FRACTURE MECHANICS: CHALLENGES IN COMPOSITE AEROSPACE STRUCTURES

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ABSTRACT

The use of fiber-reinforced composite structures has become commonplace in aerospace due to their weight reduction potential over metallic structures. Typically, a building block approach is used for certification: starting with small coupon tests for foundational material property development; moving to mid-level element and sub-component part tests for design detail evaluation and analysis method validation; and culminating in component and full-scale tests for high fidelity loads and analysis method verification. Over the past decades commercial airplane companies have established large databases with proprietary material data coupon and mid-level element test data to populate the building block. While the tailorability of composite laminates reinforces the weight advantage of composites over metals, the large number of possible permutations also exponentially grows the number of tests in the building block, thereby hindering timely and cost-efficient introduction of new materials, laminate configurations, structural architectures, or manufacturing methods. Boeing has therefore been advocating and implementing the concept of *smarter* testing through simulation [1]: *smarter* testing will maximize the benefit of *necessary* testing, expand our understanding of performance within and beyond the test envelope, and minimize unplanned tests in attaining certification. Some examples of successful applications of smarter testing at the higher building block levels will be shared. In addition, scenarios of where composite modeling might benefit from the application of fracture mechanics simulation in combination with uncertainty quantification and scientific machine learning will be discussed. Finally, the talk will be concluded with a deliberation on the challenges of applying uncertainty quantification and machine learning to aerospace structures design and certification.

REFERENCES

[1] S. Chisholm, J. Castro, B. Chapman, K. Karayev, A. Gunther, and M. Kabir, Smarter Testing Through Simulation for Efficient Design and Attainment of Regulatory Compliance, *ICAF 2019 – Structural Integrity in the Age of Additive Manufacturing*, 292–307, 2020.