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REPORT CARDS FOR BUILDINGS: A PROPOSED RATING SYSTEM FOR EXPECTED EARTHQUAKE PERFORMANCE

SEAONC Existing Buildings Committee, Building Ratings Subcommittee

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ABSTRACT

This paper previews a system under development by the SEAONC Existing Buildings Committee (Building Ratings Subcommittee) intended to clearly communicate information about relative seismic risk to the general public to facilitate awareness and sensible decision making. Although a typical engineering report can provide technical information for a single building, there is an unmet need for qualitative information to compare seismic performance among multiple buildings, and for terminology to support real-world decision making. Like other rating systems customarily used in transactions, such as the Building Owners and Managers Association (BOMA) method of rating office space, SEAONC's Earthquake Performance Rating is proposed to be strictly voluntary, and presented so that its meaning is easily grasped by non-technical personnel, providing a common vocabulary of seismic risk. The intent is to have a rating system that utilizes many of the existing evaluation methodologies but translates their results into a format that will be easily understood by building owners and the general public. Feedback from potential users, including conference participants, will contribute to the development of a system that is credible, workable, and informative.

Introduction

In 2006, responding to a request from the Board of the Structural Engineers Association of Northern California (SEAONC), its Existing Buildings Committee agreed to form a subcommittee to study the feasibility of and develop an Earthquake Performance Rating System. This paper presents the findings and recommendations of the feasibility phase (Phase 1) and reports on the current status of the development phase (Phase 2).

The proposed rating system consists of a scale of 1 through 5 stars, in each of three dimensions: Safety, Repair Cost, and Time to Re-Occupy. Preliminary descriptions of each star-value are provided in Table 1. The rating is meant to be sufficiently simple to convey earthquake performance of buildings to a non-technical audience, but contain sufficient information for the user to meaningfully compare performance among multiple buildings. The rating system is not a new evaluation methodology; rather, it will specify a procedure by which

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outputs from existing evaluation standards can be mapped to a rating value. As such, any underlying evaluation used to generate a rating effectively becomes a constituent of the rating.

The first section discusses and summarizes Phase 1, completed in January 2008, which studied the system's feasibility, and developed principles and purpose for the rating system. The second section describes the ongoing Phase 2, including progress through November 2009. It provides a more complete commentary on the performance descriptions for each rating value, and includes information on how a building evaluation might be mapped to a rating value.

PHASE 1: FEASIBILITY

Phase 1 involved a feasibility study for an Earthquake Performance Rating System (EPRS), as well as consensus on the principles and purpose for development of such a rating system. For a complete summary of Phase 1, the reader is referred to SEAONC, 2008, and the summary document posted on the SEAONC website (www.seaonc.org).

Objectives of Phase 1 included:

1. Define the objective of a potential rating system
2. Identify the audience of a potential rating system
3. Investigate existing rating systems (both engineering and non-engineering)
4. Recommend whether or not to develop a rating system and methodology
5. Establish a common understanding and direction among committee members to conduct development (Phase 2).

Rating System vs. Rating Program vs. Current Codes

The proposed rating system is a set of definitions, rules, and procedures that leads to a concise characterization of earthquake performance, in other words, a rating. It differs from a rating program, which would be the set of activities by individuals or organizations intended to produce ratings, often by implementing a system.

A building code can be understood as a basic rating system for earthquake performance of buildings. Buildings may be "rated" as either compliant or non- compliant. Further distinctions might be made based on the date of the applicable code, the importance factor, or the Seismic Design Category. The current building code, of course, is not well suited to rating older buildings. Other standards and guidelines, however, such as Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA 154, 2002) and Seismic Evaluation of Existing Buildings (ASCE 31, 2003), are specifically intended for the seismic evaluation of existing buildings.

Although existing standards are available, a separate rating system would still be valuable as *a concise standard for information tailored to a particular audience*. Other distinctions between the proposed EPRS and documents like the International Building Code (IBC, 2006), ASCE 31, or FEMA 154 include:

- The EPRS should address both new and existing buildings in consistent terms. The available documents all use different terminology.
- The EPRS should allow for measures of performance other than safety. In some ways this requires more than ASCE 31 offers; in some ways it requires less than ASCE 31 provides.

