SASPARM 2.0

EUCENTRE
European Centre for Training and Research in Earthquake Engineering

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Scuola Universitaria Superiore Pavia

Support Action for Strengthening PAlestine capabilities for seismic Risk Mitigation

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2014 PROJECT FOR CIVIL PROTECTION FINANCIAL INSTRUMENT PREPAREDNESS AND PREVENTION SCHEME

CONCEPT OF SEISMIC VULNERABILITY AND RISK

Name

e-mail

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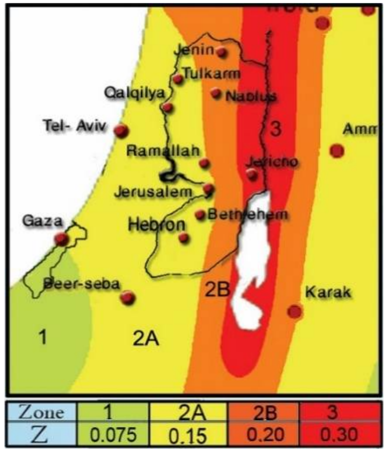
SEISMIC RISK

R= H·V·E

Hazard



Vulnerability

Exposure

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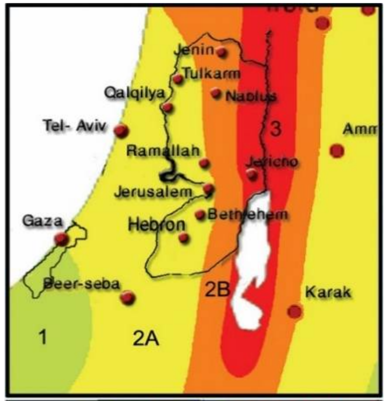
SEISMIC RISK

R= H·V·E

Target of the lecture

Hazard



Zone	1	2A	2B	3
Z	0.075	0.15	0.20	0.30

Vulnerability

Exposure

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Vulnerability

- It is fundamental to understand the vulnerability concept.
- The seismic risk, that quantifies the losses, is the convolution of vulnerability, hazard and exposure. It is impossible to act on hazard, nearly impossible to act on exposure, it is feasible to act on vulnerability. Hence, the feasible way to mitigate the seismic risk is to mitigate the seismic vulnerability.
- Vulnerability is the measure of how prone is a structure to get damaged when an earthquake occurs.
- To deal with vulnerability, a mathematical definition is needed.

Mathematical Definition of Vulnerability

$$P_{ik} = P[D \geq d_i \mid S = s_k]$$

Damage

Shaking

Methods to quantify vulnerability

- Empirical methods based on post earthquakes observation
- Mechanic methods
- Hybrid methods

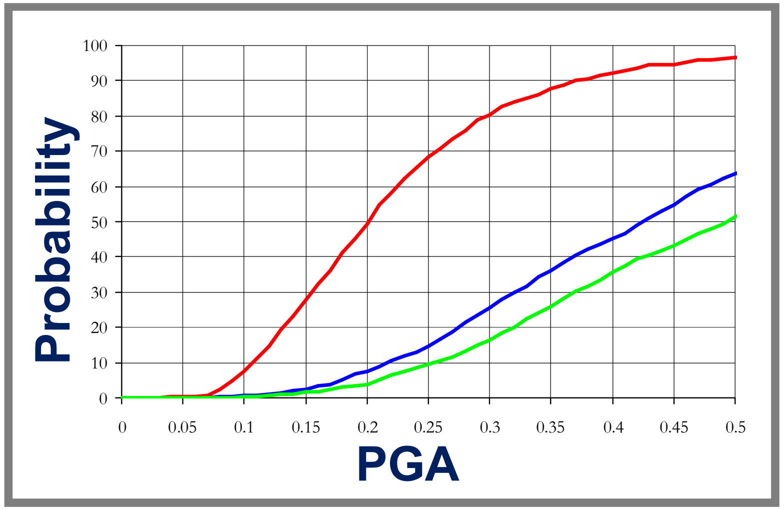
Methods to quantify vulnerability

- Damage Probability Matrix (DPM)
- Fragility curves

DPM

		Intensity Scale						
		VI	VII	VIII	IX	X	XI	XII
Damage level	0							
	1							
	2							
	3							
	4							
	5							

