Seismic Risk Assessment of "Placa" Buildings. Cost-effectiveness Analysis of Techniques for Risk Mitigation.

1st year

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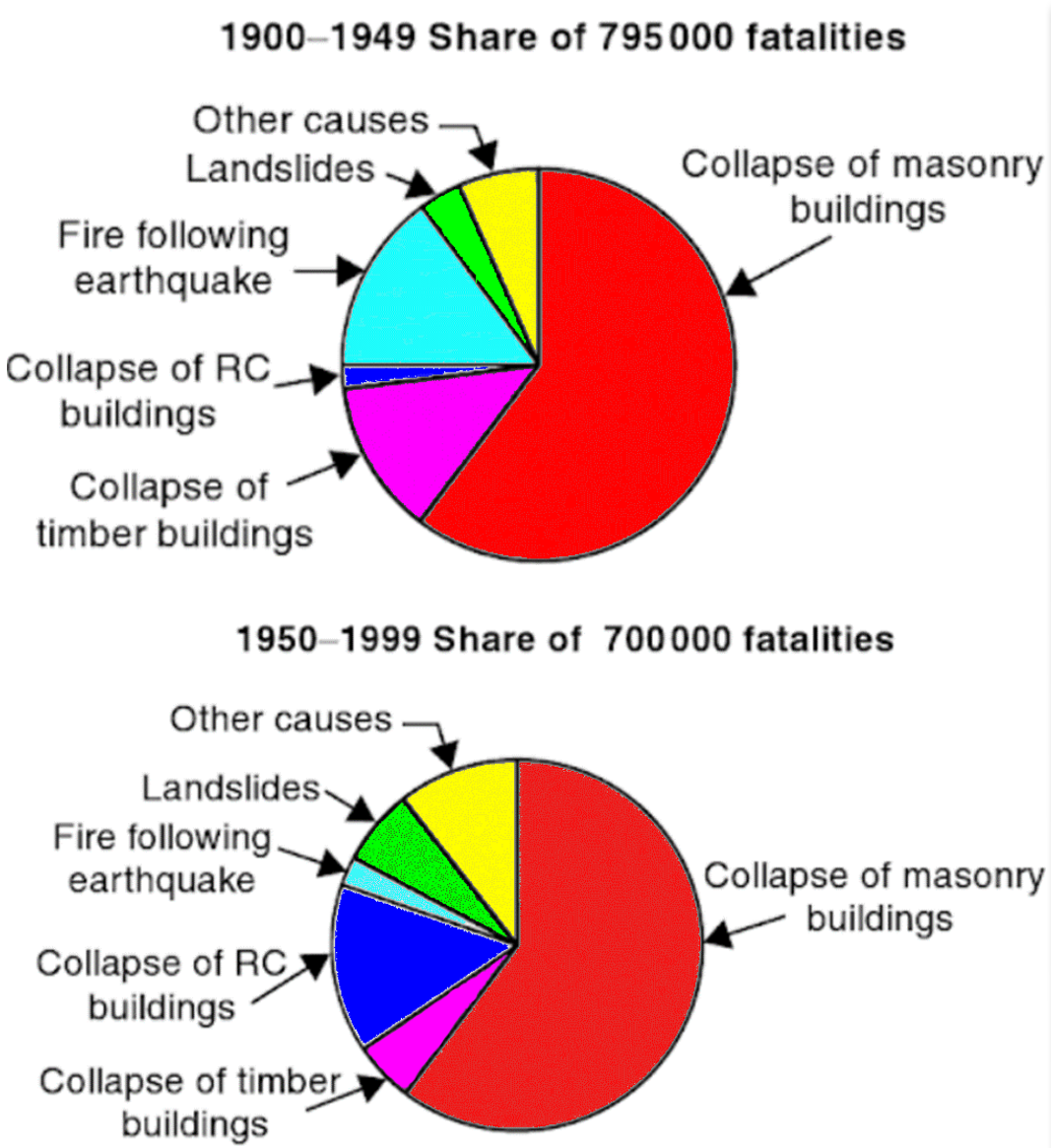
Tower of Delle Rocche castle after Emilia Earthquake, 2012

Outline

- Introduction and Motivation
- Objectives
- The “Placa” Buildings
- Seismic Risk Assessment
- Working in Progress
  - Statistics of the Elements at Risk
  - Advanced Tools for Structural Vulnerability Assessment & Risk Mitigation
  - Experimental Modal identification – 1st Case study
- Research Plan

Motivation



Coburn & Spence, 2002

Amatrice, 2016 (M= 6,2 and depth=10 km)

Ferrara, 2012 (M= 6,0 and depth=5 km)

Motivation

- **Save and protect human lives**
- Reduce the impacts and losses
- Building safe structures
- Conservation and restoration of built heritage

Staying a step ahead of a natural disaster

WE MUST!!

