Institute for Catastrophic Loss Reduction

Building resilient communities

Los Angeles' soft-story retrofit ordinance cost $1.3 billion, saves $41 billion, avoids 28,000 deaths and injuries, and prevents the loss of 65,000 housing units

Figure 1. Collapsed soft-story wood-frame multifamily dwellings in (A) San Francisco, 1989 Loma Prieta earthquake (B) Los Angeles, 1994 Northridge earthquake
(Image credits: UC Berkeley NISEE, with permission)

Soft-story woodframe buildings perform poorly in earthquakes. They collapsed in several recent California earthquakes, including notable deadly collapses in the 1989 Loma Prieta and 1994 Northridge events (Figure 1).

California has several seismically dangerous building types, but soft-story woodframe buildings are so numerous and vulnerable that San Francisco, Los Angeles, Oakland, and other cities have taken the unusual step of requiring that they be strengthened to better resist earthquakes [1,2,3,4]. Los Angeles' retrofit ordinance has led to 8,100 soft-story apartment buildings being retrofitted, protecting 117,000 housing units [5]. Recent estimates suggest that adding ground-story shearwalls, steel frames, or both to strengthen the buildings costs between $80,000 and $160,000 per building in today's dollars, or about $11,000 per housing unit [6]. That implies that Los Angeles property owners have spent about $1.3 billion to retrofit these buildings. How much benefit will that investment produce, in reduced future earthquake losses?

We answered that question using analyses from *Natural Hazard Mitigation Saves* [7], the most exhaustive benefit-cost analysis of natural-hazard mitigation ever performed. It included a study of retrofitting soft-story conditions in multifamily woodframe housing. It used FEMA's estimates of where such buildings exist, how many people live in them, and how many occupy them at various times of day [8]. It used the US Geological Survey's estimates of how frequently and strongly earthquakes shake them [9]. And it employed models of probabilistic damage given various levels of shaking [10,11]. It calculated costs and benefits on a census-tract level and presented them at the county level. We scaled the Los Angeles County results to account for the 117,000 housing units retrofitted to comply with *Resilience by Design*. Here is what we found.

Los Angeles' soft-story retrofits will avoid an estimated 1,500 deaths and 27,000 nonfatal injuries and cases of post-traumatic stress disorder. The retrofits will prevent the partial, temporary, or permanent loss of 65,000 housing units, home to 170,000 people. They will reduce future losses by $41 billion in property damage, life-safety impacts, and other economic consequences. See Table 1 and Table 2. The benefits divided by the costs, called the benefit-cost ratio, is 32 to 1, meaning $32 saved per $1 of up-front cost, a very cost-effective investment. For comparison, President Biden convinced Congress to pass the $1.3 trillion infrastructure bill partly by citing the *Mitigation Saves* estimate of the 6 to 1 benefit-cost ratio for strengthening public-sector infrastructure.

Table 1. Reduction in deaths, injuries, and loss of housing from retrofitting

	Reduction[(a)]
Deaths, nonfatal injuries, and PTSD	28,000
Impaired housing	
Collapsed housing units	5,000
Red-tagged housing units	15,000
Yellow-tagged housing units	45,000
Subtotal	65,000
Displaced residents	170,000

(a) All figures are uncertain within a factor up to 2 either way

Table 2. Monetary benefits from retrofitting (billions of 2022 US dollars)

	Benefit[(a)]
Property repairs	$20
Life safety[(b)]	$5
Additional living expenses	$10
Indirect economic costs	$6
Total	$41

(a) All figures are uncertain within a factor up to 2 either way

(b) Acceptable costs to avoid future statistical deaths and injuries, using US federal regulatory figures [12]

The 32-to-1 benefit-cost ratio is probably low

These estimates omit important but hard-to-quantify benefits such as protecting mementos, pets, peace of mind, community, and culture. They ignore debris disposal, the energy embodied in repairing or replacing the buildings, and the increase in housing costs that accompany reduced housing supply. And this analysis is silent on the potential for displaced residents to become homeless, with attendant mental and physical health impacts, demands on public services, and other harms. If we could quantify the monetary value of reducing these impacts, the benefits and benefit-cost ratio would have been higher.

Whose cost, whose benefit?

The costs and benefits described here are shared unequally. Building owners paid the $1.3 billion. Some may enjoy the benefits of reduced property damage if a big earthquake occurs in the next few years. But many investors only hold individual properties for 5 to 10 years. A large Los Angeles earthquake could happen during that time—it could strike tomorrow—and one will almost certainly occur within decades. But many owners may sell retrofitted properties before the earthquake occurs.

Still, most of these buildings will exist and house perhaps 300,000 people when a big earthquake strikes. The tenants will have employers, employees, colleagues who depend on them, children in schools, friends and family who care about their wellbeing, and connections to the broader economy. Retrofitting these buildings today will keep many tenants in their homes, avoid disrupting their lives, and enable them to go back to work or to school shortly after the earthquake. The retrofits will avoid thousands of injuries that would otherwise require emergency medical care, freeing up medical resources when they are in sudden, severe demand. The avoided losses benefit everyone.

The choice was never whether to retrofit, just whether to wait until it was too late

If Los Angeles had not mandated these retrofits, it would likely do so *after* a big earthquake. The city does not face a choice about whether or not to retrofit these buildings. Rather the choice is between doing so now, when it does the most good, and waiting until after the next big earthquake, when the harm is already done. We can wait until after the horse is out of the barn to close the barn door, but we *will* close it. We will spend the $1.3 billion one way or another. Doing so now avoids $41 billion in loss. Doing so later costs both the $1.3 billion in retrofits *and* the $41 billion in losses.

About the author

Dr. Keith Porter is a California native and licensed professional engineer. He serves as chief engineer to the Western University Institute for Catastrophic Loss Reduction, Canada's leading source for disaster resilience information. He led the engineering for the US Geological Survey's ShakeOut, ARkStorm, Tsunami, and HayWired planning scenarios. He led the *Natural Hazard Mitigation Saves* study for the National Institute of Building Sciences and its sponsors in the US Federal Emergency Management Agency, US Department of Housing and Urban Development, and other government agencies and nonprofits. He lives in London, Ontario.

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