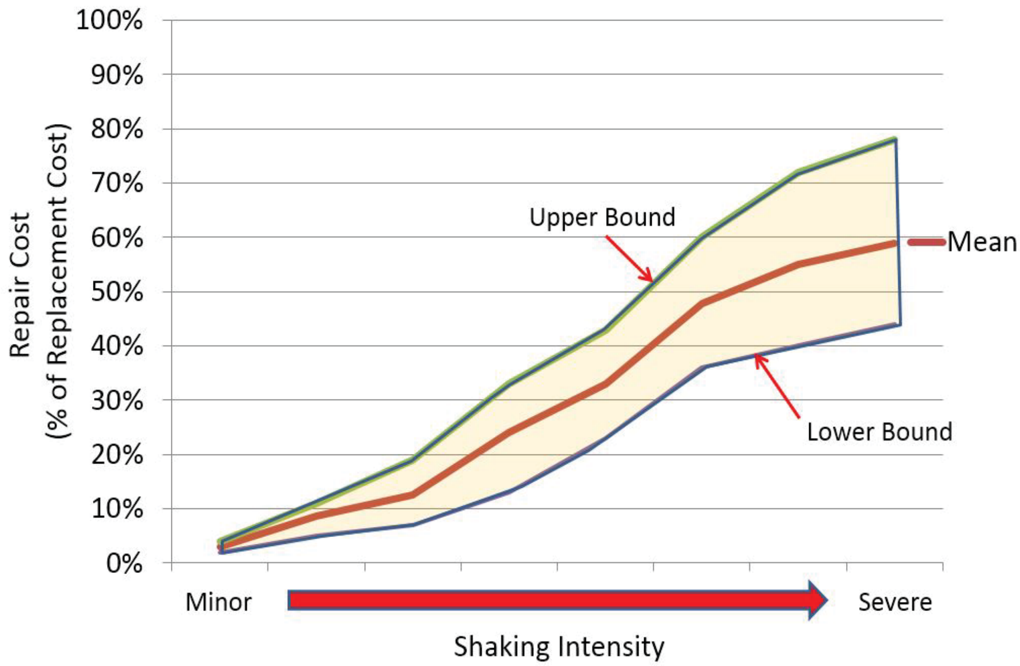
ATC **58-4**

Proceedings of

FEMA-sponsored workshop on communicating seismic performance metrics in design decision-making



ATC Applied Technology Council

Funded by
Federal Emergency Management Agency

Applied Technology Council

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Cover illustration: Variation in repair cost (percentage of replacement cost) as a function of shaking intensity (courtesy of John Gillengerten).

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Proceedings of FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

September 11, 2013
San Francisco, California

by

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Preface

In 2012, the Applied Technology Council (ATC) completed a 10-year program under contract with the Federal Emergency Management Agency (FEMA) to develop a next-generation methodology for seismic performance assessment of buildings. This program was conducted under a series of projects known as the ATC-58/ATC-58-1 Projects. The resulting products, collectively referred to as FEMA P-58, *Seismic Performance Assessment of Buildings, Methodology and Implementation*, describe a general methodology and recommended procedures to assess the probable seismic performance of individual buildings based on their unique site, structural, nonstructural, and occupancy characteristics. In the FEMA P-58 methodology, seismic performance is characterized on a probabilistic basis in terms of the potential for incurring damage or losses in the form of repair costs, repair time, casualties, unsafe placarding, and environmental impacts.

In 2012, FEMA funded a subsequent 5-year program (identified as Phase 2) to utilize the performance assessment methodology in benchmarking the performance of U.S. model codes and seismic design standards and in developing performance-based seismic design criteria. Designated the ATC-58-2 Project, the purpose of this next phase of work is to: (1) develop products that assist stakeholders in selecting appropriate performance objectives for buildings of different occupancies; and (2) assist design professionals in efficiently developing building designs that meet these objectives.

This *FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making* is the first major effort conducted under the Phase 2 program. The purpose of this workshop was to better understand how seismic performance information factors into the decision-making needs of various stakeholder groups. Attendees included a broad range of stakeholders involved in building design, construction, and management decision-making, including owners and developers, financial and insurance representatives, institutional and corporate building managers, building officials, civic building managers, and design professionals. Information gathered during this workshop will be used to guide the ATC-58-2 Project Team in developing a comprehensive series of performance-based design guides for stakeholders and design professionals.

ATC is indebted to the members of the ATC-58-2 Project Team who planned and organized the workshop, including Ron Hamburger (Project Technical Director), members of the Project Management Committee including John Gillengerten, Bill Holmes, John Hooper, and Laura Samant, and members of the Stakeholder Products Team including Maryann Phipps and Tom Tobin.

ATC gratefully acknowledges the group of invited workshop participants for their contributions to workshop plenary and breakout discussions, especially Ross Asselstine, Fouad Bendimerad, and Doug DeVeny who agreed to present their individual stakeholder perspectives in plenary sessions. ATC is also indebted to the members of the ATC-58-2 Project Steering Committee that attended the workshop, including Lucy Arendt, Christopher Deneff, John Price, Jon Siu, Jeff Soulages, and Eric Von Berg. The names and affiliations of all who attended the workshop are provided in Appendix A.

ATC also gratefully acknowledges funding provided by the Federal Emergency Management Agency, guidance and support in the conduct of this work provided by Michael Mahoney (FEMA Project Officer) and Robert Hanson (FEMA Technical Monitor), workshop logistical support provided by Bernadette Hadnagy (ATC), and report production services provided by Amber Houchen (ATC).

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Chapter 1
Introduction

In the performance-based design process, design professionals, owners, and other stakeholders jointly identify the desired building performance characteristics at the outset of a project. As design decisions are made, the effects of these decisions are evaluated to verify that the final building design is capable of achieving the desired performance. At present, communication between design professionals and decision-makers is based on concepts of performance that are embodied in present-generation design procedures such as ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007).

In 2012, the Applied Technology Council (ATC) completed a 10-year program under contract with the Federal Emergency Management Agency (FEMA) to develop next-generation concepts for seismic performance assessment of buildings. This program (Phase 1) was conducted under a series of projects known as the ATC-58/ATC-58-1 Projects. The resulting products, collectively referred to as FEMA P-58, *Seismic Performance Assessment of Buildings, Methodology and Implementation* (FEMA, 2012a; 2012b; and 2012c), describe a general methodology, recommended procedures, and new metrics for assessing and communicating the probable seismic performance of individual buildings based on their unique site, structural, nonstructural, and occupancy characteristics.

FEMA has since funded a subsequent phase of work (Phase 2), designated the ATC-58-2 Project. The purpose of this work is to utilize the recently completed methodology in developing performance-based seismic design guidance for engineers and stakeholders. This *FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*, held in San Francisco, California on September 11, 2013, is the first major effort conducted under Phase 2.

1.1 The FEMA P-58 Methodology

In present-generation procedures, performance is expressed in terms of a series of discrete performance levels (e.g., Operational, Immediate Occupancy, Life Safety, and Collapse Prevention). Although they established a vocabulary and provided a means by which engineers could quantify and communicate seismic performance to clients and other stakeholders, limitations in present-generation procedures included: (1) questions regarding the accuracy and reliability of available analytical procedures in predicting actual building response; (2) questions regarding the level of conservatism underlying the acceptance criteria; (3) the inability to reliably and economically apply performance-based procedures to the design of new buildings; and (4) the need for alternative ways of communicating performance to stakeholders that is more meaningful and useful for decision-making purposes. These limitations prompted the need for next-generation performance-based procedures.

In the FEMA P-58 methodology, seismic performance is characterized on a probabilistic basis in terms of the potential for incurring damage or losses in the form of repair costs, repair time, casualties, unsafe placarding, and environmental impacts. The general methodology and recommended procedures can be applied to seismic performance assessments of new or existing buildings of any type, regardless of age, construction, or occupancy.

Implementation of the methodology requires basic data on the vulnerability of structural and nonstructural components to damage (fragility), and information on the impacts resulting from that damage (consequence), which can be used to: (1) assess the probable performance of a building; (2) design new buildings to be capable of providing desired performance; or (3) design seismic upgrades for existing buildings to improve their performance.

Although it represents a significant achievement, the development and publication of the FEMA P-58 performance assessment methodology does not complete FEMA's objective to develop next-generation performance-based seismic design guidance. This work continues under Phase 2.

1.2 Phase 2 Purpose and Objectives

Work under Phase 2 will utilize the FEMA P-58 series of products and supporting materials (developed under Phase 1) to develop performance-based design guidance to assist in the selection of appropriate systems, configurations, and structural characteristics for meeting selected performance objectives in varying regions of seismicity. It will also include working with stakeholders to determine effective methods of communicating seismic performance. This information will be used to shape the development of a series of products that:

- Assist decision-makers in selecting appropriate performance objectives for buildings of different occupancies;
- Assist design professionals in identifying appropriate strategies for structural design of buildings to achieve specific performance objectives;

- Assist design professionals in developing efficient preliminary designs that will achieve specific performance objectives and require relatively little iteration during the design process;
- Quantify the performance capability of typical buildings designed to current prescriptive building codes to assist in development of code-equivalent performance objectives, identify inconsistencies in current prescriptive codes, illustrate the inherent limitations of prescriptive codes, and demonstrate the advantages of performance-based design; and
- Provide guidance on simplified design of buildings to achieve different performance objectives.

As part of this work, Phase 2 is also planned to: (1) exercise the FEMA P-58 methodology and identify needed improvements, if any; (2) enhance the methodology to estimate environmental impacts and potential loss of function associated with earthquake damage; (3) benchmark the performance of typical code-conforming buildings utilizing next-generation performance metrics; (4) interact with stakeholders to tailor design guidance to better suit current decision-making needs; and (5) develop training materials to assist in implementation.

1.3 Workshop on Communicating Seismic Performance Metrics

Recognizing that stakeholder input is key to the development of performance-based design guidance, Phase 2 includes significant plans for interacting with stakeholders and identifying their decision-making needs. A key objective is to establish a framework and vocabulary for interaction between decision-makers and design professionals so that stakeholders are able to communicate their seismic risk concerns and building performance expectations in a way that promotes a common understanding and enhances the design process.

This *FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making* is the first in a series of planned Phase 2 interactions with stakeholders. A similar workshop was held early in the Phase 1 developmental process (2002), and was intended to obtain information on stakeholder needs at the time. Findings from the 2002 workshop are presented in ATC-58-1, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*, (ATC, 2002). A subsequent report, ATC-58-2, *Preliminary Evaluation of Methods for Defining Performance*, (ATC, 2003) utilized workshop results to set the initial direction for next-generation performance metrics in terms of direct losses (damage and repair costs), downtime (loss of use), indirect losses associated with downtime (business interruption costs), and casualties (injuries and loss of life).

The purpose of this workshop was to revisit the decision-making needs of various stakeholder groups, and to better understand how FEMA P-58 seismic performance information might factor into current decision-making processes. Workshop attendees included a broad range of stakeholders involved in building design, construction, and management decision-making, including owners and developers, lending and insurance representatives, institutional and corporate building managers, building officials, civic building managers, and design professionals.

The workshop provided a forum for interaction among these different stakeholder groups to develop a common understanding related to how various seismic risk-related decisions are currently made, and how seismic performance assessment results could be effectively used as part of the building design and procurement process. The types of decisions that were explored included those associated with: (1) new building design; (2) existing building retrofit; (3) lending and financing; (4) insuring; (5) purchasing; (6) renting; and (7) emergency preparedness/risk planning activities.

Workshop findings will be used to guide the development of Phase 2 engineering and stakeholder guidance products.

Chapter 2
Workshop Program

A one-day *FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making* was held in San Francisco, California on September 11, 2013. This chapter summarizes the workshop program and describes the structure of the plenary and breakout discussions.

2.1 Workshop Overview and Agenda

The workshop format included plenary sessions followed by focused breakout discussions. The workshop was broadly organized into two parts, as shown in Figure 2-1. In the morning session, participants examined how stakeholders currently make decisions associated with seismic risk. In the afternoon session, participants explored how FEMA P-58 seismic performance assessment results might be used in making decisions associated with seismic risk. Workshop discussions were structured to:

- Develop an improved understanding of current stakeholder decision-making needs;
- Gain new insights into current decision-making processes;
- Collect information for targeting further study;
- Develop ideas for presenting performance-based products so that they are most relevant to current stakeholder needs (e.g., format of products and target audiences);
- Identify additional performance metrics or products that would be useful (e.g., business interruption);
- Identify additional people and resources for obtaining more input following the workshop; and
- Introduce the FEMA P-58 methodology to decision-makers.

