Rapid Visual Screening of Buildings for Potential Seismic Hazards

A Handbook

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NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

Second Edition

RAPID VISUAL SCREENING OF BUILDINGS FOR POTENTIAL SEISMIC HAZARDS: A HANDBOOK

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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.

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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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Chapter 1

Introduction

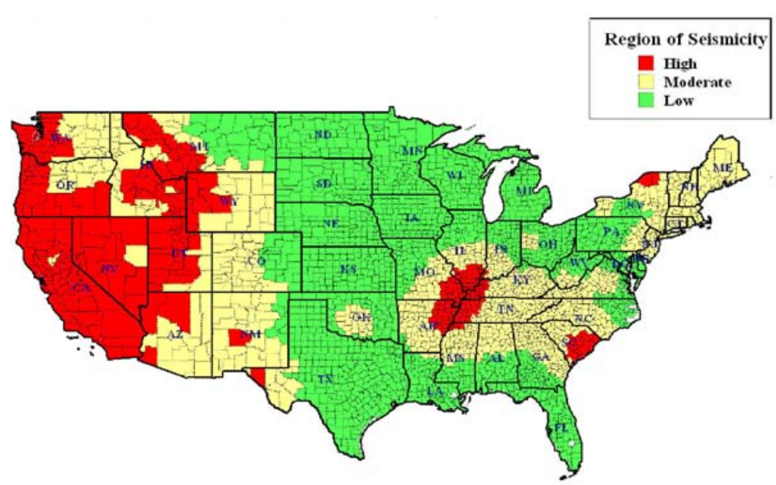
1.1 Background

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.

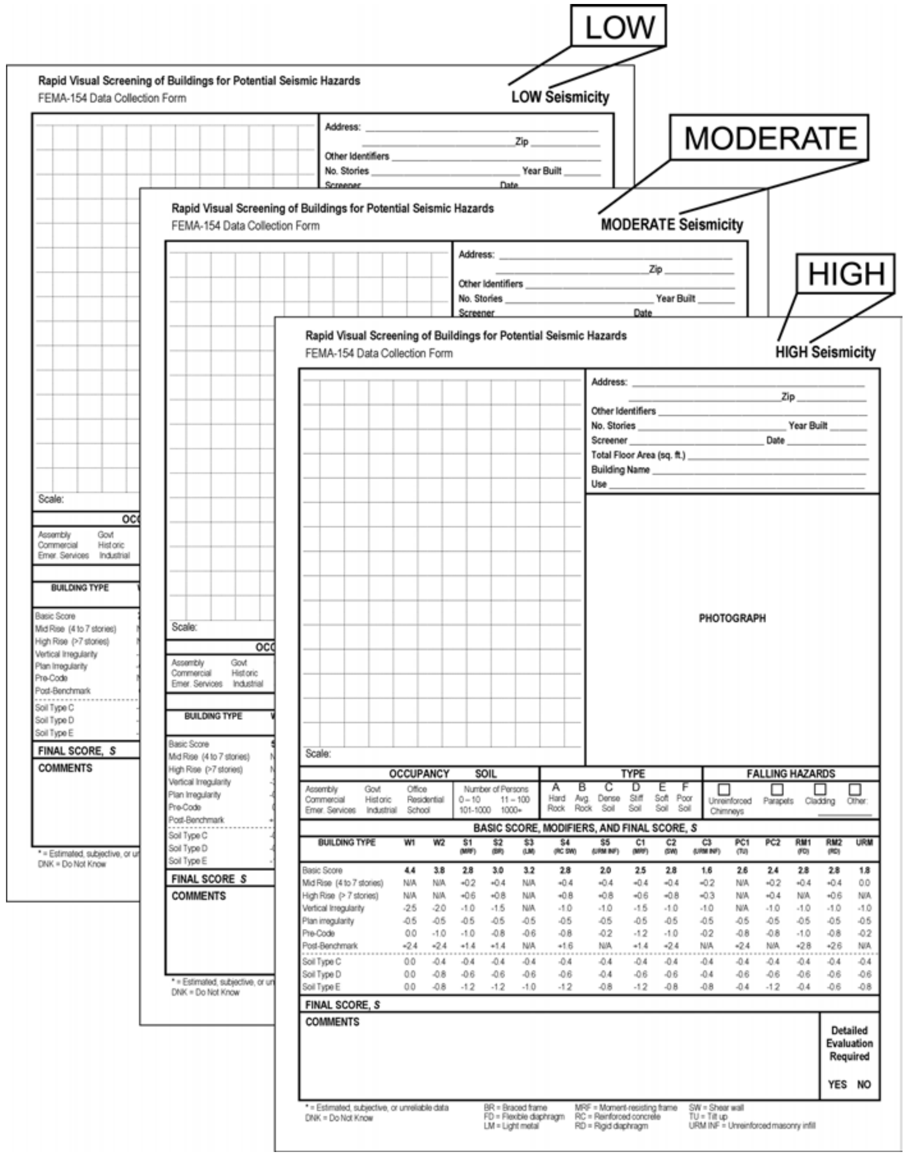


Figure 1-2 Data Collection Forms for the three designated seismicity regions (low, moderate, and high).

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;

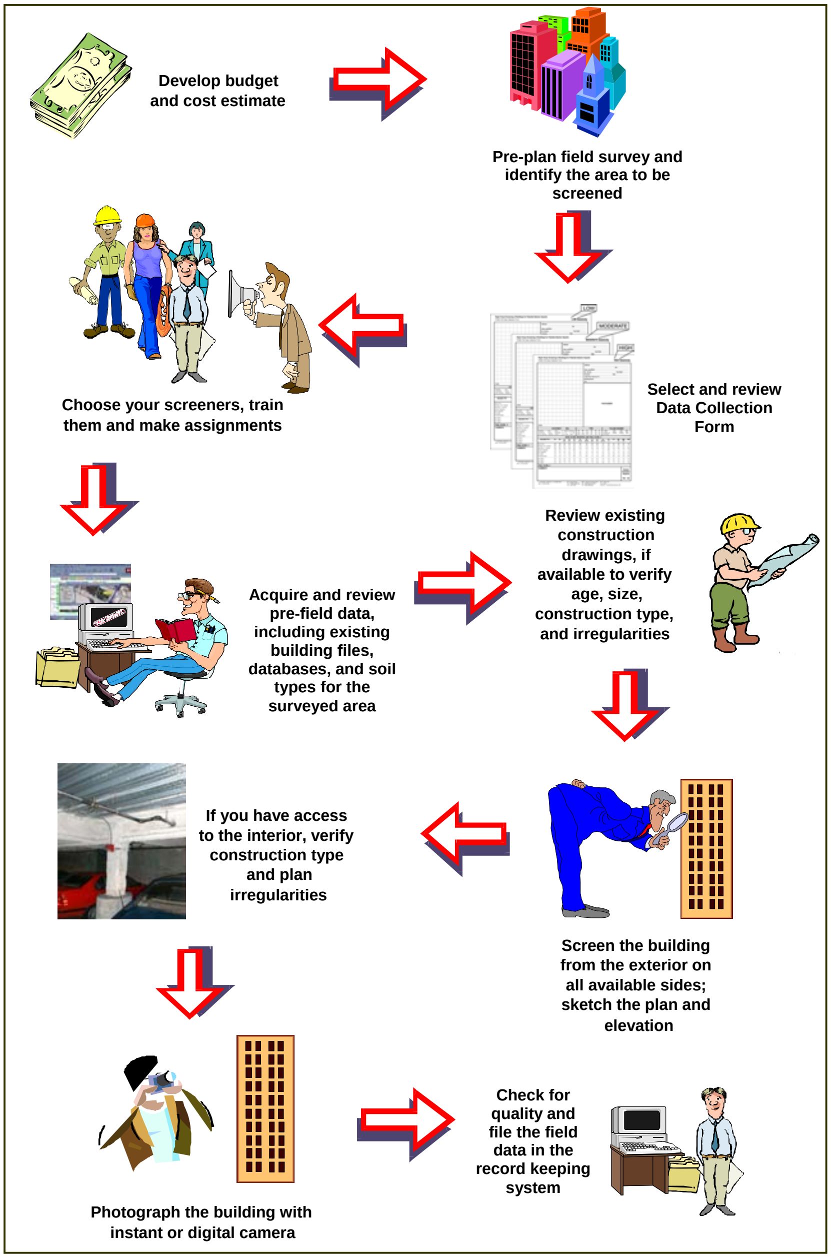


Figure 2-1 Rapid visual screening implementation sequence.

- 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.

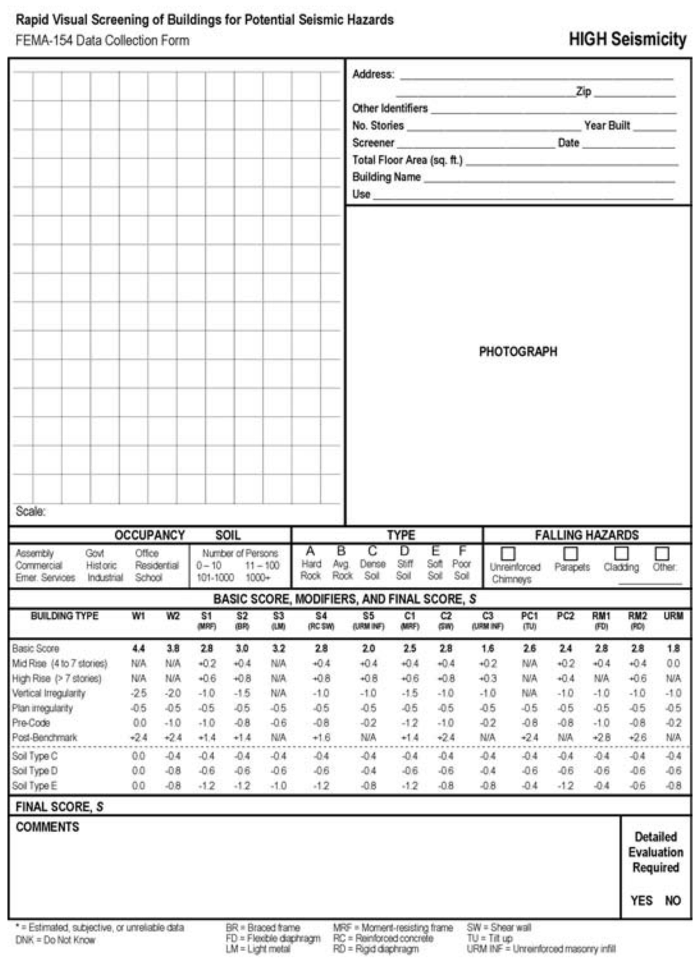
The record-keeping system will vary among RVS authorities, depending on needs, goals, budgets and other constraints, and may in fact consist of several systems. Part of this planning phase may include deciding how buildings are to be identified. Some suggestions are street address, assessor's parcel 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 ____

Scale:

PHOTOGRAPH

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

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 **Structure Types**		Year Seismic Codes Initially Adopted and Enforced*	Benchmark Year When Codes Improved
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

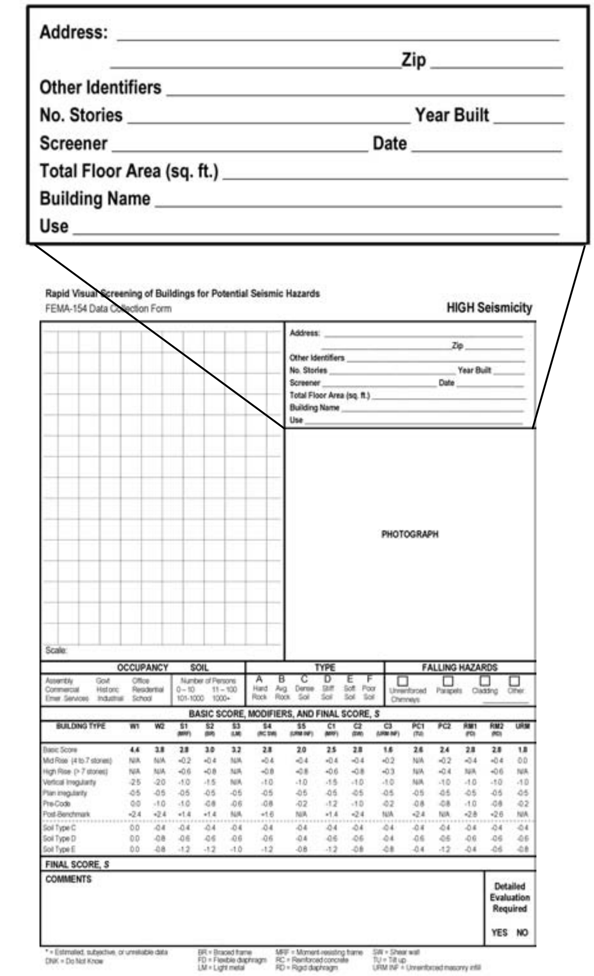


Figure 2-4 Building identification portion of RVS Data Collection Form.

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).

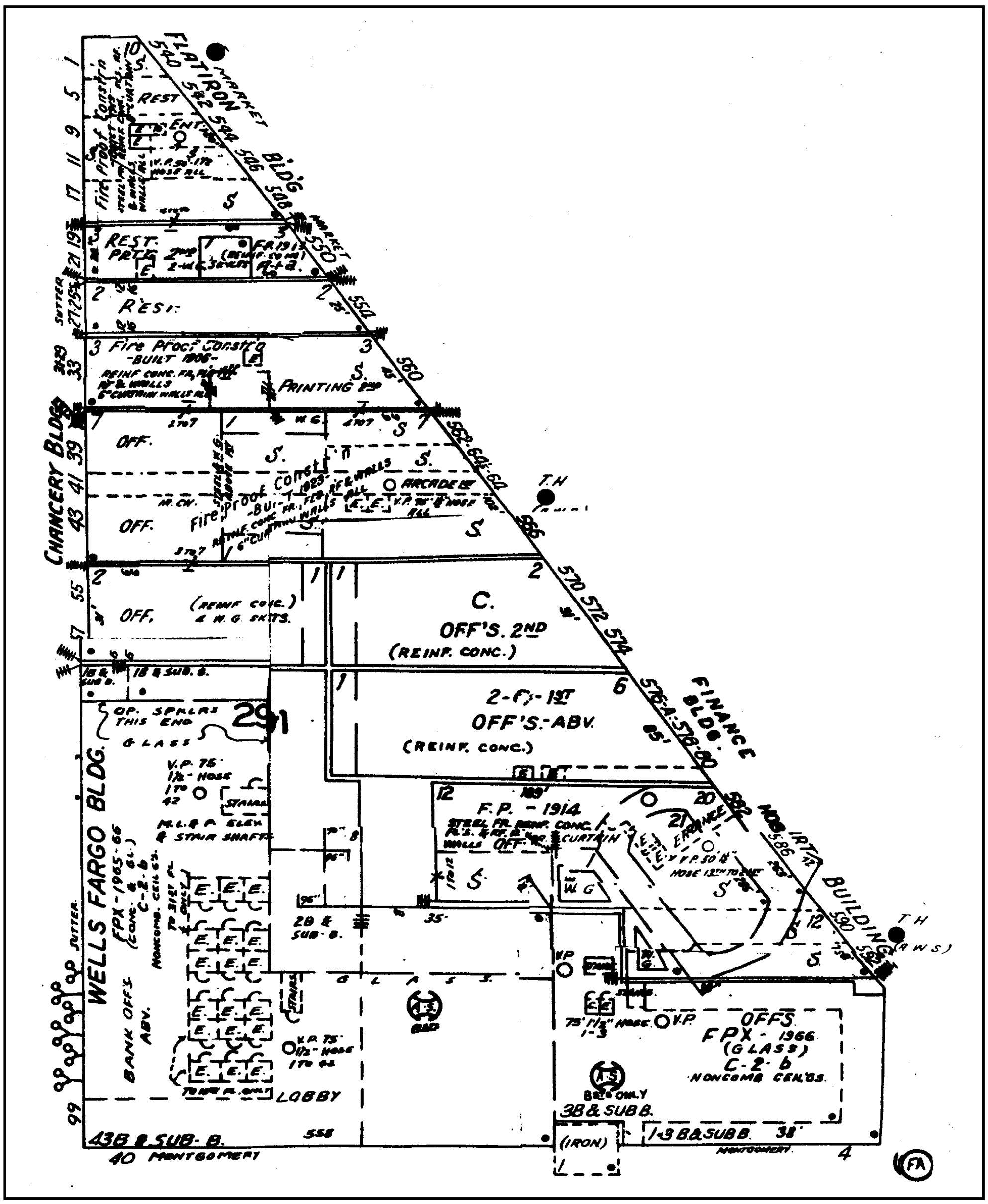


Figure 2-5 Example Sanborn map showing building information for a city block.

