Designing Disaster Resilient Buildings to Minimize Debris

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Introduction

Every year, natural disasters challenge the built environment for communities in the United States, destroying homes, businesses, and other infrastructure and costing billions of dollars in damages. As climate change increases, the frequency and severity of natural disasters, such as landslides, hurricanes, tornadoes, wildfires, and intense storms, the impacts associated with these disasters are growing and include loss of life, community disruptions, environmental impacts, property loss, and the burden of dealing with disaster debris. Natural disasters can also cause environmental justice impacts that should be addressed in all disaster phases.

What Is the Built Environment?

The built environment touches all aspects of people's lives, encompassing the buildings people live and work in, the distribution systems that provide communities with water and electricity, and the roads, bridges, and transportation systems people use to get from place to place.

Generally, the built environment encompasses the human-made or modified structures that provide people with living, working, and recreational spaces. Creating all these spaces and systems requires enormous quantities of materials.

Environmental Justice

Environmental justice[1] means the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment so that people:

- are fully protected from disproportionate and adverse human health and environmental effects (including risks) and hazards, including those related to climate change, the cumulative impacts of environmental and other burdens, and the legacy of racism or other structural or systemic barriers; and
- have equitable access to a healthy, sustainable, and resilient environment in which to live, play, work, learn, grow, worship, and engage in cultural and subsistence practices.

Due to factors such as historical discrimination, social marginalization, economic inequality, and environmental degradation, disasters and climate events often disproportionately affect communities with environmental justice concerns, worsening environmental, economic, and health injustices. For example, their proximity to industrial areas and hazardous waste sites make them more vulnerable to toxic leaks from storm damage and the mental and physical

impacts of contaminated, unmanaged disaster debris.[2] Limited access to information, resources, and assistance can exacerbate the harm to these communities.

The Federal Emergency Management Agency's (FEMA's) *2022–2026 Strategic Plan*[3] recognizes that underserved communities and specific identity groups often suffer disproportionately from disasters. As a result, disasters can worsen existing inequities in society through, for example, the unequal siting of debris staging areas or the lack of local participation in debris management and recovery planning. This cycle compounds the challenges faced by these communities and increases their risk to future disasters.

Therefore, it is critical to advance human safety and environmental justice for all by providing resilient, affordable housing and effective, equitable disaster debris planning and management, which are key to the health, safety, and recovery of communities impacted by natural disasters.

To achieve this, marginalized and overburdened communities should be ensured access to the full range of disaster mitigation, response, and recovery resources (e.g., funding, equipment, personnel) and be involved as equal partners at every level of decision-making (e.g., planning, implementation, evaluation). As Administrator Regan in EPA's FY 2022-2026 Strategic Plan[4] statement shares, "We will employ the full array of policy and legal tools at our disposal to incorporate environmental and climate justice considerations in our analysis, rulemaking, permitting, enforcement, grantmaking, operations, **disaster response and recovery**, and other activities."

Disaster response and recovery also increase the demands on energy, natural resources, and community resources. By taking action to mitigate risks before a natural disaster occurs, communities can reduce community disruption and recovery costs after a disaster, supporting environmental justice, as well as advancing a circular economy. Some of the actions that can help mitigate risks are designing resilient and adaptable buildings and retrofitting existing buildings, securing the property against expected hazards, creating a disaster debris management plan, and contacting relevant agencies and organizations.

What is a Circular Economy?

A **circular economy** keeps materials and products in circulation for as long possible. The Save Our Seas 2.0 Act refers to an economy that uses a systems-focused approach and involves industrial processes and economic activities that are restorative or regenerative by design, enables resources used in such processes and activities to maintain their highest value for as long as possible, and aims for the elimination of waste through the superior design of materials, products, and systems.[5]

What is Embodied Carbon?

Also known as embodied greenhouse gas (GHG) emissions, **embodied carbon** refers to the amount of GHG emissions associated with upstream—extraction, production, transport, and manufacturing—stages of a product's life. Many initiatives to track, disclose, and reduce embodied carbon emissions also consider emissions associated with the use of a product and its disposal.[6]

Understanding and disclosing these emissions to better inform selection of lower-embodied carbon construction materials and products is rapidly advancing and is critical to reducing the carbon footprint of the built environment.

Decisions on design, construction, and materials within the built environment can have significant impacts on carbon emissions, human health, and resiliency.

This document focuses on actions community officials, leaders, and members (including those in cities, counties, states, territories, tribes, businesses, and community organizations) can take to plan, design, improve, and adapt homes and other buildings to withstand natural disasters today and in a changing climate. It advances a circular economy approach, shifting from the model in which resources are mined, made into products, and then become waste. A circular economy reduces material use, redesigns materials to be less resource and carbon intensive, and recaptures "waste" as a resource to manufacture new materials and products.

What Is Natural Disaster Debris and Why Should We Care[7]?

Natural disaster debris refers to the material and waste streams resulting from a natural disaster.

Disaster debris often includes building materials, sediments, vegetative debris, and personal property. Large quantities of debris can make response and recovery efforts difficult by hindering emergency personnel, damaging or blocking access to necessary infrastructure, and posing threats to human health and the environment.

The needs for disaster debris mitigation and sustainable management of generated debris are growing rapidly as the frequency and severity of natural disasters continues to increase. For many communities, more and stronger disasters means larger quantities of debris will be generated that may end up in landfills, thereby leaving the circular economy.

