NIDays

ENGINEER NEXT


# MEng Filippo Dacarro

Fondazione Eucentre

Laboratori Eucentre – La sperimentazione nel campo dell’ingegneria sismica

filippo.dacarro@eucentre.it


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY

# Eucentre:

European Centre for Training and Research in Earthquake Engineering and Seismology

# Facility and Research

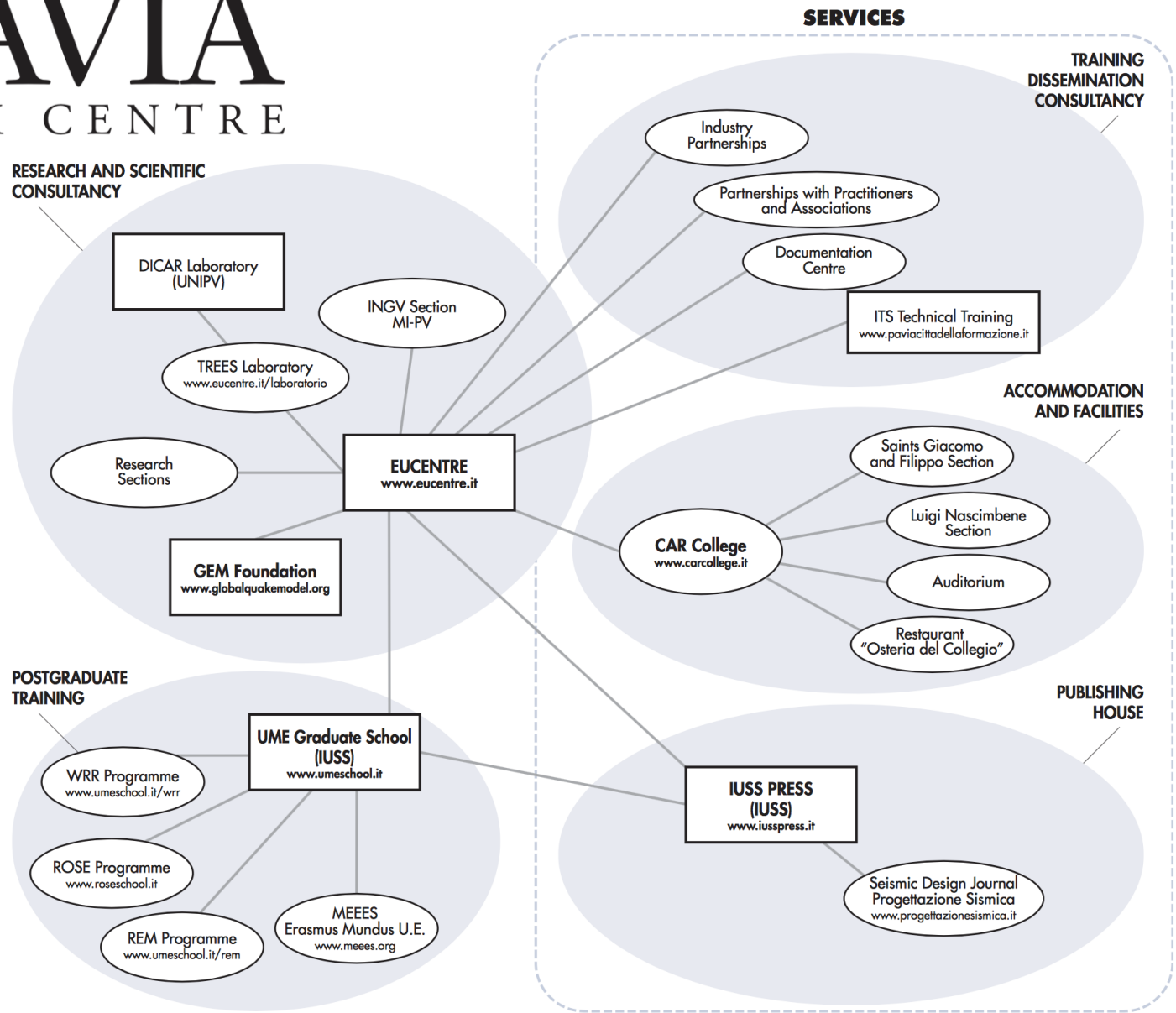

La Fondazione Eucentre, con sede a Pavia, è un ente senza fine di lucro che promuove e sviluppa la ricerca e la formazione nel campo della riduzione del rischio, in particolare sismico. La creazione di Eucentre è avvenuta nel 2003, su iniziativa dei seguenti soci fondatori: Dipartimento della Protezione Civile Nazionale, Università degli Studi di Pavia, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Istituto Universitario di Studi Superiori di Pavia (IUSS).

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

## RICERCA

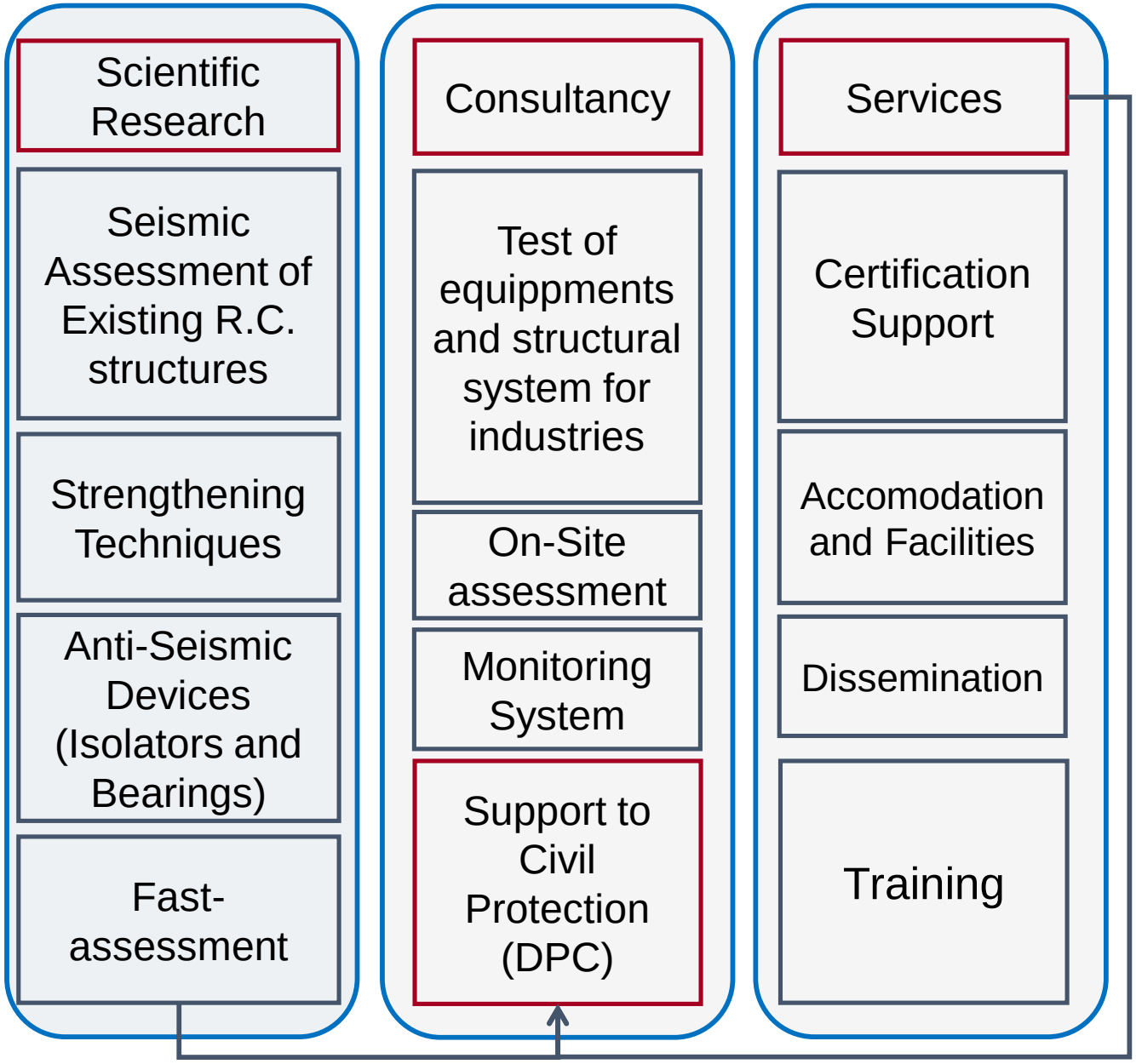
- Aerospazio
- Analisi Strutturale
- Elementi Non-Strutturali
- Geotecnica Sismica
- Innovazione Tecnologica
- Meccanica Computazionale
- Azione e Progettazione Sismica (SIDE)
- Risk Governance
- Scienze Ambientali, Salute e Sicurezza (EHS)
- Analisi multi-rischio e servizi Copernicus
- Strutture in muratura
- TREES Lab Metodi sperimentali e isolamento sismico
- Vulnerabilità e gestione territoriale

PAVIA RISK CENTRE




NATIONAL INSTRUMENTS

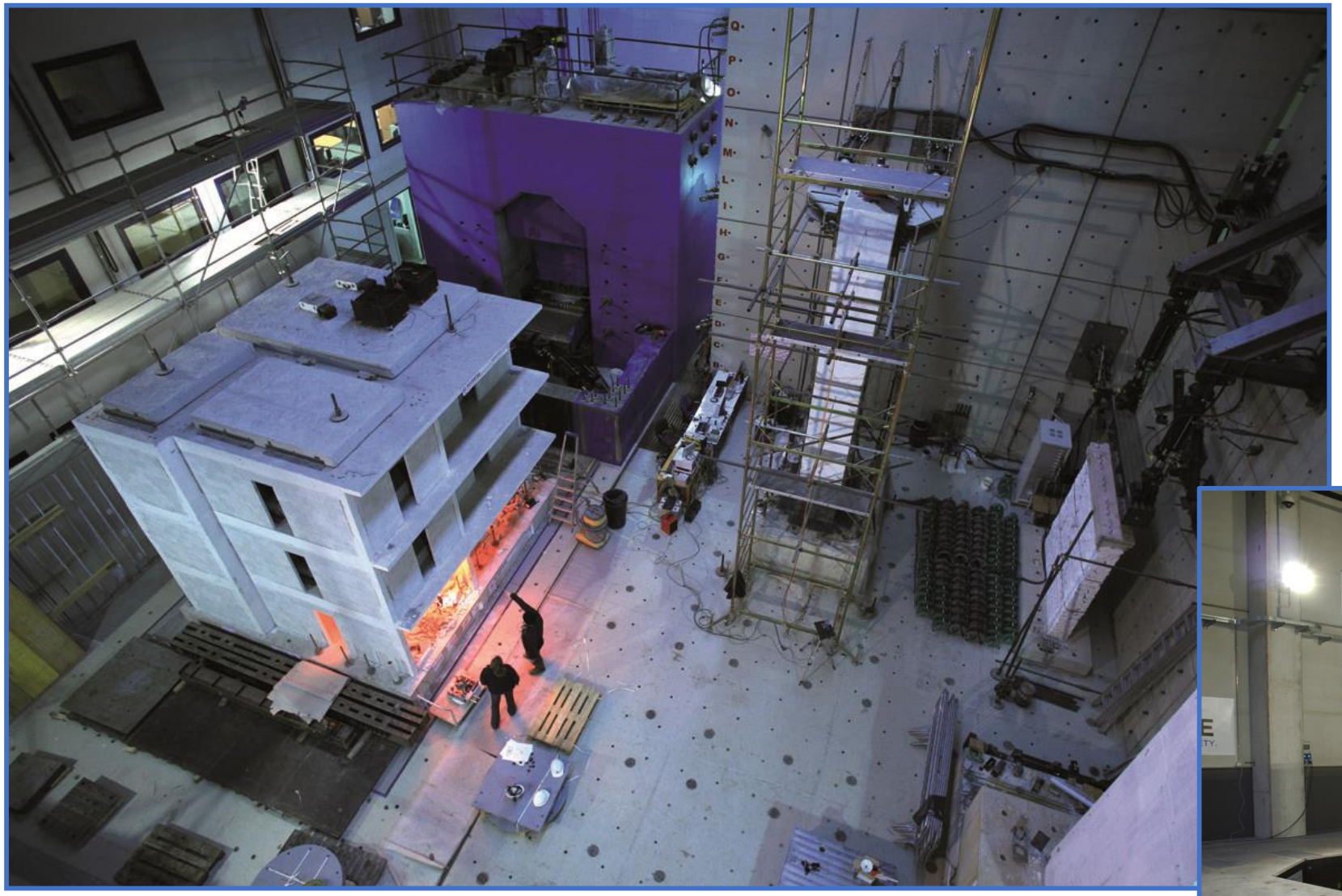
EUCENTRE
FOR YOUR SAFETY.




NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

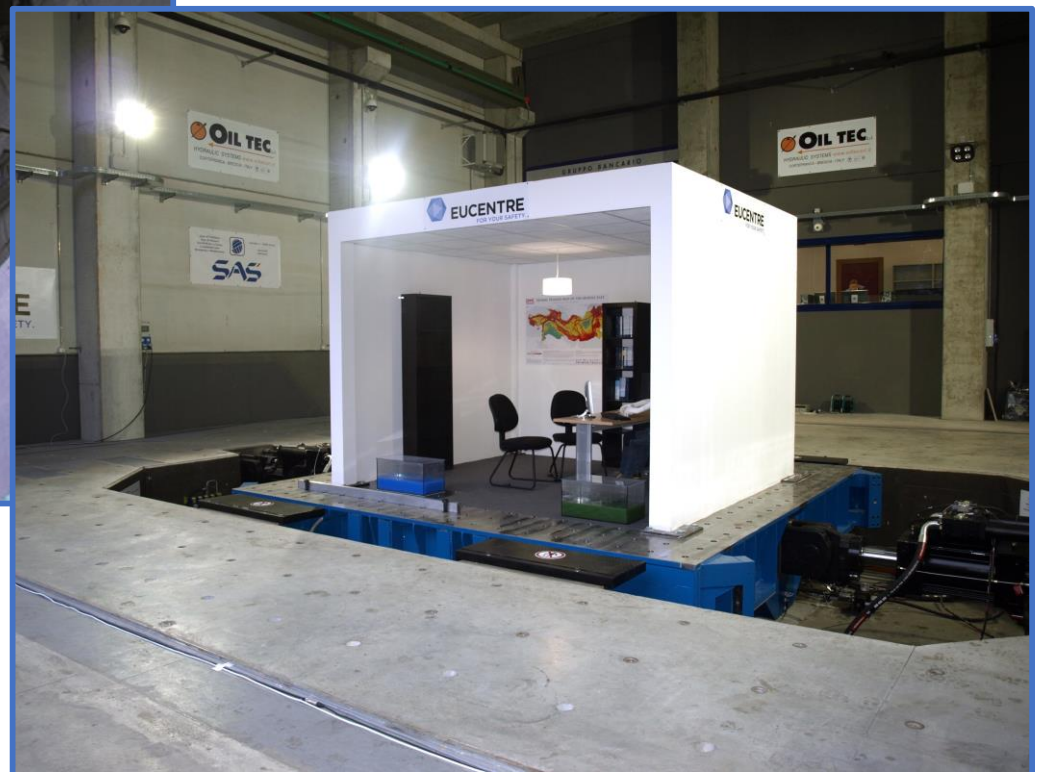
- **Ricerca Applicata** nel settore dell'ingegneria sismica, orientata a conseguire concreti obiettivi per la valutazione e riduzione della vulnerabilità e del rischio;
- **Attività Utile** alla definizione di specifiche linee di azione pubblica, di atti di indirizzo, di **linee guida**;
- **Training** formazione di operatori aventi spiccate capacità scientifiche e professionali;
- **Consulenza** scientifica e tecnologica a livello nazionale ed internazionale.

