Is Life Safety Enough?
Improvements in Earthquake Science and Risk Reduction

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Building-code earthquake provisions: safety first

2015 NEHRP RECOMMENDED SEISMIC PROVISIONS FOR NEW BUILDINGS AND OTHER STRUCTURES:

INTENT

This chapter on the Intent of the 2015 Provisions describes the expected seismic performance that is judged to be inherent in the seismic requirements in Parts 1 and 2.

1.1 INTENT

The *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* presents the minimum recommended requirements necessary for the design and construction of new buildings and other structures to resist earthquake ground motions throughout the United States. The objectives of these provisions are to provide reasonable assurance of seismic performance that will:

1. Avoid serious injury and life loss due to
    a. Structure collapse
    b. Failure of nonstructural components or systems
    c. Release of hazardous materials
2. Preserve means of egress
3. Avoid loss of function in critical facilities, and
4. Reduce structural and nonstructural repair costs where practicable.

Building-code earthquake provisions: safety first

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Building-code earthquake provisions: safety first

2015 International Building Code

101.3 Intent

The purpose of this code is to establish the minimum requirements to safeguard the public health, safety and general welfare through structural strength, *means of egress* facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations.

Building-code earthquake provisions: safety first

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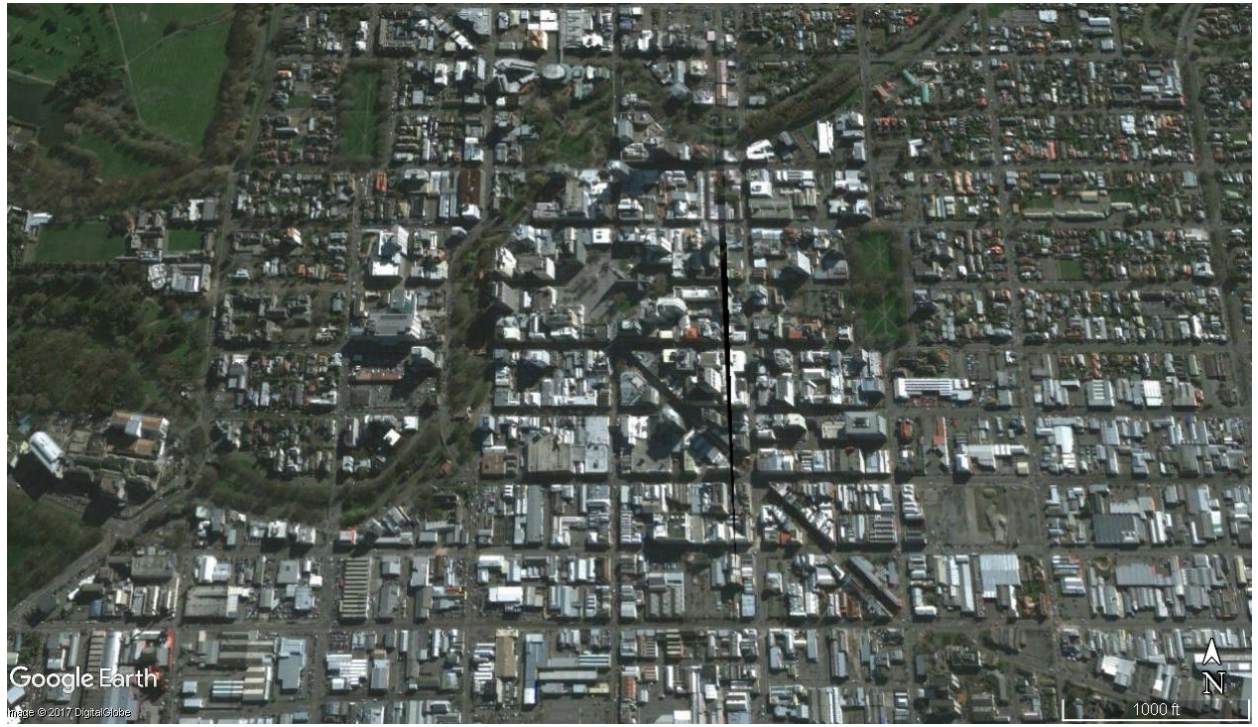
2011 Christchurch earthquake begs the question: is life safety enough?

