PhD Program in Civil, Chemical and Environmental Engineering
Curriculum in Structural and Geotechnical Engineering, Mechanics and Materials

June 2026 Call, XLII cycle - Starting date: November 1 st 2026

The research projects submitted for the admission to the PhD program must be prepared in accordance with one of the projects listed in this file, which are organized by general thematics. Click on the Thematic you are interested in to see the full list of projects.

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Projects in Structural Engineering and Mechanics

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Thematic: Structural Engineering and Mechanics

Project: War Damage to Cultural Heritage: Safety Assessment, Vulnerability Analysis and Repair Strategies

Keywords: Cultural Heritage Protection, War-Induced Structural Damage, Post-Conflict Assessment, Heritage Repair Techniques, Built Heritage Vulnerability

Brief Description:

This doctoral research focuses on the structural and conservation challenges posed by war damage to cultural heritage buildings and sites. The project will address five key aspects: (1) the assessment of safety and stability of heritage structures affected by conflict, including historical masonry, monuments, and religious buildings, using non-destructive techniques and advanced modeling; (2) the analysis of modern sources of direct damage such as drone strikes, targeted explosions, and fires, as well as indirect damage caused by prolonged exposure to weather, looting, and abandonment; (3) the evaluation of vulnerability specific to heritage typologies, considering material degradation, historical construction techniques, and modern reinforcements; (4) the decision-making process between demolition, reconstruction, or conservation-based repair, integrating structural safety with cultural, historical, and symbolic value; (5) the development and testing of repair techniques compatible with heritage conservation principles, including reversible interventions, traditional materials, and innovative low-impact solutions. The research aims to contribute to international efforts in post-conflict recovery, offering tools and guidelines for engineers, architects, and conservation professionals working to protect and restore cultural identity through built heritage.

Referent: Chiara Calderini (chiara.calderini@unige.it)

Relevant links: https://www.youtube.com/watch?v=OUEk2HA7uvQ&t=3664s

Figure: Al-Omari Mosque, Gaza's oldest mosque (Palestine), damaged by Israeli bombardment on January 5, 2024 (left) and the Church of the Holy Mother of God in Bohorodychne village (Ukraine) (right).

Link to the list of projects

Thematic: Structural Engineering and Mechanics

Project: Floor response spectra for the seismic assessment of nonstructural components in reinforced concrete buildings

Keywords: floor response spectra, nonstructural components, reinforced concrete buildings, Italian Seismic Monitoring Network

Brief Description:
The seismic assessment of nonstructural components (NSCs)—such as infill walls, architectural elements, and equipment housed within buildings—is a critical aspect of performance-based earthquake engineering. This is because most earthquake-induced damage and related economic losses are often attributed to these components. In many past major earthquakes, damage to NSCs resulted in losses that far exceeded those caused by structural damage. Moreover, such damage can severely affect the performance or functionality of critical facilities, such as hospitals. NSCs are typically classified based on their sensitivity to acceleration, deformation, or both. This PhD proposal focuses on acceleration-sensitive NSCs, for which seismic demands are commonly characterized using floor response spectra (FRS). Numerous formulas have been proposed in the literature and building codes to predict FRS for the seismic assessment of NSCs in ordinary buildings or artistic pieces hosted in monumental structures. However, these formulas are generally calibrated for specific structural typologies, raising doubts about their applicability to other building types. In this context, the proposed research aims to: (i) investigate the key parameters influencing FRS, such as higher vibration modes, structural nonlinearity, and NSC damping; and (ii) validate practitioner-oriented tools currently recommended in the literature and building codes for FRS prediction. To achieve these objectives, the study will use real data from earthquake-affected buildings monitored by the Italian Seismic Monitoring Network and results from a shaking table test campaign on scaled specimens performed at the Laboratory of Naples and planned within the NEWTON project (https://www.newton-prin.it/en/). These experimental data will be complemented by parametric numerical simulations based on models calibrated using data from dynamic identification tests and validated with the experimental results.

