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Paper No. 1859. *(quote when citing this article)*
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

SEISMIC QUALITY DECLARATION OF BUILDINGS

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ABSTRACT

In my paper I show how improvement could be made to the existing building permit routines.

Today the aim with seismic building codes is primarily to save lives. I would like to enlarge that function to also, *at the planning stage* of a building, evaluate the likely property damage consequences of a scenario earthquake for the location in question.

It would result in a declaration by a structural engineer that: "This building at address xx on subsoil type y on 99 kilometres distance from the nearest source of seismic energy will not sustain damage exceeding, say 20 % of the production cost.
Furthermore it will not be unoccupable more than z weeks."

KEYWORDS

Earthquake insurance; quality declaration; vulnerability; risks; subsoil; unoccupable; PML.

THE PROBLEM

For an insurer or a reinsurer one of the big challenges when property insurance in earthquake prone countries is written, is to judge the Probable Maximum Loss, the PML. And why is that so important? If not carefully done the insurer may take on more liabilities than he can cover with his solvency capital. This would then become a question of survival for the insurance company.
Hence, it is also a question of whether the policyholder will get his or her contractual compensation or not.
This is so important that any prudent insurer will do his best to evaluate the PML he will sustain should a serious earthquake occur.

The insurer has to evaluate three main factors:

- The hazard
- The exposed sums insured
- The vulnerability

When we at Skandia check our exposure, we first look at the *area* that can be affected, should a strong earthquake occur. We look at probabilities ranging from 0,1 - 2,0 % and establish thus how strong the earthquake may be. The area affected by damaging ground motion is then established by some attenuation function, taking the local soil conditions into consideration. We rely on observed damage patterns from historical earthquakes whenever available.

When the area is established we have to calculate what objects we have insured in the area. Our stock of insured objects (risks in insurer jargon) will consist of risks with construction year ranging from pre 1900 to present. In addition to general quality considerations like craftsmanship, construction material, hight of buildings etc, great attention is paid to the applicable building code relevant for each generation of buildings. I will revert to the building code later.

The next difficulty is to estimate the degree of damage one can expect on each category of buildings. In lieu of something better, we have to rely on intensity scales: MMI, MSK and JMA as the case may be. As the scales largely reflect old building standards there is not much guidance in respect of modern engineered buildings. This is unfortunate as these buildings account for a big share of the insured value in many markets. This is even more pronounced for a reinsurer as the reinsurer mainly participates in large risks that are too big for the direct insurer.

When we insure such risks, especially if the buildings are not new, it is difficult to obtain reliable information about the aseismic design of the buildings. If one wants to make a detailed survey it involves taking samples, ultra sound examining and "undressing" the structural elements of the building. This becomes very expensive, often prohibitively expensive.

My idea is that the aseismic design should be properly documented, including performance objectives, at the most cost-effective point in time, namely when the building permit is granted.

BUILDING CODES

Why isn't it enough with the aseismic design resulting from the building code demands? Because the purpose of a building code is: (I use the US Uniform Building Code (UBC) as example)

... to provide ***minimum*** *standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of buildings ....*
(UBC 1991)

For a building code to be effective in meeting this purpose it must be adopted as law by a city, county, or national government and enforced through effective administration.

When this is done earthquake codes become legally binding rules for design and construction, mostly covering buildings only. Most codes around the world have been influenced by the codes developed long ago in California. This explains some of the deficiencies, as those codes were based on earthquake experience with early types of buildings in California and the similar experience of Japanese engineers, whereas the architecture and design of buildings has changed greatly since then. An important observation is that also when a code is fully applied there is no assurance what so ever that there will not be severe damage to the building. It may even be expected to have exactly that, controlled damage to the building. Further, the design and construction rules found in codes are concerned almost exclusively with structural parts, and not with the performance of non-structural elements which are the cause of the overwhelming majority of losses. It would therefore be a grave error to assume that codes render buildings earthquake-safe or earthquake-resistant. Codes based on simplifying assumptions hitherto cover practically only buildings, and efforts to introduce similar rules for the design and construction of other types of risk have progressed rather slowly. The load level and general quality demanded by codes exercises a determining influence on loss spectra. Codes represent minimum requirements, risks may be designed better by using more demanding load, design and construction criteria.

A very general statement is appropriate here: it is generally not appreciated that codes represent simplifications - and often gross simplifications - of extremely complicated processes. Even the most modern proposals aiming at improving existing codes are riddled with uncertainties and flaws. Moreover, they address some of the important damage parameters inadequately or not at all. It is therefore a fallacy to believe that a code is a guarantee against serious damage or even catastrophic failure.

