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"Methodology for Comparing Strategies in Seismic Risk Management of Existing Building Population"

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Background and Objective

Society's attitude toward seismic risk has evolved from fatalistic to proactive. In many countries of the world, seismic risk reduction programs are launched (or at least discussed). They focus on the built environment (buildings, bridges, industrial facilities …) whose performance determine the level of losses in a strong earthquake. Typically, the seismic exposure is dominated by the vulnerability of existing, gravity designed, structures. Different strategies, ranging from "do nothing" to extensive retrofitting programs, are typically considered for dealing with a population of seismically inadequate buildings. The selection of measures and policies for reducing the losses increasingly requires better understanding, analysis and modelling of risk. In view of the tremendous costs and stakes linked to reducing seismic losses, it is important to provide decision makers with a rational basis on which to select seismic risk management policies.

This paper presents the approach of a current research project at the EPFL in the area of seismic risk management. The objective of the project is to define and test a methodology for the quantitative characterization and comparison of intervention strategies in a risk management framework. A tool to assist in the selection of an intervention strategy will be developed. The project includes a pilot project for the seismic risk management of a small town in Switzerland.

The selection of an intervention strategy raises two categories of problems. The first is connected to the quality of the information available. The second is connected to the variety of the criteria integrated in the decision-making process. The use of multi-criteria methods facilitates decision-making. Concerning the type of multi-criteria methods, experience has drawn attention to the quality of the "surclassement" methods (e.g. ELECTRE), because they can deal equally with qualitative or quantitative criteria.

Decision Process

The main tasks and steps of the process leading to the selection of an intervention strategy are presented in Fig 1. They are described and discussed individually below. In its general form, this process applies both for the selection of a intervention strategy for an individual building or for a building population.

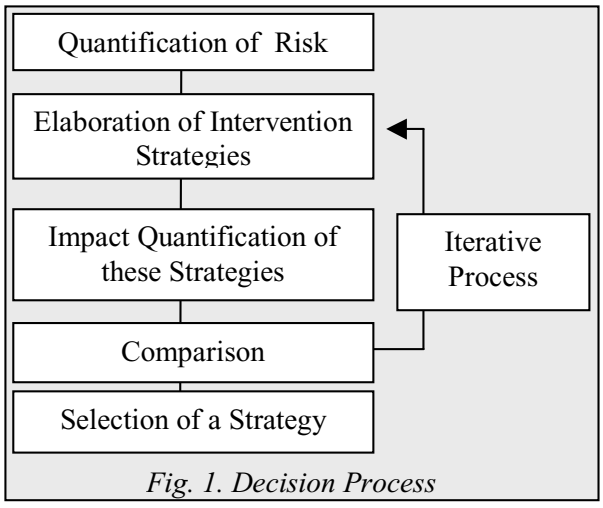

Fig. 1. Decision Process

Quantification of Risk

The quantification of risk will be based on the classic definition of risk as the product of hazard, vulnerability and potential loss of the system at risk. The quantification of seismic risk for a given system, a city or a network for example, remains a difficult task. Even if the hazard and the vulnerability (vulnerability functions for different seismic categories of structures and installations) are well characterized, potential loss estimates are difficult. The loss structure for seismic risk quantification can be defined as shown in Fig. 2. It includes:

- Direct Losses : Human lives and material losses.
- Indirect Losses : Losses incurred by damages causing disruption to production capacity and social infrastructures.
- Other Losses : This includes environmental (e.g. pollution), and cultural (e.g. destruction of historic elements) losses. It also could account for losses such as clients lost to the competition or loss of image (e.g. tourist industry). "Social losses" resulting from coping with the consequences of death, injuries and homelessness are also included in this broad category. Direct

losses are the simplest to estimate, because data from previous earthquakes are available from government, academic and re-insurance industry sources.

Indirect losses are often estimated using a multiplier of direct losses (e.g. indirect losses are one and a half times the direct losses). The "other losses" are clearly the most difficult to determine. Data and experience are scarce. Sometimes the conceptual and fundamental basis for quantifying certain losses is even missing (what is the value of an ecological system? Or of a historical edifice?).

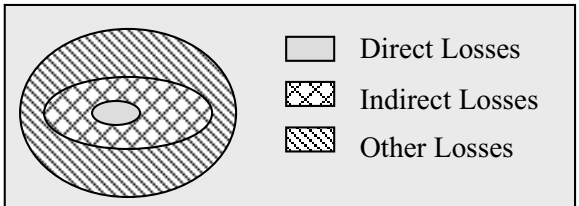

Fig. 2. Loss Structure for Seismic Risk Quantification

Even though it is difficult to quantify such losses (in monetary or other unit), it is necessary to do so in order to compare the impact of different risk reduction strategies.

Strategies of Intervention

Details of the strategies of seismic intervention vary from situation to situation and should be established according to the particulars of the system under consideration. In the case of an individual building, however one of the following approaches is often found :

- No measure (with or without insurance),
- Change of structural use,
- Retrofitting of the structure ranging from light to heavy.

For each of these strategies, it is advisable to estimate the impact in term of risk. To do this, a method of calculation is adopted by a summation of the costs by damage type.

Comparison Tool

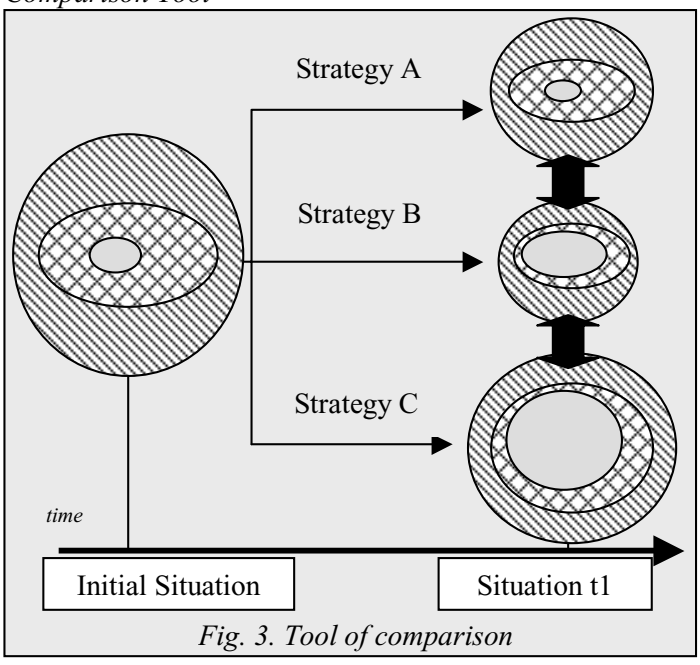

Fig. 3. Tool of comparison

Analytical multi-criteria methods combined with expert analysis methods allow a rational basis for comparing strategies. Thus, various strategies for evaluating seismic risk may be confronted with maximum rationality and rigour for finding the optimal preventative solution.

Figure 3 illustrates the comparison concept. The strategies are considered at various points on the temporal scale, incorporating the notion of life cycle costing. Comparisons are made using a range of criteria, including possibly non-economic aspects. Economic criteria include for example investment cost for retrofitting, return on investment and the cost of reducing human life losses. In many cases the comparison tool must also be able to eliminate a strategy which would have unacceptable consequences even if it is attractive in economic terms. This means for example introducing criteria which account for considerations such as architectural impact, environment protection or sociological consequences.

Conclusion

Tools for risk management should incorporate considerations of both economic and non economic elements. By using analytical multi-criteria methods adapted to the seismic problem, the engineer can supply a rational decision-making base to the decision-makers.