The workshop was attended by 45 participants. A list of participants, and their affiliations, is provided in Appendix A. Attendees included representation from Federal, State, and local government agencies, utilities, healthcare providers, universities, religious institutions, owners, developers, large corporations, lenders, insurance providers, building officials, and design professionals (architects and engineers).

ATC-58-2 Project

FEMA-Sponsored Workshop on
Communicating Seismic Performance Metrics in Design Decision-Making.

Hotel Whitcomb
1231 Market Street
San Francisco, California

September 11, 2013
9:00am - 5:00pm

Morning Session (9:00 am – 12:30 pm)

Time	*Subject*	*Leader*
9:00 am	Welcome, Introductory Remarks Applied Technology Council Federal Emergency Management Agency	 Jon Heintz Mike Mahoney
9:10 am	Self Introductions – what does earthquake risk planning mean to you?	All
9:30 am	Project Introduction	Ron Hamburger
9:45 am	Seismic Decision-Making Examples • Stanford University Seismic Program • Developer Perspective • Corporate Building Risk Perspective	 Fouad Bendimerad Ross Asselstine Douglas DeVeny
10:45 am	Set-up and Goals for the morning breakout discussion	Laura Samant
11:00 am	Breakout #1 – How do you currently make decisions about seismic risk?	Laura Samant Tom Tobin Maryann Phipps
12:00 pm	Plenary Reports	Recorders

Lunch (12:30 pm - 1:30 pm)

Afternoon Session (1:30 pm – 5:00 pm)

Time	*Subject*	*Leader*
1:30 pm	Introduction and Overview of the FEMA P-58 Methodology	Ron Hamburger
1:45 pm	What the FEMA P-58 Methodology can do for seismic risk decision-making	John Gillengerten
2:00 pm	Set-up and Goals for the afternoon breakout discussion	Laura Samant
2:15 pm	Breakout #2 – How would you use this information and what would you need to use it effectively?	Laura Samant Tom Tobin Maryann Phipps
3:45 pm	Plenary Reports	Recorders
4:30 pm	Open discussion/feedback	All
5:00 pm	Adjourn	

Figure 2-1 Agenda – FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making.

2.2 Morning Session Plenary and Breakout Discussions

In the morning plenary session, project team members set the context for the workshop and introduced the group to performance-based design concepts in general. Morning plenary presentations by the project team are provided for reference in Appendix B. In this session, all workshop participants were asked to briefly state what earthquake risk planning meant to them. Three stakeholder participants were invited to present their individual stakeholder perspectives to the overall group. These included an institutional seismic program (Stanford University), a residential developer perspective, and corporate building risk perspective (Genentech).

In the morning breakout sessions, participants were divided into three breakout groups for focused discussion. Rather than including representatives from every stakeholder group in each discussion, breakout groups were structured to include participants representing a subset of stakeholder interests, as follows:

- Breakout Group 1: Institutional, Healthcare, and Government Representatives
- Breakout Group 2: Owner/Developer, Building Official, and Design Professional Representatives
- Breakout Group 3: Corporate, Financial, and Insurance Representatives

Each morning breakout group discussed the following questions, focused on examining how their respective organizations currently make decisions about seismic risk in the process of constructing new buildings, retrofitting existing buildings, renting space, obtaining loans or financing, obtaining insurance, and conducting emergency preparedness/risk planning activities:

- How important of a role does seismic risk play in decisions about this activity?
- How does your organization make this decision now?
- Who is involved in making decisions? Whose advice or analysis do you seek or value when making these decisions?
- What information do you need to make decisions about seismic risk?
- What are the criteria you use to make decisions?
- What are your performance objectives? How much damage is acceptable to you? How much damage do you expect in a significant earthquake?
- Are there any aspects of your current process that you think could work better?

2.3 Afternoon Session Plenary and Breakout Discussions

In the afternoon plenary session, project team members presented an overview of the FEMA P-58 methodology and the types of seismic performance information that can be provided to stakeholders. Presentations included a description of: (1) the methodology and tools for implementation; (2) loss assessment scenarios; (3) performance metrics in terms of repair costs, repair time, casualties, post-earthquake tagging, functionality, and environmental impacts; (4) how these metrics vary due to uncertainty or shaking intensity; (5) and how they translate into visible damage and overall building performance. Afternoon plenary presentations by the project team are provided for reference in Appendix B.

In the afternoon breakout sessions, participants were divided into the same three stakeholder groups for focused discussion. In these sessions, participants were asked to explore how they might use seismic performance information in the form provided by the FEMA P-58 methodology, and what additional information or assistance they would need to use it effectively. Each breakout group was asked to respond to the following questions in the context of constructing new buildings, retrofitting existing buildings, renting space, obtaining loans or financing, obtaining insurance, and conducting emergency preparedness/risk planning activities:

- What FEMA P-58 outputs seem most valuable to your organization?
- What situations might your organization make use of FEMA P-58?
- How might your process be different with the type of information that FEMA P-58 provides?
- What challenges or concerns about using FEMA P-58 come to mind?
- What form of guidance/guidelines might be most helpful for your organization to make use of FEMA P-58 performance information?
- Who should FEMA P-58 guidance products be aimed at?
- What aspects of a FEMA P-58 assessment do not seem useful to you, or were difficult to understand?

For discussion purposes, the graphics in Figures 2-2 and 2-3 were used to illustrate the type of seismic performance information that could be obtained from a FEMA P-58 assessment. Figure 2-2 shows the relative contribution to total repair costs (in percent) for different structural and nonstructural components in a building, given a scenario of a specified magnitude earthquake on a specific fault. Figure 2-3 shows the potential change in probable repair time for base, enhanced, and special designs of a building.

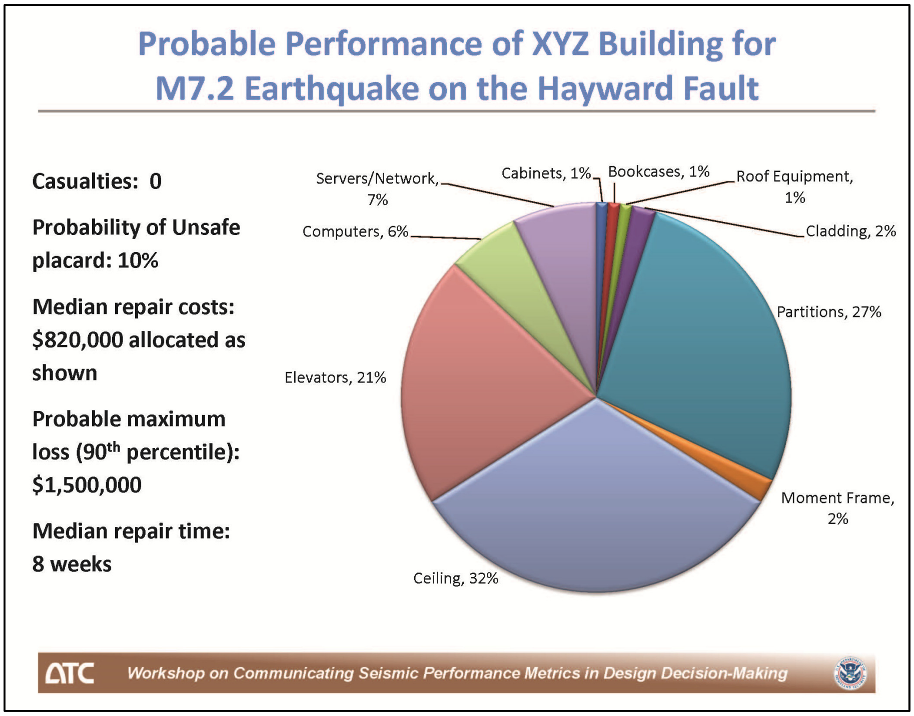

Figure 2-2 Example FEMA P-58 results showing relative contribution to total repair costs (in percent) for different structural and nonstructural components in a building, given a scenario earthquake.

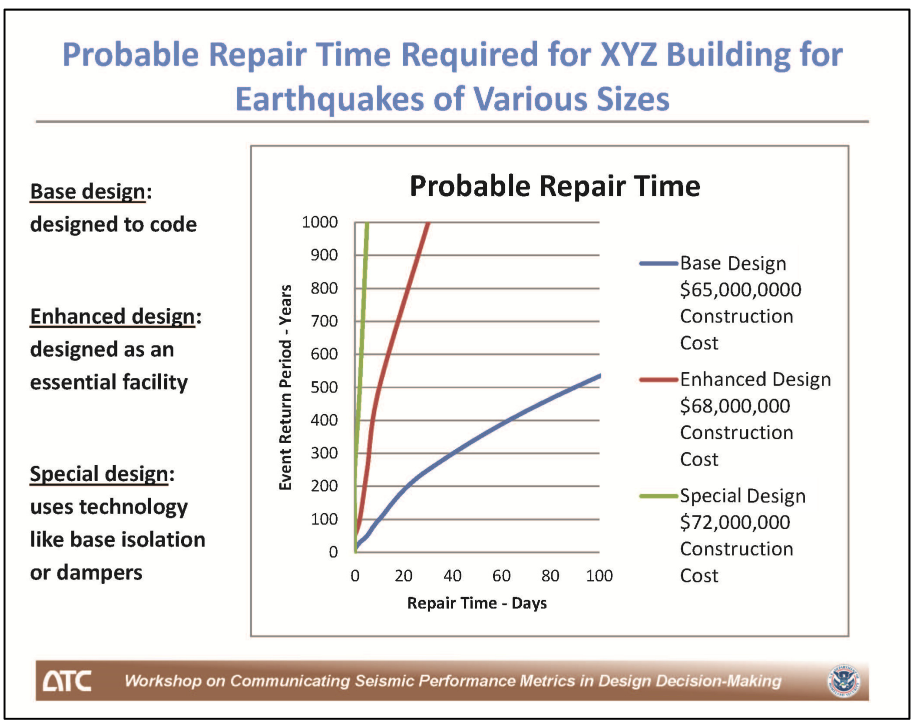

Figure 2-3 Example FEMA P-58 results showing the potential change in probable repair time for base, enhanced, and special designs for earthquakes of different return periods.

Chapter 3

Workshop Findings and Conclusions

Stakeholder representatives in each breakout group expressed differing needs and concerns related to the use of seismic performance information in the context of their building management and procurement processes. This chapter summarizes key points raised in each breakout group, followed by a summary of overarching findings and conclusions drawn from the collective information provided by all groups.

3.1 Breakout Group 1: Institutional, Healthcare, and Government Representatives

Breakout Group 1 consisted of 12 participants representing institutional organizations such as universities, utilities, and religious affiliations, healthcare providers, and Federal, State and local government agencies. During the morning and afternoon breakout sessions, this stakeholder group expressed the following opinions:

- Seismic risk is only one of many issues considered by this group, and seismic risk is usually considered less important than other issues. It was noted that sometimes stakeholders choose not to explore seismic risk in great detail because it can be challenging (or expensive) to address.
- This group was interested in understanding how FEMA P-58 could help them manage seismic risks, specifically costs associated with downtime and business continuity. These concepts link directly to the business objectives of this group, and it could be useful to show how design and retrofit decisions might impact business objectives. However, it was also noted that business continuity is affected by many issues outside of the control of the building owner, such as the functionality of offsite utilities.
- This group expressed interest in using FEMA P-58 seismic performance information during the design of a new building or the major retrofit of an existing building. They noted that the timeline for making building purchase or rental decisions is limited, making FEMA P-58 assessments less practical for these applications. They also noted that if a detailed structural analysis is necessary for assessment, the cost of performing such analyses is not likely to be justified during insurance purchase

decisions or risk planning, unless detailed analytical models for a building already exist.

