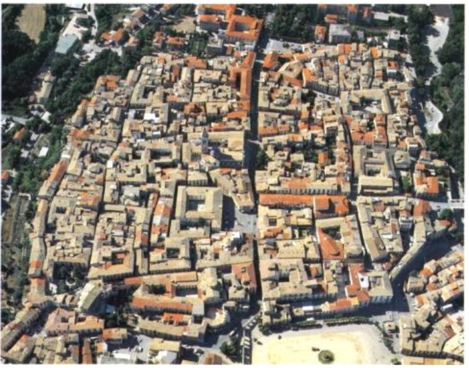
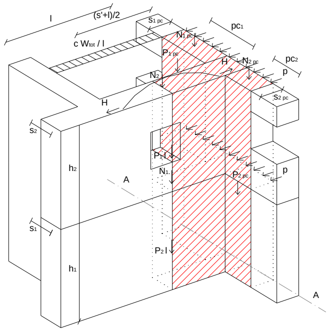
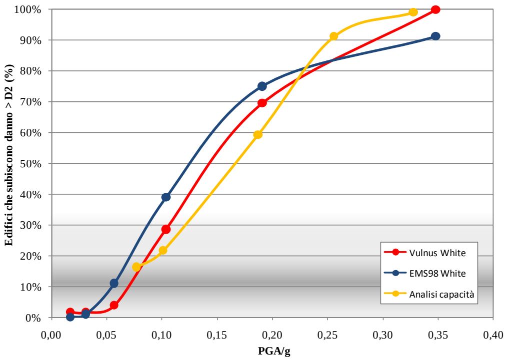
KULTURISK WORKSHOP

THE BENEFITS OF DISASTER PREVENTION MEASURES: CONSOLIDATING AND WIDENING AN INNOVATIVE RISK ASSESSMENT METHODOLOGY

VENICE, 19-20 SEPTEMBER 2013







NIKER – New Integrated Knowledge based approaches to the protection of cultural heritage from Earthquake

PROF. ING. CLAUDIO MODENA

FULL PROFESSOR OF CONSTRUCTION TECHNOLOGY

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UNIVERSITY OF PADOVA

ITALY

THE NIKER PROJECT

NIKER

Development of **integrated and knowledge based methodologies** for the protection of Cultural Heritage assets from earthquakes on the basis of optimization and **minimum intervention** approach.

THE NIKER PROJECT

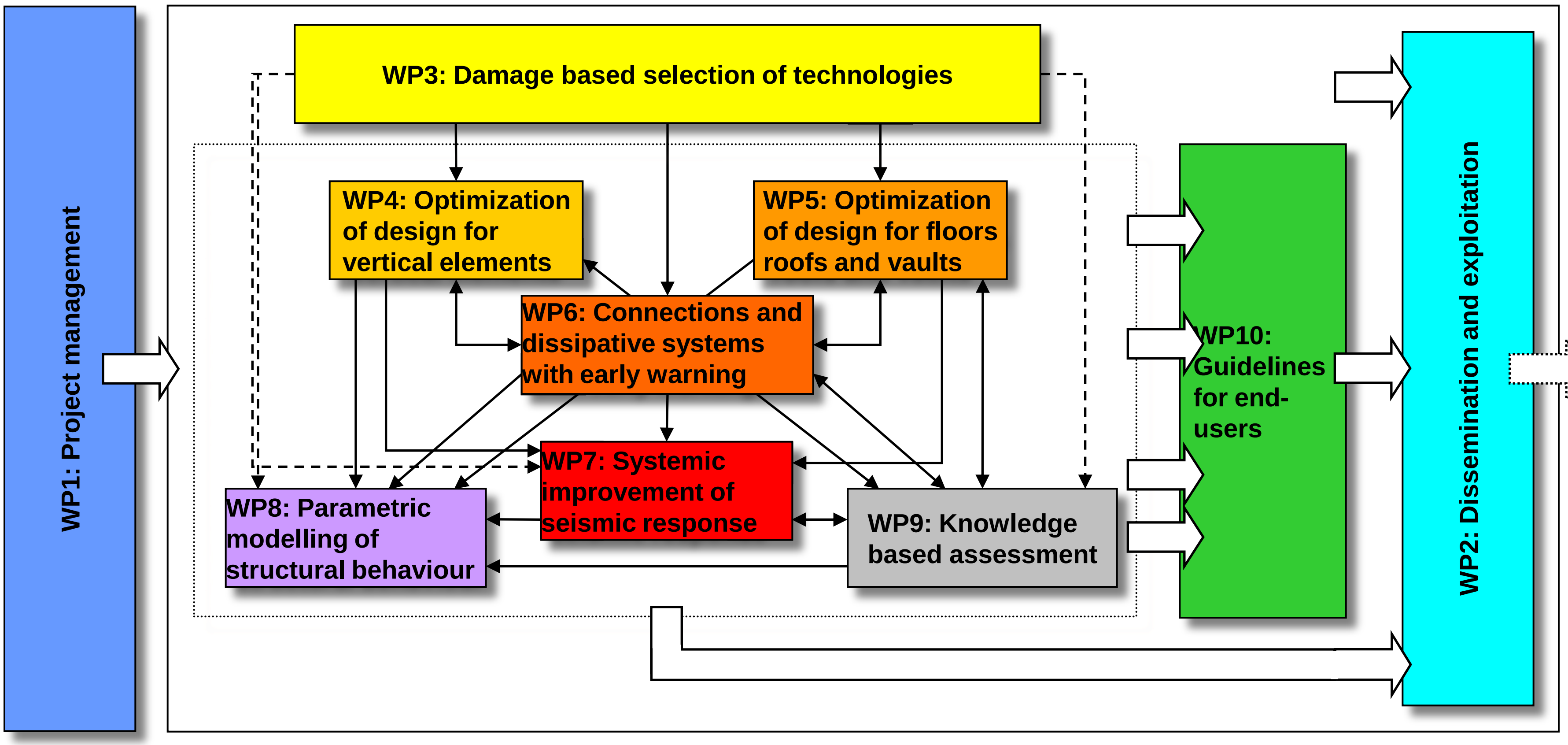
MAIN PROJECT OBJECTIVES

To overcome the current shortcomings mainly related to:

- use of inadequate materials
- use of inadequate intervention techniques
- use of inadequate tools for analysis and/or analysis carried out on the basis of limited information and/or dated design methods

THE NIKER PROJECT

Project Structure



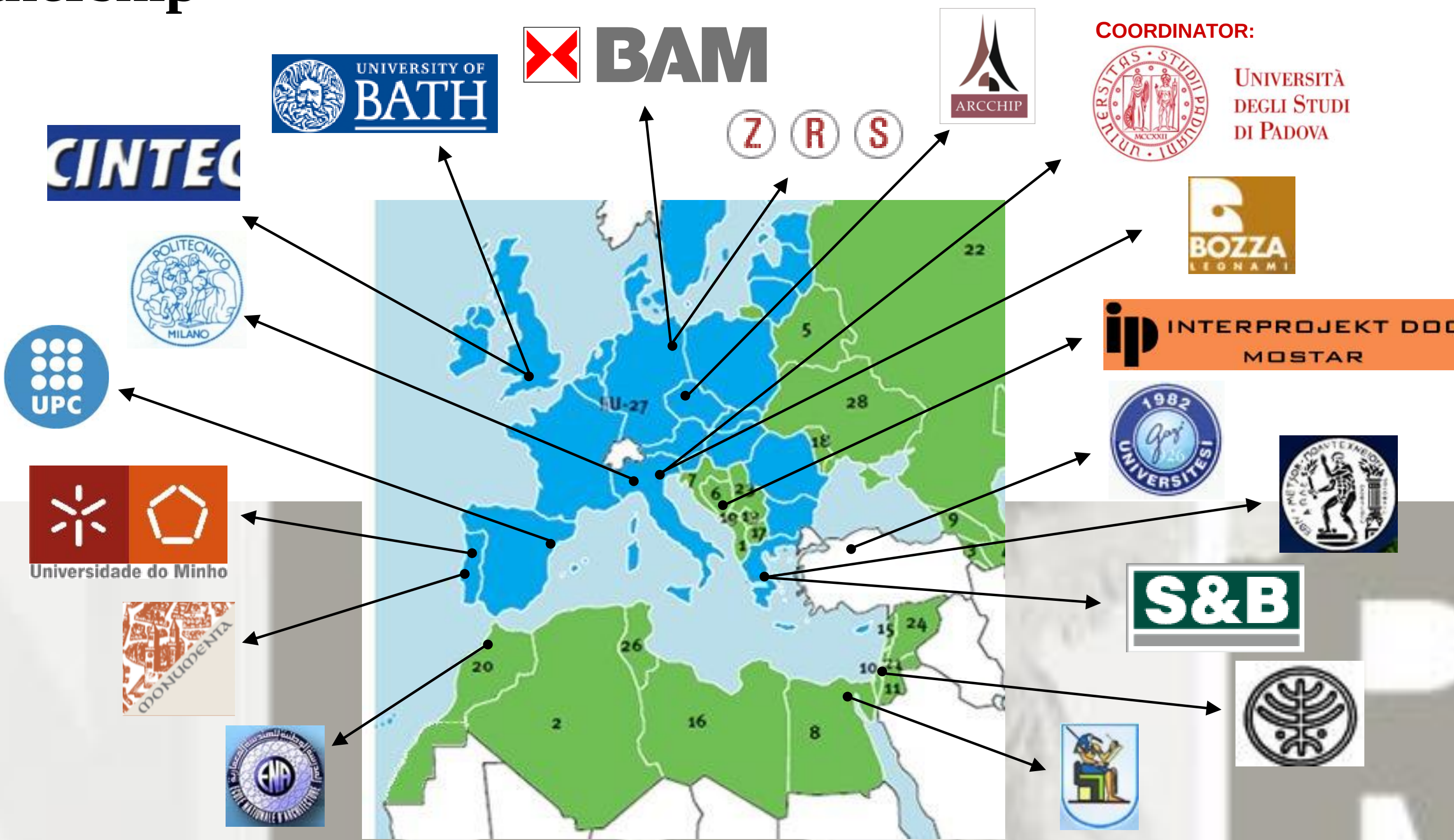
THE NIKER PROJECT

Innovation in the following areas

- **Materials and techniques for intervention**
- **Studies and techniques for structural connections**
- **Testing and sub-structuring test methods**
- **Optimization approach for CH buildings**
- **Monitoring and early warning systems**
- **Integrated, multidisciplinary approach for CH**
- **Standardization**

THE NIKER PROJECT

Partnership



- 18 partners
- 12 countries
- 9 Universities
- 2 Research centres
- 6 Enterprises
- 1 Public body

WP3 - DAMAGE BASED SELECTION OF TECHNOLOGIES

NIKER catalogue: https://niker.isqweb.it/

CONSTRUCTION TYPOLOGIES


Buildings and Palaces


Religious buildings


Towers

CONSTRUCTION ELEMENT

- **WALL**
- FLOOR
- ROOF
- ARCH/VAULT
- CONNECTION
- SUB-ASSEMBLY

MATERIAL	TYPOLOGY	FAILURE MECHANISMS: IN-PLANE FAILURE	OUT OF PLANE OVERTURNING	OUT-OF-PLANE FLEXURE	LAYER SEPARATION
EARTH MASONRY	ADOBE	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1 INTERVENTION 2	
	RAMMED	INTERVENTION 1	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1	
	COB	INTERVENTION 1	INTERVENTION 1	INTERVENTION 1	
STONE MASONRY	SINGLE-LEAF	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1	INTERVENTION 1	INTERVENTION 1 INTERVENTION 2
	MULTI-LEAF	INTERVENTION 1	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1	INTERVENTION 1 INTERVENTION 2
BRICK MASONRY	SINGLE-LEA	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1	INTERVENTION 1	INTERVENTION 1
	MULTI-LEAF	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1	INTERVENTION 1 INTERVENTION 2	INTERVENTION 1

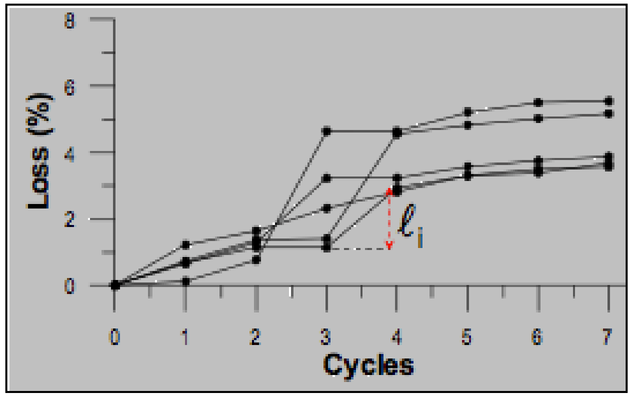
PRE-INTERVENTION PARAMETERS

Property	Symbol [Units]	Description	Range of values
Apparent density	ρ [kg/m3]		
Elastic Modulus	E [N/mm^2]		
Shear modulus	G [N/mm^2]		
Compressive strength	f_c [N/mm^2]		
Initial shear strength	f_{v0} [N/mm^2]		
Tensile strength	f_t [N/mm^2]		
….	…		

WP3 - DAMAGE BASED SELECTION OF TECHNOLOGIES

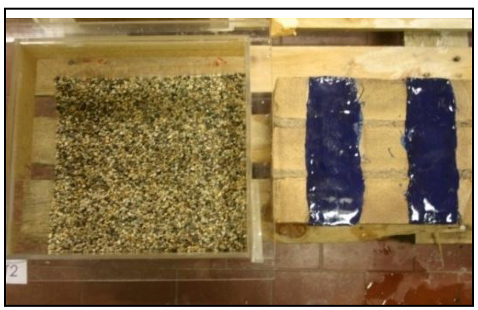
Critical evaluation of the effectiveness and compatibility of the new materials

DURABILITY OF COMMERCIAL NATURAL HYDRAULIC LIME MORTARS

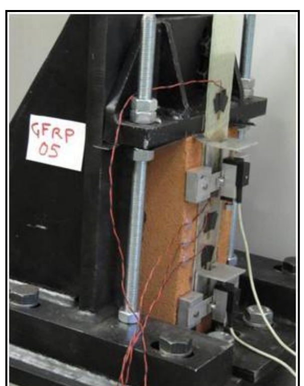


INJECTABILITY OF GROUT ADMIXTURES ON STONE MASONRY WALLS

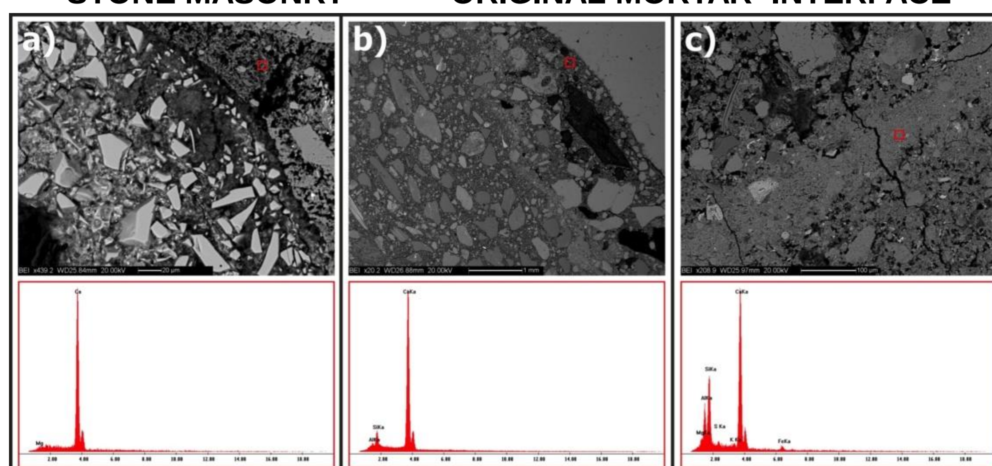
DURABILITY OF FRP APPLICATIONS ON BRICK MASONRY



BOND BEHAVIOUR OF FRP APPLIED ON BRICK MASONRY

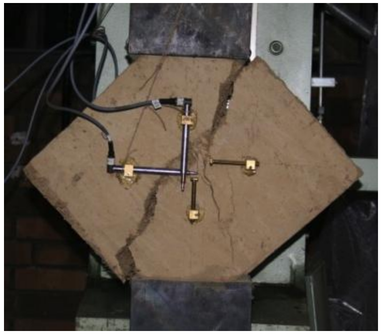


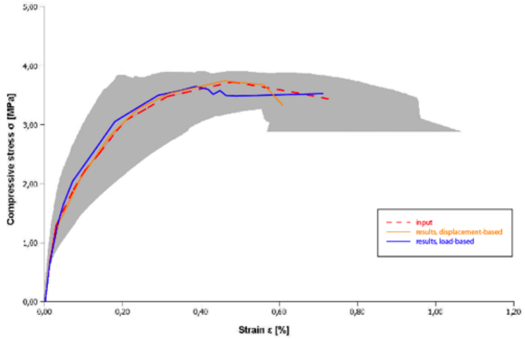
MICROSTRUCTURAL CHARACTERIZATION OF GROUT TO STONE MASONRY ORIGINAL MORTAR INTERFACE



