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Characterization and Numerical Interpretation of Non-Linear Tensile Response in UHTCMC

Antonio Maria Caporale[1*], Alessandro Airoldi[1], Pietro Galizia[2], Diletta Sciti[2]

[1]*Politecnico di Milano, Italy*

[2]*National Research Council - Institute of Science and Technology for Ceramics, Italy*

C_f-ZrB_2/SiC Ultra-High Temperature Ceramic Matrix Composites (UHTCMCs) were shown to be suited for Thermal Protection System (TPS) applications, for their resistance to high temperature, oxidation and for their toughness. Nonlinear mechanical behaviors were already observed in UHTCMCs and they were related to the presence of the severe Thermal Residual Stresses (TRS) in the material phases. In this work, tensile tests at room temperature were performed on three different families of specimens with lamination sequences oriented at 0°, 0°/90°, and 90°, called T0, T090 and T90, respectively. T0 and T090 specimen showed large pseudo-plastic behaviors, such as residual deformations, a linear strain-softening region followed by a recovery of initial slope, which brings to the global failure of the specimen. The quantitative relation between these nonlinear behaviors and the TRS were expressed in an analytical form, linking matrix damage to the composite nonlinearities. Within this analytical frame, an exemplificative monoaxial load case was defined and compared with T0 experimental curve. A more general constitutive law was then implemented in a mesoscale bi-phasic finite element model, where the degradation of the matrix phase was introduced through a constitutive law that couples Drucker-Prager plasticity with an orthotropic ductile damage. The dependence of the Drucker-Prager law on the pressure allowed to successfully capture both T0 and T090 non-linear response, considering the different TRS state, monoaxial for T0 and biaxial for T090.

*Corresponding author	Antonio Maria Caporale
Affiliation	Politecnico di Milano
E-mail address	antoniomaria.caporale@polimi.it