- Typically, seismic decisions are considered late in the process of designing a new building, after budgets are developed. As a result, there is limited opportunity for seismic issues to influence design decision-making. However, there are some exceptions. One organization, for example, changed its building procurement process so that seismic risk issues can be considered earlier, and terms that make sense to non-technical decision makers, such as the number of dormitory beds that could be unusable after an earthquake, are used.
- There is a perception among all but the most sophisticated building owners that designing a building "to code" is good enough. A common belief is that new buildings today are much more seismically resistant than they used to be. As a result, people do not see seismic risk of new buildings as a concern.
- This group wanted to know how much it costs to perform a FEMA P-58 assessment, how long it takes, and what type of qualifications are needed to conduct such an analysis. They inquired about the validity of simplified FEMA P-58 applications for some situations, or whether a detailed analysis by a highly-trained structural engineer was needed for results to be meaningful or useful.
- This group expressed concern that engineers might not know how to use the FEMA P-58 methodology properly. They need to feel confident that their engineer is qualified to do this type of analysis, and that consistent results would be obtained from different engineers performing similar analyses.
- This group wanted to know how the FEMA P-58 methodology was related to engineering tools and technologies that are currently used in their decision-making. The following sources were specifically mentioned: HAZUS (FEMA, 1999), ST-RISK (Risk Engineering Inc., 2014), Probable Maximum Loss (PML) calculations, ASCE/SEI 41-06, current building codes and standards, and the California Office of Statewide Health Planning and Development (OSHPD) requirements for hospitals.
- This group felt that the most important FEMA P-58 performance outputs were estimated casualties, estimated repair and business resumption time, and estimated repair costs.
- There were multiple opinions about the best way to present earthquake risk, seismic performance, and ground motion information to

stakeholders. Some felt scenarios were more effective (e.g., magnitude 7 earthquake on the Hayward fault). Others preferred simple descriptions of probabilistic risk.

- This group suggested that different guidance documents should be provided to different stakeholder groups, and that different guidance products should be focused on different levels within an organization. It was noted that guidelines should be simple to understand, with many compelling graphics.
- Ideas such as a "help line" and "pilot projects" were suggested to help people understand, and eventually build trust in this new approach.

3.2 Breakout Group 2: Owner/Developer, Building Official, and Design Professional Representatives

Breakout Group 2 consisted of 10 participants representing building owners and developers, local building officials, and design professionals (e.g., architects). During the morning and afternoon breakout sessions, this stakeholder group expressed the following opinions:

- Developers typically build to minimum code requirements. The market is competitive, and there is currently no price premium for buildings designed to achieve higher seismic performance than what is articulated in the building code. In general, potential buyers or tenants do not ask about seismic safety when purchasing or renting space. Interest in enhanced seismic performance needs to come from the market, and then developers will respond.
- Many developers construct buildings and sell available space during a relatively short time frame. It was suggested that FEMA P-58 results are most likely to be of interest to owners who buy and hold a property for an extended period of time.
- This group noted that probable maximum loss (PML) calculations, which are often required by financial institutions for loans, are unreliable and are typically not useful to building owners.
- Some in this group expressed concern that two engineers performing a FEMA P-58 assessment of the same building could reach different conclusions. They expressed a need to know that FEMA P-58 assessments are accurate and credible.
- This group expressed concern that FEMA P-58 seismic performance information might need to be disclosed, especially if results show that a building might perform poorly in future earthquakes. Having such information could be a disadvantage in some situations.

- Many in this group expressed concern that discussion of potential deaths and casualties could increase their legal liability. They also felt that information about deaths and casualties was not a necessary piece of information, and wondered if FEMA P-58 assessments could be performed without such calculations.
- According to this group, use of performance-based design to date has been for the purpose of designing a structural system to be as inexpensive as possible while still achieving code-equivalent performance; and not for designing a structural system to achieve enhanced performance (relative to code). It was noted, however, that engineers do not have consistent view of the performance that a code-compliant building will deliver.
- Having a clear understanding of the expected performance of code-designed buildings was considered valuable. This group liked the idea of knowing which features of a building might become damaged in an earthquake (as illustrated in Figure 2-2).

3.3 Breakout Group 3: Corporate, Financial, and Insurance Representatives

Breakout Group 3 consisted of 11 participants representing large corporations, lenders, and insurance providers. During the morning and afternoon breakout sessions, this stakeholder group expressed the following opinions:

- Other hazards (e.g., fire, flood, and power outages) are of greater concern to this group than earthquake hazards, primarily because these other hazards occur more frequently.
- This group wanted to know how FEMA P-58 assessments relate to other tools currently in use, such as EQECAT and RMS loss models.
- This group expressed disenchantment with the way that PML analyses are conducted. They expressed a desire to improve PML models, and asked if the FEMA P-58 methodology could be used to provide PML information.
- Concern was expressed about the cost of performing FEMA P-58 assessments, and how long they might take to complete.
- This group asked if analytical modeling for FEMA P-58 assessments is significantly different than what is already being done now. They wanted to know the level of detail needed to start a FEMA P-58 assessment, whether or not it could be used to analyze a portfolio of

buildings, and if it could be used as part of an operational database for facility management.

- Architects are the primary contact with building owners and decision-makers. Structural engineers typically report to architects, and often do not have an opportunity to communicate directly with owners or decision-makers. Typically, structural engineers are engaged late in the design process, after key decisions (e.g., budget, building configuration) have already been made. As a result, structural issues have limited ability to influence decisions early in the design process.
- Corporate representatives in this group stated that their organizations are very sensitive to business interruption. These organizations have sophisticated processes to manage the risks associated with their facilities. They also have committees that are involved in making decisions regarding the construction of new facilities and renovation of existing facilities. This type of process enables seismic risk issues to be considered earlier than is typically the case for most organizations.
- Corporate representatives noted that leased buildings are typically not used for facilities that are critical to business continuity. Therefore, less effort is put into managing the risk of leased properties. Other stakeholder representatives with business operations in leased spaces indicated that they expect employees to work remotely (e.g., from home) for a period of time after a damaging earthquake.
- Members of this group felt that their reputation is very important, and that poor performance of buildings in future earthquakes could damage their reputation.
- It was noted that developers respond to the market, and their primary driver is return on investment. Tenant expectations and demands are important, and can influence how much developers care about issues such as seismic risk.
- In some market segments, it can be difficult to justify the use of a new innovation (such as the FEMA P-58 methodology) unless the entire market begins to use this approach.
- Building officials were identified as being hesitant to accept alternative means of code compliance. One organization noted that previous efforts to implement performance-based design had been stymied by building department approvals and the plan check process.

- Stakeholders that are most concerned about downtime after an earthquake are most likely to be interested in FEMA P-58 seismic performance information.
- Members of this group were concerned that casualty estimates would be discoverable in future lawsuits. They asked if the capability to estimate casualties could be disabled.
- This group was interested in understanding the performance of code-compliant buildings in terms of FEMA P-58 performance metrics.
- This group stated that probability concepts are not well understood by most stakeholders.
- Case studies were suggested as being helpful for understanding how the FEMA P-58 methodology works, and what benefits it could provide.
- Certain classes of buildings (e.g., industrial buildings), and certain specialized nonstructural systems, are not adequately covered by the default fragilities provided as part of the FEMA P-58 methodology. Lack of coverage for certain buildings and systems is a significant limitation for implementation of FEMA P-58 assessments.
- The intended audience for guidance materials should be clarified. Any materials aimed at "C-suite" (i.e., high-level) decision-makers need to include simple, sound-bite information.

3.4 Overarching Findings and Conclusions

Key themes expressed across multiple breakout group discussions included the following:

- Seismic risk is only one of many issues considered by stakeholders, and is usually considered less important than other issues.
- The market is competitive, and, at present, there is little or no market for enhanced seismic performance. The prevailing perspective is that buildings "designed to code" are good enough.
- Performance metrics of downtime and repair costs were of most interest. Stakeholders that are highly sensitive to business interruption are most likely to be interested in FEMA P-58 seismic performance information.
- There is some interest and perceived value in the ability to know the breakdown of what is contributing to loss, and how much of a contribution certain elements make to total loss.

- Several stakeholders groups expressed concern regarding casualty metrics, including potential liability and the need to disclose information related to life loss and serious injury.
- There was concern over potential liability associated with knowing seismic performance information in general, and concern over the potential need to disclose information related to poor performance.
- The typical building design process does not include a structural engineer, or discussion of seismic risk, until after key decisions (e.g., budget and configuration) have already been made. However, some organizations have sophisticated procedures in place that explicitly consider seismic risk earlier in the building design and procurement process.
- New technologies (such as the FEMA P-58 methodology) need to be related to engineering tools and technologies that are currently being used by stakeholders.
- Many stakeholders expressed disenchantment with the way that PML analyses are conducted. There was a desire to improve PML modeling so that it can be a meaningful part of the decision-making process.
- Information is needed on how much it costs to perform a FEMA P-58 assessment, how long it takes, and what qualifications are necessary to conduct such an analysis.
- There was a concern that different engineers performing a FEMA P-58 assessment of the same building could reach different conclusions. Stakeholders were looking for assurances that FEMA P-58 assessments can be considered accurate and credible.
- Stakeholders were interested in understanding the performance of code-compliant buildings in terms of FEMA P-58 performance metrics.

3.5 Recommendations for Use of Workshop Findings and Conclusions

Workshop results will be used to inform the development of Phase 2 engineering and stakeholder design guidance products. Recommendations for the use of workshop findings and conclusions during Phase 2 project activities include the following:

- Different users will have different needs, and not all stakeholders will be interested in (or will need) all information that the FEMA P-58 methodology has to offer.

- The objective of guidance materials should be two-fold: (1) motivating stakeholders to utilize the information obtainable from the methodology; and (2) helping them use it.
- Stakeholder guides should be focused as narrowly as possible. Potential users should feel that the guides are immediately relevant to their situation or needs.
- Guidance should speak to (or address) potential barriers to implementation. Potential barriers identified in workshop discussions include: a perceived high cost; the length of time needed to perform an assessment; the apparent complexity of the results; disenchantment with the current PML market; and typical involvement of the structural engineer late in the design process.
- Initial guidance should focus on early adopters (i.e., those users whose needs are closely aligned with the product, are receptive to new technologies, are likely to recognize the value, and have the resources necessary to implement the technology in practice).
- Potential early adopters include: engineering practitioners interested in differentiating their services from the competition; institutions with important buildings at a fixed location (e.g., universities); manufacturers with valuable contents or operations that are sensitive to product life-cycle and business interruption concerns; corporations and businesses that are sensitive to business interruption concerns; and sophisticated building owners located in regions of high seismicity that are sensitive to seismic performance issues.
- If necessary, adjustments in the current FEMA P-58 methodology (e.g., additional fragility classifications) should be made to make it as consistent as possible with the needs of potential early adopters.
- FEMA P-58 needs to be related to engineering tools and technologies that are currently in use, including: ASCE/SEI 41-06, HAZUS, ST-RISK, PML calculations, EQECAT and RMS loss models, current building codes and standards for new buildings, and OSHPD requirements for hospitals.
- In emphasizing the next-generation change from discrete performance levels to a performance continuum, the ability to communicate performance objectives to decision-makers with recognizable acceptability criteria has been lost. Efforts should be made to bridge the communication gap between present-generation and next-generation performance metrics.

- It is important to identify the cost and level of effort necessary to get meaningful assessment results using the FEMA P-58 methodology to provide stakeholders with sufficient information for considering its use.
- FEMA P-58 should be used as a tool to describe the expected performance of code-designed buildings and compare the expected performance of minimum code-designed structural and nonstructural systems. Performance expectations for minimum code designed buildings should be transparently communicated.

The FEMA P-58 methodology has the potential to significantly change and improve the way building design, retrofit, and investment decisions are made in the future. However, change can be challenging, and even risky, for some stakeholder groups. Stakeholders will need to be convinced that a new approach is worth the risk, and worth the potential increase in cost, time, and complexity. This *FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making* provided key perspectives and necessary insights into stakeholder needs and potential barriers to implementation of the FEMA P-58 methodology in building design, management, and procurement processes. These lessons will be used to help guide future project activities in making Phase 2 guidance materials as useful and relevant as possible.

