

# Seismic Risk Assessment of Italian School Buildings



# Contest



The high number of earthquakes occurred in Italy starting from 1908 Messina earthquake, have produced changes in the regulations and in the seismic classification of the territory



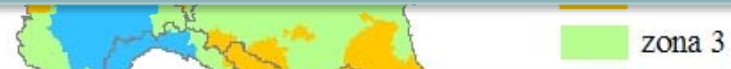
The new buildings have been designed according with the regulation at the time of their design, but the existing ones quite rarely have been adequated

Within the buildings which have not been adequated there are the schools

The economical resources available in Italy do not allow detailed investigation and eventual retrofit for all buildings



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The presented project shows a methodology targeted to identify the priority of actions to be taken to mitigate the seismic risk of school buildings

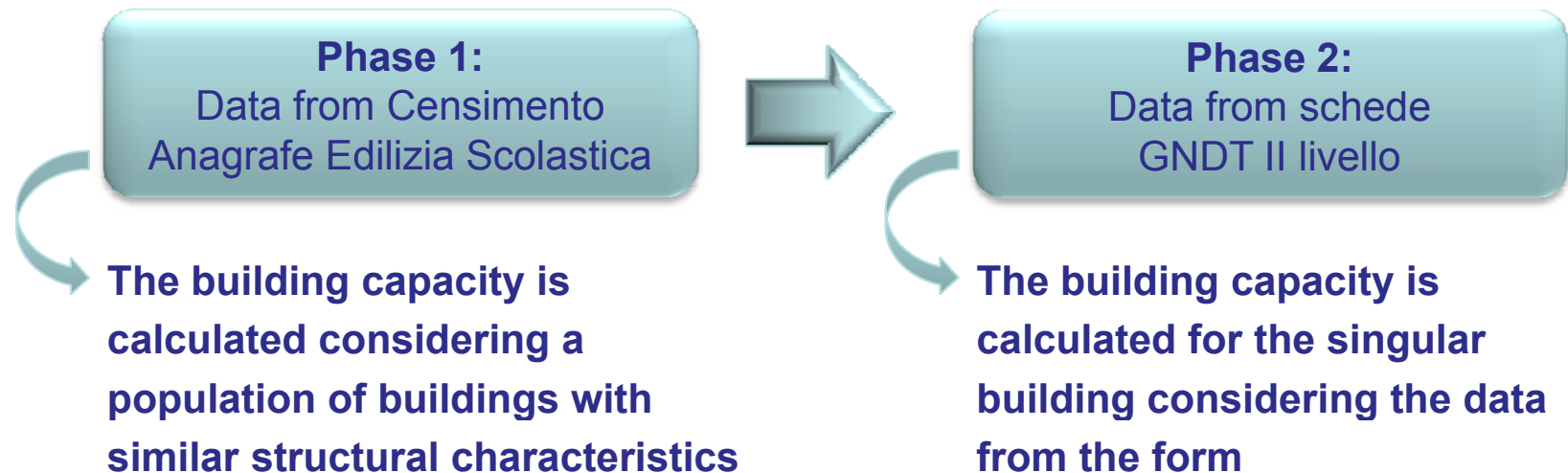
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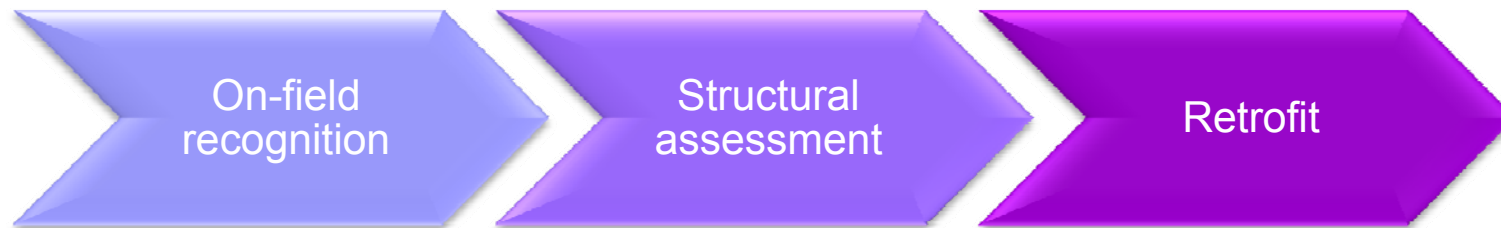
# Target of the Project



The philosophy of methodologies with progressive level of detail is that moving from one phase to the next one, the level of detail increases, while the number of buildings decreases, because only the buildings with a risk index higher than an accepted risk level will be further considered (Grant et al. 2007)



