

WHITE PAPER
POST-EARTHQUAKE REOCCUPANCY AND FUNCTIONAL RECOVERY TIMES FOR
NEW RESIDENTIAL BUILDINGS IN CALIFORNIA:
WHAT DO CURRENT CODES AND BUILDING PRACTICES PROVIDE?

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INTRODUCTION AND MOTIVATION

This white paper documents a study of expected post-earthquake recovery times for new residential buildings in California designed with the current *California Building Code* or *California Residential Code*. This information is meant to assist stakeholders assessing whether currently expected building performance is acceptable, or if building design should be improved to deliver shorter functional recovery times. This is the first paper in this series; other papers can be added to investigate different construction types, as well as various alternatives for designing for shorter recovery times.

This paper examines the recovery times of six residential building types of different heights in both high- and moderate-seismicity regions of California. The high-seismicity site is in Los Angeles, and the moderate seismicity site is in Sacramento. The building types are all of wood light-frame construction, with sizes and configurations representative of common residential buildings throughout California; the podium type comprises five stories of wood construction over a one-story concrete podium. The building designs reflect the different design requirements of each location.

The time needed to achieve three different recovery states is computed considering a “design event”:

- *Reoccupancy*: The building is safely occupiable as shelter. This recovery state is roughly equivalent to receiving a “Green Tag.”¹
- *Functional Recovery*: The building is able to support its basic intended functions. Some repairs will likely still be needed, and some functionality might still be impeded.²
- *Full Repair*: The building is fully repaired to its pre-earthquake state.
- *Design Event*: An earthquake of roughly the size used to design new residential buildings by the current *California Building Code*.³ For the Los Angeles site, the design event has ground shaking intensity similar to that experienced near the epicenter of the 1994 Northridge earthquake. For the Sacramento site, the shaking intensity is approximately half as strong as the Los Angeles site.

¹ This description is consistent with a definition provided in the January 2021 report by FEMA and NIST titled, *Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time* (FEMA/NIST, 2021).

² This description is consistent with the January 2021 FEMA-NIST report (see previous footnote) and with the text of California Assembly Bill 1329 (Nazarian, 2021). For this study, specific functions needed for Functional Recovery of each building type were developed by the authors with reference to recent and ongoing work, as described later in this paper.

³ This description is consistent with a hazard level used in NIST’s 2016 *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (NIST, 2016). For many California sites, this hazard level corresponds roughly to a 500-year event. For high-seismicity sites, it may also be thought of as above-average shaking from a Magnitude 7 earthquake; the U.S. Geological Survey (2015) estimates a 93% chance of such an event in California by 2045. For this study, the hazard involves only ground shaking, ignoring possible effects of liquefaction, landslide, fault rupture, tsunami, or fire-following-earthquake (so buildings with these localized effects would experience additional damage).

EXPECTED RECOVERY TIMES FOR NEW RESIDENTIAL BUILDINGS IN CALIFORNIA

Table 1 shows the expected recovery times for six residential building types designed for Los Angeles (high-seismicity) and Sacramento (moderate-seismicity) sites. This shows that new single-family dwellings in California are typically expected to be occupiable and functional within a few weeks after a design event at high-seismicity sites, and within a week at moderate-seismicity sites. For larger multi-unit residential buildings, reoccupancy is expected in weeks, and functional recovery is expected in 4-12 months at high-seismicity sites and 1-6 months at moderate seismicity sites.

Table 1: Expected recovery times for new residential buildings in high-seismicity areas (left) and moderate-seismicity areas (right) for a design event.

Building Type	Los Angeles Site (High-Seismicity)			Building Type	Sacramento Site (Moderate-Seismicity)		
	Reoccup.	Functional Recovery	Full Repair		Reoccup.	Functional Recovery	Full Repair
1-story (single-family)	0-1 wks.	0-1 wks.	1-6 mo.	1-story (single-family)	0-1 wks.	0-1 wks.	1-4 wks.
2-story (single-family)	1-4 wks.	1-4 wks.	4-12 mo.	2-story (single-family)	0-1 wks.	0-1 wks.	1-6 mo.
3-story (12-plex)	1-4 wks.	1-6 mo.	4-12 mo.	3-story (12-plex)	0-1 wks.	1-4 wks.	1-6 mo.
4-story (apartments)	1-4 wks.	1-6 mo.	1+ years	4-story (apartments)	1-4 wks.	1-6 mo.	4-12 mo.
5-story (apartments)	1-4 wks.	4-12 mo.	1+ years	5-story (apartments)	1-4 wks.	1-6 mo.	4-12 mo.
5-story on podium (apt.)	1-4 wks.	4-12 mo.	1+ years	5-story on podium (apt.)	1-4 wks.	1-6 mo.	4-12 mo.

ABOUT THIS STUDY

This study implemented the FEMA P-58 methodology (FEMA, 2012) to analyze the building damage and repair times, and then used several available recovery time analysis methods (REDi 2013, Terzic 2016, and preliminary results from a current project⁴) to provide ranges of the expected recovery times for these two sites and six common residential building types. Because of this, all results are shown as ranges, representing the current estimated prediction uncertainty; it is expected that these time ranges will become narrower once the project is completed. Note also that the ranges provided are for average building performance in each category; some buildings will perform better than average, and others will perform worse than average.

Finally, the functional recovery time estimates depend heavily on what damage is deemed allowable for a building to have its “basic intended function,” and these results will vary some as this definition is developed further.

⁴ The current project is a FEMA-funded project on Support of Performance Based Seismic Design Guidelines (Applied Technology Council, ATC-138 Project). Because it is ongoing, the recovery times provided in this study are preliminary results subject to revision and refinement. The results presented in this paper are those of the authors only and do not come from FEMA or the Applied Technology Council.

STUDY AUTHORS

Curt B Haselton, PhD, PE. Endowed Faculty Chair and Professor of Civil Engineering at CSU Chico, and CEO of Haselton Baker Risk Group, LLC, chaselton@csuchico.edu and curt@hbrisk.com.

D. Jared DeBock, PhD, PE. Assistant Professor of Civil Engineering at CSU Chico, and Senior Research Engineer at Haselton Baker Risk Group, LLC, ddebock@csuchico.edu.

Dustin Cook, PhD, PE. Senior Research Engineer at Haselton Baker Risk Group, LLC, dustin@hbrisk.com.

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