Appendix A

Workshop Participants

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John Hooper (Recorder)
Scott Bell, Kaiser Permanente
Fouad Bendimerad, Stanford University
Kent Ferre, PG&E
Robert Gayle, U.C. Berkeley
Ahmad Sharif Kayum, PG&E
Robert Levenson, GSA
James Liu, Degenkolb
Stephen Mahin, U.C. Berkeley
Brent Maxfield, LDS Church
Michael Monaldo, John Muir Health
Geoffrey Neumayr, S.F. International Airport
Brian Strong, City of San Francisco

Breakout Group 2: Owner/Developer, Building Official, and Design Professional Representatives

Maryann Phipps (Leader)
John Gillengerten (Recorder)
Ross Asselstine, Development Consultant
Duane Carlson, Avalon Bay
Paul Coleman, OSHPD
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Steven Winkel, The Preview Group

Breakout Group 3: Corporate, Financial, and Insurance Representatives

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Jon Heintz (Recorder)
Lucy Arendt, University of Wisconsin
Robert Biggs, Union Bank
David Bonneville, Degenkolb
Christopher Deneff, FM Global
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David Proctor, Kaiser Permanente
Jeffrey Soulages, Intel Corporation
Eric Von Berg, Newmark Realty Capital

Appendix B
Plenary Presentations

B.1 Morning Session Presentations

B.2 Afternoon Session Presentations

ATC-58-2 Project

FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

San Francisco - September 11, 2013

Jon A. Heintz
ATC Director of Projects

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Workshop Context

- Who are we?
  - FEMA-funded ATC-58-2 Project to develop Next-Generation Performance-Based Seismic Design Guidelines
- Who are you?
  - Stakeholders
  - (i.e., building owners, managers, financial and insurance representatives, building officials, and non-engineering design professionals)

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Workshop Context

- Why are you here?
  - 10 years ago…
  - 1 year ago…
  - Today…
  - We are beginning the next 5 years of development
  - We wanted to check in

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Workshop Context

- Mission: Understand stakeholder seismic decision-making needs
- Plan: Engage representatives from various stakeholder groups in interactive discussions

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Workshop Agenda - Morning

Morning Session (9:00 am – 12:30 pm)

Time	*Subject*	*Leader*
9:00 am	Welcome, Introductory Remarks Applied Technology Council Federal Emergency Management Agency	 Jon Heintz Mike Mahoney
9:10 am	Self Introductions – what does earthquake risk planning mean to you?	All
9:30 am	Project Introduction	Ron Hamburger
9:45 am	Seismic Decision-Making Examples • Stanford University Seismic Program • Developer Perspective • Corporate Building Risk Perspective	 Fouad Bendimerad Ross Asselstine Douglas DeVeny
10:45 am	Set-up and Goals for the morning breakout discussion	Laura Samant
11:00 am	Breakout #1 – How do you currently make decisions about seismic risk?	Laura Samant Tom Tobin Maryann Phipps
12:00 pm	Plenary Reports	Recorders

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Workshop Agenda - Afternoon

Afternoon Session (1:30 pm – 5:00 pm)

Time	*Subject*	*Leader*
1:30 pm	Introduction and Overview of the FEMA P-58 Methodology	Ron Hamburger
1:45 pm	What the FEMA P-58 Methodology can do for seismic risk decision-making	John Gillengerten
2:00 pm	Set-up and Goals for the afternoon breakout discussion	Laura Samant
2:15 pm	Breakout #2 – How would you use this information and what would you need to use it effectively?	Laura Samant Tom Tobin Maryann Phipps
3:45 pm	Plenary Reports	Recorders
4:30 pm	Open discussion/feedback	All
5:00 pm	Adjourn	

ATC *Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*

Logistics

Thank you!

Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

ATC-58-2

Project Overview
&
Why it is important to you!

Ronald O. Hamburger, SE
Project Technical Director

Development of Next Generation Performance-Based Seismic Design Criteria

- An introduction to performance-based design
- The present generation
- The next generation
- Why should you care?

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Performance-Based Design

- What is it?
  – An alternative to code-based design

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Building Codes – A Brief History

- Building codes were developed in response to great disasters:
  – Urban conflagrations, hurricanes and earthquakes
- Created large life and property loss
- Everyone regarded as unacceptable

New York, April 1836
Fire

Galveston – September, 1900
Hurricane

San Francisco – April, 1906
Earthquake

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Building Codes – A Brief History

- Cities develop and adopt codes through the power and responsibility of government to act to "protect the public safety"
- Adoption is through consent of the governed
- Consent is obtained in response to large losses and public outrage at the state of current practice
- This is largely a reactive rather than proactive process
  – People build cities
  – Bad events happen
  – People analyze why the bad behavior occurred
  – Code-writers add rules to the code to avoid future occurence

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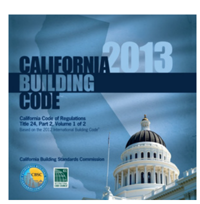
Code-based Seismic Design



– Permissible structural systems
– Minimum acceptable strength and stiffness
– Required detailing practices
– Required attachment strength for nonstructural components

Presumed to provide acceptable performance

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What Performance Is Acceptable?

- Ordinary buildings-
  - Protection of life safety for major earthquakes
  - To the extent practicable, reduction in economic costs associated with more moderate events
- Essential buildings-
  - Provide for post-earthquake function

Actual performance capability never actually evaluated

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The 80's a Decade of Earthquakes!

- 1979 Imperial Valley
- 1982 Coalinga
- 1983 Morgan Hill
- 1986 North Palm Springs
- 1987 Whittier
- 1989 Loma Prieta
- 1992 Petrolia
- 1994 Northridge

- Corporate risk mangers, lenders, investors began to realize that doing business in risky buildings was risky business
- Asked engineers to assess risk and upgrade existing buildings to minimize risk
- The birth of performance-based design

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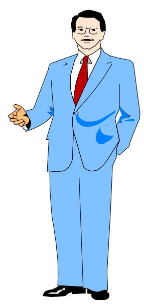
The "Essence"

- An "Decision-maker" states a desire that a building be able to "perform"
  - Protect life safety
  - Minimize potential repair costs
  - Minimize disruption of use



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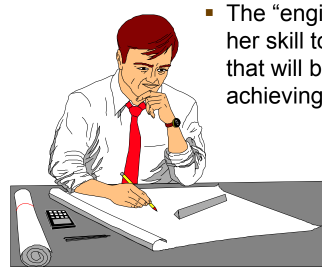
The "Essence"



- The "engineer" uses his or her skill to provide a design that will be capable of achieving these objectives

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Some Typical Performance Objectives

"I want my building to be safe- "

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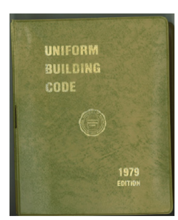
"Life Safety"



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Some Typical Performance Objectives

"I want to be able to use my building, right away - "

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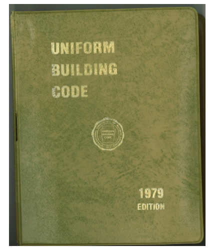
"Immediate Occupancy"



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Some Typical Performance Objectives

"I want the PML to be less than 20% -"

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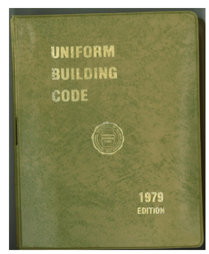
"Minimize Repair Cost"



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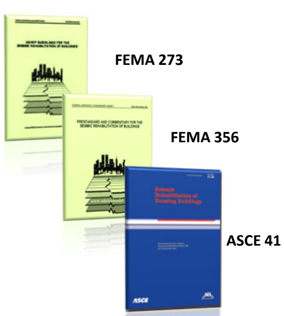
The 90s a new hope!



- FEMA, ATC and ASCE developed an "Existing Buildings" guideline which became a standard to tell engineers how to do it!

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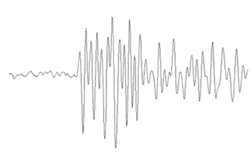
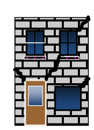
Performance Objectives

- Decision makers must chose what performance they want



Design Ground Motion



Performance Level

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Design Earthquake Choices

- Maximum Considered Earthquake
- Maximum Capable Earthquake
- Maximum Probable Earthquake
- Basic Safety Earthquake 1
- Basic Safety Earthquake 2
- 475-year earthquake
- 72-year earthquake
- 5% probability in 50-year earthquake

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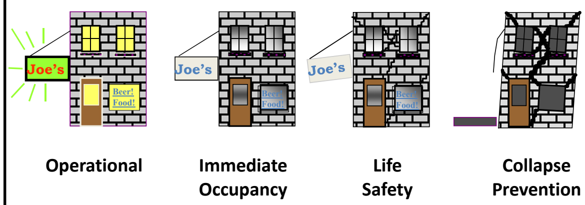
Performance Level Choices



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Goals of the ATC-58 Project

- Provide decision-makers an ability to chose performance in more meaningful terms
- Provide engineers the ability to more reliably design for requested performance
- Extend the "existing building" methodology to new buildings

ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

Phase 1 Project

- Completed in August 2011
- Technical Methodology
- Provides engineers ability to directly characterize performance in terms of potential:
  - Life Loss or injuries
  - Repair costs
  - Repair time
  - Occupancy impacts

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Phase 2 Project

- Just getting started
- Identify expected behavior of code-conforming buildings
- Identify "typical" performance goals for different buildings
- Provide tools for decision makers

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Questions

Thank you!

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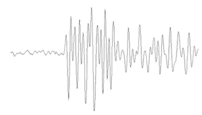
Goals for the Morning Breakout Session

Laura Samant
Stakeholder Products Team Leader

Activities that can require decisions about seismic risk



- Design of a new building
- Retrofit/rehabilitation of an existing building
- Rental decisions
- Loans or financing decisions
- Insurance decisions
- Emergency preparedness/risk planning

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FEMA P-58: A major leap forward

If you ask your engineer what will happen to your building in a specific earthquake…

Before P-58:

- Typically based on judgment and experience

Using P-58:

- A specific, technically sound answer
- An explanation of *why* that performance is expected
- Demonstration of how that performance would change if different choices were made

ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

Our goal

To provide guidance to decision makers on how to use FEMA P-58's capabilities

ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

To provide *useful* guidance…

We need to understand:

- When, how and why you make decisions about seismic risk now.
- Which aspects of FEMA P-58 might be most useful to you.

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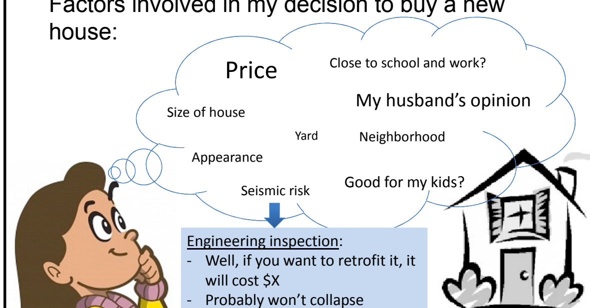
Decisions are complex

Factors involved in my decision to buy a new house:



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My decision to buy a house

- Seismic risk is one of many factors
- My husband, my engineer, and I all play a role in making decisions
- Seismic risk information was ambiguous and hard to process
- Performance objective: “probably won’t collapse”

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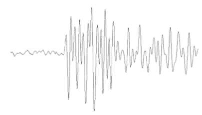
We want to understand how you make these decisions



- Design of a new building
- Retrofit/rehabilitation of an existing building
- Rental decisions
- Loans or financing decisions
- Insurance decisions
- Emergency preparedness/risk planning

ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

Breakout sessions

Morning

- Hear from you how you currently make decisions about seismic risk.

Afternoon

- Explore with you how FEMA P-58 might be used to enhance how those decisions are made.

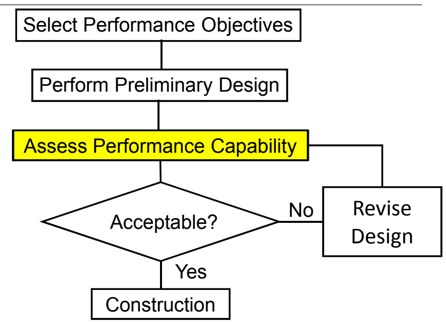
ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

An Overview of the FEMA P58 Methodology

What we can provide Decision-Makers

Ronald O. Hamburger, SE
Project Technical Director

The PBD Process



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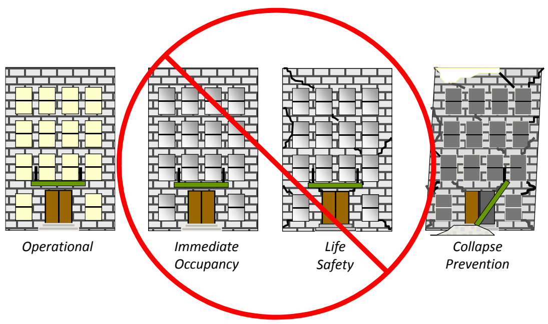
Standard Performance Levels



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Performance Prediction

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Next-Generation Performance

- Probabilistic rather than Deterministic
- Consequences of building response to earthquakes, including:
  - Casualties (deaths & serious injuries)
  - Direct economic loss (repair and replacement costs)
  - Indirect economic and social loss (red tags, repair and re-occupancy time)
  - Environmental Impacts including: energy, carbon and solid waste

ATC Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

Assessment Types

- Intensity-based
  - Performance given a specific acceleration response spectrum
- Scenario-based
  - Performance given a specific earthquake scenario, e.g. repeat of 1857 or 1906 San Andreas events
- Time-based
  - Performance over a period of time, considering all possible earthquakes, and their individual probabilities of occurence

