



20th International Symposium of MASE
"RESILIENT STRUCTURES"

September, 28th – 29th, 2023, Skopje, N. Macedonia

ERIES

ENGINEERING
RESEARCH
INFRASTRUCTURES
FOR EUROPEAN
SYNERGIES

European Research Synergies Towards Loss and Risk-driven Mitigation Approaches

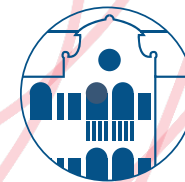
Presenter: Gerard J. O'Reilly¹

1) Centre for Training and Research on Reduction of Seismic Risk (ROSE Centre)

Scuola Universitaria Superiore IUSS Pavia, Pavia, Italy

ROSE

CENTRE FOR TRAINING AND
RESEARCH ON REDUCTION
OF SEISMIC RISK



IUSS

Scuola Universitaria Superiore Pavia



PROJECT OVERVIEW



ENGINEERING
RESEARCH
INFRASTRUCTURES
FOR EUROPEAN
SYNERGIES

- The objective of ERIES is to provide transnational access (TA) to research infrastructures to conduct research that will advance frontier knowledge related to seismic, wind and geotechnical hazards

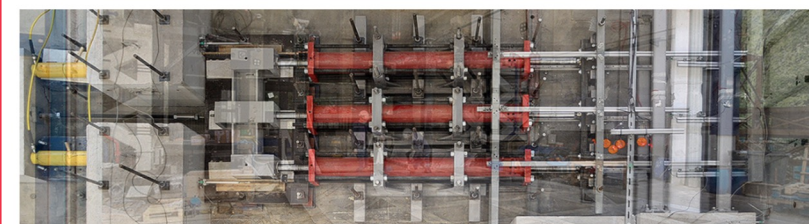
- Funding: European Commission Horizon Europe



- Total Budget: €11,616,118
 - €10,616,225 European Commission Contribution
 - €999,892 UKRI Contribution
- Duration: 4 years (01/06/2022 – 31/05/2026)



About | Research | Transnational Access | Dissemination | News and Events | FAQ



ERIES responds to the call INFRA-2021-SERV-01-07: Research infrastructure services advancing frontier knowledge with the overall objective of providing transnational access (TA) to advanced research infrastructures in the fields of structural, seismic, wind and geotechnical engineering. This project, together with the research infrastructure team assembled, provides access to leading experimental facilities that permit users to advance frontier knowledge and conduct curiosity-driven research towards: the reduction of losses and disruption due to these hazards; the management of their associated risk; and the development of innovative solutions to address them that will contribute to a greener and more sustainable society.

To this end, ERIES offers TA to the best European experimental facilities in each field, with new and unique infrastructures available for the first time in this programme, along with the provision of key infrastructure in Canada. It integrates past infrastructure projects' successful results and implementation, such as SERIES and SERA, and expands access capabilities to new communities and disciplines not yet focused on.

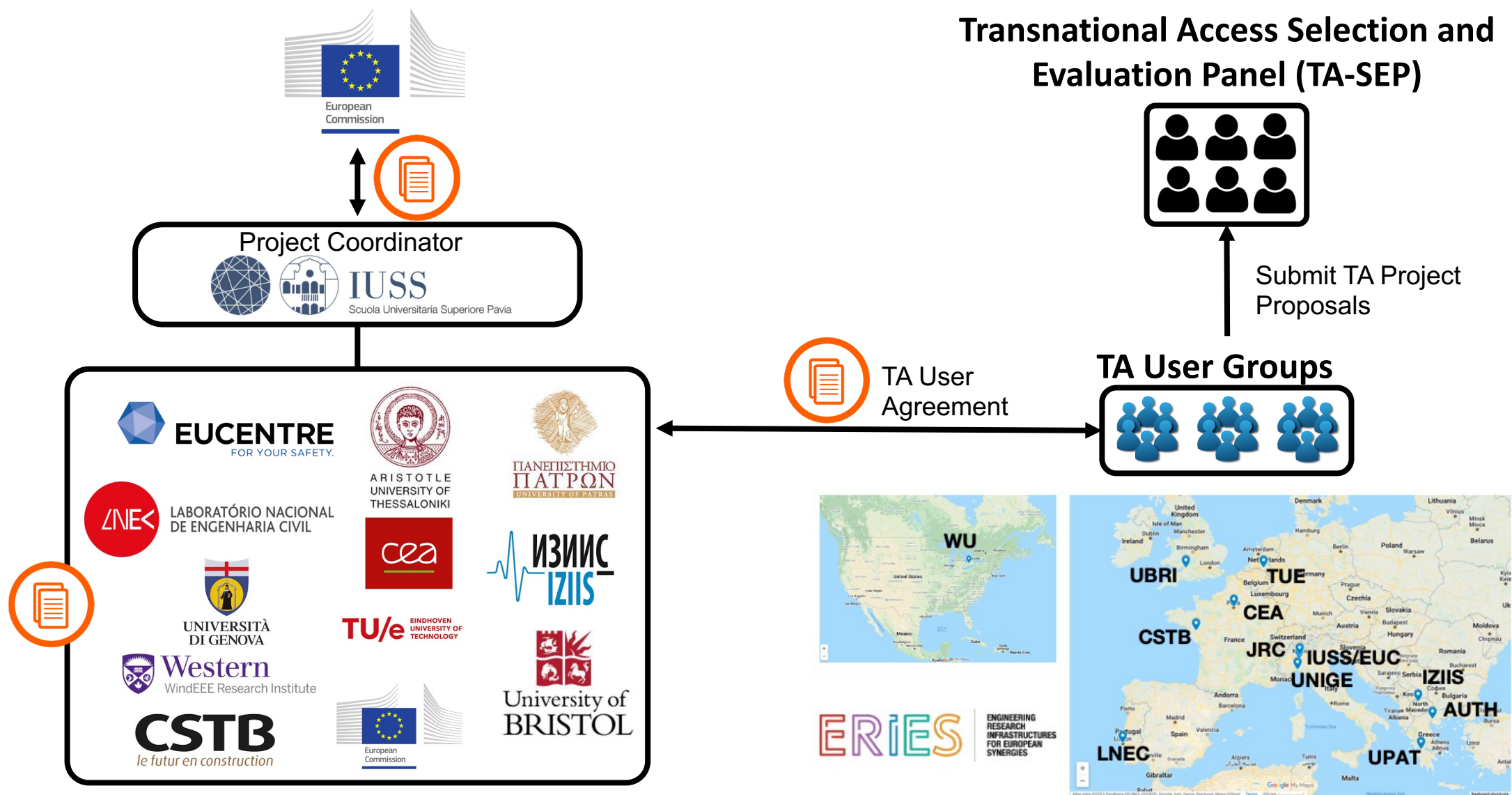
It will provide authoritative input for diverse stakeholders, from Civil Protection agencies to the European seismic building code. It will help develop future standards for experimental techniques in earthquake, wind and geotechnical engineering. It will provide a platform from which European researchers can create innovative solutions and testbed applications of next-generation technologies.

With 13 partners from 8 countries, ERIES builds an essential element toward reducing losses, managing risk, and overall a greener and more sustainable engineering future in Europe.

NEWS

Website: www.eries.eu

Email: eries@iusspavia.it





ERIES Research Infrastructures

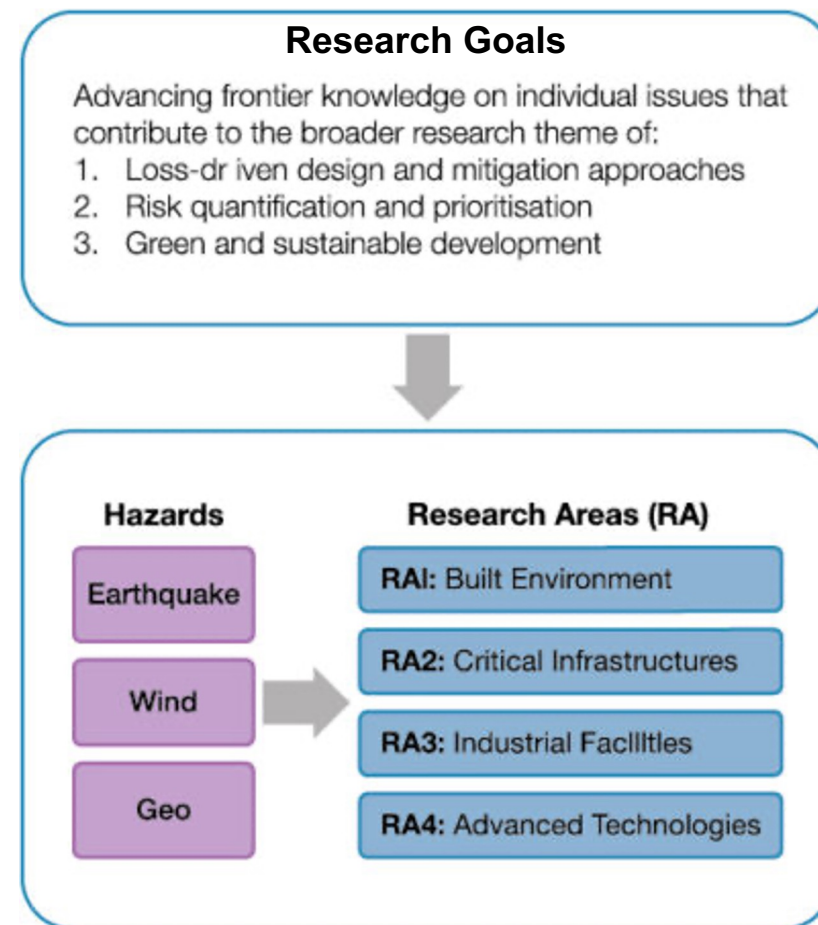
1. IUSS-EUC – Pavia, Italy
2. UPAT – Patras, Greece
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8. UNIGE – Genova, Italy
9. WU – London, Canada
10. TUE – Eindhoven, Netherlands
11. CSTB – Nantes, France
12. JRC – Ispra, Italy





RESEARCH GOALS

- It comprises three main research goals shown which TA user projects shall strive to address
- ERIES will advance frontier knowledge related to seismic, wind, and geotechnical hazards
- Research will be carried out with respect to these three hazards and in one of the four research areas listed





Research Goals

Research Goal 1:
Loss-driven design
and mitigation
approaches



Research Goal 2:
Risk quantification
and prioritisation



Research Goal 3:
Green and
sustainable
development





Research Goals

Research Goal 1:
Loss-driven design
and mitigation
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Research Goal 2:
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Research Goal 3:
Green and
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development

