QUAKESTAR – DEATHS, DOLLARS & DOWNTIME, A RELIABLE BUILDING SEISMIC RATING SYSTEM FOR NEW ZEALAND

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ABSTRACT: *QuakeStar is a proposed rating system for buildings to provide users, owners and other stakeholders in buildings an immediate, clear, concise, unambiguous understanding of a building's seismic performance.*

Since the Christchurch earthquakes in particular, QuakeStar initiators, Don Holden and Bob Burnett, have consulted stakeholders involved with commercial buildings who have indicated strong interest in an earthquake building performance rating system to enable better understanding of:

- *safety of existing commercial buildings*
- *safety, insurability and financing of new buildings*

A quakestar meeting in February was attended by over 50 industry representatives.

Don has established a steering group who plan to develop New Zealand's own Building Rating Scheme for Earthquake Performance. The system is proposed to address three main issues for commercial buildings:

- *safety (deaths)*
- *cost to recover (dollars)*
- *time to recover (downtime)*

The focus will be on Safety of existing buildings in the first instance.

Proponents of QuakeStar in New Zealand are working with Dr Ron Mayes of SEAONC, the Structural Engineers Association of Northern California, who has recently completed development of a building rating system and tools for assessing seismic performance (www.seaonc.org).

This paper will overview the proposed Quakestar system,discuss applicability of assessment tools recently developed and released in the USA, including ASCE31 and ATC 58 developed by SEAONC, and outline the next steps in development, including a pilot programme, of the system to enable ratings to be assigned in New Zealand.

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1 INTRODUCTION

Christchurch, the largest metropolitan area in the South Island of New Zealand experienced a Magnitude 7.1 earthquake on September 4 2010, and on February 22, 2011, a Magnitude 6.3 earthquake occurred in close proximity to the CBD. There were over 185 lives lost, thousands of people injured, and the earthquake devastated the CBD. Approximately 70% of the buildings in the CBD will eventually be demolished and the total estimated damage is in excess of $30 Billion or more than 16% of New Zealand's GDP.

There has been significant activity in New Zealand since October 2011 related to the development of a building rating system for the earthquake performance of buildings. This paper will chronicle the New Zealand developments that have involved the NZ Structural Engineers Association (SESOC), the NZ Insurance Council, the NZ Property Council and BRANZ, a semi-government organization. There have been technical interchanges with the Structural Engineers Association of Northern California (SEAONC) whose developments have been reported in other papers. The New Zealand system is expected to utilise a combination of current technical standards, and tools already developed by SEAONC.

2 BACKGROUND ON SEAONC RATING SYSTEM

Over the past several years, SEAONC's Building Ratings Subcommittee, a subcommittee of the SEAONC Existing Buildings Committee, has conceptualized and developed an Earthquake Performance Rating System (EPRS). Previous papers (SEAONC 2008, 2009, 2011) have described the motivation for such a system, the context for which the proposed EPRS was developed, the evolution of its key features, and the feedback received from potential users through a FEMA-sponsored workshop (ATC, 2011, SEAONC 2011). The current status of this development is given in SEAONC 2012.

In brief, the purpose of the SEAONC EPRS is to increase understanding among non-engineer stakeholders (building owners, tenants, lenders, insurers, the public, etc.), ultimately leading to market-based earthquake risk reduction.

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The EPRS is not a new assessment tool, and it does not replace any of the tools engineers currently use to evaluate buildings. Instead, the EPRS repackages the findings of other tools and methodologies, translating them into consistent, comparable, jargon-free terms.

For background and reference purposes, it is useful to re-state some of the other key features of the EPRS.

Voluntary, private context. One of the earliest insights was that a single rating system is unlikely to work effectively in all contexts. Context, meaning the program or agreement, formal or informal, under which a rating is produced. Though the context can be complex, for the present discussion its basics can be defined with three questions:

- Is production of a rating mandatory or voluntary?
- Is the rating to be produced by principal stakeholders or by a third party authority?
- Will the rating become public or private information?

The EPRS was designed for a market-based system in which the parties to a transaction (a sale or lease, for example) produce the rating themselves and hold it privately. This context allows for a relatively sophisticated system, with quality assured through negotiation between the parties.

Multiple dimensions. Engineers know that building codes focus primarily on safety, while seismic evaluations are often motivated by concerns about financial loss or business interruption – "dollars and downtime." Mindful of the goal of increasing understanding among non-engineer stakeholders, it was decided that the EPRS must explicitly communicate some information about all three dimensions of risk. Therefore the rating has three theoretically independent parts: Safety, Repair Cost, and Functional Recovery Time.