# Tavola vibrante mono-assiale



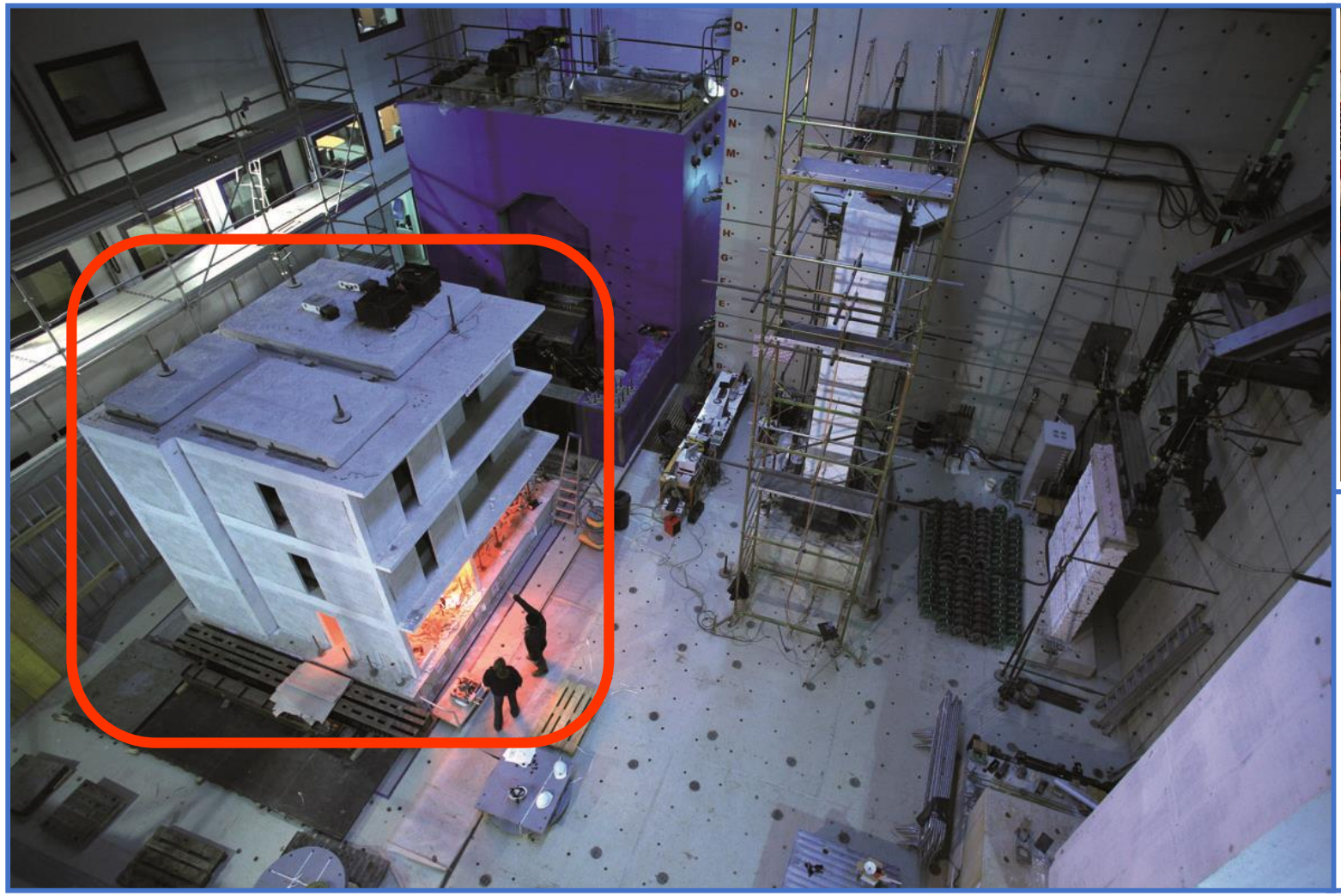
## EUCENTRE Laboratories

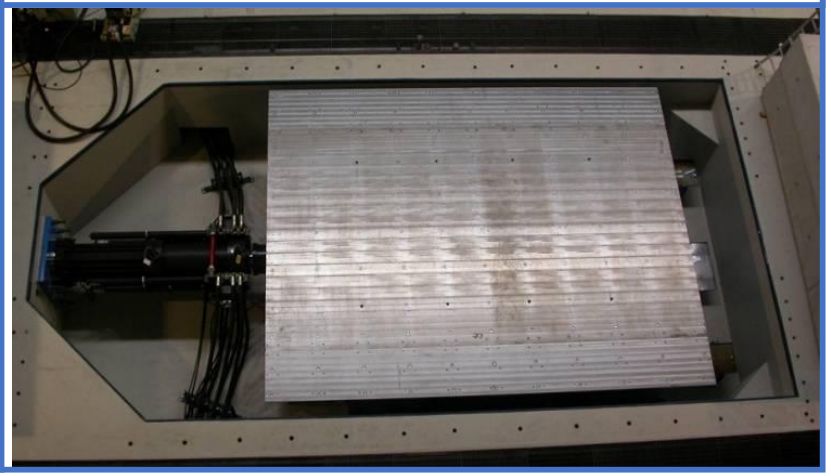
- Tavola Vibrante Mono-assiale
- Bearing Testing System
- Damper Testing System
- Reaction-walls
- Mobile Unit
- Tavola Vibrante Multi-assiale




NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Tavola vibrante mono-assiale

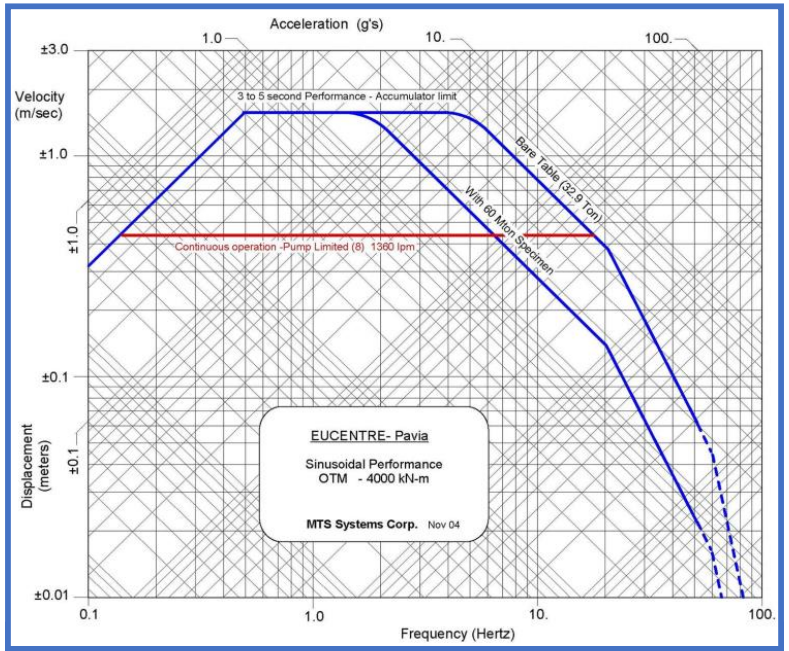


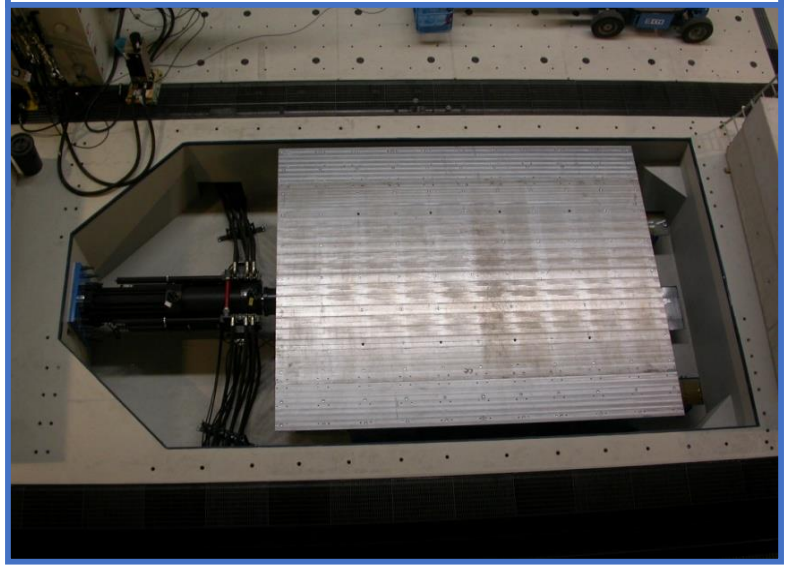


NATIONAL INSTRUMENTS

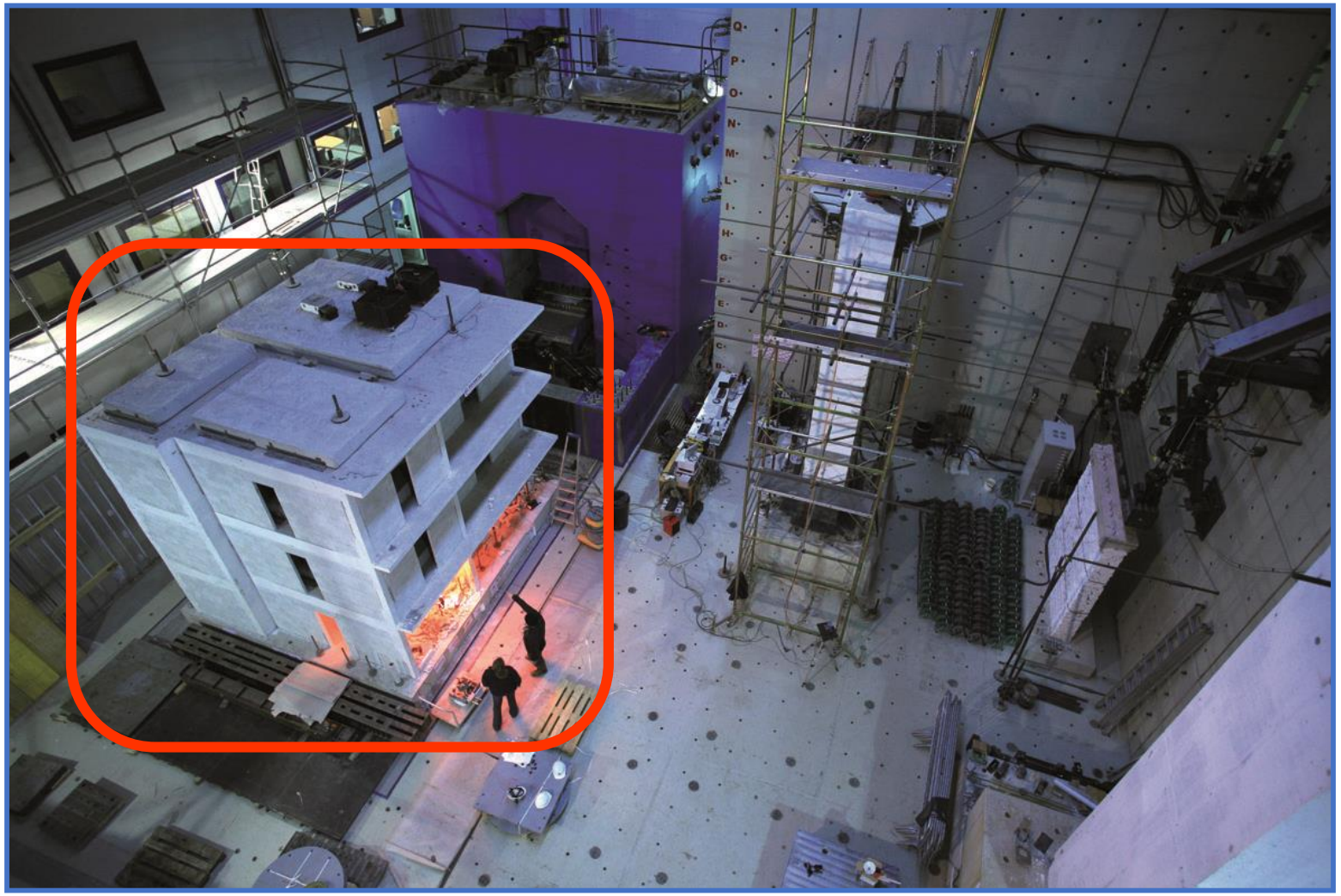
EUCENTRE
FOR YOUR SAFETY

| | |
|---|---|
| **Platten dimensions** | **5.6m x 7.0m** |
| Peak Velocity | 2.2 m/s |
| Peak acceleration (bare table) | 6.0 g |
| **Peak acceleration with rigid payload (70 ton)** | **1.8 g** |
| Flow rate | 11 000 lit/min |
| **Dynamic max force** | **1720 kN** |
| Static max force | 2150 kN |
| **Max rigid payload** | **140 ton** |
| Max overturning moment | 4000 kNm |
| First frequency of vibration of the table | 84Hz |
| Dissipation of the system | 350 N |
| Controll software | Customized MTS Adaptive |



# Tavola vibrante mono-assiale



## Recent research activities

- Struttue in cemento armato tamponate con muratura;
- Strutture in panneli sandwich di cemento armato;
- Strutture in muratura di pietra con varie tecniche di rinforzo;
- Strutture prefabbricate in legno;
- Strutture in muratura di laterizio;
- Sistemi di immagazzinamento  con dispositivi di isolamento;
- Sistemi di pareti in muratura con diverse tipologie di laterizio;
- Equippment

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

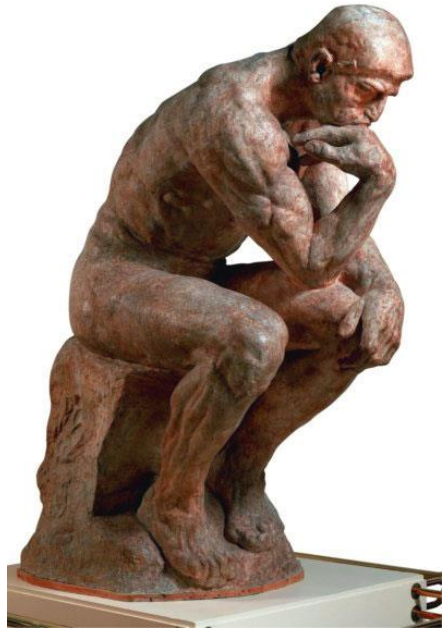
# Costruzione edifici in scala reale

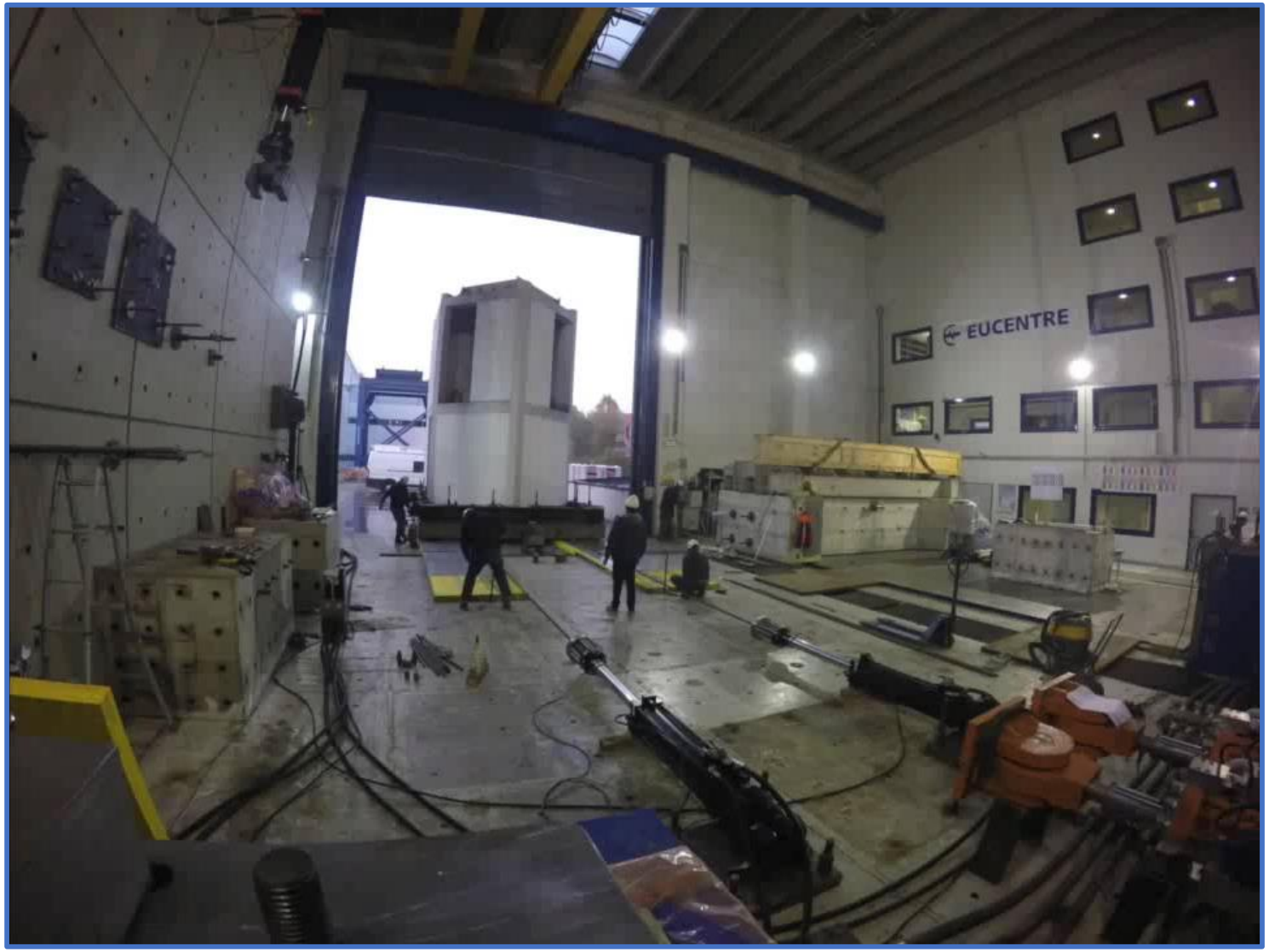


NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Trasporto edifici

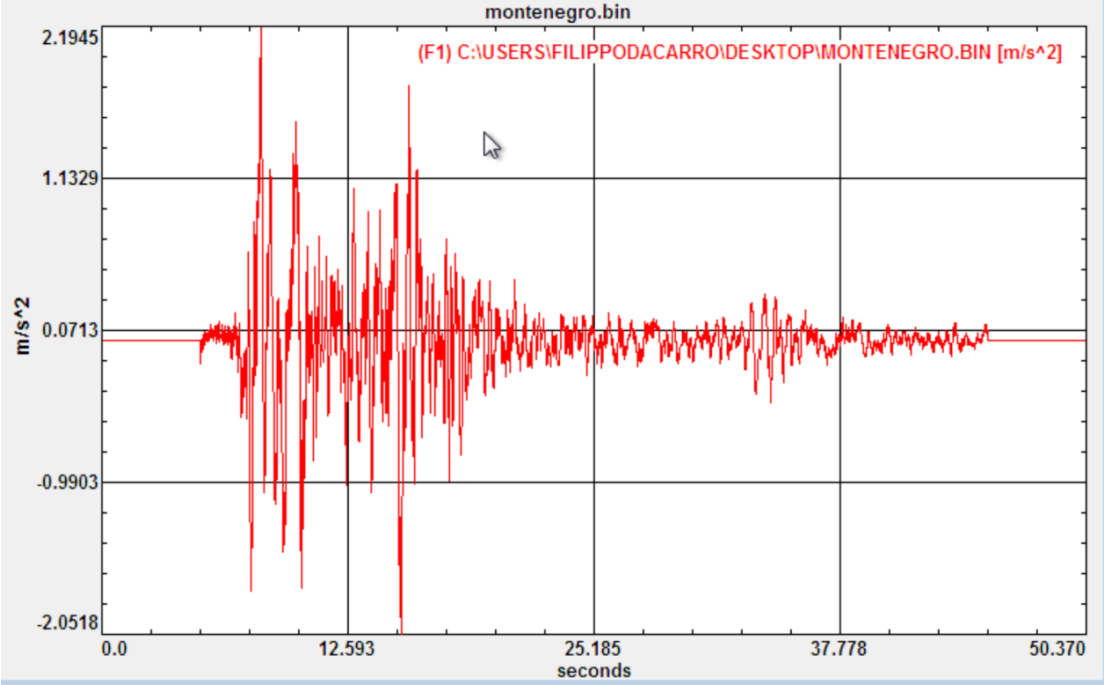



NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# DPC – Progetto Esecutivo 2005/2008 PE2

