STATE OF THE ART OF RESEARCH ON METHODS AND MODELS FOR SEISMIC RISK ASSESSMENT OF CH CONSTRUCTIONS AND SITES

Speaker: Prof. Claudio Modena

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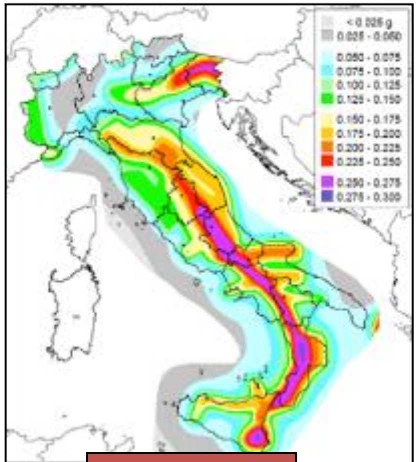
SEISMIC RISK FACTORS: HAZARD + VULNERABILITY + EXPOSURE



HAZARD

VULNERABILITY

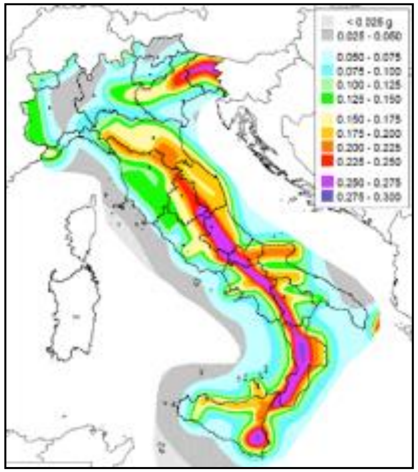
EXPOSURE

Probability of a seismic event of a given magnitude occurring in a certain interval of time.

A structure (building, bridge,..) potential for damage: probability of attaining a given level of damage due to a seismic event of a given intensity.

Losses – of the economy, of human lives, of cultural assets,.. – connected to the damages caused by a seismic event.

SEISMIC RISK MITIGATION: assessment, interventions, plans



HAZARD **VULNERABILITY** **EXPOSURE**

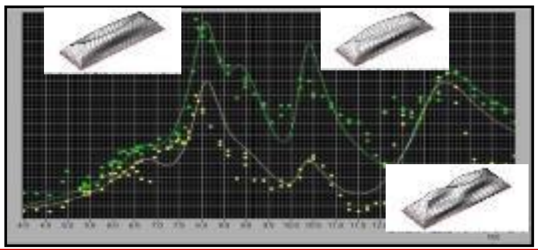
Single building- urban centers/territory

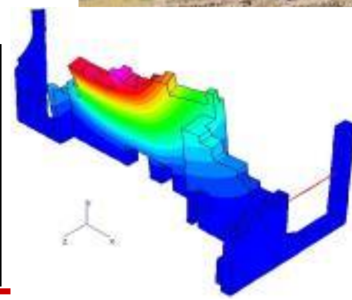
Structure's ruin – archaeological sites

Single bridge- infrastructure networks

Single artistic object – museums

SEISMIC RISK MITIGATION: assessment - interventions





MAJOR EFFORTS SOFAR FOCUSSED ON THE DEVELOPMENT OF CRITERIA, METHODLOGIES AND TECHNIQUES APPLICABLE TO CH CONSTRUCTIONS, ALLOWING FOR:

- **ASSESSING THEIR "REAL" STRUCTURAL SAFETY LEVELS PRIOR AND AFTER INTERVENTIONS**
- **DEFINING "ACCEPTABLE" VALUES OF SUCH LEVELS**
- **ATTAINING THE "TARGET" SAFETY VIA APPROPRITE REPAIR/STRENGTHENING INTERVENTIONS**

WHILE

RECOGNISING THEIR SPECIFIC STATIC/DYNAMIC BEHAVIUOR
RESPECTING THEIR INTRINSIC HSTORIC/ARTISTIC VALUES

RECENT EVOLUTION OF CODES AND GUIDELINES

International Council on Monuments and Sites
Conseil International des Monuments et des Sites

ISCARSAH

RECOMMENDATIONS FOR THE ANALYSIS,CONSERVATION AND STRUCTURAL RESTORATION OF ARCHITECTURAL HERITAGE

Guidelines

1. *General criteria*
2. *Acquisition of data: Information and Investigation*
   - 2.2 *Historical and architectural investigations*
   - 2.3 *Investigation of the structure*
   - 2.4 *Field research and laboratory testing*
   - 2.5 *Monitoring*
3. *Structural behaviour*
   - 3.1 *General aspects*
   - 3.2 *The structural scheme and damage*
   - 3.3 *Material characteristics and decay processes*
   - 3.4 *Actions on the structure and the materials*
4. *Diagnosis and safety evaluation*
   - 4.1 *General aspects*
   - 4.2 *Identification of the causes (diagnosis)*
   - 4.3 *Safety evaluation*
   - 4.3.1 *The problem of safety evaluation*
     - 4.3.2 *Historical analysis*
     - 4.3.3 *Qualitative analysis*
     - 4.3.4 *The quantitative analytical approach*
     - 4.3.5 *The experimental approach*
   - 4.4 *Judgement on safety*
5. *Decisions on interventions - The Explanatory Report*

RECENT EVOLUTION OF CODES AND GUIDELINES

GUIDELINES FOR THE ASSESSMENT AND THE REDUCTION OF SEISMIC RISK OF CULTURAL HERITAGE

- CHAP. 1: OBJECT OF THE GUIDELINES
- CHAP. 2: SAFETY AND CONSERVATION REQUIREMENTS
- CHAP. 3: SEISMIC ACTION
- CHAP. 4: BUILDING KNOWLEDGE
- CHAP. 5: MODELS FOR SEISMIC SAFETY ASSESSMENT
- CHAP. 6: SEISMIC IMPROVEMENT AND INTERVENTION TECHNIQUES CRITERIA
- CHAP. 7: RESUME OF THE PROCESS

ITALIAN GUIDELINES

interventions designed to "**improve**" , not necessarily to "**retrofit**"
the structural performance of CH constructions

Multidisciplinary decision process
based on
both structural analysis and quantitative evaluations

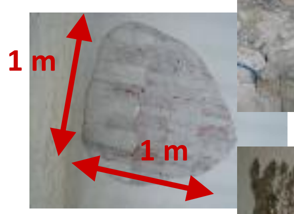
ASSESSMENT - IMPROVEMENT ↔ **~~VERIFICATION - RETROFITTING~~**

Italian Guidelines – § 4 – Building knowledge

To carry out the structural analyses, it is necessary to gain **proper knowledge** by means of surveys, historical researches, in-situ and laboratory tests:

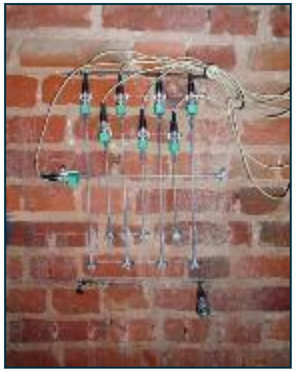
BUILDING GEOMETRY → geometry, particular elements (such as chimneys, niches, etc), crack pattern & out of plumbs

- by means of surveys



CONSTRUCTIVE DETAILS → connections, lintels, elements to counteract thrusts, vulnerable elements, masonry typology

- limited *in situ inspection*
- extended & comprehensive *in situ inspection*



MATERIAL PROPERTIES → particularly aimed at the mechanical characterization of masonry, through inspections, NDT, MDT & DT

- limited *in situ testing* (inspections)
- extended *in situ testing* (MDT & NDT)
- comprehensive *in situ testing* (DT)

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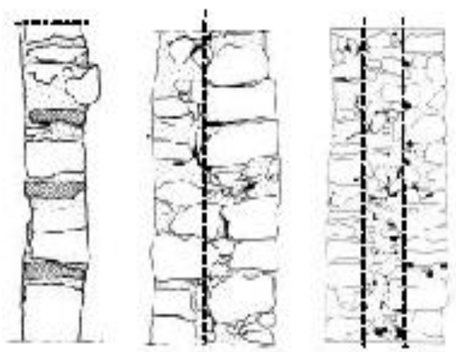
Italian Guidelines – § 4 – Building knowledge

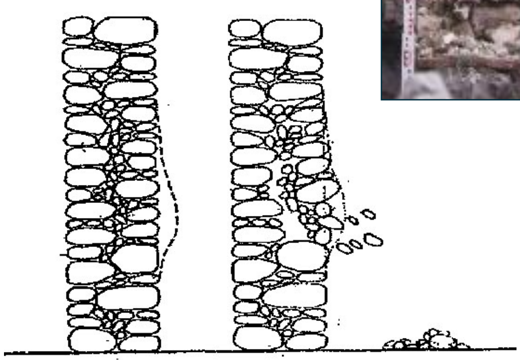
It Is possible to refer to abaci for the evaluation of the quality and bearing capacity of **masonry typologies**

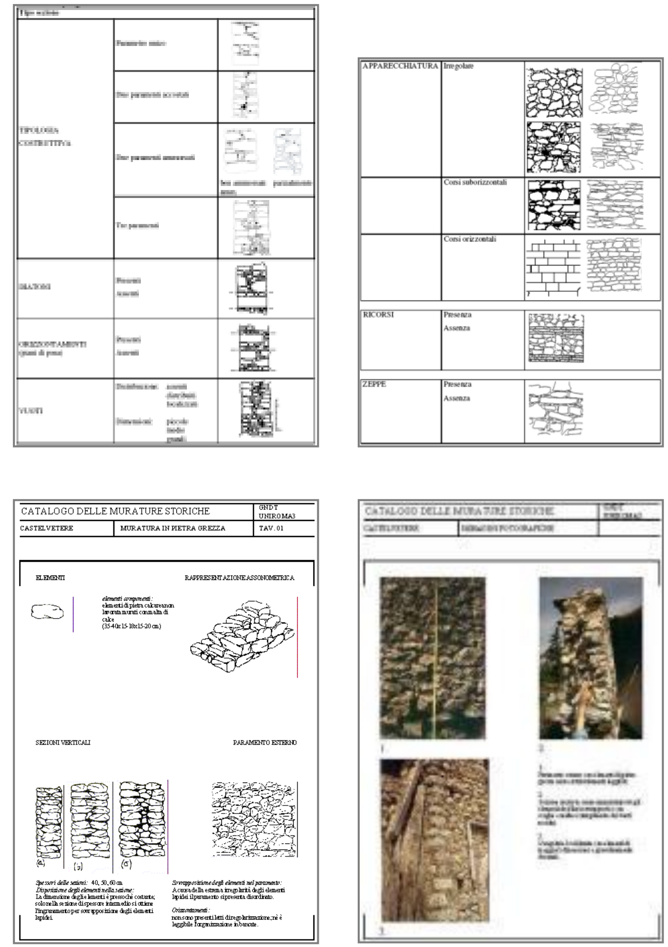
Heterogeneous masonry built up with poor materials, presence of voids, irregularities, multi-leaf sections, absence of connections

