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DEVELOPMENT OF A NATIONAL SYSTEM FOR PREVENTION AND MITIGATION OF EARTHQUAKE DAMAGES TO PEOPLE AND PROPERTIES, AND THE REDUCTION OF COSTS RELATED TO EARTHQUAKES FOR THE STATE - PreM(ium)Risk

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Introduction

Recognizing that the Italian territory is prone to disasters in connection with seismic and hydro-geological risk, it has become necessary to define novel regulations and viable solutions aimed at conveying the economical resources of the Italian Government, too often utilized for the management of post-event situations, towards prevention activities.
The CGIAM started a project open to collaboration with other Italian and International partners. This project is aimed at the development of a ***National System for prevention and mitigation of earthquake damages***, through the definition of a model that achieves the mitigation of the building collapsing risk and the consequent reduction of casualties. Such a model is based on two main issues a) a correct evaluation of risk, defined as a reliable assessment of the hazard expected at a given site and of the vulnerability of civil and industrial buildings, b) setting up of novel strategies for the safety of buildings.
The project activities are initially implemented on a study area in Southern Italy (Calabria), selected because of its tectonic complexity. The results are expected to be applicable in other hazardous seismic areas of Italy.

A - Evaluation of Seismic Risk

The Seismic Threat in Italy

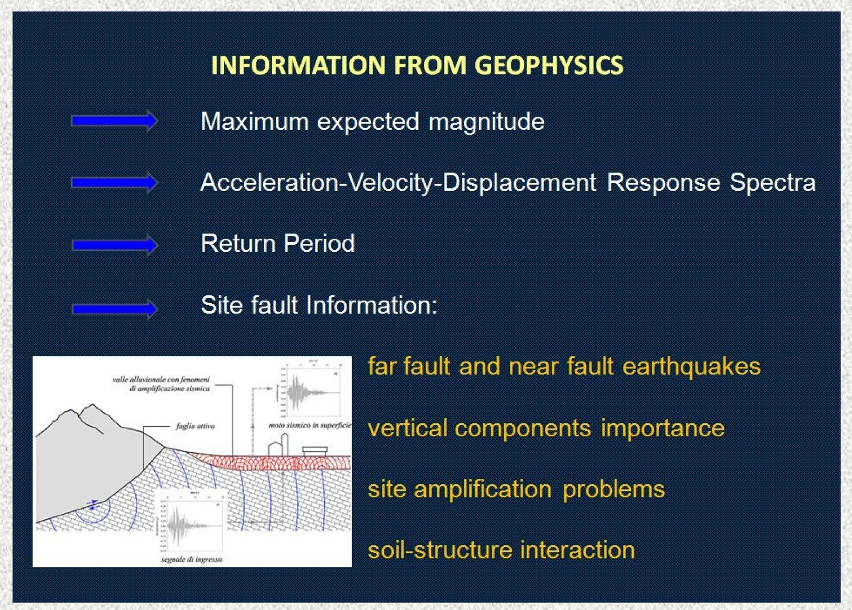
- **Thousands of earthquakes** have been felt in Italy in the last 1000 years, of which 220 of high intensity (> = VIII MCS);
- **1 violent earthquake occurs** on average every 5 years whatever the considered period
  -**41 earthquakes** with intensity greater than or equal to IX MCS in the last two centuries caused about 150,000 casualties and destroyed a large part of the historical, artistic and cultural heritage, which can not be quantified;
- **160 Billion** Euros was the cost of the last 40 years earthquakes;
  Based on the experience of the last two centuries, we should expect:
- **50,000 – 200,000 deaths and injuries** in the XXI century
- **100 – 200 Billion** Euros lost in the XXI century