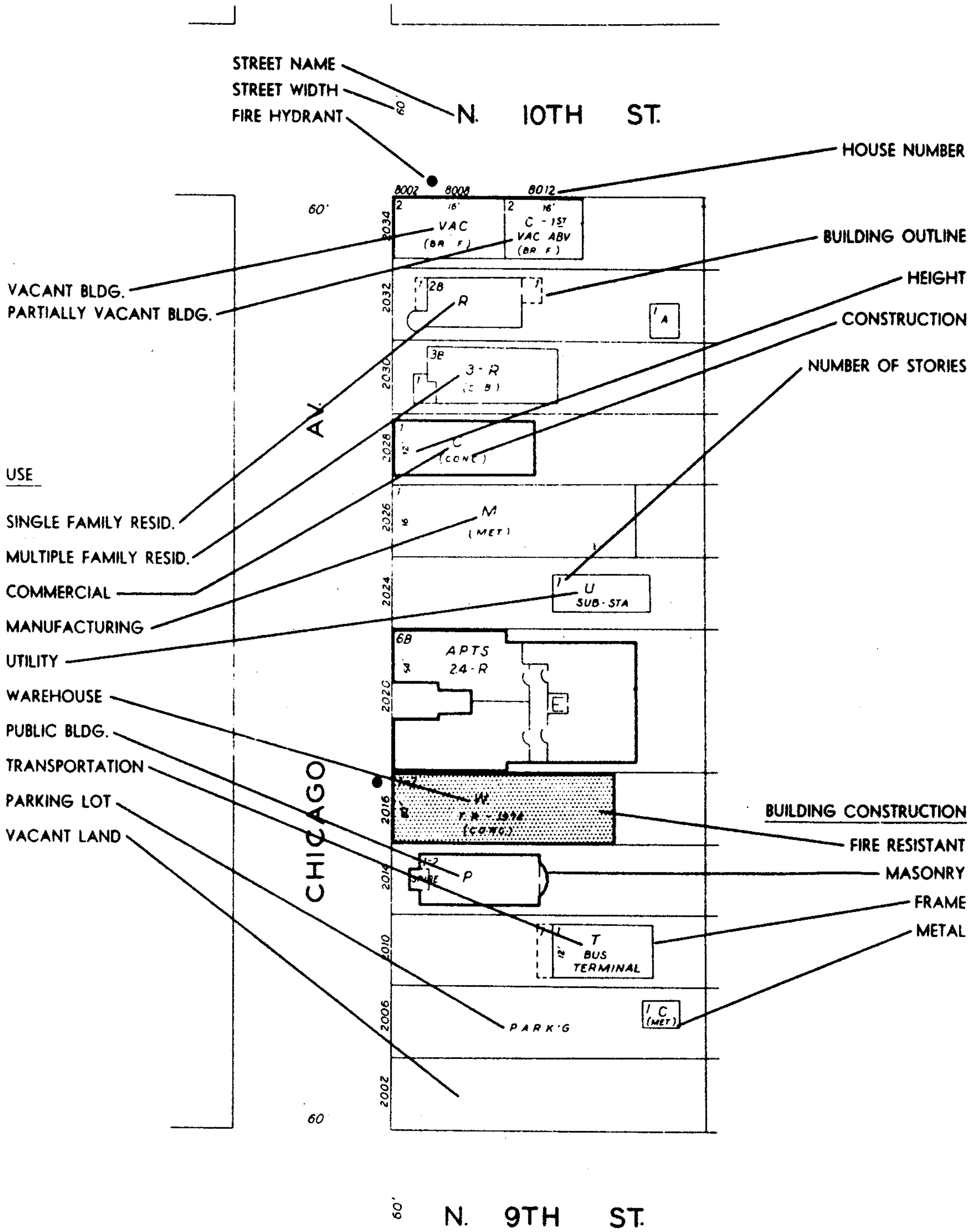
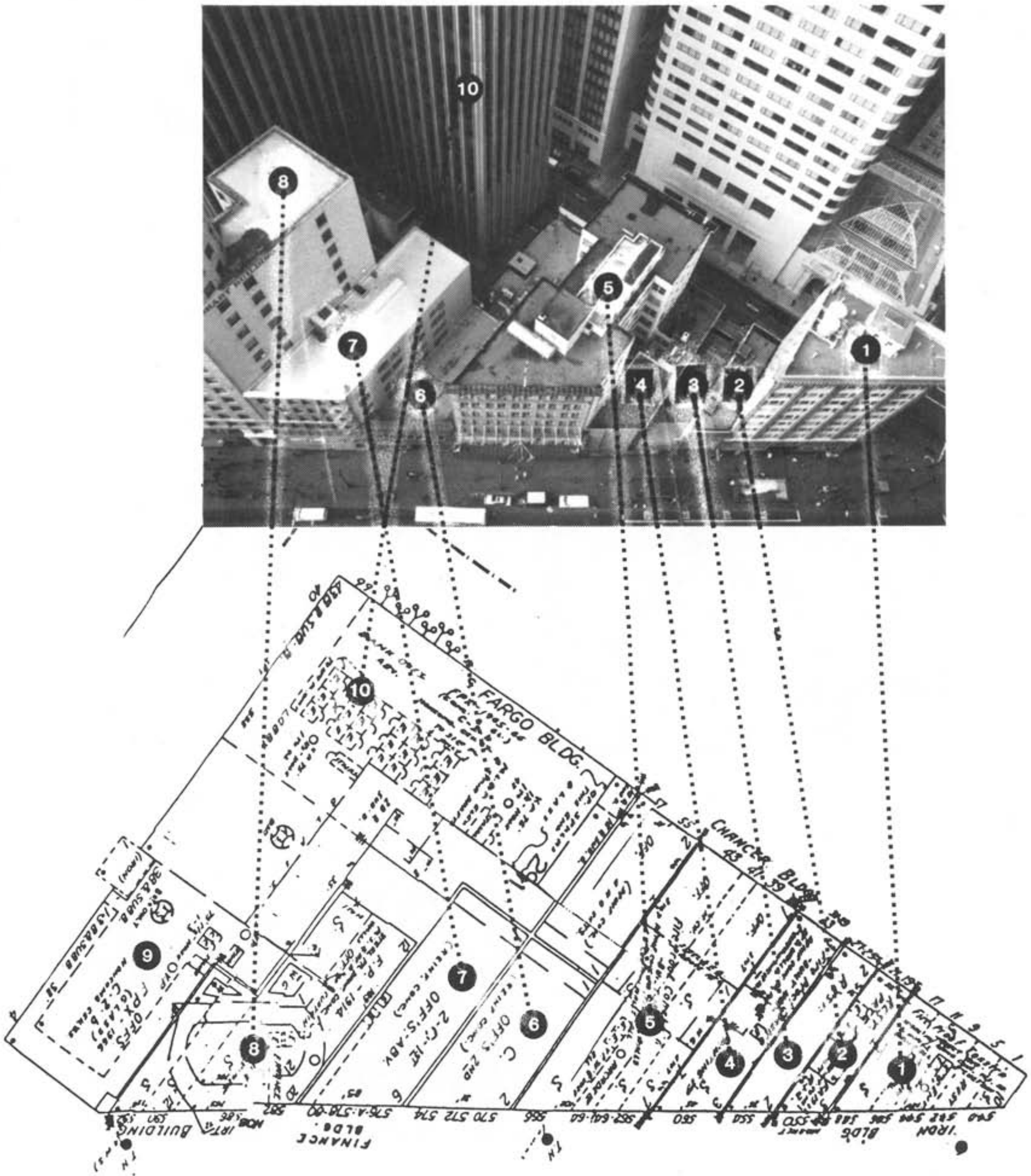


Figure 2-6 Key to Sanborn map symbols. Also, see the Internet, www.sanbornmap.com.

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.

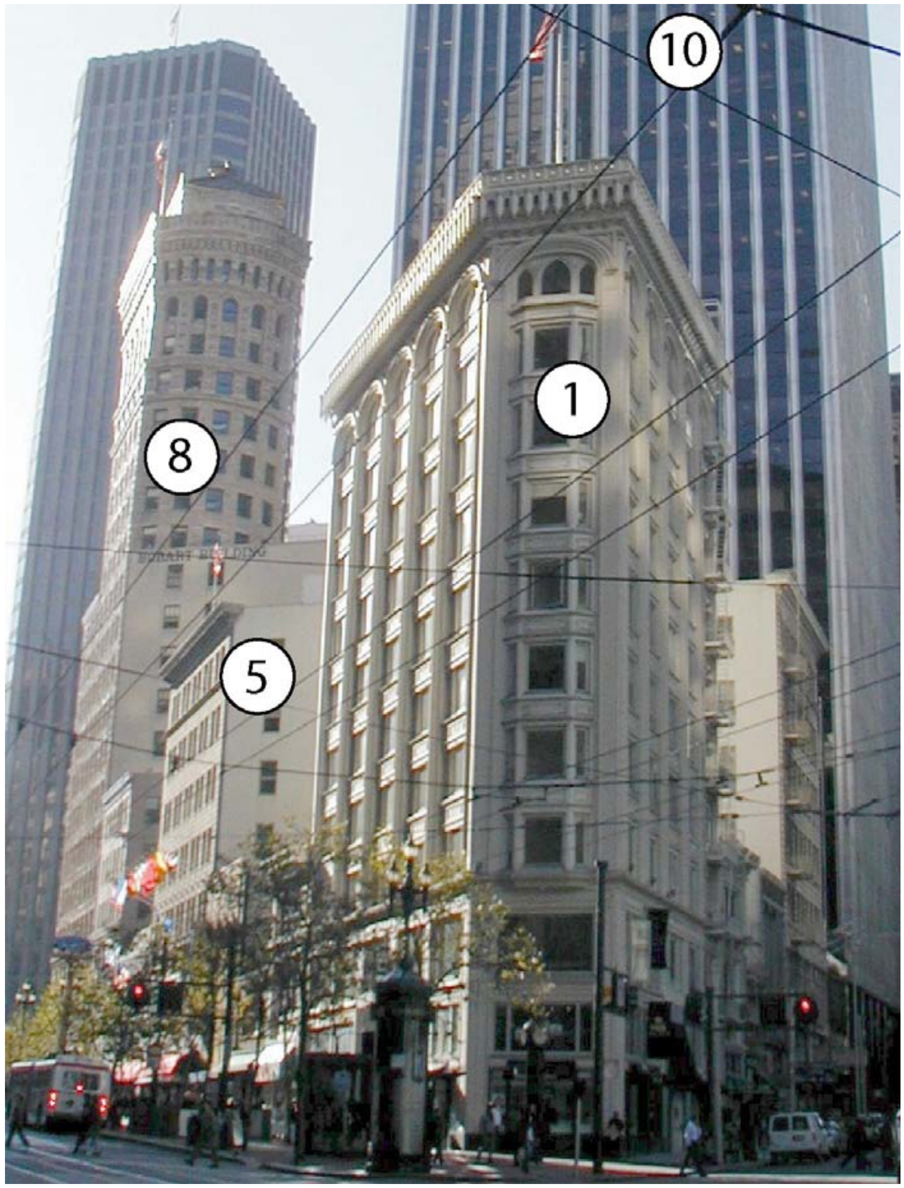


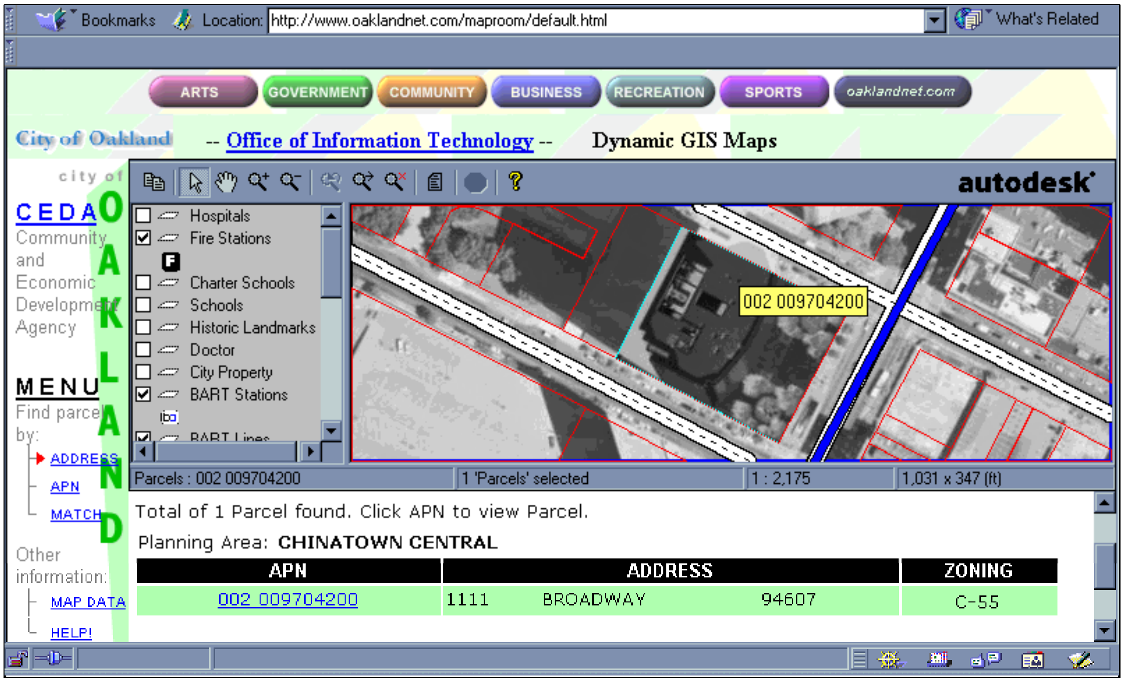
Figure 2-8 Photographs of elevation views of buildings shown in Figure 2-7.

2.6.5 Previous Studies

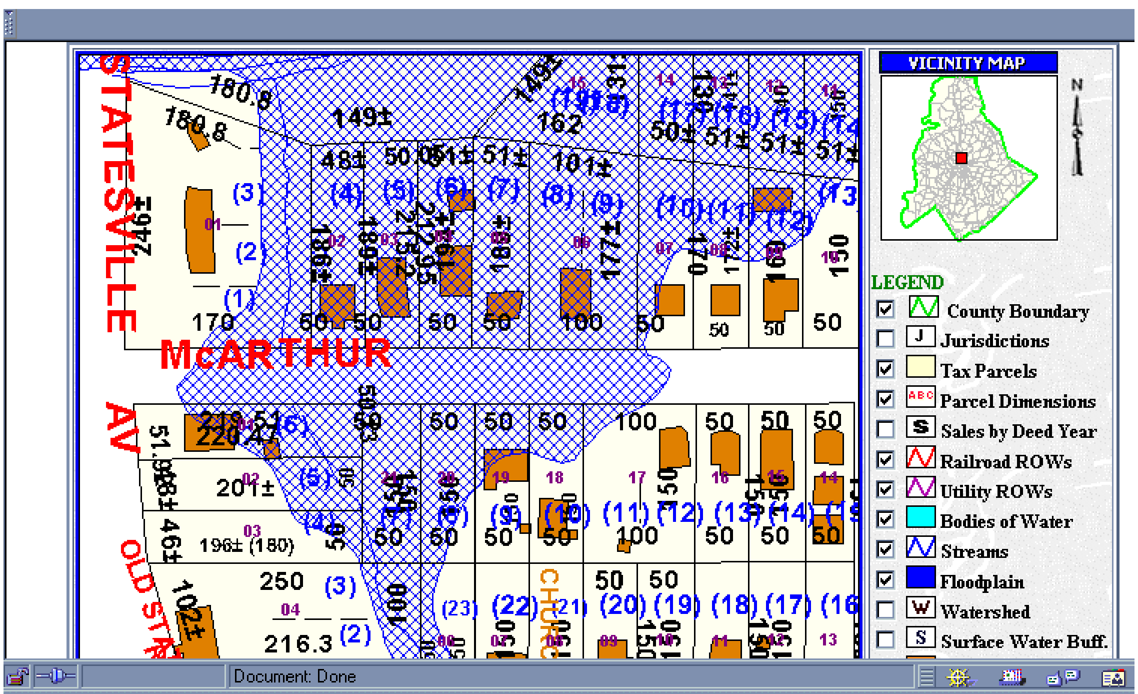
In a few cases, previous building inventories or studies of hazardous buildings or hazardous non-structural elements (e.g., parapets) may have been performed. These studies may be limited to a particular structural or occupancy class, but they may contain useful maps or other relevant structural information 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.

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.

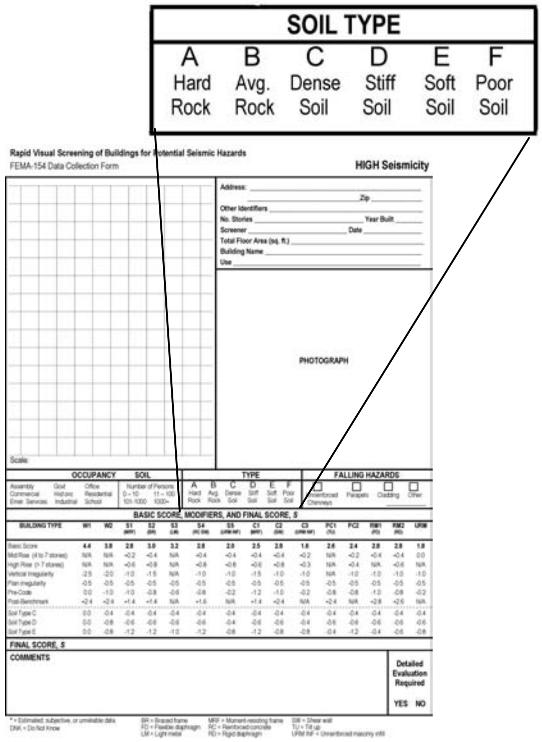


Figure 2-10 Location on Data Collection Form where soil type information is recorded.

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.

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.

[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

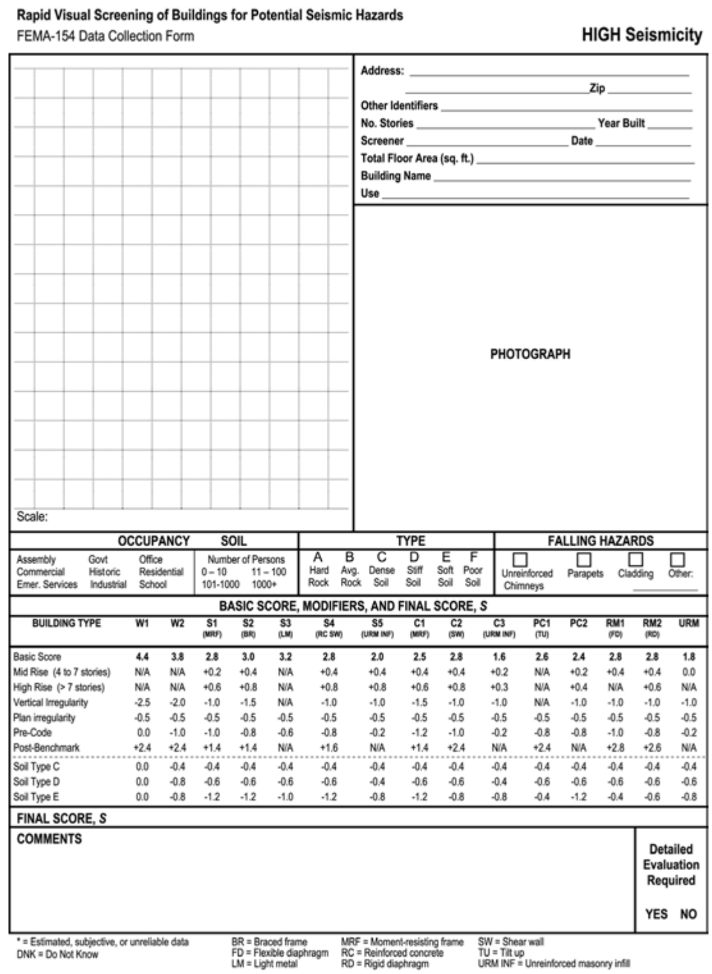
Chapter 3

Completing the Data Collection Form

3.1 Introduction

This chapter provides instructions on how to complete the Data Collection Form (Figure 3-1). It is assumed that the Data Collection Form has already been selected, based on the seismicity level of the area to be screened (as per Chapter 2). The Data Collection Form is completed for each building screened through execution of the following steps:

1. Verifying and updating the building identification information;
2. Walking around the building to identify its size and shape, and sketching a plan and elevation view on the Data Collection Form;
3. Determining and documenting occupancy;
4. Determining soil type, if not identified during the pre-planning process;
5. Identifying potential nonstructural falling hazards, if any, and indicating their existence on the Data Collection Form;
6. Identifying the seismic lateral-load resisting system (entering the building, if possible, to facilitate this process) and circling the related 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 attaching the photo to the form (if an instant camera is used), or indicating a photo reference number on the form (if a digital camera is used).



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 ____

Scale:

PHOTOGRAPH

OCCUPANCY: Assembly, Govt, Office, Commercial, Historic, Residential, Emer. Services, Industrial, School
Number of Persons: 0 – 10, 11 – 100, 101-1000, 1000+

SOIL / **TYPE**: A Hard Rock, B Avg. Rock, C Dense Soil, D Stiff Soil, E Soft Soil, F Poor Soil

FALLING HAZARDS: Unreinforced Chimneys, Parapets, Cladding, Other:

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 3-1 Example RVS Data Collection Form (high seismicity).

Full-sized copies of the Data Collection Forms (one for each seismicity region) are provided in Appendix B, along with a Quick Reference Guide defining terms used on the Data Collection Form. The form has been designed to be filled out in a progressive manner, with a minimum of writing (most items simply can be circled).