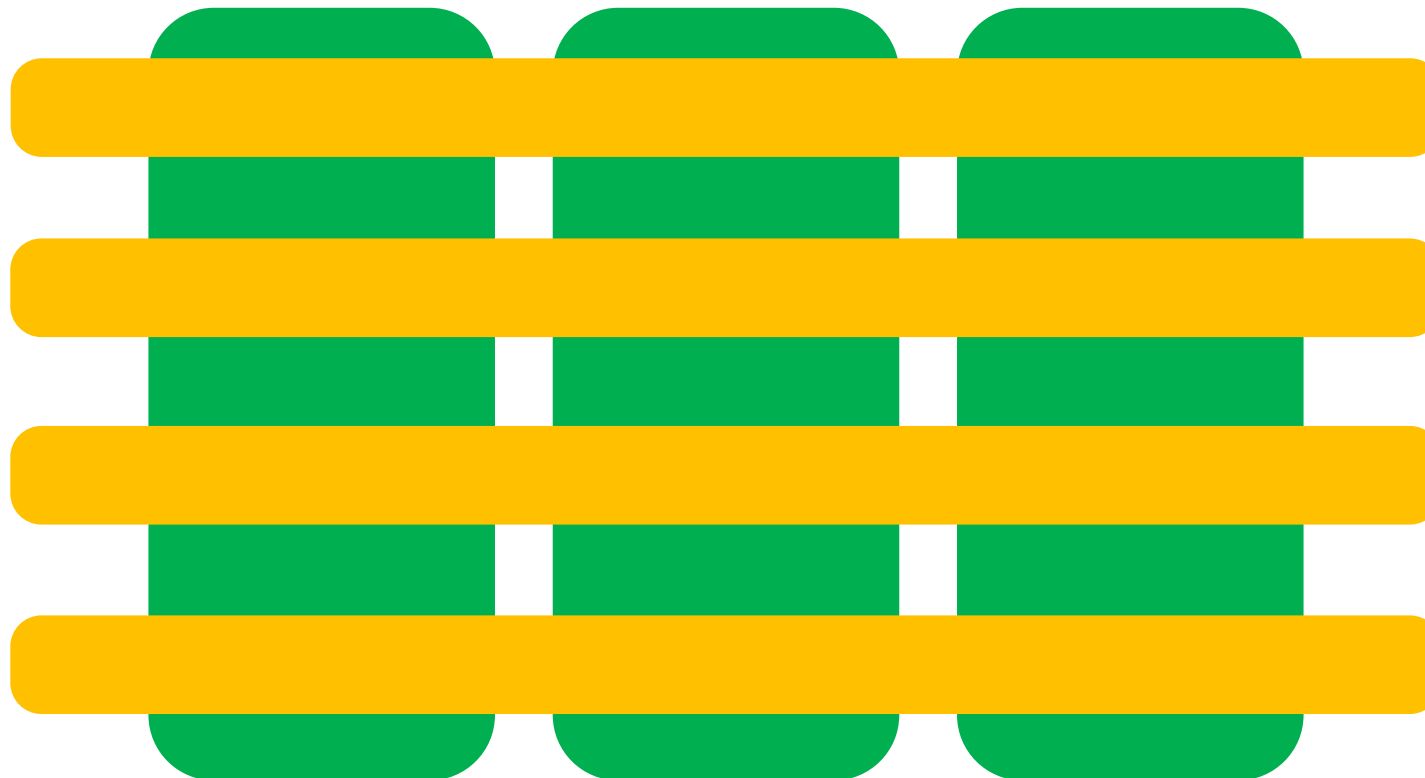
Research Areas

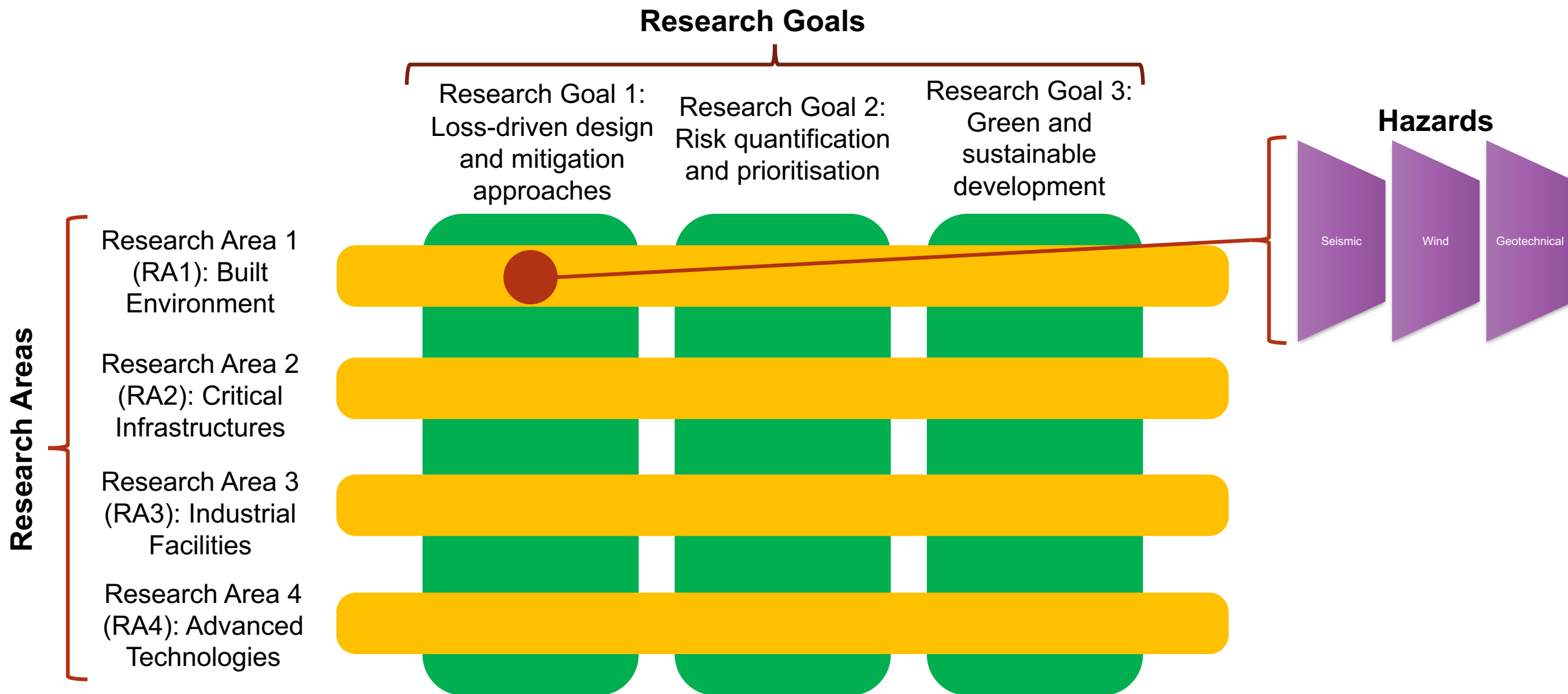
Research Area 1
(RA1): Built
Environment

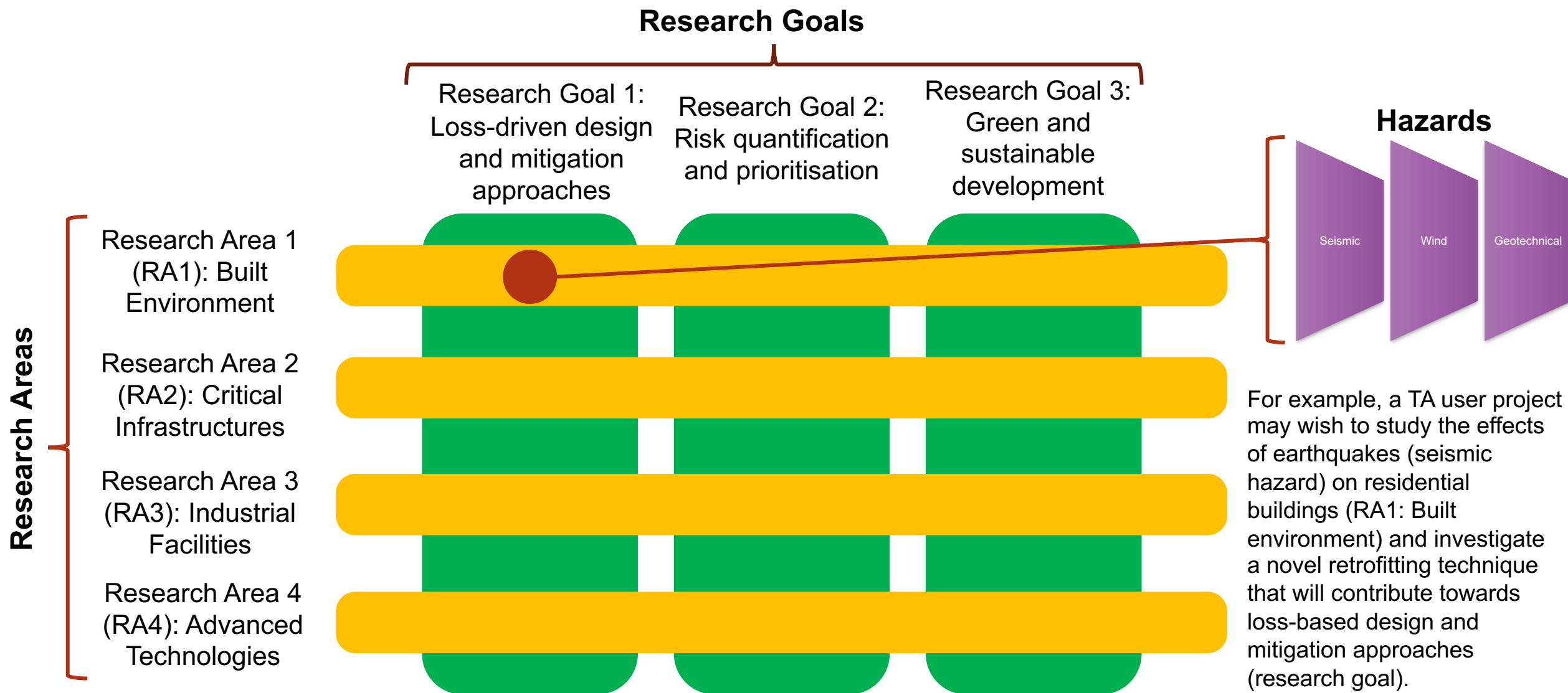
Research Area 2
(RA2): Critical
Infrastructures