Minimize future losses

Objectives

- Seismic risk assessment of “Placa” buildings in Metropolitan Area of Lisbon (MAL):
  - uncertainty in earthquake event (magnitude, depth, source, seismic waves propagation);
  - uncertainty in the structure response;
  - effect of the interaction with adjacent buildings (block response).
- Understanding and predicting local and global failure mechanisms;
- Define strategies for seismic risk mitigation based in cost-effectiveness analysis;

Portugal Masonry Buildings Typology

"Pré-Pombalinos"
(before 1755)

"Pombalinos"
(1755-1880)

"Gaioleiros"
(1880-1930)

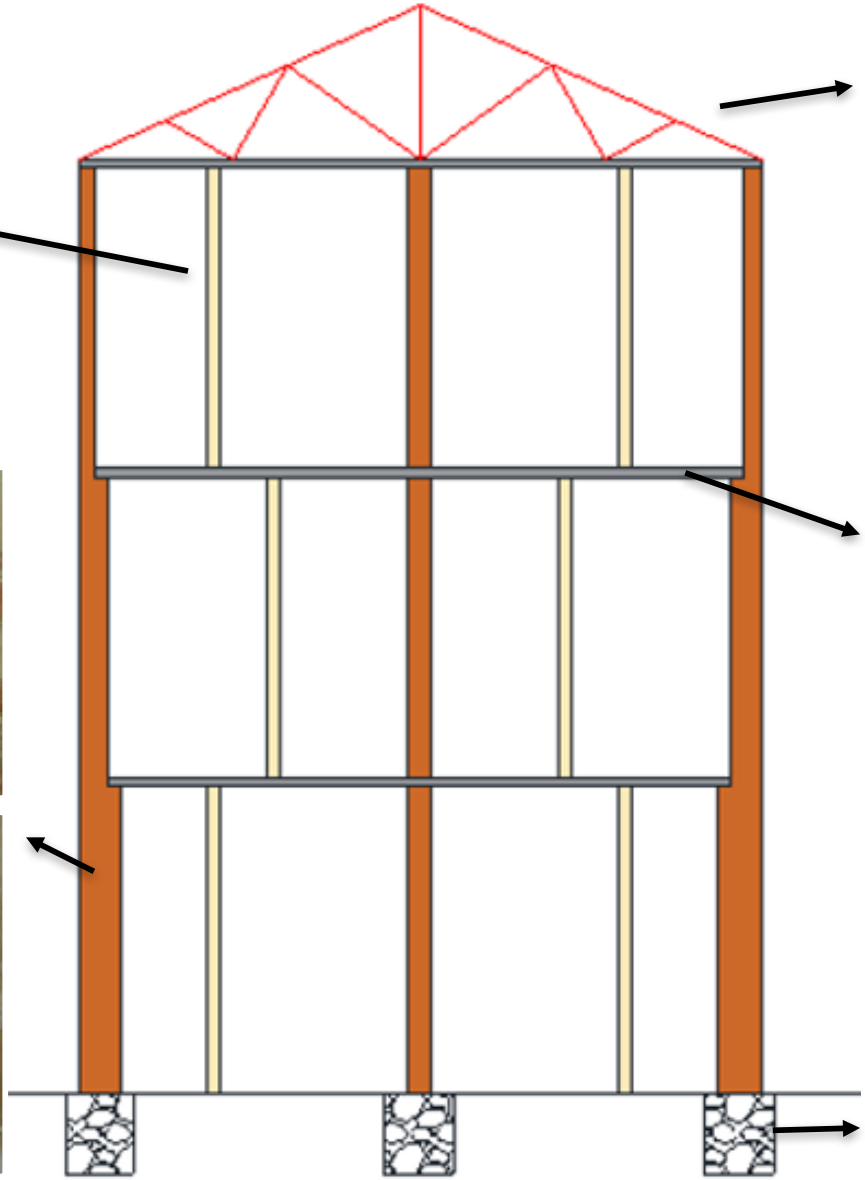
"Placa"
(1930-1960)

