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Leveraging Physics & Data for Modelling, Monitoring, and Twinning of Wind Energy Infrastructure

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Eleni Chatzi, Konstantinos Vlachas, Gregory Duthé, and Lidiya Kalathiparambil-Kennedy
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Abstract

The growing availability of high-fidelity monitoring data is transforming the way wind-energy infrastructure can be modelled, monitored, and operated. However, data-driven approaches alone often struggle to generalise beyond observed conditions and provide limited physical interpretability. This article presents a physics-enhanced machine-learning framework that combines engineering knowledge with modern learning methods to enable robust and trustworthy digital twins for wind turbines and wind farms. We first introduce adaptive hybrid digital twins that integrate reduced-order physics-based models, Bayesian inference, and utility-driven model selection to support real-time, uncertainty-aware monitoring and virtual sensing. At the wind-farm scale, graph-based surrogate models exploit the topology of wake interactions to provide fast and accurate predictions of structural loads and fatigue, while leveraging transfer learning to adapt efficiently to new sites and operating conditions. Building on these capabilities, graph-based reinforcement learning is employed to support coordinated, load-aware control and maintenance planning, embedding engineering expertise within a human-in-the-loop decision-making framework. Together, these developments illustrate how physics-informed learning can bridge the gap between high-fidelity simulation and real-world operation, paving the way toward scalable, interpretable, and computationally efficient digital twins for resilient wind-energy systems. For further details and access to the full presentation, please refer to the recorded talk here.

1. Introduction

We find ourselves today in a unique position to address complex engineering systems as cyber-physical systems, where engineering knowledge can be systematically combined with learning from data acquired under real, and often extreme, operating regimes. The increasing availability of high-fidelity monitoring data has fundamentally changed how infrastructure systems can be observed and managed. However, while data has gained remarkable potency in recent years, purely data-driven learning on its own remains insufficient. It often struggles to generalise beyond the training domain, lacks physical intuition, and offers limited interpretability: features that are critical in safety-critical engineering applications. Our approach at the Chair of Structural Mechanics & Monitoring builds on the explicit exploitation of engineering knowledge and physics-based modelling, embedding them as inductive biases within learning architectures. In the spirit of Physics-enhanced Machine Learning (PEML) (Haywood-Alexander, M. *et al.*, 2024), constraining learning with physical structure, conservation laws, and system topology, makes models more data-efficient, more robust under extrapolation, and more interpretable. This philosophy underpins recent advances in Hybrid Digital Twins (Figure 1), supporting modelling, monitoring, and decision support for infrastructure systems (Liang, H. *et al.,* 2025). The SECED seminar presented an overview of these approaches, with emphasis on applications to wind energy infrastructure.

2. Adaptive Reduced-order Modelling and Utility-driven Digital Twinning

Reduced-order models (ROMs) provide an effective means to construct parametric representations that approximate the behaviour of complex systems at a fraction of the computational cost of high-fidelity simulations. By identifying the dominant patterns or modes governing the system dynamics and projecting the problem onto a lower-dimensional space, ROMs enable fast evaluation while retaining the essential physical behaviour of the underlying system. This makes them well-suited for digital twinning and real-time applications.

In the framework overviewed by Dr Vlachas (Vlachas, K. *et al.,* 2025), local physics-based ROMs are generated and conditioned on monitored features, allowing the model representation to adapt to changing operating conditions. Learning from data complements the physics-based backbone by interpolating between model instances and capturing variability that is difficult to describe analytically. Bayesian inference enables virtual sensing and

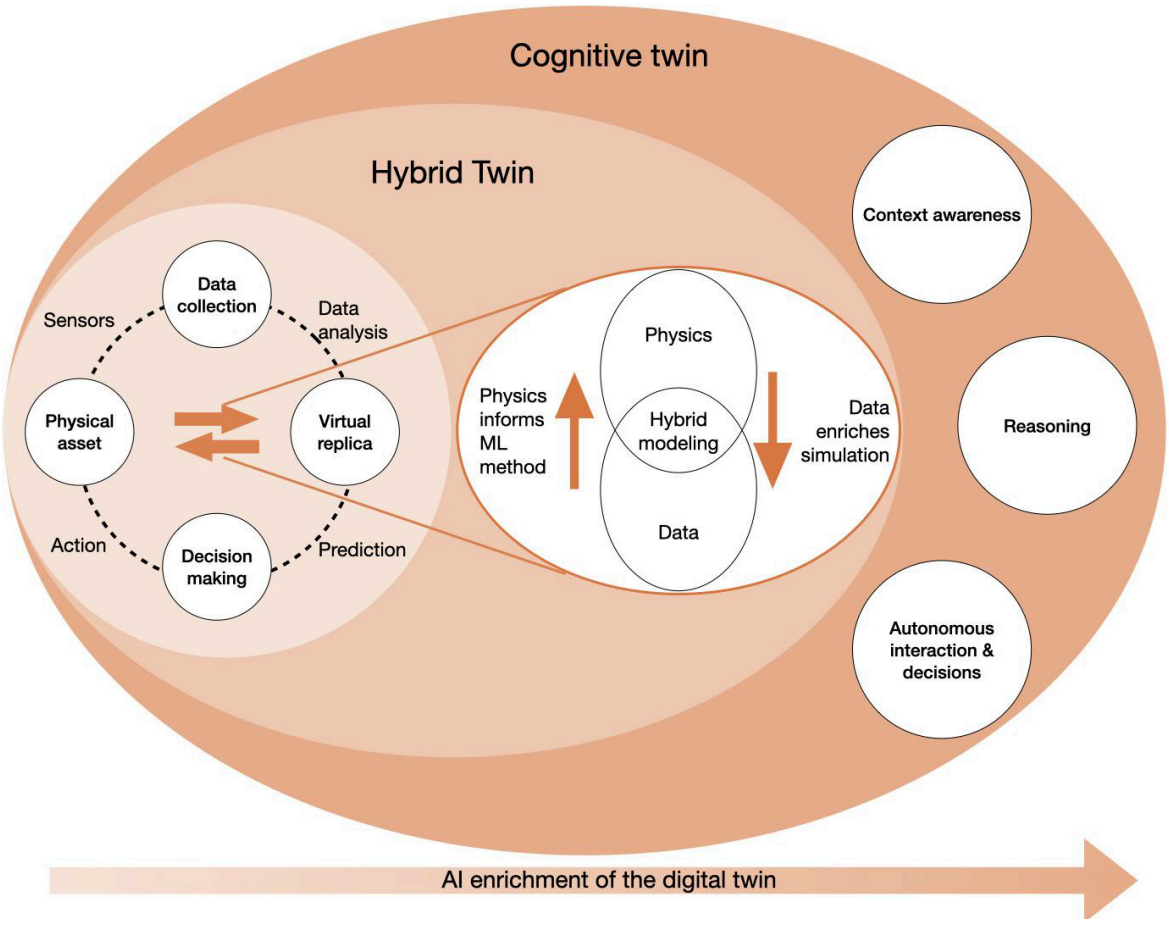


Figure 1: Hybrid digital twinning. Figure adapted from Liang, H. *et al.,* 2025.

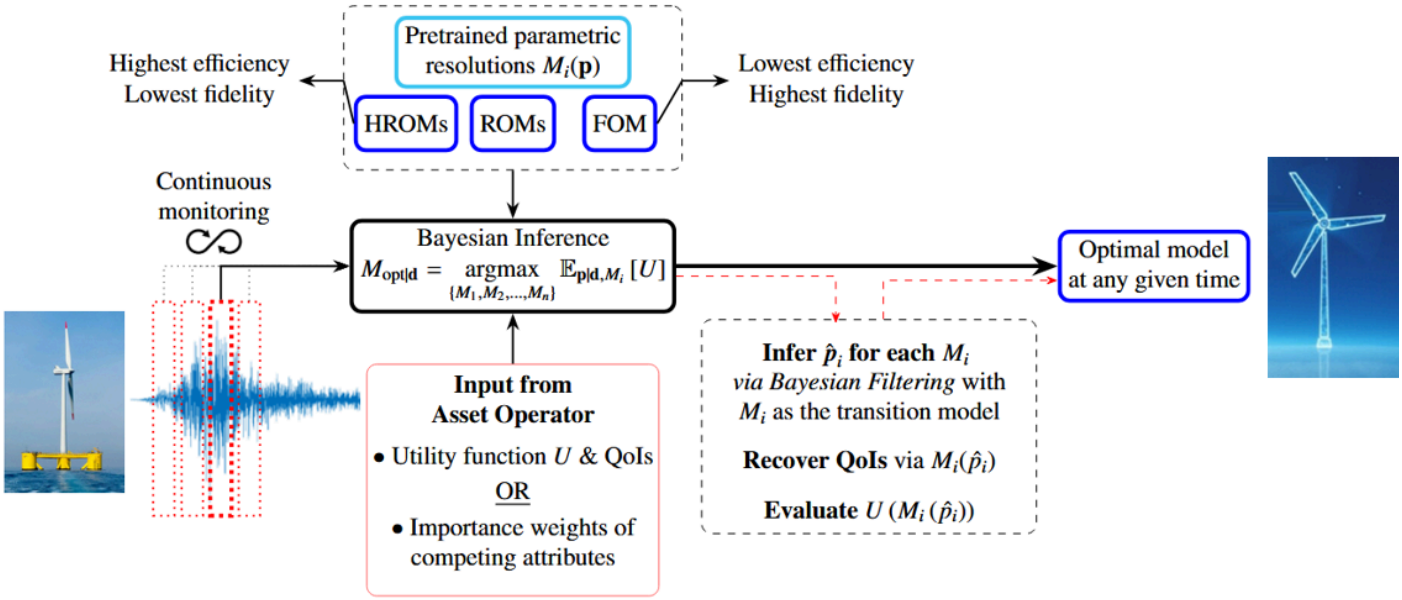


Figure 2: Adaptive hybrid digital twin architecture illustrating utility-driven model selection among candidate models M_i , ranging from high-fidelity full-order models (FOMs) to reduced-order (ROMs) and hyper-reduced-order models (HROMs). Monitoring data are assimilated through Bayesian inference to estimate model parameters P_i, while operator-defined quantities of interest (QoIs) and utility function U guide model selection. The optimal model M_{opt} is chosen by maximising an expected utility function $E_{p|d,M_i}[U]$, thereby balancing fidelity, computational cost, and uncertainty for real-time monitoring and decision support.

uncertainty-aware state estimation when measurements are sparse or noisy.

A key element of this approach is utility-driven model selection, where accuracy, computational efficiency, and uncertainty are balanced dynamically (Figure 2). Rather than relying on a single fixed model, the digital twin adaptively selects the most appropriate model at any given time, supporting real-time decision-making for operation and maintenance while maintaining quantified confidence in the predictions.

3. Graph-based Surrogate Modelling of Wake-induced Loads

As elaborated on by Dr Duthé, at the wind-farm level, wake interactions introduce strong spatial dependencies that challenge conventional modelling approaches. By representing wind farms as graphs, with turbines as nodes and wake interactions as edges, these dependencies can be encoded explicitly within the farm model structure.

