Rapid Visual Screening of Buildings for Potential Seismic Hazards

A Handbook

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Second Edition

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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.

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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 August 1999 the Federal Emergency Management Agency (FEMA) awarded the Applied Technology Council (ATC) a two-year contract to update the FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, and the companion FEMA-155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, both of which were originally published in 1988.

The impetus for the project 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 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 procedures 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 154 *Handbook* provides a standard rapid visual screening procedure to identify, inventory, and rank buildings that are potentially seismically hazardous. The scoring system has been revised, based on new information, and the *Handbook* has been shortened and focused to facilitate implementation. The technical basis for the rapid visual screening procedure, including a summary of results from the efforts to solicit user feedback, is documented in the companion second edition of the FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation.*

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 Advisory 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, U. S. Bureau of Reclamation; Amitabha Datta, General Services Administration; Ben Emam, Amazon.com; Richard K. Eisner, California Office of Emergency Services; Ali Fattah, City of San Diego; Brian Kehoe, Wiss Janney Elstner Associates, Inc.; David Leung, City and County of San Francisco; Douglas McCall, Marx/Okubo; Richard Silva, National Park Service; Howard Simpson, Simpson Gumpertz & Heger Inc.; Steven Sweeney, U. S. Army Civil Engineering Research Laboratory; Christine Theodooropoulos, University of Oregon; and Zan Turner, City and County of San Francisco. 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 and Application

This FEMA 154 Report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook,* is the first of a two-volume publication on a recommended methodology for rapid visual screening of buildings for potential seismic hazards. The technical basis for the methodology, including the scoring system and its development, are contained in the companion FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*. Both this document and the companion document are second editions of similar documents published by FEMA in 1988.

The rapid visual screening procedure (RVS) has been developed for a broad audience, including building officials and inspectors, and government agency and private-sector building owners (hereinafter, the "RVS authority"), to identify, inventory, and rank buildings that are potentially seismically hazardous. Although RVS is applicable to all buildings, its principal purpose is to identify (1) older buildings designed and constructed before the adoption of adequate seismic design and detailing requirements, (2) buildings on soft or poor soils, or (3) buildings having performance characteristics that negatively influence their seismic response. Once identified as potentially hazardous, such buildings should be further evaluated by a design professional experienced in seismic design to determine if, in fact, they are seismically hazardous.

The RVS uses a methodology based on a "sidewalk survey" of a building and a Data Collection Form, which the person conducting the survey (hereafter referred to as the screener) completes, based on visual observation of the building from the exterior, and if possible, the interior. The Data Collection Form includes space for documenting building identification information, including its use and size, a photograph of the building, sketches, and documentation of pertinent data related to seismic performance, including the development of a numeric seismic hazard score.

Once the decision to conduct rapid visual screening for a community or group of buildings has been made by the RVS authority, the screening effort can be expedited by pre-planning, including the training of screeners, and careful overall management of the process.

Completion of the Data Collection Form in the field begins with identifying the primary structural lateral-load-resisting system and structural materials of the building. Basic Structural Hazard Scores for various building types are provided on the form, and the screener circles the appropriate one. For many buildings, viewed only from the exterior, this important decision requires the screener to be trained and experienced in building construction. The screener modifies the Basic Structural Hazard Score by identifying and circling Score Modifiers, which are related to observed performance attributes, and which are then added (or subtracted) to the Basic Structural Hazard Score to arrive at a final Structural Score, *S*. The Basic Structural Hazard Score, Score Modifiers, and final Structural Score, *S*, all relate to the probability of building collapse, should severe ground shaking occur (that is, a ground shaking level equivalent to that currently used in the seismic design of new buildings). Final *S* scores typically range from 0 to 7, with higher *S* scores corresponding to better expected seismic performance.

Use of the RVS on a community-wide basis enables the RVS authority to divide screened buildings into two categories: those that are expected to have acceptable seismic performance, and those that may be seismically hazardous and should be studied further. An *S* score of 2 is suggested as a "cut-off", based on present seismic design criteria. Using this cut-off level, buildings having an *S* score of 2 or less should be investigated by a design professional experienced in seismic design.

The procedure presented in this *Handbook* is meant to be the preliminary screening phase of a multi-phase procedure for identifying potentially hazardous buildings. Buildings identified by this procedure must be analyzed in more detail by an experienced seismic design professional. Because rapid visual screening is designed to be performed from the street, with interior inspection not always possible, hazardous details will not always be visible, and seismically hazardous buildings may not be identified as such. Conversely, buildings initially identified as potentially hazardous by RVS may prove to be adequate.

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E-3, 23, 25,30; E-35, 41, 47, 48, 49	Lagorio, H., Friedman, H., and K. Wong (1986). *Issues for Seismic Strengthening of Existing Buildings: A Practical Guide for Architects.* Center for Environmental Design, University of California at Berkeley.
E-5, 12	Drawing from *National Multihazard Survey Instructions*. FEMA, TR-84.
E-11, 20	Steinbrugge, K. (1982). *Earthquakes, Volcanoes, and Tsunamis, An Anatomy of Hazards.* Skandia American Group, New York.
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Table D-2a	*A Field Guide to American Architecture* (1980), The New American Library, Inc., New York.
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E-39	Anonymous, but greatly appreciated

Chapter 1

Introduction

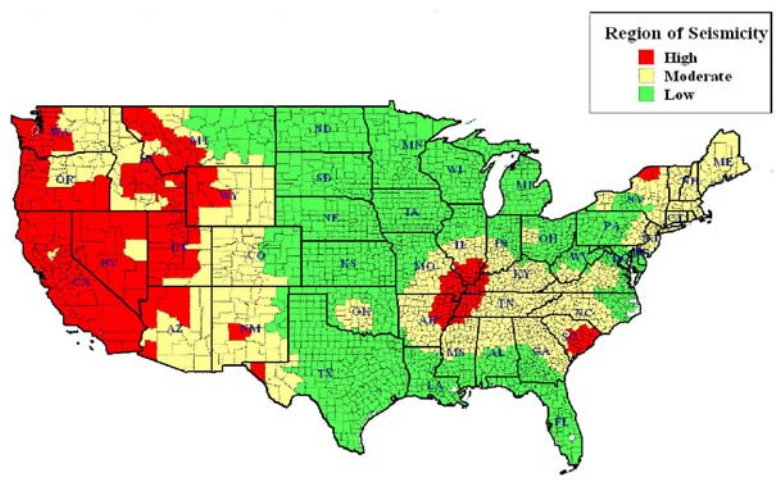
1.1 Background

Rapid visual screening of buildings for potential seismic hazards, as described herein, originated in 1988 with the publication of the FEMA 154 Report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*. Written for a broad audience ranging from engineers and building officials to appropriately trained nonprofessionals, the *Handbook* provided a "sidewalk survey" approach that enabled users to classify surveyed buildings into two categories: those acceptable as to risk to life safety or those that may be seismically hazardous and should be evaluated in more detail by a design professional experienced in seismic design.

During the decade following publication of the first edition of the FEMA 154 *Handbook*, the rapid visual screening (RVS) procedure was used by private-sector organizations and government agencies to evaluate more than 70,000 buildings nationwide (ATC, 2002). This widespread application provided important information about the purposes for which the document was used, the ease-of-use of the document, and perspectives on the accuracy of the scoring system upon which the procedure was based.

Concurrent with the widespread use of the document, damaging earthquakes occurred in California and elsewhere, and extensive research and development efforts were carried out under the National Earthquake Hazards Reduction Program (NEHRP). These efforts yielded important new data on the performance of buildings in earthquakes, and on the expected distribution, severity, and occurrence of earthquake-induced ground shaking.

The data and information gathered during the first decade after publication (experience in applying the original *Handbook*, new building earthquake performance data, and new ground shaking information) have been used to update and improve the rapid visual screening procedure provided in this second edition of the FEMA 154 Report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards*: *A Handbook*. The revised RVS procedure retains the same framework and approach of the original procedure, but incorporates a revised scoring system compatible with the ground motion criteria in the FEMA 310 Report, *Handbook for Seismic Evaluation of Buildings—A Prestandard* (ASCE, 1998), and the damage estimation data provided in the recently developed FEMA-funded HAZUS damage and loss estimation methodology (NIBS, 1999). As in the original *Handbook*, a Data Collection Form is provided for each of three seismicity regions: low, moderate, and high. However, the boundaries of the low, moderate, and high seismicity regions in the original *Handbook* have been modified (Figure 1-1), reflecting new knowledge on the expected distribution, severity, and occurrence of earthquake ground shaking, and a change in the



Note: Seismicity regions are based on ground motions having a 2% probability of exceedance in 50 years.

Figure 1-1 High, moderate, and low seismicity regions of the conterminous United States. A different RVS Data Collection Form has been developed for each of these regions. Enlarged maps are available in Appendix A.

recurrence interval considered, from a 475-year average return period (corresponding to ground motions having a 10% probability of exceedance in 50 years) to a 2475-year average return period (corresponding to ground motions having a 2% probability of excedance in 50 years).

This second edition of the FEMA 154 *Handbook* has been shortened and focused to facilitate implementation. Other improvements include:

- guidance on planning and managing an RVS survey, including the training of screeners and the acquisition of data from assessor files and other sources to obtain more reliable information on age, structural system, and occupancy;
- more guidance for identifying the structural (lateral-load-resisting) system in the field;
- the use of interior inspection or pre-survey reviews of building plans to identify (or verify) a building's lateral-load-resisting system;
- updated Basic Structural Hazard Scores and Score Modifiers that are derived from analytical calculations and recently developed HAZUS fragility curves for the model building types considered by the RVS methodology;
- the use of new seismic hazard information that is compatible with seismic hazard criteria specified in other related FEMA documents (see Section 1.4 below); and
- a revised Data Collection Form that provides space for documenting soil type, additional options for documenting falling hazards, and an expanded list of occupancy types.