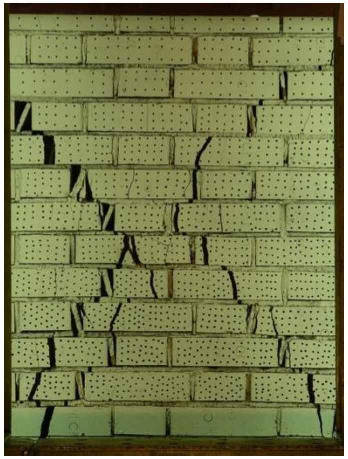
WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

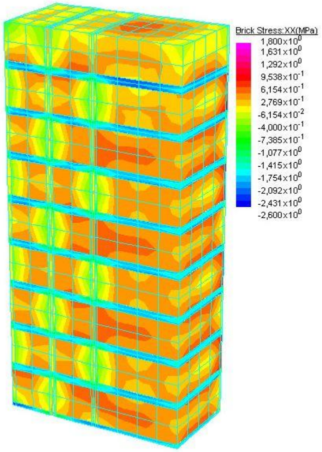
Intervention techniques, testing, modelling and design equations for:





- **Earthen walls**



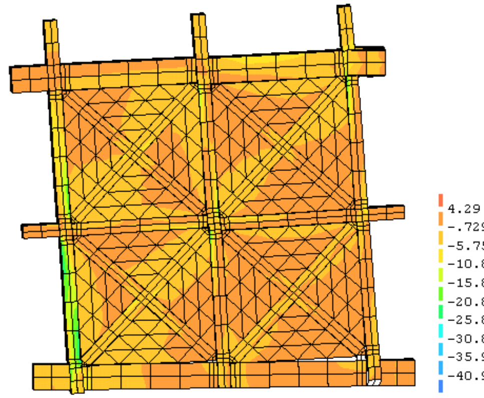


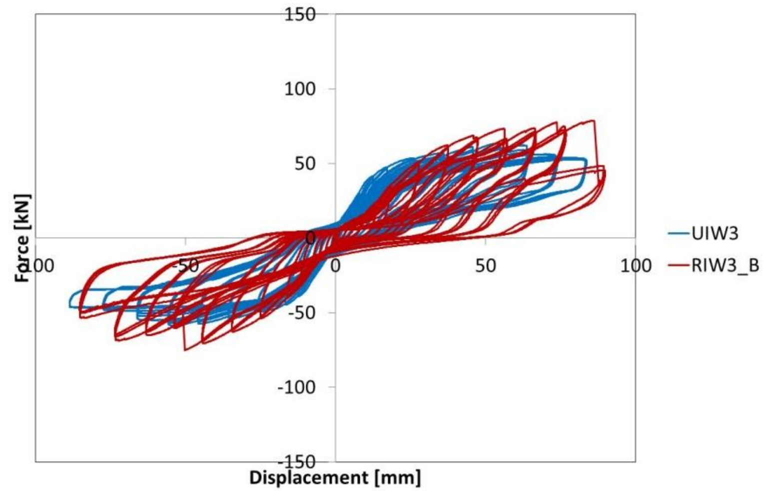
- **Brick walls**

WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

Intervention techniques, testing, modelling and design equations for:

$$\begin{cases} f_{wc,0} = (V_{ex}/V)\cdot f_{ex,c} \\ f_{wc,s} = f_{wc,0} + (V_{\inf}/V)\cdot f_{\inf,s} \end{cases}$$





- **Multi-leaf stone walls**
- **Half-timbered walls**

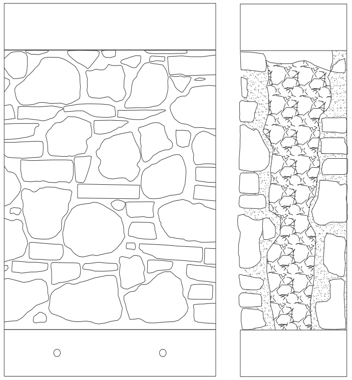
WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

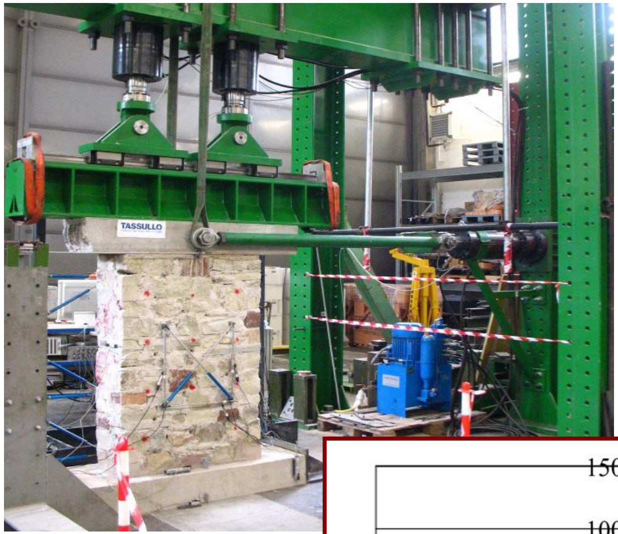
Technological solutions for vertical elements: walls and pillars, with compatibility, durability, effectiveness, feasibility and design related issues, based on:

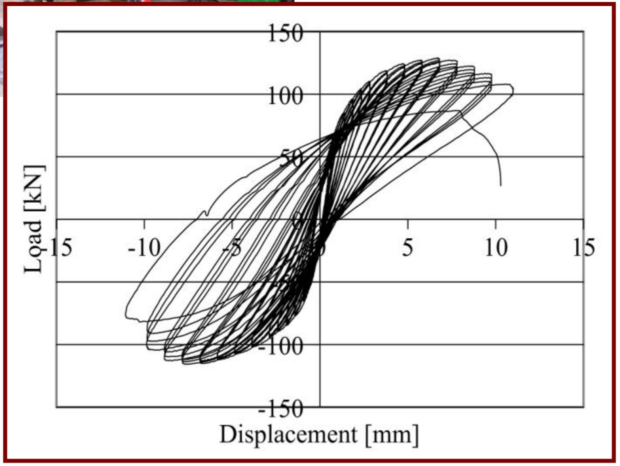
- Injection with nano-hydraulic-limes, micro-silica, earthen grouts
- Repointing and reinforced repointing
- FRP-SRP/SRG application
- Glass fibre, geo textiles and stainless steel elements

WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

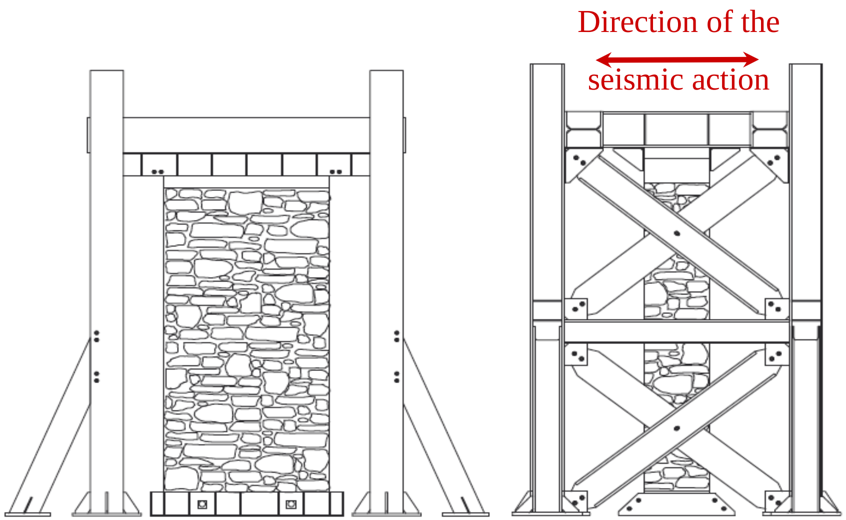
GROUT INJECTION OF STONE MASONRY WALLS:
monotonic and cyclic compression tests of three-leaf stone masonry walls







WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

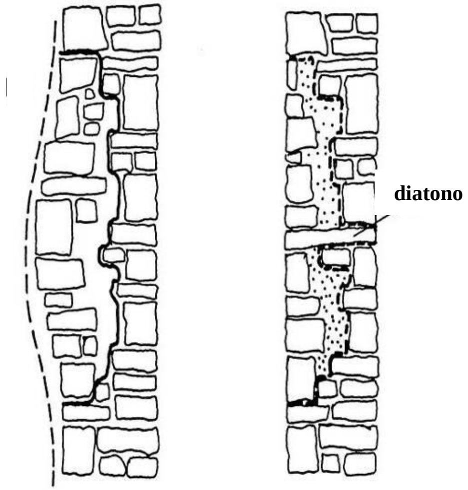


Shaking table tests on out-of-plane behaviour of single structural elements: stone masonry wall

Strengthened by:

- Injections
- Steel ties
- Both; injections + steel ties

Application of transversal elements and ties to walls:

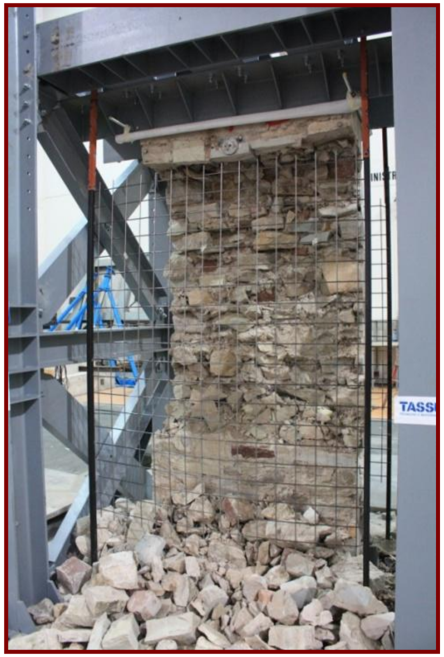


- Improvement in the strength of the wall
- Reduction of the dilatancy of the walls

WP4: OPTIMIZATION OF DESIGN FOR VERTICAL ELEMENTS

Shaking table tests on out-of-plane behavior of single structural elements: stone masonry wall

- Failure mechanisms;
- Variation of dynamic characteristics (frequencies, mode shapes);



Unstrengthened condition

0.25g

Strengthened using ties

0.45g

Strengthened using injection

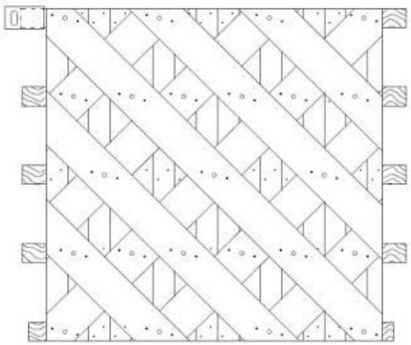
0.60g

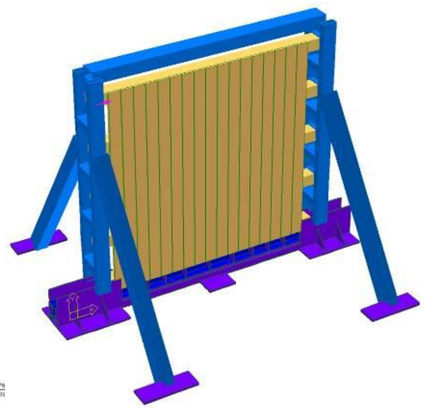
Strengthened using ties and injection

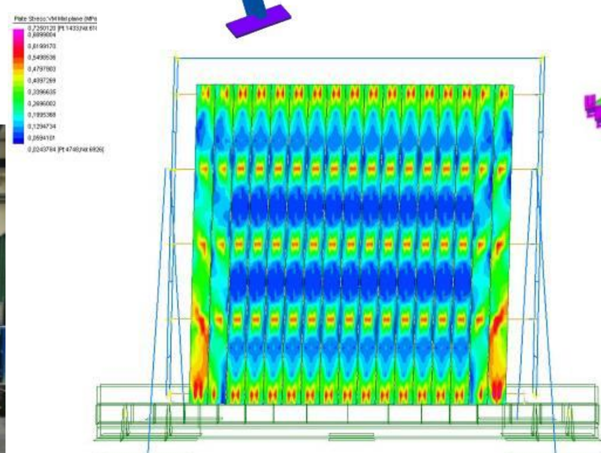
0.75g

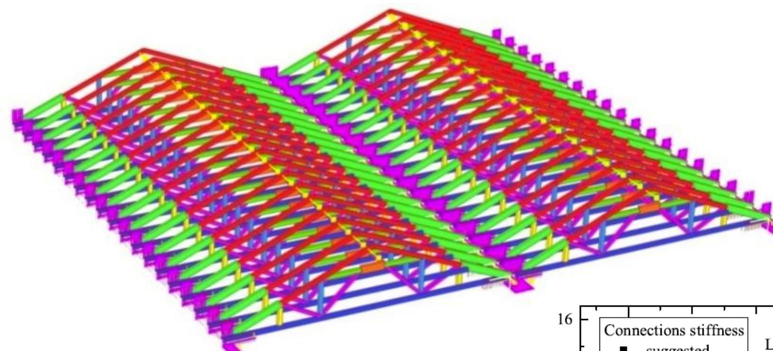
WP5: OPTIMIZATION OF DESIGN FOR HORIZONTAL ELEMENTS

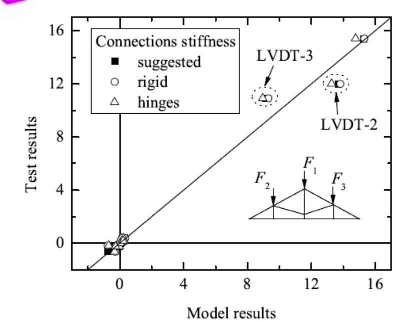
Intervention techniques, testing, modelling and design procedures for:











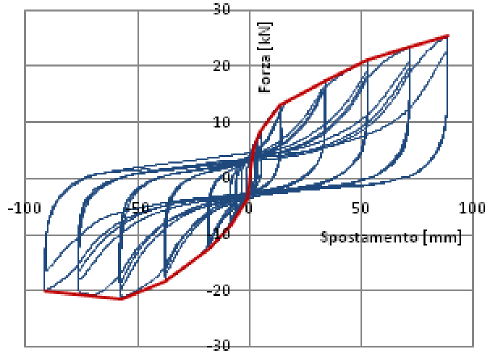
(a) 3F-C

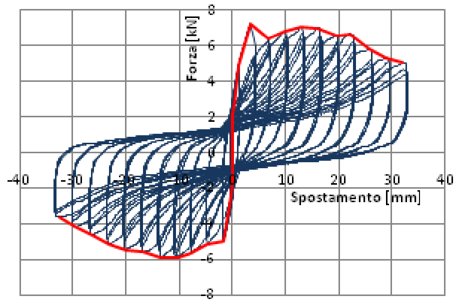
- **Wooden floors**
- **Wooden trusses/roofs**

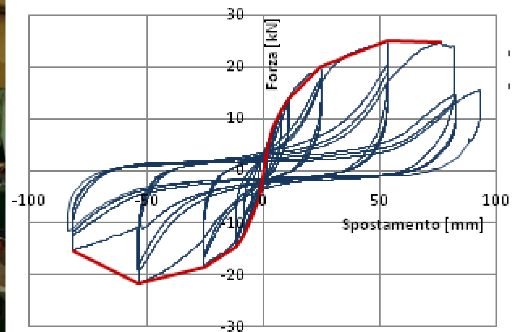
WP5: OPTIMIZATION OF DESIGN FOR HORIZONTAL ELEMENTS

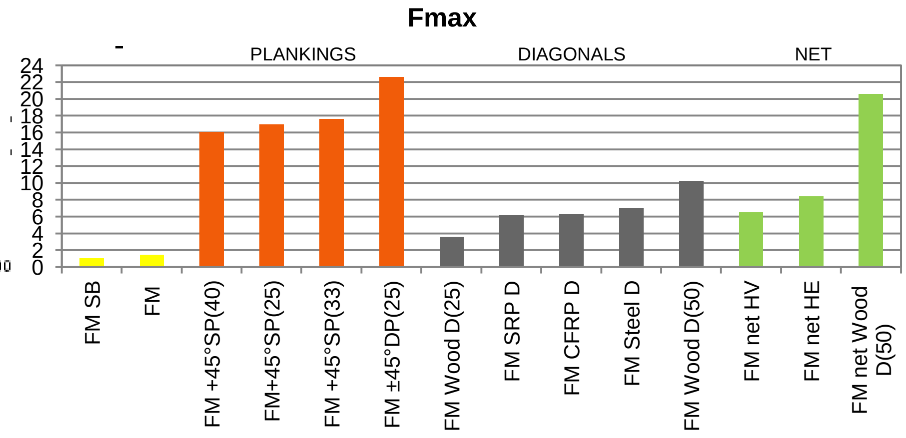
In-plane monotonic and cyclic tests on unreinforced and reinforced timber floors

