ATC-58 FRAMEWORK FOR PERFORMANCE-BASED DESIGN OF NONSTRUCTURAL COMPONENTS

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Abstract

The Applied Technology Council (ATC) has entered into a contract with the Federal Emergency Management Agency to develop a next generation of performance-based seismic design guidelines for buildings (the ATC-58 project). As currently envisioned, the ATC-58 project will extend over approximately a 12-year period. The guidelines developed by the project are to be applicable to the design of new buildings as well as the upgrade of existing buildings. In addition, the guidelines are to address the design of both building structures and the nonstructural components housed with these structures. The guidelines are intended to be applicable to all types of building structures including critical facilities. However, compiling performance data and acceptance criteria for the many structural and nonstructural systems that comprise the building inventory is an immense task, beyond the funding ability of any single private or public agency. Therefore, it is anticipated that much work associated with developing this performance data and acceptance criteria will be performed outside the project and will continue on for many years. In this paper, the background and organization of the project is described along with the current framework that will serve as the basis for developing the guidelines for the nonstructural components portion of the project.

ATC-58 Project Background

Performance-based seismic design originally evolved as a concept whereby the desired performance level for a given structure (including the nonstructural components housed within), along with a specified level of shaking, are defined at the initiation of the design process. The decision-maker is asked to select one or more of these performance levels, and a ground motion event or hazard level for which this performance is to be achieved and the designer is expected to develop a design capable of meeting these expectations. Under the ATC-58 project, this concept has evolved such that performance is defined in terms of the risk of life loss, direct economic loss (repair / replacement cost) and indirect economic loss (loss associated with facility downtime), considering either individual earthquake events or the entire range of events that may affect a facility. The designer is provided with a procedure that is intended to allow determination as to whether the desired performance can be achieved. For critical facilities, the selected performance may be dominated by the need to have designated nonstructural components function following severe earthquakes.

Existing codes for the seismic design of new buildings are prescriptive in nature and are intended principally to provide for life-safety when the design level earthquake occurs. While current codes are intended to produce buildings that meet a life safety performance level for a specified level of ground shaking, they do not provide an explicit procedure that enables the designer to determine if other performance levels will be achieved, or exceeded. During a design level earthquake, a code-designed building should achieve the goal of preventing the loss of life or life-threatening injury to the occupants, but could sustain extensive structural and nonstructural damage and be out of service for an extended period of time. In some cases, the damage may be too costly to repair, with demolition being the only viable option.

With the publication of the NEHRP *Guidelines for the Seismic Rehabilitation of Existing Buildings* (FEMA 273 Report) in 1997, the technology available for the seismic rehabilitation of buildings greatly advanced beyond the technology available for the seismic design of new buildings. Designers were provided, for the first time, with a consistent set of procedures that enabled them to execute performance-based design. These procedures were further refined in the *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 356), which was published in 2000. While these documents represent important and significant advances in seismic design practice, the FEMA 273/356 procedures have several significant shortcomings. First the procedures do not directly address control of economic loss, one of the most significant concerns of decision makers. Secondly, the procedures are focused on assessing the performance of individual building components, rather than the building as a whole. Most significantly, however, the reliability of the procedures in delivering the desired performance is not known and cannot easily be determined.

The issue of reliability in performance prediction was subsequently addressed in the FEMA-sponsored “SAC Program to Reduce Seismic Hazards in Steel Moment Frame Building”, which was initiated in response to unanticipated damage sustained by moment-resisting steel frames in the 1994 Northridge earthquake. This project developed specific design and rehabilitation criteria for steel moment-frame structures that extended the performance-based design techniques contained in FEMA-273/356. The design recommendations were published as the FEMA-350 Report, Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings, and the FEMA-351 report, Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings. These recommended design criteria specifically quantified performance in terms of the global behavior of buildings, as well as the behavior of individual components, and also incorporated a formal structural reliability framework to characterize the confidence associated with meeting intended performance goals. Although the FEMA/SAC criteria represent significant technical improvements to the performance-based design approach established in FEMA-273/356, many engineers have stated a belief that these new procedures are excessively complex for routine implementation on projects. Moreover, the effort required to extend the FEMA/SAC approach to a broader class of structural and nonstructural systems used in modern construction may be impractically high.

Concurrent with the development of FEMA 273/356 and the SAC project, FEMA also carried out a series of studies to define the requirements for overcoming the observed shortcomings in then current performance-based seismic design procedures. The first of these studies was an effort by the Earthquake Engineering Research Center (EERC) at the University of California who recommended a six-year program of research and development with an estimated implementation cost of $ 32 million (1995 dollars). These recommendations were published in the FEMA-283 report, *Performance-Based Seismic Design of Buildings*. A second study, undertaken by the Earthquake Engineering Research Institute (EERI), culminated in the development of an action plan published in April 2000 as the FEMA-349 report, *Action Plan for Performance-Based Seismic Design*. The FEMA-349 plan extended over an implementation period of ten years and required funding in amounts ranging from $ 20 to $ 27 million (1998 dollars).