The purpose of including all three dimensions is to clarify what the underlying evaluation method is really addressing and what is it not. Unsophisticated owners and tenants, for example, are sometimes advised that their building is safe, but they do not know to ask if repair will be feasible or if relocation will be necessary. Of course, some users will only be interested in one or two parts of the rating, which is reasonable. The goal is to ensure that evaluations provide complete and consistent information – or at least be clear about what they do not cover.

Pragmatic terminology. Rather than rely on judgmental categories (Good-Fair-Poor, for example) or structural limit states (Collapse Prevention, for example), the ratings are defined in terms that mean something to the end users. This is essential to the idea of translating the outputs of various evaluation methodologies, which might be given in various ways as scores, or deficiency lists, or relative to a standard such as "code performance." The Safety ratings thus distinguish between discrete types of threats, and the Repair Cost ratings are keyed to industry standards and policy precedents. The Functional Recovery Time rating is still based on rough, overlapping time periods. This avoids jargon and properly reflects the highly uncertain nature of downtime predictions.

Earthquake hazard. A performance prediction, or rating, is only meaningful when paired with a defined hazard. Since the EPRS is not a new evaluation tool, it needs to accommodate whatever hazard is assumed by the underlying method. ASCE 31-03 uses the same basic hazard as the building code for new construction – a site-specific Maximum Considered Earthquake (MCE), with an explicit 2/3 factor – but has an additional 75 percent factor built into its acceptance criteria. The 75 percent factor is a traditional reduction allowed by codes for some triggered work on existing buildings (ICC, 2012).

The EPRS is premised on a similar hazard level. Its categories are considered general enough that it can apply to any evaluation method that uses a hazard level between the code level hazard and the 75 percent reduced hazard. In the high seismic areas for which the EPRS is currently designed, this range of applicability will also cover the most common probabilistic hazards (typically, 10 to 20 percent probability of exceedence in 50 years).

3 BACKGROUND ON THE US RESILIENCY COUNCIL (USRC)

Building on the work of the SEAONC Existing Buildings Ratings Committee over the past four years, and the recommendations of an ATC User's workshop (ATC 2011) the US Resiliency Council® (USRC) was formed in 2011 (www.usrc.org.) as a non-profit organization to establish a rating and accreditation system for certifying the resiliency of buildings to natural and man-made hazards. The current status of the USRC is provided in Reis et.al. 2012 and is summarized below.

The USRC will award Certification of Resilient Engineering (CoRE®) Ratings, much like the US Green Building Council® issues LEED® ratings. The USRC intends that CoRE Ratings become the standard for quantifying the value of improved disaster resilience, and a key metric for due diligence in real estate transactions. Ratings will benefit building owners, lenders, tenants and government jurisdictions by increasing the value of well-designed properties and providing a means to quantify risk. Policy makers will use CoRE ratings to compare and prioritize relative risks and to form a basis for developing long-term resilience policy.

The USRC is modelled after the US Green Buildings Council (USGBC®), which has successfully, although not overnight, transformed the issue of environmental sustainability into one that has been broadly established within the public consciousness. Through education, support of public and private groups and the development of credible, objective standards for measuring the sustainability of buildings (LEED®), the USGBC has succeeded in making environmental sustainability a standard consideration within the building industry.

A key principle of the USRC is that it will not develop technical standards for assessing risk. Rather, the USRC's board and technical advisors will identify existing or developing technical standards that can be used to generate a CoRE rating. In this way, the USRC will take advantage of the comprehensive academic, professional and research efforts on performance based evaluation and design of buildings. The USRC's board and advisors *will* include experts in the structural engineering profession, so that the decision on whether to adopt a given technical standard will undergo rigorous review.

The first standard that the USRC will adopt is the SEAONC Existing Building Ratings Committee *Earthquake Performance Rating System.* The USRC also expects to adopt ATC-58 *Development of Next Generation Seismic Design Procedures for New and Existing Buildings* as a technical standard for rating buildings particularly at the higher ratings levels, where more precise estimates of damage and functionality are required.

4 BACKGROUND ON NEW ZEALAND DEVELOPMENTS

The Canterbury earthquakes of 2010 and 2011 have heightened the expectation of users of buildings to be assured of building safety. The Royal Commission hearings on Christchurch are revealing that, for public information, a distinction is required between the rapid assessments made during a civil defence emergency and detailed engineering evaluations.