Results - Examples







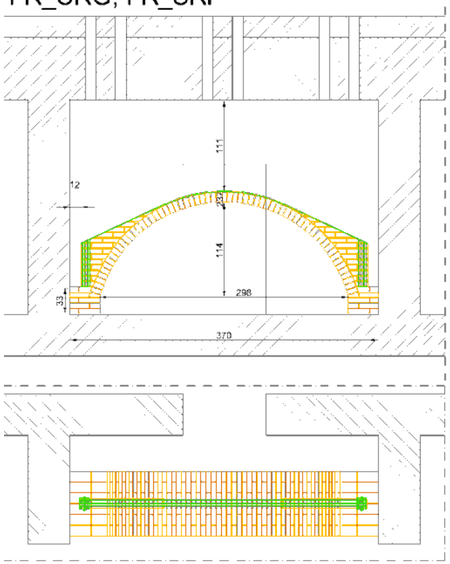


WP5: OPTIMIZATION OF DESIGN FOR HORIZONTAL ELEMENTS

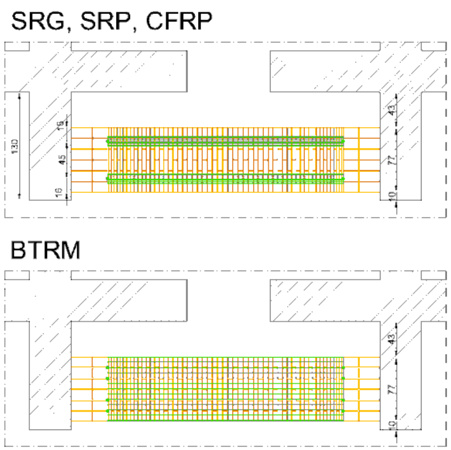
- **Brick vaults**

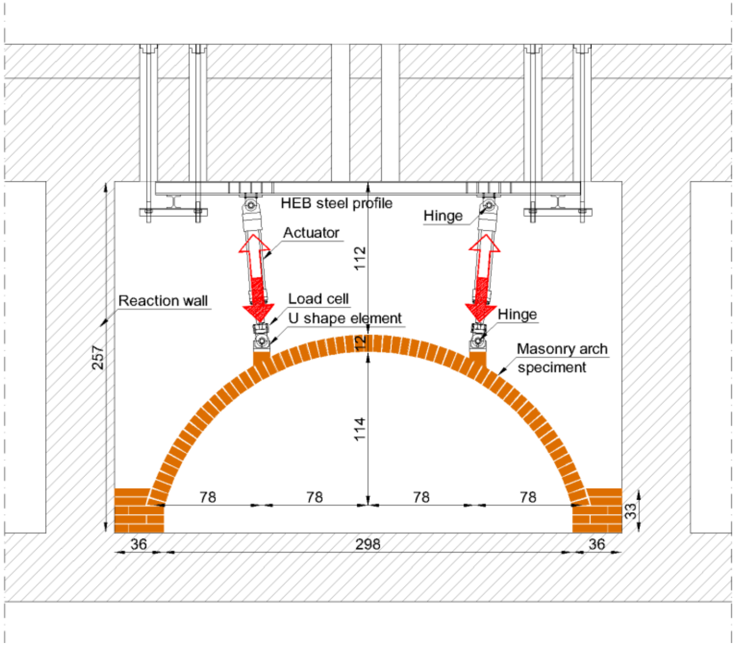
Reinforcement materials: CFRP, SRP, SRG, BTRM

WP5: OPTIMIZATION OF DESIGN FOR HORIZONTAL ELEMENTS

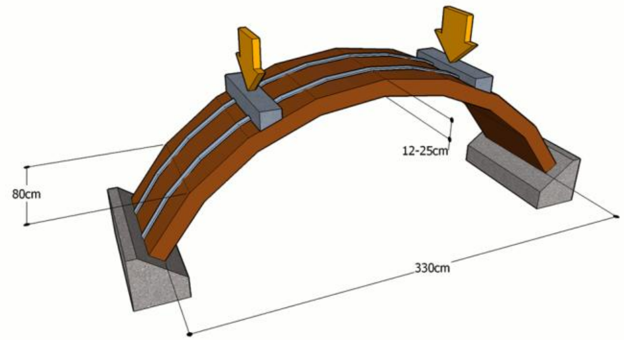


STRIP POSITION





GEOMETRY AND LOAD CONDITION

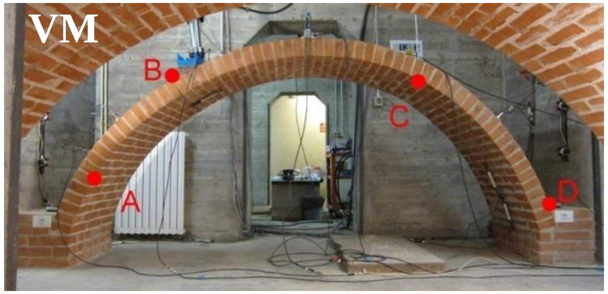


SETUP

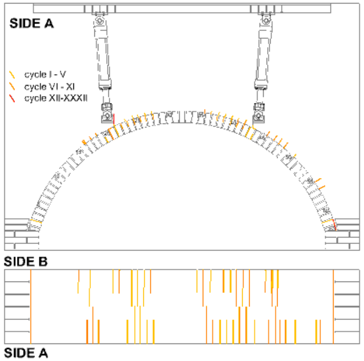
WP5: OPTIMIZATION OF DESIGN FOR HORIZONTAL ELEMENTS

FAILURE MECHANISMS

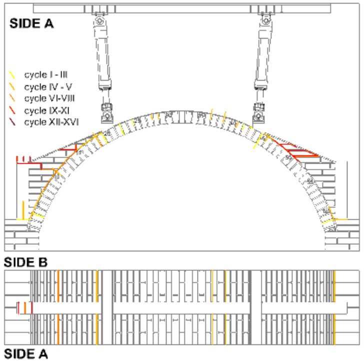
Rigid block mechanism, opening of hinges without shear failure (VM, VC_BTRM VC_FR_SRG e VC_FR_SRP)



VC_BTRM



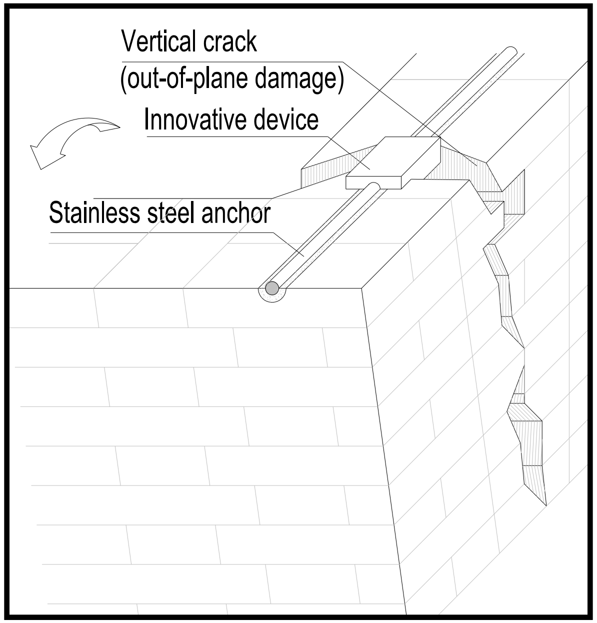
VC_FR_SRG/SRP

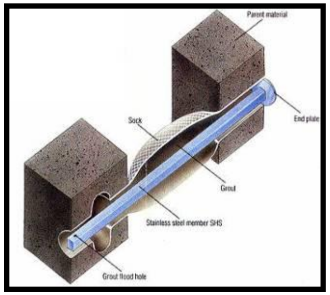


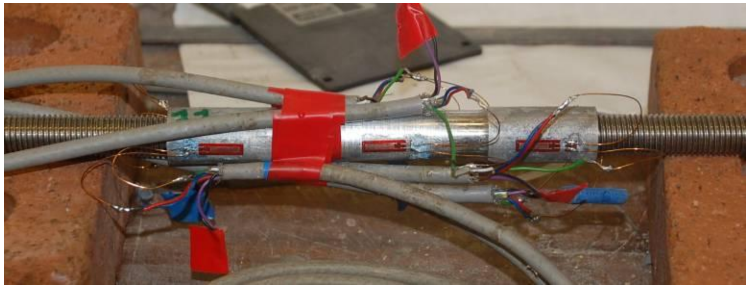
WP6: CONNECTIONS AND DISSIPATIVE SYSTEMS WITH EARLY WARNING

Intervention techniques, testing, modelling and design procedures for:



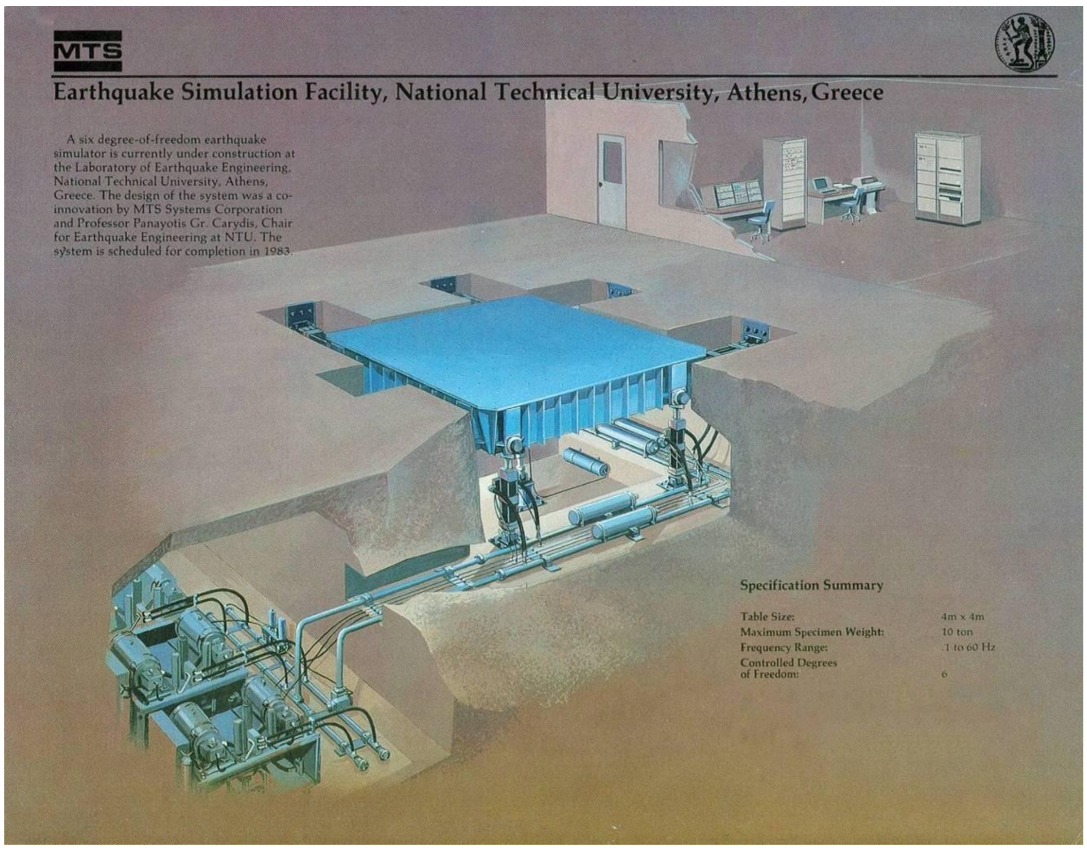



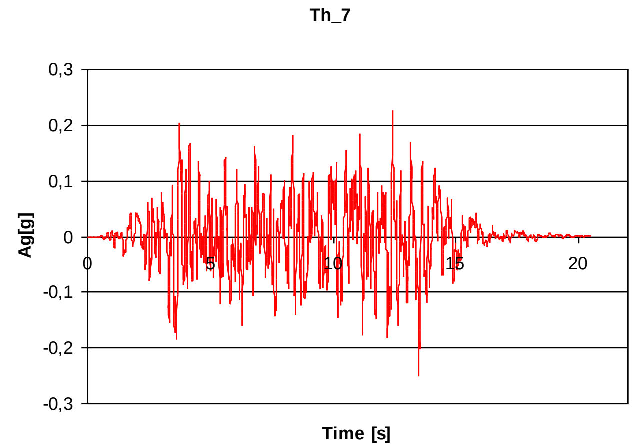


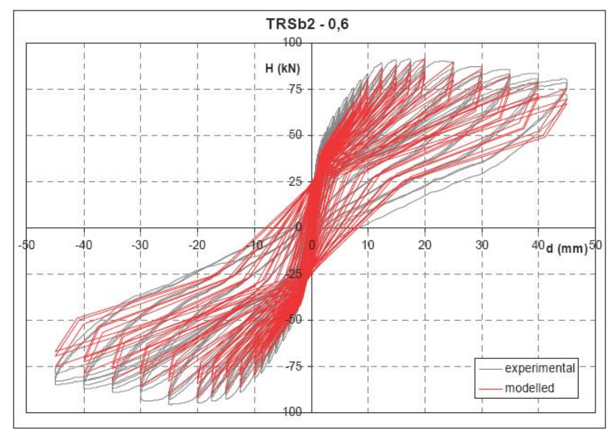


WP7: SYSTEMIC IMPROVEMENT OF SEISMIC RESPONSE

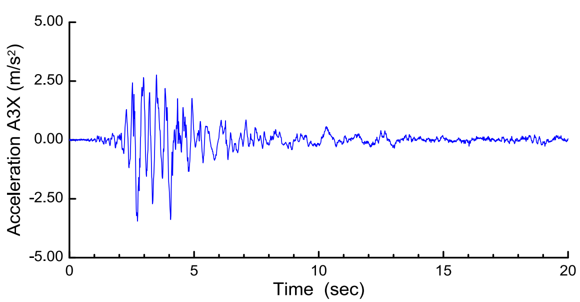
Characterization of the seismic behaviour of substructures and structures, original and strengthened with integrated interventions coming from previous tasks, by shaking table:

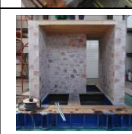




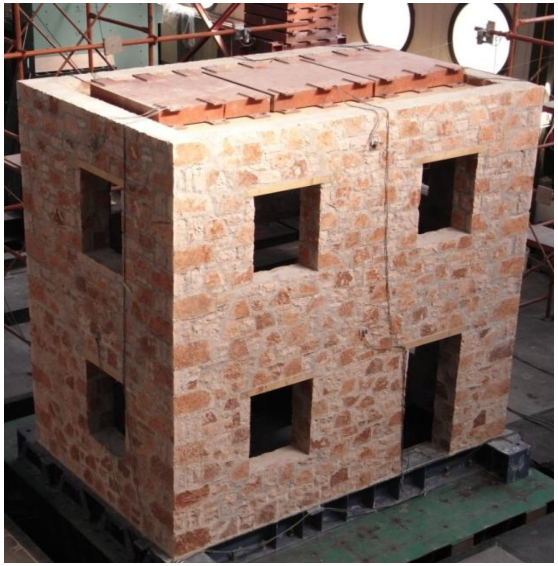


SHAKING TABLE TESTS OF SUB-STRUCTURES

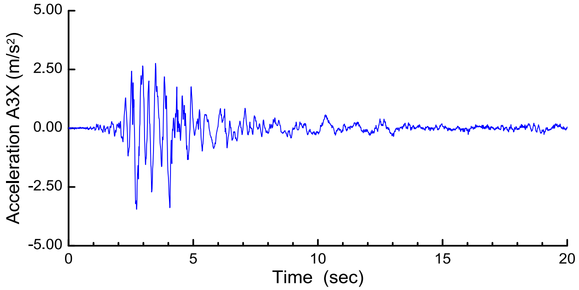


	Type of Specimen	Specimen	Materials – Description of the structure	Partner	Testing	
					Type of tests	Strengthening
1	Element		Three-leaf stone masonry	UNIPD	Shaking table tests. Out-of-plane input motion	(a) As built (b) Transverse steel ties (c) Grouting (d) Combined (b) and (c)
2	Element		Adobe	ITAM	Shaking table tests-uniaxial	Plain/reinforced walls Plain/reinforced columns
3	Subassembly		Adobe + light timber floor	BAM	Unidirectional sliding table tests	As-built
4	Subassembly		Adobe + heavy timber floor	BAM	Unidirectional sliding table tests	As-built
5	Subassembly		Adobe + light roof with stiff diaphragm	BAM, ITAM	Unidirectional sliding table tests	As-built
6	Subassembly		Three-leaf stone masonry piers + timber floor	NTUA	Shaking table tests- uniaxial	(a) As built (b) Grouting, enhancement of diaphragm action of floor
7	Subassembly		Three-leaf stone masonry piers + brick arches and cross vault	NTUA	Shaking table tests. Motion along two axes	(a) [As built] (b) Grouting, timber struts, steel ties, external vertical prestressing