FEMA-349 defines six products essential to the creation and implementation of comprehensive, acceptable *Performance-Based Seismic Design Guidelines*:

1. A *Program Management Plan* to incorporate a broadly based oversight group (the Steering Committee) to shepherd and promote the development of the Guidelines (over an extended

period , say up to 10 years), and an education and implementation strategy to facilitate the use of the Guidelines.

2. *Structural Performance Products* that quantify performance levels, specify how to evaluate a building's performance capability for a specified level of seismic hazard and with a defined reliability or level of confidence, and provide guidance on how to design a structure to meet a given performance level for a specified level of seismic hazard (with defined reliability).

3. *Nonstructural Performance Products* that provide engineers with the capability to evaluate and design nonstructural components, such as partitions, piping, HVAC equipment (heating, ventilation, and air conditioning), with the goal of ensuring that such components will meet a specified performance level of performance for a specified level of seismic hazard (with defined reliability).

4. *Risk Management Products* that provide methodologies for calculating the benefits of designing to various performance objectives and to make rational economic choices about the levels of performance desired, the levels of confidence desired , and the comparative costs to reach those levels.

5. *Performance-Based Seismic Design Guidelines* that provide methodology and criteria for design professionals, material suppliers, and equipment manufacturers to implement performance-based design.

6. A *Stakeholders Guide* that explains performance-based seismic design to non-technical audiences, including building owners, managers, and lending institutions.

In September 2001, FEMA initiated the ATC-58 project generally following the work plan of FEMA-349. The purpose of the project is to develop the series of resource documents identified above that define procedures that can be used to reliably and economically design new buildings or upgrade existing buildings to attain desired performance goals for individual buildings. The ultimate goals of performance-based design are the development of practical design criteria that give the building owner and regulator the ability to select a building's desired performance for varying levels of earthquake hazard as well as to optimize the performance of building codes relative to society's needs. While the project is funded under seismic programs, the intent is that the technologies developed in this program will be directly relevant and applicable to other extreme events, such as blast, fire and tornadic winds.

FEMA, which was made part of the Department of Homeland Security in mid 2003, has elected initially to fund the ATC-58 project in a series of three 12-18 month Phases. Under Phase 1, ATC developed a management process for the project, including formation of a Project Management Committee and Project Steering Committee; conducted a workshop a Workshop on Communicating Earthquake Risk and commenced the development of a report characterizing seismic performance. Under Phase 2, which was initiated in September of 2002 and is still underway, ATC expanded the project team with appointment of the Team Leaders for each of the major program work areas; conducted a Performance-Based Design Programming Workshop to receive input on recent and ongoing developments in performance-based engineering community into a revised Action Plan for the full 10-year program based on input received the workshop. ATC has also commenced a series of tasks related to quantifying structural and nonstructural performance, is continuing to outreach to the stakeholder community, and is preparing a final interim report on the risk communication.

Future development of the Performance Based Design Program will be conducted in two additional phases as follows:

- Phase 3 – Development of Performance Verification Methodology
- Phase 4 – Development of Design Methodology and Tools

Each of these next phases is nominally envisaged as a 5-year project that will result in the publication of guidelines, useful for the design community. The Phase 3 work will result in the publication of Guidelines for Performance Verification. These performance verification guidelines could be used directly to evaluate the performance of new and existing structures, by applying standard methods of structural analysis, coupled with structural reliability/loss estimation methods. The Phase 4 work will develop guidelines for rapidly identifying the selection of appropriate systems, configurations, strengths, stiffness, ductility and other characteristics appropriate to meeting performance of different types, in regions of varying seismicity.

Current plans call for Phase 3 to be fully funded in the fall of 2004. In the interim, a supplemental Phase 2 work effort will be undertaken which will complete the tasks which were started in Phase 2 and along with commencing on development of performance verification methodology Phase 3 tasks. Specifically in the non-structural area, the Phase 2 supplemental tasks are the completion of the quantification of nonstructural performance levels initiated under the first part of Phase 2 and developing a catalog of nonstructural components and systems that matter from a Performance-Based Design perspective.

ATC-58 Project Organization

The ATC-58 project management team reports to FEMA through the FEMA Project Officer and the FEMA Technical Monitor. Currently for the ATC 58-Project, the FEMA Project Officer is Michel Mahoney and the FEMA Technical Monitor is Robert Hanson.