- Campagna di prove sperimentali su un edificio in muratura di pietra in scala reale su due piani
- Sono stati eseguiti una serie di test di vibrazione ad intensità crescente fino a 0,4g





NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY

EUCENTRE
European Centre for Training and Research in Earthquake Engineering

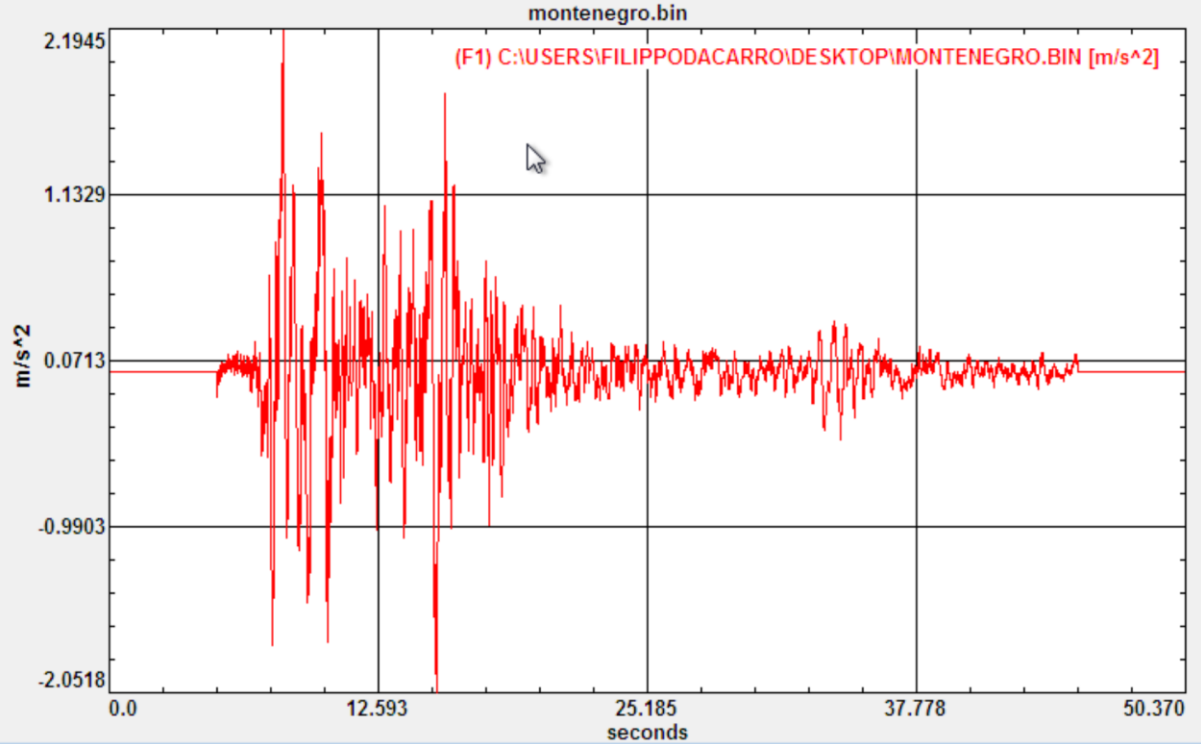
NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

## SERIES-POLYMAST Project

Il progetto è stato rifinanziato dalla EC nell'ambito del FP7 – FrameWork Series (Seismic Engineering Research Infrastructures or European Synergies), e la struttura danneggiata è stata rinforzata con un intonaco armato.

La struttura è stata quindi sottoposta ad un nuovo ciclo di prove ad intensità crescente fino a 0,6g.



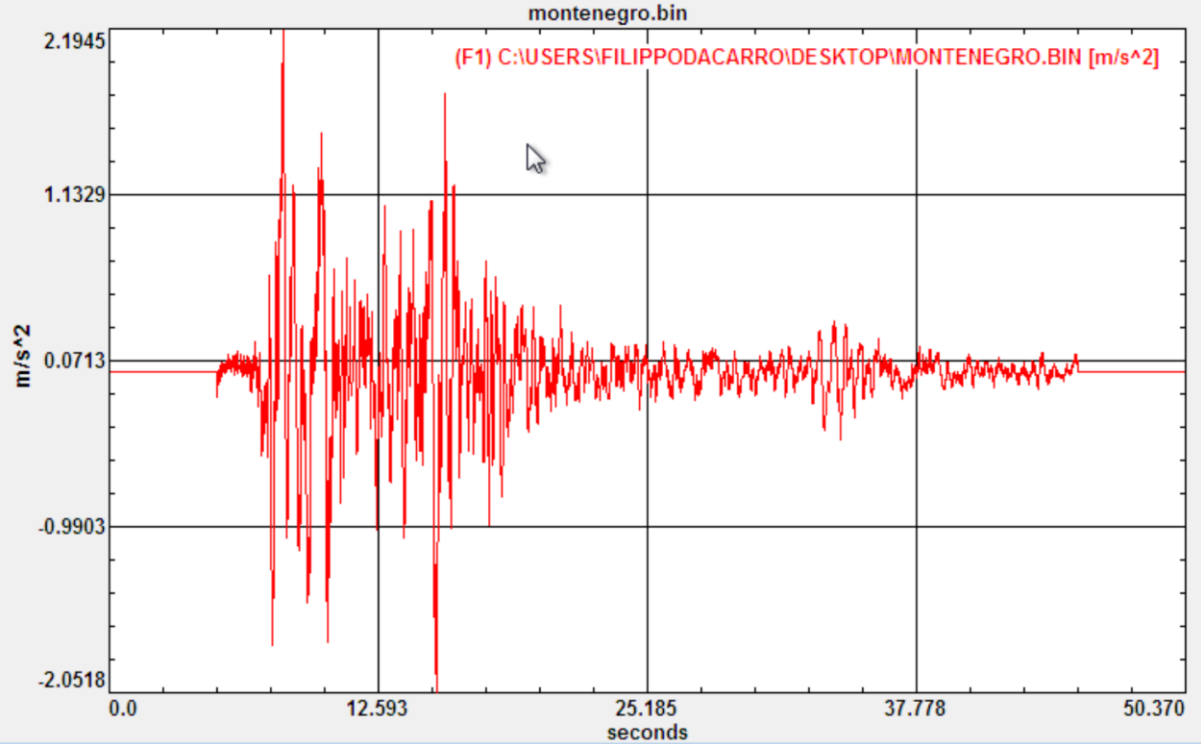


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

## SERIES-POLYMAST Project

Sempre nell'ambito del FP7 – FrameWork Series (Seismic Engineering Research Infrastructures or European Synergies) è stato finanziato un progetto per prove sperimentali su strutture miste cemento armato/muratura in scala 1:2.

Sono state raggiunte accelerazioni fino 0,8g

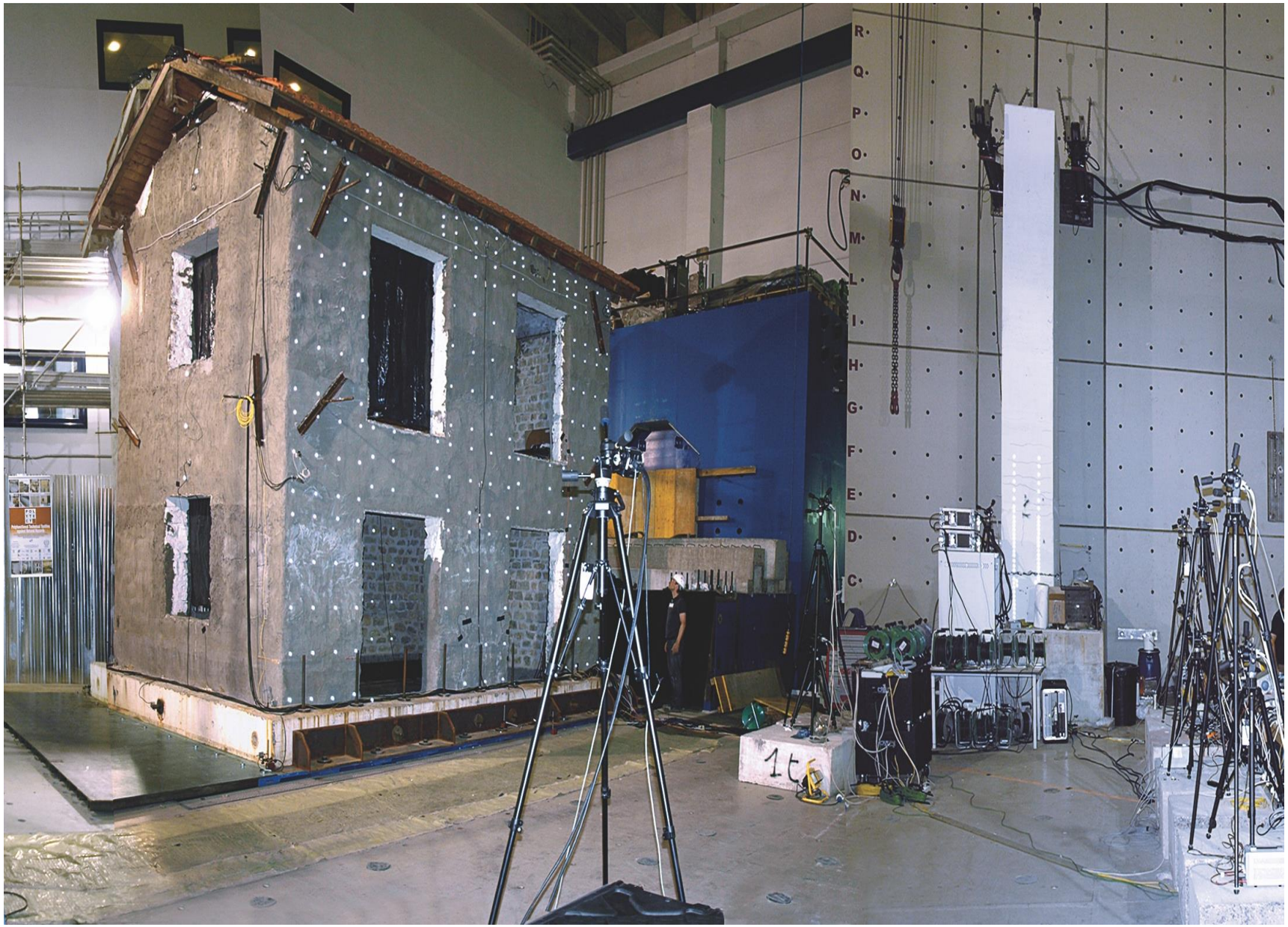




NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

NATIONAL INSTRUMENTS™ | EUCENTRE FOR YOUR SAFETY.



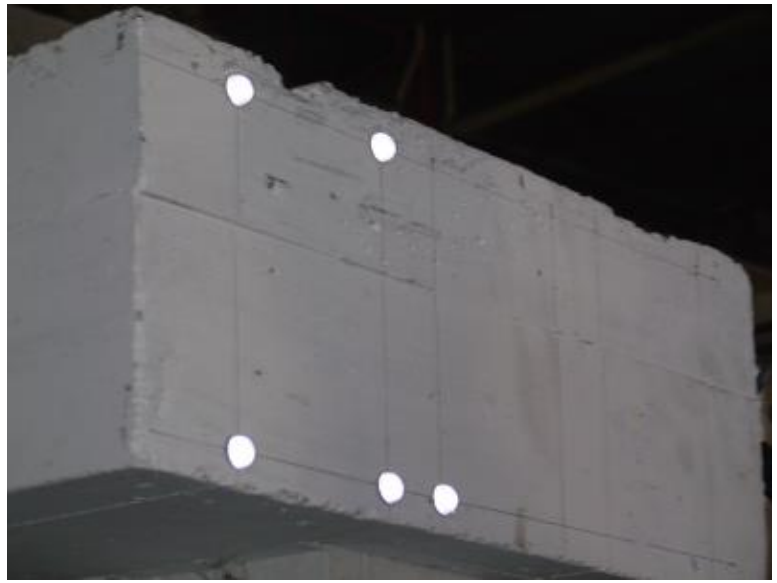
## Contactless data acquisition with High Definition Digital Cameras

Sempre nell'ambito dei progetti europei è stato realizzato un sistema di acquisizione basato su ottiche ad alta risoluzione ad integrazione dei classici sistemi di acquisizione con trasduttori wired.

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

## Machine vision system

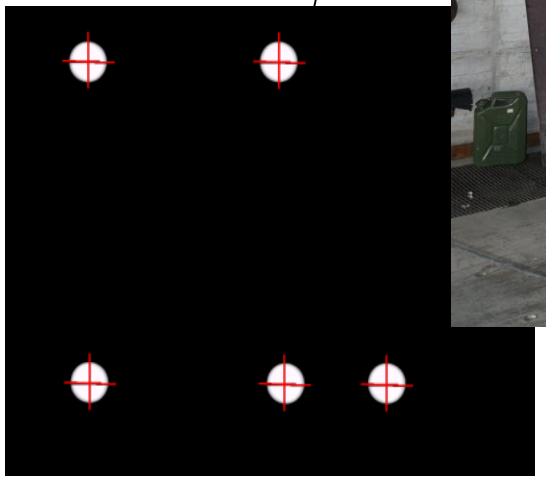
Measure positions of markers acquiring and analysing a series of digital images



Marker posizionati sulla struttura

Digital camera

Pixel Position



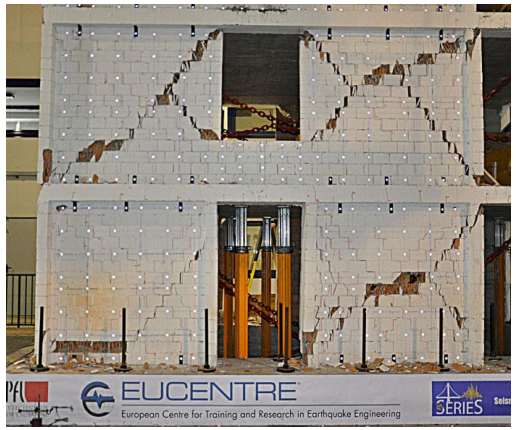
In fase di calibrazione viene definita la posizione iniziale di ogni marker

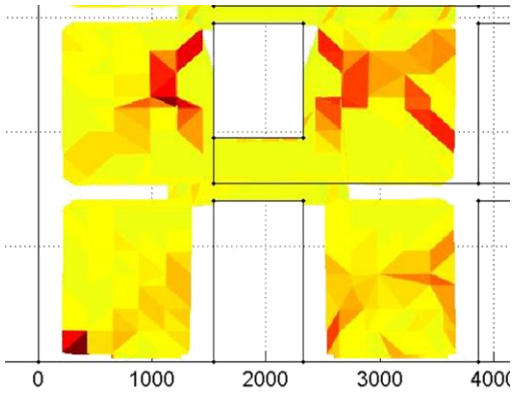
NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

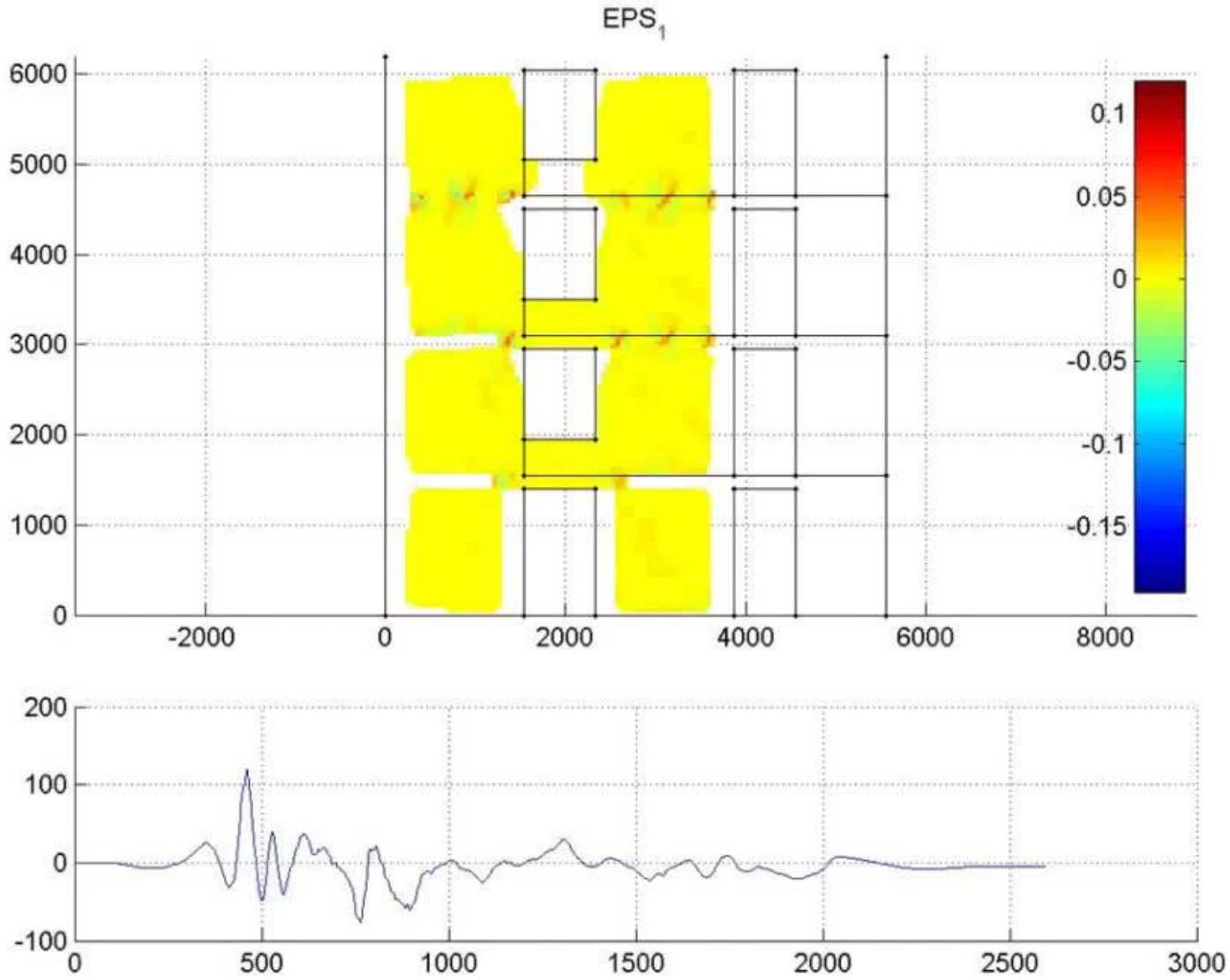
## Machine vision system

La distribuzione delle deformazioni nei pannelli di muratura può essere ottenuta dalle elaborazioni automatiche degli spostamenti di ogni singolo marker.

