="float: right;">Page R5.8</span>						
<input type="checkbox"/> Clear both sides of flood vents		¢	●			
<input type="checkbox"/> Install number and size of flood vents to meet FEMA requirements		\$-\$\$\$		●	●	
<input type="checkbox"/> Consult architect or engineer to verify flood vents function as required		\$			●	
<b>ARCHITECT OR ENGINEER CONSULTATION</b> <span style="float: right;">Page R5.8</span>						
<input type="checkbox"/> Consult architect or engineer for severe structural issues		\$			●	
<input type="checkbox"/> Consult architect or engineer to identify building resiliency improvements		\$			●	

## EXTERIOR MASONRY RESOURCES

### City of Seattle Emergency Management

Unreinforced Masonry Buildings

[seattle.gov](http://seattle.gov)

### Federal Emergency Management Administration

Requirements for Openings in Foundation Walls and Walls of Enclosures

[fema.gov](http://fema.gov)

### Historic England

Repairing Walls of an Older Home

Repointing Brick and Stone Walls

[historicengland.org.uk](http://historicengland.org.uk)

### National Park Service

A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments

Preservation Brief 1: Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings

Preservation Brief 2: Repointing Mortar Joints in Historic Masonry Buildings

Preservation Brief 22: The Preservation and Repair of Historic Stucco

Preservation Brief 41: The Seismic Rehabilitation of Historic Buildings

[nps.gov](http://nps.gov)

### Old House Journal

Repairing Stucco by Steve Jordan

Repairing Structural Brickwork by Elizabeth Wheeler

[oldhouseonline.com/repairs-and-how-to](http://oldhouseonline.com/repairs-and-how-to)

### Old House Web

General Masonry Inspection

[oldhouseweb.com/how-to-advice](http://oldhouseweb.com/how-to-advice)

### U.S. Department of Housing and Urban Development

Residential Rehabilitation Inspection Guideline

[huduser.gov](http://huduser.gov)



### REGULATIONS TO REVIEW

- International Existing Building Code
- ASCE 24-14 Flood Resistant Design and Construction
- South Carolina Building Code
- South Carolina Residential Code
- City of Charleston Code of Ordinances
- City of Charleston Flood Hazard Prevention and Control Ordinance

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

#### City of Charleston Permit Center

2 George Street, Ground Floor

Charleston, SC 29401

843.577.5550

[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)



A major hurricane hit Charleston in 1916 causing significant damage. (The Charleston Museum)

# R6 RESILIENCE GUIDANCE: WINDOWS AND DOORS

## WINDOW AND DOOR IMPROVEMENT GOALS

*Windows and doors typically comprise at least one quarter of the surface area of the exterior walls of most older buildings. They are vulnerable parts of the building envelope and must withstand water and wind hazards. They can also significantly impact indoor air temperatures.*

## MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (Refer to *Resilience Guidance: Permit Review*, page R1.5.) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

Windows and doors serve as transitions between the interior and exterior of a building and provide critical natural light, but also present a challenge because they are not as solidly built as building walls. As a result, they are more vulnerable to environmental impacts.

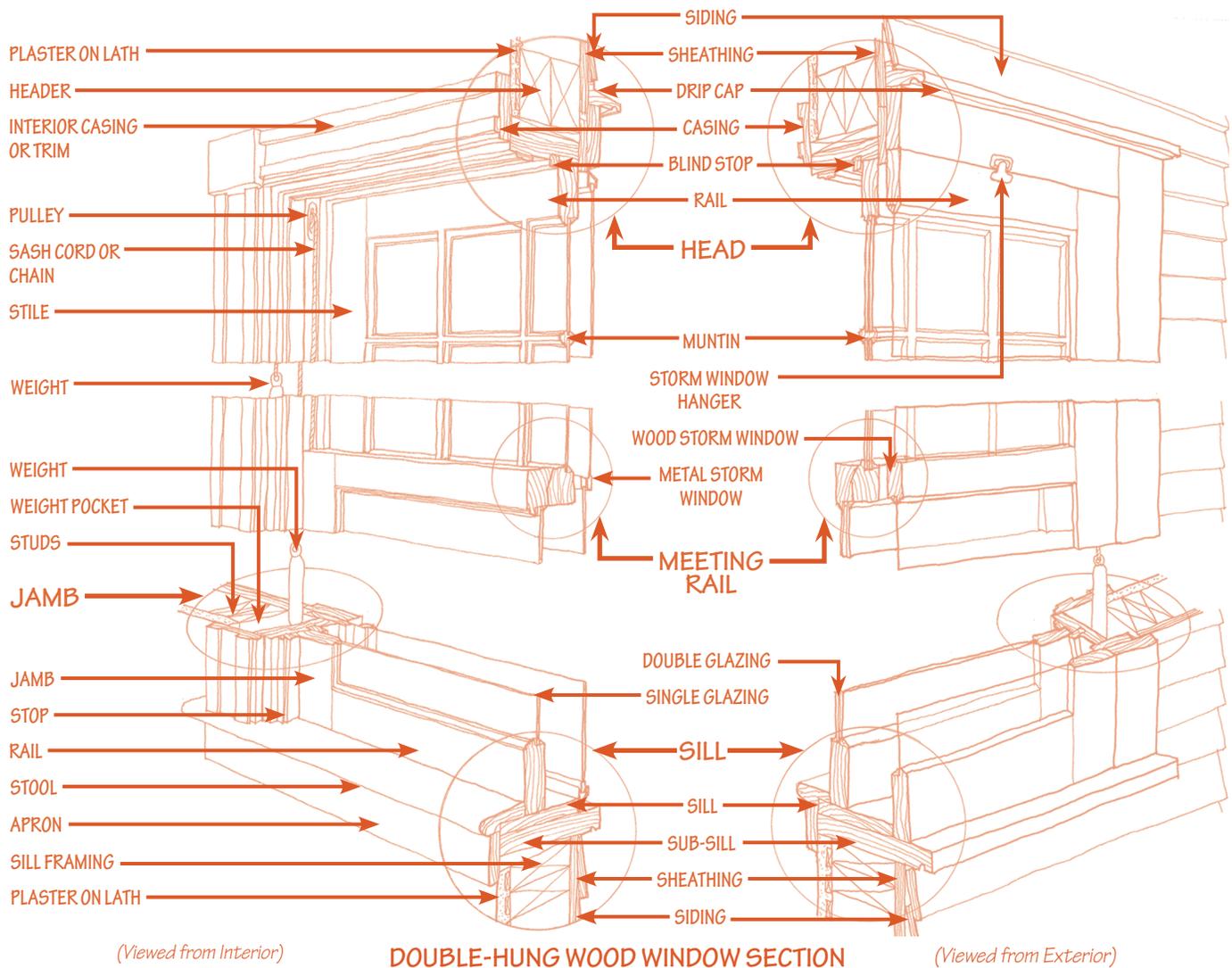
*One of the greatest vulnerabilities for windows and doors is the high winds often associated with a tropical storm or hurricane. Flying debris or severe wind pressure can shatter glass or push doors open, allowing rainwater and wind gusts to enter a building, potentially impacting the furnishings, materials, and the structural system.*

Windows and doors can also affect the temperature inside a building. Air gaps around windows and doors allow cold air to enter in the winter and interior temperatures can soar when sun rays beat down on glass in the summer, making occupants uncomfortable and increasing energy bills.

Improving resilience with windows and doors can include:

- General maintenance to increase their ability to withstand strong winds and rainwater entry
- Protecting glass from flying debris with shutters or panels prior to a storm
- Reducing heat gain through glass with thermal coatings and films and/or double glazing
- Strengthening or installing new window and door hardware (locks, latches, and hinges) that can withstand high winds
- Sealing gaps around windows and doors
- Preventing floodwater from entering doors and low windows





## MAINTAINING WINDOWS AND DOORS

There are many working parts of any window or door and the failure of any one could potentially result in more significant damage or causing heating and cooling systems to overrun. Understanding window and door materials and how the parts function will help building occupants identify and address maintenance issues and improve resilience.

### KEY TIPS:

- Regularly review condition, clean, repair, and repaint/stain windows and doors; remove rust on metal windows
- Avoid cleaning with high-pressure machines that can penetrate wood, delaminate fiberglass, and break the seals of insulated glass panels
- Verify that windows and doors fit properly in their frames and joints are tight
- Verify that hardware is operational, particularly hinges and locks, and consider replacing or strengthening hardware to resist wind forces
- Replace broken or missing components such as glass, trim, glazing, sash cords or springs, and door stops
- Remove built-up paint in jambs to ensure smooth and secure operation
- Verify that caulking, glazing putty, parting beads, and weather-stripping are applied securely and repaint
- Treat or repair deteriorated components in place if possible
- Replace deteriorated components if the majority is deteriorated

## WINDOW AND DOOR MATERIALS

The varying materials for windows and doors deteriorate differently and require specific types of repairs for their proper maintenance.

### WOOD

Basic wood window components include an upper and lower sash that slide up and down in a channel. Sashes may have multiple pieces of glass framed in smaller wood trim pieces called muntins. (Refer to *Double-Hung Wood Window Section diagram, page R6.2.*) Each component is a separate piece that interlocks like a puzzle and it can be disassembled, repaired, and reassembled. Solid wood doors can be similarly disassembled for repair as necessary.

Small repairs can usually be performed with little experience by following research guides and materials. (Refer to the *Library at WindowPreservationAlliance.org, Wood Rot and Exterior Paint, page 4.7, and Window and Door Resources, page R6.14.*) Wood in good condition can be cleaned; minor defects or rot can be filled; and then it can be sanded, primed, and painted. Small repairs will increase the longevity of the window or door by keeping moisture from seeping into the wood. A craftsperson may be needed if there is significant deterioration or drafts, or if repair of historic windows is involved. They can disassemble the pieces, re-secure and properly seal any glass, and fabricate missing or deteriorated pieces to match.



One of the advantages of historic wood windows is repairability. This photograph demonstrates a Dutchman repair at the corner of the historic wood window sash. Also note the application of new glazing putty as part of the repair.



Steel windows can rust, requiring cleaning and rust-inhibitive primer and paint.

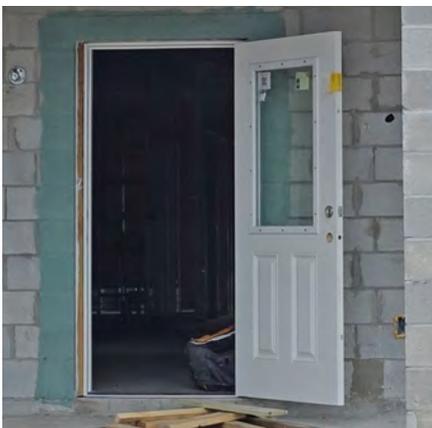


Aluminum window sashes can be easily bent allowing air and water to enter.

### METAL (ALUMINUM, STEEL)

Traditional aluminum or steel windows can be fixed in place, like a storefront window or picture window, or have sashes that crank, tilt, or slide open. Aluminum components can be easily bent and difficult to close, allowing air to flow to the interior. Steel windows and steel lintels (holding up the wall above windows and doors) are prone to rust if not properly painted. Rust can make the window difficult to operate and close tightly, creating air and rainwater openings.

Modern aluminum-clad windows and doors are made of wood, with an exterior aluminum skin. They often include double glazing and can mimic traditional wood windows and doors.



Composite doors are made of multiple layers of different materials, often with a steel or fiberglass finish.

### COMPOSITE, FIBERGLASS, AND VINYL

Most other materials can be considered a type of composite, made either from a combination of wood and plastic resins or extruded PVC/vinyl. These materials can provide a lightweight, insulated window or door. Doors can be clad in steel for increased security. Glass is typically double-glazed and can include decorative or strengthened glass. Composite, fiberglass, and vinyl windows and doors are pre-installed in frames, necessitating significant modification of historic opening surrounds. Additionally, when severely damaged, a replacement is probably necessary because repair to these materials is highly difficult or not possible.

The exterior materials of these types of windows and doors require less maintenance, but material life-spans vary greatly. Signs of wear on a door can include fading from sunlight, chalky finishes, separation of the exterior 'skin' from its core, and cracking. If these are observed, proper preparation and high-grade paints and fillers should be applied to maintain serviceability. Window sashes can become brittle and the seals between the glass panels can deteriorate and allow condensation between panes. (Refer to *Weatherstripping and Caulk, page R6.8.*)



WINDOW AND DOOR PROTECTION OPTIONS



Traditional wood shutters are designed to close and fully cover window openings, and can provide some protection from airborne debris.