1.2 Screening Procedure Purpose, Overview, and Scope

The RVS procedure presented in this *Handbook* has been formulated to identify, inventory, and rank buildings that are potentially seismically hazardous. Developed for a broad audience that includes building officials and inspectors, government agencies, design professionals, private-sector building owners (particularly those that own or operate clusters or groups of buildings), faculty members who use the RVS procedure as a training tool, and informed appropriately trained, members of the public, the RVS procedure can be implemented relatively quickly and inexpensively to develop a list of potentially hazardous buildings without the high cost of a detailed seismic analysis of individual buildings. If a building receives a high score (i.e., above a specified cut-off score, as discussed later in this *Handbook*), the building is considered to have adequate seismic resistance. If a building receives a low score on the basis of this RVS procedure, it should be evaluated by a professional engineer having experience or training in seismic design. On the basis of this detailed inspection, engineering analyses, and other detailed procedures, a final determination of the seismic adequacy and need for rehabilitation can be made.

During the planning stage, which is discussed in Chapter 2, the organization that is conducting the RVS procedure (hereinafter, the "RVS authority") will need to specify how the results from the survey will be used. If the RVS authority determines that a low score automatically requires that further study be performed by a professional engineer, then some acceptable level of qualification held by the inspectors performing the screening will be necessary. RVS projects have a wide range of goals and they have constraints on budget, completion date and accuracy, which must be considered by the RVS authority as it selects qualification requirements of the screening personnel. Under most circumstances, a well-planned and thorough RVS project will require engineers to perform the inspections. In any case, the program should be overseen by a design professional knowledgeable in seismic design for quality assurance purposes.

The RVS procedure in this *Handbook* is designed to be implemented without performing structural analysis calculations. The RVS procedure utilizes a scoring system that requires the user to (1) identify the primary structural lateral-load-resisting system; and (2) identify building attributes that modify the seismic performance expected of this lateral-load-resisting system. The inspection, data collection, and decision-making process typically will occur at the building site, taking an average of 15 to 30 minutes per building (30 minutes to one hour if access to the interior is available). Results are recorded on one of three Data Collection Forms (Figure 1-2), depending on the seismicity of the region being surveyed. The Data Collection Form, described in greater detail in Chapter 3, includes space for documenting building identification information, including its use and size, a photograph of the building, sketches, and documentation of pertinent data related to seismic performance, including the development of a

numeric seismic hazard score. The scores are based on average expected ground shaking levels for the seismicity region as well as the seismic design and construction practices for that region[1]. Buildings may be reviewed from the sidewalk without the benefit of building entry, structural drawings, or structural calculations. Reliability and confidence in building attribute determination are increased, however, if the structural framing system can be verified during interior inspection, or on the basis of a review of construction documents.

The RVS procedure is intended to be applicable nationwide, for all conventional building types. Bridges, large towers, and other non-building structure types, however, are not covered by the procedure. Due to budget or other constraints, some RVS authorities may wish to restrict their RVS to identifying building types that they consider the most hazardous, such as unreinforced masonry or nonductile concrete buildings. However, it is recommended, at least initially, that all conventional building types be considered, and that elimination of certain building types from the screening be well documented and supported with office calculations and field survey data that justify their elimination. It is possible that, in some cases, even buildings designed to modern codes, such as those with configurations that induce extreme torsional response and those with abrupt changes in stiffness, may be potentially hazardous.

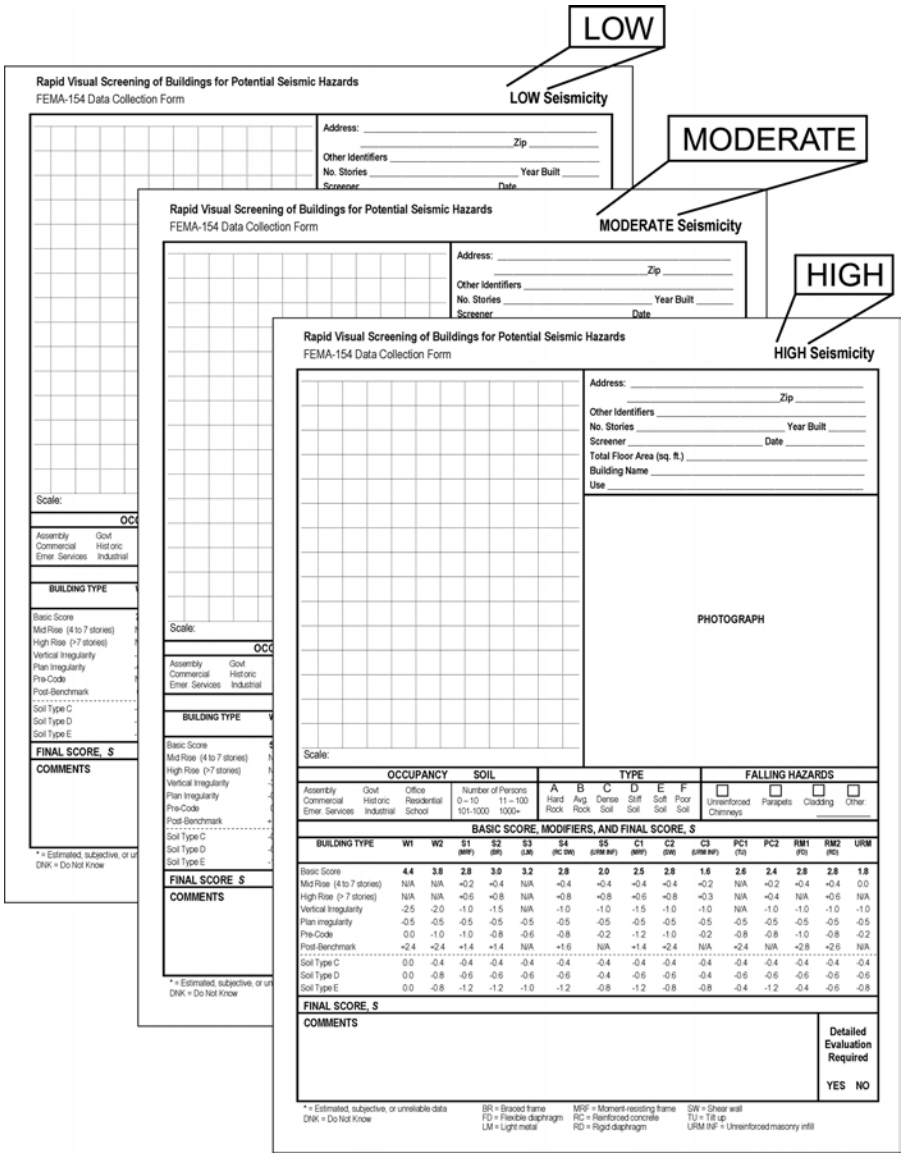


Figure 1-2 Data Collection Forms for the three designated seismicity regions (low, moderate, and high).

1.3 Companion FEMA 155 Report

A companion volume to this report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (second edition)* (FEMA 155) documents the technical basis for the RVS procedure described in this *Handbook*, including the method for calculating the Basic Structural Scores and Score Modifiers. The FEMA 155 report (ATC, 2002) also summarizes other information considered during development of this *Handbook*, including the efforts to solicit user feedback and a FEMA 154 Users Workshop held in September 2000. The FEMA 155 document is available from FEMA by

[1] Seismic design and construction practices vary by seismicity region, with little or no seismic design requirements in low seismicity regions, moderate seismic design requirements in moderate seismicity regions, and extensive seismic design requirements in high seismicity regions. The requirements also vary with time, and are routinely updated to reflect new knowledge about building seismic performance.

dialing 1-800-480-2520 and should be consulted for any needed or desired supporting documentation.

1.4 Relationship of FEMA 154 to Other Documents in the FEMA Existing Building Series

The FEMA 154 *Handbook* has been developed as an integral and fundamental part of the FEMA report series on seismic safety of existing buildings. It is intended for use by design professionals and others to mitigate the damaging effects of earthquakes on existing buildings. The series includes:

- FEMA 154 (this handbook), which provides a procedure that can be rapidly implemented to identify buildings that are potentially seismically hazardous.
- FEMA 310, *Handbook for Seismic Evaluation of Buildings—A Prestandard* (ASCE, 1998), which provides a procedure to inspect in detail a given building to evaluate its seismic resisting capacity (an updated version of the FEMA 178 *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* [BSSC, 1992]). The FEMA 310 Handbook is ideally suited for use on those buildings identified by the FEMA 154 RVS procedure as potentially hazardous.

  FEMA 310 is expected to be superseded in 2002 by ASCE 31, a standard of the American Society of Civil Engineers approved by the American National Standards Institute (ANSI). References in this *Handbook* to FEMA 310 should then refer to ASCE 31.
- FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (ASCE, 2000), which provides recommended procedures for the seismic rehabilitation of buildings with inadequate seismic capacity, as determined, for example, by a FEMA 310 (or FEMA 178) evaluation. The FEMA 356 Prestandard is based on the guidance provided in the FEMA 273 *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (ATC, 1997a), and companion FEMA 274 *Commentary on the NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (ATC, 1997b).

1.5 Uses of RVS Survey Results

While the principal purpose of the RVS procedure is to identify potentially seismically hazardous buildings needing further evaluation, results from RVS surveys can also be used for other purposes. These include: (1) ranking a community's (or agency's) seismic rehabilitation needs; (2) designing seismic hazard mitigation programs for a community (or agency); (3) developing inventories of buildings for use in regional earthquake damage and loss impact assessments; (4) planning postearthquake building safety evaluation efforts; and (5) developing building-specific seismic vulnerability information for purposes such as insurance rating, decision making during building ownership transfers, and possible triggering of remodeling requirements during the permitting process. Additional discussion on the use of RVS survey results is provided in Chapter 4.