The ATC-58 project management team consists of a Project Executive Director, Project Technical Director, and a Project Management Committee (PMC), which is responsible for day-to-day management of the project as well as the technical quality and direction of the project. The Project Executive Director and the Project Technical Director serve as chair and co-chair, respectively, of the six-person PMC. The other members of the PMC consist of four eminently qualified earthquake engineering specialists, who are also recognized leaders in the emerging field of performance-based design. Technical overview and guidance for the project is provided by the Project Steering Committee, which consists of leading available specialists and stakeholders in performance-based design, including researchers, building design professionals, building regulators, earth scientists, and representatives of the building owners and managers community, and the insurance and banking industries. Detailed project work, including preparation of project reports and tasks relating to the quantification of performance levels and development of the performance evaluation methodology, is carried out by three product development teams: a Structural Performance Products Team, a Nonstructural Performance Products Team and a Risk Management Products Team, staffed by consultants, selected on the basis of their demonstrated knowledge, experience and leadership in the development and application of performance-based approaches to engineering design. An organization chart is provided in Figure 1.

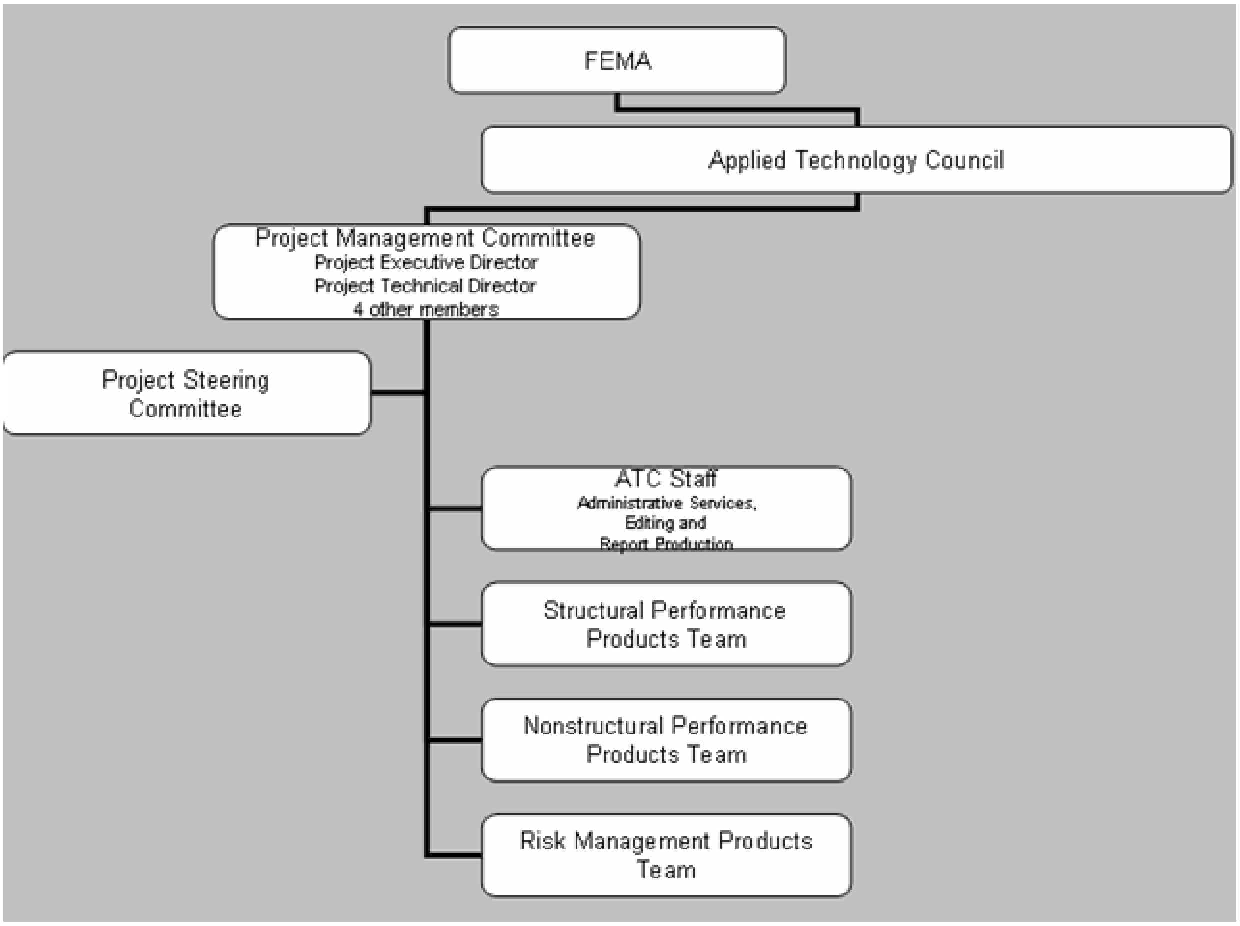

Figure 1. Organization Chart.