A consequence of the rapid assessment and placarding process is that building users expect to see a green placard on a building they wish to enter. The distinction is well understood by engineers but generally not by those outside the profession. Even less well understood by those outside the building profession is the notion of building seismic strength as a percentage of New Building Standard (NBS). This is further complicated by the classification of buildings as 'earthquake prone' as defined by the Building Act, together with the implications of territorial authorities earthquake prone building policies which define timeframes for and levels of required strengthening.

Despite a building being identified as 'earthquake prone', such a building can legally remain occupied for decades before a structural upgrade is undertaken. This allows for the ongoing use of buildings with very low seismic resistance. It is believed by an increasing number of stakeholders that a rating system will offer transparency and provide building users with information about the expected seismic resistance and, as discussed below, may accelerate the strengthening process for buildings at risk.

The situation in Christchurch in late 2011 was that insurers, re-insurers and underwriters were declining to issue cover for new buildings, which was seriously holding up the rebuild. Builders, homeowners, tenants, developers and insurance companies need to understand what's being built or repaired, so that an objective assessment of risk can be made before dollar and safety decisions are made.

In October 2011 Ron Mayes the Co-Chair of the SEAONC Ratings Sub-Committee was contacted by Don Holden and Bob Burnett enquiring about the SEAONC and USRC developments on a rating system. Don and Bob believed that a rating system applicable to the New Zealand market place would be beneficial not only to Christchurch but to all of New Zealand. They had a vision to create a New Zealand equivalent of the USRC and they have actively pursued that vision for the past 15 months and have made very significant progress. They organized a stakeholder meeting attended by over 50 industry representatives in ***February 2012*** to get feedback and provide clarifications on the concept of a Rating System for New Zealand. They have consulted stakeholders involved with commercial buildings who have indicated strong interest in an earthquake building performance rating system to enable better understanding of:

- safety of existing commercial buildings
- safety, insurability and financing of new buildings

Consultation with stakeholders involved in commercial and residential buildings over the past 15 months, has resulted in a draft plan to develop New Zealand's own Building Rating Scheme for Earthquake Performance. The group has sought input from a range of building industry stakeholders, including banks, insurance companies, materials' manufacturers, tenant groups, property owners, developers and industry sector associations, many of whom have already contributed positive feedback to date.

5 WHO IS INVOLVED IN THE NEW ZEALAND DEVELOPMENT

5.1 Steering Committee

A Stakeholder Steering Committee is being formed to govern the program development and stakeholder representatives are being approached to form a wide reaching Stakeholder Committee (including technical experts) to develop suitable methods and evaluation tools for a rating system, and to provide market feedback and ensure usability and understanding. The initial steering group proposes that work continues to further develop the necessary tools as the industry continues to evaluate existing buildings in NZ as well as start to build new buildings. The focus will be on **Safety of existing buildings** in the first instance.

5.2 STEERING GROUP

A smaller group of industry figures have been assisting Don Holden and Bob Burnett setting up the organizational structure, leading the technical development proposal, and seeking input, volunteers and sponsorship. A steering committee meeting was held in early **May 2012** involving key industry figures including:

- **Dr. David Hopkins** - (Structural Engineer specializing in Earthquake Performance)
- **John Hare –** (Structural Engineers Society NZ)
- **David Middleton** - (former CEO of EQC)
- **Chris McKenzie** (NZ Property Council)

The meeting was also attended **Dr Richard Sharpe** (BECA), **Robert Davey** (Opus), **Graeme Carroll and Blair Griffiths** (Natural Hazards).

5.3 TECHNICAL GROUP

A technical group is currently working on a funding proposal for the development of a prototype rating system sufficient to enable a pilot programme of buildings to be evaluated and provisional ratings assigned. This group comprises Will Parker, David Hopkins and John Snook. This group will co-opt another 2-3 members to work on development of the rating system for the pilot.

6 TECHNICAL DEVELOPMENTS IN NEW ZEALAND

6.1 Process Overview

The following outline process is envisaged to deliver an authoritative earthquake performance rating of a building:

1. Building owner appoints an experienced structural engineer (the Structural Engineer) to prepare an **Engineering Report** on the building.

2. The appointed structural engineer uses **Earthquake Performance Assessment Rating Tools** (EPA Rating Tools) to measure the earthquake performance of the building based on relevant data contained in the Engineering Report.