Research Area 3
(RA3): Industrial
Facilities

Research Area 4
(RA4): Advanced
Technologies





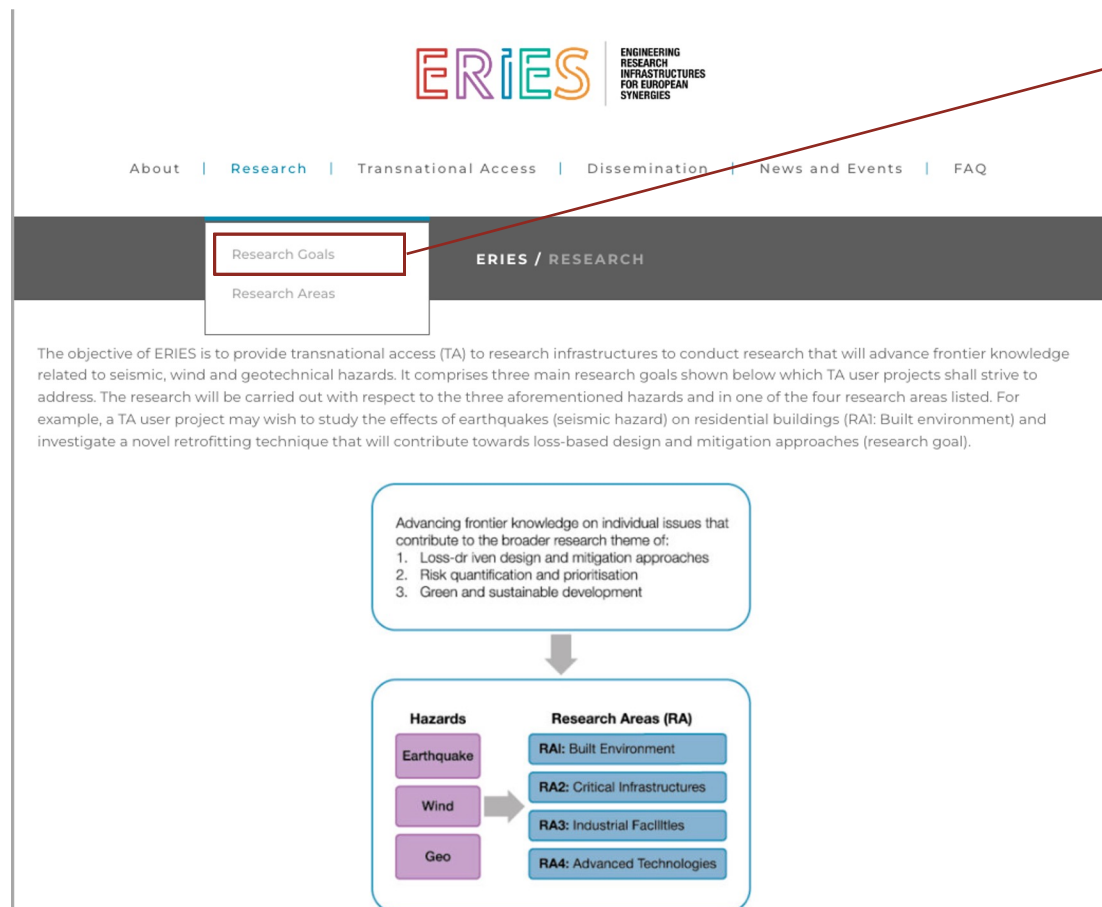




RESEARCH GOALS

<https://eries.eu/>

- Specific details can be found on the project website



The detailed view of the ERIES Research Goals page includes:

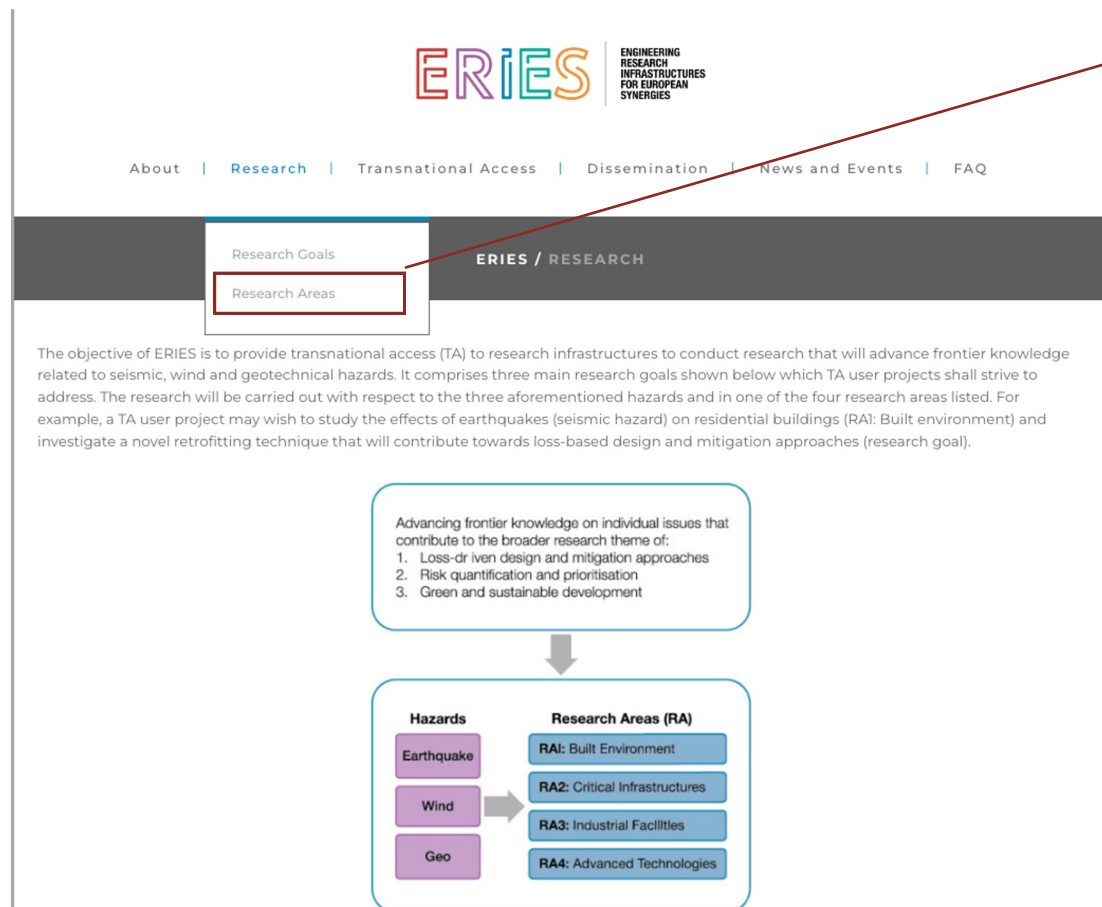
- Header: ERIES logo and "ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES".
- Navigation: About | Research | Transnational Access | Dissemination | News and Events | FAQ.
- Section: ERIES / RESEARCH GOALS.
- Section: Research Goals.
- Section: Research Goal 1: Loss-driven design and mitigation approaches.
- Text: "There are still important 'open' issues in the design and retrofit of structures against natural hazards. Past events have repeatedly highlighted their potential impact in terms of economic losses, casualties, and overall disruption (i.e., indirect loss). Additionally, there are several key areas in which further innovation and knowledge expansion can be made. This first research goal focuses on this from the perspective of loss-driven mitigation approaches."
- Section: Seismic Hazard.
- Text: "In the case of seismic design, it has become increasingly obvious that the current approach possesses several flaws both on a technical and conceptual level. This is a general statement applicable worldwide, but in the case of Europe, several particular issues arise. On the technical side, it is clear that there is still much to be learned on the behaviour and performance of existing structures to make them Eurocode-compliant, with the existing building stock in most European countries having been constructed in the post-WWII construction boom period (Crowley et al., 2020; Crowley, 2021) that predated any modern building codes based on sound seismic design principles. On a conceptual level, it is clear that even today, when structural behaviour is understood with a degree of confidence in many cases, it is still not abundantly clear what their target performance should be and how it should be ensured. This applies to structures forming a part of the built environment (e.g., residential buildings), critical infrastructures (e.g., bridge network) and industrial facilities (e.g., processing plants), which form part of RA1, RA2 and RA3 of ERIES. Hence, there is a problem with both conceptual implementations to ensure satisfactory performance and technical know-how to allow this to take place. ERIES will work through its TA activities to address both of these issues. This will be primarily through the development of necessary data for loss-based approaches. Past developments have mainly centred on US-based research, but some progress has been made on this from a European perspective. ERIES TA activity will seek to conduct research projects that can make significant contributions in this regard. This research, forming parts of RA1, RA2 and RA3 and to be conducted in the available research infrastructures, involves the detailed characterisation via experimental testing. The combination of world-class facilities and research projects make ERIES uniquely positioned to conduct world-class and cutting-edge research to address these gaps. For example, this will be done via the novel shake table system in Pavia to allow a unique way of testing and validating non-structural element damage in buildings, in addition to the diverse and complementary shaking table facilities at Lisbon, Paris, Bristol and Skopje. In addition, the unique facilities to investigate other types of damage mechanisms and potential consequences can be addressed at the laboratory facilities in Patras, Thessaloniki and the JRC's facilities at Ispra. Specific damage mechanisms, potential repair actions and associated costs will be targeted via numerous testing campaigns throughout this network of advanced research facilities to foster the development of a database of damage and cost functions for loss-driven assessment and design that will form a next-generation approach to reducing seismic risk."



RESEARCH AREAS

<https://eries.eu/>

- Specific details can be found on the project website



ERIES | ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES

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ERIES / RESEARCH AREAS

Research Areas

Research Area 1 (RA1): Built Environment
This encompasses the structures in which we live and occupy each day. They are analysed from a single-structure perspective in relation to their associated attributes; these cover the building typology (e.g., reinforced concrete, steel, unreinforced masonry), the occupancy type (e.g., residential, commercial, office) and other pertinent issues like the non-structural elements and building contents.

Research Area 2 (RA2): Critical Infrastructures
This encompasses the structures which form a more strategic and regional part of daily life. They are analysed singularly but to encompass their cascading effects on the networks to which they belong. Road, rail, water, gas or electric networks and other infrastructures like wind turbines and power plants are the main focus, which can then be subdivided based on more detailed attributes like typology (e.g., bridge, transmission line, concrete, steel), structural system (e.g., simply supported, arched, precast) in addition to the study of geotechnical issues and supplemental device behaviour (see also RA4).

Research Area 3 (RA3): Industrial Facilities
This encompasses the structures which form the basis of much industrial activity and whose characteristics and needs do not necessarily fall under RA1. In particular, industrial facilities like factories and production plants, which play a crucial role in the economical functionality of a region, are dealt with in a more specific manner. Issues like the structural performance of the unique structures that house such industrial production will be examined, in addition to the non-structural elements (see also RA1) and other components that typically occupy these facilities.

Research Area 4 (RA4): Advanced Technologies
Differing from the previous three RAs, this research area focuses on advancing technologies. This is done first from a mitigation devices perspective, whereby existing technologies such as base isolation, viscous dampers and other innovative green and sustainable materials are developed and can be readily implemented in practice. It is envisioned that their development can also indirectly impact RA1, RA2, and RA3 previously described. Secondly, this research area focuses on experimental techniques as a topic to be further developed. That is, the capacity of the different research infrastructures within ERIES to develop and expand their capabilities, with a focus on the different partners' laboratories working together in a novel form of hybrid testing, will be given adequate consideration.



