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

November 2025 Call, XLI cycle - Starting date: March 1st 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

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

Project: Structural Health Monitoring of strategic and monumental buildings assisted by new analytical, computational and intelligent methodologies

Project: Wind-induced loading and dynamic response of tall buildings due to thunderstorm outflows

Project: Developments of Vortex-Induced Vibration models for engineering applications

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

Project: Instabilities and geometric nonlinearities in composite systems

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***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 of the 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.

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Link to the list of projects

***Thematic*: Structural Engineering and Mechanics**

Project: Structural Health Monitoring of strategic and monumental buildings assisted by new analytical, computational and intelligent methodologies

Keywords: Structural Health Monitoring, existing buildings, structural identification, reduced-order models, AI-assisted automatization

Brief Description:
Existing buildings, especially if credited with strategic and monumental value, require continuous and reliable structural assessment to ensure their health and safety. The issue often presents challenging tasks due to the building complexity, the material heterogeneities, and unavailability of documentation. This research proposes a novel framework for Structural Health Monitoring (SHM) that integrates traditional analytical and computational techniques with intelligent new methodologies to address these challenges. The first research stage deals with the fusion and treatment of big data collected from a rich cross-section of sample buildings through multi-physical sensor networks to establish a behavioural baseline of the structural response. The accurate picture emerging from this data-based background serves as the standing point for the second stage, aimed at solving inverse structural problems (parameter identification, modal identification, damage detection and diagnosis). The third stage deals with the standardized development of reliable and effective data-based physically-informed models. The model synthesis and mechanical representativeness will be balanced by refined techniques of reduced order modelling and model information integration (according to strategies of Modal Synthesis, Equivalent and/or Surrogate Modelling, Building Information Modeling, Stochastic Equivalent Linearization). Recurrent modeling patterns will be recognized for homogeneous typologies of buildings, considering different homogeneity classes (e.g. construction period, construction material, geometric morphology). Finally, the resulting data-based physically-informed models will be employed to simulate the structural response in the time and frequency domains, within the linear and nonlinear ranges. The simulations will allow accurate predictions of the static and dynamic effects that may follow from anthropogenic activities (e.g. conservation, restoration, refurbishment interventions), as well as the structural response to different circumstances of natural aging and/or environmental hazards (extreme natural events). Some key steps of the research path will be assisted by novel Artificial Intelligence tools (e.g. to automate the classification of anomalies in modal analysisfor damage detection). A valuable add-on will be provided by collaborations with renowned data providers (e.g. Italian Seismic Observatory of Structures) and heritage conservation authorities.

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Relevant links:

Sivori, D., Lepidi, M., Cattari, S. (2020). Ambient vibration tools to validate the rigid diaphragm assumption in the seismic assessment of buildings. *Earthquake Engineering & Structural Dynamics*, 49(2), 194-211. https://doi.org/10.1002/eqe.3235

Sivori, D., Lepidi, M., Cattari, S. (2024). Analytical identification of dynamic structural models: Mass matrix of an isospectral lumped mass model, Earthquake Engineering and Structural Dynamics, 2024, 53(8), pp. 2447–2467. https://doi.org/10.1002/eqe.4126

Sivori, D., Ierimonti, L., Venanzi, I., Ubertini, F., Cattari, S. (2023). An Equivalent Frame Digital Twin for the Seismic Monitoring of Historic Structures: A Case Study on the Consoli Palace in Gubbio, Italy, Buildings, 2023, 13(7), 1840. https://doi.org/10.3390/buildings13071840

Link to the list of projects

***Thematic*: Structural Engineering and Mechanics**

Project: Wind-induced loading and dynamic response of tall buildings due to thunderstorm outflows

Keywords: Dynamic response, Nonstationary, Tall buildings, Thunderstorms

Brief Description:
Developing accurate models for wind loads and effects on structures is crucial to enhancing safety while minimizing costs. Given the importance of wind loads in terms of both safety and cost for tall buildings, accurately determining wind loads is essential for their design. In design codes, the calculation of wind effects on structures is based on a stationary model for the wind field, reliable for cyclonic phenomena at the synoptic scale. In regions with a mixed wind climate, thunderstorms can significantly influence design wind speeds, making their study essential for modern wind engineering. Unlike synoptic wind events, thunderstorm downbursts exhibit distinct features, including a nose-shaped mean wind speed profile and non-stationary characteristics within 10- to 60-minute time intervals.

The present Project aims to introduce suitable models for the definition of the loading and the assessment of the dynamic response of tall buildings to thunderstorms. The project involves conducting experimental work and the development of analytical models.

