**BSESC—Disaster Resistance and Resiliency**

## Proficiency Level 2: Understand

### Learning Objective 2.1

* Explain how the four key principles of building resistance and the three key features of infrastructure resilience are applied to protect buildings from disasters.

### Lecture Notes 2.1

Although often used interchangeably, within the building profession, disaster resistance refers to the ability to resist the onset and impact of a disaster, and disaster resiliency refers to the ability to absorb the impact of a disaster. Some examples of resistance include applying building codes to protect against earthquakes, fire, and high winds and applying best-practice standards. Some examples of resiliency during an emergency and after are the electronic grid operating (or coming back online quickly), accessible potable water, and working community roads and services. Disaster resistance and resiliency are very closely interrelated and involve planning and responding from a specific building level to the community and national level with all applicable professionals and with the specific building occupant/owner.

Four fundamental principles of resistance are essential for all-hazard building design (NIBS 2017):

* **Plan for fire protection**—Use a systems approach that enables the designer to analyze all of the building's components as a total building fire safety system package.
* **Protect occupant safety and health**—Implement measures that take into account issues such as indoor air quality, electrical safety, fall protection, ergonomics, and accident prevention.
* **Mitigate for natural hazards**—Anticipate the damaged buildings and infrastructure risks associated with major natural disasters, such as impacts from hurricanes, floods, earthquakes, tornados, blizzards, and other natural disasters.
* **Provide security for building occupants and assets**—Implement countermeasures to deter, detect, delay, and respond to attacks from human aggressors. It also provides for mitigating measures to limit hazards to prevent catastrophic damage and provide resiliency should an attack occur.

For new buildings, code requirements serve to define the minimum disaster resistance requirements for a local area, but minimum compliance with codes in building design is not always sufficient to guarantee that a facility will perform adequately when impacted by the forces for which it was designed. Therefore, effective building resistance involves the application throughout a building’s lifecycle (from planning to upgrades/remodeling) of regulations, codes, model codes, standards, and best practices and planning and interaction with the larger community, which interconnects with resilience.

“Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event” (NIAC 2009).

Resilience is characterized by three key features (NIAC 2009):

* “Robustness: the ability to maintain critical operations and functions in the face of crisis. This includes the building itself, the design of the infrastructure (office buildings, power generation, distribution structures, bridges, dams, levees), or in system redundancy and substitution (transportation, power grid, communications networks).
* Resourcefulness: the ability to skillfully prepare for, respond to, and manage a crisis or disruption as it unfolds. This includes identifying courses of action and business continuity planning, training, supply chain management, prioritizing actions to control and mitigate damage, and effectively communicating decisions.
* Rapid recovery: the ability to return to and/or reconstitute normal operations as quickly and efficiently as possible after a disruption. Components [of rapid recovery] include carefully drafted contingency plans, competent emergency operations, and the means to get the right people and resources to the right places.”

The National Institute of Building Sciences (NIBS 2017) proposes another key feature of resilience: redundancy, meaning back-up resources to support the originals in case of failure.

Resilience is multidisciplinary and needs the cooperation of different disciplines for successful outcome. An integrated design process is essential for disaster resistance and resiliency in building, in which all building professionals understand the safety and security goals and the interrelationship of these goals with other design objectives (i.e., sustainability, cost effectiveness, accessibility, functionality, and productivity).

### Learning Objective 2.2

* Explain why building codes and industry standards are at the core of (essential to) effective disaster resistant and resilient building.

### Lecture Notes 2.2

Building codes are essential to the success of disaster resistance and resiliency.

Building codes are sets of regulations that address structural integrity, fire resistance, safe exits, lighting, ventilation, and construction materials. They specify the minimum requirements to safeguard the health, safety, and general welfare of building occupants.