The ATC-58 Project Steering Committee serves as an advisory body to the PMC and provides diverse perspective on key technical issues and conduct of the project, including the making of recommendations pertaining to the identification of needed products, recommending candidates for various project roles, recommending timetables for various activities, and technical and content review of documents produced under the project.

The Performance Product Team Leaders report to the PMC through the Project Technical Director. Over the life of the ATC-58 Project it is anticipated that the Performance Product Team Leaders will be responsible for coordinating and leading all tasks related to development of tools to predict performance in earthquakes in their area of responsibility. It is also anticipated that the Team Leaders will participate in the development of Performance-Based Design Guidelines. Each team leader is currently supported by a product team to help in the Phase 2 and Phase 2 supplemental tasks. Each team will change and grow as the workload increases in the subsequent project phases.

The ATC-58 Framework for Performance Based Seismic Design

The overall framework for addressing Performance Based Seismic Design by the ATC-58 Projects is found in a white paper (Hamburger, 2003) “A Vision for the ATC-58 Project Development of Performance-Based Seismic Design Guidelines” which was presented at the ATC-58 Programming Workshop in February 2003. This white paper was updated in September 2003. Significant excerpts from his white paper are presented in this paper in the following sections.

Performance Design Process. The basic process of performance-based design is illustrated below in Figure 2. It consists of selection of appropriate performance objectives, development of a design believed capable of achieving those objectives, verifying that the design is capable of achieving the desired objectives and, if this is not true, iteration of the design until such verification is attained. Steps in this process are discussed below. In this paper the focus will be the path for nonstructural path for performance design.

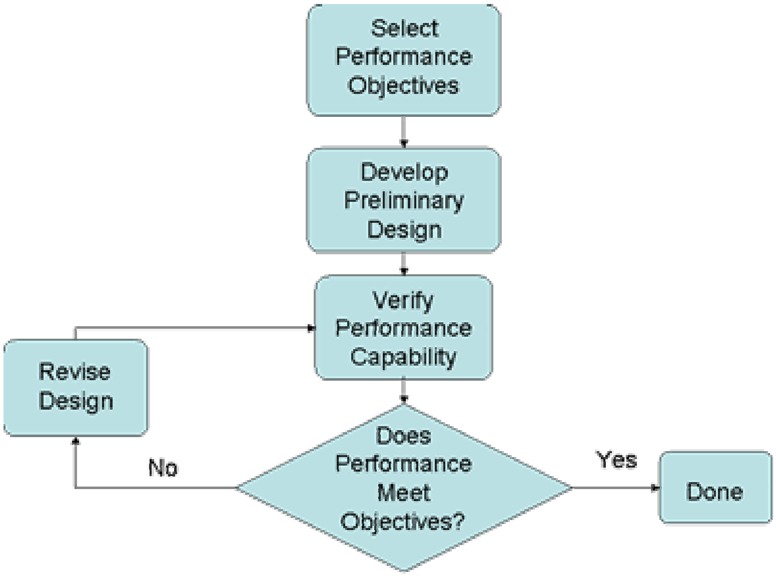

Figure 2 – Performance Design Flow Diagram

Performance Objectives. An important goal of the ATC-58 project is to utilize performance objectives that are both predictable, by the design professional, and meaningful and useful for the decision makers who must select or approve the performance objectives used as a basis for design. Preliminary project work tasks have revealed that these decision makers (or stakeholders) are a disparate group, representing many constituencies and levels of sophistication. Decision makers include building developers, corporate facilities managers, corporate risk managers, institutional managers, lenders, insurers, public agencies and regulators.

Each decision maker will view seismic performance from a different perspective and select desired performance using different decision making processes. Many decision makers will default in the selection process to the minimum performance permitted by regulatory authority. Others will select acceptable performance based on risk of ruin considerations and maximum foreseeable event scenarios. Still others may select desired performance based on elaborate cost benefit models.

Regardless of the decision process, it will involve development of an understanding of the risk associated with a given choice and the resources that must be invested to reduce this risk beyond certain thresholds. Thus, a central part of the performance-based design methodology must include procedures for estimating seismic risk on a design-specific basis. This risk should be capable of being expressed on either a deterministic event (scenario basis), or a probabilistic basis, so as to suit the varying levels of sophistication and decision styles that exist among different decision makers. Further, it should be expressed in terms of specific losses, for example, cost of restoration of a facility to service once it is damaged, time to restore a facility to service once it is damaged and potential loss of life resulting from damage. These losses, or decision variables, rather than the damage itself, or arbitrary performance levels, are most meaningful to the broad range of decision makers. For the purposes of this project, the design-specific risk estimation models that are central to this project will be termed the Performance Prediction Methodology.