↓

Out-of-plane brittle collapses





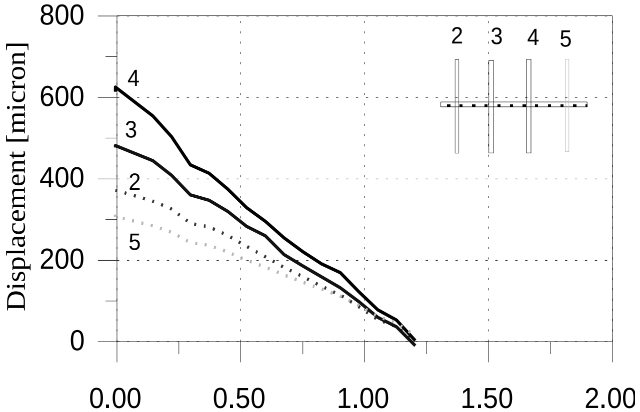


Survey forms: frequent local masonry typologies

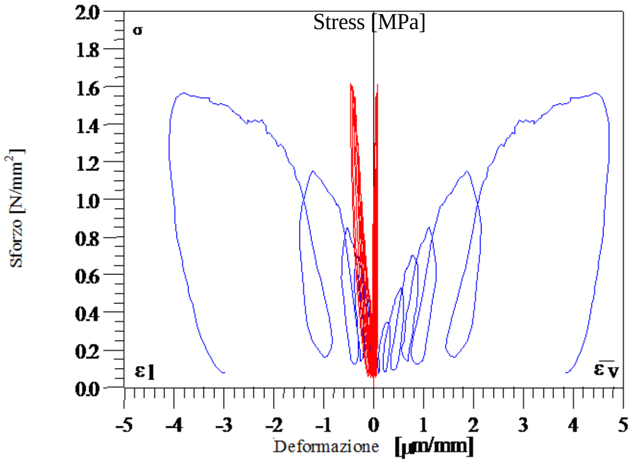
Examples of investigation techniques to control the efficiency of repairs

Minor destructive tests (MDT): Flat jack test

Single flat-jack test (detection of state of stress) carried out at the Monza Tower (Binda, 1998)

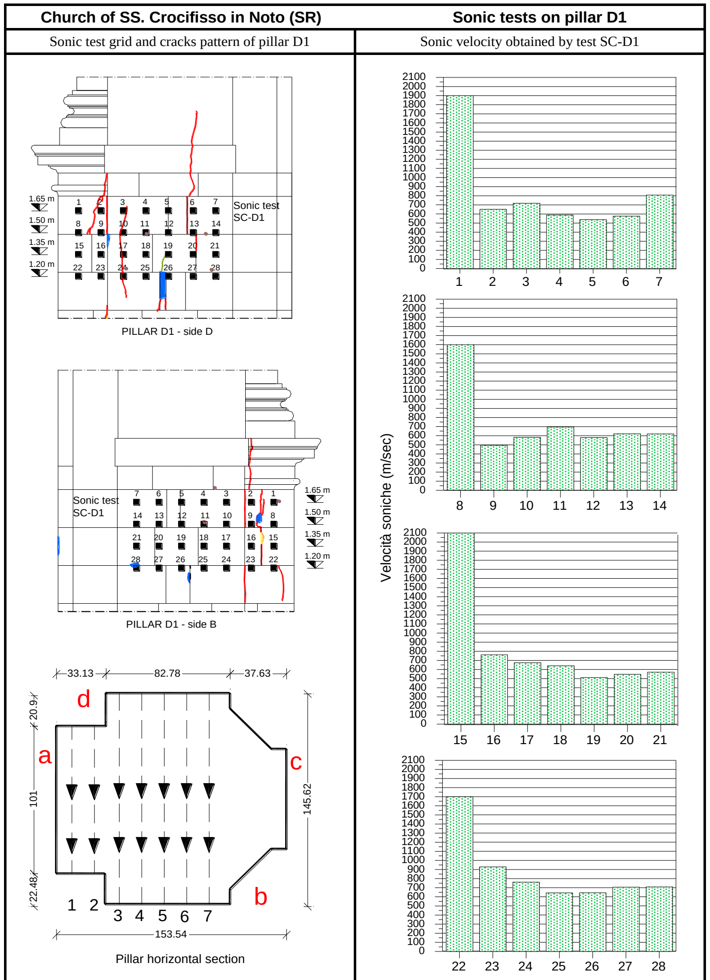


Double flat-jack test (stress-strain behaviour) on West side of the Monza Tower (Binda, 1998)

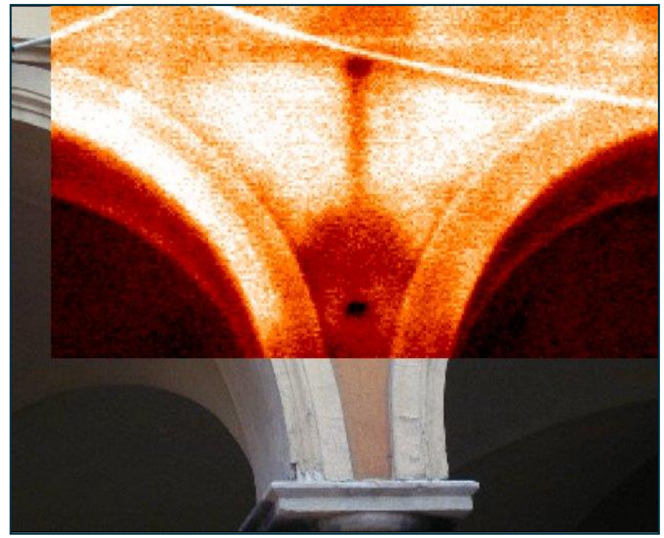


Examples of investigation techniques for knowledge and control of repairs

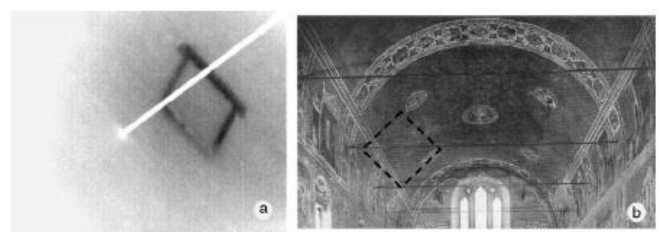
Non destructive tests (NDT): Sonic test



Thermovision



Investigation on hidden steel tie rods



Detention of a modified opening

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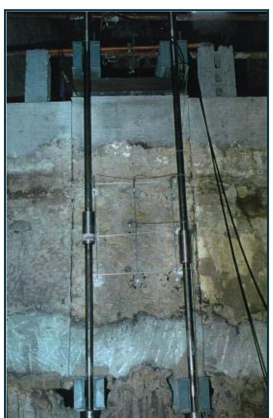
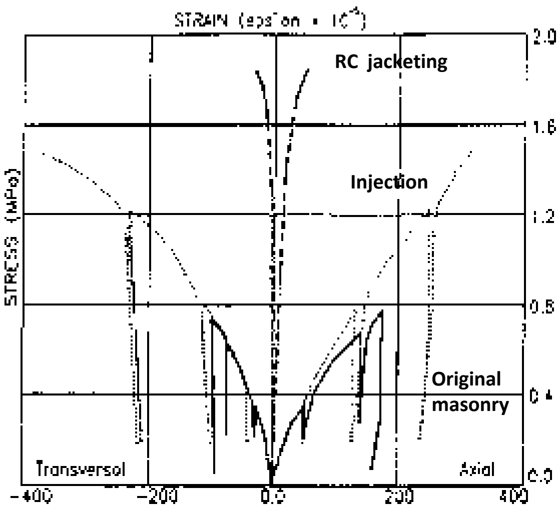
Examples of investigation techniques for knowledge and control of repairs

Destructive tests (DT) realised before and after strengthening intervention

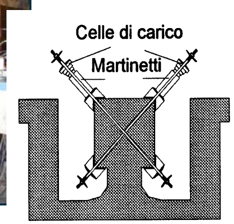
Mechanical characteristics for vertical actions

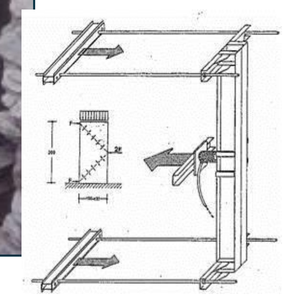
(Bettio, Modena 1993)

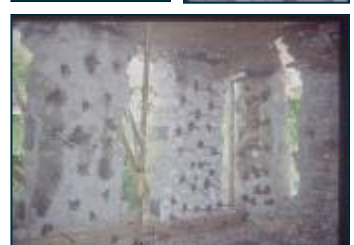


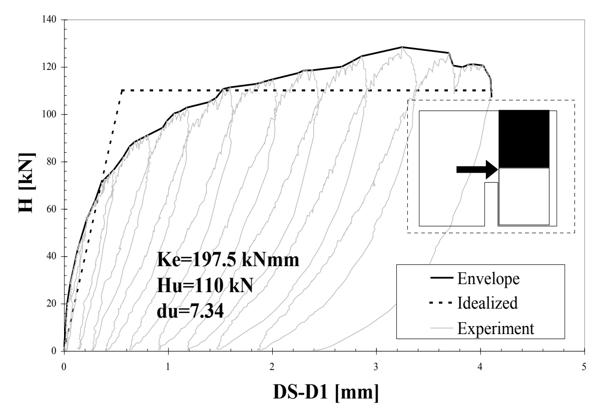


Mechanical characteristics for horizontal and vertical actions









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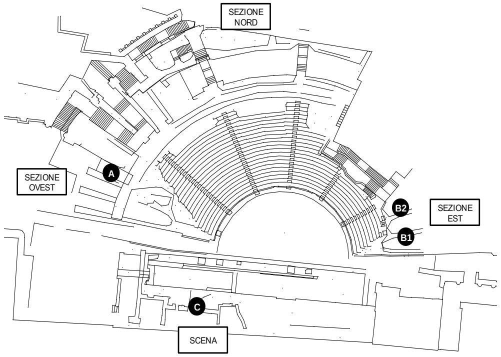
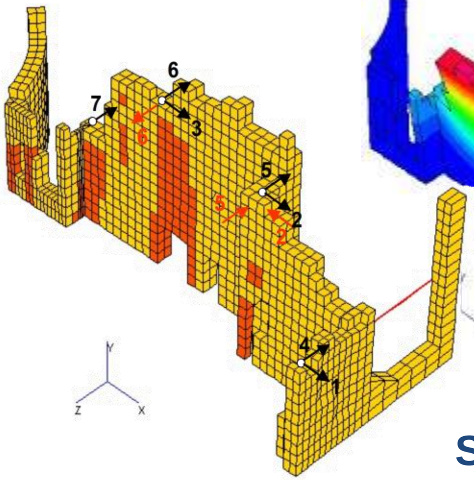
Examples of modal identification for knowledge

