SEISMIC ACADEMY

Smart BIM Buildings: è possibile rendere un edificio intelligente, sicuro e ad alte prestazioni?

Prof. Roberto Nascimbene
Professore IUSS Pavia

Con il patrocinio di

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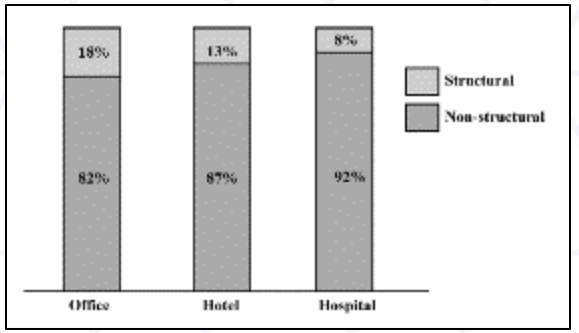
Non-structural elements: safe living environments using domotics and building automation

Non-structural elements represent most of the total construction cost of typical buildings. A significant portion of the total losses in recent earthquakes worldwide, has been attributed to damage to non-structural elements. Damage to non-structural elements occurs at low levels of ground shaking, and can significantly affect the post-earthquake functionality of buildings.



2009

M 6.3 April 6, 03:32:00 UTC

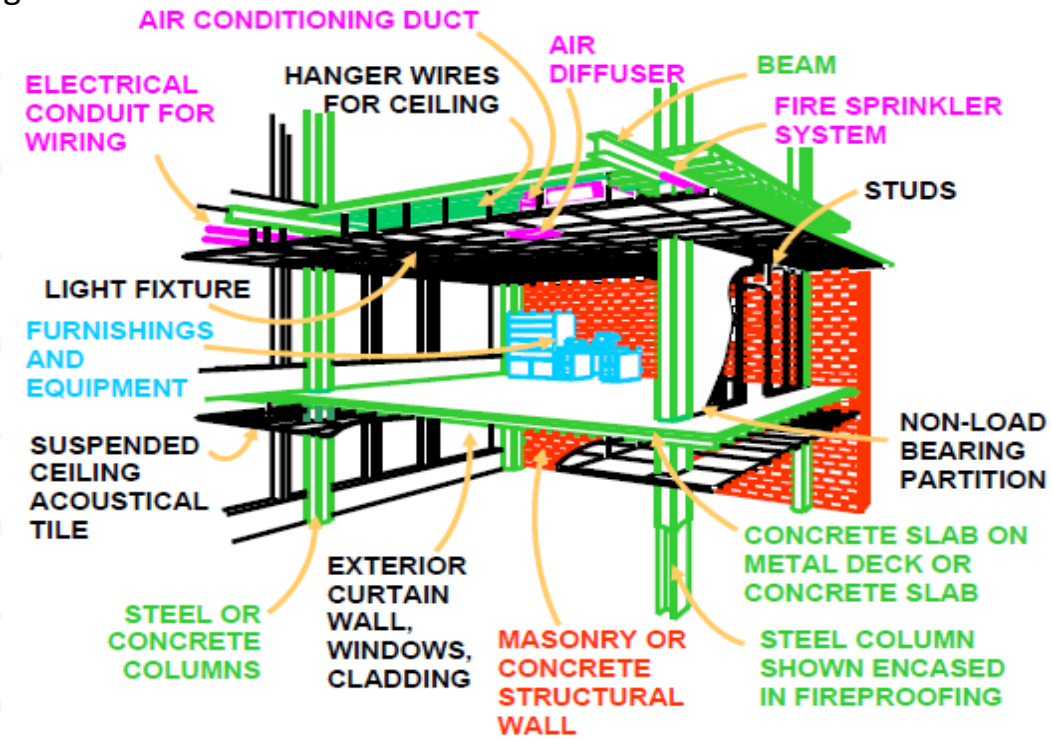
2012

M 6.0 May 20, 02:03:52 UTC
M 5.8 May 29, 09:00:03 UTC

2016

M 6.0 August 24, 01:36 UTC
M 5.4 October 26, 17:10 UTC
M 5.9 October 26, 19:18 UTC
M 6.5 October 30, 06:40 UTC

- ✓ Architectural elements
- ✓ Contents
- ✓ Mechanical Equipments



What about performance ?