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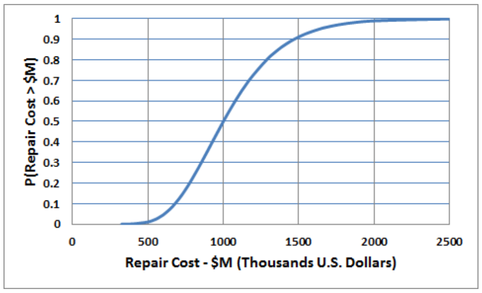
Performance Distributions



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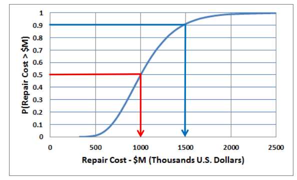
Scenario or Intensity Assessments



- 50% probability that repair cost will not exceed $1M
- 90% probability repair costs will not exceed $1.5M
- Expected repair cost is $1.1M

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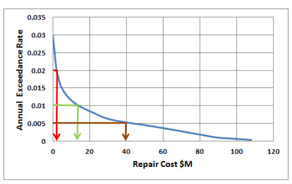
Time-based Assessment



- 50-year loss $2,000
- 100-year loss $14,000
- 200-year loss $44,000
- Average annual loss $540

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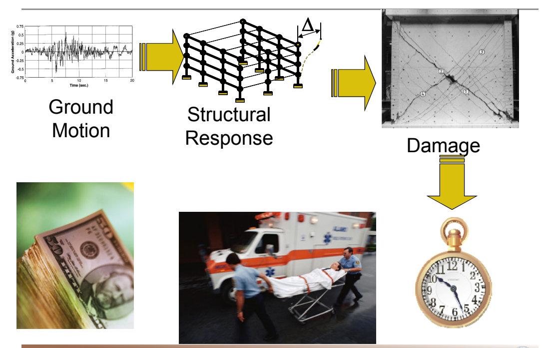
Performance-prediction Process



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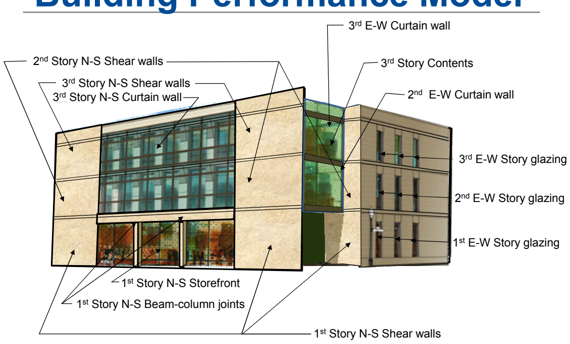
Building Performance Model



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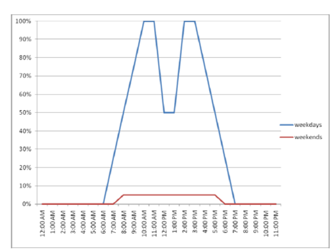
Population Models

- Common Occupancies
  - Office
  - K-12 Education
  - Healthcare
  - Residential
  - Retail
  - Laboratory
  - Warehouse
  - Hospitality



Peak occupancy = 1 person per X00 square feet

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Calculate Performance (Chapter 7)

- Monte Carlo Process
- Hundreds to thousands of “spins”
- For each “spin” termed a “realization”
- Unique
  - Demands
  - Damage
  - Consequences

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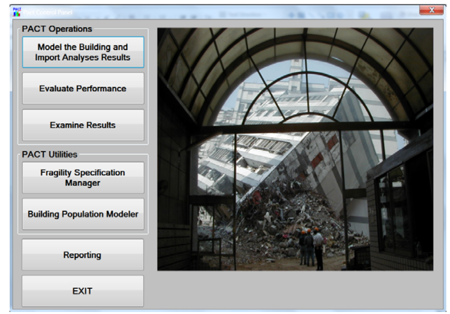
Performance Assessment Calculation Tool



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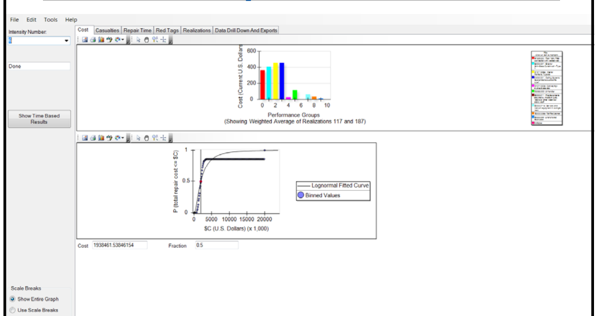
Repair Cost



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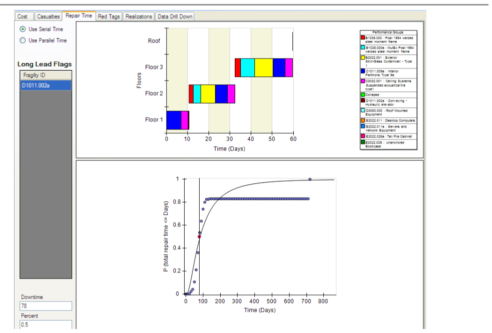
Downtime



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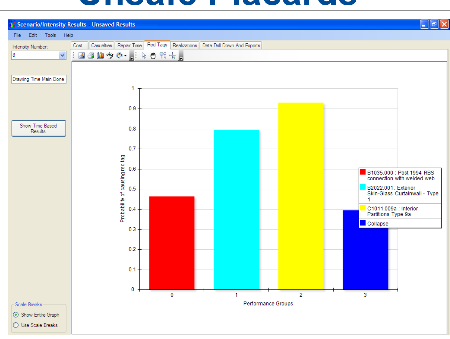
Unsafe Placards



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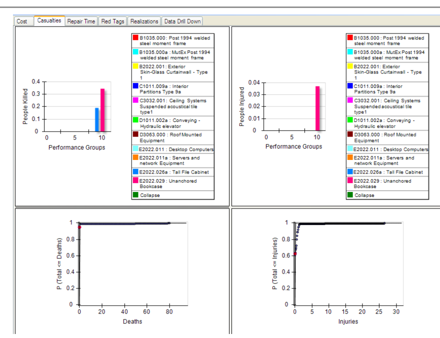
Casualties



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Questions

Thank you!

Workshop on Communicating Seismic Performance Metrics in Design Decision-Making

What FEMA P-58 can do for you…

John Gillengerten
Performance Products Team Leader

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What P-58 can tell you…

- Given a building (new or existing)
  - The losses for a particular shaking intensity, earthquake or considering all earthquakes.
  - What changes to the "design" will do.
- Enables decision makers to understand:
  - The likelihood of a "doomsday" scenario
  - Insurance purchase decisions
  - Cost-benefit of enhanced performance objectives

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How is FEMA P-58 different?

- P-58 is comprehensive
  - Integrated methodology to evaluate and reduce risk
- P-58 allows better informed decisions
  - More complete expression of the factors contributing to seismic risk
- P-58 is quantitative
  - Allows quantitative comparisons of different performance objectives
  - The effects of different design decisions on seismic performance can be studied

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Measuring Performance

- Damage
- Downtime
- Casualties
- Post-earthquake tagging
- Functionality
- Environmental impacts

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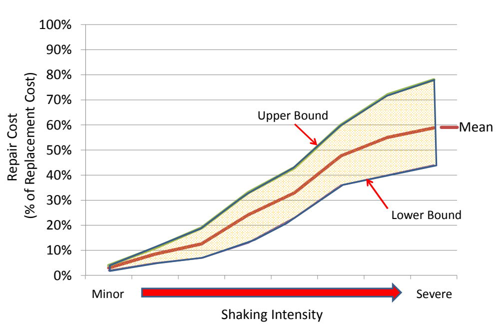
Damage - Loss Ratios



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Damage States

- A key innovation - ability to describe performance of components using different damage states
- Consider a lay-in ceiling…
  - 5 % of tiles dislodge and fall
  - 30% of tiles dislodge and fall and T-bar grid damaged
  - Total ceiling collapse

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Downtime

- Downtime estimates consider
  - Extent of the damage
  - Damage state of components
  - Long lead items
  - Number of repair workers

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Casualties

- Fatalities and serious injuries are usually associated with collapse
  - The number of occupants in the building at the time of the event
  - Occurrence and nature of collapse
- Casualties can also be caused by failure of nonstructural components

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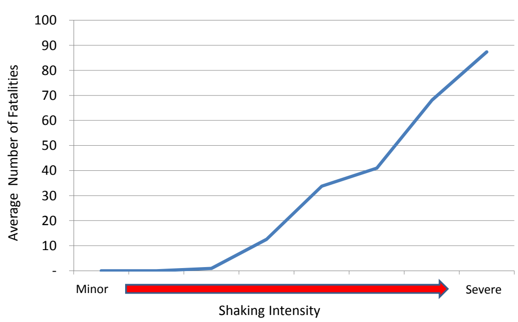
Fatalities



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Unsafe Placard

- Predicts the likelihood of an unsafe placard
- Components contributing to unsafe placards can be identified
- Choose options to reduce the chance of an unsafe placard

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Functionality

- P-58 can be used to estimate the probability that the building will be functional following an earthquake
  - Identify the building components that either must function, or will disrupt operations if they fail
  - Identify the damage states that may impair function and tolerance of damage

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Hospital Damage Tolerance

Component/ System	Building Functional	Building Not Functional
Piping	Small number of minor leaks	Large leaks
Emergency generator	Must function	Non-functional
HVAC systems	Air circulation and heating and cooling	Equipment failure Air Handler equipment failure HVAC falling hazards Pipe/duct failure
Suspended ceilings	Minor falling tiles	Total grid collapse
Elevators	At least one in operation	No elevators function

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Environmental Impacts

- Capture the environmental consequences of building response to earthquakes
  - Energy
  - Carbon
  - Solid Waste
- Use earthquake damage cost estimates to generate Life Cycle Assessment impacts
  - ATC-86: Integrating Seismic and Environmental Performance Metrics

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What can FEMA P-58 do for you?

- Framework for comprehensive seismic risk management and performance-based design
- Expected performance can be compared quantitatively to performance objectives
- Building attributes and components that degrade performance can be identified and managed

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Questions

Thank you!

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Goals for the Afternoon Breakout Session

Laura Samant
Stakeholder Products Team Leader

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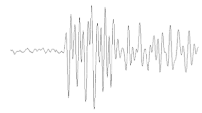
Activities that can require decisions about seismic risk



- Design of a new building
- Retrofit/rehabilitation of an existing building
- Rental decisions
- Loans or financing decisions
- Insurance decisions
- Emergency preparedness/risk planning

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Breakout sessions

Morning
- Hear from you how decisions about seismic risk are made now.

Afternoon
- Explore with you how FEMA P-58 might be used to enhance how those decisions are made.

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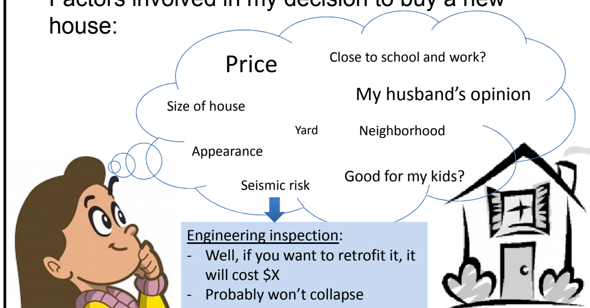
Decisions are complex

Factors involved in my decision to buy a new house:



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Back to my new house…

What if that engineer told me:

In the next 20 years
- Probability of collapse
- Probability of casualties
- Likely repair costs in earthquake X, Y, or Z
- Repair costs versus insurance costs
- Etc…

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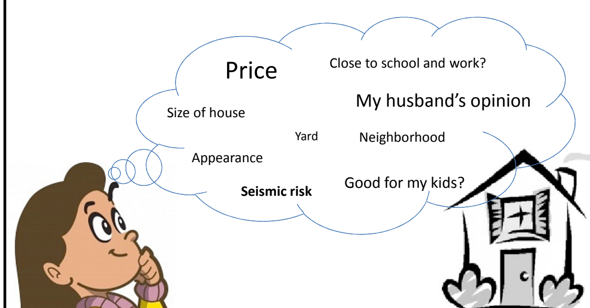
Better answers enable better choices



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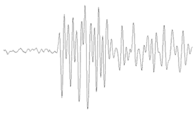
Activities that can require decisions about seismic risk



- Design of a new building
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- Emergency preparedness/risk planning

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Probable Performance of XYZ Building for M7.2 Earthquake on the Hayward Fault

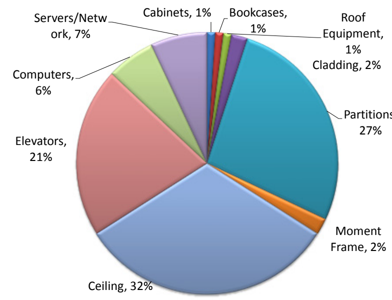
Casualties: 0

Probability of Unsafe placard: 10%

Median repair costs: $820,000 allocated as shown

Probable maximum loss (90th percentile): $1,500,000

Median repair time: 8 weeks



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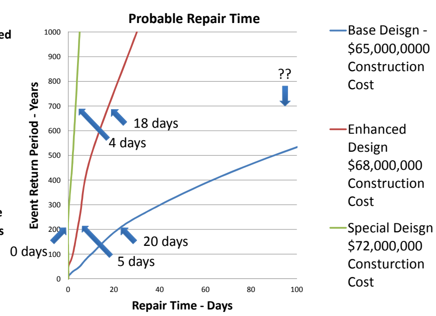
Probable Repair Time Required for XYZ Building for Earthquakes of Various Sizes

Base design: designed to code

Enhanced design: designed as an essential facility

Special design: uses technology like base isolation or dampers



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ATC, 2002, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*, ATC-58-1, Applied Technology Council, Redwood City, California.