Table 1: Conceptual Performance Descriptions for each Rating Value[1]

Rating	Safety	Repair Cost	Time to Re-Occupy
★★★★★	Building performance would not lead to conditions commonly associated with earthquake-related *entrapment*.	Building performance would lead to conditions requiring earthquake-related repairs commonly costing less than 5% of building replacement value.	Building performance would lead to no conditions inhibiting entrance and occupation of the building by its former occupants or the public immediately post-earthquake.
★★★★	Building performance would not lead to conditions commonly associated with earthquake-related *injuries*.	Building performance would lead to conditions requiring earthquake-related repairs commonly costing less than 10% of building replacement value.	Building performance would lead to no conditions inhibiting entrance and occupation of the building by its former occupants immediately post-earthquake. Public entrance is inhibited until functionality is restored.
★★★	Building performance would not lead to conditions commonly associated with earthquake-related *death*.	Building performance would lead to conditions requiring earthquake-related repairs commonly costing less than 20% of building replacement value.	Building performance would lead to conditions inhibiting entrance and occupation of the building due to a hazardous condition which could be removed by qualified personnel in a matter of days. Entrance and occupation are not inhibited by required repairs.
★★	Building performance in select locations within the building leads to conditions known to be associated with earthquake-related *death*.	Building performance would lead to conditions requiring earthquake-related repairs commonly costing more than 20% but less than 50% of building replacement value.	Building performance would lead to conditions requiring several weeks of cleanup or repair by qualified personnel before access can be permitted.
★	Performance of the building as a whole leads to conditions known to be associated with earthquake-related *death*.	Building performance would lead to conditions requiring earthquake-related repairs costing more than 50% of building replacement value.	Building performance would lead to conditions inhibiting the building from ever being occupied or functional for its pre-earthquake use.

[1] Each component is rated separately, so that 3 stars in Safety does not necessarily imply 3 stars for Repair Cost or 3 stars for Time to Re-Occupy.

- The EPRS should be supportive of non-expert users looking for concise information at a broad level for their everyday decision-making. ASCE 31 (and to some extent even FEMA 154) are typically used by owners seeking detailed or nuanced findings.
- The EPRS should more directly address stakeholder questions, which typically seek to contrast one building with another or with a norm. For example, users of a rating system might want to know "Is this building better or worse than average?" or "Is Building A significantly better than Building B?" A rating system should facilitate those comparisons, but a comprehensive standard like ASCE 31 only evaluates to absolute criteria.

The proposed EPRS can be thought of as a condensed, or "lite," version of the ongoing ATC-58 project, "Guidelines for Seismic Performance Assessment of Buildings." Although the two systems are under separate development, they both use a three-dimensional approach. However, the EPRS does not aim to predict absolute numerical outcomes in each dimension; rather, it attempts only to provide a basis for comparing buildings.

Context of a Rating System: the Rating Program

Systems and programs are linked (and should be). For a rating system to have value it must be implemented through a program, and for a program to be successful it must adopt a feasible system – one that will be accepted by key stakeholders and executable with available resources. Thus, it is the interests of the stakeholders that should determine whether a system is simple or complex, objective or judgment-based, precise or broad in its findings, focused or comprehensive in its scope, etc. Further, since earthquake performance is more than structural response, a rating system can focus on safety, habitability, code compliance, suitability to a specific occupancy, remaining useful life, insurability, recovery cost, or other measures. Thus, the subcommittee finds it neither practical nor advisable to produce a system which is all things to all people.

