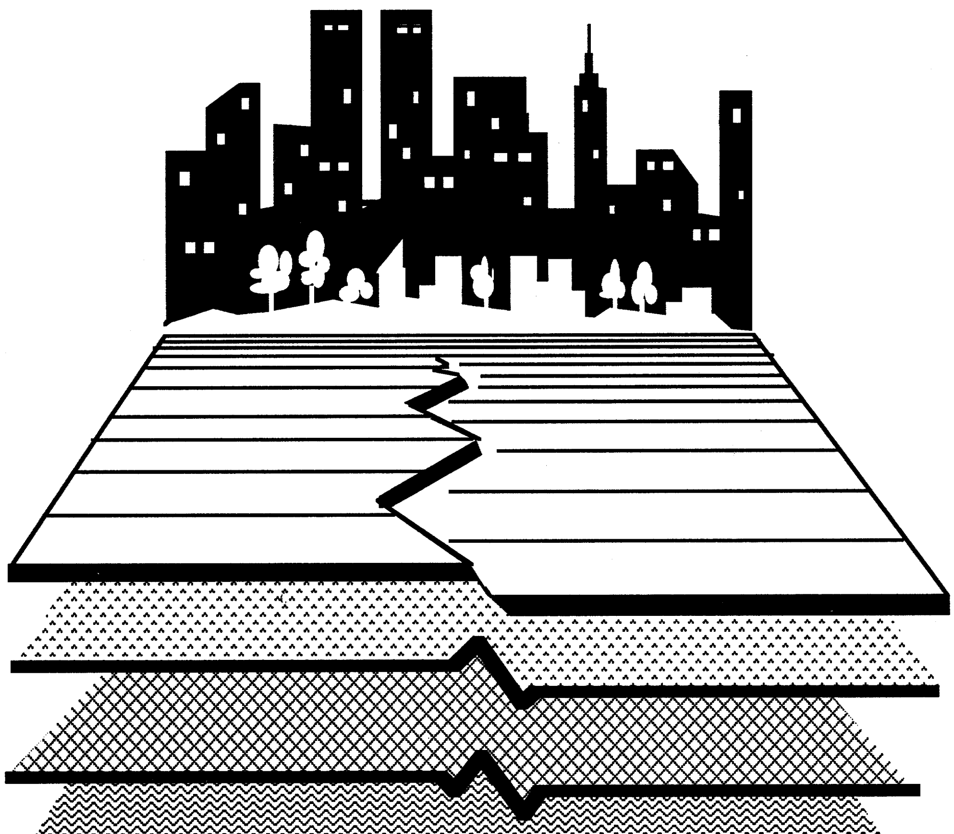
SECOND EDITION

Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation



EARTHQUAKE HAZARDS REDUCTION SERIES 41

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

Second Edition

RAPID VISUAL SCREENING OF BUILDINGS FOR POTENTIAL SEISMIC HAZARDS: SUPPORTING DOCUMENTATION

ATC

APPLIED TECHNOLOGY COUNCIL
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The Applied Technology Council (ATC) is a nonprofit, tax-exempt corporation established in 1971 through the efforts of the Structural Engineers Association of California. ATC's mission is to develop state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment. ATC also identifies and encourages needed research and develops consensus opinions on structural engineering issues in a non-proprietary format. ATC thereby fulfills a unique role in funded information transfer.

ATC is guided by a Board of Directors consisting of representatives appointed by the American Society of Civil Engineers, the National Council of Structural Engineers Associations, the Structural Engineers Association of California, the Western Council of Structural Engineers Associations, and four at-large representatives concerned with the practice of structural engineering. Each director serves a three-year term.

Project management and administration are carried out by a full-time Executive Director and support staff. Project work is conducted by a wide range of highly qualified consulting professionals, thus incorporating the experience of many individuals from academia, research, and professional practice who would not be available from any single organization. Funding for ATC projects is obtained from government agencies and from the private sector in the form of tax-deductible contributions.

2001-2002 Board of Directors

ATC DISCLAIMER

FEMA Foreword

The Federal Emergency Management Agency (FEMA) is pleased to present the second edition of the widely used *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, and its companion, *Supporting Documentation.* The policy of improving reports and manuals that deal with the seismic safety of existing buildings as soon as new information and adequate resources are available is thus being reaffirmed. Users should take note of some major differences between the two editions of the *Handbook*. The technical content of the new edition is based more on experiential data and less on expert judgment than was the case in the earlier edition, as is explained in the *Supporting Documentation*. From the presentational point of view, the *Handbook* retains much of the material of the earlier edition, but the material has been rather thoroughly rearranged to further facilitate the step-by-step process of conducting the rapid visual screening of a building. By far the most significant difference between the two editions, however, is the need for a higher level of engineering understanding and expertise on the part of the users of the second edition. This shift has been caused primarily by the difficulty experienced by users of the first edition in identifying the lateral-force-resisting system of a building without entry—a critical decision of the rapid visual screening process. The contents of the *Supporting Documentation* volume have also been enriched to reflect the technical advances in the *Handbook*.