Fragility curves



Light damage

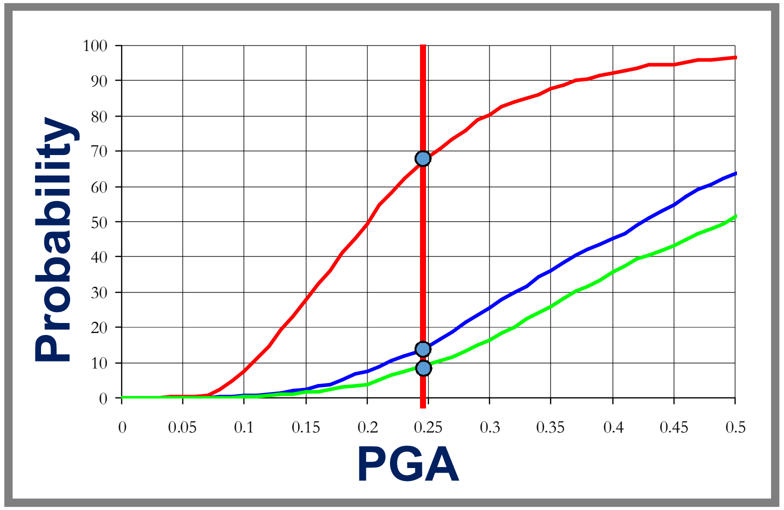
Severe damage

Collapse

Seismic Risk

- Conditional damage/failure probability

It is one point of the fragility curves and it is the conditional probability of reaching or exceeding a certain damage limit state, where the condition is to have a certain shaking severity.



Light damage

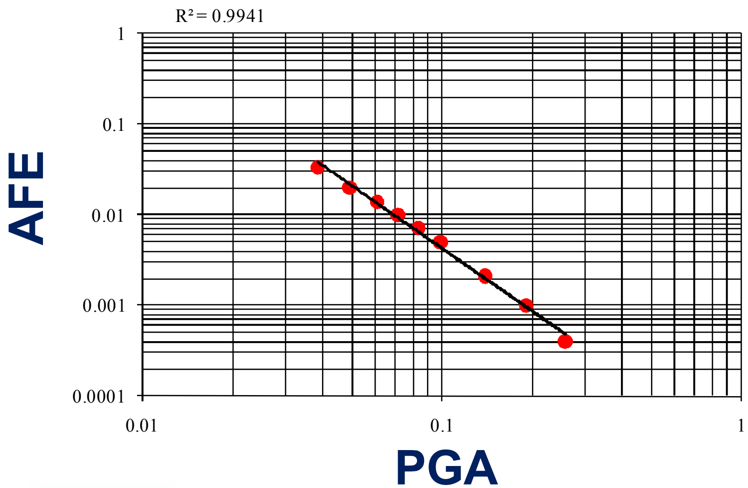
Severe damage

Collapse

Seismic Risk

- Unconditional damage/failure probability

If also the probability of having a certain ground shaking severity is taken into account, the unconditional damage/failure probability is computed. The probability of having a certain ground shaking severity is taken into account through the hazard curve:



AFE: Annual Frequency of Exceedance

AFE = $1/T_r$

with T_r the return period of the ground shaking

- Unconditional damage/failure probability

In order to compute the seismic risk, the hazard curve must be transformed in terms of probability.

Assumption: events follow the **Poisson's distribution**, that is the probability of **rare events without memory** (what happens one years is independent from what happened in the years before). The occurrence probability "q" of a ground shaking with a certain AFE in an observation time window t_d is:

$$q = 1 - \exp(t_d \, AFE)$$

The seismic risk is computed by solving the integral of structural reliability.

$$P_f = \int_{-\infty}^{+\infty} f_d(E)\,\mathrm{F_c}(E)\,\mathrm{dE} = \int_{-\infty}^{+\infty} f_c(E)\,[1-\mathrm{F_d}(E)]\,\mathrm{dE}$$

Fragility curve

Exceedance probability of ground shaking severity “q”

Where:

- f and F are respectively the probability density function and the cumulative probability;
- E is the parameter that represents the ground motion severity;
- d and c are respectively the random variables that represent the demand and the capacity.