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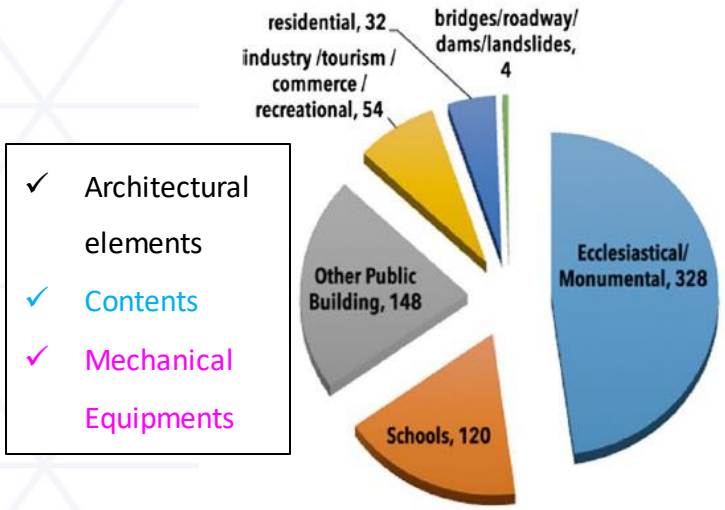
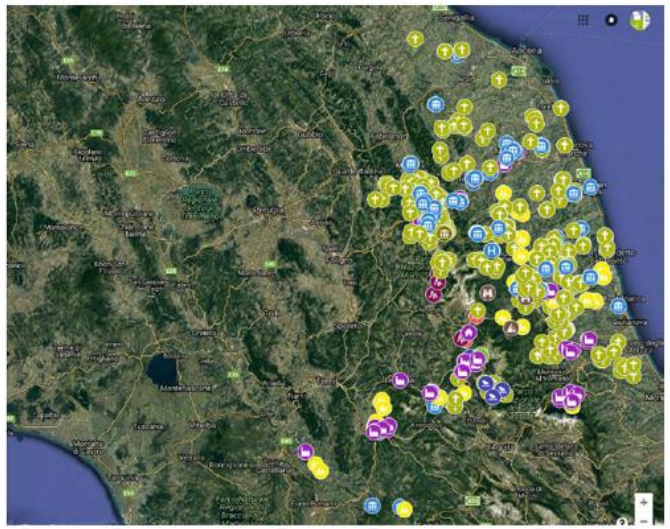
Inspections performed by EUCENTRE Team following the 2016 Central Italy earthquake

http://www.eqclearinghouse.org



Credits to Dr. Chiara Casarotti

- ✓ Architectural elements
- ✓ Contents
- ✓ Mechanical Equipments



About **700 inspections** were completed in the aftermath of the seismic events. Most of these inspections were performed on **critical** (schools, hospitals and public, industrial) and ecclesiastical/ monumental buildings.

1. **Infill walls, internal partitions and facade**
2. **Ceiling systems**
3. **Piping systems**
4. **Storage racks**
5. **Chimneys, appendages and parapets**
6. **Glazing systems**
7. **Mechanical equipment and tanks**
8. **Hospital medical equipment**
9. **Stuccoes, decoration and roof tiles**
10. **Furnitures**

→ most common non-structural damage observed during building inspections →

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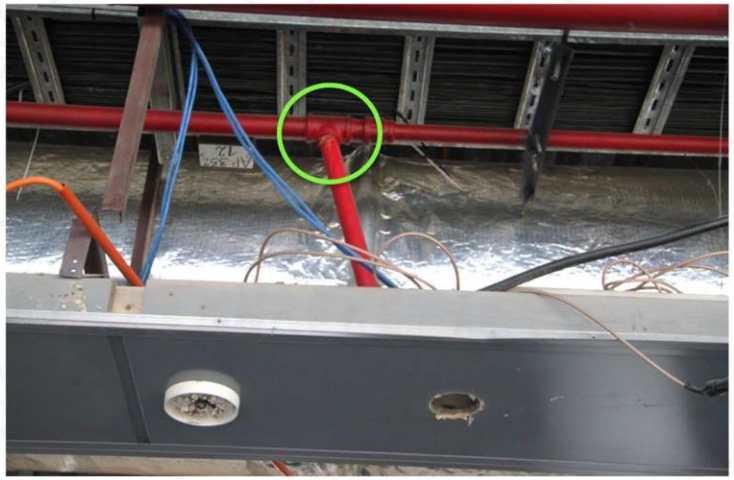
“OBSERVED” damages following the 2016 Central Italy earthquake



Closeup view

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Observation from space !!!

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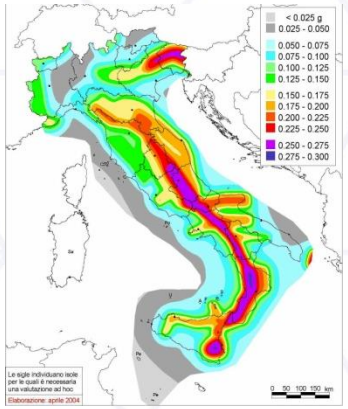
From structural “Guidelines” to non-structural rules. Is it possible ?