Graph neural networks (GNNs), which learn directly on graph-structured data through iterative message passing between connected nodes, provide an efficient surrogate modelling framework for predicting wake-induced loads and damage-equivalent fatigue quantities across arbitrary farm layouts and inflow conditions. The graph representation itself introduces a geometric and topological inductive bias, ensuring that learning respects the physical connectivity and interaction pathways of the system. Using encode–process–decode architectures, in which turbine and flow information are first embedded into a latent representation (encode), interactions are propagated through the turbine network (process), and the quantities of interest are reconstructed (decode), these models enable fast inference with orders-of-magnitude speed-ups compared to coupled aeroelastic simulations. This makes them suitable for large-scale analysis, layout studies, and integration within higher-level optimisation and control frameworks.

4. Uncertainty-aware Prediction and Multi-fidelity Transfer

Beyond point predictions, reliable engineering decision-making requires quantified uncertainty (Vadeboncoeur, A. *et al.*, 2026). Here, uncertainty-aware learning is addressed through conformal prediction, which provides statistically valid prediction intervals without strong assumptions on model form or data distribution. This allows uncertainty bounds to be attached directly to model outputs at the turbine and farm levels (Duthé, G. *et al.*, 2024a).

Input-dependent uncertainty estimation further accounts for the fact that uncertainty is not uniform across operating regimes. Turbulent inflow conditions, wake-affected downstream turbines, and extreme operating states naturally lead to increased variability. By calibrating uncertainty with respect to such inputs, predictions remain both informative and trustworthy.

A key aspect of this work is the adoption of a pretrain-then-finetune paradigm for building generalist surrogate models (Figure 3). Rather than training task-specific

networks from scratch for each farm configuration or output quantity, a foundation GNN is first pretrained on a broad distribution of farm layouts, inflow conditions, and turbine operating states. This pretraining stage encourages the model to learn transferable representations of wake physics and inter-turbine interactions that generalise across the design space. The pretrained model can then be efficiently finetuned on smaller, targeted datasets for specific downstream tasks, such as predicting fatigue loads for a particular site or adapting to a new turbine type. This strategy significantly reduces the data and computational requirements for deploying surrogates in new settings (Duthé, G. *et al.*, 2024b).

5. Graph-based Reinforcement Learning for Farm-level Decision Support

Building on fast surrogate models and uncertainty-aware predictions, graph-based reinforcement learning (RL) enables data-informed decision support at the farm level (Arcieri, G. *et al.*, 2025). Control and maintenance actions are evaluated within an environment that embeds physics-based surrogates, fatigue accumulation models, and stochastic inflow representations.

The graph structure ensures that control policies are topology-aware, allowing coordinated actions across turbines rather than isolated local decisions. Human-in-the-loop and hierarchical reinforcement learning strategies enable the integration of expert knowledge through constraints, reward shaping, and feedback mechanisms. This supports scalable learning while maintaining engineering realism and operational feasibility.

The resulting framework enables adaptive strategies that balance power production, structural loading, and long-term asset health, paving the way for resilient and economically efficient wind-farm operation (Figure 4).

The frameworks put forth illustrate a pathway toward next-generation digital twins for wind energy infrastructure. By combining tools rooted in physics-based modelling with data-driven learning, it becomes possible to bridge the gap between high-fidelity simulation and real-world operation.

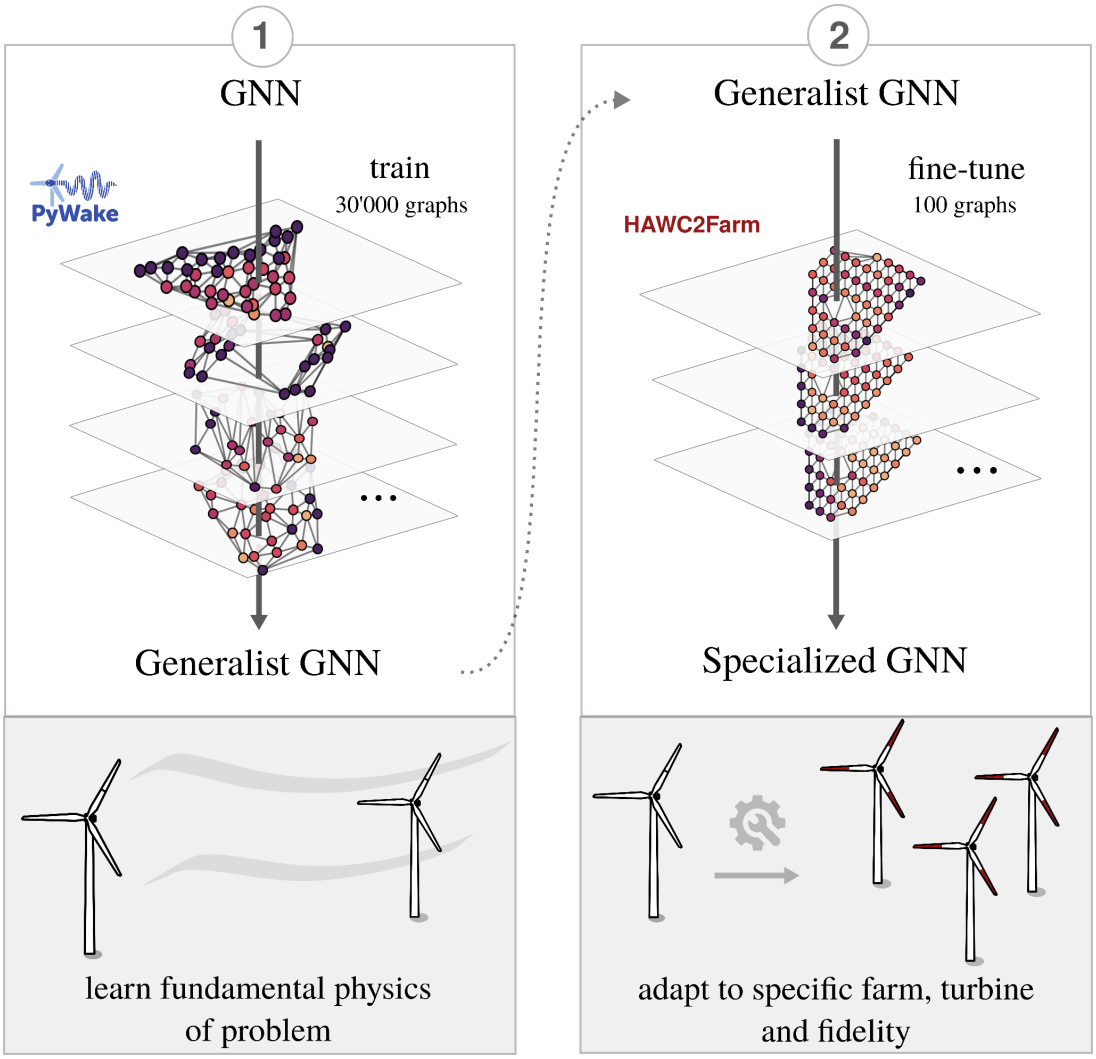


Figure 3: Overview of the pretrain-then-finetune framework: a generalist GNN is first trained on a large corpus of low-fidelity simulation data (PyWake) to learn transferable representations of wake physics, then efficiently adapted to higher-fidelity conditions (HAWC2Farm) using limited additional data. Figure reused from Duthé, G. *et al.*, 2024b.

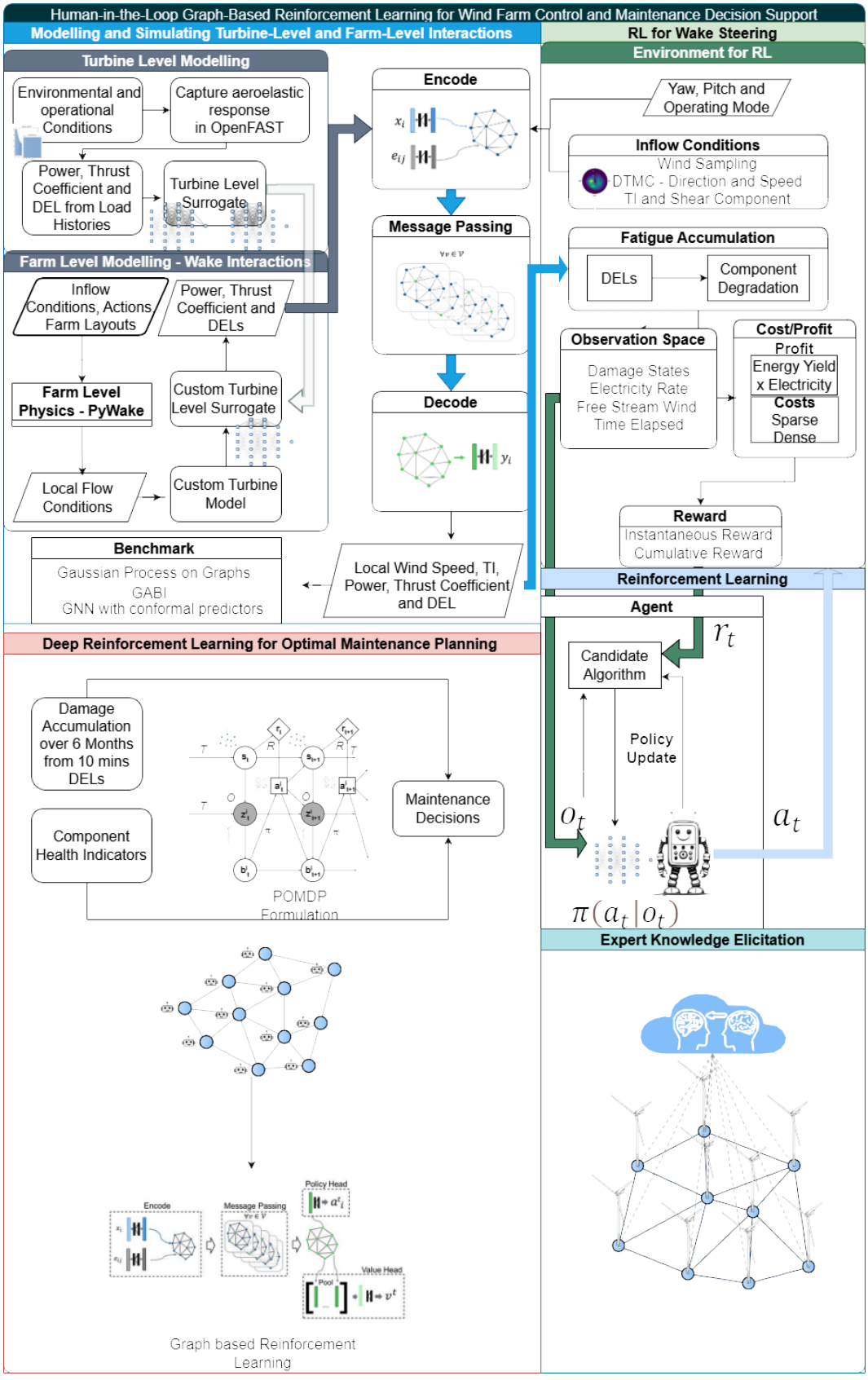


Figure 4: Overview of the proposed human-in-the-loop, graph-based reinforcement learning framework for integrated wind farm control and maintenance. Turbine- and farm-level surrogate models (left) feed a graph neural network that encodes wake interactions and decodes per-turbine power, local flow and load metrics of interest (centre). These inform two coupled RL formulations: wake steering control, where the agent optimises for maintenance-conditioned control actions under an energy-versus-cost reward (top-right), and long-horizon maintenance planning driven by damage accumulation and component health (bottom-left). Domain expert knowledge is elicited and embedded into the reward shaping and policy constraints (bottom-right), closing the loop between data-driven optimisation and engineering judgment.