Considering the health, environmental, social, and economic costs and impacts to communities associated with debris generation, cleanup, and management, the development of effective strategies to plan for, mitigate, and respond to natural disaster debris is critical for resilience. **Resilience** means the capacity to plan for, withstand, adapt to, and recover from natural disasters with minimal damage in a timely, effective, and safe manner.

From 2011 to 2022, 90 percent of U.S. counties – covering over 300 million people – experienced a flood, hurricane, wildfire, or other emergency serious enough to receive a federal disaster declaration, and more than 700 counties suffered 5 or more such disasters.[8]

When considering all the health, environmental, social, and economic costs of managing debris, including from damaged buildings, after a disaster, it is more sustainable and likely less costly to invest in resilient building siting and design before a disaster happens. A community that invests in debris mitigation actions before a natural disaster occurs can significantly reduce the generation of natural disaster debris after a disaster; protect neighborhoods; save energy, natural resources, and community resources; and, thereby, reduce response and recovery costs.

For example, the National Institute of Building Sciences' *Natural Hazard Mitigation Saves: 2019 Report* documents that rebuilding to the most recent building codes requirements saves on average $11 per $1 spent on mitigation, while exceeding building code minimum requirements saves $4 per $1 spent (Figure 1 below).[9] Additionally, FEMA's *Building Codes Save: A Nationwide Study* estimates $132 billon could be saved in property losses based on past and forecasted growth in the use of modern building codes from 2000–2040.[10]

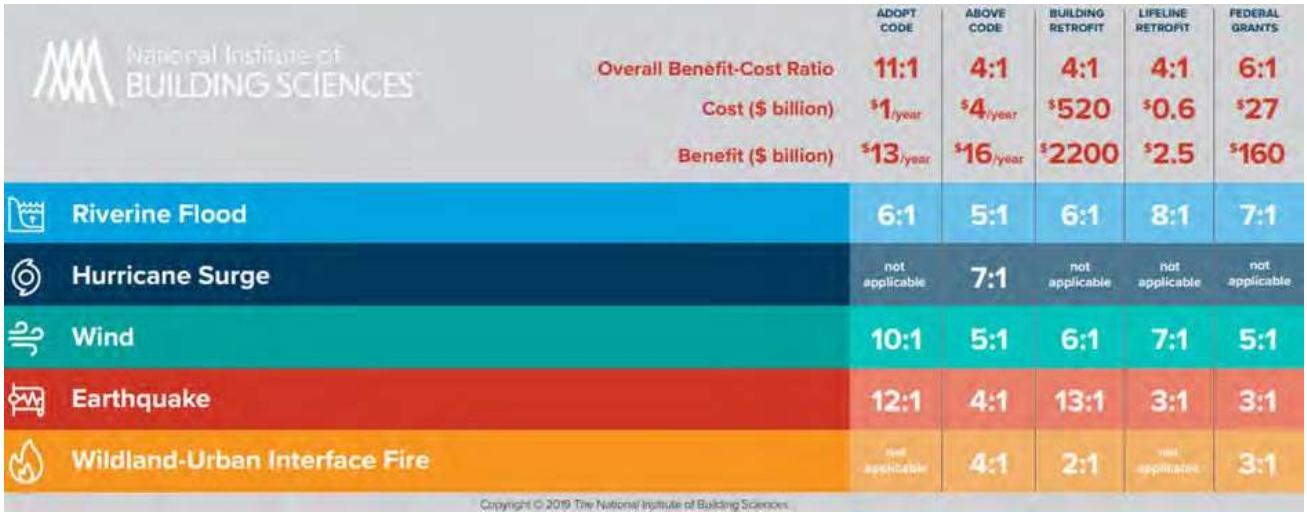

Figure 1. Benefit-Cost Ratio by Hazard and Mitigation Measure (Source: National Institute of Building Sciences' Natural Hazard Mitigation Saves: 2019 Report, *https://www.nibs.org/projects/natural-hazard-mitigation-saves-2019-report).*

To support the implementation of mitigation measures and practices that result in less disaster debris generation and, therefore, reduce the cost of response and recovery, this document provides an overview of:

1) Proven, innovative strategies for disaster-resilient buildings.

2) Lessons learned from natural disasters.

3) Resources on debris management and disaster planning.

Planners, designers, builders, disaster response experts, and community members can use this information to improve communities' adaptation and resilience to natural disasters. ***Climate adaptation*** strategies prepare a community for a changing climate, and resilience strategies increase the ability of the community to withstand and recover from natural disasters and related impacts. Incorporating these strategies together into building designs and improvements creates strong buildings and communities that can:

- **Generate significantly less debris** during and after a natural disaster.
- **Recover faster,** encouraging residents and businesses to stay in the area.
- **Save money and use fewer resources** to rebuild and recover.

Impacts of Natural Disaster Hazards on Buildings

Hazards from flooding, wind, fire, and other natural disasters vary widely and may cause a broad range of building-related damage and debris, especially if buildings have not been designed or retrofitted to withstand worsening hazards. Communities may be at risk for more than one type of natural disaster and may experience several disasters together. Their hazards can impact buildings and communities.

Purchase this course to see the remainder of the technical materials.