



# PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 39th cycle

**PNRR 117 Research Field: DEVELOPMENT OF VIRTUAL ELEMENTS FOR SOLID  
MECHANICS PROBLEMS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1195.5**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research  
in this field**

The Virtual Element Method (VEM) is a cutting-edge numerical technique that has gained significant attention in the field of computational mechanics in the last few years. Unlike the traditional FEM, which relies on polynomial basis functions defined over a fixed mesh of elements, the Virtual Element Method 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.

Despite its potential applicability to a broad range of problems and its sound mathematical foundation, the method has not been considered yet for engineering or industrial applications. One of the main difficulties is a clear definition of the stabilization parameters. The objective of the current research line is to develop a self-stabilized Virtual Element approach for Solid Mechanics problems based on linear shape functions and perfectly integrable with standard FEM codes.

The proposed approach will result in an accurate, robust and efficient simulation tool, suitable for creating digital twins in innovative engineering applications. These models will help in reducing the need for physical tests making the design of new products faster and cheaper,



	and also lowering costs, resource consumption, and the environmental impact of production.
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>Starting from an innovative approach proposed by the research group, an innovative self-stabilized Virtual Element approach will be proposed. The research work, will be divided into three phases:</p> <p>Phase 1. Formulation development, code prototyping and testing of self-stabilized Virtual Elements in 2D for small strain elastostatics problems.</p> <p>Phase 2. Formulation development, code prototyping and testing of self-stabilized Virtual Elements in 2D for large strain problems with generic constitutive laws in both incremental and total forms.</p> <p>Phase 3. Formulation development, code prototyping and testing to extend the formulations in Phases 1 and 2 to 3D Virtual Elements.</p> <p>In all the developments, particular attention will be 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.</p>
<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>	1 Full Professors 1 Associated Professors 0 Assistant Professors 0 PhD Students
<b>Name of the research directors</b>	Massimiliano Cremonesi, Umberto Perego

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

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	597.75 €
<b>By number of months</b>	6

<b>National Operational Program for Research and Innovation</b>	
<b>Company where the candidate will attend the stage (name and brief description)</b>	DASSAULT SYSTEMES SIMULIA CORP - <a href="https://www.3ds.com/">https://www.3ds.com/</a>
<b>By number of months at the company</b>	6
<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	To be defined
<b>By number of months abroad</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<b>List of Universities, Companies, Agencies and National or International Institutions that are cooperating in the research:</b>



Universities:

- Università di Milano -Bicocca
- Università degli studi di Milano
- Leibniz University Hannover

Company:

- Dassault Systemes Simulia Corp

**Educational activities** (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): 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** (availability of funding in recognition of support to teaching activities by the PhD student): 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, being 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 and desk availability:** Each Ph.D. student has his/her own computer for individual use. Each Ph.D. student has his/her own desk, cabinet and locker.