

**NIST GCR 14-917-25**



# **Recommendations for Seismic Design of Reinforced Concrete Wall Buildings Based on Studies of the 2010 Maule, Chile Earthquake**

NEHRP Consultants Joint Venture  
*A partnership of the Applied Technology Council and the  
Consortium of Universities for Research in Earthquake Engineering*



**NIST**  
National Institute of  
Standards and Technology  
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Cover illustration – Cracking, spalling, crushing, and bar buckling in a reinforced concrete shear wall of a building located in Viña del Mar, Chile (photo courtesy of Patricio Bonelli).

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Prepared for  
*U.S. Department of Commerce  
National Institute of Standards and Technology  
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By  
NEHRP Consultants Joint Venture  
*A partnership of the Applied Technology Council and the  
Consortium of Universities for Research in Earthquake Engineering*

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# Preface

The NEHRP Consultants Joint Venture is a partnership between the Applied Technology Council (ATC) and the Consortium of Universities for Research in Earthquake Engineering (CUREE). In 2007, the National Institute of Standards and Technology (NIST) awarded the NEHRP Consultants Joint Venture a National Earthquake Hazards Reduction Program (NEHRP) “Earthquake Structural and Engineering Research” task order contract (SB1341-07-CQ-0019) to conduct a variety of tasks. On February 27, 2010, a magnitude 8.8 earthquake occurred off the coast near the Maule region of central Chile. In September 2010, NIST initiated Task Order 10303 entitled “Analysis of Seismic Performance of Reinforced Concrete Buildings in the 2010 Chile Earthquake.”

Most mid-rise and high-rise buildings in the earthquake-affected regions were constructed with seismic-force-resisting systems consisting of reinforced concrete structural walls. Similar construction is also prevalent in regions of high seismicity in the Western United States. In response to the earthquake, several U.S. organizations sent reconnaissance teams to Chile to gather information that could be used to study implications for U.S. design and construction practice. The purpose of this project was to evaluate critical issues in the performance of reinforced concrete wall structures in the 2010 Maule earthquake, and to develop recommendations for improved shear wall design requirements for incorporation into U.S. practice.

Work on this project involved: (1) the collection of available reconnaissance information to identify trends in concrete building performance; (2) the conduct of focused studies on key issues including bar buckling and concrete crushing in wall boundary elements, overall wall buckling behaviors, discontinuities in building configuration, and advanced simulation techniques for concrete walls; and (3) interpretation of results for improvement in U.S. practice. In a separate project, NIST commissioned a study comparing U.S. and Chilean building codes and construction practices. Results are contained in NIST GCR 12-917-18, *Comparison of U.S. and Chilean Building Code Requirements and Seismic Design Practice 1985-2010* (NIST, 2012), and are intended to provide context for interpretation of findings and recommendations presented herein.

The NEHRP Consultants Joint Venture is indebted to the leadership of Joe Maffei, Project Director, and to the members of the Project Technical Committee, consisting of Patricio Bonelli, Dominic Kelly, Dawn Lehman, Laura Lowes, Jack Moehle, Karl Telleen, John Wallace, and Michael Willford, for their planning, conduct, and

oversight of the work. This report and the resulting recommendations are based on problem-focused analytical studies that were conducted by Begoña Aguirre, Ady Aviram, Anna Birely, Chris Hilson, Yuli Huang, and Pablo Parra under the direction of the Project Technical Committee. Technical review and comment at key developmental stages of the project were provided by the Project Review Panel consisting of S.K. Ghosh, Tara Hutchinson, Derrick Roorda, and Mete Sozen. The names and affiliations of all who contributed to this project are included in the list of Project Participants at the end of this report.

NEHRP Consultants Joint Venture also gratefully acknowledges Jack Hayes (Director, NEHRP), and Steve McCabe (Deputy Director, NEHRP), for their input and guidance in the conduct of this work, Ayse Hortacsu (ATC Associate Director of Projects) for assistance in the preparation of this report, and Amber Houchen for ATC report production services.

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