Following are detailed instructions and guidance for each of the nine steps above.

3.2 Verifying and Updating the Building Identification Information

Space is provided in the upper right-hand portion of the Data Collection Form (see Figure 3-2) to document building identification information (i.e., address, name, number of stories, year built, and other data). As indicated in Chapter 2, it is desirable to develop and document this information during the pre-planning stage, if at all possible. This information may be entered manually, or be printed on a peel-off label.

Proper identification and location of the building is critically important for subsequent use in hazard assessment and mitigation by the RVS authority. As described in Chapter 2, the authority may prefer to identify and file structures by street address, parcel number, building owner, or some other scheme. However, it is recommended that as a minimum the street address and zip code be recorded on the form. Zip code is important because it is universal to all municipalities, is an especially useful item for later collation and summary analyses. Assessor parcel number or lot number is also useful for jurisdictional record-keeping purposes.

Assuming the identification information is provided on a peel-off label, which is then affixed to the form, or preprinted directly on the form, such information should be verified in the field. If the building identification data are not developed during the pre-planning stage, it must be completed in the field. Documentation of the building address information and name, if it exists, is straightforward. Following is guidance and discussion pertaining to number of stories, year built, identification of the screener, and estimation of total floor area.

3.2.1 Number of Stories

The height of a structure is sometimes related to the amount of damage it may sustain. On soft soils, a tall building may experience considerably stronger and longer duration shaking than a shorter building of the same type. The number of stories is a good indicator of the height of a building (approximately 9-to-10 feet per story for residential, 12 feet per story for commercial or office).

Counting the number of stories may not be a straightforward issue if the building is constructed on a hill or if it has several different roof levels. As a general rule, use the largest number (that is, count floors from the downhill side to the roof). In addition, the number of stories may not be unique. A building may be stepped or have a tower. Use the comment section and the sketch to indicate variations in the number of stories.

Address: ______________________________

______________________ Zip __________

Other Identifiers ______________________

No. Stories ________________ Year Built ______

Screener ________________ Date __________

Total Floor Area (sq. ft.) ________________

Building Name ________________________

Use __________________________________

Figure 3-2 Portion of Data Collection Form for documenting building identification.

3.2.2 Year Built

This information is one of the key elements of the RVS procedure. Building age is tied directly to design and construction practices. Therefore, age can be a factor in determining building type and thus can affect the final scores. This information is not typically available at the site and thus should be included in pre-field data collection.

There may be no single "year built." Certain portions of the structure may have been designed and constructed before others. If this should be the case, the construction dates for each portion can be indicated in the comment section or on the sketch (see Section 3.3). Caution should also be used when interpreting design practices from date of construction. The building may have been designed several years before it was constructed and thus designed to an earlier code with different requirements for seismic detailing.

If information on "year built" is not available during the RVS pre-field data acquisition stage (see Section 2.6), a rough estimate of age will be made on the basis of architectural style and building use. This is discussed in more detail in Appendix D, which provides additional guidance on determining building attributes from streetside. If the year built is only an approximation, an asterisk is used to indicate the entry is estimated.

3.2.3 Screener Identification

The screener should be identified, by name, initials, or some other type of code. At some later time it may be important to know who the screener was for a particular building, so this information should not be omitted.

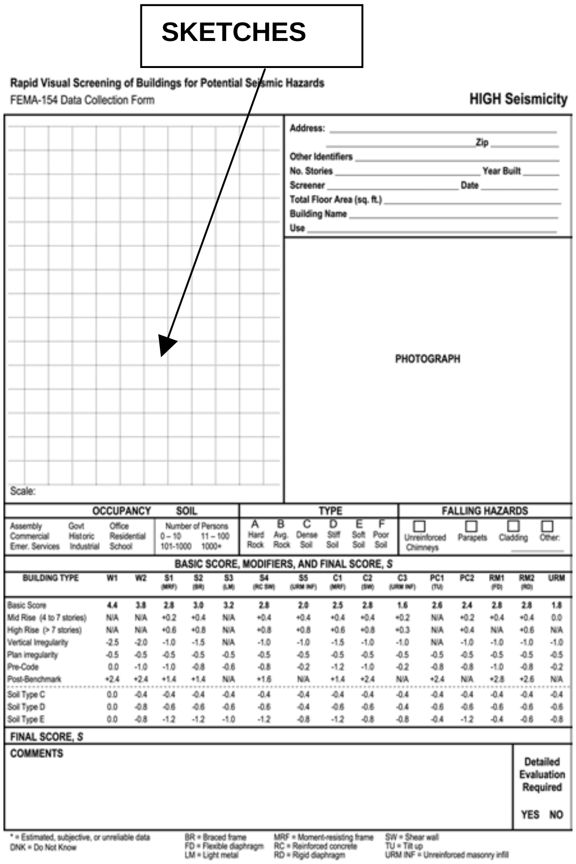


Figure 3-3 Sample Data Collection Form showing location for sketches of building plan and elevation views.

3.2.4 *Total Floor Area*

The total floor area, in some cases available from building department or assessor files (see Section 2.6), will most likely be estimated by multiplying the estimated area of one story by the total number of stories in the building. The length and width of the building can be paced off or estimated (during the planning stage) from Sanborn or other parcel maps. Total floor area is useful for estimating occupancy load (see Section 3.5.2) and may be useful at a later time for estimating the value of the building. Indicate with an asterisk when total floor area is estimated.

3.3 Sketching the Plan and Elevation Views

As a minimum, a sketch of the plan of the building should be drawn on the Data Collection Form (see Figure 3-3). An elevation may also be useful in indicating significant features. The sketches are especially important, as they reveal many of the building's attributes to the screener as the sketch is made. In other words, it forces the screener to systematically view all aspects of the building. The plan sketch should include the location of the building on the site and distance to adjacent buildings. One suggestion is to make the plan sketch from a Sanborn map as part of pre-field work (see Chapter 2), and then verify it in the field. This is especially valuable when access between buildings is not available. If all sides of the building are different, an elevation should be sketched for each side. Otherwise indicate that the sketch is typical of all sides. The sketch should note and emphasize special features such as existing significant cracks or configuration problems.

Dimensions should be included. As indicated in the previous section, the length and width of the building can be paced off or estimated (during the planning stage) from Sanborn or other parcel maps.

3.4 Determining Soil Type

As indicated in Section 2.6.6, soil type should be identified and documented on the Data Collection Form (see Figure 3-4) during the pre-field soils data acquisition and review phase. If soil type has not been determined as part of that process, it needs to be identified by the screener during the

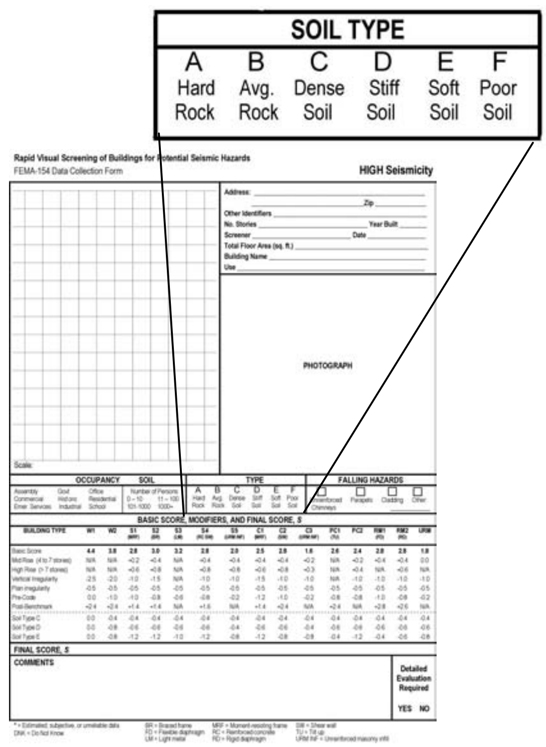


Figure 3-4 Location on Data Collection Form where soil type information is documented (circled).

building site visit. If there is no basis for classifying the soil type, 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.

3.5 Determining and Documenting Occupancy

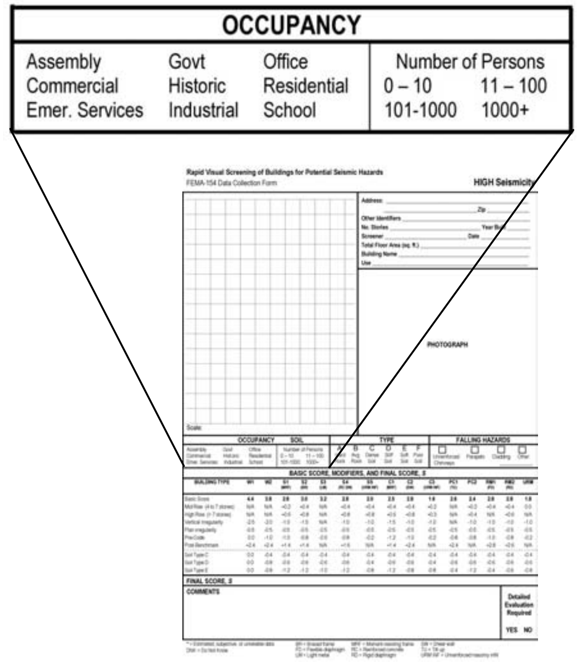
Two sets of information are needed relative to occupancy: (1) building use, and (2) estimated number of persons occupying the building.

3.5.1 Occupancy

Occupancy-related information is indicated by circling the appropriate information in the left-center portion of the form (see Figure 3-5). The occupancy of a building refers to its use, whereas the occupancy load is the number of people in the building (see Section 3.5.2). Although usually not bearing directly on the structural hazard or probability of sustaining major damage, the occupancy of a building is of interest and use when determining priorities for mitigation.

Nine general occupancy classes that are easy to recognize have been defined. They are listed on the form as Assembly, Commercial, Emergency Services (Emer. Services), Government (Govt), Historic, Industrial, Office, Residential, School buildings. These are the same classes used in the first edition of FEMA 154. They have been retained in this edition for consistency, they are easily identifiable from the street, they generally represent the broad spectrum of building uses in the United States, and they are similar to the occupancy categories in the *Uniform Building Code* (ICBO, 1997).

The occupancy class that best describes the building being evaluated should be circled on the form. If there are several types of uses in the building, such as commercial and residential, both should be circled. The actual use of the building may be written in the upper right hand portion of the form. For example, one might indicate that the building is a post office or a library on the line titled "use" in the upper right of the form (see Figure 3-2). In both of these cases, one would also circle "Govt". If none of the defined classes seem to fit the building, indicate the use in the upper right portion of the form (the building identification area) or include an explanation in the comments section. The nine occupancy classes are described below (with general indications of occupancy load):



- *Assembly.* Places of public assembly are those where 300 or more people might be gathered in one room at the same time. Examples are theaters, auditoriums, community centers, performance halls, and churches. (Occupancy load varies greatly and can be as much as 1 person per 10 sq. ft. of floor area, depending primarily on the condition of the seating—fixed versus moveable).

- *Commercial.* The commercial occupancy class refers to retail and wholesale businesses, financial institutions, restaurants, parking structures and light warehouses. (Occupancy load varies; use 1 person per 50 to 200 sq. ft.).

- *Emergency Services.* The emergency services class is defined as any facility that would likely be needed in a major catastrophe. These include police and fire stations, hospitals, and communications centers. (Occupancy load is typically 1 person per 100 sq. ft.).

- *Government.* This class includes local, state and federal non-emergency related buildings (Occupancy load varies; use 1 person per 100 to 200 sq. ft.).

- *Historic.* This class will vary from community to community. It is included because historic buildings may be subjected to specific ordinances and codes.

- *Industrial.* Included in the industrial occupancy class are factories, assembly plants, large warehouses and heavy manufacturing facilities. (Typically, use 1 person per 200 sq. ft. except warehouses, which are perhaps 1 person per 500 sq. ft.).
- *Office.* Typical office buildings house clerical and management occupancies (use 1 person per 100 to 200 sq. ft.).
- *Residential.* This occupancy class refers to residential buildings such as houses, townhouses, dormitories, motels, hotels, apartments and condominiums, and residences for the aged or disabled. (The number of persons for residential occupancies varies from about 1 person per 300 sq. ft. of floor area in dwellings, to perhaps 1 person per 200 sq. ft. in hotels and apartments, to 1 per 100 sq. ft. in dormitories).
- *School.* This occupancy class includes all public and private educational facilities from nursery school to university level. (Occupancy load varies; use 1 person per 50 to 100 sq. ft.).

When occupancy is used by a community as a basis for setting priorities for hazard mitigation purposes, the upgrade of emergency services buildings is often of highest priority. Some communities may have special design criteria governing buildings for emergency services. This information may be used to add a special Score Modifier to increase the score for specially designed emergency buildings.

3.5.2 Occupancy Load

Like the occupancy class or use of the building, the occupancy load may be used by an RVS authority in setting priorities for hazard mitigation plans. The community may wish to upgrade buildings with more occupants first. As can be seen from the form (Figure 3-5), the occupancy load is defined in ranges such as 1-10, 11-100, 101-1000, and 1000+ occupants. The range that best describes the average occupancy of the building is circled. For example, if an office building appears to have a daytime occupancy of 200 persons, and an occupancy of only one or two persons otherwise, the maximum occupancy load is 101-1000 persons. If the occupancy load is estimated from building size and use, an inserted asterisk will automatically indicate that these are approximate data.

3.6 Identifying Potential Nonstructural Falling Hazards

Nonstructural falling hazards such as chimneys, parapets, cornices, veneers, overhangs and heavy cladding can pose life-safety hazards if not adequately anchored to the building. Although these hazards may be present, the basic lateral-load system for the building may be adequate and require no further review. A series of four boxes have been included to indicate the presence of nonstructural falling hazards (see Figure 3-6). The falling hazards of major concern are:

- *Unreinforced Chimneys.* Unreinforced masonry chimneys are common in older masonry and wood-frame dwellings. They are often inadequately tied to the house and fall when strongly shaken. If in doubt as to whether a chimney is reinforced or unreinforced, assume it is unreinforced.
- *Parapets*. Unbraced parapets are difficult to identify from the street as it is sometimes difficult to tell if a facade projects above the roofline. Parapets often exist on three sides of the building, and their height may be visible from the back of the structure.
- *Heavy Cladding*. Large heavy cladding elements, usually precast concrete or cut

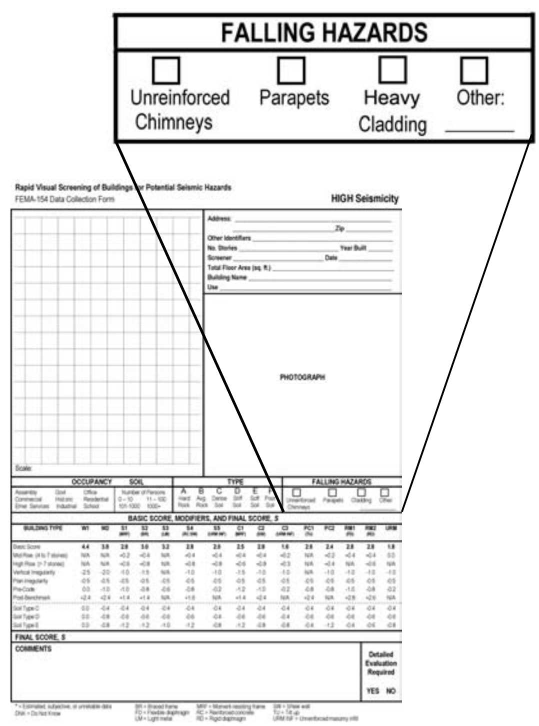


Figure 3-6 Portion of Data Collection Form for documenting nonstructural falling hazards.

stone, may fall off the building during an earthquake if improperly anchored. The loss of panels may also create major changes to the building stiffness (the elements are considered nonstructural but often contribute substantial stiffness to a building), thus setting up plan irregularities or torsion when only some fall. (Glass curtain walls are not considered as heavy cladding in the RVS procedure.) The existence of heavy cladding is of concern if the connections were designed and installed before the jurisdiction adopted seismic anchorage requirements (normally twice that for gravity loads). The date of such code adoption will vary with jurisdiction and should be established by an experienced design professional in the planning stages of the RVS process (see Section 2.4.2).

If any of the above nonstructural falling hazards exist, the appropriate box should be checked. If there are any other falling hazards, the "Other" box should be checked, and the type of hazard indicated on the line beneath this box. Use the comments section if additional space is required.

The RVS authority may later use this information as a basis for notifying the owner of potential problems.

3.7 Identifying the Lateral-Load-Resisting System and Documenting the Related Basic Structural Score

The RVS procedure is based on the premise that the screener will be able to determine the building's lateral-load-resisting system from the street, or to eliminate all those that it cannot possibly be. It is further assumed that the lateral-load-resisting system is one of fifteen types that have been observed to be prevalent, based on studies of building stock in the United States. The fifteen types are consistent with the model building types identified in the FEMA 310 Report and the predecessor documents that have addressed seismic evaluation of buildings (e.g., ATC, 1987; BSSC, 1992)). The fifteen model building types used in this document, however, are an abbreviated subset 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.

3.7.1 Fifteen Building Types Considered by the RVS Procedure and Related Basic Structural Scores

Following are the fifteen building types used in the RVS procedure. Alpha-numeric reference codes used on the Data Collection Form are shown in parentheses.

1. Light wood-frame residential and commercial buildings smaller than or equal to 5,000 square feet (W1)
2. Light wood-frame buildings larger than 5,000 square feet (W2)
3. Steel moment-resisting frame buildings (S1)
4. Braced steel frame buildings (S2)
5. Light metal buildings (S3)
6. Steel frame buildings with cast-in-place concrete shear walls (S4)
7. Steel frame buildings with unreinforced masonry infill walls (S5)
8. Concrete moment-resisting frame buildings (C1)
9. Concrete shear-wall buildings (C2)
10. Concrete frame buildings with unreinforced masonry infill walls (C3)
11. Tilt-up buildings (PC1)
12. Precast concrete frame buildings (PC2)
13. Reinforced masonry buildings with flexible floor and roof diaphragms (RM1)
14. Reinforced masonry buildings with rigid floor and roof diaphragms (RM2)
15. Unreinforced masonry bearing-wall buildings (URM)

For each of these fifteen model building types, a Basic Structural Hazard Score has been computed that reflects the estimated likelihood that building collapse will occur if the building is subjected to the maximum considered earthquake ground motions for the region. The Basic Structural Hazard Scores are based on the damage and loss estimation functions provided in the FEMA-funded HAZUS damage and loss estimation methodology (NIBS, 1999). For more information about the development of the Basic Structural Hazard Scores, see the companion FEMA 155 report (ATC, 2002).

The Basic Structural Scores are provided on each Data Collection Form in the first row of the

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

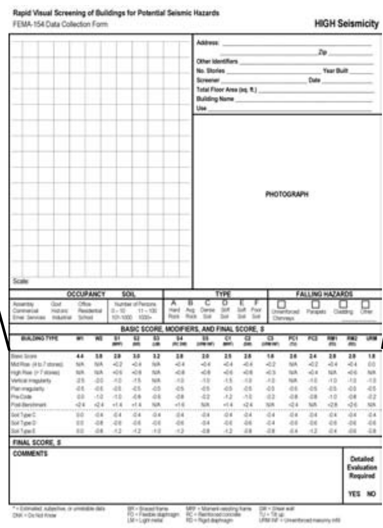


Figure 3-7. Portion of Data Collection Form containing Basic Structural Hazard Scores.

structural scoring matrix in the lower portion of the Data Collection Form (see Figure 3-7). In high and moderate seismicity regions, these scores apply to buildings built after the initial adoption and enforcement of seismic codes, but before the relatively recent significant improvement of codes (that is, before the applicable benchmark year, as defined in Table 2-2). In low seismicity regions, they apply to all buildings except those designed and constructed after the applicable benchmark year, as defined in Table 2-2.

