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Evaluation and Strengthening Guidelines for Federal Buildings - Assessment of Current Federal Agency Evaluation Programs and Rehabilitation Criteria *and* Development of Typical Costs for Seismic Rehabiliation

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ABSTRACT

The National Institute of Standards and Technology (NIST), in accordance with Public Law 101-614, is developing seismic evaluation and strengthening guidelines (Guidelines for Federal Buildings) for federally-owned and leased buildings. The project is overseen by the Interagency Committee on Seismic Safety in Construction (ICSSC) and funded by the Federal Emergency Management Agency (FEMA).

This report develops Task 2, (see Appendix A for complete scope of work) assessment of current federal agency evaluation programs and rehabilitation criteria and Task 3, development of typical costs for seismic rehabilitation. Part I of the Task 2 report includes a qualitative and quantitative comparison of six federal agency programs to the most recent versions of the NEHRP Evaluation Handbook and the NEHRP Techniques Handbook. Part II of the Task 2 report is an identification and assessment of rehabilitation criteria and program issues for the six federal programs, four private sector programs, RP-3, "Guidelines for Identification and Mitigation of Seismically Hazardous Existing Federal Buildings" and the State of California program. Task 3 outlines a program to develop typical costs for seismic rehabilitation. It includes possible approaches for different levels of effort of such programs, including an outline of recommended scopes of work.

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EXECUTIVE SUMMARY

In accordance with Public Law 101-614, the National Institute of Standards and Technology (NIST) is developing seismic evaluation and strengthening guidelines (Guidelines for Federal Buildings) for federally owned and leased buildings for the Interagency Committee on Seismic Safety in Construction (ICSSC). The project is being funded by the Federal Emergency Management Agency (FEMA). The intent of this project is to provide federal agencies guidelines for the evaluation and mitigation of seismic hazards in their building inventories, and also to provide a baseline for the level of seismic strengthening of federal buildings. These Guidelines for Federal Buildings are expected to be issued with a presidential order in December 1994.

The development of the Guidelines for Federal Buildings has been organized around five tasks. These include identification and assessment of existing programs, development of performance objectives, a typical costs program and preparation of the guidelines. This report outlines Task 2, the assessment of current federal agency programs and rehabilitation criteria, and Task 3, outline of program to develop typical costs for seismic rehabilitation.

TASK 2

The first part of this assessment (Part I) involves the comparison of the six federal agency programs selected for study (General Services Administration, Department of State - Foreign Building Office, Department of Veterans Affairs, U.S. Postal Service, Department of Defense - U.S. Navy, and Department of Energy) to the relevant portions of the most recent versions of the NEHRP Evaluation Handbook and the NEHRP Techniques Handbook. For the NEHRP Evaluation Handbook comparison, seven different parameters are compared: strength requirements, configuration guidelines, seismic zones, special details, drift requirements, system requirements and non-structural requirements. The summary of assessment results is included in Table 1. For the NEHRP Techniques Handbook comparison, a qualitative comparison of suggested details and methods is included. The summary of these assessment results is also included in Table 1. Neither the NEHRP Techniques Handbook nor any of the federal agency programs specifically dictate specific strengthening procedures but rather give suggested details and methods.

In general, all programs appear to substantially meet or exceed the provisions of the NEHRP Evaluation and Techniques Handbook with the exception of configuration guidelines for the current Tri-Service Manual.

The second part of this assessment (Part II) programs involves identification and comparison of rehabilitation criteria and program issues with the six federal agencies, four private sector organizations, RP-3, and the State of California program. The summary of federal agency rehabilitation criteria is included in Table 2. Based on the five criteria evaluated, no definite conclusions can be reached. Many programs are still under development and in need of further definition.

TASK 3

Task 3 outlines a program to develop typical costs for seismic rehabilitation. The goal of the proposed program is to provide agencies of the federal government and private building owners with reasonable cost ranges for seismic hazard mitigation that will cover a variety of conditions such as different building types, seismic zones, performance requirements, and occupancy conditions. First, the elements of an optimum cost development program are established. Then, a number of possible approaches are outlined that include a minimum scope, intermediate scope and optimum scope for such a cost study. Each approach includes an approximate scope of work and project cost.

TASK 2

I INTRODUCTION

In accordance with Public Law 101-614,

> *The President shall adopt, not later than December 1, 1994, standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government which were designed and constructed without adequate seismic design and construction standards. Such standards shall be developed by the Interagency Committee on Seismic Safety in Construction, whose chairman is the Director of the National Institute of Standards and Technology or his designee, and which shall work in consultation with appropriate private sector organizations.*

This report is intended to provide a firm foundation for the development of these standards.

The Interagency Committee on Seismic Safety in Construction (ICSSC) is composed of members representing 27 governmental agencies involved with federal building construction projects or responsible for government loans for building construction. A subset of the ICSSC, Subcommittee 1 - Standards for New and Existing Buildings, is composed of 19 member agencies who represent the major building owners of the federal government. The National Institute of Standards and Technology (NIST) is currently developing the required seismic evaluation and strengthening guidelines for federally owned and leased buildings for the ICSSC with funding from the Federal Emergency Management Agency (FEMA). NIST has subcontracted much of this work to H.J. Degenkolb Associates and Rutherford & Chekene, Consulting Engineers. The intent of these standards, hereafter called the "Guidelines for Federal Buildings," is to provide federal agencies with minimum guidelines for the evaluation and mitigation of seismic hazards in their building inventories, and also to provide a baseline for the level of seismic strengthening of federal buildings.

The standards to be developed for this project will build upon previous efforts by ICSSC in support of the National Earthquake Hazards Reduction Program. As part of that program, in March 1989, ICSSC prepared a report titled "Guidelines for Identification and Mitigation of Seismically Hazardous Existing Federal Buildings," NISTIR 89-4062, ICSSC RP-3. This report, frequently termed RP-3, consists of "Guidelines ..... intended for consideration and use as appropriate, by Federal agencies in their plans for mitigation of seismic hazards in existing buildings." RP-3 presents a systematic methodology for identifying hazardous conditions, strategies for mitigation and targets for implementation. As such, RP-3 will serve as a basic reference for the development of the 1994 Guidelines for federal buildings.

The present project is being developed to provide standards for the evaluation and strengthening of existing federally-owned and leased buildings, implementation guidelines, and an assessment of existing federal agency programs. The development of these standards has been divided into a number of major tasks:

1. Gathering information about existing federal seismic mitigation programs.

2. Assessing current federal agency evaluation programs and rehabilitation criteria.

3. Preparation of a typical costs program.

4. Establishment of a five-member project peer-review panel.

5. Completion of the evaluation and strengthening guidelines for federal buildings.

The complete Scope of Work is included in Appendix A.

The results of the first task, the information gathering phase, are described in the Task 1 Final Report, completed in January of 1992. It includes a detailed workplan and schedule for the entire project, the results of meetings and conversations with federal agencies, performance objectives for each federal agency and private sector corporation studied, and a review of ATC-28 for its applicability to these guidelines. This second report outlines the assessment of federal agency programs, and relies heavily upon the Task 1 report for background information. Definitions developed in the Task 1 report and used throughout the project are included in this report as a Glossary.

One of the key issues in developing guidelines for strengthening federal buildings is recognition of the needed level of performance for various buildings subjected to major earthquakes. These needs are often referred to as performance objectives.

In the Task 1 report, a number of performance objectives for federal buildings were defined. These include immediate occupancy, repairable damage, life-safety, and risk-reduction. Cost limitations often make it impractical to strengthen buildings to withstand a major earthquake without damage. Performance objectives then, are a tool to make the most of available resources. In practice, essential buildings are often designed or retrofit to higher standards than less important buildings. The minimum objective for all buildings should be life-safety, that is to prevent loss of life.

For the purposes of this project, the four levels of expected performance are defined as follows:

immediate occupancy: Immediate occupancy implies minimal post-earthquake damage and disruption. As much as possible, the building is to remain fully functional immediately after a major event with only some nonstructural repairs needed. Repairs can be completed within a few days.

repairable damage: Repairable damage implies that some structural and non-structural damage might occur but no damage that will significantly jeopardize life is expected. Repairs can be completed in a few days up to a few months, and may require all or part of the building to be closed during reconstruction.

life-safety: Life-safety implies that significant damage that might not be repairable is likely to occur but that no damage that will significantly endanger life or block egress is expected.

risk-reduction: Risk-reduction implies significant irreparable damage and possibly some falling hazards. Building may be a complete loss but the hazard to life is still low. Repairs may never be completed.

These descriptions are consistent with the State of California, Seismic Safety Commission Report SSC 91-1, Policy of Acceptable Levels (see Task 1 Final Report for State of California Performance Matrix).

The current task contains two parts. The first involves the comparison of the six federal agency programs selected for study (General Services Administration, Department of State - Foreign Building Office, Department of Veterans Affairs, U.S. Postal Service, Department of Defense - U.S. Navy, and Department of Energy) to the relevant portions of the most recent versions of the The NEHRP Handbook for Seismic Evaluation of Existing Buildings, hereafter referred to as the NEHRP Evaluation Handbook, and The NEHRP Handbook for Techniques for Seismically Rehabilitating Existing Buildings, hereafter referred to as the NEHRP Techniques Handbook. The second part involves identification and assessment of policy issues with the six federal agencies, four private sector organizations, RP-3, and the State of California program. This report includes:

Part I:

* A qualitative and quantitative assessment of federal agency evaluation programs in comparison to the NEHRP Evaluation Handbook.

* A qualitative assessment of federal agency strengthening techniques in comparison to the NEHRP Techniques Handbook.

* A matrix of assessment procedure results (Table 1).

Part II:

* A discussion and assessment of federal agency rehabilitation criteria and program issues.
* A matrix of rehabilitation criteria results (Table 2).

II TASK 2 - PART I: ASSESSMENT OF FEDERAL EVALUATION PROGRAMS

The project scope of work requires that six federal evaluation and strengthening programs identified in Task 1 be assessed by comparing them to the most recent versions of the NEHRP Evaluation Handbook and the NEHRP Techniques Handbook. In conjunction with NIST, the six federal programs selected for evaluation include: General Services Administration, Department of State - Foreign Building Office, Department of Veterans Affairs, Department of Defense - U.S. Navy, U.S. Postal Service, and Department of Energy.

Each federal agency has its own occupancy categories, corresponding performance objectives, and related evaluation and strengthening criteria. In Task 1, performance objectives were assigned to each agency program based on the State of California model for comparison with the related evaluation and strengthening criteria noted. In this report, the minimum standard for each occupancy category is compared to the NEHRP Handbooks. Intuitively, documents based on more strict performance objectives should always have more stringent requirements than any document based on life-safety.

The documents to be compared to the NEHRP Evaluation Handbook include:

Postal Service/All Facilities: ATC-26-1 - U.S. Postal Service Procedures for Seismic Evaluation of Existing Buildings

GSA/All Facilities: Chapter 12 of Earthquake Resistance of Buildings which is based on the current Uniform Building Code (UBC)

Army, Navy, Air Force/Essential and Normal Facilities: TM 5-809-10-2, NAVFAC P355.2, AFM 88-3, Chap 13, Sec B - Seismic Design Guidelines for Upgrading Existing Buildings (hereafter referred to as P355.2 - see glossary for "acronyms" and full names of the Tri-Service Manuals)

VA/Hospitals: H-08-8 - Seismic Design Guidelines

VA/Medical Office Buildings (MOBs): current Uniform Building Code

FBO/All Facilities: current Uniform Building Code

DOE/Moderate and High Hazard Facilities: UCRL-15910 - Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards

A. NEHRP Evaluation Handbook

For the past decade, engineers have formally developed guidelines to evaluate the seismic life-safety of existing buildings. Although the NEHRP Evaluation Handbook is the latest of these documents, it built upon the significant contributions of two earlier documents, ATC-14 and ATC-22.

ATC-14, Evaluating the Seismic Resistance of Existing Buildings, was the first evaluation procedure based directly on the performance of buildings in past earthquakes. The procedure adapts the seismic provisions of the 1985 Uniform Building Code, using "working stress" evaluation criteria. ATC-14 is founded on the assumption that one or more of the following events pose danger to human lives or comprises a "life-safety hazard": (1) the entire building collapses, (2) portions of the building collapse, (3) components of the building fail and fall, and (4) exit and entry routes are blocked, preventing excavation and rescue of the occupants.

The fundamental approach in ATC-14 is to ascertain whether there is a complete lateral force resisting system with a coherent load path and whether appendages and veneers are properly attached. The seismic performance of the structural system and components, and exterior and interior non-structural systems is expressed in terms of "capacity/demand ratio" which is the ratio of seismic capacity to seismic demand for critical structural members and their connections.

ATC-22, A Handbook for Seismic Evaluation of Existing Buildings (Preliminary), is a "second generation" document. It built upon ATC-14 by refining the various procedures, expanding the commentary information, and incorporating the "strength design" concepts of the NEHRP Provisions for new buildings. The document format was modified from ATC-14 into a Handbook for easier use by evaluating engineers.

The NEHRP Evaluation Handbook was developed by FEMA as a consensus version of ATC-22. As in ATC-14 and ATC-22, it defines fifteen model building types, and lists for each type a set of questions that are designed to uncover weaknesses in the particular building being evaluated. These "Evaluation Statements" are written so that a "true" response implies that the building is adequate regarding this issue and, therefore, does not pose a significant life-safety hazard. A "false" statement indicates an area of concern, that might be a life-safety hazard, and that needs detailed study. Following each statement are appropriate detailed analysis recommendations with corresponding acceptance criteria to be used. By following this process, the weak links in the structural system are identified and assessed and the life-safety of the building is determined. The Handbook covers both structural and nonstructural elements and includes checklists, diagrams, and sketches to aid in the evaluation.

It is important to look at the progression of these documents to provide linkage to the past and to properly bring past results into the future. Hundreds of Federal buildings have been evaluated with ATC-14 and ATC-22 and, for this reason, ATC-14 is included in the strength requirements assessment section of this report. (ATC-22 is referenced by the U. S. Postal Service's ATC-26 documents.)

For this NEHRP Evaluation Handbook comparison, seven key evaluation parameters are considered. These include the designated strength requirements, configuration guidelines, seismic zones, special details, drift requirements, system requirements, and non-structural requirements. Each of these comparisons are explained in more detail in the following sections. A summary is shown in Table 1 and detailed results are included as Appendices.

Two items addressed in the NEHRP Evaluation Handbook are not included in this comparison: condition of existing materials, and geologic site hazards. The condition of existing materials is important to check when evaluating the seismic resistance of an existing building but it is a difficult parameter to quantify. In a qualitative manner, most engineers investigate the condition of existing materials as part of general practice when performing a seismic evaluation. In addition, many agencies use codes for new construction to evaluate existing buildings which have no provisions for the evaluation of existing materials. Although the NEHRP Evaluation Handbook has some information on evaluating existing materials, lack of information in the other procedures precluded a detailed comparison. Geologic site hazards such as liquefaction, slope failure or surface fault rupture, may be a valid concern for evaluating the potential seismic performance of an existing building. However, geologic site hazards are site-specific concerns which are difficult to compare in the general manner of this report since there are no specific code standards related to their consideration. The condition of existing materials and geologic site hazards will both be specifically addressed in the development of the final Guidelines.

1. Strength Requirements Assessment

The most common way to establish the required strength of a building is with the equivalent lateral force base shear. Factors affecting base shear include: seismicity, soil conditions, period of the building, and inelastic reduction factors. The building's weight remains a constant in the base shear calculation.

It is difficult, however, to simply compare the numerical values of base shear for different evaluation criteria because some use working stress procedures while others employ ultimate strength procedures. In addition, not all criteria use equivalent static lateral forces to represent the input of earthquake ground motion. One approach used in the Tri-Service manuals, which has been used by DOE and others, uses site specific response spectra, and, in some cases, considers past yield capacities.

The Strength Requirements Assessment focuses not only on the overall base shear, but also on the required strength of an individual component. When performing a seismic evaluation of an existing building, the end goal is to check the capacity vs. demand for the critical components that make up the building's lateral force resisting system. For a braced frame building, the critical component could be the strength of a particular brace, or connection or for a concrete moment frame building, the critical component could be column ties at a potential plastic hinge location. Thus, the "base shear" manifests itself in the critical moment, shear, or axial force for a particular component. The end result of the Strength Requirements Assessment shows how the individual component capacity/demand ratios are effected by the various procedures. In Appendix B, a number of worksheets are presented that compare the agency programs using a representative set of structural components. This set was selected from the NEHRP Handbook's individual statements and represent a range of structural systems, material types and design situations. The worksheets address a number of combinations: seismic zones (high or moderate), building height (one-story or ten-story), and soil type (firm or soft). A review of the worksheets shows a substantial variation in the strength requirements of the various programs (see Table 3 and Appendix B). By reviewing the range of values for each procedure, a qualitative determination can be made as to the overall strength requirements of the program when compared to the NEHRP Evaluation Handbook.

It is important to point out that the Strength Comparison Worksheets presented in Appendix B are <u>not</u> all inclusive. More specifically, the worksheets do not address specific detailing procedures and requirements of current building codes being used as evaluation documents. The comparisons point out the differences in basic member capacity and related demand between the various procedures and are extremely useful in this regard. However, it is not clear how each agency interprets current codes when evaluating existing structures especially with regard to archaic materials and non-ductile construction details. The example presented in Part 3 of Appendix B contains additional discussion and data to emphasize this point.

In general, given a particular structural element, the "NEHRP Comparison" ratio varies widely between structural systems (see Table 3). This variability is strongly attributable to the structural system response modification factor (Rw, R, alpha, K, F_u), with few of the evaluation criteria using the same values. The large range of values is related to differences in working-stress and ultimate strength procedures, the subjective nature of these factors and different generations of thoughts. In general, the ideas represented by these reduction factors include over-strength, damping, multi-mode effects, system ductility, and soil-structure interaction.

It appears that most program's strength requirements meet or exceed those in the NEHRP Evaluation Handbook (see Table 1). A review of the worksheets in Appendix B indicates that the strength requirements of each programs vary substantially when considering structural system and building period, but yield similar values when considering soil condition and seismic zone.

It is clear from the results of the worksheets (see Table 3), that the UBC meets or exceeds the NEHRP Evaluation Handbook in regard to required strength. The NEHRP Handbook is based on 67% of the NEHRP Provisions for long-period buildings and 85% of the NEHRP Provisions for short-period buildings. The procedures with a higher performance objective than life-safety, such as the VA's H-08-8 and DOE's UCRL-15910, appear to substantially exceed the NEHRP Handbook, as expected.

The Postal Service's procedure, which uses ATC-22, also gave generally more conservative results than the NEHRP Handbooks for non-ductile elements. However, in the revision from ATC-22 to the current NEHRP Evaluation Handbook, the reference to ductile, semi-ductile and brittle elements were reduced to just two categories: ductile and non-ductile (see Appendix B). In addition, the multiplier for the demand/capacity ratio was also reduced from $0.75C_d$ to $0.5C_d$. The NEHRP Handbook also gives a minimum 1.5 multiplier for non-ductile elements which is not included in ATC-22. Thus, for a structural system with a low C_d, such as a steel frame with unreinforced masonry infill walls, ATC-22 is less conservative than the NEHRP Handbook.

For purposes of comparison, the four DOE categories were simplified into two categories: low hazard/general use, and moderate/high hazard. The minimum values for general use and moderate hazard were used in the worksheets and, in general, exceed the NEHRP requirements.

The static lateral force procedure, used by the Tri-Services, is based on the 1976 SEAOC "Blue Book" which was adopted in the 1979 UBC. Lateral forces outlined in this document are, in general, equivalent to the current UBC provisions except for braced frame buildings. A new and updated version of the Tri-Service Manual based on the 1988 SEAOC "Blue Book" is currently in draft form. As it is based on the current UBC, it generally meets or exceeds the NEHRP Handbook.

Both the current Tri-Service Manual procedure and the 1992 draft Manual procedure are included in this study. In the worksheets in Appendix B, the 1982 Tri-Service Manual procedure is termed "P355 OLD" and the 1992 draft Manual procedure is included with VA, FBO, GSA, and DOE as referencing the current UBC. For high seismic zones, the 1982 Manual is slightly more conservative than the 1992 draft Manual except for braced frames. For some moderate seismic zones, the 1982 Manual is less conservative than 1992 draft Manual and considerably less conservative than both the 1992 draft Manual and the NEHRP Handbook for braced frames.

2. Configuration Guidelines Assessment

For most evaluation procedures and building codes, configuration requirements usually take the form of guidelines to prevent soft or weak stories or plan irregularities. In new building codes, strict analysis requirements and other penalties serve to discourage engineers from designing irregular structures. When present in existing buildings, these configuration irregularities can adversely affect the seismic performance of an otherwise sound building.

Although a configuration limitation can be quantified, for example a "soft story" can be defined as a story with a lateral stiffness less than 70% of the story above, it is beyond the scope of this report to determine how "soft" a soft story should be to constitute a life-safety hazard. Also, different agency programs have different requirements for buildings having a soft story. As such, only a qualitative comparison can be made between different methodologies.

To assess configuration guidelines, the configuration irregularities detailed in the NEHRP Evaluation Handbook are used as a baseline. The configuration irregularities included in each criteria are then compared to those in the NEHRP Evaluation Handbook (see Appendix C). Configuration irregularities contained in NEHRP that are <u>not</u> included in a particular program indicates non-conformance to the NEHRP Handbook.

The majority of programs have adopted the current UBC set or the NEHRP set of configuration guidelines. These two are similar, though the UBC guidelines have more provisions addressing horizontal irregularity.

The only procedure which did not meet or exceed the NEHRP Handbook was the procedure for normal facilities based on the 1982 Tri-Service Manual (see Appendix C). The 1992 draft of the Tri-Service Manual addresses configuration requirements and as such, exceeds the NEHRP Handbook (see Table 1).

3. Seismic Zone Assessment

Seismic zones are usually based on either effective peak ground acceleration (EPA) or effective peak velocity-related ground acceleration (EPV). Maps are usually constructed by determining EPA and EPV for a number of different sites and developing smooth contours representing "zones" of expected earthquake ground motion.

One problem with comparing seismic zones is that some methodologies compute base shear using EPA values and others use both EPA and EPV values. Methods using EPV tend to increase the strength requirements for longer period structures located at greater distances from major faults. For most of the country, these two curves are similar. However, in some regions, the two curves can be significantly different. In addition, some agencies have developed site-specific values for many locations in the United States that are based on soil and geologic data at a particular site. Inconsistencies can occur between broad based zonation maps and these site specific results.

In order to affect a proper comparison, the seismic zone and related EPA and EPV values are determined for each of the largest one-hundred cities in the United States using each agency program (see Appendix D). Each city with an EPA value less than EPA or EPV for NEHRP is flagged in the worksheets.

A program meets or exceeds NEHRP if all EPA values meet or exceed the NEHRP values for the 100 cities considered. A program substantially meets NEHRP where EPA values for most cities were comparable to NEHRP values (typically within 0.05). Table 1 has been divided to distinguish the results between regions of high and low seismicity.

For all the programs, only three different maps are needed to compare the seismic zones for the United States. These include: the 1988-91 UBC map, the NEHRP maps, and the 1982 Tri-Service Manual maps (1979 UBC). For the Tri-Service Manual map, the Z coefficients are converted into peak ground acceleration values by multiplying them by 0.4. The results of the comparison are shown in Appendix D.

The EPA map for NEHRP is based on the work of Algermissen and Perkins in 1972 and 1976. Their work studied the historical seismicity of rock sites. The EPV map for NEHRP is not based on current maps but on a conversion from the EPA map to EPV contours. This conversion is based mostly on studies by McGuire, Bollinger and others. The commentary for the NEHRP Provisions for new buildings includes an excellent discussion of the creation of both NEHRP maps. The UBC map is based on both the NEHRP maps (formally ATC-3 maps) where zone boundaries incorporate both acceleration and velocity contours. If the two do not agree, the one indicating the higher zone appears to have been used. A discussion of the creation of the UBC map is included in the commentary to the SEAOC "Blue Book", the "Recommended Lateral Force Requirements" written by the Seismology Committee of the Structural Engineers Association of California (SEAOC).

Because the UBC map is based on the greater of the two NEHRP maps, and the NEHRP EPV values are always larger than the NEHRP EPA values, the UBC and NEHRP EPV maps are essentially the same. However, because the NEHRP county-by-county maps rather than the contour maps were used in this comparison, the two appear significantly different in the low seismic zones.

NEHRP sets a minimum acceleration value of 0.05g for its county-by-county map where as with the NEHRP contour map, acceleration values of less than 0.05 g are possible. In this report, the county-by-county map is used as a worst case value for a particular city. The UBC map's minimum acceleration value is zero.

In general, the variation in EPA for the majority of cities is less than 0.05. Consequently, the seismic zones used by the various agencies substantially meet the NEHRP Evaluation Handbook. Typically, large variations do not occur between the NEHRP and UBC maps, but between the NEHRP map and site-specific values. For example, the largest variation in EPA is 0.25 for San Diego between a VA site-specific EPA value and NEHRP. This particular value for San Diego is currently under investigation by the VA with the advent of more recent data. The VA reports that their site-specific EPA value will probably end up closer to 0.3.

It is important to point out that site-specific values based on geotechnical information for a particular building site is inherently more accurate than a value taken from a seismic zone map. Note that a variation in EPA does not always cause a proportionately large change in base shear. In general, the variation in seismic zones is not as significant as the difference in the strength requirements previously discussed.

4. Special Details Assessment

Special construction details significantly influence the behavior of an existing building during an earthquake. Although there is general agreement on some specific details, the amount of special detailing required by most methodologies varies. As such, this is a difficult parameter to quantify and lends itself better to a qualitative comparison.

To assess special detailing requirements, the requirements of the NEHRP Evaluation Handbook are organized by building type. These requirements are then checked against each of the other programs. By reviewing the chart of the detailing requirements (see Appendix E), a qualitative determination can be made as to the overall special detailing requirements of each program when compared to the NEHRP Evaluation Handbook.

All of the agency programs except the procedure for normal facilities based on the 1982 Tri-Service Manual were deemed to meet or exceed the NEHRP Evaluation Handbook. The Tri-Service procedure was deemed as being substantially equivalent to the NEHRP Evaluation Handbook (see Table 1). The new draft of the Tri-Service Manual based on the 1988 UBC was judged, along with the other documents based on the UBC, as being fully equivalent to or exceeding the NEHRP Evaluation Handbook.

Several agencies have reported using standards for new buildings (e.g. current UBC or NEHRP Provisions) to determine adequacy of their existing buildings. On the surface, this procedure would always meet or exceed the NEHRP Handbook and the technical comparisons used in this report yield this result. However, simple specification of codes for new buildings alone does not address the issue of archaic/non-ductile materials (structural materials or assemblies either not allowed in current code or with some characteristics that do not comply with current requirements). Most engineers experienced in seismic evaluation and retrofit would not utilize a criteria of strict adherence to such codes, which could require complete removal of the material, or elimination of the assembly from both the vertical and lateral load resisting system. Specification of these codes as criteria, therefore, normally requires additional guidance from the agency or judgment by the evaluating engineer as to appropriate properties for archaic/non-ductile materials. If guidance or overview is not provided by the agency, then the experience and judgment of the evaluating engineer becomes paramount.

The most liberal interpretation of such a criteria could amount to no more than the use of the force level for new buildings, with the resisting systems consisting entirely of archaic/non-ductile elements; the adequacy of such an evaluation would depend on the actual ductility and/or stress levels assigned to the archaic/non-ductile elements. On the other hand, an extremely conservative interpretation could require the addition of a completely new lateral force resisting system. Even if the performance of evaluations using new building criteria is limited to experienced engineers, inconsistencies of results are probable, particularly if code compliance criteria is not supplemented with a specific performance objective.

5. Drift Requirements Assessment

Just as a building's strength is important to resist the lateral loading of earthquakes, a building's stiffness is important to limit building deformations. Drift limits commonly involve restrictions placed on story drifts to limit the building's non-structural damage and prevent significant P-Δ effects.

It is difficult to compare drift limits between various programs because these limits are strongly influenced by the specified base shear. As previously discussed, some programs use working stress design procedures while others use ultimate strength design procedures and, as a result, the two drift limits are not directly comparable. To correctly compare the effects of drift limits, the required stiffness of each building must be compared directly.

To assess drift requirements, the interstory drift limit is computed for each criteria for both a one-story and a ten-story steel moment frame building and concrete moment frame building. Next, the base shear for both the one-story and the ten-story building are computed keeping the building weight as a constant. An effective stiffness indicator, K, for both the one-story and the ten-story building is determined by dividing the base shear by the product of the drift limit and the number of stories (the overall building drift).

In general, drift requirements vary substantially between procedures. In fact, there appear to be a number of methods to check story drift. It is apparent from Appendix F that both forces and the drift limit must be investigated to correctly compare different agency programs. Even when computing the effective stiffness, the range of values is large.

Every program met or exceeded the drift limits set in the NEHRP Handbook except the procedure for normal facilities based on the 1982 Tri-Service Manual (see Table 1 and Appendix F). Both H-08-8 for VA hospitals and UCRL-15910 for moderate and high hazard buildings had much stiffer drift limits than the NEHRP Evaluation Handbook.

6. Building Systems Requirements Assessment

As part of the evaluation of an existing building, the NEHRP Evaluation Handbook provides guidelines for performing "systems" checks for the lateral force resisting elements of the building. In general, these checks are non-numeric and represent a collection of "good practice" measures for improving the seismic performance of the building. The systems check outlined below are those which do not fall into the more general category of configuration guidelines nor the more-specific category of detailing guidelines. Reference should be made to each of these categories.