Hurricane shutters can be heavy and cumbersome to store. Plan for extra installation assistance prior to a storm.



Storm windows with tempered glass or impact-resistant glazing provide protection from windborne debris. (Not approved on historic properties.)



Polycarbonate shutters allow light to enter a building but are used for temporary purposes in the event of a storm.



Fabric panels are an option for temporary protection that can be easily stored and installed prior to a storm.



Shutters may also be used on the interior to limit sunlight and act as a secondary barrier protection.



Plywood panels, whether used to temporarily board a house under repair or provide storm protection, are relatively inexpensive.



French doors can have upper and lower lock mechanisms to help secure them in place during strong winds.



Garage doors are available with flood vents and structural ratings to resist flood and wind pressure. (Refer to [Garage Door Wind Protection](#), sidebar page R6.9.)



Damaging wind speeds from thunderstorms can occur more often than hurricanes or tornados. (NOAA National Severe Storms Laboratory, [nssl.noaa.gov](http://nssl.noaa.gov))



Flood panels installed for preparation of an upcoming flood event. (Courtesy of Glenn Keyes)

## WIND AND DEBRIS PROTECTION

Windows and doors are key components of the character of a building when designs complement the style. Historically, operable shutters were often used to shade the sun, provide ventilation through louvered openings, and protect a window from strong winds and impacts from airborne debris.

Buildings that lack operable shutters can be retrofitted in a variety of ways to provide protection from severe winds and airborne debris. (*Refer to Reducing Heat Gain, page R6.7.*) Window and door designs can influence the types and style of shuttering system, but the cost and ease of installation should also be considered, particularly for temporary shutters and panels.

### KEY TIPS:

- Obtain and prepare temporary hurricane protection for windows and doors for installation prior to an impending storm and store in an accessible location
- Identify and train individuals in the installation of hurricane protection prior to a storm, understanding that multiple people may be required to install some systems and contractors may not be readily available
- Install window and door protection and secure operable shutters in advance of a storm; openings should be fully covered when closed
- Secure and/or supplement window and door hardware including hinges, latches and locking hardware (*refer to Window and Door Hardware, page R6.8*)
- Protect glass to prevent shattering into small shards that can become airborne (*refer to Glass, sidebar page R6.7*)
- Protect window and door perimeter and seals from damage, including using weatherstripping to reduce air movement and prevent wind-driven rain from entering a building (*refer to Weatherstripping and Caulk, page R6.8*)
- Skylights that are not rated for hurricanes should be protected from wind damage with plywood-framed covers or blankets (*refer to Roof Projections, page R3.5, and Hurricane Resistant Products, sidebar below*)
- Garage doors and other large-scale doors are highly vulnerable to wind damage and require specialized protection (*refer to Glass, sidebar page R6.7, and Garage Door Wind Protection, sidebar page R6.9*)

### HURRICANE RESISTANT PRODUCTS

New window and door assemblies intended for hurricane regions are tested for windborne debris impacts and for specified wind pressure, and are “labeled” to indicate their resilience. Existing older windows and doors require supplementary protection to best withstand severe storm impacts.

In addition to windows and doors, hurricane shutters, skylights, garage doors, and glazed patio doors should be tested. The label should be permanently mounted to the frame and information regarding labeled elements should be shared with professionals, building inspectors, and insurance companies. **Windows used in new construction or non-historic buildings, doors, and skylights must meet current codes, including airborne debris impact requirements.**

### LOCAL PROGRAMS

Upgrading windows and doors could earn utility rebates; check with the following utility provider or agency to identify opportunities:

- SC Energy Saver Tool
- SC Sustainability Institute Home Weatherization and Energy Conservation Workshops
- Palmetto CAP Weatherization Program
- Dominion Energy
- Berkeley Electric Cooperative

Energy Star is a nationwide program that may offer rebates or other incentives. (*Refer to Potential Rebate Offers, page R7.5.*)



WIND PROTECTION FOR WINDOWS AND DOORS			
TYPE	PRE-STORM PREPARATION	PROS	CONS
<b>Traditional exterior or interior wood shutters</b>	<ul style="list-style-type: none"> <li>• None</li> </ul>	<ul style="list-style-type: none"> <li>• Available existing option</li> </ul>	<ul style="list-style-type: none"> <li>• Supplemental protection may be prudent to meet current wind requirements</li> </ul>
<b>Exterior storm/screen windows</b>	<ul style="list-style-type: none"> <li>• Must be installed prior to a storm</li> <li>• Verify the type of glass in storm windows</li> </ul>	<ul style="list-style-type: none"> <li>• Existing window remains</li> <li>• Storm windows provide thermal benefits</li> <li>• Tempered glass and woven wire insect screening may protect window from lower-velocity winds and airborne debris</li> </ul>	<ul style="list-style-type: none"> <li>• Does not meet current wind requirements</li> <li>• Standard glass storm windows are likely to shatter</li> </ul>
<b>Plywood panels</b>	<ul style="list-style-type: none"> <li>• Must be pre-cut for each window, preferably to mount into frame (not siding)</li> <li>• Pre-drill panels and mounting holes</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively inexpensive</li> <li>• Can be a do-it-yourself option</li> <li>• Minimum 5/8" exterior grade plywood with lag screws installed 12" apart can meet hurricane protection requirements (length and type of screws determined by window size and building material)</li> </ul>	<ul style="list-style-type: none"> <li>• Bulky to store</li> <li>• Difficult to install, especially on upper floors</li> <li>• Screw holes can damage window frames and should be filled when panels are removed (permanent clips are an alternative to screws)</li> <li>• Blocks interior natural light</li> </ul>
<b>Polycarbonate sheets such as "PLEXIGLAS"</b>	<ul style="list-style-type: none"> <li>• Must be pre-cut for each window (preferably to mount into frame not the siding or wall)</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively inexpensive</li> <li>• Can be a do-it-yourself option</li> <li>• Allows natural light to enter building and can be semi-permanent</li> <li>• Can protect decorative or stained glass</li> </ul>	<ul style="list-style-type: none"> <li>• Can yellow, haze, or scratch over time</li> <li>• May require ventilation holes to prevent moisture build-up between window and polycarbonate sheet</li> <li>• Impact rating may not be available for some materials</li> </ul>
<b>Fabric storm curtains</b>	<ul style="list-style-type: none"> <li>• Must be pre-made prior to a storm</li> <li>• Wall anchors must be permanently installed prior to a storm and remain visible</li> </ul>	<ul style="list-style-type: none"> <li>• Lightweight and easy to install</li> <li>• Easily stored</li> <li>• Wall anchors are small and discrete</li> <li>• Can provide some interior light when installed</li> </ul>	<ul style="list-style-type: none"> <li>• More expensive than plywood</li> </ul>
<b>Roll-down hurricane shutters</b>	<ul style="list-style-type: none"> <li>• Must be permanently installed</li> </ul>	<ul style="list-style-type: none"> <li>• Easy to close and can provide hurricane-wind rated protection</li> <li>• Often prevents interior natural light</li> </ul>	<ul style="list-style-type: none"> <li>• Very expensive</li> <li>• Permanently mounted to top of window or door with permanently mounted tracks</li> <li>• Approval unlikely on historic properties</li> </ul>
<b>Track-mounted accordion systems</b>	<ul style="list-style-type: none"> <li>• Track must be permanently installed</li> </ul>	<ul style="list-style-type: none"> <li>• Easy to close and can provide hurricane-wind rated protection</li> <li>• Often prevents interior natural light</li> </ul>	<ul style="list-style-type: none"> <li>• Very expensive</li> <li>• Permanently mounted tracks and potentially panels</li> </ul>
<b>Replace window or door</b>	<ul style="list-style-type: none"> <li>• Verify proposed window or door meets current wind requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Code-compliant replacement improves protection but may not be appropriate for historic windows</li> </ul>	<ul style="list-style-type: none"> <li>• Very expensive</li> <li>• Loss of existing windows</li> </ul>



Historic porches, awnings, and traditional shutters shield building walls and openings from the sun.



Some awnings can be manufactured as wind resistant, retractable, or removable ahead of a storm event.



Shade shutters are used during the day to block strong sun exposure.

## GLASS

Glass can easily shatter and become airborne in high winds, potentially injuring people and damaging property. The sun shining through glass can also be a significant source of heat gain. In some cases, glass can be upgraded in existing windows and doors to reduce the likelihood of shattering and potential heat gain.

- **Tempered glass** fractures into small fragments rather than shards, reducing the potential for wind-driven damage. It can be installed in historic, or new, windows or doors.
- **Impact-resistant glazing** is composed of two panes of glass with an internal sandwiched film that holds cracked glass together. Impact-resistant glazing is thicker and heavier than traditional single-paned glass. Some existing windows can be retrofitted for impact-resistant glazing, although wood sashes and frames must also be able to withstand the wind force to be effective.
- **Tempered glazing films** are clear structural films applied to glass so it performs like tempered glass. The films do not make the glass unbreakable, but they can reduce the airborne shards.
- **Thermal coatings and films** reduce the amount of UV light and IR rays that pass through glass and warm interior spaces. Coatings are factory applied to the glass while films can be cut to size and applied by property owners. Care should be taken to select coatings and film that is not reflective and will not change the glass color. *(Refer to Reducing Heat Gain, at right.)*
- **Double-glazing** (insulated) is composed of two panes of glass separated by a sealed internal spacer. Due to the thickness and weight, double-glazing is typically only installed as a new window or door unit or in new construction. Double-glazing can be manufactured to be impact-resistant and include integral thermal coatings.

## REDUCING HEAT GAIN

As the sun shines on traditional glass, ultraviolet (UV) light and infrared radiation (IR) rays pass through glass and warms a interior spaces. Planting trees or installing shading mechanisms at the exterior is not always possible. *(Refer to Trees, page R2.9.)* Solar heat gain can be reduced by up to 60% during the summer season when thermal shades are installed with a tight fit to the window frame *(U.S. Department of Energy)*. When used properly and regularly, these types of simple changes in a building can reduce energy consumption and increase indoor air comfort. Depending on the orientation of the building to the sun and available shade, more significant projects may be needed.

Interior or exterior storm windows can also be used to reduce air flow, managing interior heat loss and gain, and if fitted with tempered glass or impact-resistant glazing, can provide a secondary barrier for wind resilience.

### KEY TIPS:

- Select window blinds, shades and storm windows certified by Attachments Energy Rating Council
- Install interior white or light-colored shades, drapes, blinds, or shutters on windows and glazed doors to reflect heat
- Close shades or curtains on south- and west-facing windows during the day
- Install exterior awnings, shutters, or shades, on south- and west-facing windows to create shade
- Apply thermal film on south-facing windows or storm windows to reduce heat gain, as well as on east and west windows where possible *(refer to Glass, sidebar at left)*
- Install interior or exterior storm windows, mindful that condensation between the layers can damage wood



## WINDOW AND DOOR HARDWARE

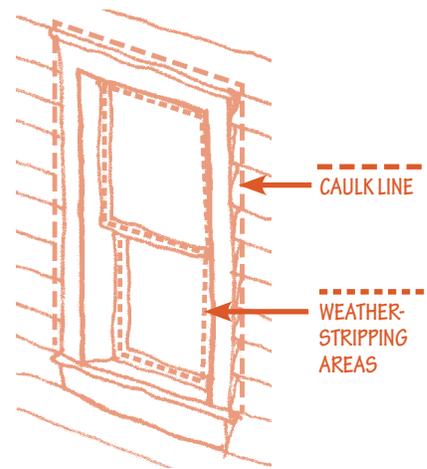
During a severe storm, an unsecured window sash or door can blow open or off in high winds, providing a path for rainwater and gusty winds to enter a building. Most residential doors swing in, while commercial doors swing out. Since they are fastened at the center of an opening, paired French doors are often more vulnerable to opening in strong winds, while out-swinging doors are more resistant. Improving window and door locks, latches, and attachments can increase the likelihood they will remain in place during high winds.

### KEY TIPS:

- Verify window locks and latches securely close the sash tight
- Install three hinges at doors and fasten with long screws
- Install door locks with deep throws (the portion of the lock that extends into the door frame)
- Install side latch bolts to the top and bottom of the locking side of a door for added protection
- Install long vertical bolts on paired doors, such as French doors, at the top and bottom of each operable door, fastening into the frame at the top of the door and the threshold at the floor
- Install long screws at exterior shutter hinges and supplement locks; zip ties can temporarily secure shutters together during severe winds



*Throw-plates should be well secured to prevent doors from blowing open.*



### DEFINITIONS

**Weatherstripping:** A narrow compressible band used between the edge of a window or door and the jambs, sill, head, and meeting rail to seal against air and water infiltration; made of various materials including spring metal, felt, plastic foam, and wood with rubber edging.