È possibile verificare il perfetto matching tra l'immagine del danneggiamento della facciata e la proiezione dello stato tensionale ottenuta dall'elaborazione dei dati dell'acquisizione ottica.



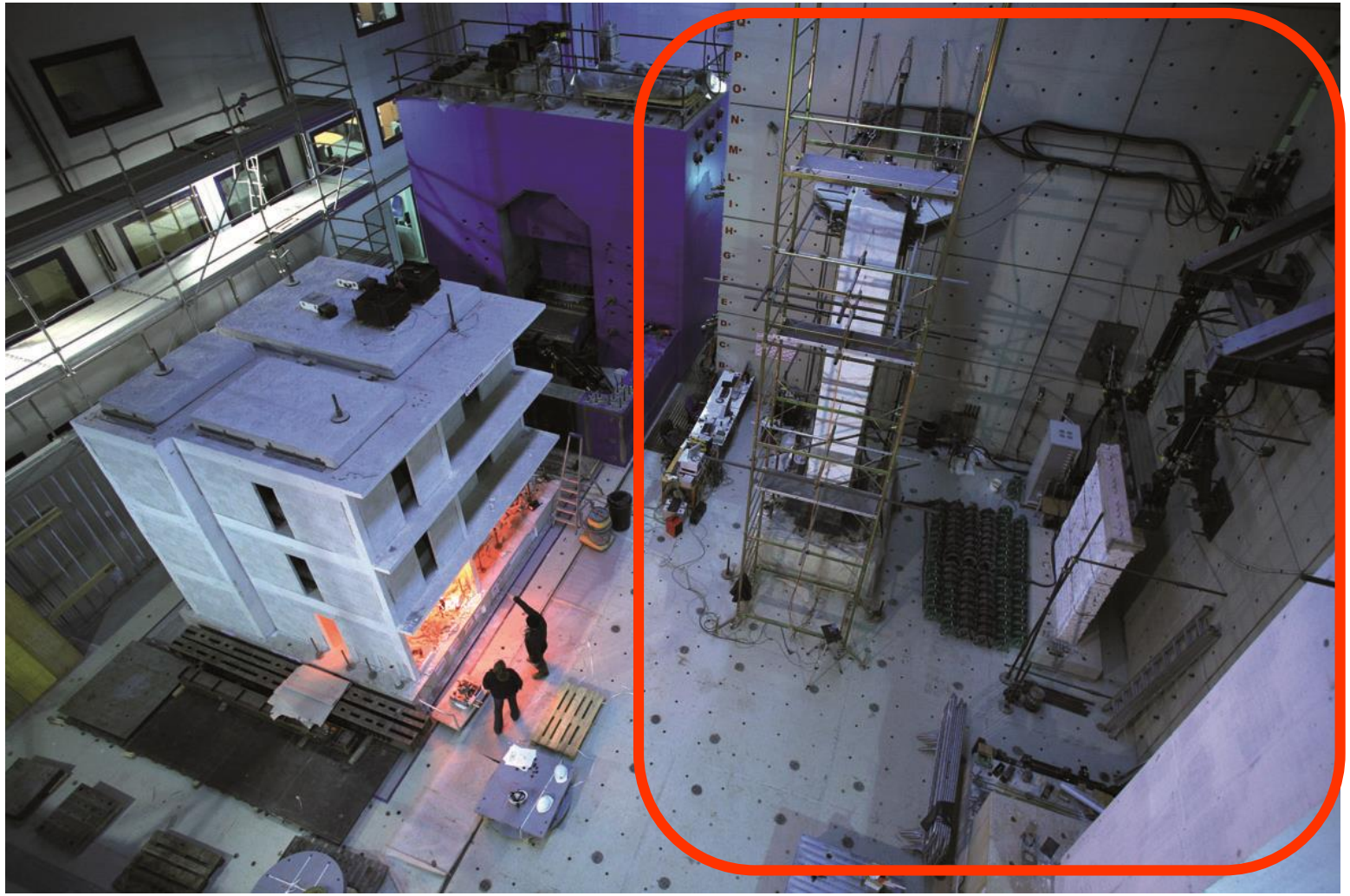



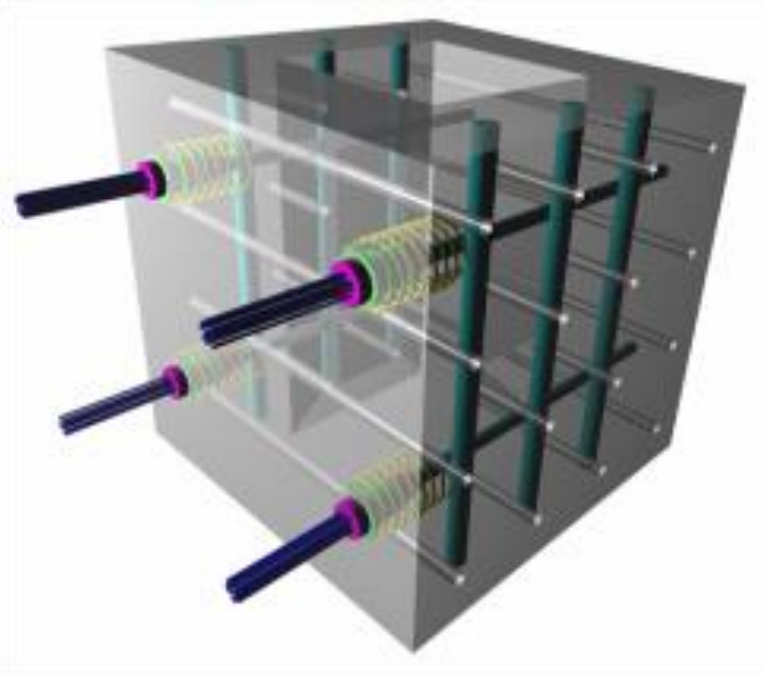

NATIONAL INSTRUMENTS

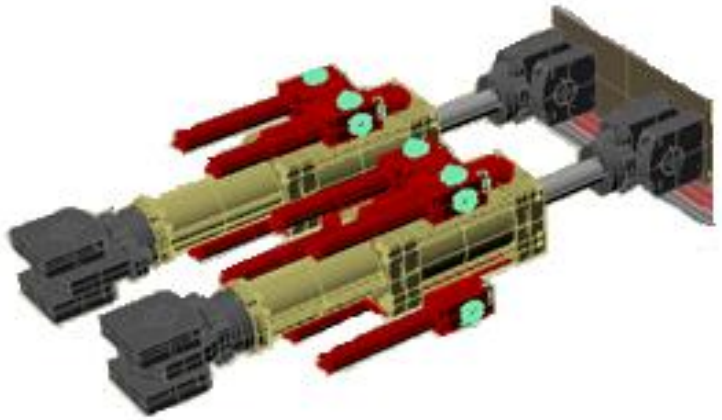
EUCENTRE
FOR YOUR SAFETY.

## 3D Reaction Walls – Strong Floor



## Precast Block Detail





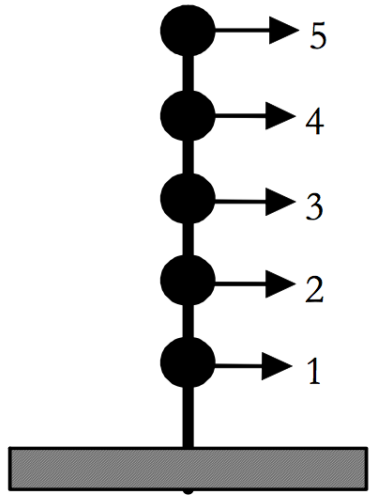
I muri di reazione del laboratorio Eucentre permettono di realizzare test PsS, PsD o Hybrid, su strutture in scala reala o componenti strutturali (pareti, nodi trave-colonna, colonna-fondazione…).

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# 3D Reaction Walls – Strong Floor

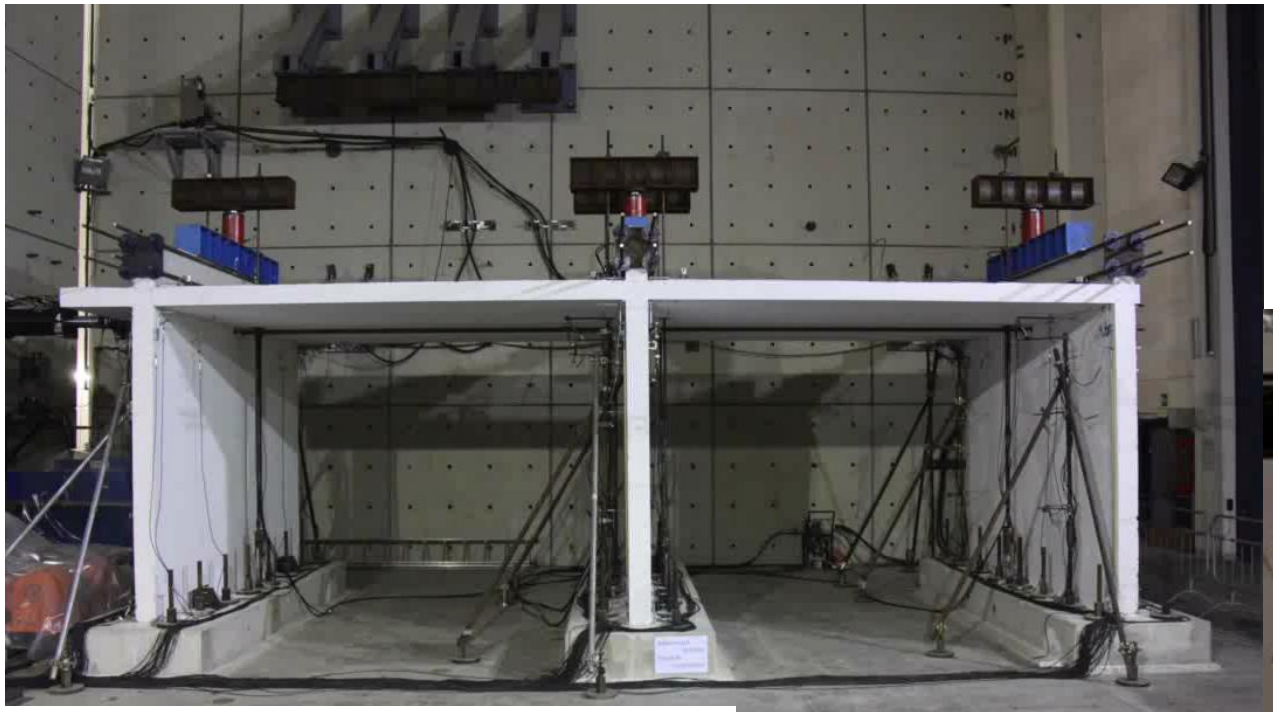
**Technical Specifications**

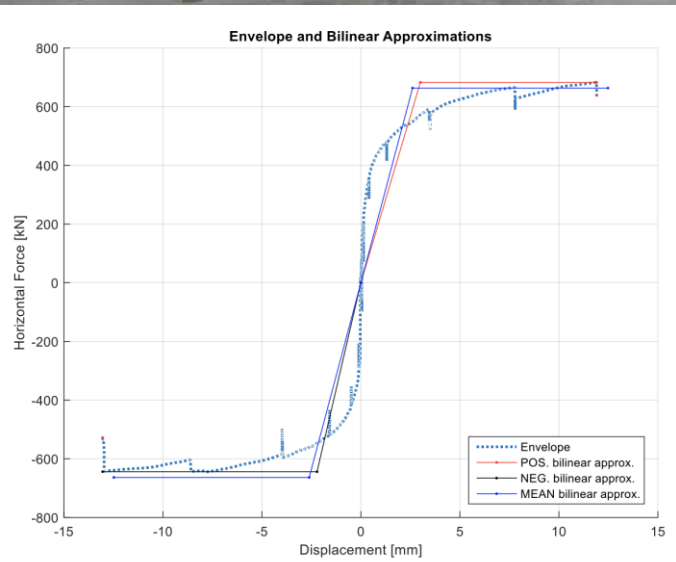
- L Shaped wall
- Area: 140 $m^2$
- Altezza: 12 m
- 11 hydraulic actuators
- Test: pseudo-static, pseudo-dynamic and hybrid simulations
- Force range: 250-2500 kN
- Stroke Range ±500 mm




$$F_s = M\ddot{u}$$

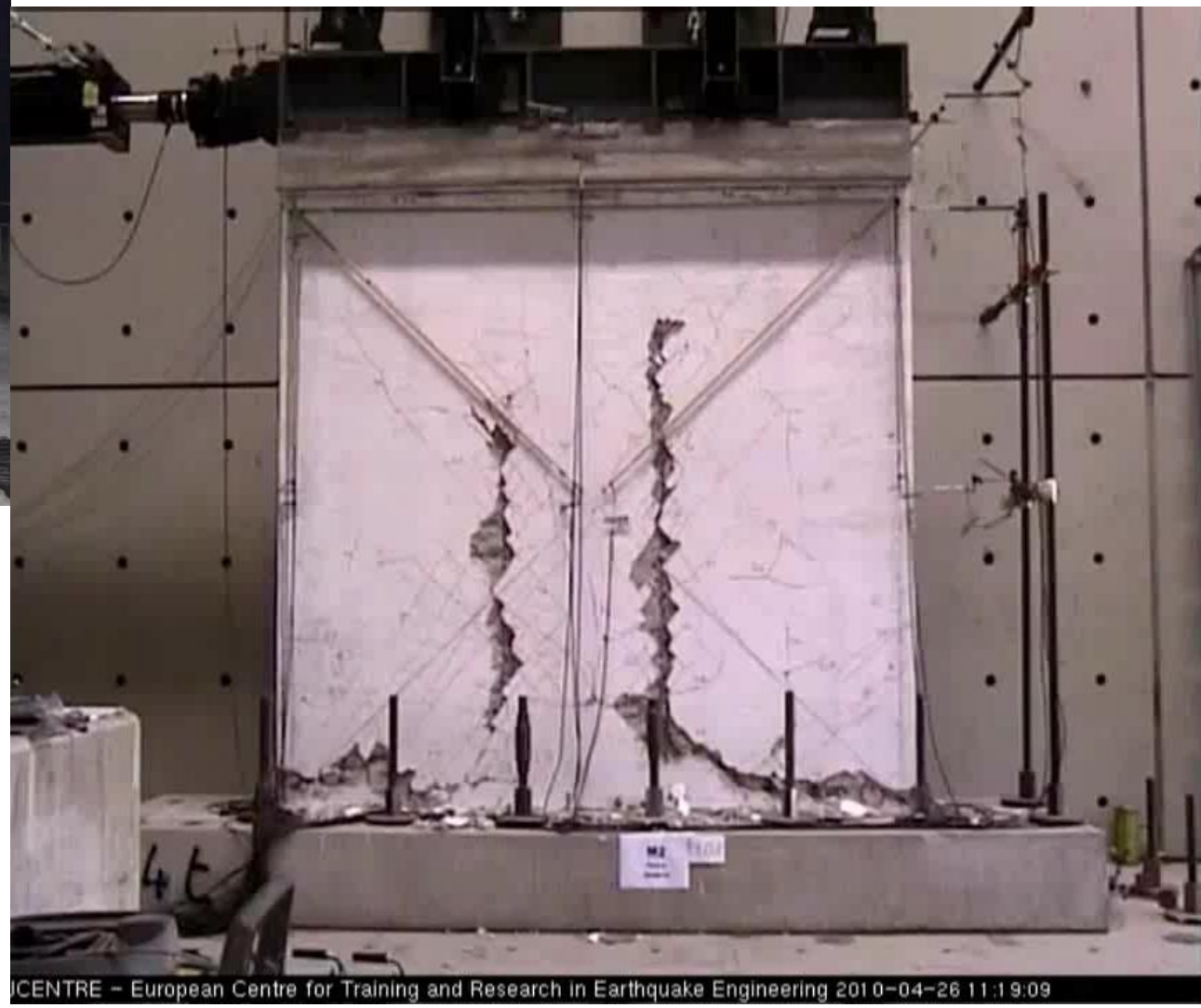
NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.