6. Conclusions

The integration of physics-based modelling, monitoring data, and machine learning is opening new opportunities for the management of wind-energy infrastructure. By combining adaptive digital twins, graph-based surrogate models, and reinforcement learning, it becomes possible to support monitoring, prediction, and decision-making within a unified framework. These developments illustrate a pathway toward scalable, interpretable, and uncertainty-aware digital twins capable of enhancing the reliability, resilience, and efficiency of future wind-energy systems.

7. About the Speakers

Eleni Chatzi is Chair of Structural Mechanics and Monitoring at ETH Zürich and former President of the European Academy of Wind Energy. Her research focuses on digital twins, structural dynamics, and physics-enhanced machine learning for infrastructure systems.

Konstantinos Vlachas is a senior researcher at the SMM Chair, specialising in adaptive reduced-order modelling, uncertainty-aware digital twinning, and utility-driven decision support for complex dynamical systems (project TURING).

Gregory Duthé is a postdoctoral researcher at the SMM Chair working on graph-based surrogate modelling, uncertainty quantification, and multi-fidelity learning for wind-farm load estimation (project MISTERY).

Lidiya Kalathiparambil-Kennedy is a doctoral researcher at the SMM Chair, developing graph-based reinforcement learning frameworks for load-aware control and decision support of wind farms (project INTELLIWIND).

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SECED

SECED, The Society for Earthquake and Civil Engineering Dynamics, is the UK national section of the International and European Associations for Earthquake Engineering and is an Associated Society of the Institution of Civil Engineers. It is also sponsored by the Institution of Mechanical Engineers, the Institution of Structural Engineers, and the Geological Society. The Society is also closely associated with the UK Earthquake Engineering Field Investigation Team. The objective of the Society is to promote co-operation in the advancement of knowledge in the fields of earthquake engineering and civil engineering dynamics including blast, impact and other vibration problems.

For further information please contact the SECED Secretary at the Institution of Civil Engineers and visit SECED Website.

SECED Newsletter

The SECED Newsletter is published quarterly. All contributions of relevance to the members of the Society are welcome. Manuscripts should be sent by email. Diagrams, pictures and text should be attached in separate electronic files. Hand-drawn diagrams should be scanned in high resolution so as to be suitable for digital reproduction. Photographs should likewise be submitted in high resolution. Colour images are welcome. Previous issues of the SECED Newsletter are available online.

Please contact the Editor of the Newsletter, Fabio Freddi, for further details. This edition of the Newsletter was co-edited by Milindu Jayasekara, Ashraf Nayel, and Atif Rasheed.

Recent Advances in EERI's Learning from Earthquakes Programme

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Abstract

The Earthquake Engineering Research Institute (EERI) Learning from Earthquakes (LFE) programme has, for over five decades, played a central role in advancing global understanding of earthquake impacts through coordinated reconnaissance efforts. This article summarises recent developments in the programme, including organisational changes, evolving reconnaissance methodologies, and lessons learned from the response to the 2023 Kahramanmaraş earthquake sequence in Türkiye. Particular emphasis is placed on multidisciplinary coordination, rapid data dissemination, and the integration of reconnaissance findings into engineering practice, including the validation of fragility relationships and damage-to-intensity observations. The work highlights the continued evolution of earthquake reconnaissance towards more inclusive, data-driven, and policy-relevant outcomes. For further details and access to the full presentation, please refer to the recorded talk here.

1. Introduction

The Earthquake Engineering Research Institute (EERI) is a leading non-profit organisation dedicated to understanding earthquake risk and improving resilience in communities worldwide. Central to its work is the Learning from Earthquakes (LFE) programme, which coordinates post-earthquake reconnaissance and disseminates technical findings. Over more than 50 years, the programme has supported multidisciplinary investigations of hundreds of earthquake events globally, contributing significantly to advances in earthquake engineering practice.

The primary objective of LFE is to accelerate learning from earthquake disasters by integrating observations across the natural, built, social, and political environments. This is achieved through the coordination of academics, practitioners, and subject matter experts, enabling rapid collection, synthesis, and dissemination of data following major events. In recent years, the programme has evolved to improve coordination, inclusivity, and long-term impact, reflecting the complexity of modern earthquake response and recovery.

2. Evolution of the LFE Programme

Recent efforts within EERI have focused on strengthening the structure and governance of LFE to better support its role as a flagship reconnaissance programme. A key aspect has been increasing participation and improved coordination across the earthquake reconnaissance community.

Historically, reconnaissance opportunities were limited to experienced researchers. However, increasing demand from early-career professionals and practitioners has driven efforts to broaden involvement. New mechanisms, such as LFE advisory committees, provide additional entry points for participation and allow expertise to be mobilised more effectively during response activities.

In parallel, there has been a strategic shift towards maintaining engagement beyond the immediate aftermath of an earthquake. LFE is increasingly supporting longer-term studies examining recovery, reconstruction, and resilience, providing a more comprehensive understanding of earthquake impacts.

3. Reconnaissance Methodology and Coordination

The LFE programme adopts a structured approach to reconnaissance, beginning in the hours following an earthquake event. Initial activities typically include coordination calls and the establishment of information-sharing platforms to support communication among researchers and stakeholders. Depending on the scale and location of the event, these may take the form of physical or virtual clearinghouses where field observations, photographs, and preliminary analyses can be shared and reviewed.

One of the key developments in recent years has been the increasing use of virtual reconnaissance teams. These teams synthesise publicly available information, including media reports, satellite imagery, and preliminary engineering data, to produce rapid initial assessments. These outputs, often prepared within 48 hours of an event, provide an early overview of impacts and help guide decisions regarding field deployments.

Where appropriate, LFE coordinates the mobilisation of field teams, including both immediate reconnaissance missions and subsequent follow-up visits. These deployments are typically conducted in collaboration with specialist groups such as GEER (Geotechnical Extreme Events Reconnaissance), StEER (Structural Extreme

Events Reconnaissance), SSEER (Social Science Extreme Events Research), and other discipline-specific teams. This multidisciplinary approach enables a more holistic understanding of earthquake impacts, encompassing structural damage, geotechnical failures, social consequences, and community resilience.

An important aspect of the programme is its emphasis on data sharing and dissemination. Findings are communicated through a range of outputs, including technical briefings, webinars, reports, and journal publications. Increasingly, there is also a focus on ensuring that information is accessible to affected communities and decision-makers, rather than solely to the technical community.

4. Response to the 2023 Kahramanmaraş Earthquake Sequence

The 2023 Kahramanmaraş earthquake sequence in Türkiye represents one of the most significant recent deployments for the LFE programme. The event consisted of two large earthquakes (moment magnitudes 7.8 and 7.7) affecting 13 provinces and over 15 million people. The scale of damage and the complexity of the response presented a major challenge for coordinated reconnaissance.

LFE's response began immediately following the earthquakes, with the rapid establishment of coordination mechanisms and information-sharing platforms. Virtual reconnaissance teams were convened to compile and synthesise initial data, while collaboration with international partners enabled the mobilisation of multidisciplinary field teams.

A key feature of the response was the integration of multiple reconnaissance groups, including GEER, StEER, and SSEER, allowing for simultaneous investigation of geotechnical, structural, and social impacts. Field deployments undertaken by the EERI Buildings Reconnaissance Team focused on documenting the performance of reinforced concrete buildings across the most severely affected regions. Observations from over 160 buildings at more than 120 sites were compiled, with particular emphasis placed on correlating damage to recorded ground motion parameters such as peak ground acceleration and peak ground velocity.

The Türkiye deployments also highlighted the value of combining immediate reconnaissance with longer-term analytical work. The development of post-event datasets enabled more detailed assessment of building performance and vulnerability, supporting both immediate learning and subsequent technical analysis of structural response and damage patterns.

5. Technical Observations and Emerging Themes

A number of important technical themes have emerged from recent LFE activities, including the response to the 2023 Türkiye earthquakes.

One area of focus has been the relationship between observed damage and shaking intensity. In the Türkiye reconnaissance, shaking intensity was characterised using a combination of peak ground acceleration or spectral acceleration (selected based on building height) together with peak ground velocity. Field observations (Figure 1) showed that for moderate levels of shaking, there was no clear relationship between damage level and intensity, with buildings exhibiting a wide range of performance from slight to complete damage at similar shaking levels. At higher intensities, however, a clearer trend emerged, with all buildings subjected to more extreme shaking being classified as extensive damage or worse. This variability at lower intensities highlights the influence of design, construction quality, and building characteristics on seismic performance.

Another key topic is the validation of fragility relationships used in performance-based earthquake engineering. In the Türkiye study, empirical cumulative distribution functions derived from observed building damage were compared with established fragility curves developed by the Global Earthquake Model for reinforced concrete buildings. The comparison showed generally good agreement for the "Extensive" damage state (Figure 2), indicating that existing models can reasonably capture this level of damage. However, for the "Complete" damage state (Figure 3), the fragility curves tended to underpredict the probability of severe damage or collapse at lower levels of spectral acceleration.

The multidisciplinary nature of recent reconnaissance efforts has also emphasised the importance of considering non-technical factors, including social vulnerability, governance, and community response. Integrating these aspects with traditional engineering analyses provides a more comprehensive understanding of earthquake impacts and supports the development of more effective mitigation strategies.

6. Lessons Learned and Future Developments

The continued evolution of the LFE programme reflects broader shifts in earthquake engineering towards more integrated, data-driven, and application-focused approaches to risk reduction.

A key lesson is the importance of multidisciplinary collaboration. Effective reconnaissance increasingly relies on the coordinated integration of engineering, geoscience, and social science expertise, enabling a more complete understanding of both structural performance and wider societal impacts.

