# Seismic risk assessment of large building portfolios: application to health care buildings in Martinique.

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Seismic hazard is considered as high in French Caribbean islands, but seismic codes and regulations have only become effective recently in France (first code PS69 since in 1977 with basic seismic considerations to Eurocode 8 since 2011). Consequently, most of the existing buildings have been built with no or only low seismic design considerations and are potentially subjected to a significant hazard.

Since 2005 in the French Caribbean, different building portfolio owners have performed a first seismic risk evaluation to identify the risk of their portfolios (social housing, rescue center, public administration, educational and police buildings) by classification of the buildings that need to be retrofitted with an estimation of the necessary budget and a prioritization.

Unlike in Switzerland, where a methodology for evaluating the seismic risk of building portfolios was proposed by the FOEN in 2005, 2006 and recently updated (2020), France, on the contrary, has no such guidelines or recommendations. Based on risk concepts, basic methodologies are developed and then, in each specific case, adjusted to the asset type, the number of the buildings, and the specific owners' objectives (Hauss et al. 2015). The main objective remains, as a first step, to identify the human and financial risk associated to the buildings knowing the seismic hazard, the seismic vulnerability and the human occupancy or the strategic value. The vulnerability assessment is performed with simplified approaches, generally based on only visual inspection. As a second step, for buildings with moderate or high risk, retrofitting measures are conceptualized and budgeted. And, as a third step, the interest of retrofitting in comparison to a reconstruction solution is analyzed.

The presumed vulnerability is assessed by highlighting the pathologies of the buildings. It is prior to any definition of possible reinforcements and makes it possible to assess the behaviour of buildings under earthquake, based on it's structural characteristics (structural type, nature and distribution of bracing elements, nature and condition of building materials...). The index method used is based on the AFPS method (AFPS-CT24, 2002) and Risk-EU (Milutinovic et al, 2003). It pairs a visual analysis of buildings, based on the recognition of vulnerability factors related to building design, with a model of structural behavior. Visual analyses of buildings and execution plans, where available, result in an estimate of the presumed vulnerability in the form of quantified indexes. This index approach allows comparison and prioritization of buildings belonging to same portfolio. The method used is therefore an expert's analysis but based on a formalized methodology and based on the feedback of past earthquakes.

Risk of damage to buildings is based on the Risk-UE (Milutinovic et al, 2003) methodology. Probability of damage grade D0 to D5 (Grunthal et al, 2001) is estimated for a given hazard. Then, buildings are categorized in 3 groups as follows:
– Group 1: Buildings with a low probability of significant structural damages, which should not compromise the safety of the occupants. These buildings does not require any specific action, or, at least, simple corrective actions.
– Group 2: Buildings with probability of significant structural damages (moderate or high), which should intend to the occupant's safety. For these buildings, reinforcement actions are technically and economically relevant and are recommended.

– Group 3: Buildings with probability of significant structural damages (moderate or high), which should intend to the occupant's safety. For these buildings, reinforcement actions are technically and economically not relevant and reconstruction is recommended.

Reinforcement solutions are considered to increase buildings' resistance as close as possible to the regulatory level for new buildings (French decree of 22.10.2010). Reinforcement costs are estimated based on internal data base of past detailed reinforcement design. An economical performance criterion is defined as the ratio of reinforcement cost to reconstruction cost. A technical performance criterion is defined as the ratio of reinforcement resistance to resistance of a new building. Then the relevance of the reinforcement is defined following Fig. 1.

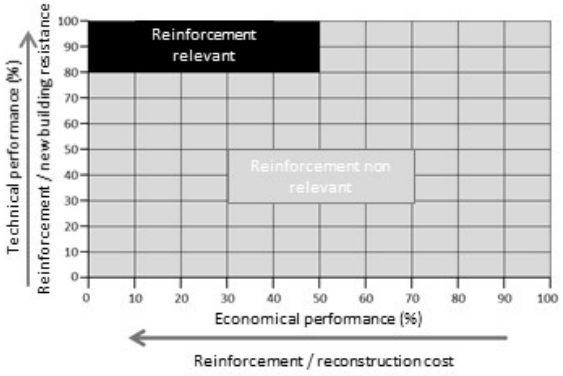


Fig. 1: Economical and technical performance analysis of reinforcement.

In 2019, this methodology was applied to the Martinique health care buildings portfolio with 166 different sites with a total of 372 buildings (480'000 $m^2$). Among them, only 27 % were built according to the most recent seismic codes (PS92 since 1998 or EC8 since 2011). Structural typologies are principally concrete walls (24 %), masonry (19 %), and concrete beams/columns (16 %). The number of levels is principally low with 43 % of one level, 32 % of 2 levels, 18 % of 3 levels.

Despite an old and vulnerable portfolio, the results show that half (51 %) of the buildings are in group 1 and require no actions. The other buildings show significant risk and need further actions. Amongst them, 13 % are in group 2 with relevant reinforcement, and 36 % are in group 3 with relevant reconstruction. Then a budget is estimated for the reinforcement and reconstructions actions. A risk analysis identifies that the 6 % of the buildings show a high risk and should be considered at first with 23 % of the estimated budget.

This application shows that for a large building portfolio, this methodology provided an efficient first screening of buildings to identify the ones at risk and to define a first budget to reduce the risk. The results can be included in the portfolio management strategy.

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