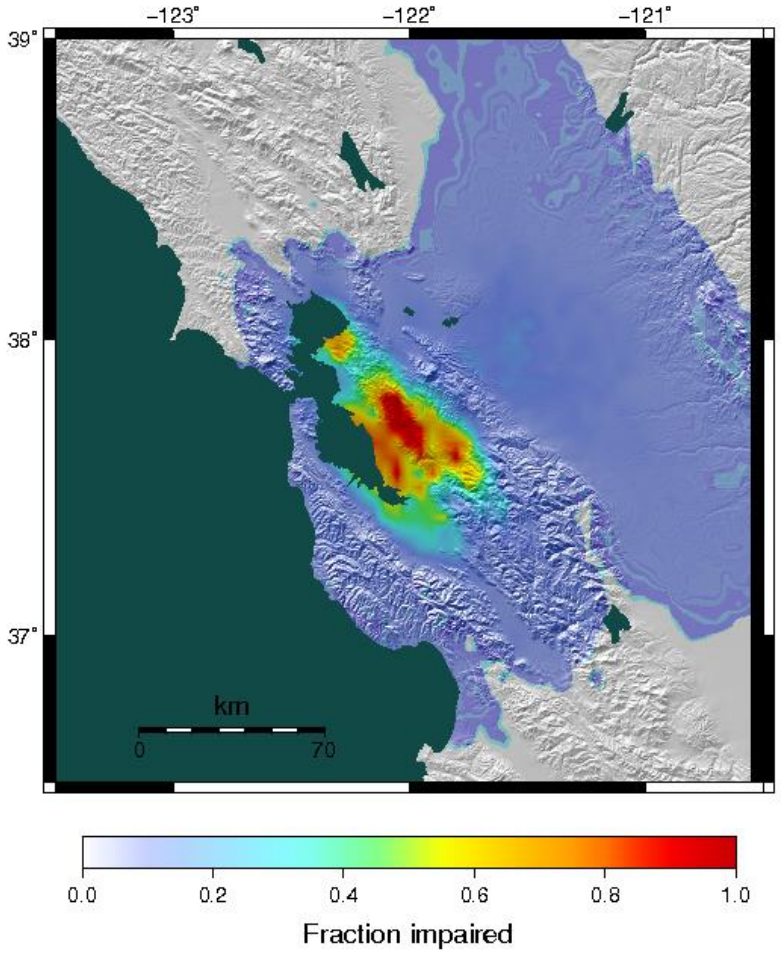
Before



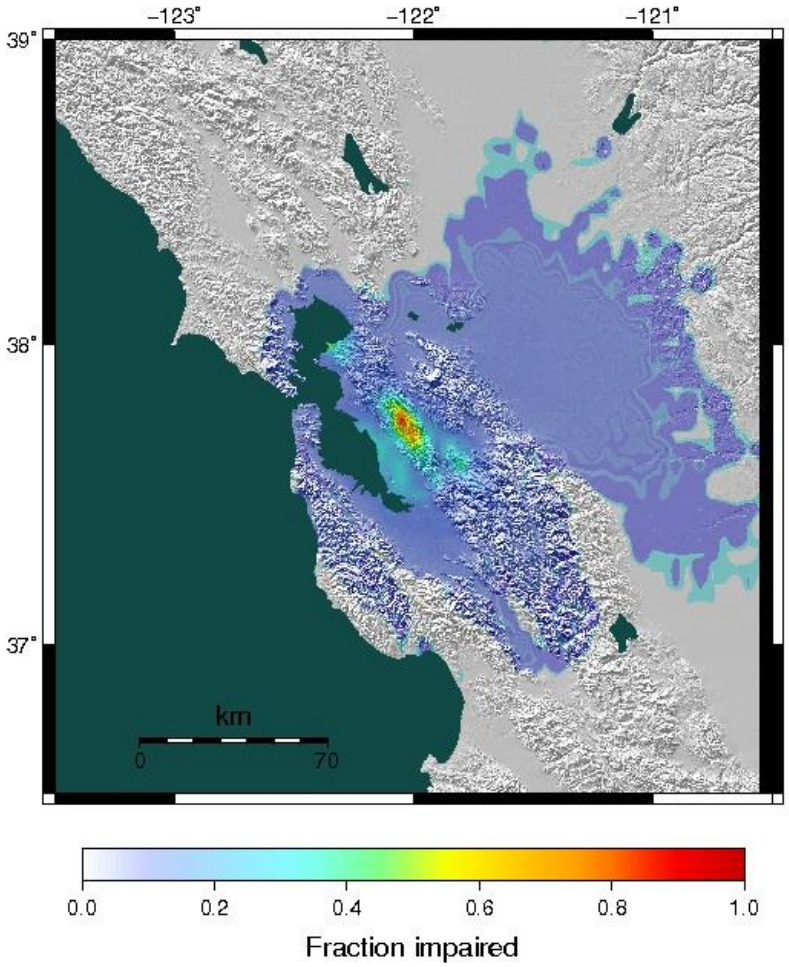
After

USGS M_w 7.0 HayWired earthquake scenario

All code-compliant buildings: 1 in 4 impaired (collapsed, red-tagged, or yellow-tagged)



If all buildings had 1½ x strength of current requirements: 1 in 20 impaired



USGS M_w 7.0 HayWired earthquake scenario

Table 4 – Estimated impairment of code-compliant or resilient buildings in M 7.0 Hayward Fault earthquake

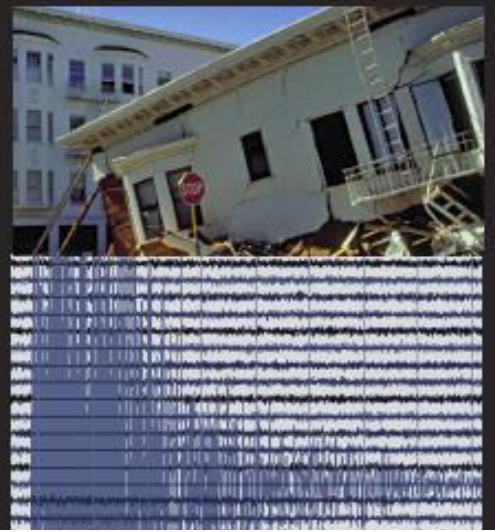
Condition	Buildings affected	
	$I_e = 1.0$	$I_e = 1.5$
Collapsed	8,000	2,000
Red tagged	102,000	27,000
Yellow tags	390,000	100,000
Total impaired buildings	500,000	130,000
Displaced people	1,500,000	390,000
Displaced businesses	150,000	39,000
% of 2,050,000 buildings in 9 San Francisco Bay area counties	**24%**	**6%**

Porter (2016) SEAOC Convention

SPUR: How Safe is Safe Enough?

SPUR REPORT 01/2012

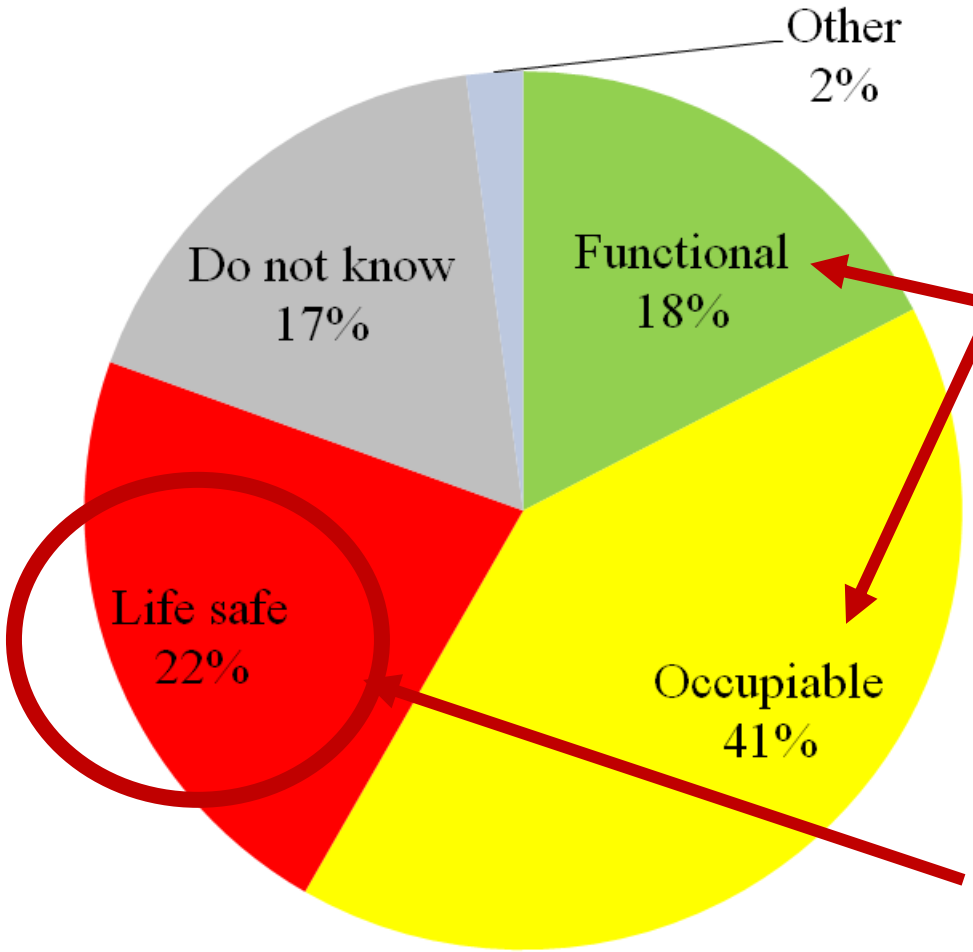
Safe Enough to Stay



What will it take for San Franciscans to live safely in their homes after an earthquake? A significant amount of housing may be too damaged to live in while it's being repaired. Residents may leave. And that will put the city's recovery at risk. Here's how to prevent San Francisco from losing its most important asset: its people.

