



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

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the *2017 Interim Report* (now included into the *2018 Interim Report*), the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of \$6 for every \$1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of \$4 for every \$1 invested.

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.

Mitigation Saves:

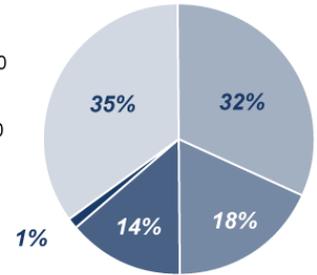
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The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save 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.

National Benefit-Cost Ratio Per Peril <small>*BCR numbers in this study have been rounded</small>		Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio		6:1	4:1
Riverine Flood		7:1	5:1
Hurricane Surge		Too few grants	7:1
Wind		5:1	5:1
Earthquake		3:1	4:1
Wildland-Urban Interface Fire		3:1	4:1

Benefit: \$4.3 billion

- 35% – Property: \$1,500
 - 32% – Direct business interruption: \$1,400
 - 18% – Deaths, injuries & PTSD: \$800
 - 14% – Indirect business interruption: \$600
 - 1% – USAR: \$30
- millions 2016 USD



Cost: \$1.2 billion

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

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

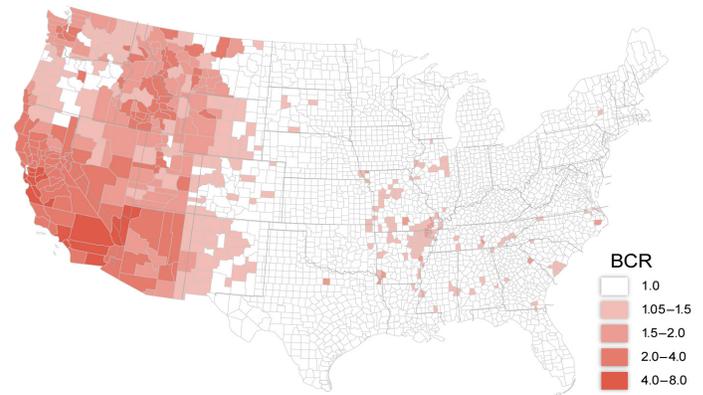
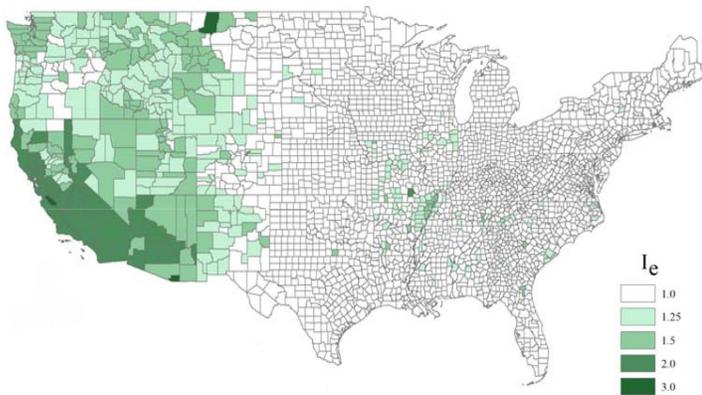


Figure 2. Maximum strength and stiffness factor I_e to exceed 2015 IBC and IRC seismic design requirements where the incremental benefit remains cost-effective.

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