Luca Di Stasio

Early Stage Researcher

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Background

I am currently employed as a full-time PhD candidate in Polymeric Composite Materials at the Division of Materials Science, Department of Engineering Sciences and Mathematics, Luleå tekniska universitet (LTU) in Luleå, Sweden. I currently teach in 4 graduate-level courses offered in the subject of Polymeric Composite Materials. The courses are offered as part of the LTU-offered Master programme in Composite Materials and the international joint Master programmes in Materials Science and Engineering EEIGM/EUSMAT (European School of Materials Science and Engineering) and AMASE (Advanced Materials Science and Engineering). Previously, I taught at the École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM) in Nancy, France in undergraduate- and graduate-level courses in Solid Mechanics, Viscoelasticity, Linear Elastic Fracture Mechanics, Mechanics of Composite Materials. I also contribute to the research activities of the Polymeric Composite Materials subject at LTU, working on integrated computational and experimental mechanics of polymers and polymer composites with a focus on fatigue, fracture and damage. In addition, I am involved in the supervision of graduate students in the context of Master theses and project courses. I am actively involved in the continuous improvement of teaching practices in the subject of Polymeric Composite Materials by proposing new experimental activities for students (composites repair laboratory, bi-axial strain gauge measurements) as well as improving the virtual learning space of the courses offered in the subject. Furthermore, I actively contribute to the pedagogical research in Higher Education; currently I am working on a contribution (article and oral presentation) to the upcoming *Development Conference for Swedish Engineering Education 2019*.

Higher Education Courses and Study Programmes

The work of my PhD thesis is devoted to the Linear Elastic Fracture Mechanics (LEFM) analysis of microscopic initiation of transverse cracking in thin-ply FRPC with the Finite Element Method (FEM). At the microscale, transverse cracks originate from fiber/matrix interface cracks or debonds, which coalesce to form what macroscopically are seen as transverse cracks. Debonds have been investigated in the past, but studies have focused on very few geometrical configurations with a restricted number of fibers embedded in an infinite matrix or homogenized composite. The novelty of my approach is twofold: analyzing configurations representative of FRPC laminates' microstructure and simulating a large number of geometrical configurations by automated model generation, simulation, data analysis, and reporting. Among other results, this approach has helped to prove a counter-intuitive claim: in cross-ply laminates the fiber/matrix interface crack, and thus initiation of transverse cracking, is influenced neither by the thickness of the $90°$ layer nor of the $0°$ ply, very differently from what has been observed macroscopically for transverse cracks. Furthermore, I have proposed a novel vectorial formulation of the Virtual Crack Closure Technique (VCCT) with which I have shown, both analytically and numerically, for the VCCT-computed Energy Release Rate (ERR) of the FEM-resolved circular interface crack (fiber/matrix interface crack): the logarithmic, and thus unbounded, nature of the convergence of Mode I and Mode II ERR; the independence of total ERR from mesh refinement and crack path direction.
Apart from the work of my PhD thesis, I have also been working on: the experimental assessment of transverse cracking in glass fiber/epoxy cross-ply laminates under different environmental and thermo-mechanical conditions (aging, high temperature, loading rate); the experimental investigation of the effect of temperature, degree of cure and curing history on mechanical properties of epoxy matrix under different combinations of thermo-mechanical loads.

Experience of Teaching and Supervision within Higher Education

In the short- to medium-term perspective, I am currently laying the groundwork for several future works: derivation of the vectorial VCCT from Eshelby's elastic energy-momentum tensor and proposal of a new mode-partitioning strategy based on eigenvalue analysis; investigation of fiber/matrix debonding with concurrent non-linear (viscoelastic, viscoplastic) behavior of the surrounding matrix; 3D modeling of fiber/matrix debonding; 3D imaging of fiber/matrix debonding using in-situ micro-tomography; development of an image analysis algorithm for automated stress-free temperature identification through curvature measurements of asymmetric laminates and its implementation with a temperature feedback loop on low-cost hardware (e.g. android handset, Arduino, Raspberry Pi); creation and real-time update of specimens' digital twins through low-cost hardware (Kinect for Xbox); application of Bayesian inference to the prediction of elastic, viscoelastic, viscoplastic, failure and fracture toughness properties.

In the long term, I envision the development of the distributed, de-centralized, remotely-controlled, integrated laboratory for composite science and engineering: a set of fully automated laboratories and high-performance computing clusters connected together by a decentralized network (peer-to-peer) and accessible through an online platform, to allow collaborative projects on integrated computational-experimental analysis and design of materials between parties located around the globe.