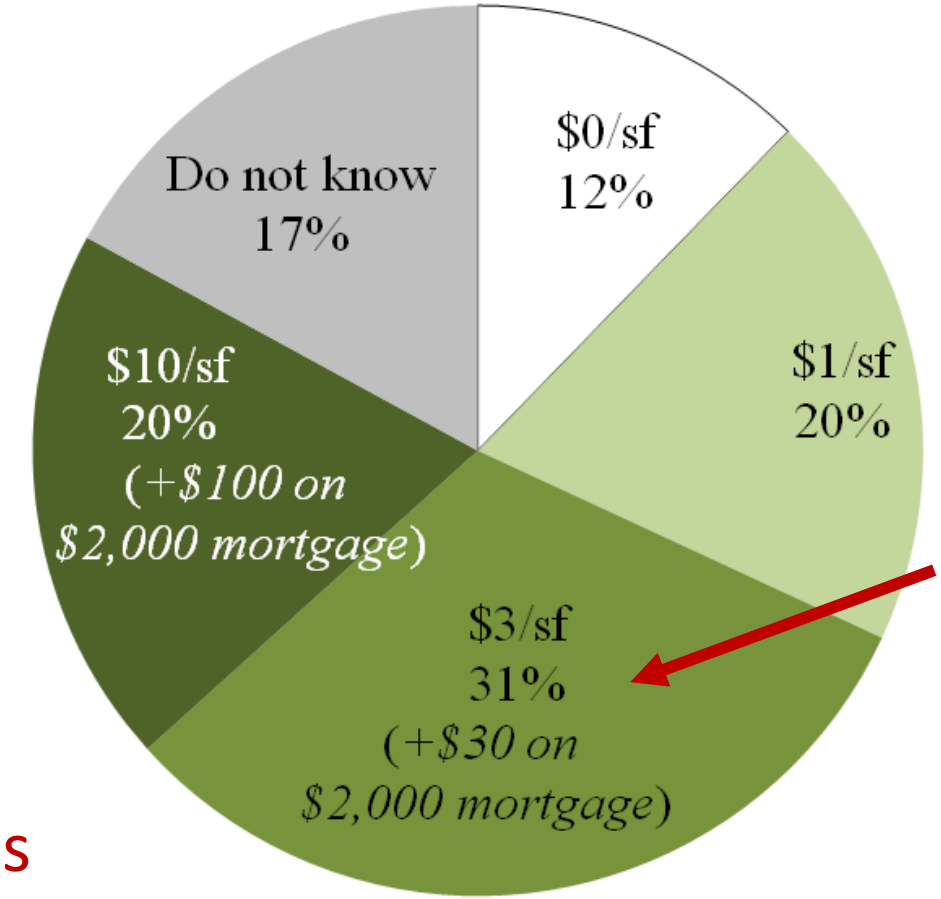
"Our research indicates that for San Francisco to avoid a slow and arduous recovery, 95 percent of its housing must be able to meet shelter-in-place standards."

The public prefers more



What people want

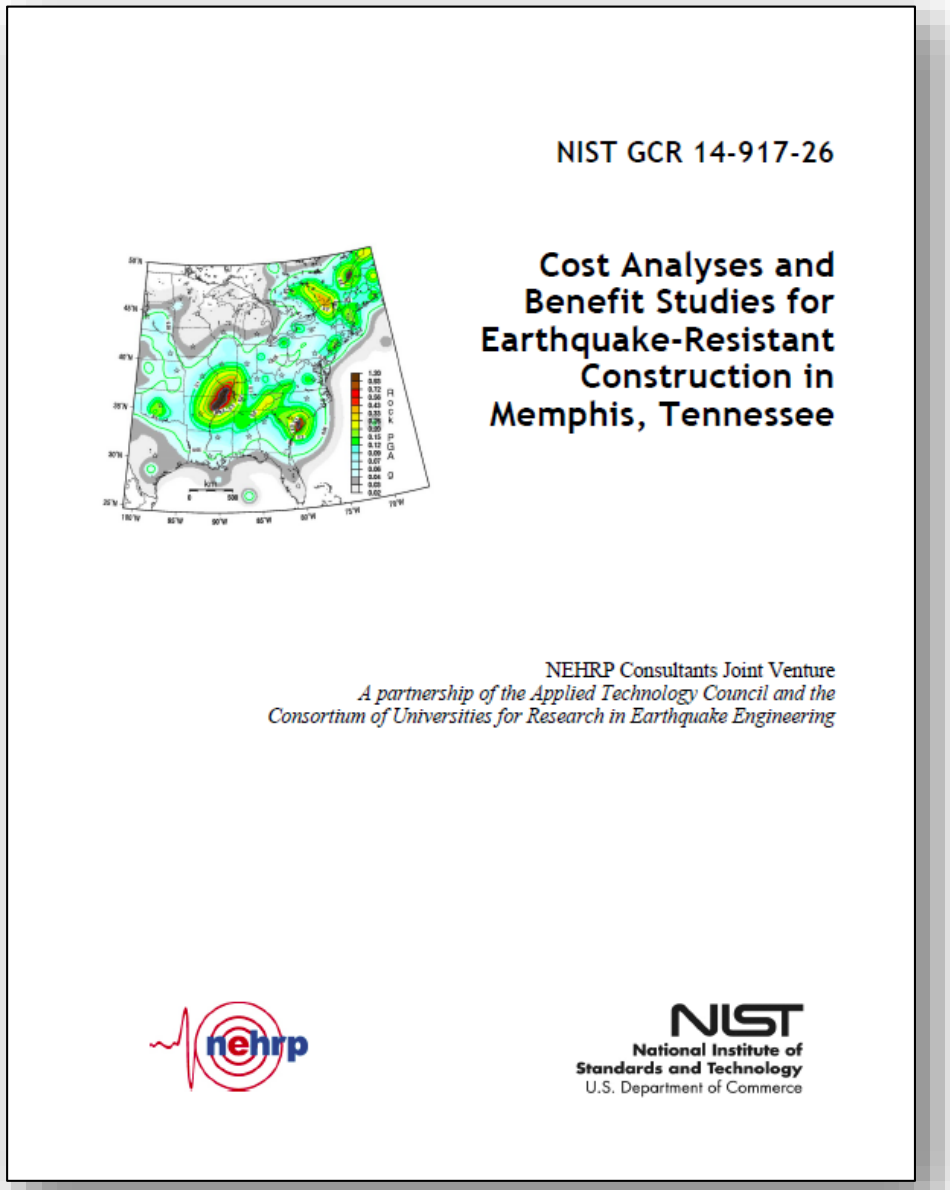
What IBC gives



What immediate occupancy costs

Davis and Porter (2016) *Earthquake Spectra*

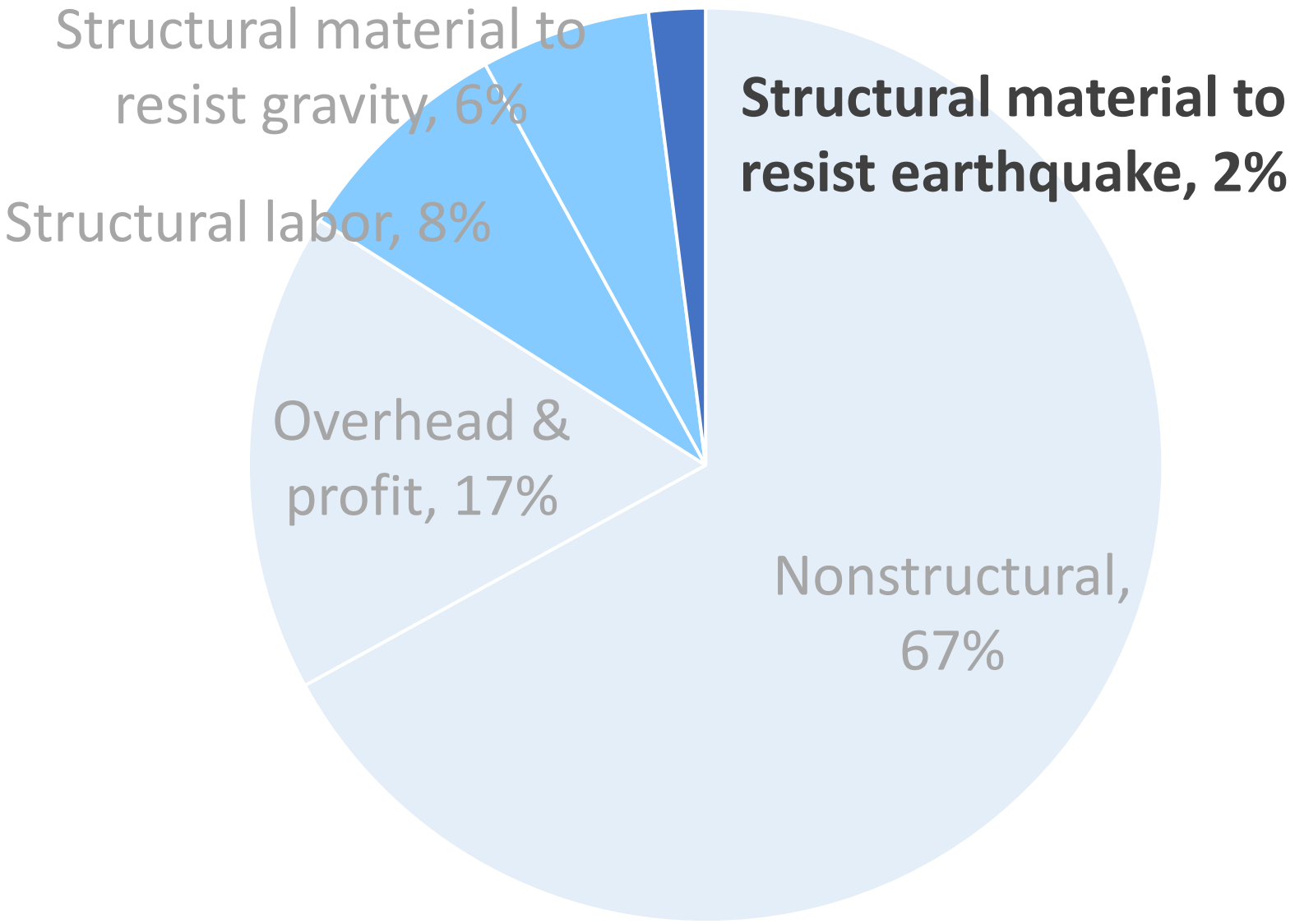
1½ x code strength & stiffness costs 1% more