Building Systems Requirements

Steel Moment Frames

4.2.2	Compact Members
4.2.8	Strong Column/Weak Beams

Concrete Moment Frames

4.3.3	Prestressed Frame Elements
4.3.6	Strong Column/Weak Beams

Braced Frames

6.1.2	Stiffness of Diagonals
6.1.4	Chevron Bracing

Wood Diaphragms

7.2.4	Span/Depth Ratio

All agencies address the seven system requirements listed to a level which, as a minimum, meets the NEHRP Evaluation Handbook requirements. In the NEHRP Evaluation Handbook, these system requirements can be found in specific sections such as diaphragms, or in various places among the detailing provisions. In other agency documents, system requirements are usually found in detailing sections for a particular structural material type.

In some instances, however, a direct comparison is not possible. For example, the NEHRP Evaluation Handbook limits the span to depth ratio for wood diaphragms. For those agencies utilizing the UBC, diaphragms are not necessarily limited by ratios but rather stress and deflection.

7. Non-Structural Requirements Assessment

Past experience with seismic events has shown that a significant amount of damage is non-structural in nature. By identifying potential hazards and taking the necessary measures to mitigate these hazards, the performance of the building and safety to its occupants can be increased to acceptable levels.

The NEHRP Evaluation Handbook compiles a checklist of non-structural items to be reviewed to ensure that an acceptable level of life-safety is maintained in the building. This checklist of non-structural items has been summarized in Appendix H to allow a comparison of agency procedures with the NEHRP Evaluation Handbook.

As shown in the Appendix, those non-structural items which are more permanent (partitions, ceiling, mechanical, etc.) are addressed by all agencies. Both the Postal Service and GSA were deemed to meet or exceed the NEHRP Evaluation Handbook. A number of agencies did not specifically address building contents, hazardous materials, or some ceiling and light fixture provisions of the NEHRP Handbook. The procedures used by VA, FBO, DOE, and both the 1982 and draft 1992 Tri-Service Manual procedures were deemed as being substantially equivalent to the NEHRP Evaluation Handbook. Moveable items such as furniture have not been reviewed for this report.

B. NEHRP Techniques Handbook

The NEHRP Techniques Handbook was developed by FEMA to be part of their long range program to deal with existing buildings. The handbook includes a discussion of seismic vulnerability of buildings focusing on concepts such as ductility, damping, load path and redundancy. The majority of the Handbook concentrates on seismic strengthening techniques for building elements, including a discussion of observed deficiencies for particular elements and a description of decreasing demand on existing systems through methods such as base isolation. Techniques for the rehabilitation of non-structural architectural, mechanical, and electrical components are also included. In addition to specific strengthening techniques, an Appendix listing fifteen building types is presented. Under each building type, common deficiencies of diaphragms, vertical resisting elements, foundations and connections are outlined. With an understanding of the structural elements for a particular building type, the engineer is directed to the appropriate strengthening techniques for those elements.

Not all federal agencies have specific guidelines or documents related to strengthening techniques. The agencies who did not have documents available for review include: Department of Veterans Affairs and Department of State - Foreign Building Office. Other agencies, such as Department of Energy, reference portions of other agency documents. DOE references P355.2. The documents compared to the NEHRP Techniques Handbook include:

Postal Service/All Facilities: ATC-26-4 - U.S. Postal Service Procedures for Seismic Retrofit of Existing Buildings

GSA/All Facilities: Chapter 12 of Earthquake Resistance of Buildings (nonstructural only)

Army, Navy, Air Force/Essential and Normal Facilities: TM 5-809-10-2 NAVFAC P355.2, AFM 88-3, Chap 13, Sec B - Seismic Design Guidelines for Upgrading Existing Buildings (P355.2)

Since neither the NEHRP Techniques Handbook nor any of the federal agencies specifically dictate certain strengthening procedures but rather give example details and methods, the NEHRP Techniques Handbook comparison is qualitative only.

1. Strengthening Techniques Assessment

Several agency programs have documented techniques for seismically strengthening buildings. It should be noted that all of the "technique" documents are put forth as recommended reference material and contain no requirements or standards. While the strengthening techniques presented in each agency's document represent common practice solutions to seismic deficiencies, engineers are not restricted from pursuing alternative methods. Additionally, specific strengthening details that are provided may be controversial as engineers often have a difference of opinion as to what approach is proper in a given situation.

To assess strengthening techniques, the techniques outlined in the NEHRP Handbook are organized in tabular form by structural element type (see Appendix G). The number of techniques provided for each element type is then tallied for the NEHRP Handbook and for each of the other programs. For example, under concrete moment frames, NEHRP includes three measures, such as "Change the system to a shear wall system by infilling the reinforced concrete frames with reinforced concrete as indicated in Figure 3-6." By looking at such a chart of strengthening techniques, a qualitative comparison can be made as to the extensiveness of sample techniques provided by each program when compared to the NEHRP Techniques Handbook. The comparison is summarized in Table 1.

The NEHRP Handbook thoroughly addresses the most common building types and structural elements to be strengthened. The Postal Service, with ATC-26-4 and with references to the NEHRP Handbook and P355.2, clearly presents the most techniques of the programs surveyed. In the chart in Appendix G, however, only the techniques given specifically in ATC-26-4 are included for comparison. P355.2 presents strengthening techniques in Chapter 6 and organizes them around eight building categories. While not presented to the extent of the NEHRP Handbook, the techniques recommended by the P355.2 (and DOE by reference) are similar to those presented in NEHRP and deemed to be substantially equivalent to the NEHRP Handbook. All other programs without a specific document, including GSA which included nonstructural guidelines only, were categorized as not having enough data available to evaluate.

It should be emphasized that no procedures in the NEHRP Techniques Handbook are required or mandatory. While listings of these techniques are helpful, particularly to engineers and architects not experienced in seismic design, the lack of formal incorporation of such documents does not render a seismic program incomplete or inadequate.

III TASK 2 - PART II: ASSESSMENT OF REHABILITATION CRITERIA

The second part of Task 2 involves identification and assessment of rehabilitation criteria and program issues within the six federal agencies, four private sector organizations, RP-3, and the State of California program. The program issues to be explored include: strengthening triggers, evaluation criteria, strengthening criteria, time frames and exemptions from strengthening. These issues will be addressed in the following sections. Table 2 presents the assessment results.

A. Strengthening Triggers

Something that requires the immediate seismic strengthening of a building is commonly termed a strengthening "trigger." The most common strengthening triggers are major architectural renovation, significant modification to the building's structure or a change in occupancy. Other triggers can be damage caused by earthquake, fire, wind or other natural hazard, or seismic resistance deficiencies found in formalized evaluation programs.

B. Evaluation Criteria

An evaluation criteria for a certain performance objective serves as a baseline with which to measure the performance of a structure. It sets the level at which a building is considered adequate. Typically, a building which does not meet the level of the evaluation criteria is considered to need strengthening. Evaluation documents such as the NEHRP Evaluation Handbook, are often based on lower levels of seismic load than current code documents. This can reflect a willingness to accept more risk in existing buildings than in new ones, acceptance of increased damage, and considerations of benefit/cost ratios of strengthening.

C. Strengthening Criteria

Once a decision is made to strengthen a building, the question becomes, to what level should the building be strengthened? The strengthening criteria, like the evaluation criteria, is dependent on performance objectives. The higher the performance objective, the more strengthening the building will require. Most buildings will be strengthened considering protection of occupants using a level that "substantially" protects life-safety.

Because of cost and disruption to occupants, some mandated programs have set levels less than substantial life-safety; these levels are often considered on the basis of costs and benefits. Although many aspects of standards for seismic strengthening may differ from codes for new buildings, the seismic demand (lateral load) is where comparisons are often focused. Similar to evaluation standards, strengthening demands are often set at levels below those of new buildings.

D. <u>Time Frames for Program</u>

Time frames for program refers to the schedule for evaluating or strengthening buildings. Schedules can be set by performance objectives, building types, or hazard levels, and can be mandatory or advisory.

Time frames can be dependent on the number of buildings in an agency's inventory, the number of seismically deficient buildings in an inventory or the amount of money available to evaluate/upgrade facilities.

Other variables that affect time frames include the amount of time the building will be occupied, and the time table for building replacement. Currently, only RP-3 and the State of California have proposed time frames that could be applicable to federal buildings. RP-3 defines the time frame for strengthening as five years or ten years from the completion of the building evaluation, depending on the severity of hazard. The State of California time frame gives specific dates with a goal of all hazards mitigated by the year 2000.

E. <u>Exemptions from Strengthening</u>

When evaluating a large building inventory, some programs choose to leave particular classes of buildings out of the process. Typically, exemptions consist of buildings constructed to recent seismic codes in low seismic zones, with small square footage, with few occupants, or scheduled for replacement within a short period of time. Other examples include: one-story, pre-engineered wood or steel buildings, and one- and two-family homes (one- or two-stories).

Buildings can also be "exempted" by neglect; that is, if lack of funds or inability to incur strengthening disruptions causes buildings not to be evaluated, they are, in fact, exempted. There are many such cases where programs may have no formal exemptions.

	Postal Service	GSA	Tri-Services			VA		FBO	DOE	
	All Facilities	All Facilities	Essential Facilities	Normal Facilities (1992 Draft TSM Based on '88 UBC)	Normal Facilities (1982 TSM)	Hospitals	MOBs	All Facilities	High and Moderate Hazards	Low Hazard and General Use
NEHRP EVALUATION HANDBOOK										
Strength Requirements	⊙[b]	O	O	O	⊙[b]	⊛	O	O	⊛	O
Configuration Guidelines	O	O	●[c]	O	●[c]	O	O	O	O	O
Moderate & High Seismic Zones	O	⊙[d]	O	⊙[d]	O	⊙[d]	⊙[d]	⊙[d]	O	⊙[d]
Low Seismic Zones (NEHRP 1 & 2)	O	⊙[d]	⊙[d]	⊙[d]	⊙[d]	⊙[d]	⊙[d]	⊙[d]	O	⊙[d]
Special Details	O	O	O	O	⊙[e]	O	O	O	O	O
Drift Requirements	O	O	O	O	O	⊛	O	O	⊛	O
Building Systems Requirements	O	O	O	O	O	O	O	O	O	O
Non-Structural Requirements	O	O	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
NEHRP TECHNIQUES HANDBOOK										
Strengthening Techniques [a]	O	◆[g]	⊙[f]	⊙[f]	⊙[f]	◆[g]	◆[g]	◆[g]	⊙[f]	⊙[f]

⊛ Exceeds two times NEHRP Handbook

O Meets or exceeds NEHRP Handbook

⊙ Substantially meets NEHRP Handbook

● Does not meet NEHRP Handbook

◆ Not enough data available to evaluate

a Non-mandatory, suggested strengthening techniques. (See also footnote g).

b 1982 Tri-Service Manual static procedure is not as stringent as NEHRP for braced frames. ATC-22 procedure not as stringent as NEHRP for steel frames with unreinforced masonry walls.

c Tri-Service configuration guidelines are not as stringent as NEHRP. The 1992 draft of the TSM which is based on 1988 UBC meets or exceeds NEHRP Handbook.

d The Tri-Service Manual's map has 3 cities out of 38 with EPA values less than NEHRP for moderate and high seismic zones and 17 cities out of 64 for low seismic zones. The UBC has 10 cities out of 38 for moderate and high seismic zones and 28 cities out of 64 for low seismic zones. VA has 10 cities out of 38 for moderate and high seismic zones and 30 out of 64 for low seismic zones.

e 1982 Tri-Service Manual does not have as stringent detailing requirements as NEHRP Handbook.

f Although not as complete as in the NEHRP Techniques Handbook, the strengthening techniques covered in P355.2 are helpful for those not familiar with seismic retrofit of buildings. (See also footnote g).

g These agencies include few strengthening techniques in their seismic mitigation programs. No procedures in the NEHRP Techniques Handbook are required or mandatory. While these techniques are helpful, we do not feel they are necessary for an adequate or complete seismic mitigation program.

TABLE 1: SUMMARY OF ASSESSMENT RESULTS

AGENCY	STRENGTHENING TRIGGERS	EVALUATION CRITERIA	STRENGTHENING CRITERIA	TIME FRAME	STRENGTHENING EXCEPTIONS
USPS	None	ATC-26-1	ATC-26-4	Pilot program is 3 years	NEHRP Zones 1 &.2
GSA	60% of replacement cost complete renovation[1]	80% of current UBC	100% of current UBC	None	Bldgs. with < 10000 sq. ft. and leased bldgs.
NAVFAC	Renovation of $150,000 or 10% bldg. replacement cost	Non-essential:85% of P355 Essential: 75% of EQI & 85% of EQII	Non-essential:100% of P355 Essential:100% of EQII	None	Bldgs. with < 500 sq. ft. single family housing, UBC Zone 0, 1-story bldgs.[2]
VA	Major renovation	Substantial compliance with H-08-8	100% of H-08-8	None	None
FBO	Planned renovation	Percentage of UBC	Full UBC	None	None
DOE	5480.1b Safety Analysis[3] plus OSHA safety clause	Reduced recurrance interval by 50%	UBC compliance for General and Low Hazard	None	None
HP	None	ATC-14	100% of ATC-14 100% of UBC based on use	Short time frame - 3 yrs	UBC Zones 0 & 1
Kaiser	None	ATC-14	Life-safety:ATC-14 Repair.damage:UBC Functionality:Title 24	None	Title 24 compliant hospitals plus short term leased bldgs
Stanford	URMs	1976 UBC or to meet category requirements	Category A:UBC w/ 1.5 Category B:100% UBC Category C:UCBC	1/2000 for URMs	None
Rocketdyne	None	Modified Tri-Service	Modified Tri-Service	None	None
RP-3	None	ATC-14 or 22 0.8-0.5 - Category I < 0.5 - Category II	Full ATC-14 or 22	Catg I - 10 years Catg II - 5 years	UBC 0, NEHRP 1,2 76' UBC or later pre-engineered
State of CA	None	None	Not yet decided	7/94 - eval of crit. facil 7/96 - eval of rest 1/2000 - vacate or strengthen all buildings	None

[1] Also includes: damaged buildings, buildings < 80% code, highest tier of DFA number
[2] Also includes: pre-engineered bldgs, replacement in 5 years, less than 5 occupants
[3] DOE safety analysis for general use facilities, reviewed every 5 years.

Table 2: Summary of Federal Agency Rehabilitation Criteria

SYSTEM	R/Rw	NEHRP	ATC-14	ATC-22	TRI-SERV (OLD)	UBC	VA (H-08-8)	DOE (MH&HH)
STEEL FRAME BUILDINGS								
SF W/ URM INFILL	1.5/6	1.00	0.38-0.45	071-1.20	***	***	***	***
SF W/ REINF. MASONRY INFILL	4.5/8	1.00	0.85-1.37	094.-1.20	0.84-1.41	1.10-1.32	1.69-2.54	4.04-4.87
STEEL BRACED FRAME	5/8	1.00	0.72	0.94-3.24	0.71-1.20	0.93-1.12	1.13-1.69	4.17-5.02
STEEL SMRSF	8/12	1.00	0.77-1.34	0.94-1.80	0.76-1.28	0.76-1.28	1.35-2.03	3.74-4.50
CONCRETE BUILDINGS								
NON-DUCTILE CONC. MF	2/5	1.00	0.56-0.75	0.94-1.20	***	***	***	***
CONCRETE SHEAR WALL	5/8	1.00	0.96-1.23	0.94-1.80	0.95-1.60	1.25-1.50	1.03-1.55	7.13-8.59
CONCRETE SMRSF	8/12	1.00	0.93	0.94-1.20	0.92-1.56	1.21-1.46	1.50-2.25	6.53-7.87

*** ISSUE NOT SPECIFICALLY ADDRESSED

TABLE 3: NEHRP COMPARISON VALUE SUMMARY - RANGES BY STRUCTURAL SYSTEM

TASK 3

I INTRODUCTION

One of the most pressing needs in the area of seismic hazard mitigation in existing buildings is the development of cost information. Considering the obvious competition between various funding needs in both the private and public arenas, most decisions on seismic hazard mitigation will be made only after careful consideration of the costs and benefits. Costs are needed by local jurisdictions when considering mandatory programs for private buildings, and by the federal, state or local governments when designing programs for hazard mitigation in public buildings; decisions to include seismic hazard mitigation on individual building projects where no organized program exists will also be heavily influenced by costs.

Costs for any specific building can always be obtained by developing a schematic design of mitigation measures, but it is unrealistic for owners to carry out such studies on every existing building in their care. Reasonable cost ranges for seismic hazard mitigation that will cover a variety of conditions such as different building types, seismic zones, performance requirements, and occupancy conditions is therefore desirable.

There are two major difficulties in developing reliable cost data. First, the data base is small, except perhaps for unreinforced masonry buildings in California, and even where data exists, it is difficult to obtain in appropriate detail. Secondly, the costs are highly variable and depend upon a multiple of factors, many of which will be unknown if estimates are to be made on a non-building-specific basis.

Nevertheless, useful seismic rehabilitation cost information can be developed by performing a careful analysis of the variables and components of strengthening projects, by simplifying and combining variables where possible, by utilizing engineering judgement in identifying trends and patterns, and by utilizing broad cost ranges where required.

II ELEMENTS OF AN OPTIMUM COST DEVELOPMENT PROGRAM

Most seismic rehabilitation projects can be described using the elements described below. Definition in these areas will greatly reduce the variability of costs although the cost of the strengthening itself will vary depending on the procedure used and this variation cannot be captured without building-specific study.

1. Building Types. At a minimum, the 15 building structural types used in the FEMA series of documents on existing buildings shall be considered; types can be combined into groups if data shows similar costs and trends. Significant cost differences caused by occupancy shall also be reported, if found. It is doubtful that sufficient data will be available to create additional subcategories such as building height, footprint area, etc. Any significant trends that can be deduced from the data should be reported to enable a user to better estimate the cost range of a given seismic retrofit.

2. Level of Strengthening. The level or intensity of strengthening is normally dependent on the seismic zone and on the performance goal:

A. Zones. NEHRP zones could be consolidated as was done in FEMA 154 (Rapid Screening):
1) low (1,2)
2) moderate (3,4)
3) high (5,6,7)

B. Performance goals. Commonly defined performance goals include:

1) immediate occupancy
2) repairable damage
3) substantial life safety
4) a fourth common goal is known as "risk reduction", but the level of work varies so widely that typical costs would be meaningless. If included in a cost study, the specific criteria used would have to be identified.

A significant simplification may be possible by combining the effects of both varying zones and varying performance goals into one factor, since both are roughly dependent on base shear or stiffness. If the performance goal of "repairable damage" is considered equivalent to the code level for new buildings, the "life safety" level could be thought of as about 75% of that level, and the "immediate occupancy" level (i.e. essential facility) could be thought of as about 150% of that level. If the NEHRP zoning EPAs are multiplied by these performance factors, the following matrix is created:

Table of NEHRP Zone EPAs Multiplied by "Performance Factors"

Performance Factor	NEHRP Zones 7	6	5	4	3	2	1
.75	.3	.2	.15	.11	.07	.03	-
1.0	.4	.3	.2	.15	.1	.05	-
1.5	.6	.45	.3	.22	.15	.07	-

A repeating pattern is set up that could be utilized to simplify these two variables of retrofit costs. For example, .3 could be used to identify "life safety" in zone 7, "repairable damage" in zone 6, and "immediate occupancy" in zone 5; similarly, rounding off, .4, .2, .15, and .1 all appear in several locations of this matrix. If this term was labeled the "Retrofit Level" factor, it could be used as a parameter to gage costs for both zone and performance level.

3. Cost Factors. There are many possible factors which influence the cost of a seismic rehabilitation project, some of which are stand-alone items and some of which are conditions that influence overall costs. Each factor must be analyzed and accounted for, as appropriate, either by adding costs directly or by percentage increases. Factors which should be considered include:

A. Cost Components

- Structural construction costs
- Associated nonstructural demolition and restoration
- Associated minor nonstructural improvements
- Associated repair of damage or deterioration
- Associated building improvements
    - Disabled access
    - Hazardous material removal
    - Exiting
- Design fees, permit, and TI costs
- Owner's overhead
    - Financing
    - Project management

B. Influence Factors

- Occupancy during construction
- Historic character or status of the building
- Regional or site characteristics
    - Regional construction cost modifiers
    - Site access, protection of adjacent properties, etc.

4. Type of Strengthening Decision. The cost components attributable to a decision to seismically upgrade will vary considerably depending on the conditions. For this purpose, it would be useful to define a term "Seismic Cost Increment" to be the costs appropriately charged to such a decision. The two extreme conditions of these decisions should be addressed:

A. Minimum Cost Seismic Strengthening Alone: In this situation all work has been caused by a decision to seismically strengthen and often is limited to the structural work plus minimum nonstructural demolition and restoration. Nonseismic life-safety improvements that may be triggered by the seismic construction should also be included as this work would not be required otherwise. An important sub-variable in this situation is the level of occupancy that can be maintained during the work. The consideration of seismic construction work in a building also generates conditions that could allow cost efficient non-required nonstructural improvements to be included. There is often great pressure from tenants to incorporate such work. Since the decision to seismically strengthen generated this non-required work, these costs may sometimes be generated in this condition. The Seismic Cost Increment for this situation would include all applicable Cost Components and Influence Factors listed above.

B. Seismic Strengthening Added to Substantially Complete Renovation: In this case, the bulk of the work is being driven by nonseismic considerations such as change of occupancy, remodeling, or updating of building systems. Nonseismic life-safety improvements would be triggered by this work in any case and should not be "charged" to seismic work. Nonstructural demolition and restoration is also substantially independent of structural work and also should not be considered part of seismic work. Buildings are typically partially or completely unoccupied during this work and therefore occupancy during construction is not an issue. The Seismic Cost Increment in this case would consist of only those Cost Components directly associated with the seismic work and could be limited to structural costs, associated structural repairs, and an increment of percentage-type costs such as fees, permits, and overhead. Certain Influence Factors could apply, but as mentioned above, probably not occupancy during construction.

III POSSIBLE APPROACHES

The cost information to be developed would be intended to be used by building owners nationwide, public and private, to approximate the costs of seismic rehabilitation of their buildings under varying conditions. Useful cost information could optionally be developed at several different levels of detail. More effort would obviously produce better data, allowing more realistic estimates of budget costs to be made using only key building or project characteristics. Data collected and analyzed in FEMA 157 "Typical Costs for Seismic Rehabilitation of Existing Buildings" can be a starting point, although it would need to be reviewed to emphasize the current interest in total costs using variables and characteristics as discussed above. Gathering additional data is time consuming and expensive and the level of effort for this activity would have a large influence on the overall scope of any cost study. Similarly, developing new data by performing schematic designs is also expensive and this technique could probably only be used sparingly. Three viable levels of cost studies are described below:

Minimum Scope for a Cost Study

The absolute minimum scope for a cost study that would be useful to decision makers would consist of a thorough discussion of the cost factors and conditions listed in items 3 and 4 above. Such a document would raise awareness of the components of cost in seismic rehabilitation and serve as a format to collect future cost data. It is estimated such a study would cost $40,000 to $60,000.

Intermediate Scope for a Cost Study

In addition to the discussion and documentation suggested above as minimum, cost ranges considering a reduced and simplified set of variables could be developed. Data from FEMA 157, other published retrofit cost studies and additional data that may be readily available to the study contractor could be used. A reduced set of building types could be used consisting of structural types for which most data is available plus more general groupings of other buildings: URM buildings and tilt-up buildings because of their availability, wood frame buildings because of their uniqueness, and all others grouped as low rise, mid rise, and high rise. It is estimated that this study would cost $100,000 to $125,000.

Optimum Scope for a Cost Study

The cost study that would be most useful would be more comprehensive and attempt to address all of the elements discussed above. The following tasks should be included:

A. Increase Database:

1. Reinvestigate old data in FEMA 157 (separate performance/zones better)

2. Add new available data
   a) cost studies by others
   b) case histories from federal agencies
   c) case histories from other owners, engineers, contractors, and cost estimators

3. Perform new analysis to fill in gaps (gaps in performance, zones, building types, or conditions)

B. Analyze Database:

1. Statistical analysis of database

2. Quantitative Analysis:

   Perform "trends" quantitative analysis of decreasing demand level for each building type. This analysis will consider typical deficiencies commonly mitigated in high seismic zones and study the likelihood and extent of reduction or elimination of each mitigation measure as the design seismic demand decreases with lower zones or lower performance goal. The conditions under which no strengthening would likely be required (the "zero case") shall be identified where possible.

C. Final Costs:

1. Combine hard data and trends analysis to approximate cost ranges under the various conditions discussed herein. It is expected that considerable professional judgement will be required to obtain comprehensive results that would consider all variables.

2. Develop graphs showing costs versus performance/zones for each building type. Variation in costs caused by differences in seismic strengthening situation, level of occupancy during construction, historic preservation, etc. shall be identified when possible. Important modifiers that have not been quantified should be well documented.

A cost study such a this could cost as much a $300,000 to $350,000, depending primarily on acquisition of new data.

REFERENCES

Applied Technology Council, 1986. Methods for Evaluating the Seismic Resistance of Existing Buildings. Applied Technology Council Report ATC-14, Redwood City, California.

------, 1989. A Handbook for Seismic Evaluation of Existing Buildings (Preliminary). Applied Technology Council Report ATC-22, Redwood City, California.

------, 1989. Seismic Evaluation of Existing Buildings Supporting Documentation. Applied Technology Council Report ATC-22-1, Redwood City, California.

------, 1991. U.S. Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim). Applied Technology Council Report ATC-26-1, Redwood City, California.

------, 1991. U.S. Postal Service Procedures for Seismic Retrofit of Existing Buildings (Interim). Applied Technology Council Report ATC-26-4, Redwood City, California.

Building Seismic Safety Council, 1985. NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings: Part 2 - Commentary. Developed by BSSC for FEMA, Washington, D.C.

------, 1985. NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings: Part 3 - Appendix. Developed by BSSC for FEMA, Washington, D.C.

------, 1988. NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings: Part 1 - Provisions. Developed by BSSC for FEMA, Washington, D.C.

------, 1991. NEHRP Handbook of Techniques for the Seismic Rehabilitation of Existing Buildings. (Ballot Copy), Developed by BSSC for FEMA, Washington, D.C.

------, 1992. NEHRP Handbook for the Seismic Evaluation of Existing Buildings. Developed by BSSC for FEMA, Washington, D.C.

California Seismic Safety Commission, 1991. Policy on Acceptable Levels of Earthquake Risk in State Buildings. California Seismic Safety Commission Report SSC 91-01, Sacramento, California.

Departments of the Army, the Navy, and the Air Force, 1982. Seismic Design for Buildings. TM 5-809-10, NAVFAC P-355, AFM 88-3, Chap 13, Washington D.C.

------, 1986. Seismic Design Guidelines for Essential Buildings. TM 5-809-10-1, NAVFAC P-355.1, AFM 88-3, Chap 13, Sec A, Washington D.C.

------, 1988. Seismic Design Guidelines for Upgrading Existing Buildings. TM 5-809-10-2, NAVFAC P-355.2, AFM 88-3, Chap 13, Sec B, Washington D.C.

General Services Administration, Public Buildings Service. Seismic Strengthening Guidelines. Chapter 12 of Earthquake Resistance of Buildings, the GSA building construction handbook, Washington D.C.

H.J. Degenkolb Associates, Engineers, 1989. Hewlett-Packard Corporate Seismic Policy Development, Phase II. San Francisco, California.

H.J. Degenkolb Associates, Engineers and Rutherford & Chekene, Consulting Engineers, 1992. Evaluation and Strengthening Guidelines for Federal Buildings: Task 1 Final Report. San Francisco, California.

Hewlett-Packard Company, 1990. Seismic Guidelines for New Construction. San Francisco, California.

------, 1990. Seismic Guidelines for Restraint of Nonstructural Components. San Francisco, California.

ICBO, 1991. Uniform Building Code. 1991 Edition, Whittier, California.

Poland, Chris D. and Malley, James O., 1989. Recommended Modifications to ATC-14. National Center for Earthquake Engineering Research Technical Report NCEER-89-0012, Buffalo, New York.

State of California, 1989. Title 24 of the California Code of Regulations. California Administrative Code consisting of UBC '88 with 1989 California amendments, Whittier, California.

Structural Engineers Association of California, 1990. Recommended Lateral Force Requirements and Commentary. The "Blue Book" prepared by the Seismology Committee of SEAOC, Sacramento, California.

United States Department of Commerce, National Institute of Standards and Technology, 1989. Guidelines for Identification and Mitigation of Seismically Hazardous Existing Federal Buildings. Report developed by the Interagency Committee on Seismic Safety in Construction (ICSSC) Subcommittee 1, sponsored by FEMA, ICSSC RP-3, NISTIR 89-4062, Gaithersburg, Maryland.

United States Department of Energy, 1990. Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards. Department of Energy UCRL-15910, Washington D.C.

Department of Veterans Affairs, 1986, Seismic Design Guidelines. Veterans Administration Seismic Design Guidelines H-08-8, Washington D.C.

------, 1986, Seismic Design Guidelines - Site Evaluation Survey for Existing Facilities. Veterans Administration Seismic Design Guidelines H-08-8, Appendix A, Washington D.C.

------, 1986, Seismic Design Guidelines - Scope of Work for Phase I and Phase II Evaluations of Existing Facilities. Veterans Administration Seismic Design Guidelines H-08-8, Appendix B, Washington D.C.

GLOSSARY

The following glossary provides an abbreviated "acronym" for each report, its full name, and a brief background and description of the report contents:

ATC-14: Methods for Evaluating the Seismic Resistance of Existing Buildings:

ATC-14 was the first generation document which developed a procedure for the seismic evaluation of existing buildings based directly on the performance of buildings in past earthquakes. The procedure is intended at evaluating life-safety concerns.

ATC-22: A Handbook for Seismic Evaluation of Existing Buildings (Preliminary):

ATC-22 was the second generation document. It built upon ATC-14 by refining the procedures, expanding the commentary type information, and incorporating the strength design concepts of the NEHRP provisions for new buildings. The document format was modified into a handbook for easier use by evaluating engineers.

ATC-26-1: U.S. Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim):

A complete procedure for evaluating existing Postal Service facilities based on ATC-22 and other available methods.

