SAC
Steel Project

Background Document

Proposed Statistical and Reliability Framework for Comparing and Evaluating Predictive Models for Evaluation and Design, and Critical Issues in Developing Such Framework

Report No. SAC/BD-97/03

SAC Joint Venture
A partnership of
Structural Engineers Association of California (SEAOC)
Applied Technology Council (ATC)
California Universities for Research in Earthquake Engineering (CUREe)

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Submitted for distribution to
SAC Joint Venture
650-595-1542
http://www.sacsteel.org

July 1, 1997

DISCLAIMER

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THE SAC JOINT VENTURE

SAC is a joint venture of the Structural Engineers Association of California (SEAOC), the Applied Technology Council (ATC), and California Universities for Research in Earthquake Engineering (CUREe), formed specifically to address both immediate and long-term needs related to solving performance problems with welded, steel moment-frame connections discovered following the 1994 Northridge earthquake. SEAOC is a professional organization composed of more than 3,000 practicing structural engineers in California. The volunteer efforts of SEAOC's members on various technical committees have been instrumental in the development of the earthquake design provisions contained in the *Uniform Building Code* and the 1997 *National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for Seismic Regulations for New Buildings and other Structures*. ATC is a nonprofit corporation founded to develop structural engineering resources and applications to mitigate the effects of natural and other hazards on the built environment. Since its inception in the early 1970s, ATC has developed the technical basis for the current model national seismic design codes for buildings; the *de facto* national standard for postearthquake safety evaluation of buildings; nationally applicable guidelines and procedures for the identification, evaluation, and rehabilitation of seismically hazardous buildings; and other widely used procedures and data to improve structural engineering practice. CUREe is a nonprofit organization formed to promote and conduct research and educational activities related to earthquake hazard mitigation. CUREe's eight institutional members are the California Institute of Technology, Stanford University, the University of California at Berkeley, the University of California at Davis, the University of California at Irvine, the University of California at Los Angeles, the University of California at San Diego, and the University of Southern California. These laboratory, library, computer and faculty resources are among the most extensive in the United States. The SAC Joint Venture allows these three organizations to combine their extensive and unique resources, augmented by subcontractor universities and organizations from across the nation, into an integrated team of practitioners and researchers, uniquely qualified to solve problems related to the seismic performance of steel moment-frame buildings.

ACKNOWLEDGEMENTS

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PREFACE

A primary objective of Phase II of the FEMA/SAC Steel Project is to produce performance-based guidelines for the seismic evaluation and design of steel moment frame structures. The responsibility for this effort lies with the Performance Prediction and Evaluation team, which is working to define limit states (performance objectives) for steel structures as well as to identify linear and nonlinear design and analysis procedures that can be used to achieve designs which reliably meet these limit states. Fundamental to this work is the development of an evaluation procedure which can be used to judge the suitability of a given analytical method, taking into account the uncertainties inherent in defining the structural capacities of and ground motion demands on a structural system and its components. The development of such a procedure is the subject of this report.

The majority of the raw data used in the development and calibration of design and analysis models is provided by the System Performance team. Response statistics are being generated through detailed nonlinear time history analyses of a number of structures in several seismic environments. The goal of these studies is to identify the influence of various parameters (ground motion intensity and character, system configuration, structural modeling, element hysteretic behavior, etc.) on selected measures of frame response using refined analytical approaches.

The Performance Prediction and Evaluation team then has the responsibility of evaluating this data and calibrating more simplified analytical procedures against the results of the nonlinear time history analyses. At this time four basic procedures are being considered, consistent with those outlined in FEMA 273 (NEHRP *Guidelines for the Seismic Rehabilitation of Buildings*, 1997): linear static, nonlinear static, linear dynamic, and nonlinear dynamic. The subcontractors evaluating these approaches are developing bias and uncertainty correction factors appropriate for each method of analysis and corresponding to particular probabilities of exceedance of specified limit states. The numerical values defining particular structural limit states adopted in the final seismic design criteria for steel moment frames developed in the Phase II project will then reflect implicitly the uncertainties in the demand and capacity sides of the structural design equation with a quantifiable reliability.

This report was developed through a series of workshops on the specification of reliability-based design procedures sponsored by the SAC Joint Venture and chaired by Y. K. Wen of the University of Illinois at Urbana-Champaign. Other participants included C. Allin Cornell (Stanford University), Armen DerKiureghian (University of California at Berkeley), Bruce Ellingwood (Johns Hopkins University), and the members of the SAC Technical Advisory Panel for Performance Prediction and Evaluation. The contributions from all of these individuals are greatly appreciated.