Perform Preliminary Design. The preliminary design for a structure includes definition of its configuration, for example the number of stories and the story height and floor plate arrangement at each story; the basic structural system, for example steel moment frame or masonry bearing walls; the presence of any protective technologies, for example seismic isolators, energy dissipation devices or damage-resistant elements; and approximate sizes and locations for the various structural and nonstructural components and systems. Presently, the engineer has little guidance available as to how to perform a preliminary design, other than to rely on personal judgment and experience. Some engineers will form a preliminary design based on the prescriptive code provisions while others will use a more intuitive approach. An important part of the ATC-58 project will be to provide engineers with guidance for selecting appropriate systems, stiffness, strength and damping for structures, in order to meet various seismic performance objectives.

Performance Verification. A proposed methodology for verifying a design's performance capability through a performance prediction process is described below. This process is similar to that utilized in the HAZUS national loss estimation software, though details of individual steps will likely be implemented differently under the ATC-58 project. Figure 3 is a flow chart for this basic performance prediction methodology. Much of this methodology is based on procedures currently under development by the Pacific Earthquake Engineering Research Center.

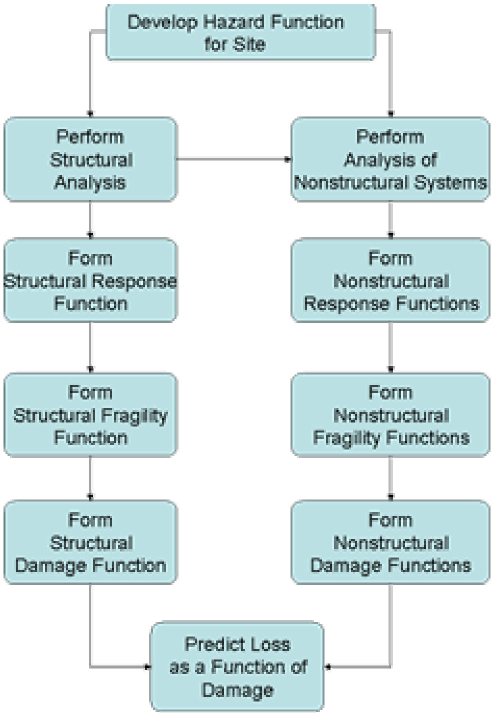

Figure 3. Flow Diagram for Performance Prediction Process

Hazard Function. The hazard function for a site is an expression of the probability that ground motion of different intensities will be experienced at the site. The hazard function may be formed on a scenario basis, that is considering only the occurrence of a specific magnitude earthquake on a specific fault, or on a probabilistic basis, considering all potential earthquakes on all known faults and seismic source zones.

For scenario-based evaluations, the hazard function will indicate the conditional probability of exceedance of different intensities of motion given that the scenario earthquake occurs. Figure 4 presents a scenario-based hazard function for a hypothetical site and scenario earthquake event, showing the median conditional probability of exceeding different intensities of ground shaking, expressed as peak ground acceleration, given that the scenario earthquake occurs. In addition to the median conditional probability, the figure also illustrates that confidence bands may be associated with these probabilities, owing to uncertainties associated with estimation of the hazard.

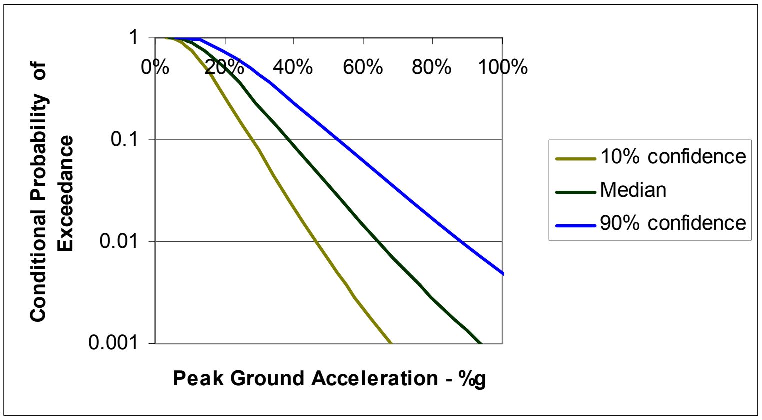

Figure 4 – Hypothetical Scenario-based Hazard Function for Site

For probabilistic evaluations, the hazard function will indicate the total probability of exceeding different intensities of motion, considering all earthquakes that may occur and the probability and associated confidence of each of these events. The probability may be expressed in the form of an annual probability of exceedance (or nonexceedance), an average return period, or the probability of exceedance (or nonexceedance) in a defined period of years, often taken as 50. It can be expressed as a mean probability, in which the uncertainty associated with the function is averaged, or confidence bounds can be expressly indicated.