Application locations:

- Perimeter of doors/windows, and between paired windows and doors
- Behind window sash track
- Between window meeting rails

**Caulk:** Flexible sealant material used to close joints between materials; made of various materials including tar, oakum, lead, putty, and modern elastomerics such as silicone and polyurethane.

Application locations:

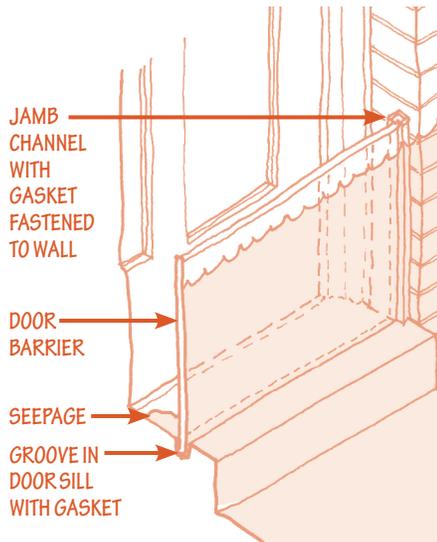
- Between door/window frame and adjacent wall surface
- Between abutting materials such as corner boards and siding, porch and wall surfaces, masonry and wood, flashing and wall surface
- Around pipe penetrations

## WEATHERSTRIPPING AND CAULK

Even in normal conditions, gaps around windows and doors can provide an opportunity for water or air to leak into a building, damaging building materials and impacting the comfort of occupants. Weatherstripping and caulk can reduce air movement around a window or door and prevent wind-driven rain from entering.

### KEY TIPS:

- Verify condition of caulk and weatherstripping annually; it can easily become damaged, loose, bent, or torn
- Install weatherstripping between moving parts of a window or door
- Install more durable weatherstripping, such as bronze or nailed felt, for heavily used entrance doors
- Install caulk to fill joints and penetration openings
- Select caulk manufactured for outdoor use, and the materials it will be applied to, following installation recommendations
- Select caulk that matches the color of adjacent material or that can be sanded and/or painted to minimize its visibility



A metal barrier plate may provide protection for floods of limited height and duration.



Pre-manufactured flood barriers are available for residential-sized openings. Perimeter gaskets should fit snugly to provide flood protection and perimeter seepage should be anticipated. (Courtesy of Glenn Keyes)



Engineered barriers can include metal panels installed in jamb channels to a height above anticipated floodwater. They typically provide greater protection but are more costly than pre-manufactured options.

### GARAGE DOOR WIND PROTECTION

The size and operability of garage doors make them very vulnerable to damage from high winds. Larger, double garage doors are more vulnerable than smaller, single doors. If the garage is attached to a building, such as a residence, a wind-damaged garage door may provide a pathway for wind and rain to enter a building and damage a home.

Older garage doors that are not pressure-rated for wind protection can be retrofitted from the interior to improve wind resilience. (Refer to *Hurricane Resistent Products, sidebar page R6.5.*) Retrofitting may include:

- Installing an interior steel track system that is anchored to the wall
- Adding steel braces with a horizontal panel system to door
- Ensuring that garage door windows have tempered glass, glazing film, or impact-resistant glazing; or are boarded prior to a storm (refer to *Glass, sidebar page 6.7*)
- Providing interior shear panels (refer to *Shear Panels, page R4.4*)

### BARRIERS AND SHIELDS FOR FLOOD PROTECTION

There is a wide range of temporary barriers and shields for flood protection that range from sandbags to engineered options. Temporary barriers and shields can reduce flood damage if installed at building openings or surrounding a building. However, these methods do not meet regulations for residential building codes or reduce flood insurance premiums for residential buildings. Still, they may serve as affordable and effective solutions because they can be installed quickly using relatively available materials.

Landscape barriers can include sand bags, water-filled rubber tubes, or structural walls with barriers installed in openings. An existing wall may be retrofitted to resist floodwaters, although seepage should be anticipated. (Refer to *Walls and Fences, page R2.11, and Temporary Flood Barriers, sidebar page R2.11.*)

#### KEY TIPS:

- Carefully position sandbags so they are stacked to prevent water seepage prior to a flood event, and properly dispose of sandbags as hazardous waste after contaminated floodwaters recede
- Install metal barrier plates at vulnerable door and window openings that are fitted and sealed with gaskets where the opening meets the building wall, door or window sill, or ground surface (refer to *diagram above*)
- Seal openings at the perimeter of the building including open mortar joints (excluding weep holes) and crevices around hose bibs and conduits (refer to *Mortar, page R5.4, and Weatherstripping and Caulk, page R6.8*)
- Consider purchasing engineered barriers and shields that can withstand several feet of floodwater for long durations of time if conditions warrant
- Perform regular maintenance and emergency drills to ensure that barriers and shields are in good condition, and available labor is trained to install them prior to an anticipated flood event



## WINDOW AND DOOR MODIFICATION FOR FLOOD PROTECTION

When temporary barriers or other flood prevention measures are not sufficient as a long-term solution, more substantial construction projects may be considered. In some cases, these alterations will affect window and door openings and will require compliance with the National Flood Insurance Program (NFIP) and City of Charleston Building and Floodplain ordinances.

**Projects with any of these qualifiers should be undertaken with the advice of an architect and/or engineer that is familiar with Charleston's building and floodplain management regulations.**

### KEY TIPS:

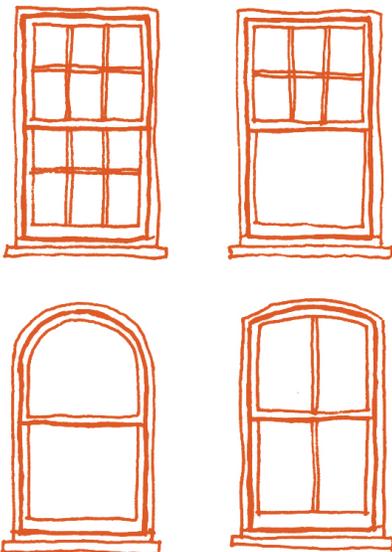
- Limit exterior modification of windows and doors to the greatest extent possible



Window openings can be altered while still revealing the architectural character of the molding details.

### HISTORIC WINDOW REPLACEMENT

*Historic window replacements are not required to be code compliant. The BAR actively encourages creative solutions, like using shutters, temporary protection, or interior supplementary windows to meet this need without compromising the historic window or door. (Refer to Wind and Debris Protection, page R6.5, and Window and Door Protection Options, page R6.4.)*



When selecting door and window replacements, the design should match the original style or be consistent with examples in the neighborhood.

## WINDOW AND DOOR REPLACEMENT

If the majority of the window or door components are deteriorated, damaged, or missing and in need of replacement, it may be necessary to install a new window or door. While windows at historically-designated properties may not be required to be code compliant, there are a range of options for replacement units that can also improve the building's energy efficiency and weather resilience, and potentially reduce exterior maintenance.

### KEY TIPS:

- Select new windows and doors that fit with the architecture of the building or neighborhood
- Consider warranties and maintenance requirements in the selection process; vinyl and aluminum-clad windows do not require exterior painting but aluminum-clad windows will remain serviceable longer, postponing costly replacement
- Follow all manufacturer's instructions and building regulations for the materials, opening size, number, and location of fasteners
- Ensure that proper weatherstripping, caulk, and flashing is installed at the header, jamb, and sill (*refer to Weatherstripping and Caulk, page R6.8*)
- Select windows, doors, and skylights for new or non-historic buildings that meet the current building code requirements for impact resistance, wind pressure loads, and thermal transmission; verify BAR compliance for designated buildings (*refer to Hurricane Resistant Products, sidebar page R6.5, and Historic Window Replacement, sidebar at left*)
- Install double-glazing and include thermal coating to units in direct sunlight to reduce heat gain (*refer to Glass, sidebar page R6.7*)
- Replace standard garage doors with ones that are rated for wind pressure and impact protection; include integral flood vents as required (*refer to Garage Door Wind Protection, sidebar page R6.9*)
- Contact the insurance company regarding potential premium reductions prior to ordering replacement windows or doors



**BAR POLICY STATEMENTS**

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- Hurricane Protection Panels
- Solar Panels
- Storm Windows

**HISTORIC PRESERVATION CONSIDERATIONS**

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly. Information is provided below for best practices toward maintaining the historic character of a property when changes are made to windows and doors.

**MAINTENANCE**

- Maintain and repair existing windows and doors as long as feasible

**WIND AND DEBRIS PROTECTION**

- Install period-appropriate, operable shutters with secure locking hardware
- Install inconspicuous anchors for cloth or rigid hurricane protection
- Paint permanent tracks and fasteners to match adjacent window and door trim
- Paint storm windows and doors to match window or door trim; avoid storm windows or doors with interior grills or decorative elements
- Vent exterior storm panels to reduce condensation
- Avoid leaving temporary protection installed beyond storm use
- Improve historic door resilience with supplemental hardware

**HEAT GAIN**

- Install exterior awnings that do not obscure historic features and are period-appropriate
- Avoid colored or reflective coatings for window films

**DOOR AND WINDOW SHIELDS**

- Install channels, grooves, and other attachment mechanisms in a manner that minimizes their visibility; paint to match adjacent material

**REPLACEMENT WINDOWS AND DOORS**

- Select replacement windows and doors that maintain the size, trim profiles, and materials when available

**WINDOW AND DOOR IMPROVEMENT CHECKLIST**

The Window and Door Improvement Checklist on the following pages identifies maintenance needs and potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person’s abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building’s resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

WINDOW AND DOOR RESILIENCE IMPROVEMENT CHECKLIST

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>MAINTAINING WINDOWS AND DOORS</b> <span style="float: right;">Page R6.2</span>						
<input type="checkbox"/> Regularly review condition, repair frame and hardware, routinely clean, and repaint/stain windows and doors		¢	●			
<input type="checkbox"/> Verify that windows and doors fit properly in their frames and joints are tight		¢-\$	●			
<input type="checkbox"/> Replace broken or missing components like trim, glazing, sash cords or springs, door stops		\$-\$-\$	●	●		●
<input type="checkbox"/> Verify that caulking, glazing putty, parting beads, and weather-stripping are applied securely and repaint and ensure smooth and secure operation		¢-\$-\$	●	●		
<b>WIND AND DEBRIS PROTECTION</b> <span style="float: right;">Page R6.5</span>						
<input type="checkbox"/> Obtain, prepare, and/or install hurricane protection for windows, doors, and skylights for installation prior to an impending storm		\$-\$-\$-\$	●	●		●
<input type="checkbox"/> Install tempered glazing film to prevent small shards from becoming airborne		\$-\$-\$	●			●
<input type="checkbox"/> Replace existing glass with tempered or impact-resistant glass		\$-\$-\$	●			●
<input type="checkbox"/> Pre-install anchors for garage door bracing		\$-\$-\$	●			●
<b>REDUCING HEAT GAIN</b> <span style="float: right;">Page R6.7</span>						
<input type="checkbox"/> Install interior white or light-colored shades, drapes, blinds, or shutters at windows		\$-\$-\$	●			●
<input type="checkbox"/> Close shades or curtains on south- and west-facing windows during the day		¢	●			
<input type="checkbox"/> Install exterior awnings, shutters, or shades		\$-\$-\$-\$	●	●	●	●
<input type="checkbox"/> Apply thermal film to windows or storm windows to reduce heat gain		\$-\$-\$	●	●		
<input type="checkbox"/> Install interior or exterior storm windows		\$-\$-\$	●	●		
<b>WINDOW AND DOOR HARDWARE</b> <span style="float: right;">Page R6.8</span>						
<input type="checkbox"/> Verify window and door locks, latches, and hinges are securely fastened and re-secure or supplement as required		¢	●			