Damage and Destructiveness of Italian Earthquakes

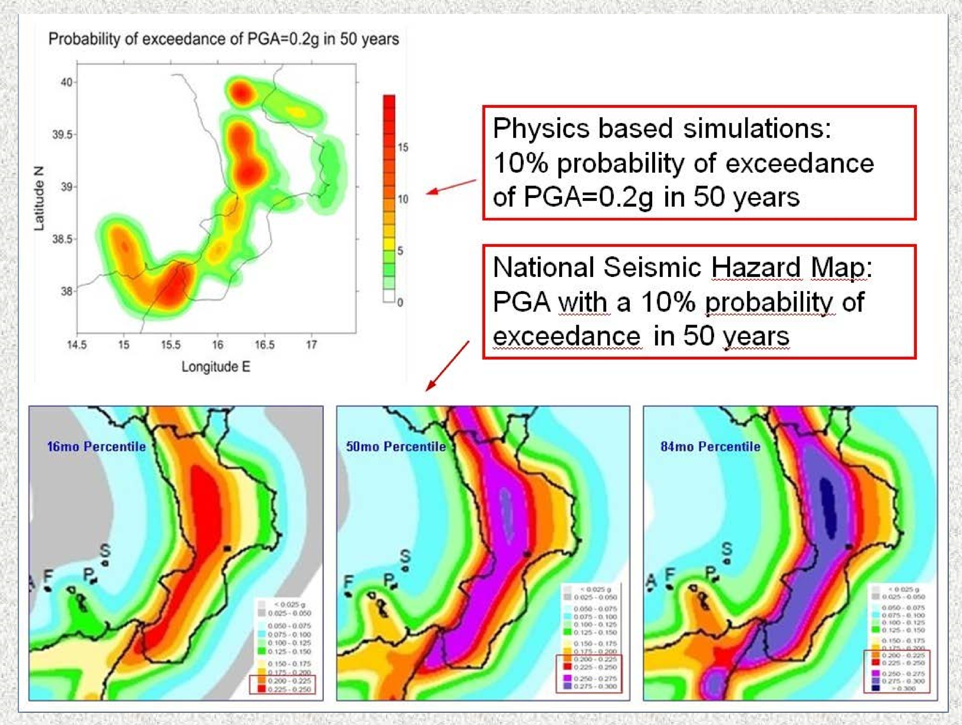
The high seismic risk depends on the high vulnerability of the structures, determined by numerous factors, including:

- Presence of a large number of old, historical and monumental buildings
- Deterioration of suburbs in metropolitan areas,
- Illegal construction ("spontaneous") prevalent in areas with greater seismic hazard,
- Imperfect knowledge of the seismic hazard of the area
- Inadequacy of the standards adopted at the time of construction of the buildings and their application.

The **hazard assessment** is pursued through the application of innovative multidisciplinary geophysical methodologies.
The table to the right shows examples of geophysical information that is required as input to seismic engineering.



As an example of **methodological development** carried out in this project, the figure to the right (top panel) shows a map of probability of exceedance of PGA=0.2 g in 50 years for stiff soil in Calabria. It was obtained from a synthetic seismic catalog lasting 100,000 years produced by the application of a physically based earthquake simulator.
This preliminary result is compared (bottom panels) with the hazard maps adopted for the same region by the Italian National Building Code (NTC2008) for the 16th, 50th and 84th percentile, respectively.
The application of this ongoing methodological study is supposed to be transferable to a variety of different environments for planning and verification purposes.



The **structural vulnerability** of buildings is estimated by means of simplified techniques based on few representative parameters (such as different structural typologies, dynamic soil-structure interaction, etc.) and, for detailed studies, standard protocols for model updating techniques. An example of seismic classification of buildings based on the concept of **Expected Annual Loss** is shown in this figure

A PARAMETER FOR SEISMIC CLASSIFICATION OF A BUILDING

The Expected Annual Loss – EAL – is a synthetic parameter that could be used such as a global parameter to evaluate the "seismic quality" of a structure or, using an accurate expression, the "seismic resilience" of a structure (RS).

As example, it could be possible to estabilish that a building characterized by an EAL < 0.5% of the Rebuilding Cost (RC) falls within the Class of Seismic Resilience A, i.e.:

if EAL < 0.5 % RC then RS = A

similarly, as example:

if EAL < 1.0 % RC then RS = B
if EAL < 2.0 % RC then RS = C

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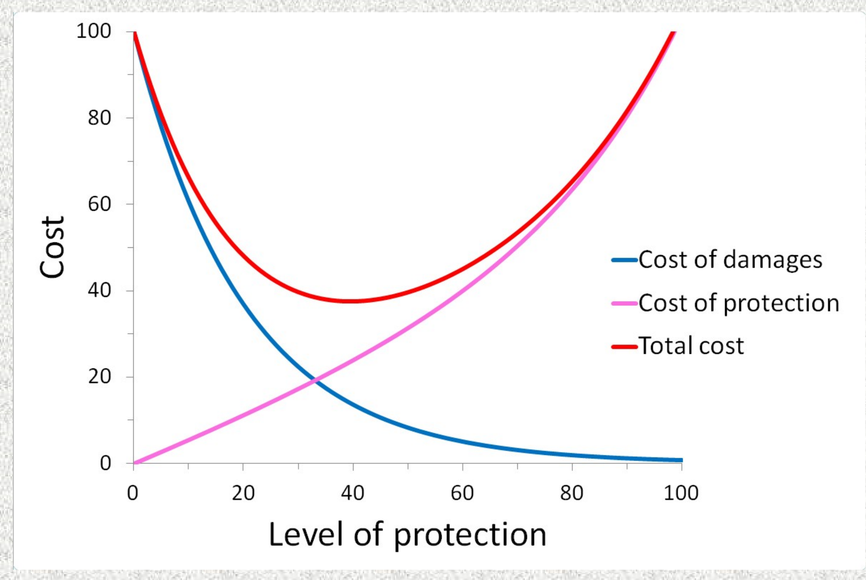
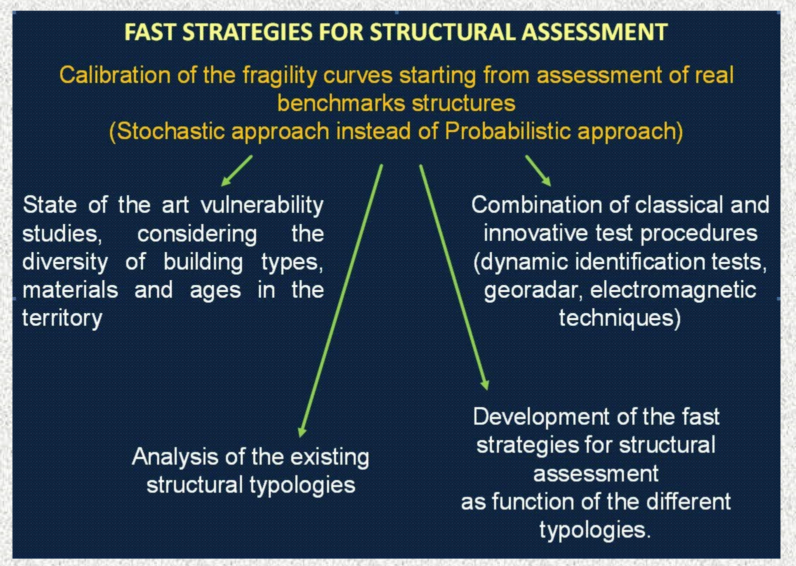
B - Novel Strategies for the Safety of Buildings