A key issue to be addressed in the planning stage (as recommended in Section 2.4.2) is the identification of those years in which seismic codes were initially adopted and later significantly improved. 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 PC1 (tiltup) buildings is 1941, (the default year specified in the HAZUS criteria, NIBS, 1999). For PC1 (tiltup) buildings, the initial year in which effective seismic codes were specified is 1973 (ICBO, 1973). As described in Sections 3.8.5 and 3.8.6, the Data Collection Form includes Score Modifiers that provide a means for modifying the Basic Structural Hazard Score as a function of design and construction date.

Brief summaries of the physical characteristics and expected earthquake performance of each of the fifteen model building types, along with a photograph of a sample exterior view, and the Basic Structural Scores for regions of low (L), moderate (M), and high (H) seismicity are provided in Table 3-1.

Additional background information on the physical characteristics and earthquake performance of these building types, not essential to the RVS procedure, is provided in Appendix E.

3.7.2 Identifying the Lateral-Force-Resisting System

At the heart of the RVS procedure is the task of identifying the lateral-force-resisting system from the street. Once the lateral-force-resisting system is identified, the screener finds the appropriate alpha-numeric code on the Data Collection Form and circles the Basic Structural Hazard Score immediately beneath it (see Figure 3-7).

Ideally, the lateral-force-resisting system for each building to be screened would be identified prior to field work through the review and interpretation of construction documents for each building (i.e., during the planning stage, as discussed in Section 2.7).

If prior determination of the lateral-force-resisting system is not possible through the review of building plans, which is the most likely scenario, this determination must be made in the field. In this case, the screener reviews spacing and size of windows, and the apparent construction materials to determine the lateral-force resisting system. If the screener cannot identify with complete assuredness the lateral-force-resisting system from the street, the screener should enter the building interior to verify the building type selected (see Section 3.7.3 for additional information on this issue.)

If the screener cannot determine the lateral-force-resisting system, and access to the interior is not possible, the screener should eliminate those lateral-force-resisting systems that are not possible and assume that any of the others are possible. In this case the Basic Structural Hazard Scores for all possible lateral-force-resisting systems would be circled on the Data Collection Form. More guidance and options pertaining to this issue are provided in Section 3.9.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
W1 Light wood frame residential and commercial buildings equal to or smaller than 5,000 square feet		H = 2.8 M = 5.2 L = 7.4	• Wood stud walls are typically constructed of 2-inch by 4-inch vertical wood members set about 16 inches apart (2-inch by 6-inch for multiple stories). • Most common exterior finish materials are wood siding, metal siding, or stucco. • Buildings of this type performed very well in past earthquakes due to inherent qualities of the structural system and because they are lightweight and low rise. • Earthquake-induced cracks in the plaster and stucco (if any) may appear, but are classified as non-structural damage. • The most common type of structural damage in older buildings results from a lack of connection between the superstructure and the foundation, and inadequate chimney support.
W2 Light wood frame buildings greater than 5,000 square feet		H = 3.8 M =4.8 L = 6.0	• These are large apartment buildings, commercial buildings or industrial structures usually of one to three stories, and, rarely, as tall as six stories.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

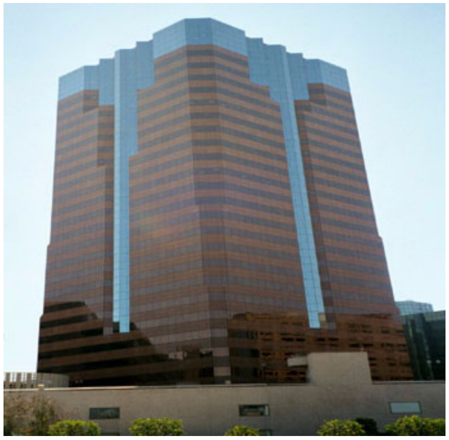
Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
S1 Steel moment-resisting frame		H = 2.8 M = 3.6 L = 4.6	• Typical steel moment-resisting frame structures usually have similar bay widths in both the transverse and longitudinal directions, around 20-30 ft. • The floor diaphragms are usually concrete, sometimes over steel decking. This structural type is used for commercial, institutional and public buildings. • The 1994 Northridge and 1995 Kobe earthquakes showed that the welds in steel moment- frame buildings were vulnerable to severe damage. The damage took the form of broken connections between the beams and columns.
S2 Braced steel frame	  Zoom-in of upper photo	H = 3.0 M = 3.6 L = 4.8	• These buildings are braced with diagonal members, which usually cannot be detected from the building exterior. • Braced frames are sometimes used for long and narrow buildings because of their stiffness. • From the building exterior, it is difficult to tell the difference between steel moment frames, steel braced frames, and steel frames with interior concrete shear walls. • In recent earthquakes, braced frames were found to have damage to brace connections, especially at the lower levels.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
S3 Light metal building		H = 3.2 M = 3.8 L = 4.6	• The structural system usually consists of moment frames in the transverse direction and braced frames in the longitudinal direction, with corrugated sheet-metal siding. In some regions, light metal buildings may have partial-height masonry walls. • The interiors of most of these buildings do not have interior finishes and their structural skeleton can be seen easily. • Insufficient capacity of tension braces can lead to their elongation and consequent building damage during earthquakes. • Inadequate connection to a slab foundation can allow the building columns to slide on the slab. • Loss of the cladding can occur.
S4 Steel frames with cast-in-place concrete shear walls		H = 2.8 M = 3.6 L = 4.8	• Lateral loads are resisted by shear walls, which usually surround elevator cores and stairwells, and are covered by finish materials. • An interior investigation will permit a wall thickness check. More than six inches in thickness usually indicates a concrete wall. • Shear cracking and distress can occur around openings in concrete shear walls during earthquakes. • Wall construction joints can be weak planes, resulting in wall shear failure below expected capacity.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
S5 Steel frames with unreinforced masonry infill walls		H = 2.0 M = 3.6 L = 5.0	• Steel columns are relatively thin and may be hidden in walls. • Usually masonry is exposed on exterior with narrow piers (less than 4 ft wide) between windows. • Portions of solid walls will align vertically. • Infill walls are usually two to three wythes thick. • Veneer masonry around columns or beams is usually poorly anchored and detaches easily.
C1 Concrete moment-resisting frames		H = 2.5 M = 3.0 L = 4.4	• All exposed concrete frames are reinforced concrete (not steel frames encased in concrete). • A fundamental factor governing the performance of concrete moment-resisting frames is the level of ductile detailing. • Large spacing of ties in columns can lead to a lack of concrete confinement and shear failure. • Lack of continuous beam reinforcement can result in hinge formation during load reversal. • The relatively low stiffness of the frame can lead to substantial nonstructural damage. • Column damage due to pounding with adjacent buildings can occur.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

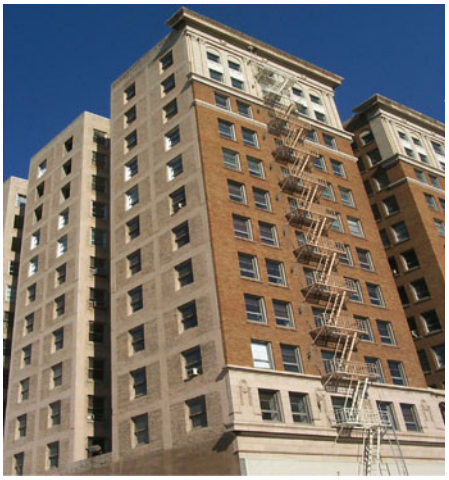
Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
C2 Concrete shear wall buildings		H = 2.8 M = 3.6 L = 4.8	• Concrete shear-wall buildings are usually cast in place, and show typical signs of cast-in-place concrete. • Shear-wall thickness ranges from 6 to 10 inches. • These buildings generally perform better than concrete frame buildings. • They are heavier than steel-frame buildings but more rigid due to the shear walls. • Damage commonly observed in taller buildings is caused by vertical discontinuities, pounding, and irregular configuration.
C3 Concrete frames with unreinforced masonry infill walls		H =1.6 M = 3.2 L = 4.4	• Concrete columns and beams may be full wall thickness and may be exposed for viewing on the sides and rear of the building. • Usually masonry is exposed on the exterior with narrow piers (less than 4 ft wide) between windows. • Portions of solid walls will align vertically. • This type of construction was generally built before 1940 in high-seismicity regions but continues to be built in other regions. • Infill walls tend to buckle and fall out-of-plane when subjected to strong lateral out-of-plane forces. • Veneer masonry around columns or beams is usually poorly anchored and detaches easily.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
PC1 Tilt-up buildings	  Partial roof collapse due to failed diaphragm-to-wall connection	H = 2.6 M = 3.2 L = 4.4	• Tilt-ups are typically one or two stories high and are basically rectangular in plan. • Exterior walls were traditionally formed and cast on the ground adjacent to their final position, and then "tilted-up" and attached to the floor slab. • The roof can be a plywood diaphragm carried on wood purlins and glulam beams or a light steel deck and joist system, supported in the interior of the building on steel pipe columns. • Weak diaphragm-to-wall anchorage results in the wall panels falling and the collapse of the supported diaphragm (or roof).

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
PC2 Precast concrete frame buildings	 Building under construction  Detail of the precast components  Building nearing completion	H = 2.4 M = 3.2 L = 4.6	• Precast concrete frames are, in essence, post and beam construction in concrete. • Structures often employ concrete or reinforced masonry (brick or block) shear walls. • The performance varies widely and is sometimes poor. • They experience the same types of damage as shear wall buildings (C2). • Poorly designed connections between prefabricated elements can fail. • Loss of vertical support can occur due to inadequate bearing area and insufficient connection between floor elements and columns. • Corrosion of metal connectors between prefabricated elements can occur.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
RM1 Reinforced masonry buildings with flexible diaphragms	  Truss-joists support plywood and lightweight concrete slab  Detail showing reinforced masonry	H = 2.8 M = 3.6 L = 4.8	• Walls are either brick or concrete block. • Wall thickness is usually 8 inches to 12 inches. • Interior inspection is required to determine if diaphragms are flexible or rigid. • The most common floor and roof systems are wood, light steel, or precast concrete. • These buildings can perform well in moderate earthquakes if they are adequately reinforced and grouted, with sufficient diaphragm anchorage. • Poor construction practice can result in ungrouted and unreinforced walls, which will fail easily.

Table 3-1 Build Type Descriptions, Basic Structural Hazard Scores, and Performance in Past Earthquakes (Continued)

Building Identifier	*Photograph*	*Basic Structural Hazard Score*	*Characteristics and Performance*
RM2 Reinforced masonry buildings with rigid dia-phrams		H = 2.8 M = 3.4 L = 4.6	• Walls are either brick or concrete block. • Wall thickness is usually 8 inches to 12 inches. • Interior inspection is required to determine if diaphragms are flexible or rigid. • The most common floor and roof systems are wood, light steel, or precast concrete. • These buildings can perform well in moderate earthquakes if they are adequately reinforced and grouted, with sufficient diaphragm anchorage. • Poor construction practice can result in ungrouted and unreinforced walls, which will fail easily.
URM Unreinforced masonry buildings		H = 1.8 M = 3.4 L = 4.6	• These buildings often used weak lime mortar to bond the masonry units together. • Arches are often an architectural characteristic of older brick bearing wall buildings. • Other methods of spanning are also used, including steel and stone lintels. • Unreinforced masonry usually shows header bricks in the wall surface. • The performance of this type of construction is poor due to lack of anchorage of walls to floors and roof, soft mortar, and narrow piers between window openings.

Determining the lateral-force-resisting system in the field is often difficult. A useful first step is to determine if the building structure is a frame or a bearing wall. Examples of frame structures and bearing wall structures are shown in Figure 3-8, 3-9, and 3-10.

Information to assist the screener in distinguishing if the building is a bearing wall or frame structure is provided in the side bar. Once this determination has been made and the

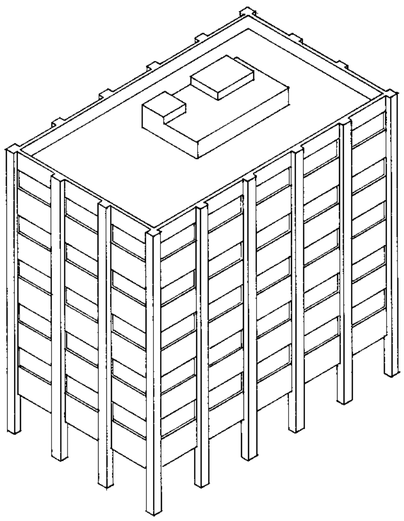


Figure 3-8 Typical frame structure. Features include: large window spans, window openings on many sides, and clearly visible column-beam grid pattern.

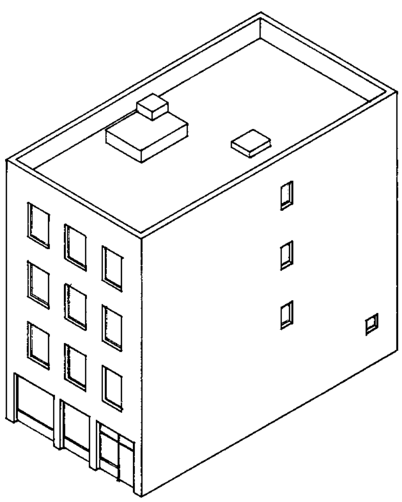


Figure 3-9 Typical bearing wall structure. Features include small window span, at least two mostly solid walls, and thick load-bearing walls.

Distinguishing Between Frame and Bearing Wall Building Systems.

A frame structure (for example, S1, S2, S3, S4, C1, PC2) is made up of beams and columns throughout the entire structure, resisting both vertical and lateral loads. A bearing wall structure (for example, PC1 and URM) uses vertical-load-bearing walls, which are more or less solid, to resist the vertical and lateral loads.

When a building has large openings on all sides, it is probably a frame structure as opposed to a bearing wall structure. A common characteristic of a frame structure is the rectangular grid patterns of the facade, indicating the location of the columns and girders behind the finish material. This is particularly revealing when windows occupy the entire opening in the frame, and no infill wall is used. A newer multistory commercial building should be assumed to be a frame structure, even though there may exist interior shear walls carrying the lateral loads (this would be a frame structure with shear walls).

Bearing wall systems carry vertical and lateral loads with walls rather than solely with columns. Structural floor members such as slabs, joists, and beams, are supported by load-bearing walls. A bearing wall system is thus characterized by more or less solid walls and, as a rule of thumb, a load-bearing wall will have more solid areas than openings. It also will have no wide openings, unless a structural lintel is used.

Some bearing-wall structures incorporate structural columns, or are partly frame structures. This is especially popular in multistory commercial buildings in urban lots where girders and columns are used in the ground floor of a bearing wall structure to provide larger openings for retail spaces. Another example is where the loads are carried by both interior columns and a perimeter wall. Both of these examples should be considered as bearing wall structures, because lateral loads are resisted by the bearing walls. Bearing wall structures sometimes utilize only two walls for load bearing. The other walls are non-load-bearing and thus may have large openings. Therefore, the openness of the front elevation should not be used to determine the structure type. The screener should also look at the side and rear facades. If at least two of the four exterior walls appear to be solid then it is likely that it is a bearing wall structure.

Window openings in older frame structures can sometimes be misleading. Since wide windows were excessively costly and fragile until relatively recently, several narrow windows separated by thin mullions are often seen in older buildings. These thin mullions are usually not load bearing. When the narrow windows are close together, they constitute a large opening typical of a frame structure, or a window in a bearing wall structure with steel lintels.

Whereas open facades on all sides clearly indicate a frame structure, solid walls may be indicative of a bearing wall structure or a frame structure with solid infill walls. Bearing walls are usually much thicker than infill walls, and increase in thickness in the lower stories of multi-story buildings. This increase in wall thickness can be detected by comparing the wall thickness at windows on different floors. Thus, solid walls can be identified as bearing or non-bearing walls according to their thickness, if the structural material is known.

A bearing wall system is sometimes called a box system.

Example of a Frame Building

Example of a Bearing Wall Structure

Figure 3-10 Frame and bearing wall structures

principal structural material is identified, the essential information for determining the lateral-force-resisting system has been established. It is then useful to know that:

- unreinforced masonry and tilt-up buildings are usually bearing-wall type,
- steel buildings and pre-cast concrete buildings are usually frame type, and
- concrete and reinforced masonry buildings may be either type.

A careful review of Table 3-1 and the information provided in Appendices D and E, along with training by knowledgeable building design professionals, should assist the screener in the determination of lateral-force-resisting systems. There will be some buildings for which the lateral-force-resisting system cannot be identified because of their facade treatment. In this case, the screener should eliminate those lateral-force-resisting systems that are not possible and assume that any of the others are possible.

3.7.3 Interior Inspections

Ideally, whenever possible, the screener should seek access to the interior of the building to identify, or verify, the lateral-force-resisting system for the building. In the case of reinforced masonry buildings, entry is particularly important so that the screener can distinguish between RM1 buildings, which have flexible floor and roof diaphragms, and RM2 buildings, which have rigid floor and roof diaphragms.

As with the exterior inspection, the interior process should be performed in a logical manner, either from the basement to the roof, or roof to basement. The screener should look at each floor thoroughly.

The RVS procedure does not require the removal of finish materials that are otherwise permanently affixed to the structure. There are a number of places within a building where it is possible to see the exposed structure. The following are some ways to determine the structure type.

1. If the building has a basement that is not occupied, the first-floor framing may be exposed. The framing will usually be representative of the floor framing throughout the building.
2. If the structural system is a steel or concrete frame, the columns and beams will often be exposed in the basement. The basement walls will likely be concrete, but this does not mean that they are concrete all the way to the roof.
3. High and mid-rise structures usually have one or more levels of parking below the building. When fireproofed steel columns and girders are seen, the screener can be fairly certain that the structure is a steel building (S1, S2, or S4 see Figure 3-11).
4. If the columns and beams are constructed of concrete, the structure type is most likely a concrete moment-frame building (C1, see Figure 3-12). However, this is not guaranteed as some buildings will use steel framing above the ground floor. To ascertain the building type, the screener will need to look at the columns above the first floor.
5. If there is no basement, the mechanical equipment rooms may show what the framing is for the floor above.

Figure 3-11 Interior view showing fire-proofed columns and beams, which indicate a steel building (S1, S2, or S4).