The International Code Council (ICC) ([www.iccsafe.org](http://www.iccsafe.org/)) family of codes covers all aspects of construction and includes (but is not limited to):

1. International Building Code (IBC): Applies to new and existing buildings, except those residential buildings covered under the International Residential Code.
2. International Residential Code (IRC): Applies to new and existing one- and two-family dwellings and townhouses of not more than three stories in height.
3. International Property Maintenance Code (IPMC): Applies to all existing buildings and addresses maintenance issues for continued safe use of buildings.
4. International Existing Building Code (IEBC): Applies to the alteration, repair, addition, or change in occupancy of existing structures.

The International Code Council (ICC) ([www.iccsafe.org](file:///C:\Users\metz285\Documents\Building%20America\Building%20Science%20Education\BSE%20Solution%20Center\Content\Disaster%20Resiliancy\www.iccsafe.org)) publishes updated codes every three years.

In partnership with the ICC, the Federal Emergency Management Agency (FEMA) supports the development of building codes by continuously monitoring, strengthening, and championing disaster-resistant provisions of national model codes and standards. Over the past 30 years, FEMA and other government organizations have worked with national model codes and standards groups as well as engineering and construction industry groups to propose and gain adoption of numerous disaster-resistant provisions for earthquake, wind, and flood hazards in the Nation’s model building codes and standards.

The development and widespread adoption of building codes is beneficial in that it has created a uniform regulatory environment in which design professionals and contractors are held to a set of standards adopted by and applicable to the jurisdiction in which they work. More importantly, building codes provide individuals, their families, and the community protection in the event of a natural disaster.

It is the responsibility of state and local jurisdictions to adopt and enforce building codes. Today, most U.S. communities formally adopt a building code and have a system in place for building regulation. However, some rural areas in America still have not adopted a building code and in these areas it is legal to design and construct structures using any standards deemed appropriate by the designers and builders/contractors.

Many communities, depending on their geographic location, are at significant risk of experiencing severe damage from earthquakes, hurricanes, floods, tornados, wildland fires and other natural events. Adoption and effective enforcement of up to date building codes is the best line of defense against such severe events. Owners and local communities can also take effective steps in protecting themselves by strengthening or building tornado safe rooms and storm shelters, and taking other effective steps to protect lives, property and community.

It is critical that property owners, planners, designers, contractors, elected officials, emergency managers, and other decision makers understand the building code and its value as well as support the adoption, use and enforcement of codes, incorporating codes into local resilience efforts and allowing builders/contractors to construct structures to higher standards are important steps to becoming more disaster-resilient.

Having an understanding of local building code requirements is critical prior to executing any construction projects. Locally adopted building codes define the details necessary for permitting, inspection, and rebuilding techniques. Most remodeling projects and all new construction require one or more building permits before work can begin.

Building permits are generally required for any alteration that changes the structure, size, safety, or use of living space. They are usually not required for projects considered to be normal maintenance such as painting or wallpapering.

Visit your local building department before you start construction to find out the type of permits that are necessary for your project. Ask if inspections are necessary and at what stage of construction. Once the work begins, an inspector should visit the site to be sure that the project is code compliant. If a building permit is not obtained for a project that requires one, the property owner may be subject to legal action. If the project is completed without a building permit and does not meet building code standards, the building department may require that additional work be done at the owner’s expense. After construction is completed, any additional work to bring a building up to code will in most cases be much more expensive than if the building was originally designed and built code compliant. Designing and building to the code not only help save lives and property; in many cases it can save time, money and potential legal action. Codes can also help ensure that the history of a building is preserved if that is applicable. Guidance on this topic is available here: <https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/historic_homes_guide.pdf>.