R.S.C.C.S. – First Portuguese regulation for seismic design – 1958

The “Placa” Buildings

Interior walls

Exterior walls



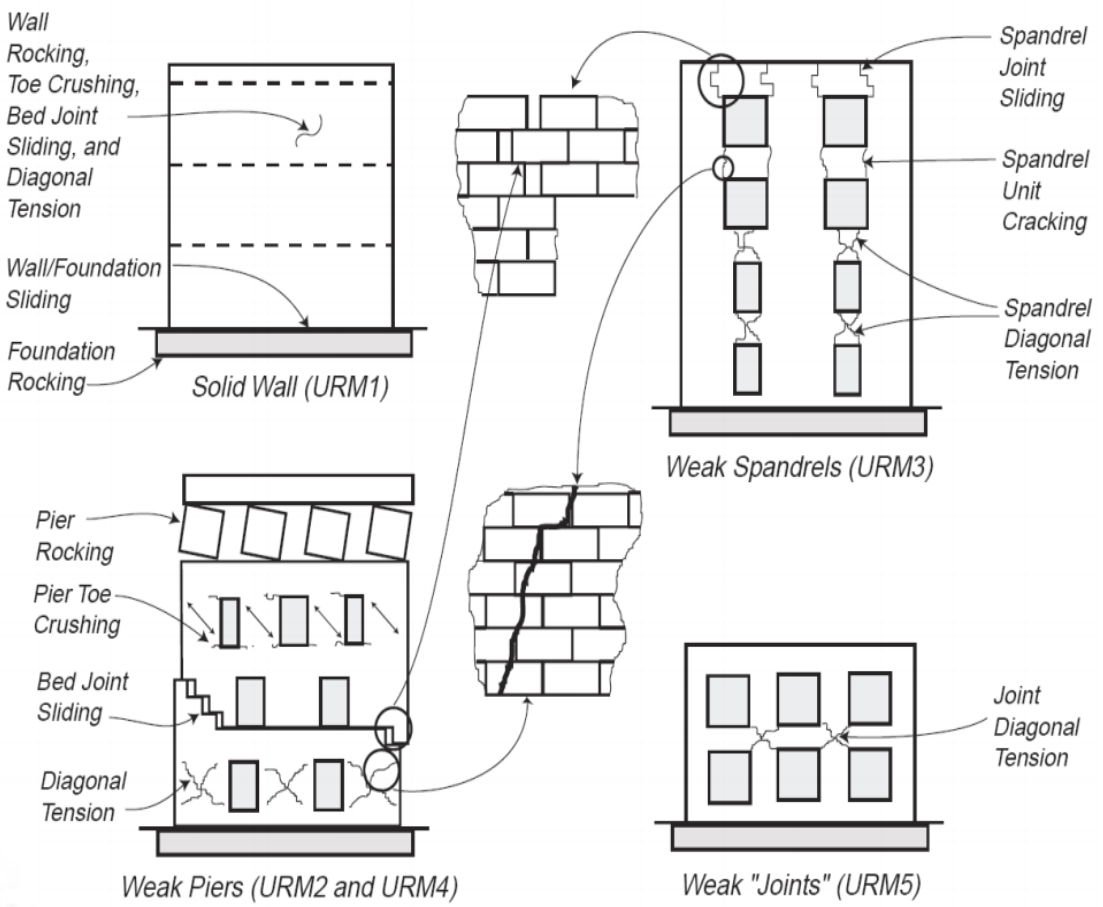
Roof – Timber Structure

RC Slab (Lopes, 2008)

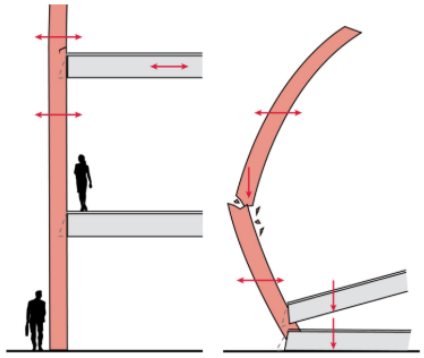
Foundation

Weak Points and Typical Failure Modes

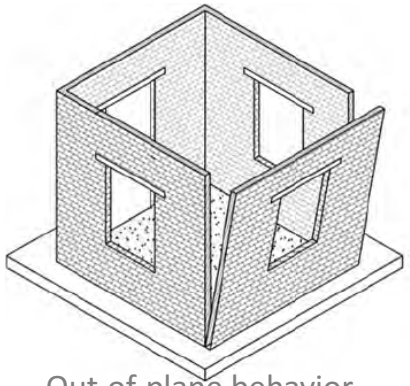
- Vertical structural elements with low resistance to shear and bending;
- Very heavy structure;
- For horizontal shaking, floors and roofs can disconnect from the walls;
- Pounding on adjacent buildings;
- Addition of floors or structural changes (openings or removed walls);



