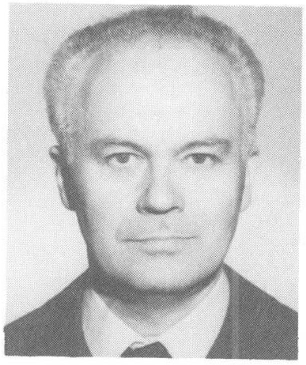
Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 77 (1998)

Artikel: Saving buildings under conditions of high seismic risk
Autor: Sandi, Horea
DOI: https://doi.org/10.5169/seals-58282

Saving Buildings Under Conditions of High Seismic Risk

Horea SANDI
Research Advisor
INCERC
Bucharest, Romania



Horea Sandi, born 1932, received his civil engineering degree and his doctoral degree from the Inst. of Civil Engineering, Bucharest, and his mathematics degree from the Univ. Bucharest. Humboldt fellow at the Technical Univ. Hanover, 1968-69. Vice-president of EAEE, 1982-1986.

Summary

Some specific features of the problem of saving buildings in areas affected by high seismic risk are dealt with. The case of Romania, especially of its part affected mainly by Vrancea earthquakes, is considered a relevant case in this view. Some data on the seismic conditions and on vulnerability and risk affecting buildings of Romania are given. The development of risk reduction strategies is then dealt with. The specific framework and the development of cost-benefit analyses are discussed.

Keywords: seismic risk, risk mitigation, vulnerability, cost-benefit analysis.

1. Introduction

The intention to save buildings in areas affected by high seismicity, which exist in Romania as in some other countries of Central and Eastern Europe, must face the additional problems raised by a high seismic risk which affects, according to experience and to knowledge at hand, extensive parts of the existing building stock. The additional problems raised by seismic risk are highly acute. The need to reduce the seismic risk that affects in Romania, as elsewhere, important parts of the existing building stock, may easily become the highest priority as compared with other aspects related to the preservation of this heritage, that are common to various countries or regions.

2. Some data on the state of the art in Romania

The natural seismic conditions are determined by the existence of several source zones. Out of these, the intermediate depth Vrancea source zone, located outside of the bow of the Carpathians, delivers more than 95 % of the energy delivered in the average per century in Romania. This source zone affects with high intensities several times per century extensive parts of the territory. The return periods of Gutenberg-Richter magnitudes are in the range of 6 years for $M = 6.$, 14 years for $M = 6.5$, 32 years for $M = 7.$, 46 years for $M = 7.2$, 82 years for $M = 7.4$. 126 years for $M = 7.5$, 234 years for $M = 7.6$ etc. (the strongest magnitudes observed in this century were 7.4 on 1940.11.10, 7.2 on 1977.03.04, 7.0 on 1986.08.30, while the strongest earthquake during last two centuries, with $M \geq 7.6$, occurred in 1802). The hazard analyses performed in INCERC led for the City of Bucharest to return periods in the range of 10 years for $I = 6.$, 20 years for $I = 7.$, 50 years for $I = 8.$, 200 years for $I = 9.$ etc..

Direct experience shows that, in Bucharest, the most endangered buildings are the relatively tall buildings built before 1940. They are handicapped by the lack of concern for earthquake resistant design, by low material quality, by the cumulative effects of the successive strong earthquakes referred to, by corrosion, fatigue due to urban traffic, sometimes also by unsuited interventions aimed to modify their functionality, finally by the fact that the predominant periods of ground motion tended to be close to their fundamental natural periods. Other categories of buildings are in general less vulnerable, but several of them do not fulfil general requirements and criteria, such as set by some modern codes. The post-war built repetitive tall buildings with r.c. structures, designed before 1977, raise such problems, even if only two of them underwent partial collapse in 1977. Another endangered category is that of relatively low-rise (up to 4-5 storeys tall) masonry buildings lacking r.c. horizontal diaphragms. An additional view on the situation of the building stock is provided by the outcome of a parametric probabilistic risk analysis. This study showed that, in case one leaves the most vulnerable buildings referred to previously as they are, for some decades to come, the collapse probabilities are in the range of several tens of percents. This is an unacceptable risk. The experience at hand shows the obstacles to intervention raised by the high costs and by the lack of a buffer area for occupants who should clear their apartments.

3. Considerations on the development of intervention strategies

The degrees of freedom of the solutions of intervention are related to structural, functional, architectural aspects. The number of degrees of freedom increases of course in cases one deals with urban areas. A degree of freedom not to be forgotten is the intervention time. Especially under conditions of frequently occurring strong earthquakes like those due to the Vrancea seismogenic zone, the time coordinate may play a crucial role. The alternative solutions or strategies may be characterized by several criteria. The problem of cost-benefit analyses under these conditions is obviously multi-criterial. In case one considers the different components of benefits and costs/losses, corresponding to different criteria, there are several factors, contributing with corresponding terms: benefits derived from normal service, costs of investment, costs of maintenance, costs related to the use, losses due to earthquake occurrence, benefits/costs related to the integration of buildings in urban systems and in plans of further development, perhaps others too. Cost-benefit analyses can be performed using different approaches and algorithms. One can look e.g. for a minimum of costs/losses or a maximum of net utility. Another approach is a differential one, where attention is paid to the additional cost per (expected) additional life saved. An approach to the cost-benefit analysis, proposed by the author, relies on a tabular format, where the various columns correspond to the different criteria, or non-commensurable components of benefits or costs/losses, while the various rows correspond to the different alternative strategies.
such cases it becomes interesting, if possible, to use non-Poissonian earthquake recurrence models, to account to some extent for the features of physics of earthquake generation.

4. Final considerations

The importance of considering earthquake protection is in case one wants to save existing buildings located in seismic areas. On the other hand, the concern for earthquake protection should never lead to situations where other essential requirements set by now by the legislation in force in numerous countries are neglected when one develops proposals for decision related to the future of the existing buildings. The importance of developing a general strategy for partial preservation and partial, gradual, replacing of the existing building stock is obvious.