ATC-26-4: U.S. Postal Service Procedures for Seismic Retrofit of Existing Buildings (Interim):

Presents guidelines for the seismic retrofit of existing buildings (fifteen building types) and nonstructural elements tailored to the Postal Service needs.

ATC-28: Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings Phase 1: Issues, Identification and Resolution:

ATC-28, identifies and discusses all the issues that must be considered, resolved and included in the FEMA guidelines for the seismic strengthening of existing buildings.

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Tri-Services Manual: TM5-809-10, NAVFAC P-355, AFM 88-3, Chapter 13: Seismic Design for Buildings:

A seismic design manual prepared by the Army, using the static load approach. Latest edition written in 1982. The 1992 Edition is approved for publication.

P-355.1: TM5-809-10-1, NAVFAC P-355-1, AFM 88-3, Chapter 13, Section A: Seismic Design Guidelines for Essential Buildings:

A seismic design manual for new, essential buildings, prepared by the Army, using the dynamic loading approach. Latest edition 1986.

P-355.2: TM5-809-10-2, NAVFAC P355-2, AFM 88-3, Chapter 13, Section B: Seismic Design Guidelines for Upgrading Existing Buildings:

A manual prepared by the Army outlining a methodology for screening and evaluating of existing buildings to determine their vulnerability to seismic events. It also includes recommendations for detailed structural analysis. Latest edition 1988.

H-08-8: Earthquake Resistant Design Requirements for VA Hospital Facilities:

Seismic design guidelines for new and existing construction prepared for the Department of Veterans Affairs. These guidelines were first adopted in 1973, have been updated on a regular basis and are currently under substantial revision to make them consistent with model building codes.

UBC: Uniform Building Code:

The current standard of practice for seismic design in the Western United States. The seismic provisions within the UBC were adapted from the Structural Engineers Association of California (SEAOC) "Blue Book". The current edition of the UBC was written in 1991.

UCBC: Uniform Code for Building Conservation:

The UCBC establishes life-safety requirements for all existing buildings that undergo alteration or change in use. It is predominantly used for the seismic rehabilitation of unreinforced masonry structures (Appendix Chapter 1).

APPENDIX A

Scope of Work

Summary of Changes in Scope of Work

SECTION C - DESCRIPTION/SPECIFICATIONS/WORK STATEMENT

C.1 STATEMENT OF WORK/SPECIFICATIONS

The Contractor shall furnish the necessary personnel, material, equipment, services and facilities (except as otherwise specified), to perform the following Statement of Work/Specifications.

Background: Section 8(a) of the NEHRP Reauthorization Act (Public Law 101-614) calls upon the Interagency Committee on Seismic Safety in Construction (ICSSC), chaired by NIST, to work in consultation with appropriate private sector organizations to develop standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government.

In support of ICSSC objectives to develop seismic standards for existing federal buildings, the contractor shall perform the following tasks. The contractor shall be responsible for acquiring the reports, codes, standards, and other documents and information required to be reviewed by this contract or otherwise necessary for completion of the tasks below. During the period of the contract, the contractor shall submit monthly written reports. These reports shall include, for both contractor and any and all subcontractors, at a minimum, a brief description of work accomplished during the previous month, an estimation of the percent of each task completed, a description of any problems hindering timely progress of the work, and an identification of any anticipated problems which are expected to hinder work in the future. As requested by the COTR, the contractor shall provide NIST with copies of work in progress, in the form of drafts of the reports and plans described in the tasks below.

<u>Task 1</u>

a. The contractor shall prepare a draft report containing, but not limited to, the following information:

- A detailed workplan for the project.
- An identification of existing and proposed federal agency evaluation and strengthening programs, including rapid screening processes. The listing shall be, to the greatest extent possible, comprehensive, and shall include the program of the United States Postal Service.
- A compilation of existing and proposed federal, state, and private sector seismic performance objectives for existing buildings, including performance objectives of at least six federal agency programs identified above. Among the additional relevant documents to be included is the California Seismic Safety Commission document "Policy on Acceptable Levels of Earthquake Risk in State Buildings".
- A matrix of recommended performance objectives by occupancy and seismicity for existing federally owned or leased buildings, and rationale behind the recommendations.

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- A review of ATC 28 issues for applicability to requirements for federal buildings, and rationale defending identification of any issues deemed not relevant to the federal effort.
- An identification of any issues not included in ATC 28 that are relevant to the federal effort.
- Recommended resolution of applicable issues identified above, and rationale behind the recommendations.

b. Based on NIST and ICSSC review comments on the draft report, the contractor shall prepare a final report.

<u>Task 2</u>

a. The contractor shall prepare a draft report containing, but not limited to, the following information:

- An assessment of at least six existing federal evaluation and strengthening programs identified in task 1, including but not limited to a comparison of relevant portions of federal programs to the most recent versions of "The NEHRP Handbook for Seismic Evaluation of Existing Buildings" and "The NEHRP Handbook for Techniques for Seismically Rehabilitating Existing Buildings".
- An identification and assessment of the rehabilitation criteria currently in use, recommended for use, or in development by federal, state, local, or private organizations. The six federal programs reviewed above, ICSSC Recommended Practice 3, "Guidelines for Identification and Mitigation of Seismically Hazardous Existing Federal Buildings", and at least four other programs known to the contractor shall be included in the study. Criteria to be assessed shall include, but are not limited to:
  - "triggers" that require rapid hazard screening, detailed capacity assessment, or other evaluation to be performed,
  - level of understrength or other criteria that require strengthening, stiffenening, or other risk-reduction efforts to be initiated,
  - levels of strength or stiffness to be achieved,
  - time frames specified for evaluation or strengthening,
  - exemptions from evaluation and strengthening programs and rationale for such exemptions.
- A detailed summary of seismic evaluation and strengthening standards for existing buildings, including rehabilitation criteria being developed for general use by FEMA (or contractor to FEMA).

b. Based on NIST and ICSSC review comments on the draft report, the contractor shall prepare a final report.

<u>Task 3</u>

a. The contractor shall prepare a draft plan for a trial design program to develop a rational basis for recommending minimum required strength levels for retrofit of existing structures. The trial design program shall consider, as a minimum, seismicity, performance objective, structural system, retrofit method, and level of strengthening. The contractor shall recommend the number and structural type of buildings to be assessed. Rehabilitation costs shall be determined as part of the trial designs.

b. Based on NIST and ICSSC review comments on the draft plan, the contractor shall prepare a final plan.

Task 4

The contractor shall establish a panel of five experts from the private sector to review draft reports and plans. Selection of panel members shall be made jointly with NIST. The contractor shall arrange for at least two meetings of this panel, at a location within the continental United States that minimizes travel for the contractor and the panel members. Dates of the two meetings of the expert panel shall be established by the contractor in consultation with NIST. The contractor shall be responsible for meeting room costs; travel, board and lodging costs for panel members; and any other costs incurred in completion of this task. The panel will review the draft versions of reports and plans described above. The contractor shall produce mintues of the meetings and incorporate comments of the review panel in the final drafts of the documents.

a. The first of the two required meetings shall be held.

b. The second of the two required meetings shall be held.

Task 5

a. The contractor shall prepare a draft report containing, but not limited to, the following information:

- A draft standard for evaluation and strengthening of existing federally owned and leased buildings, with commentary. The draft standard shall reflect the results of the trial design program, shall consider previously established performance objectives and resolutions of ATC-28 (and other) issues, and shall coordinate with anticipated standards being developed by FEMA for general use.
- Implementation guidelines for the draft standard including, but not limited to, information on using existing (or planned) FEMA documents on seismic evaluation and strengthening techniques.
- An assessment, based on the results of task 2, of existing federal agency programs, indicating which programs exceed and which do not meet the requirements of the draft standard and the recommended implementation procedures.

b. Based on NIST and ICSSC review comments on the draft report, the contractor shall prepare a final report.

Schedule of Deliverables

Task 1 a. Three copies of the initial draft report covering identification of existing and proposed programs, recommendation of performance objectives, and sugeested resolution of issues shall be submitted to NIST no later than six weeks after the contract award date.
b. Within 14 calender days following receipt of NIST and ICSSC comments, three copies of the final report and a floppy disk containing a file (in WordPerfect or other compatible format) of the final report, shall be submitted to NIST.

Task 2 a. Three copies of the initial draft report assessing existing federal programs, identifying rehabilitation criteria, and summarizing standards being developed by FEMA shall be submitted to NIST no later than January 17, 1992.
b. Within 21 calender days following receipt of NIST and ICSSC comments, three copies of the final report and 1 copy of a floppy disk containing a file (in WordPerfect or other compatible format) of the final report, shall be submitted to NIST.

Task 3 a. Three copies of the initial draft trial design plan shall be submitted to NIST no later than January 17, 1992.
b. Within 21 calender days following receipt of NIST and ICSSC comments, three copies of the final plan and 1 copy of a floppy disk containing a file (in WordPerfect or other compatible format) of the final plan, shall be submitted to NIST.

Task 4 a. The first meeting shall not be scheduled later than eight weeks after the contract award date. Minutes shall be provided to NIST and to the panel members within 30 days of the meeting.
b. The second meeting shall not be scheduled later than January 31, 1992. Minutes shall be provided to NIST and to the panel members within 30 days of the meeting.

Task 5 a. Three copies of the initial draft report recommending standards for federal use shall be submitted to NIST no later than February 12, 1993.
b. Within 21 calender days following receipt of NIST and ICSSC comments, three copies of the final report and 1 copy of a floppy disk containing a file (in WordPerfect or other compatible format) of the final report, shall be submitted to NIST.

Summary of Changes in Scope of Work

The following are changes to the original Scope of Work as agreed upon by NIST and H. J. Degenkolb Associates/Rutherford & Chekene in project meetings:

November 8, 1991

* Development of the matrix of performance objectives (Task 1C) moved into Task 2.

* Looseleaf copy of both draft and final reports should be included for each task under "Schedule of Deliverables."

February 6, 1992

* The Trial Design Program (Task 3) will be a costing program that will expand the cost data now available from FEMA's typical cost study by Englekirk and Hart. Ranges of costs will be developed for each level of strengthening. The level of detail provided and the number of building types specifically listed will depend on the funding available.

* Resolution of ATC-28 policy issues pertinent to the federal effort (Task 1F) will involve a workshop with ICSSC Subcommittee 1. After we present the issues, Sub 1 members will discuss and form a consensus for this project.

May 4, 1992

* Summary of the FEMA Guidelines effort (Task 2C) moved to Task 5 since nothing is currently available to summarize.

* Development of the matrix of performance objectives (originally Task 1C, now Task 2E) moved into Task 5 to obtain input from ICSSC during Policy Workshop.

* It was agreed to eliminate the first Review Panel meeting originally scheduled to occur during Task 2 to fund the ICSSC Policy Workshop. We agreed to still have one Review Panel meeting during Task 5 sometime in the middle of December.

* It was agreed that no separate report for the Policy Workshop was needed but that the meeting minutes would suffice to document the resolutions decided upon at the Workshop.

APPENDIX B

Part 1: Definition of Symbols

Table 2.4.3.1 from the NEHRP Evaluation Handbook

Table 23-O from the 1991 Uniform Building Code

Table 4-7 from UCRL-15910

Table 1 from H-08-8

Table 3-3 from the Tri-Service Manual

Part 2: NEHRP Evaluation Handbook/ATC-22 Comparison

Part 3: Strength Assessment Example

Part 4: Strength Assessment Worksheets

Part 5: NEHRP Comparison Value Summary

APPENDIX B - Strength Assessment Procedure

Part 1: **Definition of Symbols**

The four pages of hand calculations in this section define the symbols and variables used in the strength assessment worksheets in Part 4 of Appendix B. Most of the symbols are recognizable with the exception of the "Base Shear Factor" and the "Beta Factor".

The "Base Shear Factor" accounts for the differences in design earthquakes between the various procedures. The first line is the equation for base shear, V, as written in the particular code or methodology. The second line pulls out constants between procedures (like "W") and substitutes common variables (like "A" for Av or Aa).

The "Beta Factor" is a fictitious factor to increase the demand side of the evaluation equation to account for brittle elements. This should not be confused with the VA criteria's "beta" for displacement ductility.

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ALLOWABLE STRESS INCREASE: (ASI)

	WOOD	CONCRETE	STEEL	MASONRY
NEHRP	2.0	1.0	1.7	2.5
PS/ATC-22	2.0	1.0	1.7	2.5
TRI-SERVICE/P355 OLD	1.33	1.0	1.33	1.33
VA, FBO, GSA, DOE/UBC	1.33	1.0	1.33	1.33
VA/H 08-8	1.5	1.0	1.7	1.33
DOE/UCRL-15910	1.7	1.0	1.7	1.7
ATC-14	1.33	1.0	1.33	1.33

STRENGTH REDUCTION FACTOR: (φ) [USED BY NEHRP, ATC-22]

WOOD:

1.0 : ALL STRESSES, BOLTS TIMBER CONNECTIONS

0.6 : SHEAR ON CARRIDGE BOLTS

0.9 : LAG & WOOD SCREWS

0.85 : SHEAR ON DIAPHRAGMS AND PLYWOOD WALLS

CONCRETE

0.9 : FLEXURE

0.85 : SHEAR

0.75 : COMPRESSION. WITH SPIRAL REINFORCEMENT

0.70 : COMPRESSION OR BEARING.

STEEL:

0.9 : FLEXURE / STRENGTH

0.67 : CONNECTIONS THAT DO NOT DEVELOP FULL MEMBER STRENGTH

0.6 : METAL DECK DIAPHRAGMS

0.8 : PARTIAL PEN WELDS IN COLUMNS SUBJECTED TO TENSION

MASONRY:

0.8 : AXIAL, FLEXURAL COMPRESSION AND BEARING

0.6 : SHEAR CARRIED BY REBAR AND BOLTS AND MASONRY TENSION ∥ TO BED JOINTS

0.4 : MASONRY TENSION ⊥ TO BED JOINTS

BASE SHEAR FACTOR - ACCOUNTS FOR DIFFERENCES IN DESIGN EARTHQUAKE USING NEHRP HANDBOOK AS BASELINE.

NEHRP

$$V = \frac{0.8 A_v S}{R T^{2/3}} W < \frac{2.12 A_a}{R} W$$

$$BSF = \frac{0.8 A S}{T^{2/3}} < 2.12 A$$

UBC

$$V = \frac{Z I C}{R_w} W = \frac{1.25 Z I S}{R_w T^{2/3}} W < \frac{2.75 Z I}{R_w} W$$

$$BSF = \frac{1.25 A S}{T^{2/3}} < 2.75 A$$

POST OFFICE / ATC-22

$$V = \frac{0.96 A_v S}{R T^{2/3}} W < \frac{2.0 A_a}{R} W$$

$$BSF = \frac{0.96 A S}{T^{2/3}} < 2.0 A$$

VA / H-08-8

$$V = 0.75 A_{max} \alpha (DAF) W = \frac{0.75 A_{max} (DAF)}{1/\alpha} W$$

$$BSF = 0.75 A (DAF).$$

1982 TRI-SERVICE MANUAL

$$V = ZIKCSW = ZIK \frac{1}{15\sqrt{T}} S W < 0.14\, ZIKW$$

$$BSF = Z \frac{1}{15\sqrt{T}} S < 0.14 Z$$

ATC-14

$$V = \frac{0.8 A_v S}{R_W T^{2/3}} W < \frac{2.12 A_a}{R_W} W$$

$$BSF = \frac{0.8 A S}{T^{2/3}} < 2.12 A$$

DOE/UCRL-15910

$$V = \frac{ZIC}{F_M} W = \frac{1.25 ZIS}{F_M T^{2/3}} W < \frac{2.75 ZI}{F_M} W$$

$$BSF = \frac{1.25 A S}{T^{2/3}} < 2.75 A$$

BETA FACTOR : (β) - A FICTICIOUS FACTOR TO INCREASE THE DEMAND FOR BRITTLE ELEMENTS.

NEHRP

$\beta = 0.5 C_d$ FOR BRITTLE ELEMENTS > 1.5.

PS/ATC-22

$\beta = 0.75 C_d$ FOR BRITTLE ELEMENTS.

ATC-14

$\beta = 0.4 R_w$ FOR BRITTLE ELEMENTS

LOAD FACTOR : (L.F.)

- MOST OF THE PROCEDURES BASED ON STRENGTH USE A LOAD FACTOR OF 1.0 FOR EARTHQUAKE LOAD FOR MOST MATERIALS.
- THE EXCEPTION IS USUALLY CONCRETE WHERE THE LOAD FACTOR FOR UBC IS 1.4 AND FOR DOE IS 1.7.

TABLE 2.4.3.1
Response Coefficients*

R	C_d	System
		Bearing Wall Systems
6.5	4	Light-framed walls with shear panels
4.5	4	Reinforced concrete shear walls
3.5	3	Reinforced masonry shear walls
4	3.5	Concentrically braced frames
1.25	1.25	Unreinforced masonry shear walls
		Building Frame Systems
8	4	Eccentrically braced frames, moment resisting connections at columns away from link
7	4	Eccentrically braced frames, non-moment resisting connections at columns away from link
7	4.5	Light-framed walls with shear panels
5	4.5	Concentrically braced frames
5.5	5	Reinforced concrete shear walls
4.5	4	Reinforced masonry shear walls
3.5	3	Tension-only braced frames
1.5	1.5	Unreinforced masonry shear walls
		Moment Resisting Frame System
8	5.5	Special moment frames of steel
8	5.5	Special moment frames of reinforced concrete
4	3.5	Intermediate moment frames of reinforced concrete
4.5	4	Ordinary moment frames of steel
2	2	Ordinary moment frames of reinforced concrete
		Dual System with a Special Moment Frame Capable of Resisting at Least 25% of Prescribed Seismic Forces
		Complementary seismic resisting elements
8	4	Eccentrically braced frames, moment resisting connections at columns away from link
7	4	Eccentrically braced frames, non-moment resisting connections at columns away from link
6	5	Concentrically braced frames
8	6.5	Reinforced concrete shear walls
6.5	5.5	Reinforced masonry shear walls
8	5	Wood sheathed shear panels
		Dual System with an Intermediate Moment Frame of Reinforced Concrete or an Ordinary Moment Frame of Steel Capable of Resisting at Least 25% of Prescribed Seismic Forces
		Complementary seismic resisting elements
5	4.5	Concentrically braced frames
6	5	Reinforced concrete shear walls
5	4.5	Reinforced masonry shear walls
7	4.5	Wood sheathed shear panels
		Inverted Pendulum Structures
2.5	2.5	Special moment frames of structural steel
2.5	2.5	Special moment frames of reinforced concrete
1.25	1.25	Ordinary moment frames of structural steel

*The response modification factors, (R), and deflection amplification factors, (C_d), are from Table 3-2 of the 1988 *NEHRP Recommended Provisions*; see these provisions for details.

NOTE: The American Iron and Steel Institute has written a minority opinion concerning this table; see the conclusion of this document.

TABLE NO. 23-O—STRUCTURAL SYSTEMS

BASIC STRUCTURAL SYSTEM[1]	LATERAL LOAD-RESISTING SYSTEM—DESCRIPTION	R_w[2]	H[3]
A. Bearing Wall System	1. Light-framed walls with shear panels		
	a. Plywood walls for structures three stories or less	8	65
	b. All other light-framed walls	6	65
	2. Shear walls		
	a. Concrete	6	160
	b. Masonry	6	160
	3. Light steel-framed bearing walls with tension-only bracing	4	65
	4. Braced frames where bracing carries gravity loads		
	a. Steel	6	160
	b. Concrete[4]	4	—
	c. Heavy timber	4	65
B. Building Frame System	1. Steel eccentrically braced frame (EBF)	10	240
	2. Light-framed walls with shear panels		
	a. Plywood walls for structures three stories or less	9	65
	b. All other light-framed walls	7	65
	3. Shear walls		
	a. Concrete	8	240
	b. Masonry	8	160
	4. Concentrically braced frames		
	a. Steel	8	160
	b. Concrete[4]	8	—
	c. Heavy timber	8	65
C. Moment-resisting Frame System	1. Special moment-resisting frames (SMRF)		
	a. Steel	12	N.L.
	b. Concrete	12	N.L.
	2. Concrete intermediate moment-resisting frames (IMRF)[6]	8	—
	3. Ordinary moment-resisting frames (OMRF)		
	a. Steel	6	160
	b. Concrete[7]	5	—
D. Dual Systems	1. Shear walls		
	a. Concrete with SMRF	12	N.L.
	b. Concrete with steel OMRF	6	160
	c. Concrete with concrete IMRF[6]	9	160
	d. Masonry with SMRF	8	160
	e. Masonry with steel OMRF	6	160
	f. Masonry with concrete IMRF[4]	7	—
	2. Steel EBF		
	a. With steel SMRF	12	N.L.
	b. With steel OMRF	6	160
	3. Concentrically braced frames		
	a. Steel with steel SMRF	10	N.L.
	b. Steel with steel OMRF	6	160
	c. Concrete with concrete SMRF[4]	9	—
	d. Concrete with concrete IMRF[4]	6	—
E. Undefined Systems	See Sections 2333 (h) 3 and 2333 (i) 2	—	—

[1]Basic structural systems are defined in Section 2333 (f).
[2]See Section 2334 (c) for combination of structural system.
[3]*H*—Height limit applicable to Seismic Zones Nos. 3 and 4. See Section 2333 (g).
[4]Prohibited in Seismic Zones Nos. 3 and 4.
[5]N.L.—No limit.
[6]Prohibited in Seismic Zones Nos. 3 and 4, except as permitted in Section 2338 (b).
[7]Prohibited in Seismic Zones Nos. 2, 3 and 4.

1991 UNIFORM BUILDING CODE

DOE/UCRL-15910

Table 4-7 Code Reduction Coefficients, R_W and Inelastic Demand Capacity Ratios, F_μ

Structural System (terminology is identical to Ref. 8)	Category		
	GU & I or LH	MH	HH
	R_W	F_μ	
MOMENT RESISTING FRAME SYSTEMS - Beams			
Steel Special Moment Resisting Space Frame (SMRSF)	12	3.0	2.5
Concrete SMRSF	12	2.7	2.2
Concrete Intermediate Moment Frame (IMRSF)	7	1.5	1.2
Steel Ordinary Moment Resisting Space Frame	6	1.5	1.2
Concrete Ordinary Moment Resisting Space Frame	5	1.2	1
SHEAR WALLS			
Concrete or Masonry Walls	8 (6)	1.7	1.4
Plywood Walls	9 (8)	1.7	1.4
Dual System, Concrete with SMRSF	12	2.5	2.0
Dual System, Concrete with Concrete IMRSF	9	2.0	1.7
Dual System, Masonry with SMRSF	8	1.5	1.2
Dual System, Masonry with Concrete IMRSF	7	1.4	1.1
STEEL ECCENTRIC BRACED FRAMES (EBF)			
Beams and Diagonal Braces	10	2.7	2.2
Beams and Diagonal Braces, Dual System with Steel SMRSF	12	3.0	2.5
CONCENTRIC BRACED FRAMES			
Steel Beams	8 (6)	2.0	1.7
Steel Diagonal Braces	8 (6)	1.7	1.4
Concrete Beams	8 (4)	1.7	1.4
Concrete Diagonal Braces	8 (4)	1.5	1.2
Wood Trusses	8 (4)	1.7	1.4
Beams and Diagonal Braces, Dual Systems			
Steel with Steel SMRSF	10	2.7	2.2
Concrete with Concrete SMRSF	9	2.0	1.7
Concrete with Concrete IMSRF	6	1.4	1.1

Note: Values herein assume good seismic detailing practice per Section 4.3 and Reference 8, along with reasonably uniform inelastic behavior. Otherwise, lower values should be used.

Values in parentheses apply to bearing wall systems or systems in which bracing carries gravity loads.

F_μ for columns of all structural systems is 1.5 for Moderate Hazard facilities and 1.2 for High Hazard facilities. For columns subjected to combined axial compression and bending, interaction formulas from Figures 4-2 and 4-3 of Reference 9 should be used for Moderate and High Hazard facilities.

Connections for steel concentric braced frames should be designed for the lesser of:
- the tensile strength of the bracing.
- the force in the brace corresponding to F_μ of unity.
- the maximum force that can be tranferred to the brace by the structural system

Connections for steel moment frames and eccentric braced frames and connections for concrete, masonry, and wood structural systems should follow Reference 8 provisions utilizing the prescribed seismic loads from these guidelines and the strength of the connecting members. In general, connections should develop the strength of the connecting members or be designed for member forces corresponding to F_μ of unity, whichever is less.

F_μ for chevron, vee, and K bracing is 1.5 for Moderate Hazard facilities and 1.2 for High Hazard facilities. K bracing is not permitted in buildings of more than two stories for Z of 0.25g or more. K bracing requires special consideration for any building if Z is 0.25g or more.

For Moderate and High Hazard facilities, it is permissible to use the F_μ value which applies to the overall structural system for structural elements not mentioned on the above table. For example, to evaluate diaphragm elements, footings, pile foundations, etc., F_μ of 3.0 may be used for a Moderate Hazard steel SMRSF. In the case of a Moderate Hazard steel concentric braced frame, F_μ of 1.7 may be used.

TABLE 1

STRUCTURAL SYSTEM FACTOR α AND DRIFT COEFFICIENT β

	α	β
Structural Steel Moment Resisting Frames		
Ductile Frames	1/4	4
Conventional Frames	1/3	3
Reinforced Concrete Moment Resisting Frames		
Ductile	1/4	3
Semi-Ductile Frames	1/4	3
Conventional Frames	1/2	2
Structural Walls		
*Steel Bracing (Conventional)	1/2	2
Steel Bracing (Ductile)	1/3	3/2
R/C Shear Walls	1/4	3
Reinforced Masonry Shear Walls	1/3	1
**Unreinforced Masonry	2/3	1
Wood	1/3	-

*"Conventional" steel bracing may be used without the 1.25 multiplier in the Uniform Building Code. "Ductile bracing" must be approved by VA to permit the use of the lower α value.

**Where A_{max} is 0.10 or higher, all masonry construction shall be in accordance with the reinforced masonry requirements of the current Uniform Building Code.

Existing Buildings

The above α and β values are to be used for existing buildings with the following exceptions:

	α	β
Reinforced Concrete Shear Walls	1/3	3/2
Conventional (non ductile) Reinforced Concrete Frames: $A_{max} \geq 0.05$	2/3	3/2
$A_{max} < 0.05$	1/2	-

Elevated Tanks

Elevated tanks plus full contents, on braced legs and not supported by a building, shall have the appropriate α above multiplied by 2. (The β requirement is waived for this case.)

*Table 3-3. Horizontal Force Factor "K" for Buildings or Other Structures**
(Refer to Table 3-7 (Paragraph 3-6) for Summary Tables for K Values for Each Seismic Zone.)

Basic System	Category	Type or Arrangement of Resisting Elements	Value of K[a,b]
100% Frames	1	Buildings with a ductile moment resisting space frame designed in accordance with the following criteria: The ductile moment resisting space frame shall have the capacity to resist the total required lateral force.	0.67
	2	Buildings with moment resisting space frames designed in accordance with the following criteria: The moment resisting space frame shall have the capacity to resist the total required lateral force and shall comply with the height limitations and frame specifications of Table 3-7.	1.00
Dual Systems	3	Buildings with a dual bracing system consisting of a moment resisting space frame and shear walls or braced frames designed in accordance with the following criteria: a. The moment resisting space frames shall comply with the specifications and height limitations of Table 3-7. b. The frame and shear walls or braced frames shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the shear walls and frames. c. The shear walls or braced frames acting independently of the moment resisting space frame shall resist the total required lateral force. d. The moment resisting space frame shall have the capacity to resist not less than 25 percent of the required lateral force.	0.80
100% Walls or Braced Frames	4	Buildings with a vertical load carrying space frame and shear walls or braced frames designed in accordance with the following criteria: a. In Seismic Zones 2, 3, and 4 the height of the building shall not exceed 160 feet.[c] b. The shear wall or braced frame shall have the capacity to resist the total required lateral force and shall comply with the height limitations and wall specifications of Table 3-7. c. The interaction between the vertical load carrying space frame and the shear walls or braced frames shall not result in the loss of the vertical load carrying capacity of the space frame in the case of damage occurring to a portion of the lateral force resisting system (see paragraph 3-3(J)1d).	1.00
	5	Building with wood frame construction and plywood shear walls designed in accordance with the following criteria:** a. The height of the building shall not exceed 40 feet or three stories. b. The plywood shear walls shall have the capacity to resist the total required lateral force. c. Masonry veneers shall not be used. (If veneers are used, K = 1.33.)	1.00
	6	Buildings with a box system designed in accordance with the following criteria: a. In Seismic Zones 2, 3, and 4 the height of the building shall not exceed 160 feet.[c] b. The shear walls or braced frames shall have the capacity to resist the total lateral force and shall comply with the height limitations and wall specifications of Table 3-7.	1.33[a]
Elevated Tanks and Inverted Pendulums	7	Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a building. The braced frame requirements of paragraph 3-3(J)1g and the torsional requirements of paragraph 3-3(E)5 shall apply. The product of KCS will not be less than 0.12. Refer to Chapter 11 for inverted pendulums.[d]	2.5[d]
Structures Other Than Buildings	8	Structures other than buildings, elevated tanks, or minor structures set forth in Table 3-4. The product of KCS will not be less than 0.10. Also, refer to Chapter 11.[d]	2.0

*Modification of SEAOC Table 1A.

**In 1980 SEAOC modified this category to include "buildings--with stud wall framing and using horizontal diaphragms and vertical shear panels for the lateral force system." Therefore, walls in accordance with either paragraph 6-5a or paragraph 6-5b of Chapter 6 will be in compliance with item 5b above.

Part 2: <u>**NEHRP Evaluation Handbook/ATC-22 Comparison**</u>

This table compares the brittle, semi-ductile and ductile provisions in ATC-22 with those in the NEHRP Evaluation Handbook. The NEHRP Handbook does not include most of the semi-ductile provisions of ATC-22 and in general is less conservative than ATC-22 and more in line with ATC-14. In the strength assessment worksheets in Part 4 of Appendix B, only ductile and non-ductile provisions are compared.