FEMA & ATC, 1998

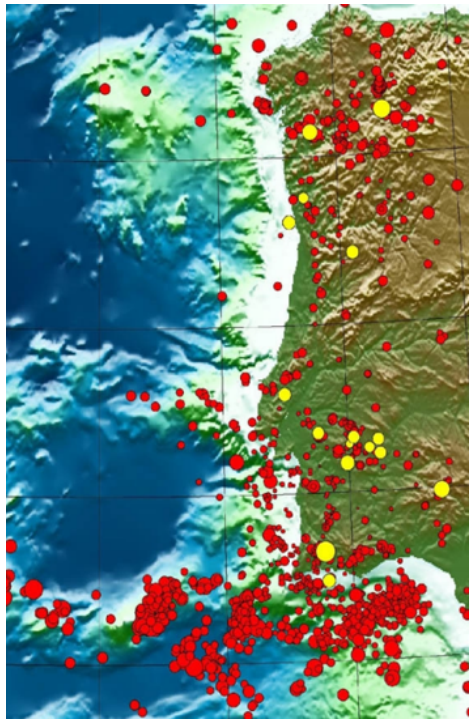


Vertical bending, Kevinsh 2017



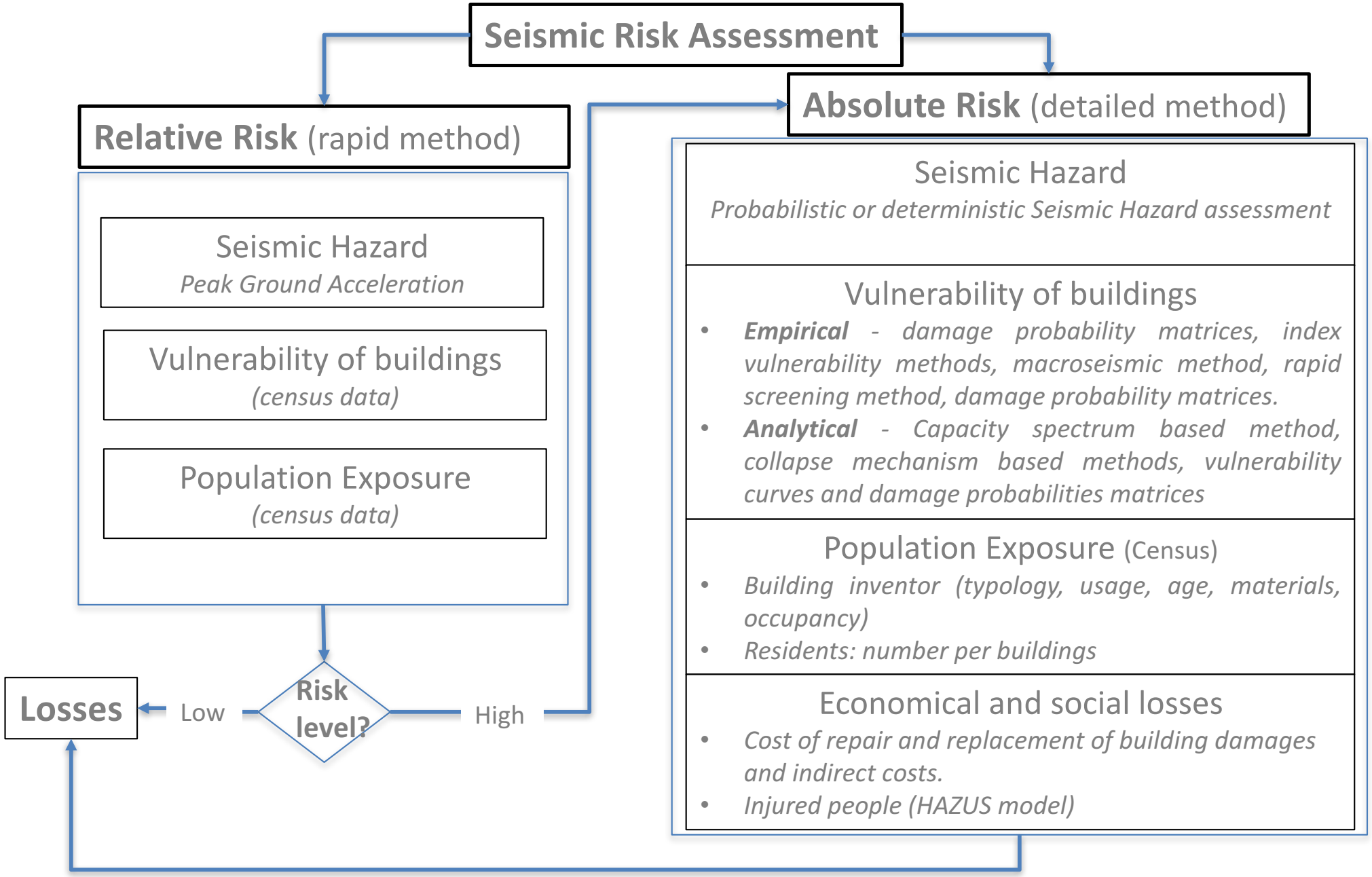
Out-of-plane behavior

Seismic Risk Assessment - Basic Definition



HAZARD X **VULNERABILITY** X **EXPOSURE**

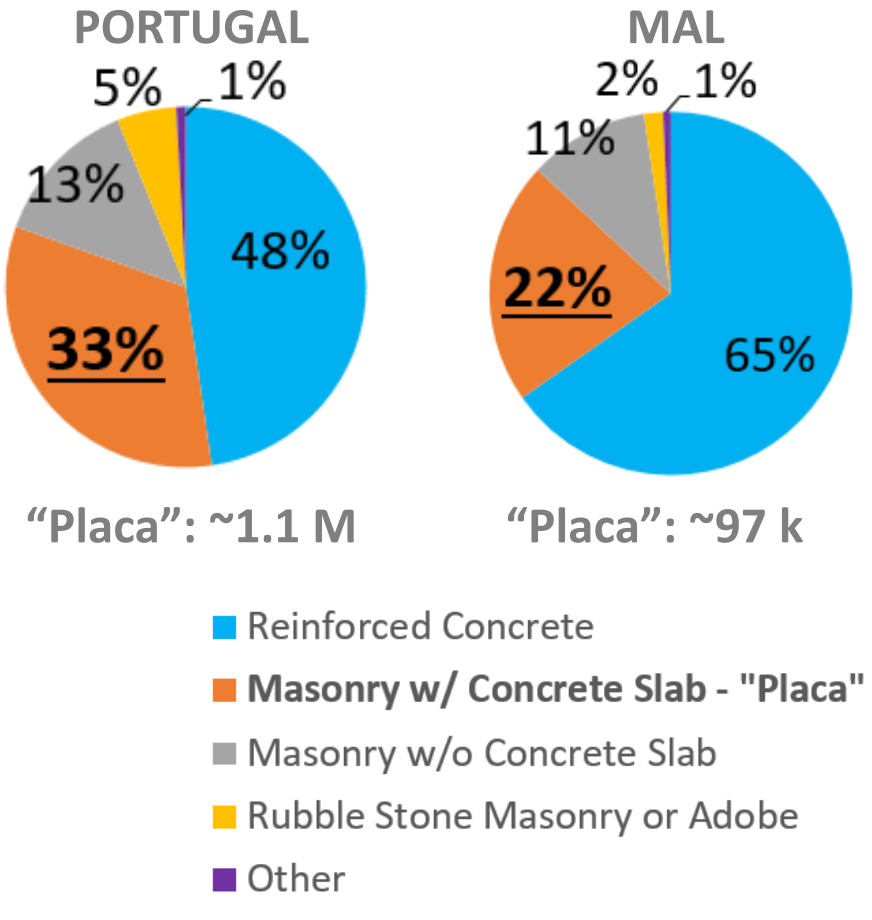
Seismic Risk Assessment - Framework



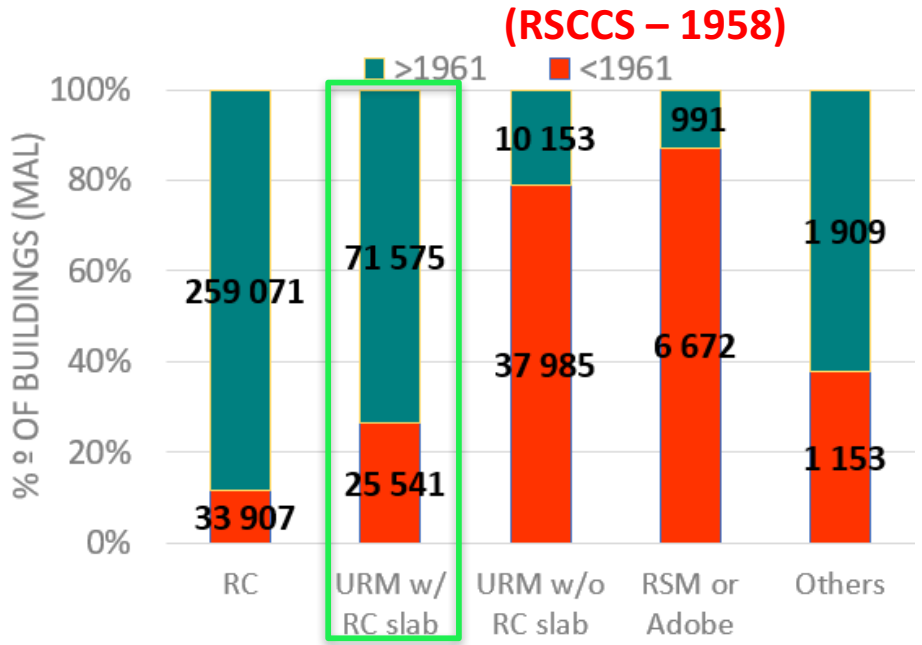
Work in Progress

Global Statistics of Elements at Risk (Census 2011)