1.6 How to Use this Handbook

The *Handbook* has been designed to facilitate the planning and execution of rapid visual screening. It is assumed that the RVS authority has already decided to conduct the survey, and that detailed guidance is needed for all aspects of the surveying process. Therefore, the main body of the *Handbook* focuses on the three principal activities in the RVS: planning, execution, and data interpretation. Chapter 2 contains detailed information on planning and managing an RVS. Chapter 3 describes in detail how the Data Collection Form should be completed, and Chapter 4 provides guidance on interpreting and using the results from the RVS. Finally, Chapter 5 provides several example applications of the RVS procedure on real buildings.

Relevant seismic hazard maps, full-sized Data Collection Forms, including a Quick Reference Guide for RVS implementation, guidance for reviewing design and construction drawings, and additional guidance for identifying a building's seismic lateral-load-resisting system from the street are provided in Appendices A, B, C, and D, respectively. Appendix E provides additional information on the building types considered in the RVS procedure, and Appendix F provides an overview of earthquake fundamentals, the seismicity of the United States, and earthquake effects.

Chapter 2

Planning and Managing Rapid Visual Screening

Once the decision to conduct rapid visual screening (RVS) for a community or group of buildings has been made by the RVS authority, the screening effort can be expedited by pre-planning and careful overall management of the process. This chapter describes the overall screening implementation sequence and provides detailed information on important pre-planning and management aspects. Instructions on how to complete the Data Collection Form are provided in Chapter 3.

2.1 Screening Implementation Sequence

There are several steps involved in planning and performing an RVS of potentially seismically hazardous buildings. As a first step, if it is to be a public or community project, the local governing body and local building officials should formally approve of the general procedure. Second, the public or the members of the community should be informed about the purpose of the screening process and how it will be carried out. There are also other decisions to be made, such as use of the screening results, responsibilities of the building owners and the community, and actions to be taken. Some of these decisions are specific to each community and therefore are not discussed in this *Handbook*.

The general sequence of implementing the RVS procedure is depicted in Figure 2-1. The implementation sequence includes:

- Budget development and cost estimation, recognizing the expected extent of the screening and further use of the gathered data;
- Pre-field planning, including selection of the area to be surveyed, identification of building types to be screened, selection and development of a record-keeping system, and compilation and development of maps that document local seismic hazard information;

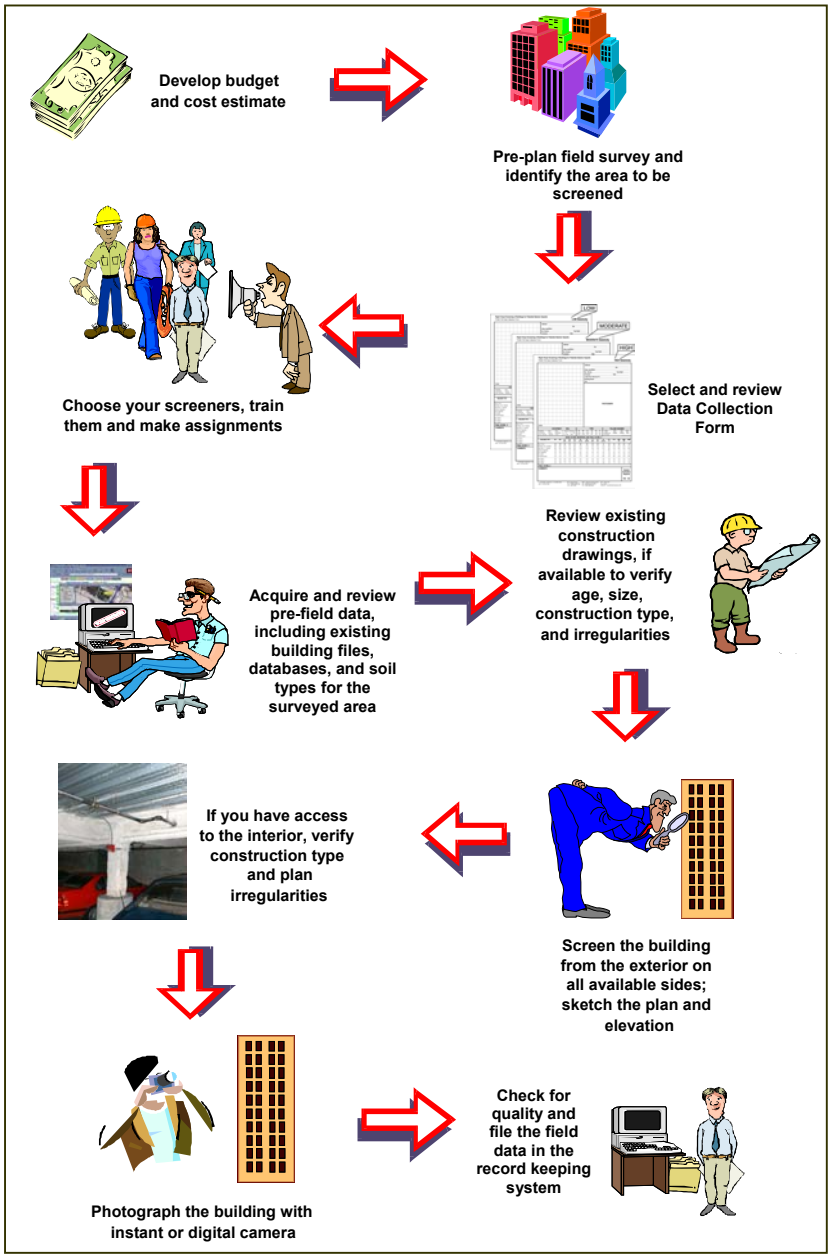


Figure 2-1 Rapid visual screening implementation sequence.

- Selection and review of the Data Collection Form;
- Selection and training of screening personnel;
- Acquisition and review of pre-field data; including review of existing building files and databases to document information identifying buildings to be screened (e.g., address, lot number, number of stories, design date) and identifying soil types for the survey area;
- Review of existing building plans, if available;
- Field screening of individual buildings (see Chapter 3 for details), which consists of:
    1. Verifying and updating building identification information,
    2. Walking around the building and sketching a plan and elevation view on the Data Collection Form,
    3. Determining occupancy (that is, the building use and number of occupants),
    4. Determining soil type, if not identified during the pre-planning process,
    5. Identifying potential nonstructural falling hazards,
    6. Identifying the seismic-lateral-load-resisting system (entering the building, if possible, to facilitate this process) and circling the Basic Structural Hazard Score on the Data Collection Form,
    7. Identifying and circling the appropriate seismic performance attribute Score Modifiers (e.g., number of stories, design date, and soil type) on the Data Collection Form,
    8. Determining the Final Score, *S* (by adjusting the Basic Structural Hazard Score with the Score Modifiers identified in Step 7), and deciding if a detailed evaluation is required, and
    9. Photographing the building; and
- Checking the quality and filing the screening data in the record-keeping system, or database.

2.2 Budget Development and Cost Estimation

Many of the decisions that are made about the level of detail documented during the rapid visual screening procedure will depend upon budget constraints. Although the RVS procedure is designed so field screening of each building should take no more than 15 to 30 minutes (30 minutes to one hour if access to the interior is obtained), time and funds should also be allocated for pre-field data collection. Pre-field data collection can be time consuming (10 to 30 minutes per building depending on the type of supplemental data available). However, it can be extremely useful in reducing the total field time and can increase the reliability of data collected in the field. A good example of this is the age, or design date, of a building. This might be readily available from building department files but is much more difficult to estimate from the street. Another issue to consider is travel time, if the distance between buildings to be screened is large. Because pre-field data collection and travel time could be a significant factor in budget allocations, it should be considered in the planning phase.

Other factors that should be considered in cost estimation are training of personnel and the development and administration of a record-keeping system for the screening process. The type of record keeping system selected will be a function of existing procedures and available funds as well as the ultimate goal of the screening. For example, if the screening is to be used solely for potential seismic damage estimation purposes, administrative costs will be different from those of a screening in which owners of low-scoring buildings must subsequently be notified, and compliance with ordinances is required.

2.3 Pre-Field Planning

The RVS authority may decide due to budget, time or other types of constraints, that priorities should be set and certain areas within the region should be surveyed immediately, whereas other areas can be surveyed at a later time because they are assumed to be less hazardous. An area may be selected because it is older and may have a higher density of potentially seismically hazardous buildings relative to other areas. For example an older part of the RVS authority region that consists mainly of commercial unreinforced masonry buildings may be of higher priority than a newer area with mostly warehouse facilities, or a residential section of a city consisting of wood-frame single-family dwellings.

Compiling and developing maps for the surveyed region is important in the initial planning phase as well as in scheduling of screeners. Maps of soil profiles, although limited, will be directly useful in the screening, and maps of landslide potential, liquefaction potential, and active faults

provide useful background information about the relative hazard in different areas. Maps of lots will be useful in scheduling screeners and, as data are collected, in identifying areas with large numbers of potentially hazardous buildings.

Another important phase of pre-field planning is interaction with the local design profession and building officials. Discussions should include verification of when certain aspects of seismic design and detailing were adopted and enforced. This will be used in adjusting the scoring system for local practices and specifying benchmark years.

The record-keeping system will vary among RVS authorities, depending on needs, goals, budgets and other constraints, and may in fact consist of several systems. Part of this planning phase may include deciding how buildings are to be identified. Some suggestions are street address, assessor's parcel number, census tract, and lot number or owner. Consideration should be given to developing a computerized database containing location and other building information, which could easily be used to generate peel-off labels for the Data Collection Form, or to generate forms that incorporate unique information for each building.