On February 20th, 2017, the General Assembly of the **Consiglio Superiore dei Lavori Pubblici** unanimously expressed a favorable opinion on the text of the "Guidelines for the classification of seismic risk in buildings".

The Guidelines provide the instrument for regulating tax incentives, linked to the measure of the so-called **Sismabonus**, with a specific reference to private and productive construction, constituting the first tool for activating a concrete **Seismic Prevention policy** of the residential and productive building heritage of the our Country.

class A+ (less risk)
class A
class B
class C
class D
class E
class F
class G (more risk)

HAZARD → VULNERABILITY → EXPOSURE



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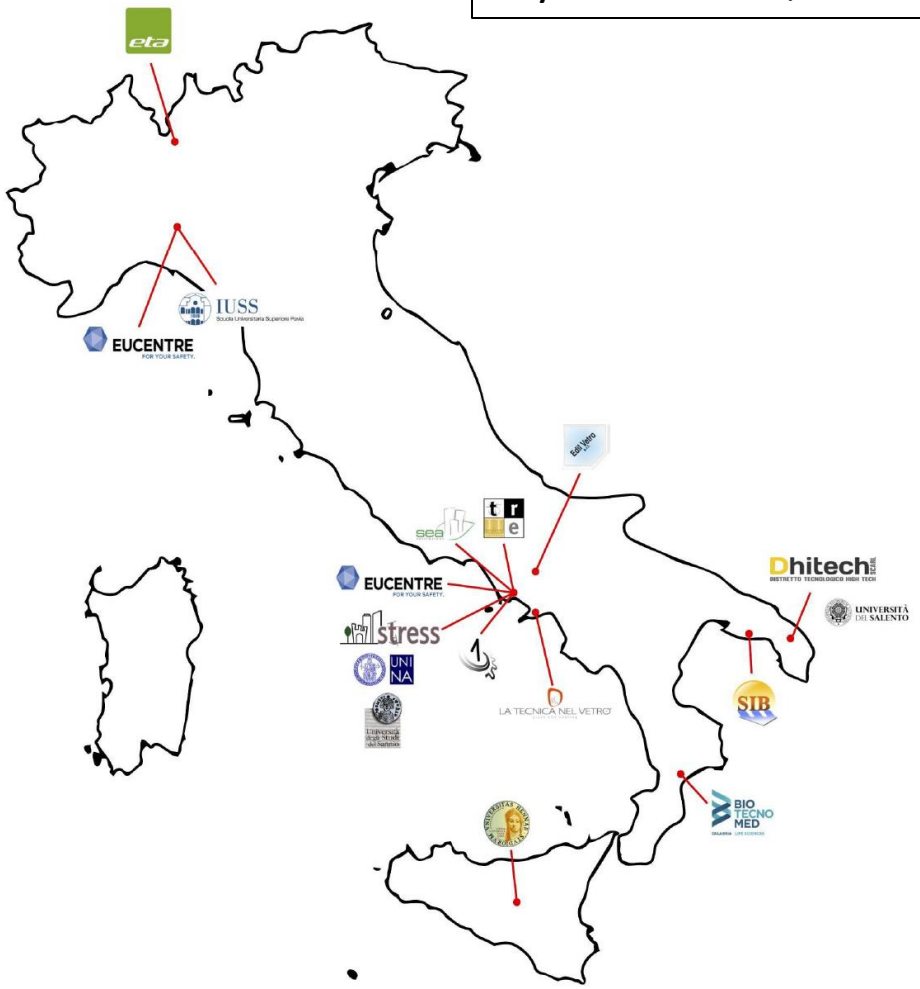
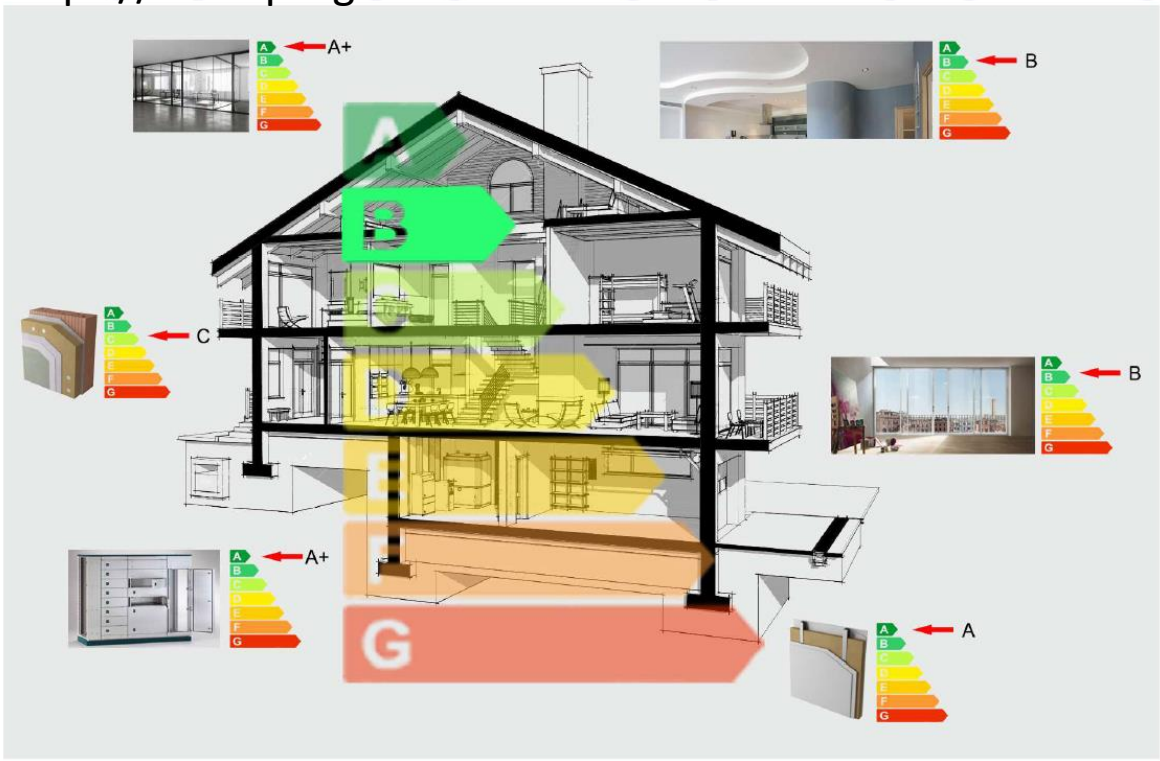
YES is the answer… CADS Research Project – «Creazione Ambiente Domotico Sicuro»