ATC, 2003, *Preliminary Evaluation of Methods for Defining Performance*, ATC-58-2, Applied Technology Council, Redwood City, California.

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FEMA, 2012b, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide*, FEMA P-58-2, prepared by the Applied Technology Council for the Federal Emergency Management Agency, Washington, D.C.

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Risk Engineering Inc., 2014, *ST-RISK Technical Information*, Risk Engineering Inc., last accessed on July 11, 2014, http://www.st-risk.com/tech.html.

Applied Technology Council Projects and Report Information

One of the primary purposes of the Applied Technology Council is to develop engineering applications and resources that translate and summarize useful information for practicing building and bridge design professionals. This includes the development of guidelines and manuals, as well as the development of research recommendations for specific areas determined by the profession. ATC is not a code development organization, although ATC project reports often serve as resource documents for the development of codes, standards and specifications.

Applied Technology Council conducts projects that meet the following criteria:

1. The primary audience or benefactor is the design practitioner in structural engineering.
2. A cross section or consensus of engineering opinion is required to be obtained and presented by a neutral source.
3. The project fosters the advancement of structural engineering practice.

Funding for projects is obtained from government agencies and tax-deductible contributions from the private sector. Brief descriptions of completed ATC projects and reports are provided below.

ATC-1: This project resulted in five papers published as part of *Building Practices for Disaster Mitigation, Building Science Series 46*, proceedings of a workshop sponsored by the National Science Foundation (NSF) and the National Bureau of Standards (NBS). Available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22151, as NTIS report No. COM-73-50188.

ATC-2: The report, *An Evaluation of a Response Spectrum Approach to Seismic Design of Buildings*, was funded by NSF and NBS and was conducted as part of the Cooperative Federal Program in Building Practices for Disaster Mitigation. Available through ATC. (Published 1974, 270 Pages)

ATC-3: The report, *Tentative Provisions for the Development of Seismic Regulations for Buildings* (ATC-3-06), was funded by NSF and NBS. The tentative provisions in this report served as the basis for the seismic provisions of the 1988 and subsequent issues of the *Uniform Building Code* and the *NEHRP Recommended Provisions for the Development of Seismic Regulation for New Building and Other Structures*. The second printing contains proposed amendments prepared by a joint committee of the Building Seismic Safety Council (BSSC) and the NBS. Available through ATC. (Published 1978, amended 1982, 505 pages plus proposed amendments)

ATC-3-2: The project, “Comparative Test Designs of Buildings Using ATC-3-06 Tentative Provisions”, was funded by NSF. It consisted of a study to develop and plan a program for making comparative test designs of the ATC-3-06 Tentative Provisions. The project report was intended for use by the Building Seismic Safety Council in its refinement of the ATC-3-06 Tentative Provisions.

ATC-3-4: The report, *Redesign of Three Multistory Buildings: A Comparison Using ATC-3-06 and 1982 Uniform Building Code Design Provisions*, was published under a grant from NSF. Available through ATC. (Published 1984, 112 pages)

ATC-3-5: The project, “Assistance for First Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council,” was funded by the Building Seismic Safety Council to obtain assistance in conducting the first phase of its program to develop trial designs for buildings in Los Angeles, Seattle, Phoenix, and Memphis.

ATC-3-6: The project, "Assistance for Second Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting the second phase of its program to develop trial designs for buildings in New York, Chicago, St. Louis, Charleston, and Fort Worth.

ATC-4: The report, *A Methodology for Seismic Design and Construction of Single-Family Dwelling*s, was published under a contract with the Department of Housing and Urban Development (HUD). Available through ATC. (Published 1976, 576 pages)

ATC-4-1: The report, *The Home Builders Guide for Earthquake Design*, was published under a contract with HUD. Available through ATC. (Published 1980, 57 pages)

ATC-5: The report, *Guidelines for Seismic Design and Construction of Single-Story Masonry Dwellings in Seismic Zone 2*, was developed under a contract with HUD. Available through ATC. (Published 1986, 38 pages)

ATC-6: The report, *Seismic Design Guidelines for Highway Bridges*, was published under a contract with the Federal Highway Administration (FHWA). Available through ATC. (Published 1981, 210 pages)

ATC-6-1: The report, *Proceedings of a Workshop on Earthquake Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1979, 625 pages)

ATC-6-2: The report, *Seismic Retrofitting Guidelines for Highway Bridges*, was published under a contract with FHWA. Available through ATC. (Published 1983, 220 pages)

ATC-7: The report, *Guidelines for the Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1981, 190 pages)

ATC-7-1: The report, *Proceedings of a Workshop on Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1980, 302 pages)

ATC-8: The report, *Proceedings of a Workshop on the Design of Prefabricated Concrete Buildings for Earthquake Loads*, was funded by NSF. Available through ATC. (Published 1981, 400 pages)

ATC-9: The report, *An Evaluation of the Imperial County Services Building Earthquake Response and Associated Damage*, was published under a grant from NSF. Available through ATC. (Published 1984, 231 pages)

ATC-10: The report, *An Investigation of the Correlation Between Earthquake Ground Motion and Building Performance*, was funded by the U.S. Geological Survey (USGS). Available through ATC. (Published 1982, 114 pages)

ATC-10-1: The report, *Critical Aspects of Earthquake Ground Motion and Building Damage Potential*, was co-funded by the USGS and the NSF. Available through ATC. (Published 1984, 259 pages)

ATC-11: The report, *Seismic Resistance of Reinforced Concrete Shear Walls and Frame Joints: Implications of Recent Research for Design Engineers*, was published under a grant from NSF. Available through ATC. (Published 1983, 184 pages)

ATC-12: The report, *Comparison of United States and New Zealand Seismic Design Practices for Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1982, 270 pages)

ATC-12-1: The report, *Proceedings of Second Joint U.S.-New Zealand Workshop on Seismic Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1986, 272 pages)

ATC-13: The report, *Earthquake Damage Evaluation Data for California*, was developed under a contract with the Federal Emergency Management Agency (FEMA). It presents expert-opinion earthquake damage and loss estimates for industrial, commercial, residential, utility and transportation facilities in California. Included are damage probability matrices for 78 classes of structures and estimates of time required to restore damaged facilities to pre-earthquake usability. Available through ATC. (Published 1985, 492 pages)

ATC-13-1: The report, *Commentary on the Use of ATC-13 Earthquake Damage Evaluation Data for Probable Maximum Loss Studies of California Buildings*, was developed with funding from the ATC Endowment Fund. It provides guidance for using ATC-13 expert-opinion data for probable maximum loss (PML) studies of California buildings. Included are discussions of the limitations on the use of the ATC-13 expert-opinion data, and appendices containing information not included in the original ATC-13 report, such as model building type descriptions, beta damage distribution parameters for ATC-13 model building types, and PML values for ATC-13 model building types. Available through ATC. (Published 2002, 66 pages)

ATC-14: The report, *Evaluating the Seismic Resistance of Existing Buildings*, was developed under a grant from the NSF. It describes a methodology for performing preliminary and detailed seismic evaluations of buildings. A precursor to the eventual ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*, it contains useful background information including a state-of-practice review; seismic loading criteria; data collection procedures; a detailed description of the building classification system; preliminary and detailed analysis procedures; and example case studies, including nonstructural considerations. Available through ATC. (Published 1987, 370 pages)

ATC-15: The report, *Comparison of Seismic Design Practices in the United States and Japan*, was published under a grant from NSF. Available through ATC. (Published 1984, 317 pages)

ATC-15-1: The report, *Proceedings of Second U.S.-Japan Workshop on Improvement of Building Seismic Design and Construction Practices*, was published under a grant from NSF. It includes state-of-the-practice papers and case studies of actual building designs and information on regulatory, contractual, and licensing issues. Available through ATC. (Published 1987, 412 pages)

ATC-15-2: The report, *Proceedings of Third U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes state-of-the-practice papers on steel braced frame and reinforced concrete buildings, base isolation and passive energy dissipation devices, and comparisons between U.S. and Japanese design practice. Available through ATC. (Published 1989, 358 pages)

ATC-15-3: The report, *Proceedings of Fourth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on postearthquake building damage assessment; acceptable earthquake damage; repair and retrofit of earthquake-damaged buildings; base-isolated buildings, Architectural Institute of Japan recommendations for design; active damping systems; and wind-resistant design. Available through ATC. (Published 1992, 484 pages)

ATC-15-4: The report, *Proceedings of Fifth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on performance goals and acceptable damage; seismic design procedures and case studies; seismic evaluation, repair and upgrade; construction influences on design; isolation and passive energy dissipation; design of irregular structures; and quality control for design and construction. Available through ATC. (Published 1994, 360 pages)

ATC-16: The FEMA 90 report, *An Action Plan for Reducing Earthquake Hazards of Existing Buildings*, was funded by FEMA and was conducted by a joint venture of ATC, the Building Seismic Safety Council and the Earthquake Engineering Research Institute. Available through FEMA. (Published 1985, 75 pages)

ATC-17: The report, *Proceedings of a Seminar and Workshop on Base Isolation and Passive Energy Dissipation*, was published under a grant from NSF. It includes papers describing case studies in the United States, applications and developments worldwide, recent innovations in technology development, and structural and ground motion issues in base-isolation and passive energy-dissipation. Also included is a proposed 5-year research agenda. Available through ATC. (Published 1986, 478 pages)

ATC-17-1: The report, *Proceedings of a Seminar on Seismic Isolation, Passive Energy Dissipation and Active Control,* was published under a grant from NCEER and NSF. Available through ATC. (Published 1993, 841 pages in two volumes)

ATC-18: The report, *Seismic Design Criteria for Bridges and Other Highway Structures: Current and Future***,** was developed under a grant from NCEER and FHWA. Available through ATC. (Published, 1997, 151 pages)

ATC-18-1: The report, *Impact Assessment of Selected MCEER Highway Project Research on the Seismic Design of Highway Structures***,** was developed under a contract with the Multidisciplinary Center for Earthquake Engineering Research (MCEER, formerly

NCEER) and FHWA. Available through ATC. (Published, 1999, 136 pages)

ATC-19: The report, *Structural Response Modification Factors* was funded by NSF and NCEER. Available through ATC. (Published 1995, 70 pages)

ATC-20: The report, *Procedures for Postearthquake Safety Evaluation of Buildings*, was developed under a contract with the California Office of Emergency Services (OES), California Office of Statewide Health Planning and Development (OSHPD) and FEMA. It provides procedures and guidelines for inspecting buildings that have been damaged in an earthquake, and making decisions regarding their continued use and occupancy. Written for volunteer structural engineers and building inspectors, it includes rapid and detailed evaluation procedures for posting buildings as “inspected” (apparently safe, green placard), “limited entry” (yellow) or “unsafe” (red). Available through ATC (Published 1989, 152 pages)

ATC-20-1: The report, *Field Manual: Postearthquake Safety Evaluation of Buildings, Second Edition*, was funded by Applied Technology Council. A companion to the ATC-20 report, the *Field Manual* summarizes postearthquake safety evaluation procedures in a concise format designed for ease of use in the field. Available through ATC. (Published 2004, 143 pages)

ATC-20-2: The report, *Addendum to the ATC-20 Postearthquake Building Safety Procedures* was published under a grant from the NSF and funded by the USGS. It provides updated assessment forms, placards, and evaluation procedures based on application and use in five earthquake events that occurred after the initial release of the ATC-20 report. Available through ATC. (Published 1995, 94 pages)

