LMPS, UMR 9026

LABORATORY OF MECHANICS PARIS-SACLAY

On January 1, 2022 the Paris-Saclay Mechanics Laboratory (LMPS) was created from the merger of the Mechanics and Technology Laboratory (LMT) and the Mechanics of Soils, Structures and Materials Laboratory (MSSMat). The merger of these two laboratories was all the more natural as they share scientific themes on all facets of solid mechanics: mechanics of materials and structures, civil engineering, fine experimentation and high-performance computing. With nearly 220 members (half permanent members and half doctoral and post-doctoral students), this new research unit, dedicated to experimentation, modeling, and simulation in solid mechanics, aims to contribute to meeting the challenges in the strategic areas of safe and efficient clean energy development, resource management and adaptation to climate change, sustainable transport, and urban systems, reliability of complex systems and industrial renewal. To help overcome the associated scientific challenges, It develops both experimental observation and characterization methods, aims at formulating appropriate models for the physically identified mechanisms, and advanced computational methods and simulation codes able to handle these models efficiently.

With 3 research support resource centers, a management center, an experimentation and development center and a simulation center, the laboratory comprises 4 research teams, plus 2 joint laboratories run by the laboratory and an international partnership with the University of Hanover.

Research Teams

COMMET: Materials Behaviour, Modeling, Experimentation and Theory

The objective is to develop tools for observing and quantifying deformation, damage and failure mechanisms, to propose and formulate reliable mathematical behaviour models for materials and structures, and to implement them numerically. These physically-based models of mechanical behaviour are intended to be adapted to industrial problems and needs and to predict the behaviour of these materials and structures in service and in extreme conditions.

The team pays particular attention to the development of state-of-the-art experiments, from the atomic scale, with transmission electron microscopy (TEM), to the scale of the continuous medium and structures, via intermediate scales with the latest generation tools such as the SEM-FIB, SEM, nanoindenter, tomograph, X-ray diffractometer, etc., within which in situ mechanical tests are carried out. These developments involve complex loadings (uniaxial or multiaxial, under monotonic or non-monotonic conditions, quasi-static or dynamic, fatigue, multiphysics, under environment). This includes aspects from test management to the most modern techniques for identifying and validating models developed in parallel in the team.

STAN: Advanced Science and Techniques in Numerical Mechanics

The core business of the team is modeling and simulation in mechanical engineering sciences and its interactions. Closely blending classical disciplines (material sciences, applied mathematics, etc.) and other more emerging disciplines (such as AI), the team develops modeling approaches and computational strategies that integrate new knowledge and allow to address major societal challenges. These approaches and strategies are focused on the analysis of physics and are largely influenced by the needs of the mechanical engineering sectors and their interactions, so that they are adapted, effective and innovative in an industrial context.

One of the team's objectives is to contribute, through its upstream research productions, to the progress of mechanical sciences in terms of advanced modeling and numerical simulation. This progress is necessary to better understand and apprehend the complex physical systems studied, and to meet current and future challenges in various fields such as health, energy, the environment and mobility.

Another objective of the team is to make a strong and relevant contribution to controlled design in multiple industrial sectors, under increasingly demanding specifications (safety, durability, cost, impact on the environment, compatibility with engineering time, etc.) requiring the elaboration and processing, at the right cost, of increasingly complex problems (multi-scale, multi-physics, stochastic, etc.). The aim is to propose methods and tools to assist in the decision making process in order to imagine, design, characterise, optimise, certify and control the complex materials, structures and systems of today and tomorrow, and thus contribute to the development of the industry of the future.

MILA: Architectural Environments

Some materials, biomaterials or structures, whether manufactured or natural, derive their particular properties from the organization of their internal constituents. The study of the mechanisms and interactions that determine these functional properties at different scales is the focus of our research.

The team is then particularly interested in:

- the different levels of structural organization of organs such as bones and teeth, from their biofabrication in vitro from cells to their repair or regeneration in vivo;
- the synthesis and inclusion of nano-reinforcements in polymeric, ceramic or metallic composite materials in order to couple and optimize multiphysical properties;
- filament assemblies that can constitute composite reinforcements; composite materials for the transport and energy industries;
- non-classical macroscopic behaviour resulting from complex interactions between fibrous components at lower scales.