ERIES Research Infrastructures

1. IUSS-EUC – Pavia, Italy
2. UPAT – Patras, Greece
3. UBRI – Bristol, UK
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- Geographical diversity

Users from:

- Europe
- North America
- Oceania
- Asia





European Research Synergies Towards Loss and Risk-driven Mitigation
Approaches - Gerard J. O'Reilly

Collaboration (1st and 2nd Call)

The map illustrates a global network of flight routes, primarily centered in Europe. Key cities and their connections include:

- North America:** Vancouver, Oshawa, Montreal, Toronto, Grand Rapids, Blacksburg, San Francisco, Fort Collins, Havana.
- Australia/New Zealand:** Melbourne, Auckland.
- Europe:** Stavanger, Ås, Aarhus, Elsinore, Lyngby, Gdansk, Hamburg, Berlin, Groningen, Essen, Bad Berleburg, Aachen, Liège, Nancy, Munich, Vienna, Bratislava, Košice, Bucharest, Belgrade, Skopje, Patras, Athens, Gaziantep, Abu Dhabi, Istanbul, Komotini, Thessaloniki, Messina, Catania, Naples, Rome, Pescara, Ancona, Perugia, Sassuolo, Bologna, Parma, Ferrara, Brescia, Trento, Udine, Trieste, Turin, Pisa, Pavia, Genova, A Coruña, Porto, Braga, Guimarães, Aveiro, Ericeira, Gurem, Madrid, Barcelona, Granada, Lisbon, Lisboa, A Coruña.
- Other Regions:** Fuzhou (China), Stavanger (Norway), Ås (Norway), Aarhus (Denmark), Elsinore (Denmark), Lyngby (Denmark), Gdansk (Poland), Hamburg (Germany), Berlin (Germany), Groningen (Netherlands), Essen (Germany), Bad Berleburg (Germany), Aachen (Germany), Liège (Belgium), Nancy (France), Munich (Germany), Vienna (Austria), Bratislava (Slovakia), Košice (Slovakia), Bucharest (Romania), Belgrade (Serbia), Skopje (North Macedonia), Patras (Greece), Athens (Greece), Gaziantep (Turkey), Istanbul (Turkey), Komotini (Bulgaria), Thessaloniki (Greece), Messina (Italy), Catania (Italy), Naples (Italy), Rome (Italy), Pescara (Italy), Ancona (Italy), Perugia (Italy), Sassuolo (Italy), Bologna (Italy), Parma (Italy), Ferrara (Italy), Brescia (Italy), Trento (Italy), Udine (Italy), Trieste (Italy), Turin (Italy), Pisa (Italy), Pavia (Italy), Genova (Italy), A Coruña (Spain), Porto (Portugal), Braga (Portugal), Guimarães (Portugal), Aveiro (Portugal), Ericeira (Portugal), Gurem (Portugal), Madrid (Spain), Barcelona (Spain), Granada (Spain), Lisbon (Portugal), Lisboa (Portugal).

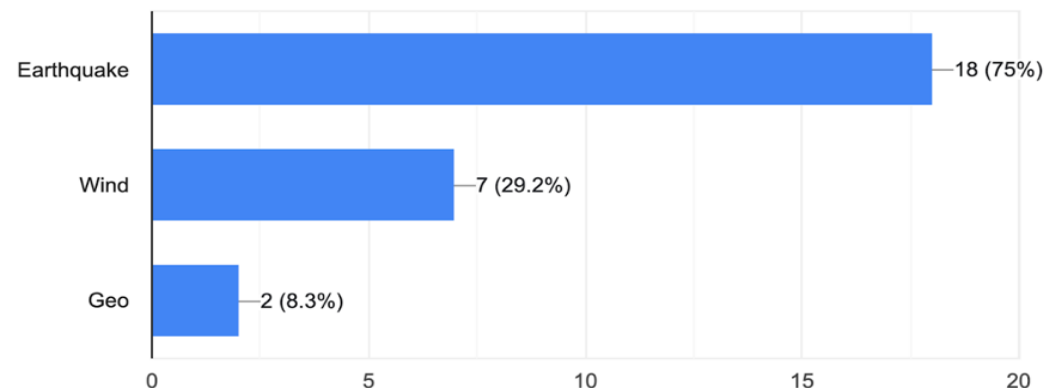


Transactional Access - 1st call

- 24 applications from 10 different countries around Europe
- Transactional access (TA) to infrastructures in the fields of structural, seismic, wind, and geotechnical engineering
- Majority of proposals focus on earthquake related research areas
- 5 research areas where the proposal focuses on with the majority related to Built Environment

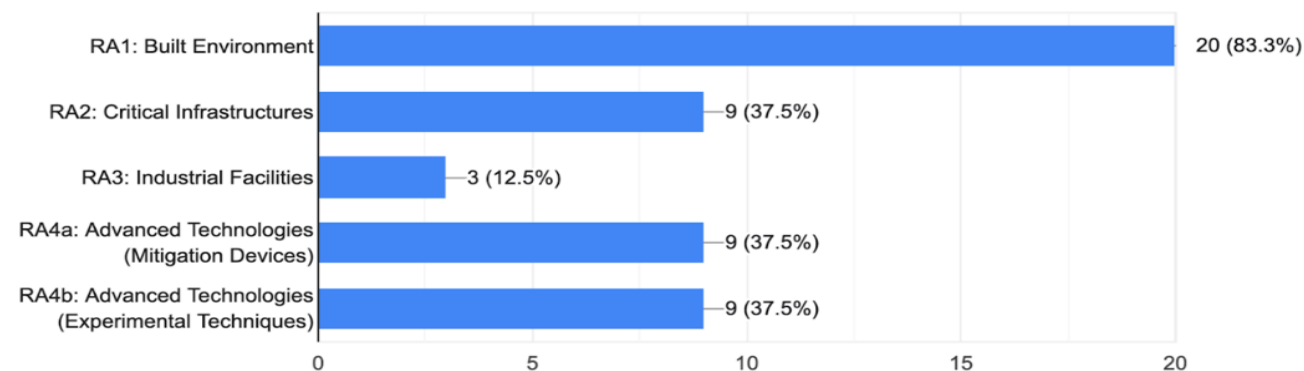
Which of the three hazards addressed in ERIES does the proposal focus on?

24 responses



Which of the four ERIES Research Areas does the proposal focus on?

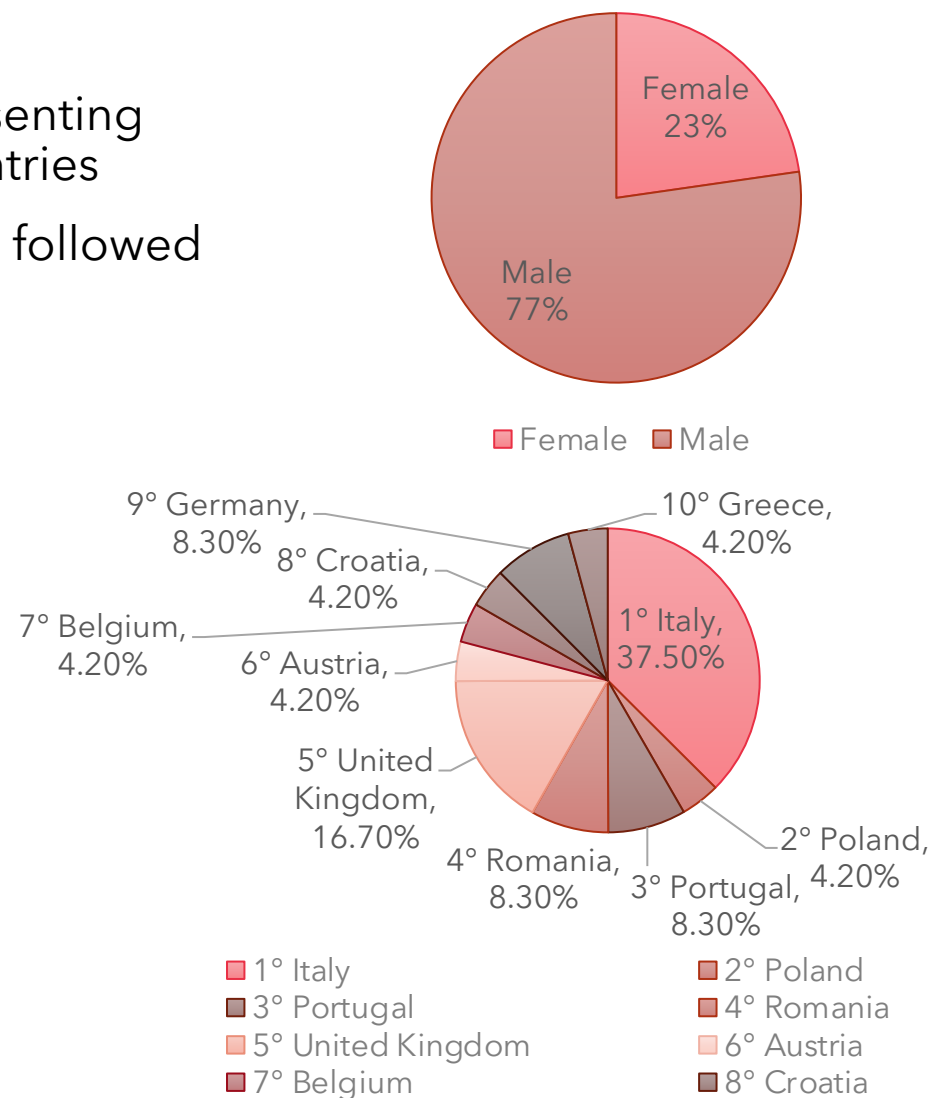
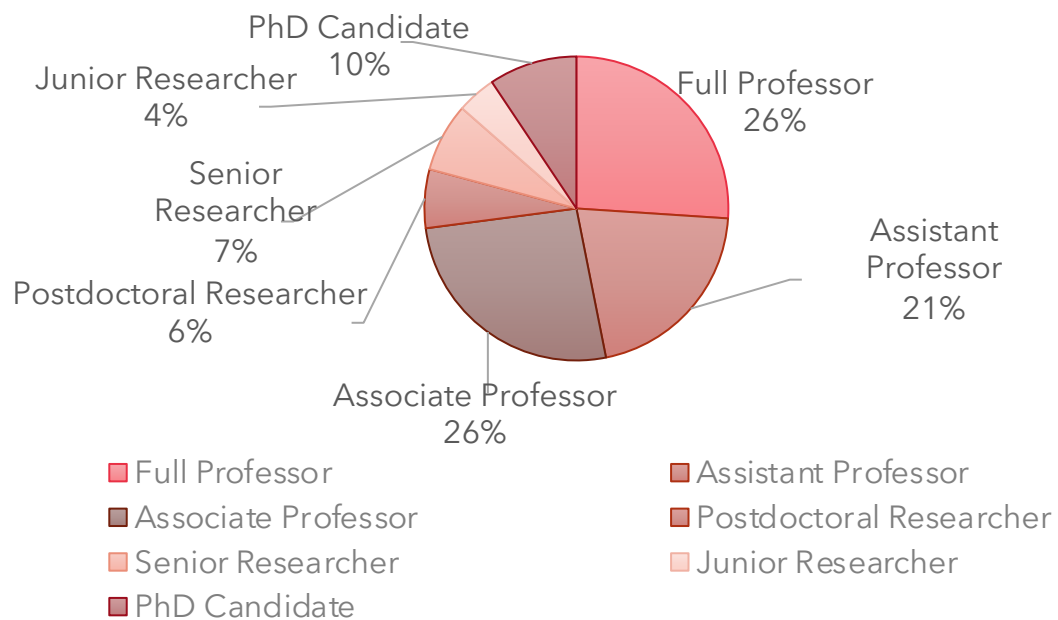
24 responses