The code information above is from the Department of Homeland Security website. Federal Emergency Management Agency. February 5, 2013. “FEMA Building Codes Toolkit Factsheet.” Available at <https://www.fema.gov/media-library/assets/documents/30423>

Industry Standards

The information below, which focuses more on industry standards and code adoption, is from theNational Institute of Building Sciences Building Seismic Safety Council. December 2010. *Earthquake-Resistant Design Concepts: An Introduction to the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures*. Prepared for the Federal Emergency Management Agency of the U. S. Department of Homeland Security by the National Institute of Building Sciences Building Seismic Safety Council. Available at <https://www.fema.gov/media-library-data/20130726-1759-25045-5477/fema_p_749.pdf>

As the model building codes were evolving, various industries (e.g., concrete, masonry, steel, wood) established professional associations to develop technical criteria for the design and construction of structures using each industry’s specialized materials and systems. Eventually, the industry associations began issuing their guidance documents in the form of industry standards developed following rigorous consensus procedures promulgated by the American National Standards Institute (ANSI) and the model code organizations began adopting those documents into their codes by reference. The industry consensus standards typically are revised and updated every five years.

Among the more important consensus standards presently referenced by the building codes are the following:

* + - *Minimum Design Loads for Buildings and Other Structures,* ASCE/SEI 7, published by the Structural Engineering Institute of the American Society of Civil Engineers;
      * *Building Code Requirements for Reinforced Concrete,* ACI 318, published by the American Concrete Institute;
      * *National Design Specification,* NDS, published by the American Forest and Paper Association;
      * *Specification for Steel Buildings,* AISC 360, published by the American Institute of Steel Construction;
      * *North American Specification for the Design of Cold Formed Steel Structural Members,* AISI S100, published by the American Iron and Steel Institute; and
      * *Building Code Requirements and Specification for Masonry Structures,* TMS 402/ACI 530/ASCE 5 and TMS 602/ACI 530.1/ASCE 6, jointly published by the Masonry Society, the American Concrete Institute, and the American Society of Civil Engineers.

Code Adoption and Enforcement

Building codes are adopted by state and local governments to protect the health, safety, and welfare of the public by establishing minimum acceptable design and construction requirements intended to provide safe and reliable buildings and structures. These codes affect all aspects of building construction including structural stability, fire resistance, means of egress, ventilation, plumbing and electrical systems, and even energy efficiency. Once adopted by a state or local government, the building code becomes law and is typically enforced by a government official. This official generally is identified as the Chief Building Official but he or she may have another title such as Fire Marshall or Clerk. Collectively, the people empowered to enforce the requirements of a building code are identified in the codes as the Authority Having Jurisdiction (AHJ).

In communities that have adopted a building code, it is illegal to construct a structure unless the AHJ issues a building permit. Before issuing the permit, the AHJ typically will review the design documents to ensure that they were prepared by an appropriately qualified and licensed (generally by the state) professional and that they conform, in a general sense, to the technical requirements of the building code. Once the AHJ is satisfied that a design conforms to the applicable requirements and appropriate fees are paid, the AHJ issues a permit for construction, a document commonly referred to as the “building permit” that generally is posted at the construction site.

During the construction period, the AHJ requires a series of inspections to ensure that the design is being properly executed by the builders/contractors. These inspections may be directly performed by the AHJ or the AHJ’s staff, by private individuals or firms with the appropriate qualifications, or by a combination of the two. When an inspection is performed, the conformance of the construction with the design and code requirements is documented by a series of reports and/or by the inspector’s signature on the building permit. If an inspector finds that the construction does not conform in some way to the code requirements, the builder/contractor must correct this situation before a sign-off is given. Upon completion of construction and submittal of documentation by the builder/contractor of evidence that the building has passed all required inspections, the AHJ will issue an “occupancy permit” that allows the structure to be open to the public. If a building is occupied without this permit, the AHJ can require that other law enforcement officials vacate the premises and lock it. Even after an occupancy permit has been issued for a structure, the AHJ can revoke the permit if there is reason to believe that the structure has become unsafe in some way. It is not uncommon for this to occur after a fire, earthquake, hurricane, or other event that causes extreme damage to buildings and structures. This also can occur if a building’s occupants allow its various systems to deteriorate to a point at which the structure is no longer safe for use.