Mechanics Based Vulnerability Assessment:

SP-BELA

(Simplified Pushover – Based Earthquake Loss Assessment)

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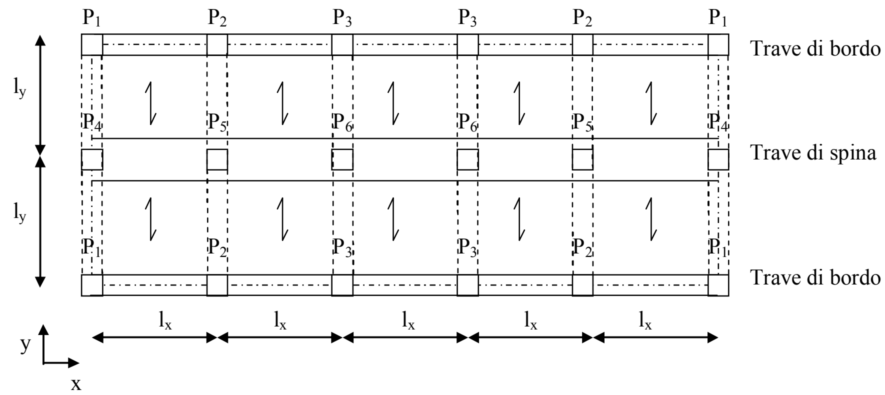
SP – BELA – Building Capacity

1st step: choice of prototype building



2nd step: definition of random variables that describe the building (*i.e.*: loads, material, geometry, etc.)

3rd step: Montecarlo generation of buildings population

4th step: simulated building design with reference to the regulation adopted in the year of real building design

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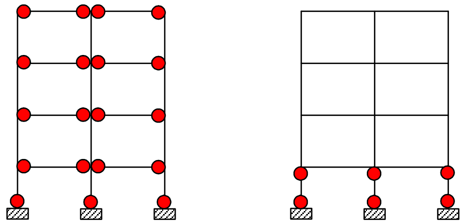
5th step: simplified pushover analysis

Check of relative resistance of beams and columns

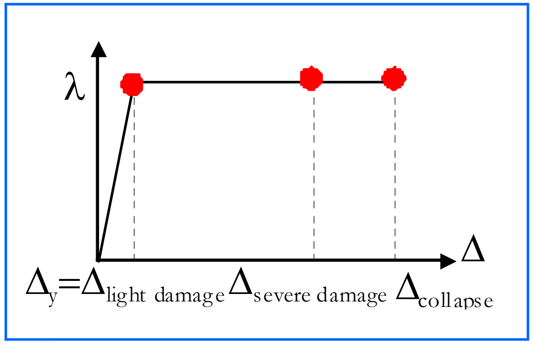
Collapse mechanism



Deformed shape:
- ✓ Assumption of linear deformed shape into the elastic range;
- ✓ Deformed shape consistent with the failure mechanism into the inelastic range

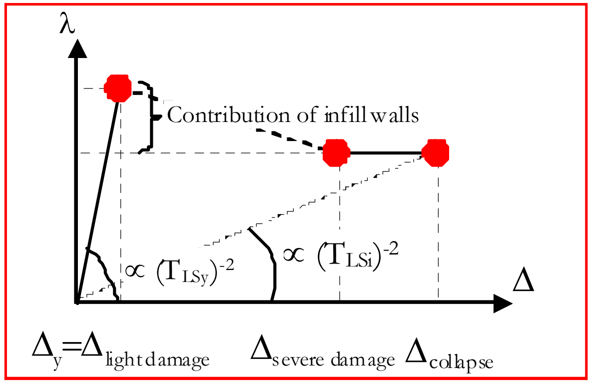
Resistance

Once the deformed shape, limit conditions and resistance is known…



Bare frame

Frame with infill walls



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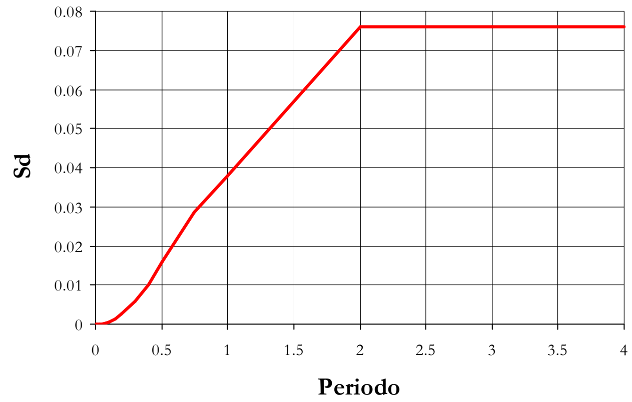
SP – BELA – Seismic Demand

1st step: choice of spectral shape



2nd step: definition of random variables that describe the spectral shape (*i.e.*: corner, periods, dynamic amplification, etc.)