## Selection fo buildings

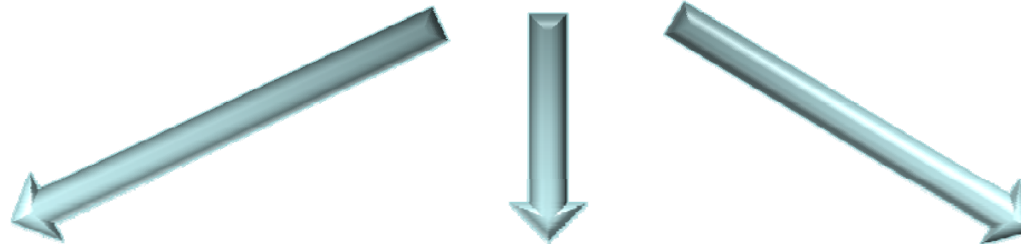


# Deliverables



Seismic risk maps for the school buildings on the national territory

WebGIS Platform



view the  
seismic risk  
maps

view input data  
and output  
results

compute real time  
damage scenarios



# Input Data



## CENSUS OF “ANAGRAFE DELL’EDILIZIA SCOLASTICA”

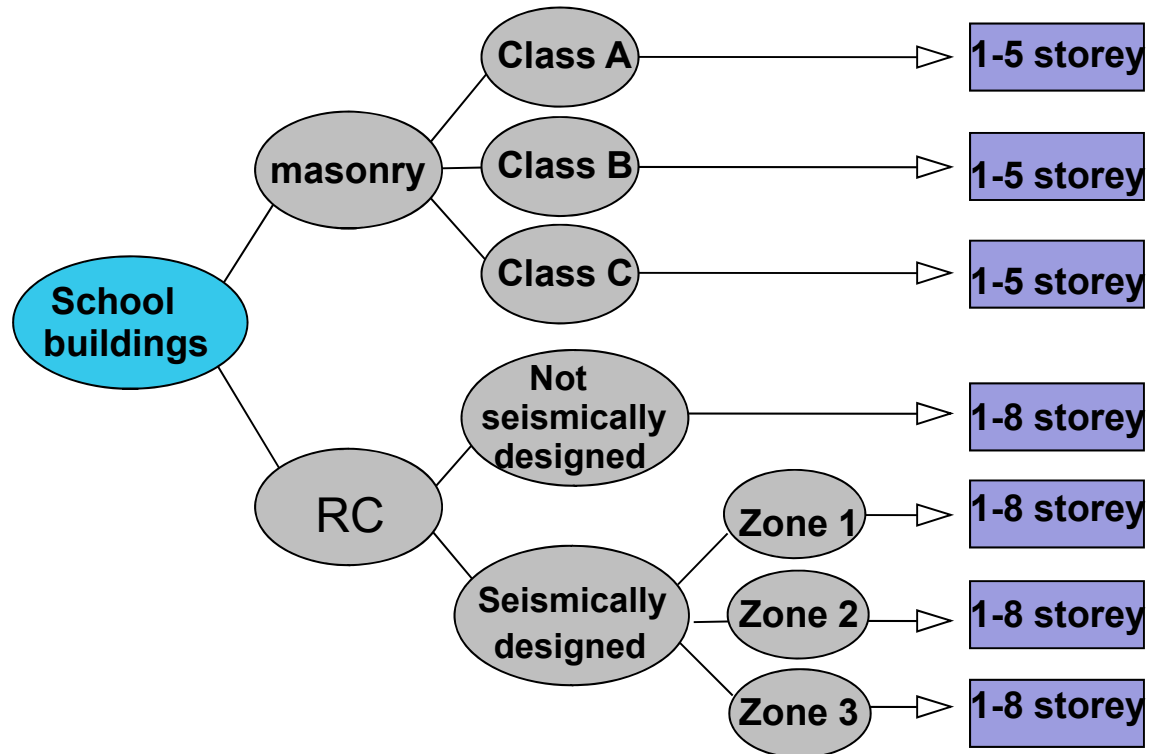
- ✓ DB with about 50'000 buildings on about 60.000 over all
- ✓ Forms that could be processed are about 40'000
- ✓ 10'000 forms deleted as a consequence of incomplete data, which are fundamental for the model, and that could not be assumed on the bases of other data included in the form

## 2<sup>ND</sup> LEVEL GNDT FORMS FOR MASONRY BUILDINGS

- ✓ DB with about 9'800 masonry buildings
- ✓ Forms that could be processed and that have a corresponding form in the DB “Anagrafe” are 3'548
- ✓ Perfect match ONLY for 698 buildings



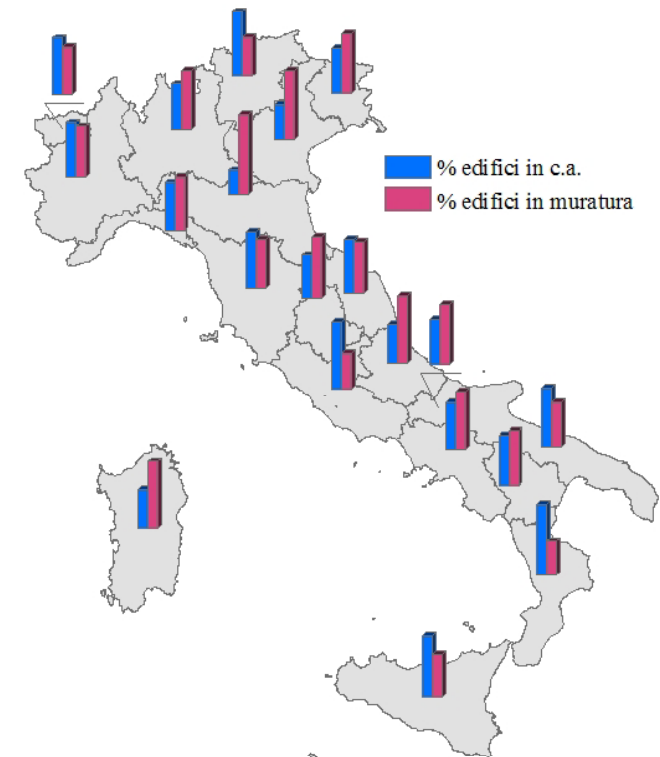
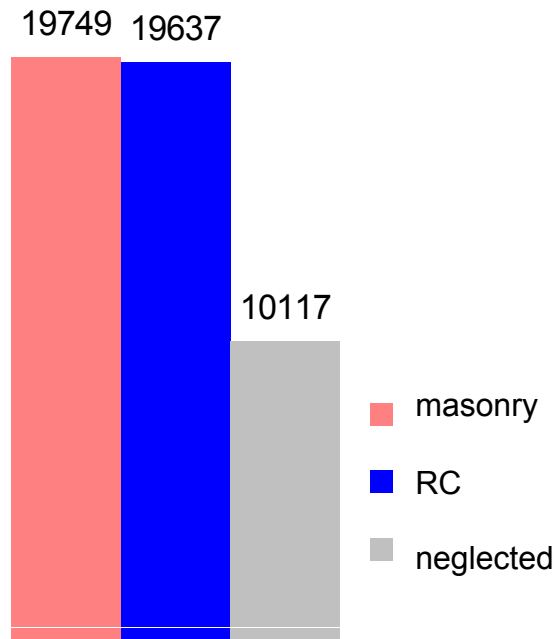
The school buildings in DB “Anagrafe dell’Edilizia Scolastica” (MIUR) are classified in 47 structural types