The experimental tests will constitute a continuation of the activities carried out within the framework of ERIES-TLTB Project. Wind tunnel tests on a benchmark tall building model will be carried out in the Giovanni Solari Wind Tunnel using an active grid to simulate both the nose-shaped mean wind profile as well as the nonstationary characteristics of thunderstorms. High Frequency Pressure Integration Tests will allow to derive the pressure distribution as well as the resultant wind loading on the building.

The analytical modelling activity involves the introduction of a statistical model for the characterization of the thunderstorm-induced wind field along a linear domain, that could be derived based on the statistical analysis of full-scale data. The model will be used to derive thunderstorm-induced loads and wind tunnel tests results will constitute a reference for comparison. The final aim is the generalization to thunderstorm-induced loading of current procedures adopted in standards to define equivalent static wind loading, that are formulated with reference to the synoptic wind model.

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Relevant links: https://eries.eu/

Figure: CAARC Building model in the Giovanni Solari Boundary Layer Wind Tunnel

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***Thematic*: Structural Engineering and Mechanics**

Project: Developments of Vortex-Induced Vibration models for engineering applications

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

Brief Description:
Vortex-Induced Vibrations (VIVs) represent one of the most important issues concerning wind-excited slender structures in both air and water. Despite its great significance, the engineering description of this phenomenon mainly relies on experimental evidence and empirical models. Engineering verifications (e.g., EN 1991-1-4, 2010) commonly use two calculation procedures. The spectral model (Vickery & Basu 1983, JWEIA 12(1), 49-74) supplies an analytical expression for an equivalent aerodynamic damping; the harmonic model (Ruscheweyh 1994, In: Sockel, Wind-Excited Vibrations of Structures. Springer-Verlag, Wien) supplies a vortex-induced force. The spectral formulation is considered sounder, more prudential and more reliable at high Scruton numbers, where the response tends to be in the so-called "forced vibration" regime. Both formulations may involve considerable uncertainties compared to full-scale measurements. Recent developments suggest that a classic van der Pol formulation, as used in the spectral model, may no longer be reliable (e.g., Lupi et al. 2021, JWEIA 208 104438, Guo et al. 2022, JWEIA 221 104887).

However, engineering applications often need extreme simplifications, the reliability of which has not yet been adequately explored. There are also classes of slender structures, such as chimneys, tubular poles and super tall buildings, in which resonant vortex shedding can be resonant with higher vibration modes, leading to intense vibrations and fatigue damage. In this case, the spectral method does not yet find a codified procedure, effectively making this procedure unusable. Moreover, several issues are still open, such as the choice of the limiting vibration amplitude in the lock-in regime and the estimation of the peak coefficient in transient regime. With particular reference to the spectral method, the proposed project will investigate developments for technical applications, focusing on the parameters whose choice is crucial in the response calculation of lightweight, low-damped systems, and on the generalization to higher vibration modes. The project may include experimental tests to be carried out in the 'Giovanni Solari' Wind Tunnel.

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Figure: Vortex shedding flow visualization in the 'Giovanni Solari' Wind Tunnel

Link to the list of projects

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.

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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: Instabilities and geometric nonlinearities in composite systems

Keywords: sandwich composites; thin films on substrates

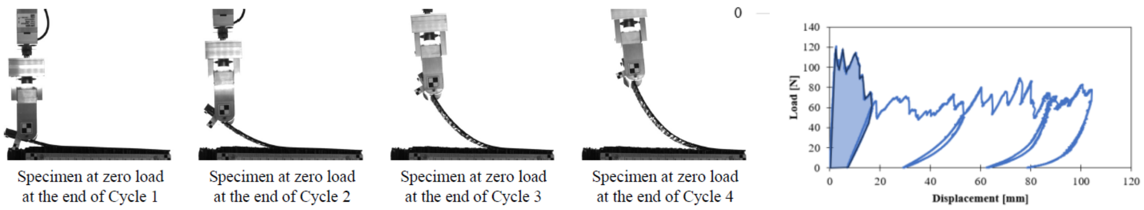
Brief Description:
The aim of the project is to investigate and develop fundamental solutions that can accurately describe the nonlinear behavior of composite systems used in many engineering applications. The research will address problems such as the peeling of thin films from substrates (used in coatings and electronic devices), the detachment of thin aluminum facesheets in sandwich composites involving large displacements and localized plasticity (relevant to aerospace structures) and the local instability of the honeycomb cells in sandwich composites.

The methodology will employ concepts from elasticity, plasticity, structural mechanics and fracture mechanics.