NEHRP EVALUATION HANDBOOK - ATC-22 COMPARISON OF BRITTLE, SEMI-DUCTILE, AND DUCTILE PROVISIONS

PROVISION	SPECIFIC ITEM TO BE CHECKED	ATC-22[1] MODIFIER	NEHRP[2] MODIFIER
BRITTLE PROVISIONS			
PRECAST CONCRETE SHEARWALLS		0.75Cd	DELETED
BRACED FRAME	K-BRACING	0.75Cd	0.5Cd
WEAK STORY		0.75Cd	0.5Cd
CONCRETE CORBEL CONNECTIONS		0.75Cd	0.5Cd
STEEL COLUMN SPLICES	PARTIAL PEN WELDS	0.75Cd	0.5Cd
PRECAST CONNECTIONS		0.75Cd	0.5Cd
VERTICAL DISCONTINUITY	COLUMN OVERTURNING	0.75Cd	0.5Cd
CONC. COLUMN SPLICES		0.75Cd	0.5Cd
PRECAST PANEL-TO-PANEL CONN.		0.75Cd	0.5Cd
SEMI-DUCTILE PROVISIONS			
REINFORCING STEEL		0.375Cd	1.25*Force
BRACED FRAME - DIAG. STIFFNESS		0.375Cd	1.25*Force
CONFINEMENT REINFORCEMENT		0.375Cd	1.25*Force
BRACED FRAME	CHEVRON-BRACING	0.375Cd	1.0
MOMENT CONNECTIONS		0.375Cd	1.0
SOFT STORY		0.375Cd	1.0
PRECAST FRAMES		0.375Cd	1.0
TORSION		0.375Cd	1.0
FRAMES NOT PART OF LAT. SYS.	COMPLETE FRAMES	0.375Cd	1.0
COMPACT MEMBERS		0.375Cd	1.0
OVERDRIVEN NAILS		0.375Cd	1.0
COUPLING BEAMS		0.375Cd	1.0
PRESTRESSED MEMBERS		0.375Cd	0.75*R
INFILL WALLS	SHEAR CAP. OF COLUMNS	0.375Cd	0.5Cd
DUCTILE PROVISIONS			
NO CHANGES		1.0	1.0

1 MODIFIER OF Q_E APPLIED TO BRITTLE, SEMI-DUCTILE, AND DUCTILE ELEMENTS. SEE SECTION 2.4.10 OF ATC-22.

2 MODIFIER OF Q_E APPLIED TO NON-DUCTILE AND DUCTILE ELEMENTS. THE "0.5Cd" MODIFIER MUST BE GREATER THAN 1.5 "1.25*FORCE" IMPLIES THAT Q_E FOR A PARTICULAR ELEMENT IS INCREASED 25%. R REFERS TO THE NEHRP STRUCTURAL SYSTEM MODIFICATION FACTORS.

APPENDIX B - Strength Assessment Procedure

Part 3: <u>Strength Assessment Example</u>

This example presents sample calculations to illustrate the results of the Strength Assessment Worksheets in Part 4. The building selected, the Foothill Medical Center in San Fernando, is a two-story, steel-frame building. Its lateral force resisting system consists of moment frames in the longitudinal direction and braced frames in the transverse direction. The building suffered some damage to its braced frame during the 1971 San Fernando earthquake. It was selected because a good deal of information is known about the building and the information is readily available. [See "San Fernando, California, Earthquake of February 9, 1971," U.S. Department of Commerce, NOAA, Washington, D.C., pp. 179-188 for more complete information about the building].

First, the design earthquake force in one of the first-story braces of the braced frame at line 3 is computed using the original static lateral design loads of the 1962 Los Angeles Building Code. The force in the brace is then re-computed using the lateral forces derived from each of the evaluation methodologies. The soil type is assumed to be S2, the building importance to be normal occupancy and the seismic zone to be Zone 4 (UBC). Then, the capacity of the existing brace is computed using each of the procedures. Finally, the capacity/demand ratio is computed for each procedure and the C/D ratios are normalized with NEHRP as the basis. A discussion of the results follows the calculations.

STRENGTH ASSESSMENT EXAMPLE

FOOTHILL MEDICAL CENTER

12502 VAN NUYS BOULEVARD, SAN FERNANDO

A) LOADING.

ROOF:

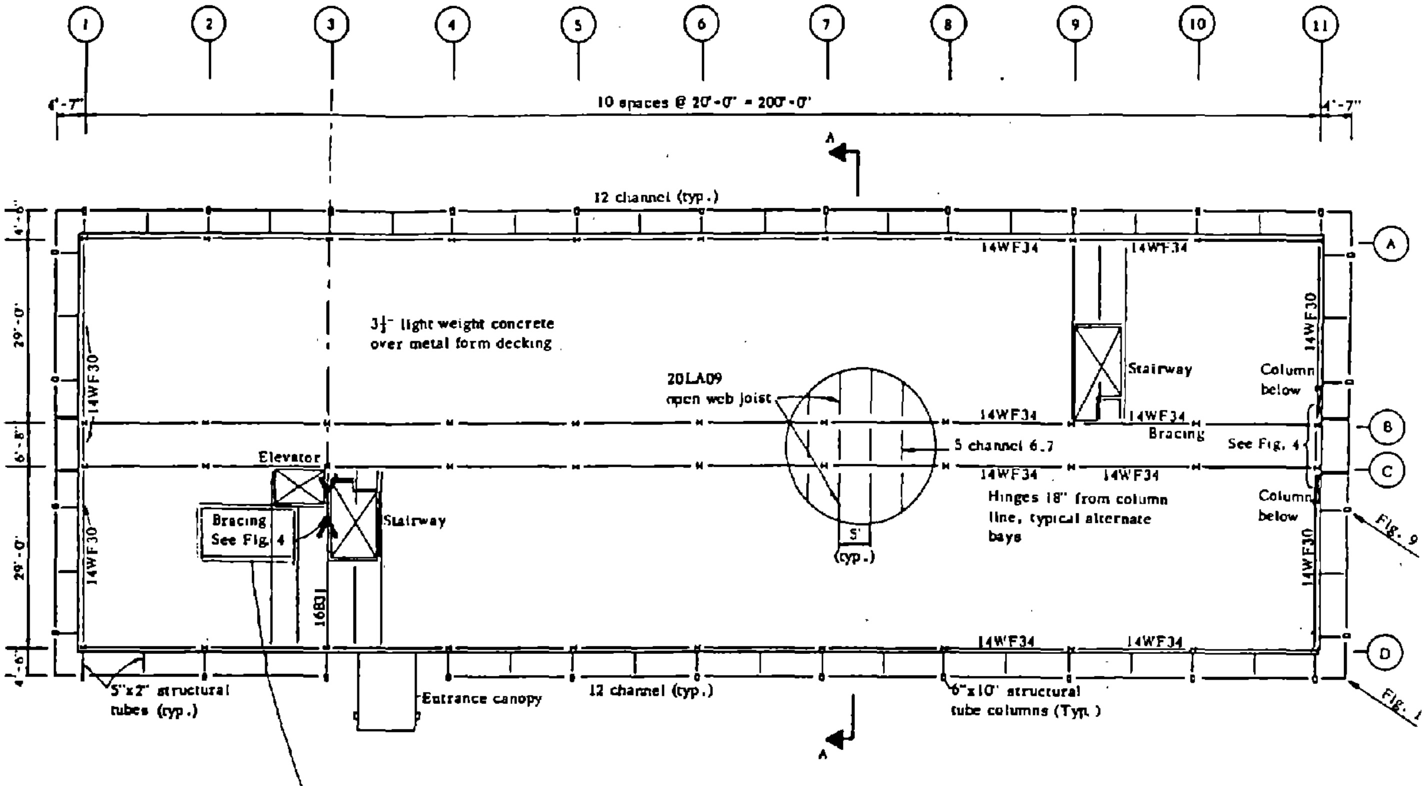
ROOF:	JOISTS & BEAMS	7 psf
	ROOFING	6
	DECK	1
	DUCTS	2
	CEILING	10
	3" LT. WT. CONC. FILL	26
		52 psf

WEIGHT OF ROOF = (0.052 ksf)(201')(66') = 690^k
\+ 34^k (MECH'L EQUIP.)
(0.018 ksf)(37')(54') = 36^k (PENTHOUSE)

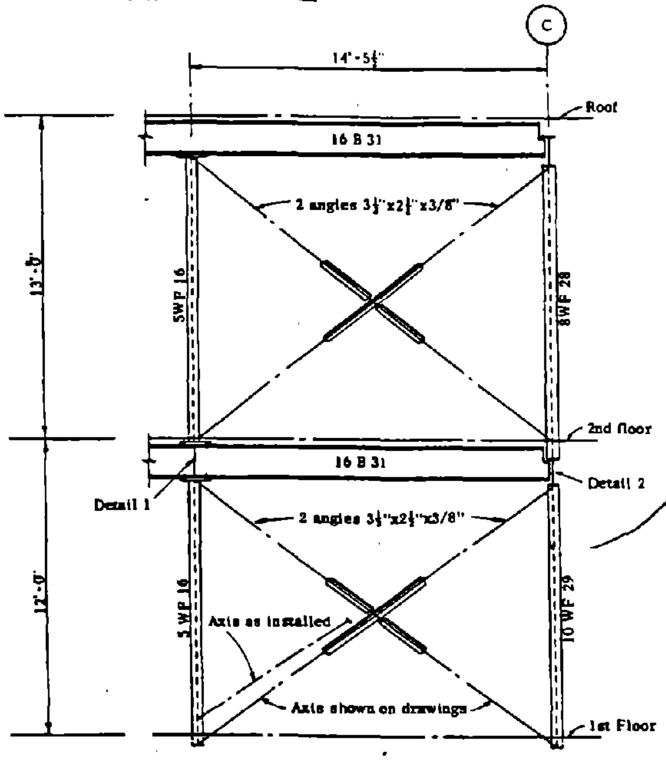
760^k

2ND FLOOR:	JOISTS & BEAMS	7 psf
	FIN. FLOOR	1
	DECK	2
	DUCTS	2
	CEILING	10
	PARTITIONS	20
	3½" LT. WT. CONC. FILL	31
		73 psf

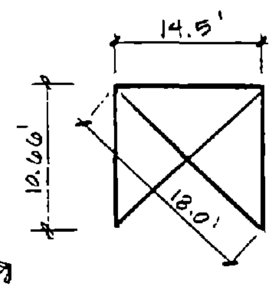
WEIGHT OF 2ND FLOOR = (0.073 ksf)(201')(66') = 968^k



SECOND FLOOR FRAMING PLAN



ELEVATION OF BRACING LINE 3



SOURCE: "SAN FERNANDO, CALIFORNIA, EARTHQUAKE OF FEBRUARY 9, 1971," U.S. DEPT. OF COMMERCE, NOAA, WASHINGTON D.C., 1973, pp 181, 183.

B) BASE SHEAR / BRACE FORCE - TRANSVERSE DIRECTION

1.) ORIGINAL DESIGN - 1962 L.A. BUILDING CODE

$V = KCW$ where $K = 1.33$ - BRACED FRAME
$C = 0.1$

$V = (1.33)(0.1)W = 0.133\,W$ $\quad 0.133(760) = 101^k$
$0.133(968) = 129^k$
230^k

- ASSUME FRAME ON LINE - 3 TAKES 62.5% OF SEISMIC LOAD IN TRANSV. DIRECTION:
  (TRIB. AREA = WORST CASE)

$\therefore V_{line\,3} = 0.625(230^k) = 143^k$

- LOAD IN ONE DIAGONAL BRACE ASSUMING BOTH DIAGONALS WORK IN TENSION AND COMPRESSION:

$$\therefore V_{brace} = \frac{143^k}{2\text{ braces}}\left(\frac{18.00}{14.5}\right) = 89^k$$

2.) NEHRP EVALUATION HANDBOOK

$$V = \frac{0.8\,A_v\,S}{R\,T^{2/3}}W \quad \text{where}$$

limited by $\frac{2.12\,A_a}{R}W$

$A_a = 0.4$
$A_v = 0.4$ - LOS ANGELES
$S = 1.2$ - DENSE SOIL > 200'
$R = 5$ - BRACED FRAME
$T = 0.22$ sec - $0.02(25')^{3/4}$

$$V = \frac{0.8(0.4)(1.2)}{(5)(0.22)^{2/3}}W = 0.21\,W \qquad \frac{2.12(0.4)}{5}W = 0.17\,W$$
(CONTROLS)

$0.17(760) = 129^k$
$0.17(968) = 165^k$
294^k

$V_{line\,3} = 0.625(294^k) = 184^k$

$V_{brace} = 0.621(184^k) = 114^k$

3.) ATC-14

$$V = \frac{0.8 A_v S}{R_w T^{2/3}} W \quad \text{limited by} \quad \frac{2.12 A_a}{R_w} W$$

where
$A_v = 0.4$, $A_a = 0.4$
$S = 1.2$
$R_w = 8$ - BRACED FRAME
$T = 0.22$ sec

$$V = \frac{0.8(.4)(1.2)}{(8)(0.22)^{2/3}} W = 0.132 \qquad \frac{2.12(.4)}{8} W = 0.106 W$$

↑ CONTROLS

$0.106\ (760) = 81^k$
$0.106\ (968) = 103^k$
184^k

$V_{line\ 3} = 0.625(184^k) = 115^k$

$V_{brace} = 0.621\ (115^k) = 71^k$

4.) POSTAL SERVICE / ATC-22

$$V = \frac{0.96 A_v S}{R T^{2/3}} W \quad \text{limited by} \quad \frac{2.0 A_a}{R} W$$

where A_v, A_a, S, R & T are same as for NEHRP

$$V = \frac{0.96(0.4)(1.2)}{(5)(0.22)^{2/3}} W = 0.253 W \qquad \frac{2.0(0.4)}{5} W = 0.16 W$$

↑ CONTROLS

$0.16\ (760) = 122^k$
$0.16\ (968) = 155^k$
277^k

$V_{line\ 3} = 0.625(277^k) = 173^k$

$V_{brace} = 0.621\ (173^k) = 107^k$

5) 1982 TRI-SERVICE MANUAL

$V = ZIK \frac{1}{15\sqrt{T}} SW$ limited by $0.14\,ZIKW$

where:
- Z = 1.0 - ZONE 4, LOS ANGELES
- I = 1.0 - IMPORTANCE = NORMAL FACILITY
- K = 1.0 - STEEL BRACED FRAME
- S = 1.2
- T = 0.22 sec

$V = (1.0)(1.0)(1.0) \frac{1}{15\sqrt{0.22}} (1.2) W = 0.171 W$ $\quad 0.14(1.0)(1.0)(1.0) W = 0.14 W$ ← CONTROLS

$0.14(760) = 106^k$
$0.14(968) = 136^k$
$\overline{242^k}$

V line 3 = $0.625(242^k) = 151^k$

V brace = $0.621(151^k) = \underline{94^k}$

6) UNIFORM BUILDING CODE

$V = \frac{1.25\,Z\,I\,S}{R_w\,T^{2/3}} W$ limited by $\frac{2.75\,Z\,I}{R_w} W$

where:
- Z = 0.4 - ZONE 4, LOS ANGELES
- I = 1.0 - IMPORTANCE = NORMAL FACILITY
- S, Rw & T are same as for ATC-14.

$V = \frac{1.25(.4)(1.0)(1.2)}{8\,(0.22)^{2/3}} W = 0.204 W$ $\quad \frac{2.75(.4)(1.0)}{8} W = 0.138 W$ ← CONTROLS

$0.138(760) = 105^k$
$0.138(968) = 134^k$
$\overline{239^k}$

V line 3 = $0.625(239^k) = 149^k$

V brace = $0.621(149^k) = \underline{93^k}$

7) V.A. / H-08-8

$$V = 0.75\, A_{max}\, \alpha\, (DAF)\, W$$

where:
A_{max} = 0.4 - LOS ANGELES
α = 1/3 - DUCTILE STEEL BRACING
DAF = 3.0 - FOR T = 0.22 sec

$$V = 0.75(0.4)(1/3)(3.0)\,W = 0.30\,W$$

$0.3(760) = 228^k$
$0.3(968) = 290^k$
518^k

$V_{line\ 3} = 0.625(518^k) = 324^k$

$V_{brace} = 0.621(324^k) = 201^k$

8) DOE / UCRL-15910 / MH & HH BUILDINGS

$$V = \frac{1.25\, Z\, I\, S}{F_\mu\, T^{2/3}}\, W \quad \text{limited by} \quad \frac{2.75\, Z I}{F_\mu}\, W$$

where F_μ = 1.4 - STEEL BRACED FRAME MEMBERS
Z, I, S, & T are the same as for UBC

$$V = \frac{1.25(0.4)(1.0)(1.2)}{1.4\,(0.22)^{2/3}}\,W = 1.17\,W \qquad \frac{2.75(.4)(1.0)}{1.4}\,W = 0.786\,W$$

CONTROLS

$0.786(760) = 597^k$
$0.786(968) = 761^k$
1358^k

$V_{line\ 3} = 0.625(1358^k) = 849^k$

$V_{brace} = 0.621(849^k) = 527^k$

c) CHECK BRACE

1962 LA / ATC-14 / 1982 TSM / UBC

- DOUBLE ANGLE BRACES : ⅃L $3\frac{1}{2} \times 2\frac{1}{2} \times 3/8''$
- A-7 STEEL ; ASSUME $F_y = 33$ ksi

ALLOWABLE TENSION CAPACITY : $T = 1.33(0.6) F_y A$

$= 1.33(0.6)(33\text{ksi})(4.22 \text{ in}^2)$

$= \underline{\underline{111^k}}$

- ASSUME DIAGONAL IN TENSION BRACES DIAGONAL IN COMPRESSION
- UNBRACED LENGTH = $l/r = 96$

$kl/r = (1.0)96 = 96$ $C_c = 131.7$ $\frac{kl/r}{C_c} = 0.73$ $F_a = 0.392$

ALLOWABLE COMPRESSION CAPACITY : $P = 1.33 F_a F_y A$

$= 1.33(0.392)(33 \text{ ksi})(4.22 \text{ in}^2)$

$= \underline{\underline{73^k}}$ ← CONTROLS

NEHRP / ATC-22

- DOUBLE ANGLE BRACES : ⅃L $3\frac{1}{2} \times 2\frac{1}{2} \times 3/8''$
- A-7 STEEL ; ASSUME $F_y = 33$ ksi

TENSION STRENGTH : $T = \phi F_y A$

$= 0.9(33 \text{ksi})(4.22 \text{ in}^2)$

$= \underline{\underline{125^k}}$

COMPRESSION STRENGTH : $P = \phi\, 1.7 F_a F_y A$

$= 0.9 (1.7)(0.392)(33 \text{ksi})(4.22 \text{ in}^2)$

$= \underline{\underline{84^k}}$ ← CONTROLS

H-08-B / UCRL-15910

- DOUBLE ANGLE BRACES : ⅃L 3½ × 2½ × 3/8"
- A-7 STEEL ; ASSUME F_y = 33 ksi

<u>TENSION STRENGTH</u> :

$$T = F_y A$$
$$= (33\ ksi)(4.22\ in^2)$$
$$= \underline{\underline{139^k}}$$

<u>COMPRESSION STRENGTH</u> :

$$P = 1.7\ F_a F_y A$$
$$= 1.7\ (0.392)(33\ ksi)(4.22\ in^2)$$
$$= \underline{\underline{93^k}} \leftarrow \text{CONTROLS}$$

D) CAPACITY / DEMAND

- NORMALIZE ALL VALUES SO THAT NEHRP = 1.00

	CAPACITY	DEMAND	C/D	NEHRP COMPARISON
NEHRP	84^k	114^k	0.74	1.00
ATC-14	73^k	71^k	1.03	0.72
PS/ATC-22	84^k	107^k	0.79	0.94
1982 TSM	73^k	94^k	0.78	0.95
UBC	73^k	93^k	0.78	0.95 *
VA / H-08-B	93^k	201^k	0.46	1.61
DOE / UCRL-15910	93^k	527^k	0.18	4.11
1962 L.A.	73^k	89^k	0.82	0.90

* IGNORES DETAILING PROVISIONS — SEE DISCUSSION NEXT PAGE

E.) DISCUSSION.

- THE CAPACITY/DEMAND RATIOS SHOW THAT ONLY ONE PROCEDURE, ATC-14, WOULD DEEM THE BRACE AS ADEQUATE. ALL OTHER PROCEDURES WOULD DEEM THE BRACE AS INADEQUATE. FOR ALL PROCEDURES (EXCEPT ATC-14) THE BRACE WOULD HAVE TO BE STRENGTHENED TO ACHIEVE A $C/D > 1.0$.

- THE "NEHRP COMPARISON" VALUES ARE VERY CLOSE TO THOSE OBTAINED IN THE STRENGTH ASSESSMENT WORKSHEETS (SEE PART 4, APPENDIX B) FOR SHORT PERIOD, STEEL BRACED FRAMES, IN HIGH SEISMIC ZONES.

- IT IS IMPORTANT TO NOTE THAT THIS EVALUATION EXAMPLE HAS NEGLECTED SPECIFIC DETAILING PROCEDURES AND REQUIREMENTS OF MODERN CODES. FOR EXAMPLE, THE UBC IN §2710 (h) REQUIRES a) l/r OF BRACES NOT TO EXCEED $720\sqrt{F_y}$, b) l/r OF BUILT-UP BRACES BETWEEN STICH PLATES NOT TO EXCEED 75% OF l/r OF MEMBER AS A WHOLE AND c) BRACES MUST BE COMPACT. OUR EXAMPLE BUILDING FAILS ALL THREE OF THESE CRITERIA. THE UBC, HOWEVER, HAS A SPECIFIC ALTERNATIVE FOR BRACES IN 1- AND 2- STORY BUILDINGS THAT DO NOT MEET THE ABOVE CRITERIA. UBC §2710 (h) 5 ALLOWS BRACES NOT MEETING THE DUCTILITY REQUIREMENTS TO HAVE STRENGTH TO RESIST $3/8\,R_w$ TIMES THE CODE EQUIVALENT STATIC FORCES. THIS WOULD CAUSE THE DEMANDS TO TRIPLE FOR AGENCIES USING THE UBC TO EVALUATE THIS BUILDING THE NEW "NEHRP COMPARISON" VALUE WOULD BE 2.83 FOR THE UBC RATHER THAN 0.95. ALSO NOTE, HAD THE BUILDING BEEN THREE STORIES, A STRICT INTERPRETATION OF THE UBC WOULD HAVE REQUIRED THE OLD BRACE TO BE REMOVED OR NEGLECTED BECAUSE IT DOES NOT MEET THE DETAILING REQUIREMENTS.

Part 4: Strength Assessment Worksheets

The worksheets in this Section compare different agency programs using a representative set of individual statements from the NEHRP Evaluation Handbook. The intent of the worksheets is to present quantitative comparisons of strength influenced by a number of different variables: seismic zone, soil condition, building period, structural system, local ductility, and agency criteria. Such a comparison requires consideration of differences on both the demand and capacity side of the criteria.

The eight worksheets cover combinations of: moderate/high seismic zones, soft/firm soil sites, and 1-story/10-story buildings. Each worksheet addresses the following structural systems: special steel moment frame, steel braced frame, non-ductile concrete moment frame, special concrete moment resisting frame, concrete shear wall, steel frame with unreinforced masonry infill walls, and steel frame with reinforced masonry infill walls. For each system, both a ductile and a non-ductile statement are selected, if applicable. The strength procedures in the NEHRP Evaluation Handbook are used as a basis for the rest of the criteria. The NEHRP Handbook is compared to: ATC-14, ATC-22 (Postal Service ATC-26-1), 1976 SEAOC "Blue Book" (1982 Tri-Service Manual), 1988 UBC (VA for Medical Office Buildings, FBO, GSA, DOE for General Use buildings, 1992 draft Tri-Service Manual), H-08-8 (VA for Hospitals) and UCRL-15910 (DOE for Moderate Hazard facilities using static procedure).

At the start of each worksheet, the base shear is normalized using the NEHRP Evaluation Handbook as a baseline. First, the various factors to be investigated are input into the worksheet (seismic zone EPA, soil factor, building period, Dynamic Amplification Factor for VA using their spectrum, and seismic coefficient for Tri-Service criteria). Next, the value of base shear on the spectrum curve is computed and the cutoff value for low period buildings is computed. The "Base Shear" is the taken as the minimum of these two values. The "Base Shear" does not include the weight of the building or any building system reduction coefficients and can be thought of the base shear in percentage of gravity before reduction. The "Base Shear Factor" is the ratio of a criteria's "Base Shear" to the "Base Shear" of NEHRP which has been normalized to one.

The procedure for each statement is identical. First, the variables for each code or methodology are input into the worksheet (see Part 1 of Appendix B for definitions of symbols). Then, the rated capacity is computed using each criteria taking into account any allowable stress increases or phi factors. The capacity for NEHRP is fixed at 100 and the rest of the values are normalized to NEHRP. For example, using the NEHRP Handbook, for a connection in a steel braced frame which does not develop the full strength of the member, the allowable stress increase is 1.7 and the phi factor is 0.67. For a "rated" capacity of 100, the actual capacity of the connection is 100/(1.7*0.67) = 87.8. The same connection capacity calculated with ATC-22 would use an allowable stress increase of 1.33 and a phi factor of 1.0. Thus, for ATC-22, if the "rated" capacity of NEHRP is 100, the "rated" capacity of ATC-22 is (1.33)(1.0)(87.8) = 116.8.

The "related" demand is then computed for each criteria taking into account any strength reduction factors, beta factors, base shear factors, or load factors. The demand for NEHRP is also fixed at 100 and the rest of the values are again normalized to NEHRP using the same technique used for the capacity values.

Because both the NEHRP "rated" capacity and "related" demand values were set at 100, the NEHRP capacity/demand ratio is always equal to one. The "NEHRP Comparison" value can be thought of as the ratio of the capacity/demand ratio of NEHRP (always 1) to the capacity/demand ratio of another code or methodology. Values equal to one indicate that an individual criteria is "equivalent" to the NEHRP Handbook for the particular element checked. A value of greater than one indicates that an individual criteria is <u>more</u> conservative than NEHRP and how much more capacity is required for each unit of demand. A value of less than one indicates that an individual criteria is <u>less</u> conservative than NEHRP and how much less capacity is required for each unit of demand.

