Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories

FEMA P-807 / May 2012

FEMA

nehrp

Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories

Prepared by

APPLIED TECHNOLOGY COUNCIL
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065
www.ATCouncil.org

Prepared for

FEDERAL EMERGENCY MANAGEMENT AGENCY
Michael Mahoney, Project Officer
Cathleen Carlisle, Project Monitor
Daniel Shapiro, Technical Monitor
Washington, D.C.

TASK ORDER CONTRACT MANAGEMENT
Christopher Rojahn (Project Executive Director)
Thomas R. McLane (Project Manager)
Jon A. Heintz (Project Quality Control Monitor)
William T. Holmes (Project Technical Monitor)

PROJECT REVIEW PANEL
Chris Poland (Chair)
Tony DeMascole
Laurence Kornfield
Bret Lizundia
Joan MacQuarrie
Andrew Merovich
Tom Tobin

PROJECT MANAGEMENT COMMITTEE
David Mar (Project Technical Director)
David Bonowitz
Kelly Cobeen
Dan Dolan
Andre Filiatrault
John Price

ANALYSIS CONSULTANTS
Maikol Del Carpio
Mike Korolyk

May 2012

FEMA

nehrp

Cover Photo: Near-collapse of typical weak-story wood-frame buildings in the 1989 Loma Prieta earthquake.

Foreword

The Federal Emergency Management Agency (FEMA) has the goal of reducing the ever-increasing cost that disasters inflict on our country. Preventing losses before they happen by designing and building to withstand anticipated forces from these hazards is one of the key components of mitigation, and is the only truly effective way of reducing the cost of disasters. As part of its responsibilities under the National Earthquake Hazards Reduction Program (NEHRP), and in accordance with the National Earthquake Hazards Reduction Act of 1977 (PL 94-125) as amended, FEMA is charged with supporting activities necessary to improve technical quality in the field of earthquake engineering. The primary method of addressing this charge has been supporting the investigation of seismic technical issues as they are identified by FEMA, the development and publication of technical design and construction guidance products, the dissemination of these products, and support of training and related outreach efforts.

In recent earthquake events, FEMA has observed that multi-unit wood-frame buildings with a weak first story represent a significant risk in highly seismic regions of the United States because of their high potential for collapse. This risk is magnified by the sheer numbers of these buildings that still exist and the numbers of people who occupy them. This collapse potential is due primarily to their soft or weak first-story walls, which have often been weakened by large numbers of openings such as garages or store front windows.

FEMA worked with ATC to develop these guidelines to address seismic retrofit requirements for weak-story wood-frame buildings in seismically active regions of the United States, with a particular focus on Northern and Southern California and the Pacific Northwest. The guidelines focus on multi-family, multi-story buildings with weak first stories, such as those damaged in the Marina District of San Francisco in the 1989 Loma Prieta earthquake, and apartment buildings with tuck-under parking, such as those damaged in Southern California in the 1994 Northridge earthquake.

These seismic retrofitting guidelines are the first to focus solely on the weak first story and to provide just enough additional strength to protect the first floor from collapse but not so much as to drive earthquake forces into the upper stories, placing them at risk of collapse. They are also the first to take into account the strength provided by existing non-structural walls. Both of these steps will make seismic retrofitting more affordable. This methodology does presume, however, that the upper stories are basically regular and do provide enough strength to match the retrofitted first story.

FEMA is indebted to the Project Management Committee of David Mar (Project Technical Director), David Bonowitz, Kelly Cobeen, Dan Dolan, Andre Filiatrault, and John Price, for preparing this report, and to Mike Korolyk, who as the Analysis Consultant conducted the computer analyses to validate the guidelines. We also wish to thank the Project Review Panel of Chris Poland (Chair), Tony DeMascole, Laurence Kornfield, Bret Lizundia (ATC Board Representative), Joan MacQuarrie, Andrew Merovich, and Tom Tobin, who provided expert review and guidance throughout the developmental effort. Without their dedication and hard work, this project would not have been possible.

– Federal Emergency Management Agency

Preface

In May 2009 the Applied Technology Council (ATC), with funding from the Federal Emergency Management Agency (FEMA) under Task Order Contract HSFEHQ-08-D-0726, commenced development of simplified guidelines for the seismic retrofit of weak-story wood-frame buildings—one of several projects in a task order series to develop written guidance for FEMA on the creation, update, and maintenance of seismic evaluation and rehabilitation documents for existing buildings.

Multi-unit wood-frame buildings with a weak first story represent a significant risk in highly seismic regions of the United States, not only because of their damage and collapse potential, but also because of their size, prevalence and the high numbers of people who occupy them. In San Francisco, for example, approximately 4,400 older, pre-seismic-code, wood-frame residential buildings have been inventoried that contain five or more living units and are 3 or more stories in height (ATC, 2009a). Most of these buildings have potentially soft or weak ground floor (first story) walls, as do an expectedly high but unknown number of pre-seismic-code 3-to-5 story wood-frame commercial buildings, and similar buildings constructed after 1974 not included in the San Francisco inventory.

FEMA and ATC agreed that the retrofit guidelines development project should address seismic retrofit requirements for weak-story wood-frame buildings in seismically active regions of the United States, focusing primarily on Northern and Southern California and the Pacific Northwest. Configurations to be addressed included multi-family, multi-story buildings with weak first stories, such as those prevalent in San Francisco, and apartment buildings with tuck-under parking, such as those significantly damaged by the 1994 Northridge earthquake in Southern California. The project team was also charged with developing practical, model code provisions for seismic retrofit of weak-story wood-frame buildings that can be adopted by cities such as San Francisco and that are written to ensure that application and enforcement is uniform and enforceable.

This *Guidelines* document sets forth the framework for procedures for seismic evaluation and retrofit of weak-story wood-frame buildings. Throughout this document the term weak-story is used to describe a building's vulnerability, rather than soft-story. The reason is that while both flexibility and strength contribute to the structure's response, strength is the more dominant characteristic.

ATC is indebted to the ATC Project Management Committee, which consisted of David Mar (Project Technical Director), David Bonowitz, Kelly Cobeen, Dan Dolan, Andre Filiatrault, and John Price, for their efforts in researching and preparing this report; to Mike Korolyk, who served as the Analysis Consultant and conducted thousands of computer analyses to support and validate the guidelines; to Maikol Del Carpio, who assisted in the data analysis; and to the Project Review Panel, which consisted of Chris Poland (Chair), Tony DeMascole, Laurence Kornfield, Bret Lizundia (ATC Board Representative), Joan MacQuarrie, Andrew Merovich, and Tom Tobin, who provided expert review and guidance throughout the developmental effort. Thomas R. McLane served as Project Manager, William Holmes served as the Project Technical Monitor, and Peter Mork provided report production services. The affiliations of these individuals are provided in the list of Project Participants.

ATC also gratefully acknowledges the input, support, and guidance provided by Michael Mahoney (FEMA Project Officer), Cathleen Carlisle (FEMA Project Monitor), Robert Hanson (FEMA Subject Matter Expert), and Daniel Shapiro (FEMA Technical Monitor).

Jon A. Heintz	Christopher Rojahn
ATC Director of Projects	ATC Executive Director

Table of Contents