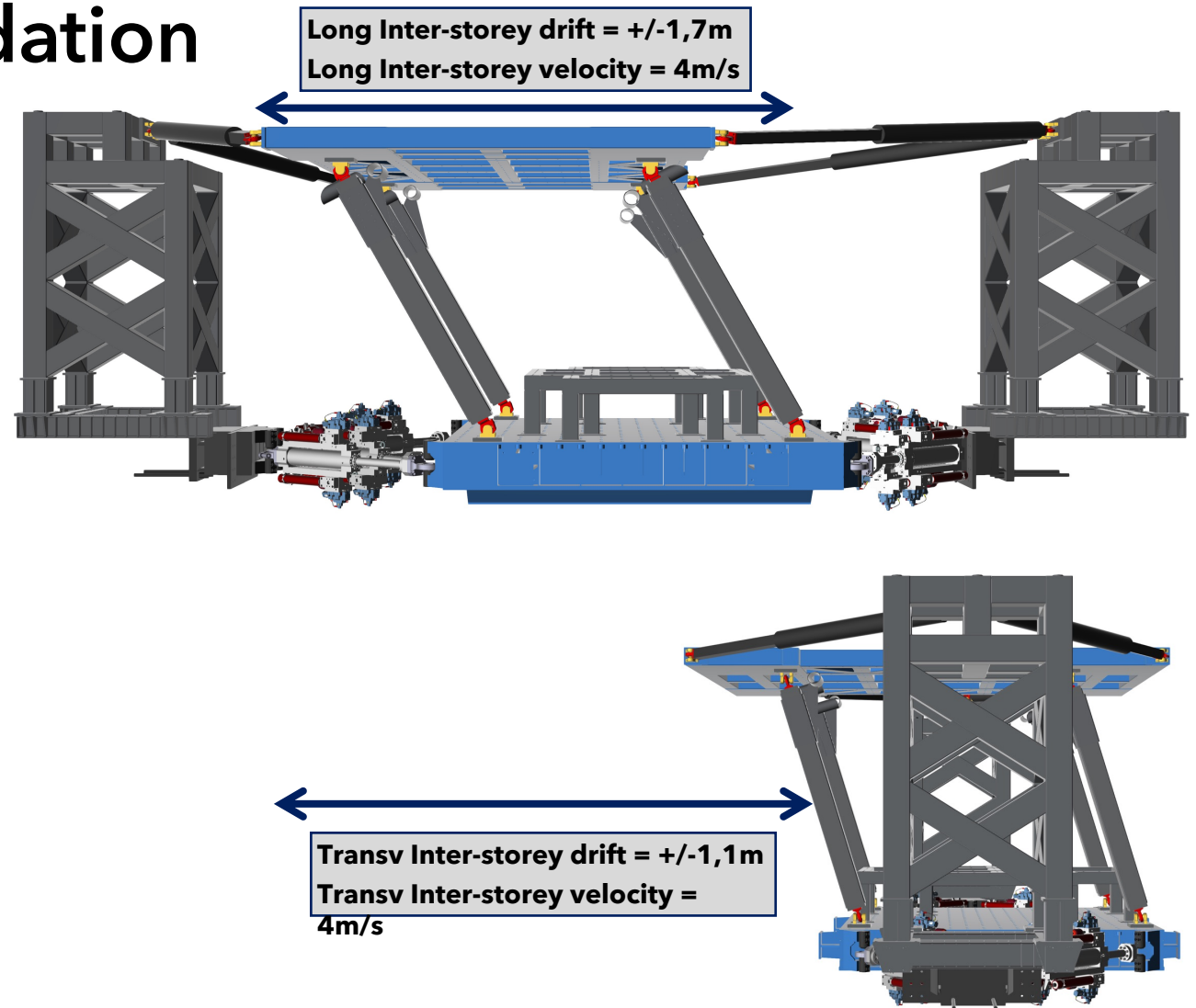
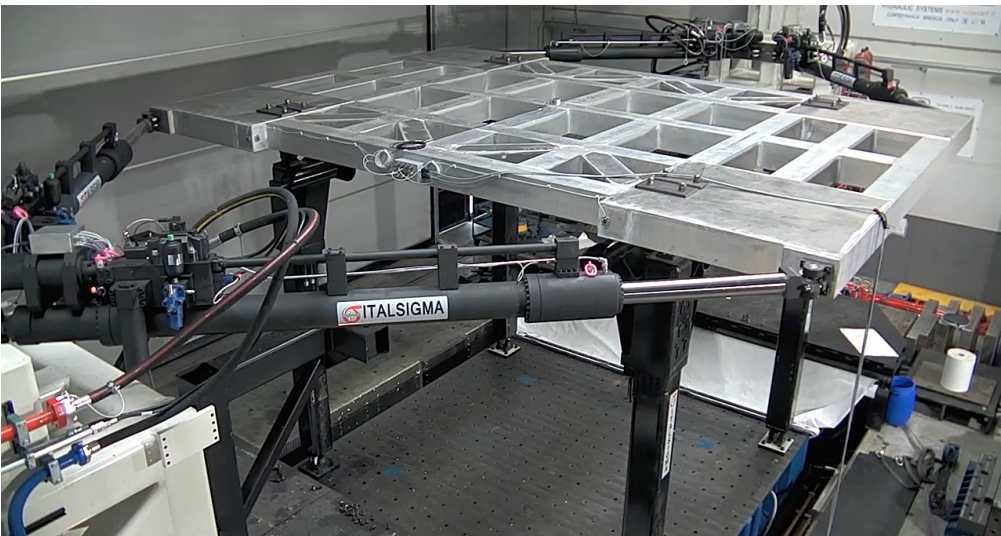
User groups - 1st call

- Diverse group of people of different profiles representing universities, research institutions and different countries
- Highest number of applications received from Italy, followed by United Kingdom and Portugal
- 10 different countries





9DLAB at EUCENTRE Foundation

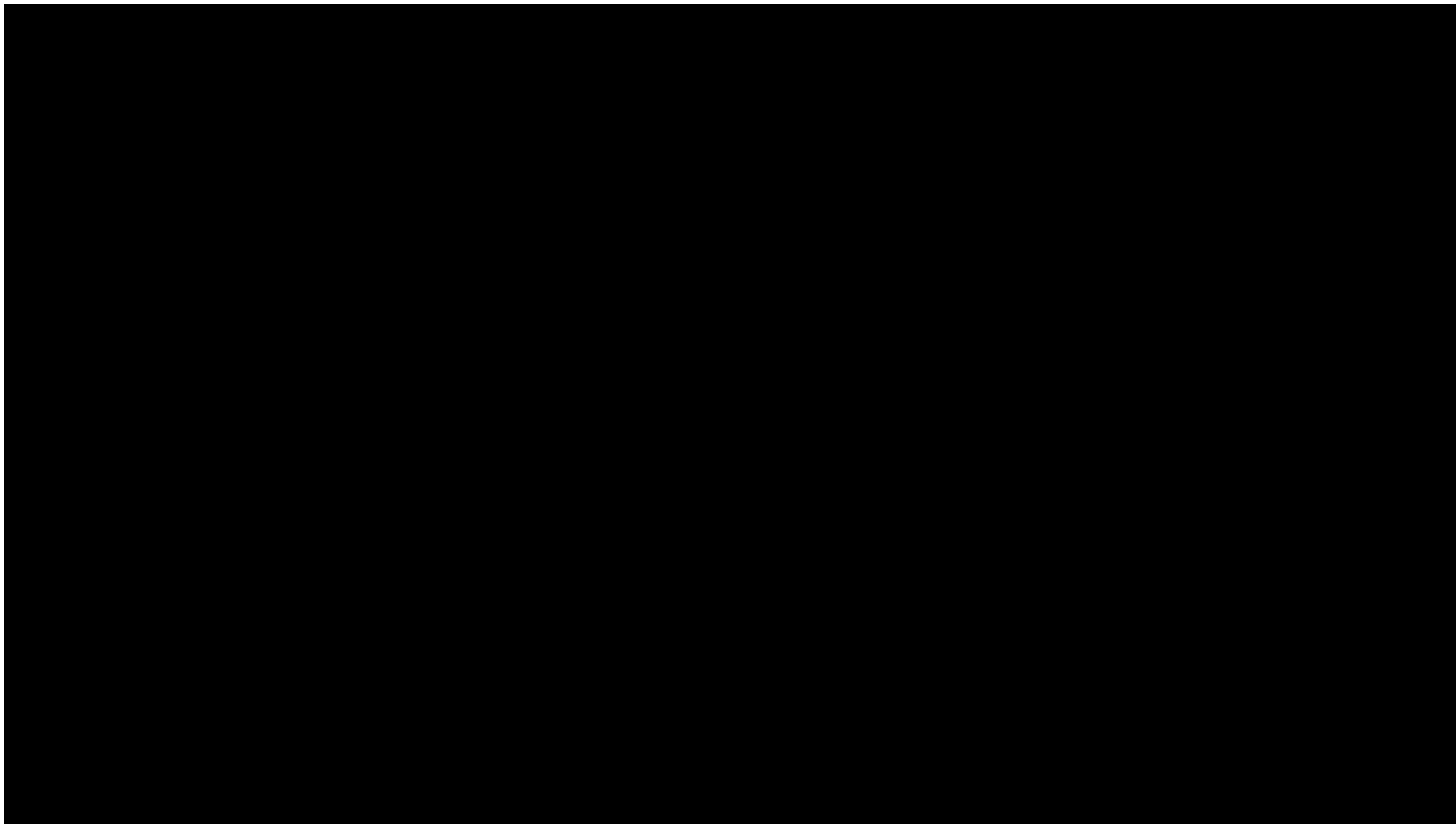




MASE 20 - "RESILIENT STRUCTURES"

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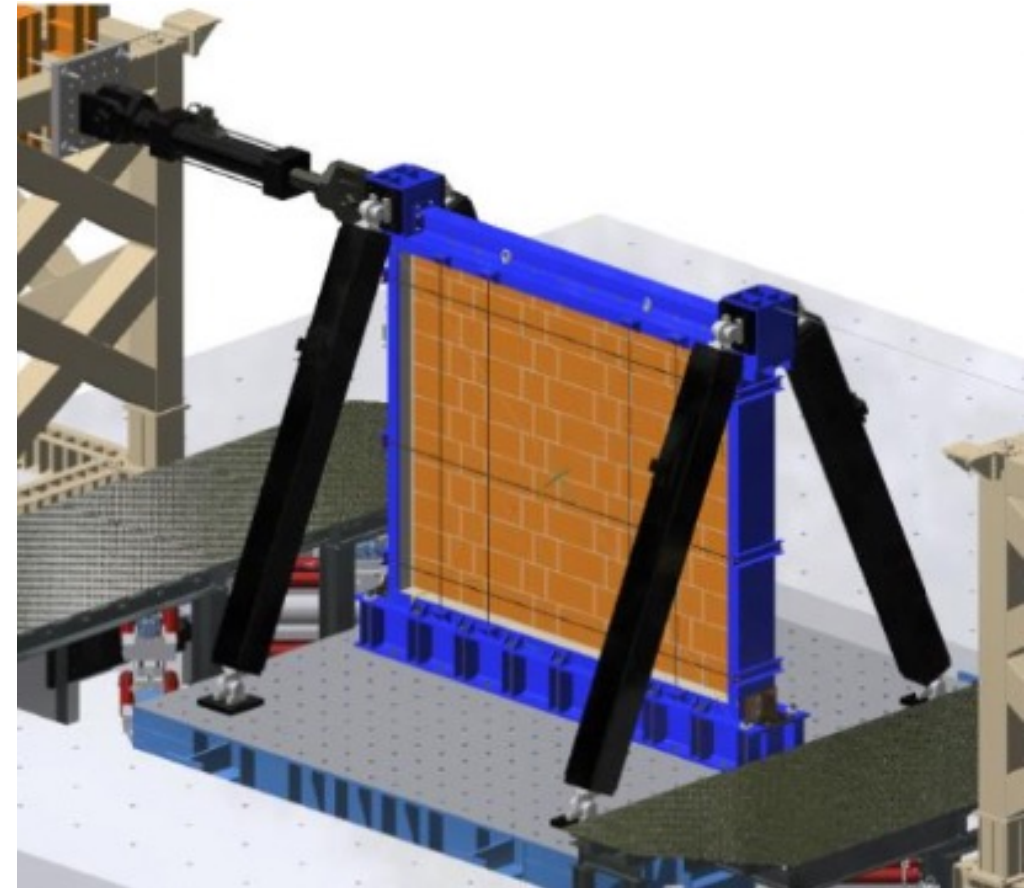
European Research Synergies Towards Loss and Risk-driven Mitigation
Approaches - Gerard J. O'Reilly