HIGH SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

Aa= 0.4 (San Francisco site)
S= 1.5 (soft soil conditions)
T= 0.1 (1-story, short period building)
DAF= 3 (for VA criteria only)
Z= 1 (for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	2.2245	0.8480	0.8480	1.00
ATC-14	2.2245	0.8480	0.8480	1.00
PS/ATC-22	2.6731	0.8000	0.8000	0.94
TRI-SERVICE/P355 OLD	0.3162	0.1400	0.1400	0.17
VA,FBO,GSA,DOE/UBC	3.4807	1.1000	1.1000	1.30
VA/H08-8	0.9000	0.9000	0.9000	1.06
DOE-MH/UCRL-15910	3.4807	1.1000	1.1000	1.30

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.17	1.00	32.02	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	31.45	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	77.19	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	150.94	****
DUCTILE PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.17	1.00	88.05	1.01
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	86.48	0.99
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	212.26	1.91
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	415.09	3.74

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS									
CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	0.94	1.00	255.09	2.55
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.17	1.00	66.04	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.30	1.00	64.86	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.06	1.00	141.51	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.30	1.00	370.62	****
DUCTILE									
ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.17	1.00	82.55	0.95
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.30	1.00	81.07	0.93
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.06	1.00	176.89	1.59
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.30	1.00	463.27	4.17
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	30.82	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	48.43	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	294.03	****
DUCTILE									
JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	46.23	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	72.64	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	441.04	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.17	1.40	123.27	1.23
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.30	1.40	121.07	1.21
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	212.26	2.12
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.30	1.70	653.39	6.53
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.17	1.40	50.85	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.30	1.40	49.94	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.06	1.00	58.37	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.30	1.70	285.38	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	127.12	1.27
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.30	1.40	124.85	1.25
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	145.93	1.46
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.30	1.70	713.44	7.13

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw, R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	0.94	1.00	71.07	0.71
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.17	1.00	16.51	****
VA,FEO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.30	1.00	21.62	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.30	1.00	108.10	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.17	1.00	24.76	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.30	1.00	32.43	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.30	1.00	162.15	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.17	1.00	74.29	1.12
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.30	1.00	72.97	1.10
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.06	1.00	159.20	2.39
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.30	1.00	343.37	4.04

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

Aa= 0.4 (San Francisco site)
S= 1.5 (soft soil conditions)
T= 1.0 (10-story, long period building)
DAF= 1.2 (for VA criteria only)
Z= 1 (for Tri-Service Manual "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	0.4800	0.8480	0.4800	1.00
ATC-14	0.4800	0.8480	0.4800	1.00
PS/ATC-22	0.5760	0.8000	0.5760	1.20
TRI-SERVICE/P355 OLD	0.1000	0.1400	0.1000	0.21
VA,FBO,GSA,DOE/UBC	0.7500	1.1000	0.7500	1.56
VA/H08-8	0.3600	0.3600	0.3600	0.75
DOE-MH/UCRL-15910	0.7500	1.1000	0.7500	1.56

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.21	1.00	40.40	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	37.88	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	0.75	1.00	54.55	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	181.82	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.21	1.00	111.11	1.28
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	104.17	1.20
VA/H08-8	1.70	1.00	111.11	4.0	1.00	0.75	1.00	150.00	1.35
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	500.00	4.50

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	1.20	1.00	324.48	3.24
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.21	1.00	83.33	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.56	1.00	78.12	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	0.75	1.00	100.00	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.56	1.00	446.43	****
DUCTILE ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.21	1.00	104.17	1.20
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.56	1.00	97.66	1.12
VA/H08-8	1.70	1.00	111.11	3.0	1.00	0.75	1.00	125.00	1.13
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.56	1.00	558.04	5.02
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	38.89	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	58.33	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	0.75	1.00	50.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	354.17	****
DUCTILE JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	58.33	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	87.50	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	0.75	1.00	75.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	531.25	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.21	1.40	155.56	1.56
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.56	1.40	145.83	1.46
VA/H08-8	1.00	0.90	100.00	4.0	1.00	0.75	1.00	150.00	1.50
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.56	1.70	787.04	7.87
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.21	1.40	64.17	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.56	1.40	60.16	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	0.75	1.00	41.25	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.56	1.70	343.75	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	160.42	1.60
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.56	1.40	150.39	1.50
VA/H08-8	1.00	0.90	100.00	4.0	1.00	0.75	1.00	103.13	1.03
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.56	1.70	859.37	8.59

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	1.20	1.00	90.40	0.90
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.21	1.00	20.83	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.56	1.00	26.04	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	0.75	1.00	50.00	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.56	1.00	130.21	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.21	1.00	31.25	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.56	1.00	39.06	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	0.75	1.00	75.00	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.56	1.00	195.31	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.21	1.00	93.75	1.41
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.56	1.00	87.89	1.32
VA/H08-8	1.33	1.00	66.50	3.0	1.00	0.75	1.00	112.50	1.69
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.56	1.00	413.60	4.87

**** INDICATES THAT CONDITION IS NOT PERMITTED

NEHRP STRENGTH COMPARISON
NIST TASK 2 ASSESSMENT REPORT
DEGENKOLB/RUTHERFORD & CHEKENE

HIGH SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

Aa=	0.4	(San Francisco site)
S=	1.0	(firm soil conditions)
T=	0.1	(1-story, short period building)
DAF=	3	(for VA criteria only)
Z=	1	(for Tri-Service Manual "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	1.4830	0.8480	0.8480	1.00
ATC-14	1.4830	0.8480	0.8480	1.00
PS/ATC-22	1.7821	0.8000	0.8000	0.94
TRI-SERVICE/P355 OLD	0.2108	0.1400	0.1400	0.17
VA,FBO,GSA,DOE/UBC	2.3204	1.1000	1.1000	1.30
VA/H08-8	0.9000	0.9000	0.9000	1.06
DOE-MH/UCRL-15910	2.3204	1.1000	1.1000	1.30

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.17	1.00	32.02	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	31.45	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	77.19	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	150.94	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.17	1.00	88.05	1.01
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	86.48	0.99
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	212.26	1.91
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	415.09	3.74

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS									
CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	0.94	1.00	255.09	2.55
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.17	1.00	66.04	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.30	1.00	64.86	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.06	1.00	141.51	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.30	1.00	370.62	****
DUCTILE									
ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.17	1.00	82.55	0.95
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.30	1.00	81.07	0.93
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.06	1.00	176.89	1.59
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.30	1.00	463.27	4.17
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	30.82	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	48.43	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	294.03	****
DUCTILE									
JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	46.23	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	72.64	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	441.04	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.17	1.40	123.27	1.23
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.30	1.40	121.07	1.21
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	212.26	2.12
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.30	1.70	653.39	6.53
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.17	1.40	50.85	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.30	1.40	49.94	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.06	1.00	58.37	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.30	1.70	285.38	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.17	1.40	127.12	1.27
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.30	1.40	124.85	1.25
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	145.93	1.46
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.30	1.70	713.44	7.13

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	0.94	1.00	71.07	0.71
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.17	1.00	16.51	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.30	1.00	21.62	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.30	1.00	108.10	****
DUCTILE									
INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.17	1.00	24.76	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.30	1.00	32.43	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.30	1.00	162.15	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.17	1.00	74.29	1.12
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.30	1.00	72.97	1.10
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.06	1.00	159.20	2.39
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.30	1.00	343.37	4.04

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

Aa= 0.4 (San Francisco site)
S= 1.0 (firm soil conditions)
T= 1.0 (10-story, long period building)
DAF= 1.2 (for VA criteria only)
Z= 1 (for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	0.3200	0.8480	0.3200	1.00
ATC-14	0.3200	0.8480	0.3200	1.00
PS/ATC-22	0.3840	0.8000	0.3840	1.20
TRI-SERVICE/P355 OLD	0.0667	0.1400	0.0667	0.21
VA,FBO,GSA,DOE/UBC	0.5000	1.1000	0.5000	1.56
VA/H08-8	0.3600	0.3600	0.3600	1.13
DOE-MH/UCRL-15910	0.5000	1.1000	0.5000	1.56

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1:00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.21	1.00	40.40	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	37.88	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.13	1.00	81.82	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	181.82	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.21	1.00	111.11	1.28
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	104.17	1.20
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.13	1.00	225.00	2.03
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	500.00	4.50

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	1.20	1.00	324.48	3.24
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.21	1.00	83.33	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.56	1.00	78.12	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.13	1.00	150.00	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.56	1.00	446.43	****
DUCTILE ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.21	1.00	104.17	1.20
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.56	1.00	97.66	1.12
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.13	1.00	187.50	1.69
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.56	1.00	558.04	5.02
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	38.89	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	58.33	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.13	1.00	75.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	354.17	****
DUCTILE JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	58.33	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	87.50	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.13	1.00	112.50	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	531.25	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.21	1.40	155.56	1.56
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.56	1.40	145.83	1.46
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.13	1.00	225.00	2.25
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.56	1.70	787.04	7.87
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.21	1.40	64.17	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.56	1.40	60.16	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.13	1.00	61.88	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.56	1.70	343.75	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.21	1.40	160.42	1.60
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.56	1.40	150.39	1.50
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.13	1.00	154.69	1.55
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.56	1.70	859.37	8.59

**** INDICATES THAT CONDITION IS NOT PERMITTED

HIGH SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	1.20	1.00	90.40	0.90
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.21	1.00	20.83	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.56	1.00	26.04	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.13	1.00	75.00	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.56	1.00	130.21	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.21	1.00	31.25	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.56	1.00	39.06	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.13	1.00	112.50	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.56	1.00	195.31	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.21	1.00	93.75	1.41
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.56	1.00	87.89	1.32
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.13	1.00	168.75	2.54
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.56	1.00	413.60	4.87

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

Aa=	0.2	(Memphis site)
S=	1.5	(soft soil conditions)
T=	0.1	(1-story, short period building)
DAF=	3	(for VA criteria only)
Z=	0.375	(for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	1.1123	0.4240	0.4240	1.00
ATC-14	1.1123	0.4240	0.4240	1.00
PS/ATC-22	1.3366	0.4000	0.4000	0.94
TRI-SERVICE/P355 OLD	0.1186	0.0525	0.0525	0.12
VA,FBO,GSA,DOE/UBC	1.7403	0.5500	0.5500	1.30
VA/H08-8	0.4500	0.4500	0.4500	1.06
DOE-MH/UCRL-15910	1.7403	0.5500	0.5500	1.30

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.12	1.00	24.01	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	31.45	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	77.19	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	150.94	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.12	1.00	66.04	0.76
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	86.48	0.99
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	212.26	1.91
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	415.09	3.74

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS									
CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	0.94	1.00	255.09	2.55
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.12	1.00	49.53	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.30	1.00	64.86	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.06	1.00	141.51	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.30	1.00	370.62	****
DUCTILE									
ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.12	1.00	61.91	0.71
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.30	1.00	81.07	0.93
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.06	1.00	176.89	1.59
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.30	1.00	463.27	4.17
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	23.11	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	48.43	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	294.03	****
DUCTILE									
JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	34.67	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	72.64	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	441.04	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.12	1.40	92.45	0.92
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.30	1.40	121.07	1.21
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	212.26	2.12
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.30	1.70	653.39	6.53
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.12	1.40	38.14	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.30	1.40	49.94	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.06	1.00	58.37	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.30	1.70	285.38	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	95.34	0.95
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.30	1.40	124.85	1.25
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	145.93	1.46
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.30	1.70	713.44	7.13

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	0.94	1.00	71.07	0.71
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.12	1.00	12.38	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.30	1.00	21.62	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.30	1.00	108.10	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.12	1.00	18.57	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.30	1.00	32.43	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.30	1.00	162.15	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.12	1.00	55.72	0.84
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.30	1.00	72.97	1.10
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.06	1.00	159.20	2.39
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.30	1.00	343.37	4.04

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

Aa= 0.2 (Memphis site)
S= 1.5 (soft soil conditions)
T= 1.0 (10-story, long period building)
DAF= 1.2 (for VA criteria only)
Z= 0.375 (for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	0.2400	0.4240	0.2400	1.00
ATC-14	0.2400	0.4240	0.2400	1.00
PS/ATC-22	0.2880	0.4000	0.2880	1.20
TRI-SERVICE/P355 OLD	0.0375	0.0525	0.0375	0.16
VA,FBO,GSA,DOE/UBC	0.3750	0.5500	0.3750	1.56
VA/H08-8	0.1800	0.1800	0.1800	0.75
DOE-MH/UCRL-15910	0.3750	0.5500	0.3750	1.56

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.16	1.00	30.30	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	37.88	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	0.75	1.00	54.55	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	181.82	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.16	1.00	83.33	0.96
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	104.17	1.20
VA/H08-8	1.70	1.00	111.11	4.0	1.00	0.75	1.00	150.00	1.35
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	500.00	4.50

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS									
CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	1.20	1.00	324.48	3.24
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.16	1.00	62.50	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.56	1.00	78.12	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	0.75	1.00	100.00	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.56	1.00	446.43	****
DUCTILE									
ALL DIAGONAL BRAÇES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.16	1.00	78.13	0.90
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.56	1.00	97.66	1.12
VA/H08-8	1.70	1.00	111.11	3.0	1.00	0.75	1.00	125.00	1.13
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.56	1.00	558.04	5.02
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	29.17	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	58.33	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	0.75	1.00	50.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	354.17	****
DUCTILE									
JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	43.75	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	87.50	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	0.75	1.00	75.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	531.25	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.16	1.40	116.67	1.17
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.56	1.40	145.83	1.46
VA/H08-8	1.00	0.90	100.00	4.0	1.00	0.75	1.00	150.00	1.50
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.56	1.70	787.04	7.87
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.16	1.40	48.13	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.56	1.40	60.16	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	0.75	1.00	41.25	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.56	1.70	343.75	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	120.31	1.20
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.56	1.40	150.39	1.50
VA/H08-8	1.00	0.90	100.00	4.0	1.00	0.75	1.00	103.13	1.03
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.56	1.70	859.37	8.59

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - SOFT SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	1.20	1.00	90.40	0.90
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.16	1.00	15.63	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.56	1.00	26.04	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	0.75	1.00	50.00	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.56	1.00	130.21	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.16	1.00	23.44	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.56	1.00	39.06	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	0.75	1.00	75.00	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.56	1.00	195.31	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.16	1.00	70.31	1.06
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.56	1.00	87.89	1.32
VA/H08-8	1.33	1.00	66.50	3.0	1.00	0.75	1.00	112.50	1.69
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.56	1.00	413.60	4.87

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

Aa=	0.2	(Memphis site)
S=	1.0	(firm soil conditions)
T=	0.1	(1-story, short period building)
DAF=	3	(for VA criteria only)
Z=	0.375	(for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	0.7415	0.4240	0.4240	1.00
ATC-14	0.7415	0.4240	0.4240	1.00
PS/ATC-22	0.8910	0.4000	0.4000	0.94
TRI-SERVICE/P355 OLD	0.0791	0.0525	0.0525	0.12
VA,FBO,GSA,DOE/UBC	1.1602	0.5500	0.5500	1.30
VA/H08-8	0.4500	0.4500	0.4500	1.06
DOE-MH/UCRL-15910	1.1602	0.5500	0.5500	1.30

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.12	1.00	24.01	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	31.45	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	77.19	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	150.94	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.12	1.00	66.04	0.76
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.30	1.00	86.48	0.99
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.06	1.00	212.26	1.91
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.30	1.00	415.09	3.74

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	0.94	1.00	255.09	2.55
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.12	1.00	49.53	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.30	1.00	64.86	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.06	1.00	141.51	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.30	1.00	370.62	****
DUCTILE ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.12	1.00	61.91	0.71
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.30	1.00	81.07	0.93
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.06	1.00	176.89	1.59
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.30	1.00	463.27	4.17
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	23.11	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	48.43	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	294.03	****
DUCTILE JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	34.67	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.30	1.40	72.64	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.30	1.70	441.04	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.12	1.40	92.45	0.92
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.30	1.40	121.07	1.21
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	212.26	2.12
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.30	1.70	653.39	6.53
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	0.94	1.00	141.51	1.42
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.12	1.40	38.14	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.30	1.40	49.94	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.06	1.00	58.37	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.30	1.70	285.38	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.12	1.40	95.34	0.95
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.30	1.40	124.85	1.25
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.06	1.00	145.93	1.46
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.30	1.70	713.44	7.13

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 1 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	0.94	1.00	71.07	0.71
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.12	1.00	12.38	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.30	1.00	21.62	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.06	1.00	70.75	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.30	1.00	108.10	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.12	1.00	18.57	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.30	1.00	32.43	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.06	1.00	106.13	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.30	1.00	162.15	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	0.94	1.00	94.34	0.94
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.12	1.00	55.72	0.84
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.30	1.00	72.97	1.10
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.06	1.00	159.20	2.39
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.30	1.00	343.37	4.04

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

Aa= 0.2 (Memphis site)
S= 1.0 (firm soil conditions)
T= 1.0 (10-story, long period building)
DAF= 1.2 (for VA criteria only)
Z= 0.375 (for Tri-Service Manual, "P355 Old" criteria only)

	BASE SHEAR CURVE	BASE SHEAR CUTOFF	BASE SHEAR	BASE SHEAR FACTOR
NEHRP	0.1600	0.4240	0.1600	1.00
ATC-14	0.1600	0.4240	0.1600	1.00
PS/ATC-22	0.1920	0.4000	0.1920	1.20
TRI-SERVICE/P355 OLD	0.0250	0.0525	0.0250	0.16
VA,FBO,GSA,DOE/UBC	0.2500	0.5500	0.2500	1.56
VA/H08-8	0.1800	0.1800	0.1800	1.13
DOE-MH/UCRL-15910	0.2500	0.5500	0.2500	1.56

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL STEEL MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	2.75	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	4.80	1.00	1.00	116.36	1.34
PS/ATC-22	1.70	0.90	100.00	8.0	4.13	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.16	1.00	30.30	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	37.88	****
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.13	1.00	81.82	****
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	181.82	****
DUCTILE									
PENETRATIONS IN BEAM WEBS < 1/4 BEAM DEPTH									
NEHRP (BASIS)	1.70	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	12.0	1.00	1.00	1.00	66.67	0.77
PS/ATC-22	1.70	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.5	1.00	0.16	1.00	83.33	0.96
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	12.0	1.00	1.56	1.00	104.17	1.20
VA/H08-8	1.70	1.00	111.11	4.0	1.00	1.13	1.00	225.00	2.03
DOE-MH/UCRL-15910	1.70	1.00	111.11	2.5	1.00	1.56	1.00	500.00	4.50

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL BRACED FRAME									
NON-DUCTILE ELEMENTS									
CONNECTION DOES NOT DEVELOP FULL STRENGTH OF MEMBER									
NEHRP (BASIS)	1.70	0.67	100.00	5.0	1.25	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	116.77	8.0	3.20	1.00	1.00	160.00	1.37
PS/ATC-22	1.70	0.67	100.00	5.0	3.38	1.20	1.00	324.48	3.24
TRI-SERVICE/P355 OLD	1.33	1.00	116.77	1.0	1.00	0.16	1.00	62.50	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	116.77	8.0	1.00	1.56	1.00	78.12	****
VA/H08-8	1.70	1.00	149.25	3.0	1.00	1.13	1.00	150.00	****
DOE-MH/UCRL-15910	1.70	1.00	149.25	1.4	1.00	1.56	1.00	446.43	****
DUCTILE									
ALL DIAGONAL BRACES ARE CONCENTRIC TO BEAM-COLUMN JOINTS									
NEHRP (BASIS)	1.70	0.90	100.00	5.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	86.93	8.0	1.00	1.00	1.00	62.50	0.72
PS/ATC-22	1.70	0.90	100.00	5.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	86.93	1.0	1.00	0.16	1.00	78.12	0.90
VA,FBO,GSA,DOE/UBC	1.33	1.00	86.93	8.0	1.00	1.56	1.00	97.66	1.12
VA/H08-8	1.70	1.00	111.11	3.0	1.00	1.13	1.00	187.50	1.69
DOE-MH/UCRL-15910	1.70	1.00	111.11	1.4	1.00	1.56	1.00	558.04	5.02
NON-DUCTILE CONCRETE MOMENT FRAME									
NON-DUCTILE ELEMENTS									
WEAK STORY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	2.00	1.00	1.40	74.67	0.75
PS/ATC-22	1.00	0.90	100.00	2.0	1.50	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	29.17	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	58.33	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.13	1.00	75.00	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	354.17	****
DUCTILE									
JOINT ECCENTRICITY									
NEHRP (BASIS)	1.00	0.90	100.00	2.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	5.0	1.00	1.00	1.40	56.00	0.56
PS/ATC-22	1.00	0.90	100.00	2.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	43.75	****
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	5.0	1.00	1.56	1.40	87.50	****
VA/H08-8	1.00	0.90	100.00	2.0	1.00	1.13	1.00	112.50	****
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.0	1.00	1.56	1.70	531.25	****

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
SPECIAL CONCRETE MOMENT RESISTING FRAME									
DUCTILE ELEMENTS									
NEHRP (BASIS)	1.00	0.90	100.00	8.0	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	12.0	1.00	1.00	1.40	93.33	0.93
PS/ATC-22	1.00	0.90	100.00	8.0	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.5	1.00	0.16	1.40	116.67	1.17
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	12.0	1.00	1.56	1.40	145.83	1.46
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.13	1.00	225.00	2.25
DOE-MH/UCRL-15910	1.00	0.90	100.00	2.7	1.00	1.56	1.70	787.04	7.87
CONCRETE SHEAR WALL									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	1.00	0.85	100.00	5.5	2.50	1.00	1.00	100.00	1.00
ATC-14	1.00	0.85	100.00	8.0	3.20	1.00	1.40	123.20	1.23
PS/ATC-22	1.00	0.85	100.00	5.5	3.75	1.20	1.00	180.00	1.80
TRI-SERVICE/P355 OLD	1.00	0.85	100.00	1.0	1.00	0.16	1.40	48.12	****
VA,FBO,GSA,DOE/UBC	1.00	0.85	100.00	8.0	1.00	1.56	1.40	60.16	****
VA/H08-8	1.00	0.85	100.00	4.0	1.00	1.13	1.00	61.88	****
DOE-MH/UCRL-15910	1.00	0.85	100.00	1.7	1.00	1.56	1.70	343.75	****
DUCTILE REINFORCING AT OPENINGS									
NEHRP (BASIS)	1.00	0.90	100.00	5.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.00	0.90	100.00	8.0	1.00	1.00	1.40	96.25	0.96
PS/ATC-22	1.00	0.90	100.00	5.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.00	0.90	100.00	1.0	1.00	0.16	1.40	120.31	1.20
VA,FBO,GSA,DOE/UBC	1.00	0.90	100.00	8.0	1.00	1.56	1.40	150.39	1.50
VA/H08-8	1.00	0.90	100.00	4.0	1.00	1.13	1.00	154.69	1.55
DOE-MH/UCRL-15910	1.00	0.90	100.00	1.7	1.00	1.56	1.70	859.37	8.59

**** INDICATES THAT CONDITION IS NOT PERMITTED

MODERATE SEISMIC ZONE - FIRM SOIL SITE - 10 STORY BUILDING

	ALLOWABLE STRESS INCREASE	PHI FACTOR	RATED CAPACITY	1/K 1/ALPHA Rw,R Fu	BETA FACTOR	BASE SHEAR FACTOR	LOAD FACTOR	RELATED DEMAND	NEHRP COMPARISON
STEEL FRAME WITH UNREINFORCED MASONRY INFILL WALLS									
NON-DUCTILE ELEMENTS WEAK STORY									
NEHRP (BASIS)	2.50	0.60	100.00	1.5	1.50	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	88.67	6.0	2.40	1.00	1.00	40.00	0.45
PS/ATC-22	2.50	0.60	100.00	1.5	1.13	1.20	1.00	90.40	0.90
TRI-SERVICE/P355 OLD	1.33	1.00	88.67	1.0	1.00	0.16	1.00	15.62	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	88.67	6.0	1.00	1.56	1.00	26.04	****
VA/H08-8	1.33	1.00	88.67	1.5	1.00	1.13	1.00	75.00	****
DOE-MH/UCRL-15910	1.70	1.00	113.33	1.2	1.00	1.56	1.00	130.21	****
DUCTILE INFILL PANELS ENCOMPASS STEEL FRAME AROUND PERIMETER									
NEHRP (BASIS)	2.50	0.80	100.00	1.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	6.0	1.00	1.00	1.00	25.00	0.38
PS/ATC-22	2.50	0.80	100.00	1.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.16	1.00	23.44	****
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	6.0	1.00	1.56	1.00	39.06	****
VA/H08-8	1.33	1.00	66.50	1.5	1.00	1.13	1.00	112.50	****
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.2	1.00	1.56	1.00	195.31	****
STEEL FRAME WITH REINFORCED MASONRY INFILL WALLS									
DUCTILE ELEMENTS									
NEHRP (BASIS)	2.50	0.80	100.00	4.5	1.00	1.00	1.00	100.00	1.00
ATC-14	1.33	1.00	66.50	8.0	1.00	1.00	1.00	56.25	0.85
PS/ATC-22	2.50	0.80	100.00	4.5	1.00	1.20	1.00	120.00	1.20
TRI-SERVICE/P355 OLD	1.33	1.00	66.50	1.0	1.00	0.16	1.00	70.31	1.06
VA,FBO,GSA,DOE/UBC	1.33	1.00	66.50	8.0	1.00	1.56	1.00	87.89	1.32
VA/H08-8	1.33	1.00	66.50	3.0	1.00	1.13	1.00	168.75	2.54
DOE-MH/UCRL-15910	1.70	1.00	85.00	1.7	1.00	1.56	1.00	413.60	4.87

**** INDICATES THAT CONDITION IS NOT PERMITTED

Part 5: NEHRP Comparison Value Summary

The three sheets in this section summarize all the "NEHRP Comparison" values for the eight worksheets of Part 4 of Appendix B. They are sorted by structural system, ductile/non-ductile provision, high/moderate seismic zone, soft/firm soil conditions, and 1-story/10-story building. The sheets were used to create the ranges of values for Table 3 in the main text.

	NEHRP (BASIS)	ATC-14	ATC-22	TRI-SERV (OLD)	UBC	VA (H-08-8)	DOE (MH&HH)
STEEL FRAME BUILDINGS							
STEEL FRAME BUILDING W/ URM INFILL R/Rw = 1.5/6							
NON-DUCT/HIGH/SOFT/1-STORY	1.00	0.45	0.71	***	***	***	***
NON-DUCT/HIGH/SOFT/10-STORY	1.00	0.45	0.90	***	***	***	***
NON-DUCT/HIGH/FIRM/1-STORY	1.00	0.45	0.71	***	***	***	***
NON-DUCT/HIGH/FIRM/10-STORY	1.00	0.45	0.90	***	***	***	***
NON-DUCT/MOD/SOFT/1-STORY	1.00	0.45	0.71	***	***	***	***
NON-DUCT/MOD/SOFT/10-STORY	1.00	0.45	0.90	***	***	***	***
NON-DUCT/MOD/FIRM/1-STORY	1.00	0.45	0.71	***	***	***	***
NON-DUCT/MOD/FIRM/10-STORY	1.00	0.45	0.90	***	***	***	***
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.38	0.94	***	***	***	***
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.38	1.20	***	***	***	***
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.38	0.94	***	***	***	***
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.38	1.20	***	***	***	***
DUCTILE/MOD/SOFT/1-STORY	1.00	0.38	0.94	***	***	***	***
DUCTILE/MOD/SOFT/10-STORY	1.00	0.38	1.20	***	***	***	***
DUCTILE/MOD/FIRM/1-STORY	1.00	0.38	0.94	***	***	***	***
DUCTILE/MOD/FIRM/10-STORY	1.00	0.38	1.20	***	***	***	***
STEEL FRAME BUILDING W/ REINF. MASONRY INFILL R/Rw = 4.5/8							
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.85	0.94	1.12	1.10	2.39	4.04
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.85	1.20	1.41	1.32	1.69	4.87
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.85	0.94	1.12	1.10	2.39	4.04
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.85	1.20	1.41	1.32	2.54	4.87
DUCTILE/MOD/SOFT/1-STORY	1.00	0.85	0.94	0.84	1.10	2.39	4.04
DUCTILE/MOD/SOFT/10-STORY	1.00	0.85	1.20	1.06	1.32	1.69	4.87
DUCTILE/MOD/FIRM/1-STORY	1.00	0.85	0.94	0.84	1.10	2.39	4.04
DUCTILE/MOD/FIRM/10-STORY	1.00	0.85	1.20	1.06	1.32	2.54	4.87
STEEL BRACED FRAME BUILDING R/Rw = 5/8							
NON-DUCT/HIGH/SOFT/1-STORY	1.00	1.37	2.55	***	***	***	***
NON-DUCT/HIGH/SOFT/10-STORY	1.00	1.37	3.24	***	***	***	***
NON-DUCT/HIGH/FIRM/1-STORY	1.00	1.37	2.55	***	***	***	***
NON-DUCT/HIGH/FIRM/10-STORY	1.00	1.37	3.24	***	***	***	***
NON-DUCT/MOD/SOFT/1-STORY	1.00	1.37	2.55	***	***	***	***
NON-DUCT/MOD/SOFT/10-STORY	1.00	1.37	3.24	***	***	***	***
NON-DUCT/MOD/FIRM/1-STORY	1.00	1.37	2.55	***	***	***	***
NON-DUCT/MOD/FIRM/10-STORY	1.00	1.37	3.24	***	***	***	***
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.72	0.94	0.95	0.93	1.59	4.17
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.72	1.20	1.20	1.12	1.13	5.02
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.72	0.94	0.95	0.93	1.59	4.17
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.72	1.20	1.20	1.12	1.69	5.02
DUCTILE/MOD/SOFT/1-STORY	1.00	0.72	0.94	0.71	0.93	1.59	4.17
DUCTILE/MOD/SOFT/10-STORY	1.00	0.72	1.20	0.90	1.12	1.13	5.02
DUCTILE/MOD/FIRM/1-STORY	1.00	0.72	0.94	0.71	0.93	1.59	4.17
DUCTILE/MOD/FIRM/10-STORY	1.00	0.72	1.20	0.90	1.12	1.69	5.02

*** INDICATES THAT CONDITION IS NOT PERMITTED

NEHRP COMPARISON VALUE SUMMARY

	NEHRP (BASIS)	ATC-14	ATC-22	TRI-SERV (OLD)	UBC	VA (H-08-8)	DOE (MH&HH)
STEEL SPECIAL MOMENT RESISTING FRAME BUILDING							
R/Rw = 8/12							
NON-DUCT/HIGH/SOFT/1-STORY	1.00	1.34	1.42	***	***	***	***
NON-DUCT/HIGH/SOFT/10-STORY	1.00	1.34	1.80	***	***	***	***
NON-DUCT/HIGH/FIRM/1-STORY	1.00	1.34	1.42	***	***	***	***
NON-DUCT/HIGH/FIRM/10-STORY	1.00	1.34	1.80	***	***	***	***
NON-DUCT/MOD/SOFT/1-STORY	1.00	1.34	1.42	***	***	***	***
NON-DUCT/MOD/SOFT/10-STORY	1.00	1.34	1.80	***	***	***	***
NON-DUCT/MOD/FIRM/1-STORY	1.00	1.34	1.42	***	***	***	***
NON-DUCT/MOD/FIRM/10-STORY	1.00	1.34	1.80	***	***	***	***
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.77	0.94	1.01	0.99	1.91	3.74
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.77	1.20	1.28	1.20	1.35	4.50
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.77	0.94	1.01	0.99	1.91	3.74
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.77	1.20	1.28	1.20	2.03	4.50
DUCTILE/MOD/SOFT/1-STORY	1.00	0.77	0.94	0.76	0.99	1.91	3.74
DUCTILE/MOD/SOFT/10-STORY	1.00	0.77	1.20	0.96	1.20	1.35	4.50
DUCTILE/MOD/FIRM/1-STORY	1.00	0.77	0.94	0.76	0.99	1.91	3.74
DUCTILE/MOD/FIRM/10-STORY	1.00	0.77	1.20	0.96	1.20	2.03	4.50
CONCRETE BUILDINGS							
NON-DUCTILE CONCRETE MOMENT FRAME BUILDING							
R/Rw = 2/5							
NON-DUCT/HIGH/SOFT/1-STORY	1.00	0.75	0.94	***	***	***	***
NON-DUCT/HIGH/SOFT/10-STORY	1.00	0.75	1.20	***	***	***	***
NON-DUCT/HIGH/FIRM/1-STORY	1.00	0.75	0.94	***	***	***	***
NON-DUCT/HIGH/FIRM/10-STORY	1.00	0.75	1.20	***	***	***	***
NON-DUCT/MOD/SOFT/1-STORY	1.00	0.75	0.94	***	***	***	***
NON-DUCT/MOD/SOFT/10-STORY	1.00	0.75	1.20	***	***	***	***
NON-DUCT/MOD/FIRM/1-STORY	1.00	0.75	0.94	***	***	***	***
NON-DUCT/MOD/FIRM/10-STORY	1.00	0.75	1.20	***	***	***	***
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.56	0.94	***	***	***	***
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.56	1.20	***	***	***	***
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.56	0.94	***	***	***	***
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.56	1.20	***	***	***	***
DUCTILE/MOD/SOFT/1-STORY	1.00	0.56	0.94	***	***	***	***
DUCTILE/MOD/SOFT/10-STORY	1.00	0.56	1.20	***	***	***	***
DUCTILE/MOD/FIRM/1-STORY	1.00	0.56	0.94	***	***	***	***
DUCTILE/MOD/FIRM/10-STORY	1.00	0.56	1.20	***	***	***	***

***** INDICATES THAT CONDITION IS NOT PERMITTED**

NEHRP COMPARISON VALUE SUMMARY

	NEHRP (BASIS)	ATC-14	ATC-22	TRI-SERV (OLD)	UBC	VA (H-08-8)	DOE (MH&HH)
CONCRETE SHEAR WALL BUILDING							
R/Rw = 5/8							
NON-DUCT/HIGH/SOFT/1-STORY	1.00	1.23	1.42	***	***	***	***
NON-DUCT/HIGH/SOFT/10-STORY	1.00	1.23	1.80	***	***	***	***
NON-DUCT/HIGH/FIRM/1-STORY	1.00	1.23	1.42	***	***	***	***
NON-DUCT/HIGH/FIRM/10-STORY	1.00	1.23	1.80	***	***	***	***
NON-DUCT/MOD/SOFT/1-STORY	1.00	1.23	1.42	***	***	***	***
NON-DUCT/MOD/SOFT/10-STORY	1.00	1.23	1.80	***	***	***	***
NON-DUCT/MOD/FIRM/1-STORY	1.00	1.23	1.42	***	***	***	***
NON-DUCT/MOD/FIRM/10-STORY	1.00	1.23	1.80	***	***	***	***
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.96	0.94	1.27	1.25	1.46	7.13
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.96	1.20	1.60	1.50	1.03	8.59
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.96	0.94	1.27	1.25	1.46	7.13
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.96	1.20	1.60	1.50	1.55	8.59
DUCTILE/MOD/SOFT/1-STORY	1.00	0.96	0.94	0.95	1.25	1.46	7.13
DUCTILE/MOD/SOFT/10-STORY	1.00	0.96	1.20	1.20	1.50	1.03	8.59
DUCTILE/MOD/FIRM/1-STORY	1.00	0.96	0.94	0.95	1.25	1.46	7.13
DUCTILE/MOD/FIRM/10-STORY	1.00	0.96	1.20	1.20	1.50	1.55	8.59
CONCRETE SPECIAL MOMENT RESISTING FRAME BUILDING							
R/Rw = 8/12							
DUCTILE/HIGH/SOFT/1-STORY	1.00	0.93	0.94	1.23	1.21	2.12	6.53
DUCTILE/HIGH/SOFT/10-STORY	1.00	0.93	1.20	1.56	1.46	1.50	7.87
DUCTILE/HIGH/FIRM/1-STORY	1.00	0.93	0.94	1.23	1.21	2.12	6.53
DUCTILE/HIGH/FIRM/10-STORY	1.00	0.93	1.20	1.56	1.46	2.25	7.87
DUCTILE/MOD/SOFT/1-STORY	1.00	0.93	0.94	0.92	1.21	2.12	6.53
DUCTILE/MOD/SOFT/10-STORY	1.00	0.93	1.20	1.17	1.46	1.50	7.87
DUCTILE/MOD/FIRM/1-STORY	1.00	0.93	0.94	0.92	1.21	2.12	6.53
DUCTILE/MOD/FIRM/10-STORY	1.00	0.93	1.20	1.17	1.46	2.25	7.87

***** INDICATES THAT CONDITION IS NOT PERMITTED**

APPENDIX C

Configuration Assessment Procedure

Configuration Assessment Worksheet

APPENDIX C - Configuration Assessment Procedure

The following worksheet compares different agency programs against NEHRP comparing configuration guidelines. The configuration irregularities outlined in the NEHRP Evaluation Handbook are used as a baseline. The NEHRP Handbook includes 7 of the irregularities listed on the table. The other statements are from the Uniform Building Code which includes more statements than does NEHRP. Each provision was investigated using each criteria and the results are shown on the configuration assessment worksheet.