The parameter used to describe the intensity of ground motion is termed an intensity measure (or measures). Intensity measures should be both useful and efficient. For a measure to be useful it must be compatible with the structural analysis that will be used to evaluate structural and nonstructural response and must correlate well with structural response and damage either to structural or nonstructural elements. In addition, it must be a parameter that can be predicted as a function of earthquake source, travel path and site characteristics either using empirical or analytical approaches so that a hazard function (or preferably, national hazard maps) can be developed for the measure. An intensity measure is efficient if the variability associated with predictions of response and damage that are associated with it tend to be small.

The earliest intensity measures used in engineering were the various intensity scales including Rossi-Forrell and Modified Mercalli. In fact, the first national seismic hazard maps contained in U.S. building codes categorized seismic zones in terms of anticipated maximum Modified Mercalli Intensity. As MMI does not correlate well with damage to individual structures, cannot be directly used to perform structural analysis and has high variability, it is not considered sufficiently useful or efficient for implementation in performance-based design. For more than 30 years, design procedures have used linear acceleration response spectra as the basic intensity measure. While linear acceleration response spectra are useful and form the basis for present national seismic hazard maps, they are not particularly efficient. This is exhibited by the fact that different accelerograms, when scaled to be compatible with a single response spectrum, may produce significant variability in terms of predicted structural response. Further, linear response spectra cannot account for duration effects and are applicable to nonlinear methods of analysis only through approximate means. More efficient intensity measures that account for the characteristics of ground motion that are important to nonlinear response, that include duration effects and which are efficient, are needed. Several projects currently being performed by the Pacific Earthquake Engineering Research Center are evaluating ground motion intensity measures that address some of these issues.

Perform Structural Analyses and Form Structural Response Function. Structural analysis is used in performance prediction process for two basic purposes:

1. Prediction of structural response parameters (engineering demand parameters) that can be used as predictors of the damage sustained by the structure. Examples of engineering demand parameters (EDPs) include inelastic rotations at beam columns joints or interstory drift.

2. Prediction of the input EDPs placed on nonstructural elements and systems supported by the structure, at different intensities of ground motion. Examples of input EDPs include peak floor acceleration, floor response spectra and interstory drift. From a nonstructural perspective input EDPs are similar in effect to ground motion intensity measures for structures.

In general, in order to obtain the structural response function, nonlinear time history analyses of the structure will be performed for a series of ground motion records which are consistent with the intensity of ground motion under consideration. Because of the nonlinear behavior of the structure and the uncertainty of ground motion, a range of structure responses result. In addition, it is expected that modeling parameters of the structures such as stiffness, mass, damping and hysteretic parameters also are uncertain and vary from the assumed values to some degree. If a series of analyses of the structure are performed, varying these parameters within bounding limits, it is possible to predict the additional variation in possible EDPs at a given level of ground motion intensity resulting from these uncertainties. These additional uncertainties will tend to broaden, somewhat, the scatter associated with the response function. A hypothetical resulting structural response function for one EDP, interstory drift, is illustrated below in Figure 5.

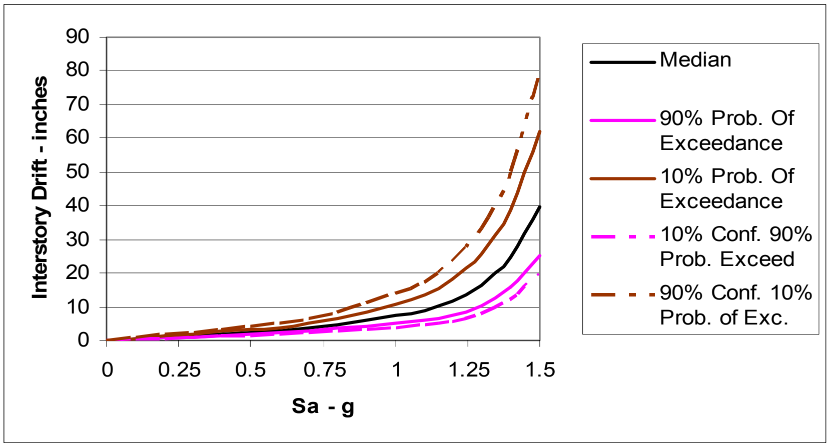

Figure 5. Hypothetical Response Function Indication Uncertainties

Perform Structural Analysis of Nonstructural Components and Form Nonstructural Response Function. Some nonstructural components which behave primarily as structural systems will need to be analyzed similarly to the primary structural system using as input the support motions (both relative and absolute) determined by the structural analysis of the primary structure for the range of determined responses. Nonlinear time history analyses will typically be performed and the response EDPs determined. The response EDPs are parameters such as inelastic rotations at pipe couplings or maximum inelastic strains from which fragility or damage can be based. The resulting hypothetical nonstructural response function will likely be similar in shape to Figure 5 although the magnitude of the values are likely to be significantly different.