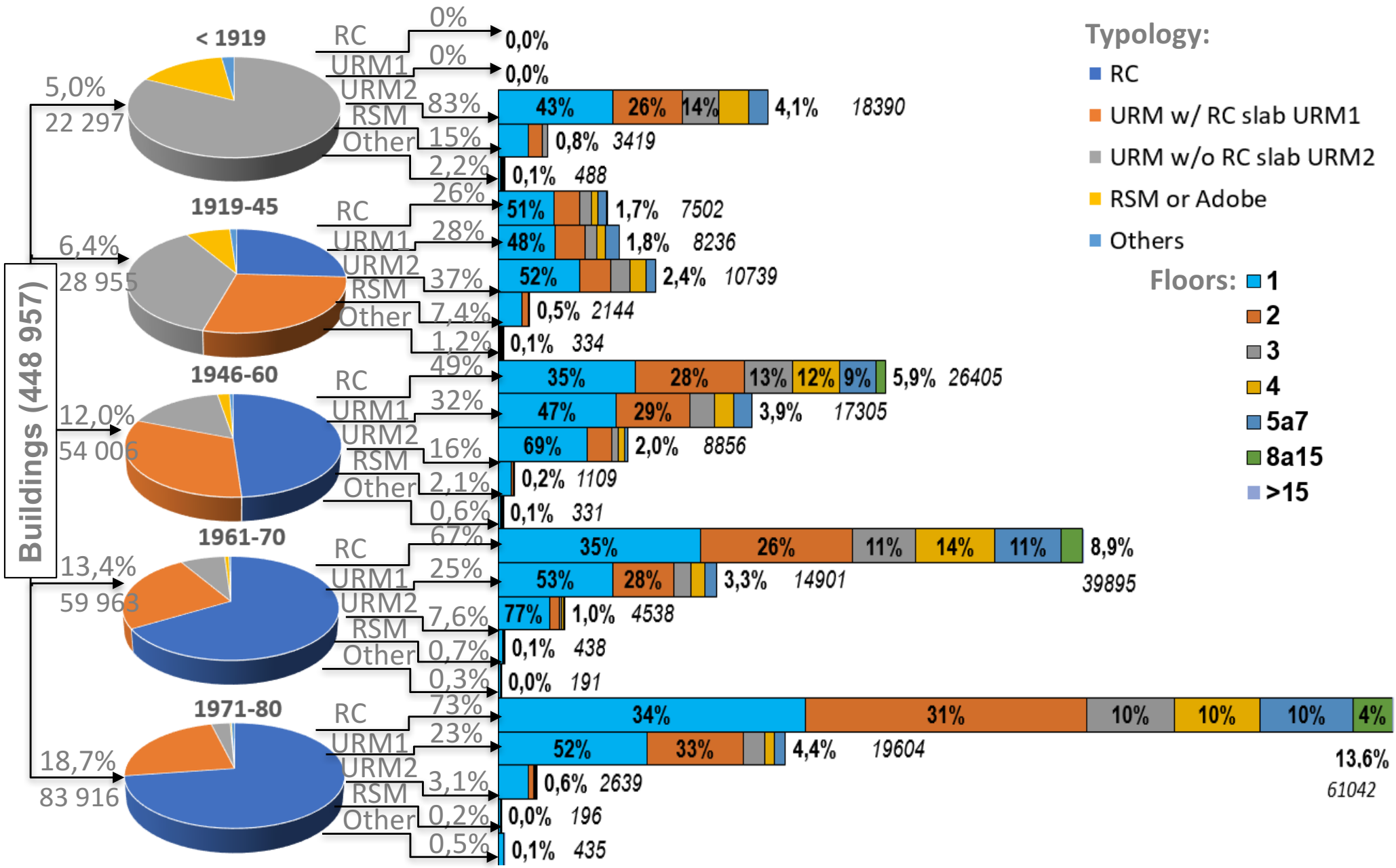
Elements at Risk	Continental Portugal (PT)			Metropolitan Area of Lisbon (MAL)		
	2001	2011	Rate	2001	2011	Rate
Buildings	2 997 659	**3 353 610**	11,9% (355 951)	394 520	**448 957**	13,8% (54 437)
Accomodations	4 840 122	**5 632 800**	16,4% (792 894)	1 283 872	**1 485 780**	15,7% (201 908)
Occupants	9 789 109	**9 905 473**	1,19% (116 364)	2 597 379	**2 785 824**	7,3% (188 445)