Equally important is the rapid and targeted dissemination of findings. The ability to produce timely outputs that can inform both technical communities and decision-makers is critical, particularly where post-event

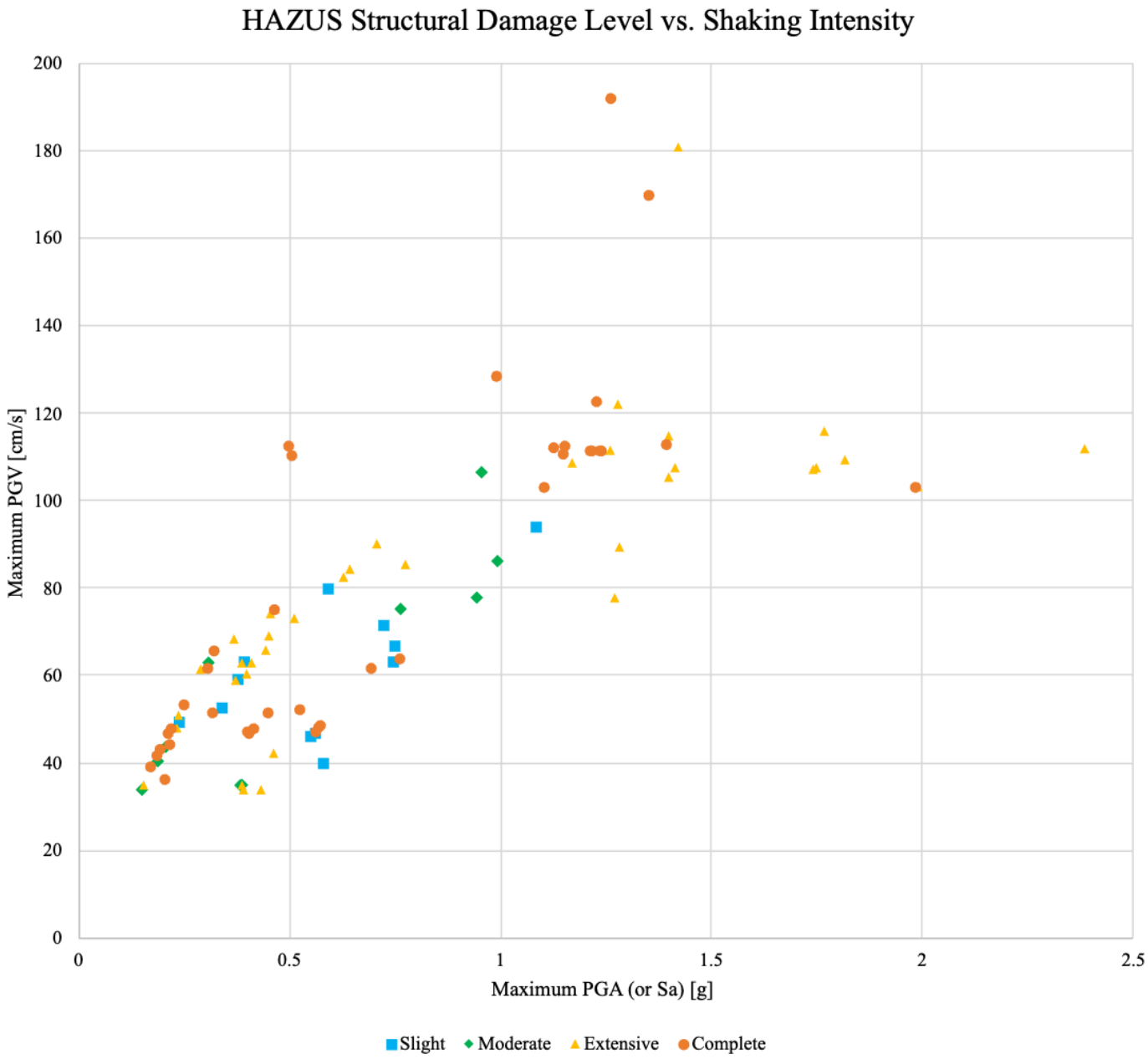


Figure 1: Distribution of damage level as a function of estimated maximum shaking intensity for RC buildings visited by the EERI Team using HAZUS definitions (Gencturk, B. *et al.*, 2025).

data—such as observed damage and empirically derived performance relationships—can be used to validate and refine analytical models.

There is also a growing emphasis on translating reconnaissance observations into practice. Linking field evidence to improvements in design standards, construction quality, and regulatory frameworks remains a central challenge, particularly in light of observed discrepancies between predicted and actual building performance.

Finally, recent experience highlights the importance of sustained engagement beyond the immediate response phase. Longer-term studies of recovery, reconstruction, and resilience provide essential context for interpreting initial damage observations and understanding how systems perform under repeated or cumulative loading.

Looking ahead, further development of the LFE programme is likely to focus on strengthening coordination across organisations, improving the quality and accessibility of post-earthquake datasets, and expanding opportunities for participation. In doing so, the programme will continue to play a key role in advancing earthquake engineering knowledge and supporting more reliable assessments of seismic risk.

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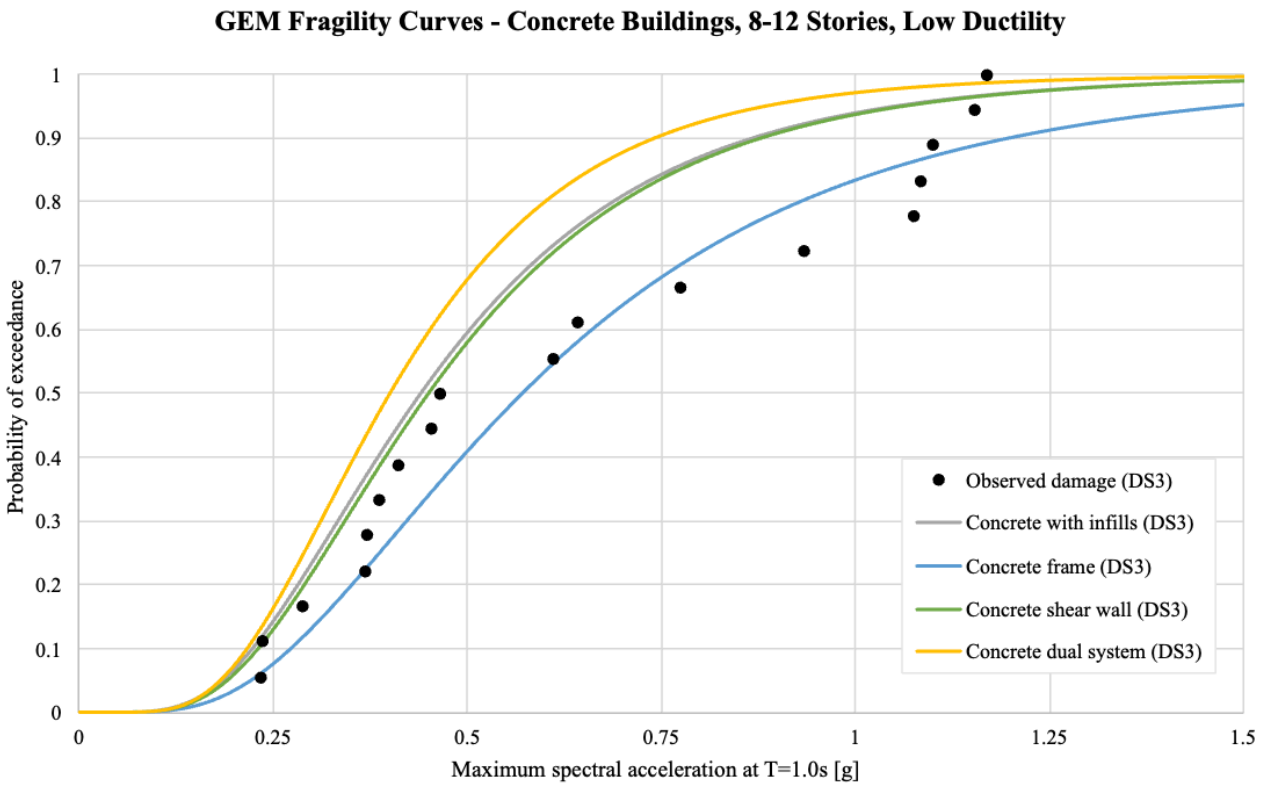


Figure 2: Empirical cumulative distribution function (ECDF) of 8- to 12-storey concrete buildings classified as "Extensive" damage per the HAZUS damage classification system, compared to GEM fragility curves for low-ductility, 10-storey RC buildings with various structural systems with "Extensive" damage (DS3) (Gencturk, B. *et al.*, 2025).

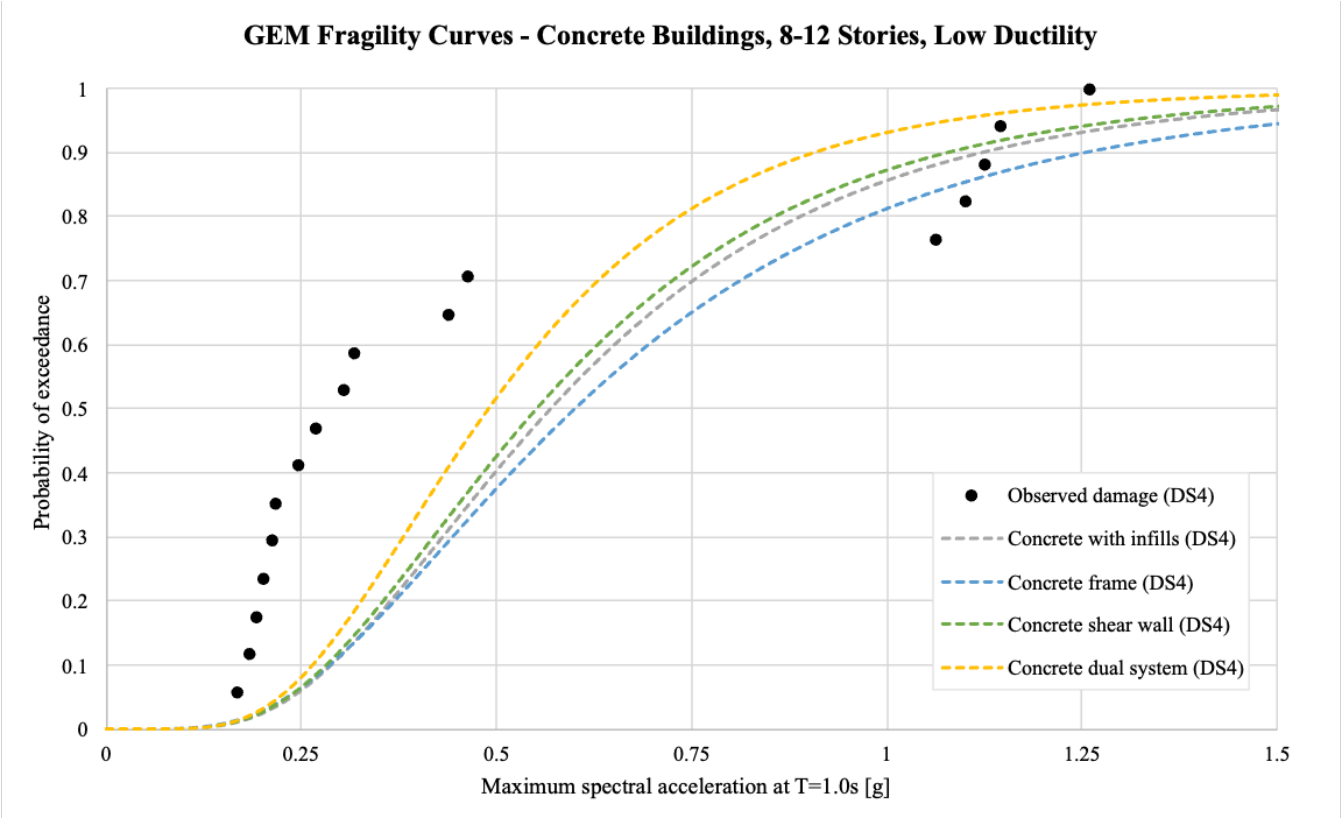


Figure 3: Empirical cumulative distribution function (ECDF) of 8- to 12-storey concrete buildings classified as "Complete" damage per the HAZUS damage classification system, compared to GEM fragility curves for low-ductility, 10-storey RC buildings with various structural systems with "Complete" damage (DS4) (Gencturk, B. *et al.*, 2025).

