Experimental and numerical studies on the damage behavior of open hole CFRP composite specimen subjected to compression

Karthik Dongri[§], Naresh Reddy Kolanu[†], K Varaprasad[‡], Gangadharan Raju[*]

[§] PhD Student, Department of Mechanical and Aerospace Engineering,
Indian Institute of Technology Hyderabad, Telangana, India, 502285
e-mail: ME17MTECH11027@iith.ac.in
[†] PhD Student, Department of Mechanical and Aerospace Engineering,
Indian Institute of Technology Hyderabad, Telangana, India, 502285
e-mail: me13m15p000006@iith.ac.in
[‡] Mtech Student, Department of Mechanical and Aerospace Engineering,
Indian Institute of Technology Hyderabad, Telangana, India, 502285
e-mail: ME16MTECH11012@iith.ac.in
[*] NDT&E Lab, Assistant Professor, Department of Mechanical and Aerospace Engineering,
Indian Institute of Technology Hyderabad, Telangana, India, 502285
e-mail:gangadharanr@iith.ac.in- Web page: https://me.iith.ac.in/faculty.html

ABSTRACT

In this work, the progressive failure of open hole composite specimen subjected to compression is studied. CFRP laminates of various stacking sequence (unidirectional, cross-ply, quasi-isotropic) with a circular hole are fabricated and tested under compressive loading. An anti-buckling compression fixture is used to prevent buckling of specimens. In this work, a unified experimental approach comprising of digital image correlation (DIC), acoustic emission (AE) and strain gauge are used to study the damage mechanisms of open hole CFRP specimen under compression. DIC is employed to capture the surface strain field near the hole of the CFRP specimen. AE is used to study the initiation and progression of various damage modes in the CFRP specimen. AE parameters are then used to classify the various damage events in uni-directional, cross-ply and quasi-isotropic laminates. Strain gauges are also employed to capture the failure strain information close to the hole. Subsequently, fractography studies are carried out to ascertain the occurrence of various damage modes in the specimen. In additon, finite element (FE) simulation of the progressive damage failure of the open hole CFRP specimen is done using ABAQUS software. Three-dimensional brick elements (C3D8R) are used to simulate the compression failure in the CFRP specimen. A VUMAT subroutine is coded to study the matrix compression and fiber kink failure based on Pinho's damage model. Numerical results obtained from FE simulations are then compared with experimental observations, and the accuracy of the FE model is validated.

Keywords: Acoustic emission, Digital image correlation, Open hole compression, Fiber kinking

REFERENCES

[1] S.T.Pinho, L.Iannucci, P.Robinson. Physically-based failure models and criteria for laminated fibre-reinforced composites with emphasis on fibre kinking: Part I: Development. *Composites Part A: Applied Science and Manufacturing* (2006) **37(1)**:63-73.

[2] S.T.Pinho, L.Iannucci, P.Robinson. Physically based failure models and criteria for laminated fibre-reinforced composites with emphasis on fibre kinking. Part II: FE implementation. *Composites Part A: Applied Science and Manufacturing* (2006) **37(5)**:766-777.