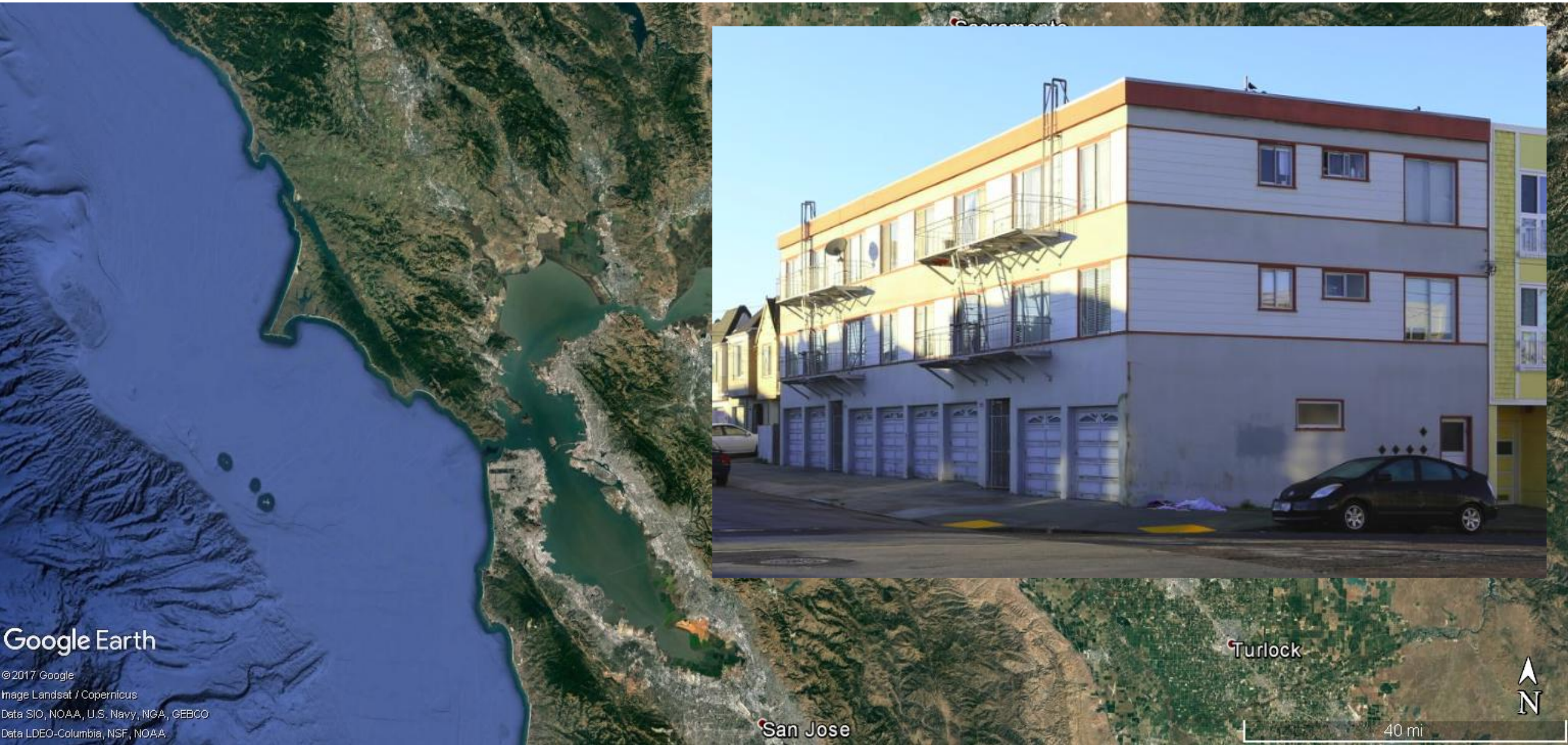
To make 6 Memphis buildings meet 2012 IBC rather than 1999 SBC requires greater strength & stiffness

	Strength increase	Cost increase
Apartment	41%	0.9%
Office	14%	0.7%
Retail	84%	0.2%
Warehouse	88%	1.0%
Hospital	-4%	0.0%
School	49%	0.4%