FEMA and the Project Officer wish to express their gratitude to the members of the Project Advisory Panel, to the technical and workshop consultants, to the project management, and to the report production and editing staff for their expertise and dedication in the upgrading of these two volumes.

The Federal Emergency Management Agency

Preface

In 1988 the Applied Technology Council, with funding from the Federal Emergency Management Agency (FEMA), completed the first edition of the FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, and the companion first edition of the FEMA-155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation.* A little over a decade later, ATC was awarded a second contract by FEMA to update the first edition of both documents.

The impetus for the update effort stemmed in part from the general recommendation in the FEMA 315 report, *Seismic Rehabilitation of Buildings: Strategic Plan 2005*, to update periodically all existing reports in the FEMA-developed series on the seismic evaluation and rehabilitation of existing buildings. In addition, a vast amount of information had been developed since 1988, including (1) new knowledge about the performance of buildings during damaging earthquakes, including the 1989 Loma Prieta and 1994 Northridge earthquakes; (2) new knowledge about seismic hazards, including updated national seismic hazard maps published by the U. S. Geological Survey in 1996; (3) other new seismic evaluation and damage prediction tools, such as the FEMA 310 report, *Handbook for the Seismic Evaluation of Buildings – a Prestandard*, (an updated version of FEMA 178, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings*), and HAZUS, FEMA's tool for estimating potential losses from natural disasters; and (4) experience from the widespread use of the original FEMA 154 *Handbook* by federal, state and municipal agencies, and others.

The update project included the following tasks: (1) an effort to obtain users feedback, which was executed through the distribution of a voluntary FEMA 154 Users Feedback Form to organizations that had ordered or were known to have used FEMA 154 (the Feedback Form was also posted on ATC's web site); (2) a review of available information on the seismic performance of buildings, including a detailed review of the HAZUS fragility curves and an effort to correlate the relationship between results from the use of both the FEMA 154 rapid visual screening procedure and the FEMA 178 detailed seismic evaluation procedure on the same buildings; (3) a Users Workshop midway in the project to learn first hand the problems and successes of organizations that had used the rapid visual screening procedure on buildings under their jurisdiction; (4) updating of the original FEMA 154 *Handbook* to create the second edition; and (5) updating of the original FEMA 155 *Supporting Documentation* report to create the second edition.

This second edition of the FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, contains the technical basis for the updated rapid visual screening procedure, including (1) a summary of results from the efforts to solicit user feedback, and (2) a detailed description of the Basic Structural Hazard Score and the Score Modifier developmental effort. The minutes of the Users Workshop are also provided as an appendix.

ATC gratefully acknowledges the personnel involved in developing the second editions of the FEMA 154 and FEMA 155 reports. Charles Scawthorn served as Co-Principal Investigator and Project Director. He was assisted by Kent David, Vincent Prabis, Richard A. Ranous, and Nilesh Shome, who served as Technical Consultants. Members of the Project Engineering Panel, who provided overall review and guidance for the project, were: Thalia Anagnos, John Baals, James R. Cagley (ATC Board Representative), Melvyn Green, Terry Hughes, Anne S. Kiremidjian, Joan MacQuarrie, Chris D. Poland, Lawrence D. Reaveley, Doug Smits, and Ted Winstead. William T. Holmes served as facilitator for the Users Workshop, and Keith Porter served as recorder. Stephanie A. King verified the Basic Structural Hazard Scores and the Score Modifiers. A. Gerald Brady, Peter N. Mork, and Michelle Schwartzbach provided report editing and production services. The affiliations of these individuals are provided in the list of project participants.

ATC also gratefully acknowledges the valuable assistance, support, and cooperation provided by Ugo Morelli, FEMA Project Officer. In addition, ATC acknowledges participants in the FEMA 154 Users Workshop, which included, in addition to the project personnel listed above, the

following individuals: Al Berstein, Amitabha Datta, Ben Emam, Richard K. Eisner, Ali Fattah, Brian Kehoe, David Leung, Douglas McCall, Richard Silva, Howard Simpson, Steven Sweeney, Christine Theodooropoulos, and Zan Turner. The affiliations of these individuals are provided in the list of project participants. Those persons who responded to ATC's request to complete the voluntary FEMA 154 Users Feedback form are also gratefully acknowledged.

Christopher Rojahn, Principal Investigator
ATC Executive Director

Summary

The technical approach employed to update the first edition of the FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards* (ATC, 1988a), described in this second edition of the FEMA *Supporting Documentation* report, encompassed a variety of efforts, including: (1) an outreach effort to obtain feedback from users of the first edition of FEMA 154; (2) updating of the building classification system; (3) updating of the rapid visual screening scoring system, based on (a) new knowledge on seismic hazard mapping, and (b) new knowledge on earthquake performance of buildings; and (4) the development of other enhancements to facilitate implementation of rapid visual screening. The project also included an extensive effort to calibrate the scoring system of the First Edition based on information derived from studies of buildings evaluated using both the first edition of the FEMA 154 rapid visual screening procedure and the detailed seismic evaluation procedure of the FEMA 178 *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* (BSSC, 1992). That effort, however, did not produce results useful for improving the rapid visual screening scoring system.