Develop Nonstructural Fragilities. Nonstructural fragilities are functions that relate the probability that a nonstructural component will experience damage greater (or less) than a certain level, given that it is driven to a certain level of response, as measured by the response engineering demand parameter. As noted earlier for nonstructural components a response engineering demand parameter might be the inelastic rotation in a pipe coupling. It might also be, depending on the component, the peak floor acceleration, peak instructure acceleration at the component fundamental period or the interstory drift.

As is the case with response functions, fragilities are expressed as probability distributions, rather than deterministic relationships in order to account for the variability and uncertainty inherent in the process of predicting nonstructural damage as a function of nonstructural response. The variability is associated with such factors as the random character of the primary structural and associated nonstructural response to individual ground motion records and the inability of simple engineering demand parameters to distinguish between this response variation and the damage it causes. For example, two different ground motions may each produce peak interstory drift demands of 4 inches in a structure, however, one of these ground motions may cycle the structure to this drift level one time then restore the structure to small oscillations about its original position while the second ground motion may cycle the structure to this drift level several times and leave the structure displaced nearly to this level. Clearly the latter motion will be more damaging of the structure than the first motion, though the value of the engineering demand parameter is the same. Such effects are not predictable unless the precise ground motion and structural response is known. Uncertainty is introduced through such factors as lack of precise definition of material strength and construction quality.

In order to form fragility functions it is first necessary to establish measures of damage. A variety of such measures are possible. Damage states that may be meaningful for nonstructural components and systems could include “no damage,” “loss of function,” “loss of structural integrity” and “toppling”. In general, each class of nonstructural component or system, such as suspended ceilings, fire sprinkler systems, interior partitions, etc, will have different fragility functions, tied to several different intensity measures. These can be determined through collection of earthquake performance data on damage sustained by actual installations, through laboratory testing programs and in some cases, through structural analysis, just as would be done for the building structure itself. For critical equipment which must function, the fragility data may come form seismic qualification testing. Figure 6 is a hypothetical fragility curve for a single drift-sensitive nonstructural component (exterior curtain walls). The intensity measure for this fragility curve is structural interstory drift. The damage states of interest are taken as cracking of panels, breakage of glass, fallout of glass, and failure of panel connections. The fragilities shown in the figure are illustrative only and are not representative of real data.

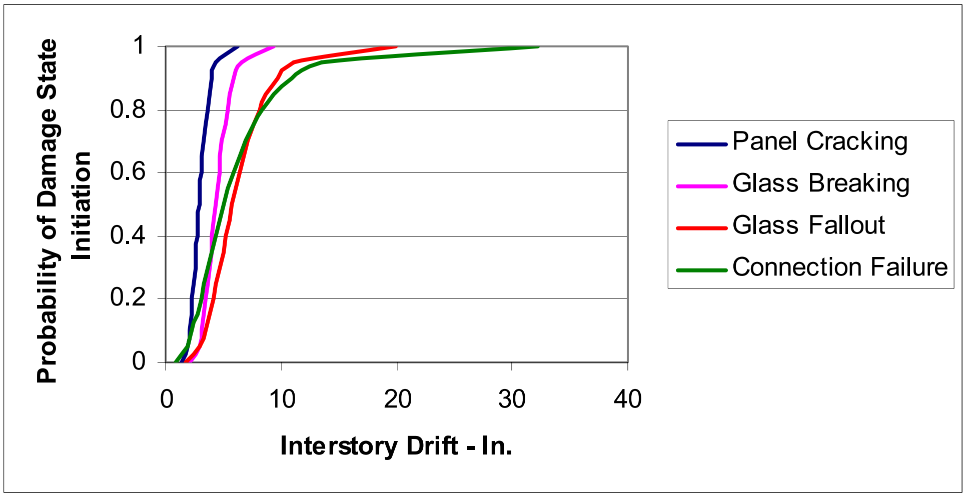

Figure 6. Illustrative Fragility Curve for Exterior Cladding

Loss Functions. Loss functions indicate the probability of incurring various levels of loss, given that a structure or nonstructural component or system is damaged to a given level, expressed in such parameters as repair cost (dollars), lives lost (deaths) and hours of lost service or occupancy (downtime). These curves show the probability, that loss will be less than or equal to an indicated amount, given that the building is damaged to a given level. Loss functions can be constructed for a given building or class of buildings, by postulating damage to the structure (or nonstructural component/system) that is representative of a damage level for which there is an available fragility function, and estimating the losses associated with this damage. By varying the assumptions, or exploring the level of uncertainty associated with these assumptions inherent in these estimates, it is possible to determine probability distributions of the possible losses, as a function of the damage state. Alternatively, if sufficient historical data on actual losses incurred in past earthquakes are available, it should be possible to construct such curves directly from the historical data.

