POLITECNICO DI TORINO Repository ISTITUZIONALE

Thermoelastic micromechanical analysis of CFRP with voids

Original Thermoelastic micromechanical analysis of CFRP with voids / Trombini, M.; Masia, R.; Pagani, A.; Petrolo, M.; Carrera, E ELETTRONICO (2023). (Intervento presentato al convegno 9th ECCOMAS Thematic Conference on the Mechanical Response of Composites - COMPOSITES 2023 tenutosi a Trapani nel 12-14 September 2023).
Availability: This version is available at: 11583/2982434 since: 2023-09-24T13:24:15Z
Publisher: ECCOMAS
Published DOI:
Terms of use:
This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository
Publisher copyright

(Article begins on next page)

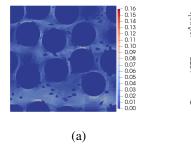
Thermoelastic micromechanical analysis of CFRP with voids

M. Trombini, R. Masia, A. Pagani, M. Petrolo and E. Carrera

MUL² Lab, Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Italy

ABSTRACT

Manufacturing of carbon fiber reinforced polymers (CFRPs) can generate defects, e.g., dispersed air gaps - voids - in the matrix that can alter the microstructure of the materials and affect thermoelastic properties [1]. The present work investigates the effect of voids on the local stress and strain fields, including plasticity over the matrix. The micromechanics framework is based on the use of 1D higher-order structural theories obtained via the Carrera Unified Formulation (CUF) and periodic boundary conditions (PBC) [2]. Voids in the matrix are randomly generated, and several distributions for each void volume fraction are chosen to carry out a statistical analysis. Figure 1a illustrates the equivalent plastic strain (PEEQ) over the matrix of an RVE with a random distribution of fibers and 3% of voids. Moreover, the micromechanical approach retrieves the homogenized coefficients of thermal expansion (CTEs) of CFRP with defects. Figure 1b shows the variation of mean transversal CTE for each void volume fraction by comparing CUF results and the work of [3].



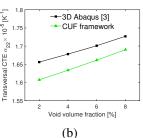


Figure 1: Distribution of PEEQ over the cross-section of random RVE with 3% of voids applying ε_{xz} (a), and variation of the transversal thermal expansion coefficient according to the void volume fraction (b).

Numerical results have shown that increments of void fractions lead to higher stress and strain values. Regarding the CTEs, the results have shown a good agreement with the benchmarks references, thus confirming that voids have a remarkable effect on thermoelastic properties.

REFERENCES

- [1] E. Carrera, M. Petrolo, M. H. Nagaraj, and M. Delicata. Evaluation of the influence of voids on 3D representative volume elements of fiber-reinforced polymer composites using CUF micromechanics. *Composite Structures*, 254:112833, 2020.
- [2] Z. Xia, Y. Zhang, and F. Ellyin. A unified periodical boundary conditions for representative volume elements of composites and applications. *Int J Solids Struct*, 40(8):1907–1921, 2003.
- [3] K. L. Wei, J. Li, H. B. Shi, and M. Tang. Numerical evaluation on the influence of void defects and interphase on the thermal expansion coefficients of three-dimensional woven carbon/carbon composites. *Compos Interfaces* 2020; 27: 873-892.