SHAKING TABLE TESTS OF MODEL BUILDINGS



	Type of specimen	Specimen	Materials – Description of the structure	Partner	Testing	
					Type of tests	Strengthening
1	Model building		Three-leaf stone masonry + timber floors (double planking and steel ties)	UNIPD	Shaking table tests. Motion along two axes	(a) As-built (b) Grouting
2	Model building		Three-leaf stone masonry + timber floors (double planking and steel ties)	UNIPD	Shaking table tests. Motion along two axes	(a) Grouting
3	Model building		Three-leaf stone masonry + timber floors	NTUA	Shaking table tests. Motion along two axes	(a) As built (b) Grouting of masonry and enhancement of diaphragm action of floors
4	Model building		Three-leaf stone masonry + timber floors + timber laces	NTUA	Shaking table tests. Motion along two axes	(a) As built (b) Grouting (c) Enhancement of diaphragm action of top floor



WP7: SYSTEMIC IMPROVEMENT OF SEISMIC RESPONSE

Dynamic behaviour whole structures Building Models

Floor Dimensions: 2.40m x 2.8m

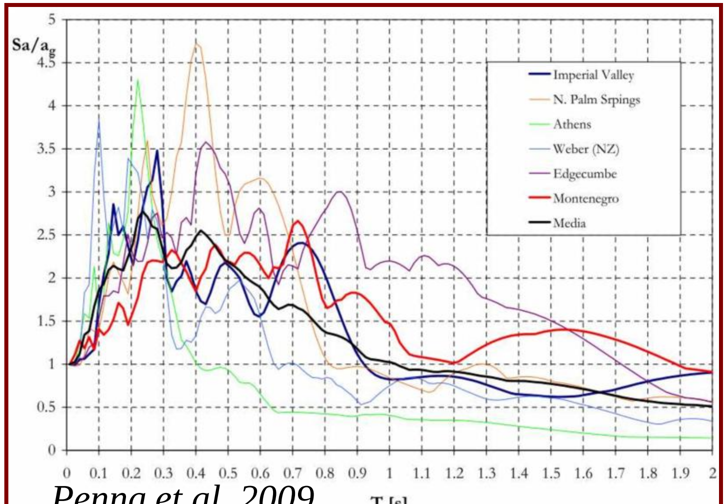
Masonry deepness: 0.33m (12cm external layers 9cm internal filler)

Height: 3.60m

Double planking wooden floors

Regular openings

Additional masses (500kg per floor)

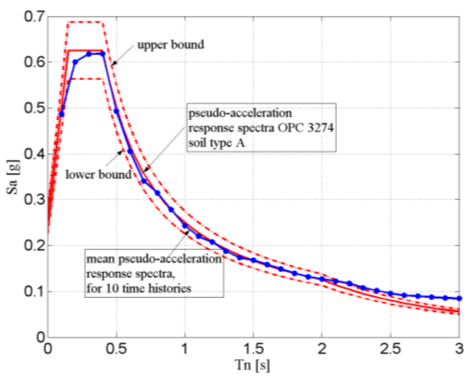


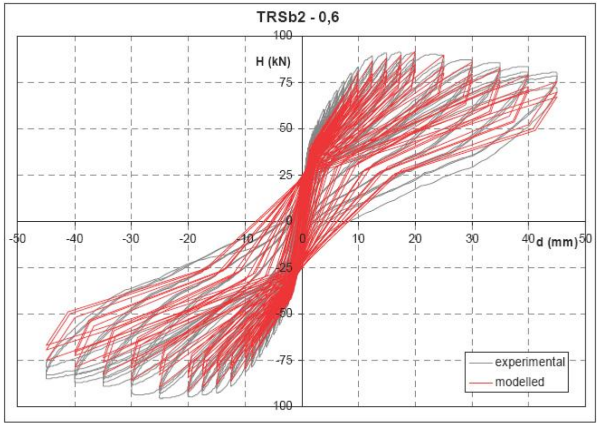
Penna et al. 2009

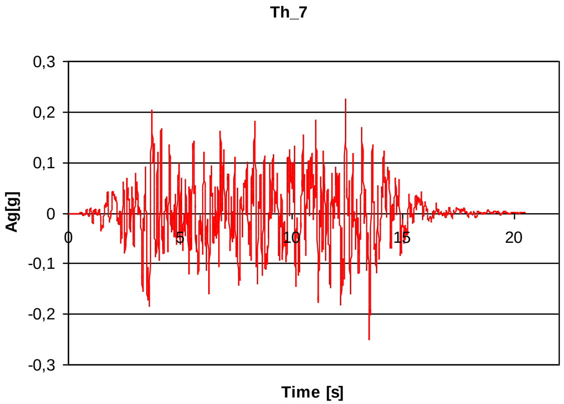
Montenegro earthquake (14/4/1979) was chosen and the signal was elaborated considering the scale factor of 2:3

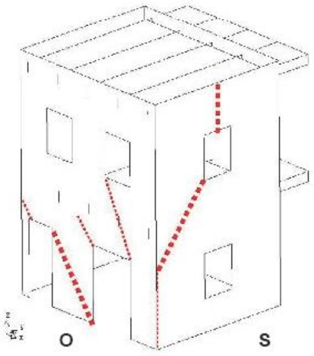
WP8: PARAMETRIC MODELLING OF STRUCTURAL BEHAVIOUR

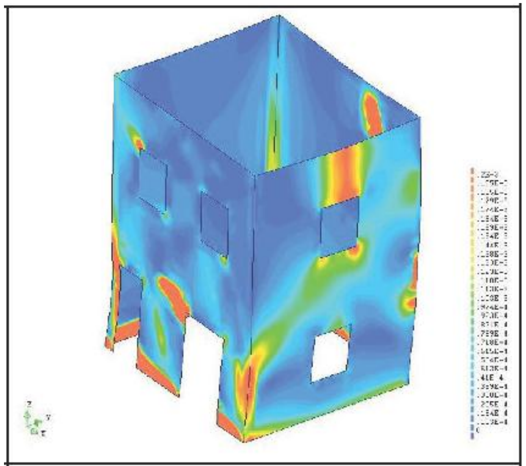
- Reliable models for connections and substructures;
- parametric assessment for identifying interactions;
- sensitivity study to quantify building seismic performance and response parameters;
- development of optimized performance based design procedures;

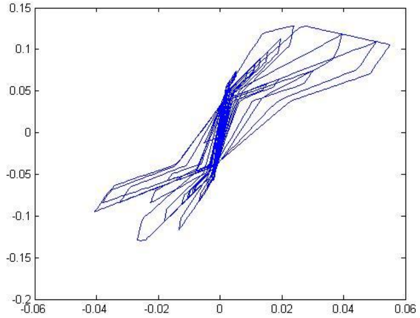












WP9: KNOWLEDGE BASED ASSESSMENT

- **15 case-studies, well representative of various typologies**
- **Entire methodology, including intervention with developed techniques**
- **Cooperation among partners, geographical distribution**

INSPECTION	MONITORING	MODELLING	INTERVENTION
✗	✗	✗	✗

- **Example:**

S. BIAGIO&S.GIUSEPPE CHURCHES (L'AQUILA)

PARTNERS INVOLVED: UNIPD, POLIMI, UBATH, CINTEC

COORDINATING PARNER: UNIPD

- **DAMAGE SURVEY AND NEED FOR INTERVENTION**

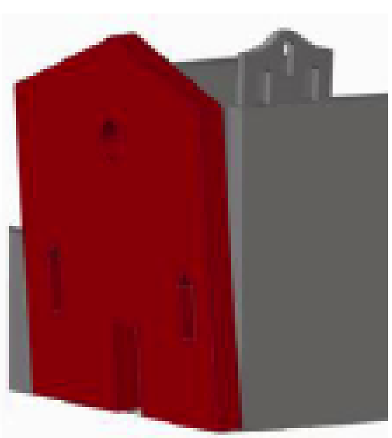
WP9: KNOWLEDGE BASED ASSESSMENT

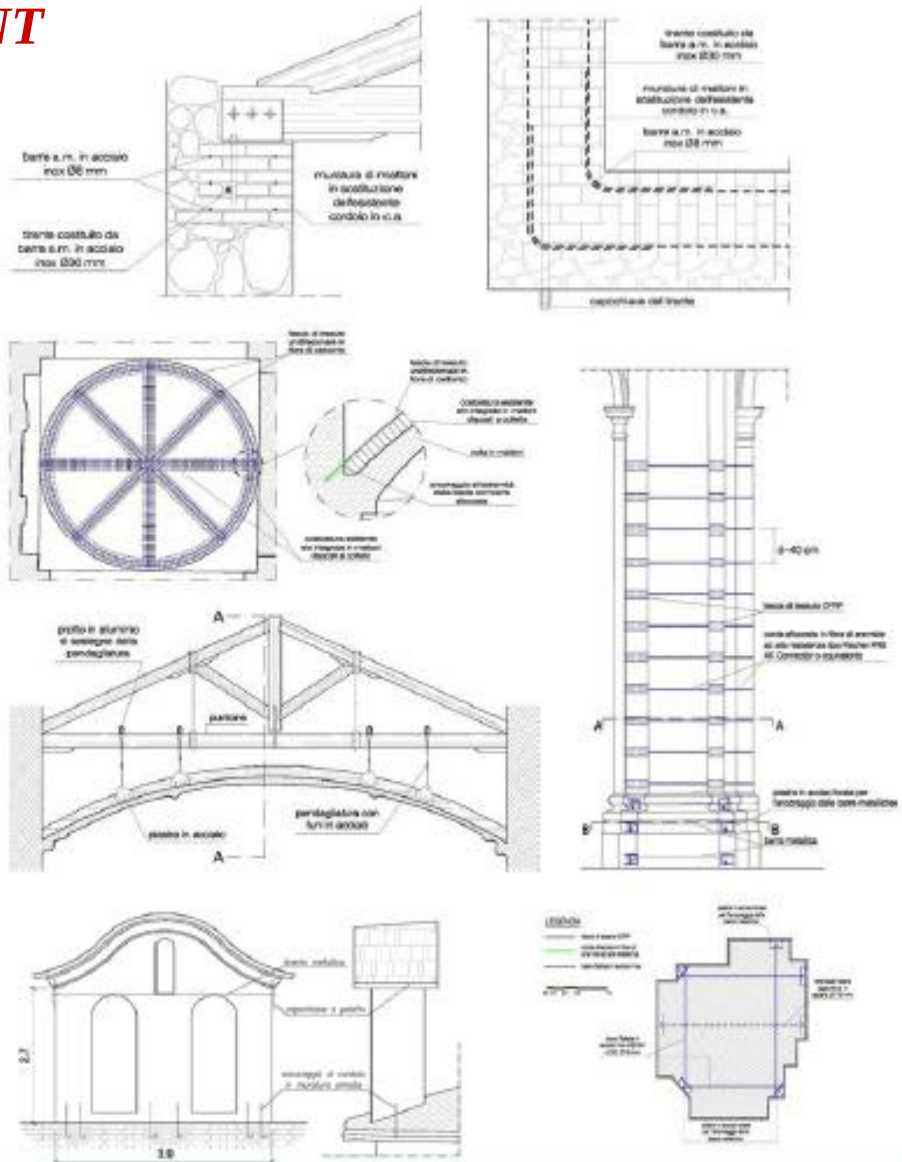
S. BIAGIO&S.GIUSEPPE CHURCHES (L'AQUILA)

PARTNERS INVOLVED: UNIPD, POLIMI, UBATH, CINTEC

COORDINATING PARNER: UNIPD

- INVESTIGATION AND MONITORING
- PROVISIONAL INTERVENTIONS
- MODEL CALIBRATION AND UPDATING
- STRENGTHENING INTERVENTIONS





WP10: GUIDELINES FOR END-USERS

Public bodies, authorities

Stakeholder, owners

Architects/ Engineers

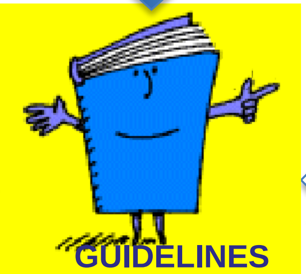
Service providers

Designers

Industry

Standardization & research

Construction companies



EUROPE

WORLD

- D10.1: GUIDELINES FOR DESIGN & EXECUTION OF INTERVENTIONS
- D10.2: GUIDELINES FOR ASSESS. & IMPR. OF CONNECTIONS & BUILDINGS
- D10.3: GUIDELINES FOR STICK-SLIP & HYSTERETIC DISSIPATIVE ANCHORS
- D10.4: GUIDELINES FOR SEISMIC ANALYSIS & KNOWLEDGE BASED ASSESS
- D10.5: INTEGRATED METHODOLOGY FOR PROTECTION & IMPROVEMENT OF CH

TECH

METH

ProVaCI - PON01J32324 (PON R&C 2007-2013)
Technologies for seismic protection and enhancement of cultural complexes

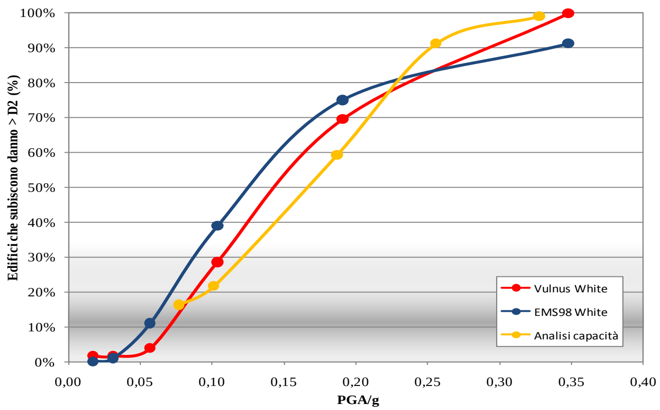
PARTERSHIP

STRESS s.c.a r.l. : COORDINATOR
Consorzio TRE - Università degli Studi di Napoli "Federico II
Consorzio Cetma, SI.PRE. S.r.l.,
Università degli Studi di Padova, C.R.A.C.A. Soc. Coop., Veneto Nanotech S.c.ar.l.

Development of sustainable techniques and reliable methodologies for seismic protection, sustainable regeneration, enhancement and enjoyment of masonry structures and archaeological sites of historic and artistic interest

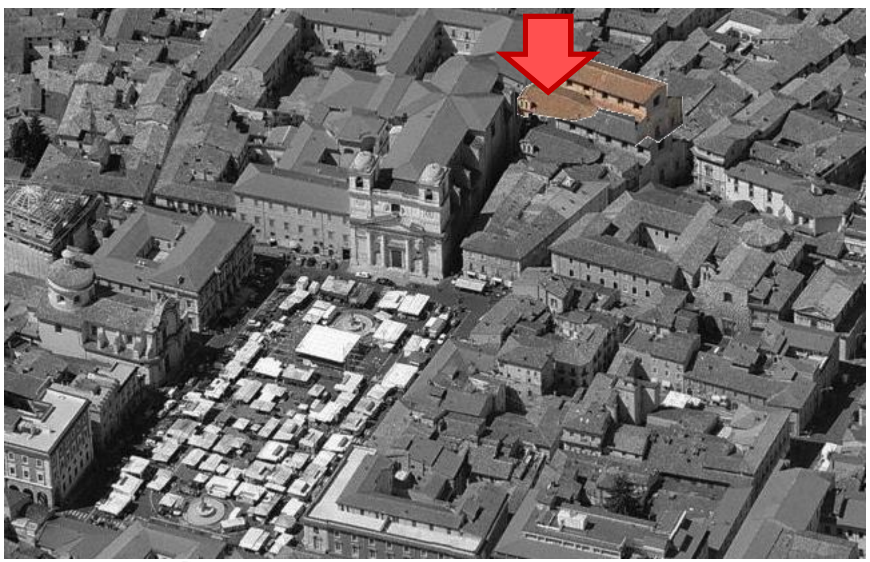
OBJECTIVES

- OR 1 **Development and innovative methodologies for the evaluation of the seismic vulnerability at territorial scale**
- OR 2 Integration of knowledge processes
- OR 3 Study of high-tech solutions for the mitigation of risk
- OR 4 Evaluation of sustainability of solutions for seismic protection
- OR 5 Integration of innovative techniques and methods of monitoring
- OR 6 Methodologies and tools for the development of complex historical and artistic interest
- OR 7 Demonstrators



DEVELOPMENT AND INNOVATIVE METHODOLOGIES FOR THE EVALUATION OF THE SEISMIC VULNERABILITY AT TERRITORIAL SCALE

- Analysis and selection of existing methods for vulnerability assessment;
- Study of correlations between structural vulnerability and artistic asset;
- Implementation of the levels of analysis for a coordinated assessment between territory, complex structures and fine art;
- Identification of priorities.