Using Earthquake Depths to Understand Isolated Intraplate Earthquakes in India

Alice Turner
University of Cambridge

Abstract

Earthquakes usually happen where they have happened before — on fault lines. But what happens when they don't? And what can seismologists do to help understand earthquake size far from fault zones? For further details and access to the full presentation, please refer to the recorded talk here.

1. Plate Boundary Earthquakes

Most earthquakes globally happen along plate boundaries, where the rigid plates that make up the Earth's surface meet and interact. Mapping earthquake locations was one of the key pieces of information supporting plate tectonics (McKenzie, D. P. *et al.*, 1967), the theory that describes the motion of the plates. In India, where my postdoctoral work focuses, most earthquakes occur along the plate boundary between the Indian and Eurasian plates, as shown in Figure 1, which shows the locations of all earthquakes in the International Seismological Centre (ISC) earthquake catalogue since 1964.

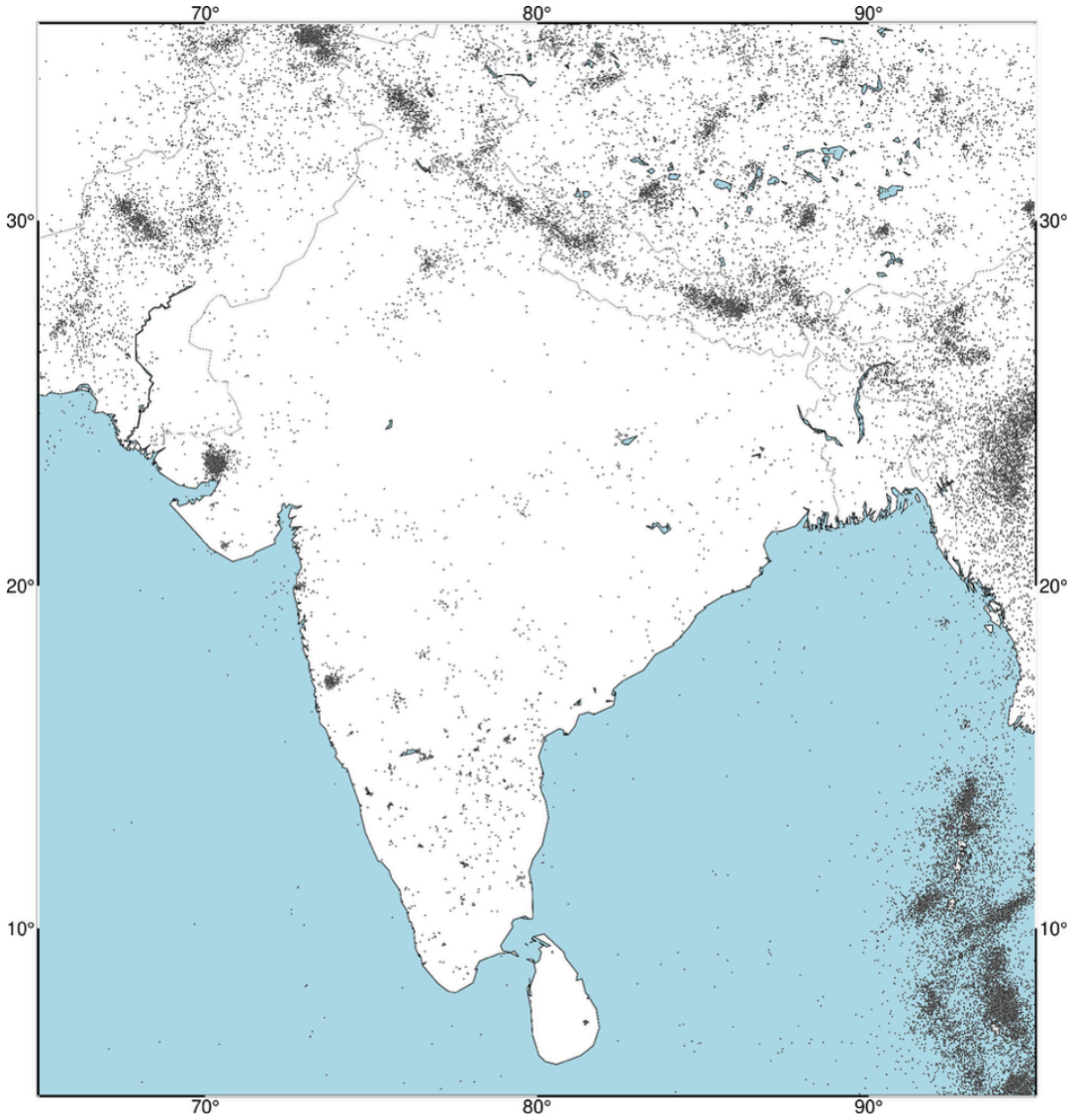


Figure 1: Map of India showing the distribution of earthquakes recorded since 1964 from the International Seismological Centre catalogue. Note the high density of earthquakes in the North, which is along the Himalayan mountain range, and the sparse seismicity in central and southern India.

You've probably heard of the plate boundary in India where these earthquakes cluster: the Himalayan mountains, which stretch 2,900 km along the border between India and Tibet and are the highest mountain chain in the world. But 200 million years ago, this location would have been on the coast – an ocean lay between India and Eurasia. Over the intervening time, India has moved slowly northwards, until the two plates collided, as shown in Figure 2. The Himalayan mountains are the crumple zone resulting from this continental scale collision.

The same motions between India and Eurasia are also accommodated through sudden fault motion in earthquakes. The compressional forces of the tectonic plates colliding cause stress build up, until the rocks can no longer sustain it. The rock then fails, and the stress is released in an earthquake which produces the seismic waves and ground shaking. As the plates are continually moving, this cycle of accumulating and releasing stress repeatedly happens in the "earthquake cycle". This is the interesting thing about geology: we are working with two very different timescales – the timescale of plate motion, where plates move at cm per year (about the rate that your fingernails grow!), and the short timescale of seconds for earthquakes.

This earthquake cycle operates along the Himalayan mountain range – earthquakes with magnitude greater than 8 on the moment magnitude scale happen along the mountain range every 200–500 years, with the most recent having occurred in 1950 (Molnar, P. *et al.*, 1989). In highly active plate boundary regions, seismic hazard estimates rely on the distribution of locations and magnitudes of historic earthquakes: earthquakes will happen where they have happened before, at magnitudes they have occurred previously.

2. Intra-plate Earthquakes

But what about the flipside? In Figure 1, there are very few earthquakes in the interior of the Indian plate, far away from the plate boundary.

On 26 January 2001, a magnitude 7.6 earthquake struck near the town of Bhuj in the state of Gujarat, India. The intense shaking was felt throughout much of Northwest India and Pakistan, leaving hundreds of thousands homeless and destroying or damaging more than a million buildings. The death toll exceeded 20,000, making it one of the most devastating intraplate earthquakes in recent history (Narayan, J. P. *et al.*, 2002). This earthquake occurred nearly 1000 km from the Himalayan margin and 500 km from the next-closest plate boundary.

Earthquakes that occur far away from plate boundaries –so-called intraplate earthquakes – are rare, estimated to make up only a few percent of the global seismic catalogue (Sykes, L. R. 1978), and happen infrequently. The same earthquake cycle framework that was used to explain plate boundary earthquakes above applies here – the only difference is that the stress build up is much slower, so the time it takes to build up and be released in an earthquake is much longer. And they can cause big problems for

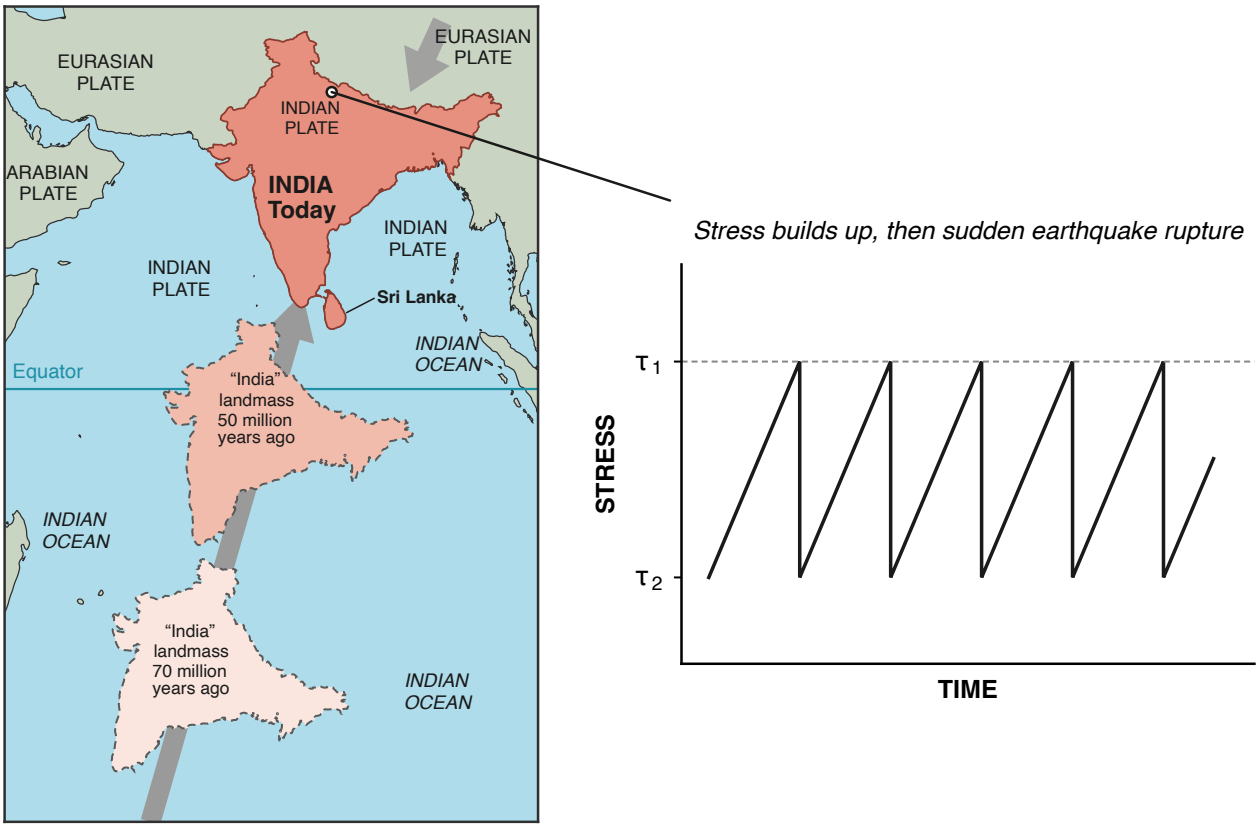


Figure 2: Illustration of the motion of India into Eurasia. The inset shows the seismic cycle – stress related to the collision of India with Eurasia builds up and then is released in an earthquake. Figure modified from USGS.

probabilistic seismic hazard assessment – if you don't have any historic earthquakes to go on, how can we tell how large an earthquake could be?