The PhD student will be based at the University of Genova (UniGe) and will collaborate to the activities of an international team that includes leading european universities and research centers (DTU, Fraunhofer IMWS) and industrial partners (Airbus Helicopters, Airbus commercial Aircraft, Leonardo, and Dupont)

Referent: Roberta Massabò, Roberta.massabo@unige.it

Figure: Crack propagation with localized plasticity of thin aluminum facesheets in sandwich composite for aerospace applications



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Projects in Mechanics of Materials

Project: Advanced design of avant-garde active microstructured metamaterials

Project: Disbond of sandwich systems in aviation, fundamental solutions and stardardization

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

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Thematic**:** Mechanics of Materials

Project: Advanced design of avant-garde active microstructured metamaterials

Keywords: Active metamaterials, hierarchical architected microstructure, multi-field physical phenomena, non-local dynamic homogenisation

Brief Description:
The design of technologically innovative materials with enhanced or exotic mechanical properties constitutes an area of significant interest in Mechanics. Important results have been obtained with the development of artificial composite materials, a combination of different ingredient materials spatially organised according to avant-garde innovative and optimised topologies. Artificial architected heterogeneous materials and active metamaterials with extreme mechanical performances can be obtained with active periodic microstructures with empty spaces and cavities properly designed. Developments in this open research field still appear to be very promising, as evidenced by the current extensive literature on the subject and the new challenges that result from it. Moreover, the conceptualisation and the tailored optimal design of innovative materials with complex microstructures, for cutting-edge and smart applications in many engineering and technological fields, are also fueled by recent developments in the technological fields of high-precision microengineering and high-fidelity additive manufacturing.

Within this framework, the present PhD research project focuses on developing technologies that pave the way to almost endless opportunities for designing avant-garde active materials and metamaterials that can be activated in a controlled fashion to change shape, configuration, or physical properties in response to external stimuli. Advancement of knowledge concerns the conceptualisation, modelling, and design, together with prototyping and proof-of-concept of reprogrammable multi-functional metadevices for wave propagation control, energy harvesting, sensing, and stress-controlled failure programs. Physical-mathematical analytical formulations will be exploited to establish the governing equations, which will be solved by means of analytical and computational methods. Enhanced multi-field homogenization/continualization schemes will be conceptualised for a thermodynamically consistent constitutive characterisation of active hierarchical metamaterials with complex architected microstructure. Theoretical results will be optimised via homogenization-based optimisation numerical schemes and verified by virtual testing.

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Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

***Thematic*: Mechanics of Materials**

Project: Disbond of sandwich systems in aviation, fundamental solutions and stardardization

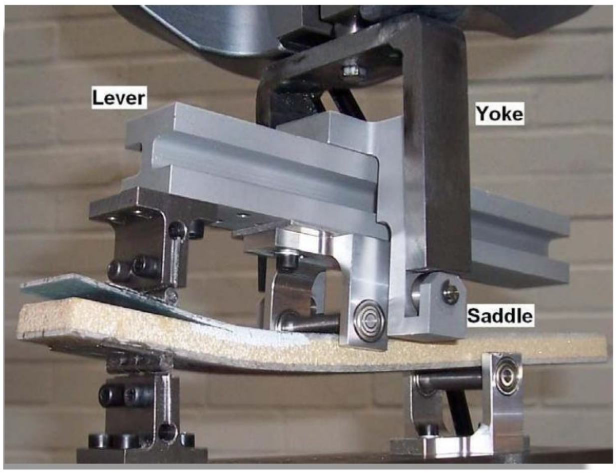
Keywords: sandwich composites; characterization of material properties; standardization.

Brief Description:
The aim of the project is to derive fundamental solutions based on elasticity, structural mechanics, linear elastic fracture mechanics and nonlinear fracture mechanics to complement and support experimental work for the characterization of the resistance to disbond fracture of sandwich composites (static and fatigue) used in aviation (see CMH17, Composite Mechanics Handbook 17). The work is part of *Horizon Europe Project DESIGN - Evolutions of airworthiness standards for new aircraft structure designs using materials, processes, and advanced manufacturing methods*, aimed at developing key enablers for safe design and use of sandwich structures in principal structural elements applications in aviation.

The PhD student will participate to the activities of an international team of researchers including, in addition to UniGE, various European Universities/research centers (DTU, Fraunhofer IMWS) and companies (Airbus Helicopters, Airbus commercial Aircraft, Leonardo, NSE Composites, Dupont.