Referent: Stefania Degli Abbati, stefania.degliabbati@unige.it; Sergio Lagomarsino, sergio.lagomarsino@unige.it

Relevant links:

link to the Italian Seismic Monitoring Network:
https://rischi.protezionecivile.gov.it/it/sismico/attivita/osservatorio-sismico-delle-strutture/

link to the NEWTON project: https://www.newton-prin.it/en/

Link to the list of projects

Thematic: Structural Engineering and Mechanics

Project: Wind-Induced Aeroelastic Phenomena in Super-Slender Tall Buildings

Keywords: Aerodynamics, Aeroelasticity, Experimental testing, Galloping, Reduced-order models, Vortex-Induced Vibrations

Brief Description:

Wind-induced aeroelastic phenomena are a major concern for slender structures, especially tall and super-tall buildings. Among them, vortex-induced vibrations (VIVs) can generate significant oscillations that, in tall buildings, mainly affect serviceability, particularly occupant comfort. In very slender structures, higher-order vibration modes may also contribute to the dynamic response within the design wind-speed range, making their role especially important in acceleration-based performance checks. In addition, square cross-sections may be susceptible to galloping, which can lead to large-amplitude motions and may govern ultimate limit state conditions. In some cases, the transition between VIV and galloping is not clear-cut, making their interaction domain a key issue for design and assessment.
This project proposes an experimental investigation on a super-slender aeroelastic building model with a height-to-breadth ratio of 20:1. The model will be designed to test different square cross-section configurations, including sharp-edged and rounded-corner geometries with varying radii of curvature, by using interchangeable external claddings. Tests will be carried out in both smooth flow and atmospheric boundary-layer turbulent conditions, in order to reproduce simplified and more realistic wind environments. Particular attention will be devoted to the role of higher-order vibration modes, especially the second mode, and to the influence of the wind angle of attack in selected configurations. The experimental results will then be interpreted with reduced-order engineering models, including spectral formulations for VIV (Vickery & Basu 1983, JWEIA 12(1), 49-74), to support a clearer understanding of the observed aeroelastic behaviour and its dependence on geometry and flow conditions.

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Aeroelastic model of a super tall building in the TPU Wind Tunnel (Japan)

[Link to the list of projects]()

Thematic: Structural Engineering and Mechanics

Project: Understanding the response of long-span bridges to thunderstorm downbursts

Keywords: Long-span bridges, Aerodynamics, Aeroelasticity, Experimental testing, Non-synoptic winds, Numerical simulation

Brief Description:

Climate change is expected to increase the frequency and severity of extreme atmospheric events, including thunderstorm-related winds, which represent a growing challenge for the resilience and safety of long-span bridges. Unlike conventional synoptic boundary-layer winds, these events are highly transient, spatially varying, and non-Gaussian, so they are not adequately captured by current design assumptions based on stationary flow and quasi-steady structural response models. Full-scale observations from bridges such as the Forth Road Bridge (Owen et al. 2020, JWEIA 206) and the Hardanger Bridge (Fenerci et al. 2018, JWEIA 172) have shown that storm events can produce structural responses that differ markedly from those predicted by standard approaches.

This PhD project aims to advance the understanding of the response of long-span bridges to thunderstorm wind events through a combined experimental and numerical approach. On the experimental side, sectional model tests will be carried out in the “Giovanni Solari” Wind Tunnel using the active multi-blade device to reproduce accelerated flow scenarios representative of non-synoptic winds, with the goal of assessing their influence on bridge aerodynamics and aeroelastic behaviour. On the numerical side, dedicated algorithms (e.g., Xhelaj et al. 2020, JWEIA 207) will be applied to simulate downburst wind fields and generate time histories of wind speed and direction along the bridge deck. The integration of these two approaches within a numerical FEM framework may support more reliable predictions of bridge response under thunderstorm winds, contributing to improved safety assessment and the development of enhanced monitoring and design strategies. A particularly interesting case study is the Hardanger Bridge, which seems particularly suitable as a benchmark for validating the models developed in this project, given the availability of full-scale monitoring data.