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CONFIGURATION GUIDELINES COMPARISON TO NEHRP

	NEHRP	GSA (UBC)	FBO (UBC)	VA HOSPITALS (UBC)	VA MOBS (UBC)	POSTAL SERVICE (NEHRP)	TRI-SERVICE ESSENTIAL	TRI-SERVICE P355 NEW	TRI-SERVICE P355 OLD	DOE HIGH & MODERATE	DOE LOW & GENERAL
WEAK STORY	✓	✓	✓	✓	✓	✓		✓		✓	✓
SOFT STORY	✓	✓	✓	✓	✓	✓		✓		✓	✓
GEOMETRIC IRREGULARITY	✓	✓	✓	✓	✓	✓		✓		✓	✓
MASS IRREGULARITY	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
VERTICAL DISCONTINUITY	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
TORSIONAL IRREGULARITY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
REENTRANT CORNERS		✓	✓	✓	✓			✓		✓	✓
DIAPHRAGM DISCONTINUITY		✓	✓	✓	✓			✓		✓	✓
OUT-OF-PLANE OFFSETS		✓	✓	✓	✓			✓			
NON-PARALLEL SYSTEMS		✓	✓	✓	✓		✓	✓	✓		
BUILDING SEPARATIONS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

APPENDIX D

Seismic Zone Assessment Procedure

Seismic Zone Assessment Worksheets

- Sorted alphabetically
- Sorted by maximum difference
- Sorted by NEHRP Seismic Zones
- Cities with different EPA & EPV Zones

Figure 23-2 from the 1991 Uniform Building Code

Figure 3-1 from the Tri-Service Manual

Figure 3-2 from the Tri-Service Manual

Figure 3-3 from the Tri-Service Manual

Figure 2.1a from the NEHRP Evaluation Handbook

Figure 2.1b from the NEHRP Evaluation Handbook

Figure 2.1c from the NEHRP Evaluation Handbook

Figure 2.1d from the NEHRP Evaluation Handbook

APPENDIX D - Seismic Zone Assessment Procedure

The following worksheets compare different agency programs against NEHRP comparing seismic zones. The NEHRP Evaluation Handbook Maps are used as a baseline. The 100 largest cities in the United States are included in the table as well as a few other cities of interest.

The first two columns are city name and state where city is located. The next four columns are the NEHRP acceleration zone, NEHRP acceleration coefficient (equivalent to EPA), the NEHRP velocity zone, and the NEHRP velocity coefficient (equivalent to EPV). These define the NEHRP baseline for each city. The NEHRP Handbook uses the velocity coefficient for its base shear response spectrum and the acceleration coefficient for its base shear spectrum cutoff for low period buildings. Because it is always larger than the EPA value, The NEHRP EPV value is used for comparison. Note that the comparison uses the NEHRP county-by-county maps rather than the contour maps. This was done to obtain a worst-case value of EPA/EPV for any particular city.

The next two columns are the UBC zone and UBC effective peak ground acceleration coefficient for each city. The UBC maps are used by GSA, FBO, DOE for General Use and Low Hazard facilities, and by the 1992 draft Tri-Service Manual document. The next two columns are the VA and Postal Service EPA values based on site specific accelerations and the UBC and NEHRP maps respectively. The Postal Service's site specific values for the Pacific Northwest are always larger than NEHRP. The next column is the EPA values based on the 1982 Tri-Service Manual maps. These are a modified version of the maps in the 1979 Uniform Building Code. The "MAX DIFF" column relates the maximum difference between the NEHRP EPV value and any of the other criteria values.

If a city has a lesser value of EPA than NEHRP for any particular criteria, that column will have a "LESS" indicator in it. If the EPA value is <u>greater</u> than NEHRP, than no indication will be made under the criteria. The total number of cities with EPA values less than NEHRP for each criteria is at the end of the list.

The first three worksheets have exactly the same information, but are sorted in three different ways. The first worksheet is sorted alphabetically by city name. The second worksheet is sorted by "MAX DIFF," the maximum difference between NEHRP and any other criteria. The third worksheet is sorted by NEHRP acceleration zones and breaks out subtotals for NEHRP zones 3 through 7, termed "moderate and high seismic zones" and NEHRP zones 1 & 2, termed "low seismic zones." These two categories appear on Table 1 in the main report text. The final worksheet lists those cities surveyed with different NEHRP acceleration and velocity zones. In addition, it lists the difference between the EPV and EPA values and the corresponding UBC zones and EPA values.

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SEISMIC ZONE COMPARISON
NIST TASK 2 ASSESSMENT REPORT
ALPHA SORT BY CITY
DEGENKOLB/RUTHERFORD & CHEKENE

NIST STANDARDS
91101

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	GSA/FBO/DOE UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP: UBC	VA	PS	1982 TSM
Akron	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Albuquerque	NM	3	0.100	3	0.100	2B	0.200	0.200	0.100	0.150	0.100				
Anaheim	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Anchorage	AK	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Arlington	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Atlanta	GA	3	0.100	3	0.100	1	0.075	0.120	0.100	0.150	0.050	LESS			
Aurora	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Austin	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Bakersfield	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Baltimore	MD	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Baton Rouge	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Birmingham	AL	2	0.050	2	0.050	1	0.075	0.110	0.050	0.150	0.100				
Boston	MA	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Buffalo	NY	3	0.100	3	0.100	1	0.075	0.070	0.100	0.150	0.050	LESS	LESS		
Charlotte	NC	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Charlston	SC	3	0.100	3	0.100	2A	0.150	0.150	0.250	0.300	0.200				
Chicago	IL	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Cincinatti	OH	2	0.050	2	0.050	1	0.075	0.060	0.050	0.075	0.025				
Cleaveland	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Colorado Springs	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Columbus	GA	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Columbus	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Corpus Christi	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Dallas	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Dayton	OH	2	0.050	2	0.050	1	0.075	0.050	0.050	0.150	0.100				
Denver	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Des Moines	IA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Detroit	MI	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
El Paso	TX	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Fort Wayne	IN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Fort Worth	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Fremont	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Fresno	CA	7	0.400	7	0.400	3	0.300	0.230	0.400	0.300	0.170	LESS	LESS		LESS
Garland	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Glendale	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Grand Rapids	MI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Greensboro	NC	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Hialeah	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Honolulu	HI	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		

ALPHA SORT BY CITY

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	GSA/FBO/DOE UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP: UBC	VA	PS	1982 TSM
Houston	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Huntington Beach	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Indianapolis	IN	2	0.050	2	0.050	1	0.075	0.020	0.050	0.150	0.100		LESS		
Jackson	MS	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Jacksonville	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Jersey City	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Kansas City	MO	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Las Vegas	NV	3	0.100	4	0.150	2B	0.200	0.200	0.100	0.150	0.100				
Lexington	KY	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Lincoln	NE	3	0.100	3	0.100	1	0.075	0.100	0.100	0.075	0.025	LESS			LESS
Littlerock	AR	2	0.050	2	0.050	1	0.075	0.050	0.050	0.075	0.025				
Long Beach	CA	7	0.400	7	0.400	4	0.400	0.390	0.400	0.400	0.010		LESS		
Los Angeles	CA	7	0.400	7	0.400	4	0.400	0.250	0.400	0.400	0.150		LESS		
Louisville	KY	1	0.050	2	0.050	1	0.075	0.100	0.050	0.150	0.100				
Lubbock	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Madison	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Memphis	TN	5	0.200	5	0.200	3	0.300	0.250	0.200	0.300	0.100				
Mesa	AZ	1	0.050	4	0.150	1	0.075	0.075	0.050	0.075	0.025	LESS	LESS		LESS
Miami	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Milwaukee	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Minneapolis	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Mobile	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Montgomery	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Nashville	TN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
New Orleans	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
New York	NY	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Newark	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Newport News	VA	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Norfolk	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Oakland	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Oklahoma City	OK	3	0.100	3	0.100	1	0.075	0.100	0.100	0.150	0.050	LESS			
Omaha	NE	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Pheonix	AZ	1	0.050	4	0.150	1	0.075	0.050	0.050	0.075	0.025	LESS	LESS		LESS
Philadelphia	PA	2	0.050	3	0.100	2A	0.150	0.150	0.050	0.150	0.100				
Pittsburgh	PA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Portland	OR	2	0.050	2	0.050	2B	0.200	0.150	0.100	0.075	0.150				
Raleigh	NC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				

ALPHA SORT BY CITY

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	GSA/FBO/DOE UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP: UBC	VA	PS	1982 TSM
Richmond	VA	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Riverside	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Rochester	NY	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Sacramento	CA	5	0.200	6	0.300	3	0.300	0.300	0.200	0.300	0.100				
Salt Lake City	UT	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
San Antonio	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
San Diego	CA	7	0.400	7	0.400	3	0.300	0.150	0.400	0.400	0.250	LESS	LESS		
San Francisco	CA	7	0.400	7	0.400	4	0.400	0.300	0.400	0.400	0.100		LESS		
San Jose	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Santa Ana	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Seattle	WA	5	0.200	5	0.200	3	0.300	0.200	0.200	0.300	0.100				
Shreveport	LA	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Spokane	WA	2	0.050	2	0.050	2B	0.200	0.200	0.050	0.075	0.150				
Stockton	CA	6	0.300	6	0.300	3	0.300	0.300	0.300	0.300	0.000				
St. Louis	MO	3	0.100	3	0.100	2A	0.150	0.110	0.100	0.150	0.050				
St. Paul	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
St. Petersburg	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Tacoma	WA	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
Tampa	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Toledo	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Tulsa	OK	3	0.100	3	0.100	1	0.075	0.075	0.100	0.075	0.025	LESS	LESS		LESS
Tuscon	AZ	2	0.050	4	0.150	2B	0.200	0.050	0.050	0.075	0.150		LESS		LESS
Virginia Beach	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Washington	DC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Wichita	KS	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Yonkers	NY	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
										TOTAL OUT OF 102		38	40	0	20

SEISMIC ZONE COMPARISON
NIST TASK 2 ASSESSMENT REPORT
SORT BY MAXIMUM EPA DIFFERENCE
DEGENKOLB/RUTHERFORD & CHEKENE

NIST STANDARDS
91101

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP: UBC	VA	PS	1982 TSM
San Diego	CA	7	0.400	7	0.400	3	0.300	0.150	0.400	0.400	0.250	LESS	LESS		
Charlston	SC	3	0.100	3	0.100	2A	0.150	0.150	0.250	0.300	0.200				
Fresno	CA	7	0.400	7	0.400	3	0.300	0.230	0.400	0.300	0.170	LESS	LESS		LESS
Los Angeles	CA	7	0.400	7	0.400	4	0.400	0.250	0.400	0.400	0.150		LESS		
Portland	OR	2	0.050	2	0.050	2B	0.200	0.150	0.100	0.075	0.150				
Spokane	WA	2	0.050	2	0.050	2B	0.200	0.200	0.050	0.075	0.150				
Tuscon	AZ	2	0.050	4	0.150	2B	0.200	0.050	0.050	0.075	0.150		LESS		LESS
San Francisco	CA	7	0.400	7	0.400	4	0.400	0.300	0.400	0.400	0.100		LESS		
Albuquerque	NM	3	0.100	3	0.100	2B	0.200	0.200	0.100	0.150	0.100				
Las Vegas	NV	3	0.100	4	0.150	2B	0.200	0.200	0.100	0.150	0.100				
Birmingham	AL	2	0.050	2	0.050	1	0.075	0.110	0.050	0.150	0.100				
Dayton	OH	2	0.050	2	0.050	1	0.075	0.050	0.050	0.150	0.100				
El Paso	TX	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Fort Wayne	IN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Greensboro	NC	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Indianapolis	IN	2	0.050	2	0.050	1	0.075	0.020	0.050	0.150	0.100		LESS		
Louisville	KY	1	0.050	2	0.050	1	0.075	0.100	0.050	0.150	0.100				
Philadelphia	PA	2	0.050	3	0.100	2A	0.150	0.150	0.050	0.150	0.100				
Rochester	NY	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Memphis	TN	5	0.200	5	0.200	3	0.300	0.250	0.200	0.300	0.100				
Sacramento	CA	5	0.200	6	0.300	3	0.300	0.300	0.200	0.300	0.100				
Salt Lake City	UT	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
Seattle	WA	5	0.200	5	0.200	3	0.300	0.200	0.200	0.300	0.100				
Tacoma	WA	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
Arlington	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Austin	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Baton Rouge	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Chicago	IL	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Columbus	GA	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Corpus Christi	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Dallas	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Des Moines	IA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Fort Worth	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Garland	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Grand Rapids	MI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Hialeah	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Houston	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Jacksonville	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Lubbock	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		

SORT BY MAXIMUM EPA DIFFERENCE

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP UBC	VA	PS	1982 TSM
Madison	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Miami	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Milwaukee	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Minneapolis	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Mobile	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Montgomery	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
New Orleans	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
San Antonio	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
St. Paul	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
St. Petersburg	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Tampa	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Atlanta	GA	3	0.100	3	0.100	1	0.075	0.120	0.100	0.150	0.050	LESS			
Boston	MA	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Buffalo	NY	3	0.100	3	0.100	1	0.075	0.070	0.100	0.150	0.050	LESS	LESS		
Charlotte	NC	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Honolulu	HI	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Jersey City	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Kansas City	MO	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
New York	NY	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Newark	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Oklahoma City	OK	3	0.100	3	0.100	1	0.075	0.100	0.100	0.150	0.050	LESS			
St. Louis	MO	3	0.100	3	0.100	2A	0.150	0.110	0.100	0.150	0.050				
Yonkers	NY	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Lincoln	NE	3	0.100	3	0.100	1	0.075	0.100	0.100	0.075	0.025	LESS			LESS
Tulsa	OK	3	0.100	3	0.100	1	0.075	0.075	0.100	0.075	0.025	LESS	LESS		LESS
Akron	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Aurora	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Baltimore	MD	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Cincinatti	OH	2	0.050	2	0.050	1	0.075	0.060	0.050	0.075	0.025				
Cleaveland	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Colorado Springs	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Columbus	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Denver	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Detroit	MI	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Jackson	MS	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Lexington	KY	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Littlerock	AR	2	0.050	2	0.050	1	0.075	0.050	0.050	0.075	0.025				
Mesa	AZ	1	0.050	4	0.150	1	0.075	0.075	0.050	0.075	0.025	LESS	LESS		LESS

SORT BY MAXIMUM EPA DIFFERENCE

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP UBC	VA	PS	1982 TSM
Nashville	TN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Newport News	VA	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Norfolk	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Omaha	NE	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Pheonix	AZ	1	0.050	4	0.150	1	0.075	0.050	0.050	0.075	0.025	LESS	LESS		LESS
Pittsburgh	PA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Raleigh	NC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Richmond	VA	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Shreveport	LA	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Toledo	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Virginia Beach	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Washington	DC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Wichita	KS	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Long Beach	CA	7	0.400	7	0.400	4	0.400	0.390	0.400	0.400	0.010		LESS		
Anaheim	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Anchorage	AK	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Bakersfield	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Fremont	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Glendale	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Huntington Beach	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Oakland	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Riverside	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
San Jose	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Santa Ana	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Stockton	CA	6	0.300	6	0.300	3	0.300	0.300	0.300	0.300	0.000				
											TOTAL OUT OF 120	38	40	0	20

SEISMIC ZONE COMPARISON
NIST TASK 2 ASSESSMENT REPORT
DEGENKOLB/RUTHERFORD & CHEKENE

NIST STANDARDS
91101

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP UBC	VA	PS	1982 TSM
Anaheim	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Anchorage	AK	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Bakersfield	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Fremont	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Fresno	CA	7	0.400	7	0.400	3	0.300	0.230	0.400	0.300	0.170	LESS	LESS		LESS
Glendale	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Huntington Beach	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Long Beach	CA	7	0.400	7	0.400	4	0.400	0.390	0.400	0.400	0.010		LESS		
Los Angeles	CA	7	0.400	7	0.400	4	0.400	0.250	0.400	0.400	0.150		LESS		
Oakland	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Riverside	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
San Diego	CA	7	0.400	7	0.400	3	0.300	0.150	0.400	0.400	0.250	LESS	LESS		
San Francisco	CA	7	0.400	7	0.400	4	0.400	0.300	0.400	0.400	0.100		LESS		
San Jose	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Santa Ana	CA	7	0.400	7	0.400	4	0.400	0.400	0.400	0.400	0.000				
Stockton	CA	6	0.300	6	0.300	3	0.300	0.300	0.300	0.300	0.000				
Memphis	TN	5	0.200	5	0.200	3	0.300	0.250	0.200	0.300	0.100				
Sacramento	CA	5	0.200	6	0.300	3	0.300	0.300	0.200	0.300	0.100				
Salt Lake City	UT	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
Seattle	WA	5	0.200	5	0.200	3	0.300	0.200	0.200	0.300	0.100				
Tacoma	WA	5	0.200	5	0.200	3	0.300	0.300	0.200	0.300	0.100				
Albuquerque	NM	3	0.100	3	0.100	2B	0.200	0.200	0.100	0.150	0.100				
Atlanta	GA	3	0.100	3	0.100	1	0.075	0.120	0.100	0.150	0.050	LESS			
Boston	MA	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Buffalo	NY	3	0.100	3	0.100	1	0.075	0.070	0.100	0.150	0.050	LESS	LESS		
Charlotte	NC	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Charlston	SC	3	0.100	3	0.100	2A	0.150	0.150	0.250	0.300	0.200				
Honolulu	HI	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Jersey City	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Kansas City	MO	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
Las Vegas	NV	3	0.100	4	0.150	2B	0.200	0.200	0.100	0.150	0.100				
Lincoln	NE	3	0.100	3	0.100	1	0.075	0.100	0.100	0.075	0.025	LESS			LESS
New York	NY	3	0.100	3	0.100	2A	0.150	0.100	0.100	0.150	0.050				
Newark	NJ	3	0.100	3	0.100	1	0.075	0.075	0.100	0.150	0.050	LESS	LESS		
Oklahoma City	OK	3	0.100	3	0.100	1	0.075	0.100	0.100	0.150	0.050	LESS			
St. Louis	MO	3	0.100	3	0.100	2A	0.150	0.110	0.100	0.150	0.050				
Tulsa	OK	3	0.100	3	0.100	1	0.075	0.075	0.100	0.075	0.025	LESS	LESS		LESS
Yonkers	NY	3	0.100	3	0.100	2A	0.150	0.150	0.100	0.150	0.050				
						MODERATE AND HIGH SEISMIC ZONES				TOTAL OUT OF 38		10	10	0	3

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP UBC	VA	PS	1982 TSM
Akron	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Aurora	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Birmingham	AL	2	0.050	2	0.050	1	0.075	0.110	0.050	0.150	0.100				
Cincinatti	OH	2	0.050	2	0.050	1	0.075	0.060	0.050	0.075	0.025				
Cleaveland	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Colorado Springs	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Columbus	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Dayton	OH	2	0.050	2	0.050	1	0.075	0.050	0.050	0.150	0.100				
Denver	CO	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Detroit	MI	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
El Paso	TX	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Fort Wayne	IN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Greensboro	NC	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Indianapolis	IN	2	0.050	2	0.050	1	0.075	0.020	0.050	0.150	0.100		LESS		
Littlerock	AR	2	0.050	2	0.050	1	0.075	0.050	0.050	0.075	0.025				
Nashville	TN	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Newport News	VA	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Omaha	NE	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Philadelphia	PA	2	0.050	3	0.100	2A	0.150	0.150	0.050	0.150	0.100				
Portland	OR	2	0.050	2	0.050	2B	0.200	0.150	0.100	0.075	0.150				
Richmond	VA	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Rochester	NY	2	0.050	2	0.050	1	0.075	0.075	0.050	0.150	0.100				
Spokane	WA	2	0.050	2	0.050	2B	0.200	0.200	0.050	0.075	0.150				
Toledo	OH	2	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Tuscon	AZ	2	0.050	4	0.150	2B	0.200	0.050	0.050	0.075	0.150		LESS		LESS
Wichita	KS	2	0.050	2	0.050	1	0.075	0.070	0.050	0.075	0.025				
Arlington	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Austin	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Baltimore	MD	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Baton Rouge	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Chicago	IL	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Columbus	GA	1	0.050	2	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Corpus Christi	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Dallas	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Des Moines	IA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Fort Worth	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Garland	TX	1	0.050	2	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Grand Rapids	MI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Hialeah	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	GSA/FBO/DOE UBC ZONE	UBC EPA	VA EPA	POSTAL SERVICE EPA	1982 TSM EPA	MAX DIFF	# OF CITIES LESS THAN NEHRP UBC	VA	PS	1982 TSM
Houston	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Jackson	MS	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Jacksonville	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Lexington	KY	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
Louisville	KY	1	0.050	2	0.050	1	0.075	0.100	0.050	0.150	0.100				
Lubbock	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Madison	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Mesa	AZ	1	0.050	4	0.150	1	0.075	0.075	0.050	0.075	0.025	LESS	LESS		LESS
Miami	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Milwaukee	WI	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Minneapolis	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Mobile	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Montgomery	AL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
New Orleans	LA	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
Norfolk	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Pheonix	AZ	1	0.050	4	0.150	1	0.075	0.050	0.050	0.075	0.025	LESS	LESS		LESS
Pittsburgh	PA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Raleigh	NC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
San Antonio	TX	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Shreveport	LA	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
St. Paul	MN	1	0.050	1	0.050	0	0.000	0.000	0.050	0.075	0.050	LESS	LESS		
St. Petersburg	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Tampa	FL	1	0.050	1	0.050	0	0.000	0.000	0.050	0.000	0.050	LESS	LESS		LESS
Virginia Beach	VA	1	0.050	1	0.050	1	0.075	0.075	0.050	0.075	0.025				
Washington	DC	1	0.050	2	0.050	1	0.075	0.075	0.050	0.075	0.025				
						LOW SEISMIC ZONES			TOTAL OUT OF 64			28	30	0	17

SEISMIC ZONE COMPARISON
NIST TASK 2 ASSESSMENT REPORT
MAXIMUM (EPV - EPA) VALUE
DEGENKOLB/RUTHERFORD & CHEKENE

NIST STANDARDS
91101

CITY	ST	NEHRP ACCEL ZONE	NEHRP EPA	NEHRP VELOC ZONE	NEHRP EPV	EPV-EPA	CITIES UBC ZONE	CITIES UBC EPA	CITIES LESS THAN NEHRP
Mesa	AZ	1	0.050	4	0.150	0.10	1	0.075	LESS
Pheonix	AZ	1	0.050	4	0.150	0.10	1	0.075	LESS
Tuscon	AZ	2	0.050	4	0.150	0.10	2B	0.200	
Sacramento	CA	5	0.200	6	0.300	0.10	3	0.300	
Philadelphia	PA	2	0.050	3	0.100	0.05	2A	0.150	
Las Vegas	NV	3	0.100	4	0.150	0.05	2B	0.200	

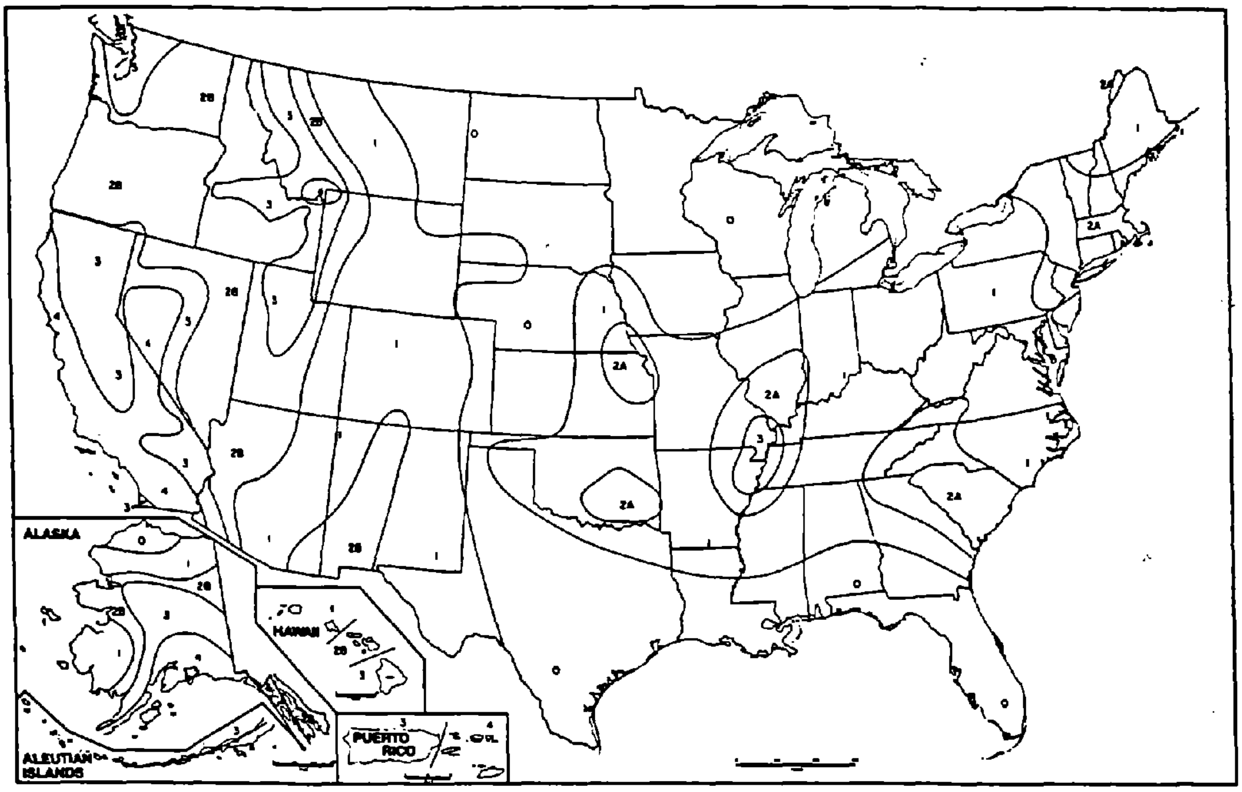


FIGURE NO. 23-2—SEISMIC ZONE MAP OF THE UNITED STATES

For areas outside of the United States, see Appendix Chapter 23.