The advantage of using a computerized record generation and collection system is that graphical data, such as sketches and photographs, are increasingly more easily converted to digital form and stored on the computer, especially if they are collected in digital format in the field. This can be facilitated through the use of personal digital assistants (PDAs), which would require the development of a FEMA 154 application, and the use of digital cameras.

If a computerized database is not used, microfilm is a good storage medium for original hard copy, because photographs, building plans, screening forms and subsequent follow-up documentation can be kept together and easily copied. Another method that has been used is to generate a separate hard-copy file for each building as it is screened. In fact, the screening form can be reproduced on a large envelope and all supporting material and photographs stored inside. This solves any problems associated with attaching multiple sketches and photographs, but the files grow rapidly and may become unmanageable.

2.4 Selection and Review of the Data Collection Form

There are three Data Collection Forms, one for each of the following three regions of seismicity: low (L), moderate (M), and high (H). Full-sized versions of each form are provided in Appendix B, along with a Quick Reference Guide that contains definitions and explanations for terms used on the Data Collection Form. Each Data Collection Form (see example, Figure 2-2) provides space to record the building identification information, draw a sketch of the building (plan and elevation views), attach a photograph of the building, indicate the occupancy, indicate the soil type, document the existence of falling hazards, develop a Final Structural Score, *S*, for the building, indicate if a detailed evaluation is required, and provide additional comments. The structural scoring system consists of a matrix of Basic Structural Hazard Scores (one for each building type and its associated seismic lateral-force-resisting system) and Score Modifiers to

Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA-154 Data Collection Form **HIGH Seismicity**

Address: _____
_____ Zip _____
Other Identifiers _____
No. Stories _____ Year Built _____
Screener _____ Date _____
Total Floor Area (sq. ft.) _____
Building Name _____
Use _____

PHOTOGRAPH

Scale:

OCCUPANCY			SOIL		TYPE						FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons		A	B	C	D	E	F	☐	☐	☐	☐
Commercial	Historic	Residential	0 – 10	11 – 100	Hard Rock	Avg. Rock	Dense Soil	Stiff Soil	Soft Soil	Poor Soil	Unreinforced Chimneys	Parapets	Cladding	Other _____
Emer. Services	Industrial	School	101-1000	1000+										

BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S*

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	4.4	3.8	2.8	3.0	3.2	2.8	2.0	2.5	2.8	1.6	2.6	2.4	2.8	2.8	1.8
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.4	+0.4	+0.4	+0.4	+0.2	N/A	+0.2	+0.4	+0.4	0.0
High Rise (> 7 stories)	N/A	N/A	+0.6	+0.8	N/A	+0.8	+0.8	+0.6	+0.8	+0.3	N/A	+0.4	N/A	+0.6	N/A
Vertical Irregularity	-2.5	-2.0	-1.0	-1.5	N/A	-1.0	-1.0	-1.5	-1.0	-1.0	N/A	-1.0	-1.0	-1.0	-1.0
Plan irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Pre-Code	0.0	-1.0	-1.0	-0.8	-0.6	-0.8	-0.2	-1.2	-1.0	-0.2	-0.8	-0.8	-1.0	-0.8	-0.2
Post-Benchmark	+2.4	+2.4	+1.4	+1.4	N/A	+1.6	N/A	+1.4	+2.4	N/A	+2.4	N/A	+2.8	+2.6	N/A
Soil Type C	0.0	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Soil Type D	0.0	-0.8	-0.6	-0.6	-0.6	-0.6	-0.4	-0.6	-0.6	-0.4	-0.6	-0.6	-0.6	-0.6	-0.6
Soil Type E	0.0	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8	-1.2	-0.8	-0.8	-0.4	-1.2	-0.4	-0.6	-0.8

FINAL SCORE, *S*

COMMENTS

Detailed Evaluation Required
YES NO

* = Estimated, subjective, or unreliable data
DNK = Do Not Know

BR = Braced frame
FD = Flexible diaphragm
LM = Light metal

MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm

SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

Figure 2-2 Example RVS Data Collection Form (high seismicity).

account for observed attributes that modify seismic performance. The Basic Structural Hazard Scores and Score Modifiers are based on (1) design and construction practices in the region, (2) attributes known to decrease or increase seismic resistance capacity, and (3) maximum considered ground motions for the seismicity region under consideration. The Basic Structural Hazard Score, Score Modifiers, and Final Structural Score, *S*, all relate to the probability of building collapse, should the maximum ground motions considered by the RVS procedure occur at the site. Final *S* scores typically range from 0 to 7, with higher *S* scores corresponding to better seismic performance.

The maximum ground motions considered in the scoring system of the RVS procedure are consistent with those specified for detailed building seismic evaluation in the FEMA 310 Report, *Handbook for the Seismic Evaluation of Buildings—A Prestandard*. Such ground motions generally have a 2% chance of being exceeded in 50 years, and are multiplied by a 2/3 factor in the FEMA 310 evaluation procedures and in the design requirements for new buildings in FEMA 302, *Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (BSSC, 1997). (Ground motions having a 2% probability of being exceeded in 50 years are commonly referred to as the maximum considered earthquake (MCE) ground motions.)

2.4.1 Determination of Seismicity Region

To select the appropriate Data Collection Form, it is first necessary to determine the seismicity region in which the area to be screened is located. The seismicity region (H, M, or L) for the screening area can be determined by one of two methods:

1. Find the location of the surveyed region on the seismicity map of Figure 1-1, or one of the enlarged seismicity maps provided in Appendix A, and identify the corresponding seismicity region, or;
2. Access the U.S. Geological Survey web page (http://geohazards.cr.usgs.gov/eq/), select "Hazard by Zip Code" or "Hazard by Lat/Long" under the "Seismic Hazard" heading, enter the appropriate values of zip code or latitude and longitude, select the spectral acceleration value (SA) for a period of 0.2 seconds and the SA value for a period of 1.0 second, multiply the SA values by 2/3, and use the criteria of Table 2-1 to select the appropriate seismicity region, assuming that the highest seismicity level defined by the parameters in Table 2-1 shall govern.

   Use more recent additions of these maps when they become available.

The web site approach of Method 2, which uses seismicity region definitions used in other recently developed FEMA documents, is preferred as it enables the user to determine seismicity based on a more precisely specified location. In contrast, each county shown in Figure 1-1 is assigned its seismicity on the basis of the highest seismicity in that county, even though it may only apply to a small portion of the county.

Table 2-1 Regions of Seismicity with Corresponding Spectral Acceleration Response (from FEMA 310)

Region of Seismicity	*Spectral Acceleration Response, SA (short-period, or 0.2 sec)*	*Spectral Acceleration Response, SA (long-period or 1.0 sec)*
Low	less than 0.167 *g* (in horizontal direction)	less than 0.067 *g* (in horizontal direction)
Moderate	greater than or equal to 0.167 *g* but less than 0.500 g (in horizontal direction)	greater than or equal to 0.067 *g* but less than 0.200 g (in horizontal direction)
High	greater than or equal to 0.500 *g* (in horizontal direction)	greater than or equal to 0.200 *g* (in horizontal direction)

Notes: *g* = acceleration of gravity

2.4.2 Determination of Key Seismic Code Adoption Dates and Other Considerations

The Data Collection Form is meant to be a model that may be adopted and used as it is presented in this *Handbook*. The form may also be modified according to the needs of the RVS authority. Therefore, another aspect of the screening planning process is to review the Data Collection Form to determine if all required data are represented or if modifications should be made to reflect the needs and special circumstances of the authority. For example, an RVS authority may choose to define additional occupancy classes such as "parking structure" or "multi-family residential."

One of the key issues that must be addressed in the planning process is the determination of (1) the year in which seismic codes were initially

Table 2-2. Benchmark Years for RVS Procedure Building Types (based on FEMA 310)

Building Type	Model Building Seismic Design Provisions			
	BOCA	SBCC	UBC	NEHRP
W1: Light wood-frame residential and commercial buildings smaller than or equal to 5,000 square feet	1992	1993	1976	1985
W2: Light wood-frame buildings larger than 5,000 square feet	1992	1993	1976	1985
S1: Steel moment-resisting frame buildings	**	**	1994	**
S2: Braced steel frame buildings	1992	1993	1988	1991
S3: Light metal buildings	*	*	*	*
S4: Steel frame buildings with cast-in-place concrete shear walls	1992	1993	1976	1985
S5: Steel frame buildings with unreinforced masonry infill walls	*	*	*	*
C1: Concrete moment-resisting frame buildings	1992	1993	1976	1985
C2: Concrete shear-wall buildings	1992	1993	1976	1985
C3: Concrete frame buildings with unreinforced masonry infill walls	*	*	*	*
PC1: Tilt-up buildings	*	*	1997	*
PC2: Precast concrete frame buildings	*	*	*	*
RM1: Reinforced masonry buildings with flexible floor and roof diaphragms	*	*	1997	*
RM2: Reinforced masonry buildings with rigid floor and roof diaphragms	1992	1993	1976	1985
URM: Unreinforced masonry bearing-wall buildings	*	*	1991	*

*No benchmark year; **contact local building department for benchmark year.
BOCA: Building Officials and Code Administrators, *National Building Code*
SBCC: Southern Building Code Congress, *Standard Building Code*.
UBC: International Conference of Building Officials, *Uniform Building Code*
NEHRP: National Earthquake Hazard Reduction Program, *FEMA 302 Recommended Provisions for the Development of Seismic Regulations for New Buildings*

adopted and enforced by the local jurisdiction, and (2) the year in which significantly improved seismic codes were adopted and enforced (this latter year is known as the benchmark year). In high and moderate seismicity regions, the Basic Structural Hazard Scores for the various building types are calculated for buildings built after the initial adoption of seismic codes, but before substantially improved codes were adopted. For these regions, Score Modifiers designated as "Pre Code" and "Post Benchmark" are provided, respectively, for buildings built before the adoption of codes and for buildings built after the adoption of substantially improved codes. In low seismicity regions, the Basic Structural Hazard Scores are calculated for buildings built before the initial adoption of seismic codes. For buildings in these regions, the Score Modifier designated as "Pre Code" is not applicable (N/A), and the Score Modifier designated as "Post Benchmark" is applicable for buildings built after the adoption of seismic codes.