Seismic vulnerability analysis of historic buildings at a **territorial level**

Simplified methodologies and models, that are reliable, based on empiric parameters

Level of analysis

Level 0: general data from inventories or censuses (ANCITEL, ISTAT…), typological classes definitions
Level 1:speed survey on typological base, more information about structural behaviour
Level 2: detailed tests and surveys, damage observation, study of the buildings in great detail
(Level 3: study in order to define intervention for the seismic improvement of the building)

RECONTRUCTION PLAN

AREA OMOGENEA 4

Comune di Castel del Monte
Sindaco Luciano Mucciante

Comune di Castelvecchio Calvisio
Sindaco Dionisio Ciuffini

Comune di Santo Stefano di Sessanio
Sindaco Antonio D'Aloisio

Comune di Villa Santa Lucia degli Abruzzi
Sindaco Maria Pia Colagrande

- UNIVERSITÀ DEGLI STUDI DI PADOVA
prof. ing. Claudio Modena

- CONSIGLIO NAZIONALE DELLE RICERCHE
Istituto per le Tecnologie della Costruzione - sede di L'Aquila
ing. Giandomenico Cifani,

- POLITECNICO DI MILANO
Dipartimento di Progettazione dell'Architettura
prof. arch. Maria Grazia Folli

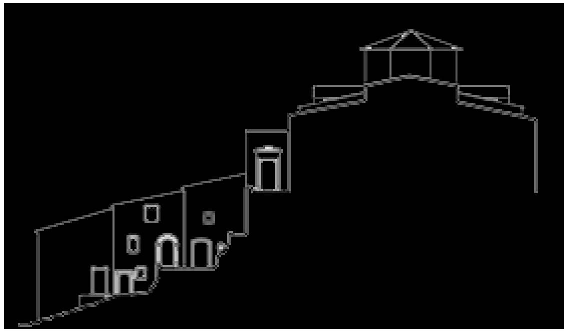
Dipartimento di Ingegneria Strutturale
prof. arch. Luigia Binda

- UNIVERSITÀ "SAPIENZA" DI ROMA
Scuola di Specializzazione in Beni Architettonici e del Paesaggio
prof. arch. Giovanni Carbonara

IDENTIFICATION AREA: CASTEL DEL MONTE

Castel del Monte is a fortified village characterized by:

- narrow streets,
- small squares,
- four towers,
- terraced houses
- wall-houses
- outside stairs

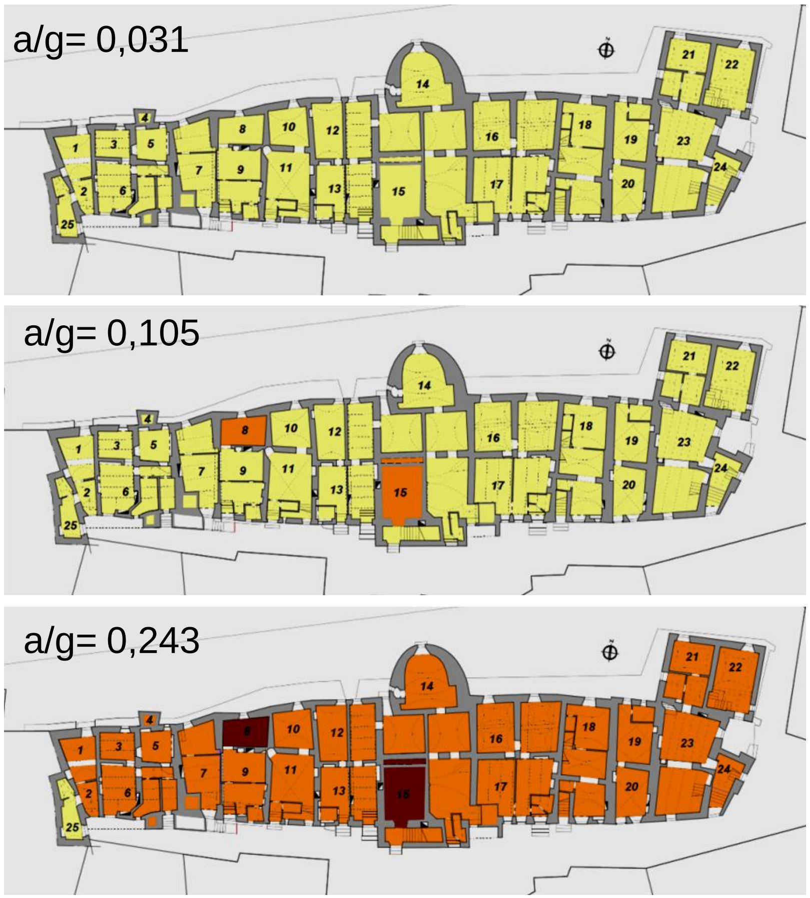


METHODOLOGY OF THE STUDY: SEISMIC VULNERABILITY ANALYSIS

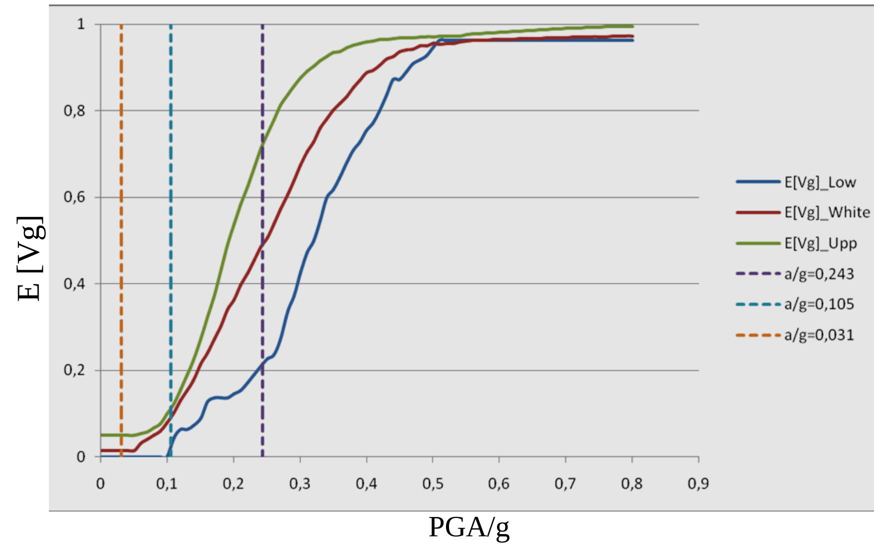
Vulnus provides global vulnerability assessments and it assesses the critical horizontal average acceleration level corresponding to the activation of in-plane mechanisms (I1 index) or out-of-plane mechanisms (I2 index).

METHODOLOGY OF THE STUDY: SEISMIC VULNERABILITY ANALYSIS

Vulnerability of the structural units



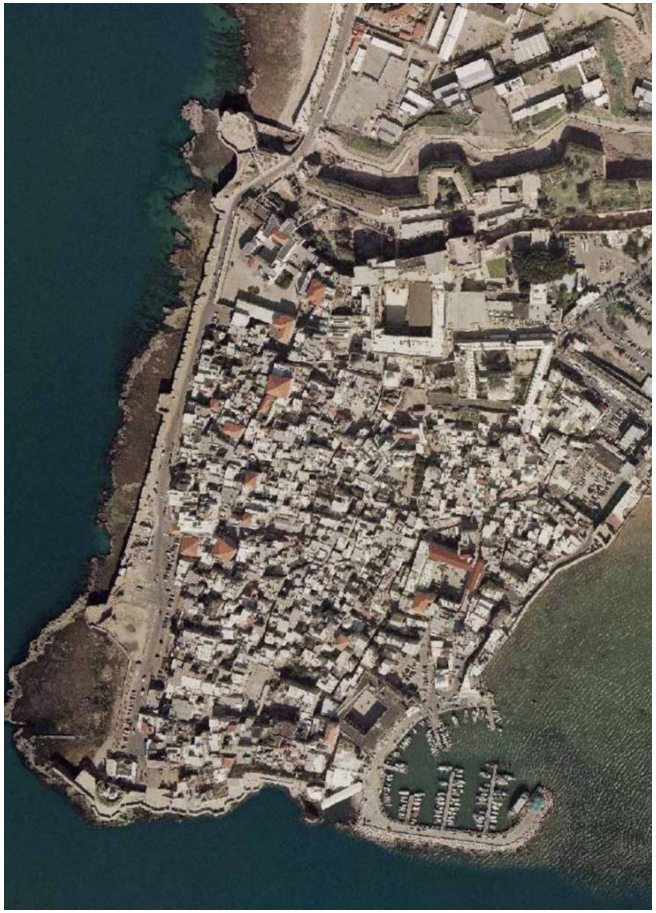
VERY LOW LOW MEAN HIGH VERY HIGH



- a/g = 0,031 earthquake 06/04/2009
  Very Low
- a/g = 0,105 earthquake 13/01/1915
  Very Low
- a/g = 0,243 according to the italian code
  Mean

Vulnerability assessment – fragility curves

Seismic vulnerability assessment on an urban scale: ISRAEL



Acre

Zefat

- Identification of the blocks

Block 3

Acre

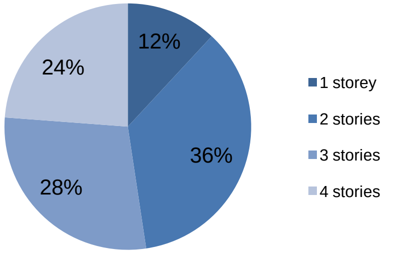
- Photographic survey

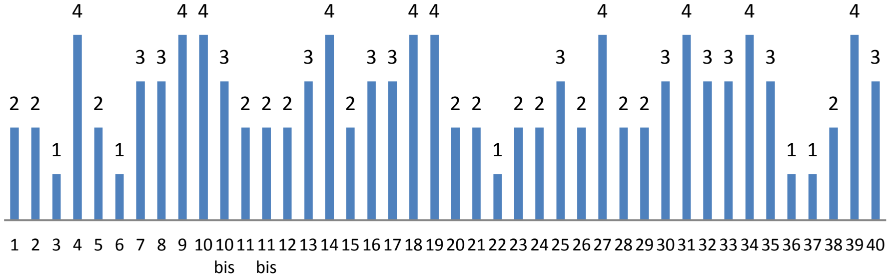
Acre

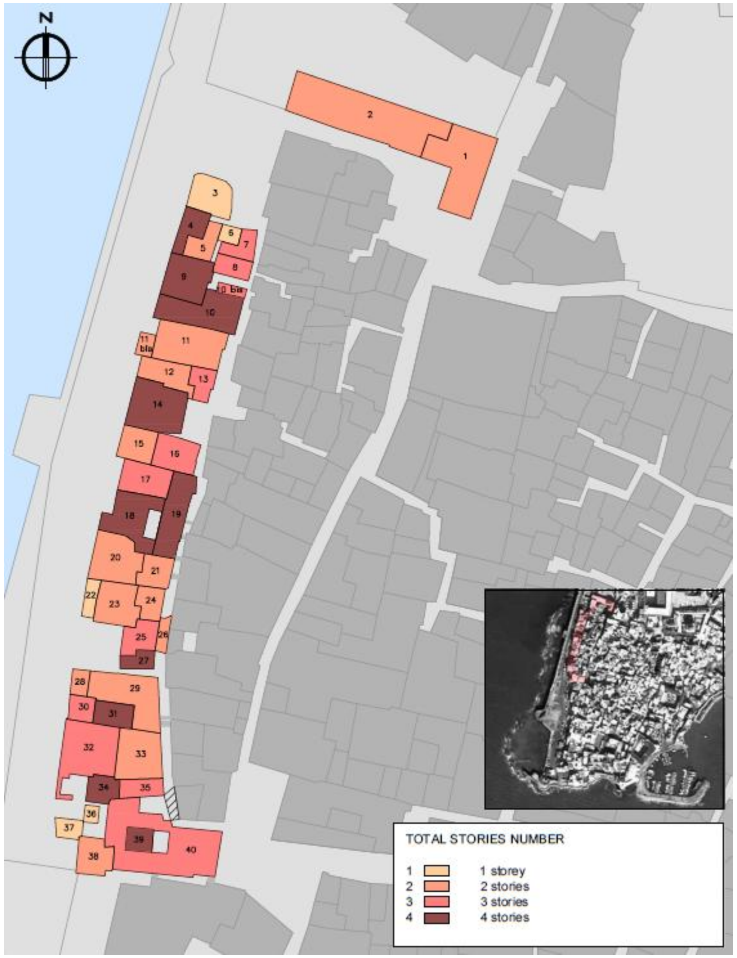
- Data analysis

Total stories number

TOTAL STORIES NUMBER	n.	%
1 storey	5	11.9
2 stories	15	35.7
3 stories	12	28.6
4 stories	10	23.8





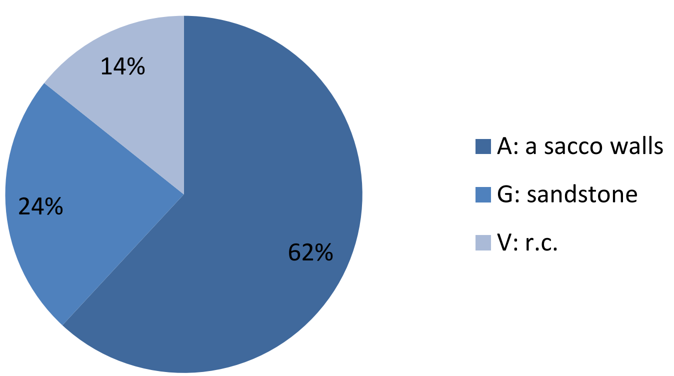


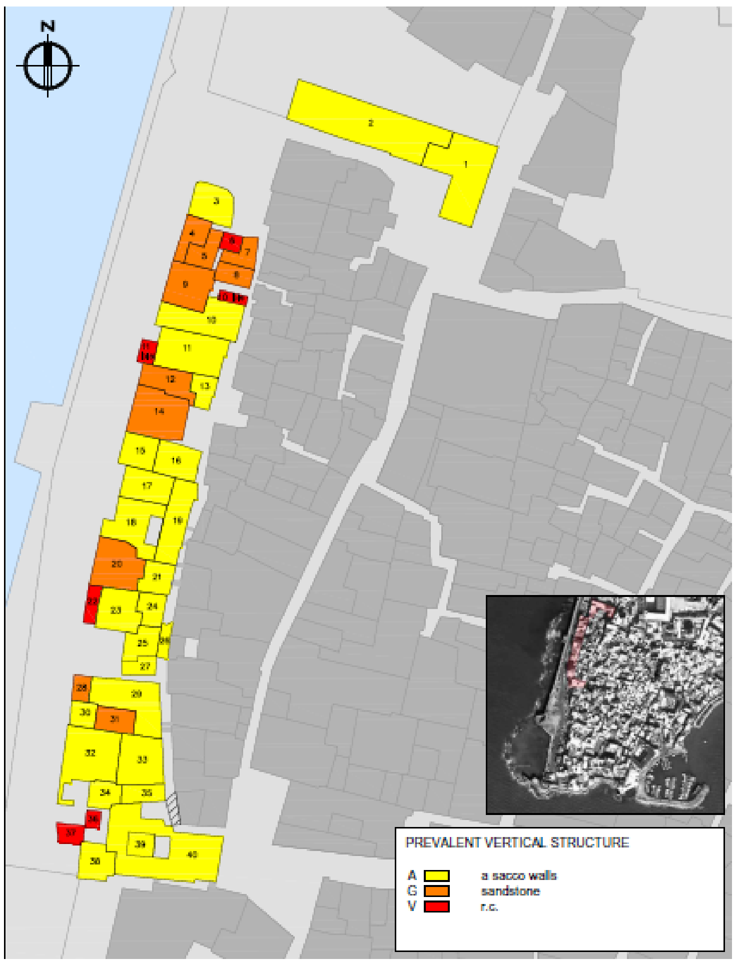
Acre

- Data analysis

Prevalent vertical structure

PREVALENT VERTICAL STRUCTURE	n.	%
A: a sacco walls	26	61.9
G: sandstone	10	23.8
V: r.c.	6	14.3

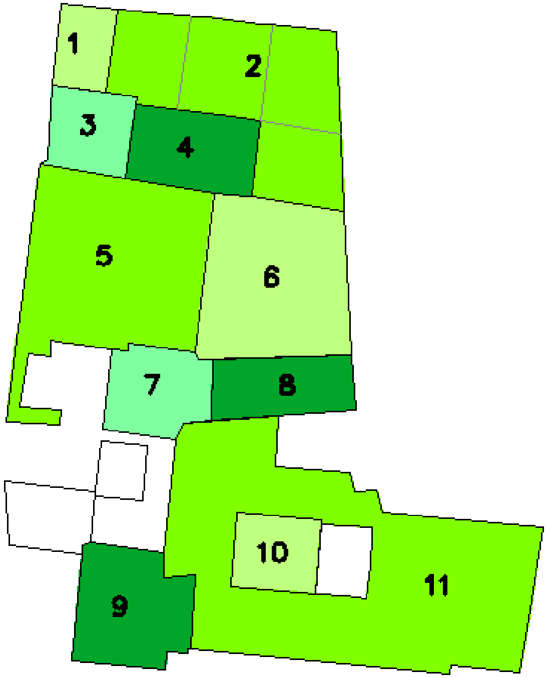




Acre

- Vulnus results

Vulnus S.U. identification

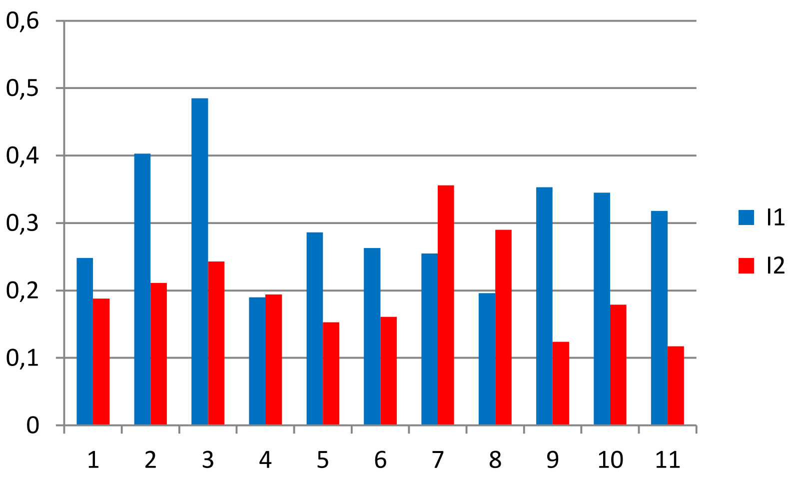


Acre

- Vulnus results

Using I1 and I2 indexes, Vulnus gives a preliminary vulnerability analysis. When the I1 index value is bigger than the I2 value, it means that the highest vulnerability is obtained for out of plane mechanisms.