OMEIR: Structures, Materials, Environment: Interactions and Risks

The upcoming climate transition will significantly increase natural hazards on structures, infrastructures and urban systems. The increasing density of urban environments and the interconnection of systems increase the exposure and vulnerability of societies that want to be increasingly protected. The transition from a prudential society protected by law and regulation to an insurance society requires an assessment of risks and associated uncertainties at increasingly fine scales.

Part of the answer lies in the implementation of numerical twins or even hybrids. Simulation methods, however advanced, are not sufficient, due to lack of data or insufficient validation. Massive data, routinely acquired by monitoring and maintenance systems, must be assimilated and analyzed by these digital twins as they are beginning to exist in other sectors. Finally, advanced experiments on sub-systems but simulating the complete system must be able to be carried out to better control the uncertainties associated with the models.

Thus, the OMEIR team proposes to contribute to the energy, ecological and digital transition of the entire sector related to cities and infrastructures. To do this, it brings together the expertise of research groups specializing in: construction materials and natural materials, the modeling of various physical phenomena (mechanical, thermal, hydric, chemical), fine experimentation, natural risks, complex and large-scale numerical simulations and statistical learning.

RESOURCE CENTERS

Experimentation and Development Center

The Experimentation and Development Center brings together the resources dedicated to experimental research at LMPS. The Experimentation and Development Center (EDC) is a research support department reporting to the laboratory management. It brings together the testing resources and associated skills pooled for the laboratory's experimental research. The EDC is first and foremost a team of twenty engineers and technicians. This team is responsible for the development of original and unique experiments, from design to final measurement. It is also responsible for maintaining the equipment and training researchers in its use. EDC's premises cover an area of 4,000 m². The equipment is dedicated to the analysis of all types of materials: metals, ceramics, concretes, composites, nanomaterials, living tissues, etc. The samples characterized range in scale from the nanometer to the meter: from the arrangement of atoms to structural elements up to three meters long. The material resources of these poles are spread across the two LMPS sites: CentraleSupélec and Ecole Normale Supérieure Paris-Saclay.

Simulation Center

The Simulation Center has a staff of 7 and is organized into 2 divisions: Administration & Networks and Development. The main mission of the LMPS Simulation Center is to provide LMPS members with a hardware, software and service environment that is sufficiently powerful, reliable and secure to enable them to work in optimum comfort and efficiency. It offers an environment based on Linux platforms for the use of industrial software and the production of scientific software incorporating the latest advances in research in the fields of materials and structures, as well as new multiscale, multiphysics and parallel computing strategies. It also ensures the operation of the various servers essential to the various activities.

Management center

The Management center supports and advises LMPS members in their day-to-day scientific and technical activities. It is responsible for the administrative, financial and budgetary management of the laboratory. The center focuses on 5 main axes: Budget - Finance, Human Resources, Communication, Development, Logistics.

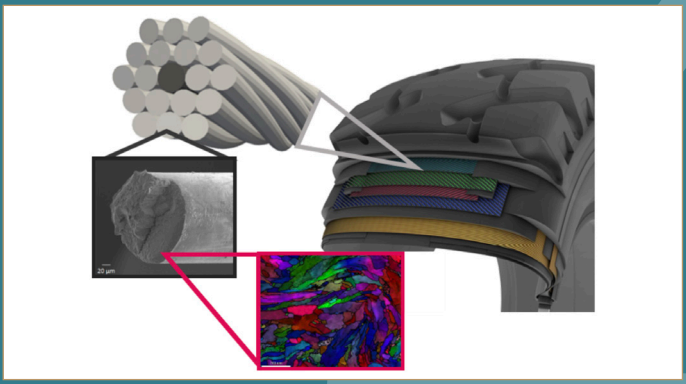
APPLICATION DOMAINS

- Safe and efficient clean energy
- Sustainable transport and urban systems
- Reliability of complex systems
- Industrial renewal
- Sober resource management
- Safe societies - protecting freedom and security.

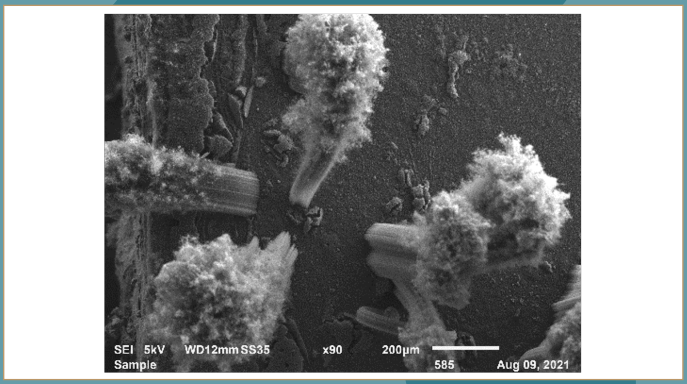
HIGHLIGHTS 2023

- LMPS, Safran Aircraft Engines and SafranTech have set up a joint research programming group (GPRC) on the theme of "Numerical and experimental mechanics for the performance of aeronautical engines and structures".

