National Institute of BUILDING SCIENCES™
Innovative Solutions for the Built Environment

Mitigation Saves: For Earthquakes, Designing to Exceed 2015 Codes Provides $4 Benefit for Each $1 Invested

EVERY AMERICAN FACES NATURAL HAZARDS, AND THE RISK IS GROWING

U.S. disaster losses from wind, floods, earthquakes, and fires now average $100 billion per year, and in 2017 exceeded $300 billion—25% of the $1.3 trillion building value put in place that year. Fortunately, there are affordable and highly cost-effective strategies that policymakers, building owners, and the building industry can deploy to reduce these impacts. These strategies include adopting and strengthening building codes, upgrading existing buildings, and improving utilities and transportation systems. The benefits and costs associated with these mitigation measures have been identified through the most exhaustive benefit-cost analysis of natural hazard mitigation to date and documented in Natural Hazard Mitigation Saves. The study was funded by three federal agencies and four private-sector sponsors and produced by the National Institute of Building Sciences – the nation's Congressionally chartered convener of experts from the building professions, industry, labor, consumer interests, and government. For the report and accompanying fact sheets, see www.nibs.org/mitigationsaves. This fact sheet summarizes the study findings and significant savings associated with various mitigation measures.

- **Adopting the latest building code requirements is affordable and saves $11 per $1 invested.** Building codes have greatly improved society's disaster resilience, while adding only about 1% to construction costs relative to 1990 standards. The greatest benefits accrue to communities using the most recent code editions.
- **Above-code design could save $4 per $1 cost.** Building codes set minimum requirements to protect life safety. Stricter requirements can cost-effectively boost life safety and speed functional recovery.
- **Private-sector building retrofits could save $4 per $1 cost.** The country could efficiently invest over $500 billion to upgrade residences with 15 measures considered here, saving more than $2 trillion.
- **Lifeline retrofit saves $4 per $1 cost.** Society relies on telecommunications, roads, power, water, and other lifelines. Case studies show that upgrading lifelines to better resist disasters helps our economy and society.
- **Federal grants save $6 per $1 cost.** Public-sector investment in mitigation since 1995 by FEMA, EDA, and HUD cost the country $27 billion but will ultimately save $160 billion, meaning $6 saved per $1 invested.

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

TABLE 1. Nationwide average benefit-cost ratio by hazard and mitigation measure. BCRs can vary geographically and can be much higher in some places. Find more details in the report.

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RESULTS OF EXCEEDING CODE FOR EARTHQUAKES

Considering just counties where design to exceed 2015 I-Code requirements for earthquakes has a benefit-cost ratio (BCR) greater than 1.0, if all new buildings were built to their county's incrementally efficient maximum (IEMax) level of strength and stiffness for one year the costs would total approximately $1.2 billion. The sum of the benefits totals approximately $4.3 billion. Therefore, the overall average BCR is approximately 4:1, e.g., an average of $4 saved for every $1 spent to build new buildings stronger and stiffer.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed earthquake design requirements of the 2015 IBC. The IEMax strength and stiffness for approximately 2,700 counties (from a BCR perspective) is 1.0, e.g., current code minimum. For approximately 400 counties however, design to exceed 2015 I-Code earthquake requirements appears to be cost-effective. Approximately 40 million people, 13% of the 2010 population of the U.S., live in counties where the IEMax strength and stiffness is twice the code minimum. Another 30 million people—10% of the United States population—live where it would be cost-effective to design to 25% or 50% greater than code-minimum strength and stiffness. The current code makes economic sense on a benefit-cost basis for about three-quarters of the United States population. The IEMax strength and stiffness by county is illustrated in Figure 2. The national-level BCRs aggregate study findings across state and local BCRs. The costs reflect only the added cost relative to the 2015 IBC.

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

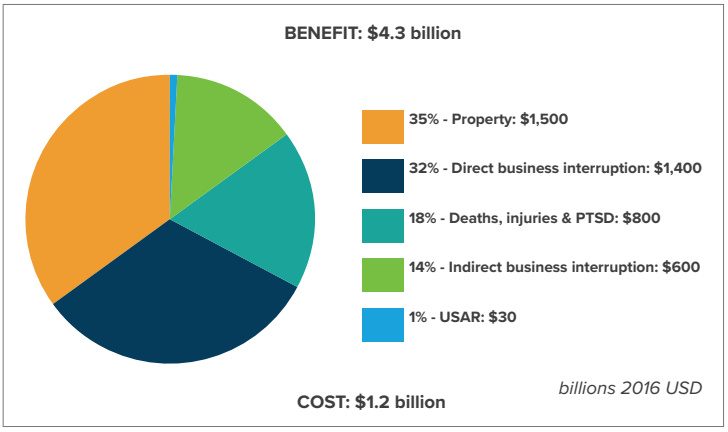

FIGURE 1. Contribution to benefits from exceeding 2015 I-Code earthquake requirements.

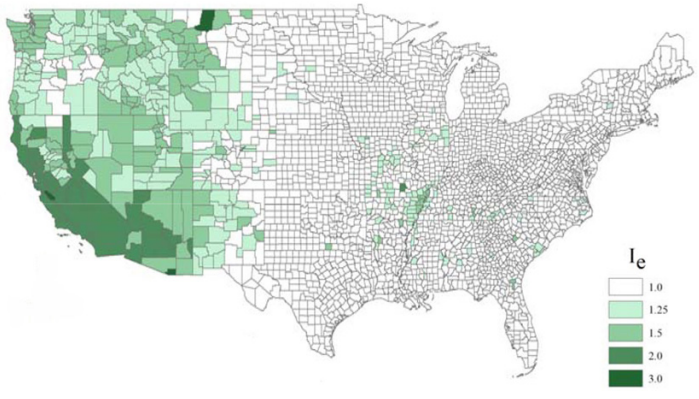

FIGURE 2. Maximum strength and stiffness factor Ie to exceed 2015 IBC and IRC seismic design requirements where the incremental benefit remains cost-effective.

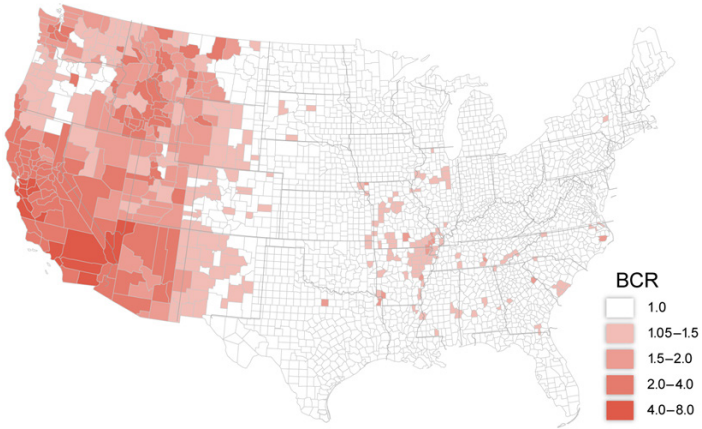

FIGURE 3. BCR of earthquake mitigation by increasing strength and stiffness in new buildings (by county).