6. If suspended ceilings are used, one of the ceiling tiles can be lifted and simply pushed back. In many cases, the floor framing will then be exposed. Caution should be used in identifying the framing materials, because prior to about 1960, steel beams were encased in concrete to provide fireproofing. If steel framing is seen with what appears to be concrete beams, most likely these are steel beams encased in concrete.
7. If plastered ceilings are observed above suspended ceilings, the screener will not be able to identify the framing materials; however, post-1960 buildings can be eliminated as a possibility because these buildings do not use plaster for ceilings.
8. At the exterior walls, if the structural system is a frame system, there will be regularly spaced furred out places. These are the building columns. If the exterior walls between the columns are constructed of brick masonry and the thickness of the wall is 9 inches or more, the structure type is either steel frame with unreinforced masonry infill (S5) or concrete frame with unreinforced masonry infill (C3).
9. Pre-1930 brick masonry buildings that are six stories or less in height and that have wood-floor framing supported on masonry ledges in pockets formed in the wall are unreinforced masonry bearing-wall buildings (URM).

3.7.4 Screening Buildings with More Than One Lateral-Force-Resisting System

In some cases, the screener may observe buildings having more than one lateral-force-resisting system. Examples might include a wood-frame building atop a precast concrete parking garage, or a building with reinforced concrete shear walls in one direction and a reinforced moment-resisting frame in the other.

Buildings that incorporate more than one lateral-force-resisting system should be evaluated for all observed types of structural systems, and the lowest Final Structural Score, *S*, should govern.

Figure 3-12 Interior view showing concrete columns and girders, which indicate a concrete moment frame (C1).

Score Modifier

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

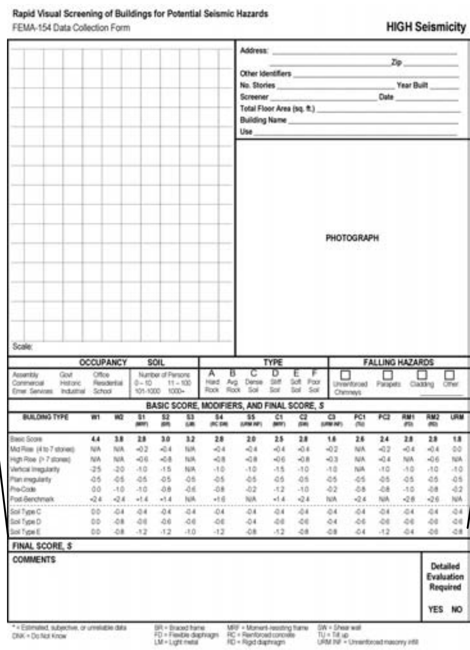

Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA-154 Data Collection Form
HIGH Seismicity
PHOTOGRAPH
OCCUPANCY
SOIL
TYPE
FALLING HAZARDS
BASIC SCORE, MODIFIERS, AND FINAL SCORE, S
FINAL SCORE, S
COMMENTS
Detailed Evaluation Required
YES NO

Figure 3-13. Portion of Data Collection Form containing attributes that modify performance and associated score modifiers.

3.8 Identifying Seismic Performance Attributes and Recording Score Modifiers

This section discusses major factors that significantly impact structural performance during earthquakes, and the assignment of Score Modifiers related to each of these factors (attributes). The severity of the impact on structural performance varies with the type of lateral-force-resisting system; thus the assigned Score Modifiers depend on building type. Score Modifiers associated with each performance attribute are indicated in the scoring matrix on the Data Collection Form (see Figure 3-13). Score Modifiers for the building being screened are circled in the appropriate column (i.e., under the reference code for the identified lateral-force-resisting system for that building).

Following are descriptions of each performance attribute, along with guidance on how to recognize each from the street. If a performance attribute does not apply to a given building type, the Score Modifier is indicated with "N/A", which indicates "not applicable."

3.8.1 Mid-Rise Buildings

If the building has 4 to 7 stories, it is considered a mid-rise building, and the score modifier associated with this attribute should be circled.

3.8.2 High-Rise Buildings

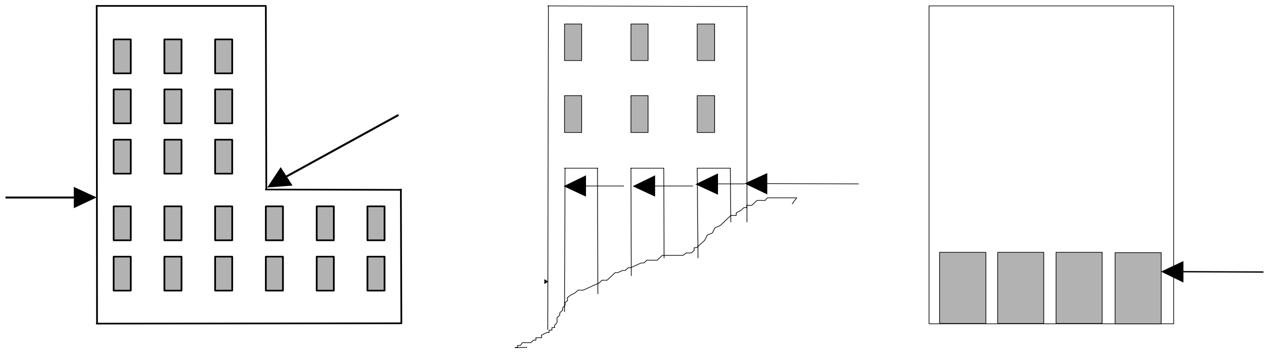
If the building has 8 or more stories, it is considered a high-rise building, and the score modifier associated with this attribute should be circled.

3.8.3 Vertical Irregularity

This performance attribute applies to all building types. Examples of vertical irregularity include buildings with setbacks, hillside buildings, and buildings with soft stories (see illustrations of example vertical irregularities in Figure 3-14).

If the building is irregularly shaped in elevation, or if some walls are not vertical, then apply the modifier (see example in Figure 3-15).

If the building is on a steep hill so that over the up-slope dimension of the building the hill rises at least one story height, a problem may exist because the horizontal stiffness along the lower side may be different from the uphill side. In addition, in the up-slope direction, the stiff short columns attract the seismic shear forces and may fail. In this case the performance modifier is applicable. See Figure 3-14 for an example.



Setbacks   Hillside   Soft Story

Figure 3-14 Elevation views showing vertical irregularities, with arrows indicating locations of particular concern.

A soft story exists if the stiffness of one story is dramatically less than that of most of the others (see Figure 3-15). Examples are shear walls or infill walls not continuous to the foundation. Soft stories are difficult to verify without knowledge of how the building was designed and how the lateral forces are to be transferred from story to story. In other words, there may be shear walls in the building that are not visible from the street. However, if there is doubt, it is best to be conservative and indicate the existence of a soft story by circling the vertical irregularity Score Modifier. Use an asterisk and the comment section to explain the source of uncertainty. In many commercial buildings, the first story is soft due to large window openings for display purposes. If one story is particularly tall or has windows on all sides, and if the stories above have fewer windows, then it is probably a soft story.

A building may be adequate in one direction but be "soft" in the perpendicular direction. For example, the front and back walls may be open but the side walls may be solid. Another common example of soft story is "tuck under" parking commonly found in apartment buildings (see Figure 3-16). Several past earthquakes in California have shown the vulnerability of this type of construction.

Vertical irregularity is a difficult characteristic to define, and considerable judgment and experience are required for identification purposes.

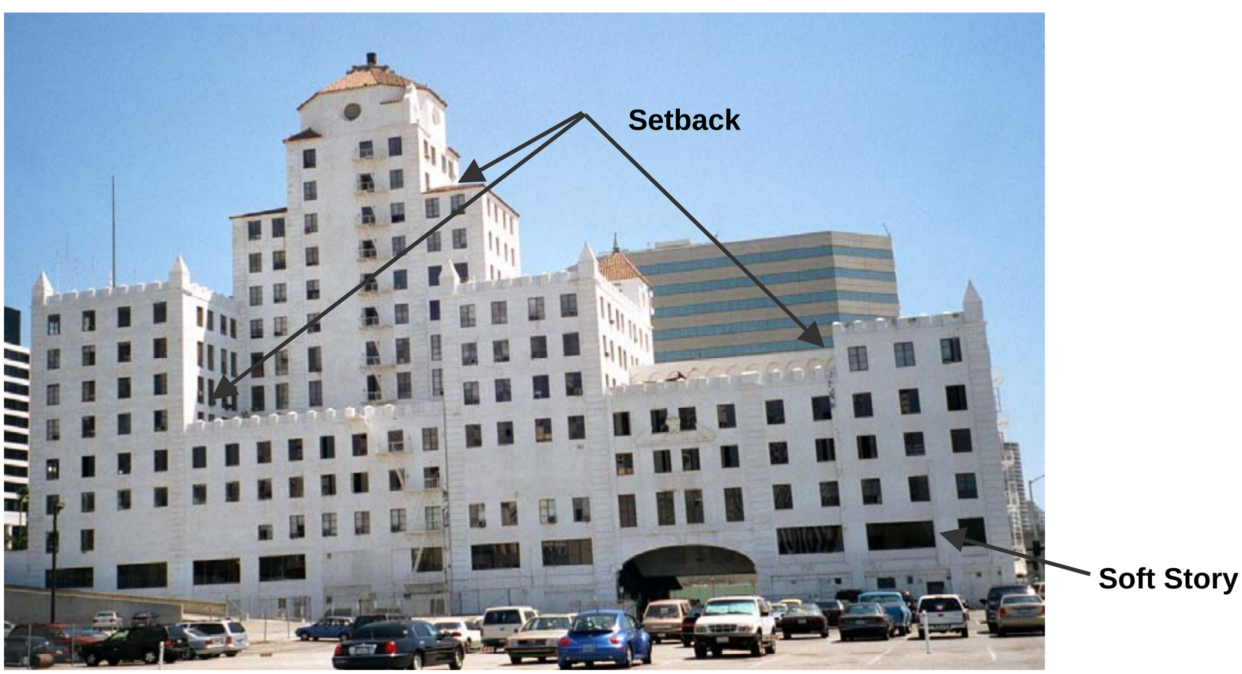


Figure 3-15 Example of setbacks (see Figure 3-14) and a soft first story.

Figure 3-16 Example of soft story conditions, where parking requirements result in large weak openings.

3.8.4 Plan Irregularity

If a building has a vertical or plan irregularity, as described below, this modifier applies. Plan irregularity can affect all building types. Examples of plan irregularity include buildings with re-entrant corners, where damage is likely to occur; buildings with good lateral-load resistance in one direction but not in the other; and buildings with major stiffness eccentricities in the lateral-force-resisting system, which may cause twisting (torsion) around a vertical axis.

Buildings with re-entrant corners include those with long wings that are E, L, T, U, or + shaped (see Figures 3-17 and 3-18). See SEAOC (1996) for further discussion of this issue.)

Plan irregularities causing torsion are especially prevalent among corner buildings, in which the two adjacent street sides of the building are largely windowed and open, whereas the other two sides are generally solid. Wedge-shaped buildings, triangular in plan, on corners of streets not meeting at 90°, are similarly susceptible (see Figure 3-19).

Although plan irregularity can occur in all building types, primary concern lies with wood, tilt-up, pre-cast frame, reinforced masonry and unreinforced masonry construction. Damage at connections may significantly reduce the capacity of a vertical-load-carrying element, leading to partial or total collapse.

3.8.5 Pre-Code

This Score Modifier applies for buildings in high and moderate seismicity regions and is applicable if the building being screened was designed and constructed prior to the initial adoption and enforcement of seismic codes applicable for that building type (e.g., steel moment frame, S1). The year(s) in which seismic codes were initially adopted and enforced for the various model building types should have been identified as part

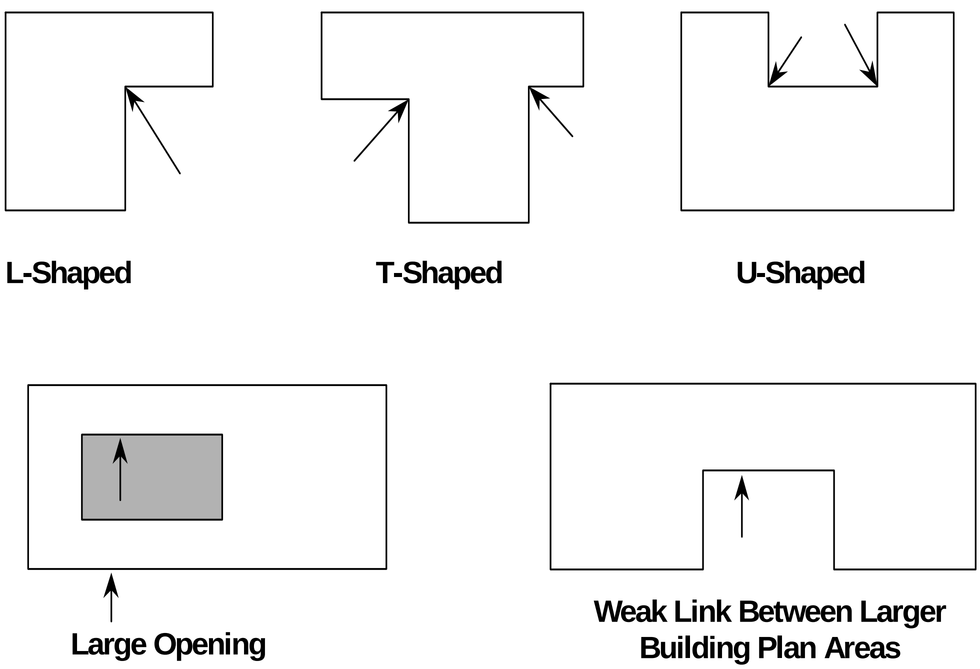


Figure 3-17 Plan views of various building configurations showing plan irregularities; arrows indicate possible areas of damage.

Figure 3-18 Example of a building, with a plan irregularity, with two wings meeting at right angles.

of the Data Collection Form review process during the pre-planning stage (as recommended in Section 2.4.2). If this determination was not made during the planning stage, the default year is 1941, for all building types except PC1, in which case it is 1973. Because of the method used to calculate the Basic Structural Hazard Scores, this modifier does not apply to buildings in the low seismicity region.

3.8.6 *Post-Benchmark*

This Score Modifier is applicable if the building being screened was designed and constructed after significantly improved seismic codes applicable for that building type (e.g., concrete moment frame, C1) were adopted and enforced by the local jurisdiction. The year in which such improvements were adopted is termed the "benchmark" year. Benchmark year(s) for the various model building types should have been identified as part of the Data Collection Form review process during the pre-planning stage (as recommended in Section 2.4.2). Benchmark years for the various building types (designed in accordance with various model codes) are provided in Table 2-2.

3.8.7 *Soil Type C, D, or E*

Score Modifiers are provided for Soil Type C, Type D, and Type E. The appropriate modifier should be circled if one of these soil types exists at the site (see Section 3.4 for additional discussion regarding the determination of soil type). If sufficient guidance or data are not available during the planning stage to classify the soil type as A

Figure 3-19 Example of a building, triangular in plan, subject to torsion.

through E, a soil type E should be assumed. However, for one- or two-story buildings with a roof height equal to or less than 25 feet, a class D soil type may be assumed if the actual site conditions are not known.

There is no Score Modifier for Type F soil because buildings on soil type F cannot be screened effectively by the RVS procedure. A geotechnical engineer is required to confirm the soil type F and an experienced professional engineer is required for building evaluation.

3.9 Determining the Final Score

The Final Structural Score, *S*, is determined for a given building by adding (or subtracting) the Score Modifiers for that building to the Basic Structural Hazard Score for the building. The result is documented in the section of the form entitled Final Score (see Figure 3-20). Based on this information, and the "cut-off" score selected during the pre-planning process (see Section 2.4.3), the screener then decides if a detailed evaluation is required for the building and circles "YES" or "NO" in the lower right-hand box (see Figure 3-20). Additional guidance on this issue is provided in Sections 4.1, and 4.2.

When the screener is uncertain of the building type, an attempt should be made to eliminate all unlikely building types. If the screener is still left with several choices, computation of the Final Structural Score *S* may be treated several ways:

1. The screener may calculate *S* for all the remaining options and choose the lowest

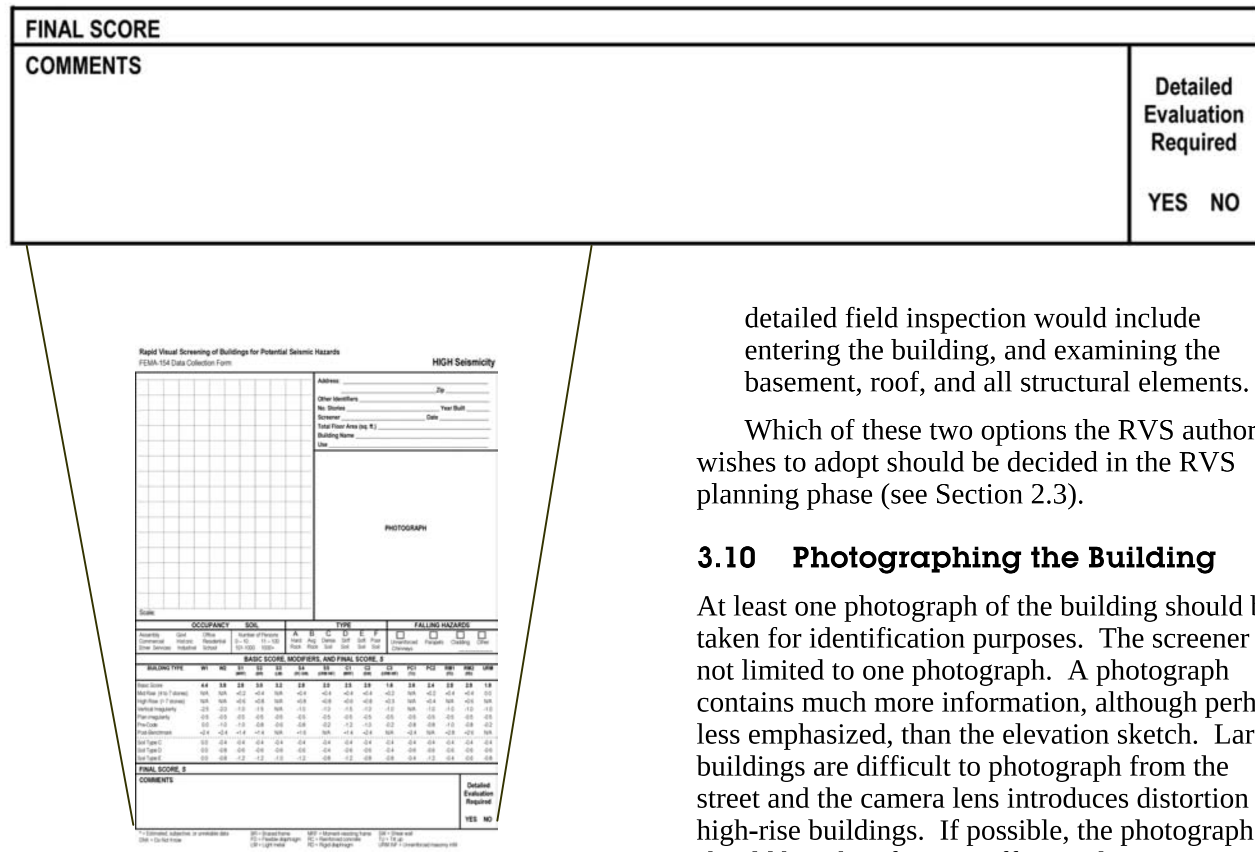


Figure 3-20 Location on Data Collection Form where the final score, comments, and an indication if the building needs detailed evaluation are documented.

score. This is a conservative approach, and has the disadvantage that it may be too conservative and the assigned score may indicate that the building presents a greater risk than it actually does. This conservative approach will not pose problems in cases where all the possible remaining building types result in scores below the cut-off value. In all these cases the building has characteristics that justify further review anyway by a design professional experienced in seismic design.