3. Back to Basics

To answer this question, first let's think about what controls the magnitude of an earthquake. It's actually pretty simple: the magnitude of the earthquake is controlled by 1) the shear strength of the rock (μ), 2) how big the fault is, and 3) how far that fault slips (Aki, K. *et al.*, 2002). It turns out that the shear strength of the rock and the average amount of slip don't vary all that much, so in simple terms, the magnitude of the earthquake is proportional to the size of the fault. So we can determine the maximum possible earthquake by mapping out the possible fault zones. And to make things even simpler, most earthquake faults tend to have a square aspect ratio – e.g., they are about the same distance along the surface as they are deep. So, using this logic, if we know how big a possible fault zone is, we can tell, anywhere, even when there haven't been many earthquakes before, the maximum size of an earthquake.

4. Seismogenic Thickness

At shallow depths, rocks are cold, brittle, and strong enough to break in earthquakes, but as you get deeper, things get hotter, and earthquakes stop (Sibson, R. H. 1982). The depth of this colder, stronger region that can host earthquakes is the so-called "seismogenic thickness". The bottom of this region represents the depth that can no longer host earthquakes. Therefore, the maximum size of a fault that can host an earthquake is limited by the depth at which the material becomes unable to host brittle failure. In other words, the maximum earthquake magnitude in a region is proportional to the thickness of the seismogenic layer (e.g., Jackson, J. A. 2002a).

In the tectonics group at the University of Cambridge, we aim to better map changes in seismogenic thickness. To do this, we can use the depths of smaller magnitude earthquakes – they cluster within the seismogenic layer, and their deepest occurrences define its lower boundary. By cataloguing where these smaller earthquakes stop occurring, we can map how the thickness of this brittle layer changes across a region, even where larger earthquakes are rare, as illustrated in Figure 3.

5. Back to the Bhuj Earthquake

We can demonstrate this in the location of the Bhuj earthquake. In the region surrounding the 2001 Mw 7.6 event, small earthquakes happen throughout the crust (the very outer layer of our Earth), down to 44 km. The fault plane of the earthquake itself extended down 25–30 km (Copley, A. *et al.*, 2011), contained within the seismogenic thickness defined by small magnitude earthquakes. In the case of rare intraplate earthquakes, we cannot look back into the historical record. Instead, we must look downward–through understanding the crustal properties, such as temperature or rock type that control seismogenic thickness, we can estimate the maximum size of faults that could rupture and, therefore, the maximum earthquake magnitude the region could experience.

If you want to read more about tectonics and earthquakes, I would recommend James Jackson's article: Jackson, J. A. (2002b). "Using earthquakes for continental tectonic geology." *In International Handbook of Earthquake & Engineering Seismology.*

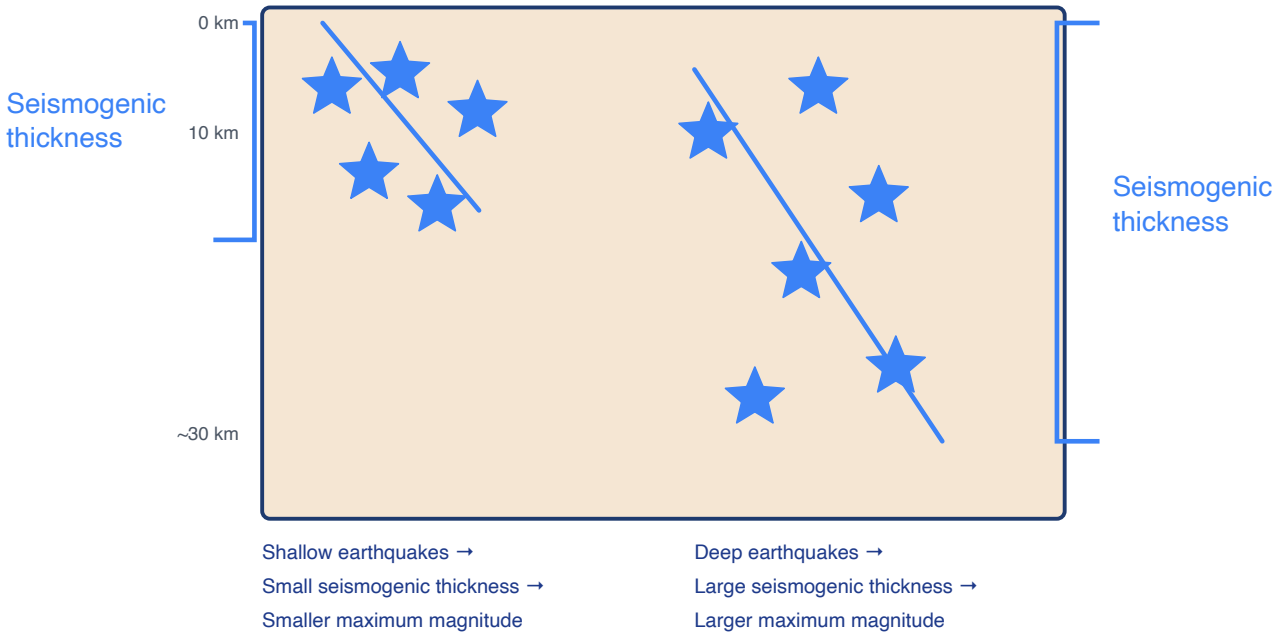


Figure 3: Illustration of the relationship between small earthquakes and the seismogenic thickness – the region where the rock is cold and brittle enough to break in earthquakes. When the earthquakes are shallow, the seismogenic thickness is small, and the maximum possible magnitude is small. When the earthquakes are deep, the seismogenic thickness is large and the maximum possible earthquake magnitude is larger.

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Annual General Meeting of the SECED Young Members' Sub-Committee

Mohamed Elzeadani

SECED YMSC Outgoing Chair

On the evening of 28 October 2026, we gathered at the Institution of Civil Engineers in London for the Annual General Meeting of the SECED Young Members' Sub-Committee (YMSC). As the outgoing Chair, it was a pleasure to deliver my annual report, acknowledging the members who served on the committee and summarising the work undertaken by the YMSC between November 2025 and October 2026.

Three members were elected to the YMSC for the 2025–2026 term: Atif Rasheed from Imperial College London, Maria Maglio from the University of Salerno, and James Douglas from AtkinsRéalis. The YMSC also welcomed four co-opted members, namely Milindu Jayasekara from the University of Cambridge, Chunrong Lu from Imperial College London, Imad El Khouri from AtkinsRéalis, and Ludovica Pieroni from University College London.

In addition to the new members, the YMSC benefited from the continued contributions of Jessica Christie from AtkinsRéalis, Ashraf Nayel from Imperial College London, and Zeyad Khalil from Imperial College London. Maria Liapopoulou from the University of Cambridge also served on the YMSC as an ex-officio member in her capacity as Immediate Past Chair, while Jessica Christie served as Vice-Chair during the 2025–2026 term.

The YMSC was organised into three teams, with Jessica Christie, Maria Maglio, and Chunrong Lu serving on the Website Team; Ashraf Nayel, Atif Rasheed, and Milindu Jayasekara serving on the Newsletter Team; and Zeyad Khalil, James Douglas, Imad El Khouri, and Ludovica Pieroni serving on the Podcast Team.

It was a busy and productive year for the YMSC, building on the work of previous committees while introducing new outreach activities aimed at raising awareness of SECED among engineering students and early-career engineers.

The Newsletter Team produced four issues (including this one), covering a wide range of technical contributions and relevant announcements. The Podcast Team released Episode 6 of SECED Talks in March 2026, featuring Sebastian Kaminski from Arup in conversation with host Rafik Nizarali, also from Arup. Episode 7, featuring Allin Azarbakht from AtkinsRéalis and hosted by James Douglas, is currently being finalised.

The YMSC also administered the fifth edition of the SECED Fund. Eleven eligible applications were received, of which six were from outside the UK. The applicants comprised three master's students, seven PhD students and one postdoctoral researcher. The 2026 SECED Fund recipient, announced at the AGM, was Ali Roumieh from University College London, who received £1,500 to support his project, "Free from Damage Self-Centring Beam-to-Column Connections".

A total of eight lunchtime webinars were organised by the YMSC during the year, covering a wide range of topics related to earthquake engineering and civil engineering dynamics, featuring speakers from academia and industry, both within the UK and internationally. The eight webinars collectively attracted 260 live attendances and more than 1,230 YouTube views.

A site visit to Servotest Testing Systems Ltd in Egham was also organised by the YMSC on 11 June 2026. A total of 14 SECED members attended the visit, which included a technical presentation by Darren Burke of Servotest, followed by a tour of the company's facilities. The site visit concluded with an informal networking session, providing attendees with an opportunity to exchange ideas and strengthen professional connections.

A notable new initiative this year was the YMSC's participation in outreach activities in Bristol. SECED was invited alongside other professional engineering societies, including the Institution of Power Engineers, the Institution of Mechanical Engineers and the Institution of Engineering and Technology, to participate in CHAIN: Bristol 2026 on 11 February, where we introduced SECED and its activities to engineering students and early-career professionals. The following day, YMSC members visited the University of Bristol to engage with engineering students and raise awareness of SECED and the opportunities it offers.

The three newly appointed YMSC members for the November 2026–October 2028 term were also announced at the AGM: Milindu Jayasekara, now with WSP, Chunrong Lu from Imperial College London, and Harshit Agrawal from AtkinsRéalis.

The YMSC will now be chaired by Jessica Christie, who has been an active member of the committee for the past two years, and I am confident that she will build on the committee's achievements and lead it successfully into its next chapter.

The date for the next AGM was also announced as 27 October 2027, with the venue to be confirmed in due course.

Beyond the committee itself, the YMSC benefited from the support of numerous individuals, whom we acknowledged at the AGM. These included Katherine Coldwell for her administrative support; Valentina Putrino for social media support; Fabio Freddi for coordinating and reviewing the SECED Newsletter; Manuela Davì for supporting the Website Team; Damian Grant and Barnali Ghosh for reviewing and approving YMSC events; Fabio Freddi, Barnali Ghosh and Guillermo Aldama-Bustos for reviewing applications to the SECED Fund; Brian Young and Way Way Sim for processing YMSC claims; and David Galloway for his support with earthquake records.

Lastly, it has been a genuine pleasure to lead the YMSC over the past year. I am grateful to all committee members for their time, enthusiasm and commitment, and to the wider SECED community for its continued support. I wish Jessica and the incoming committee every success and look forward to seeing the YMSC continue to grow and thrive in the years ahead.