A ny kind of risk is quantitatively definable as the cost that, on the long term, the community needs to pay as a consequence of damaging events. Such cost is separable in a part that is paid before the calamitous event (prevention) and a part that is paid after each event (rescue and recovering of the lost goods). In principle, the **optimal strategy** would be the adoption of the level of protection that **minimizes the risk in terms of total costs**, as shown in ideal way in the plot to the right.



In the context of strategies to achieve a better safety, the implementation of an **insurance system** can be regarded as a kind of **risk transfer**. It means that the cost of damages is shared among all the individuals subject to the same risk and distributed uniformly in time. It doesn't have direct influence on the total costs: however, the tax break and the reduction of the insurance premium for the individuals who decide to upgrade their buildings, can produce an incentive to risk mitigation measures, having indirect influence on the factor of vulnerability and so contributing to the reduction of risk itself.

We analyze, through numerical and experimental approaches, **new solutions** for the use of **innovative materials**, and **new techniques for the reduction of seismic vulnerability** of structural, non-structural and accessorial elements. These concepts are schematically represented in this sketch.



EAL – Expected Annual Loss

Cost-Benefit Analysis

"Expected annual loss" for retrofitted structures

LIMIT STATE		Strengthening Strategy: Existing* (do-nothing)	Element (50%)	FPS Isolation**	Shear Walls	Added Damping
Fully Operational	RP (y)	20	20	20	30	30
	$Loss_{Direct}$ | O (%)	4.00%	4.00%	4.00%	2.90%	4.00%
	$Loss_{Indirect}$ | O (%)	1.17%	1.17%	1.17%	1.17%	1.17%
Damage Control	RP (y)	72	72	72	140	200
	$Loss_{Direct}$ | DC (%)	28.27%	28.27%	28.27%	24.73%	28.27%
	$Loss_{Indirect}$ | DC (%)	5.00%	5.00%	5.00%	5.00%	5.00%
Life Safety	RP (y)	273	975	3400	2000	3200
	$Loss_{Direct}$ | LS (%)	100%	66.50%	39.8%	62.53%	66.50%
	$Loss_{Indirect}$ | LS (%)	90.00%	30.00%	5.00%	30.00%	30.00%
Near Collapse	RP (y)	2475	2475	3400	4400	4300
	$Loss_{Direct}$ | NC (%)	100%	81.38%	39.8%	81.17%	81.38%
	$Loss_{Indirect}$ | NC (%)	90.00%	90.00%	5.00%	90.00%	90.00%
Expected Annual Loss	EAL_{Direct} (%)	**1.70%**	**1.37%**	**1.20%**	**0.79%**	**0.84%**
	$EAL_{Direct+Indirect}$ (%)	**2.66%**	**1.81%**	**1.41%**	**1.06%**	**1.07%**

*Brittle collapse is expected at a 273 year return period for the existing building and near collapse downtime is assumed
**The FPS Isolation case assumes only damage control level of downtime beyond the stick-slip activation of bearings

In this table to the left we present the results on an initial **cost-benefit analysis** of the expected costs related to the application of retrofitting measures to existng buildings in Italy.

Conclusions

We conclude stating **that seismic risk can be reduced in cost-effective** manner by the implementation of appropriate risk mitigation measures, as proposed through this poster and represented in the figure below.