Case-Study Project: ENFRAG

- A case study example is described to illustrate the types of projects and how they address the research goals and areas outlined previously
- The project is ENFRAG (ENhancing state-dependent FRAGility through experimentally validated Energy-Based Approaches)
- It is led by the University College London, UK alongside Sapienza, Rome and is accessing the 9DLAB facilities at the Eucentre Foundation in Pavia, Italy



SAPIENZA
UNIVERSITÀ DI ROMA

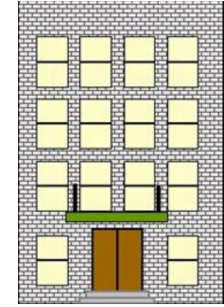


Background

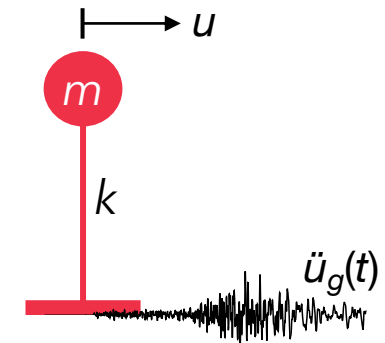
- The aim is to investigate the impact of energy dissipation in buildings on the seismic response and damage estimation
- If we test two identical structures (A and B) with the same earthquake scaled to $PGA_A=0.2g$ and $PGA_B=0.5g$



Structure A



Structure B



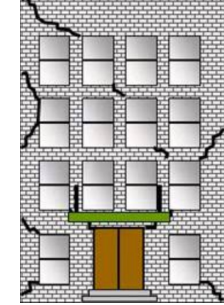


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Structure A



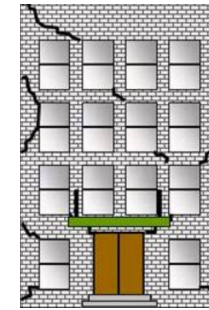
Structure B

Structure B is
damaged
more



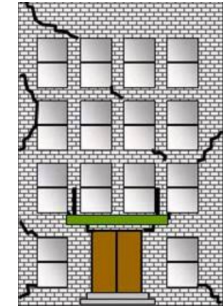
Background

- If we run a second earthquake on them at $PGA=1g$, specimen B will be more damaged than A
- This is because of the damage it suffered accumulated previously
- Most numerical modelling and seismic fragility models used in risk assessment don't account for this



Structure A

Same
damage?

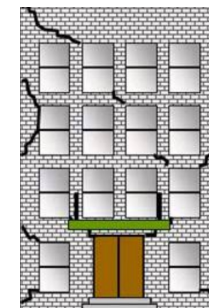


Structure B

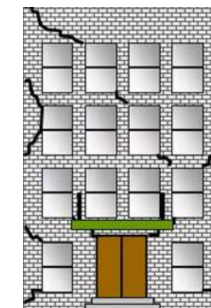


Background

- If we run a second earthquake on them at $PGA=1g$, specimen B will be more damaged than A
- This is because of the damage it suffered previously
- State-independent fragility functions would say they have the same damage state
- We know this is not the case
- Most numerical modelling and seismic fragility models used in risk assessment don't account for this

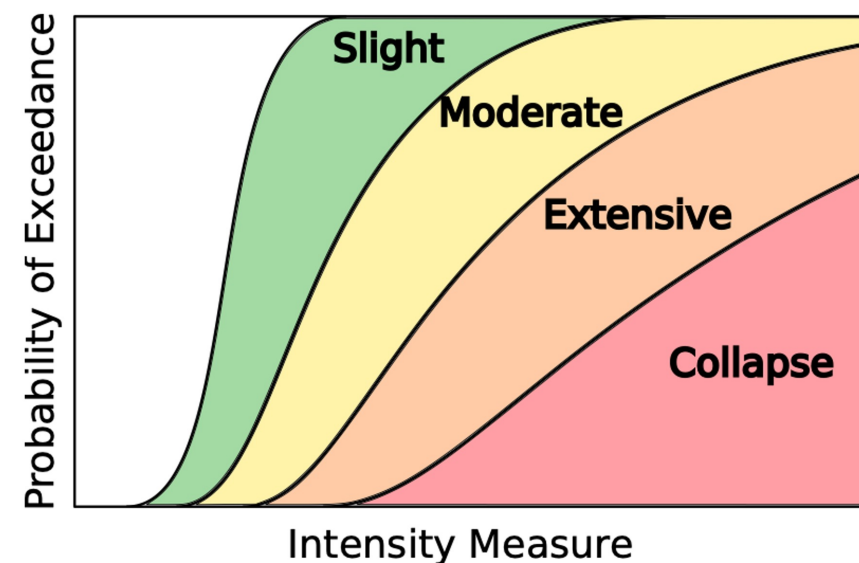


Structure A



Structure B

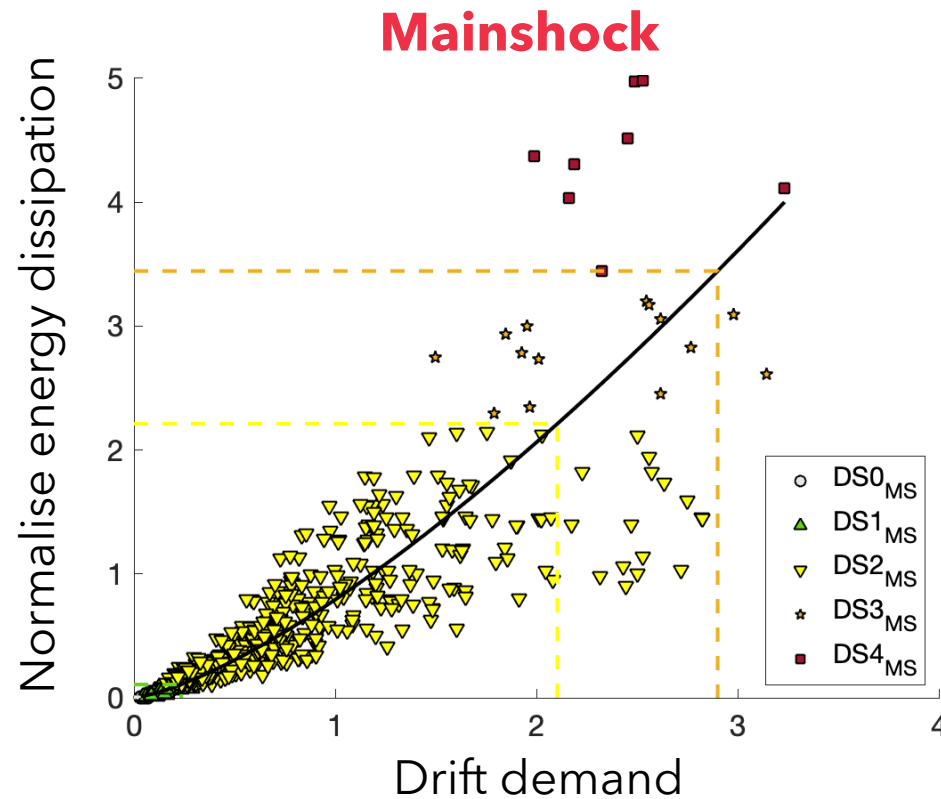
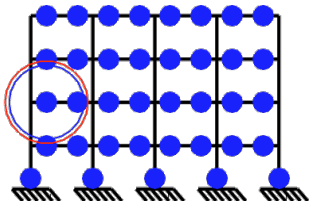
Same
damage?





Objectives

Aim to perform experimental research on peak drift vs. hysteretic energy



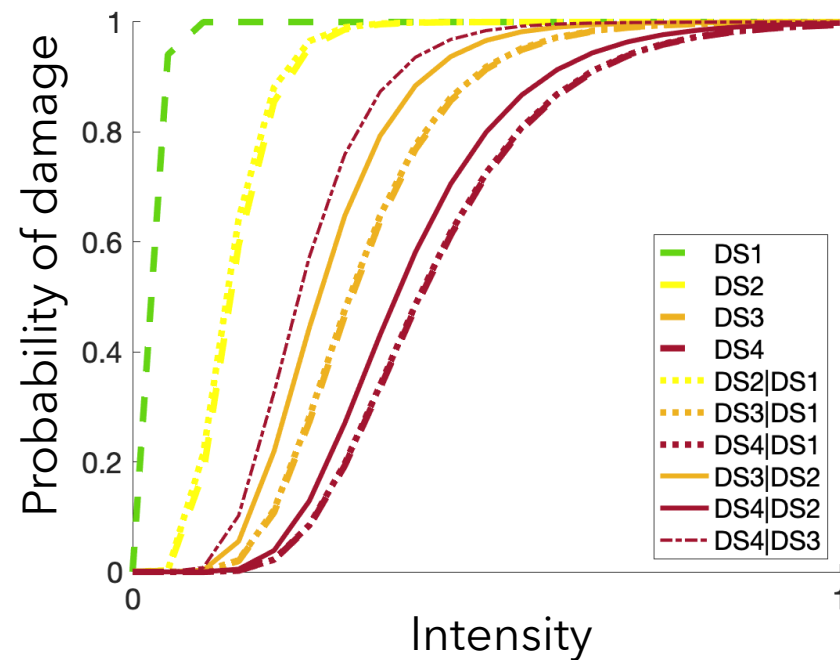
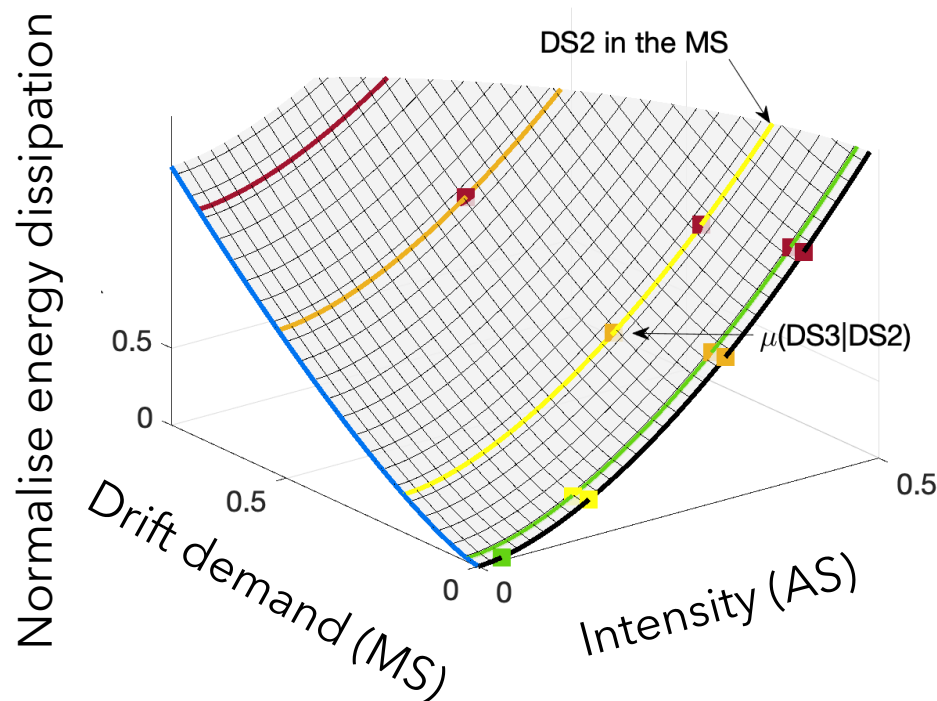
Gentile R, Galasso C. (2020) Hysteretic energy-based state-dependent fragility for ground motion sequences. *EESD*.