Young Members' Sub-Committee members after the Annual General Meeting

SECED 2027 Conference Updates

8–9 July 2027
University of Bristol, Temple Quarter Campus
Bristol, UK

Chairs:
Flavia De Luca
Christian Málaga-Chuquitaype
Fabio Freddi

The SECED 2027 Conference, Engineering for a Dynamic Future, will take place on 8–9 July 2027 at the new Temple Quarter campus of the University of Bristol. The conference will bring together researchers, engineers and practitioners from across academia and industry to exchange knowledge and discuss recent developments in earthquake engineering and civil engineering dynamics.

Since the initial announcement, the conference programme has been further developed, with individual sessions now defined across a broad range of topics. These sessions are grouped around the following themes and theme leads.

Seismic Hazard, Geotechnical Engineering and Experimental Methods

- *Seismic Hazard and Engineering Seismology* — M. Davì, M. Villani and I. Mosca.
- *Geotechnical Earthquake Engineering and Soil–Structure Interaction* — B. Ghosh, O. Adamidis and A. Thomson.
- *Experimental Methods* — G. O'Reilly, S. Bousias and A. Sextos.

Catastrophe Risk, Resilience and Sustainability

- *Catastrophe Risk Modelling and Multi-Hazard Risk Assessment* — C. Galasso and V. Putrino.
- *Risk, Reliability and Resilience* — F. Jalayer and V. Silva.
- *Sustainability, Net-Zero and Low-Carbon* — S. Bianchi, M. Caruso and S. Mitoulis.

Earthquake Impacts, Assessment and Structural Design

- *Lessons Learned from Earthquakes, Recovery Paths and Public Policy* — M. Whitworth and V. Novelli.
- *Seismic Assessment and Retrofitting* — I. Hajirasouliha, R. Monteiro and B. Pantò.
- *Structural Design and Codes Development* — D. Grant, P. Franchin and A. Correia.

Structural Dynamics, Protective Systems and Artificial Intelligence

- *Vibration Control and Innovative Protective Systems* — E. Tubaldi, J. Rees and N. Nikitas.
- *Blast, Impact and Robustness* — F. Parisi, N. Chandra Makoond and J. Adam.
- *AI in Earthquake Engineering* — J. Byun and C. Demartino.

Nuclear Safety, Energy Infrastructure and Computational Methods

- *Design and Assessment for Nuclear Safety & Special Facilities* — M. Asinari, D. Vamvatsikos and A. Mair.
- *Design and Assessment of the Energy Infrastructure* — R. De Risi, A. Giaralis, J. Douglas and I. Ward.
- *Advances in Computational Dynamics and Seismic Analysis* — A. Nielsen, B. Izzuddin and E. Spacone.

The conference programme reflects the breadth of the discipline, bringing together established areas of earthquake engineering with emerging approaches and challenges in research and practice.

SECED welcomes abstracts presenting original research, practical developments and innovative approaches across the conference sessions. Prospective authors are encouraged to consult the SECED 2027 conference website for submission guidelines, full session descriptions and further information. Prospective contributors are encouraged to contact the relevant session leads for further information about individual topics.

The conference will also feature an outstanding line-up of international keynote speakers, bringing together leading experts whose work spans academic research, engineering practice and industry. The announced speakers are:

- Jamie Padgett, Stanley C. Moore Professor and Department Chair at Rice University;
- Peter Ford, Director of Ford Nuclear Services Ltd;

- Katrin Beyer, Professor at EPFL and Head of the Earthquake Engineering and Structural Dynamics Laboratory;
- Daniel Powell, Director, Technical Specialist Services, Arup;
- Domniki Asimaki, Chair in Geotechnical Earthquake Engineering at Imperial College London;
- Giacomo Sevieri, Head of Catastrophe Analytics for EMEA at Aon;
- Xinzheng Lu, Professor at Tsinghua University;
- John Douglas, Managing Consultant at Frazer-Nash Consultancy.

Collectively, they bring exceptional expertise and diverse perspectives to some of the most important challenges earthquake engineering and civil engineering dynamics face today.

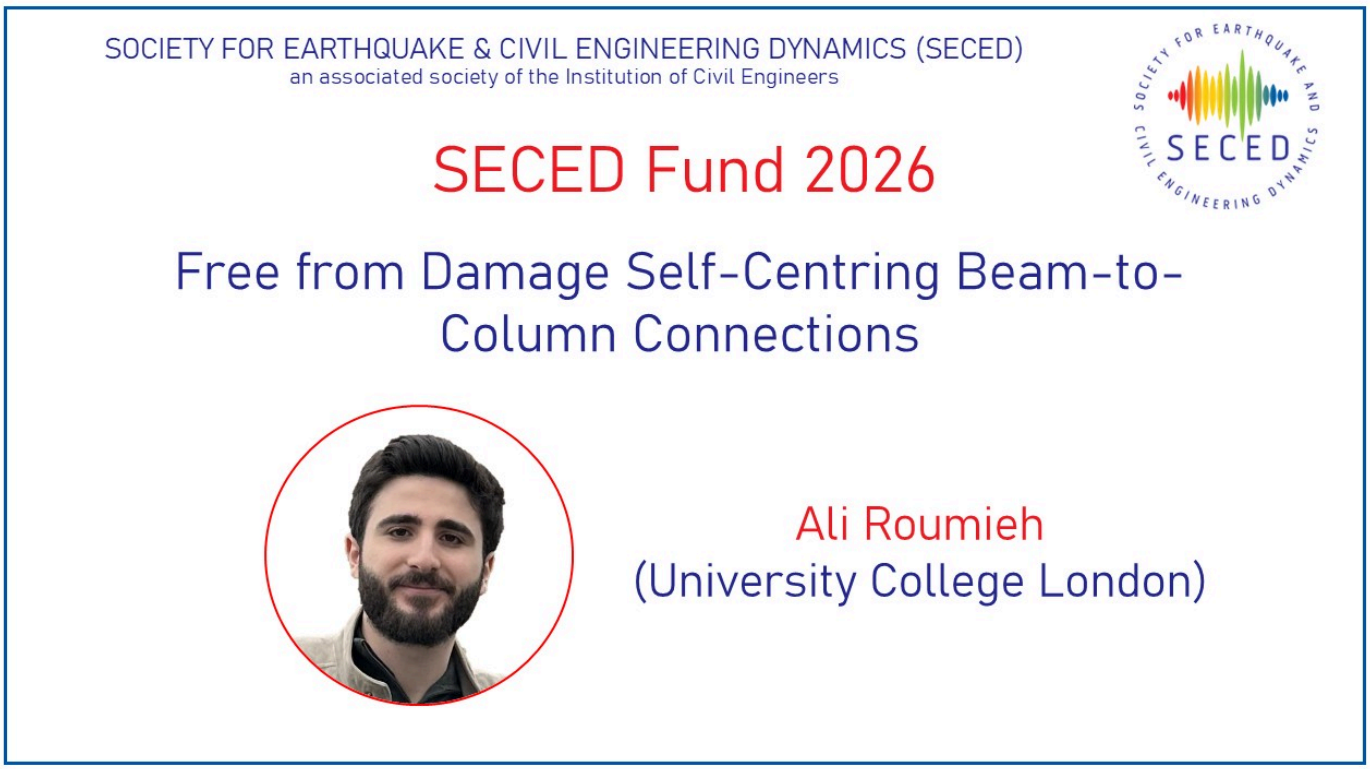
Winner of the SECED Fund 2026

The SECED Fund 2026 has been awarded to Ali Roumieh, a PhD researcher at University College London, for his project entitled "Free from Damage Self-Centring Beam-to-Column Connections".

The project aims to investigate innovative beam-to-column connections that can undergo deformation during seismic events while minimising structural damage. The research seeks to improve the resilience of structures and reduce the need for post-earthquake repairs by incorporating self-centring mechanisms in the connections.

Now in its fifth edition, the SECED Fund continues to support students and early-career researchers working in earthquake engineering and structural dynamics. This year, eleven eligible applications were received, including six from outside the UK, reflecting the international reach of the initiative.

Ali Roumieh will receive £1,500 to support his research. SECED congratulates Ali on his successful application and thanks all applicants for their interest in the Fund.Further information about the SECED Fund can be found at here.



Forthcoming Events

1. The Twentieth Mallet-Milne Lecture

The Evolution of Site Response Analysis: Where We Have Been & Where Are We Going

Ellen M. Rathje
University of Texas

Event Date: 26 May 2027 at 18:00
Location: Institution of Civil Engineers, 1 Great George St, London SW1P 3AA, UK

1. Introduction

We are delighted to announce that Professor Ellen M. Rathje has accepted the invitation by the SECED Committee to deliver the 20th Mallet-Milne Lecture next year. As with previous Mallet-Milne lecture nominees, this recognises Prof Rathje's wide contributions to earthquake engineering theory, practice and education. The 20th Mallet-Milne lecture will be delivered in the ICE Headquarters in Westminster, London, on the 26th of May 2027.

2. Synopsis

Local soil conditions can dramatically amplify — or in some cases attenuate — the ground shaking that reaches a structure during an earthquake. For more than five decades, one-dimensional (1D) site response analysis has been the foundational tool for simulating these effects, and it remains central to seismic design practice today. Yet the method has evolved substantially, and understanding this evolution is essential for anyone who relies on site response results for seismic hazard assessments, design ground motions, or performance-based evaluations.

This lecture traces that evolution through the lens of Prof Rathje's extensive experience on seismic hazard projects for nuclear facilities — a context that demands exceptional rigour, transparency, and defensibility, and one that has consistently pushed the boundaries of engineering practice. The lecture traces the developments that span the full arc of site response analysis, from advances in small-strain site characterisation (shear wave velocity, damping, and HVSR measurements) to improved approaches for modelling large-strain behaviour. It also examines the role of Random Vibration Theory (RVT), which enables robust analyses without the need for input ground motion time histories, as well as emerging methods for quantifying parametric uncertainty in key model inputs.

The practical role of open-source tools — particularly strata and the Python-based pystrata — is highlighted, demonstrating how these platforms have made advanced analysis methods more accessible to practising engineers. The lecture concludes with a forward-looking discussion of the field's priorities, including the need for broader validation across diverse site conditions and shaking intensities, and the challenges associated with incorporating multi-dimensional site response effects.

For further information about the Mallet-Milne Lecture, SECED's biennial prestige lecture, and its previous awardees, please see here.

3. Biography

Prof Ellen M. Rathje is the Janet S. Cockrell Centennial Chair in Engineering in the Fariborz Maseeh Department of Civil, Architectural, and Environmental Engineering and a Senior Research Fellow at the Bureau of Economic Geology at the University of Texas at Austin. She is an expert in the areas of engineering seismology, seismic ground response, and earthquake-induced ground failure.

Prof Rathje is the current President of the Earthquake Engineering Research Institute and she is a founding member and previous Co-Chair of the Geotechnical Extreme Events Reconnaissance (GEER) Association. She leads the DesignSafe cyberinfrastructure that supports research in natural hazards engineering. Her awards include the 2022 Peck Lecture Award from the ASCE Geo-Institute, the 2018 William B. Joyner Lecture Award from the Seismological Society of America and the Earthquake Engineering Research Institute, and election to the National Academy of Engineering in 2025.

4. Further Information

Further information will be published in due course at the event link here.