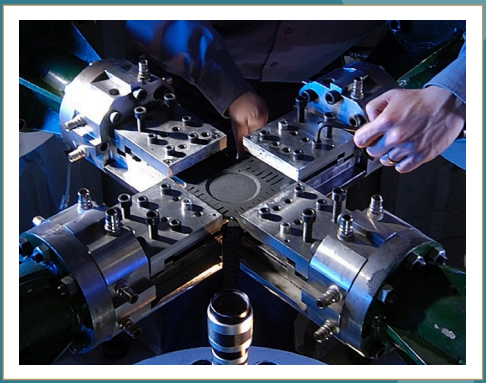
- The L'Oréal-UNESCO Foundation's *Prix Jeunes Talents France 2023* For Women In Science was awarded to **Amandine Asselin** for her thesis work on chloride diffusion in concrete, carried out at the Laboratoire de Mécanique Paris-Saclay, in co-supervision with Polytechnique Montréal. The prize is awarded each year to 35 young women researchers, and aims to support the involvement of young women in scientific research.



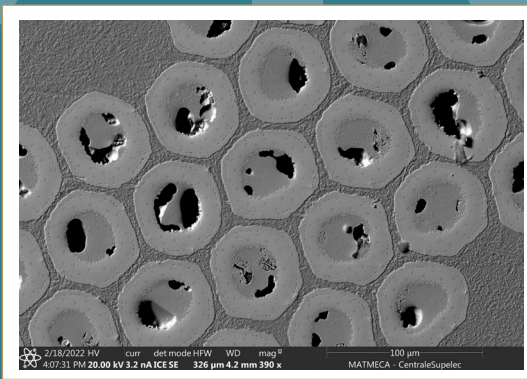
The need for multi-scale approaches to tire design



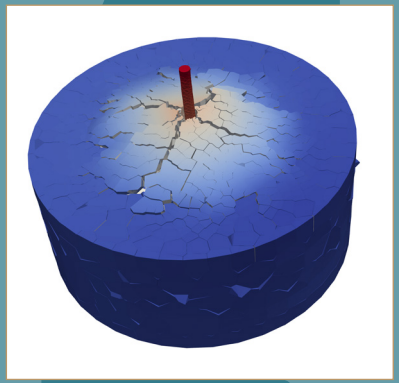
Carbon nanotube NanoCabbages



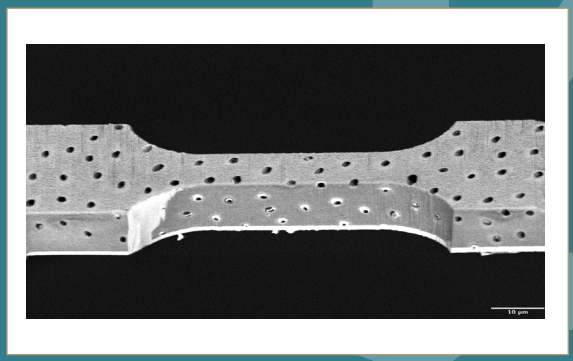
2D multiaxial test with the triaxial testing machine ASTREE



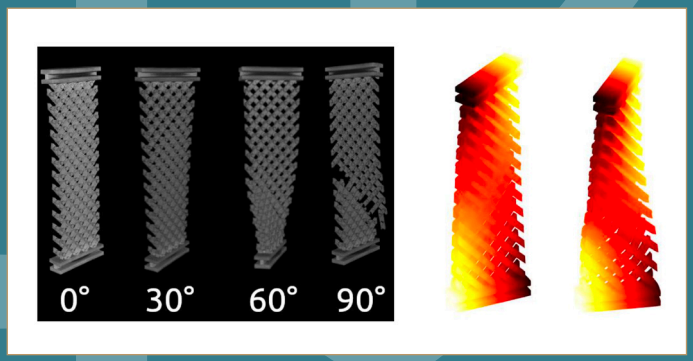
View of a superconducting strand Niobium–tin