3rd step: Montecarlo generation of a population of spectral shapes

SP – BELA – Comparison

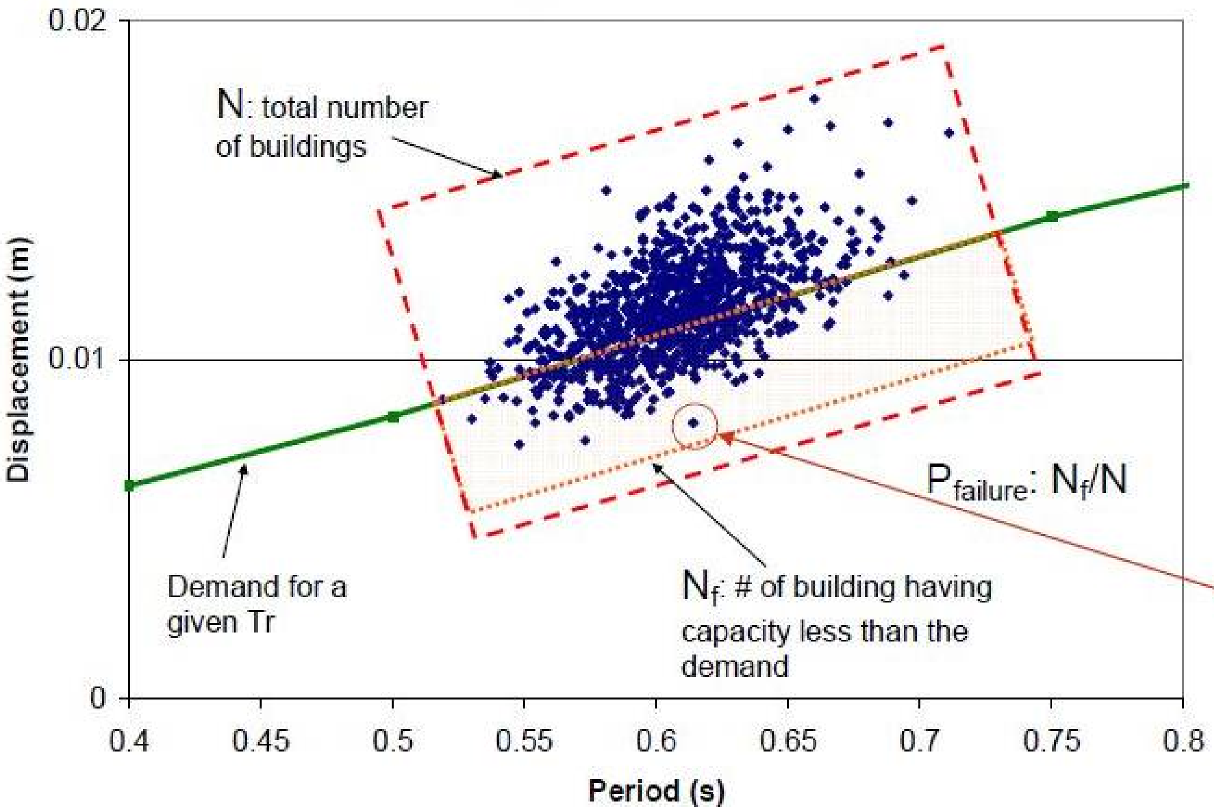
Last step:

Comparison between Displacement Capacity and Displacement Demand

Displacement spectral shape anchored to each value of PGA for which the vulnerability is calculated

Define the proportion of buildings of the dataset that survive the considered limit conditions

SP – BELA – Comparison



Vibration period and displacement capacity at SL_i of a single building part of random sample

Probability of exceedance Limit State: ratio between number of buildings having capacity less than the demand e total number of buildings in the random sample [$P_{failure}$= N_f/N]

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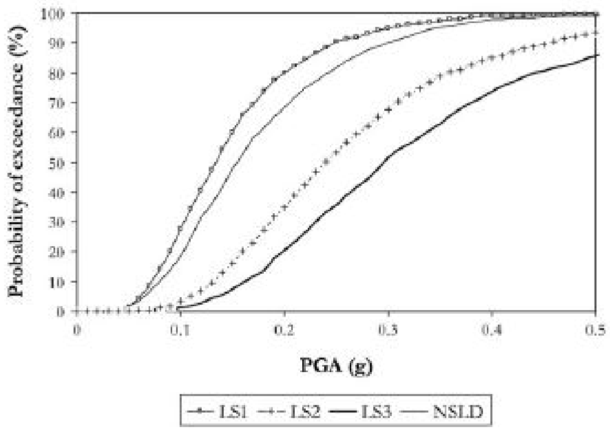
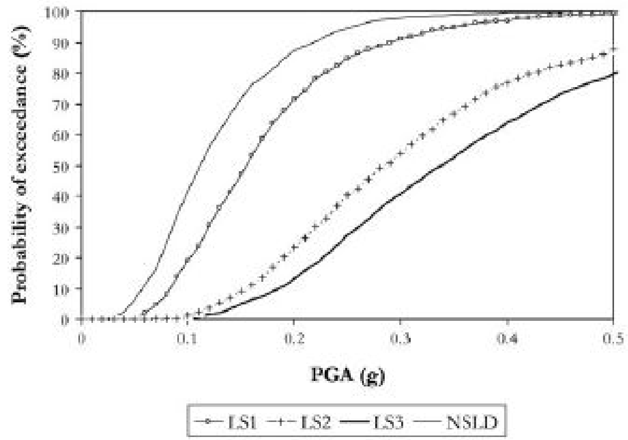
SP – BELA
Vulnerability curve examples