Non - structural IUSS Team leaded by Prof. André Filiatrault with help from Bryan Chalarca, Roberto Merino and Daniele Perrone



https://www.progetto-cads.it



https://sites.google.com/iusspavia.it/nonstructural/

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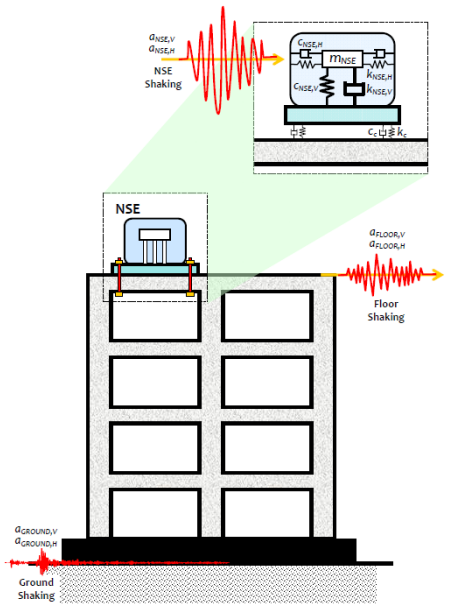
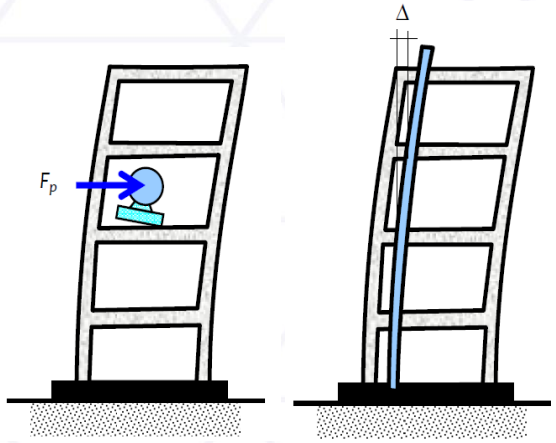
Actuation phase of the project



Seismic demand NSE

MAIN dynamic prop. NSE (freq., stiff., conn.)



Vulnerability identification:
1) **acceleration sensitive**
2) **displacement sensitive**

Capacity evaluation:
1) Exp. test
2) Past seismic events
3) Numerical models

NSE classification and then….could be … certification!!!

IT IS OF OUTMOST IMPORTANCE THE PERFORMANCE OF THE NSE

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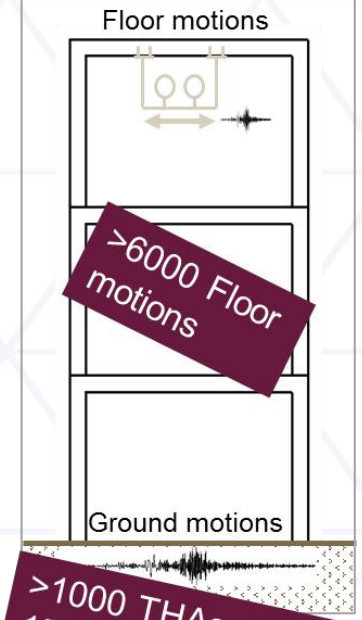
HILTI KNOWS VERY WELL THIS ASPECT !!!

