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PROGRESSIVE FAILURE ANALYSIS OF FILLED HOLE AND BEARING COMPOSITE LAMINATE BOLTED JOINTS

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ABSTRACT

Bolted joints are extensively used in composite aircraft assemblies because of their efficiency in transferring loads and ease of maintenance. The aircraft industry calculates the reserve factor of bolted joints by comparing the internal loads from a linear finite element model against the material allowables calculated with an analytical approach. While this methodology has proven successful in the development of commercial aircrafts, the calibration of analytical models relies on large experimental campaigns that results in significant cost and lead time. The aim of this study is to simulate the progressive failure of composite bolted joints using two mesoscale continuum damage mechanics (CDM) models. The advantage of using CDM models for predicting failure load is that, once validated, a lower number of tests would be required for aircraft sizing. Also, this will result in more accurate strength predictions by accounting for the different phases of the damage progression: initiation, stress redistribution, and softening. In this study, two constitutive models currently under evaluation in Airbus are investigated:

- The damage model developed at the University of Porto-Girona [1] - [2].
- Onera Progressive Failure Model (OPFM) [3].

The analysis will first focus on elementary filled-hole/bearing specimens and subsequently increase in complexity to simulate more representative bolted joints. Composite laminates are made of carbon/epoxy unidirectional prepreg. The simulations are carried out by two consecutive steps: bolt preload and laminate loading; whereas the constitutive models are implemented in Abaqus/Explicit via user-defined subroutines. The mechanical response of the numerical models is compared against experimental data and analytical methods available at Airbus. Based on the observed tendencies, the study provides insight into anticipated challenges in order to implement the models at larger structural scale.

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