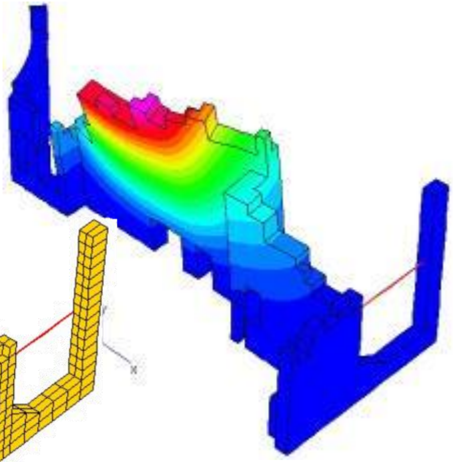
Roman Theatre (Verona)

- **shock test**
- **stepped sine test**
- **modal identification**

Proprietà 1	E	1.2E+03	MPa
	ρ	1.3E+03	kg/m³
Proprietà 2	E	3.2E+03	MPa
	ρ	1.3E+03	kg/m³
Proprietà 3	E	1.2E+03	MPa
	ρ	1.5E+03	kg/m³







Scene f_1=3.44 Hz

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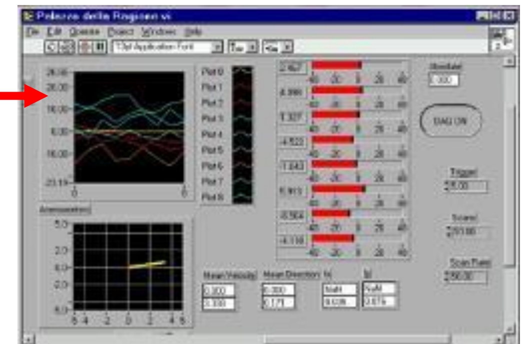
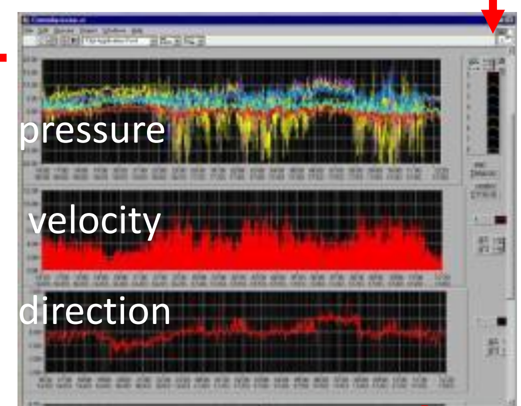
Examples of monitoring systems for knowledge and control of repairs

Palazzo della Ragione (Padova, XIII-XV C.)

Idea:
- wind effects monitoring
- stepped sine test
- FE modeling
- modal identification
- www data management



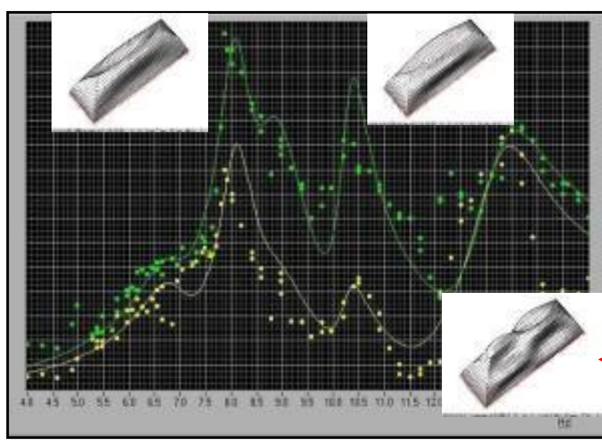
Data acquisition



www database

Web monitoring home page

Modal analysis



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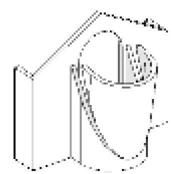
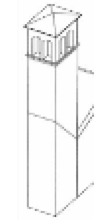
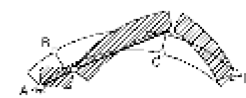
Italian Guidelines – § 5 – Models for seismic safety assessment

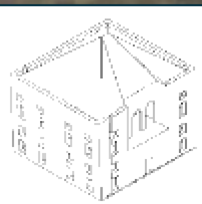
Modelling for typologies

Simplified tools (for **LV1** level of assessment) are given for the analysis and modelling of buildings that can be ascribed to specific constructive typologies:

Palaces, villas, and other buildings with in-between horizontal floors and load bearing wall
Churches, oratories, and other buildings with large rooms without in-between floors
Towers, bell-towers and other buildings with main vertical length
Masonry bridges, triumphal arches and other arch and vaulted structures



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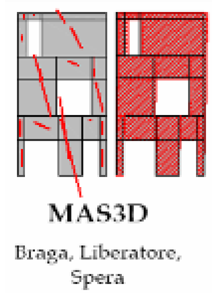
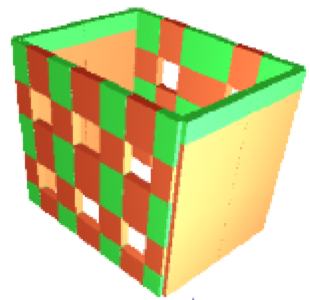
Italian Guidelines – § 5 – Models for seismic safety assessment

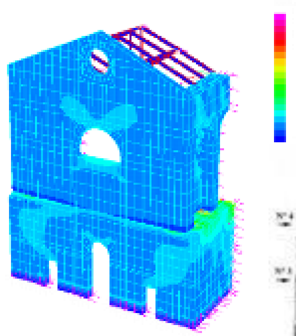
Structural modelling and seismic analysis methods

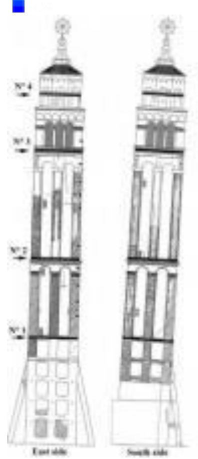
For existing masonry buildings it is possible to consider **various analysis methods**, according to the considered **appropriate model** which describe the structure and its seismic behaviour.
It is possible to consider:

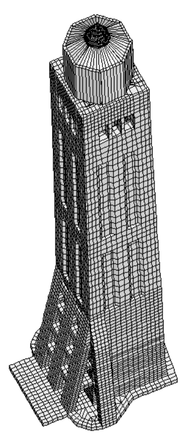
- **Macro-elements models**
- **Equivalent frame models**
- **Finite elements models**

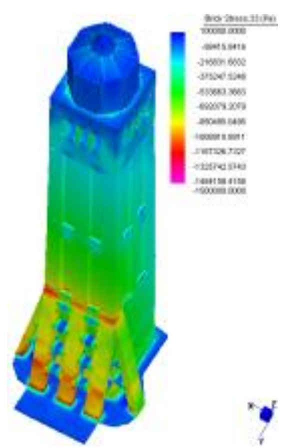


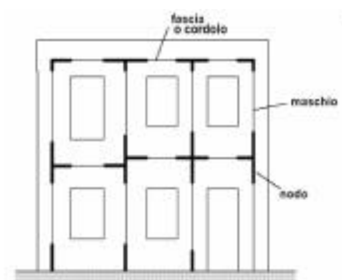


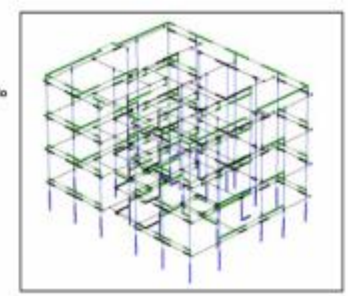












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EXTENSIVE EXPERIMENTAL RESEARCHES TO VALIDATE REPAIR/STRENGTHENING TECHNIQUES

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

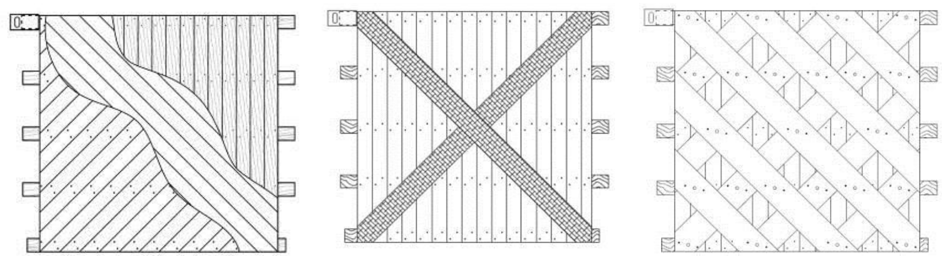
Unstrengthened condition
0.25g

Strengthened using ties
0.45g

Strengthened using injection
0.60g

Strengthened using ties and injection
0.75g

- **Different strenghetning systems** (plankings, diagonals, nets, ..) and materials (wood, earth, FRP, Natural fibres) applied at the extrados, for a total of **35 laboratory tests**
- High performance obtained for wooden **planking** (45°, single or double) both for strength and deformation capacity
- The **shear stiffness** of the joist ceiling is principally influenced by the planking thickness
- The **shear capacity** of the floors is linearly related with the strength of the fasteners
- Proper double **planking** provides stiffness capable to redistribute horizontal loads to bearing walls, comparable to the effect of more modern floors