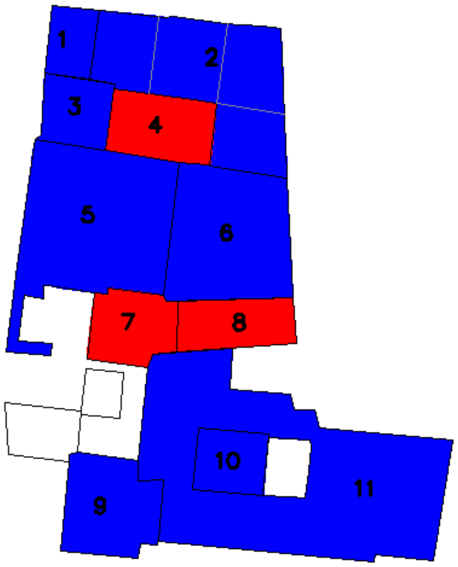
S.U.	I1	I2	I1/I2
1	0,248	0,188	1,318
2	0,403	0,211	1,911
3	0,485	0,243	1,997
4	0,19	0,194	0,977
5	0,286	0,153	1,868
6	0,263	0,161	1,631
7	0,255	0,356	0,715
8	0,196	0,29	0,677
9	0,353	0,124	2,839
10	0,345	0,179	1,923
11	0,318	0,117	2,711



Acre

I1>I2 VULNERABILITY FOR OUT OF PLANE MECHANISM

I2>I1 VULNERABILITY FOR IN PLANE MECHANISM



A probabilistic methodology

Different levels of knowledge of the starting information:

- Tridimensional aereo-photogrammetric survey;

- laser scanner survey;

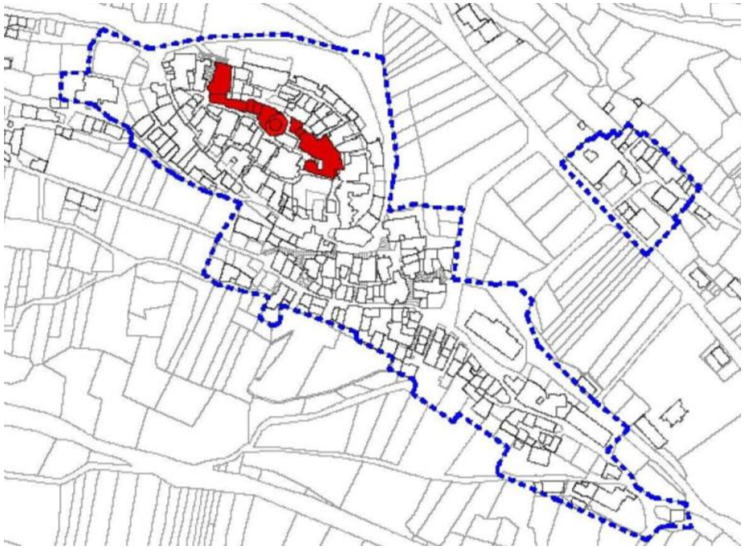
- traditional survey of a limited sample of buildings to integrate one of the two previous surveys.

The data required for this type of approach are limited: they can be integrated with probabilistic information.

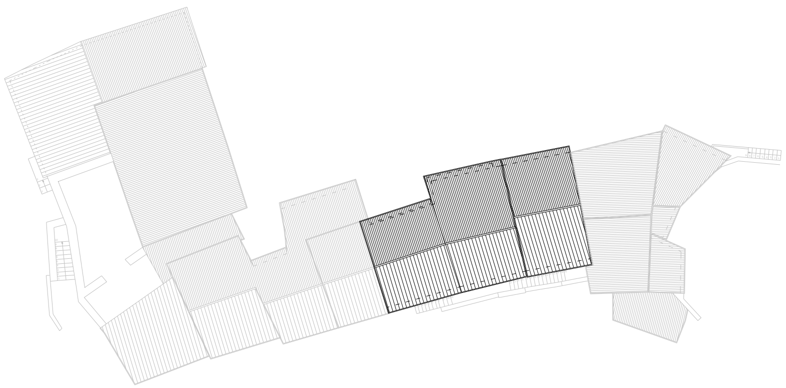
Parameters defined with the probabilistic method:
- floors height;
- walls thickness;
- openings percentage;
- localization of openings within bearing walls;
- …

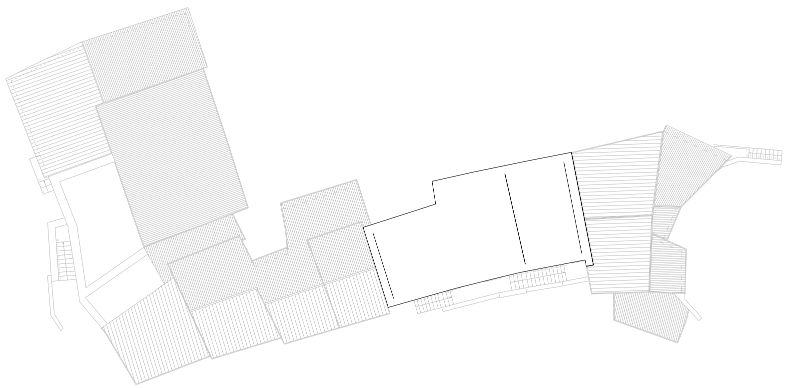
A probabilistic methodology

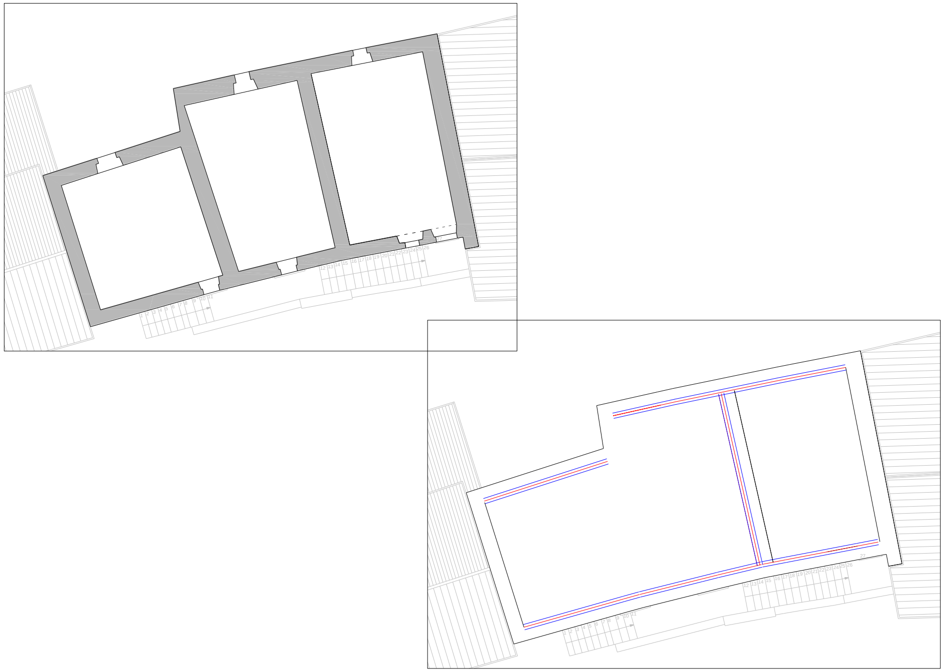
The aim is realizing probabilistic models:
- in the case on wherein it is not possible to have all the geometrical information of buildings;
- for the optimization of time and cost (avoiding the burden of an accurate survey)

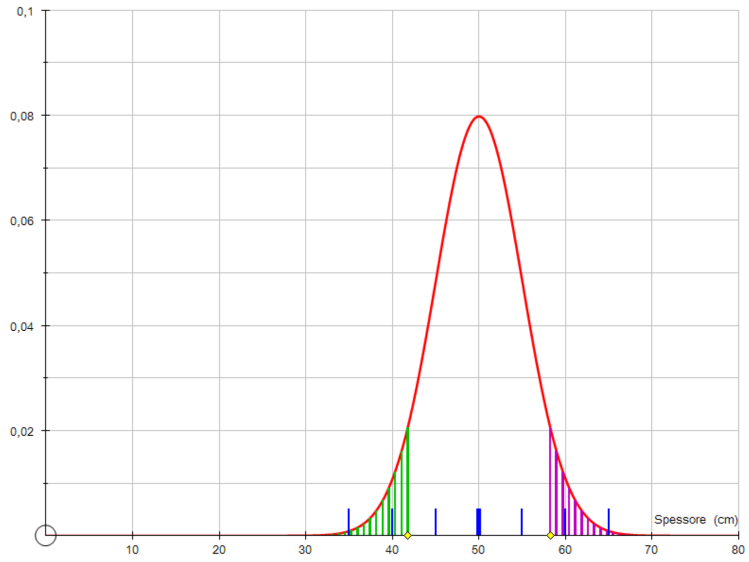


A probabilistic methodology



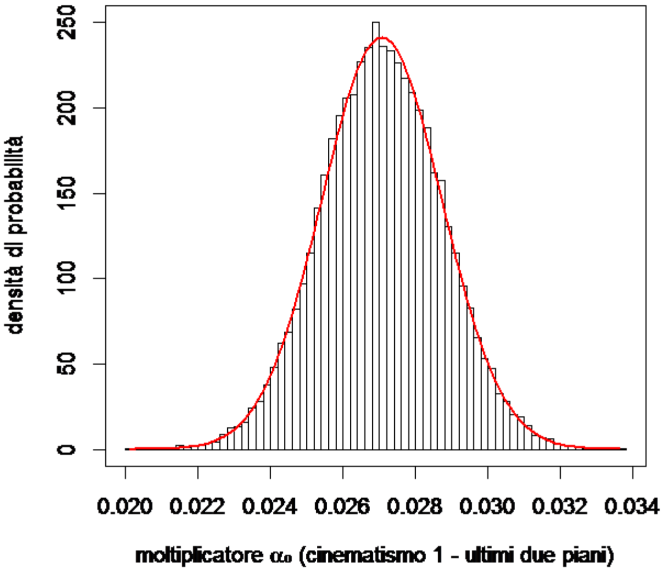


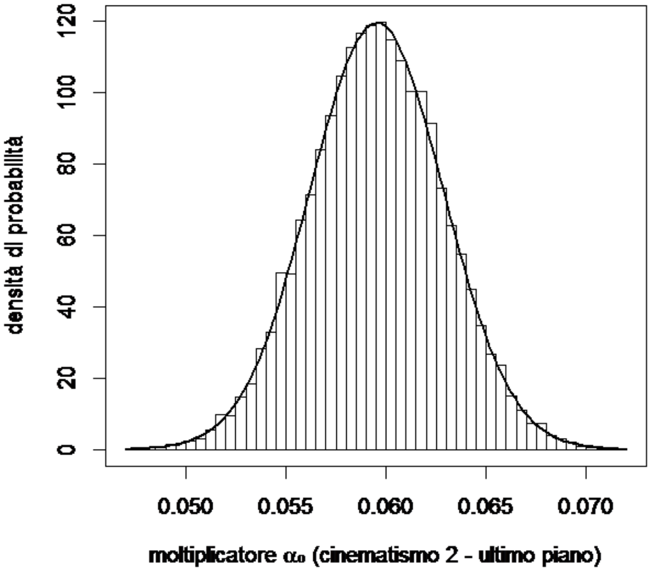




Overturning of the wall upper part

Results

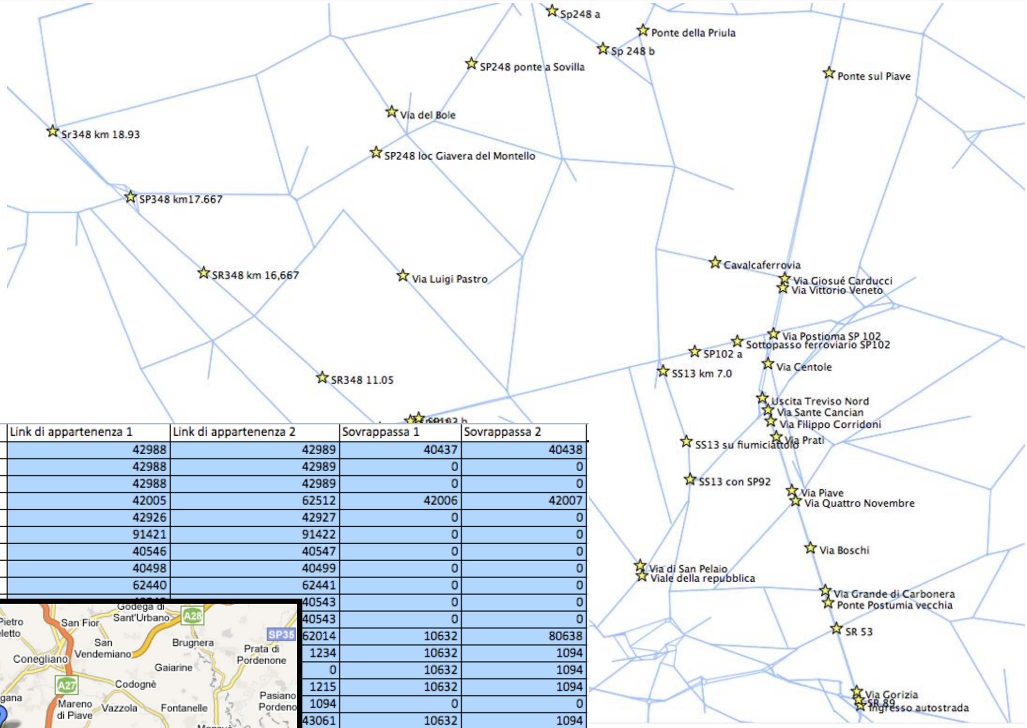




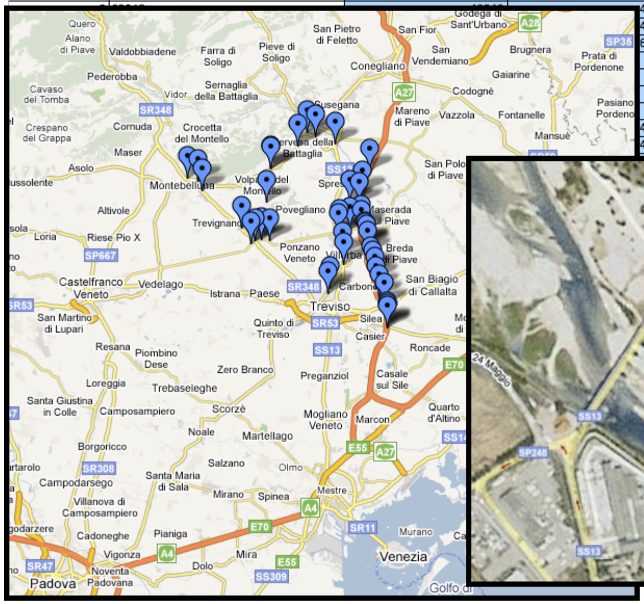
EXAMPLE OF A NETWORK OF BRIDGES IN THE AREA OF TREVISO

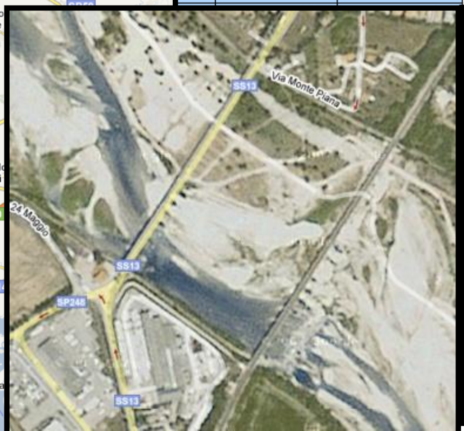
CATALOGUE OF BRIDGES

- Database Ibrid
- Surveys
- Gis Maps



Codice ponte	Descrizione	Link di appartenenza 1	Link di appartenenza 2	Sovrappassa 1	Sovrappassa 2
0	SR348 km 9.1	42988	42989	40437	40438
1	SR348 km 11.5	42988	42989	0	0
2	SR348 km 16.667	42988	42989	0	0
3	SR348 km 17.668	42005	62512	42006	42007
4	Sr348 km 18.93	42926	42927	0	0
5	SS13 km 7.0	91421	91422	0	0
6	Ponte della Priula	40546	40547	0	0
7	SP248 ponte a Sovilla	40498	40499	0	0
8	SP248 loc Giavera del Montello	62440	62441	0	0
			40543	0	0
			40543	0	0
			62014	10632	80638
			1234	10632	1094
			0	10632	1094
			1215	10632	1094
			1094	0	0
			43061	10632	1094
			40617	10632	1094