Therefore, as part of this review process, the RVS authority should identify (1) the year in which seismic codes were first adopted and enforced in the area to be screened, (2) the "benchmark" year in which significantly improved seismic code requirements were adopted for each building type considered by the RVS procedure (see Table 2-2), and (3) the year in which the community adopted seismic anchorage requirements for heavy cladding. If the RVS authority in high and moderate seismicity regions is unsure of the year(s) in which codes were initially adopted, the default year for all but one building type is 1941 (the default year specified in the HAZUS criteria; NIBS, 1999). The one exception is PC1 (tilt-up) buildings, for which it is assumed that seismic codes were initially adopted in 1973, the year in which wall-diaphragm (ledger) connection requirements first appeared in the *Uniform Building Code* (ICBO, 1973).

During the review of the Data Collection Form, the RVS authority should confer with the

1. Model Building Types and Critical Code Adoption and Enforcement Dates		Year Seismic Codes Initially Adopted and Enforced*	Benchmark Year When Codes Improved
Structure Types			
W1	Light wood frame, residential or commercial, ≤ 5000 square feet	_____	_____
W2	Wood frame buildings, > 5000 square feet	_____	_____
S1	Steel moment-resisting frame	_____	_____
S2	Steel braced frame	_____	_____
S3	Light metal frame	_____	_____
S4	Steel frame with cast-in-place concrete shear walls	_____	_____
S5	Steel frame with unreinforced masonry infill	_____	_____
C1	Concrete moment-resisting frame	_____	_____
C2	Concrete shear wall	_____	_____
C3	Concrete frame with unreinforced masonry infill	_____	_____
PC1	Tilt-up construction	_____	_____
PC2	Precast concrete frame	_____	_____
RM1	Reinforced masonry with flexible floor and roof diaphragms	_____	_____
RM2	Reinforced masonry with rigid diaphragms	_____	_____
URM	Unreinforced masonry bearing-wall buildings	_____	_____

*Not applicable in regions of low seismicity

2. Anchorage of Heavy Cladding

Year in which seismic anchorage requirements were adopted: _____

Figure 2-3 Sections 1 and 2 of Quick Reference Guide (for use with Data Collection Form).

chief building official, plan checkers, and other design professionals experienced in seismic design to identify the years in which the affected jurisdiction initially adopted and enforced seismic codes (if ever) for the building lateral-force-resisting structural systems considered by the RVS procedure. Since municipal codes are generally adopted by the city council, another source for this information, in many municipalities, is the city clerk's office. In addition to determining the year in which seismic codes were initially adopted and enforced, the RVS authority should also determine (1) the benchmark years in which substantially improved seismic codes were adopted and enforced for the various lateral-load-resisting systems and (2) the year in which anchorage requirements for cladding were adopted and enforced. These dates should be inserted on the Quick Reference Guide (Appendix B) that has been created to facilitate the use of the Data Collection Form (see Figure 2-3).

During the Data Collection Form review process, it is critically important that the Basic Structural Hazard Scores and Score Modifiers, which are described in detail in Chapter 3, not be changed without input from professional engineers familiar with earthquake-resistant design and construction practices of the local community. A checklist of issues to be considered when reviewing the Data Collection Form is provided in Table 2-3.

Table 2-3 Checklist of Issues to be Considered During Pre-Field Work Review of the Data Collection Form

- ☐ Evaluate completeness of occupancy categories and appropriateness of occupancy loads
- ☐ Determine year in which seismic codes were initially adopted in the jurisdiction
- ☐ Determine "benchmark" years in which the jurisdiction adopted and enforced significantly improved seismic codes for the various building types considered by the RVS procedure
- ☐ Determine year in which the jurisdiction adopted and enforced anchorage requirements for heavy cladding

2.4.3 Determination of Cut-Off Score

Use of the RVS on a community-wide basis enables the RVS authority to divide screened buildings into two categories: those that are expected to have acceptable seismic performance, and those that may be seismically hazardous and

should be studied further. This requires that the RVS authority determine, preferably as part of the pre-planning process, an appropriate "cut-off" score.

An *S* score of 2 is suggested as a "cut-off", based on present seismic design criteria. Using this cut-off level, buildings having an *S* score of 2 or less should be investigated by a design professional experienced in seismic design (see Section 3.9, 4.1 and 4.2 for additional information on this issue).

2.5 Qualifications and Training for Screeners

It is anticipated that a training program will be required to ensure a consistent, high quality of the data and uniformity of decisions among screeners. Training should include discussions of lateral-force-resisting systems and how they behave when subjected to seismic loads, hw to use the Data Collection Form, what to look for in the field, and how to account for uncertainty. In conjunction with a professional engineer experienced in seismic design, screeners should simultaneously consider and score buildings of several different types and compare results. This will serve as a "calibration" for the screeners.

This process can easily be accomplished in a classroom setting with photographs of actual buildings to use as examples. Prospective screeners review the photographs and perform the RVS procedure as though they were on the sidewalk. Upon completion, the class discusses the results and students can compare how they did in relation to the rest of the class.

2.6 Acquisition and Review of Pre-Field Data

Information on the structural system, age or occupancy (that is, use) may be available from supplemental sources. These data, from assessor and building department files, insurance (Sanborn) maps, and previous studies, should be reviewed and collated for a given area before commencing the field survey for that area. It is recommended that this supplemental information either be written directly on the Data Collection Forms as it is retrieved or be entered into a computerized database. The advantage of a database is that selected information can be printed in a report format that can be taken into the field, or printed onto peel-off labels that can be affixed to the Data Collection Form (see Figure 2-4). In addition, screening data can be added to the databases and

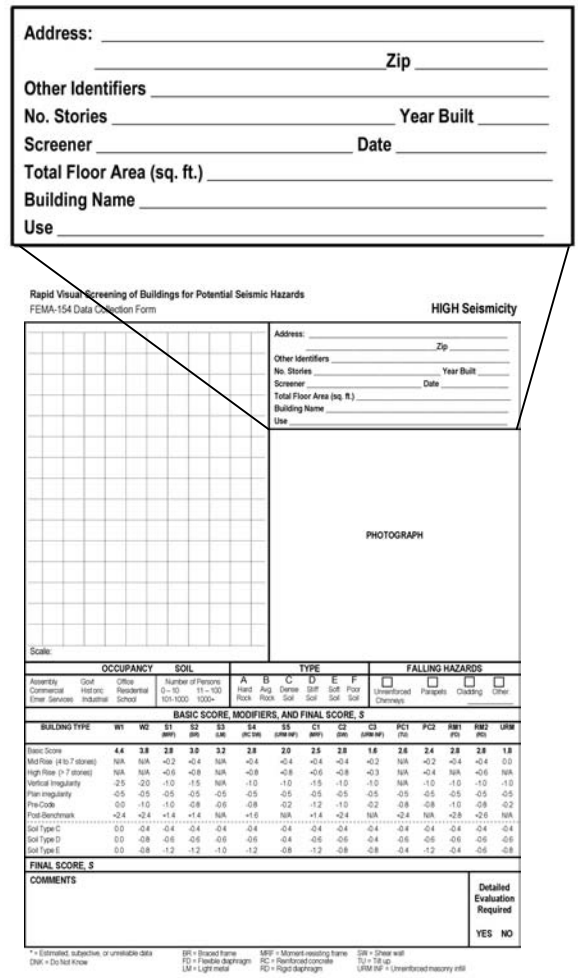


Figure 2-4 Building identification portion of RVS Data Collection Form.

used to generate maps and reports. Some sources of supplemental information are described in Sections 2.6.1 through 2.6.5.

2.6.1 Assessor's Files

Although assessor's files may contain information about the age of the building, the floor area and the number of stories, most information relates to ownership and assessed value of the land and improvements, and thus is of relatively little value for RVS purposes. The construction type indicated is often incorrect and in most cases should not be used. In addition, the age of a building retrieved from assessor's files may not, and most likely is not, the year that the structure was built. Usually assessor's files contain the year that the building was first eligible for taxation. Because the criteria for this may vary, the date may be several years after the building was designed or constructed. If no other source of information is available this will give a good estimate of the period during which the building

was constructed. However, this date should not be used to establish conclusively the code under which the a building was designed. Assessor's offices may have parcel or lot maps, which may be useful for locating sites or may be used as a template for sketching building adjacencies on a particular city block.

2.6.2 Building Department Files

The extent and completeness of information in building department files will vary from jurisdiction to jurisdiction. For example, in some locations all old files have been removed or destroyed, so there is no information on older buildings. In general, files (or microfilm) may contain permits, plans and structural calculations required by the city. Sometimes there is occupancy and use information, but little information about structural type will be found except from the review of plans or calculations.

2.6.3 Sanborn Maps

These maps, published primarily for the insurance industry since the late 1800s, exist for about 22,000 communities in the United States. The Sanborn Map Company stopped routinely updating these maps in the early 1960s, and many communities have not kept these maps up-to-date. Thus they may not be useful for newer construction. However, the maps may contain useful data for older construction. They can be found at the library or in some cases in building department offices. Figure 2-5 provides an example of an up-to-date Sanborn map Figure 2-6 shows a key to identifiers on Sanborn maps.

