



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: THE VIRTUAL ELEMENT METHOD FOR ENGINEERING APPLICATIONS TO IMPROVE DISASTER RISK FORECAST AND MANAGEMENT**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1300.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>HAVING REGARD to the D.D. 1409 of 14/09/2022 (call PRIN PNRR 2022), within the framework of the National Recovery and Resilience Plan, Mission 4 Education and research - Component 2 From research to business - Investment 1.1, funded by the European Union - NextGenerationEU.</p> <p>Partial financing through project funds PRIN PNRR 2022 will take place in the first months of activation of the doctoral scholarship, until the expected PRIN PNRR 2022 amount is disbursed.</p> <p>PRIN PNRR 2022 Project: Polyhedral Galerkin methods for engineering applications to improve disaster risk forecast and management: stabilization-free operator-preserving methods and optimal stabilization methods - Project code: P2022BH5CB - CUP: D53D23018840001.</p> <p>The proposal concerns the development of numerical methods suitable for simulations for safety assessments in several fields of civil and environmental engineering and it is framed within a PRIN-PNRR national research project, involving also research units from the Politecnico di Torino, the Bicocca University of Milan and from Pavia University.</p> <p>Civil structures are subject to aging and the evolution of</p>



	<p>the surrounding environment increases the possibility of dramatic events. This project aims to develop Virtual Element Methods (VEM) capable to overcome usual modelling difficulties such as, for example, mesh generation problems, mesh adaptation problems, mesh quality problems, and incompressibility conditions. Unlike the traditional FEM, which relies on polynomial basis functions defined over a fixed mesh of elements, the VEM offers a more flexible and adaptive framework based on non-polynomial functions. It allows for the incorporation of irregular, non-conforming and non-convex elements, making it exceptionally well-suited for modeling complex geometries and dealing with problems involving singularities or evolving discontinuities.</p> <p>Although its great success in managing many of the overmentioned problems, some issues still affect its applicability in fields like non-linear elasticity, elastoplasticity, viscoplasticity and in strongly non-linear engineering problems, One of the main issues is related to the non-consistent stabilization term needed by these methods to get well-posed discrete problems for the simulation.</p> <p>This project will focus on stabilization-free VEMs with the aim of retaining the key features of VEM but without the side-effect of the pollution introduced by the stabilizing terms. Stabilization-free VEMs will be derived and applied to elasticity, elastoplasticity and fluid-structure interaction problems.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Starting from an approach proposed by the research group, an innovative self-stabilized Virtual Element Method will be proposed. The research work, will be divided into two phases:</p> <p>Phase 1. Formulation development, code prototyping and testing of self-stabilized Virtual Elements in 2D for elasticity and elastoplasticity problems in both small and large strains context.</p> <p>Phase 2. Formulation development, code prototyping and testing to extend the formulations in Phases to 3D Virtual Elements.</p> <p>In all the developments, particular attention will be</p>



	devoted to efficiency and to the integration within existing finite element codes. All the progress will be shared and discussed with the company involved in the project.
<b>Educational objectives</b>	<p>Given the groundbreaking nature of the proposed research project, the selected candidate will have the opportunity to collaborate with various laboratories and research groups both within Italy and internationally. Specifically, a research internship within one of the most active groups specializing in Virtual Elements will be arranged. Furthermore, the candidate will gain valuable insights into the industrial environment through a research stage within the company.</p> <p>This experience will equip the candidate with specialized knowledge in computational mechanics, with a particular focus on Virtual Element methods and their applications in solid mechanics. The candidate is expected to develop the proficiency needed to address complex problems and devise innovative and effective solution strategies.</p>
<b>Job opportunities</b>	In R&D departments of large companies and research centers, there is a growing need for individuals with specific expertise in computational mechanics and high-performance computing. In addition, engineering companies are increasingly seeking expertise in modelling complex, multiphysics engineering problems using new and unconventional approaches.
<b>Composition of the research group</b>	<p>3 Full Professors                  1 Associated Professors                  0 Assistant Professors                  1 PhD Students</p>
<b>Name of the research directors</b>	Massimiliano Cremonesi, Umberto Perego

<b>Contacts</b>	
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	650.0 €
By number of months	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research**

**Universities:**

- Politecnico di Torino
- University of Milano -Bicocca
- University of Milano
- University of Pavia
- Leibniz University Hannover

**Company:**

- Dassault Systemes Simulia Corp

**Educational activities**

The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year.

**Teaching assistanship**

Ph.D. students are encouraged to apply upon prior authorization to the calls to support teaching activities at the undergraduate and Master levels at Politecnico, and they are paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

**Computer availability**

Each Ph.D. student has his/her own computer for individual use.

**Desk availability**

Each Ph.D. student has his/her own desk, cabinet and locker.