The buildings processed in phase 1 are 19'749 masonry buildings and 19'637 RC buildings

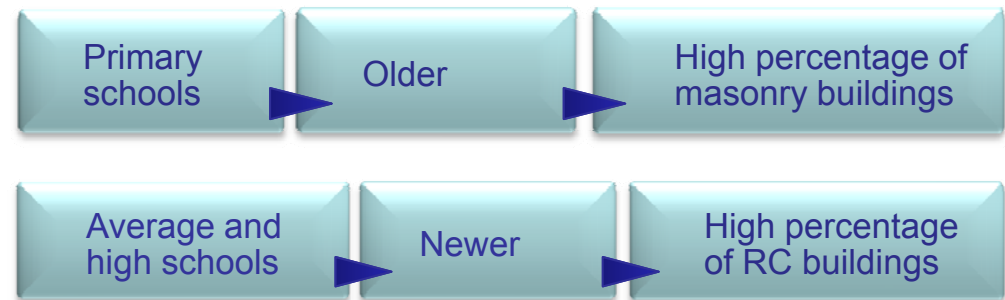
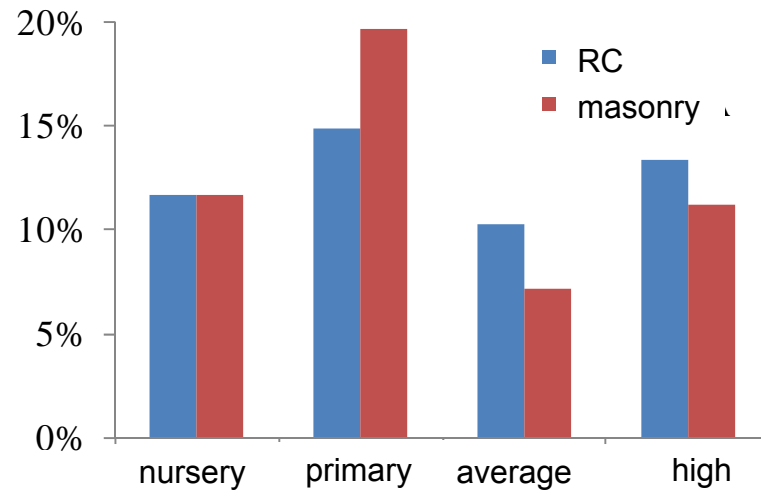
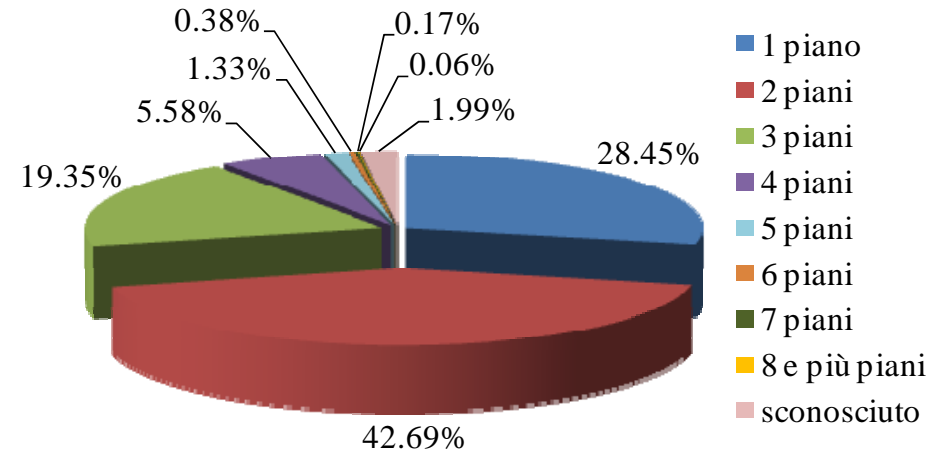