3. The appointed structural engineer uses a **Star Rating Guide** to convert the measures of earthquake performance into Star Ratings for the building covering safety, damage and downtime.

4. An Earthquake Rating Agency nominates a Peer Review Engineer to review the Engineering Report, the Earthquake Performance Assessment and the Star Rating determined by the appointed structural engineer.

5. The Peer Review Engineer confers with the Structural Engineer to discuss and resolve any concerns arising from the peer review, particularly any differences in their respective assessments of Star Ratings.

6. The Structural Engineer and the Peer Review Engineer produce a joint report stating their agreed Star Ratings for the building. (In cases of disagreement after reasonable attempts to agree, the lower rating shall apply.)

7. The Earthquake Rating Agency reviews the joint report and records the ratings in a database which is accessible to the public.

8. An appeals process would be available. New evidence relating to the earthquake performance of the building would be needed.

6.2 ENGINEERING REPORT

The Engineering Report would include all relevant data affecting the earthquake performance of the building. This would include structural, architectural, building services and other drawings, geotechnical and seismological information. It would identify key parameters affecting the earthquake performance, including those of the principal structural elements, secondary structural elements, cladding and contents.

The report would clearly identify the "design earthquake" in terms of the nature and intensity of expected ground motions. It would also cover the principal structural characteristics of the building as they relate to likely earthquake response.

It is proposed to develop a prescription for the Engineering Report defining the data and characteristics which need to be included. This will be done by reviewing several existing documents which require information for the assessment of earthquake performance of buildings. These will include the IEP, NZSEE Guidelines 2006, ASCE 31, ATC 58, proposed Design Features Report and the recent guidelines for Detailed Engineering Evaluations developed by SESOC. The objective is to distil the requirements to a reasonable minimum that would suffice for the assessment of New Zealand buildings for the purposes of determining a Star Rating. It is anticipated that the Engineering Report would contain data and factual information that could be used to assess the earthquake performance of a building.

6.3 EARTHQUAKE PERFORMANCE ASSESSMENT RATING TOOLS

This part of the process is to assess the performance of the building in relation to safety, damage or downtime. This will involve consideration of the building data and information in the Engineering Report and the implications on the performance of the building in these three ways. It is envisaged that the performance assessment would require a system by which to measure or score the performance in each of the three aspects.

The Structural Engineers Association of Northern California (SEAONC) has been working to developing rating tools. To date they have developed a tool which is effectively a checklist for ASCE 31 which is a performance based standard titled "Seismic Evaluation of Existing Buildings". SEAONC have also developed ATC 58 which is a tool which can be used to rate new or existing buildings. It is a more sophisticated approach requiring inputs of building floor acceleration and drifts, along with input fragility curves for the various systems within the building. Outputs from this tool give numerical assessments of the three 'D's which can be converted directly to a building rating.

The task for New Zealand is to tailor the requirements to suit local building types and market conditions. In developing an assessment based on reports and assessments commonly completed in New Zealand, the NZSEE Guidelines 2006 and the SESOC Detailed Engineering Evaluation would be suitable reports on which a safety rating could be readily assessed, however further work would be required to assess damage and downtime.

At this stage it is envisaged that it should be possible to allow buildings to be rated with more than one tool. At this stage only the tools based on ASCE31 and ATC58 have been tested, therefore we consider that these should be allowed to be used subject to them being compared and aligned to New Zealand Building types and New Zealand fragility curves and also checked by comparison with the NZSEE 2006 and SESOC DEE reports. We further envisage that a rating across all three dimensions should be possible from the NZSEE 2006 and SESOC DEE reports, although there is a considerable amount of work required to formulate the damage and downtime dimensions, especially considering that these reports currently consider only the structural components of a building.

6.4 STAR RATINGS

This guide would define the processes by which the scores or measurement of performance are to be converted in to Star Ratings. The assessment may be on a continuous scoring system, but the Star Rating requires discrete divisions to be made at selected levels. The definitions and descriptions of the Star Ratings need to be meaningful to owners and users. The Star Ratings must provide the best possible understanding of likely outcomes in the event of a design earthquake – being the ground motions used to design a new building on the site of the subject building.

Star Rating descriptors have been proposed by SEAONC and a copy of these is attached. It is important that these levels relate well to real New Zealand buildings, both existing and new. They need to be set to provide the best possible incentives for building owners to improve their buildings.