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	<b>RESILIENCE BENEFIT</b>	<b>COST</b>	<b>DO-IT-YOURSELF</b>	<b>CONTRACTOR MAY BE REQUIRED</b>	<b>ARCHITECT OR ENGINEER MAY BE REQUIRED</b>	<b>“OFF-THE-SHELF” SOLUTION AVAILABLE</b>
<b>WEATHERSTRIPPING AND CAULK</b> <span style="float: right;">Page R6.8</span>						
<input type="checkbox"/> Review condition of caulk and weatherstripping annually, and repair or replace if damaged, loose, bent, or torn		¢	●			
<input type="checkbox"/> Install weatherstripping between moving parts of a window or door with more durable weatherstripping, such as bronze or nailed felt, for heavily used entrance doors		\$\$\$	●			●
<input type="checkbox"/> Install caulk appropriate for location and material to fill gaps around openings and trim; follow manufacturer’s installation recommendations		¢-\$\$	●	●		
<b>BARRIERS AND SHIELDS FOR FLOOD PROTECTION</b> <span style="float: right;">Page R6.9</span>						
<input type="checkbox"/> Learn to position sandbags so they are stacked to prevent water seepage prior to a flood event		¢	●			●
<input type="checkbox"/> Obtain metal barrier plates for vulnerable door and window openings and install gasketed channels and grooves		\$\$\$	●	●		●
<input type="checkbox"/> Seal openings at building perimeter including open mortar joints and install caulk around wall crevices and penetrations like hose bibs and conduits in areas vulnerable to flooding		¢-\$	●			●
<input type="checkbox"/> Consider purchasing engineered barriers and shields that can withstand several feet of floodwater for long durations of time		\$\$\$	●			●
<input type="checkbox"/> Perform regular maintenance and emergency drills to ensure that barriers and shields are in good order and available personnel is trained to install them		¢	●	●		
<b>WINDOW AND DOOR MODIFICATION FOR FLOOD PROTECTION</b> <span style="float: right;">Page R6.10</span>						
<input type="checkbox"/> Review options for modifying windows and doors to reduce flood risk and limit modification to the greatest extent possible		\$\$\$	●	●	●	●
<b>WINDOW AND DOOR REPLACEMENT</b> <span style="float: right;">Page R6.10</span>						
<input type="checkbox"/> Select windows, doors, and garage doors that fit with the surrounding neighborhood meeting all code requirements		\$\$\$\$	●	●	●	●
<input type="checkbox"/> Install caulk, weatherstripping, and flashing at the header, jamb, and sill		\$	●	●		●

## WINDOW AND DOOR RESOURCES

### Attachments Energy Rating Council

[aercenergyrating.org](http://aercenergyrating.org)

### Berkeley Electric Cooperative

[berkeleyelectric.coop](http://berkeleyelectric.coop)

### Dominion Energy

[dominionenergy.com](http://dominionenergy.com)

### Federal Emergency Management Agency (FEMA)

Reducing Water Intrusion through Windows and Doors  
Wind Retrofit Guide for Residential Buildings, FEMA P-804  
[fema.gov](http://fema.gov)

### National Park Service

Preservation Brief 3: Improving Energy Efficiency in Historic Buildings  
Preservation Brief 9: The Repair of Historic Wood Windows  
Preservation Brief 11: Rehabilitating Historic Storefronts  
Preservation Brief 13: Repair and Thermal Upgrade of Historic Steel Windows  
Preservation Brief 32: Making Historic Properties Accessible  
Preservation Brief 44: Awnings: Repair, Replacement, and New Design  
[nps.gov](http://nps.gov)

### Palmetto Community Action Partnership

Weatherization  
[palmettocap.org](http://palmettocap.org)

### South Carolina Department of Insurance

Mitigation Techniques Resource Document, Section G: Opening Protection  
[doi.sc.gov](http://doi.sc.gov)

### South Carolina Energy Office

Energy Saver for Your Home  
[energysaver.sc.gov](http://energysaver.sc.gov)

### The Sustainability Institute

[sustainabilityinstitutesc.org](http://sustainabilityinstitutesc.org)

### U.S. Department of Energy

Energy Efficient Window Coverings  
[energy.gov](http://energy.gov)

### Window Preservation Alliance Library

[windowpreservationalliance.org](http://windowpreservationalliance.org)



### REGULATIONS TO REVIEW

- International Existing Building Code
- South Carolina Building Code
- South Carolina Residential Code
- City of Charleston Code of Ordinances
- City of Charleston Climate and Geographic Design Criteria
- City of Charleston Flood Hazard Prevention and Control Ordinance

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

**City of Charleston Permit Center**  
2 George Street, Ground Floor  
Charleston, SC 29401  
843.577.5550  
[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)



Charleston's early architecture relied on windows and piazzas for natural ventilation and shade. (www.loc.gov)

# R7

## RESILIENCE GUIDANCE: BUILDING SYSTEMS

### SYSTEMS IMPROVEMENT GOALS

*Power and water supply systems are critical for health and safety and can become severely compromised during a natural hazard event. Installation of secondary and back-up systems will limit secondary dangers like mold and fire, and aid the recovery process. Reducing energy and water use saves money and improves resilience.*

### MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (Refer to Resilience Guidance: Permit Review, page R1.5.) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

Building systems and equipment can be significantly impacted by environmental factors. If damaged, they are typically costly to repair or replace, and if rendered non-functional, they can impact recovery after an event such as a severe storm. Resilience upgrades for building systems and equipment can address preventive measures to reduce direct impacts from climate threats, as well as secondary goals, such as improving efficiency and reducing energy and water use. Limiting water use also reduces wastewater and its volume in the combined sewage and stormwater systems, reducing potential flood risk.

Vulnerable systems and equipment include mechanical, electrical, plumbing, and telecommunication elements that can be located on interior spaces, mounted on a building's roof or walls, or located elsewhere on the property.

- **Flooding or heavy rains** can damage systems and components that require electricity to operate and cause backups in plumbing systems
- **High winds** and impact from airborne debris can dislodge equipment, topple trees onto electrical lines, and rupture gas line connections, potentially causing a fire and interrupting utility services
- **Earthquake** shaking can topple roof-mounted equipment and hot water heaters, potentially rupturing gas lines and water supply lines
- **Extreme heat** burdens electrical systems through increased use of fans and air conditioners

The upgrades referenced in this section can be completed incrementally with modifications to existing systems. Others are best completed when a system, such as an air conditioning unit, is being replaced or as part of a building improvement project.





A significant remodeling project can provide an opportunity to elevate electrical and plumbing components to improve resilience.

## BUILDING SYSTEM COMPONENTS

Building systems are made up of a number of parts that work together to service a space. These systems generally fall under the mechanical, electrical, and plumbing categories listed below, but can also include fire protection in larger residential and commercial buildings.

- **Mechanical systems** primarily provide the heating and cooling for a space, and they also ventilate through air movement and fresh air intake. Heating systems can be powered by gas, oil, or electricity; while the other components are usually powered by electricity.
- **Electrical systems** provide power within and outside a building and they power mechanical systems, kitchen and laundry appliances, internet service, and some hot water heaters. Power systems include electrical panels, conduits, junction boxes, outlets, and switches. Power can also be supplied through alternative means such as solar panels, wind turbines, and generators, which can be beneficial if there is a disruption in the city's electrical service. *(Refer to Solar Collectors, page R3.8.)*
- **Plumbing systems** include basic water service, plumbing fixtures, roof vents, roof drains, floor drains, hot water heaters, and irrigation systems.
- **Fire protection systems** tend to be limited to commercial buildings and larger-scale residential buildings, and typically include a sprinkler system and potentially a fire pump.

There are several basic system maintenance tasks that can be completed by property owners, while repairs and system inspections may require a specialized service person and a building permit. ***A trained technician should be contracted to perform manufacturer's recommended system service or any work that is unfamiliar or potentially dangerous.***

### BUILDING SYSTEM COMPONENTS

The types of system components found in a building varies, but may include any of the items listed below.

- Mechanical equipment, air conditioner compressor units, heaters
- Electrical systems and fans
- Vents, including restaurant exhaust, plumbing, and laundry
- Satellite dishes and antennae
- Hot water heaters
- Generators
- Septic tanks
- Solar panels
- Wind turbines
- Building-mounted piping
- Irrigation systems

### SPECIALTY PERMITTING

In addition to a building permit, specialty contractor permits may be required for mechanical, electrical, plumbing, and fire protection technicians. *(Refer to Resilience Guidance: Permit Review, page R1.5.)*

### SYSTEM MAINTENANCE MANUAL

A maintenance manual can help keep track of conditions, problems, maintenance tasks, and contractors who perform the work. Information could include:

- Names and telephone numbers of repair technicians
- Information on the installed system components, maintenance manuals, warranties
- List of recommended maintenance requirements and frequency, such as how often to replace air filters in an HVAC unit
- Log describing maintenance and repair work performed, including date and who performed the tasks

*(Refer to Maintenance Manual, page R1.3.)*



Replacing an older thermostat with a compatible digital model can be a DIY project to help maximize efficiencies.



A combination of habits, like closing shades on southern exposures in the summer and reducing air conditioning, can save utility costs and prolong the system's lifespan.



Secure propane tanks to reduce movement during a flood or earthquake.

## BASIC SYSTEMS MAINTENANCE TO IMPROVE RESILIENCE

For optimal performance and increased resilience, building systems need to be maintained, weaknesses or deficiencies identified, and repairs made on a regular basis. The list below includes relatively basic tasks that may be possible for a property owner to complete. All work performed, including regular maintenance, should be recorded in a Maintenance Manual. *(Refer to System Maintenance Manual, sidebar page R7.2, and Maintenance Manual, page R1.3.)*

### KEY TIPS:

- Replace incandescent light bulbs with LEDs to reduce electrical use and heat generation from bulbs
- Limit use of heat-generating appliances, including clothes dryers, ovens, and dishwashers to the evening or early morning
- Set the thermostat temperature as high as tolerable in the summer and reduce use while sleeping or away
- Install a programmable thermostat and smart bulbs or and/or motion-activated lights to reduce energy use
- Clean or replace heating/air conditioning filters monthly to improve efficiency
- Clean registers and keep furniture, carpeting, or drapes from blocking air flow
- Locate main water shutoff and know how to turn it off in case of a leak
- Drain sediment from water tank or instant hot water heater every 6 months to improve efficiency
- Remove air from radiators to increase heat output
- Adjust window shades seasonally: keep them open in colder months on south-facing windows during the daytime and closed at night for better insulation; in warmer months keep shades closed to reduce heat impact from the sun
- Locate exterior sewer clean-out valve and maintain an accessible area around it
- Inspect septic tanks annually and pump out every 3-5 years at a minimum to prevent clogs
- Avoid driving or parking on drain fields to reduce possible piping damage
- Ensure any gaps around water pipes, electric wiring, internet cables, or other conduits are sealed *(refer to Weatherstripping and Caulk, page R6.8)*
- Monitor fasteners for building- or ground-mounted equipment for rust, and missing or broken pieces
- Clear clogged or slow-draining pipes as they are discovered to avoid potential backups and reduce flood risk
- Close fireplace flues when not in use to minimize drafts
- Secure outdoor grills, and pool or spa power supplies
- Ensure connections to propane tanks are securely fastened and install straps to prevent tank from floating or toppling during a flood or earthquake
- Test smoke and carbon monoxide detectors monthly and replace batteries every 6 months to reduce fire risk



Stands for elevating equipment can be purchased or made from lumber at home. Stainless steel or galvanized connectors will limit rusting.



Relocate ducts to attic, above potential floodwater. Installing new insulated ductwork will increase system efficiency. ([www.energy.gov](http://www.energy.gov))



Package-style HVAC systems require more space and exterior ductwork at ground level, which can complicate system elevation. Ducts in flood-prone areas are vulnerable to damage.

## HEATING AND AIR CONDITIONING

Damage to building systems and equipment can be a costly effect of flooding. Traditionally, heating, ventilation, and air conditioning (HVAC) systems and equipment are located in a crawl space, on the first floor, at exterior grade, or mounted on building roofs or walls. For equipment located in flood-vulnerable areas, even short-term exposure to floodwater will necessitate replacement and render them useless when they are needed most during the first critical days of recovery. In addition, relocating equipment to a higher elevation level may limit an environmental hazard by preventing gas, oil, and chemicals from mixing with floodwater, and avoid potential electrification. Equipment mounted to building walls or a roof can be dislodged in high winds or an earthquake if not securely fastened.