Strengthening materials: CFRP, SRP, SRG, BTRM

SEISMIC RISK MITIGATION: plans /strategies - territorial level

- Historic centres

- Industrial areas

- Infrastructures

- Archaeological sites

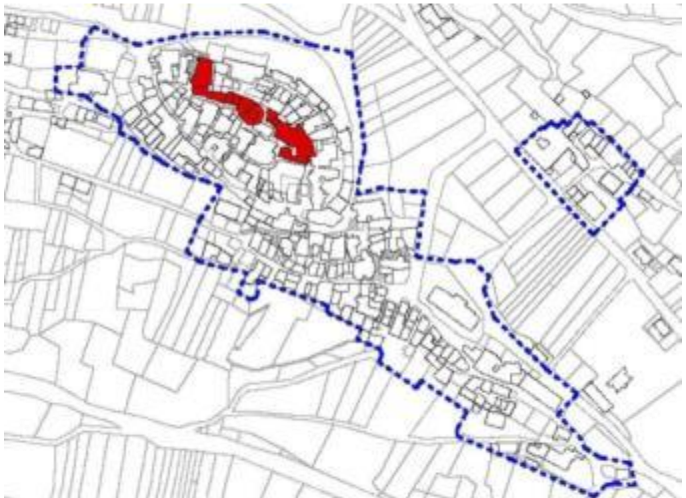
URBAN CENTERS: SIMPLIFIED METHODOLOGIES BASED ON MECHANICAL MODELS

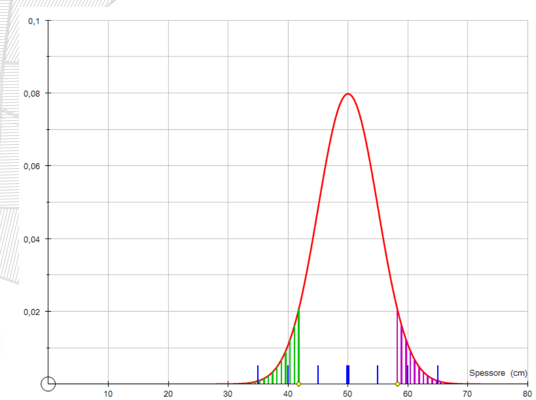
Automatic procedures for the systematic assessment of the existing masonry buildings vulnerability developed by the University of Padova:

Vulnus: global seismic vulnerability analysis (vulnerability assessment and damage probability) of isolated or clustered masonry buildings through different in plane and out of plane mechanisms combinations and qualitative informations.

c-Sisma: local analysis of vulnerability through the application of single kinematic models applied to the more significant macroelements. It also performs the safety analysis according to the Italian regulation

SIMPLIFIED METHODOLOGIES BASED ON REMOTE SENSING DATA PROCESSING





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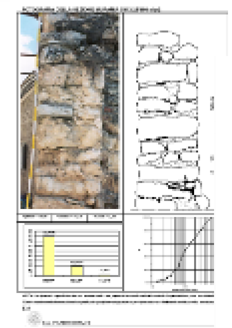
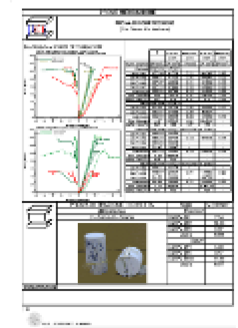
SIMPLIFIED METHODOLOGIES BASED ON MECHANICAL MODELS

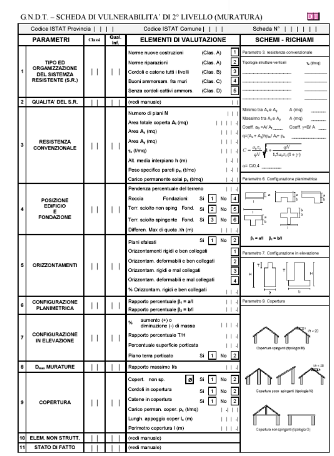
SURVEY FORMS

- **Scheda di 1° livello di rilevamento Danno, pronto intervento e Agibilità per edifici ordinari nell'Emergenza post-Sismica (AeDES)**
  - typological and damage in the emergency phase
  - physical evaluation of the damage
  - conformity to standards analysis





- **Scheda di rilievo per la catalogazione delle caratteristiche tipologiche, della vulnerabilità e del danno (PoliMI):**
  - in site geometrical and damage survey
  - qualitative masonry information
  - in site and laboratory tests



- **Scheda di vulnerabilità di 2°livello (muratura) – G.N.D.T.:**

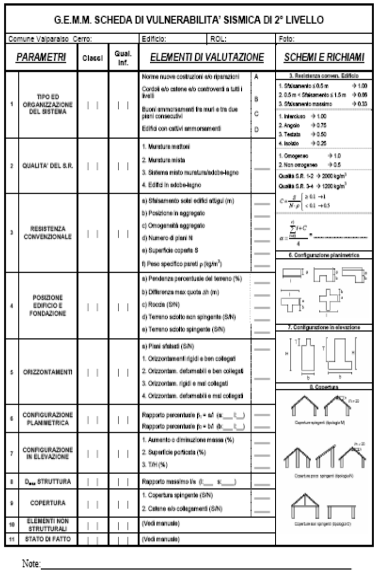
  sum of factors which define the vulnerability index:
  - definition of the vulnerability classes for different parameters
  - data quality information assessment

SIMPLIFIED METHODOLOGIES BASED ON MECHANICAL MODELS

MARVASTO PROJECTS – VALPARAISO (CILE)

Speed seismic vulnerability schedule for the survey of 70 buildings of the Cerro Cordillera in Valparaiso (UNESCO zone):

- definition and classification of 11 parameters;
- weighted and normalized average of the classes scores gives the I_V Vulnerability index.

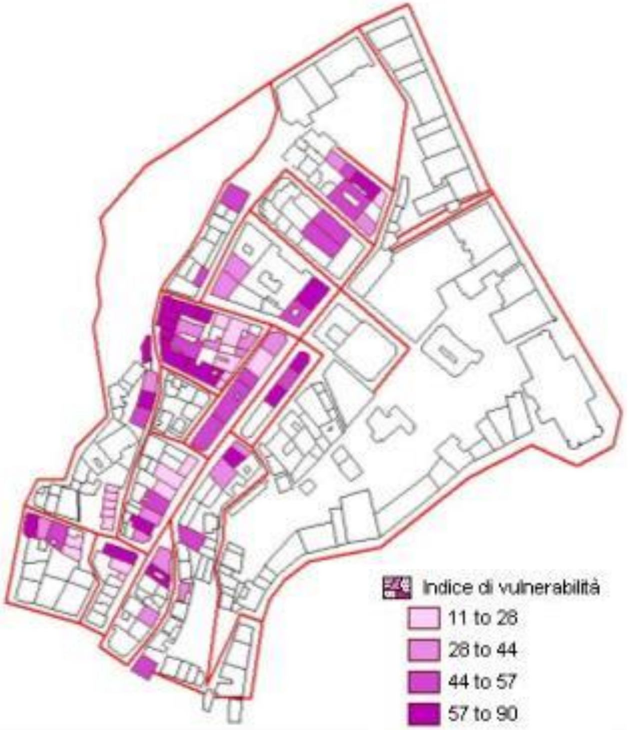


G.E.M.M. SCHEDA DI VULNERABILITA' SISMICA DI 2° LIVELLO

Comune Valparaiso Cerro: | Edificio: | ROL: | Foto:

	PARAMETRI	Classi	Qual. Inf.	ELEMENTI DI VALUTAZIONE		SCHEMI E RICHIAMI
1	TIPO ED ORGANIZZAZIONE DEL SISTEMA	| |	| |	Norme nuove costruzioni e/o riparazioni Cordoli e/o catene e/o controventi a tutti i livelli Buoni ammorsamenti fra muri e tra due piani consecutivi Edifici con cattivi ammorsamenti	A B C D	3. Resistenza conven. Edificio 1. Sfalsamento ≤ 0.5 m → 1.00 2. 0.5 m < Sfalsamento ≤ 1.5 m → 0.66 3. Sfalsamento massimo → 0.33 1. Intercluso → 1.00 2. Angolo → 0.75 3. Testata → 0.50 4. Isolato → 0.25
2	QUALITA' DEL S.R.	| |	| |	1. Muratura mattoni 2. Muratura mista 3. Sistema misto muratura/adobe-legno 4. Edifici in adobe-legno	___	1. Omogeneo → 1.0 2. Non omogeneo → 0.5 Qualità S.R. 1-2 → 2000 kg/m³ Qualità S.R. 3-4 → 1200 kg/m³
3	RESISTENZA CONVENZIONALE	| |	| |	a) Sfalsamento solai edifici attigui (m) b) Posizione in aggregato c) Omogeneità aggregato d) Numero di piani N e) Superficie coperta S f) Peso specifico pareti ρ (kg/m³)	___ ___ ___ ___ ___ ___	$C = \frac{S}{N \cdot \rho} \begin{cases} \geq 0.1 \rightarrow 1 \\ < 0.1 \rightarrow 0.5 \end{cases}$ $\alpha = \frac{\sum I + C}{4}$ = ________
4	POSIZIONE EDIFICIO E FONDAZIONE	| |	| |	a) Pendenza percentuale del terreno (%) b) Differenza max quota Δh (m) c) Roccia (S/N) d) Terreno sciolto non spingente (S/N) e) Terreno sciolto spingente (S/N)	___ ___ ___ ___ ___	6. Configurazione planimetrica
5	ORIZZONTAMENTI	| |	| |	a) Piani sfalsati (S/N) 1. Orizzontamenti rigidi e ben collegati 2. Orizzontam. deformabili e ben collegati 3. Orizzontam. rigidi e mal collegati 4. Orizzontam. deformabili e mal collegati	___ ___	7. Configurazione in elevazione
6	CONFIGURAZIONE PLANIMETRICA	| |	| |	Rapporto percentuale β_1 = a/l (a:___ l:___) Rapporto percentuale β_2 = b/l (b:___ l:___)	___ ___	8. Copertura
7	CONFIGURAZIONE IN ELEVAZIONE	| |	| |	1. Aumento o diminuzione massa (%) 2. Superficie porticata (%) 3. T/H (%)	___ ___ ___	
8	D_{max} STRUTTURA	| |	| |	Rapporto massimo l/s (l:___ s:___)	___	
9	COPERTURA	| |	| |	1. Copertura spingente (S/N) 2. Catene e/o collegamenti (S/N)	___ ___	
10	ELEMENTI NON STRUTTURALI	| |	| |	(Vedi manuale)		
11	STATO DI FATTO	| |	| |	(Vedi manuale)		

