Do Disaster-Resistant Buildings Deliver Climate Benefits?

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The congressionally-established National Institute of Building Sciences (NIBS) has found that every year of new construction in the United States that complies with current building codes avoids $13 billion in future losses, 32 percent ($4.3 billion) from avoided building losses. The median construction cost per square foot for a home in the United States is about $120. The median size of new detached single-family homes is roughly 2,300 square feet. Using these numbers, one can estimate that constructing buildings to current codes has the equivalent value of preserving about 15,000 new homes per year. New home construction embodies roughly 100 lbs. CO_2 per square foot. Based on that estimate, preserving 15,000 new homes per year through current codes avoids 1.5 million metric tons of CO_2 emissions per year. Code improvements could double those savings.

Over the long term, building codes have caused newer buildings to be generally more resistant to earthquake, wind, and flood damage compared with buildings built to older codes. Comparing US construction of about 1988 versus that of about 2018, my coauthors and I of *Natural Hazard Mitigation Saves* estimated that every year of new construction to comply with the 2018 I-codes avoids $13 billion per year in future losses, one third ($4.3 billion) from avoided building losses[1]. According to the US Census Bureau, the US puts in place approximately $1.3 trillion in new construction annually[2], so $4.3 billion represents avoided future building losses of 0.3% of new construction. At current average house construction costs (approximately $120 per square foot omitting land value[3]), $4.3 billion in avoided future building loss equates with approximately 35 million square feet of new construction.

Thus, the last 30 years of code development helps the US to avoid replacing 35 million square feet of buildings and all their contents over the life of new buildings built in a given year. The average new house has approximately 2,300 square feet of floor area[4], so 35 million square feet equates with 15,000 single family dwellings saved for every year of new construction. The average house embodies about 100 metric tons of CO_2[5]. Thus, avoiding the replacement of 15,000 single-family dwellings also avoids the release of 1.5 million metric tons of CO_2 per year of new construction over the 75-year life of new buildings.

Modern codes are not yet optimally efficient or resilient with respect to earthquakes, floods, and other extreme loads. They aim to assure life safety while minimizing initial construction cost, *not* to minimize society's total cost to own new buildings. Optimal design for disaster-related loads would generally require greater resilience: stronger, stiffer, more fire-resistant, more flood-resistant buildings. If code disaster provisions were optimized for resilience to minimize societal ownership cost, climate benefits could approximately double.

[1] Multi-Hazard Mitigation Council (2019). *Natural Hazard Mitigation Saves: 2019 Report*. National Institute of Building Sciences. Washington, DC, 619 p, https://scholar.colorado.edu/concern/reports/r494vm29h; figures 2-21, 2-22, and 2-24. Assumes 65% of total avoided property loss is building repair and replacement (as opposed to contents), based on unpublished intermediate findings for riverine flood and fire code provisions.

[2] US Census Bureau (2018). Monthly Construction Spending, January 2018. Release Number CB18-29. https://www.census.gov/construction/c30/pdf/pr201801.pdf [accessed March 29, 2019]

[3] Ford, C. (2017). Cost of Constructing a Home. National Association of Home Builders. https://www.nahbclassic.org/generic.aspx?genericContentID=260013/ [accessed October 26, 2021]: sample-average total new-house sale price minus finished lot cost ($335,896) divided by sample-average total new-house finished area (2,776 sq ft)

[4] US Census Bureau (2020). Highlights of annual 2020 characteristics of new housing. Characteristics of New Housing. https://www.census.gov/construction/chars/highlights.html [accessed October 26, 2021]

[5] Monahan and Powell (2011), An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework. Energy and Buildings 43(1): 179-188, https://www.sciencedirect.com/science/article/pii/S0378778810003154 [accessed October 26, 2021], average of scenarios 1 and 2: timber frame with timber or brick veneer.