### KEY TIPS:

- Elevate or relocate furnace/heat pumps, air conditioners, hot water heaters, and vulnerable kitchen and laundry appliances to limit flood vulnerability
- Secure roof-mounted and wall-mounted equipment to prevent dislodging in high winds or an earthquake
- Secure fuel supplies and connections to prevent potential ruptured lines
- Replace damaged or worn duct systems; relocate to attic or above floodwater level or install ducts certified for wet installations
- Insulate ducts to reduce cooling or heat loss
- Replace older HVAC equipment with right-sized, high energy-rated, variable-speed models that also help with dehumidification, and seek financial incentives

from local and national rebate programs (*refer to Right-Size Heating and Cooling Equipment, sidebar below, and Potential Rebate Offers, sidebar page R7.5*)

- Minimize the visibility of equipment to the public right-of-way and neighboring properties
- Locate equipment to meet all applicable codes and the manufacturers' recommended requirements for clearance, access, and ventilation
- Replace multiple window air conditioner units with a more efficient, ductless mini-split cooling system
- Use a dehumidifier, fan, or ceiling fan to improve comfort and reduce air conditioner use
- Install a whole-house fan in the attic if conditions allow

### RIGHT-SIZE HEATING AND COOLING EQUIPMENT

Mechanical engineers and HVAC contractors can calculate heating and cooling requirements for a building to determine the size of equipment needed to meet occupant demands.

- When equipment is oversized, initial costs are higher, heating/cooling efficiency is reduced, more duct leakage occurs due to higher operating duct pressures, comfort may be compromised, and energy costs increase with larger fan use
- Similar to an automobile in stop-and-go traffic, the overall efficiency of an air conditioner, furnace, or heat pump is reduced by excessive cycling in oversized units
- As the overall efficiency of a building is improved by reducing air leakage or adding insulation, the recommended size of the HVAC system should drop (U.S. Dept. of Energy)

## ELECTRICAL

Electricity is used to power many building systems, appliances, equipment, medical devices, and communication devices. A loss of power, even temporarily, can be highly disruptive, potentially hindering recovery from an event like a severe storm. Without electricity, food in refrigerators can spoil, fans and dehumidifiers cannot be used to minimize mold in flood events, internet service may be impacted, sump pumps are idle, and cell phones and power tools cannot be charged.

### KEY TIPS:

- Trim tree limbs that may fall onto power lines (*refer to Trees, page R2.9*)
- Convert overhead utility lines to underground lines to reduce potential downed service, fire, and electrification
- Elevate associated secondary elements such as electrical outlets, junction boxes, switches, disconnects, panels, and meters above potential flood level
- Install and maintain a generator that can power equipment, including fans, a sump pump, dehumidifier, refrigerators, and essential needs
- Obtain portable photovoltaic panels with battery storage that can be mobilized and deployed temporarily
- Consider installation of solar panels (*refer to Solar Collectors, page R3.8*)
- Replace older appliances with Energy Star products and seek financial incentives from local and national rebate programs (*refer to Potential Rebate Offers, sidebar below*)



When charged, portable, solar powered backup batteries can be deployed in an emergency. (Example from Solar Stik)



Generators can be installed as a permanent system that is ready to use when there is a power outage.

### ENERGY ASSESSMENTS

Reducing energy saves money and improves resilience. An energy check-up is one of the best ways to understand how a building uses energy and where improvements can be made. A professional home energy assessment can identify improvements that may include adding or replacing insulation or sealing openings to reduce heat loss or gain, and drafts. It can also identify appliances or systems that are inefficient, near the end of their life spans or are costly to operate, allowing replacement to be planned prior to failure.

### KEY TIPS:

- Obtain a building energy check-up with a certified energy assessor ([www.energy.gov](http://www.energy.gov))
- Install insulation in areas otherwise un-insulated or upgrade insulation, particularly in attics and crawl spaces (*refer to Attic, page R3.9, and Insulation Matrix, page R8.6*)
- Seal openings to prevent drafts (*refer to Weatherstripping and Caulk, page R6.8*)
- Select high-efficiency appliances and building system components when replacement is warranted
- Retrofit a traditional fireplace with a fireplace insert to increase heat output

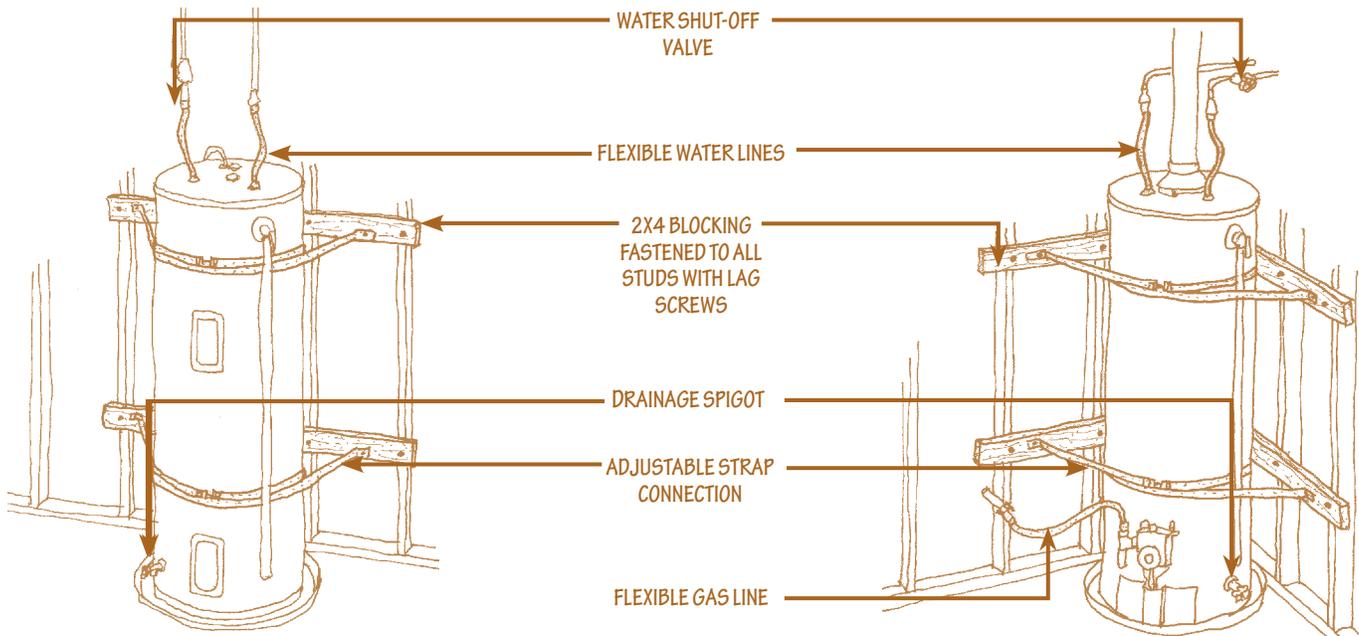
### POTENTIAL REBATE OFFERS

Rebates and tax credits for energy efficiency retrofits for single- and multifamily-buildings may be available depending on program funding, the amount of energy savings achieved, and applicant's income. The federal Energy Star website has information about efficient products, rebates, and tax credits. (*Refer to [www.energystar.gov](http://www.energystar.gov).*) In addition, contact the South Carolina Energy Office for information if replacing appliances or performing improvements identified below. (*Refer to [www.energy.sc.gov](http://www.energy.sc.gov).*)

- Clothes dryers
- Space heating and cooling
- Water heaters
- Electric panel and wiring upgrades
- Stoves, cooktops, ranges, and ovens
- Air sealing
- Duct sealing
- Building insulation (*refer to Insulation Matrix, page R8.6*)
- Ventilation systems

*The City of Charleston website includes links to energy companies and energy audit programs. ([www.charleston-sc.gov/2020/You-Can-Help](http://www.charleston-sc.gov/2020/You-Can-Help))*





Straps and flexible fuel and water lines can improve the resilience of traditional hot water heaters. Fitted insulation can be added around tank to decrease standby heat loss. (Base diagrams obtained from [www.fema.gov](http://www.fema.gov).)

## PLUMBING

When there are intense rains or a flood event, plumbing systems can be vulnerable to backups as can septic systems and drainage fields. While most backups occur at landscape drains or floor drains, when the water is higher, backups can occur through toilets and sinks. Additionally, a leaking drain in an area with a high water table can contaminate local waterways. (Refer to *Drains*, page R2.8.)

Hot water heaters can represent another resilience vulnerability. Traditional hot water tanks can float in floodwater and topple in earthquakes. This can cause a hazard by rupturing water and fuel lines and damaging electrical connections.

### KEY TIPS:

- To minimize the potential for sewage backup through floor drains, toilets, and sinks, install a backflow preventer
- Install low-flow shower heads and efficient toilets to reduce water use
- Install straps to secure hot water tanks
- Install flexible fuel and water lines at hot water tanks
- Install fitted insulation at hot water heater tanks and metal piping to decrease standby heat loss
- Secure fuel supplies and connections
- Replace tank-style hot water heater with an on-demand or “instant” hot water system to reduce energy use



The backflow preventer, disguised by the green cover, keeps floodwater from backing up into drains and plumbing fixtures.



On-demand hot water heaters reduce energy use since it is not necessary to maintain a tank of water warm at all times.



The generator is highly obscured by fencing and surrounding plants.

**BAR**

Refer to the BAR Jurisdiction Chart and Map or speak with City staff to determine if a property has additional permit or review requirements.

BAR Policy Statements:

- Solar Collectors
- Storm Windows

**HISTORIC PRESERVATION CONSIDERATIONS**

Properties located in a historic district or design review district may require additional City review whether a permit is required or not. Contact the Permit Center, or the BAR or DRB staff, to speak with someone directly. Information is provided below for best practices toward maintaining the historic character of a property when changes are made to building systems and equipment.

**BASIC MAINTENANCE**

- Preserve existing fireplaces and chimneys, making any retrofits to the interior flue and fireplace
- When making any repairs to building-mounted equipment, limit damage to historic materials and repair with in-kind materials

**EXISTING SYSTEMS AND EQUIPMENT**

- Relocate all building systems and equipment out of flood-prone areas to an inconspicuous location, minimizing visibility from the public way and neighboring properties
- Screen ground-mounted systems and equipment with landscaping or fencing to minimize visibility

**INSTALL SECONDARY POWER SOURCES**

- Locate secondary power sources out of flood prone areas to an inconspicuous location
- Locate roof or wall-mounted secondary power sources, including solar panels, in a manner that minimizes visibility from the public right-of-way

**BUILDING SYSTEMS IMPROVEMENT CHECKLIST**

The Building Systems Improvement Checklist on the following pages identifies maintenance information, system upgrades, and other related potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person’s abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building’s resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

**BUILDING SYSTEMS IMPROVEMENT CHECKLIST**

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	<b>RESILIENCE BENEFIT</b>	<b>COST</b>	<b>DO-IT-YOURSELF</b>	<b>CONTRACTOR MAY BE REQUIRED</b>	<b>ARCHITECT OR ENGINEER MAY BE REQUIRED</b>	<b>“OFF-THE-SHELF” SOLUTION AVAILABLE</b>
<b>BASIC SYSTEM MAINTENANCE TO IMPROVE RESILIENCE</b> <span style="float: right;">Page R7.3</span>						
<input type="checkbox"/> Replace incandescent light bulbs with LEDs		¢	●			●
<input type="checkbox"/> Limit use of heat-generating appliances to evening and early morning		¢	●			
<input type="checkbox"/> Install a programmable thermostat and set as high as tolerable in the summer and reduce further while sleeping or away from home		¢	●			●
<input type="checkbox"/> Clean or replace heating/air conditioning filters and clean registers		¢	●			●
<input type="checkbox"/> Drain sediment from water tank every 6 months and bleed air from radiators		¢-\$	●	●		
<input type="checkbox"/> Use window shades seasonally		¢	●			
<input type="checkbox"/> Locate exterior sewer clean-out valve and keep a clear space around it		¢	●			
<input type="checkbox"/> Ensure any gaps around water pipes, electric wiring, internet cables, or other conduits are sealed		¢	●			●
<input type="checkbox"/> Pump out septic tanks every 3-5 years at a minimum to prevent clogs		\$		●		
<input type="checkbox"/> Avoid driving or parking on septic drain fields		¢	●			
<input type="checkbox"/> Monitor building- or ground-mounted equipment fasteners for rust, and missing or broken pieces		\$	●	●		
<input type="checkbox"/> Clear clogged or slow-draining pipes as they are discovered		¢-\$\$	●	●		
<input type="checkbox"/> Close fireplace flues when not in use		¢	●			
<input type="checkbox"/> Ensure outdoor barbecue grills, propane tanks, and pool or spa power supplies are secured when not in use		¢	●			●
<input type="checkbox"/> Locate, test, and service smoke and carbon monoxide detectors, replacing batteries every 6 months		¢	●			●