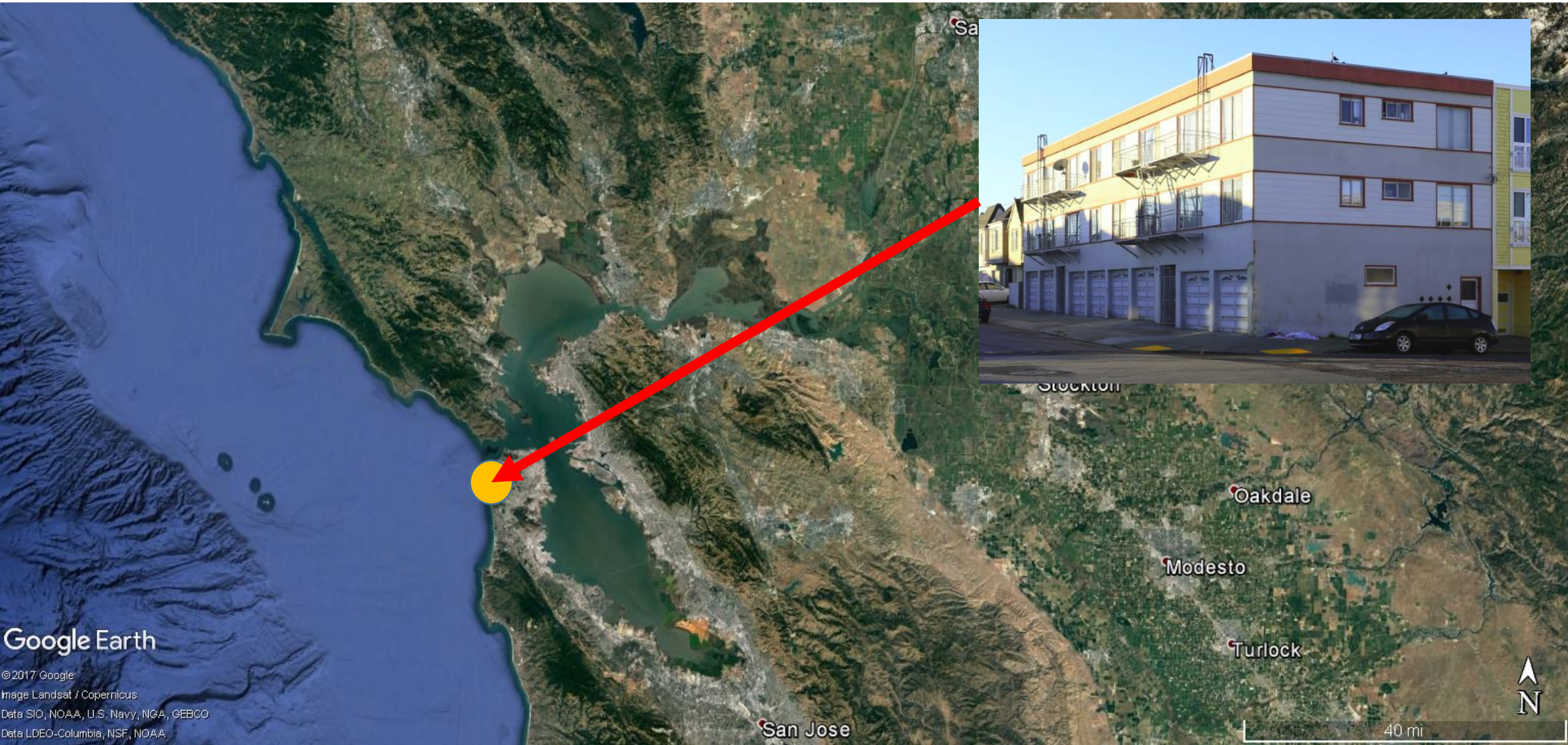
How can 1½ x strength & stiffness only cost 1%?



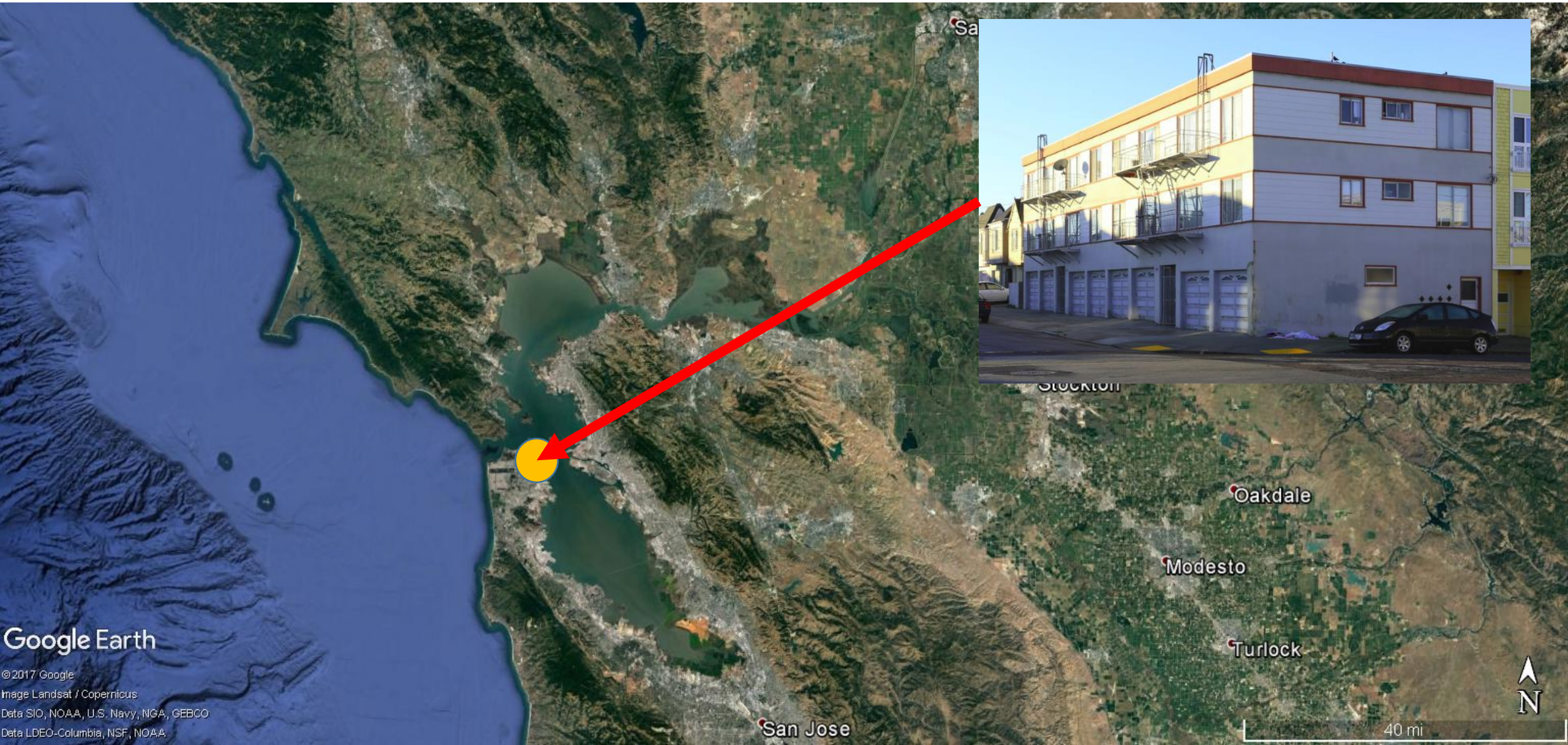
Stronger, stiffer buildings are clearly practical