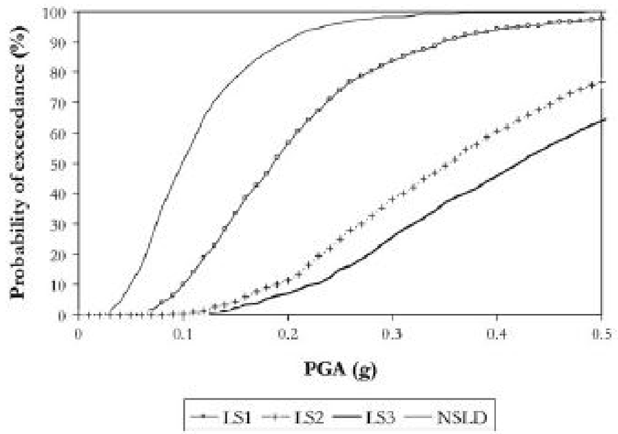
2 Storey



4 Storey



6 Storey



NSLS: Non-structural light damage limit state

LS1: Slight damage limit state

LS2: Significant damage limit state

LS3: Collapse limit condition

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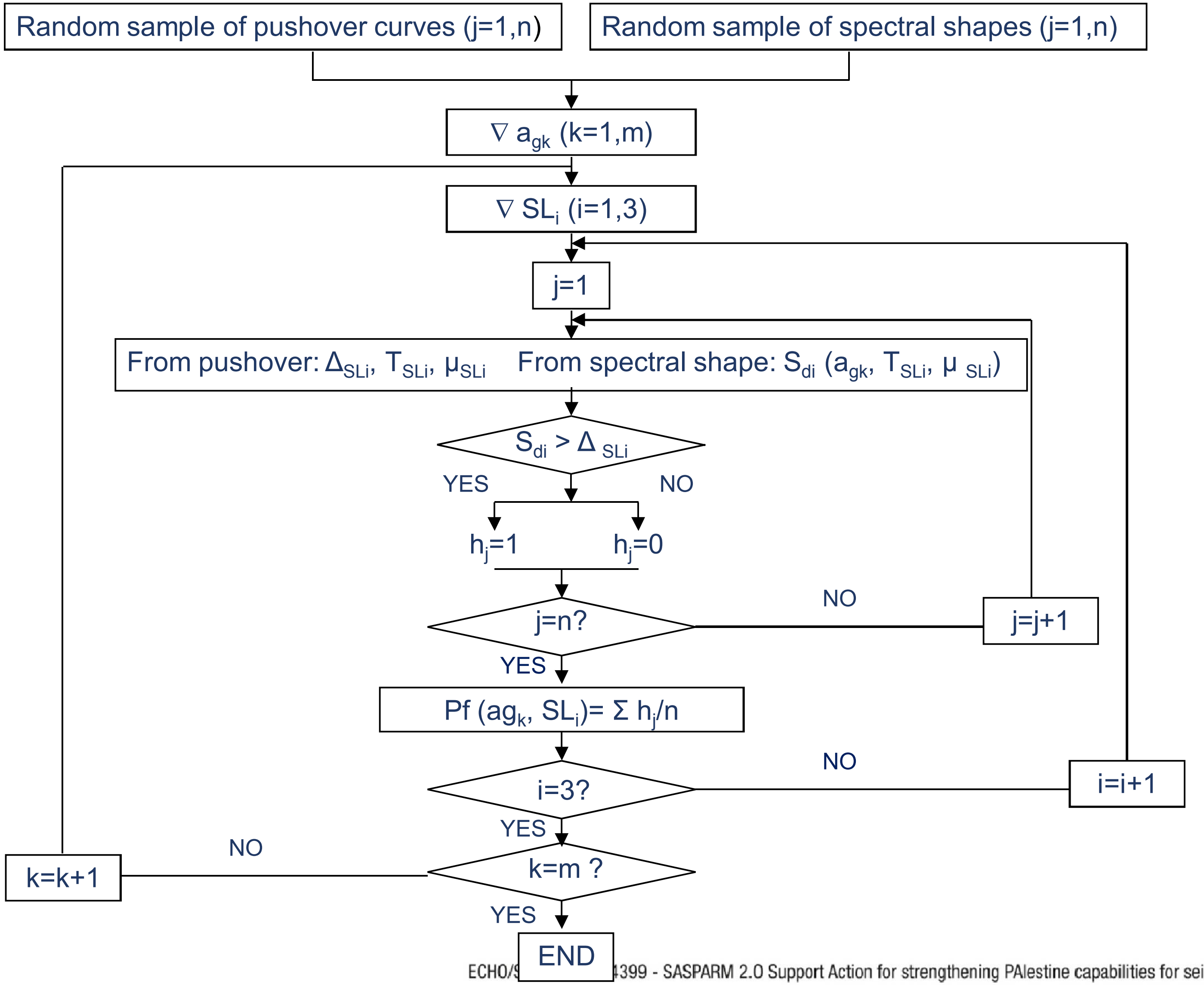
SP – BELA – Flowchart



