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PRACTICAL CHALLENGES IN FORMULATING VIRTUAL TESTS

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ABSTRACT

Recent successes in developing high fidelity simulations of damage evolution in engineering structural composites will be reviewed, which encourage the expectation that virtual tests may soon replace many (but never all) real tests in the design and qualification of composite structures. We shall consider especially the problem of linking top-down and bottom-up modeling approaches (or, we might say more realistically in today's modeling world, reconciling opposing top-down and bottom-up mind-sets!). The top-down view of damage modeling seeks the least complex model that will represent all the mechanisms of damage that have an observable effect on the outcome of an engineering test. This stipulation leads to the association of a length scale with any mechanism, which defines the minimum volume that must be affected by the mechanism for its consequences to be macroscopically observable. The length scale can also be associated with parameters that describe the constitutive behaviour of the deforming material in the affected volume. The bottom-up approach seeks to account for macroscopic deformation and failure starting from models at much smaller scales, even down to single atoms and molecules. Results from bottom-up studies often map into top-down strategies by informing a model that describes localized material nonlinearity within the material (gauge length) affected by a particular mechanism. Thus the influence expressed in terms of the gauge length can be transferred to decide whether a detail that has been analysed in bottom-up work will be important to structural response. In all of these considerations, experiments are an essential presence, determining mechanisms and the influence of mechanisms, calibrating nonlinear material constitutive laws, and testing the correctness of predictions. Some interesting challenges arise in inventing experiments that can perform all these tasks: the information that will decide key questions is often beyond the resolution of current techniques and apparatus.