A new code-minimum building here…



… is 1½ x stronger than required here



almost 2x stronger than required here

Sacramento
Elk Grove
Stockton
Oakdale
Modesto
Turlock
San Jose
Google Earth
©2017 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
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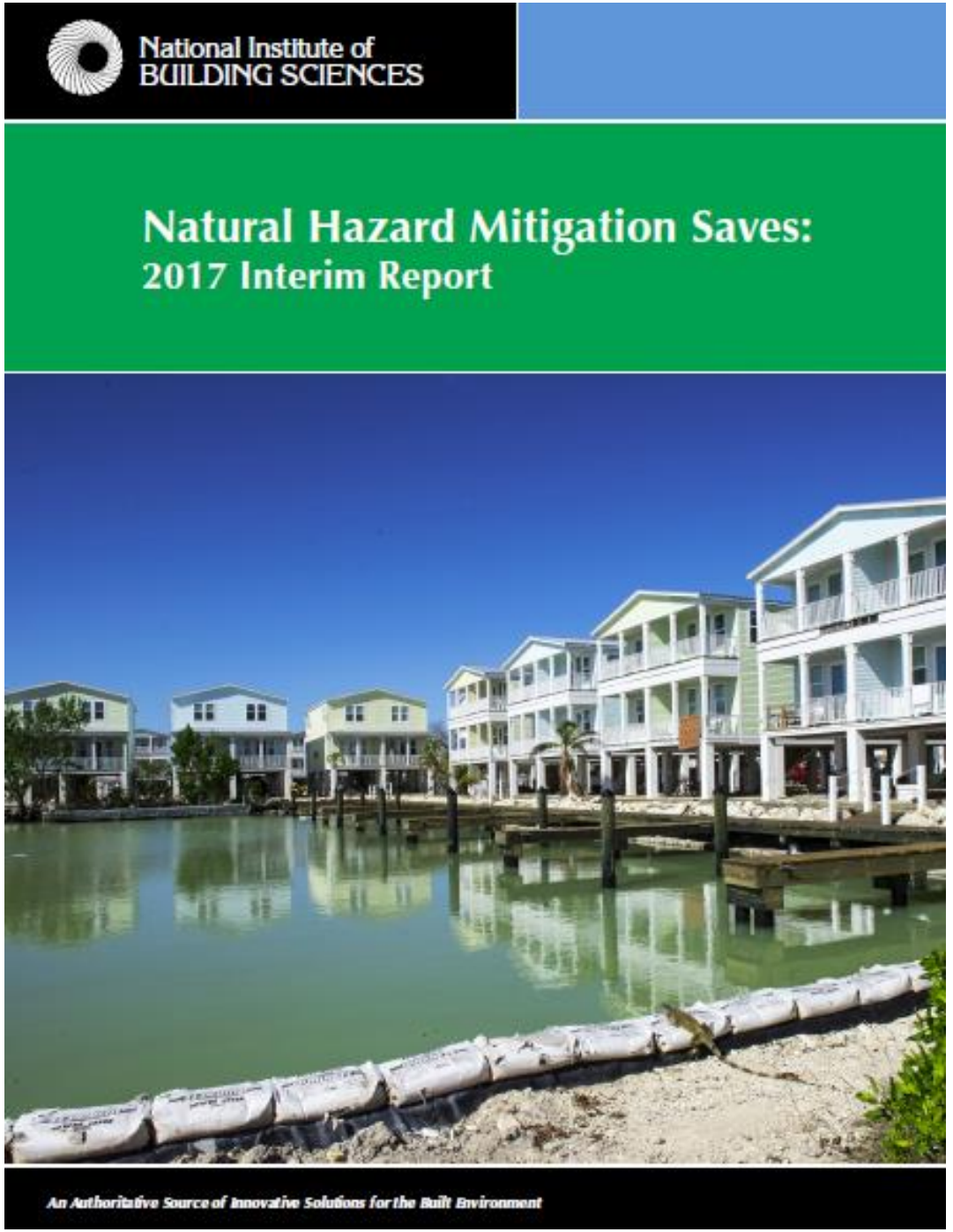
Building stronger and stiffer than the code requires is cost-effective across much of the U.S.



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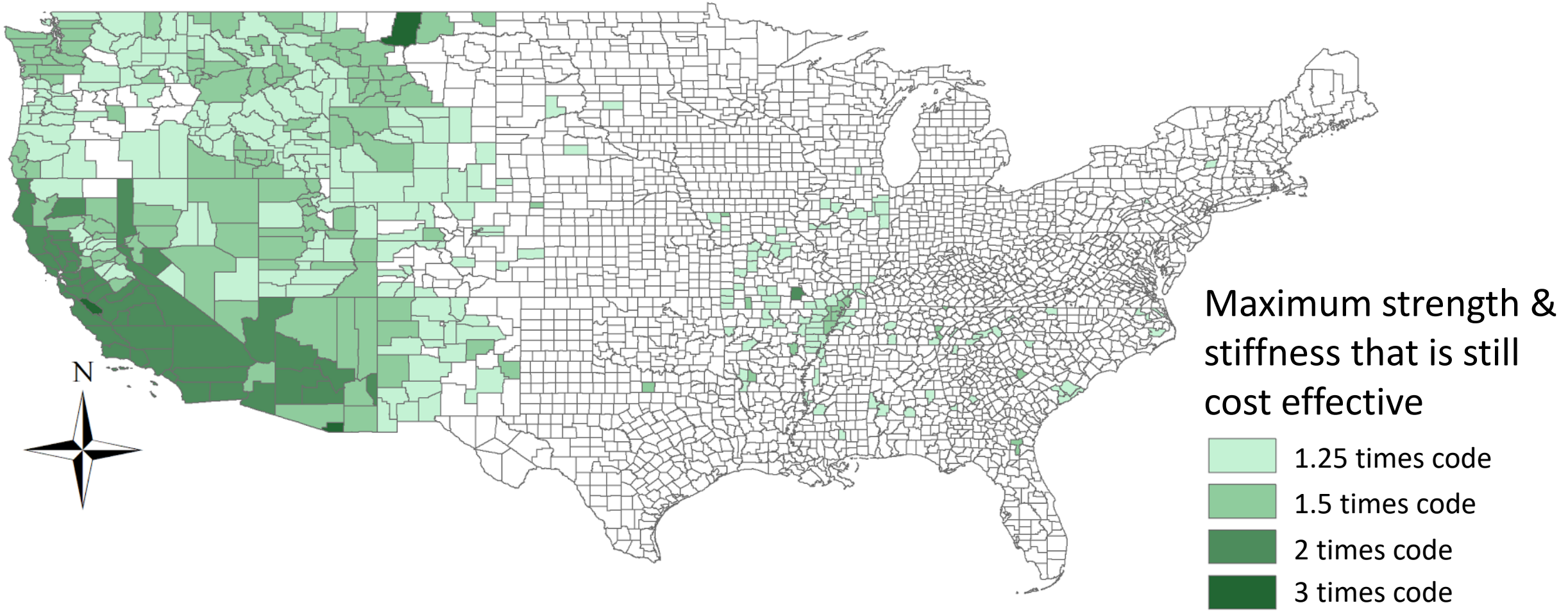
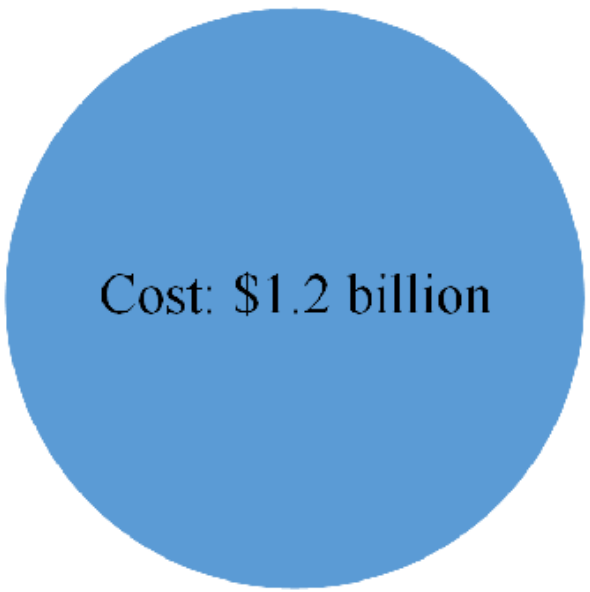
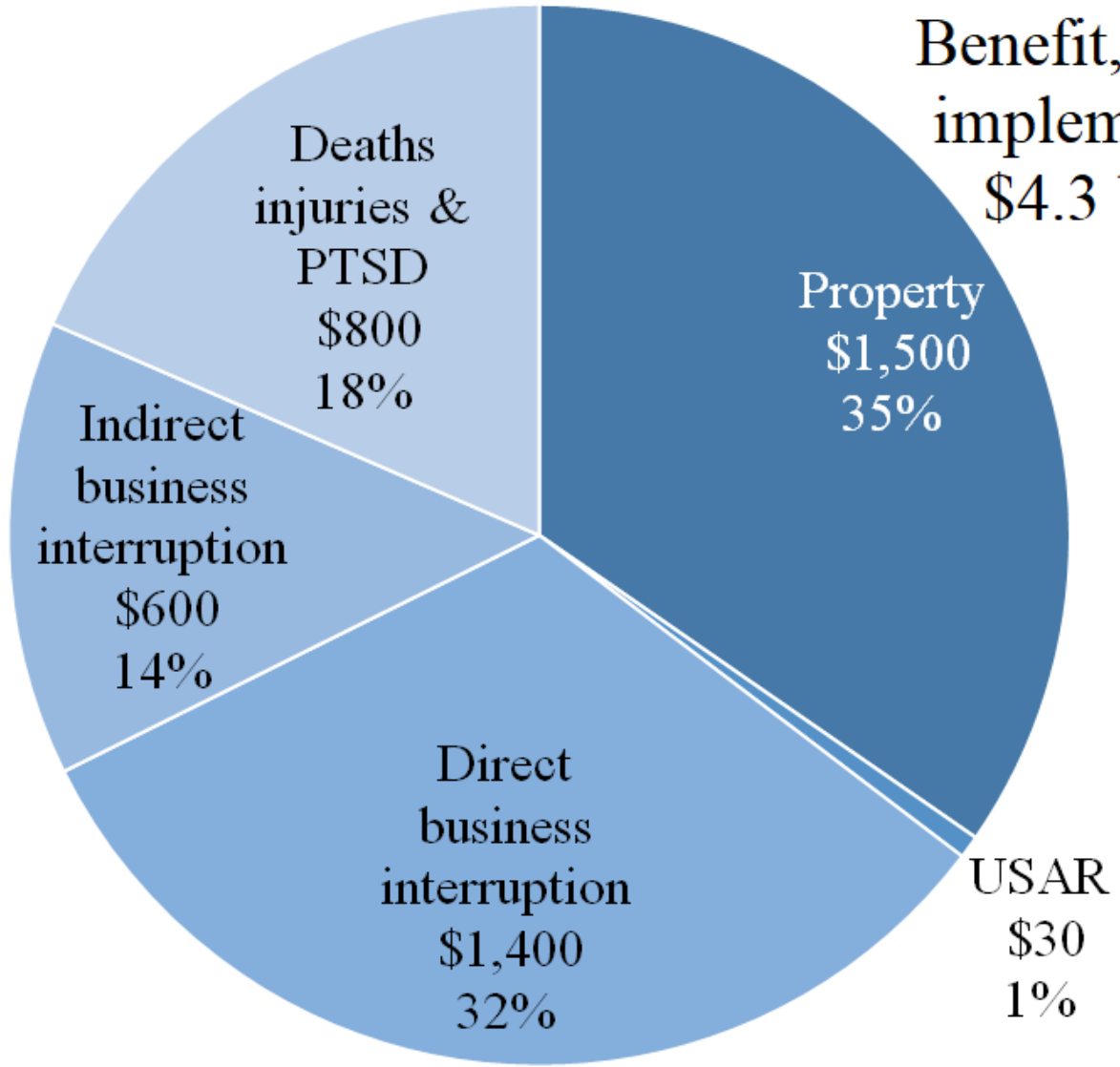