Instead, *an earthquake performance rating system will be feasible and valuable, only if it is designed for the **context** in which it will be used.* Thus, when envisioning an appropriate context for a rating system, i.e., the program that will apply it, the subcommittee considered the following points:

- SEAONC's primary objective here is to communicate seismic risk to non-engineers. A rating system endorsed by SEAONC might be one way to do that.
- Successful risk reduction programs are multidisciplinary. SEAONC's expertise, and its most useful contribution, is in structural engineering, not law or economics.
- The biggest challenges to earthquake risk reduction are not in engineering but in finance, policy, and regulation (as confirmed ATC-71 (ATC, 2008). Yet public policy, market forces, and the competing interests of building owners are largely outside our control.

The most feasible and effective broad-based rating program – the kind SEAONC should have in mind when proposing a rating system – would therefore be one that:

- Fills existing knowledge gaps
- Leverages the interests of motivated stakeholders
- Does not preach to or force itself on those without the resources to act
- Does not have a system already in place, and
- Would involve minimal logistical costs to implement and regulate.

The subcommittee discussed and debated a number of potential programs and scenarios. *The selected program is a voluntary program to inform purchase or lease transactions, because it most closely matches the list of desired attributes.*

Objective of a Rating System

The objective of a system that rates the earthquake performance of buildings is to *communicate seismic risk to non-engineers*. The ultimate goal is for the rating system to spur action that will reduce seismic risk in the overall building inventory. This effort aligns with SEAONC's mission statement: "SEAONC endeavors to enhance the life safety, environmental health, and economic well-being of the public served by Structural Engineers."

Users of the Rating System

The system should be usable by occupants, buyers, sellers, and tenants of a building. Thus, the audience for the system includes a broad group of people who make decisions about buildings, though many of them might know little about seismic risk. The system should be usable by all who assess, mitigate, insure or accept risk. However, the system requires integrity and clarity without regard to the users or their objectives.

The subcommittee feels that by serving the identified target audience, which is motivated to accept information but is not well served by existing rating systems and programs, the rating system will fill a gap in the current reach of our profession.

Content of a Rating

Current documents such as ASCE 31 are most often used to assess only safety. While this might be the primary concern of most system users, an expanded understanding of earthquake risk would also include notions of community resilience. Many residents already know enough to ask "Is my building safe?" We would like to educate our communities so that residents also begin to ask questions such as, "Will my building be re-occupiable? Is my job at risk? Can I afford not to insure my house?" Similarly, a rating system based entirely on estimated financial losses would not communicate the full spectrum of risk.

The subcommittee recommends that the rating provide comparative information on the seismic risk inherent in any given building, using dimensions of safety ("deaths"), repair cost ("dollars", or damage), and time to re-occupy ("downtime"). The rating should not specifically predict numerical values for deaths, dollar amounts, or downtimes, since such predictions would change through time due to changes in occupancy, best practices, etc. Rather, the rating should convey comparative values through a "number of stars" (1 through 5) for each dimension. The ratings should avoid words that imply promises of performance, such as the de-facto "ratings" of SEAOC's Vision 2000 report, "Performance Based Seismic Engineering of Buildings" (SEAOC, 1995) ("Collapse Prevention," "Immediate Occupancy," etc.), even though these performance levels may be embedded in the assessment process.

Applicability of the Rating System

All building types should be considered in the effort, including single family residences. The committee considered limiting the scope to exclude single family residences, mainly because the inventory is so diverse and distributed. However, specifically because single-family residences constitute such a large portion of existing buildings, excluding them might not achieve the goal of significantly influencing the overall risk of the whole building inventory. This goal of including all building types has not yet reached consensus among the subcommittee.

Motivation for Obtaining a Rating

Obtaining a rating should be strictly voluntary. It is not within our committee's or our profession's interest (or power) to specify the uses of a rating system. However, we see greatest value in a system that meshes with economic decisions. Thus, we have envisioned that the context for use would be a real estate acquisition (sale, lease, etc.), where a building rating would be one of many standard disclosures. In the context of a transaction, we envision that market pressures would encourage buyers and/or sellers to obtain a rating, making it part of pre-purchase due diligence. Examples of this market mechanism include the BOMA rating system for office space (Class A, B, C), and pre-purchase inspections of houses. The adversarial tension inherent in these transactions could enable adoption of a rating system, even if it is voluntary, since either or both the buying and selling parties may wish to obtain a rating independently. We do not intend to limit the use of the system to only this scenario; however, choosing one context helped us focus the recommendations.