6.5 NEXT STEPS – DEVELOPMENT OF TOOL & PILOT STUDY

In order to develop the technical processes, engineering work is required. It is also important to maintain momentum, as it is understood that there is a need to press ahead with the rating system as there are several market imperatives which currently exist. To this end, it is proposed that a pilot study be carried out and Wellington City Council has agreed to part fund assessment and rating of three buildings. In addition, we intend to carry out a rating on a number of Christchurch Buildings, and seek support from Christchurch City Council. In order to pilot a rating system, development of the engineering approach is required.

For the pilot, it is intended that the buildings be assessed using both the NZSEE 2006 or SESOC DEE reports, and the ASCE 31 approach, with suitable adjustments for NZ. If funding is forthcoming, it would also be possible to rate one or more of the buildings using ATC58. Work using ATC 58 is also being progressed by other groups and any results may be able to be included.

7 ORGANIZATIONAL DEVELOPMENTS IN NEW ZEALAND

7.2 EARTHQUAKE RATING AUTHORITY

The Earthquake Rating Authority (ERA) will be the independent authority administering the rating system, and may consist of a board of up to 14 members from as many stakeholder sectors as possible, being Industry associations, private sector, engineering societies, architecture institutes, BRANZ (Building Research Association NZ), Property Council, Insurance Council, DBH, and others, as well as having a wider membership among all individuals and entities directly or indirectly associated with the Construction, building -owning and -managing industries in New Zealand. There will be three key committees that will comprise the ERA;

The ERA will:

- receive building reports from the applicant building owner, assign a peer review engineer, and release the rating to the applicant
- exercise integrity, independence and accountability in performance of its functions,
- ensure the materials, methods and systems used are in accordance with latest and best practice globally
- Co-operate with international agencies wherever possible so as to ensure compliance with the above point, with the intent that the ERA and any offshore similar body will receive the degree of international respect, recognition and credibility necessary to achieve acceptance in the insurance and investment industries globally as the certifying and approving body of choice

7.3 ERA TECHNICAL COMMITTEE

The ERA technical committee will:

- Research, design and implement methods for collection of structural and geotechnical data on a building, and, using existing methodologies (such as ATC 58 and %NBS) to evaluate that data, translating that data into a rating system to enable ease of understanding of seismic risk of a building by all stakeholders
- Examine the formation and operation of group of suitably qualified reviewers, and/or Delphi panel, including all building disciplines for cost-effective, quick and effective review during both assessment and design phases

- Facilitate technical collaboration on building resilience with all sectors of the international research community, academia, industry, government and non-governmental organizations

7.4 ERA USER GROUP

The ERA user group will:

- Provide input to ensure that the system design is aligned with the market needs – the market including the public as visitors, guests, employees, tenants, bankers, funders, insurers, investors.

- To collaborate with the steering committee and the technical group on the achievement of their objectives

- To offer assistance with planning the governance, funding and marketing of the concept

- Report to the Steering Committee

7.5 ERA STAKEHOLDER GROUP

The ERA Stakeholder Steering Committee will be the group having responsibility for completing the research program over the next 6 to 12 months, and then implementing the ERA and its Governance structure, and is:

- To have overall responsibility for successful outcomes from the technical and user groups

- To have responsibility for all communication and liaison with outside entities including media

- To design and implement all rules and governance relating to the successful operation of the system

- To be responsible for the funding, administration and marketing of the system

- To consider, and make recommendations on, all present and pending legislation relating to building such as the Building Act, and to promote inclusion in such legislation of quality assurance systems, peer reviews, the establishment of a centre of expertise embracing all building disciplines

- To work with SESOC, NZSEE, GNS, and all other institutions in furtherance of these aims

- To liaise direct with Government both national and local in promoting the objectives of better buildings

8 CONCLUSIONS

The creation of a rating system for New Zealand comes at a time following a very significant earthquake in one of New Zealand's major metropolitan areas with an economic impact in excess of 15% of its GDP. Economic and social losses of this magnitude and the awareness of the potential effects of another catastrophic event are a clear call for a better system to relate the earthquake performance to those stakeholders that use and inhabit buildings. Significant progress has occurred towards the development of a rating system for New Zealand as reported herein but much remains to be done.

The rating system will offer a technically defensible and replicable methodology for implementing a consistent and measurable rating system. Ratings will build upon existing technical standards and will be usable by both the public and private sector, by building owners and occupants, for financial and safety assessments. It is believed also that a rating system should provide encouragement to owners to enhance their buildings.

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