Note: ________________

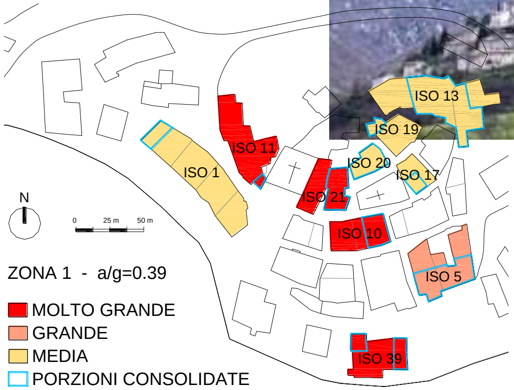


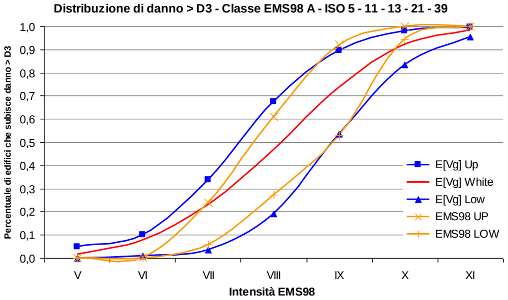
METHODOLOGY APPLICATION: ITALIAN HISTORIC CENTRES

Montesanto , Roccanolfi, Campi Alto e Castelluccio di Norcia (PG)
Vittorio Veneto (TV), Campo di Brenzone (VR)
Sulmona (AQ)

- Complex clustered buildings analysis:
  - concidering interaction because of the structural continuites
  - individuation of the structural seismic units (U.S.); global simplified evaluation of the seismic capacity

- Elaboration of useful post seismic condition tools for the Protezione Civile and the public administrations for the reduction of the seismic vulnerability on an urban scale:
  - vulnerability maps
  - fragility curves
  - damage scene





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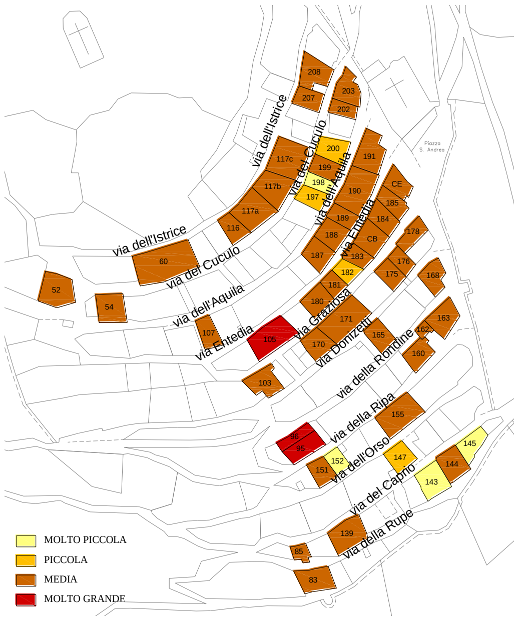
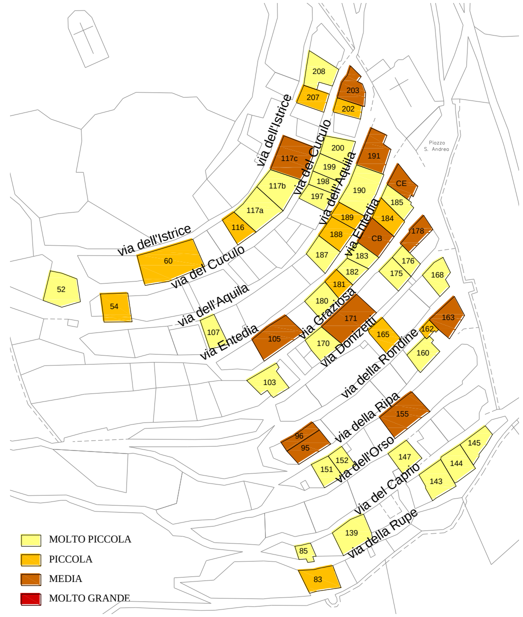
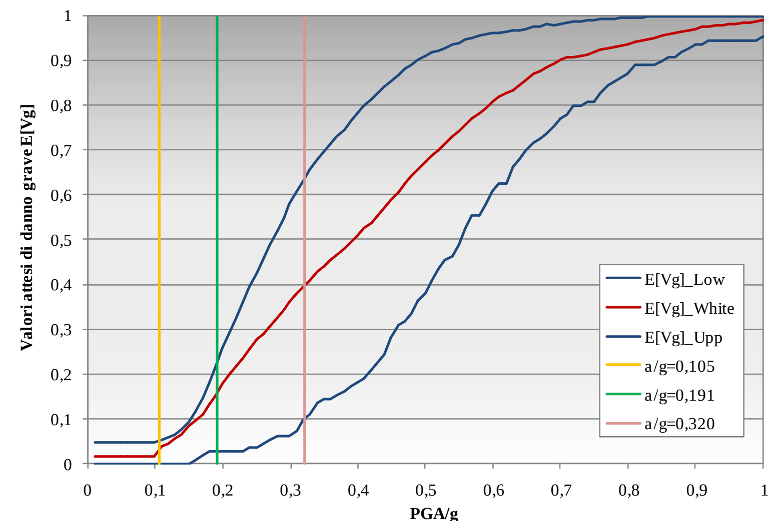
Linguistic assessment of vulnerability MEDIUM (a/g = 0,32) and VERY SMALL (a/g = 0,19)







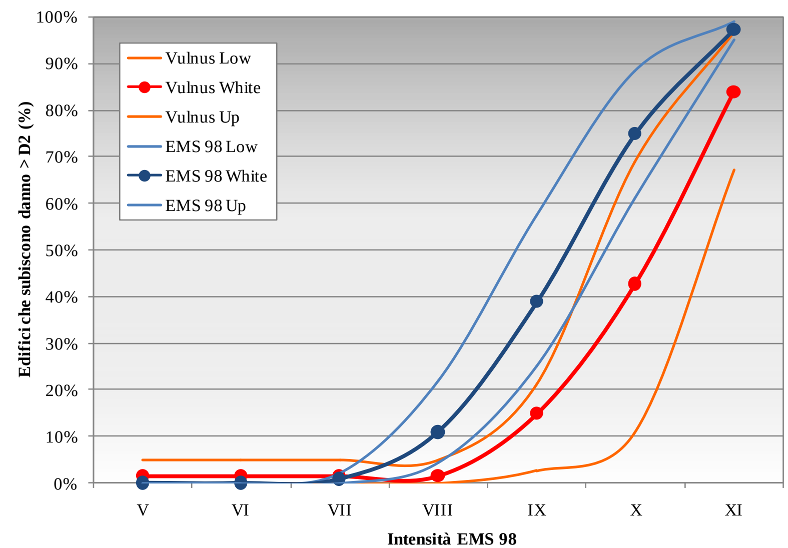
a/g = 0,32 **a/g = 0,19**

- a/g = 0,32 (NTC2008) ⇒ E[Vg] > 40%
- a/g = 0,19 (storico) ⇒ E[Vg] ≈ 15%

Classe EMS98A: 0 U.S.

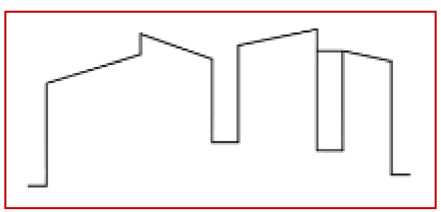
Classe EMS98B: 1 U.S.

Classe EMS98C: 49 U.S.



CAMPI ALTO

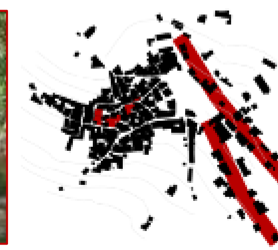
APPLICATION ON DAMAGE SCENARIOS: RECONSTRUCTION PLANS IN ABRUZZO



SANTO STEFANO DI SESSANIO

CASTELVECCHIO CALVISIO

CASTEL DEL MONTE



VILLA SANTA LUCIA DEGLI ABRUZZI

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UNIVERSITÀ DEGLI STUDI DI PADOVA

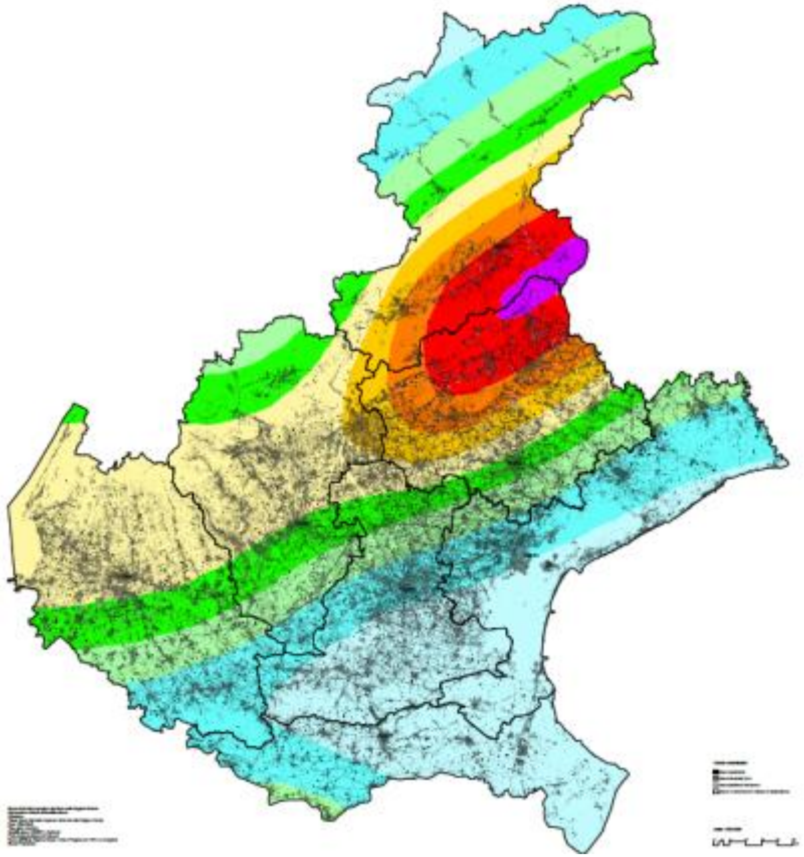
SETTE AZIONI PER AGGIORNARE IL P.T.R.C. adottato