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The active multi-blade device installed at the Giovanni Solari Wind Tunnel

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Projects in Mechanics of Materials

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Thematic: Mechanics of Materials

Project: Conceptualization, modeling, analysis and design of textile metamaterials

Keywords: textile metamaterials; beam lattices; linear and nonlinear dynamics; parametric microengineering; spectral design and vibration control

Brief Description:

The free and forced oscillations of periodic microstructures have long represented foundational topics in the fields of linear and nonlinear dynamics. This classical area of theoretical and applied research is currently experiencing a remarkable revival, driven by the disruptive emergence of new engineered materials and mechanical metamaterials. Within this vibrant and rapidly evolving scientific background, the proposed PhD project focuses on an emerging class of beam-lattice materials, known as *textile metamaterials*. These materials are being developed for a wide range of conventional and innovative applications across multiple technological domains, like civil, mechanical, aerospace, biomedical, acoustic, and sports engineering.

The primary objective of the project is to develop novel physical-mathematical formulations for deriving the equations of motion governing the behaviour of textile metamaterials. Particular emphasis is devoted to unveiling the complex dynamic phenomena arising in both small- and large-amplitude oscillation regimes. The research methodology combines parametric analyses, computational approaches, virtual simulations, and experimental validations. Ultimately, the project aims to establish an integrated platform for the systematic design, simulation, and parametric engineering of textile metamaterials, enabling the exploration of their multifunctional properties and facilitating their tailored application across a broad range of engineering contexts, thereby contributing to the advancement of metamaterial science.

References

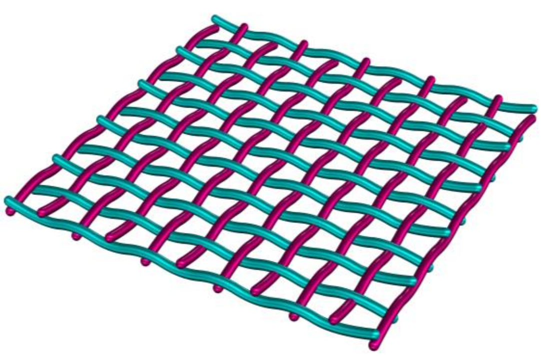
[1] Arena A., Lepidi M. (2025). Nonlinear wave propagation in a two-dimensional lattice model of textile metamaterials. *Nonlinear Dynamics* 113(18), pp.23863-23884.

[2] Arena A., Lepidi M. (2025). Free wave propagation in pretensioned two-dimensional textile metamaterials. *Journal of Computational and Nonlinear Dynamics* 20(8), id.081011.

[3] Parente L., Addessi D., Di Re P., Gatta C., Sacco E. (2025). Micromechanical buckling analysis of soft lattice metamaterials accounting for randomly distributed imperfections. *Mechanics Research Communications* 148, id.104450.

[4] Di Re P., Benaim Sanchez D. M. (2024). Finite difference technique for the evaluation of the transverse displacements in force-based beam finite elements. *Computer Methods in Applied Mechanics and Engineering* 428, id.117067.

Referent: Marco Lepidi (marco.lepidi@unige.it), Paolo Di Re (paolo.dire@unige.it), Andrea Arena



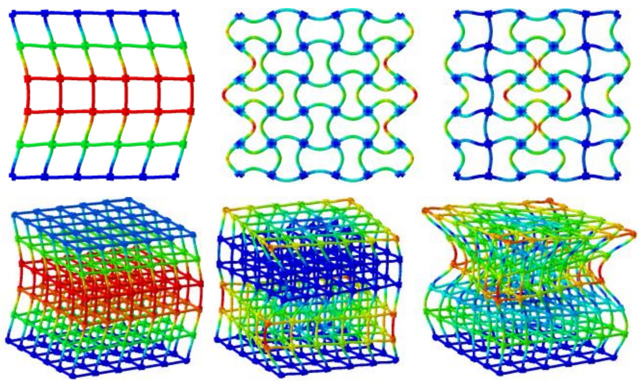


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Figure: Beam lattices: (left) textile metamaterials, (right) 2D and 3D buckled configurations

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DICCA Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

Thematic: Mechanics of Materials

Project: AI-assisted Inverse Design of Architectured Lattice-like Materials

Keywords: Mechanical Metamaterials; Microstructures; Constitutive models; Additive manufacturing

Brief Description:

Recent advances in additive manufacturing have dramatically expanded the design space of architectured materials, making lattice-like microstructures increasingly attractive for lightweight, multifunctional, and programmable engineering applications. Periodic beam lattices, block lattices, and hybrid beam-block architectures offer exceptional flexibility thanks to their inherent modularity, geometric adaptability, and manufacturability, enabling the realization of materials with properties unattainable in conventional solids. This research project proposes a novel physics-informed framework for the inverse design of periodic lattice materials by combining analytical homogenization, generalized micropolar continuum mechanics, and artificial intelligence. Rather than learning a direct mapping between geometry and effective properties, the proposed methodology exploits the irreducible decomposition of the equivalent micropolar constitutive tensor as the latent constitutive space for physics-informed artificial intelligence. Closed-form homogenization relations will be employed to generate large analytical datasets linking the geometric parameters of periodic unit cells to their constitutive descriptors, eliminating the computational burden associated with conventional finite element-based dataset generation. Machine learning models will be trained to identify the relationship between lattice geometry, symmetry class, and constitutive decomposition, enabling the rapid prediction and inverse design of periodic architectures exhibiting prescribed mechanical behavior. Square, rectangular, oblique, and hexagonal unit cells, in both regular and irregular configurations, including non-centrosymmetric and chiral topologies, will be systematically investigated to achieve unconventional elastic couplings, tailored wave dispersion characteristics, and enhanced fracture resistance through microstructure-driven crack path control.
The proposed framework introduces a constitutive-space paradigm for AI-assisted material design, enabling systematic control over constitutive symmetries, anisotropy, micropolar couplings, and size effects, and opening new perspectives for multifunctional lattice metamaterials with tailored mechanical, dynamic, and fracture properties.

Referents: Vito Diana (vito.diana@unige.it); Andrea Bacigalupo (andrea.bacigalupo@unige.it); Claudio Boni (claudio.boni@unige.it)

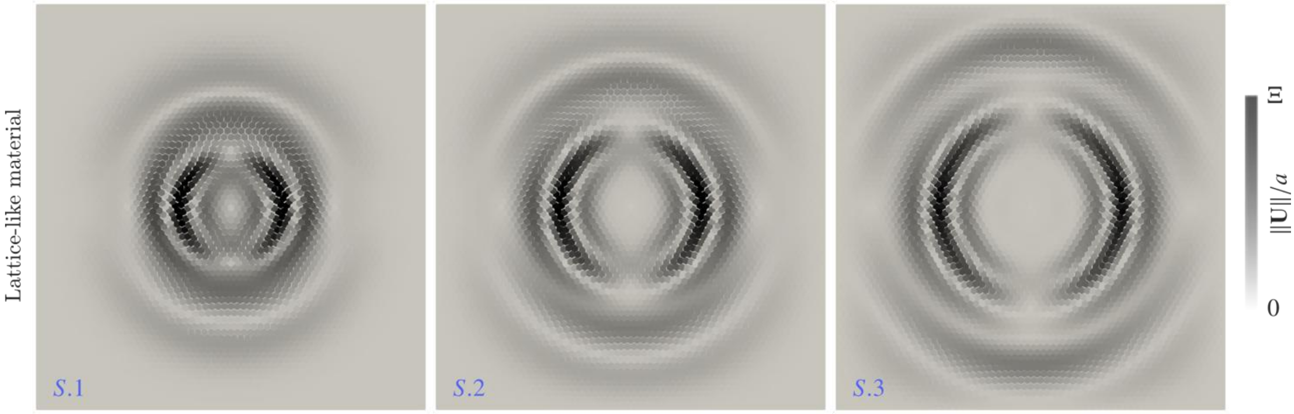

Figure: Wave propagation in a designed periodic hexagonal block lattice in three subsequent time steps

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Thematic: Mechanics of Materials

Project: Computational/analytical mechanics and asymptotic matching in the training of machine learning frameworks for the solution of fracture problems

Keywords: fracture mechanics, analytical/numerical modeling, machine learning, Physics-informed neural networks, asymptotic matching

Brief Description:

Machine learning (ML) has been successfully employed in a wide range of applications in solid and fracture mechanics, for instance for constructing surrogate models, advancing multiscale modeling, designing engineered materials, obtaining material data from measured fields. Such models are typically physics-informed, and physical laws, e.g. equilibrium, compatibility and constitutive equations, provide a-priori information that can be integrated into the ML framework during training, thereby reducing the need to collect a large data set. In most of the engineering applications ML frameworks are trained on synthetic data derived through computational methods (physics-based data driven approaches), e.g. the cohesive crack model or the phase field method in fracture applications. Important advances in the field of experimental mechanics have also been reached, e.g. through big-data generating experiments.