Information found on a Sanborn map includes:

- height of building,
- number of stories,
- year built,
- thickness of walls,
- building size (square feet),
- type of roof (tile, shingle, composite),
- building use (dwelling, store, apartment),
- presence of garage under structure, and
- structural type (wood frame, fireproof construction, adobe, stone, concrete).

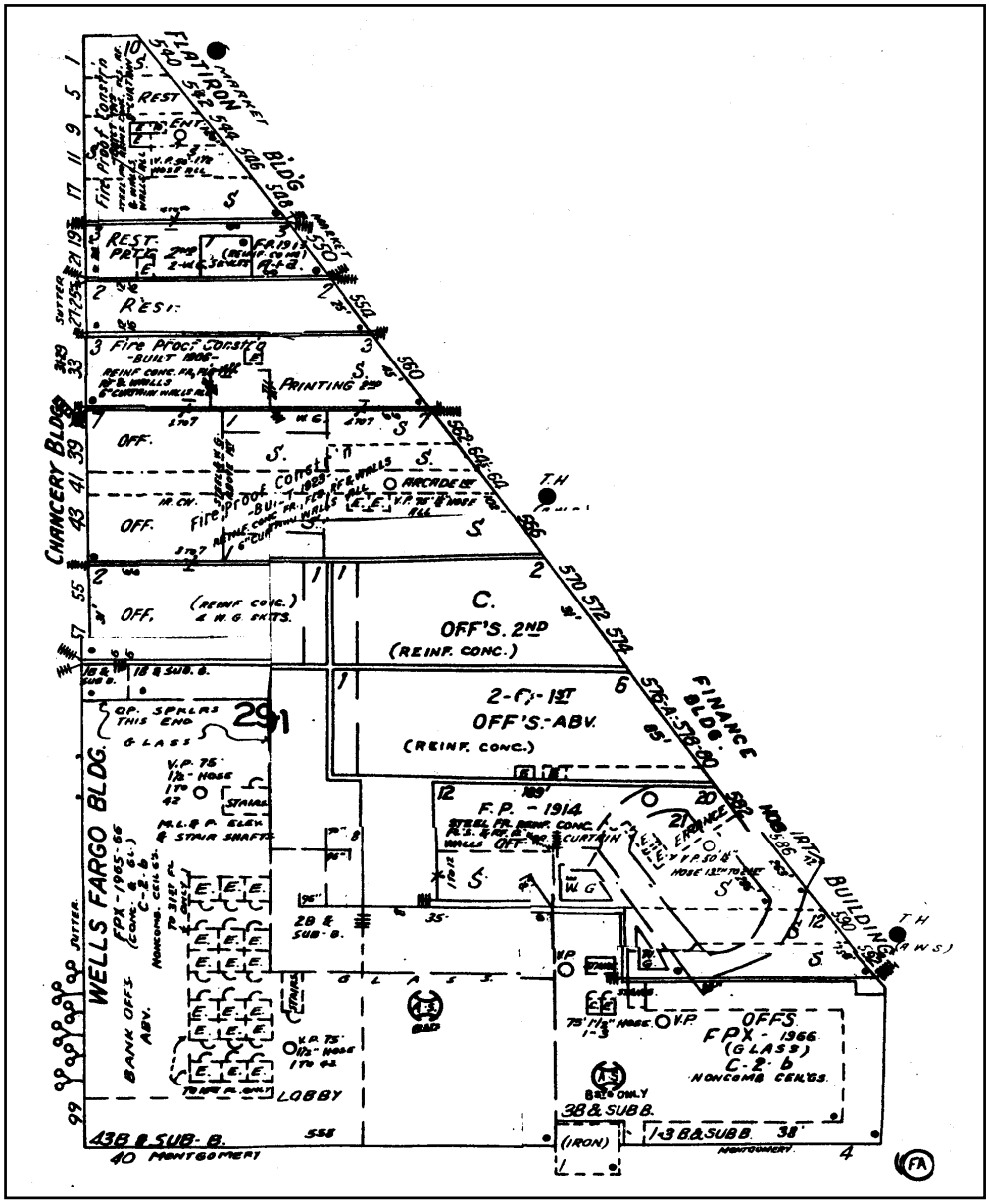


Figure 2-5 Example Sanborn map showing building information for a city block.

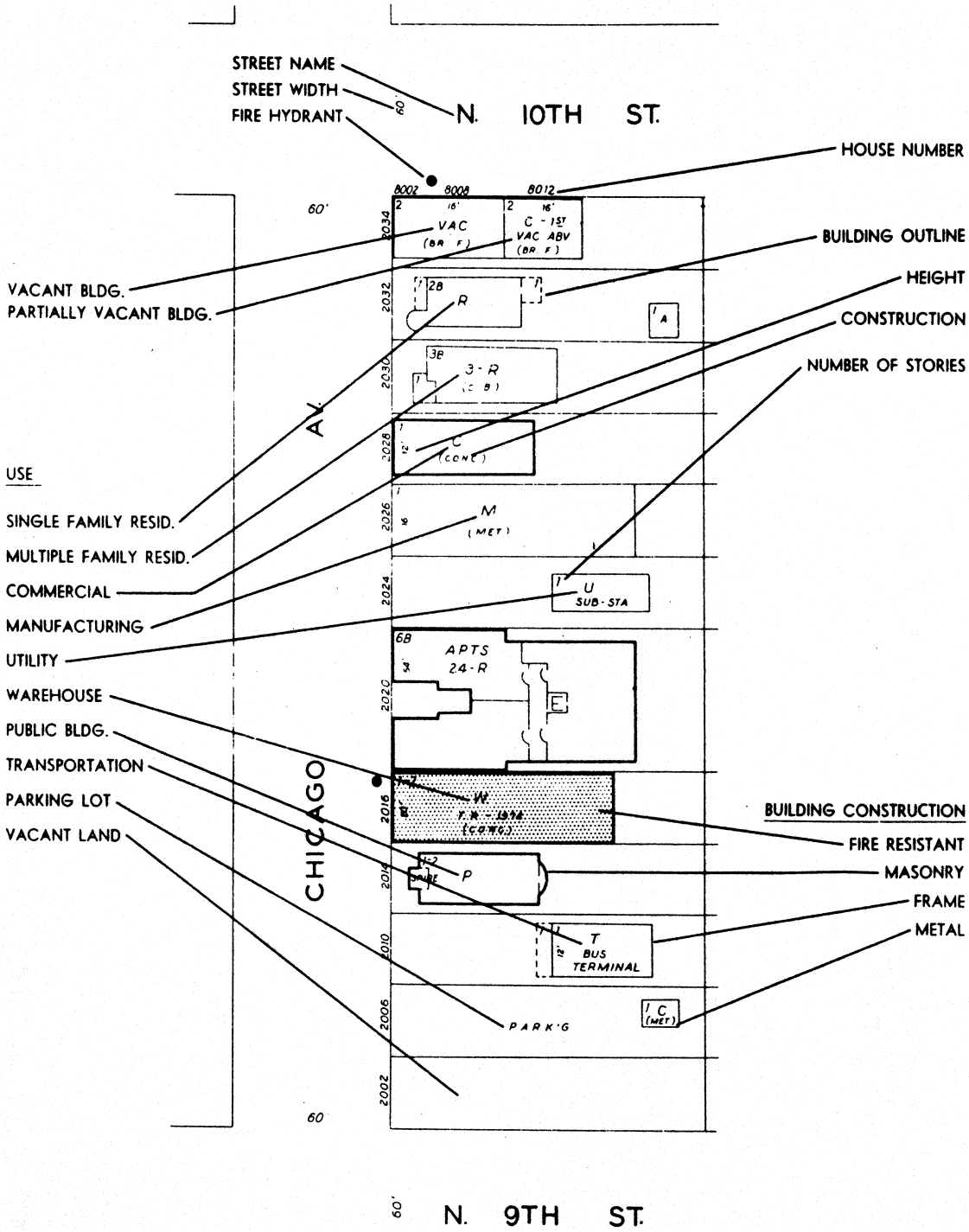
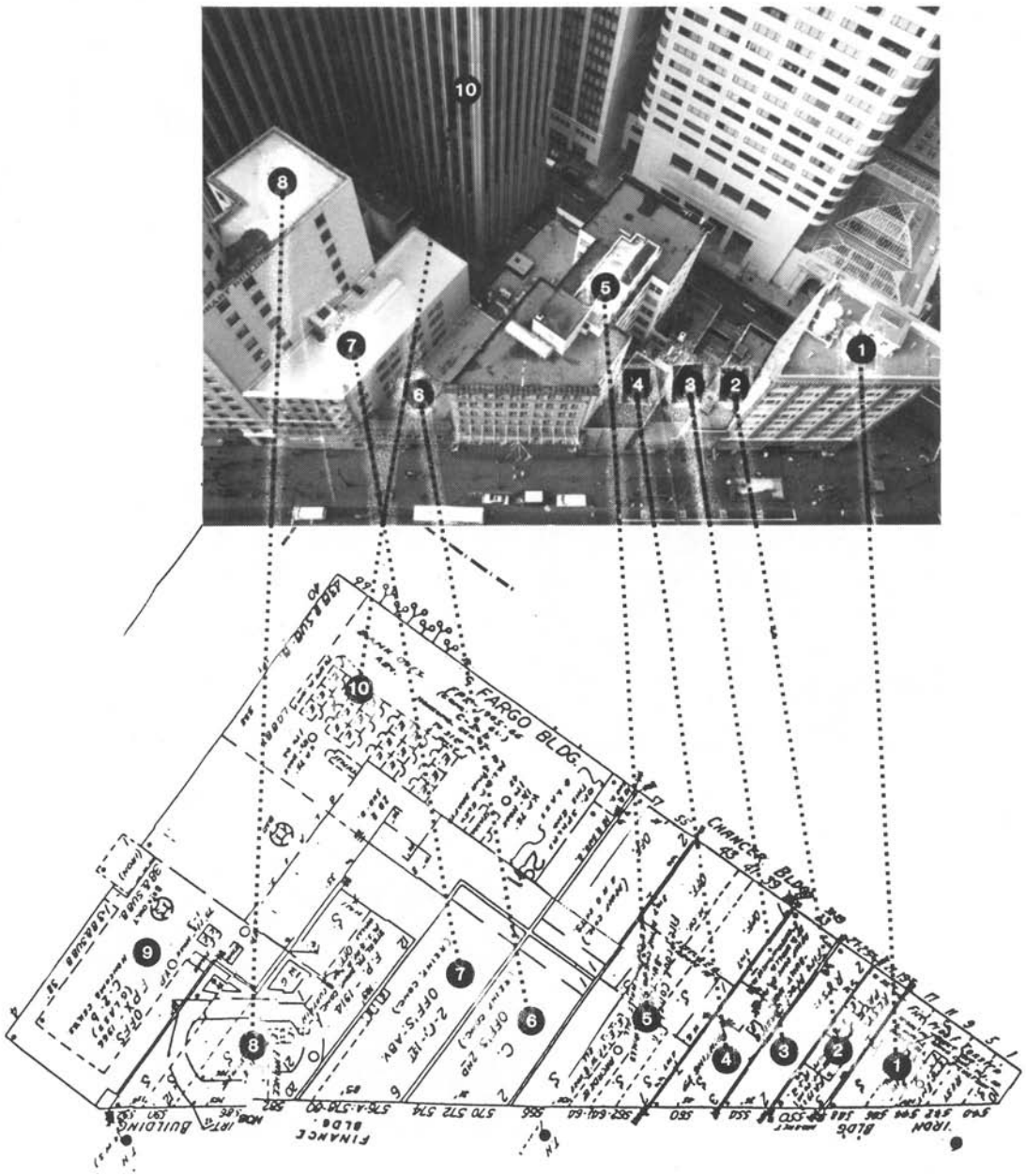