Structural type	Number of buildings
Masonry	19749
RC	19637
TOT	39386



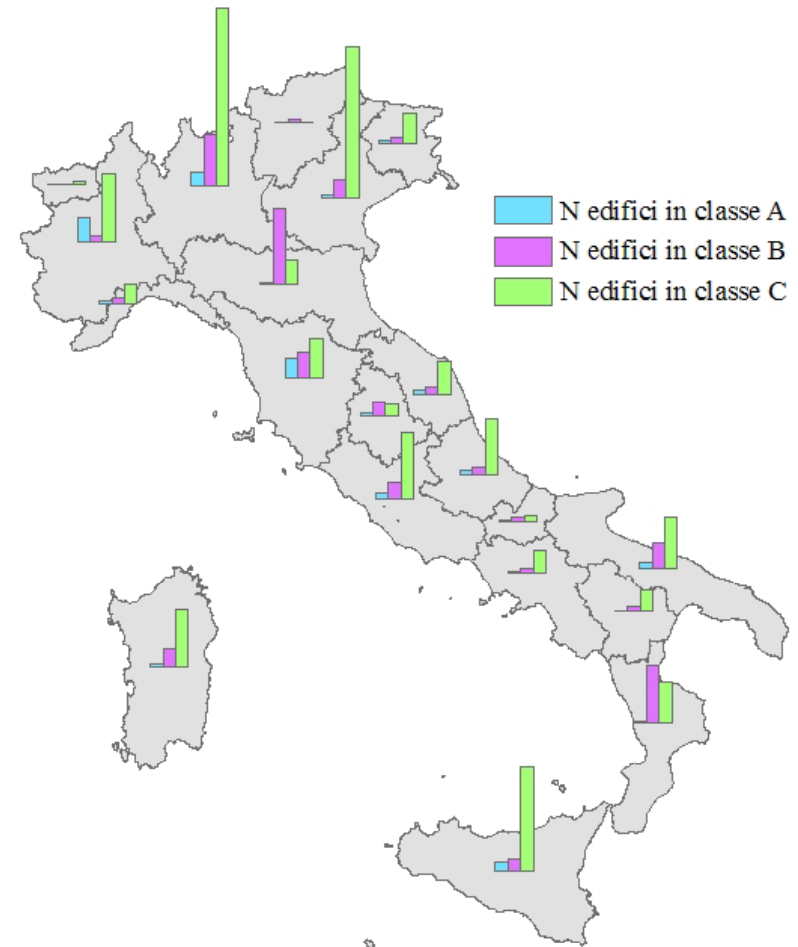
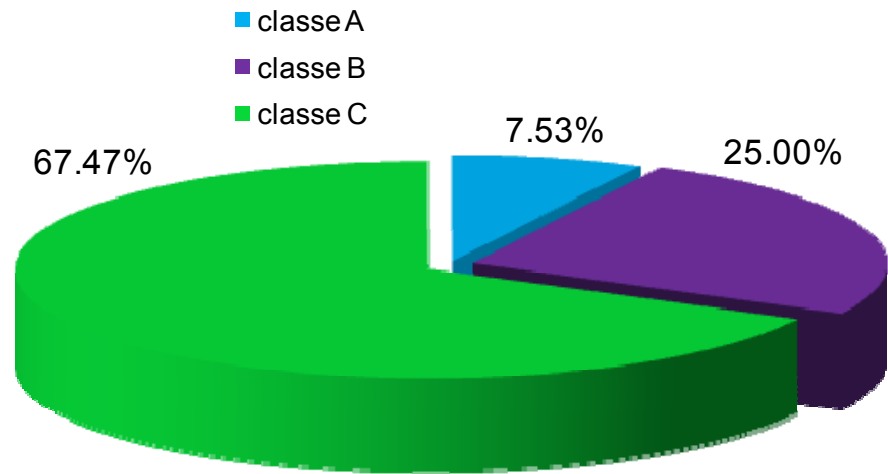
	RC	masonry	total
<b>1 storey</b>	6355	4850	11205
<b>2 storeys</b>	8221	9377	17598
<b>3 storeys</b>	3413	4209	7622
<b>4 storeys</b>	1073	1124	2197
<b>5 storeys</b>	334	189	523
<b>8 storeys</b>	151	-	151
<b>7 storeys</b>	68	-	68
<b>≥ 8 storeys</b>	22	-	22
<b>total</b>	19637	19749	39386