It is very important for insurers to note that the basic aim of earthquake codes remains unaltered, namely the provision of an acceptable degree of protection against injury from a moderate earthquake with hopefully little or no loss of life, a certain degree of protection for property and, in the case of a large earthquake, protection of human life by the avoidance of structural collapse. It must be realised that this approach is based on an accepted or calculated risk. It must also be stressed that this calculated risk includes not only parameters like the probability of a given degree of ground shaking, the adequacy of simplified models and rules and similar scientific or technical issues, but also social factors, such as commercial considerations, lobbies, local, regional and national politics. (See References 2, 3 and 5)

How shall we overcome or at least reduce these shortcomings? It may be fruitful to change the focus a little and look at what we want to achieve instead!

SEISMIC PERFORMANCE OBJECTIVES

If we look at the recently published "Standards of Seismic Safety for Existing Federal Buildings" (See Reference 1 and Appendix 2) some Seismic Performance Objectives have been proposed.

Fully Functional: Performance objective where the earthquake causes no damage to facilities and has no effect on building function. In practise this very ambitious objective is reached only for very critical installations such as nuclear reactors.

Immediate Occupancy: Performance objective where the earthquake causes minor damage, facility disruption is minimal, and only some non structural repairs and cleanup will be required. The facility is expected to remain occupied and be functional immediately after the earthquake event.

Damage Control: Performance objective where the earthquake damage is controlled in order to protect some other feature of the building or its function beyond life safety, for example, to control economic loss to the building itself, to prevent the release of toxic materials, or to protect building contents. The term "damage control" covers a range of performance objectives, from protection somewhat greater than that required for Substantial Life-Safety to somewhat less than needed for immediate occupancy.

Substantial Life-Safety: Performance objective where the earthquake may cause significant building damage that may not be repairable, though it is not expected to significantly jeopardise life from structural collapse, falling hazards or blocked routes of entrance or egress. This is the minimum performance objective of these Standards. Compliance with FEMA 178 is assumed to achieve this level of performance.

Risk reduction: Performance objective where the earthquake damage state is greater than acceptable for life-safety but less than would have occurred in the building if no rehabilitative action had been taken. The extent of damage depends on the extent of the improvements made. As used in these Standards, "risk-reduction" includes incremental strengthening as an interim measure in total process aimed at achieving Substantial Life-Safety.

SEISMIC QUALITY DECLARATION

Now, if we accept to use seismic performance objectives, I would like to suggest the following (voluntary) routine:

When a building permit is requested, in addition to the regular documentation a Seismic Quality Declaration should be made. In this a structural engineer will declare what seismic performance objective the building will meet when certain ground motion occur. It could look like this (see also Appendix 1):

> *The office building on High street no 1, which is situated on subsoil type 3 and located 16 kilometres from the nearest source of seismic energy will not sustain damage exceeding 20 % of the production cost, if the scenario earthquake assumed in the building code of magnitude 7.5 Mw occurs.*
>
> *Furthermore, the building will not be unoccupable more than 6 weeks due to necessary repair time.*

This is a challenge to the seismic engineering community of the world. More demanding in some parts of the world than other but, by and large, I believe that it is doable. A special problem will arise from litigation prone countries like the US. There it might be difficult to find anyone prepared to stand the risk of being sued should the expected damage level be exceeded. As there always is uncertainty involved in seismic risk, maybe it would be proper to give a 90% confidence level.

COST BENEFIT ANALYSIS

We assume that the ambition will be to reach the repairable damage level. In most cases there will be some additional costs involved. Not always though as there are several examples of the positive cost saving effects of seismic construction parameters applied already on an early design phase. For the most cases, however, an additional built in seismic strength will cause additional expenses, typically in the 0,5 - 5 % range. (See Reference 5 p 142 ff.)

Can such extra costs be defended for a building with an expected lifetime of about 50 years?

First of all it depends on the seismic situation for the building. What is the likely return period for a damaging earthquake for the building site? If the return period is in the same time frame, there is no problem to defend the extra costs.

Also if the expected return period is much longer than the expected life time of the building, the extra costs can be motivated as there are gains involved.