Figure 2-6 Key to Sanborn map symbols. Also, see the Internet, www.sanbornmap.com.

Parcel maps are also available and contain lot dimensions. If building size information cannot be obtained from another source such as the assessor's file, the parcel maps are particularly helpful for determining building dimensions in urban areas where buildings cover the entire lot. However, even if the building does not cover the entire lot, it will be easier to estimate building dimensions if the lot dimensions are known.

Figures 2-7 and 2-8 show a Sanborn map and photographs of a city block. Building descriptions obtained from the Sanborn maps are also included.



1. 10 story commercial office
2. 3 story commercial, built 1913
3. 2 story commercial
4. 3 story commercial, reinforced concrete frame, built 1906
5. 7 story commercial office, reinforced concrete frame, built 1923
6. 2 story commercial, reinforced concrete
7. 5 story commercial office, reinforced concrete
8. 20 story commercial office, steel frame with reinforced concrete, built 1914
9. 4 story commercial, built 1966
10. 40 story commercial office, built 1965-66, concrete and glass exterior

Figure 2-7 Sanborn map and corresponding aerial photograph of a city block.

Although the information on Sanborn maps may be useful, it is the responsibility of the screener to verify it in the field.

2.6.4 Municipal Databases

With the widespread use of the internet, many jurisdictions are creating "on-line" electronic databases for use by the general public. These databases provide general information on the various building sites within the jurisdiction. These databases are not detailed enough at this point in time to provide specific information about the buildings; they do, however, provide some good demographic information that could be of use. As the municipalities develop more comprehensive information, these databases will become more useful to the RVS screening. Figure 2-9 shows examples of the databases from two municipalities in the United States.

2.6.5 Previous Studies

In a few cases, previous building inventories or studies of hazardous buildings or hazardous non-structural elements (e.g., parapets) may have been performed. These studies may be limited to a particular structural or occupancy class, but they may contain useful maps or other relevant structural information and should be reviewed. Other important studies might address related seismic hazard issues such as liquefaction or landslide potential. Local historical societies may have published books or reports about older buildings in the community. Fire departments are often aware of the overall condition and composition of building interiors.

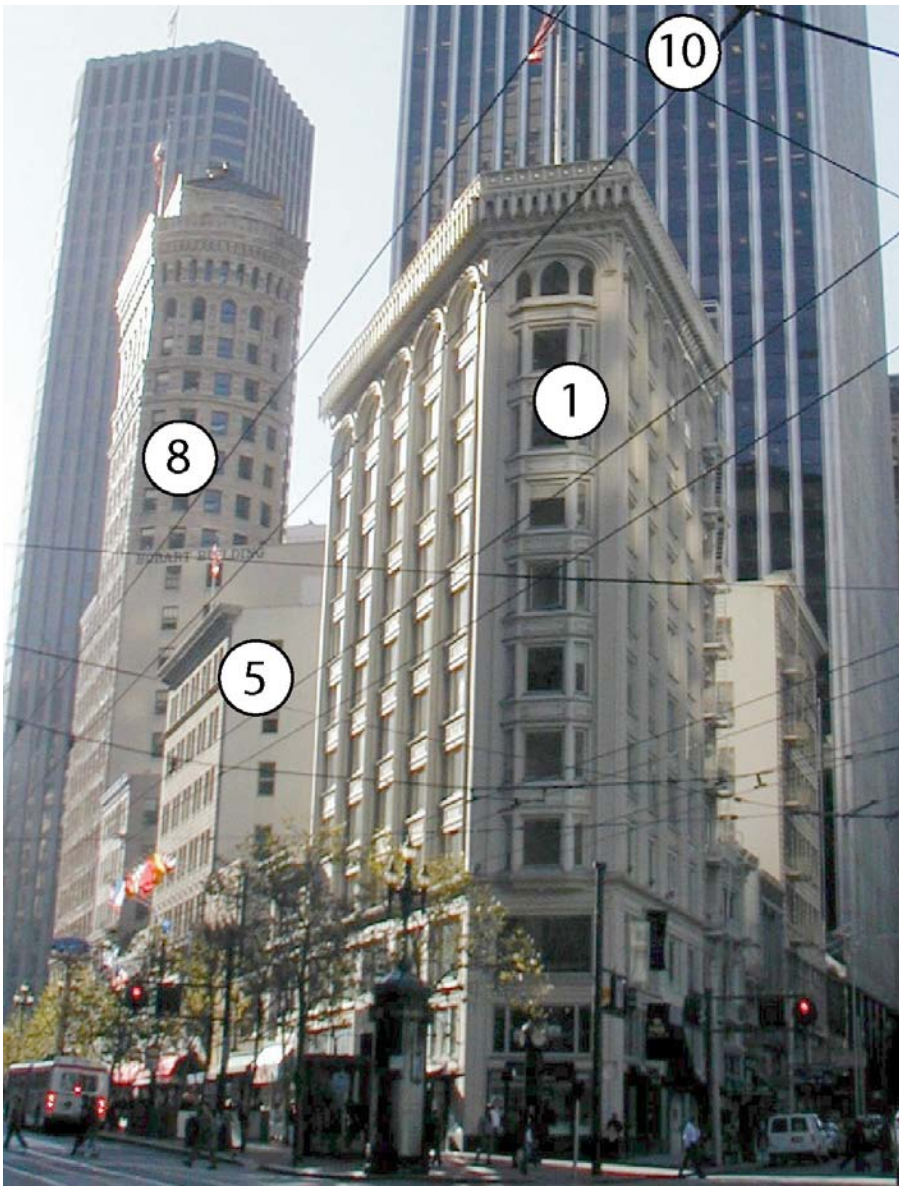
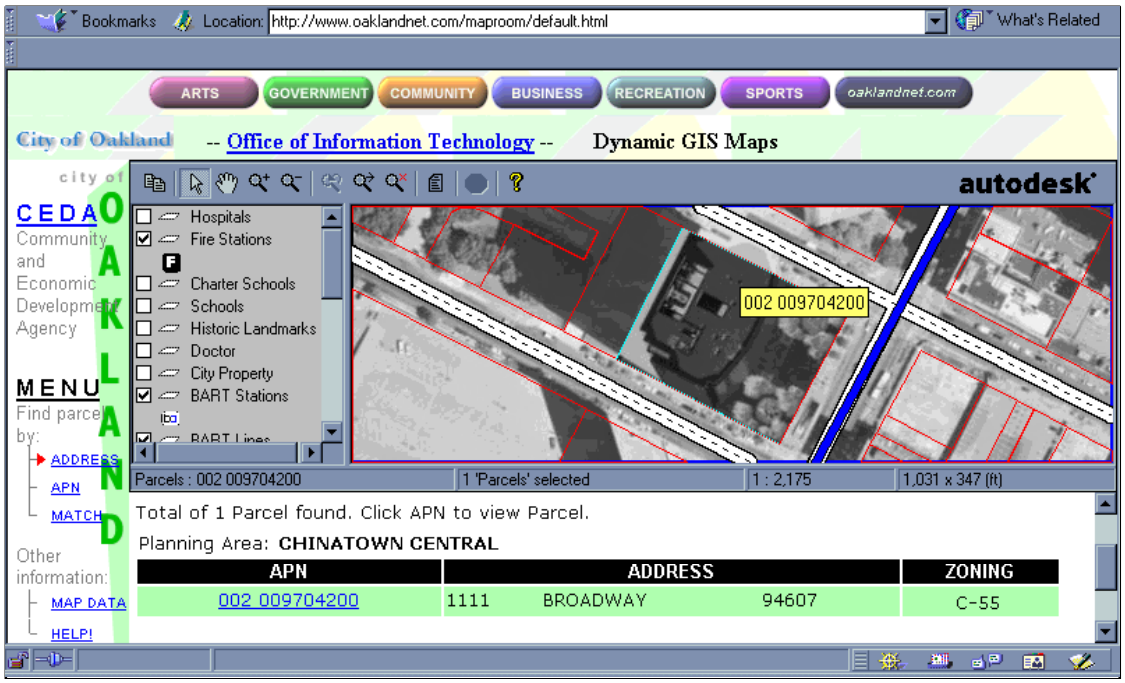