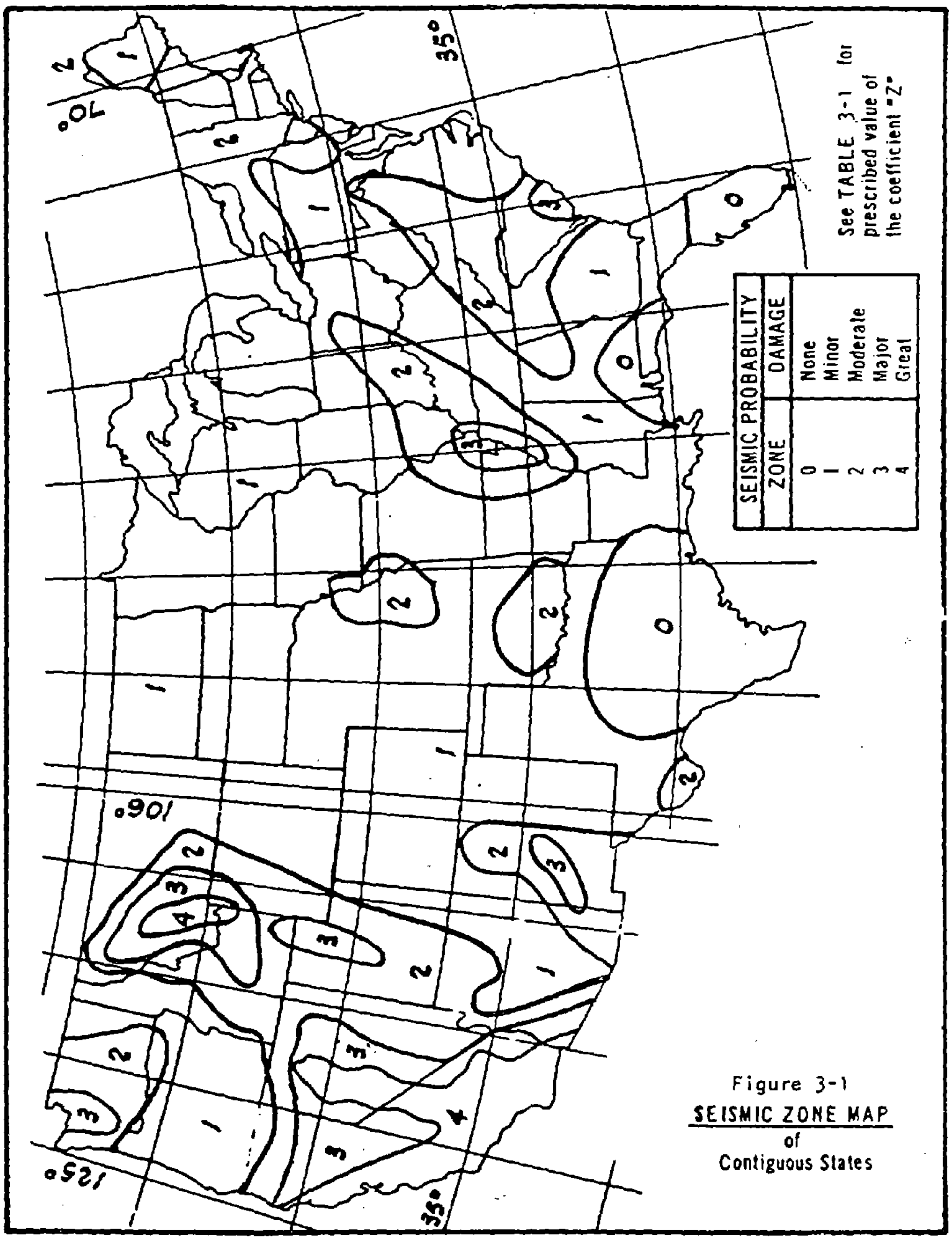


Figure 3-1
SEISMIC ZONE MAP
of
Contiguous States

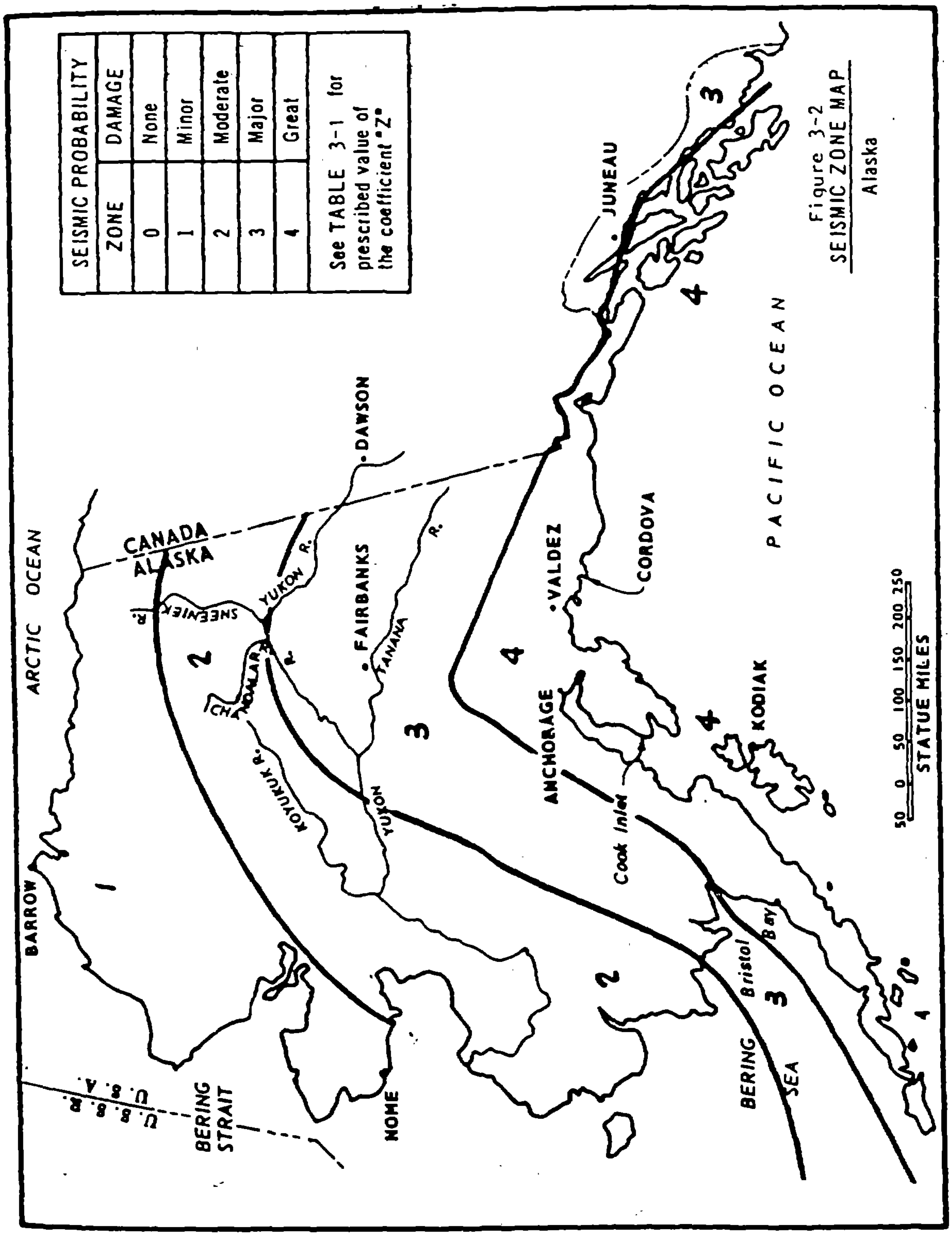
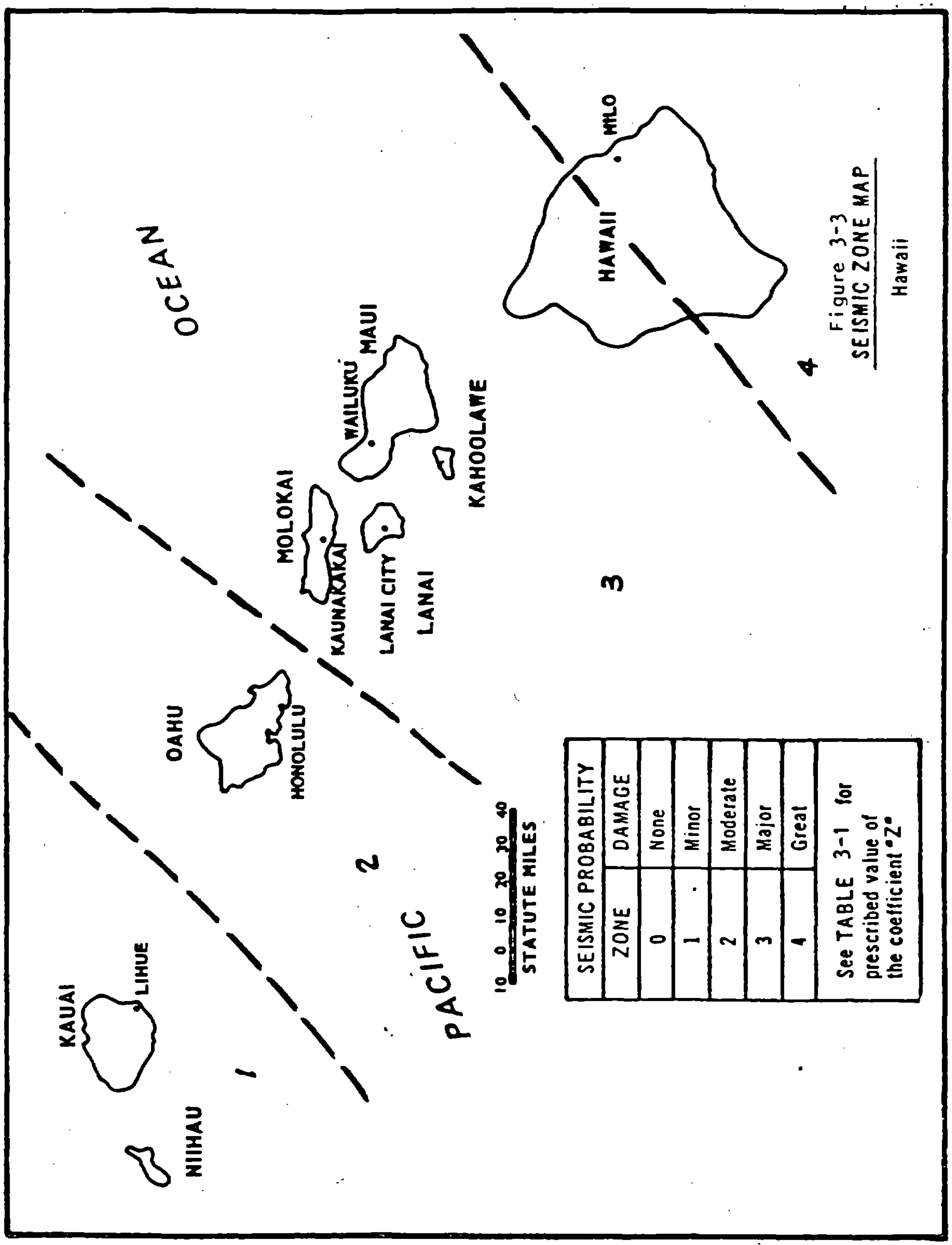


Figure 3-2
SEISMIC ZONE MAP
Alaska

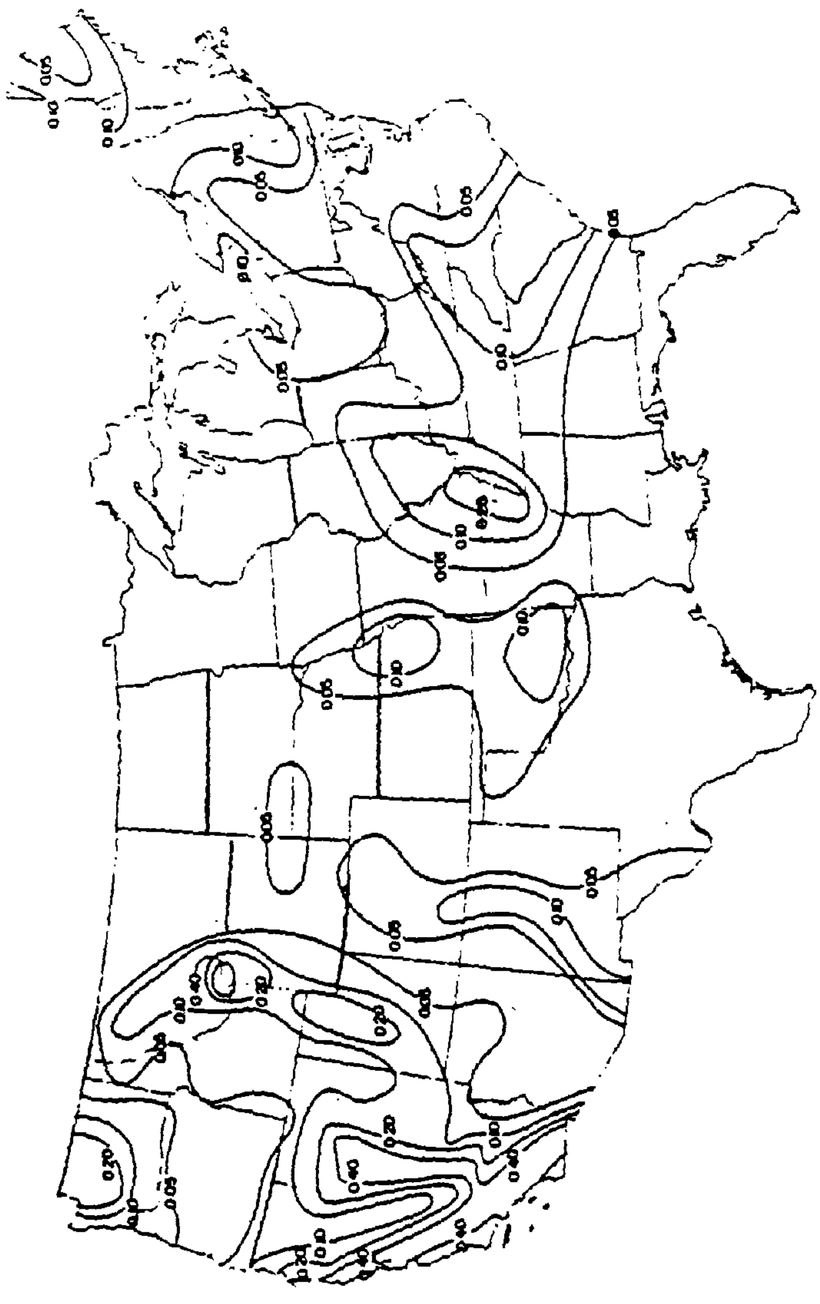


SEISMIC PROBABILITY	
ZONE	DAMAGE
0	None
1	Minor
2	Moderate
3	Major
4	Great

See TABLE 3-1 for prescribed value of the coefficient "Z"

Figure 3-3
SEISMIC ZONE MAP
Hawaii

NEHRP. EVALUATION HANDBOOK



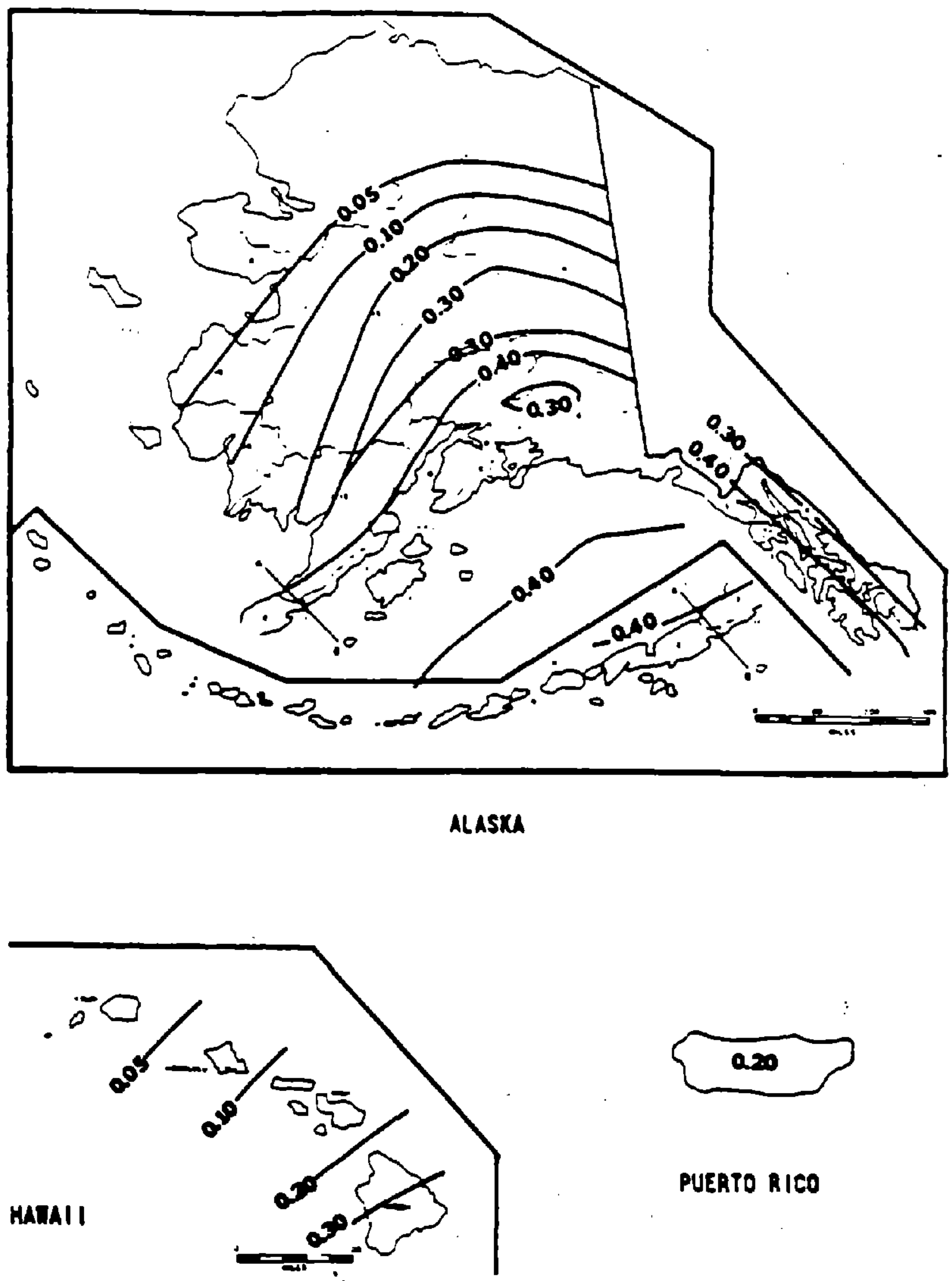


FIGURE 2.1b Contour map for the effective peak acceleration coefficient (A_a) for Alaska, Hawaii, and Puerto Rico.

NEHRP EVALUATION HANDBOOK

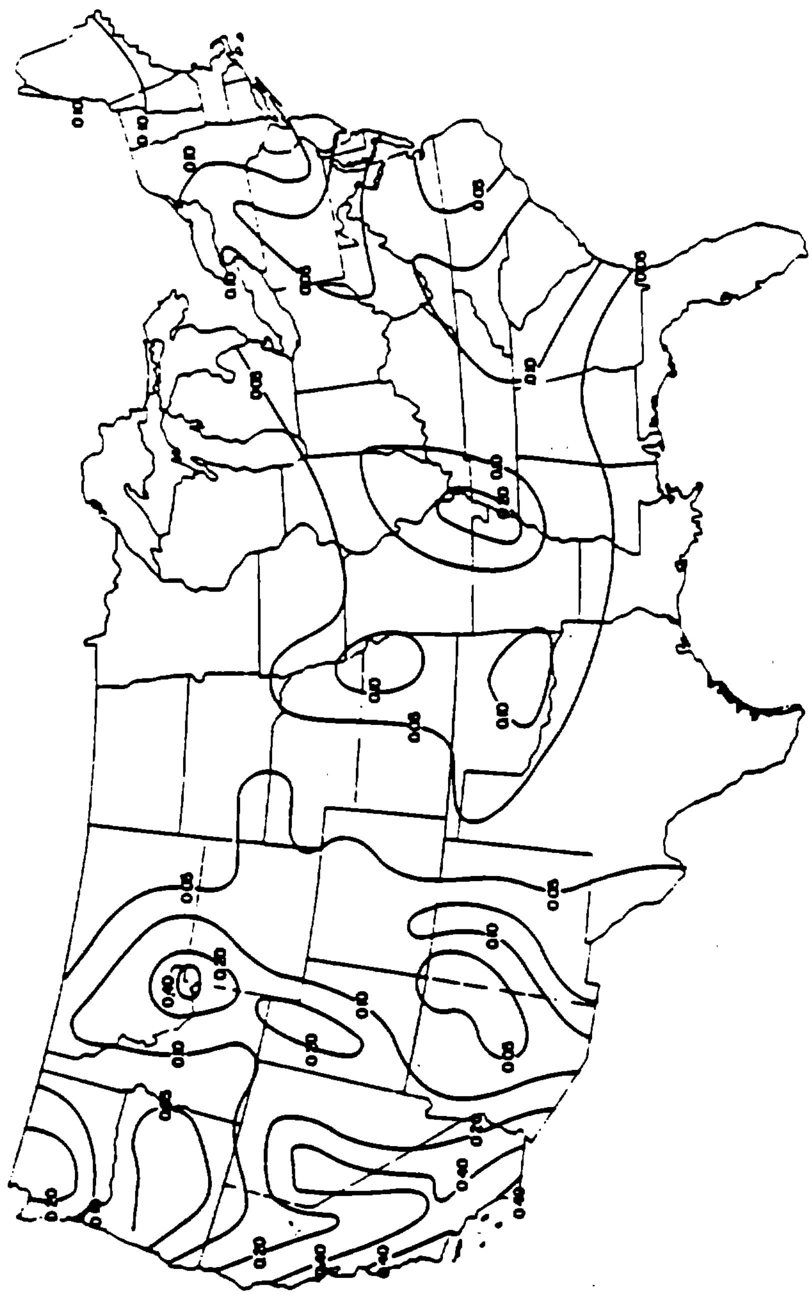


FIGURE 2.1c Contour map for the effective peak velocity-related acceleration coefficient (A_v) for the continental United States.

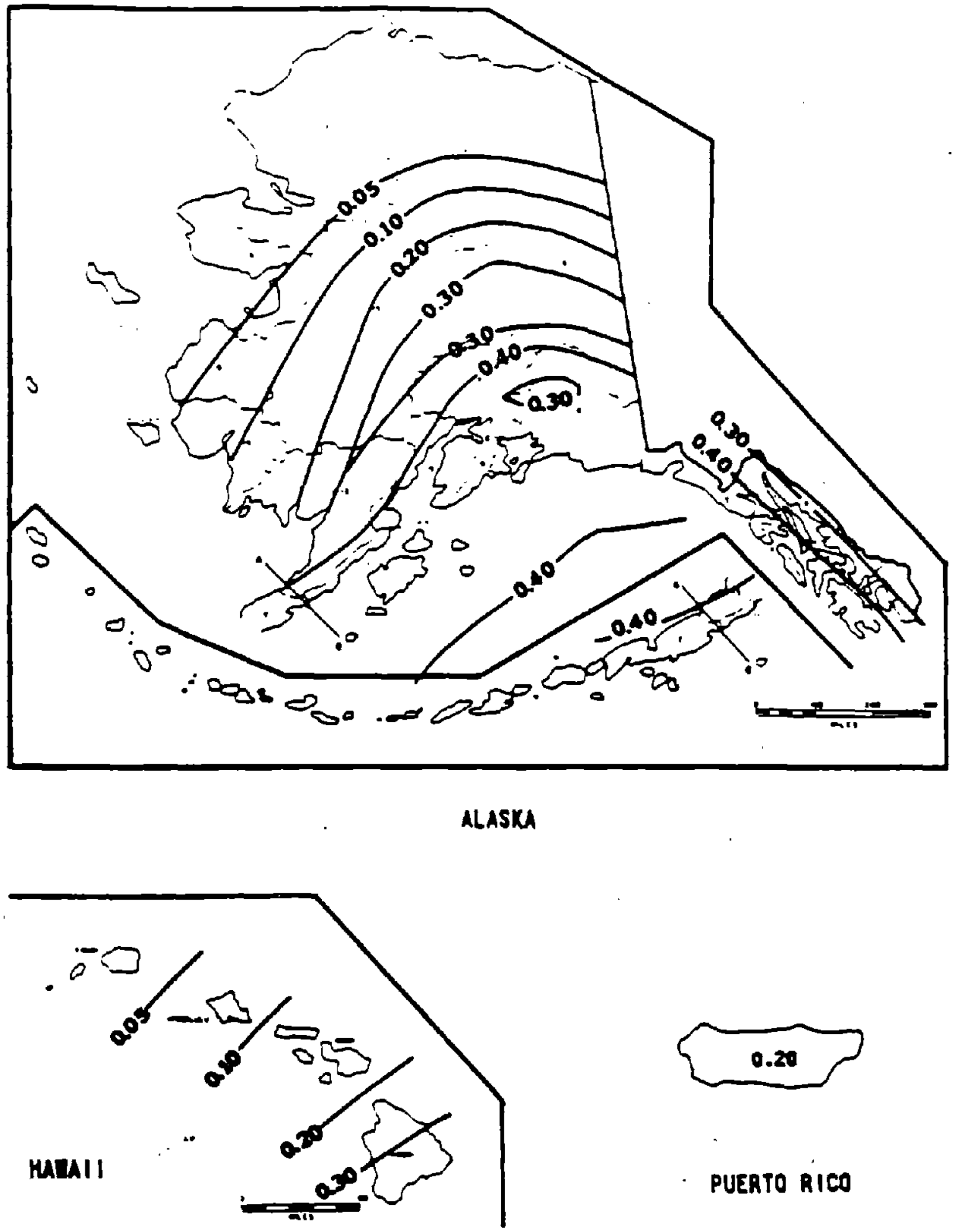


FIGURE 2.1d Contour map for the effective peak velocity-related acceleration coefficient (A_v) for Alaska, Hawaii, and Puerto Rico.

APPENDIX E

Special Details Assessment Procedure

Special Details Assessment Table

APPENDIX E - Special Details Assessment Procedure

The NEHRP Evaluation Handbook includes detailing checks as part of the evaluation process. For example, for moment frames, detailing checks include: moment connections, column splices, joint webs, girder-flange continuity plates, and out-of-plane bracing.

The Special Details Assessment Table has been prepared to compare the detailing checks required by the various criteria with those of the NEHRP Evaluation Handbook. The first column of the table lists the detailing requirements of the NEHRP Evaluation Handbook. If a criteria has a similar detailing requirement which meets or exceeds NEHRP, an asterisk (*) is shown. This procedure is illustrated as follows. Under the heading of Concrete Moment Frames, NEHRP indicates that stirrup and tie hooks should be bent to 135 degrees. The 1982 Tri-Service Manual and the UBC, referenced by FBO, GSA, DOE, and VA, addresses the issue directly. Consequently, an asterisk is provided. Another example, Frames with Infill Walls, is not allowed by the UBC. Consequently, the requirements of the UBC are more restrictive than NEHRP and thus again, an asterisk is provided.

Where a detailing requirement has not been specifically addressed, the item has been indicated with footnote (2). For example, chord, tie, and collector connections for precast concrete frames are not specifically addressed by the UBC; however, the requirements of the code would require that these items be addressed.

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NEHRP HANDBOOK DETAILING REQMNTS (SEE NOTE 4)	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
FRAMES WITH INFILL WALLS							
4.1.1 ISOLATION JOINTS	*	*	*	*	*	*	*
STEEL MOMENT FRAMES							
4.2.4 MOMENT CONNECTIONS	*	*	*	*	*	*	*
4.2.5 COLUMN SPLICES	*	*	*	*	*	*	*
4.2.6 JOINT WEBS	*	*	*	*	*	*	*
4.2.7 GIRDER FLANGE CONTINUITY PLS	*	*	*	*	*	*	*
4.2.9 OUT-OF-PLANE BRACING	*	*	*	*	*	*	*
CONCRETE MOMENT FRAMES							
4.3.7 STIRRUP AND TIE HOOKS	*	*	*	*	*	*	*
4.3.8 COLUMN TIE SPACING	*	*	*	*	*	*	*
4.3.9 COLUMN BAR SPLICING	*	*	*	*	*	*	*
4.3.10 BEAM BARS	*	*	*	*	*	*	*
4.3.11 BEAM BAR SPLICES	*	*	*	*	*	*	*
4.3.12 STIRRUP SPACING	*	*	*	*	*	*	*
4.3.13 BEAM TRUSS BARS	*	(2)	(2)	(2)	(2)	(2)	(2)
4.3.14 JOINT REINFORCING	*	*	*	*	*	*	*
PRECAST CONCRETE FRAMES							
4.4.2 CHORD,TIE,COLLECTORS	*		(2)	(2)	(2)	(2)	(2)
CONCRETE SHEAR WALLS							
5.1.3 COUPLING BEAM REINF.	*		*	*	*	*	*
5.1.4 COLUMN SPLICES	*	*	*	*	*	*	*
5.1.5 WALL CONNECTIONS	*	*	*	*	*	*	*
5.1.6 CONFINEMENT REINF	*		*	*	*	*	*
5.1.7 REINF STEEL LIMITS	*	*	*	*	*	*	*
5.1.8 OPENING REINF.	*	*	*	*	*	*	*
PRECAST CONCRETE SHEARWALLS							
5.2.1 PANEL TO PANEL CONN.	*	*	(2)	(2)	(2)	(2)	(2)
REINFORCED MASONRY SHEAR WALLS							
5.3.2 STEEL REINF LIMITS	*	*	*	*	*	*	*
5.3.3 OPENING REINF	*	*	*	*	*	*	*
UNREINF. MASONRY SHEARWALLS							
5.4.2 MASONRY LAYUP	*	*	*	*	*	*	*

NOTES:

1) AN ASTERISK (*) INDICATES THAT THE ITEM IS ADDRESSED BY THE AGENCY OR THAT THE REQUIREMENTS OF THE AGENCY ARE MORE RESTRICTIVE THAN NEHRP
2) NOT SPECIFICALLY ADDRESSED
3) COLUMNS DESIGNATED AS "1982 TSM" AND "1992 TSM" REFER TO THE CURRENT AND DRAFT VERSIONS OF THE TRI-SERVICE MANUAL, RESPECTIVELY.
4) AN INTERRUPTION IN THE NUMBERING SEQUENCE SIGNIFIES A NON-DETAILING REQUIREMENT.