Loss functions tend to incorporate significant uncertainty as compared with hazard curves, response functions and fragility curves because they are highly dependent on human factors including the owner's ability to act rapidly in retaining the necessary design professionals and construction contractors to effect repairs, the efficiency with which the design professionals and contractors operate and the speed with which building departments approve proposed repair programs.

Figure 7 is a hypothetical loss curve that relates repair cost for a single beam-column connection for a moment resisting steel frame structure for the several damage levels i.e., beam flange yielding, beam flange buckling and beam flange fracturing. It is roughly based on the estimated cost of repairing moment-resisting steel frames developed during the FEMA/SAC program. Similar loss functions will be developed for nonstructural components.

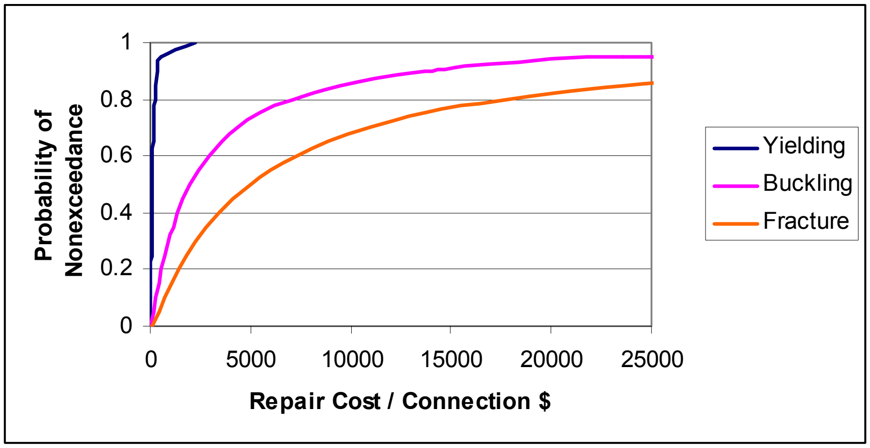

Figure 7 Hypothetical Loss Curve for Moment-Resisting Steel Frame in $/Connection

Computation of Losses. Given the hazard functions for appropriate intensity measures, response curves for the structure, fragility curves for the structure and its nonstructural components, and loss curves for each of these, it then becomes possible to characterize building performance, and thereby, building performance objectives, in a number of different ways.

Many stakeholders will wish to deal with performance and risk information on a scenario basis, for example, they may wish to know how much loss they can expect, given that a certain magnitude earthquake occurs. Others may wish to know an upper bound (at some confidence level) of the amount of loss they may incur for an event having a given return period. Still others, may wish to know the probability in a single year or number of years that losses of a given size will be experienced. Each of these, and other means of expressing loss, can be derived with the use of the hazard, response, fragility and loss functions.

Major ATC-58 Nonstructural Task Planned for Phase 3

To support the Development of Performance Verification Methodology, the following primary tasks are currently contemplated for the Nonstructural Performance Products Team for Phase 3.

1. Identify the nonstructural systems and components that are important to the performance of buildings and identify damage states that are meaningful to each of these components and systems.
2. Identify intensity measures that are useful and efficient for predicting damage to various nonstructural components and systems.
3. Identify engineering demand parameters that are necessary to predict damage to various nonstructural components and systems.
4. Identify loss functions for nonstructural components and systems relative to the damage states identified in Task 1.
5. Identify existing fragility and loss functions for nonstructural components and systems, available in the industry.
6. Identify standard procedures for qualifying the performance capability (fragility and loss functions) for various types of components and systems including testing protocols.

7. Working in coordination with the Structural Performance team, develop model buildings for use in developing and refining the performance evaluation methodologies.
8. Working in coordination with the Structural Performance team, perform performance evaluations of the nonstructural components and systems contained in the model buildings, designed to current standards.

Concluding Remarks

The purpose of the ATC-58 Project is to develop a series of resource documents that define procedures that can be used to reliably and economically design new buildings (including the nonstructural components house within the building) or upgrade existing buildings to attain desired performance goals, and to assist stakeholders in selecting appropriate design performance goals for individual buildings. The project leadership fully recognizes the significance and importance of nonstructural components in achieving the stakeholder goals and have included them as a major part of the project. One of the important goals of the project is to develop procedures that will assure with great confidence that nonstructural components will function as desired when the structure in which they are housed is subjected anticipated earthquake motions. It is believed that this project will provide an exciting opportunity to make a significant improvement in the seismic design, retrofit and performance of nonstructural components.

Acknowledgement

The primary author acknowledges that most of the material presented in this paper are the work of Ron Hamburger and is found in his paper “A Vision of the ATC-58 Project, Development of Performance-Based Seismic Guidelines”.

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