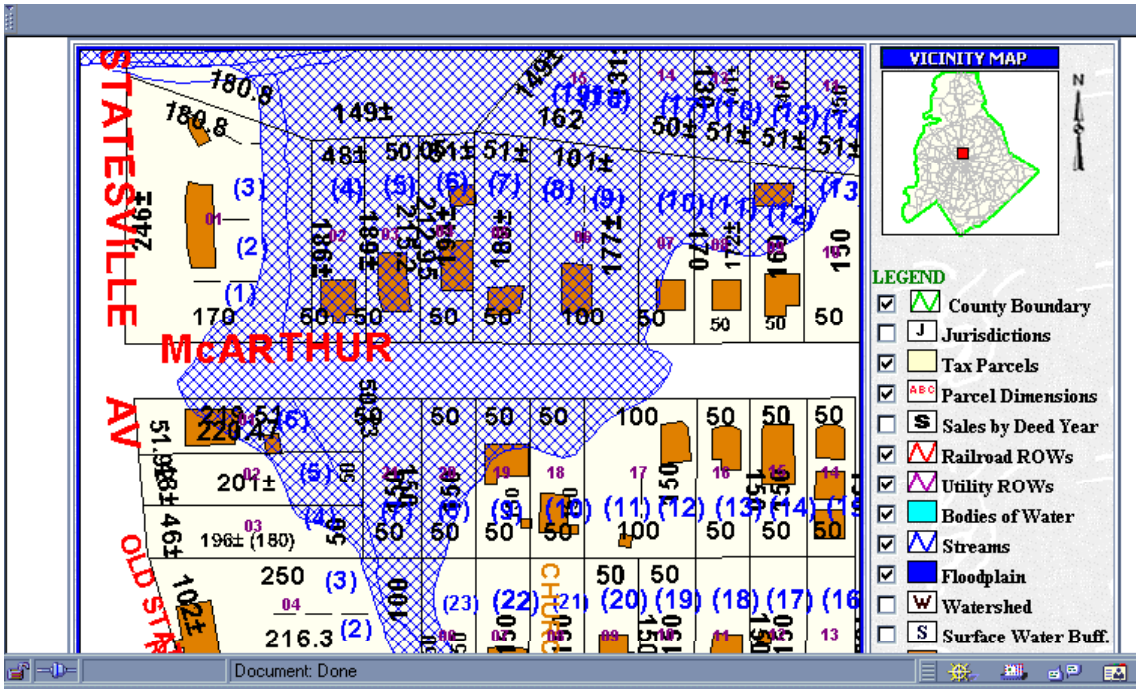
Figure 2-8 Photographs of elevation views of buildings shown in Figure 2-7.

2.6.6 Soils Information

Soil type has a major influence on amplitude and duration of shaking, and thus structural damage. Generally speaking, the deeper the soils at a site, the more damaging the earthquake motion will be. The six soil types considered in the RVS procedure are the same as those specified in the FEMA 302 report, *NEHRP Recommended Provisions for the Seismic Design of New Buildings and Other Structures* (BSSC, 1997): hard rock (type A); average rock (type B); dense soil (type C), stiff soil (type D); soft soil (type E), and poor soil (type F). Additional information on these soil types and how to identify



City of Oakland, California



Mecklenburg County, North Carolina

Figure 2-9 Examples of in-house screen displays of municipal databases.

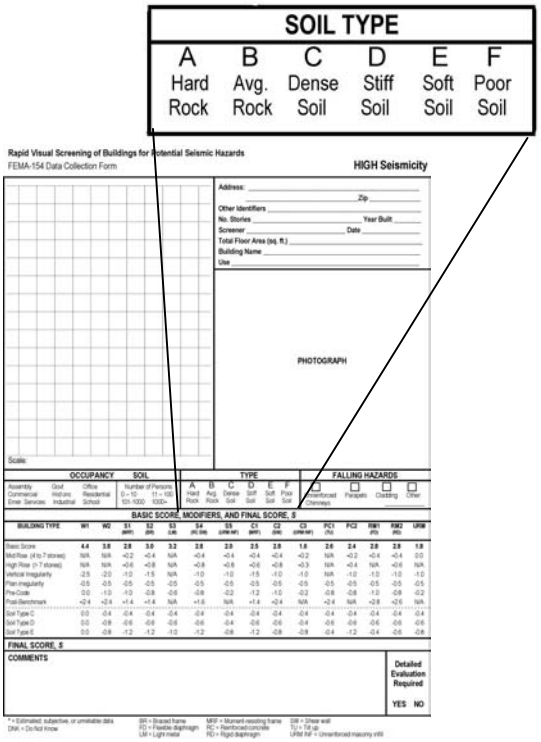


Figure 2-10 Location on Data Collection Form where soil type information is recorded.

them are provided in the side bar. Buildings on soil type F cannot be screened effectively by the RVS procedure, other than to recommend that buildings on this soil type be further evaluated by a geotechnical engineer and design professional experienced in seismic design.

Since soil conditions cannot be readily identified by visual methods in the field, geologic and geotechnical maps and other information should be collected during the planning stage and put into a readily usable map format for use during RVS. During the screening, or the planning stage, this soil type should also be documented on the Data Collection Form by circling the correct soil type, as designated by the letters A through F, (see Figure 2-10). If sufficient guidance or data are not available during the planning stage to classify the soil type as A through E, a soil type E should be assumed. However, for one-story or two-story buildings with a roof height equal to or less than 25 feet, a class D soil type may be assumed when site conditions are not known. (See the note in preceding paragraph regarding soil type F.)

2.7 Review of Construction Documents

Whenever possible, design and construction documents should be reviewed prior to the conduct of field work to help the screener identify the type of lateral-force- resisting system for each building. The review of construction documents to identify the building type substantially improves the confidence in this determination. As described in Section 3.7, the RVS procedure requires that each building be identified as one of 15 model building types[2]. Guidance for reviewing design and construction drawings is provided in Appendix C.

Soil Type Definitions and Related Parameters

The six soil types, with measurable parameters that define each type, are:

Type A (hard rock): measured shear wave velocity, v_s > 5000 ft/sec.

Type B (rock): v_s between 2500 and 5000 ft/sec.

Type C (soft rock and very dense soil): v_s between 1200 and 2500 ft/sec, or standard blow count N > 50, or undrained shear strength s_u > 2000 psf.

Type D (stiff soil): v_s between 600 and 1200 ft/sec, or standard blow count N between 15 and 50, or undrained shear strength, s_u between 1000 and 2000 psf.

Type E (soft soil): More than 100 feet of soft soil with plasticity index PI > 20, water content w > 40%, and s_u < 500 psf; or a soil with $v_s \leq 600$ ft/sec.

Type F (poor soil): Soils requiring site-specific evaluations:

- Soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils, quick and highly-sensitive clays, collapsible weakly-cemented soils.
- Peats or highly organic clays (H > 10 feet of peat or highly organic clay, where H = thickness of soil.).
- Very high plasticity clays (H > 25 feet with PI > 75).
- More than 120 ft of soft or medium stiff clays.

The parameters v_s, N, and s_u are, respectively, the average values (often shown with a bar above) of shear wave velocity, Standard Penetration Test (SPT) blow count and undrained shear strength of the upper 100 feet of soils at the site.

[2]The 15 model building types used in FEMA 154 are an abbreviated list of the 22 types now considered standard by FEMA; excluded from the FEMA 154 list are sub-classifications of certain framing types that specify that the roof and floor diaphragms are either rigid or flexible.

2.8 Field Screening of Buildings

RVS screening of buildings in the field should be carried out by teams consisting of two individuals. Teams of two are recommended to provide an opportunity to discuss issues requiring judgment and to facilitate the data collection process. If at all possible, one of the team members should be a design professional who can identify lateral-force-resisting systems.

Relatively few tools or equipment are needed. Table 2-4 contains a checklist of items that may be needed in performing an RVS as described in this *Handbook*.

2.9 Checking the Quality and Filing the Field Data in the Record-Keeping System

The last step in the implementation of rapid visual screening is checking the quality and filing the RVS data in the record-keeping system established for this purpose. If the data are to be stored in file folders or envelopes containing data for each building that was screened, or on microfilm, the process is straightforward, and requires careful organization. If the data are to be stored in digital form, it is important that the data input and verification process include either double entry of all data, or systematic in-depth review of print outs (item by item review) of all entered data.

It is also recommended that the quality review be performed under the oversight of a design professional with significant experience in seismic design.

Table 2-4 Checklist of Field Equipment Needed for Rapid Visual Screening

- ☐ Binoculars, if high-rise buildings are to be evaluated
- ☐ Camera, preferably instant or digital
- ☐ Clipboard for holding Data Collection Forms
- ☐ Copy of the FEMA 154 *Handbook*
- ☐ Laminated version of the Quick Reference Guide defining terms used on the Data Collection Form (see Appendix B)
- ☐ Pen or pencil
- ☐ Straight edge (optional for drawing sketches)
- ☐ Tape or stapler, for affixing photo if instant camera is used