Generating a Rating and Required Level of Effort

A system developed largely for voluntary use in the private sector must necessarily leave room for engineering judgment, as opposed to being entirely prescriptive or bureaucratic. The system must also be reliable even when applied by individuals of varied experience, since no single agency or entity will oversee its use on a private sector program.

The rating should be done by a licensed civil or structural engineer. We do not intend to specify the amount of effort, but we imagine a wide range, depending on the complexity of structural analysis, as structural evaluations are conducted presently. For example, a preliminary rating, assigned with minimal engineering input and at a low cost, could be used to decide whether to follow-up with a more detailed evaluation and subsequent rating.

To integrate a measure of confidence in the system, the committee has considered limiting the best possible rating that can be achieved according to the type of analysis performed. In other words, with a “simpler” evaluation, the rating could have an upper bound, with the highest rating(s) requiring a more detailed evaluation. This upper bound could vary according to complexity of building type. Using upper bounds to represent confidence assumes that error shrinks with additional analysis.

Basis of a Rating

The rating must be reproducible, and therefore tied to technical standards or objective guidelines. The rating system will provide a procedure for producing a rating value from the outputs of various existing evaluation standards, such as the score from FEMA 154, the deficiency list or demand-capacity ratios from ASCE 31, or the PML from a loss estimation procedure. The original evaluation should be preserved as part of the rating.

Validation and Regulation

The committee realizes the critical importance of this issue for the system’s credibility and likelihood of adoption. The committee discussed two approaches to validation. The first approach would be to have a third-party expert review board that independently verifies ratings, as for the US Green Building Council’s LEED ratings. The other possibility is market-based “enforcement,” i.e., verification by way of multiple competing opinions. This would work only in scenarios containing adversarial tension (such as a purchase), where counterparties (the buyer and seller) would each self-validate the other’s rating by obtaining separate, independent ratings. Market-based validation is consistent with the voluntary nature of the rating, and it is simpler and faster to implement. It is also the process by which due diligence evaluations are currently done.

PHASE 2: DEVELOPMENT

Phase 2 of our work has involved two main steps: first, defining the meaning of each rating value, and second, establishing a procedure by which to derive the rating value from outputs of various accepted standards for evaluation of a building. Any underlying evaluation used to generate a rating can be understood as a constituent of the rating.

Definitions for each Rating Value

The subcommittee’s recent work has focused on defining the earthquake performance corresponding to each rating value (1 star through 5 stars), for each dimension (safety, repair cost, time to re-occupy). Essential to the rating system is the idea that each of the three dimensions is rated separately. A given building, for example, might receive three stars for safety but only two stars for repair cost and time to re-occupy. It would even be possible that a given building would receive no rating for one or more dimensions, if the nature of the underlying evaluation would not support a reliable conclusion.

Definitions, provided in the preceding Table 1, are meant to separate distinctly different limit states or owner decisions. Although the definitions describe performance on an absolute basis, a rating is meant to convey a conceptual level of performance rather than predict specific numerical values. The rating definitions are pending validation and confirmation during testing of the system. *Particular definitions still pending validation include:*

- The appropriateness of using specific numerical thresholds for repair cost
- The demand level used for input to the evaluation of performance. In developing the table, the subcommittee envisioned a demand level equivalent to the design-basis earthquake, although this decision is pending consensus.
- Whether the "downtime" definitions should relate solely to the amount of time before a building can be entered, or whether they should relate to the time before a building can achieve its full functionality. The final system may contain these as two separate dimensions, or may define a direct relationship between the two.

Several factors affect a building's performance and thus affect the assigned rating. A selection of factors is listed in Table 2 below. It should be noted that not all the factors can feasibly be considered by the rating system. The subcommittee considered as many factors as practical, but many are outside of the scope or feasibility of the envisioned system. It is also notable that, as the ratings are defined, current standards might not be capable of producing all information required to assign a rating.

