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Title of Dissertation/ Thesis: Performance Assessment of Seismic Resistant Steel Structures

Institution conferring degree: Virginia Polytechnic Institution

Degree awarded (abbreviate; e.g., Ph.D.): Ph. D.

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Year manuscript completed: 2013

Advisor/Committee Chair: Dr. Finley Charney

Committee Member: Dr. Matthew Eatherton

Committee Member: Dr. Adrian Rodriguez-Marek

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Nonlinear Response History Analysis

FEMA P-58

FEMA P-695

ASCE 7

Innovative Systems

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# Performance Assessment of Seismic Resistant Steel Structures

Jordan Alesa Jarrett

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Civil Engineering

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# Performance Assessment of Seismic Resistant Steel Structures

Jordan Alesa Jarrett

## Abstract

This work stems from two different studies related to this performance assessment of seismic resistant systems. The first study compares the performance of newly developed and traditional seismic resisting systems, and the second study investigates many of the assumptions made within provisions for nonlinear response history analyses.

In the first study, two innovative systems, which are hybrid buckling restrained braces and collapse prevention systems, are compared to their traditional counterparts using a combination of the FEMA P-695 and FEMA P-58 methodologies. Additionally, an innovative modeling assumption is investigated, where moment frames are evaluated with and without the lateral influence of the gravity system. Each system has a unique purpose from the perspective of performance-based earthquake engineering, and analyses focus on the all intensity levels of interest. The comparisons are presented in terms consequences, including repair costs, repair duration, number of casualties, and probability of receiving an unsafe placard, which are more meaningful to owners and other decision makers than traditional structural response parameters. The results show that these systems can significantly reduce the consequences, particularly the average repair costs, at the important intensity levels.

The second study focuses on the assumptions made during proposed updates to provisions for nonlinear response history analyses. The first assumption investigated is the modeling of the gravity system's lateral influence, which can have significant effect on the system behavior and should be modeled if a more accurate representation of the behavior is needed. The influence of residual drifts on the proximity to collapse is determined, and this work concludes that a residual drift check is unnecessary if the only limit state of interest is collapse prevention. This study also finds that spectrally matched ground motions should cautiously be used for near-field structures. The effects of nonlinear accidental torsion are also examined in detail and are determined to have a significant effect on the inelastic behavior of the analyzed structure. The final investigation in this study shows that even if a structure is designed per ASCE 7, it may not have the assumed probability of collapse under the maximum considered earthquake when analyzed using FEMA P-695.