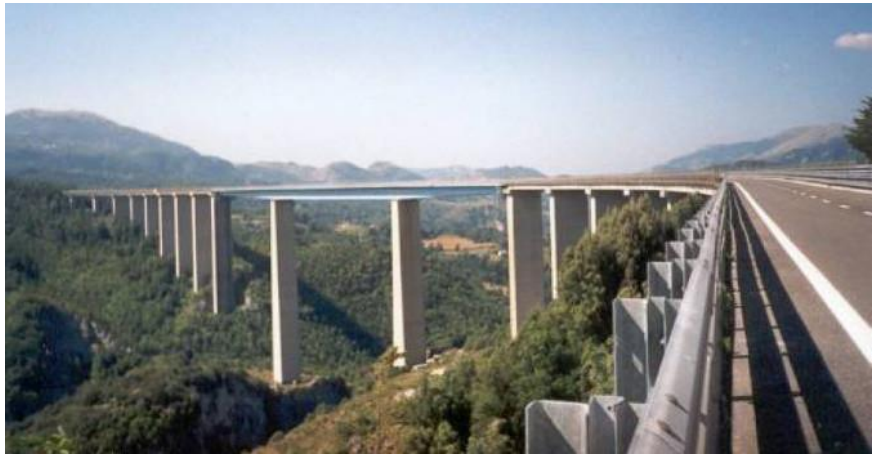


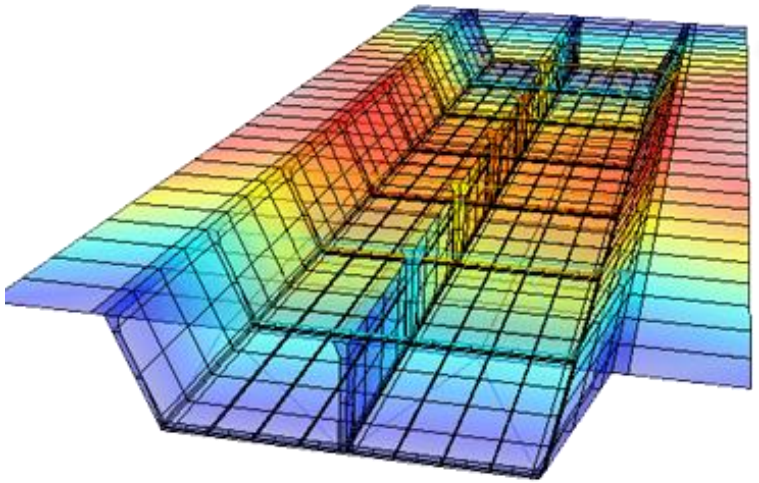

NATIONAL INSTRUMENTS

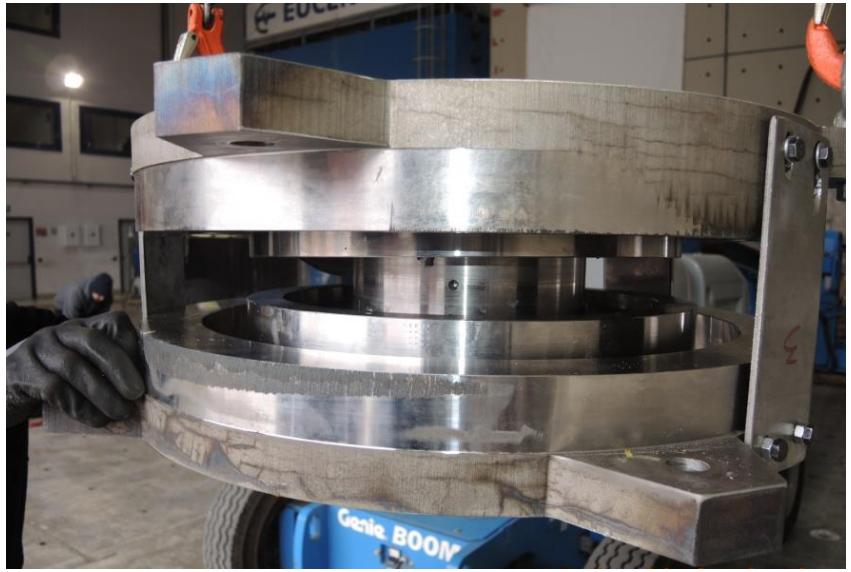
EUCENTRE
FOR YOUR SAFETY.



# Eucentre Hybrid Testing System (HTS)



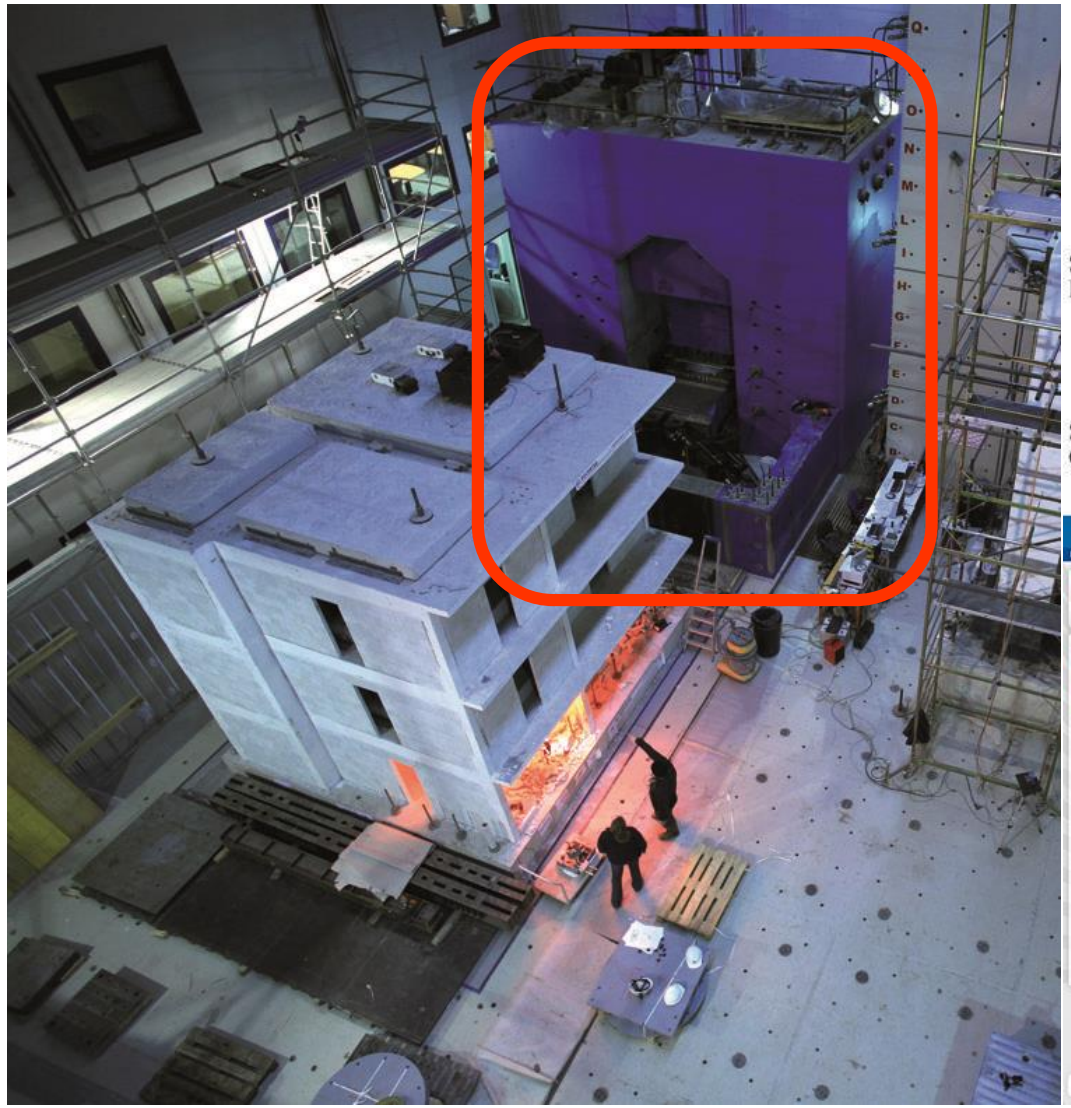





NATIONAL INSTRUMENTS

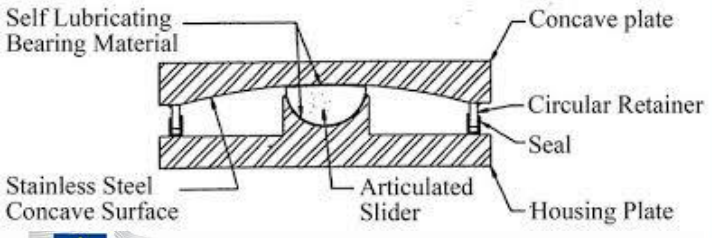
EUCENTRE
FOR YOUR SAFETY.

## Eucentre Bearing Testing System

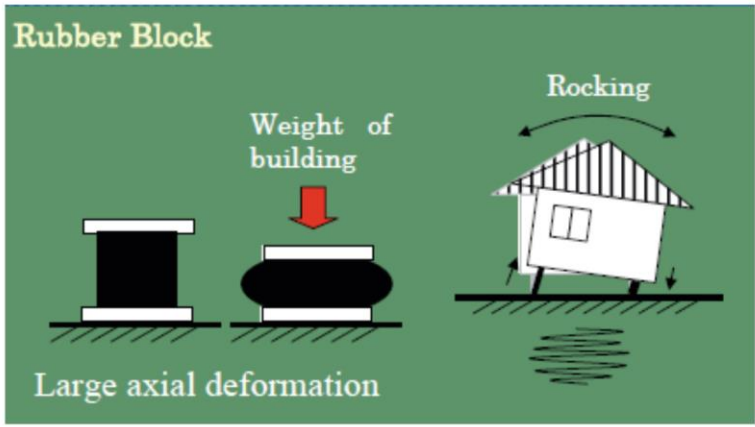


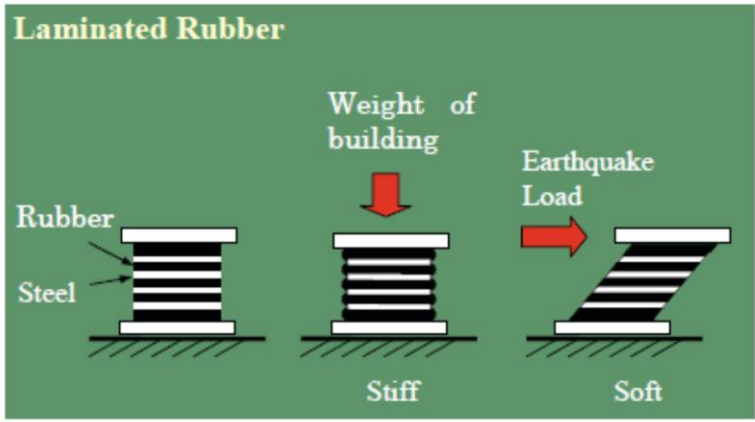
Il BTS (Bearing Tester System) è una macchina di prova multi-assiale dedicata a test su dispositivi di appoggio e isolamento sismico di grandi dimensioni.

Supporto alla ricerca e all'industria per quanto riguarda la progettazione e certificazione dei dispositivi





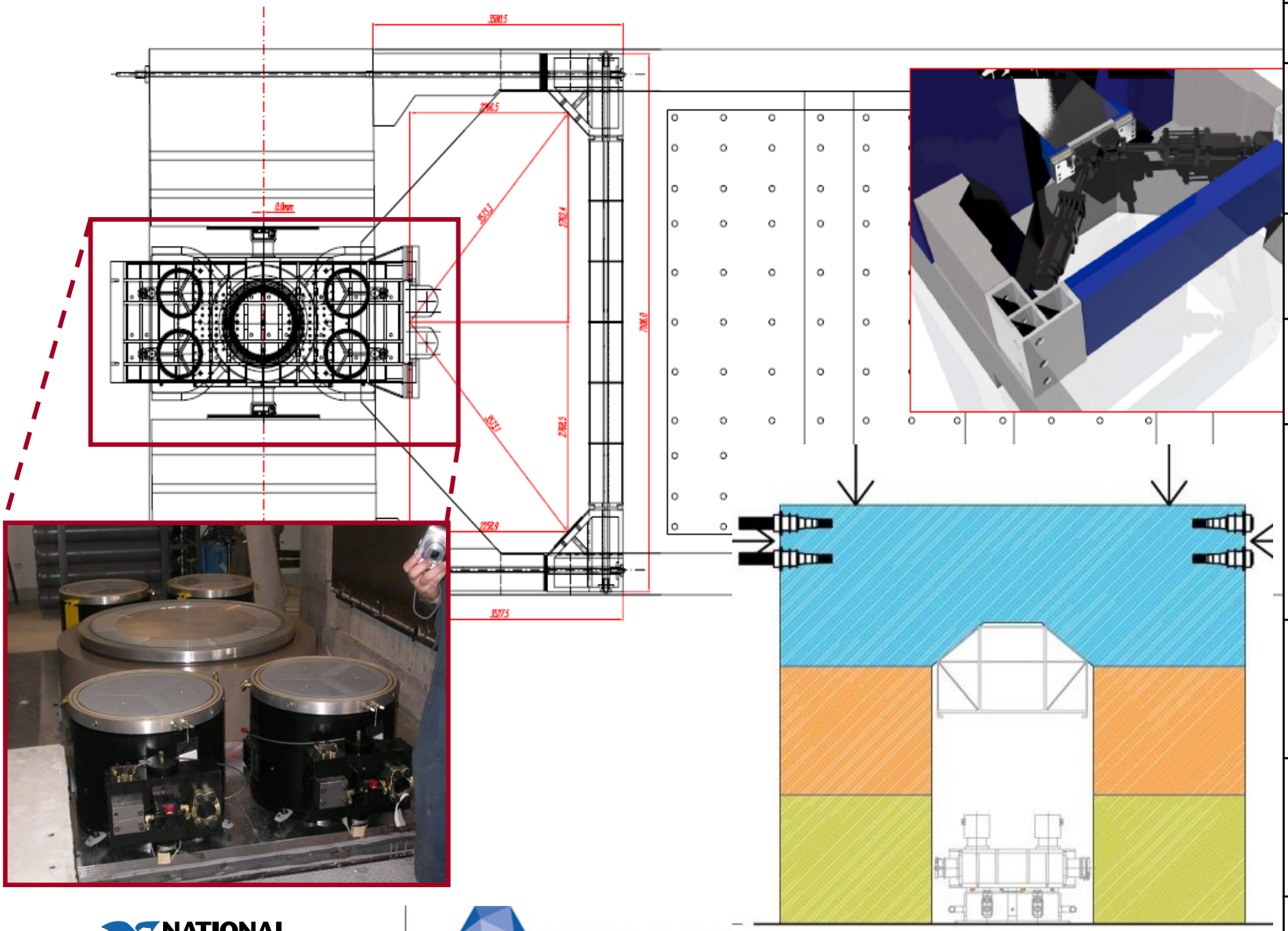



NATIONAL INSTRUMENTS

EUCENTRE FOR YOUR SAFETY

# Eucentre Bearing Testing System



| | |
|---|---|
| Platen dimension | 1.700 m x 1.990 m |
| Table mass | 22.0 ton |
| **5 controlled DoF** | **Longitudinal, Vertical, Roll, Pitch, Yaw** |
| **Max displacement** | **O: ±495 mm**<br>V: ±75 mm |
| Peak Velocity | O: ±2.2 m/s,<br>V:±250 mm/sec |
| **Max Force** | H: 1 900 kN (4400 kN),<br>**V: 40 000 kN ± 10 000 kN** |
| Max Overturning Moment | 20 000 kNm |
| Operational Frequency range | 0-20 Hz |
| Flow rate | 11 000+16 000 lit/min |

NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY

# Examples of testing protocols

HIGH DAMPING RUBBER BEARING



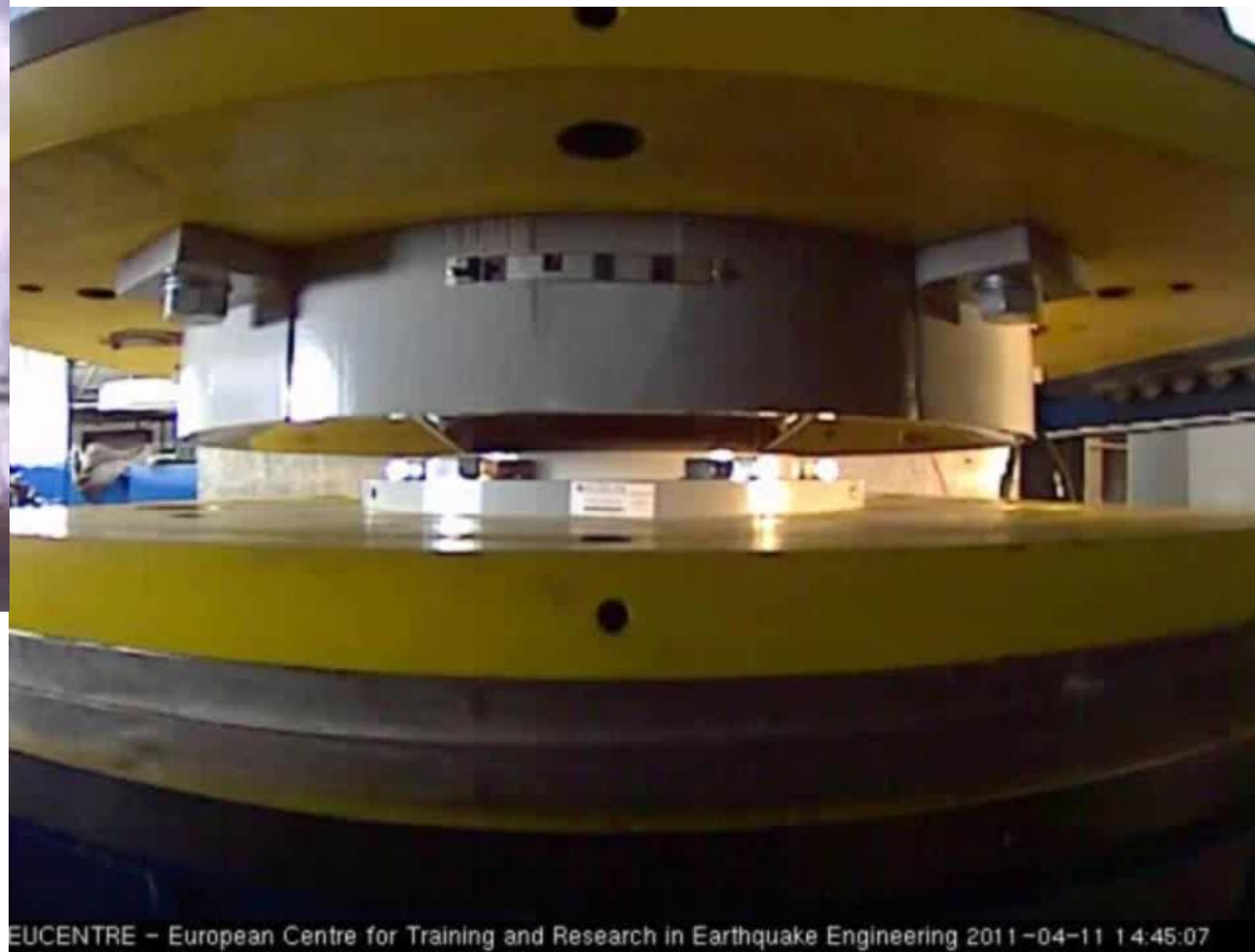
CURVED SURFACE SLIDER

NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Examples of testing protocols

## FAILURES

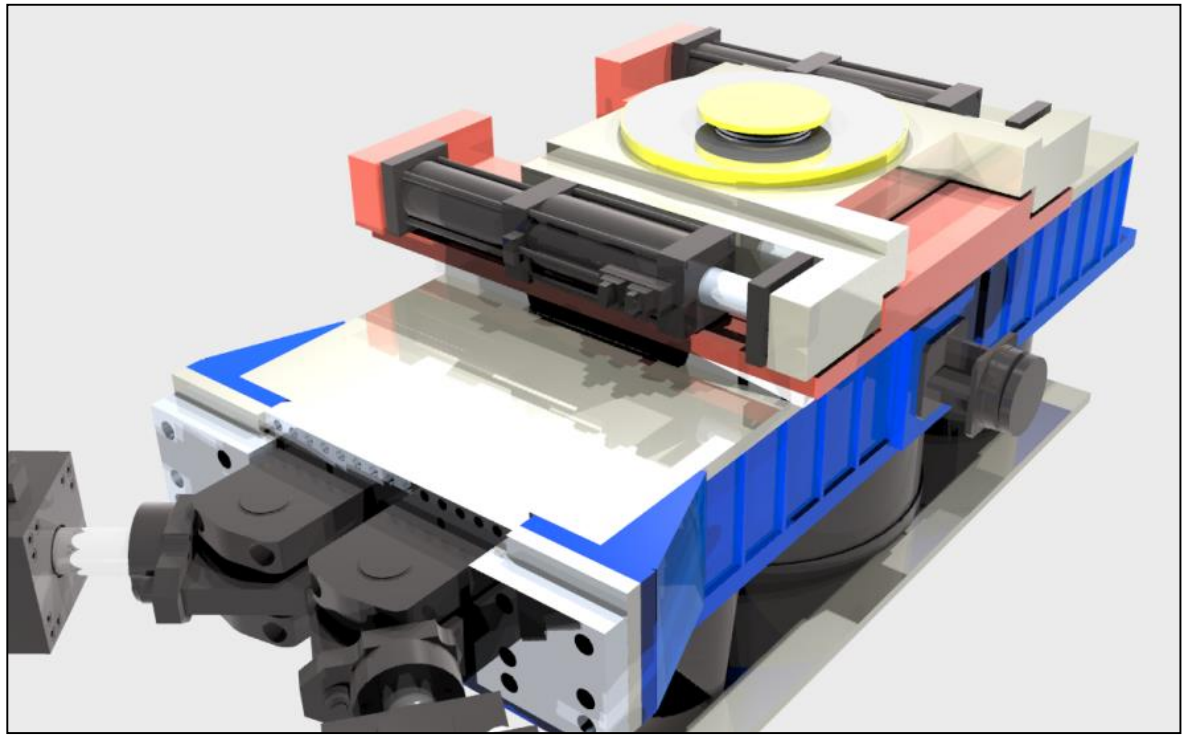


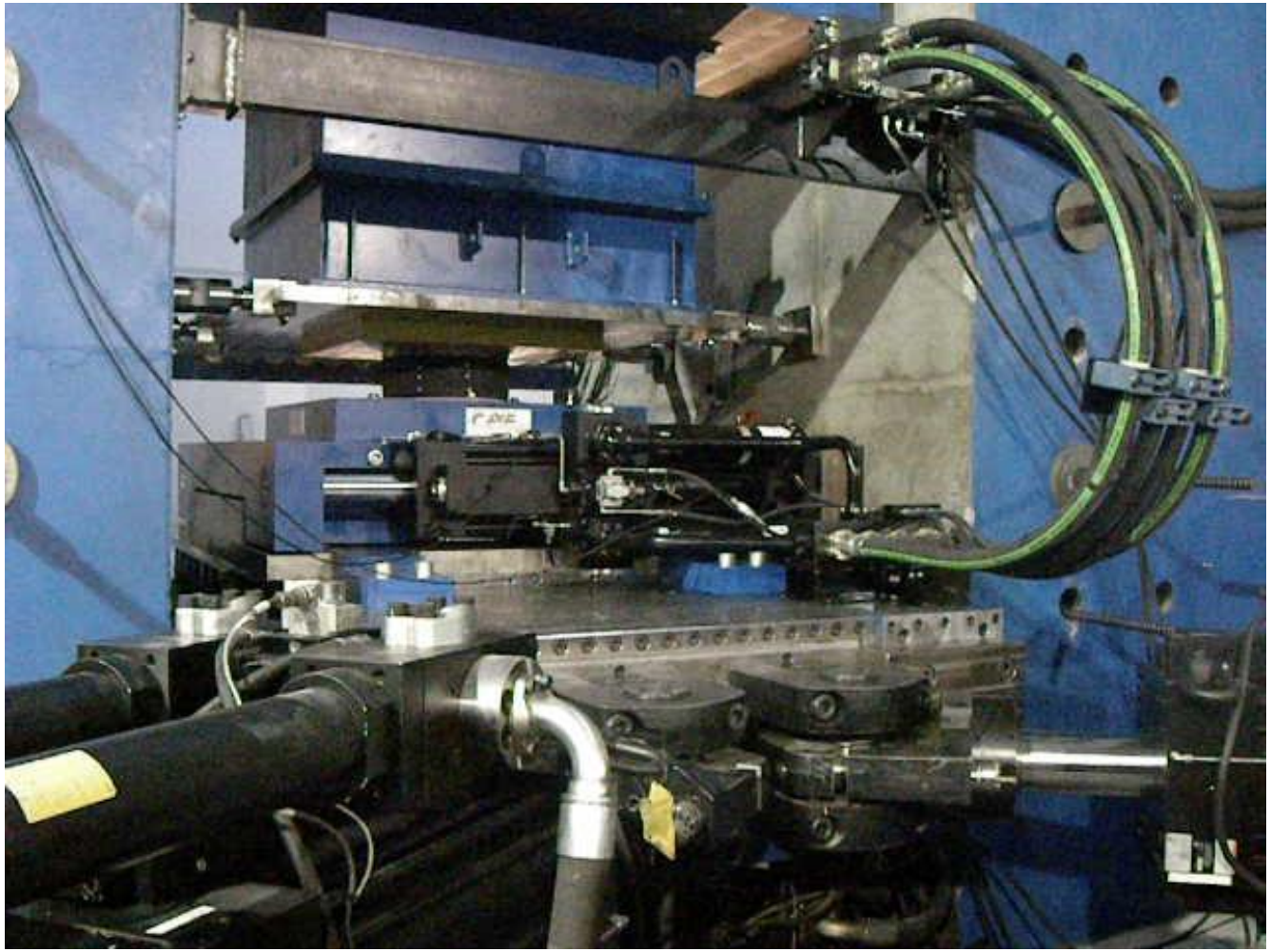

NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Bearing Testing System

Evoluzione 6gdl

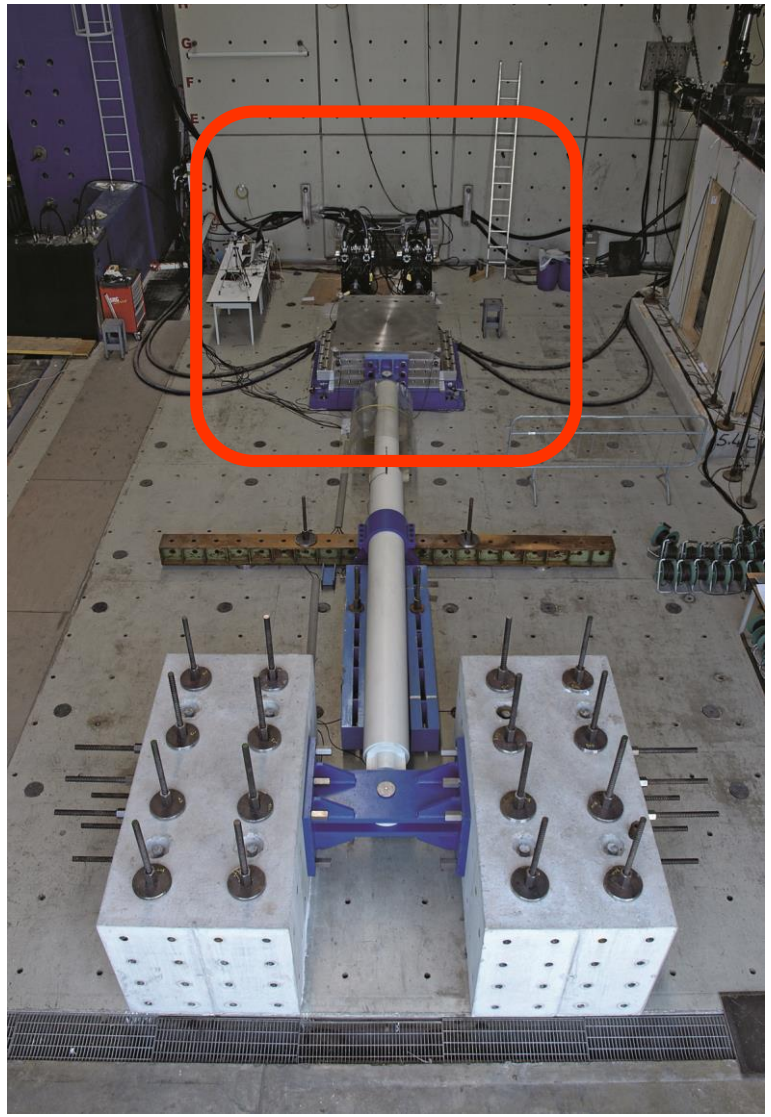


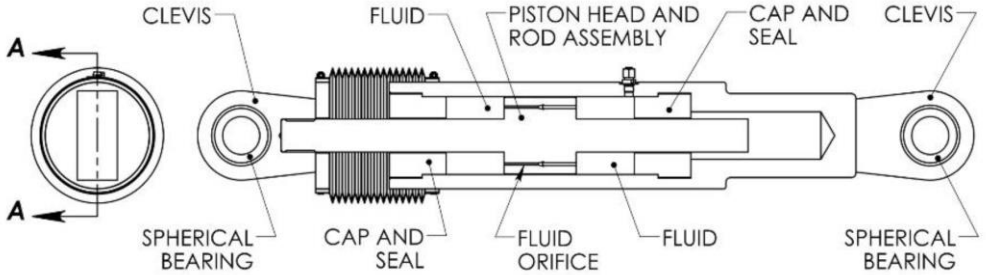


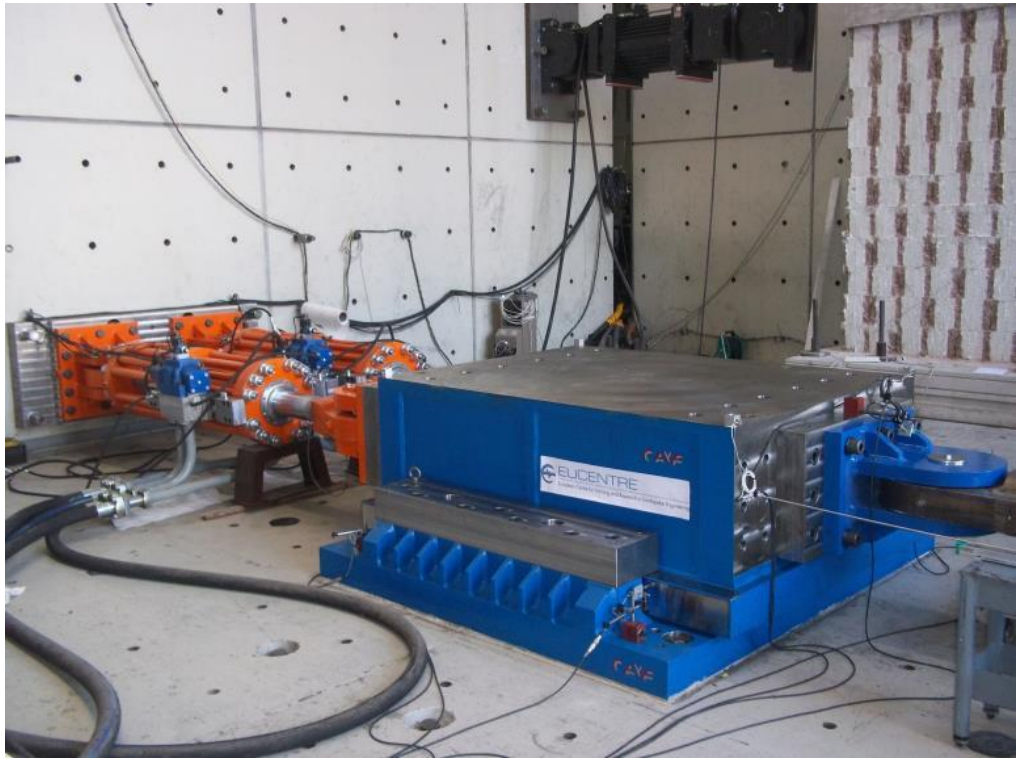
NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Damper Testing System