Computation of seismic risk

Hazard or Seismic input	Average spectra and average ±standard deviation
Vulnerability	Attitude of property present in a structure to undergo a certain level of damage as a result of a certain level of shaking (SP-BELA method for R.C. buildings and SP-BELA + results from observation for masonry buildings)
Exposure	Distribution of the population and civil activities in seismic areas; it depends on the historical evolution of the settlements

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Computation of seismic risk

Data collection necessary to:

- ✓ Identify significant typologies;
- ✓ Elaborate vulnerability functions;
- ✓ Assign vulnerability function to each building typology.

TAXONOMY

able to classify all the different kinds of structures

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Computation of seismic risk

TAXONOMY

4 building types in Nablus:

- ✓ Reinforced concrete frame buildings;
- ✓ Shear wall buildings;

- ✓ Masonry buildings;
- ✓ Buildings with soft storey.

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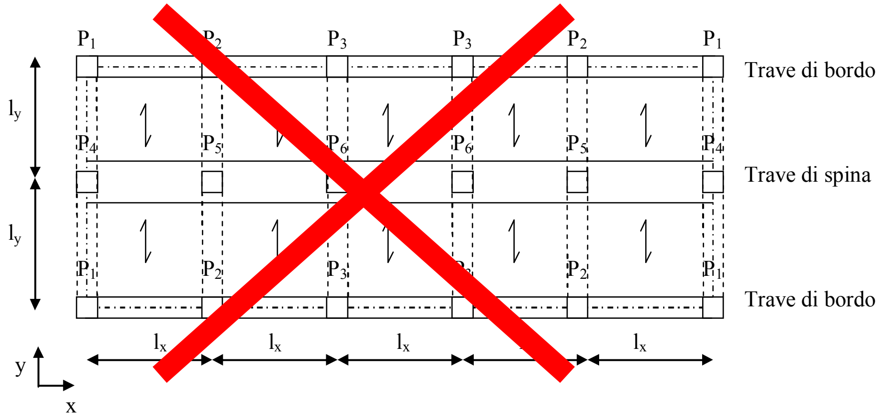
How to define Fragility Curves for Nablus Taxonomy

Toning SP-BELA to Nablus Taxonomy:

1st step: choice of prototype building



Validating Fragility Curve trough analyses of buildings prototype representative on Nablus Taxonomy (fundamental data collection)