REGIONE DEL VENETO
PTRC
piano territoriale regionale di coordinamento

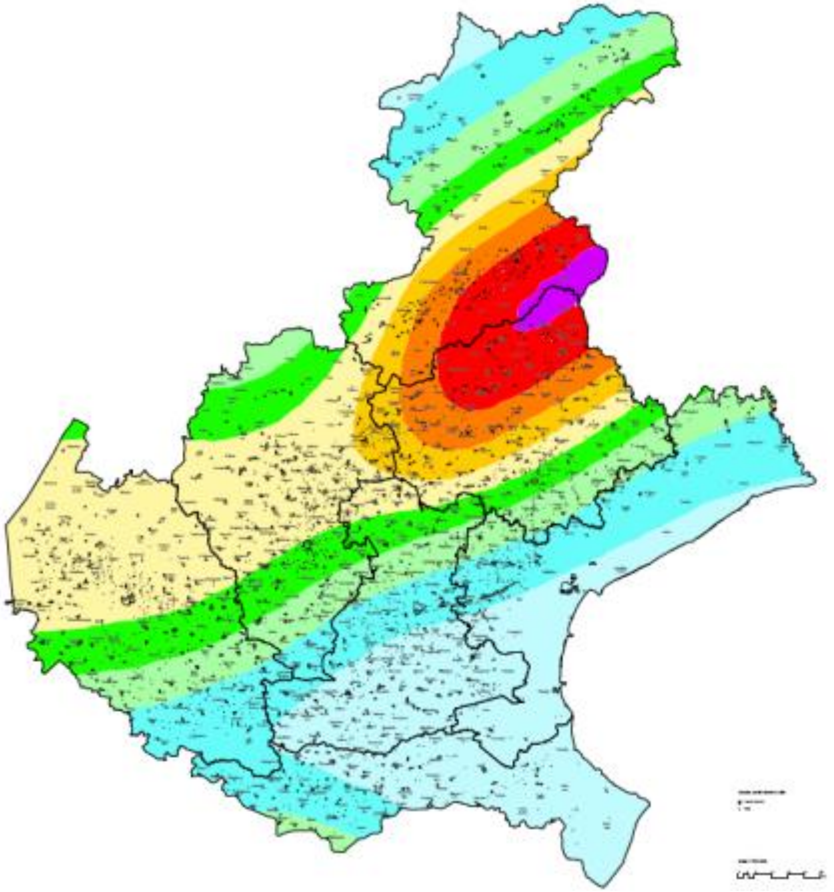
REGIONAL COORDINATION TERRITORIAL PLAN

Agreement for the definition of general criteria for seismic vulnerability assessment of systems (historic and urban centres, industrial areas, infrastructural systems) on a regional scale and for mitigation of seismic risk in areas with a significant hazard

- **Development of strategies for seismic risk reduction in the framework of the hierarchical planning system**



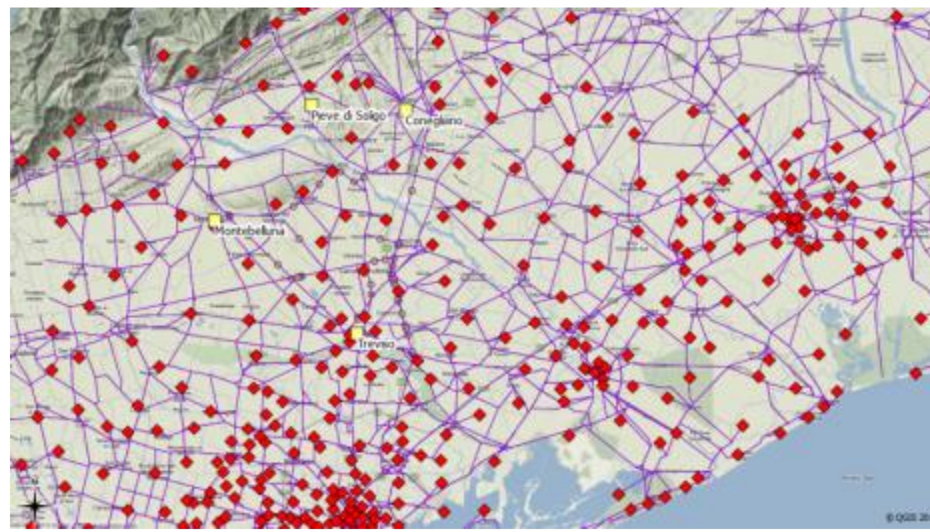
Urban areas and historic centres



Venetian Villas

THE MODELS TO PERFORM SEISMIC RISK ANALYSIS (SRA) FOR BUSINESS AND TRANSPORTATIONS LOSSES

- Hazard
  - Scenario Earthquake
- Vulnerability:
  - Bridge
  - Industrial building
- Risk:
  - Loss of production



THE MODELS TO PERFORM SEISMIC RISK ANALYSIS (SRA) FOR BUSINESS AND TRANSPORTATIONS LOSSES

- Hazard
  - Scenario Earthquake
- Vulnerability:
  - Bridge
  - Industrial building
- Risk:
  - Loss of production
  - Transportation

A GENERAL LOSS MODEL FOR SEISMIC RISK ANALYSIS

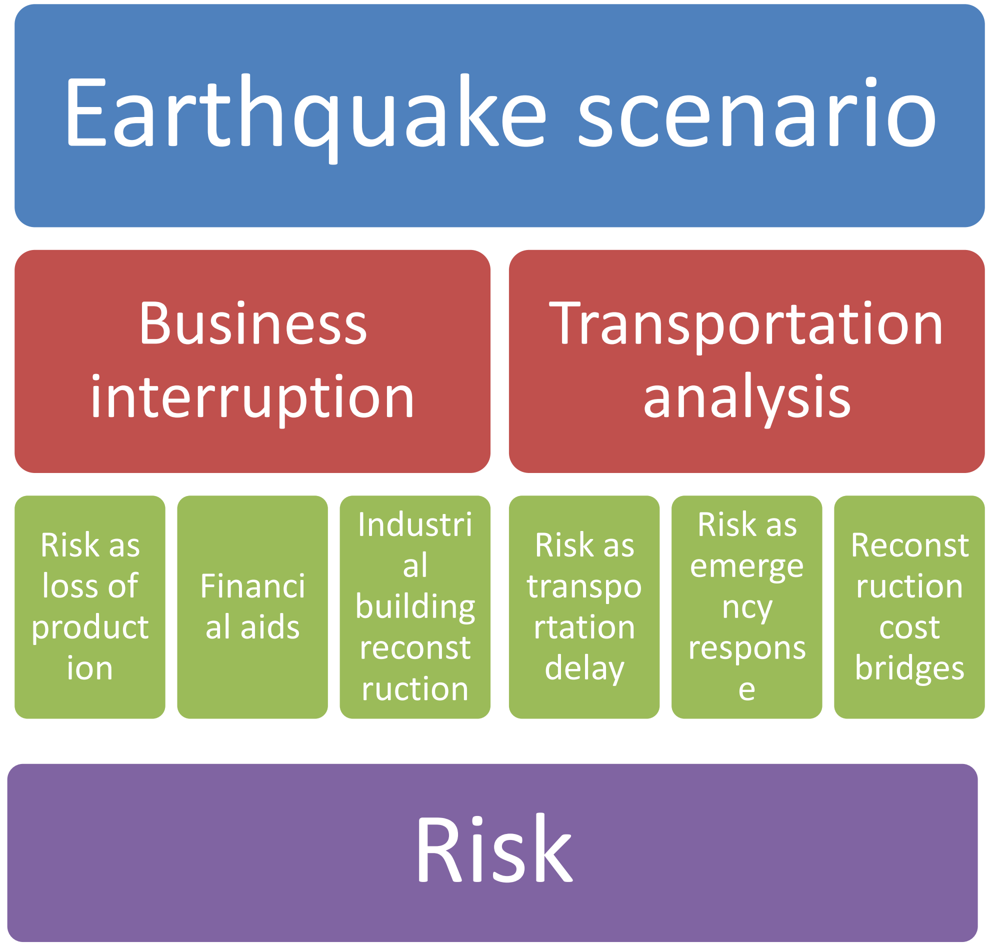
$$Loss = D + I$$

$$D = Bu + Br$$

$$I = Time + Product$$

D: Direct losses
I:Indirect losses
Bu: Direct losses connected to reconstruction cost in buildings
Br: Direct losses in term of bridge recontruction/rehabilitation cost

Time: The increase in transportation network time can be monetized as: 15.00€/hour
Product: Loss of production due to earthquake damage to industrial facilities



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BUSINESS LOSSES - HOW TO DEAL WITH BUSINESS DAMAGE

Earthquakes scenario

Damage State

$$P[ds|PGA] = \Phi\left[\frac{1}{\beta_{ds}}\ln\left(\frac{PGA}{\overline{PGA}_{d,ds}}\right)\right]$$

Residual functionality

$$RF = f(DS)$$

Residual productivity

$$Loss = F \times P$$

Residual functionality model	Economic data	Recovery model	Estimation of reconstruction cost
• Loss of functionality	• Loss of Gross Regional Product	• Recovery process	• Cost Benefit analysis

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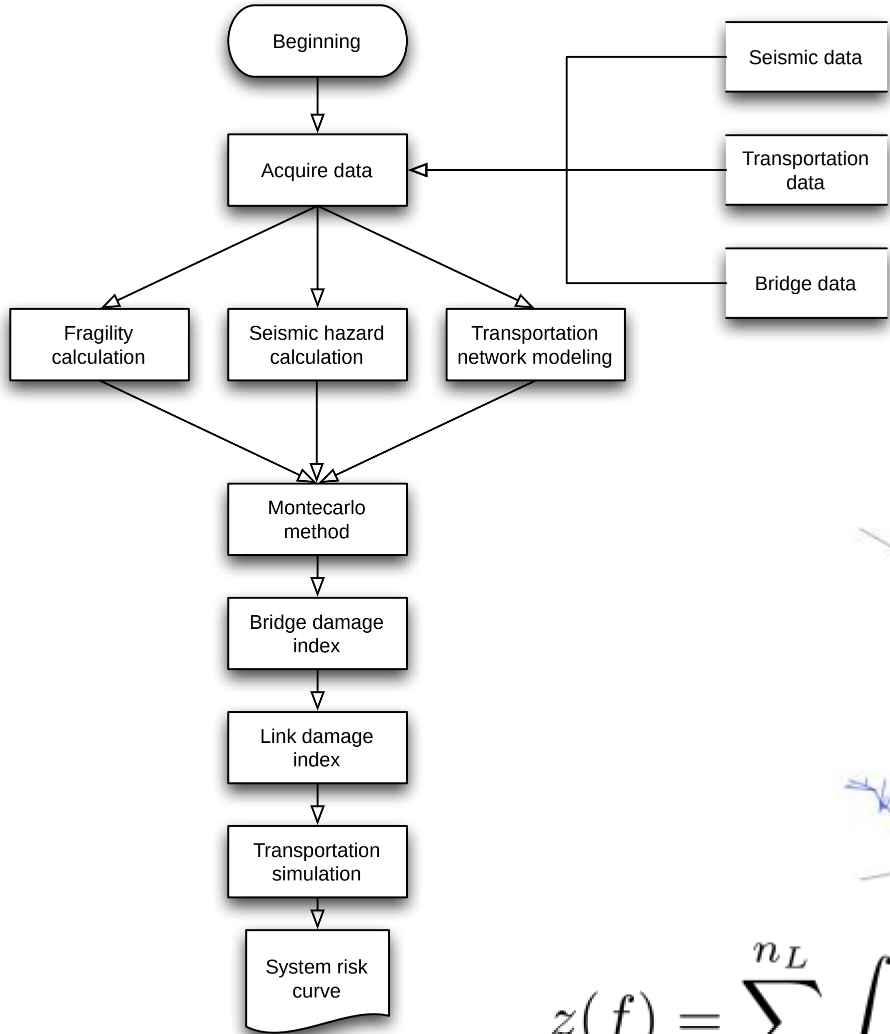
$$BD = F(PR, RF, FR, E)$$