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>HEATING AND AIR CONDITIONING</b> <span style="float: right;">Page R7.4</span>						
<input type="checkbox"/> Elevate or relocate furnace/heat pumps, air conditioners, and vulnerable appliances		\$\$-\$	●	●		●
<input type="checkbox"/> Secure roof-mounted and wall-mounted equipment to prevent toppling		C-\$	●	●		
<input type="checkbox"/> Secure fuel supplies and connections		C-\$	●	●		
<input type="checkbox"/> Replace damaged or worn ducts, relocate above flood level, install wet-certified products		\$\$\$\$		●		
<input type="checkbox"/> Insulate ducts to reduce heat/cooling loss		\$\$-\$	●	●		
<input type="checkbox"/> Replace older HVAC equipment and locate with minimal visibility that meets code		\$\$\$\$		●		
<input type="checkbox"/> Replace multiple window air conditioner units with an efficient ductless mini-split		\$\$\$\$		●		●
<input type="checkbox"/> Use a dehumidifier, fan, or ceiling fan		\$	●			●
<input type="checkbox"/> Install a whole-house fan in the attic		\$\$		●		●
<b>ELECTRICAL</b> <span style="float: right;">Page R7.5</span>						
<input type="checkbox"/> Trim tree limbs that may fall on power lines		C-\$	●	●		
<input type="checkbox"/> Bury overhead utility lines		\$\$\$		●		
<input type="checkbox"/> Elevate electrical system elements like outlets, junction boxes, and switches		\$\$-\$		●		
<input type="checkbox"/> Install and maintain a generator		\$\$\$	●			●
<input type="checkbox"/> Obtain portable photovoltaic panels with battery storage		\$\$	●			●
<input type="checkbox"/> Install permanent solar panels		\$\$\$		●	●	
<input type="checkbox"/> Replace old appliances with Energy Star products		\$\$-\$	●			●
<b>PLUMBING</b> <span style="float: right;">Page R7.6</span>						
<input type="checkbox"/> Install a backflow preventer		\$\$-\$		●		●
<input type="checkbox"/> Install efficient shower heads and toilets		C-\$	●	●		
<input type="checkbox"/> Install straps to secure water tanks and use flexible fuel and water lines		C	●			●
<input type="checkbox"/> Secure fuel supplies and connections		C	●			
<input type="checkbox"/> Insulate hot water tank and metal piping		C-\$	●	●		●
<input type="checkbox"/> Replace tank-style hot water heater with an on-demand or "instant" hot water system		\$\$-\$		●		●

## BUILDING SYSTEMS RESOURCES

### Charleston Water System

Overview of Backflow Prevention

[charlestonwater.com](http://charlestonwater.com)

### City of Charleston

Guidelines and Requirements for HVAC System Ducts

Sustainability: You Can Help

[charleston-sc.gov](http://charleston-sc.gov)

### Dominion Energy

Ductwork Improvement Rebate

Virtual Home Energy Check-up

[dominionenergy.com](http://dominionenergy.com)

### Federal Emergency Management Administration

Earthquake Safety at Home P-530

Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems: New and Substantially Improved Buildings, 3.1

Protecting Building Utility Systems from Flood Damage, P-348

[fema.gov](http://fema.gov)

### Mississippi State Extension Office

Energy Efficient Homes: Air Conditioning

[extension.msstate.edu](http://extension.msstate.edu)

### State of South Carolina

Energy Saver Tool and Energy Audit

[energysaver.sc.gov](http://energysaver.sc.gov)

### U.S. Department of Energy

Energy Star Products

Fact Sheet 31318 Right-Size Heating and Cooling Equipment

Finding and Selecting an Energy Assessor

Minimizing Energy Losses in Ducts

[energy.gov](http://energy.gov)



### REGULATIONS TO REVIEW

- International Existing Building Code
- South Carolina Residential Code
- South Carolina Mechanical; Fuel, Fire, Plumbing
- City of Charleston Code of Ordinances
- City of Charleston Flood Hazard Prevention and Control Ordinance

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

#### City of Charleston Permit Center

2 George Street, Ground Floor  
Charleston, SC 29401  
843.577.5550  
[permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)



Interior space documented by the Historic American Buildings Survey, post-1933. ([www.loc.gov](http://www.loc.gov))

# R8

## RESILIENCE GUIDANCE: BUILDING INTERIOR

### INTERIOR IMPROVEMENT GOALS

*People spend most of their time indoors, between work and home. Increasing safety during a disaster, speeding recovery, and maintaining air and temperature comforts can increase physical and emotional resilience.*

### MAINTENANCE AND PERMITTING

A building permit may be required for any of these suggested work items. (*Refer to Resilience Guidance: Permit Review, page R1.5.*) Also, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center. Additional resources and codes can be found on the last page of this topic section.

Small, low-cost changes can be implemented for residential and commercial interiors to improve resilience. As a starting point, it is important to identify areas of vulnerability within a building. These can include interior finishes on walls and floors, the location of appliances and building systems, the types and location of furnishings, and the way the sun impacts interior environmental conditions at different times of the day. Some changes are behavioral suggestions to improve indoor comfort, while others include physical changes to improve occupant safety and resilience.

Improving resilience for interior spaces can reduce the effects of:

- **Flood Damage:** Relocate items stored on or near a low floor, install water-resistant building materials, modify electrical systems and outlets, and reduce water use to decrease sewer discharge
- **Wind:** Relocate fragile items away from window and door openings and install functional shutters or prepare temporary opening protection
- **Earthquake Damage:** Secure ceiling-mounted, wall-mounted, and tabletop items, as well as large furnishings that are at risk for falling and creating injury or blocking exit paths
- **Extreme Heat:** Identify interior areas where the sun has the greatest impact, manage interior sunlight by adjusting window shades, decrease heat output of interior appliances and light fixtures

These natural threats may occur seasonally, and with or without advance notice. Implementing small, preventive measures can decrease preparation and recovery time, and damage, for impacted occupants.





Even if there is no major structural or exterior damage, the loss of personal belongings, costs for replacing appliances and furniture, and the clean-up labor can be overwhelming. Preventive measures can reduce the severity of flood loss and speed recovery for owners and tenants.

## REDUCING INTERIOR FLOOD DAMAGE

Just an inch of floodwaters can cause significant damage, and if left untreated, the resulting moisture can promote mold growth. Even more challenging circumstances occur if floodwaters are contaminated. Adhere to any safety precautions issued by local officials when dealing with contaminated floodwaters. **Depending on the flood risk and past events, it may be prudent to establish a water-resistant threshold 6 to 18 inches above the ground floor.** Assuming this area could become inundated, consider basic changes that will reduce potential damage and ease the clean-up process.

### ELECTRIC/GAS APPLIANCES AND EQUIPMENT

Relocating equipment to a higher elevation level may reduce a potential environmental hazard by preventing gas, oil, and chemicals from mixing with floodwater, and also reduce the chance of electrocution. Equipment and appliances include boilers, kitchen appliances, water heaters, electrical panels, washers, dryers, computers, and entertainment systems. When relocating these items, aim to raise them to the Design Flood Elevation (DFE) at a minimum. (Refer to *Building Construction in Flood Zones*, [charleston-sc.gov](http://charleston-sc.gov).)

#### KEY TIPS:

- Elevate major appliances and other energy-powered equipment on raised platforms made of flood-resistant materials, or locate on upper floors
- Raise secondary elements such as electrical outlets, power strips, junction boxes, switches, disconnects, panels, and utility meters
- Protect utility connection openings or close gaps where possible, and convert outlets to GFCI receptacles below the DFE
- Refer to *Section R7: Building Systems* for recommendations regarding hot water heaters, HVAC systems, and other building-wide utilities



Appliance pedestals can be purchased or built.



It is easier to relocate electric outlets to reduce future flood damage when wall finishes are removed and repaired.

## RESIDENTIAL FURNISHINGS AND STORAGE

Property owners and tenants should consider selecting furnishings and appliances that can be easily moved or cleaned and disinfected if exposed to floodwater. This can also include purchasing secured, plastic storage containers for use during, or in preparation of, a flood event. (*Refer to Hurricane and Flood Preparedness for Resilience, page R1.12.*)

### RESIDENCES

- Select floor-mounted kitchen cabinets, appliances, bookcases, dressers, chairs, sofas, etc., with metal legs or those constructed of water-resistant materials to ease the cleaning process
- Minimize fabrics and soft materials near floors, such as rugs, cloth chairs, sofas, bed linens, and drapes

### STORAGE

- Limit storage and equipment in flood-vulnerable areas, particularly valuable papers, photographs, and heirlooms
- If flood-vulnerable storage is the only option, elevate items above the floor on shelves or raised surfaces, and store them in secured plastic bins to prevent flotation in the water



*Selectively relocate items to upper floors and use plastic storage bins. Protect window openings prior to a storm and have plastic sheathing available to protect items from small roof leaks if necessary.*



*Moveable cabinets and shelves allow for flexible storage on upper floors.*



*Equipment that cannot be hosed down will need to be temporarily relocated.*

## COMMERCIAL FURNISHINGS AND STORAGE

Non-residential interiors usually have high-powered equipment, large furniture, and densely packed storage spaces. As employment centers, they depend on staff returning to work in safe conditions.

### RETAIL STORES

- Utilize metal and/or plastic wall-mounted and free-standing merchandise displays
- Limit merchandise storage on the floor

### OFFICES

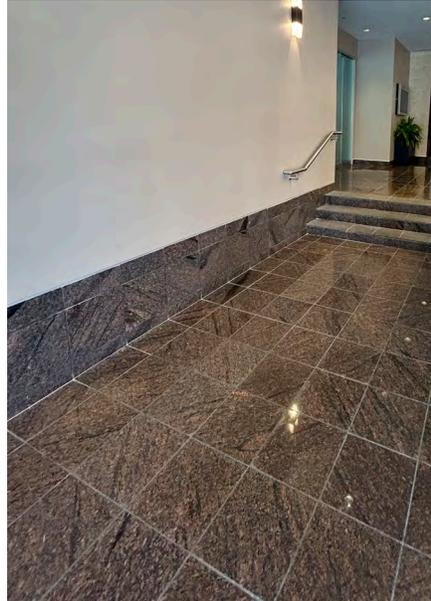
- Locate all equipment, including computers, servers, printers, and associated power supplies above flood-prone areas
- Store valuable papers above flood-prone areas
- Maintain electronic copies of documents in a secure off-site location

### RESTAURANTS

- Store equipment and supplies on shelving, or mount kitchen equipment on wheels to allow relocation to higher ground
- Install quick-release valves at gas connections to allow fast relocation of equipment and install flexible fuel lines (*refer to Reducing Earthquake Damage, page R8.5*)
- Select easily-cleaned, lightweight chairs that can stack on tables
- Utilize concrete or other solid surface materials for bars and banquettes for easy cleaning



Wood floors can 'cup' while curing and should be dried out slowly after a flood.



The ground floor and lower walls of this commercial space are covered with granite tile that can be sprayed down following a flood event.



Insurance should be supplemented with physical mitigation practices.

## FLOOD DAMAGE RESISTANT MATERIALS

Certain building materials are less affected than others when submerged in water. When planning a renovation or repairing storm damage, evaluate whether the existing materials can withstand a flood event. **Compliance with local and federal regulations for floodproofing may necessitate replacement of certain materials with alternative flood damage resistant materials below the Design Flood Elevation (DFE) as required by the local ordinance.** (Refer to *Building Construction in Flood Zones*, [charleston-sc.gov](http://charleston-sc.gov).)

### FLOORS

- Select floor finishes that are easy to clean and disinfect, such as a solid-surface material like tile or polished concrete flooring, instead of carpet or wood laminate
- Obtain professional advice from preservation experts to determine if traditional flooring materials can be repaired or salvaged

### WALLS

- Evaluate opportunities to replace vulnerable wall materials with materials that are flood-resistant, or are removable, in areas that are flood-prone
- Reduce opportunities for mold growth by removing standing water and wet insulation as soon as possible, and ventilating the room and wall cavity
- Install baseboards and cornices that are easily removed
- Obtain dehumidifiers and fans to deploy when needed
- Apply paint with a mold-resistant additive to discourage mold from spreading to other walls

### FLOOD INSURANCE

Flood insurance is available for tenants and property owners for building contents, not just the building itself. The National Flood Insurance Program (NFIP) offers insurance for building and separately for contents for both residential and commercial properties. (Refer to *Floodsmart*, sidebar below.) Flood insurance is also available from private companies, although amounts may vary.