The effort to obtain feedback from users had two components: the development and distribution of a Voluntary Users' Feedback Form at the beginning of the project in late 1999 and a Users Workshop midway in the project.

While the number of Users' Feedback Forms completed and returned was much smaller than anticipated, the 23 responders represented entities that had surveyed a total of almost 70,000 buildings. Their responses indicated that: (1) the users were representatives of federal, state, and local agencies and practicing professionals engaged in earthquake risk reduction (owners of private buildings and insurers did not respond); (2) the general organization, relative chapter length and *Handbook* content were satisfactory; (3) with the exception of the line drawings of architectural elevations, the printing and graphic quality of the *Handbook* was generally acceptable; (4) the building classification was generally satisfactory, but should be made consistent with FEMA 178 and other related documents; (5) the Structural Hazard Scores and Performance Modification Factors were generally satisfactory, but should be reviewed and updated where necessary in light of data developed since 1988; (6) the mean time required to conduct a building survey was 2 hours per building; and (7) the Data Collection Form was satisfactory.

Input gathered during the Users Workshop in September 2000 confirmed these findings. Workshop participants indicated that the methodology was easy to explain and grasp, but that implementation was sometimes difficult, principally because of the difficulty in determining (1) the structural system without access to plans, to the building interior, and for remodeled buildings and those with numerous additions, and (2) the soil conditions for the site. Users also discussed the difficulty in information sharing and identified the varied uses of the methodology, including rating for insurance purposes, assessing the potential vulnerability of individual buildings, development of building inventory information for damage and loss estimation studies; and identification and ranking of building rehabilitation needs.

During the development of the second edition of the FEMA 154 *Handbook*, considerable effort was expended on the evaluation of data and information that could be used to update the Basic Structural Hazard (BSH) Scores and Performance Modification Factors (PMFs) from the first edition. The BSH Scores in the first edition of FEMA-154 were calculated using (1) expert-opinion Damage Probability Matrices from the ATC-13 report, *Earthquake Damage Evaluation Data for California* (ATC, 1985) modified for use in regions outside of California; and (2) ground motion maps provided with the *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings* (BSSC, 1985), which specified effective peak acceleration ground motion having a 10% probability of being exceeded in 50 years. The PMFs in the first edition were based on engineering judgment, and lacked an analytical basis.

As a result of user input and the extensive research and development effort to improve the BSH Scores and PMFs, which were renamed to Score Modifiers, several significant changes and enhancements were incorporated in the second edition of the FEMA 154 *Handbook.* These included:

- an updated scoring system, formatted like the scoring system in the First Edition, and consisting of:
  - new Basic Structural Hazard Scores based on (1) the HAZUS methodology and fragility curves (NIBS, 1999) for low-rise buildings and assuming soil type B, and (2) new Maximum Considered Earthquake (MCE) seismic design spectral acceleration response values (developed by the U. S. Geological Survey and the Building Seismic Safety Council), which are based on ground motion having a 2% probability of being exceeded in 50 years, adjusted to incorporate the 2/3 reduction factor specified in the FEMA 310 *Handbook for the Seismic Evaluation of Buildings – A Prestandard* (ASCE,1998); and
  - new Score Modifiers for mid-rise buildings, high-rise buildings, plan irregularity, vertical irregularity, pre-code buildings, post-benchmark buildings, soil type C, soil type D, and soil type E, all but one of these modifiers being based on calculations to reflect the HAZUS fragility curves and methodology, and the other modifier being based on judgment;
- a slightly modified building classification system developed to be consistent with building classification systems in other related FEMA-funded documents pertaining to the seismic evaluation and rehabilitation of buildings, such as FEMA 310, the FEMA 273 NEHRP *Guidelines for the Seismic Rehabilitation of Existing Buildings* (ATC, 1997), and the FEMA 356 *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (ASCE, 2000);
- new material and guidance for interior inspection, which includes photographs and instruction on building interior cues, to assist the screener in determining or verifying the lateral-load resisting system for the building;
- additional information on organizing and implementing the rapid visual screening (RVS) procedure, including (1) an example case study illustrating the procedures to be followed when conducting an RVS survey in a hypothetical community; and (2) linking of the RVS methodology with municipal geographic information system (GIS) property databases; and
- a new set of three Data Collections Forms (one each for low seismicity, moderate seismicity, and high seismicity regions) that retains the original format but includes the new BSH Scores and Score Modifiers and other minor revisions.

At the suggestion of users and the advisory Project Engineering Panel, the FEMA 154 Update Project Team also considered the development of an application of the RVS methodology on a personal digital assistant (PDA), but this effort was concluded to be outside the scope of the project.

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