Quantification of Building Seismic Performance Factors: Component Equivalency Methodology

Prepared by

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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 and related multi-hazard 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. These voluntary resource guidance products present criteria for the design, construction, upgrade, and function of buildings subject to earthquake ground motions in order to minimize the hazard to life in all buildings and increase the expected performance of critical and higher occupancy structures.

This publication builds upon an earlier FEMA publication, FEMA P-695 *Quantification of Building Seismic Performance Factors* (FEMA, 2009b). FEMA P-695 presents a procedural methodology for reliably quantifying seismic performance factors, including the response modification coefficient, R, the system overstrength factor, Ω_O, and the deflection amplification factor, C_d, used to characterize the global seismic response of a system.

While the methodology contained in FEMA P-695 provides a means to evaluate complete seismic-force-resisting systems proposed for adoption into building codes, a component-based methodology was needed to reliably evaluate structural elements, connections, or subassemblies proposed as substitutes for equivalent components in established seismic-force-resisting systems. The Component Equivalency Methodology presented in this document fills this need by maintaining consistency with the probabilistic, system-based collapse assessment concepts of FEMA P-695 while providing simple procedures for comparing the tested performance of different components. It is intended to be of assistance to organizations, such as the International Code Council Evaluation Service, who need to compare the seismic performance of alternate components to those contained in established seismic force resisting system.

FEMA wishes to express its sincere gratitude to Charlie Kircher, Project Technical Director, and to the members of the Project Team for their efforts in the development of this publication, including the Project Management Committee consisting of Greg Deierlein, Andre Filiatrault, Jim Harris, John Hooper, Helmut Krawinkler, and Kurt Stochlia; the Project Working Groups consisting of Curt Haselton, Abbie Liel, Jackie Steiner, and Seyed Hamid Shivaee; and the Project Review Panel consisting of S.K. Ghosh, Mark Gilligan, Ramon Gilsanz, Ron Hamburger, Rich Klingner, Phil Line, Bonnie Manley, Rawn Nelson, Andrei Reinhorn, and Rafael Sabelli. Without their dedication and hard work, this project would not have been possible.

Federal Emergency Management Agency

Preface

In 2008, the Applied Technology Council (ATC) was awarded a "Seismic and Technical Guidance Development and Support" contract (HSFEHQ-08-D-0726) by the Federal Emergency Management Agency (FEMA) to conduct a variety of tasks, including one entitled "Quantification of Building System Performance and Response Parameters." Designated the ATC-63-1 Project, this work was the continuation of the ATC-63 Project, funded under an earlier FEMA contract, which resulted in the publication of the FEMA P-695 report, *Quantification of Building Seismic Performance Factors* (FEMA, 2009b). This report outlined 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, used to characterize the global seismic response of a system.

While the FEMA P-695 Methodology provided a means to evaluate complete seismic-force-resisting systems proposed for adoption into building codes, a component-based methodology was still needed that could reliably evaluate structural elements, connections, or subassemblies proposed as substitutes for equivalent components in current code-approved seismic-force-resisting systems. The purpose of the ATC-63-1 Project was to develop such a methodology.

The recommended Component Equivalency Methodology described in this report balances the competing objectives of: (1) maintaining consistency with the probabilistic, analytical, system-based collapse assessment concepts of the FEMA P-695 Methodology; and (2) providing simple procedures for comparing the tested performance of different components. It was developed based on probabilistic concepts using results from collapse sensitivity studies on key performance parameters.

ATC is indebted to the leadership of Charlie Kircher, Project Technical Director, and to the members of the ATC-63-1 Project Team for their efforts in the development of the recommended methodology. The Project Management Committee, consisting of Greg Deierlein, Andre Filiatrault, Jim Harris, John Hooper, Helmut Krawinkler, and Kurt Stochlia monitored and guided the technical development efforts. The Project Working Groups, which included Curt Haselton, Abbie Liel, Seyed Hamid Shivaee, and Jackie

Steiner, deserve special recognition for their contributions in developing, investigating, and testing the methodology, and in preparing this report. The Project Review Panel, consisting of S.K. Ghosh, Mark Gilligan, Ramon Gilsanz, Ronald Hamburger, Richard Klingner, Philip Line, Bonnie Manley, Rawn Nelson, Andrei Reinhorn, and Rafael Sabelli provided technical review, advice, and consultation at key stages of the work. Ayse Hortacsu served as ATC project manager for this work. The names and affiliations of all who contributed to this report are provided in the list of Project Participants.

ATC also gratefully acknowledges Michael Mahoney (FEMA Project Officer), Robert Hanson (FEMA Technical Monitor), and William Holmes (ATC Project Technical Monitor) for their input and guidance in the preparation of this report, Peter N. Mork for ATC report production services, and Ramon Gilsanz as ATC Board Contact.

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