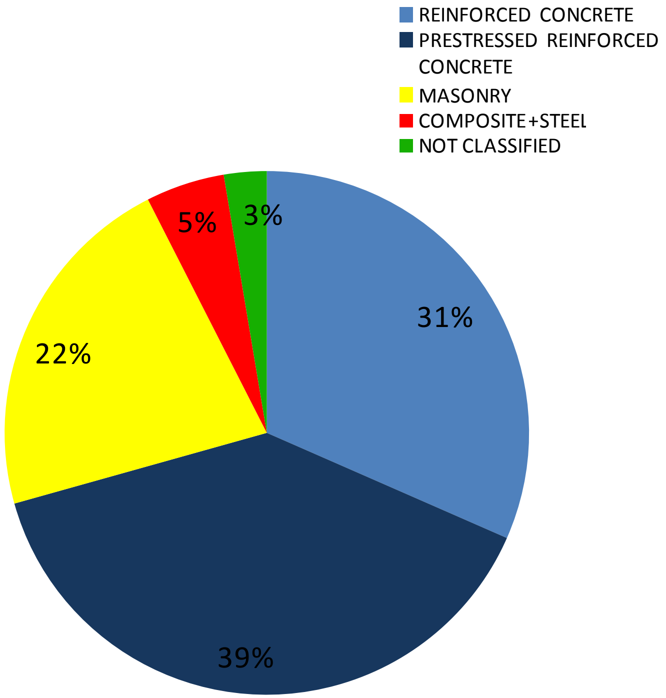


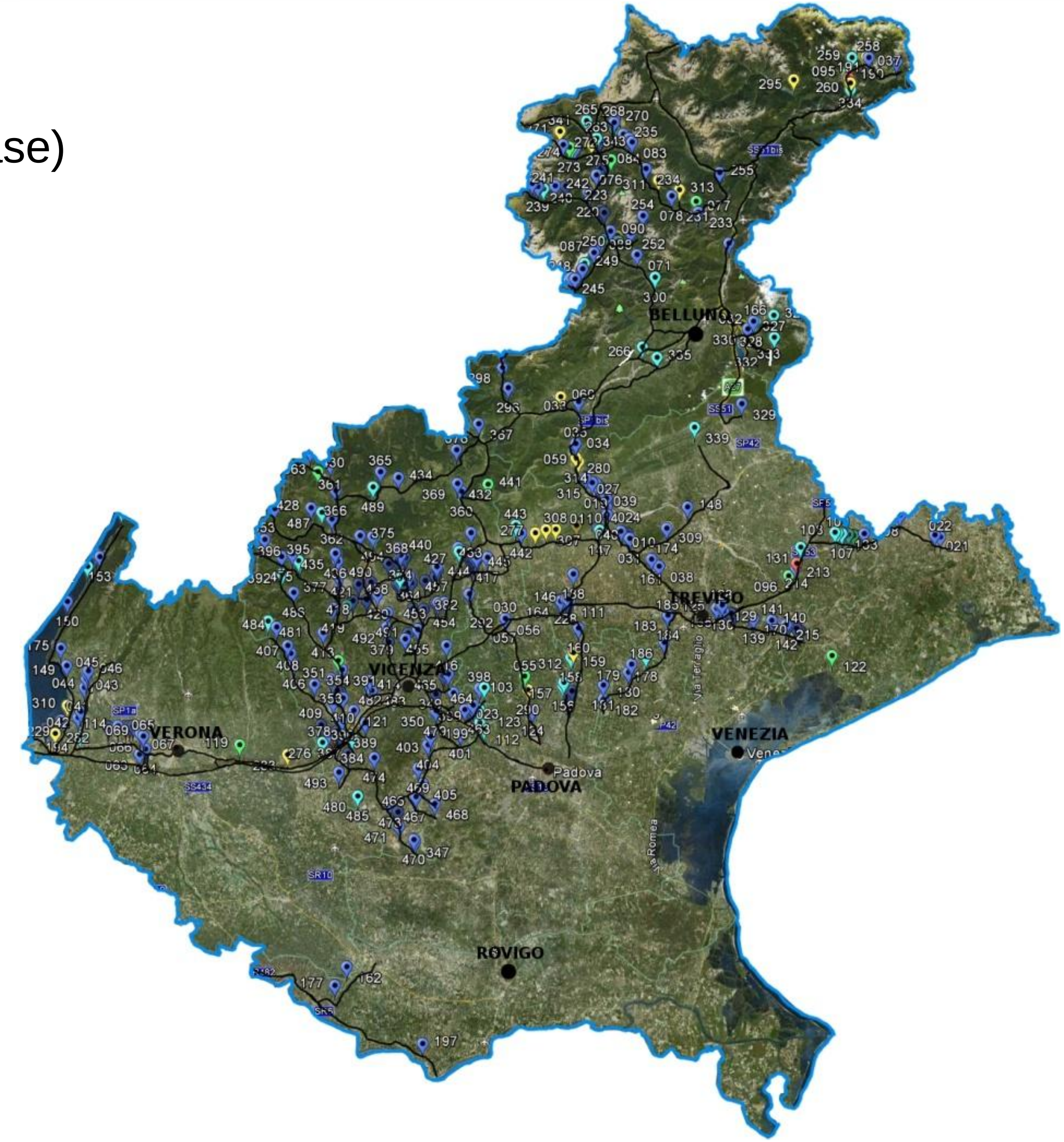


Database **IBrID**
(Italian Bridge Interactive Database)

http://ibrid.dic.unipd.it

500 bridges
Veneto Region





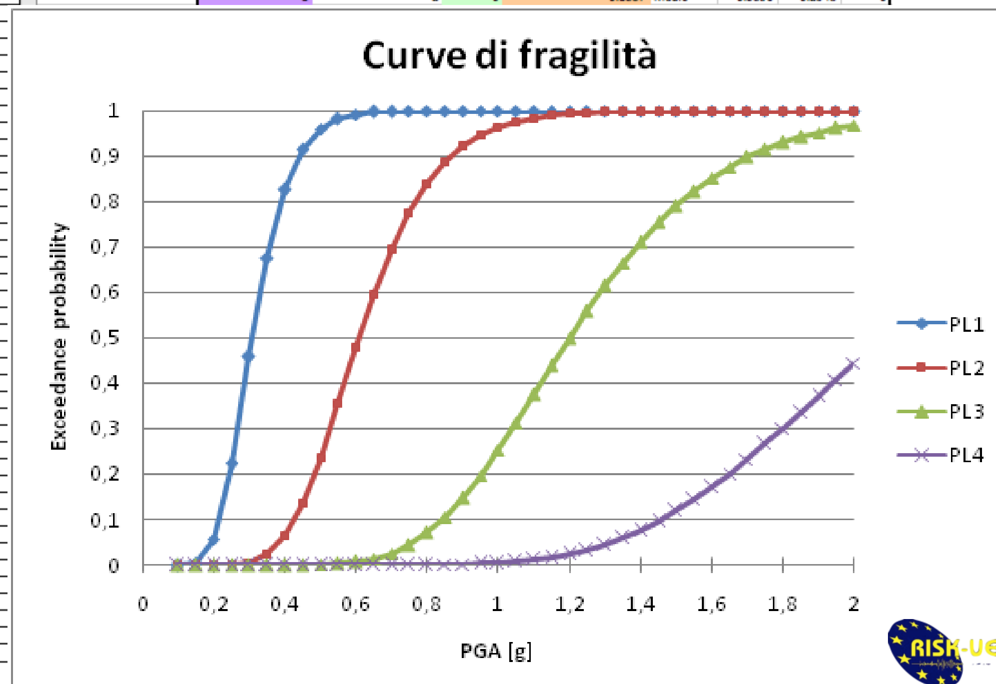
CLASSIFICATION OF DAMAGE LIMIT STATES CAUSED BY EARTHQUAKES

RiskUe (Hazus) classification:

- Typology
- Number of Spans
- Form Factor
- Soil

PL1 danno lieve - PL2 danno moderato - PL3 danno esteso - PL4 collasso

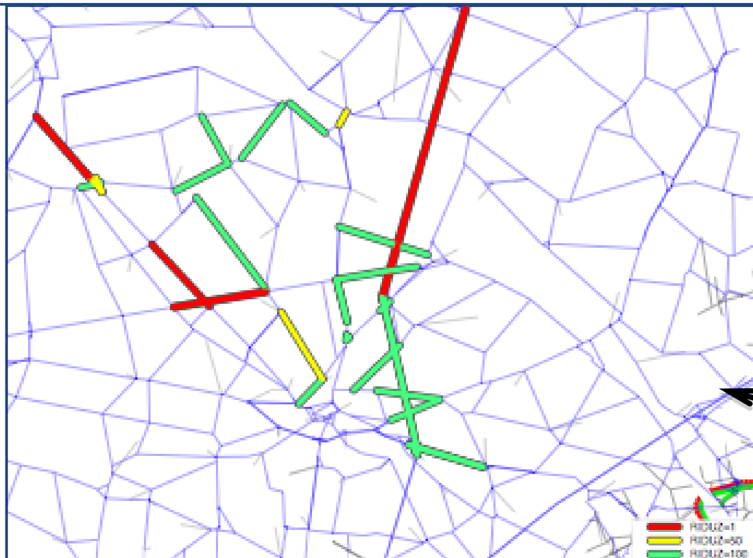
Descrizione	Parametri in ingresso	Tipologia adottata	N(numero di campate)	I_shape	Pga_bedrock (Tr=475anni)	Suolo tipo	Sa(0.3s)	Sa(1.0s)	Skew
SR348 km 9.1		7	3	0	0.1761	Medio	0.5502	0.2751	20
SR348 km 11.5		1	2	0	0.1887	Medio	0.5896	0.2948	0
SR348 km 16.667									
SR348 km 17.668									
Sr348 km 18.93									
SS13 km 7.0									
Ponte della Priula									
SP248 ponte a Sovilla									
SP248 loc Giavera del Montello									
SP248 a									
SP248 b									
Ingresso autostrada									
SR89									
Via Gorizia									
SR53									
Ponte Postumia vecchia									
Via Grande di Carbonera									
Via Quattro Novembre									
Via Piave									
Via Prati									
Via Filippo Corridoni									
Via Sante Cancian									
Uscita Tv Nord									
Via Centole									
Via Postioma SP102									
Via Vittorio Veneto									
Via Giosué Carducci									
Ponte sul Piave									
Sottopasso ferroviario SP102									
SP102 a									
SP102 b									
SP102 c									
SP102 cavalcaferrovia									
SS 13 con SP 92									
Calvaferrovia									
Via di San Pelaio									
Via del Bolé									
Via Luigi Pastro									
Via Boschi									
SS13 su fiumiciattolo									
Viale della Repubblica									

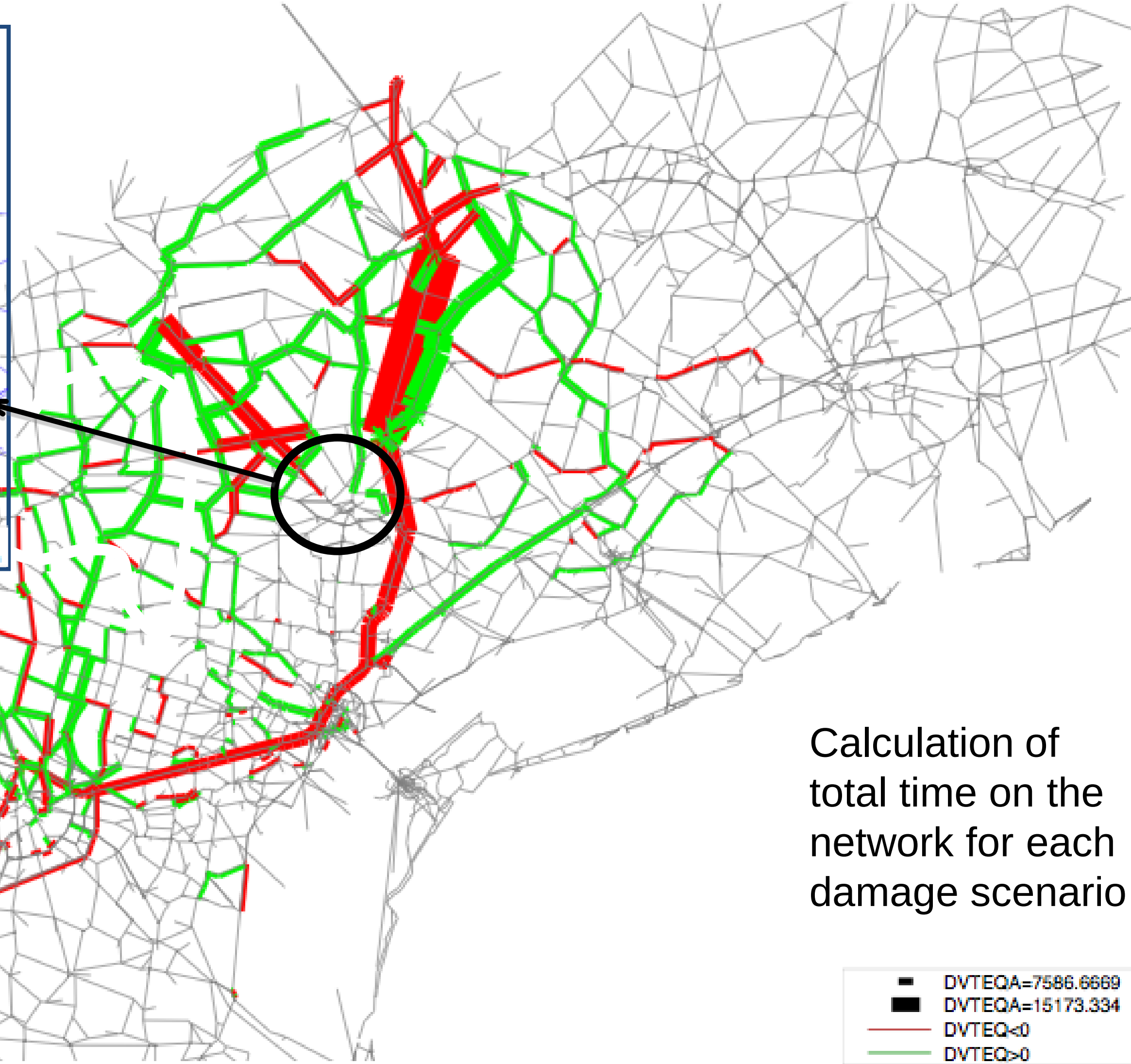


<u>The fragility curve</u> defines the probability of passing a given state of damage for a given seismic intensity