ATC-20-3: The report, *Case Studies in Rapid Postearthquake Safety Evaluation of Buildings,* was funded by ATC and R.P. Gallagher Associates. Containing over 50 case studies using the ATC-20 Rapid Evaluation procedure, the report is intended for use as a training and reference manual. It describes how buildings are inspected and evaluated, and is illustrated with photos and completed safety assessment forms and placards. Available through ATC. (Published 1996, 295 pages)

ATC-20-T: The *Postearthquake Safety Evaluation of Buildings Training CD* was developed in cooperation with FEMA. The 4½-hour training seminar includes photographs, schematic drawings, and textual information. Available through ATC. (Published 2002, 230 PowerPoint slides with Speakers Notes)

ATC-21: The FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, *Second Edition*, was developed under a contract with FEMA. It describes a rapid visual screening procedure for identifying buildings that might pose serious risk of loss of life and injury in the event of a damaging earthquake. The screening procedure utilizes an approach that involves identification of the primary structural load-resisting system and materials of construction, and assignment of a structural hazard score based on observed building characteristics. It identifies those buildings that are potentially hazardous and should be analyzed in more detail by an experienced professional engineer. Available through ATC and FEMA. (Published 2002, 161 pages)

ATC-21-1: The FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, *Second Edition*, was developed under a contract with FEMA. It provides the technical basis for the updated rapid visual screening procedure. Available through ATC and FEMA. (Published 2002, 117 pages)

ATC-21-2: The report, *Earthquake Damaged Buildings: An Overview of Heavy Debris and Victim Extrication*, was developed under a contract with FEMA. (Published 1988, 95 pages)

ATC-21-T: The report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards Training Manual, Second Edition,* was developed under a contract with FEMA. Training materials include120 slides in PowerPoint format and companion narrative coordinated with the presentation. Available through ATC. (Published 2004, 148 pages and PowerPoint presentation on companion CD)

ATC-22: The report, *A Handbook for Seismic Evaluation of Existing Buildings (Preliminary)*, was developed under a contract with FEMA in 1989. Based on the information originally developed in ATC-14, this report was revised by BSSC and published as the FEMA 178 report, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* in 1992, revised by ASCE and published as the FEMA 310 report, *Handbook for the Seismic Evaluation of Buildings – a Prestandard* in 1998. Currently available through the American Society of Civil Engineers as the ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*.

ATC-22-1: The report, *Seismic Evaluation of Existing Buildings: Supporting Documentation*, was developed under a contract with FEMA. (Published 1989, 160 pages)

ATC-23A: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part A: Survey Description, Summary of Results, Data Analysis and Interpretation*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 58 pages)

ATC-23B: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part B: Raw Data*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 377 pages)

ATC-24: The report, *Guidelines for Seismic Testing of Components of Steel Structures*, was jointly funded by the American Iron and Steel Institute (AISI), American Institute of Steel Construction (AISC), National Center for Earthquake Engineering Research (NCEER), and NSF. Available through ATC. (Published 1992, 57 pages)

ATC-25: The report, *Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous State*s, was developed under a contract with FEMA. Available through ATC. (Published 1991, 440 pages)

ATC-25-1: The report, *A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 147 pages)

ATC-26: This project, "U.S. Postal Service National Seismic Program," was funded under a contract with the U.S. Postal Service (USPS), and resulted in the following interim documents:

ATC-26 Report, *Cost Projections for the U. S. Postal Service Seismic Program* (Completed 1990)

ATC-26-1 Report, *United States Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim)* (Completed 1991)

ATC-26-2 Report, *Procedures for Post-disaster Safety Evaluation of Postal Service Facilities (Interim)*. Available through ATC. (Published 1991, 221 pages)

ATC-26-3 Report, *Field Manual: Post-earthquake Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 133 pages)

ATC-26-3A Report, *Field Manual: Post Flood and Wind Storm Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 114 pages)

ATC-26-4 Report, *United States Postal Service Procedures for Building Seismic Rehabilitation (Interim)* (Completed 1992)

ATC-26-5 Report, *United States Postal Service Guidelines for Building and Site Selection in Seismic Areas (Interim)* (Completed 1992)

ATC-28: The report, *Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings, Phase I: Issues Identification and Resolution*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 150 pages)

ATC-29: The report, *Proceedings of a Seminar and Workshop on Seismic Design and Performance of Equipment and Nonstructural Elements in Buildings and Industrial Structures*, was developed under a grant from NCEER and NSF. It includes papers describing current practice, codes and regulations; earthquake performance; analytical and experimental investigations; development of new seismic qualification methods; and research, practice, and code development needs for nonstructural elements and systems. Available through ATC. (Published 1992, 470 pages)

ATC-29-1: The report, *Proceedings of a Seminar on Seismic Design, Retrofit, and Performance of Nonstructural Components*, was developed under a grant from NCEER and NSF. It includes papers on observed performance in recent earthquakes; seismic design codes, standards, and procedures for commercial and institutional buildings; design issues relating to industrial and hazardous material facilities; and seismic evaluation and rehabilitation of components in conventional and essential facilities. Available through ATC. (Published 1998, 518 pages)

ATC-29-2: The report, *Proceedings of Seminar on Seismic Design, Performance, and Retrofit of Nonstructural Components in Critical Facilities*, was developed under a grant from MCEER (formerly NCEER) and NSF. It includes papers on seismic design, performance, and retrofit of nonstructural components in critical facilities including current practices and emerging codes; seismic design and retrofit; risk and performance evaluation; system qualification and testing; and advanced technologies. Available through ATC. (Published 2003, 574 pages)

ATC-30: The report, *Proceedings of Workshop for Utilization of Research on Engineering and Socioeconomic Aspects of 1985 Chile and Mexico Earthquakes*, was developed under a grant from the NSF. Available through ATC. (Published 1991, 113 pages)

ATC-31: The report, *Evaluation of the Performance of Seismically Retrofitted Buildings*, was developed under a contract with the National Institute of Standards and Technology (NIST, formerly NBS) and funded by the USGS. Available through ATC. (Published 1992, 75 pages)

ATC-32: The report, *Improved Seismic Design Criteria for California Bridges: Provisional Recommendations,* was funded by the California Department of Transportation (Caltrans). Available through ATC. (Published 1996, 215 pages)

ATC-32-1: The report, *Improved Seismic Design Criteria for California Bridges: Resource Document,* was funded by Caltrans. Available through ATC. (Published 1996, 365 pages; also available on CD-ROM)

ATC-33: The project, funded under a contract with the Building Seismic Safety Council, was initiated by FEMA to develop nationally applicable, state-of-the-art guidance for performance-based seismic rehabilitation of buildings. Work resulted in the publication of:

> FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (Published 1997, 440 pages). Revised by ASCE and published as the FEMA 356 report, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* in 2000. Currently available through the American Society of Civil Engineers as the ASCE 41 Standard, *Seismic Rehabilitation of Existing Buildings*.
>
> FEMA 274, *NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 492 pages)
>
> FEMA 276, *Example Applications of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 295 pages)

ATC-34: The report, *A Critical Review of Current Approaches to Earthquake Resistant Design***,** was developed under a grant from NCEER and NSF. Available through ATC. (Published, 1995, 94 pages)

ATC-35: The report, *Enhancing the Transfer of U.S. Geological Survey Research Results into Engineering Practice* was developed under a cooperative agreement with the USGS. Available through ATC. (Published 1994, 120 pages)

ATC-35-1: The report, *Proceedings of Seminar on New Developments in Earthquake Ground Motion Estimation and Implications for Engineering Design Practice*, was developed under a cooperative agreement with USGS. It includes papers describing state-of-the-art information on regional earthquake risk; new techniques for estimating strong ground motions as a function of earthquake source, travel path, and site parameters; and new developments applicable to geotechnical engineering. Available through ATC. (Published 1994, 478 pages)

ATC-35-2: The report, *Proceedings: National Earthquake Ground Motion Mapping Workshop*, was developed under a cooperative agreement with USGS. It includes papers on ground motion parameters; reference site conditions; probabilistic versus deterministic basis; and the treatment of uncertainty in seismic source characterization and ground motion attenuation. Available through ATC. (Published 1997, 154 pages)

ATC-35-3: The report, *Proceedings: Workshop on Improved Characterization of Strong Ground Shaking for Seismic Design,* was developed under a cooperative agreement with USGS. It includes papers on identifying needs and developing improved representations of earthquake ground motion for use in seismic design practice and building codes. Available through ATC. (Published 1999, 75 pages)

ATC-37: The report, *Review of Seismic Research Results on Existing Buildings***,** was developed in conjunction with the Structural Engineers Association of California (SEAOC) and California Universities for Research in Earthquake Engineering (CUREe) under a contract with the California Seismic Safety Commission (SSC). Available through the Seismic Safety Commission as Report SSC 94-03. (Published, 1994, 492 pages)

ATC-38: The report, *Database on the Performance of Structures near Strong-Motion Recordings: 1994 Northridge, California, Earthquake*, was developed with funding from the USGS, the Southern California Earthquake Center (SCEC), OES, and the Institute for Business and Home Safety (IBHS). Available through ATC. (Published 2000, 260 pages, with CD-ROM containing complete database).

ATC-40: The report, *Seismic Evaluation and Retrofit of Concrete Buildings***,** was developed under a contract with the California Seismic Safety Commission. It provides guidance on performance objectives, hazard characterization, identification of deficiencies, retrofit strategies, nonlinear static analysis procedures, modeling rules, foundation effects, and response limits for seismic evaluation and retrofit of concrete buildings. Available through ATC. (Published, 1996, 612 pages in two volumes)

ATC-41 (SAC Joint Venture, Phase 1): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 1," was funded by FEMA and OES and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 1 the following documents were prepared:

SAC-94-01, *Proceedings of the Invitational Workshop on Steel Seismic Issues, Los Angeles, September 1994*. Available through ATC. (Published 1994, 155 pages)

SAC-95-01, *Steel Moment-Frame Connection Advisory No. 3*. Available through ATC. (Published 1995, 310 pages)

SAC-95-02, *Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment-Frame Structures* (FEMA 267 report) (Published 1995, 215 pages; superseded by FEMA 350 to 353)

SAC-95-03, *Characterization of Ground Motions During the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 179 pages)

SAC-95-04, *Analytical and Field Investigations of Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 900 pages in two volumes)

SAC-95-05, *Parametric Analytical Investigations of Ground Motion and Structural Response, Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 274 pages)

SAC-95-06, *Surveys and Assessment of Damage to Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 315 pages)

SAC-95-07, *Case Studies of Steel Moment Frame Building Performance in the Northridge Earthquake of January 17, 1994* (Published 1995, 260 pages, Available through ATC)

SAC-95-08, *Experimental Investigations of Materials, Weldments and Nondestructive Examination Techniques*. Available through ATC. (Published 1995, 144 pages)

SAC-95-09, *Background Reports: Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame systems, Behavior* (FEMA 288 report). Available through ATC and FEMA. (Published 1995, 361 pages)

SAC-96-01, *Experimental Investigations of Beam-Column Subassemblages, Part 1 and 2*. Available through ATC. (Published 1996, 924 pages, in two volumes)

SAC-96-02, *Connection Test Summaries* (FEMA 289 report). Available through ATC and FEMA. (Published 1996, 144 pages)

ATC-41-1 (SAC Joint Venture, Phase 2): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 2," was funded by FEMA and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 2 the following documents were prepared:

SAC-96-03, *Interim Guidelines Advisory No. 1 Supplement to FEMA 267 Interim Guidelines* (FEMA 267A report) (Published

1997, 100 pages; superseded by FEMA 350 to 353)

SAC-99-01, *Interim Guidelines Advisory No. 2 Supplement to FEMA 267 Interim Guidelines* (FEMA 267B report, superseding FEMA 267A). (Published 1999, 150 pages; superseded by FEMA 350 to 353)

FEMA 350, *Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 190 pages)

FEMA 351, *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 210 pages)

FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 353, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 354, *A Policy Guide to Steel Moment-Frame Construction*. Available through ATC and FEMA. (Published 2000, 27 pages)

FEMA 355A, *State of the Art Report on Base Materials and Fracture*. Available through ATC and FEMA. (Published 2000, 107 pages; in print and on CD-ROM).

FEMA 355B, *State of the Art Report on Welding and Inspection*. Available through ATC and FEMA. (Published 2000, 185 pages; in print and on CD-ROM).

FEMA 355C, *State of the Art Report on Systems Performance of Steel Moment Frames Subject to Earthquake Ground Shaking*. Available through ATC and FEMA. (Published 2000, 322 pages; in print and on CD-ROM).