<https://doi.org/10.1002/eqe.3387>



Objectives

Energy-based state-dependent fragility curves



Line colour represents DS(AS)
Line type represents DS(MS)

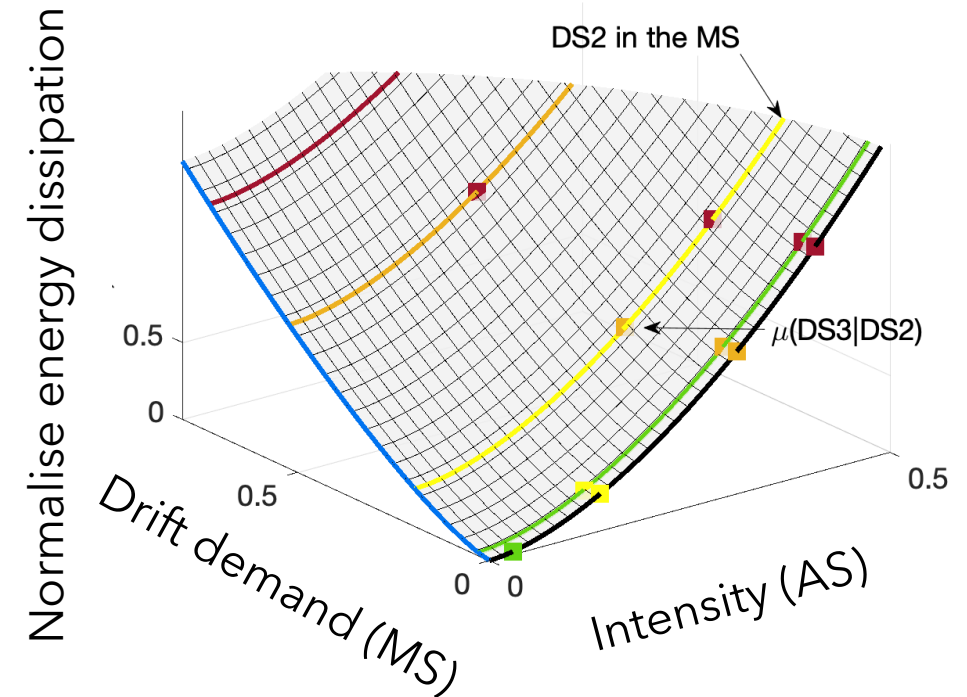
Gentile R, Galasso C. (2020) Hysteretic energy-based state-dependent fragility for ground motion sequences. *EESD*.

<https://doi.org/10.1002/eqe.3387>

Experimental test programme

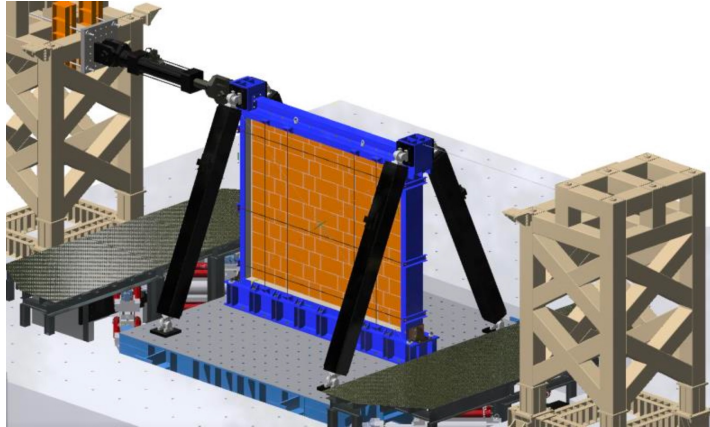


- Four nominally-identical masonry infill walls:
 - quasi-static cyclic displacement-controlled IP tests
 - and sequential shaking-table dynamic OOP tests
- Those are tested with different load protocols
- This will induce the same values of peak-based EDPs while modulating the energy-based demand conditional to the above peak quantities ($Eh|EDP_{IP}$ and $Eh|EDP_{OOP}$)

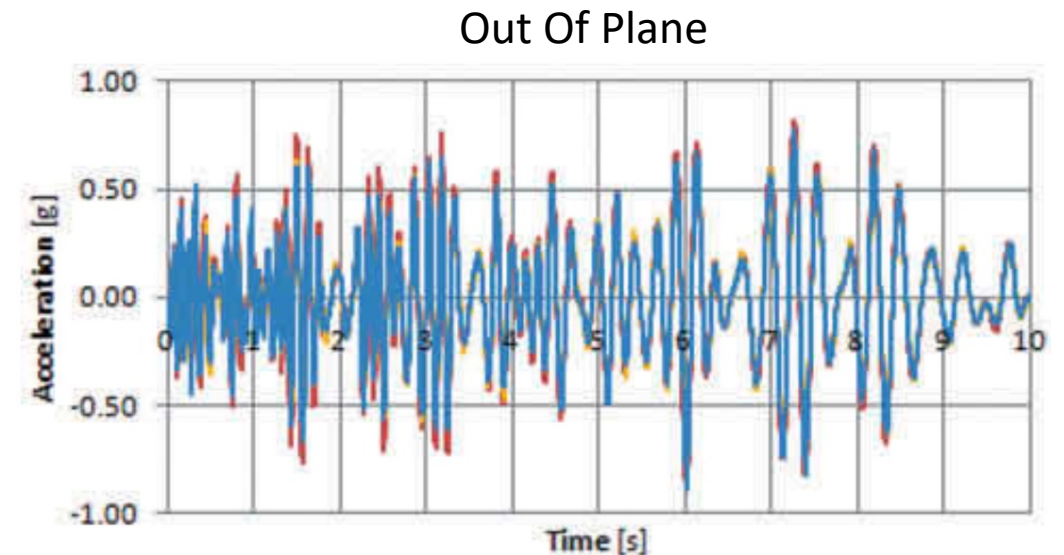
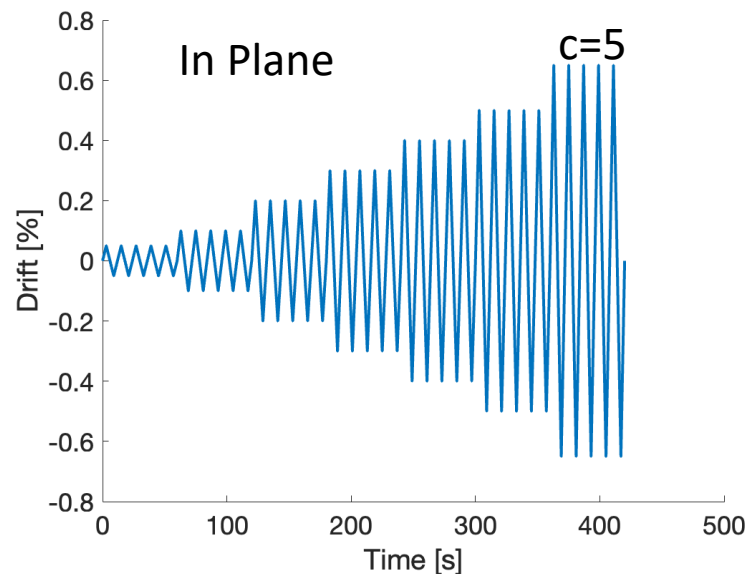




Experimental test programme



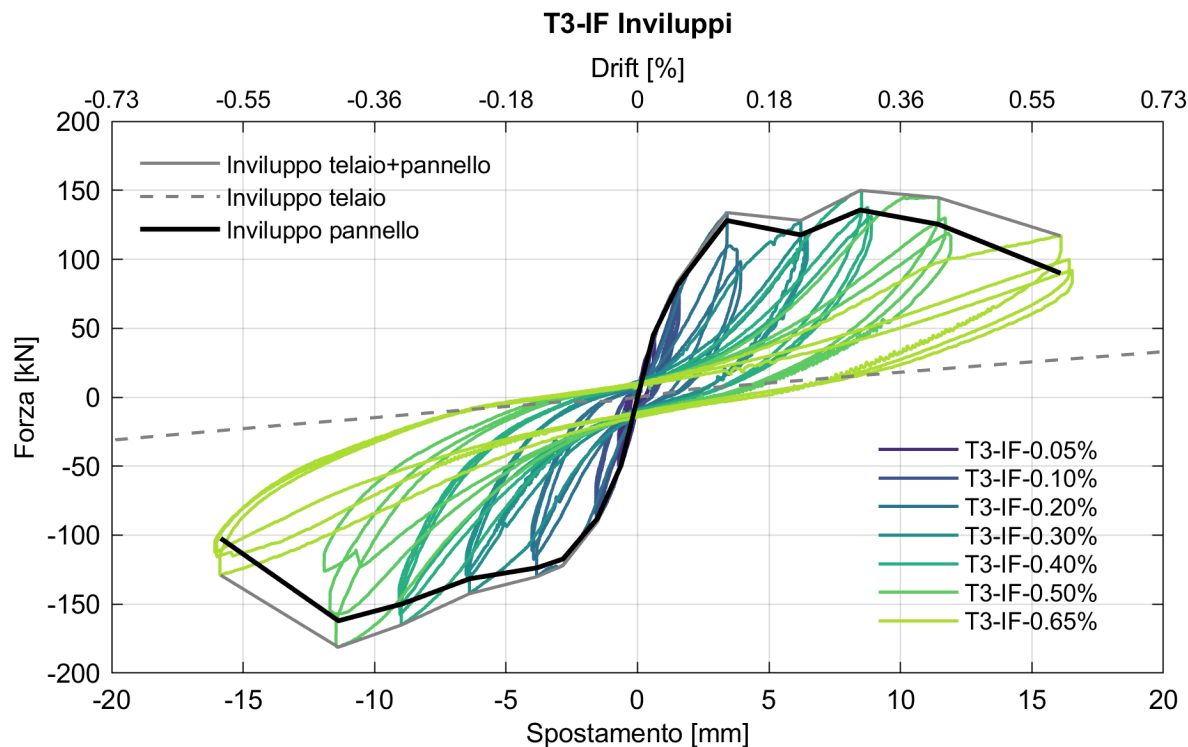
	θ_{max}	d	c	a(t)	ΔPFA	Notes
Test1	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	<u>5</u>	AC156	0.10g	<u>more</u> $E_h EDP_{IP}$ increasing EDP_{IP} cycles
Test2	[0.05, 0.3, 0.65]%	<u>3</u>	3	AC156	0.10g	<u>less</u> $E_h EDP_{IP}$ decreasing EDP_{IP} levels
Test3	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	3	AC156	<u>0.05g</u>	<u>more</u> $E_h EDP_{OOP}$ with more PFA levels
Test4	[0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.65]%	7	3	<u>AC156 w/ half duration</u>	0.10g	<u>less</u> $E_h EDP_{OOP}$ changing frequency content of PFA input



