Failure Criteria for Design

Failure Criteria for Polymer Composites under 3D Stress States: The Second Worldwide Failure Exercise (WWFE-II)
MJ Hinton, AS Kaddour (QinetiQ)
The authors (hereafter referred to as the ‘organisers’) are coordinating a ‘Second World-Wide Failure Exercise’ (WWFE-II) to establish the current status of theoretical methods for predicting structural failure in fibre reinforced composite materials when subjected to 3-D states of stress. (F12:1)

Closed-Form Equations for Composite Strengths: from Constituents to Structures
Z-M Huang, Ye-X Zhou (Tongji Univ)
Closed-form equations for calculating progressive failure strengths of a laminated composite by using its constituent properties and laminate geometric parameters are available based on the micromechanics bridging model. Through a user-subroutine UGENS, the bridging model theory has been incorporated into ABAQUS to define elemental instantaneous stiffness matrix and to capture ultimate strength of a structure made of or containing composite laminates. (F12:2)

Failure Testing of Large Composite Aerospace Structures
GE Sanford, AC Biskner (CSA Engineering Inc) JS Welsh (US Air Force ORS)
Large composite aerospace structures were tested to failure under flight-like static load conditions. Through rigorous test discipline and testing of relevant aerospace hardware, this research program provides previously unavailable experimental data to validate and augment current and advanced analytical techniques. (F12:3)

Multiscale Hybrid Failure Approach for Strength Analysis of Composite Structures subjected to Complex 3D Loadings
F Laurin, N Carrère, J-F Maire (ONERA)
A micromechanical based hybrid mesoscopic approach is proposed to predict the failure of laminates under complex triaxial loadings, such as combined hydrostatic pressure and in-plane loadings. The main idea of this model is to introduce micromechanical aspects (effects of local debondings on the behaviour and strength) at the mesoscopic scale. (F12:4)

Pressure-Dependent Constitutive and Failure Model for Laminated Composites
ST Pinho, P Robinson (Imperial College London) C Schuecker (Luxner Engineering ZT) PP Camanho (Univ do Porto)
This paper presents a non-linear, pressure-dependent, three dimensional constitutive law and associated failure criteria for laminated composites with UD plies. The failure criteria result from a physical model for each failure mode. In-situ strengths are used for matrix failure and fibre kinking. The model is validated against experimental data. (F12:5)

A Unique Criterion for Describing Failure of Foam Core Sandwich Materials- A Design Engineering Perspective
J Feldhusen, SK Krishnamoorthy (KWTH Aachen)
The Tsai-Wu criterion in its simplified or modified form could be quite suitable to describe the failure of most of the commercially available cellular foams and for proper dimensioning of foam core sandwich materials. Using this criterion for closed cell polyvinylchloride foams (PVC) has already shown good agreement with the experimental results [1]. (F12:6)
Damage Prediction in Polymer Composites: Preliminary Results from the Third Worldwide Failure Exercise (WWFE-III)

MJ Hinton, AS Kaddour (QinetiQ), S Li (Univ of Manchester), PA Smith (Univ of Surrey)

The need for a comprehensive understanding of damage prediction is driven by a clear and steady increase in the use of composites in current and future aerospace and other industries, and also by the lack of robust design criteria for predicting accurately the occurrence of damage and its subsequent significance. (F12:7)

Multicontinuum Failure Analysis of Composites

AC Hansen, DJ Kenik (Univ of Wyoming), EE Nelson (Firehole Technologies)

A progressive failure analysis of composite laminates is presented. The analysis efficiently crosses multiple geometric scales to capture microstructural information where failure initiates while recognizing the practical constraints imposed by the size of the structure. Comparisons to coupon level data as well as analysis of a composite pressure vessel are presented. (F12:8)

Development of a Failure Criterion for Cavitation Induced Failure Under Transverse Loading in Model Multi-Fiber Composites

D Foster (US Air Force RL) G Tandon (Univ of Dayton)

Using model composite systems employing a novel cross shaped specimen, matrix cavitation was observed to occur as a function of fiber spacing. The cruciform shaped specimens utilized multiple fibers positioned transverse to the applied load. Analytical results indicate that a 3D analogy to the Mohr-Coulomb criterion predicts the occurrence of cavitation initiation. (F12:9)

Caspar Payload Adapter Structural Failure Test Results and Analytical Predictions

A Biskner, G Sanford (CSA Engineering) J Welsh (US Air Force ORSO)

The CASPAR payload adapter was tested to structural failure at the Air Force Research Laboratory as part of a larger program intended to determine the ultimate capacity of three large composite structures and to evaluate failure analysis methods. This paper discusses the failure test results, comparing them to multiple analytical predictions. (F12:10)

Optimization of a Cruciform Composite Specimen under Biaxial Loading by Means of Evolutionary Algorithms

E Lamkanfi, W Van Paepegem, J Degrieck (Ghent Univ) A Makris, C Ramault, D Van Hemelrijck (Free Univ of Brussels)

In this paper a newly developed algorithm based on evolutionary strategies is presented for the optimization of a composite specimen under biaxial loading. Starting from a general geometry with a specific lay-up, the strain is increased significantly in the central zone which is necessary to characterize the material in biaxial (fatigue) loading. (F12:11)

Generating Design Allowable from Smooth Specimens

PD Shah, JDD Melo, CA Cimini Jr (Stanford Univ)

The use of notched specimens (open hole and filled hole specimens) to generate design allowable is common practice among aircraft designers. In this work, numerical models were applied in a parametric study to investigate the effects of parameters such as ply orientation and loading conditions (uniaxial and bi-axial) on the strength of smooth and open hole specimens. (F12:12)