More than 90% have less than 4 storeys



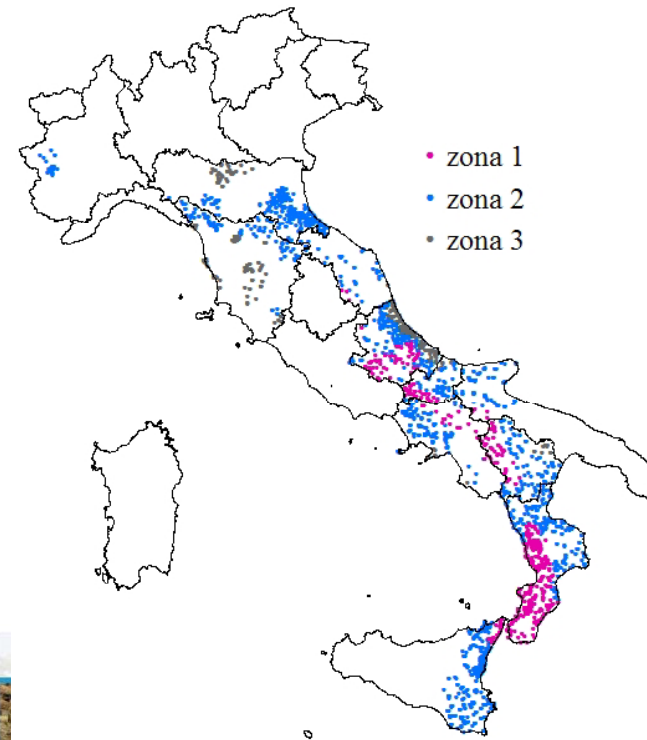
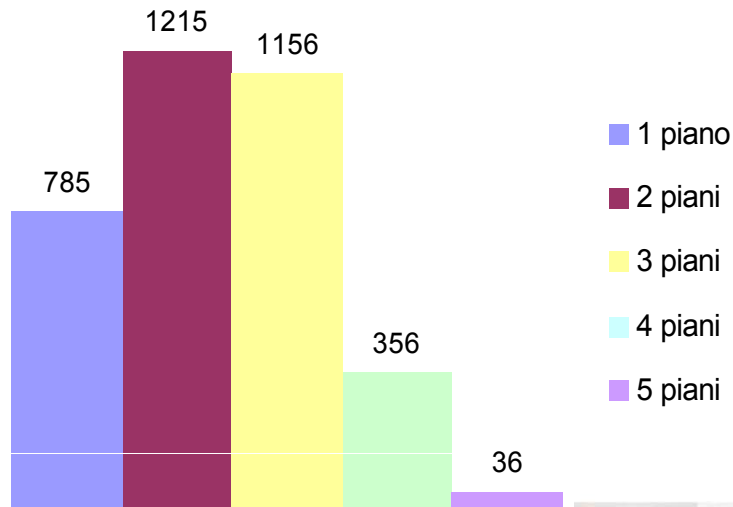
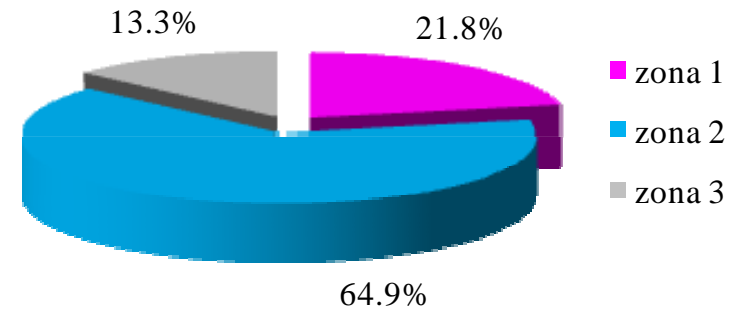
The 19'749 masonry buildings are classified in the following vulnerability classes:

- class A = 1488
- class B = 4937
- class C = 13324



The buildings processed in phase 2 are 3'548, all masonry buildings

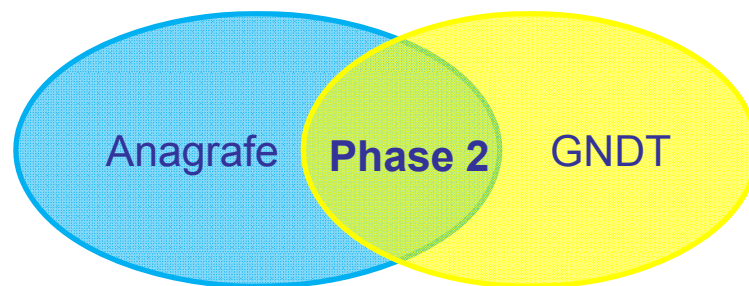
Number of storeys	Number of buildings
1 storey	785
2 storeys	1215
3 storeys	1156
4 storeys	356
5 storeys	36
TOT	3548



## ATTENTION!

In order to run a multiphase methodology, buildings in phase 1 and phase 2, shall be the same

Hence for phase 2, only the masonry buildings, which have a correspondence in phase 1, and have all the data to compute the conventional resistance, have been processed (C) → 3'548 school buildings processed



Difficult match due to lack of coordination between various census → BIG LOSS OF INFORMATION



# Definition of capacity



The building's capacity is defined with reference to 3 damage limit conditions like:

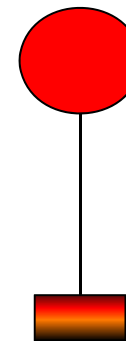
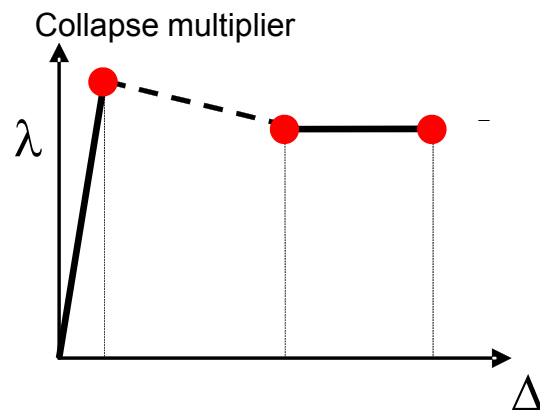
- ✓ **Light damage**: the building can be used after the earthquake and does not need to be retrofit
- ✓ **Severe damage**: the building must be retrofit
- ✓ **Collapse**: the building is not adequate to support the design gravity loads; retrofitting measures are not applicable, and in any case, not convenient from an economical point of view. The building must be demolished



