Model-wise algorithm for the resolution of fatigue problems

Lucia G. Barbu*, Xavier Martinez†, Sergio Oller† and Alex H. Barbat†

*,†Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE)
Universidad Politècnica de Catalunya (UPC)
Campus Norte UPC, 08034 Barcelona, Spain
e-mail : lgratiela@cimne.upc.edu; x.martinez@upc.edu; sergio.oller@upc.edu; alex.barbat@upc.edu

ABSTRACT

The fatigue phenomenon is defined in the ASTM E1823 standard as: "*the process of permanent, progressive and localized structural change which occurs to a material point subjected to strains and stresses of variable amplitudes which produce cracks which lead to total failure after a certain number of cycles*" [1]. In this definition it is possible to include all fatigue ranges, from "Ultra Low Cycle Fatigue" (ULCF), to "Low Cycle Fatigue" (LCF) and "High Cycle Fatigue" (HCF).

While in HCF failure generally occurs under cyclic loads that do not surpass the material elastic threshold, LCF and ULCF are characterized by levels of stress superior to the elastic limit, habitually generating large plastic strains.

Due to the fundamental differences in mechanical behaviour among the three types of fatigue, different constitutive models based on the coupling of damage and plasticity have been devised in each case. This conditions the use of numerical simulations in real life problems where, frequently, the number of cycles to failure is unknown. It is difficult to know beforehand if plasticity or damage models are to be used and, when conducting the analysis with a model that is not adequate to the behaviour exhibited by the material, either the simulation cannot be completed due to erroneous model input data or the results obtained are not consistent with the physical behaviour of the material.

The present work presents a general constitutive model formulation and a numerical algorithm for automatically selecting the appropriate coupling of damage and plasticity as a function of the number of cycles the material has been subjected to, up to the moment the strength threshold is reached. The algorithm then discriminates between a damage model when the variables of interest indicate HCF behaviour [2], a coupled plastic damage model when LCF behaviour [3] is indicated and a plasticity model where ULCF [4] is concerned.

REFERENCES

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