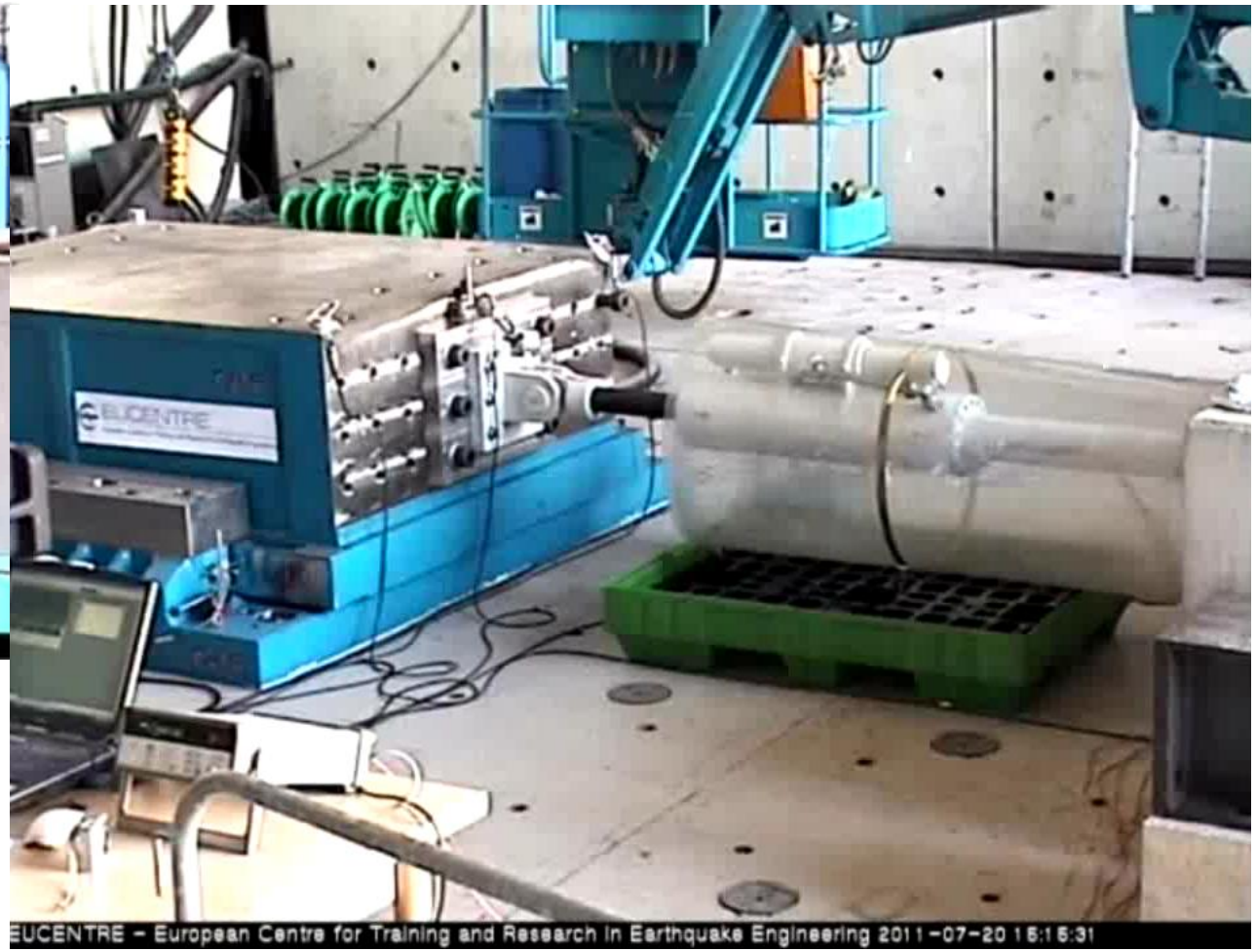



NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Damper Testing System


NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

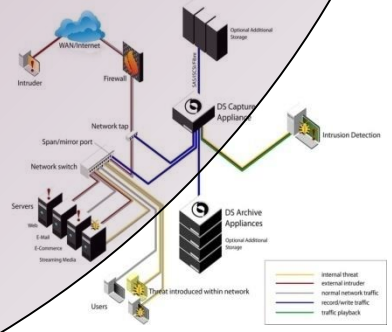
## Mobile Unit

Lo scopo della Mobile Unit è quello di rendere possibile l’esecuzione rapida di test di valutazione strutturale in situazione di crisi conseguente ad un evento sismico o genericamente di calamità naturale.


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Mobile Unit


Advanced data management and telepresence

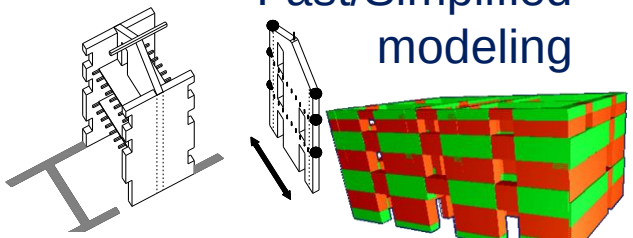



operative unit for advanced structural assessment

Assessor teams


Transmission system

Fast/Simplified modeling



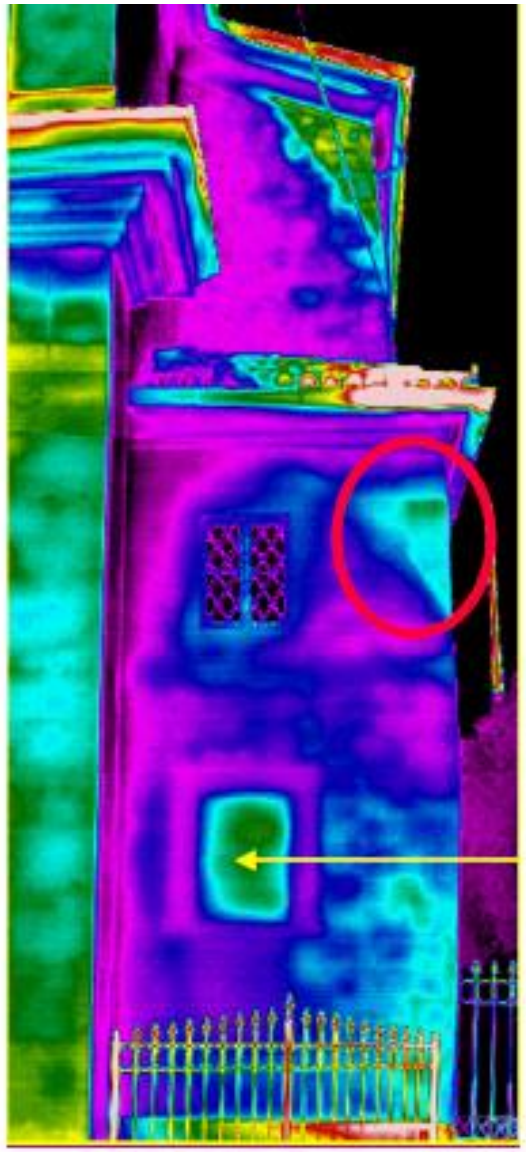


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

## Other Experimental Tests

- Sonreb
- Pacometro
- Carotaggi e prove di compressione ciclica
- Prelievo e prove di trazione su barre di armatura
- Prove soniche e ultrasoniche
- Termografia
- Martinetti piatti
- Shove test
- Pull-out
- Identificazione dinamica di edifici
- Prove MASW e ReMi

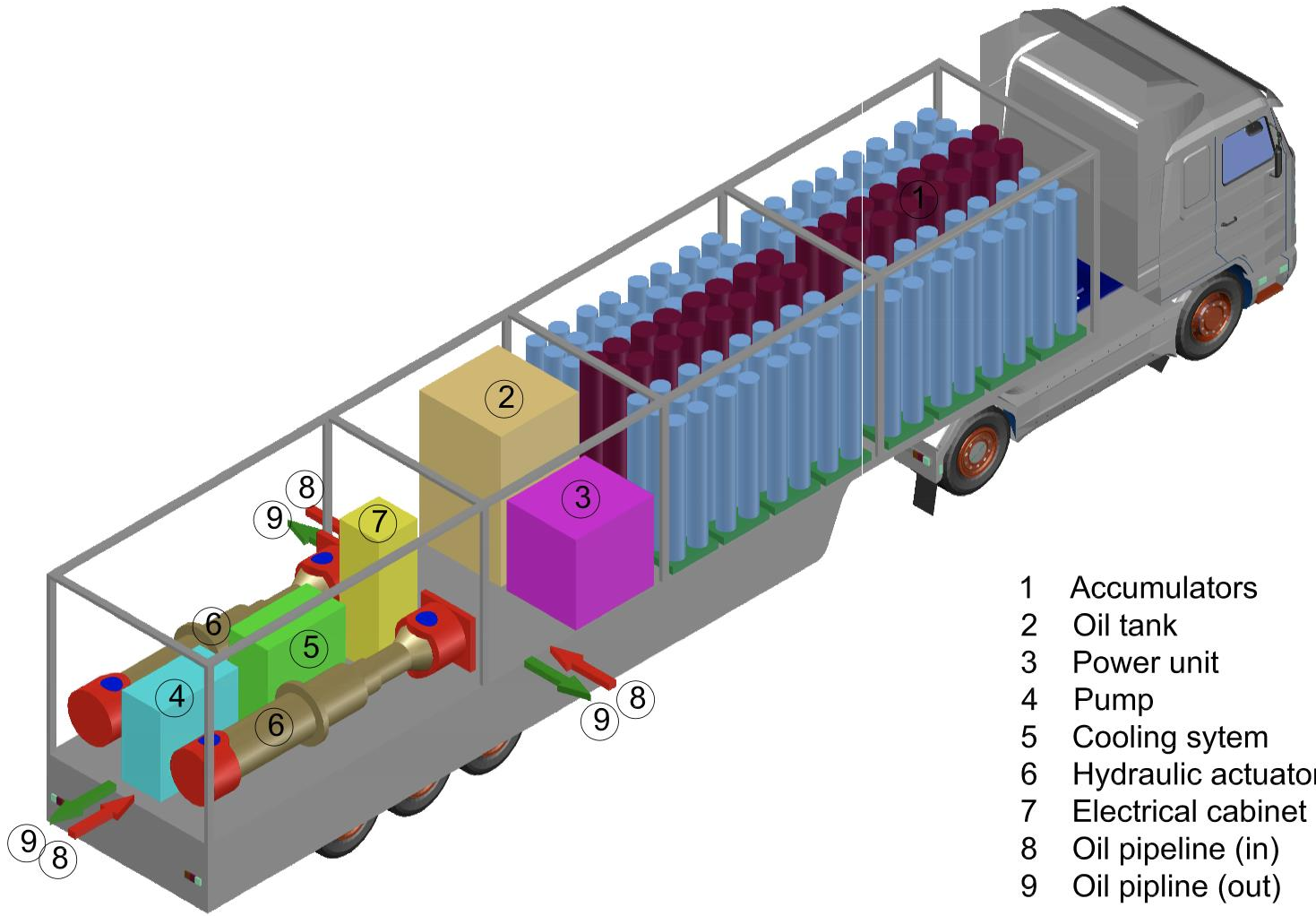
**TOOLS**: infrared camera, pc
**APPLICATIONS**: evaluation of wall homogeneity



NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Laboratorio mobile per prove dinamiche in situ

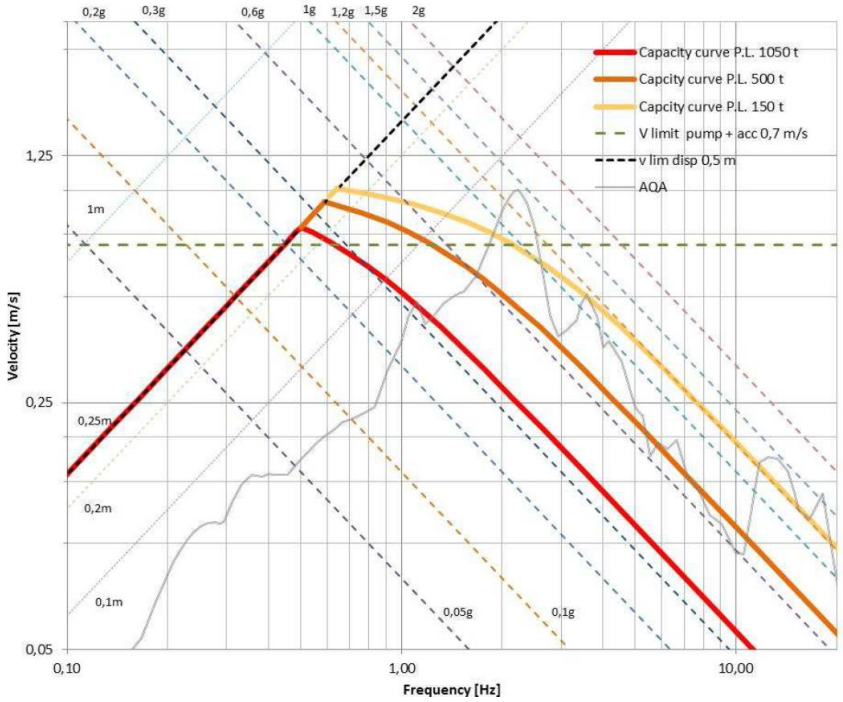


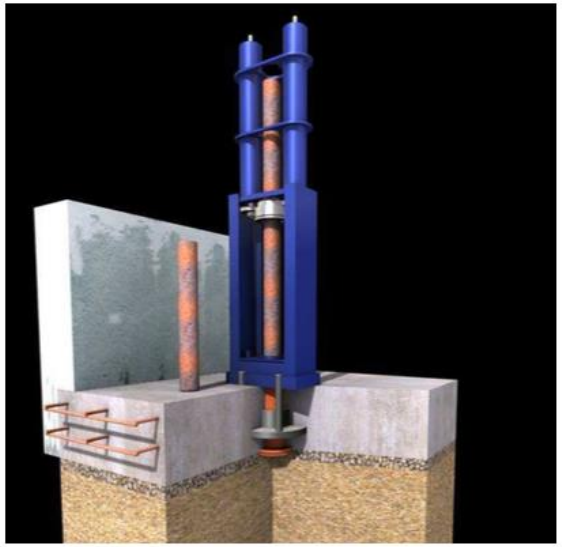



1 Accumulators
2 Oil tank
3 Power unit
4 Pump
5 Cooling sytem
6 Hydraulic actuators
7 Electrical cabinet
8 Oil pipeline (in)
9 Oil pipline (out)

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Laboratorio mobile per prove dinamiche in situ



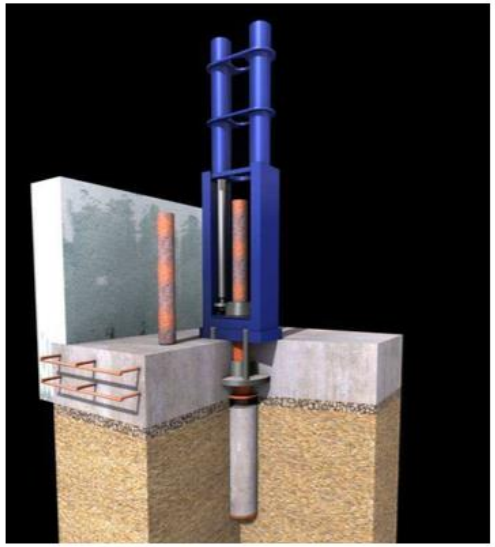


Figure 12 – From left to right: Phase 1 "Demolition of ground floor"; Phase 2 "Construction of new foundations: RC slab and piles"

Figure 13 – From left to right: Phase 3 "Construction of a new RC upper slab"; Phase 4 "Installation of jacks"; Phase 5 "Uplifting"

Figure 14 – From left to right: Phase 6 "Installation of isolation devices"; Phase 7 "Lowering and finishing works"

NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

## DR HOUSE

If no accommodation is available, the team will stay in a campsite arranged by the Eucentre TREES Lab.

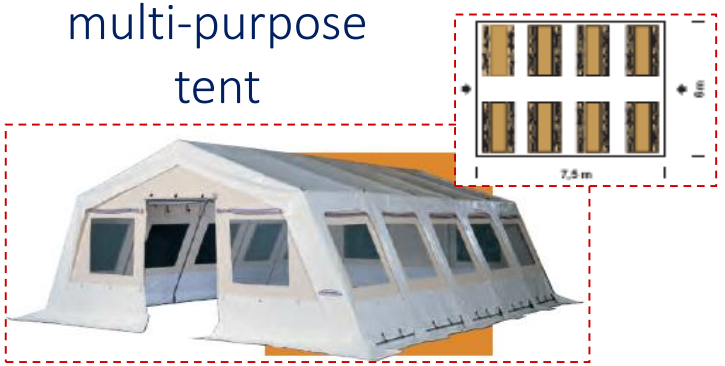
deposit

3 dorms

services (wc – shower)

camp equipment

multi-purpose tent



## Compact Seismic Simulator (CSS)

The CSS is a system by which is possible to simulate seismic event and to observe its effects to structures. The small shaking table is controlled with a remote device (iPad).



NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

## Compact Seismic Simulator (CSS)

| | |
|---|---|
| Table dimensions | 1250 x 1250 mm |
| Maximum stoke | 500 mm |
| Peak velocity (at full load) | 0.5 m/s |
| Peak acceleration (at full load) | 1 g |
| Maximum payload | 100 kg |
| Engine torque | 11.5 kNm |
| Peak dynamic force | 1.5 kN |
| Maximum overturning moment | 450 Nm |


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

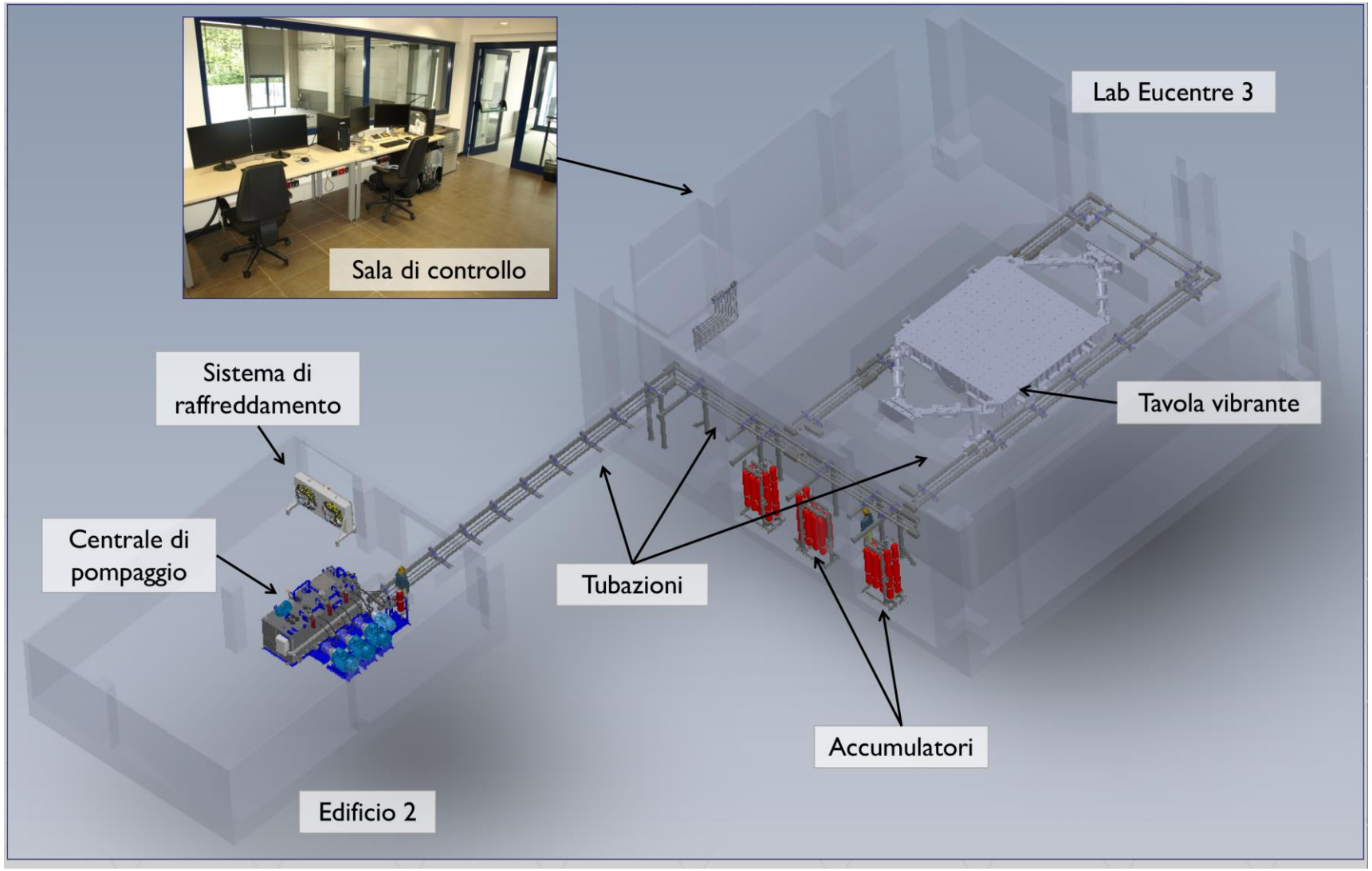
# Tavola vibrante multi-assiale


NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Tavola vibrante multi-assiale

Sistema completo:

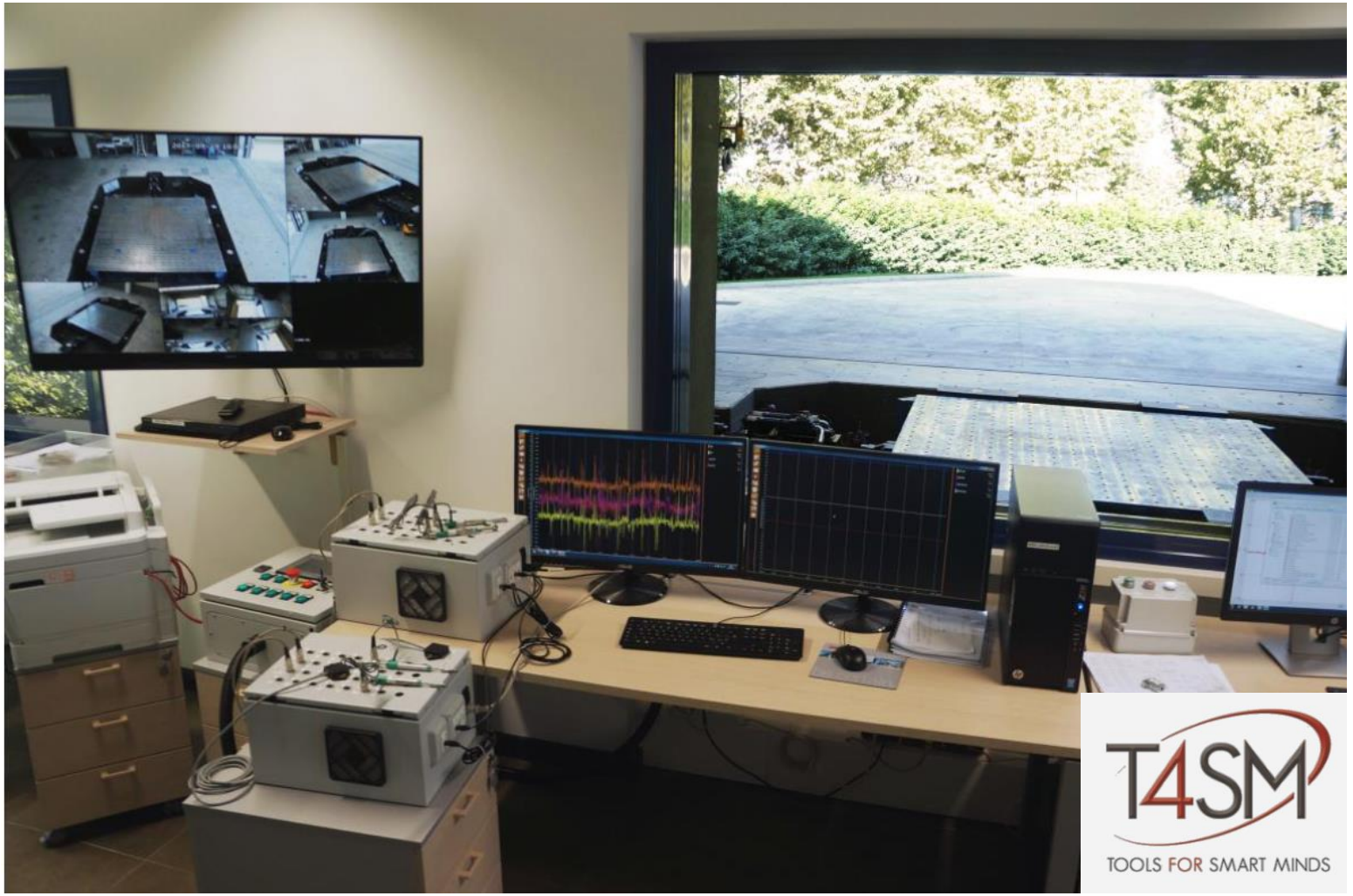
a) tavola vibrante;
b) tubazioni;
c) Accumulatori;
d) centrale di pompaggio;
e) raffreddamento;
f) sala di controllo




NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Tavola vibrante multi-assiale – sala controllo

Acquisizione dati basata su: a) moduli cDAQ9188XT; b) iDAQ; c) Easy Data Logger

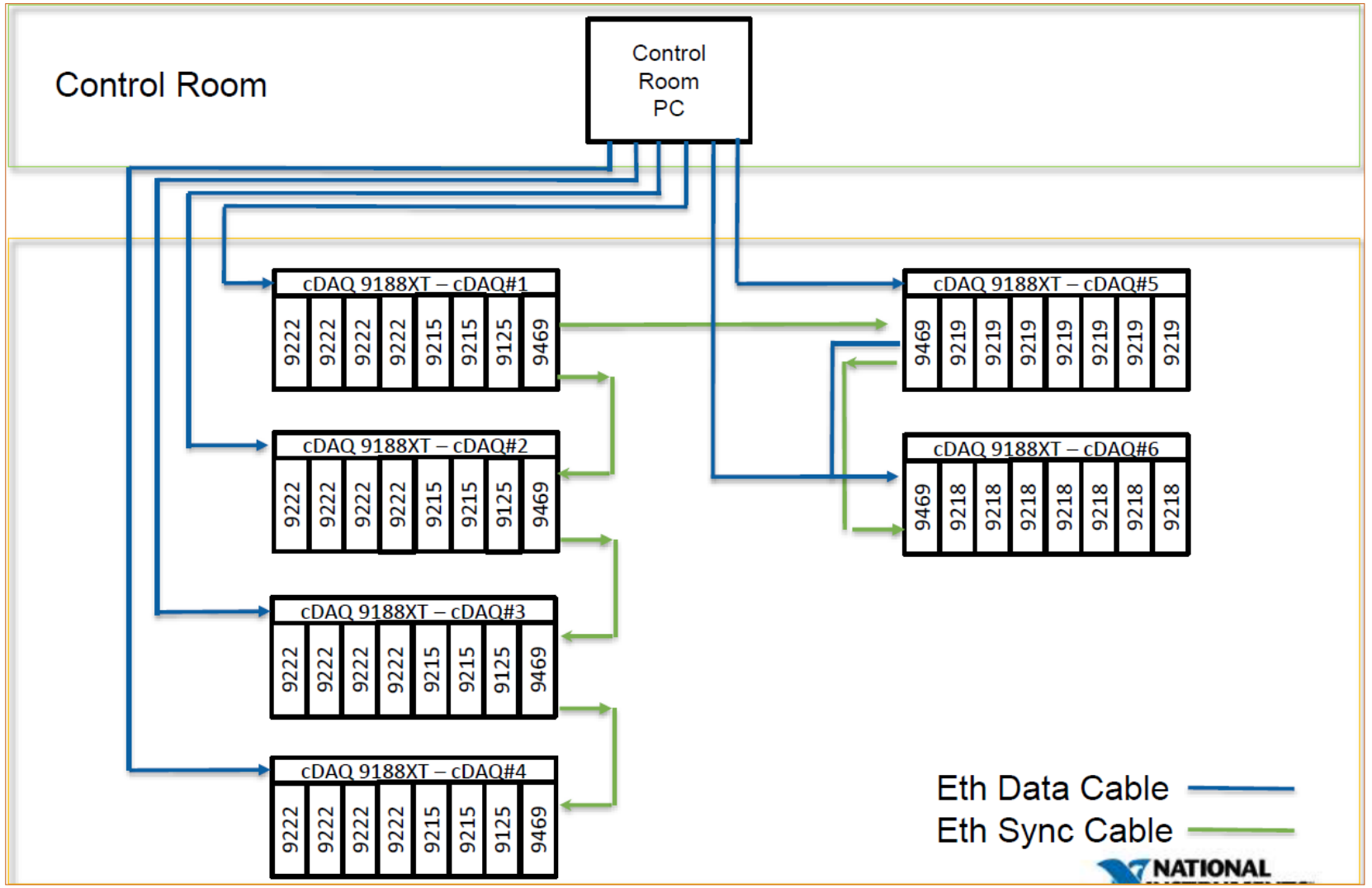


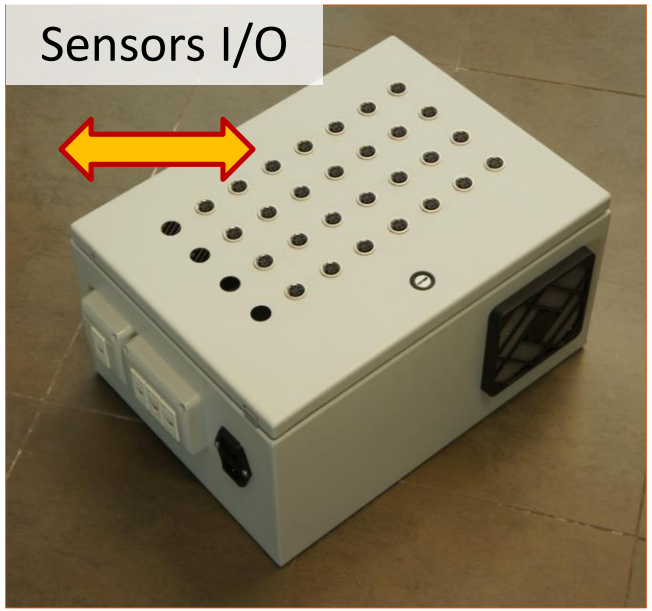
T4SM
TOOLS FOR SMART MINDS

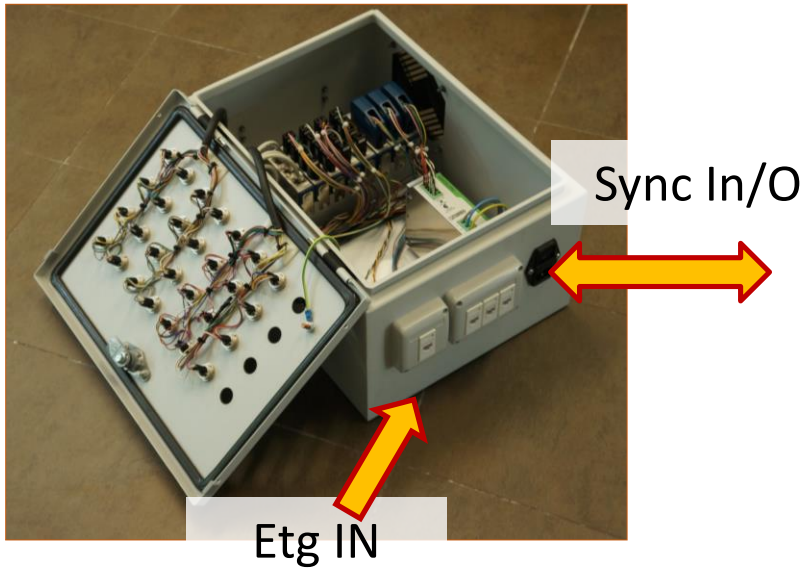
NATIONAL INSTRUMENTS

EUCENTRE
FOR YOUR SAFETY.

# Tavola vibrante multi-assiale – sistema di acquisizione dati



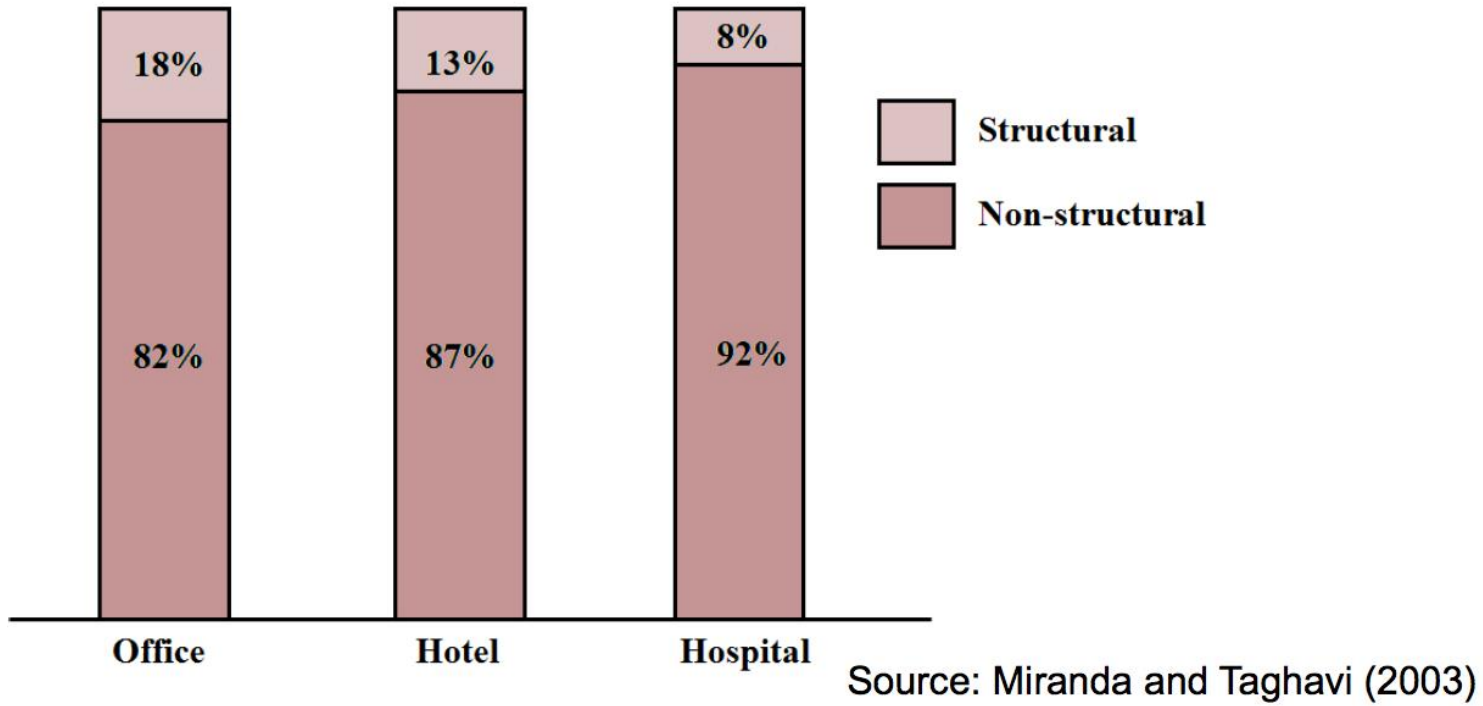




NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY

NATIONAL INSTRUMENTS™

EUCENTRE
FOR YOUR SAFETY.




Source: Miranda and Taghavi (2003)

Qualifica sismica secondo Standard internazionali:

- AC156 – Acceptance Criteria For Seismic Certification ByShake-Table Testing of NonStructural Components;
- IEEE693-2005 - Recommended Practice for Seismic Design of Substations;
- IEC 62271-207 - Seismic qualification for gas-insulated switchgear assemblies;
- ISO/CD 13033 - Bases for design of structures - Loads,forces and other actions — Seismic actions on nonstructural components for building applications

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY

If you want to go fast,

*go alone.*

If you want to go far,

*go together.*

- African Proverb -


# Thanks for your attention

For further information please visit: www.eucentre.it

Be sure to check our latest video on the EUCENTRE YouTube channel

NATIONAL INSTRUMENTS | EUCENTRE FOR YOUR SAFETY.

# Stay Connected During and After NIDays

ni.com/niweekcommunity


facebook.com/NationalInstruments


twitter.com/niglobal


youtube.com/nationalinstruments

NIDays

ENGINEER NEXT