The buildings are classified as a function of structural type

For each class → Monte Carlo simulation → sample of 1000 buildings

For each building of the sample → A capacity curve is computed



Equivalent simplified system



# Computation of seismic risk

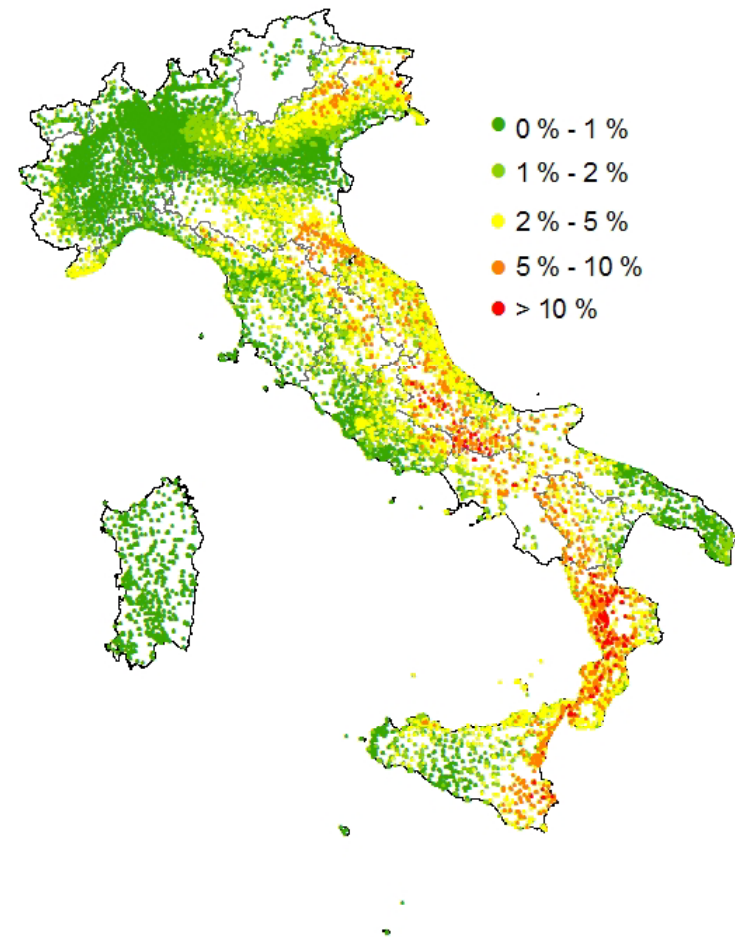


## Results: Seismic risk maps

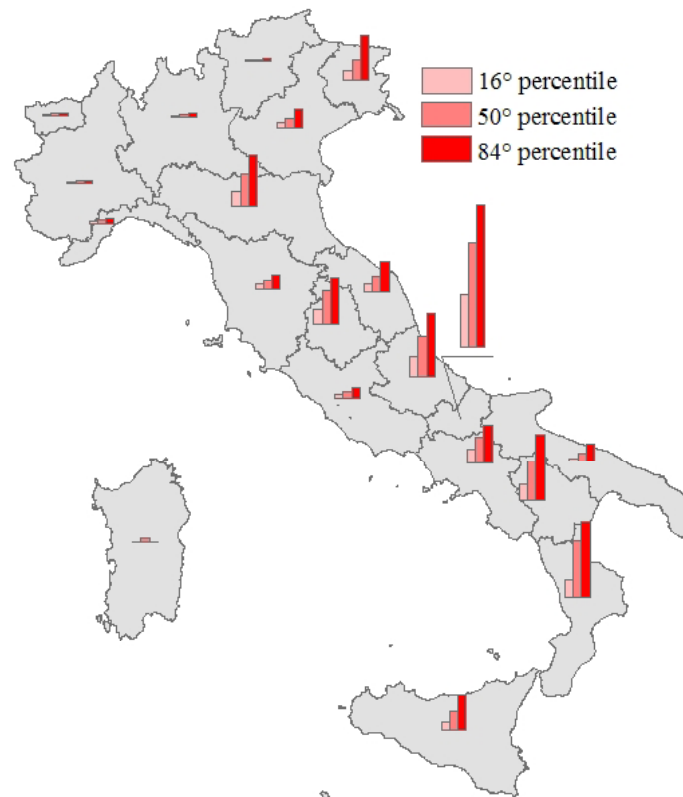
**Seismic hazard** based on INGV-DPC probabilistic study adopted in the current Italian regulation

By means of a comparison between capacity of the building and demand imposed by the earthquake we have compute:

- The **conditional seismic risk** corresponding to the occurrence of events with a certain return period  $T_r$  (9 return periods ranging from 30 to 2500 years used in Italian regulation);
- The **unconditional seismic risk** if the probability of occurrence of the event in a certain observation time windows  $t_d$  (1, 10 and 50 years) is considered.