FEMA 355D, *State of the Art Report on Connection Performance*. Available through ATC and FEMA. (Published 2000, 292 pages; in print and on CD-ROM).

FEMA 355E, *State of the Art Report on Past Performance of Steel Moment-Frame Buildings in Earthquakes*. Available through ATC and FEMA. (Published 2000, 190 pages; in print and on CD-ROM).

FEMA 355F, *State of the Art Report on Performance Prediction and Evaluation of Steel Moment-Frame Structures*. Available through ATC and FEMA. (Published 2000, 347 pages; in print and on CD-ROM).

ATC-43: The reports, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual* (FEMA 306), *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources* (FEMA 307), and *The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings* (FEMA 308), were developed for FEMA under a contract with the Partnership for Response and Recovery, a Joint Venture of Dewberry & Davis and Woodward-Clyde. Available through ATC and FEMA. (Published, 1998 in print and on CD-ROM; *Basic Procedures Manual*, 270 pages; *Technical Resources*, 271 pages; *Repair Manual*, 81 pages)

ATC-44: The report, *Hurricane Fran, North Carolina, September 5, 1996: Reconnaissance Report*, was funded by the Applied Technology Council. Available through ATC. (Published 1997, 36 pages)

ATC-45: The report, *Field Manual*, *Safety Evaluation of Buildings After Wind Storms and Floods*, was developed with funding from the ATC Endowment Fund and the Institute for Business and Home Safety (IBHS). It provides rapid and detailed evaluation procedures for inspecting buildings that have been damaged in wind storms and floods, and making decisions regarding their continued use and occupancy. Presented in a concise format designed for ease of use in the field, it is intended for use by volunteer structural engineers and building inspectors in posting buildings as “inspected” (apparently safe, green placard), “restricted use” (yellow) or “unsafe” (red). Available through ATC. (Published 2004, 132 pages)

ATC-48 (ATC/SEAOC Joint Venture Training Curriculum): The training curriculum, *Built to Resist Earthquakes, The Path to Quality Seismic Design and Construction for Architects, Engineers, and Inspectors*, was developed under a contract with the California Seismic Safety Commission and prepared by a Joint Venture partnership between ATC and SEAOC. Available through ATC. (Published 1999, 314 pages)

ATC-49: The 2-volume report, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges; Part I: Specifications* and *Part II: Commentary and Appendices*, were developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, *Part I*, 164 pages and *Part II*, 294 pages)

ATC-49-1: The document, *Liquefaction Study Report, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges,* was developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, 208 pages)

ATC-49-2: The report, *Design Examples, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges*, was developed under the ATC/MCEER Joint Venture partnership with funding from the Federal Highway Administration. Available through ATC. (Published 2003, 316 pages)

ATC-51: The report, *U.S.-Italy Collaborative Recommendations for Improved Seismic Safety of Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey). Available through ATC. (Published 2000, 154 pages)

ATC-51-1: The report, *Recommended U.S.-Italy Collaborative Procedures for Earthquake Emergency Response Planning for Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey, NSS). Available in English and Italian through ATC. (Published 2002, 120 pages)

ATC-51-2: The report, *Recommended U.S.-Italy Collaborative Guidelines for Bracing and Anchoring Nonstructural Components in Italian Hospitals*, was developed under a contract with the Department of Civil Protection, Italy. Available in English and Italian through ATC. (Published 2003, 164 pages)

ATC-52: The project, "Development of a Community Action Plan for Seismic Safety (CAPSS), City and County of San Francisco", was conducted under a contract with the San Francisco Department of Building Inspection. The following reports were prepared:

ATC-52-1, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts*. Available through ATC. (Published 2010, 78 pages)

ATC-52-1A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts Technical Documentation*. Available through ATC. (Published 2010, 160 pages)

ATC-52-2, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: A Community Action Plan for Seismic Safety*. Available through ATC. (Published 2010, 92 pages)

ATC-52-3, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings*. Available through ATC. (Published 2009, 60 pages)

ATC-52-3A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings Documentation Appendices*. Available through ATC. (Published 2009, 206 pages)

ATC-52-4, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Post-Earthquake Repair and Retrofit Requirements*. Available through ATC. (Published 2010, 130 pages)

ATC-53: The report, *Assessment of the NIST 12-Million-Pound (53 MN) Large-Scale Testing Facility*, was developed under a contract with NIST. Available through ATC. (Published 2000, 44 pages)

ATC-54: The report, *Guidelines for Using Strong-Motion Data and ShakeMaps in Postearthquake Response*, was developed under a contract with the California Geological Survey. Available through ATC. (Published 2005, 222 pages)

ATC-55: The FEMA 440 report, *Improvement of Nonlinear Static Seismic Analysis Procedures*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2005, 152 pages)

ATC-56: The report, FEMA 389, *Primer for Design Professionals: Communicating with Owners and Managers of New Buildings on Earthquake Risk*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2004, 194 pages)

ATC-56-1: The report, FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks – Providing Protection to People and Buildings*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2003, 106 pages)

ATC-57: The report, *The Missing Piece: Improving Seismic Design and Construction Practices*, was developed under a contract with NIST. It provides a framework for eliminating the technology transfer gap that has emerged within the National Earthquake Hazards Reduction Program (NEHRP) that limits the adaptation of basic research knowledge into practice. Available through ATC. (Published 2003, 102 pages)

ATC-58/ATC-58-1: This series of projects, "Development of Next-Generation Performance-Based Seismic Design Guidelines for New and Existing Buildings," was a multi-year, multi-phase effort funded by FEMA that has resulted in the publication of the following:

ATC-58-1, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*. Available through ATC. (Published 2002, 87 pages).

ATC-58-2, *Preliminary Evaluation of Methods for Defining Performance*. Available through ATC. (Published 2003, 99 pages).

ATC-58-3, *Proceedings of a FEMA-Sponsored Workshop on Performance-Based Design*. Available through ATC. (Published 2003, 146 pages).

FEMA 445, *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings*. Available through ATC and FEMA. (Published 2006, 131 pages).

FEMA 461, *Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components*. Available through ATC and FEMA. (Published 2007, 113 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology*. Available through ATC and FEMA. (Published 2012, 319 pages).

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide*. Available through ATC and FEMA. (Published 2012, 365 pages).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. Available through ATC and FEMA. (Published 2012, on CD).

ATC-60: The 2-volume report, *SEAW Commentary on Wind Code Provisions, Volume 1* and *Volume 2 - Example Problems,* was developed by the Structural Engineers Association of Washington (SEAW) in cooperation with ATC. Available through ATC. (Published 2004; *Volume 1*, 238 pages; *Volume 2*, 245 pages)

ATC-61: The 2-volume report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, Volume 1 – Findings, Conclusions, and Recommendations*, and *Volume 2 – Study Documentation,* was prepared for the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences, with funding provided by FEMA. Available through ATC and the MMC. (Published 2005; *Volume 1*, 11 pages; *Volume 2*, 366 pages)

ATC-62: The report, FEMA P-440A, *Effects of Strength and Stiffness Degradation on Seismic Response*, was developed under a contract with FEMA. Developed as a supplement to the FEMA 440 report, it provides additional guidance on modeling of nonlinear degrading response. Available through ATC and FEMA. (Published 2009, 310 pages)

ATC-63: The report, FEMA P-695, *Quantification of Building Seismic Performance Factors*, was developed under a contract with FEMA. It describes a methodology for establishing seismic performance factors (R , Ω_0, and C_d) that involves the development of detailed system design information and probabilistic assessment of collapse risk. It utilizes nonlinear analysis techniques, and explicitly considers uncertainties in ground motion, modeling, design, and test data. The technical approach is a combination of traditional code concepts, advanced nonlinear dynamic analyses, and risk-based assessment techniques. Available through ATC and FEMA. (Published 2009, 420 pages)

ATC-63-1: The report, FEMA P-795, *Quantification of Building Seismic Performance Factors: Component Equivalency Methodology*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 264 pages)

ATC-64: The reports, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis* (FEMA P-646), and *Vertical Evacuation from Tsunamis: A Guide for Community Officials* (FEMA P-646A), were developed under a contract with FEMA. Available through ATC and FEMA. (*Design Guidelines*, Published 2008, 174 pages; *Guide for Community Officials*, Published 2009, 62 pages)

ATC-65: The FEMA P-455 report, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risks*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 174 pages)

ATC-66: The report, FEMA P-774, *Unreinforced Masonry Buildings and Earthquakes, Developing Successful Risk Reduction Programs*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 194 pages)

ATC-68: The FEMA P-420 report, *Engineering Guideline for Incremental Seismic Rehabilitation*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 94 pages)

ATC-69: The report, *Reducing the Risks of Nonstructural Earthquake Damage, State-of-the-Art and Practice Report*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2008, 144 pages)

ATC-69-1: The electronic document, FEMA E-74, *Reducing the Risks of Nonstructural Earthquake Damage, A Practical Guide*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 750 pages)

ATC-70: The report, NIST Technical Note 1476, *Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report*, was developed under a contract with NIST. Available through NIST. (Published 2006, 222 pages)

ATC-71: The reports, *Workshop on Meeting the Challenges of Existing Buildings, Part 1 Workshop Proceedings; Part 2: Status Report on Seismic Evaluation and Rehabilitation of Existing Buildings;* and *Part 3: Action Plan for the FEMA Existing Buildings Program*, were developed under a contract with FEMA. Available through ATC and FEMA. (*Part 1*, Published 2008, 142 pages; *Part 2*, Published 2009, 140 pages; *Part 3*, Published 2009, 118 pages)

ATC-72: The report, *Proceedings of Workshop on Tall Building Seismic Design and Analysis Issues* (ATC-72) was prepared for the Building Seismic Safety Council of the National Institute of Building Sciences, with funding provided by FEMA. The report, *Modeling and Acceptance Criteria for Seismic Design and Analysis of Tall Buildings* (PEER/ATC-72-1) was prepared for the Pacific Earthquake Engineering Research Center. Available through ATC and PEER. (*Proceedings*, Published 2007, 84 pages; *Modeling and Acceptance Criteria*, Published 2010, 242 pages)

ATC-73: The report, *NEHRP Workshop on Meeting the Challenges of Existing Buildings, Prioritized Research for Reducing the Seismic Hazards of Existing Buildings,* was developed under a grant from NSF. Available through ATC. (Published 2007, 22 pages)

ATC-74: The report, *Collaborative Recommended Requirements for Automatic Natural Gas Shutoff Valves in Italy,* was funded by the Department of Civil Protection, Italy. Available through ATC. (Published 2007, 76 pages)

ATC-75: The report, *Improvements to BIM Structural Software Interoperability*, was developed under a contract with the Charles Pankow Foundation. Available through ATC and CPF. (Published 2013, 155 pages)

ATC-76-1/ATC-76-4: The report, *Evaluation of the FEMA P-695 Methodology for the Quantification of Building Seismic Performance Factors,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-8. (Published 2010, 240 pages)

ATC-76-3: The reports, *NEHRP Technical Brief No. 1, Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers* and *NEHRP Technical Brief No. 2, Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers,* were developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST (*Technical Brief No. 1*, Report GCR 08-917-1. Published 2008, 32 pages; *Technical Brief No.*

2, Report GCR 09-917-3, Published 2009, 38 pages)

ATC-76-5: The report, *Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-7. (Published 2010, 80 pages)

ATC-76-6: The report, *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-9. (Published 2010, 196 pages plus CD)

ATC-76-7: The report, *NEHRP Technical Brief No. 3, Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-4. (Published 2010, 30 pages)

ATC-76-8: The report, *NEHRP Technical Brief No. 4, Nonlinear Structural Analysis for Seismic Design: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 10-917-5. (Published 2010, 32 pages)

ATC-78: The report, *Identification and Mitigation of Seismically Hazardous Older Concrete Buildings: Interim Methodology Evaluation* (ATC-78), and its successor report, *Evaluation of the Methodology to Select and Prioritize Collapse Indicators in Older Concrete Buildings* (ATC-78-1), were developed under a contract with FEMA. ATC-78-1 is currently available through ATC. (Published 2012, 153 pages)

ATC-82: The report, *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 11-917-5. (Published 2011, 234 pages)

ATC-83: The report, *Soil-Structure Interaction for Building Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-21. (Published 2012, 292 pages)

ATC-84: The report, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC, CUREE, and NIST as GCR 12-917-20. (Published 2012, 302 pages)

ATC-86: The report, FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*, was developed under a contract with FEMA in support of the ATC-58 Project. Available through ATC and FEMA. (Published 2012, 120 pages)

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