Benefits with an ambitious Seismic Quality Declaration for buildings are i a:

1. The building will attract tenants that are good employers, that care about the safety of their staff.
2. The tenant will be able to know for how long time his or her business will be interrupted as a consequence of an earthquake. By knowing this he or she may plan production in such a way that deliveries to the customers can be maintained without disruption. Thus the tenant can avoid losing market.
3. The owner will be able to reduce the insurance cost for his building if he agrees to a quality level higher than the code minimum
4. The public authorities will know what buildings and installations they can rely upon for rescue operations after the earthquake such as fire stations, police stations, hospitals etc
5. The public authorities will be able to give reliable advise to the population on meeting points, evacuation routes, shelters, distribution centres etc *before* the earthquake strikes.

6. The quality of the PML calculations, which is vital for both Society and the insurance companies, will improve dramatically.

Many of these benefits are difficult to measure in economic terms, but I am certain that many owners of buildings will be prepared to accept some extra cost to achieve a high seismic quality of his or her building!

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SEISMIC QUALITY DECLARATION

The office building on Highstreet no 1, which is situated on subsoil type 3 and located 16 kilometres from the nearest source of seismic energy will not sustain damage exceeding 20 % of the production cost, if the scenario earthquake assumed in the building code of magnitude 8.0 Mw occurs.

Furthermore, the building will not be unoccupable more than 6 weeks due to necessary repair time.

Acapulco June 23 , 1996

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Structural Engineer

TABLE C1

from California Seismic Safety Commission Report SSC 91-1

Earthquake Performance Objectives for Existing State Buildings

Earthquake Performance Objectives	Post-Earthquake Functions Within	Building Standards[1]	Occupancy Categories[2]							
			Hospitals, Essential Services	Hazardous Materials	Public Schools	Nursing, Prisons	University, Research	Offices, Courts	Other Occupancies	Historic, Non-essential
Fully Functional, no significant damage	Immediate	Nuclear Reg. Commission	✱	✱	✱	✱	✱	✱	✱	✱
Immediate Occupancy, minimal post-earthquake disruption, some non-structural cleanup required	Hours	Title 24 I = 1.50, 1.25	◆[3]	○[4]	○	○	○	○	○	○[5]
Repairable Damage, some structural and nonstructural damage, will not significantly jeopardize life	Days to Months	Title 24 I = 1, 1.15 Current UBC[6]	●	○[4]	○	○	○	○	○	○[5]
Substantial Life Safety, significant damage may not be repairable, will not significantly jeopardize life	Year(s)	75% of the 1988 UBC; ATC 14 & 22; or 1973 UBC[7]	●	◆[4]	◆	◆	◆	◆	◆	○[5]
Life Hazards Reduced, unrepairable damage very likely, some falling hazards, building may be a total loss, low life hazards.	No Limit	UCBC Appendix Ch. 1 for URM Bearing Wall Buildings	●	●	●	●	◆[8]	◆[8]	◆[8]	◆[5]
Very Poor Life Safety, collapse likely, unrepairable damage and total loss highly likely, significant life hazards	No Limit	None	●	●	●	●	●	●	●	●
Unsafe for Occupancy	No Limit	None	●	●	●	●	●	●	●	●
Unknown Performance	No Limit	None	●	●	●	●	●	●	●	●

Key:

◆ = Minimum Acceptable Earthquake Performance Objective
○ = Acceptable Earthquake Performance Objective
● = Unacceptable Earthquake Performance Objective
✱ = Typically does not apply, except to nuclear facilities

Abbreviations:

ATC—Applied Technology Council
I—Occupancy Importance Factor (pursuant to Ch. 23, Title 24)
Title 24 (Part 2, California Code of Regulations)—California Building Code
UBC—Uniform Building Code
UCBC—Uniform Code for Building Conservation
URM—Unreinforced Masonry

Footnotes:

1—Most building standards are not currently required by law for existing buildings, unless triggered by voluntary or mandatory strengthening, major alterations, additions, or changes of occupancy. This policy recommends that all existing state government buildings meet minimum earthquake performance objectives by the year 2000.
2—Emergency and recovery plans required for all occupancies.
3—Communications, emergency services, and acute care services shall be capable of functioning after earthquakes, as well as having immediate occupancy throughout the building.
4—Acceptable if chance of release of hazardous materials is remote.
5—Acceptable if anticipated earthquake damage is repairable, and the building also complies with the State Historical Building Code.
6—Applies to state leased buildings.
7—A uniform seismic retrofit building standard must be developed.
8—Acceptable for strengthened URM bearing wall buildings only.