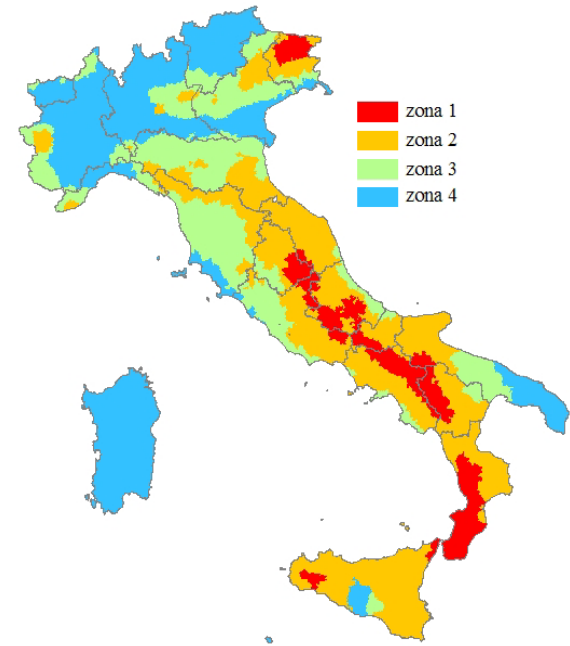
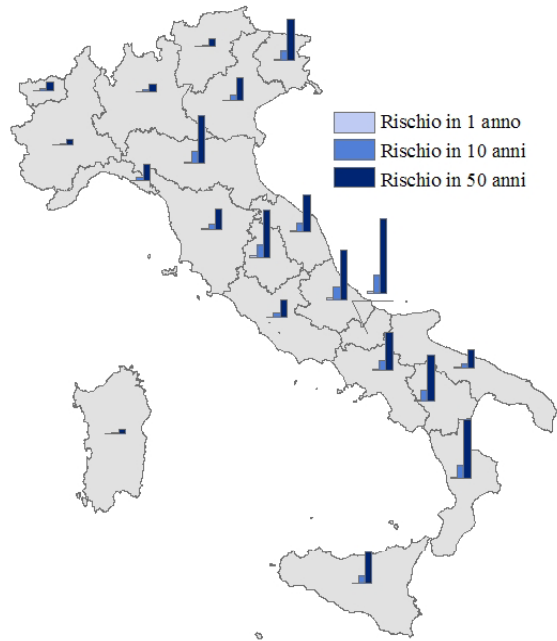
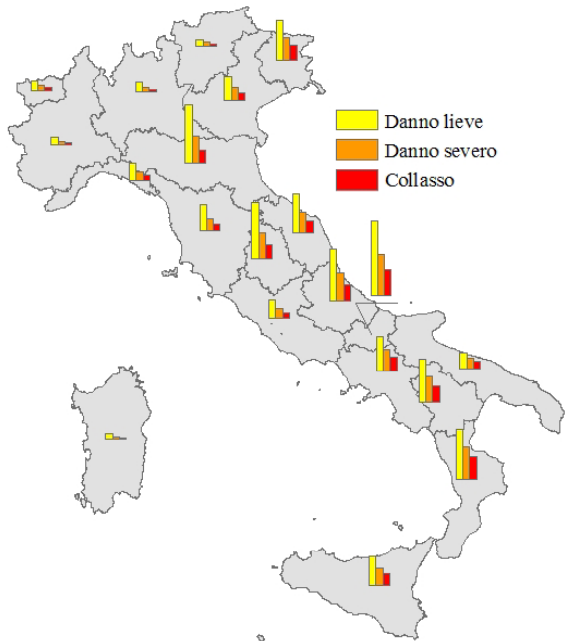
Average probability of severe damage for 475 years return period of the earthquake for each district and for the average  $\pm$  standard deviation spectra



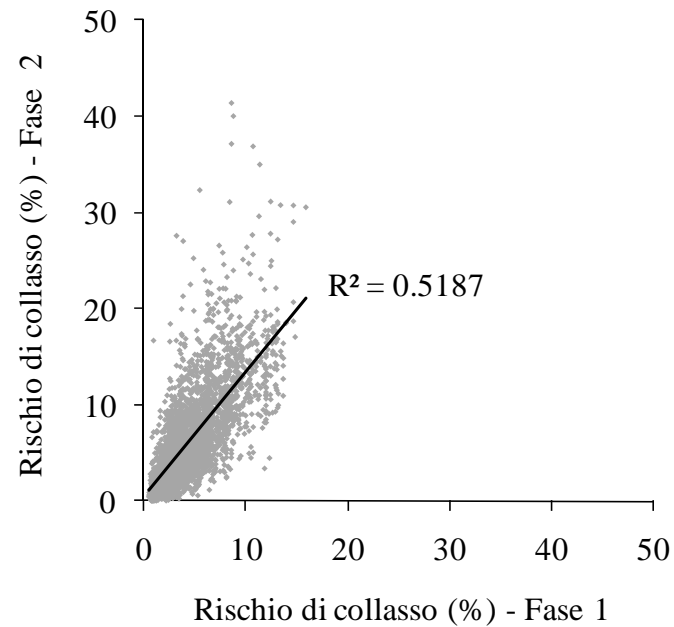
Unconditional probability of reaching or exceeding each damage limit condition in 50 years time observation window

Unconditional probability of reaching or exceeding the severe damage in 1, 10 and 50 years observation windows

Seismic zones (2006)



## Correlation between phase 1 and phase 2



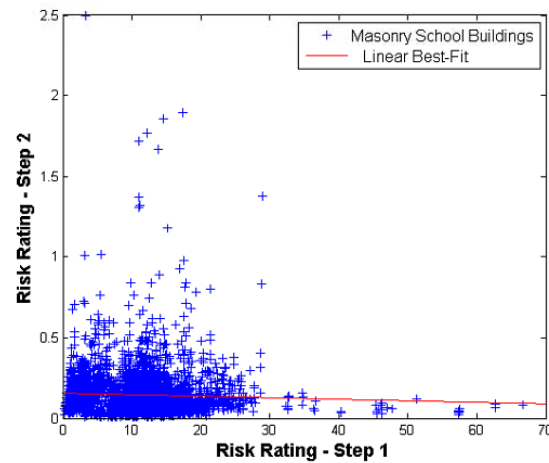
### Good correlation:

The points above the trend line correspond to an underestimation of the risk in phase 1