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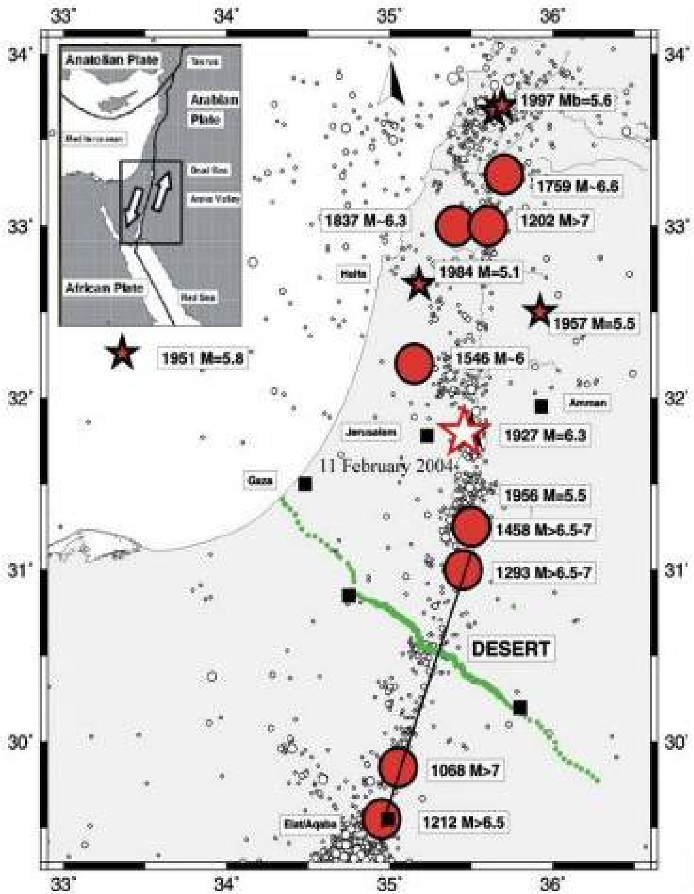
How to define the seismic hazard



- ✓ Seismicity largely affected and controlled by the geodynamic processes acting along the Dead Sea Transform

- ✓ The DST is a **left-lateral fault** between the Arabia and the Sinai tectonic plates that transfers the opening at the Red Sea to the Taurus-Zagrous collision zone

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Slide 23

BB2 metti mappa di hazard della palestina e i riferimenti a quello studio
Barbara Borzi; 21/10/2015

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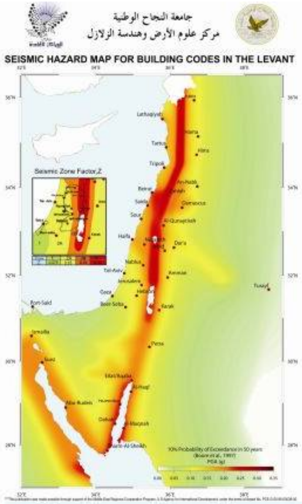
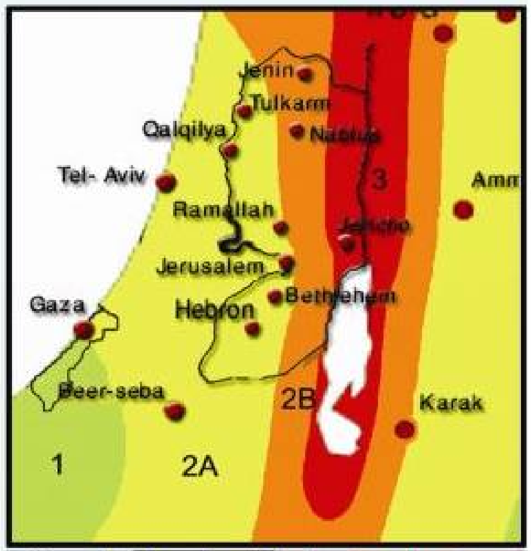
BB2

How to define the seismic hazard



Seismic Zone Factor,Z



Zone	1	2A	2B	3
Z	0.075	0.15	0.20	0.30

- ✓ Palestine has the following zones: 1, 2A, 2B and 3 (based on PGA Map).
- ✓ According to UBC97, the PGA is assumed equal to the seismic zone factor (Z) on the rock for the above mentioned zones.
- ✓ Palestine is considered as moderate to relative strong seismic areas.