On the other side, words of cautions have been expressed recently, on the use of machine learning technique for the solution of problems requiring major extrapolations from the existing database; examples are the problems dominated by size-scale effects. And the importance of supporting experimental and computational derivations of data with exact asymptotic analytical solutions, has been recently highlighted by the research group at UniGe when dealing with the standardization of fracture mechanics tests for sandwich composites.

The aim of this project is to investigate the combined use of machine learning and computational methods with analytical methods and asymptotic matching techniques in the solution of mechanics problems, with special focus on fracture problems. The first problem that will be investigated is the cohesive fracture of heterogeneous and layered materials. This is a problem for which effective computational methods have been developed, e.g. cohesive zone model and phase field model, and exact analytical solutions have been derived for special limiting cases, e.g. small-scale yielding/bridging solutions.

Prerequisites: the student applying for this fellowship should have solid bases in solid and structural mechanics and fracture mechanics. Knowledge in ML techniques will be a plus.

Referent: Prof. Roberta Massabò (Roberta.massabo@unige.it)

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Projects in Geotechnical Engineering

Project: The key role of soil water content in the geotechnical modelling of rain-induced shallow landslides: from monitoring to geotechnical analysis

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Thematic: Geotechnical Engineering

Project: The key role of soil water content in the geotechnical modelling of rain-induced shallow landslides: from monitoring to geotechnical analysis.

Keywords: Soil moisture; Landslide; Geotechnics; Monitoring; Stability analysis

Brief Description:

Rapid shallow landslides pose a critical threat to hilly and mountainous areas, primarily disrupting the unsaturated, uppermost layers of slopes within the first two meters. Rainwater infiltration drives these shallow soil layers toward full saturation, drastically minimizing apparent cohesion and triggering abrupt slope failures.

Because spatiotemporal variations in soil moisture dictate surficial slope stability, accurately quantifying soil water content is crucial for geotechnical modelling.

This research aims to develop an advanced geotechnical modelling that integrates field monitoring and remote sensing soil moisture data to improve the analysis and prediction of rain-induced shallow landslides.

The study demands expertise in geotechnical engineering—specifically unsaturated soil mechanics and numerical slope stability modelling—complemented by a strong background in hydrology and geomatics.

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Relevant links:

https://isprs-archives.copernicus.org/articles/XLVIII-4-W1-2022/517/2022/

https://link.springer.com/chapter/10.1007/978-3-031-91141-5_1

https://www.mdpi.com/2076-3263/10/10/409

https://www.emerald.com/jgeot/article-pdf/74/8/820/9585558/jgeot_22_00042.pdf

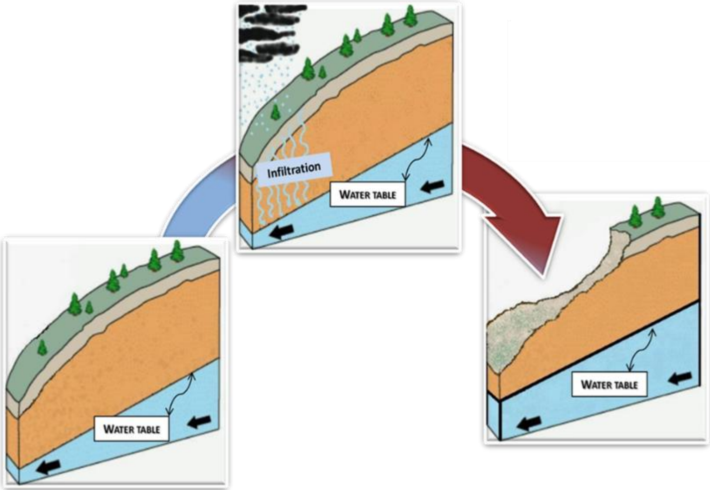

Figure: Schematic representation of rainfall-induced landslide triggering

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Other Projects

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