### FLOODSMART

FloodSmart, administered by FEMA, is the official website of the National Flood Insurance Program (NFIP). It is a valuable resource for property owners and includes information regarding flood risk, flood insurance, and reducing flood risk. ([www.floodsmart.gov](http://www.floodsmart.gov))

### RENTERS

According to the 2022 U.S. Census Bureau, 43.3% of Charleston housing units are renter-occupied. The landlord's insurance will not cover damage to the tenant's personal belongings or furnishings. Similarly, the landlord's flood insurance policy will not cover damage to a commercial property.

**To be covered, the residential or commercial tenant must obtain a separate flood insurance policy for their contents.**



Heavy and tall objects near stairways and exit doors should be secured with straps attached to wall studs.

## REDUCING EARTHQUAKE DAMAGE

Most often there is little notice of an impending earthquake. It is important for building occupants to consider permanent changes that can accommodate the building use and access to everyday items. As a priority, secure or relocate heavy objects to reduce potential injury or more severe property damage. Items to consider include overhead fixtures, wall-mounted items, and tall furniture, in addition to flammable or toxic chemicals.

### FURNITURE, LOOSE OBJECTS, AND WALL DECOR

Conduct a visual audit of all interior spaces to identify objects that are loosely stowed, sizeable items that may fall onto individuals or block exits, and hanging on walls over sitting and sleeping areas.

#### KEY TIPS:

- If there is sufficient warning, fragile personal items can be removed from shelves and securely stowed away; be aware that sentimental or valuable breakable items may fall, or vibrations can weaken loosely secured pieces
- Anchor tall furniture pieces such as armoires, chests of drawers, book cases, and file cabinets to wall studs with hardware straps
- Strap down tabletop televisions and computer screens
- Suspend wall mounted paintings and mirrors with at least two fasteners tied into wall studs, and avoid hanging these over beds or seating areas
- Secure wall-mounted kitchen cabinets to studs and install latches to prevent contents from spilling out and causing personal injury; options include child-proof latches or latches available for boats and RVs
- Place non-skid matting under electronics and use putty or museum wax to keep items on shelves from slipping off

### PERMANENT APPLIANCES, FIXTURES, AND GLAZED OPENINGS

Heavy appliances and fixtures should be inspected to ensure they are properly anchored to improve their resistance to major vibrations and shockwaves.

#### KEY TIPS:

- Know the location of electric shut-offs, gas and water valves, and how to operate them
- Install secondary shut-offs that do not require special tools
- Restrain free-standing appliances (such as hot water heaters with straps anchored to wall studs (*refer to Plumbing, page R7.6*))
- Replace rigid water and gas pipe connectors with flexible connectors to hot water heaters and appliances (*refer to Plumbing, page R7.6*)
- Ensure heavy, wall-mounted equipment, fireplace mantles, and stone and brick veneers are anchored to wall studs (*refer to Locating Studs Under a Wall, sidebar at left*)
- Install safety wires from ceiling-mounted fans and lights to ceiling joists
- Install tempered glazing film on glass that is overhead or near exit routes to protect occupants from shattered glass (*refer to Glass, sidebar page R6.7*)



#### LOCATING STUDS UNDER A WALL

- Modern wall studs are set at 16" apart while older studs (top) varies and can be as much as 24" apart
- Use a studfinder tool or inspect areas at wall corners or left- and right-sides of an electric outlet.
- Use a tape measure to estimate where the next stud should be, and confirm by drilling a small hole after verifying no electrical or gas lines are present



INSULATION MATRIX		
TYPE /MATERIAL	BENEFITS	DISADVANTAGES
<p><b>Blanket–Batts and Rolls</b></p> <ul style="list-style-type: none"> <li>• Fiberglass</li> <li>• Mineral wool</li> <li>• Plastic fiber</li> <li>• Natural fiber</li> </ul>	<ul style="list-style-type: none"> <li>• Sized to fit between standard spaced studs, joists, and beams that are relatively free of obstructions such as pipes, conduits, and braces</li> <li>• Relatively inexpensive</li> <li>• Can be used to insulate ducts</li> <li>• Can be do-it-yourself project; wear protective eye wear and clothing</li> </ul>	<ul style="list-style-type: none"> <li>• Can become matted-down if wet</li> <li>• Vapor barriers found on most blanket insulation can cause condensation problems and rot wood framing; install without backing or with air barrier only on outside face of sheathing to reduce possible mold and mildew</li> <li>• Should not be “stuffed” around obstructions since it can be a fire hazard around damaged electrical wiring and fixtures that are not rated for contact</li> </ul>
<p><b>Loose-Fill and Blown-In Insulation</b></p> <ul style="list-style-type: none"> <li>• Cellulose</li> <li>• Fiberglass</li> <li>• Mineral wool</li> </ul>	<ul style="list-style-type: none"> <li>• Good for irregularly spaced areas and around obstructions</li> <li>• Only minor disturbance of finishes required for installation</li> <li>• Some materials can be poured rather than blown-in</li> </ul>	<ul style="list-style-type: none"> <li>• Generally must be blown-in using special equipment</li> <li>• Settles over time, requiring additional application, particularly in walls</li> <li>• Cellulose, the most common, is essentially newspaper; when wet, it retains water and can rot wood framing</li> <li>• Cellulose can become homes for nesting pests or insects such as termites and carpenter ants; borate treatment can corrode metal pipes, conduit, and electrical wiring</li> </ul>
<p><b>Radiant Barriers and Reflective Insulation</b></p> <ul style="list-style-type: none"> <li>• Foil-faced kraft paper</li> <li>• Plastic film</li> <li>• Polyethylene bubble</li> <li>• Cardboard</li> </ul>	<ul style="list-style-type: none"> <li>• Reflects radiant heat, such as sunlight, away from living space; can be highly effective in attics</li> <li>• Sized to fit between standard spaced studs, joists, and beams</li> <li>• Bubble systems can be effective around obstructions</li> <li>• Can be a do-it-yourself project</li> </ul>	<ul style="list-style-type: none"> <li>• Must face an air space, such as an attic, to be effective</li> <li>• If not properly installed, can act as a vapor barrier and cause condensation and rot wood framing members (<i>refer to Blanket–Batts and Rolls, above</i>)</li> <li>• Cardboard can become home for nesting pests or insects such as termites and carpenter ants; borate treatment can corrode metal pipes, conduit, and electrical wiring</li> </ul>
<p><b>Sprayed Foam and Foamed-in-Place</b></p> <ul style="list-style-type: none"> <li>• Cementitious</li> <li>• Phenolic</li> <li>• Polyisocyanurate</li> <li>• Polyurethane</li> </ul>	<ul style="list-style-type: none"> <li>• Good for irregularly spaced areas and around obstructions</li> <li>• Typically no disturbance of finishes required for installation</li> <li>• Spray foam polyurethane (SPF) can be used in an attic to improve an existing roof’s wind resilience</li> </ul>	<ul style="list-style-type: none"> <li>• Made from fossil fuels; can have toxic fumes and be highly flammable</li> <li>• Requires professional installation; adheres to all surfaces, can have voids if not properly installed, relatively expensive installation</li> <li>• Termites and carpenter ants can tunnel through, increasing infestation risk</li> <li>• Open-cell softer, often not a vapor barrier</li> <li>• Closed-cell is a vapor barrier and can cause condensation problems and rot at wood framing; removal generally requires “chiselling out” between all framing members</li> </ul>
<p><b>Foam Board</b></p> <ul style="list-style-type: none"> <li>• Polystyrene</li> <li>• Polyisocyanurate</li> <li>• Polyurethane</li> </ul>	<ul style="list-style-type: none"> <li>• High insulation value for relatively little thickness</li> </ul>	<ul style="list-style-type: none"> <li>• Made from fossil fuels, can have toxic fumes and be highly flammable</li> <li>• Must be cut to fit around all obstructions; requires complete removal of wall finish</li> <li>• Termites and carpenter ants can tunnel through, increasing infestation risk</li> <li>• Can be installed under un-vented, low-sloped roofs</li> </ul>



Dehumidifiers can help regulate indoor humidity and increase comfort.

## INDOOR HEAT RESILIENCE

Improvements that reduce the impacts of extreme heat and sun for indoor spaces will also improve energy sustainability to some degree. Most buildings rely on equipment to regulate indoor air comfort, so if their run time is reduced and energy efficient equipment is installed, there is not as much strain on the building system and, collectively, the community grid. Several projects with minimal cost can go a long way to reduce heat production and energy consumption.

### KEY TIPS:

- Install thermal blinds or shades for windows and glazed doors, and close window coverings on the south and west sides of the building in summer afternoons (*refer to Reducing Heat Gain, page R6.7*)
- Upgrade or replace wall insulation (*refer to Insulation Matrix, page R8.6*)
- Replace ineffective or worn weatherstripping (*refer to Weatherstripping and Caulk, page R6.8*)
- Replace incandescent and CFL bulbs with LED bulbs that use less energy and emit less heat (*refer to Light Bulbs Generate Heat, sidebar at left*)
- Install a digital thermostat (*refer to Basic Systems Maintenance to Improve Resilience, page R7.3*)
- Use a fan to improve air circulation; maintain a bowl of ice water in front to feel cooler
- Use dehumidifiers in summer months sized appropriately for the space; connect a hose to easily convey collected water to a floor drain
- Limit oven use during summer months; instead use outdoor grill, toaster oven, or microwave if available
- Dry dishes on a rack or limit use of dishwasher to full loads in the evening and early morning
- Hang clothes to dry or install a moisture sensor on clothes dryer to prevent over-drying, run full loads, remove lint after every load, limit use of clothes dryer to evening and early morning
- Install a water cooler or keep a water bottle in the refrigerator for easy access to cold water
- Replace older appliances with Energy Star rated appliances; seek rebates and tax credits if applicable (*refer to Potential Rebate Offers, sidebar page R7.5*)
- Place high-energy appliances on north or west sides of the building, increase insulation, and reduce thermal absorption from the building exterior (*refer to Reducing Heat Gain, page R6.7 and Insulation Matrix, page R8.6*)
- Replace older air conditioning units with variable speed Energy Star products that include dehumidification (*refer to Potential Rebate Offers, sidebar page R7.5*)
- Install a whole-house attic fan in un-insulated buildings to minimize possible humidity and mold issues at insulated buildings (*refer to Heating and Air Conditioning, page R7.4*)

### LIGHT BULBS GENERATE HEAT

- LED lights emit very little heat; although they may be warm to the touch, they are not hot like incandescent and compact fluorescent bulbs
- Incandescent bulbs can be over 400 degrees and they release 90% of this energy as heat
- Compact fluorescent lights (CFL), while still more efficient than incandescent, release about 80% of their energy as heat

([www.energy.gov](http://www.energy.gov))

### REDUCING WIND DAMAGE

Damage from winds during a thunderstorm, tornado, or hurricane event will most likely be caused from compromised window or door openings, flying debris, or fallen trees. Secure indoor items away from windows, cover or secure items in storage containers, and anchor items to the walls. (*Refer to Wind and Debris Protection, page R6.5.*)



## HISTORIC PRESERVATION CONSIDERATIONS

Most buildings, even if located in a historic district, do not have historic preservation regulations associated with interior spaces. In very few cases, properties may be subject to a private easement. Information is provided below to identify best practices toward maintaining the historic character of a property when changes are made to interior spaces.

### FLOODING

- Repair and retain historic materials to the extent possible (*refer to Flood-Resistant Materials: An Alternative Approach, sidebar page R8.12*)
- Limit the use of replacement flood-resistant materials to highly vulnerable areas
- For locations where flood-resistant materials are required, select alternatives that are visually compatible to historic materials
- Obtain insurance coverage for replacement cash value versus actual cash value for contents (*refer to Flood Insurance, sidebar page R8.4*)

### EARTHQUAKE

- If significant structural bracing is undertaken, remove as little historic fabric as possible and prioritize the most significant changes for spaces of least significance
- Consult conservation specialists to anchor fine antiques

### HEAT

- Select interior window coverings that are visually neutral from the exterior
- Consult with a preservation architect for recommendations regarding insulation improvements



Modifications that could affect interior spaces include changing molding and trim details or materials, removing historic plaster, and installing any permanent reinforcing systems.

## BUILDING INTERIOR IMPROVEMENT CHECKLIST

The Building Interior Improvement Checklist on the following pages identifies maintenance needs and potential resilience improvements. Information on the relative costs, expertise, and vulnerabilities addressed are keyed with icons described at right.