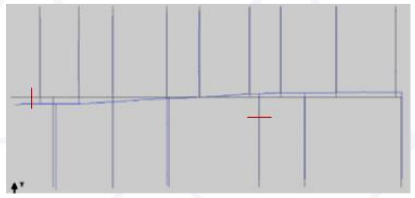
Buildings
Dynamic Analysis



>6000 Floor motions

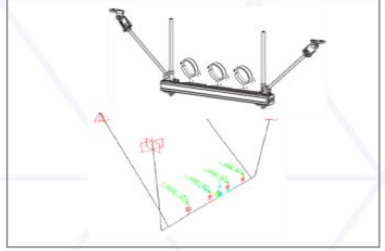
>1000 THAs with 15 Italian buildings

Piping Systems
Numerical Time History Analysis

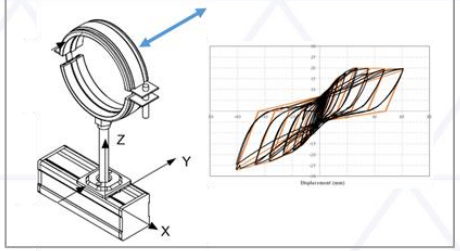


7200 THAs

Sub-Systems
Numerical Modelling



Individual Components
Numerical Modelling



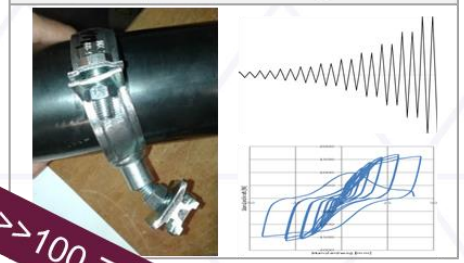
Research Output

1. How to test and what to measure
2. Software modelling for flexibility
3. Cyclic testing protocol
4. Behaviour factors from ductility
5. Design guideline to avoid leakage
6. Deflection of pipes at firestops

Cyclic Testing

18 + 3 Tests

Cyclic Testing



>>100 Tests

…safe living environments using domotics and building automation ???

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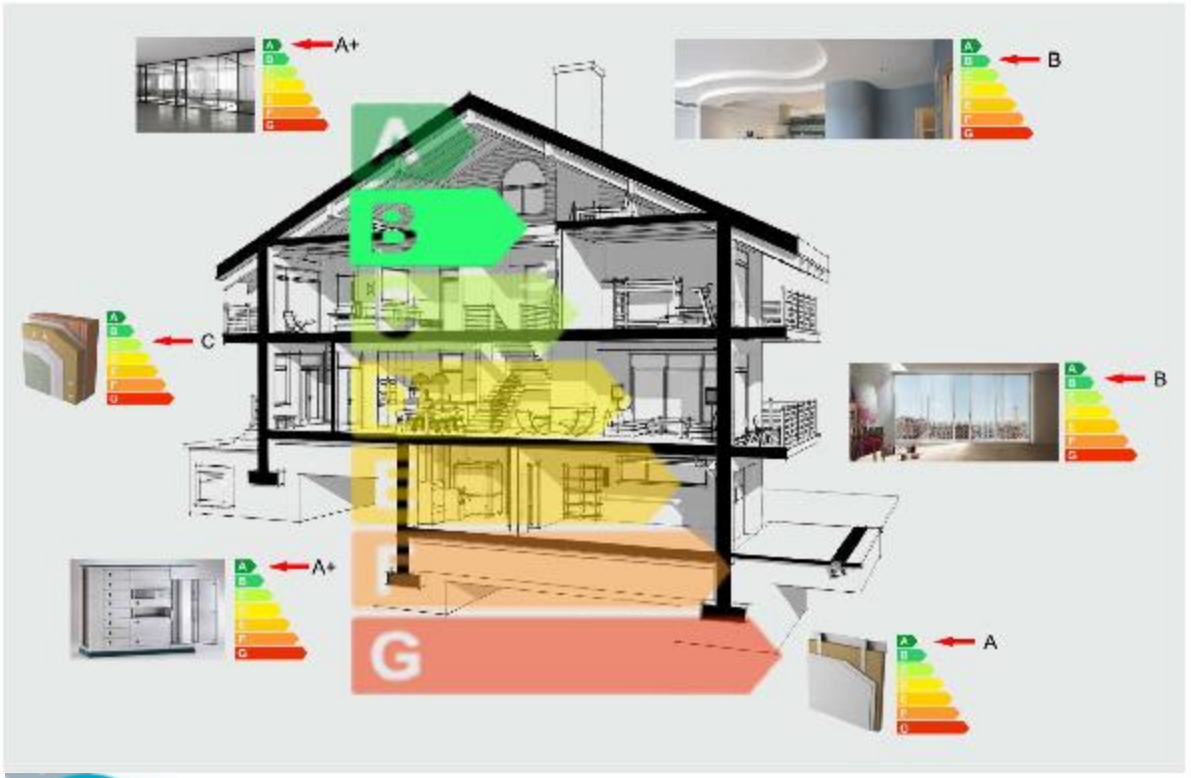
Advanced monitoring real time techniques to help building domotic … is it possible ?