- BD: Business Damage
- PR: Residual Productivity
- RF: Residual Functionality
- FR: Fragility of building
- E: Earthquake

TRANSPORTATION LOSSES - HOW TO MODEL THE TRANSPORTATION NETWORK

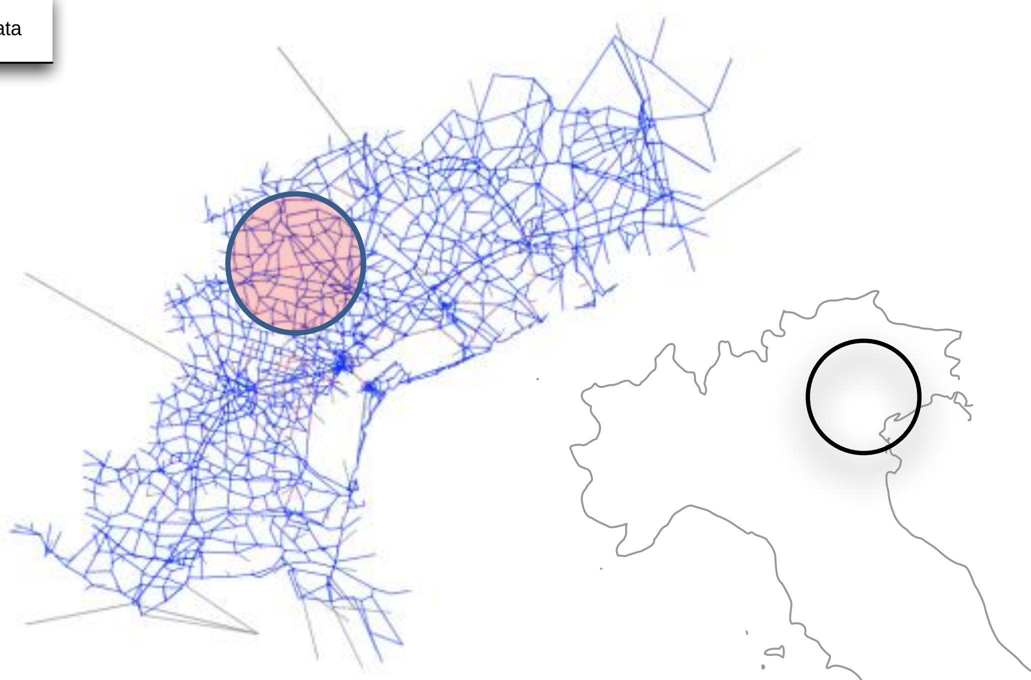


Number of bridges = 41

Number of links = 11’149

Number of nodes = 5294

Spatial extension = 100 km x 100 km



$$z(f) = \sum_{l=0}^{n_L} \int_0^{f_l} c_l(x)\ dx$$

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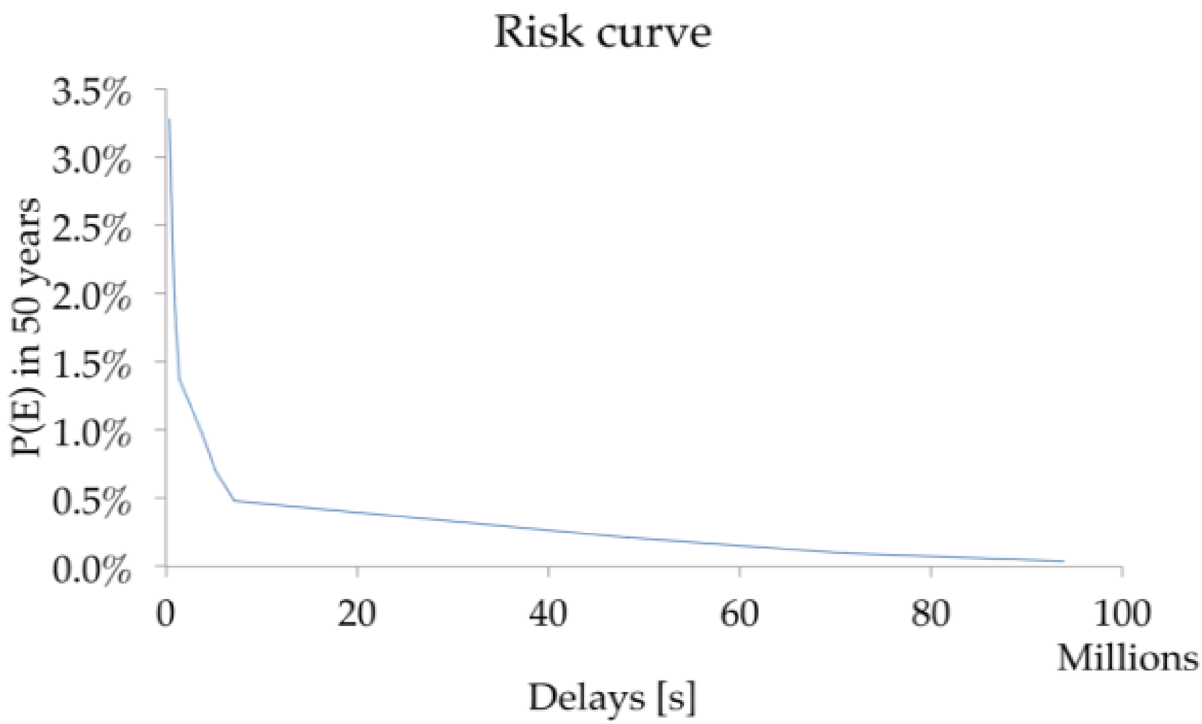
THE FINAL RISK CURVE FOR INDIRECT LOSSES IN THE TRANSPORTATION



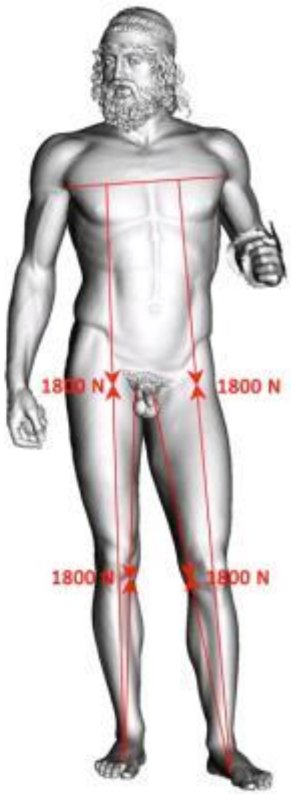
$$T_s = \sum_{l=0}^{n_L} f_{l,s} \cdot \bar{c}_l(f_{l,s}) \forall \ s$$

$$T_i = \frac{1}{N_{it\ MC}} \sum_{s=0}^{N_{scn}} T_s \quad \forall \ i$$

SEISMIC RISK MITIGATION: artistic objects - museums

BRONZO A

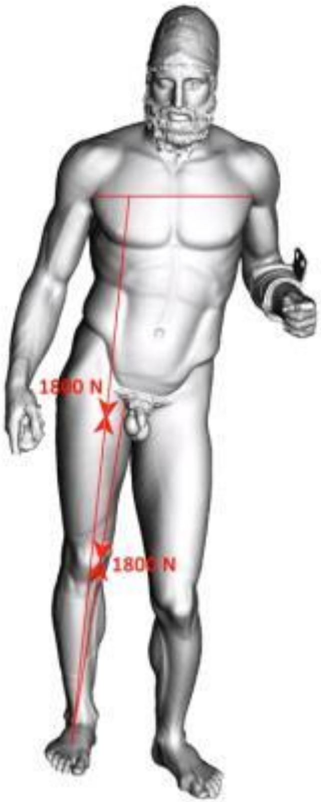
OLD SEISMIC ISOLATION



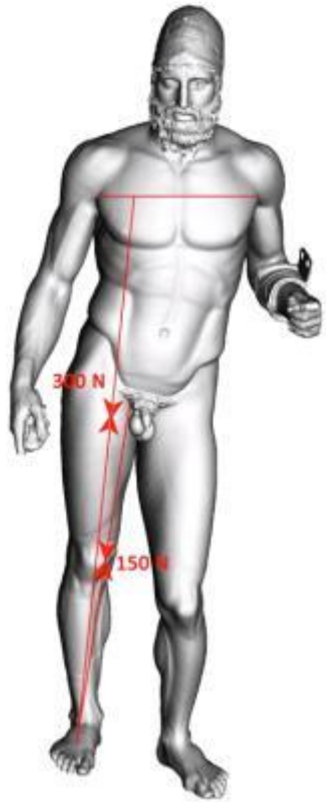
NEW SEISMIC ISOLATION

BRONZO B

OLD SEISMIC ISOLATION



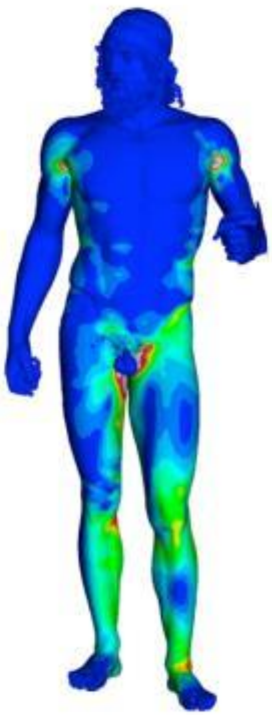
NEW SEISMIC ISOLATION



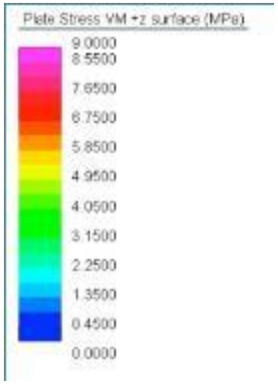
(I) STRESS DISTRIBUTIONS- VON MISES CRITERION (MPA)

EXTERNAL SURFACE OF THE BRONZO

OLD SEISMIC ISOLATION



NEW SEISMIC ISOLATION



EXTERNAL SURFACE OF THE BRONZO

OLD SEISMIC ISOLATION

NEW SEISMIC ISOLATION

Seismic protection and mitigation measures for artworks

Damage to the collection of the Archaeological Museum in Kobe, Japan (1995)

Museography design is generally conceived so that artworks can be displayed in a variety of manners:

1. works directly laid on the floor (statues)
2. works that are displayed inside bigger display cases
3. works directly laid on the podiums
4. works under a glass bell jar put on the podiums.