	PT		MAL	
	2001	2011	2001	2011
Accomodation/Building	1,61	**1,68**	3,25	**3,31**
Residents/Accomodation	2,02	**1,76**	2,02	**1,87**



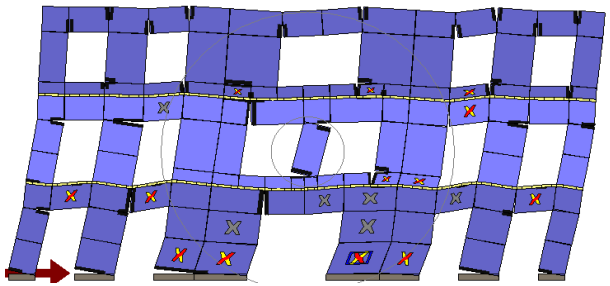
Disaggregation of Census 2011 Data for Buildings – M.A.L.

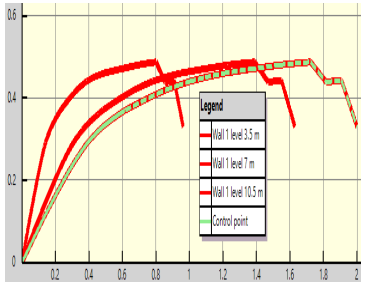


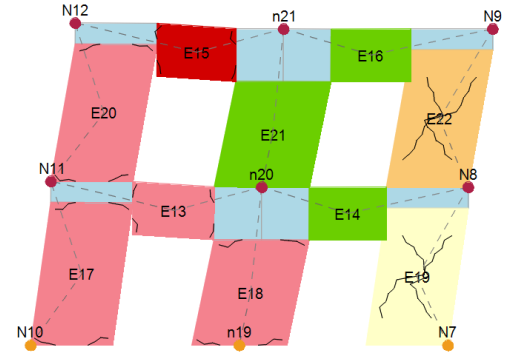
Tools for Structural Vulnerability Assessment & Risk Mitigation

➢ Macro Element Formulation:

- Tremuri (non-linear beam element for modeling piers and spandrels – in plane);
- 3DMacro (discrete elements)

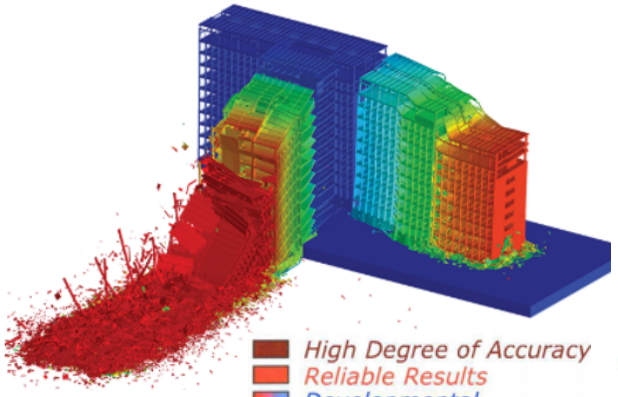


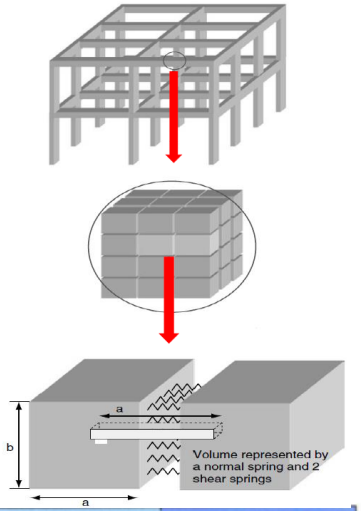


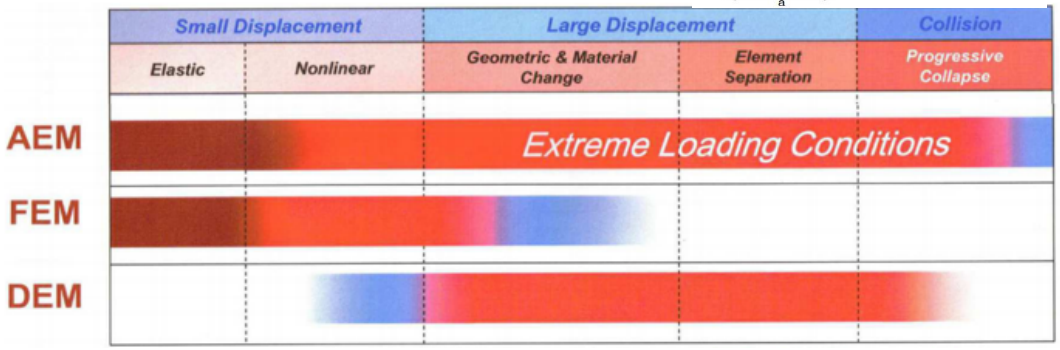


➢ Applied Element Method:

- Real simulation of masonry (brick + mortar);
- Useful to determine standoff distances, safety perimeters and potential collateral damage;
- Visualize scenarios and their consequences;