2. Rock On! Advancing Seismic Resilience Using Controlled Rocking

Lydell Wiebe
McMaster University

Event Date: 25 November 2026 at 17:30
Location: Institution of Civil Engineers, 1 Great George St, London SW1P 3AA, UK

1. Synopsis

As seismic design increasingly emphasises not only safety but also community resilience, engineers are seeking structural systems that can efficiently achieve enhanced performance objectives.

Controlled rocking systems offer one such solution: simply by allowing targeted structural elements to uplift from the foundation under large lateral loads, peak seismic forces are limited in a way that avoids structural damage and residual deformations. This rocking behaviour can then be controlled using post-tensioning and/or energy dissipation.

This seminar will draw on examples from both research and practice to illustrate the opportunities and challenges of implementing controlled rocking in steel, mass timber, and reinforced masonry. While each material requires unique detailing considerations at the rocking interface and the diaphragm connections, their global dynamic response is remarkably similar.

Key design challenges include: (1) peak displacements that often exceed the equal displacement assumption, and (2) higher mode effects that reduce the ability of rocking to limit the internal forces.

The seminar will introduce easy design tools that allow engineers to predict these effects without nonlinear analysis, allowing the benefits of controlled rocking to be harnessed while keeping the design process as simple as for other common seismic force resisting systems.

Attendees will learn about not only the structural behaviour of controlled rocking systems, but also how these systems affect the demands on non-structural components, including comparisons with other seismic force resisting systems in terms of expected seismic losses. The seminar will conclude with an overview of the current state of prescriptive design requirements and codification.

2. About the Speaker

Lydell Wiebe is Professor and Chair of the Department of Civil Engineering at McMaster University in Hamilton, Canada, where he also holds the Endowed Chair in Effective Design of Structures. His research aims to develop economical ways of enhancing seismic resilience, with a focus on designing steel structures to minimise the time and cost of post-earthquake repair.

He is a leader in Canadian code development, chairing the Seismic Design Working Group for the Canadian Standard on Design and Construction of Steel Structures and voting on the Canadian National Model Codes Committee for Seismic Design. His awards include the HA Krentz Research Award from the Canadian Institute of Steel Construction, multiple Best Paper awards from the ASCE Journal of Structural Engineering, and the McMaster University Faculty of Engineering Teaching Excellence Award.

3. Attend In-person

The event will be held in-person at the Institution of Civil Engineers. Registration will take place from 17:30 to 18:00, with tea, coffee and biscuits served on arrival. Refreshments are served at the foyer, next to the lecture theatre. Seats are allocated on a first come, first served basis. We encourage everyone to attend in person if they can.

4. Join Online

Click the Zoom link here to attend the meeting online. The event is organised by SECED. The event is open to all and is free to attend.

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This newsletter is supported by membership fees. More information about individual and corporate memberships can be found online.

Notable Earthquakes
May 2026 – August 2026

Reported by British Geological Survey

Issued by: David Galloway, British Geological Survey, October 2026.
Non-British Earthquake Data supplied by: United States Geological Survey.

Year	Day	Mon	Time UTC	Lat	Lon	Dep km	Magnitude ML	Mb	Mw	Location
2026	01	MAY	17:52	51.97N	1.61E	8	2.2			SOUTHERN NORTH SEA
2026	10	MAY	04:33	56.60N	6.28W	5	1.9			MULL, ARGYLL & BUTE
Felt Mull (3 EMS).										
2026	12	MAY	07:33	52.37N	3.35W	5	2.7			LLANBISTER, POWYS
Felt Rhayader, Tregynon and Mochdre (3 EMS).										
2026	12	MAY	13:13	54.55N	0.97W	11	1.7			BROTTON, NORTH YORKSHIRE
2026	13	MAY	09:11	54.16N	2.83W	3	2.3			SILVERDALE, LANCASHIRE
Felt Silverdale, Carnforth, Arnside, Milnthorpe, Burton-in-Kendal, Grange-over-Sands and surrounding villages (4 EMS).										
2026	15	MAY	11:22	38.94N	142.16E	42			6.7	OFFSHORE HONSHU, JAPAN
2026	17	MAY	16:21	24.43N	109.24E	10			5.0	GUANGXI, CHINA
Two people killed, at least five injured and 16 homes destroyed and another 970 damaged in Liuzhou region.										
2026	20	MAY	12:23	57.06N	5.53W	8	2.6			BARRISDALE, HIGHLAND
2026	20	MAY	17:43	56.00S	122.30W	10			6.6	SOUTH PACIFIC OCEAN
2026	24	MAY	20:10	50.10N	0.67E	8	2.2			ENGLISH CHANNEL
2026	25	MAY	21:52	22.37S	68.60W	109			6.9	NORTHERN CHILE
2026	26	MAY	21:11	53.73N	3.18E	30	2.3			SOUTHERN NORTH SEA
2026	06	JUN	21:35	54.17N	2.83W	3	2.2			SILVERDALE, LANCASHIRE
Felt Silverdale, Carnforth, Arnside, Milnthorpe, Burton-in-Kendal, Grange-over-Sands and surrounding villages, mainly from within around 20 km of the epicentre (5 EMS).										
2026	07	JUN	17:13	54.17N	2.82W	3	1.1			SILVERDALE, LANCASHIRE
Felt Silverdale (2 EMS).										
2026	07	JUN	19:31	54.17N	2.81W	3	0.7			SILVERDALE, LANCASHIRE
Felt Silverdale (2 EMS).										
2026	07	JUN	23:37	5.60N	125.06E	57			7.8	MINDANAO, PHILIPPINES
At least 93 people killed (20 still missing), over 1,300 others injured and over 100,000 buildings destroyed or damaged across Mindanao. A tsunami was generated with a maximum wave height of 1.48 m recorded at Kiamba, Philippines.										
2026	08	JUN	00:55	5.48N	125.22E	75			6.5	MINDANAO, PHILIPPINES
2026	10	JUN	05:43	52.33N	1.81W	7	1.5			TANWORTH, WARWICKSHIRE

Year	Day	Mon	Time UTC	Lat	Lon	Dep km	Magnitude ML	Mb	Mw	Location
2026	16	JUN	03:23	1.17S	120.13E	10			6.7	SULAWESI, INDONESIA
Three people killed, at least 108 others injured and over 3,000 buildings damaged or destroyed in Central Sulawesi.										
2026	16	JUN	09:06	37.89N	95.49E	10			6.3	QINGHAI, CHINA
One person killed, eight others injured and several buildings damaged in Da Qaidam.										
2026	17	JUN	18:56	0.58S	20.05W	10			6.6	SOUTH ATLANTIC OCEAN
2026	19	JUN	06:52	52.80N	160.69E	14			6.6	KAMCHATKA (OFFSHORE)
2026	20	JUN	13:34	56.53N	4.59W	5	1.6			PUBIL, PERTH & KINROSS
2026	22	JUN	00:38	54.17N	2.83W	3	0.7			SILVERDALE, LANCASHIRE
Felt Silverdale (2 EMS).										
2026	24	JUN	16:43	51.93N	3.12W	9	1.5			LLANBEDR, POWYS
2026	24	JUN	22:04	10.37N	68.56W	10			7.2	VENEZUELA
At least 6,500 people killed, 226,696 others injured with an estimated 50,000 people still missing. Extensive damage to infrastructure with over 59,000 buildings damaged or destroyed. Damage estimated at 37 billion US dollars. Coastal uplift of around 6 m was observed at Galfa Point, Trinidad & Tobago. A tsunami was generated with maximum recorded wave heights of 4 cm on Isla de Mona and at Puerto Yabucoa.										
2026	24	JUN	22:05	10.44N	68.47W	10			7.5	VENEZUELA
Casualties and damage information are included with the 7.2 Mw Venezuela earthquake around 40 seconds earlier, at 22:04 UTC.										
2026	24	JUN	22:30	40.26N	142.18E	34			6.9	OFFSHORE HONSHU, JAPAN
2026	26	JUN	11:34	5.29N	125.07E	42			6.5	MINDANAO, PHILIPPINES
2026	29	JUN	12:45	51.78N	1.21W	5	1.6			ELSFIELD, OXFORDSHIRE
2026	30	JUN	19:23	60.30N	1.57E	10	3.1			NORTHERN NORTH SEA
2026	01	JUL	00:52	52.44N	2.65W	7	1.6			COLD WESTON, SHROPSHIRE
2026	11	JUL	04:46	56.44N	5.83W	3	1.5			MULL, ARGYLL & BUTE
Felt Mull (3 EMS).										
2026	14	JUL	03:39	53.30N	2.76E	10	3.0			SOUTHERN NORTH SEA
2026	17	JUL	00:38	57.42N	5.53W	7	2.3			LOCHCARRON, HIGHLAND
2026	17	JUL	14:48	14.57N	92.96W	22			7.3	CHIAPAS, MEXICO
At least 18 people were injured and over 450 buildings were destroyed or damaged in Chiapas and one person was injured and 64 buildings were damaged in Guatemala. A tsunami was generated with maximum wave heights of 32 cm recorded at Salina Cruz, Mexico.										
2026	20	JUL	06:58	50.69N	4.57W	4	1.4			WARBSTOW, CORNWALL
Felt Davidstow, Boscastle and Camelford (3 EMS).										

Year	Day	Mon	Time UTC	Lat	Lon	Dep km	Magnitude ML	Mb	Mw	Location
2026	28	JUL	03:09	56.87N	4.89W	8	2.5			SPEAN BRIDGE, HIGHLAND
Felt Spean Bridge, Roybridge, Inverlair, Fort William and surrounding villages, mainly from within around 20 km of the epicentre (4 EMS).										
2026	28	JUL	07:27	32.62N	130.66E	10			6.8	KYUSHU, JAPAN
At least 39 people were killed, over 160 others were injured and some 700 homes were destroyed and over 8,200 were damaged in Kumamoto prefecture.										
2026	31	JUL	00:31	57.00N	1.91E	10	3.2			CENTRAL NORTH SEA
2026	05	AUG	03:39	54.25N	1.14E	10	2.1			SOUTHERN NORTH SEA
2026	08	AUG	12:34	4.86N	76.25W	116			7.4	COLOMBIA
At least 331 people killed, with over 110 still reported as missing, over 4,650 more injured and many thousands of homes and buildings damaged or destroyed across seven departments in western Colombia.										
2026	14	AUG	21:58	8.34S	121.35E	10			7.8	FLORES SEA
At least 136 people were killed, over 1,770 others were injured and some 102,800 buildings were destroyed or damaged in the region. A tsunami was generated with a maximum wave height of 1.69 m recorded in Reok, Manggarai Regency, Indonesia.										
2026	15	AUG	10:54	2.99N	98.99E	175			6.9	NORTH SUMATRA, INDONESIA
2026	20	AUG	18:00	14.63S	73.64W	99			6.7	SOUTHERN PERU
At least 3 people were injured and over 600 homes were damaged.										
2026	25	AUG	18:47	53.55N	0.09W	3	2.2			GRIMSBY, LINCOLNSHIRE
Felt Grimsby and surrounding area, mainly from within around 10 km of the epicentre (5 EMS).										