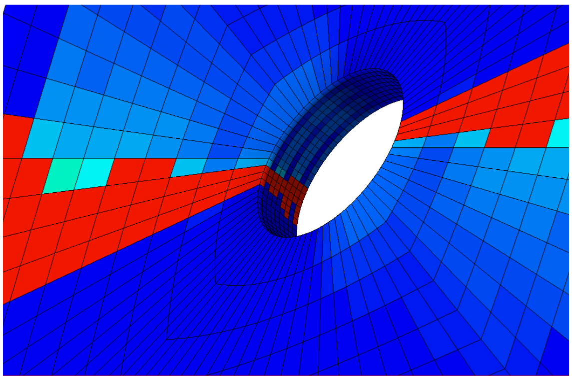
Case Study: Digimat Virtual Allowables

Allowables … at your fingertips

Challenge

Designing lightweight CFRP structures with confidence requires access to allowables values. Allowables generation is extremely time and money consuming.

Various layups, coupon tests and environment conditions must be covered for each characterized material system. Each test configuration must be repeated many times to obtain a statistical evaluation of the mechanical property.



Failure pattern of open hole tensile test

"NIAR has been researching on virtual allowable development for past few years and was excited to see some of the methodologies are implemented in Digimat-VA in a user-friendly manner. NIAR and e-Xstream partnership brings the knowledge of decades of material allowable development and simulations to produce great tools such as Digimat-VA."

– Dr Waruna Seneviratne, Sr Research Engineer, Wichita State University, NIAR

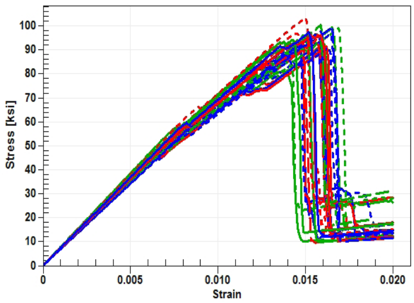
Solution

Virtual allowables can be predicted thanks to advanced multiscale simulation. By combining mean-field homogenization, progressive failure, non-linear FEA analysis and stochastic methods, allowables become accessible at a fraction of the usual cost and time. Material models are calibrated based on standard ply level stiffness and strength data, thus requiring minimal user input.

Results/Benefits

Design can start using virtual allowable in parallel to physical testing. Virtual allowables can be used to test any desired layup and select the most promising candidates for physical testing.

Root-cause analysis of the laminate strength distribution becomes accessible.



Results Validation / Correlation to Test Data

Digimat-VA has been applied on AS4/8552 UD material at Room Temperature Dry condition.

Unnotched (UNT) and open hole tension (OHT) tests for quasi-isotropic (layup1), soft (layup2) and hard (layup3) layups were considered. *(Figure 1)*

Using ply properties provided in NCAMP NCP-RP-2010-008-Rev D document, the following predictions where obtained. *(Figure 1)*

Test	Digimat-VA prediction (ksi)	Experimental mean strength (ksi)	Error
UNT1	92.05	88.6	3.9%
UNT2	60.48	63.62	-5.0%
UNT3	157.95	152.3	3.7%
OHT1	46.95	47.6	-1.4%
OHT2	33.44	39.17	-14.6%
OHT3	72.20	68.55	5.3%

Figure 1: Prediction of laminate mean strength

Constituent properties and fiber volume fraction coefficient of variability (CoV) can be reverse engineered from 0 and 90° ply level CoV. Applying the known or identified micro-level CoV and running 30 iterations of each test allows to compute A and B-basis values. *(Figure 2, Figure 3)*

Digimat-VA successfully predicted allowable values within 10% error for all cases except the soft open-hole tension scenario. Typical run times for unnotched tests were 3 minutes, while it look less than 10 minutes for open-hole cases.

Identified prameter	Value
Matrix Young (CoV)	10%
Matrix Strenght (CoV)	10%
Fiber Axial Strenght (CoV)	5%
Fiber Strenght (CoV)	4%
Fiber Volume Fraction (CoV)	3%
Fiber Allignment (std dev)	1 °

Figure 2: micro-level variability parameters

	Digimat-VA B-basis (ksi)	Experiment B-basis (ksi)	Error	Digimat-VA A-basis (ksi)	Experiment A-basis (ksi)	Error
UNT1	84.17	80.13	6.0%	78.3	74.12	5.6%
OHT1	43.06	45.11	-4.5%	40.41	43.43	-7.0%

Figure 3: virtual allowable comparison with experiment for several laminates

Key Highlights:

Digimat:
Digimat-VA

Industry:
Aerospace, Automotive

For more information on Digimat and for additional Case Studies, please visit www.e-Xstream.com

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