2. If the screener has little or no confidence about any choice for the structural system, the screener should write DNK below the word “Building Type” (see Figure 3-7), which indicates the screener does not know. In this case there should be an automatic default to the need for a detailed review of the building by an experienced design professional. A more detailed field inspection would include entering the building, and examining the basement, roof, and all structural elements.

Which of these two options the RVS authority wishes to adopt should be decided in the RVS planning phase (see Section 2.3).

3.10 Photographing the Building

At least one photograph of the building should be taken for identification purposes. The screener is not limited to one photograph. A photograph contains much more information, although perhaps less emphasized, than the elevation sketch. Large buildings are difficult to photograph from the street and the camera lens introduces distortion for high-rise buildings. If possible, the photograph should be taken from a sufficient distance to include the whole building, and such that adjacent faces are included. A wide angle or a zoom lens may be helpful. Strong sunlit facades should be avoided, as harsh contrasts between shadows and sunlit portions of the facade will be introduced. Lastly, if possible, the front of the building should not be obscured by trees, vehicles or other objects, as they obscure the lower (and often the most important) stories.

3.11 Comments Section

This last section of the form (see Figure 3-20) is for recording any comments the screener may wish to make regarding the building, occupancy, condition, quality of the data or unusual circumstances of any type. For example, if not all significant details can be effectively photographed or drawn, the screener could describe additional important information in the comments area. Comments may be made on the strength of mortar used in a masonry wall, or building features that can be seen at or through window openings. Other examples where comments are helpful are described throughout Chapter 3.

Chapter 4
Using the RVS Procedure Results

The rapid visual screening procedure presented in this *Handbook* is meant to be the preliminary screening phase of a multi-phase procedure for identifying earthquake-hazardous buildings. Buildings identified by this procedure as potentially hazardous 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 identified as potentially hazardous may prove to be adequate.

Since the original publication of FEMA 154 in 1988, the RVS procedure has been widely used by local communities and government agencies. A critical issue in the implementation of FEMA 154 has been the interpretation of the Final Structural Score, *S*, and the selection of a "cut-off" score, below which a detailed seismic evaluation of the building by a design professional in seismic design is required.

Following are discussions on: (1) interpretation and selection of the "cut-off" score; (2) prior uses of the FEMA 154 RVS procedure, including decisions regarding the "cut-off" score; and (3) other possible uses of the FEMA 154 RVS procedure, including resources needed for the various possible uses. These discussions are intended to illuminate both the limitations and potential applications of the RVS procedure.

4.1 Interpretation of RVS Score

Having employed the RVS procedure and determined the building's Final Structural Score, *S*, which is based on the Basic Structural Hazard Score and Score Modifiers associated with the various performance attributes, the RVS authority is naturally faced with the question of what these *S* scores mean. Fundamentally, the final *S* score is an estimate of the probability (or chance) that the building will collapse if ground motions occur that equal or exceed the maximum considered earthquake (MCE) ground motions (the current FEMA 310 ground motion specification for detailed seismic evaluation of buildings). These estimates of the score are based on limited observed and analytical data, and the probability of collapse is therefore approximate. For example, a final score of $S = 3$ implies there is a chance of 1 in 10^3, or 1 in 1000, that the building will collapse if such ground motions occur. A final score of $S = 2$ implies there is a chance of 1 in 10^2, or 1 in 100, that the building will collapse if such ground motions occur. (Additional information about the basis for the RVS scoring system is provided in the second edition of the companion FEMA 155 Report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*.) An understanding and appreciation of the physical essence of the scoring system, as described above, will facilitate the interpretation of results from implementation of the RVS procedure.

4.2 Selection of RVS "Cut-Off" Score

One of the most difficult issues pertaining to rapid visual screening is answering the question, "What is an acceptable *S*?" This is a question for the community that involves the costs of safety versus the benefits. The costs of safety include:

- the costs of reviewing and investigating in detail hundreds or thousands of buildings in order to identify some fraction of those that would actually sustain major damage in an earthquake; and
- the costs associated with rehabilitating those buildings finally determined to be unacceptably weak.

The most compelling benefit is the saving of lives and prevention of injuries due to reduced damage in those buildings that are rehabilitated. This reduced damage includes not only less material damage, but fewer major disruptions to daily lives and businesses. The identification of hazardous buildings and the mitigation of their hazards are critical because there are thousands of existing buildings in all parts of the United States that may suffer severe damage or possible collapse in the event of strong ground shaking. Such damage or collapse can be accompanied by loss of life and serious injury. In a great earthquake deaths could number in the thousands.

Each community needs to engage in some consideration of these costs and benefits of seismic safety, and decide what value of *S* is an appropriate "cut-off' for their situation. The final decision involves many non-technical factors, and is not straightforward. Perhaps the best quantification of the risk inherent in modern building codes was a study regarding design practice by the National Bureau of Standards (NBS, 1980), which observed:

> *In selecting the target reliability it was decided, after carefully examining the resulting reliability indices for the many design situations, that a β_0 =3 is a representative average value for many frequently used structural elements when they are subjected to gravity loading, while β_0 =2.5 and β_0 = 1.75 are representative values for loads that include wind and earthquake, respectively*[3].

In other words, present design practice is such that a value of *S* of about 3 is appropriate for day-to-day loadings, and a value of about 2, or somewhat less, is appropriate for infrequent, but possible, earthquake loadings.

More recently, recommendations for seismic design criteria for new steel moment-frame buildings (SAC, 2000) concluded that:

> *…it is believed that…structures designed in accordance with [these recommendations] provide in excess of 90% confidence of being able to withstand [shaking that has a 2% probability of exceedance in 50 years] without global collapse….*

This statement can be shown to be equivalent to the findings in the NBS (1980) study.

Unless a community itself considers the cost and benefit aspects of seismic safety, an *S* value of about 2.0 is a reasonable preliminary value to use within the context of RVS to differentiate adequate buildings from those potentially inadequate and thus requiring detailed review. Use of a higher cut-off *S* value implies greater desired safety but increased community-wide costs for evaluations and rehabilitation; use of a lower value of *S* equates to increased seismic risk and lower short-term community-wide costs for evaluations and rehabilitation (prior to an earthquake).

Further guidance on cost and other societal implications of seismic rehabilitation of hazardous buildings is available in other publications of the FEMA report series on existing buildings (see FEMA-156 and FEMA-157, *Typical Costs for Seismic Rehabilitation of Buildings,* 2nd Edition, Volumes 1 and 2, and FEMA-255 and FEMA-256, *Seismic Rehabilitation of Federal Buildings – A Benefit/Cost Model*, Volumes 1 and 2 (VSP, 1994).

4.3 Prior Uses of the RVS Procedure

During the decade following publication of the first edition of the FEMA 154 *Handbook*, the rapid visual screening procedure was used by private-sector organizations and government agencies to evaluate more than 70,000 buildings nationwide (ATC, 2002). As reported at the FEMA 154 Users Workshop in San Francisco in September 2000 (see second edition of FEMA 155 report for additional information), these applications included surveys of (1) commercial buildings in Beverly Hills, California, (2) National Park Service facilities, (3) pubic buildings and designated shelters in southern Illinois; (4) U. S. Army facilities, (5) facilities of the U. S. Department of the Interior and (6) buildings in other local communities and for other government agencies. The results from some of these efforts are described below.

In its screening of 11,500 buildings using the FEMA 154 RVS procedure, the U. S. Army Corps of Engineers Civil Engineering Research Laboratory (CERL) used a cut-off score of 2.5, rather than 2.0 (S. Sweeney, oral communication, September 2000), with the specific intent of using a more conservative approach. As a result of the FEMA 154 screening, approximately 5,000 buildings had final *S* scores less than 2.5. These buildings, along with a subset of buildings that had FEMA 154 scores higher than 2.5, but were of concern for other reasons, were further evaluated in detail using the FEMA 178 *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* [BSSC, 1992]). Results from the subsequent FEMA 178 evaluations indicated that some buildings that failed the FEMA 154 RVS procedure (that is, had scores less than 2.5) did not fail the FEMA 178 evaluations and that some that passed the FEMA 154 RVS procedure (with scores higher than 2.5) did not pass the FEMA 178 evaluation (that is, were found to have inadequate seismic resistance). This finding emphasizes the

[3] β_0 as used in the National Bureau of Standards study is approximately equivalent to *S* as used herein.

concern identified at the beginning of this chapter that the use of FEMA 154 may not identify potentially earthquake hazardous buildings as such, and that buildings identified as potentially hazardous may prove to be adequate.

Other conclusions and recommendations pertaining to the use of the FEMA 154 RVS procedure that emanated from these applications included the following:

- Involve design professionals in RVS implementation whenever possible to ensure that the lateral-force-resisting structural systems are correctly identified (such identification is particularly difficult in buildings that have been remodeled and added to over the years);
- Conduct intensive training for screeners so that they fully understand how to implement the methodology, in all of its aspects;
- Inspect both the exterior and, if at all possible, the interior of the building;
- Review construction drawings as part of the screening process;
- Review soils information prior to implementation of the methodology in the field; and
- Interpret the results from FEMA 154 screenings in a manner consistent with the level of resources available for the screening (for example, cut-off scores may be dictated by budget constraints).

Most of these recommendations were incorporated in the updated RVS procedure described in this *Handbook*.

4.4 Other Possible Uses of the RVS Procedure

In addition to identifying potentially seismically hazardous buildings needing further evaluation, results from RVS surveys can also be used for other purposes, including: (1) designing seismic hazard mitigation programs for a community (or agency); (2) ranking a community's (or agency's) seismic rehabilitation needs; (3) developing inventories of buildings for use in regional earthquake damage and loss impact assessments; (4) developing inventories of buildings for use in 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.

Following are descriptions of how RVS results could be used for several of these purposes.

4.4.1 Using RVS Scores as a Basis for Hazardous Building Mitigation Programs

Communities need to develop hazard mitigation plans to establish a solid foundation for the detailed seismic evaluation and rehabilitation of buildings. In developing any hazardous buildings mitigation program, the cost effectiveness of the seismic evaluation and rehabilitation work must be determined. The costs should be evaluated against the direct benefits of the seismic rehabilitation program (that is, reduced physical damage, reduced injuries and loss of life). Additionally, secondary benefits to the community should be considered with the direct benefits. These secondary benefits are difficult to quantify in dollars, but must be considered. Secondary benefits are those that apply to the community as a whole. Examples include:

- reduced interruption to business;
- reduced potential for secondary damage (for example, fires) that could impact otherwise undamaged structures;
- reduced potential for traffic flow problems around areas of significant damage; and
- other reduced economic impacts.

The process of selecting buildings to be rehabilitated begins with the determination of the cut-off Structural Score, *S*, below which detailed building seismic evaluation is required (e.g., by use of the FEMA 310 procedures). Such a determination allows estimates to be made on the costs of additional seismic evaluation and rehabilitation work. From this the benefits are determined. The most cost-effective solution will be the one where the least amount is spent in direct costs to gain the greatest direct and secondary benefits.

After the RVS authority establishes the appropriate cut-off score and completes the screening process, it needs to determine the best way to notify building owners of the need for more review of buildings that score less than the cut-off (if the authority is not the owner of the buildings being screened). At the same time the community needs to develop the appropriate standards (for example, adoption of FEMA 356, *Prestandard and Commentary on the Seismic Rehabilitation of Buildings* [ASCE, 2000]) to accomplish the goal of the mitigation program. Ultimately, the mitigation program needs to address those buildings that represent the largest potential threat to life safety and the community. Timelines for compliance with the new standards and the mitigation program should be developed on a priority basis, such that the first priority actions relate to those buildings posing the most significant risk, after which those posing a lesser risk are addressed.

4.4.2 Using RVS Data in Community Building Inventory Development

RVS data can be used to establish building inventories that characterize a community's seismic risk. For example, RVS data could be used to improve the HAZUS (NIBS, 1999) characterization of the local inventory, which has a default level based on population, economic factors, and regional trends. Similarly, RVS could be incorporated directly into a community's Geographic Information System (GIS), allowing the community to generate electronic and paper maps that reflect the building stock of the community. Electronic color coding of the various types of buildings under the RVS authority, based on their ultimate vulnerability, allows the community to see at a glance where the vulnerable areas of the community are found.

4.4.3 Using RVS Data to Plan Post-earthquake Building-Safety-Evaluation Efforts

In a postearthquake environment one of the initial response priorities is to determine rapidly the safety of buildings for continued occupancy. The procedure most often used is that represented in the ATC-20 Report, *Procedures for Postearthquake Safety Evaluation of Buildings* (ATC, 1989, 1995). This procedure is similar in nature to that of the RVS procedure in that initial rapid evaluations are performed to find those buildings that are obviously unsafe (Red placard) and those that have no damage or damage that does not pose a threat to continued occupancy (Green placard). All other buildings fall into a condition where occupancy will need to be restricted in some form (Yellow placard).

The database developed following the completion of the RVS process in a given community will be valuable in setting the priorities of where safety evaluation will be performed first, after a damaging earthquake. For example, a community could use HAZUS software, in combination with RVS-based inventory information, to determine areas where significant damage may exist for various earthquake scenarios. Similarly, a community could use an existing GIS containing RVS inventory data and computer-generated maps of strong ground shaking, such as the ShakeMaps developed by the USGS (ATC, in progress), to estimate the location and distribution of damaged buildings. With such information, community officials would be able to determine those areas where building safety evaluations should be conducted.

Later, the data collected during the postearthquake building safety evaluations could be added to the RVS authority's RVS-based building inventory database. Using GIS, maps can then be prepared showing the damage distribution within the community based on actual building damage. Building locations could be electronically color-coded in accordance with the color of the safety-evaluation placard that is placed on the building: Green, Yellow, or Red.

4.4.4 Resources Needed for the Various Uses of the RVS Procedure

For most applications of the RVS procedure, the resources needed to implement the process are similar, consisting principally of an RVS manager (the RVS authority), technical specialists to train screeners, a team of screeners, materials to be taken into the field (e.g., the *Handbook* and other items listed in Section 2.8), and building construction drawings. Most applications are assisted by the development and maintenance of a computerized database for recordkeeping and the use of geographic information systems (GIS). A matrix showing recommended resources for various FEMA 154 RVS applications is provided in Table 4-1.

Table 4-1 Matrix of Recommended Personnel and Material Resources for Various FEMA 154 RVS Applications*

	Resources						
Application	*RVS Manager*	*RVS Trainer*	*Screeners*	*Screening Equipment and Supplies*	*Building Drawings*	*Computerized Record Keeping System*	*GIS*
1. Ranking seismic rehabilitation needs	X	X	X	X	X	X	X
2. Designing seismic hazard mitigation programs	X	X	X	X	X	X	X
3. Developing inventories for regional earthquake damage and loss studies	X	X	X	X	X	X	X
4. Planning postearthquake building safety evaluation efforts	X	X	X	X	X	X	X
5. Developing building specific vulnerability information	X	X	X	X	X		

*It is recommended that rapid visual screening projects be carried out under the oversight of a design professional with significant experience in seismic design.

Chapter 5

Example Application of Rapid Visual Screening

Presented in this chapter is an illustrative application of the rapid visual screening procedure in the hypothetical community of Anyplace USA. The RVS implementation process (as depicted in Figure 2-1) is described, from budget development to selection of the appropriate Data Collection Form, to the screening of individual buildings in the field. Prior to implementation of the RVS procedure, the RVS authority (the Building and Planning Department of Anyplace) has reviewed the *Handbook* and established the purpose for the RVS.

5.1 Step 1: Budget and Cost Estimation

The RVS authority has been instructed by the city council to conduct the RVS process to identify all buildings in the city, excluding detached single-family and two-family dwellings, that are potentially earthquake hazardous and that should be further evaluated by a design professional experienced in seismic design (the principal purpose of the RVS procedure). It is understood that, depending on the results of the RVS, the city council may adopt future ordinances that establish policy on when, how and by whom low-scoring buildings should be evaluated and on future seismic rehabilitation requirements. It is also desired that the results from the RVS be incorporated in the geographic information system that the city recently installed to map and describe facilities throughout the city, including all buildings and utility systems within the city limits.

The RVS authority has determined there are approximately 1,000 buildings in the city that are not detached single-family or two-family dwellings and that some of the buildings are at least 100 years old. The RVS authority plans (1) to conduct a pre-field data collection and evaluation process to examine and assess information in its existing files and to document building location, size, use, and other information on the Data Collection Forms prior to field screening; (2) to review available building plans prior to field screening; (3) to inspect the interiors of buildings whenever possible; (4) to establish an electronic RVS record-keeping system that is compatible with its GIS; and (5) to train screeners prior to sending them into the field.

Costs to conduct these activities have been estimated, assuming an average of $40 per hour (salary plus benefits) for personnel who perform data evaluation, screening, and record management. Costs are in 2001 dollars. It is assumed that three persons will carry out the pre-field data collection and evaluation process, that four two-person teams of design professionals will conduct the review of building plans and the field screening, that two persons will file all screening data, and that the entire RVS process will take approximately six months. Based on these rates and assumed times to conduct the various activities, the following RVS budget has been established:

1.	Pre-field data collection, evaluation, and processing (1,000 buildings × 0.4 hr/building × $40/hr)	$16,000
2.	Training, including trainer time (24 hours), screener time (8 hours per screener), and materials	4,000
3.	Review of available building plans (500 plan sets × 0.75 hr/plan set × $40/hr)	15,000
4.	Field screening (1,000 buildings × 0.75 hr/building × $40/hr)	30,000
5.	Record-keeping system development	5,000
6.	Electronic filing of Data Collection Forms, including verification of data input (1,000 forms × 0.75 hour/form × $40/hour)	30,000
7.	Subtotal	$100,000
8.	Management (10% of item 7)	10,000
9.	Total	$110,000

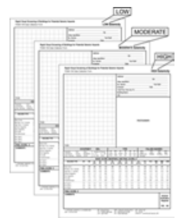
5.2 Step 2: Pre-Field Planning

During the pre-field planning process the RVS authority confirmed that the existing geographic information system was capable of being expanded to include RVS-related information and results. In addition, the RVS authority decided that sufficient soil information was available from the State Geologist to develop an overlay for their GIS containing soils information for the entire city. While not required as part of the RVS process, it was also determined that the city included an area that had isolated pockets of low liquefaction potential, and that there was no area with landslide potential. Consequently the RVS authority concluded that GIS overlays for liquefaction and landslide potential were not warranted.

The RVS authority also verified that the existing GIS had reference tables containing address information for most of the properties in the city (developed earlier from the tax assessor's files) and that these tables could be extracted and included in a new GIS-compatible electronic relational database containing the RVS results. It was also determined that other building and planning department's files contained reliable information on building name, use, size (height and area), structural system, and age for buildings built or remodeled within the last 30 years, and that Sanborn maps, which contain size, age, and other building attribute information (see Section 2.6.3) were available (at the local library) for most of the downtown sector.

