



**UNIVERSITY OF PISA**  
**Department of Civil and Industrial Engineering**  
Visiting Fellows Programme 2021

On Friday 28 May 2021 from 10:30 to 11:30

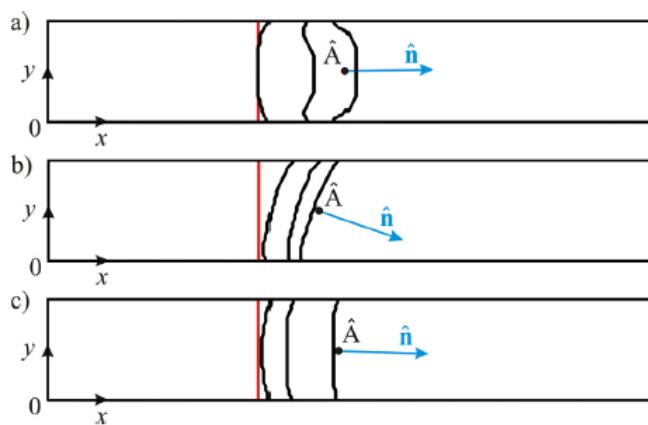
**Prof. Sylwester SAMBORSKI, DSc PhD Eng**

Associate Professor at Lublin University of Technology, Poland,  
and Visiting Fellow at the University of Pisa, Italy,

will hold a seminar titled

## **Finite Element Analysis of Interlaminar Crack Propagation in CFRP Laminates with Elastic Couplings**

**Abstract.** The field of applications of composite laminates in contemporary engineering could be extended with usage of coupled layups. Similarly to the standard CFRP laminates, those with general orientation of fibers in subsequent plies are prone to damage having a common form of delamination. The lecturer will present his attempts to properly simulate delamination onset and propagation using the finite element method (FEM) led on the multidirectional CFRP beam models to obtain the distributions of the strain energy release rate along the crack front. The FEM simulations in general preceded the experiments led by the lecturer's team in order to plan the tests properly. The virtual crack closure technique (VCCT) was used in the simulations performed with the Abaqus FEM software with the Reeder Law exploited as the fracture criterion because of its capability to describe the three separate fracture modes, as well as the mixed modes. In particular, an original approach to trace delamination propagation direction with the equipollent vector in case of the elastically coupled laminates will be explained. The specialized Python scripts were elaborated and applied to the Abaqus output database files for three typical fracture toughness tests simulations. The results obtained in 2D space were more than satisfactory – compared to the experimental outcomes – and could be related to other measures of the delamination process irregularities, defined in the preceding articles of the author's. The presented front-tracking method can be generalized to 3D space, with respect to anticlastic effects influencing the overall deformation of the coupled laminated beams.



The seminar will be offered through Microsoft Teams at <https://tinyurl.com/uakb3ct4>

For further information, please contact Prof. Paolo S. VALVO ([p.valvo@ing.unipi.it](mailto:p.valvo@ing.unipi.it)).

**Acknowledgement:** The research was financially supported by the Ministerial Research Project No. DEC-2016/21/B/ST8/03160 financed by the Polish National Science Centre. Financial support from the University of Pisa through the Visiting Fellows Programme 2021 is also gratefully acknowledged.