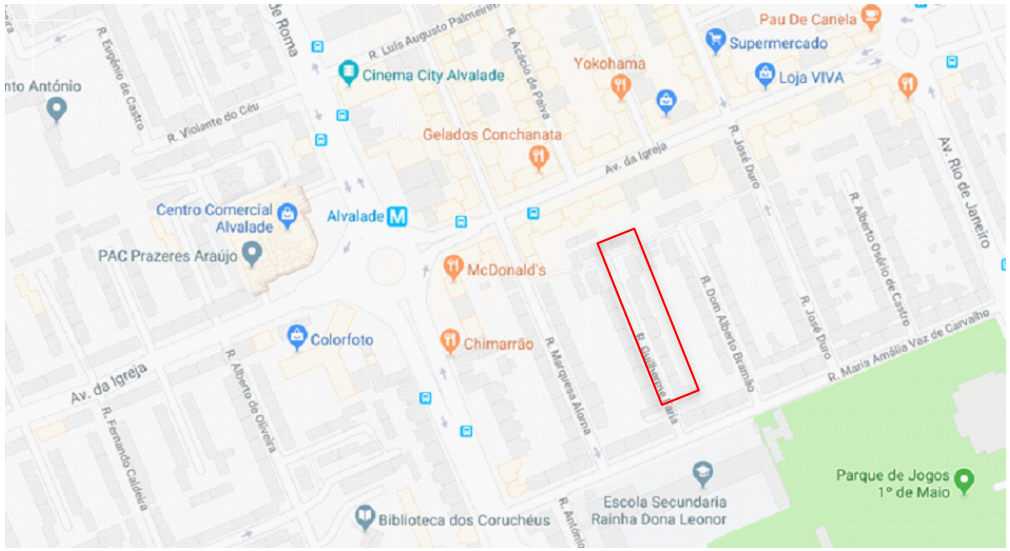


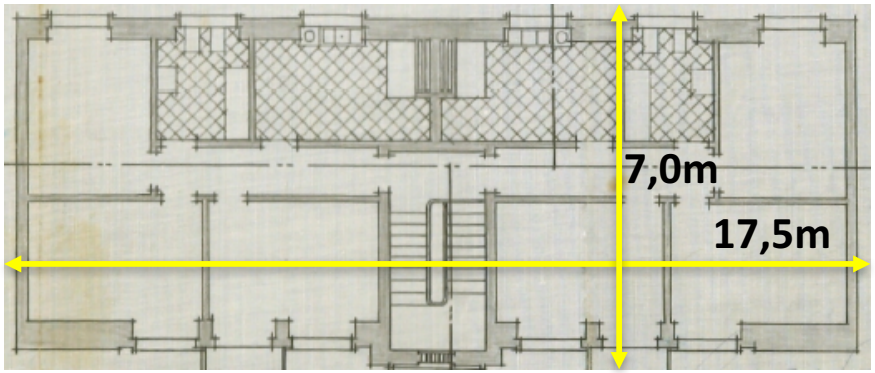




Experimental Modal Identification

1st Case Study: Group of “Placa” buildings (Bairro de Alvalade)