Referent: Roberta Massabò, Roberta.massabo@unige.it

Figure: Mixed Mode Bending Sandwich specimen (courtesy by DTU)



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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 been foundational topics in the fields of linear and nonlinear dynamics. This classical area of theoretical and applied research is currently undergoing a remarkable revival, driven by the disruptive advent of new engineered materials and mechanical metamaterials. Within this vibrant and rapidly evolving scientific landscape, the proposed PhD project is centered on a emerging class of beam-lattice materials known as *textile metamaterials*. These materials are designed 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 mechanical behaviour of textile metamaterials. Particular emphasis is placed on unfolding the complex dynamic phenomena that arise across both small and large amplitude oscillation regimes. The research methodology integrates parametric analyses, computational strategies, virtual simulations, and experimental validations. Ultimately, the goal of this research is to develop an integrated platform that supports the systematic design, simulation, and parametric engineering of textile metamaterials, enabling the exploration of their multifunctional properties and facilitating their tailored application across various engineering contexts, thereby advancing the knowledge in 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.
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[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.

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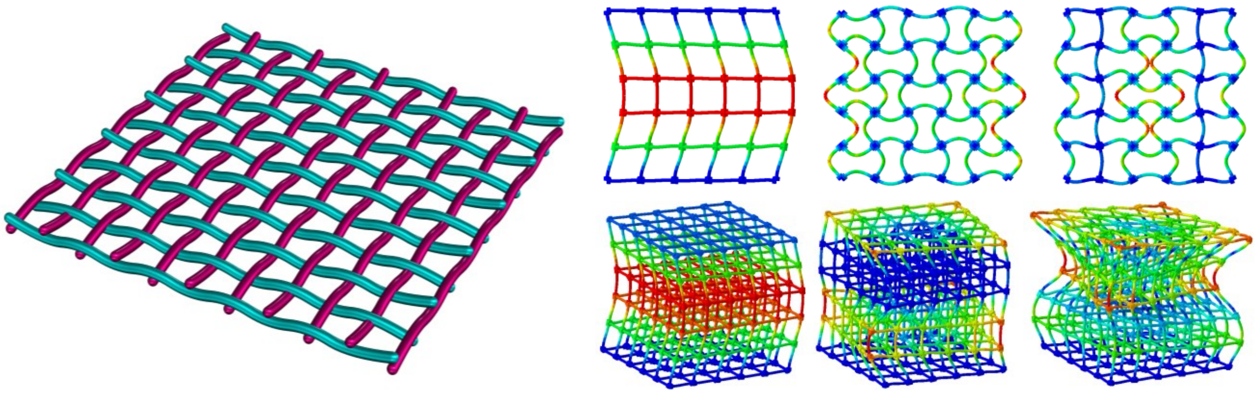

Figure: Beam lattices: (left) textile metamaterials, (right) 2D and 3D buckled configurations

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Projects in Geotechnical Engineering

Project: Combined alkali activation and carbonation effects on the hydro-mechanical behaviour and CO_2 sequestration of partially saturated fine-grained stabilized soils

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***Thematic*: Geotechnical Engineering**

Project: Combined alkali activation and carbonation effects on the hydro-mechanical behaviour and CO_2 sequestration of partially saturated fine-grained stabilized soils

Keywords: Ground improvement; Soil stabilisation; Alkali-activation; Carbonation; Partial saturation

Brief Description:
The shift toward sustainable soil stabilisation has renewed interest in using industrial and agricultural by-products as alternatives to conventional binders like Portland cement and lime. Alkali-activated binders, formed by reacting aluminosilicate-rich precursors with sodium or potassium activators, are promising alternatives due to their capacity to bond soil particles together, increasing both stiffness and strength of the material. However, concerns about CO_2 exposure effects on calcium-rich, alkali-activated materials have arisen. In these materials, carbon dioxide diffuses into soil pores and reacts with calcium to form calcium carbonate—a process known as carbonation. While well-studied in Portland cement and lime-stabilized soils, the impact of carbonation on the microstructure and hydro-mechanical behaviour of alkali-activated soils remains underexplored. The main aim of this doctoral project is therefore to investigate the kinetics of alkali activation and carbonation reactions, focusing on micro- and macro-scale changes in partially saturated fine-grained soils under near-surface conditions. It examines how CO_2 concentration, temperature, relative humidity, and curing time influence the geo-mechanical behaviour of the material, linking theoretical research to practical applications. The study will combine theoretical modelling, focusing on soil strength gain and CO_2 sequestration, and experimental characterisation, involving a broad range of multi-scale experimental techniques.

Both modelling and experimental research activities will be carried out at the Department of Civil, Chemical and Environmental Engineering of the 'Università di Genova' (UniGe, Italy) and the Department of Construction, Architecture and Urban Planning of the 'Université Libre de Bruxelles' (ULB, Belgium), leading to a double PhD degree in Civil Engineering.

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Other Projects

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