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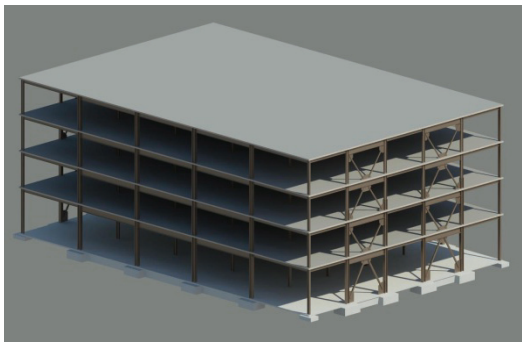

Evaluation of the FEMA P-695 Methodology for Quantification of Building Seismic Performance Factors

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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Cover photo – Illustration of steel concentrically braced frame archetype for performance evaluation.

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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 a National Earthquake Hazards Reduction Program (NEHRP) "Earthquake Structural and Engineering Research" contract (SB1341-07-CQ-0019) to the NEHRP Consultants Joint Venture to conduct a variety of tasks, including Task Orders 67344 and 68002 entitled "Quantification of Building System Performance and Response Parameters."

This work was an extension of work conducted under the ATC-63 Project, funded by the Federal Emergency Management Agency (FEMA), which resulted in the publication of the FEMA P-695 report, *Quantification of Building Seismic Performance Factors* (FEMA 2009). The FEMA P-695 report outlines a procedural methodology for reliably quantifying seismic performance factors, including the response modification coefficient (R factor), the system overstrength factor (Ω_0), and the deflection amplification factor (C_d). While the ATC-63 Project included testing of the Methodology on selected systems (e.g., special and ordinary reinforced concrete moment frames and wood light-frame structural panel shear walls), the purpose of this NIST project was to expand the testing of the Methodology to additional seismic force-resisting systems.

Beta testing was overseen by members of the original ATC-63 Project Team, but was conducted by working groups consisting of individuals who were not directly involved in the development of the Methodology. The following systems were tested as part of this work: (1) special and ordinary reinforced masonry shear walls; (2) special and ordinary reinforced concrete shear walls; (3) special steel concentrically braced frames and buckling-restrained braced frames; and (4) special steel moment frames. With certain exceptions, results confirmed the applicability of the Methodology for quantifying seismic performance factors and verified that currently approved seismic force-resisting systems generally meet the inherent safety against collapse intended by current seismic codes and standards.

The NEHRP Consultants Joint Venture is indebted to the leadership of Charlie Kircher, Project Director, and to the members of the project team for their efforts in testing the Methodology and developing this report. The Project Technical Committee, consisting of Greg Deierlein, John Hooper, Helmut Krawinkler, Steve

Mahin, Benson Shing, and John Wallace monitored and guided the beta testing work. The Working Groups, including Chui-Hsin Chen, Brian Dean, Aysegul Gogus, Ioannis Koutromanos, Dimitrios Lignos, and Farzin Zareian prepared archetype designs and conducted nonlinear response history analyses. The Project Review Panel, consisting of Ron Hamburger, Jim Harris, Bill Holmes, Rich Klingner, Phil Line, Nico Luco, Bonnie Manley, Laurence Novak, Rafael Sabelli, and Kurt Stochlia provided technical review, advice, and consultation at key stages of the work. The names and affiliations of all who contributed to this report are provided in the list of Project Participants.

The NEHRP Consultants Joint Venture also gratefully acknowledges Jack Hayes (NEHRP Director), Jay Harris (NIST Project Manager), Michael Mahoney (FEMA Project Officer), and Robert Hanson (FEMA Technical Monitor) for their input and guidance in the preparation of this report, and Ayse Hortacsu and Peter N. Mork for ATC report production services.

Jon A. Heintz
Program Manager

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