SENSOR !!!



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SAMBA Research Project – «Smart Advanced Multitenats Building»

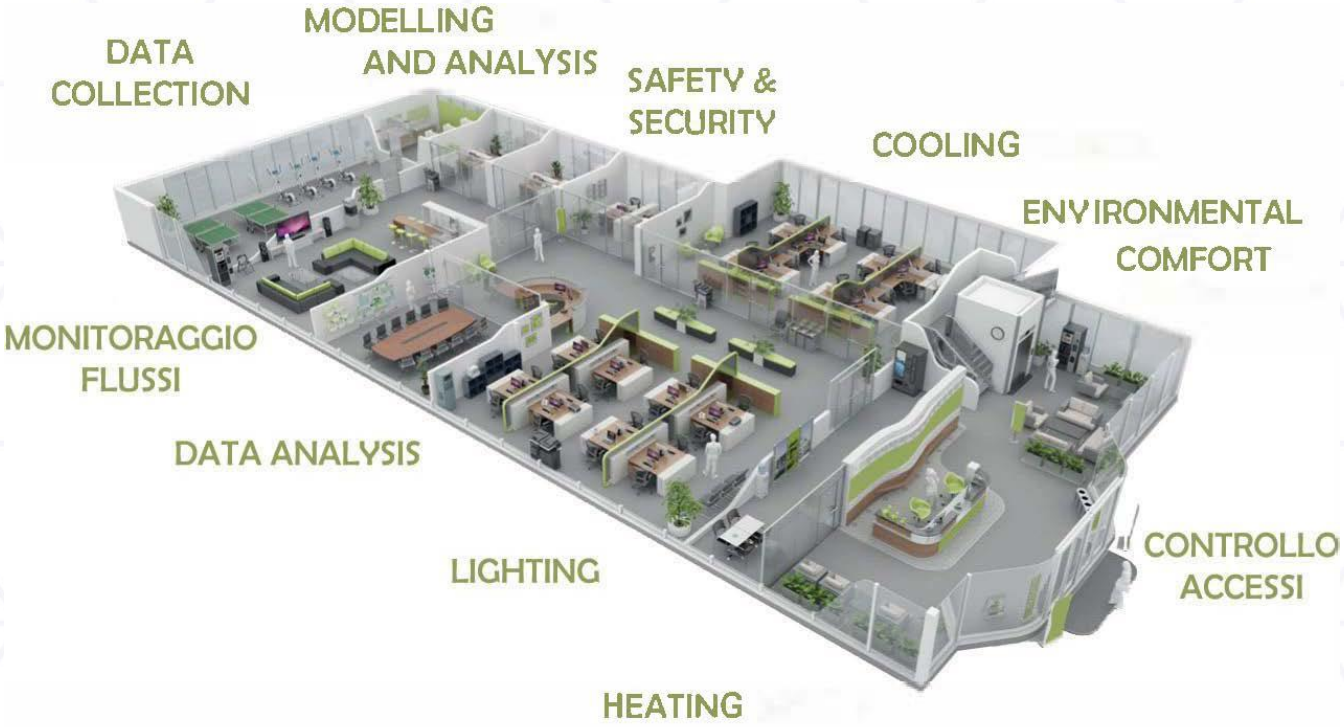
https://italiansmartbuilding.eu

SAMBA
Smart Advanced Multitenants Building Automation

Energy management *Sensing & Forecast*

Grid Management *Energy Prediction*

Access Management *Security & Event Monitoring*