Commentary for Rating Definitions

In the safety dimension, the ability to assign a rating value exceeding 3 stars requires knowledge of factors typically excluded from conventional structural analyses, including falling hazards (structural and nonstructural), and jamming of doors and elevators, since these affect entrapment and egress. Consequently, a conventional structural evaluation is expected to only allow a 3-star rating to be achieved.

In the repair cost dimension, the thresholds for percentage of replacement value were selected to correspond to real-world decision points. For example, the 5% threshold between 4 and 5 stars is meant to correspond to the funds typically allocated to a building maintenance budget, which can be liquidated and disbursed immediately. The numerical value for this threshold needs further research. The 10% threshold between 3 and 4 stars is meant to correspond to an earthquake insurance deductible, and the 20% threshold between 2 and 3 stars is meant to correspond to the maximum losses required when securing financing (in the absence of insurance). Finally, the 50% threshold between 2 and 1 stars appears in historic code provisions, in FEMA criteria for flood repair and upgrade, and in FEMA feasibility criteria for repair funding, and in addition, may be an approximate threshold for an owner to "walk-away."

In the dimension for "downtime," the committee distinguished between two different modes of re-occupying a building: the time before the building can be re-entered for activities such as contents retrieval and repairs, and the time before the building is fully functional according to its prior use and occupancy. The definitions provided in Table 1 correspond to the

Table 2: Factors Affecting Earthquake Performance for Each Dimension

Factors	Safety	Repair Cost	Time to Re-Occupy or Regain Functionality
Structural	• Collapse • Falling hazards • Permanent drift	• Level of structural damage • Ability to occupy during repairs • Gravity system & material • Lateral system & material • Triggered upgrade	• Level of structural damage • Ability to occupy during repairs • Nature of repair work • Triggered upgrade
Nonstructural: Architecture	• Falling hazards • Egress	• Level of architectural damage • Ability to occupy during repairs • Uniqueness of facility • Quality of finishes • Historic fabric • Triggered upgrade	• Level of architectural damage • Weather resistance • Security • Viability as public accommodation • Perception of occupants
Nonstructural: Equipment & Systems	• Gas lines • Wiring • Falling hazards	• Level of damage • Amount of obsolete equipment	• Power system • Sewer system • Potable water availability • Egress and fire suppression systems
Geotechnical	• Landslide • Surface rupture • Liquefaction		
Other (excluded from consideration)	• Release of Hazmat / Asbestos-Containing Material (ACM)	• Level of contents damage • Availability of contractors • Availability of financing / government assistance / insurance adjustment process • Availability of lifelines • Hazmat / ACM release	• Level of contents damage • Availability of lifelines • Hazmat / ACM release

time before re-entry and not full functionality. The subcommittee also developed a second set of definitions corresponding to full functionality, but these definitions similarly use terms relating to cleanup, required skill level of repair, and timeframes of "weeks" and "months."

Definitions are generally meant to exclude performance of contents, since it is not practical to modify rating values for each change in tenancy or occupancy. While contents can significantly affect downtime and other losses, they must generally be excluded from the rating system scope because they will not typically be known during the transaction negotiations when the rating is produced.

Detailed Mapping Phase and Other Future Work

The procedure specifying how to derive a rating from outputs of accepted evaluation standards remains to be completed. It requires complex mapping between the many permutations of an evaluation and the corresponding rating, and as such, is a detailed effort. Currently the committee is focusing on mapping ASCE-31 results to the ratings. It remains to determine the appropriateness of combining the three dimensions into a single rating – and to develop a method of doing so. One proposal under consideration is to assign the "overall" rating to be the lowest number of stars achieved in any of the three dimensions.

Summary

Our initial efforts are focused on developing a system that structural engineers and earthquake professionals can agree upon. If we are successful in this effort within this community, our next step is to engage the broader building interest groups for their input.

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