Based on this information, the RVS authority confirmed its prior preliminary decision under Step 1 to develop an electronic RVS record keeping system (relational database) that could be imported into the existing GIS. The RVS authority also decided to focus on the downtown sector of Anyplace during the initial phase of the RVS field work, and to expand to the outlying areas later.

5.3 Step 3: Selection and Review of the Data Collection Form



To choose the correct Data Collection Form, the RVS authority elected to establish the seismicity for Anyplace USA by using Method 2 (see Section 2.4.1), rather than by selecting the seismicity region from the maps in Appendix A. Method 2, using the zip-code option, provides more precision than the Appendix A maps which use county boundaries. Method 2 was executed by accessing the USGS seismic hazard web site (http://geohazards.cr.usgs.gov/eq/), selecting Hazard by Zip Code, entering the zip code, 91234, and obtaining spectral acceleration (SA) values for 0.2 second and 1.0 second for ground motions having a 2% probability of being exceeded in 50 years (see Figure 5-1). The values of 2.10 *g* and 0.88 *g* for 0.2 second and 1.0 second, respectively, were multiplied by 2/3 to obtain the reduced values of 1.40 *g* and 0.59 *g*, respectively, for 0.2


```
The input zip-code is 91234.
   ZIP CODE                         91234
   LOCATION                         33.7754 Lat. -118.1860 Long.
   DISTANCE TO NEAREST GRID POINT   3.0229 kms
   NEAREST GRID POINT               33.8 Lat. -118.2 Long.
   Probabilistic ground motion values, in %g, at the Nearest Grid
   point are:
               10%PE in 50 yr    5%PE in 50 yr    2%PE in 50 yr
      PGA       51.809940         70.680931        96.476959
   0.2 sec SA  118.997299        157.833496       210.008403
   0.3 sec SA  114.200897        148.213104       194.634995
   1.0 sec SA   42.566330         60.786320        88.084427
```

Figure 5-1 Screen capture of USGS web page showing SA values for 0.2 sec and 1.0 sec for ground motions having 2% probability of being exceeded in 50 years (values shown in boxes).

second and 1.0 second. These reduced values were compared to the criteria in Table 2-1 to determine that the reduced (using the 2/3 factor) USGS assigned motions met the “high seismicity” criteria for both short-period and long-period motions (that is, 1.40 *g* is greater than 0.5 *g* for the 0.2 second [short-period] motions, and 0.59 *g* is greater than 0.2 *g* for the 1.0 second [long-period] motions). All other zip codes in Anyplace were similarly input to the USGS web site, and the results indicated high seismicity in all cases. On this basis the RVS authority selected the Data Collection Form for high seismicity (Figure 5-2).

Using the checklist of Table 2-3, the RVS authority reviewed the Data Collection Form to determine if the occupancy categories and occupancy loads were useful for their purposes and evaluated other parameters on the form, deciding that no changes were needed. The RVS authority also conferred with the chief building official, the department’s plan checkers, and local design professionals to establish key seismic code adoption dates for the various building lateral-load-resisting systems considered by the RVS and for anchorage of heavy cladding. It was determined that Anyplace adopted seismic codes for W1, W2, S1, S5, C1, C3, RM1, and RM2 building types in 1933, and that seismic codes were never adopted for URM buildings (after 1933 they were no longer permitted to be built). For S2, S3, S4 and PC2 buildings, it was assumed for purposes of the RVS procedure that seismic codes were adopted in 1941, using the default year recommended in Section 2.4.2. For PC1 buildings, it was assumed that seismic codes were first adopted in 1973 (per the guidance provided in Section 2.4.2). It was also determined that seismically rehabilitated URM buildings should be treated as buildings designed in accordance with a seismic code (that is, treated as if they were designed in 1933 or thereafter). Because Anyplace has been consistently adopting the *Uniform Building Code* since the early 1960s, benchmark years for all building types, except URM, were taken from the “UBC” column in Table 2-2. The year in which seismic anchorage requirements for heavy cladding was determined to be 1967. These findings were indicated on the Quick Reference Guide (See Figure 5-3).

5.4 Step 4: Qualifications and Training for Screeners

Anyplace USA selected RVS screeners from two sources: the staff of the Department of Building and Planning, and junior-level engineers from local engineering offices, who were hired on a temporary consulting basis. Training was carried out by one of the department’s most experienced plan checkers, who spent approximately 24 hours reading the FEMA 154 *Handbook* and preparing training materials.

As recommended in this *Handbook*, the training was conducted in a classroom setting and consisted of: (1) discussions of lateral-force-resisting systems and how they behave when subjected to seismic loads; (2) how to use the Data Collection Form and the Quick Reference Guide; (3) a review of the Basic Structural Hazard Scores and Score Modifiers; (4) what to look for in the field; (5) how to account for uncertainty; and (6) an exercise in which screeners were shown interior and exterior photographs of buildings and asked to identify the lateral-load-resisting system and vertical and plan irregularities. The training class also included focused group interaction sessions, principally in relation to the identification of structural systems and irregularities using exterior and interior photographs. Screeners were also instructed on items to take into the field.

5.5 Step 5: Acquisition and Review of Pre-Field Data

As described in the Pre-Field Planning process (Step 2 above), the RVS authority of Anyplace USA already had electronic GIS reference tables containing street addresses and parcel numbers for most of the buildings in the city. These data (addresses and parcel numbers) were extracted from the electronic GIS system (see screen capture of GIS display showing parcel number and other available information for an example site, Figure 5-4) and imported into a standard off-the-shelf electronic database as a table. To facilitate later

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 ______________________________

Scale:

PHOTOGRAPH

OCCUPANCY			**SOIL**							**TYPE**	**FALLING HAZARDS**
Assembly	Govt	Office	Number of Persons	A Hard Rock	B Avg. Rock	C Dense Soil	D Stiff Soil	E Soft Soil	F Poor Soil		☐ Unreinforced Chimneys ☐ Parapets ☐ Cladding ☐ Other: ________
Commercial	Historic	Residential	0 – 10 / 11 – 100								
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 5-2 High seismicity Data Collection Form selected for Anyplace, USA.

Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA 154)

Quick Reference Guide (for use with Data Collection Form)

1. Model Building Types and Critical Code Adoption and Enforcement Dates

Structural Types		Year Seismic Codes Initially Adopted and Enforced*	Benchmark Year when Codes Improved
W1	Light wood frame, residential or commercial, ≤ 5000 square feet	1933	1976
W2	Wood frame buildings, > 5000 square feet.	1933	1976
S1	Steel moment-resisting frame	1933	1994
S2	Steel braced frame	1941	1988
S3	Light metal frame	1941	None
S4	Steel frame with cast-in-place concrete shear walls	1941	1976
S5	Steel frame with unreinforced masonry infill	1933	None
C1	Concrete moment-resisting frame	1933	1976
C2	Concrete shear wall	1941	1976
C3	Concrete frame with unreinforced masonry infill	1933	None
PC1	Tilt-up construction	1973	1997
PC2	Precast concrete frame	1941	None
RM1	Reinforced masonry with flexible floor and roof diaphragms	1933	1997
RM2	Reinforced masonry with rigid diaphragms	1933	1976
URM	Unreinforced masonry bearing-wall buildings	1933	N/A

*Not applicable in regions of low seismicity

2. Anchorage of Heavy Cladding

Year in which seismic anchorage requirements were adopted: 1967

3. Occupancy Loads

Use	Square Feet, Per Person	Use	Square Feet, Per Person
Assembly	varies, 10 minimum	Industrial	200-500
Commercial	50-200	Office	100-200
Emergency Services	100	Residential	100-300
Government	100-200	School	50-100

4. Score Modifier Definitions

Mid-Rise:	4 to 7 stories
High-Rise:	8 or more stories
Vertical Irregularity:	Steps in elevation view; inclined walls; building on hill; soft story (e.g., house over garage); building with short columns; unbraced cripple walls.
Plan Irregularity	Buildings with re-entrant corners (L, T, U, E, + or other irregular building plan); buildings with good lateral resistance in one direction but not in the other direction; eccentric stiffness in plan, (e.g. corner building, or wedge-shaped building, with one or two solid walls and all other walls open).
Pre-Code:	Building designed and constructed prior to the year in which seismic codes were first adopted and enforced in the jurisdiction; use years specified above in Item 1; default is 1941, except for PC1, which is 1973.
Post-Benchmark:	Building designed and constructed after significant improvements in seismic code requirements (e.g., ductile detailing) were adopted and enforced; the benchmark year when codes improved may be different for each building type and jurisdiction; use years specified above in Item 1 (see Table 2-2 of FEMA 154 *Handbook* for additional information).
Soil Type C:	Soft rock or very dense soil; S-wave velocity: 1200 – 2500 ft/s; blow count > 50; or undrained shear strength > 2000 psf.
Soil Type D:	Stiff soil; S-wave velocity: 600 – 1200 ft/s; blow count: 15 – 50; or undrained shear strength: 1000 – 2000 psf.
Soil Type E:	Soft soil; S-wave velocity < 600 ft/s; or more than 100 ft of soil with plasticity index > 20, water content > 40%, and undrained shear strength < 500 psf.

Figure 5-3 Quick Reference Guide for Anyplace USA showing entries for years in which seismic codes were first adopted and enforced and benchmark years.

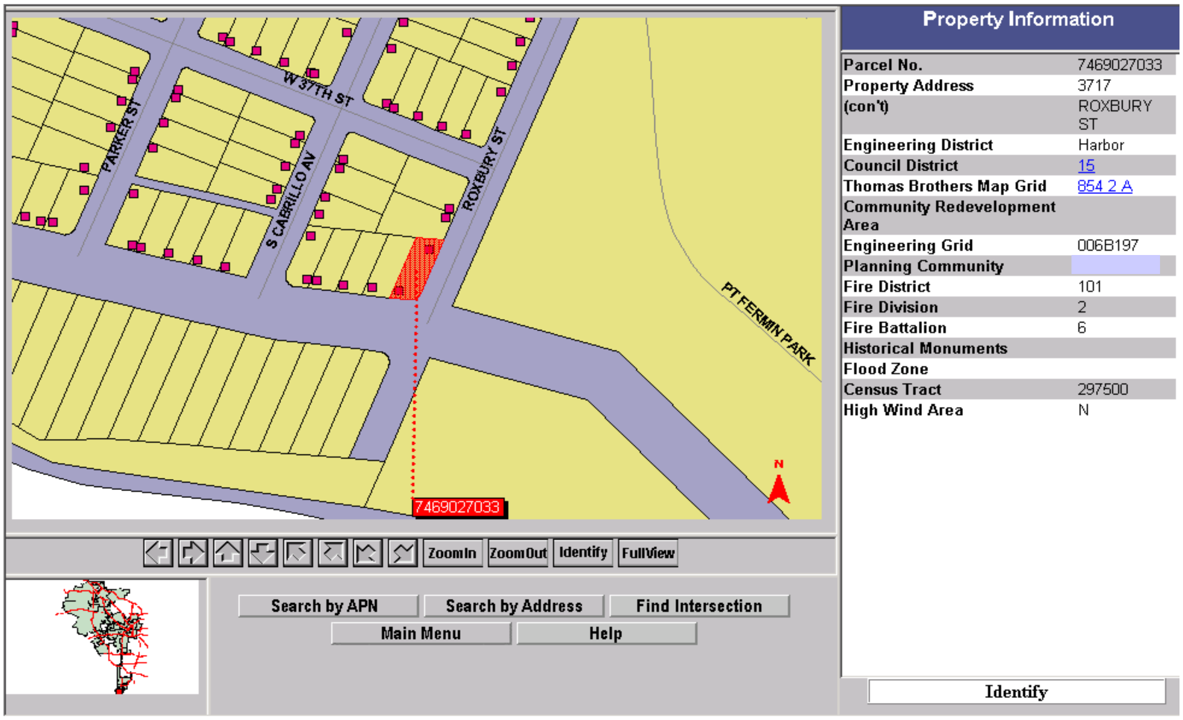


Figure 5-4 Property information at example site in city's geographic information system.

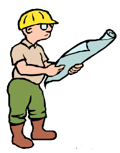
use in the GIS, the street addresses were subdivided into the following fields: the numeric part of the address; the street prefix (for example, "North"); the street name; and the street suffix (for example, "Drive"). A zip code field was added, zip codes for each street address were obtained using zip code lists available from the US Postal Service, and these data were also added to the database. This process yielded 950 street addresses, with parcel number and zip code, andestablished the initial information in Anyplace's electronic "Building RVS Database".

Permitting files, which contained data on buildings constructed or remodeled within the last 30 years (including parcel number), were then reviewed to obtain information on building name (if available), use, building height (height in feet and number of stories), total floor area, age (year built), and structural system. This process yielded information (from paper file folders) on approximately 500 buildings. Fields were added to the Building RVS Database for each of these attributes and data were added to the appropriate records (searching on parcel number) in the database; in the case of structure type, the entry included an asterisk to denote uncertainty. If an address was missing in the database, a new record containing that address and related data was added. On average, 30 minutes per building were required to extract the correct information from the permitting files and insert it into the electronic database.

The city's librarian provided copies of available Sanborn maps, which were reviewed to identify information on number of stories, year built, building size (square footage), building use, and limited information on structural type for approximately 200 buildings built prior to 1960. These data were added to the appropriate record (searching on address) in the Building RVS Database; in the case of structure type, the entry included an asterisk to denote uncertainty. If an address was missing in the database, a new record containing that address and related data was added. For this effort, 45 minutes per building, on average, were required to extract the correct information from the Sanborn maps and insert it into the electronic database.During the pre-field data collection and review process the RVS authority also obtained an electronic file of soils data (characterized in terms of the soil types described in Section 2.6.6) from the State Geologist and created an overlay of this information in the city's GIS system. Points defined by the addresses in the GIS reference tables (including newly identified addresses added to the references tables as a result of the above-cited efforts) were combined with the soils type overlay, and soil type was then assigned to each point (address) by a standard GIS operating procedure. The soils type information for each address was then transferred back to the Building RVS Database table into a new field for each building's soil type.

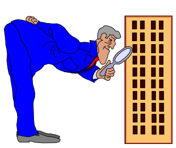
Based on the above efforts, Anyplace's Building RVS Database was expanded to include approximately 1,000 records with address, parcel number, zip code, and soils information, and approximately 700 of these records also contained information on building name (if any), use, number of stories, total floor area, year built, and structure type.

5.6 Step 6: Review of Construction Documents



Fortuitously, the city had retained microfilm copies of building construction documents submitted with each permit filing during the last 30 years, and copies of these documents were available for 500 buildings (the same subset described in Step 5 above). Teams consisting of one building department staff member and one consulting engineer reviewed these documents to verify, or identify, the lateral-force-resisting system for each building. Any new or revised information on structure type derived as part of this process was then inserted in the Building RVS Database, in which case, previously existing information in this field, along with the associated asterisk denoting uncertainty, was removed. On average, this effort required approximately 30 minutes per plan set, including database corrections.

5.7 Step 7: Field Screening of Buildings



Immediately prior to field screening (that is, at the conclusion of Step 6 above), the RVS authority acquired an electronic template of the Data Collection Form from the web site of the Applied Technology Council (www.atcouncil.org) and used this template to create individual Data Collection Forms for each record in the Building RVS Database. Each form contained unique information in the building identification portion of the form, with "Parcel Number" shown as "Other Identifiers" information (see Figure 5-2). In those instances where structure type information was included in the database, this information was also added as "Other Identifiers" information, with an asterisk if still uncertain. Soil type information was indicated on each form by circling the appropriate letter (and brief description) in the "Soil Type" section of the form (see Figure 5-2).

The Data Collection Forms, including blank forms for use with buildings not yet in the Building RVS Database, were distributed to the RVS screeners along with their RVS assignments (on a block-by-block basis). Screeners were advised that some of the database information printed on the form (e.g., number of stories, structure type denoted with an *) would need to be verified in the field, that approximately 700 of the 1,000 Data Collection Forms had substantially complete, but not necessarily verified, information in the location portion of the form, and that all 1,000 forms had street, address, parcel number, zip code, and soil type information.

Prior to field work, each screener was reminded to complete the Data Collection Form at each site before moving on to the next site, including adding his or her name as the screener and the screening date (in the building identification section of the form).

Following are several examples illustrating rapid visual screening in the field and completion of the Data Collection Form. Some examples use forms containing relatively complete building identification information, including structure type, obtained during the pre-field data acquisition and review process (Step 5); others use forms containing less complete building identification information; and still others use blank forms completely filled in at the site.

Example 1: 3703 Roxbury Street

Upon arriving at the site the screeners observed the building as a whole (Figure 5-5) and began the process of verifying the information in the building identification portion of the form (upper right corner), starting with the street address. The building's lateral-force-resisting system (S2, steel braced frame) was verified by looking at the building with binoculars (see Figure 5-6). The number of stories (10), use (office), and year built (1986) were also confirmed by inspection. The base dimensions of the building were estimated by pacing off the distance along each face, assuming 3 feet per stride, resulting in the determination that it was 75 ft x 100 ft in plan.

Figure 5-5 Exterior view of 3703 Roxbury Street.

On this basis, the listed square footage of 76,000 square feet was verified as correct (see Figure 5-7). The screeners also added their names and the date of the field screening to the building identification portion of the form.

A sketch of the plan and elevation views of the building were drawn in the "Sketch" portion of the form.

The building use was circled in the "Occupancy" portion, and from Section 3 of the Quick Reference Guide, the occupancy load was estimated at 75,000/150 = 500. Hence, the occupancy range of 101-1000 was circled.

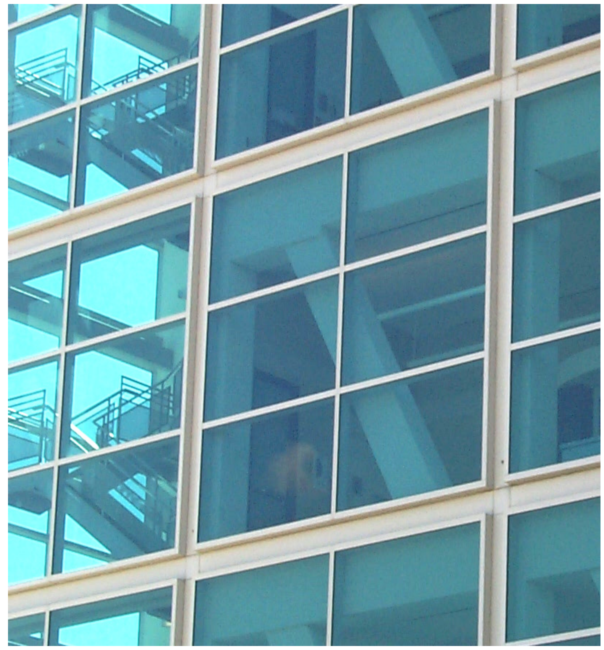
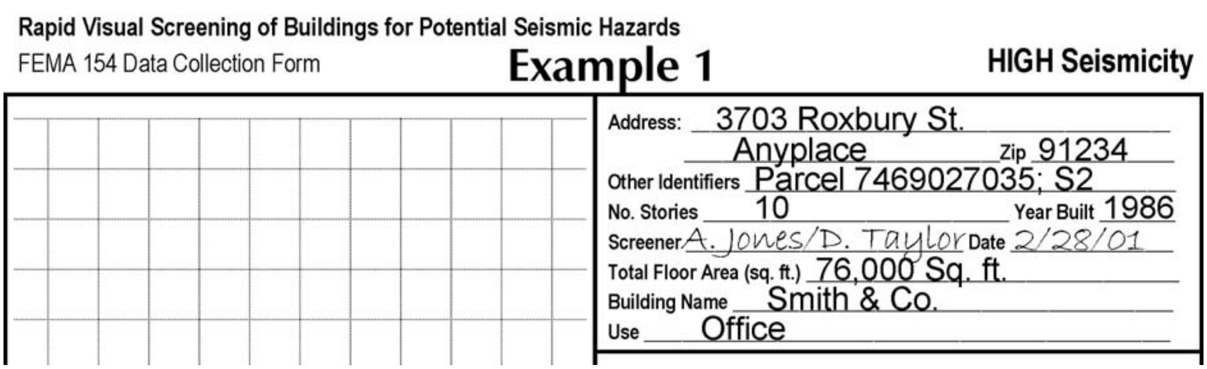


Figure 5-6 Close-up view of 3703 Roxbury Street exterior showing perimeter braced steel framing.