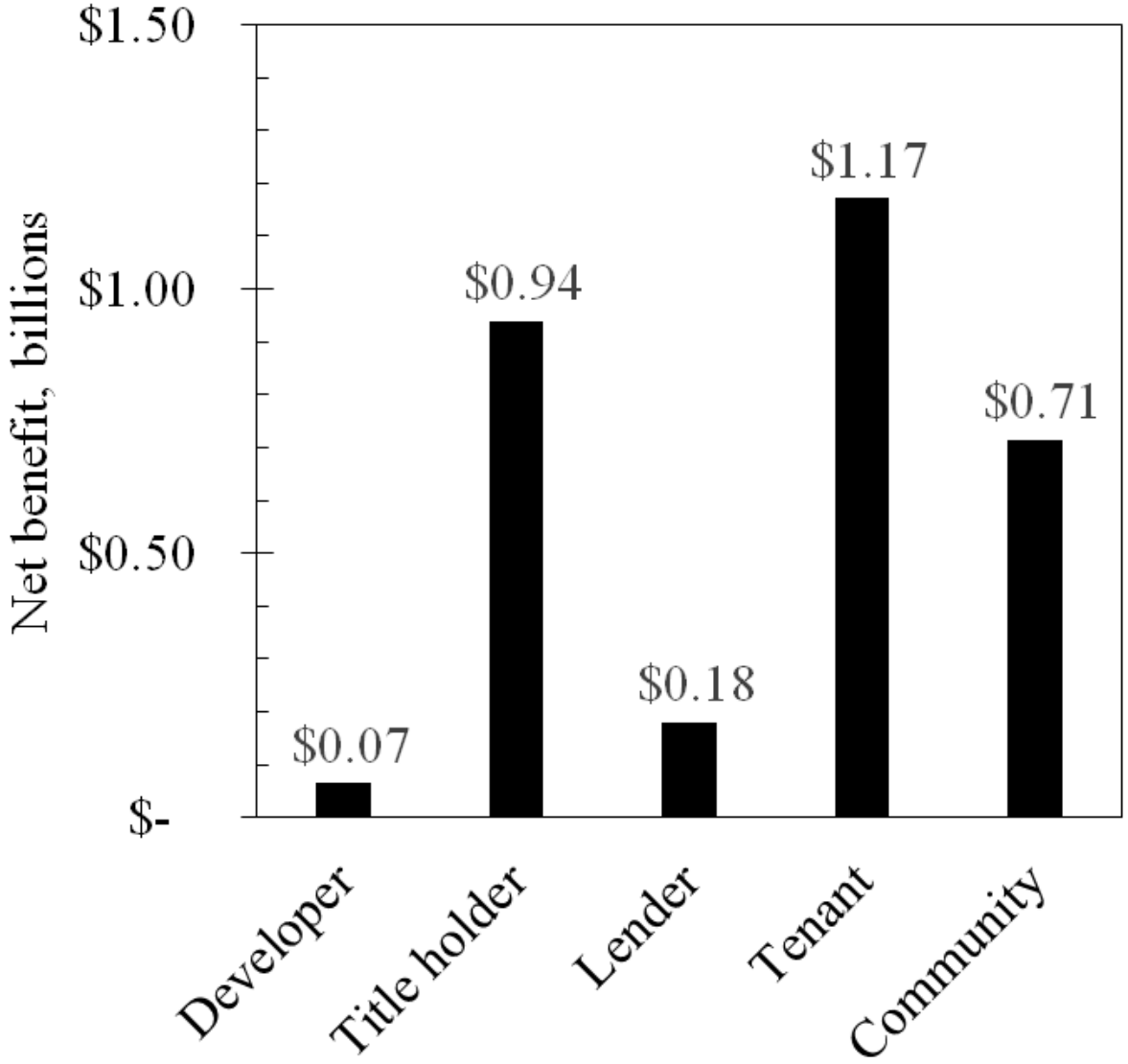
National Institute of Building Sciences (2018)