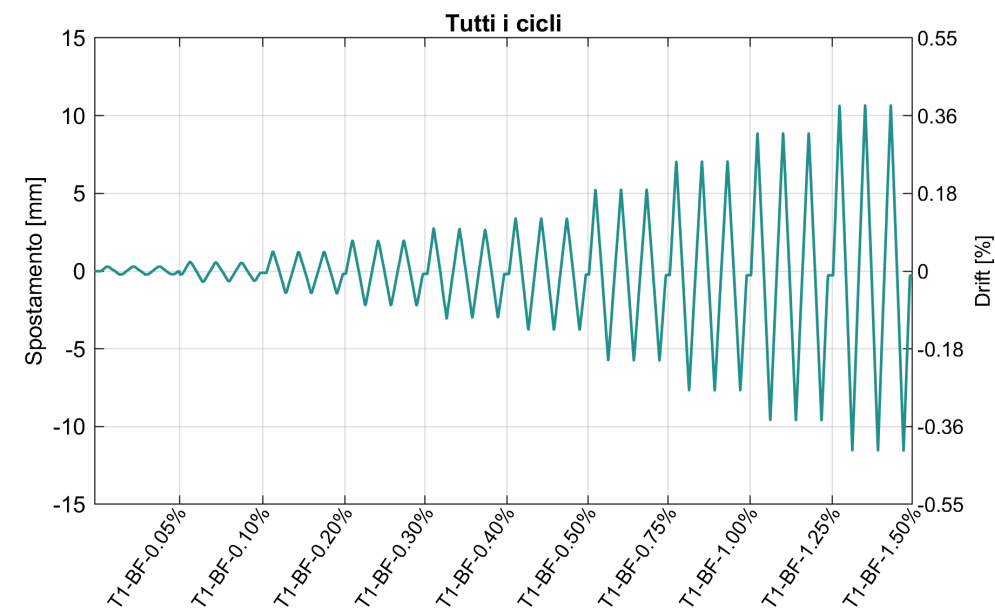


Experimental data elaboration

- Reference tests: Kurukulasuriya et al., 2022
- Specimens - infill panel surrounded by a steel frame (mimicking RC column stiffness)
- Load Protocol - IP quasi-static + OOP sequential IDA



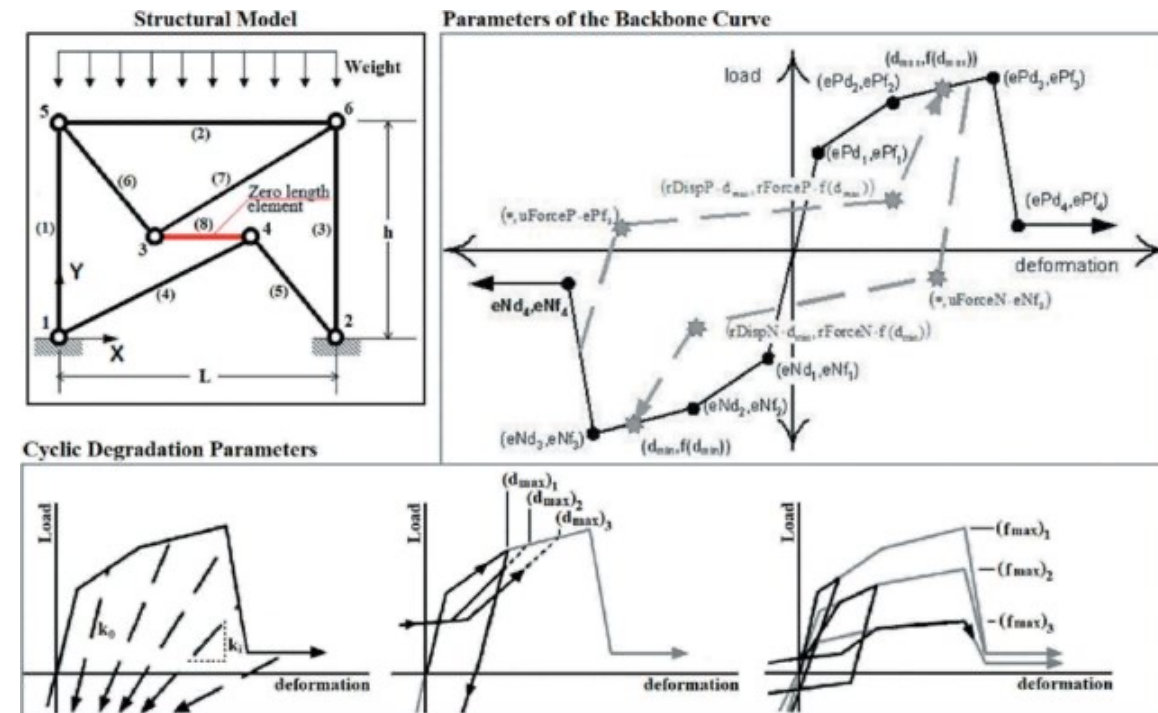
Kurukulasuriya et al., 2022





Potential impacts

- Understanding energy dissipation can be useful for:
 - Experimental test comparison
 - Numerical modelling calibration
- Tests carried out using different loading protocols can be difficult to compare
- With these insights, it can pave the way to compare two different tests via the energy dissipated in both specimens
- Utilising the experimental test data collected for nominally identical specimens, we can calibrate hysteretic parameters for numerical models
- Use OpenSeesPy Hysteretic and Pinging4 models
- Use maximum likelihood method to estimate the most representative set of hysteretic parameters based on energy dissipated during experimental testing





Conclusions

- This presentation gave an overview of the research possibilities with the ERIES research project
- It showed how frontier research is targeted through experimental testing facilities around Europe and Canada
- Case study example project ENFRAG described the investigation of the impact of energy dissipation in damage estimation
- It is envisaged that similar research projects can have a lasting impact on earthquake engineering through the problems tackled and the experimental data produced

RESEARCH GOALS

Advancing frontier knowledge on individual issues that contribute to the broader research theme of:

- Loss-driven design and mitigation approaches
- Risk quantification and prioritisation
- Green and sustainable development



RESEARCH AREAS (RA)

HAZARDS

Earthquake

Wind

Geotech/SSI



RA1: Built Environment

RA2: Critical Infrastructures

RA3: Industrial Facilities

RA4: Advanced Technologies

TA User Groups



Total Budget:
€11,616,118
Duration: 4 years
(01/06/2022 –
31/05/2026)

The objective of ERIES is to provide transnational access (TA) to research infrastructures to advance frontier knowledge related to seismic, wind and geotechnical hazards

Project Coordinator



Research Infrastructures



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ERIES: Engineering Research Infrastructures for European Synergies (2022-2026)
Funded under the Horizon Europe Framework Programme
Ref: 101058684-HORIZON-INFRA-2021-SERV-01-07

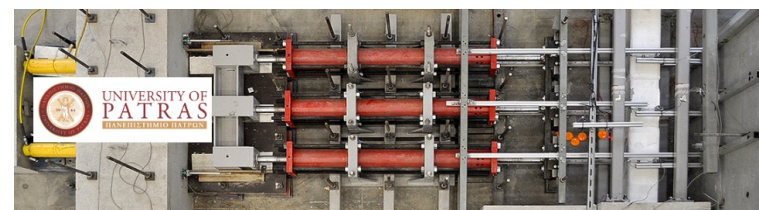
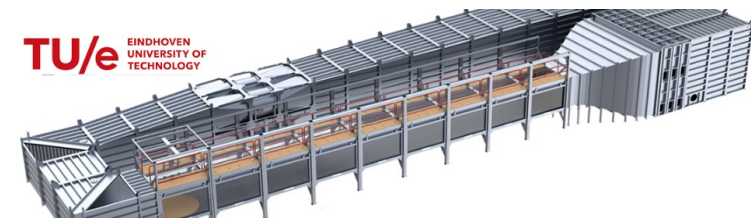
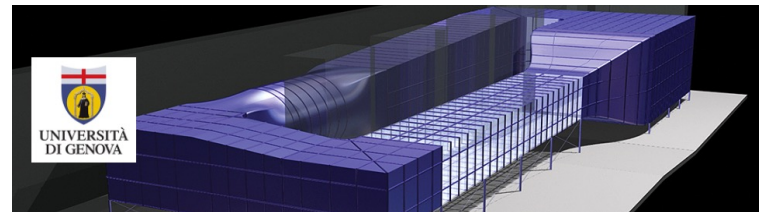
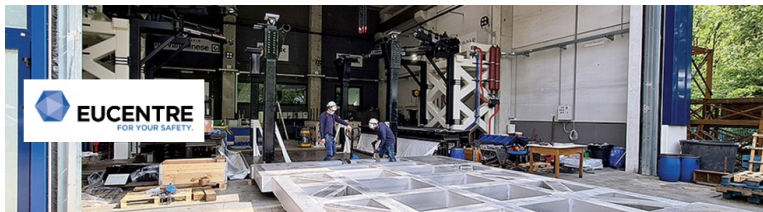
TA User Groups



World-class experimental research infrastructures include:

- Shaking Tables
- Reaction Walls
- Soil Pits
- Wind Tunnels
- Doppler Lidar Systems
- Hybrid-Simulation Capabilities (Multi-lab)

- External user groups prepare project proposals in line with the goals of ERIES
- They collaborate with ERIES research infrastructures via transnational access
- This means European* users travel to another country and use the research infrastructures made available as part of ERIES
- Cost of experimental testing in addition to travel and accommodation of user groups are covered



More information



Applications collected and evaluated at cut-off dates:

- 30th Sep 2022
- 8th Jan 2023
- 7th Jun 2023
- 3rd Nov 2023

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