SAMBA
Smart Advanced Multitenants Building Automation

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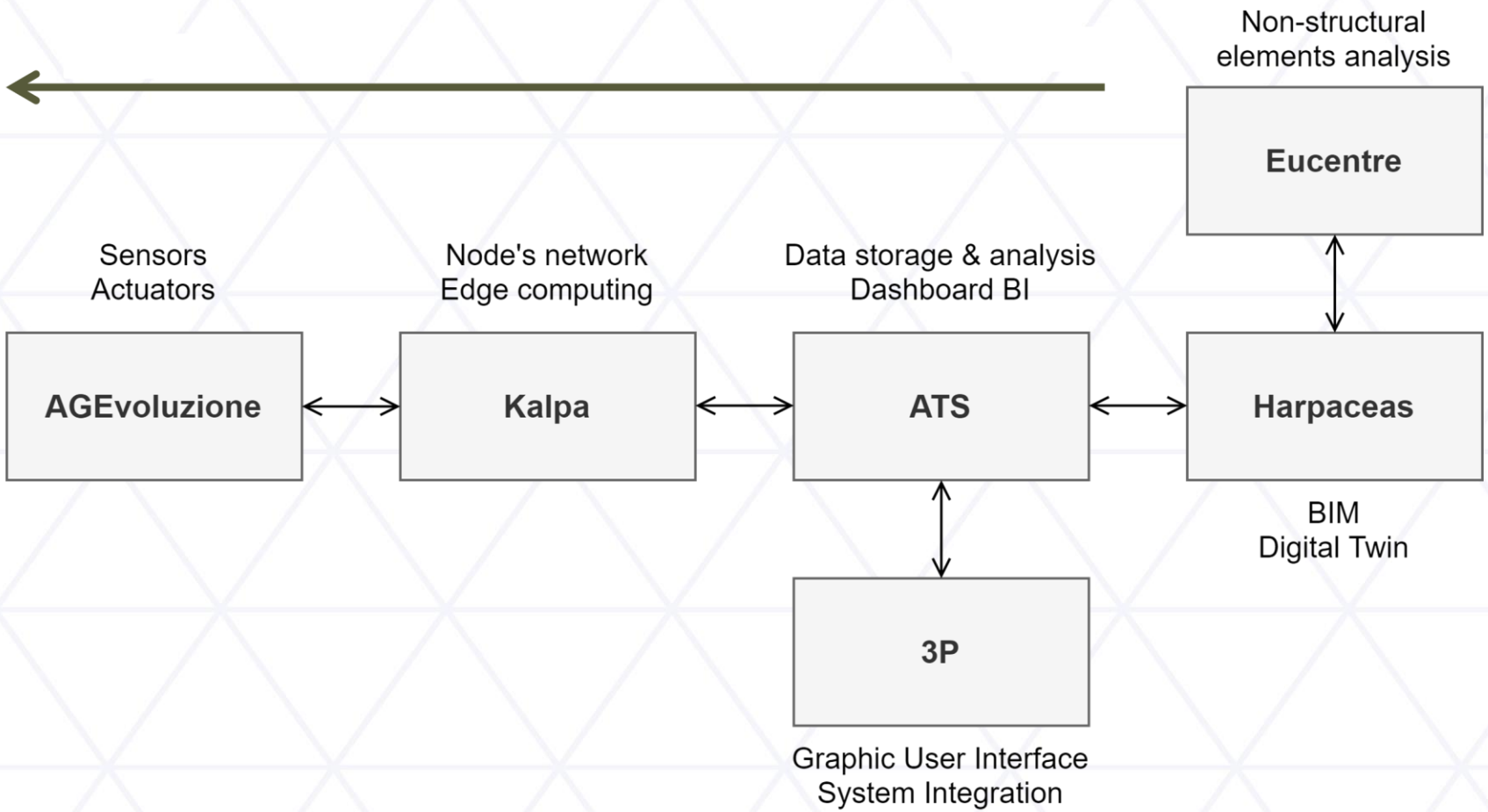
SAMBA Research Project – «Smart Advanced Multitenats Building»



SAMBA
Smart Advanced Multitenants Building Automation

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SAMBA Research Project – Digital Twin -

