Innovation in structural integrity prediction models

João Alves[1,2][0009-0001-1083-0871], Teresa Morgado[2,3,4,5][0000-0003-3294-042X] Suzana Lampreia[5][0000-0002-9216-9174] and Rui Martins[1,3,4][0000-0001-8155-0079]

[1] DEMI/FCTNOVA, NOVA School of Science and Technology, University of Lisbon, Almada, Portugal
[2] UniRE & ISEL/IPL, Polytechnic University of Lisbon, Lisboa, Portugal
[3] UNIDEMI, NOVA School of Science and Technology, University of Lisbon, Almada, Portugal
[4] LASI, Universidade do Minho, Minho, Portugal
[5] CINAV, Naval Research Center, Almada, Portugal
jfg.alves@campus.fct.unl.pt

Abstract. Strong predictive models are needed for precise, reliable mechanical design in the aeronautical industry, to control the typically observed fatigue variability. Especially with the advances of additive manufacturing and the emergence of organic geometries. This paper reviews the development of structural integrity models, from early empirical formulations to advanced physics-based methods. The historical reliance on empirical models like Paris Law and the edge of its concept, The NASGRO, which, despite their utility, are often limited due to their empirical nature, is analyzed. One of the central themes of discussion is the scientific conflict between the "Global Driving Force" school, centered on extrinsic crack closure, and the “Local Cyclic Plasticity school, mainly focused on the induced plasticity at the crack tip. The limitations of both “schools” are scrutinized, including the inability of closure-based models to describe the behavior at high stress ratios and the kinematic constrains linked to the local plasticity models. At the end of this research paper, the Christopher-James-Patterson (CJP) model is presented as a conciliatory approach, considering the crack as a plastic inclusion within an elastic material. This model provides a mechanistic description that accounts for plasticity-induced shielding and retardation without requiring arbitrary geometry correction factors. This review suggests the CJP model as the future of fatigue crack growth predictions.

Keywords: Structural Integrity, Fracture of Mechanics, Predictive Models.