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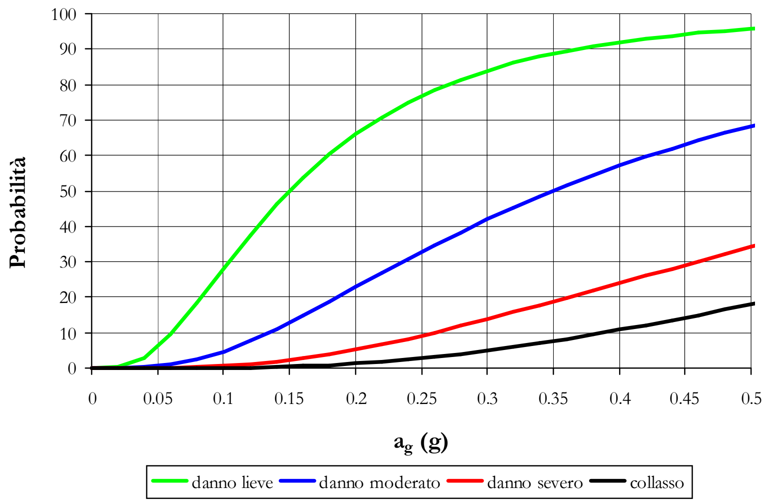
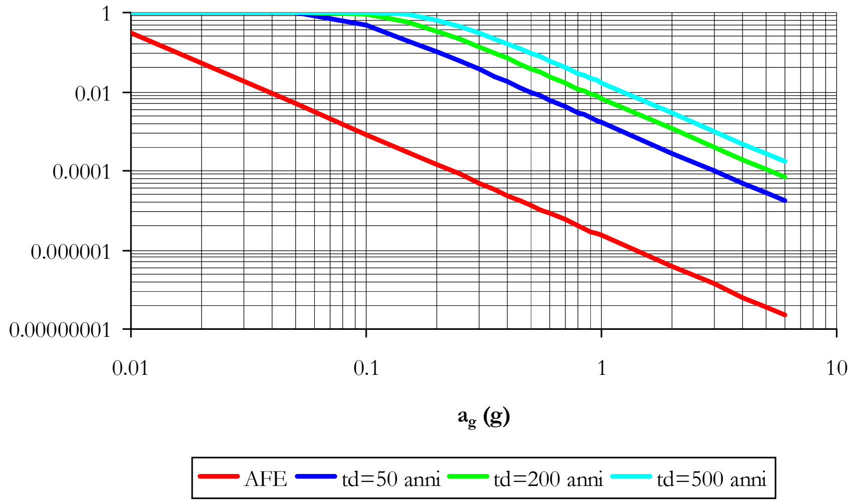
Computation of Risk

Vulnerability function



Seismic Hazard

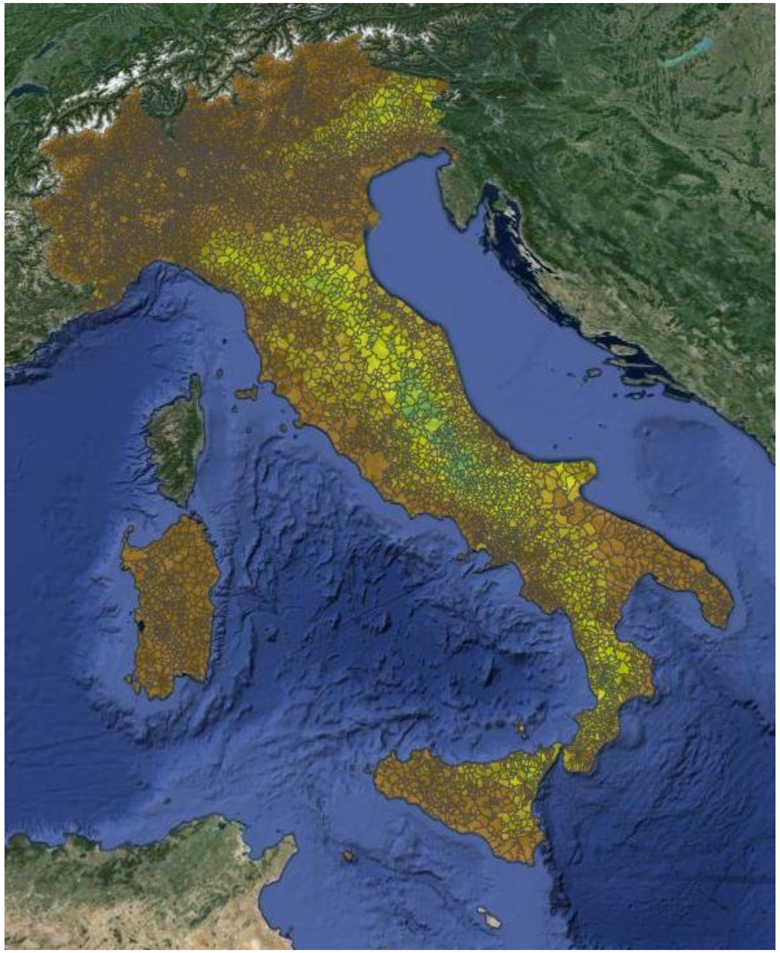


$$P_f = \int_{-\infty}^{+\infty} f_d(E)\,\mathrm{F_c}(E)\,\mathrm{dE} = \int_{-\infty}^{+\infty} f_c(E)\,[1-\mathrm{F_d}(E)]\,\mathrm{dE}$$

Example of Italian Seismic Risk Map in 1 year

% usable buildings:

97.1 - 97.6
97.6 - 98.1
98.1 - 98.5
98.5 - 99
99 - 99.5
99.5 - 100



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