since 1990 HARPACEAS More than BIM

SAMBA
Smart Advanced Multitenants Building Automation

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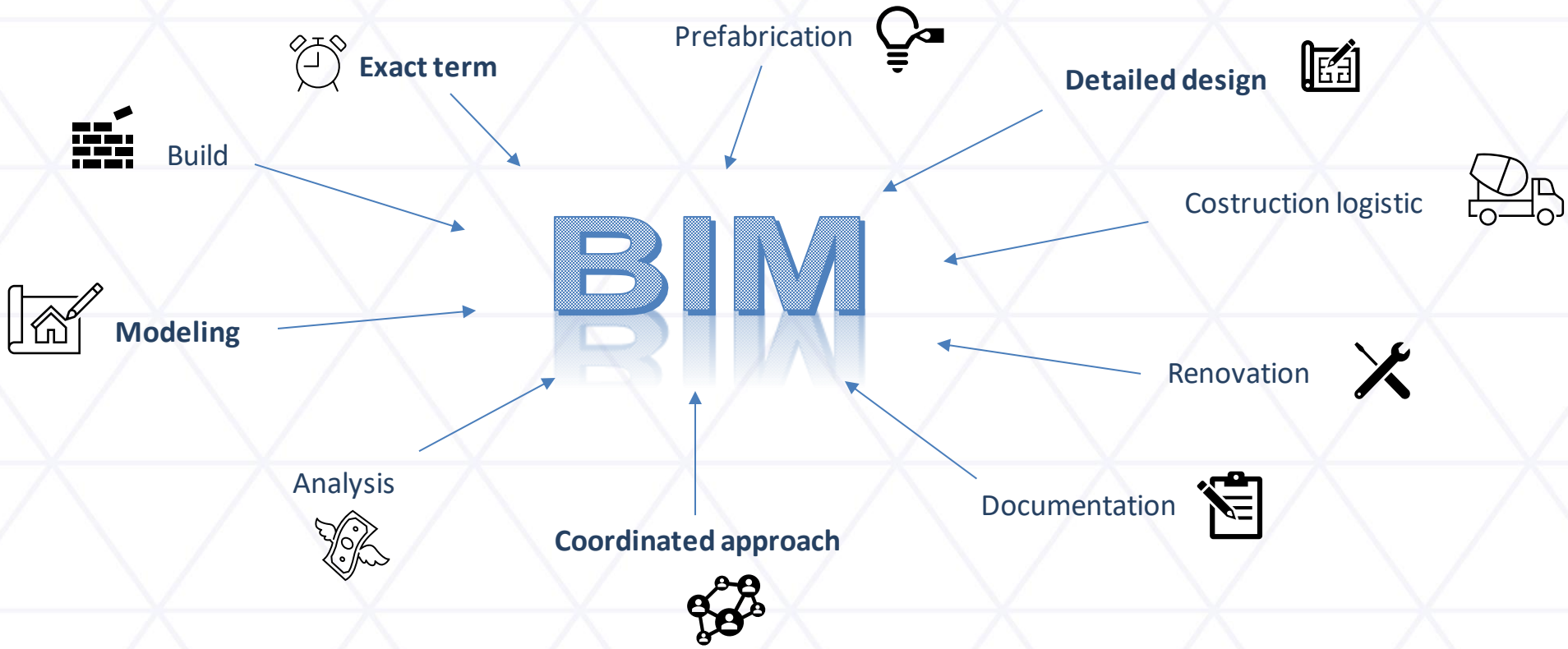
Use of BIM for the seismic design of NSEs

Non - structural IUSS Team leaded by Prof. André Filiatrault with help from Milena Casto and Daniele Perrone



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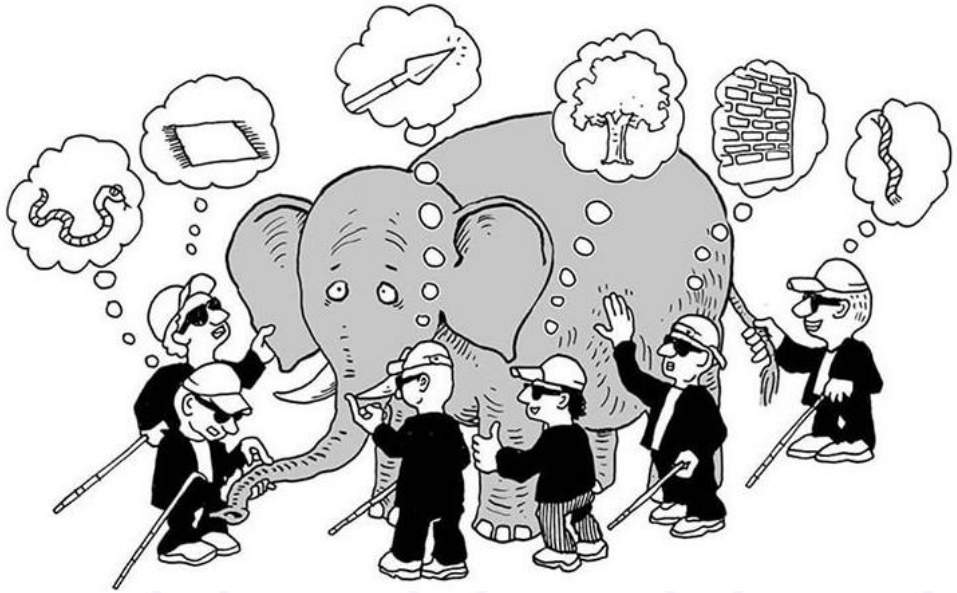
Conclusions

- The current state of art allows to evaluate the seismic performance of non-structural elements, even if further efforts are required to reach the same level of knowledge available for structural elements

- Building Information Modelling could be a possible solution to include the seismic design of non-structural elements into practice

- Develop a robust experimental nonstructural hysteretic database

- Develop a general simplified procedure to construct design floor relative displacement response spectra



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