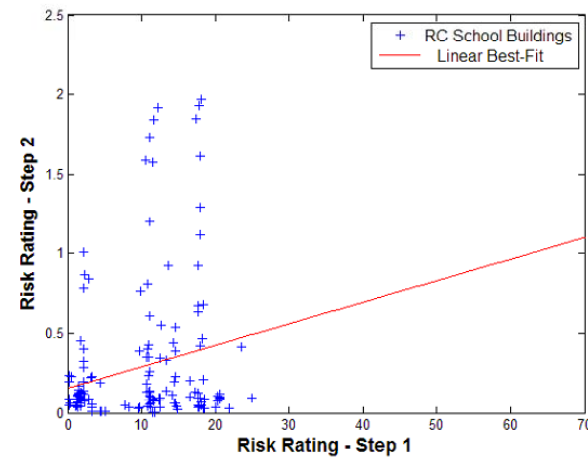


## Correlation between progressive phases in previous study

Masonry buildings



RC buildings



Grant (2007) method (Crowley et al.,2008)

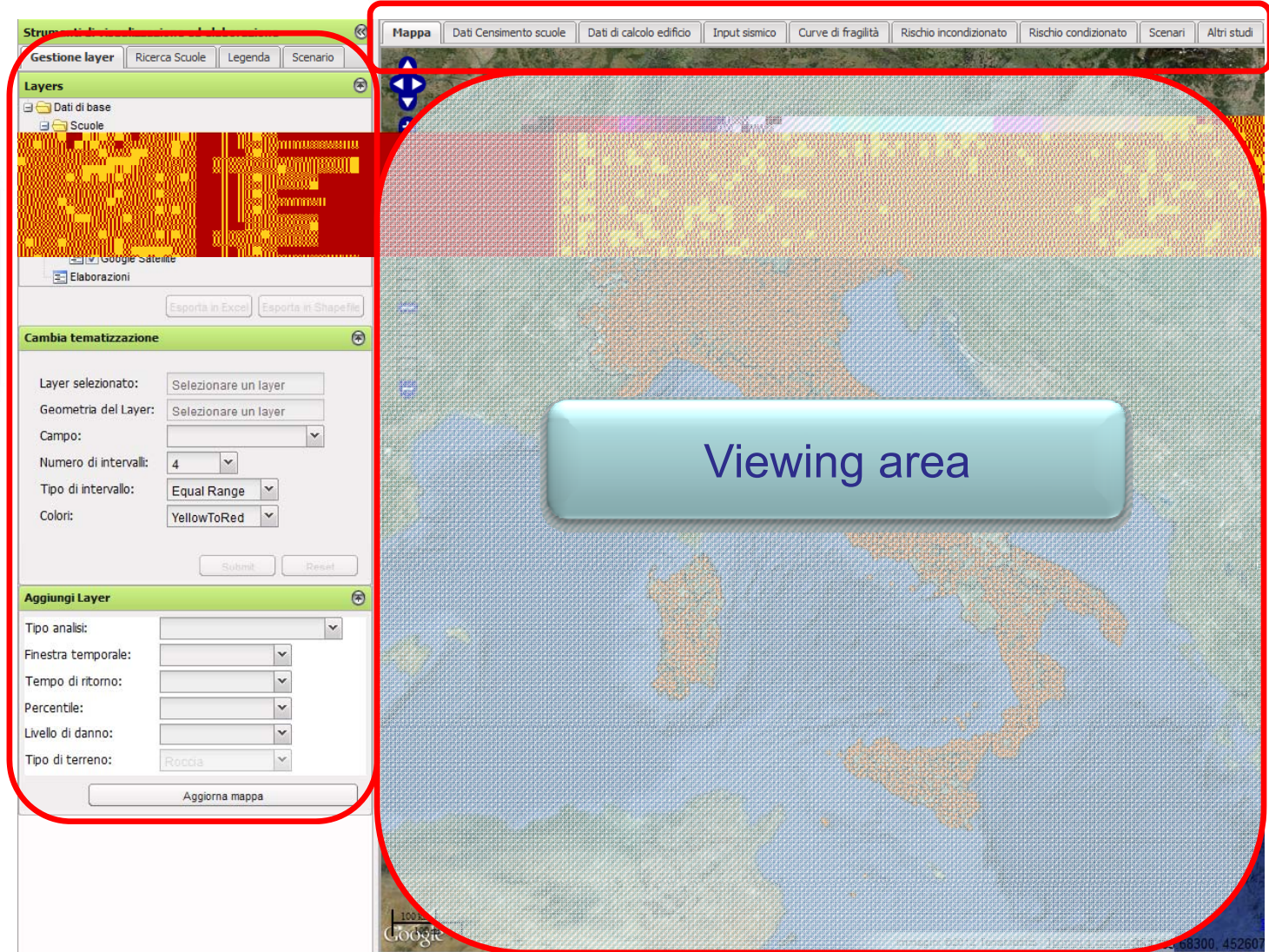


# WebGIS



# Data forms

Viewing tools  
and analysis  
tools



Mappa | Dati Censimento scuole | Dati di calcolo edificio | Input sismico | Curve di fragilità | Rischio incondizionato | Rischio condizionato | Scenari | Altri studi

**Viewing area**



# Closure and Further Developments



## Closure

A WebGIS platform has been developed in order to:

- 1) Digitalize all the available information on Italian school buildings
- 2) Identify critical conditions on the bases of the seismic risk index, in order to promote priority programs
- 3) Compute real time damage scenario in the case of occurrence of an earthquake

## Further Developments

A third step of the multifase assessment methodology is under implementation. Such step uses the results of seismic investigation on school buildings according to the regulation and coming from a financing program of civil department protection, that was run at district level.

A new webGIS platform has been implemented for the management and monitoring of seismic upgrade of school buildings. This webGIS and the one here presented are integrated such as when a building is upgraded, its seismic risk index is updated.



**Thanks for your attention**