DAMAGE LIMIT STATE FOR BRIDGES IN DIFFERENT SEISMIC SCENARIOS

ALLOCATION OF TRANSPORT DEMAND



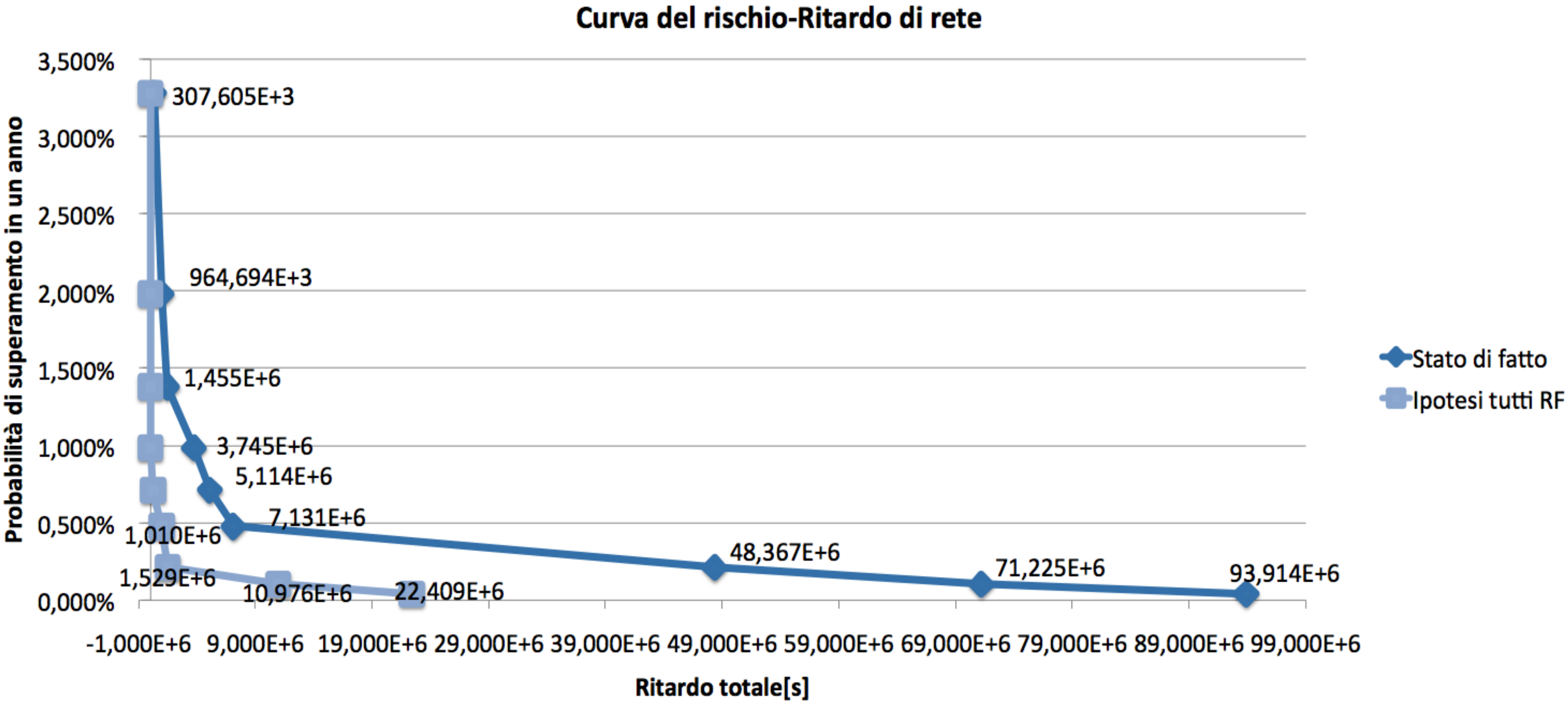


Example of redistribution of traffic flows in the central Venetian area caused by an earthquake with an epicenter near the town of Treviso

Calculation of total time on the network for each damage scenario

PRIORITY FOR RETROFITTING

The benefit resulting from the retrofitting of all the artifacts present in the considered transportation network has been initially assessed in terms of reduction of the value of the total delay travel on the network.



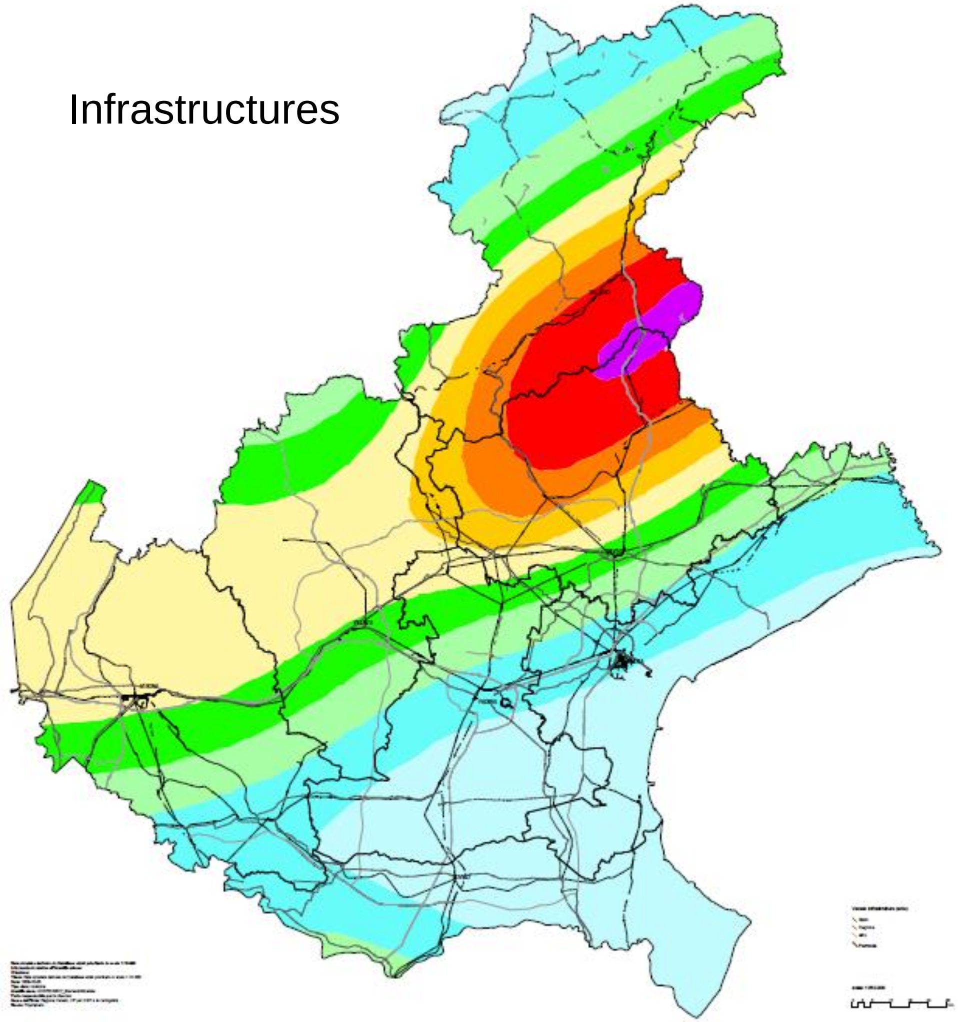
REGIONE DEL VENETO

PTRC

piano territoriale regionale di coordinamento

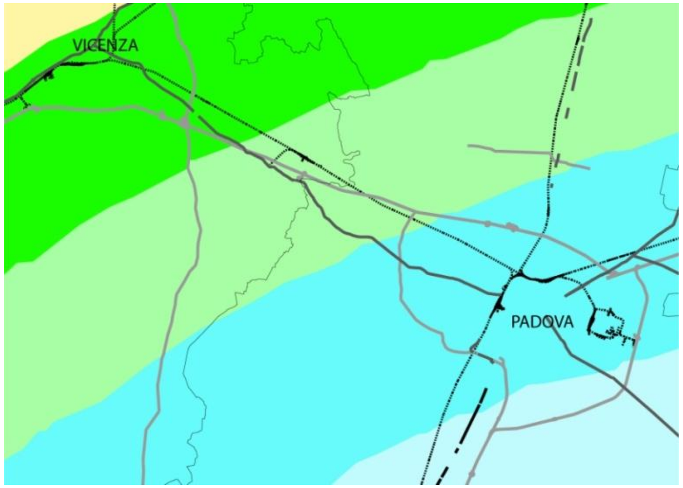
VENETO REGION
regional territorial plan of coordination

Infrastructures



Assessment of priority retrofitting of bridges

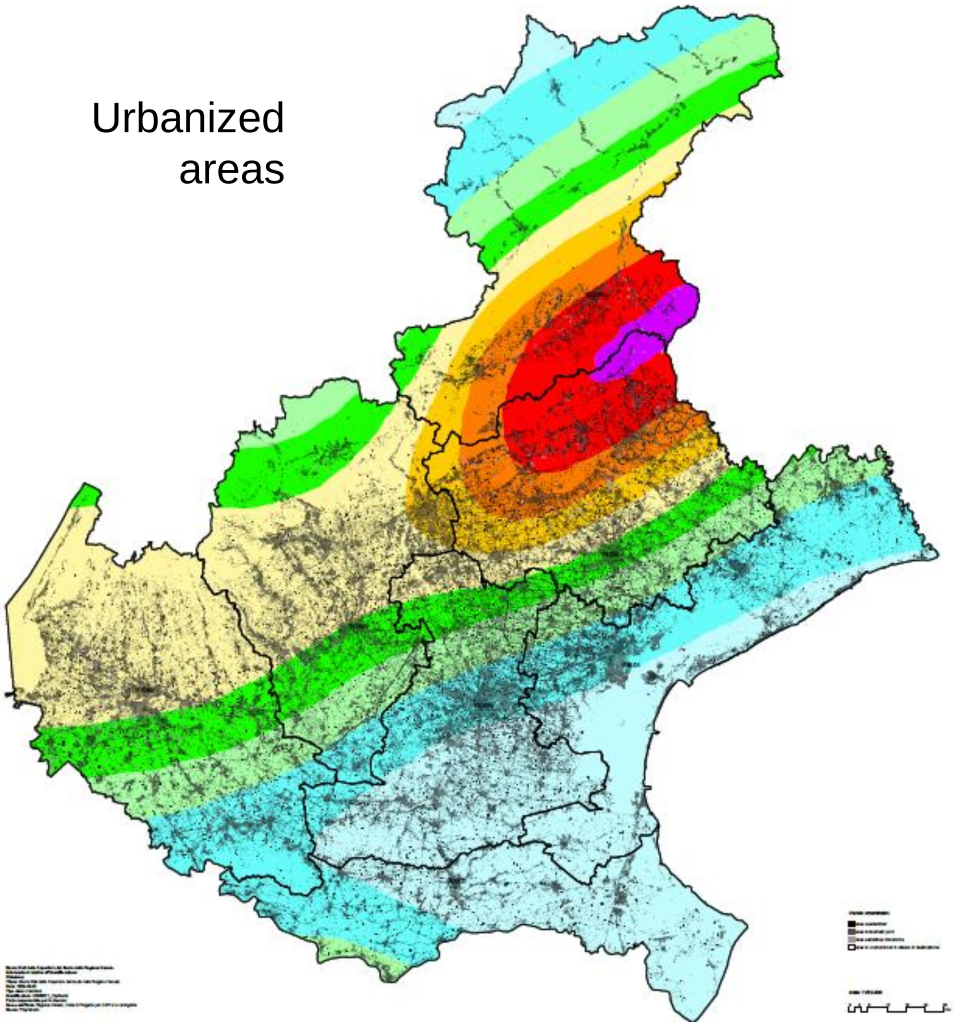
- vulnerability of the individual components of the infrastructure network
- vulnerability of the infrastructure network as a whole



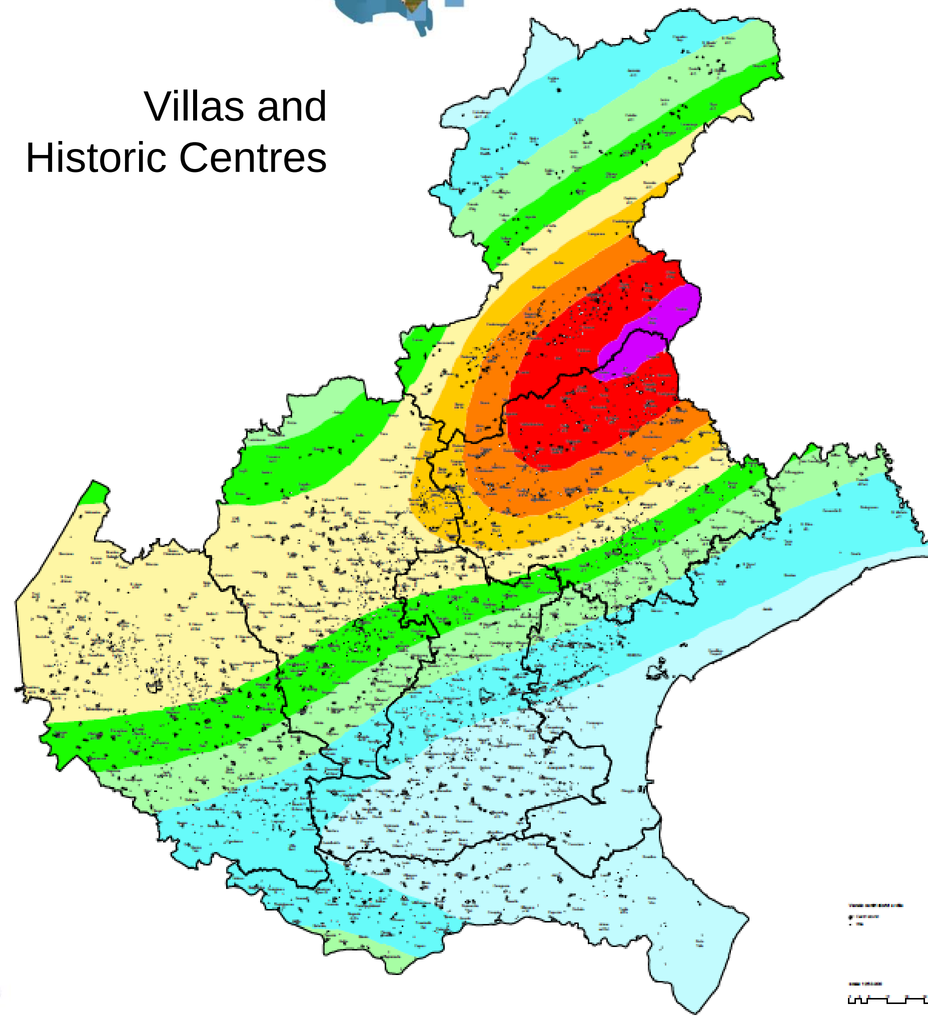
VENETO REGION
regional territorial plan of coordination

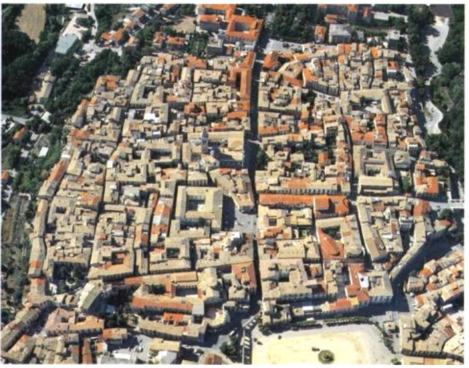
REGIONE DEL VENETO
PTRC
piano territoriale regionale di coordinamento

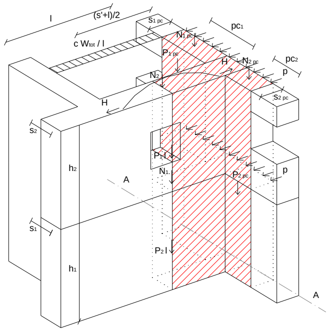
Urbanized areas

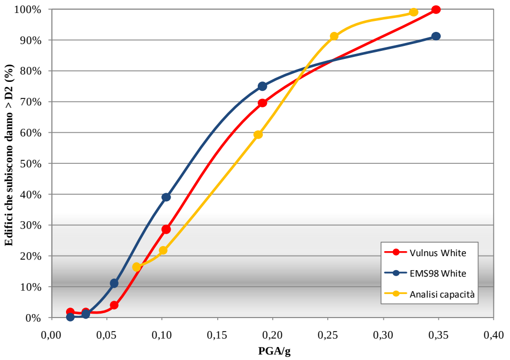


Villas and Historic Centres









Thank you for your attention…!

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FULL PROFESSOR OF CONSTRUCTION TECHNOLOGY

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UNIVERSITY OF PADOVA
ITALY