POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: NUMERICAL MODELLING AND EXPERIMENTAL CHARACTERIZATION OF COMPOSITE STRUCTURES

Monthly net income of PhDscholarship (max 36 months)
1500.0 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	Composite materials and technical polymers, both reinforced and unreinforced, are widely employed for mechanical applications and have been studied extensively in the past decades. However, when employed in structures and components, the complexity of the environmental and loading conditions often makes their mechanical behaviour unclear and difficult to predict, particularly in the framework of durability (fatigue and creep). Understanding these aspects is crucial for an efficient and effective use of composite materials in components that can withstand long-term use in demanding environments without failure. Moreover, innovative and recent technologies like additive manufacturing are emerging as possible alternatives to established processes like injection or compression moulding or lamination. This poses new challenges, related to the specific microstructure and the different manufacturing routes. Additive manufacturing causes an anisotropic behaviour due to layer-by-layer construction and coherent fibre orientation, while in conventional technologies the fibre orientation is determined manually (for lamination or other methods involving continuous fibres) or by the stochastic distribution due to in-mould flow (for injection or compression moulding).The proposed research aims at investigating and modelling the mechanical behavior of composite materials and polymers, with a focus on their use in industry-relevant scenarios. This involves specific approaches that combine

	experimental testing, advanced monitoring techniques, and simulation tools to develop a thorough understanding of the materials' behavior when adopted in structures and parts.
Methods and techniques that will be developed and used to carry out the research	The research is planned to have both experimental and modelling activities. Experimental Activities:The experimental activities will focus on both quasi-static and fatigue testing of materials and structures. These tests will be enhanced by advanced monitoring techniques to ensure precise and comprehensive data collection. Key techniques to be employed include: Digital Image Correlation (DIC), Micro Computed Tomography (Micro-CT), particularly useful for identifying internal defects, porosities, and the overall internal structure of the materials being tested, and various Non-Destructive Testing (NDT) Methods to assess the integrity and properties of the materials without causing any damage. Modelling Activities:The modelling activities will be centered around the development and refinement of simulation tools within the framework of Finite Element Modelling (FEM). The aim is to develop new or improve existing design tools for composite structures. These activities will include: Validation of experimental tests: Utilising FEM to reproduce the mechanical tests on materials and structures. FEM will be used to analyse the stress, strain, and deformation of the specimens and parts tested under different loading scenarios. The aim is to gain a deeper understanding of the material behavior and to validate the experimental results. Development of design Tools: Creating accurate and efficient simulation models to predict the behaviour of materials and structures under various conditions. This involves developing new algorithms and improving existing ones to enhance the accuracy, efficiency and reliability of the simulations. Integration of Experimental Data: Incorporating data obtained from experimental activities into the simulation models to improve their accuracy. This includes using DIC data for surface strain validation and Micro-CT data for

	internal structure representation in the models. The research activity is particularly suited for candidates who have experience in either experimental techniques, such as DIC and Micro-CT, or modelling activities, particularly in FEM. Ideally, the candidate will have experience in both fields, as this dual expertise will allow for a more integrated and comprehensive approach to the research. Coding skills are also consider essentials, but can be developed during the doctoral training. Candidates with a background in material science, mechanical engineering, or a related field, and who have hands-on experience with these advanced techniques and modelling tools, will be well-prepared to contribute to and benefit from this research project.
Educational objectives	The Doctor in Mechanical Engineering will be able to define, start and carry out original research by working in a team or leading a research group. Both theoretical and experimental skills will be mastered.
Job opportunities	The holder of a PhD in Mechanical Engineering will have job opportunities in structures/organizations aimed at innovation and/or research and technical development, high-tech SMEs, and government departments ruling on public needs. Specifically, the proposed research topic can offer job opportunities in the field of advanced manufacturing of composite structures. Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/ The activities planned for this thesis could lead to possible cooperation with the following universities •AMADE (Analysis and Advanced Materials for Structural Design) research group of the University of Girona •KU Leuven •TU Delft •EPFL
Composition of the research group	1 Full Professors 1 Associated Professors

	1 Assistant Professors 4 PhD Students
Name of the research directors	Proff. A. Bernasconi, M. Carboni, Dr. L. Martulli

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month- net amount). Additionally, PhD candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3,000 to cover travel expenses. Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.