Benefit-cost ratio: more than 3 to 1





Everyone saves when we design to exceed life-safety



Stronger & stiffer is only one option

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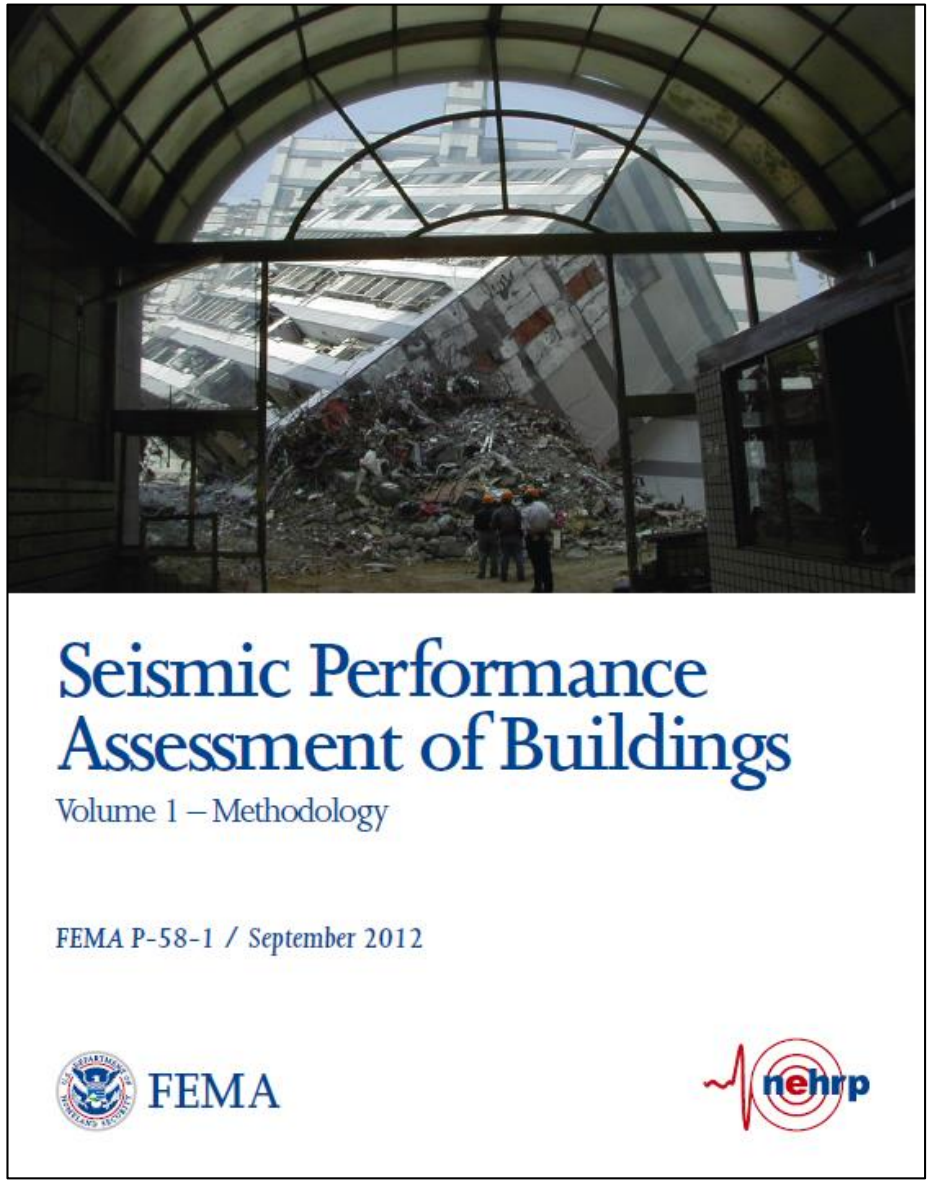
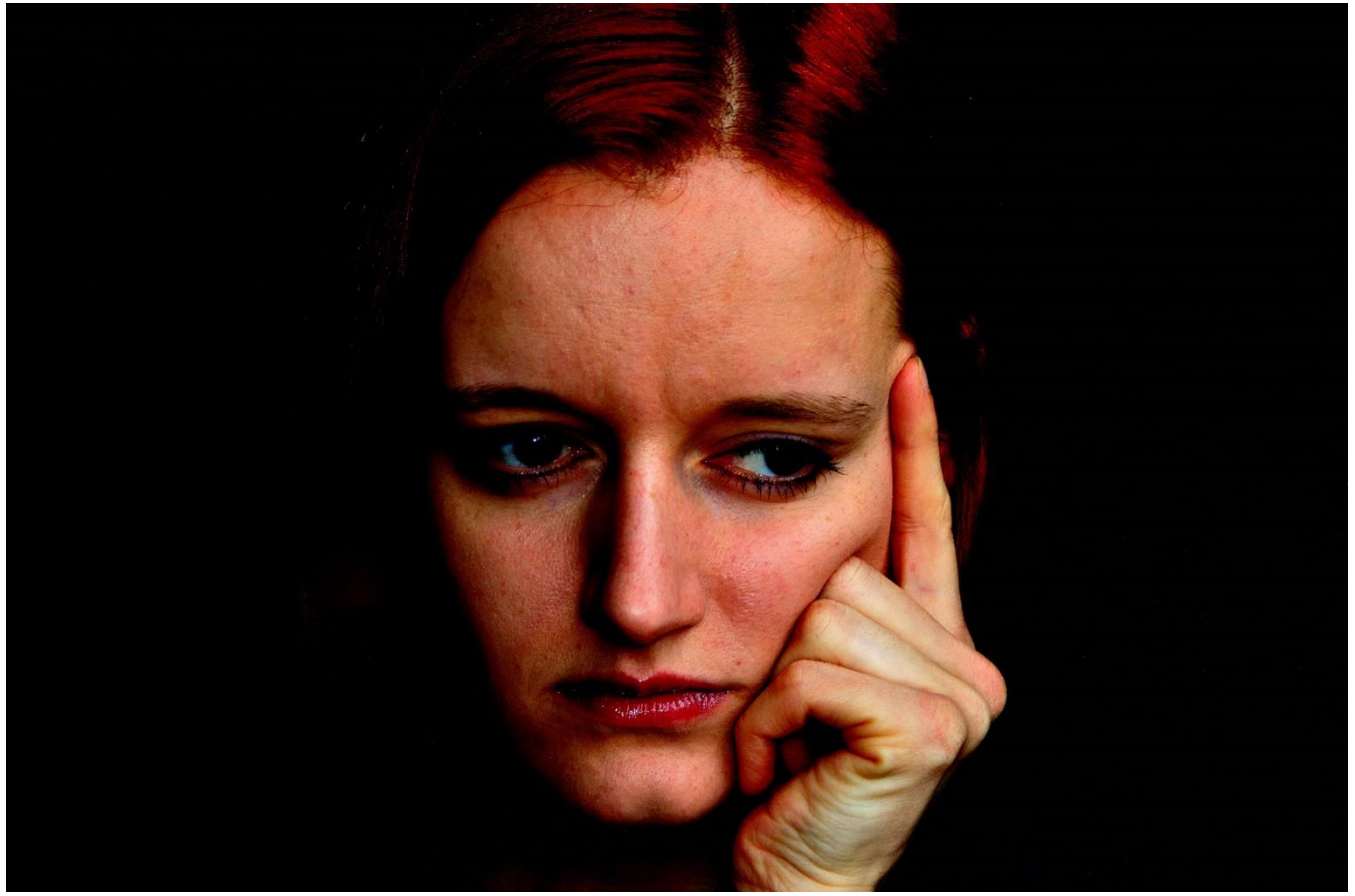


BCR is one consideration among many

Other uses for resources

Resource limitations

Legal, time constraints



Justice & equity

Risk attitudes

& more

A long-overdue engineers' debate on acceptable risk has just begun

Development of a Probability Based Load Criterion for American National Standard A58

Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

Issued June 1980

The public and its leaders seem to be deciding that life safety is not enough

California Assembly Bill 1857 (January 2018)

"Until an immediate occupancy standard is adopted, the commission shall adopt, by supplement to the triennial building code, a strength and stiffness standard for engineered buildings that is one and one-half times the level of the current standard."

New buildings cost the US $1 trillion per year. How will we prudently satisfy the public's demand for buildings that exceed life safety without NEHRP?

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www.sparisk.com/pubs/Porter-2018-AAAS.pdf