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Taking into account transport mechanisms in crack tracking problem of heterogeneous materials: application to the operating lifespan of nuclear power plant.

†L. Bichet[1,3], F. Dubois[1,3], Y. Monerie[1,3] and F. Perales[2,3]

[1]Laboratoire de Mécanique et Génie Civil (LMGC), Université de Montpellier, CNRS, Montpellier, France
[2]Institut de Radioprotection et de Sûreté Nucléaire, CE Cadarache Bât. 702, BP3-13115 Saint-Paul-lez-Durance, France
[3]Laboratoire de Micromécanique et Intégrité des Structures, Université de Montpellier, CNRS, IRSN, France

†Corresponding and presenting author: lionel.bichet@umontpellier.fr

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During their life on a nuclear power plant, the constitutive equipments may be exposed to thermo-mechanical loads. The authors investigate here the crack tracking problem under those conditions in an ageing cement based material.

The mechanical discontinuities are computed by the Non Smooth Fracture Dynamic (NSFD) method [1]. It is composed of: 1/ a volumetric multibody (finite element and/or rigid) approach linked with a surface behaviour between each body 2/ a wide choice of interaction law (Mohr-Coulomb, cohesive zone models [2]...) 3/ the Non Smooth Contact Dynamic [3]. Two steps are used for the thermo-mechanical computation: after the resolution of the mechanics, the thermal field is computed.

In order to take into account discontinuities in the thermal field, a cohesive flux ($\boldsymbol{\phi_{CZM}}$) is introduce between the volumetric behaviour (heat equation). Depending on the damage parameter ($\beta = 1$ represents an intact interface whereas $\beta = 0$ a completely broken interface), the flux through the crack is written as [4]:

$$\boldsymbol{\phi_{CZM}} = \lambda_{CZM} \nabla T_{CZM} \text{ with } \lambda_{CZM} = \beta \lambda_{\beta} + (1-\beta)\, \lambda_{(1-\beta)},\, \beta \in [1, 0]$$

λ_{CZM} is the homogenized conductivity of the interface, λ_{β} the conductivity of the undamaged part and $\lambda_{(1-\beta)}$ the conductivity through the damaged part (depending on the fluid contain into the crack). The implementation of the thermal gradient leads to a penalization of the solved matrix. The authors propose to solve the system according to the value of β: while $\beta = 1$ the nodes of the mesh are merged then the expression of ϕ_{CZM} is used. With this strategy, the thermal crack closure contact is also taking into account.

A wide panel of chemical reaction are the source of the ageing behaviour of a cement based material. As an example, the alkali-silica reaction [5] is caused by late formation of ettringite. An expansive gel around the aggregate appears and leads to the initiation and the propagation of cracks at the interface between the matrix and the aggregate. Initial cracks are approximated here by an interface partially broken between the aggregate and the matrix. A thermo-mechanical analysis is proposed on Table 1. A temperature is imposed ($T_{imp} = 150\,^{\circ}C$) on the right side of a square plate composed of a circular inclusion in a matrix. All the plate is initially at $T_{ini} = 0\,^{\circ}C$ and the inclusion has a dilatation coefficient greater than the one of the matrix. Depending on location of predegradation, four situations are proposed: 1/ without

predegradation, 2/ on the left, 3/ above, 4/ on the right. Clearly then, the results from Table 1 establish a dependence between the location of the predegradation and the crack path.

The method is used on an elementary volume representative of cement media with a random predegradation.

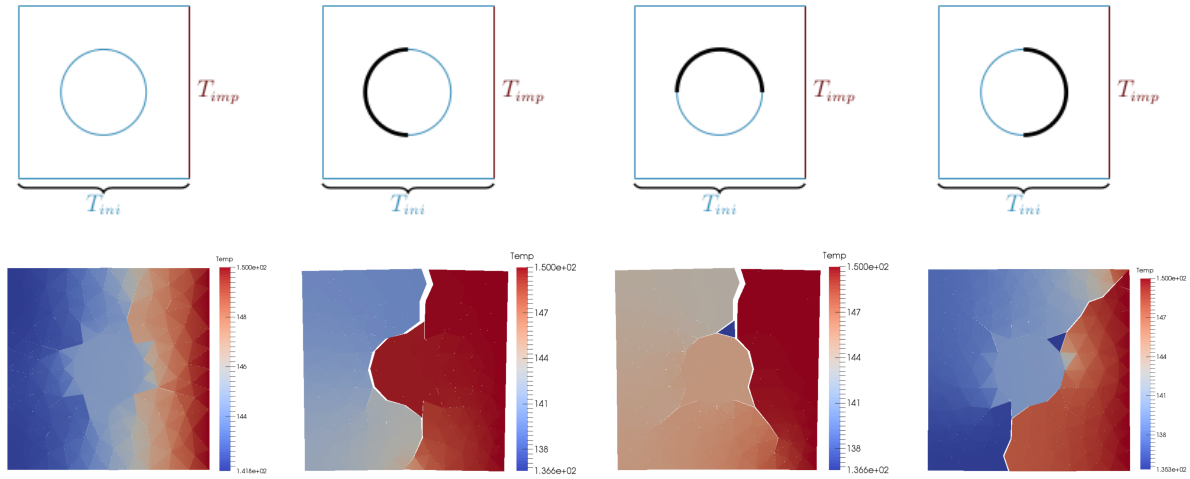

Table 1: Thermo-mechanical analysis of a predegraded matrix-inclusion compound. Thermal field an crack path.

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