**Level of Risk and Professional Help:** The Checklist identifies work that can be completed by property owners or tenants who are able to safely and comfortably use hand tools or power equipment, as needed. Any lifting, bending, or exertion beyond a person’s abilities should be undertaken by professionals.

**Vulnerabilities:** The icons below are used throughout this guide. Completion of the proposed improvements can increase a building’s resilience from the following vulnerabilities:

-  Flood
-  Wind
-  Earthquake
-  Heat
-  Good maintenance

**Cost:** The relative cost of the proposed improvement is denoted by symbols below. The cost will vary based on the conditions and extent of the impacted area.

- ¢ Minimal supplies under \$100
- \$ \$100-\$1,000
- \$\$ \$1,000-\$5,000
- \$\$\$ \$5,000 and above

**“Off-the-Shelf” Solution Available:** An item that is relatively available for purchase and easy to install by a property owner or contractor.

**BUILDING INTERIOR IMPROVEMENT CHECKLIST**

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	<b>RESILIENCE BENEFIT</b>	<b>COST</b>	<b>DO-IT-YOURSELF</b>	<b>CONTRACTOR MAY BE REQUIRED*</b>	<b>ARCHITECT OR ENGINEER MAY BE REQUIRED</b>	<b>“OFF-THE SHELF” SOLUTION AVAILABLE</b>
<b>REDUCING INTERIOR FLOOD DAMAGE</b> <span style="float: right;">Page R8.2</span>						
<input type="checkbox"/> Elevate major appliances and other energy-powered equipment on raised platforms		¢-\$	●	●		●
<input type="checkbox"/> Raise secondary elements such as electrical outlets, junction boxes, switches, disconnects, panels, and utility meters		\$-\$\$		●		
<input type="checkbox"/> Protect utility connection openings or close gaps as much as possible and convert outlets to GFCI receptacles below the DFE		\$-\$\$		●		
<input type="checkbox"/> Select floor-mounted kitchen cabinets, appliances, bookcases, dressers, chairs, sofas, etc., with flood-resistant materials and use items that are easily stacked/relocated		\$-\$\$	●			●
<input type="checkbox"/> Minimize fabrics and soft materials near floors		¢	●			
<input type="checkbox"/> Limit storage and equipment in flood-vulnerable areas; elevate items above the floor, store in secured plastic bins		¢	●			●
<input type="checkbox"/> Utilize metal and/or plastic wall-mounted and free-standing or movable cabinets		¢-\$	●			●
<input type="checkbox"/> Maintain electronic copies of files off-site		¢-\$	●			
<input type="checkbox"/> Install quick-release valves at gas connections to allow quick relocation of equipment; install flexible fuel and water lines		\$-\$\$	●	●		●
<input type="checkbox"/> Select floor finishes that are easy to clean		¢-\$\$	●	●		
<input type="checkbox"/> Consult preservation experts to determine if traditional flooring materials can be repaired		¢-\$\$			●	
<input type="checkbox"/> Replace, or use removable, vulnerable wall and insulation materials		\$-\$\$		●		
<input type="checkbox"/> Install baseboards and cornices that are easily removed to ventilate wall cavity		¢-\$\$	●	●		
<input type="checkbox"/> Obtain dehumidifiers and fans		¢-\$	●			●
<input type="checkbox"/> Apply paint with a mold-resistant additive		¢-\$\$	●			●

# RESILIENCE GUIDANCE: BUILDING INTERIOR

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED*	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>REDUCING EARTHQUAKE DAMAGE</b>						
<input type="checkbox"/> Remove fragile items from shelves and securely stow		¢	●			
<input type="checkbox"/> Anchor tall furniture pieces such as armoires, chests of drawers, book cases, and file cabinets to wall studs with strap hardware		¢	●			●
<input type="checkbox"/> Strap down televisions and computer screens		¢	●			●
<input type="checkbox"/> Suspend wall-mounted paintings and mirrors with at least two fasteners tied into wall studs; avoid hanging over beds or seating areas		¢	●			●
<input type="checkbox"/> Secure wall-mounted kitchen cabinets to studs and install latches		¢-\$	●			●
<input type="checkbox"/> Place non-skid matting under electronics and use putty or museum wax to keep items in place		¢	●			●
<input type="checkbox"/> Inspect anchoring of heavy appliances and fixtures		¢	●			
<input type="checkbox"/> Know where electric shut-offs, gas and water valves are located and how to turn them off		¢	●			
<input type="checkbox"/> Install secondary shut-offs that do not require a special tool		\$\$-\$		●		
<input type="checkbox"/> Restrain free-standing appliances such as hot water heaters with straps anchored to wall studs		¢-\$	●	●		●
<input type="checkbox"/> Replace rigid water and gas pipe connectors with flexible connectors to appliances and equipment like hot water heaters		¢-\$	●	●		●
<input type="checkbox"/> Ensure heavy, wall-mounted equipment or brick veneers and mantels are anchored to wall studs		¢-\$	●	●		
<input type="checkbox"/> Install safety wires from overhead light fixtures and ceiling fans to ceiling joists		¢-\$	●	●		
<input type="checkbox"/> Install tempered glazing film on glass that is overhead or near exit routes		¢-\$	●	●		●

<b>ACTION / PROJECT</b> <i>PERMITS: A building permit may be required for any of these suggested work items. Additionally, if the property is subject to review by the Board of Architectural Review or Design Review Board, additional reviews may be required. For any questions or concerns, contact the Permit Center.</i>	RESILIENCE BENEFIT	COST	DO-IT-YOURSELF	CONTRACTOR MAY BE REQUIRED*	ARCHITECT OR ENGINEER MAY BE REQUIRED	"OFF-THE-SHELF" SOLUTION AVAILABLE
<b>INDOOR HEAT RESILIENCE</b> <span style="float: right;">Page R8.7</span>						
<input type="checkbox"/> Install thermal blinds or shades at windows and glazed doors, and close window coverings on the south and west sides of the building in summer afternoons		\$\$-\$	●			●
<input type="checkbox"/> Upgrade or replace wall insulation		\$\$\$\$		●		
<input type="checkbox"/> Replace ineffective or worn weatherstripping		\$\$\$\$	●			●
<input type="checkbox"/> Replace incandescent and CFL bulbs with LED bulbs that use less energy and emit less heat		¢-\$	●			●
<input type="checkbox"/> Install a digital thermostat		¢	●			●
<input type="checkbox"/> Use dehumidifiers in summer months according to performance capacity and size of the space		¢-\$	●			●
<input type="checkbox"/> Use a fan to improve air circulation, maintain a bowl of ice water in front to feel cooler		¢	●			●
<input type="checkbox"/> Limit oven use during summer months and use alternate or outdoor sources		¢	●			●
<input type="checkbox"/> Limit use of dishwasher during summer months and use rack for drying		¢	●			
<input type="checkbox"/> Limit use of clothes dryer during summer months, install a moisture sensor to prevent over-drying		¢	●			●
<input type="checkbox"/> Install a water cooler or keep a water bottle in the refrigerator for easy access to cold water		¢	●			●
<input type="checkbox"/> Replace older appliances with Energy Star rated appliances, seek rebates and tax credits if applicable		\$\$\$\$	●	●		
<input type="checkbox"/> Place high-energy appliances on north or east sides of the building		¢-\$	●	●		●
<input type="checkbox"/> Replace older air conditioning units with variable speed Energy Star products that include dehumidification		\$\$-\$\$\$		●		
<input type="checkbox"/> Install a whole-house attic fan in un-insulated building		¢-\$\$	●	●		●

## BUILDING INTERIOR RESOURCES

### California Department of General Services

Guidelines for Bracing Residential Water Heaters  
[dgs.ca.gov](http://dgs.ca.gov)

### Charleston Water System

Boil Water Advisories  
[charlestonwater.com](http://charlestonwater.com)

### City of Charleston

Building Construction in Flood Zones  
[charleston-sc.gov](http://charleston-sc.gov)

### Federal Emergency Management Agency (FEMA)

After the Flood: Advice for Salvaging Damaged Family Treasures  
Earthquake Safety at Home P-530  
Seismic Retrofit Guidelines for Detached, Single-Family Wood Frame Dwellings P-50-1  
Technical Bulletin 2-08 Flood Damage Resistant Materials Requirements  
[fema.gov](http://fema.gov)

### National Park Service

Preservation Brief 41: The Seismic Rehabilitation of Historic Buildings  
Testing the Flood Resilience of Traditional Building Assemblies  
[nps.gov](http://nps.gov)

## FLOOD-RESISTANT MATERIAL REQUIREMENTS

Compliance with NFIP Flood Damage Resistant Materials Requirements may necessitate replacement of historic materials with alternative flood damage resistant materials below the BFE/DFE as required by the local ordinance.

## FLOOD-RESISTANT MATERIALS: AN ALTERNATIVE APPROACH

To best preserve historic building components, deploy a slow, temperature-controlled, and carefully monitored process of drying-out. Although Historic England acknowledges that there will be some material degradation, particularly for high floods or if the floodwater contains salts or other contaminants, they argue that many historic materials can be saved with proper care. This approach may be an appropriate alternative to material replacement where not otherwise required for NFIP compliance.

## REGULATIONS TO REVIEW

- International Existing Building Code
- South Carolina Building Code / Residential Code
- City of Charleston Code of Ordinances / Flood Hazard Prevention and Control Ordinance

*This is not a comprehensive list and is intended only to provide additional resources to consider when planning a project. Contact the Permit Center for detailed information.*

### City of Charleston Permit Center

2 George Street, Ground Floor; Charleston, SC 29401  
843.577.5550; [permits@charleston-sc.gov](mailto:permits@charleston-sc.gov)

### State of South Carolina

Energy Saver Tool, [energysaver.sc.gov](http://energysaver.sc.gov)  
How to Keep Your Flood Insurance Cost as Low as Possible, [doi.sc.gov](http://doi.sc.gov)  
Earthquake Coverage, [doi.sc.gov](http://doi.sc.gov)  
South Carolina Emergency Management Division:  
Earthquake Guide, [scemd.org](http://scemd.org)

### U.S. Department of Energy

Whole House Ventilation  
[energy.gov](http://energy.gov)

### U.S. Environmental Protection Agency

Climate Change: What you can do at Home  
[epa.gov](http://epa.gov)

## HISTORIC ENGLAND—FLOODING AND HISTORIC BUILDINGS

*Although relatively resistant to flood damage, historic-building materials can all suffer some degradation and may need appropriate treatment. These materials include stone, solid brick-and-mortar walls, timber frames, wattle-and-daub panels, timber boarding and paneling, earthen walls and floors, lime-plaster walls and ceilings and many decorative finishes.*

*Organic materials such as timbers swell and distort when wet and suffer fungal and insect infestations if left damp for too long. If dried too quickly and at temperatures that are too high, organic materials can shrink and split, or twist if they are restrained in panels. Inorganic porous materials do not generally suffer directly from biological attack.*

*Significant damage can occur when inherent salt and water (frost) crystals carried through the substrate are released through inappropriate drying or very cold conditions. (Historic England, 2015; [www.historicengland.org](http://www.historicengland.org))*

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[www.charleston-sc.gov](http://www.charleston-sc.gov)

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of CHARLESTON

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## ABOUT THE AUTHORS



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In 1995, Dominique established Preservation Design Partnership as a planning and design practice focusing exclusively on offering high-quality professional services for clients with nationally significant historic sites and buildings. Her work is at the forefront of addressing change at historic buildings and settings through design, the regulatory process, and the impacts of climate change and flooding at historic properties. Dominique's work maintains the highest standards of planning, design, and preservation and has been recognized with several national, regional, and local preservation and design awards. In 2022, Dominique was the recipient of the Harley J. McKee Award for outstanding contribution to the field of preservation technology, the highest honor of the Association for Preservation Technology International. She currently serves on the Board of the National Center for Preservation Technology and Training.



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Jennifer holds a Master of Science in Architectural Studies from the University of Florida and has worked in a combination of local, state, and non-profit levels of historic preservation for 15 years. Most importantly, she served as the Historic Preservation Officer for the City of St. Augustine that successfully implemented Certified Local Government procedures and grants from the Florida Division of Historical Resources. She qualifies for the 36 CFR 61 Professional Qualification Standards in Architectural History. Jennifer served as the preservation planning specialist in the preparation of Resilience Guidance for Charleston, supporting all project activities under Dominique's leadership.

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