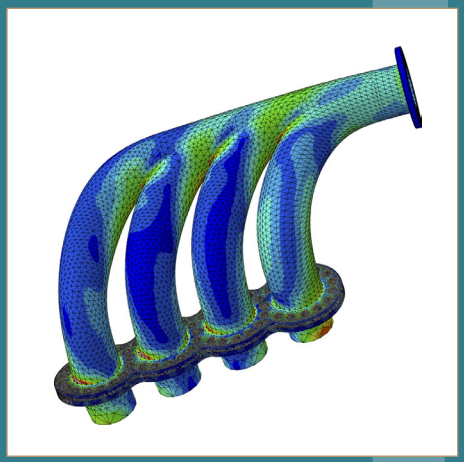
Particle-lattice model simulation of the pull-out of a pegged anchoring system



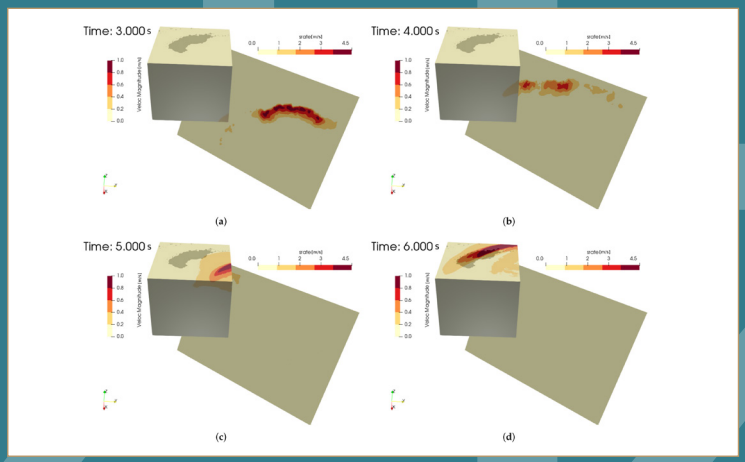
Micro-tensile test piece in dentine



In-situ torsion testing of a 3D printed pantograph under tomography with image correlation



Study of a manifold avatar with connector model for bolted connections



Simulation of the seismic response of the Argostoli basin using SEM3D on HPC facilities (local Paris-Saclay University meso-center and National Occigen)

Industrial Partners

- Airbus, Ariane Group, CNES, Dassault Aviation, MBDA, Safran, Thalès
- Renault, Stellantis, Michelin, RATP, SNCF
- EDF, IRSN, IFP, Mitsubishi Electric, Orano, Saint-Gobain
- ArcelorMittal, Aperam, Tata Steel, Vallourec
- Bouygues construction, Ecocem, sixense, ANDRA, CEMENTYS, IREX
- Altair, Dassault Systèmes, EikoSim, ESI, SIEMENS
- Air Liquide, BIOMODEX, cetim, GE Healthcare, iXblue.

Academic Partners

CEA, DGA, INRIA, ISL, ONERA
Institut Farman, Fédération francilienne F2M-msp, Collège doctoral Franco-Allemand SNTA
ICMMO (Université Paris-Saclay), MATEIS (INSA Lyon), Centre des Matériaux et CEMEF (Mines Paris-Tech), LMS (Polytechnique), SPMS et LGPM (CentraleSupélec), ONERA (DMAS), KTH (Suède), Université de Zagreb (Croatie), UFSCar et USP (Brésil), Université Leibniz de Hanovre (Allemagne), Université Rome Sapienza et l'Aquila (Italie), Université Trondheim (Norvège), Université du Kansas (USA), Université de Talca (ECOS), Université de Sao Paolo, Università di Roma la Sapienza, Laser Institute of Shandong Academy of Science, Ecole Polytechnique de Montréal, MSME(U. Paris-Est Créteil / U. Paris- Est MLV), IJRLDA (Sorbonne U.), PIMM (ENSAM), GeM (EC Nantes/U. Nantes), LVTS et URB2i (U. Paris), G2ELab (U. Grenoble), CRPP (U. Bordeaux), LiPHY (UGA Grenoble).

Key figures

• Professors, Associate Professors & Researchers	65
• Engineers & Administrative staff	31
• PhD Students	90
• PostDocs	10
• Visiting Professors	3
• Publications of the year (WoS)	155

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