Show cases not adequately anchored can **slide**, **rock** and/or **overturn** during earthquake and cause damages to the case itself and its content. On the other hand show cases, even adequately bolted or anchored, **can suffer high acceleration amplifications**, requiring a number of reliable anti-seismic devices (elastic net, clips, etc.) applied to the single item, or group of objects exhibited in the display case.

There are **many techniques available** to reduce potential non-structural earthquake damage:
-providing base isolation or seismic shock absorber for standing-alone showcases or large podia (*rolling bearing device*, *wheels on rails isolators*, …) ;
-mitigation measures intended to increase resistance and structural redundancy of the case itself, like using of adequate anchor bolts to provide rigid anchorage to the floor, or bracing to the structural slab.

Anti-seismic devices for lightweight structures

PRINCIPAL CHARACTERISTICS FOR A GENERAL ANTI-SEISMIC DEVICE:

- ability to support gravity loads, both under static and seismic conditions;
- high deformability (or low stiffness) in the horizontal direction under seismic actions;
- appropriate energy dissipation capacity;
- adequate resistance for the horizontal non-seismic actions.

Another important characteristic, although *not essential*, is:

- ability to re-centering, which allows to have no or negligible residual displacements at the end of the seismic actions.

UNSUITABILITY OF TRADITIONAL ANTI-SEISMIC DEVICES FOR LIGHTWEIGHT STRUCTURES**:**

ELASTOMERIC DEVICES: they are neither economically advantageous nor, in some cases, technically suitable, because *the bearing function* ***is coupled*** *to the reduction function of horizontal stiffness*

With low values of mass to isolate (< 10 t) in fact, to achieve a sufficiently high natural period of vibration is possible to act on two device's parameters: increase the height or decrease the plan size of device → increase of the slenderness !

IT IS BETTER TO SEPARATE FUNCTIONS INTO:

- **bearing of load**
- **accommodation of horizontal displacement**
  + provision of a restoring force

} **sliding / rolling bearings**
+ dished tracks or auxiliary springs

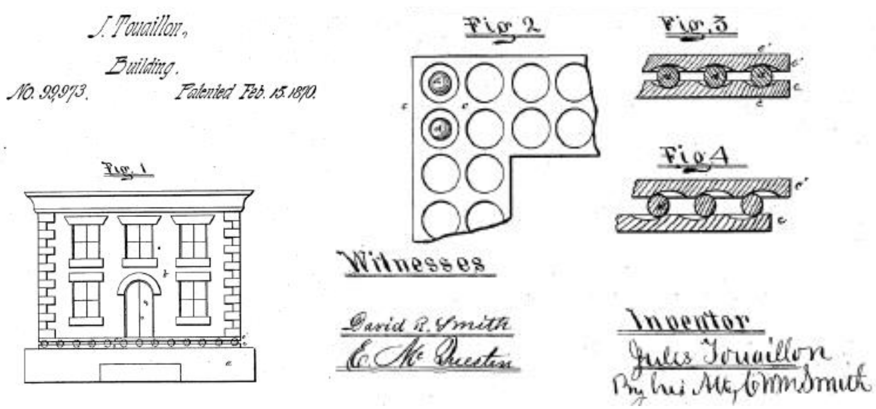
Anti-seismic devices for lightweight structures

Snag: sliding bearings are rigid until a threshold force; this would leads to have an amplification of the seismic excitation on the artwork for small intensity earthquake.
Instead, rolling devices tend to have too little rolling resistance.

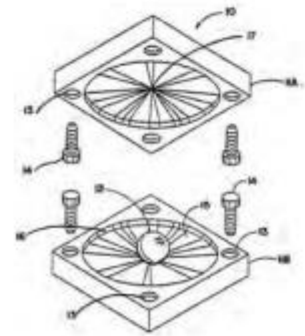
So the idea is to provide **rolling devices** with **damping** by using ***rubber layers*** on rollers or tracks, or using other ***frictional materials***, or with some ***auxiliary damping devices*** (that work in parallel).
For the **restoring force**, generally, it is used rubber or steel coil ***spring***, or ***no-flat rolling plane***.

The first patent about the rolling ball devices is by *Touaillon in 1870* (see *Tsai et al., 2010, Earthq Eng & Eng Vib, 9: 103-112*) . Other studies were performed by other researchers, as Schar (1910), Cummings (1930), Bakker (1935), Wu (1989), Kemeny (1997), Tsai (2006) …

Touaillon, 1870



Ball-in-cone seismic isolation bearing, Kemeny, 1997.



Ball pendulum system «BPS», Tsai 2006.

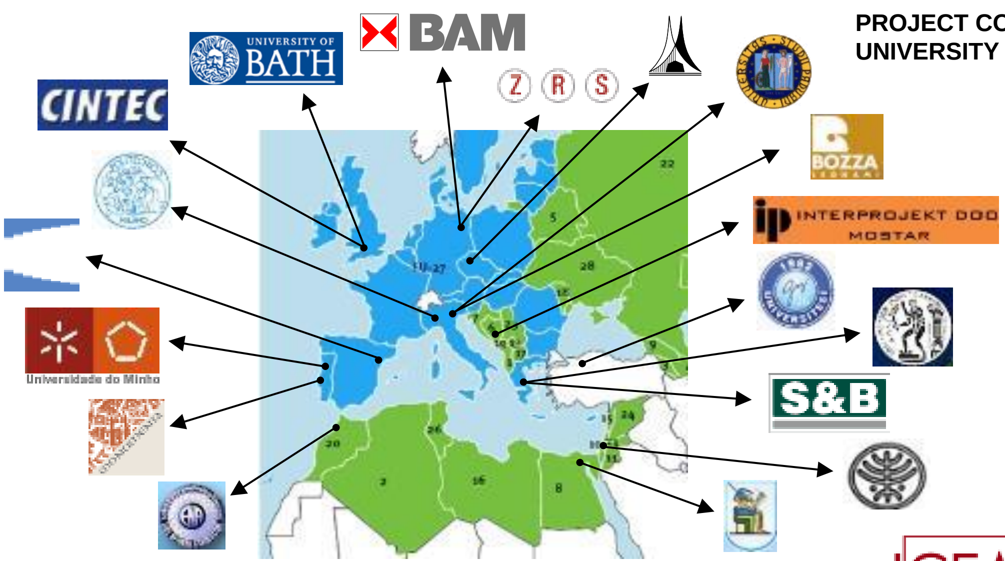
Seismic Risk Preparedness and Mitigation of Culture Heritage Sites

מוכנות והיערכות לסיכוני רעידות אדמה באתרי מורשת תרבות

Israel, Jerusalem. 19-20 January 2014 ירושלים. יח'-יט' בשבט, תשע"ד

NIKER

NEW INTEGRATED KNOWLEDGE BASED APPROACHES TO THE PROTECTION OF CULTURAL HERITAGE FROM EARTHQUAKE INDUCED RISK - FP7-ENV-2009-



PROJECT COORDINATOR:
UNIVERSITY OF PADOVA

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www.niker.eu

ProVaCI Formazione


Assisi (PG)


Aquileia (UD)

Progetto **PROVACI**

Tecnologie per la **PRO**tezione sismica e la **VA**lorizzazione di **C**omplessi di **I**nteresse culturale

IL PROGETTO DI RICERCA

Sviluppo di tecniche e metodologie integrate per la protezione sismica, la tutela, la riqualificazione sostenibile e la valorizzazione di siti e strutture di interesse storico-artistico

9 aprile 2010

Development of sustainable techniques and methodologies for seismic protection, sustainable redevelopment and valorization of masonry buildings and archeological sites

PARTNERS:

- STRESS S.c.a.r.l.
- CONSORZIO TRE
- UNIVERSITA' DI NAPOLI "FEDERICO II"
- CONSORZIO CETMA
- SI.PRE s.r.l.
- **UNIVERSITA' DI PADOVA**
- C.R.A.C.A. Soc. Coop.
- NANOFAB s.c.a.r.l.

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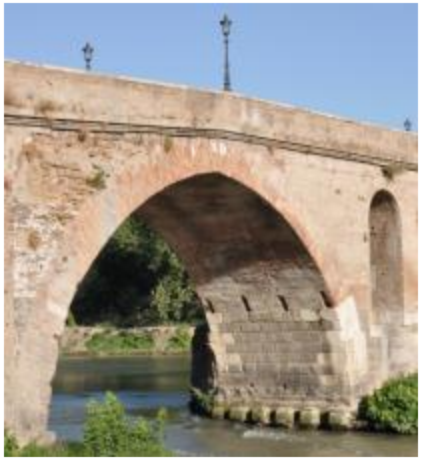
AGREEMENT AND PROJECTS WITH PUBLIC AUTHORITIES

- ARCUS – Seismic vulnerability analysis of Public National Museums and art objects, MIBAC
- Seismic vulnerability assessment of the regional road network – Regione Veneto
- Seismic vulnerability assessment by macro-classes of railway masonry bridges, RELUIS-RFI
- Vulnerability assessment of historic centres, public authorities and National Civil Defense
- Seismic analysis of relevant and strategic buildings (level 1 and level 2, OPCM 3274 e il DPCM 21/10/03), public authorities and National Civil Defense
- Activities related to L'Aquila (6/4/2009) and Emilia Romagna/Veneto/Lombardia (May 2012) earthquakes, Agreements with Regional Directorates of MIBAC, Municipalities, Technical Service for Reconstruction



THANK YOU!

SPEAKER: PROF. CLAUDIO MODENA

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