Rua Guilherme Faria – Bairro de Alvalade

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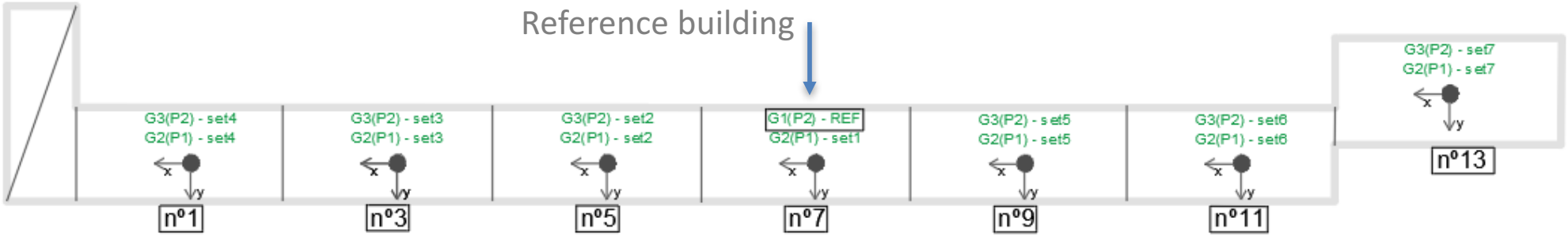
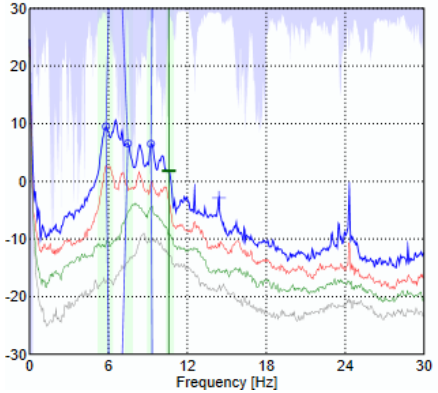
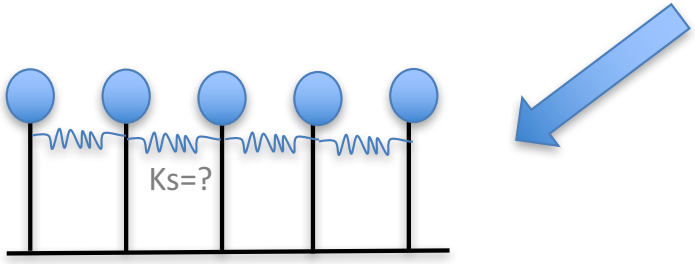
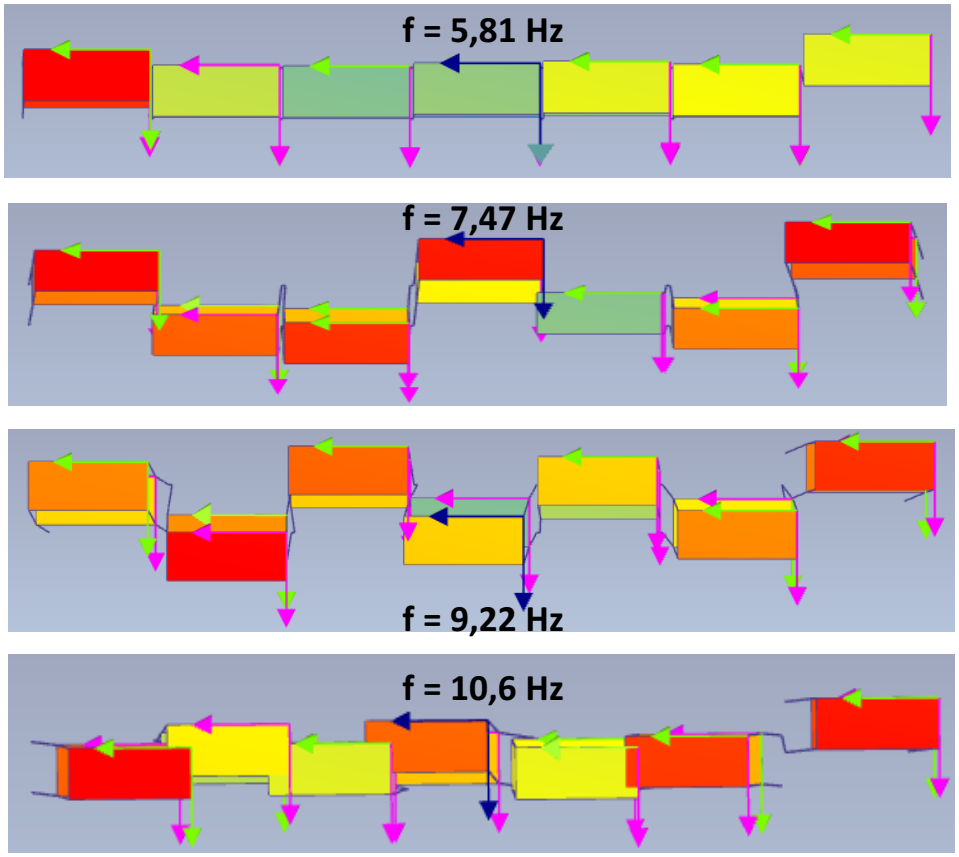
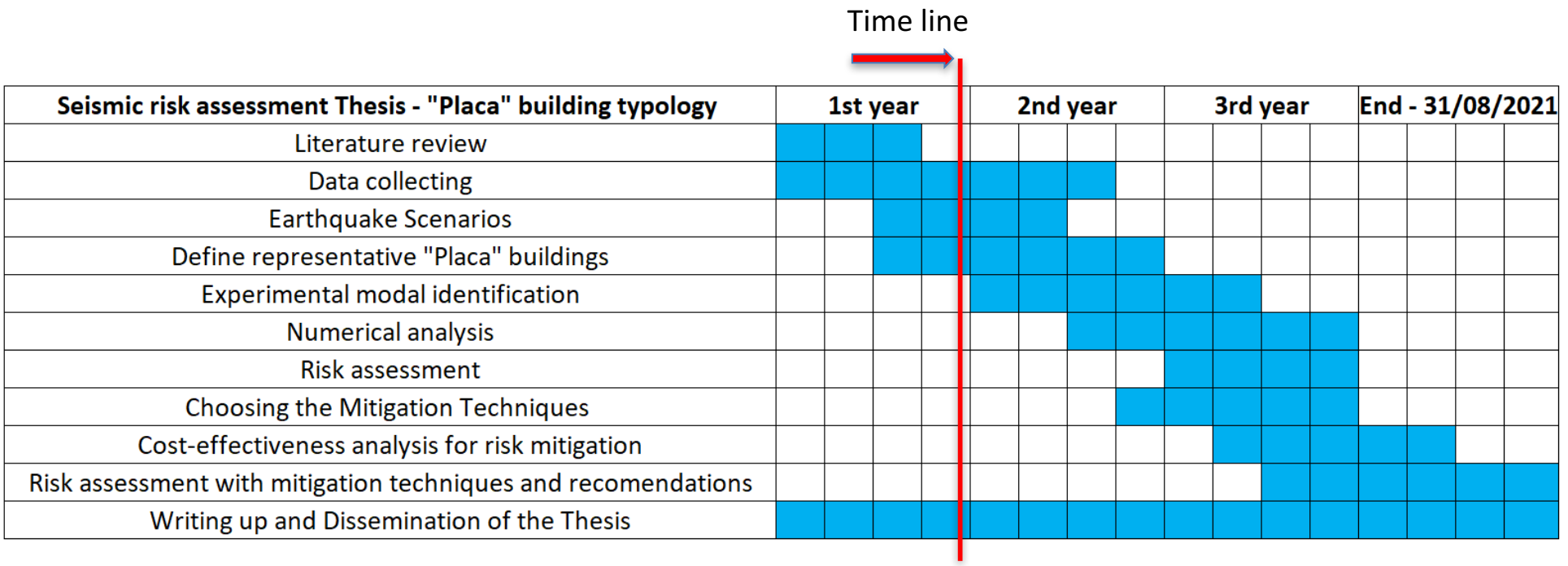








Research Plan



KEEP
CALM
AND
DO
SOMETHING
BEFORE

THANK YOU!

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