TABLE 1 - COMPARISON OF STRUCTURAL DETAILS

NEHRP HANDBOOK DETAILING REQMNT (SEE NOTE 4)	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
INFILL WALLS AT FRAMES							
5.5.2 SOLID WALLS	*	*	*	*	*	*	*
5.5.3 INFILL WALLS	*	*	*	*	*	*	*
5.5.4 WALL CONNECTIONS	*	*	*	*	*	*	*
WALLS IN WOOD FRAMED BLDGS							
5.6.3 NAILING	*	*	*	*	*	*	*
5.6.3 HOLD DOWNS	*	*	*	*	*	*	*
5.6.4 CRIPPLE WALLS	*	*	*	*	*	*	*
BRACED FRAMES							
6.1.2 BRACE STIFFNESS	*		*	*	*	*	*
6.1.5 CONCENTRIC JOINTS	*		*	*	*	*	*
6.1.6 CONNECTION STRENGTH	*		*	*	*	*	*
6.1.7 COLUMN SPLICES	*		*	*	*	*	*
DIAPHRAGMS							
7.1.2 CROSS TIES	*	*	*	*	*	*	*
7.1.3 REINFORCEMENT @ OPENINGS	*	*	*	*	*	*	*
7.5.1 TOPPING SLAB CONN.	*	*	*	*	*	*	*
STRUCTURAL CONNECTIONS							
8.2.1 WOOD LEDGERS	*	*	*	*	*	*	*
8.2.2 WALL ANCHORAGE	*	*	*	*	*	*	*
8.2.3 WALL ANCHOR TYPE	*	*	(2)	(2)	(2)	(2)	(2)
8.2.4 ANCHOR SPACING	*	*	(2)	(2)	(2)	(2)	(2)
8.2.5 TILT-UP WALLS	*	(2)	(2)	(2)	(2)	(2)	(2)
8.2.6 PANEL-ROOF CONNECTION	*	(2)	(2)	(2)	(2)	(2)	(2)
8.3.1-3 DIAPHRAGM SHEAR TRANSFER	*	*	*	*	*	*	*
8.4.1 STL COL TO FOUNDATION	*	*	*	*	*	*	*
8.4.2 CONC. COLUMN TO FOUNDATIO	*	*	*	*	*	*	*
8.4.3 WOOD POSTS	*	*	*	*	*	*	*
8.4.4 WALL REINF	*	*	*	*	*	*	*
8.4.5 BOUNDARY ELEMENTS	*	*	*	*	*	*	*
8.4.6 WALL PANELS	*	*	*	*	*	*	*
8.4.7 WOOD SILLS	*	*	*	*	*	*	*
8.5.1 GIRDER TO PILASTER	*	(2)	*	*	*	*	*
8.5.2 CORBEL BEARING	*	(2)	(2)	(2)	(2)	(2)	(2)
8.5.3 CORBEL CONNECTION	*	(2)	(2)	(2)	(2)	(2)	(2)

NOTES:

1) AN ASTERISK (*) INDICATES THAT THE ITEM IS ADDRESSED BY THE AGENCY OR THAT THE REQUIREMENTS OF THE AGENCY ARE MORE RESTRICTIVE THAN NEHRP

2) NOT SPECIFICALLY ADDRESSED

3) COLUMNS DESIGNATED AS "1982 TSM" AND "1992 TSM" REFER TO THE CURRENT AND DRAFT VERSIONS OF THE TRI-SERVICE MANUAL, RESPECTIVELY.

4) AN INTERRUPTION IN THE NUMBERING SEQUENCE SIGNIFIES A NON-DETAILING REQUIREMENT.

TABLE 1 - COMPARISON OF STRUCTURAL DETAILS

APPENDIX F

Drift Requirements Assessment Procedure

Drift Requirements Assessment Calculations

APPENDIX F - Drift Requirements Assessment Procedure

The following calculations compare different agency programs against NEHRP comparing drift requirements. The NEHRP Evaluation Handbook drift procedures are used as a baseline.

To assess drift requirements, the interstory drift limit is computed for each criteria for both a one-story and a ten-story steel moment frame building and concrete moment frame building. Next, the base shear for both the one-story and the ten-story building are computed keeping the building weight as constant. An effective stiffness indicator, K, for both the one-story and the ten-story building is determined by dividing the base shear by the product of the drift limit and the number of stories (the overall building drift).

DRIFT ASSESSMENT

- CHECK FOUR CASES :
  - 1 STORY STEEL SPECIAL MOMENT FRAME
  - 10 STORY STEEL SPECIAL MOMENT FRAME
  - 1 STORY CONCRETE SPECIAL MOMENT FRAME
  - 10 STORY CONCRETE SPECIAL MOMENT FRAME
- ASSUME BUILDING LOCATION IS SAN FRANCISCO (0.4g)
- ASSUME SOIL CONDITIONS ARE UNKNOWN (S = 1.5)
- ASSUME PERIOD = 0.1 sec FOR 1 STORY BLDG.
  1.0 sec FOR 10 STORY BLDG.
- ASSUME STORY HEIGHT = 12'-0" FOR ALL FLOORS.
- ASSUME NORMAL BLDG. CONFIGURATION AND IMPORTANCE

$$\text{STIFFNESS COEF} = K = \frac{V}{\Delta * N}$$

V = BASE SHEAR
Δ = ALLOWABLE STORY DRIFT
N = # OF STORIES

SUMMARY

	1 STORY	10 STORY
NEHRP	1.90W	0.14W
UBC	2.3 W	0.21W
VA	9.4 W	0.38 W
DOE	6.1 W	0.42W
TRI-SERVICE	2.34W	0.167W

NEHRP

DRIFT: - ALLOWABLE DRIFT = 1.3?? * NEHRP PROVISIONS.

- ASSUME NO BRITTLE FINISHES, BUT ROOF MOUNTED EQUIP.

- SEISMIC HAZARD EXPOSURE GROUP = I

1 STORY: $\Delta_{a_1} = \dfrac{0.020 h_{sx}}{Cd}$

10 STORY: $\Delta_{a_{10}} = \dfrac{0.015 h_{sx}}{Cd}$

h_{sx} = STORY HEIGHT BELOW LEVEL "x" (ft)

Cd = DISP. AMPLIFICATION FACTOR = 5.5 FOR BOTH STEEL AND CONCRETE MOMENT FRAMES

BASE SHEAR:

R = 8 FOR BOTH STEEL AND CONCRETE MOMENT FRAMES.

1 STORY: $C_{S_1} = \dfrac{0.8 A_v S}{R T^{2/3}} = \dfrac{(.8)(.4)(1.5)}{8\,(0.1)^{2/3}} = 0.28$ LIMITED BY: $\dfrac{2.12 A_a}{R} = 0.11$ $\therefore V = .11W.$

10 STORY: $C_{S_{10}} = \dfrac{0.8(.4)(1.5)}{8\,(1)^{2/3}} = 0.06 < 0.11$ $\therefore V = 0.06W$

STIFFNESS:

$$K_1 = \frac{0.11W\,(5.5)}{1.3??(0.02)(12')\,(1)} = 1.90W$$

$$K_{10} = \frac{0.06W\,(5.5)}{1.3??\,(0.015)(12)(10)} = 0.14W$$

UBC

DRIFT :

- ALLOWABLE DRIFT CHANGES WITH BUILDING PERIOD.

$T < 0.7$ sec : $\Delta = \frac{0.04}{R_w} h_{st}$ OR $\Delta = 0.005\, h_{st}$

$T > 0.7$ sec : $\Delta = \frac{0.03}{R_w} h_{st}$ OR $\Delta = 0.004\, h_{st}$

↑ CONTROLS w/ $R_w = 12$

BASE SHEAR :

$R_w = 12$ FOR BOTH STEEL AND CONCRETE MOMENT FRAMES.

1 STORY: $V_1 = \frac{ZICW}{R_w} = \frac{(.4)(1.0)\frac{1.25(1.5)}{(.1)^{2/3}}}{12} W = 0.29\,W$

LIMITED BY: $\frac{2.75(.4)}{12} W = 0.092\,W$

$C = \frac{1.25\,S}{T^{2/3}}$

$\therefore V_1 = 0.092 \cdot W$

10 STORY: $V_{10} = \frac{(.4)(1.0)\frac{1.25(1.5)}{(1)^{2/3}}}{12} W = 0.063\,W$

STIFFNESS:

$$K_1 = \frac{0.092\,W\,(12)}{0.04\,(12)\;(1)} = 2.3\,W$$

$$K_{10} = \frac{0.063\,W\,(12)}{(0.03)(12')\;(10)} = 0.21\,W$$

VA / H·08-8

DRIFT :

- ALLOWABLE DRIFT = $\Delta = \frac{0.008\ h_{st}}{\beta}$

β = DRIFT REDUCTION FACTOR = 4 FOR STEEL MOMENT FRAMES
3 FOR CONCRETE MOMENT FRAMES

BASE SHEAR :

$\alpha = 1/4$ FOR BOTH STEEL AND CONCRETE MOMENT FRAMES

1 STORY : $V_1 = A_{max}\ \alpha\ (DAF)\ W = .4(1/4)(3)\ W = 0.3W$

↑ FROM H·08-8 DESIGN SPECTRUM

10 STORY : $V_{10} = (.4)(1/4)(1.2)\ W = 0.12\ W$

STIFFNESS :

	STEEL	CONCRETE
$K_1 = \frac{0.30W\ (4)}{0.008\ (12')\ (1)}$ =	12.5 W	9.4 W
$K_2 = \frac{0.120W\ (4)}{0.008\ (12')\ (10)}$ =	0.5 W	0.38 W

DOE - MODERATE / HIGH HAZARD.

ALLOWABLE DRIFT.

$$\Delta = 0.015 h_{st} \quad \text{(NO RW REDUCTION)}.$$

BASE SHEAR

- FROM ELASTIC DYNAMIC ANALYSIS.
- APPROXIMATED BY UBC STATIC w/ NO RW REDUCTION.

1 STORY: $V_1 = ZICW = (.4)(1.0)(2.75)W = 1.1\ W$

10 STORY: $V_{10} = (.4)(1.0)\dfrac{1.25\,(1.5)}{(1)^{2/3}} W = 0.75W$

STIFFNESS:

$$K_1 = \frac{1.1\ W}{0.015(12')\ (1)} = 6.1\ W$$

$$K_{10} = \frac{0.75\ W}{0.015(12')(10)} = 0.42\ W$$

TRI SERVICE / P355.2

- USING STATIC PROCEDURE.

ALLOWABLE DRIFT:

$$\Delta = 0.005 h_{st} \cdot K$$

K = 0.67 FOR BOTH STEEL AND CONCRETE MOMENT FRAMES.

BASE SHEAR:

1 STORY: $V_1 = ZIKCSW = (1.0)(1.0)(0.67)\left(\frac{1}{15\sqrt{.1}}\right)(1.5)\,W = 0.21\,W$

$C = \frac{1}{15\sqrt{T}}$ LIMITED BY: $0.14\,ZIKW = 0.14(1.0)(1.0)(.67)W = \underline{0.094\,W}$

10 STORY: $V_{10} = (1.0)(1.0)(.67)\left(\frac{1}{15\sqrt{1}}\right)(1.5)\,W = 0.067W.$

STIFFNESS:

$$K_1 = \frac{0.094\,W}{0.005(12')(0.67)(1)} = 2.34W$$

$$K_2 = \frac{0.067\,W}{0.005\,(12')(0.67)(10)} = 0.167W$$

APPENDIX G

Strengthening Techniques Assessment Procedure

APPENDIX G - Strengthening Techniques Assessment Procedure

Several agencies have documented techniques for seismically strengthening buildings. These techniques have been compared with the NEHRP Techniques Handbook in the Strengthening Techniques Assessment Table.

The method employed to compare the techniques of the NEHRP Handbook and the techniques of the various agencies is strictly qualitative. Strengthening techniques provided in the NEHRP Handbook are categorized with respect to framing, material, or element type. Recommendations for particular categories have been added to provide a measure for comparison. For example, the NEHRP Handbook provides three alternatives for strengthening concrete moment frames:

1) jacket the beams and columns to increase ductility
2) reduce stresses by providing additional vertical and/or lateral force resisting elements
3) infill the frames to create shear walls

By comparison, P355.2 lists six alternatives:

1) add steel frames
2) add concrete shear walls
3) add steel shear walls
4) add concrete or steel exterior buttresses
5) use new building additions to support existing building
6) remove and replace elements with new construction

As can be seen, some alternatives presented in the Handbook and in P355.2 are similar. Additionally, the choice of strengthening technique is largely dependent upon several factors including economics and building use. The factors may vary from building to building. Consequently, what may be suitable for one project may not be suitable for another.

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	NEHRP	USPS	P355.2	FBO	DOE	VA	GSA
STEEL MOMENT FRAMES	14	9	7		7		
CONCRETE MOMENT FRAMES	3	2	6		6		
MOMENT FRAMES WITH INFILL WALLS	2	2	7		7		
PRECAST CONCRETE MOMENT FRAMES	2		2		2		
CONCRETE SHEAR WALLS	6	3					
COUPLING BEAMS	4	4					
PRECAST CONCRETE SHEAR WALLS	8	5					
UNREINFORCED MASONRY SHEAR WALLS	8	4	3		3		
WOOD SHEAR WALLS	5	1					
BRACED FRAMES	16	5	5		5		
ECCENTRIC BRACED FRAMES	2						
WOOD DIAPHRAGMS	11	3	3		3		
CONCRETE DIAPHRAGMS	9		3		3		
GYPSUM DIAPHRAGMS	10						

NOTES:
1) FIGURES INDICATE NUMBER OF RECOMMENDATIONS FOR LINE ITEM.
2) FIGURES FOR USPS ARE FOR THE METHODS PRESENTED IN ATC 26-4 ONLY.
ATC 26-4 REFERENCES THE METHODS PRESENTED IN THE NEHRP HANDBOOK AND NAVFAC P355.2 ALSO.
3) AN ASTERISK (*) INDICATES THAT THE AGENCY PROVIDES GUIDELINES ON THE ITEM BUT NO SPECIFIC DETAIL.
4) ALTERNATIVE METHODS REFERS TO BASE ISOLATION, ENERGY DISSIPATION,ETC.
5) DOE REFERENCES NAVFAC P355.2
6) FROM UCRL-15815. DOCUMENT NOT AVAILABLE FOR REVIEW

TABLE 3(i) - COMPARISON OF STRENGTHENING METHODS

	NEHRP	USPS	P355.2	FBO	DOE	VA	GSA
PRECAST CONCRETE DIAPHRAGMS	9	2					
STEEL DECK DIAPHRAGMS	10	4	3		3		
HORZ. STEEL BRACING	5		1		1		
CONT. FOUNDATIONS	7	6	2		2		
PIER/COLUMN FOOTINGS	13	6	2		2		
PILES/DRILLED PIERS	6	6	1		1		
MAT FOUNDATIONS	3	2					
TIMBER CONNECTIONS	11	2					
CONCRETE CONNECTIONS	5						
GYPSUM DIAPHRAGM CONNECTIONS	3						
PRECAST CONCRETE DIAPHRAGMS	3	1					
DECK W/O FILL CONNECTIONS	5	1					
DECK WITH FILL CONNECTIONS	4	1					
HORIZONTAL BRACING CONNECTIONS	3						
WOOD STUD WALL TO FOUNDATIONS	5	2					
PRECAST CONCRETE TO FOUNDATIONS	4	2					

NOTES:

1) FIGURES INDICATE NUMBER OF RECOMMENDATIONS FOR LINE ITEM.

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ATC 26-4 REFERENCES THE METHODS PRESENTED IN THE NEHRP HANDBOOK AND NAVFAC P355.2 ALSO.

3) AN ASTERISK (*) INDICATES THAT THE AGENCY PROVIDES GUIDELINES ON THE ITEM BUT NO SPECIFIC DETAIL.

4) ALTERNATIVE METHODS REFERS TO BASE ISOLATION, ENERGY DISSIPATION,ETC.

5) DOE REFERENCES NAVFAC P355.2

6) FROM UCRL-15815. DOCUMENT NOT AVAILABLE FOR REVIEW

TABLE 3(ii) - COMPARISON OF STRENGTHENING METHODS

	NEHRP	USPS	P355.2	FBO	DOE	VA	GSA
BRACED FRAMES TO FOUNDATIONS	4						
MOMENT FRAMES TO FOUNDATIONS	3						
CURTAIN WALLS	1	2	1		1		
PARAPETS	2	2					
PARTITIONS	1	2	3		3		*
CEILINGS	1	2	1		1		*
LIGHTING FIXTURES	1	4	*		*		*
ACCESS FLOORS	1	1					
MECH./ELEC. EQUIPMENT	4	4	2		NOTE 6		*
DUCT/PIPING SUPPORT	2	4			NOTE 6		2
EMERGENCY POWER	1	3					*
HAZARDOUS MATERIALS	2	1					*
COMMUNICATION SYSTEMS	4	4					
FURNITURE		2					*
ALTERNATIVE METHODS	Y	Y					Y

NOTES:

1) FIGURES INDICATE NUMBER OF RECOMMENDATIONS FOR LINE ITEM.

2) FIGURES FOR USPS ARE FOR THE METHODS PRESENTED IN ATC 26-4 ONLY.
ATC 26-4 REFERENCES THE METHODS PRESENTED IN THE NEHRP HANDBOOK AND NAVFAC P355.2 ALSO.

3) AN ASTERISK (*) INDICATES THAT THE AGENCY PROVIDES GUIDELINES ON THE ITEM BUT NO SPECIFIC DETAIL.

4) ALTERNATIVE METHODS REFERS TO BASE ISOLATION, ENERGY DISSIPATION,ETC.

5) DOE REFERENCES NAVFAC P355.2

6) FROM UCRL-15815. DOCUMENT NOT AVAILABLE FOR REVIEW

TABLE 3(iii) - COMPARISON OF STRENGTHING METHODS

APPENDIX H

Non-Structural Requirements Assessment Procedure

APPENDIX H - Non-Structural Requirements Assessment Procedure

The NEHRP Evaluation Handbook includes non-structural requirements as part of the evaluation process. For example, partitions, ceiling systems and light fixtures must be braced, cladding and veneer must be anchored, and mechanical and electrical equipment must be fastened to the building.

The Non-Structural Requirements Assessment Table has been prepared to compare the non-structural details required by the various criteria with those of the NEHRP Evaluation Handbook. The first column of the table lists the non-structural detailing requirements of the NEHRP Evaluation Handbook. If a criteria has a similar requirement which meets or exceeds NEHRP, an asterisk (*) is shown. A zero (0) indicates that a criteria does not meet NEHRP for a particular requirement. For items designated with note (3) in the Table, it is assumed that NEHRP non-acceptance of these elements is only true if the elements do not meet life-safety standards, as indicated in NEHRP Section 10.3. Since all agency requirements in this case would be covered by general statements, equivalence with NEHRP is difficult to determine.

The Non-Structural Requirements Assessment has not reviewed agency requirements for movable contents or furniture.

NEHRP HANDBOOK NONSTRUCTURAL REQMNTS	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
10.5.1 PARTITIONS							
-UNBRACED UNREINF. MASONRY OR CMU	*	*	*	*	*	*	*
-DETAILING FOR INTERSTORY DRIFT	*	*	*	*	*	*	*
-SEISMIC JOINTS @ BLDG SEPARATIONS	*	*	*	*	*	*	*
-LATERAL BRACING @ TOP OF PARTITIONS	*	*	*	*	*	*	*
10.5.2 CEILING SYSTEMS							
-LATERAL BRACING	*	*	*	*	*	*	*
-CEILINGS NOT SUSPENDED PLASTER OR GYP BOARD	*	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	*
-LAY-IN TILES NOT USED	*	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	*
-CEILING/WALL SEPARATIONS	*	*	*	*	*	*	*
-CEILING JOINTS @ SEISMIC JOINTS	*	*	*	*	*	*	*
-CEILING DOESNT LATERALLY SUPPORT WALLS	*	*	*	*	*	*	*
10.5.3 LIGHT FIXTURES							
-FIXTURES BRACED. IND OF SUSPENSION SYS	*	*	*	*	*	*	*
-MULT FIXTURES BRACED THRU-OUT LENGTH	*	*	*	*	*	*	*
-DIFFUSERS W SAFETY DEV.	*	*	*	*	*	*	*
-NO PENDANT FIXTURES	*	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	*
-NO DBL STEM FIXTURES	*	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	*
-EMER. LGHTING ANCHORED	*	*	*	*	*	*	*

COMPARISON OF NON-STRUCTURAL SEISMIC MITIGATION REQUIREMENTS

NOTES

1) AN ASTERISK (*) INDICATES THAT THE AGENCY'S REQUIREMENTS MEET OR EXCEED NEHRP
2) A ZERO (0) INDICATES THAT THE NEHRP REQUIREMENTS ARE NOT MET.
3) IT IS ASSUMED THAT NEHRP NON-ACCEPTANCE OF THESE ELEMENTS IS ONLY TRUE IF THE ELEMENTS DO NOT MEET LIFE-SAFETY STANDARD, AS INDICATED IN NEHRP SECTION 10.3. SINCE AGENCY'S REQUIREMENTS IN THIS CASE WOULD BE COVERED BY GENERAL STATEMENTS, EQUIVALENCE WITH NEHRP IS DIFFICULT TO DETERMINE.
4) NOT COVERED EXCEPT AS AN ELEMENT OF UNREINFORCED MASONRY BUILDINGS.
5) AGENCY REQUIREMENTS FOR CONTENTS HAVE NOT BEEN REVIEWED.
6) COLUMNS DESIGNATED AS "1982 TSM" AND "1992 TSM" REFER TO THE CURRENT AND DRAFT VERSIONS OF THE TRI-SERVICE MANUAL, RESPECTIVELY.

NEHRP HANDBOOK NONSTRUCTURAL REQMNTS	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
10.5.4 CLADDING GLAZING, & VENEER							
-CLADDING ANCHORED	*	*	*	*	*	*	*
-CORROSION-RESISTANT TIES	*	*	*	*	*	*	*
-PANELS ISOLATED	*	*	*	*	*	*	*
-TWO BEARING CONN.	*	*	*	*	*	*	*
-INSERTS	*	*	*	*	*	*	*
-CONN. FOR OUT-OF-PLANE FORCES	*	*	*	*	*	*	*
-WELDED CONN. FAILURE MO	*	*	*	*	*	*	*
-ECCENTRICITY ACCT'D FOR	*	*	*	*	*	*	*
-QUALITY CONTROL	*	*	*	*	*	*	*
-CONN. CONDITION	*	*	*	*	*	*	*
-NO STRUCTURAL DISTRESS	*	*	*	*	*	*	*
-GLAZING ISOLATED	*	*	*	*	*	*	*
-NO WATER LEAKAGE	*	*	*	*	*	*	*
-NO TEMP. DAMAGE	*	*	*	*	*	*	*
10.5.4.1 METAL STUD BACKUP SYSTEMS							
-ADD'L STUDS @ OPENINGS	*	*	*	*	*	*	*
-CONDITIONS OF TIES	*	*	*	*	*	*	*
-CONN. OF STUD TRACKS	*	*	*	*	*	*	*

COMPARISON OF NON-STRUCTURAL SEISMIC MITIGATION REQUIREMENTS

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NEHRP HANDBOOK NONSTRUCTURAL REQMNTS	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
10.5.4.2 MASONRY VENEER WITH STUD BACKUP							
-SHELF ANGLES	*	*	*	*	*	*	*
-CORROSION RESIST. TIES	*	*	*	*	*	*	*
-WEEP HOLES,BASE FLASH.	*	*	*	*	*	*	*
-TENSILE STRESS LIMITS	*	*	*	*	*	*	*
-MORTAR JOINTS COND.	*	*	*	*	*	*	*
10.5.4.3 MASONRY VENEER WITH CONCRETE BACKUP							
-SHELF ANGLES	*	*	*	*	*	*	*
-ADEQUATE ANCHORAGE	*	*	*	*	*	*	*
-REIN. MASONRY	*	*	*	*	*	*	*
-BLOCK/FRAME CONN.	*	*	*	*	*	*	*
-MORTAR JOINTS COND.	*	*	*	*	*	*	*
10.5.4.4 THIN STONE PANELS							
-ADEQUATE ANCHORAGE	*	*	*	*	*	*	*
10.5.4.5 WOOD/AGG. PANELS							
-COND. OF SCREWS	*	*	*	*	*	*	*
10.5.5 PARAPETS	*	*	*	*	*	*	*
-MASONRY PARAPETS BRACE	*	*	*	*	*	*	*
-CONC. PARAPETS REINF.	*	*	*	*	*	*	*
-PROPER ANCHORAGE FOR SIGNS	*	*	*	*	*	*	*

COMPARISON OF NON-STRUCTURAL SEISMIC MITIGATION REQUIREMENTS

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NEHRP HANKBOOK NONSTRUCTURAL REQMNTS	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
10.5.6 CHIMNEYS							
-EXTENT OF CHIMNEY ABOVE ROOF	*	0 (4)	0 (4)	0 (4)	0 (4)	0 (4)	0 (4)
-ANCHORAGE TO FLR,ROOF	*	*	*	*	*	*	*
10.5.7 MEANS OF EGRESS							
-NO HCT OR UNREINF MASO @STRS,ELEVTRS,CORRDRS	*	*	*	*	*	*	*
-NO PIPING IN STAIRS	*	*	*	*	*	*	*
-VENEER,CORNICES,CANOPI ABOVE EXITS WELL ANCHOR	*	*	*	*	*	*	*
-CEILINGS SECURED @ EXITS	*	*	*	*	*	*	*
-CANOPIES ANCHORED	*	*	*	*	*	*	*
10.5.8 BLDG CONTENTS (5)							
-CABINETS SUPPORTED	*	0	0	0	0	0	*
-CABINETS STABLE	*	0	0	0	0	0	*
-DRAWER LATCHES	*	0	0	0	0	0	*
-BREAKABLE ITEMS SECURED	*	0	0	0	0	0	*
-COMPUTERS ANCHORED	*	0	0	0	0	0	*
-ACCESS FLOORS BRACED	*	0	0	0	0	0	*
10.5.9 MECH,ELEC EQUIP							
-EQUIP ANCHORED	*	*	*	*	*	*	*
-ISOL. EQUIP RESTRAINED	*	*	*	*	*	*	*
-LIFE SAFETY EQUIP COUNTINUED OPERATION	*	*	*	*	*	*	*
-SEISMIC BRACING	*	*	*	*	*	*	*
SUSPENDED EQUIP	*	*	*	*	*	*	*
-ELEC. EQUIP. ATTACHED	*	*	*	*	*	*	*
-EQUIP ON ACCESS FLRS	*	*	*	*	*	*	*

COMPARISON OF NON-STRUCTURAL SEISMIC MITIGATION REQUIREMENTS

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NEHRP HANDBOOK NONSTRUCTURAL ELEMENTS	USPS	1982 TSM	1992 TSM	FBO	DOE	VA	GSA
10.5.10 PIPING							
-FIRE PIPING DETAILING	*	*	*	*	*	*	*
-GAS & OIL PIPING	*	*	*	*	*	*	*
-SHUTOFF DEVICES	*	*	*	*	*	*	*
-PIPING AT SEISMIC JOINTS	*	*	*	*	*	*	*
-PIPING SUPPORT	*	*	*	*	*	*	*
-PIPE SLEEVES	*	*	*	*	*	*	*
-MAJOR PIPING, NO C-CLAMPS	*	*	*	*	*	*	*
10.5.11 DUCTS							
-SMOKE DUCTS BRACED	*	*	*	*	*	*	*
-LONG LINES LAT. BRACED	*	*	*	*	*	*	*
-DUCTS NOT SUPPORTED BY NONSTRUCTURAL ELEMENTS	*	*	*	*	*	*	*
-FLEXIBLE SECTIONS @ JOINTS	*	*	*	*	*	*	*
10.5.12 HAZARD. MATLS (5)							
-GAS CYLINDERS RESTRAINED	*	0	0	0	0	0	*
-LAB CHEM. ADEQ. STORED	*	0	0	0	0	0	*
-PIPING W SHUTOFF VALVES	*	0	0	0	0	0	*
10.5.13 ELEVATORS							
-SUPPORTS ANCHORED	*	*	*	*	*	*	*
-GUIDE RAIL DEFLECT LIMITS	*	*	*	*	*	*	*
-SNAG POINT DETAILING	*	*	*	*	*	*	*
-CAB/CNTRWGT CLEARANCE	*	*	*	*	*	*	*
-CABLE RETAINER GUARDS	*	*	*	*	*	*	*
-RETAINER PL	*	*	*	*	*	*	*
-RETAINER PL/ RAIL CLRNCE	*	*	*	*	*	*	*
-RAIL BRACKET SPCING	*	*	*	*	*	*	*
-INT. SPREADER BRACKET	*	*	*	*	*	*	*
-ELEV. MOTOR REST.	*	*	*	*	*	*	*
-CONTROL PNL ANCHOR.	*	*	*	*	*	*	*

COMPARISON OF NON-STRUCTURAL SEISMIC MITIGATION REQUIRMENTS

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