ANTHONY M. WAAS-UNIVERSITY OF MICHIGAN

A SEMI-DISCRETE MODEL

A SEMI-DISCRETE MODEL FOR PROGRESSIVE DAMAGE AND FAILURE OF FIBER REINFORCED LAMINATES

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ABSTRACT

High-strength and high-stiffness carbon fiber-reinforced polymer composite laminates (CFRP) are being increasingly used for primary load bearing structures in many industries. The most common material system used is based on thermoset resins (matrix material), which come in the form of convenient prepreg tapes allowing high flexibility and productivity using advanced automated manufacturing technologies. Engineers must provide robust and predictive models for the deformation response and failure of these materials and structures. The mechanisms responsible for progressive damage accumulation and failure are (intralaminar) matrix cracks, which can lead to delamination initiation and spreading resulting in ultimate failure. Interlaminar fracture in CFRP, often called delamination, is defined as an out-of-plane discontinuity between two adjacent plies of a laminate. Delamination behavior has been studied by many researchers and now can be characterized in a standardized manner. Fracture properties of Mode I, Mode II, and mixed-mode (between Mode I and Mode II) delamination can be obtained from ASTM standard tests in conjunction with finite element analysis (FEA). In a CFRP structural component, the intralaminar and interlaminar modes of failure interact, therefore developing a computational model to accurately replicate the failure mechanisms and their interaction has been challenging. In this presentation, a series of experimental results that delineate the different mechanisms of failure will be used as a foundation, for a novel and computationally efficient semi-discrete progressive damage and failure modeling framework that can be used for assessing the structural integrity and damage tolerance of CFRP structures.

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Prior to that he was the Boeing Egtvedt Endowed Chair Professor and Department Chair in the William E. Boeing Department of Aeronautics and Astronautics at the University of Washington (UW), Seattle. His current research interests are: robotically manufactured lightweight structures, computational modeling of composite structures, 3D printed structures, damage tolerance of composite structures, affordable textile composites, and data science applications in modeling of materials and structures. Professor Waas was the Felix Pawlowski Collegiate Chair Professor of Aerospace Engineering and Director, Composite Structures Laboratory at the University of Michigan, from 1988 to 2014, prior to joining UW in January 2015. He assumed his current position in Fall 2018. Professor Waas is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineering (ASME), the American Society for Composites (ASC), the American Academy of Mechanics (AAM) and the Royal Aeronautical Society, UK. He is a recipient of several best paper awards, the 2016 AIAA/ASME SDMaward, the AAM Jr. Research Award, the ASC Outstanding Researcher Award, and several distinguished awards from the University of Michigan, including the Stephen S. Attwood award for Excellence in Engineering, one of the highest honors for an Engineering faculty member at the University of Michigan. He received the AIAA-ASC James H. Starnes, jr. Award, 2017, for seminal contributions to composite structures and materials, and for mentoring students and other young professionals. In 2017, Professor Waas was elected to the Washington State Academy of Sciences, and in 2018 to the European Academy of Sciences and Arts. He is also the recipient of the AIAA ICME Prize, 2020, and the ASME Warner T. Koiter Medal, 2020. Recently, Prof. Waas was elected to the US National Academies Aeronautics and Space Engineering Board. Prof. Waas was awarded the AIAA Dryden Lecture in Research to be presented in January, 2022 at the International AIAA SciTech Conference.