No falling hazards were observed, as glass cladding is not considered as heavy cladding.

The next step in the process was to circle the appropriate Basic Structural Hazard Score and the appropriate Score Modifiers. Having verified the lateral-force-resisting system as S2, this code was circled along with the Basic Structural Score beneath it (see Figure 5-8). Because the building is high rise (8 stories or more) this modifier was circled. Noting that the soil is type D, as already determined during the pre-field data acquisition phase and indicated in the Soil Type portion of the form, the modifier for Soil Type D was circled. By adding the column of circled numbers, a Final Score of 3.2 was determined. Because this score was greater than the cut-off score of 2.0, the building did not require a detailed evaluation by an experienced seismic design professional. Lastly, an instant camera photo of the building was attached to the form.



Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA 154 Data Collection Form

Example 1

HIGH Seismicity

Address: 3703 Roxbury St.

Anyplace Zip 91234

Other Identifiers Parcel 7469027035; S2

No. Stories 10 Year Built 1986

Screener A. Jones/D. Taylor Date 2/28/01

Total Floor Area (sq. ft.) 76,000 Sq. ft.

Building Name Smith & Co.

Use Office

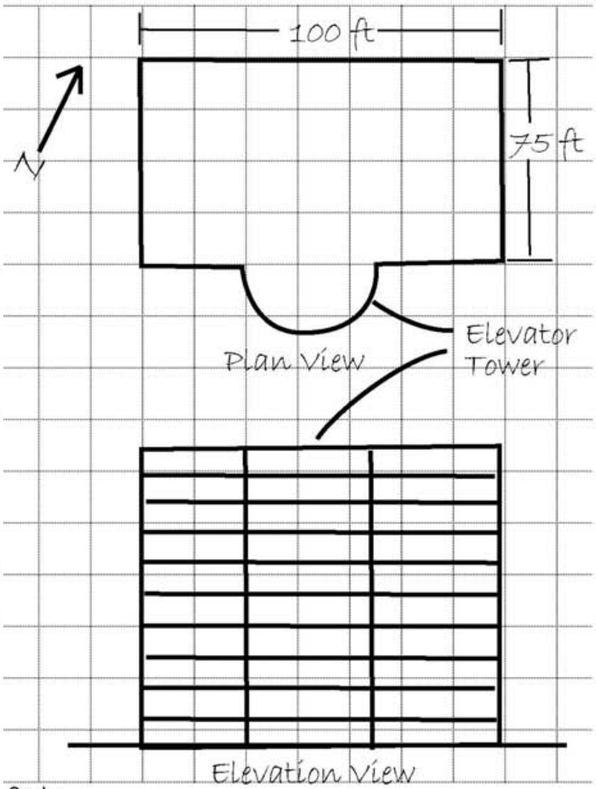
Figure 5-7 Building identification portion of Data Collection Form for Example 1, 3703 Roxbury Street.

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

Example 1

HIGH Seismicity



Scale:

Address: 3703 Roxbury St.
Anyplace **Zip** 91234
Other Identifiers Parcel 7469027035; S2
No. Stories 10 **Year Built** 1986
Screener A. Jones/D. Taylor **Date** 2/28/01
Total Floor Area (sq. ft.) 76,000 Sq. ft.
Building Name Smith & Co.
Use Office

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

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR) (circled)	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 (circled)	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 (circled)	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 (circled)	-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				3.2											

COMMENTS

Detailed Evaluation Required
YES NO (circled)

* = 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 5-8 Completed Data Collection Form for Example 1, 3703 Roxbury Street.

Example 2: 3711 Roxbury Street

Upon arrival at the site, the screeners observed the building as a whole (Figure 5-9). Unlike Example 1, there was little information in the building identification portion of the form (only street address, zip code, and parcel number were provided). The screeners determined the number of stories to be 12 and the building use to be commercial and office. They paced off the building plan dimensions to estimate the plan size to be 58 feet x 50 feet. Based on this information, the total square footage was estimated to be 34,800 square feet (12 x 50 x 58), and the number of stories, use, and square footage were written on the form. Based on a review of information in Appendix D of this *Handbook*, the year of construction was estimated to be 1944 and this date was written on the form.

A sketch of the plan and elevation views of the building were drawn in the "Sketch" portion of the form.

The building use was circled in the "Occupancy" portion, and from Section 3 of the Quick Reference Guide, the occupancy load was estimated at 34,800/135♦ = 258. Hence, the occupancy range of 101-1000 was circled.

The cornices at roof level were observed, and entered on the form.

Noting that the estimated construction date was 1944 and that it was a 12-story building , a review of the material in Table D-6 (Appendix D), indicated that the likely options for building type were S1, S2, S5, C1, C2, or C3. On more careful examination of the building exterior with the use of binoculars (see Figure 5-10), it was determined the building was type C3, and this alpha-numeric code, and accompanying Basic Structural Score, were circled on the Data Collection Form.

Because the building was high-rise (more than 7 stories), this modifier was circled, and because the four individual towers extending above the base represented a vertical irregularity, this modifier was circled. Noting that the soil is type D, as already determined during the pre-field data acquisition phase and indicated in the Soil Type portion of the form, the modifier for Soil Type D was circled.

By adding the column of circled numbers, a Final Score of 0.5 was determined. Because this score was less than the cut-off score of 2.0, the building required a detailed evaluation by an experienced seismic design professional. Lastly, an instant camera photo of the building was attached to the Data Collection Form (a completed version of the form is provided in Figure 5-11).

♦ The "135" value is the approximate average of the mid-range occupancy load for commercial buildings (125 sq. ft. per person) and the mid-range occupancy load for office buildings (150 sq. ft. per person).

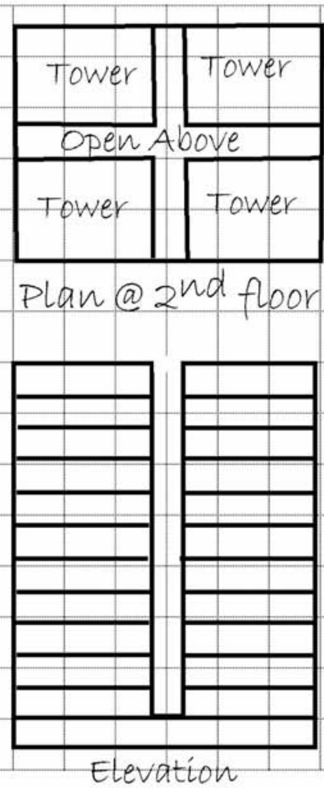
Figure 5-9 Exterior view of 3711 Roxbury.

Figure 5-10 Close-up view of 3711 Roxbury Street building exterior showing infill frame construction.

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

Example 2

HIGH Seismicity



Scale:

Address: 3711 Roxbury St.
Anyplace **Zip** 91234
Other Identifiers Parcel 7469027034
No. Stories 12 **Year Built** 1944
Screener A. Jones/D. Taylor **Date** 2/28/01
Total Floor Area (sq. ft.) 34,800
Building Name
Use Commercial and Offices above

OCCUPANCY			SOIL						TYPE	FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons	A Hard Rock	B Avg. Rock	C Dense Soil	D Stiff Soil	E Soft Soil	F Poor Soil	Unreinforced Chimneys	Parapets	Cladding	☒ Other: Cornices
Commercial	Historic	Residential	0 – 10 / 11 – 100										
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										0.5					

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 5-11 Completed Data Collection Form for Example 2, 3711 Roxbury Street.

Example 3: 5020 Ebony Drive

Example 3 was a high-rise residential building (Figure 5-12) in a new part of the city in which new development had begun within the last few years. The building was not included in the electronic Building RVS Database, and consequently there was not a partially prepared Data Collection Form for this building. Based on visual inspection, the screeners determined that the building had 22 stories, including a tall-story penthouse, estimated that it was designed in 1996, and concluded that its use was both commercial (in the first story) and residential in the upper stories. The screeners paced off the building plan dimensions to estimate the plan size to be approximately 270 feet x 180 feet. Based on this information and considering the symmetric but non-rectangular floor plan, the total square footage was estimated to be 712,800 square feet. These data were written on the form, along with the names of the screeners and the date of the screening. The screeners also drew a sketch of a portion of the plan view of the building in the space on the form allocated for a “Sketch”.

The building use (commercial and residential) was circled in the “Occupancy” portion, and from Section 3 of the Quick Reference Guide, the occupancy load was estimated at 712,800/200 = 3,564. Based on this information, the occupancy range of 1000+ was circled.

While the screeners reasonably could have assumed a type D soil, which was the condition at the adjacent site approximately ½ mile away, they concluded they had no basis for assigning a soil type. Hence they followed the instructions in the *Handbook* (Section 3.4), which specifies that if there is no basis for assigning a soil type, soil type E should be assumed. Accordingly, this soil type was circled on the form.

Given the design date of 1996, the anchorage for the heavy cladding on the exterior of the building was assumed to have been designed to meet the anchorage requirements initially adopted in 1967 (per the information on the Quick Reference Guide). No other falling hazards were observed.

The window spacing in the upper stories and the column spacing at the first floor level indicated the building was either a steel moment-frame building, or a concrete moment-frame building. The screeners attempted to view the interior but were not provided with permission to do so. They elected to indicate that the building was either an S1 or C1 type on the Data Collection Form and circled both types, along with their Basic Structural Scores. In addition, the screeners circled the modifiers for high rise (8 stories or more) and post-benchmark year, given that the estimated design date (1996) occurred after the benchmark years for both S1 and C1 building types (per the information on the Quick Reference Guide). They also circled the modifier for soil type E (in both the S1 and C1 columns).

By adding the circled numbers in both the S1 and C1 columns, Final Scores of 3.6 and 3.3 respectively were determined for the two building types. Because both scores were greater than the cut-off score of 2.0, a detailed evaluation of the building by an experienced seismic design professional was not required. Before leaving the site, the screeners photographed the building and attached the photo to the Data Collection Form. A completed version of the Data Collection Form is provided in Figure 5-13.

Figure 5-12 Exterior view of 5020 Ebony Drive.

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

Example 3

HIGH Seismicity

Address: 5020 Ebony Drive
Anyplace **Zip** 91011

Other Identifiers

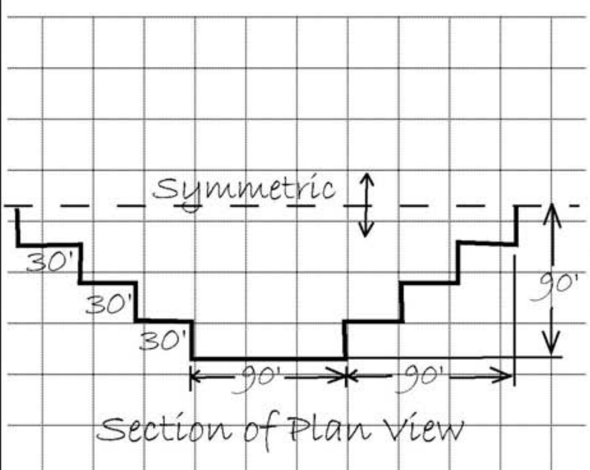
No. Stories 22 **Year Built** 1996

Screener A. Jones/D. Taylor **Date** 2/28/01

Total Floor Area (sq. ft.) 712,800

Building Name

Use Residential and Commercial



Scale:

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

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			3.6					3.3							

COMMENTS Screeners could not determine if building type was C1 or S1; hence both types were scored, with similar results.

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 5-13 Completed Data Collection Form for Example 3, 5020 Ebony Drive.

Figure 5-14 Exterior view of 1450 Addison Avenue.

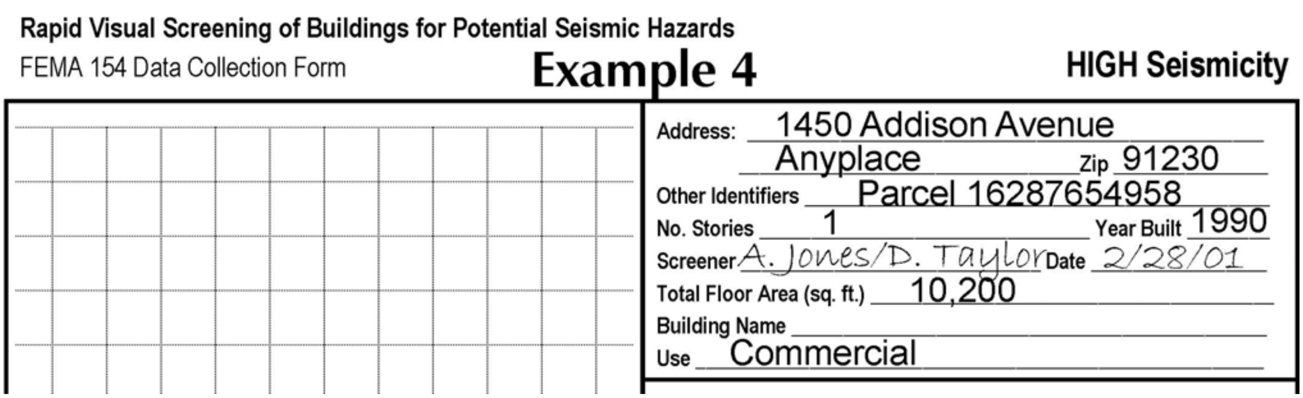
Example 4: 1450 Addison Avenue

The building at 1450 Addison Avenue (see Figure 5-14) was a 1-story commercial building designed in 1990, per the information provided in the building identification portion of the Data Collection Form. By inspection the screeners confirmed the address, number of stories, use (commercial), and year built (Figure 5-15). The screeners paced off the building plan dimensions to estimate the plan size (estimated to be 10,125 square feet), confirming the square footage shown on the identification portion of the form. The L-shaped building was drawn on the form, along with the dimensions of the various legs.

The building's commercial use was circled in the "Occupancy" portion, and from Section 3 of the Quick Reference Guide, the occupancy load was estimated at 10,200/125 = 80. Hence, the occupancy range of 11-100 was circled. No falling hazards were observed.

The building type (W2) was circled on the form along with its Basic Structural Score. Because the building was L-shaped in plan the modifier for plan irregularity was circled. Because soil type C had been circled in the Soil Type box (based on the information in the Building RVS Database) the modifier for soil type C was circled.

By adding the column of circled numbers, a Final Score of 5.3 was determined. Because this score was greater than the cut-off score of 2.0, the building did not require a detailed evaluation by an experienced seismic design professional. Lastly, an instant camera photo of the building was attached to the Data Collection Form. A completed version of the form is provided in Figure 5-16.



Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA 154 Data Collection Form **Example 4** **HIGH Seismicity**

Address: 1450 Addison Avenue
Anyplace Zip 91230
Other Identifiers Parcel 16287654958
No. Stories 1 Year Built 1990
Screener A. Jones/D. Taylor Date 2/28/01
Total Floor Area (sq. ft.) 10,200
Building Name
Use Commercial

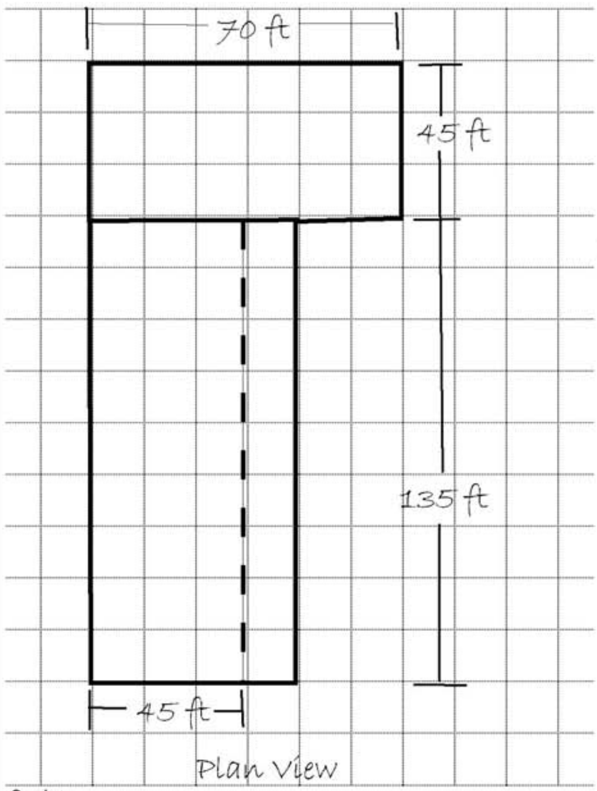
Figure 5-15 Building identification portion of Data Collection Form for Example 4, 1450 Addison Avenue.

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

Example 4

HIGH Seismicity



Scale:

Address: 1450 Addison Avenue
Anyplace **Zip** 91230
Other Identifiers Parcel 16287654958
No. Stories 1 **Year Built** 1990
Screener A. Jones/D. Taylor **Date** 2/28/01
Total Floor Area (sq. ft.) 10,200
Building Name
Use Commercial

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

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	W1	W2 (circled)	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 (circled)	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 (circled)	-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 (circled)	+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 (circled)	-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		5.3													

COMMENTS

Detailed Evaluation Required

YES / NO (circled)

* = 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 5-16 Completed Data Collection Form for Example 4, 1450 Addison Avenue.

5.8 Step 8: Transferring the RVS Field Data to the Electronic Building RVS Database

The last step in the implementation of rapid visual screening for Anyplace USA was transferring the information on the RVS Data Collection Forms into the relational electronic Building RVS Database. This required that all photos and sketches on the forms be scanned and numbered (for reference purposes), and that additional fields (and tables) be added to the database for those attributes not originally included in the database.

For quality control purposes, data were entered separately into two different versions of the electronic database, except photographs and sketches, which were scanned only once. A double-entry data verification process was then used, whereby the data from one database were compared to the same entries in the second database to identify those entries that were not exactly the same. Non-identical entries were examined and corrected as necessary. The entire process, including scanning of sketches and photographs, required approximately 45 minutes per Data Collection Form.

After the electronic Building RVS Database was verified, it was imported into the city's GIS, thereby providing Anyplace with a state-of-the-art capability to identify and plot building groups based on any set of criteria desired by the city's policy makers. Photographs and sketches of individual buildings could also be shown in the GIS simply by clicking on the dot or symbol used to represent each building and selecting the desired image.