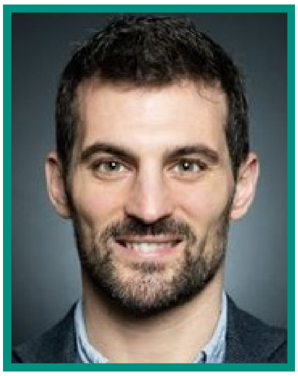
Politecnico di Torino
Department of Structural, Geotechnical and Building Engineering

DISEG



PROF. EMILIO MARTINEZ-PANEDA

Virtual testing of components exposed to hydrogen and corrosive environments

Monday, 10th June 2024 11:00 AM
Albenga Room - DISEG Entry 1 - 2nd Floor

The biggest challenges in science and engineering arguably lie at the interface between disciplines. We have a good understanding of how materials and structures behave when subjected to mechanical loads but predicting material behaviour due to combined exposure to applied loads and a degrading environment has long been considered to be an elusive goal. Complex environmentally-assisted material degradation phenomena such as localized corrosion, hydrogen embrittlement and corrosion fatigue are difficult to predict and continue to compromise the durability of structures and materials. The problem has very much come to the fore in recent years due to the ageing of our infrastructure, the rise of the hydrogen economy, and the higher susceptibility to hydrogen embrittlement of modern, high-strength alloys.

The speaker and his collaborators have pioneered the development of electro-chemo-mechanical phase field formulations for localized corrosion and hydrogen embrittlement, which can predict environmentally-assisted material degradation as a function of the environment, the material and the loading conditions. The talk will address the steps taken to achieve this milestone and showcase the predictive capabilities of the models developed. Emphasis will be placed on how the use of the phase field paradigm can be used to track the evolution of the corrosion front and the growth of cracks, as assisted by hydrogen. This has enabled us to explicitly resolve the underlying electrical, chemical and mechanical physical mechanisms at play, removing assumptions from the modelling and providing a mechanistic, physically-based framework for corrosion and hydrogen embrittlement, for the first time. Model predictions will be compared with a wide range of experiments on samples exposed to corrosion and hydrogen-containing environments, showcasing the success of phase field approaches in enabling predictive modelling in the areas of corrosion and hydrogen embrittlement. Large-scale case studies of engineering interest will also be addressed to demonstrate the potential of multi-physics phase field modelling in enabling Virtual Testing in corrosive and hydrogen-containing environments. Among others, these will include simulations addressing two case studies of significant technological interest: (1) quantifying the critical pressure at which hydrogen can be transported in natural gas pipelines without leading to structural integrity issues in welds, and (2) conducting reliable virtual hydrogen-assisted fatigue crack growth experiments for arbitrary choices of loading frequency, material, load ratio, pre-charging condition, and hydrogen pressure. Finally, it will be shown how phase field corrosion and hydrogen embrittlement approaches can be combined to develop a generalized multi-phase field formulation that can predict environmentally-assisted cracking phenomena for arbitrary choices of environment without any ‘a priori’ assumption on the dominant mechanism.

BIO:
Prof Emilio Martinez-Paneda is an Associate Professor at the University of Oxford. Prior to joining Oxford, he was a Reader (Associate Professor) at Imperial College London, where he led an interdisciplinary research group from 2019 to 2023 (2019: Lecturer, 2021: Senior Lecturer, 2023: Reader). Before that, he was an 1851 Research Fellow at the University of Cambridge. Prof Emilio Martinez-Paneda’s research spans a wide range of challenges lying at the interface between mechanics and other disciplines such as biology, geology, chemistry and materials science, being particularly known for his pioneering contributions to the area of hydrogen embrittlement. Prof Emilio Martinez-Paneda has been the PI on over 4.5M GBP of funding in the past five years (ERC Starting Grant, UKRI) and his work has been recognized through multiple awards, including the 2021 UK Young Engineer of the Year (Royal Academy of Engineering), the 2022 Imperial College President’s Medal for Excellence in Research, and the 2021 Gustavo Colonnetti Medal (RILEM).