A mixed hybrid mixture formulation for 2D porous media

A mixed hybrid mixture formulation for 2D porous media

F. Pizzocolo, J.M. Huyghe, K. Ito, J.J.C. Remmers

This research is funded by MuST-STW program (POROMULT 10112).

Introduction

The intervertebral disc (Fig.1) is a ionised porous medium. As measurements in living humans are complex, finite element (FE) models have become an important tool to study load distribution in healthy and degenerated disc. A model with these features has been used to explore the biomedical implications of disc degeneration on its function and integrity [3]. In this code the local mass balance is only fulfilled globally. At crack tip the local flow is underestimated influencing the global behavior and structural integrity. A hybrid mixed formulation [4] should alleviate this problem.

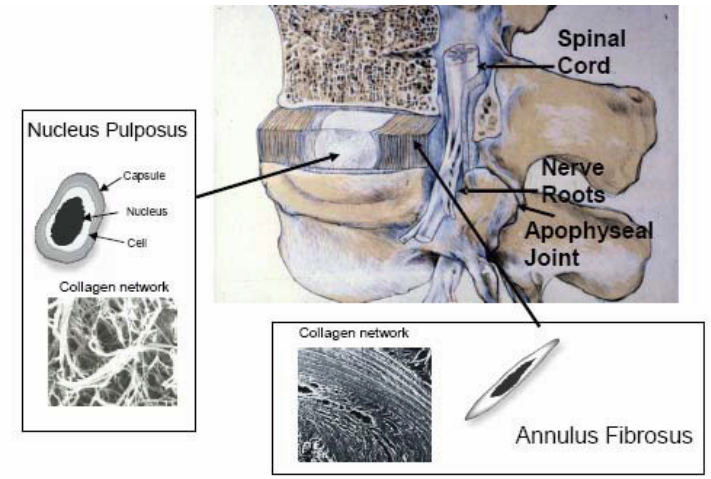

Figure 1: Structure of the intervertebral disc

Objective

Development of a mixed hybrid finite element (MHFE) formulation in 2D to study crack evolution in porous media as a result of shear loading.

Method

To numerically simulate the interaction of the solid skeleton with the pore fluid, the media are modeled by Lanir's biphasic theory [2]. A representative element volume around any mathematical point in the media is always assumed to contain the ionised solid phase and ionised fluid phase (Fig.2). For the simulation of strong discontinuities, the PU-FEM combined with cohesive zone approach [1] is used (Fig.3). The governing equations consist of equations for the bulk and for the discontinuity, dominated by mass balance, momentum balance and constitutive behavior.

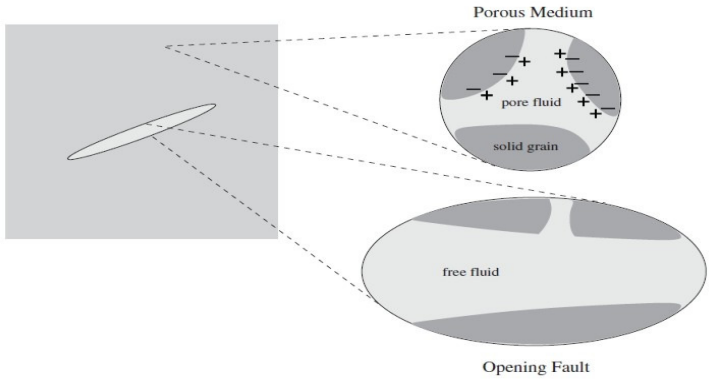

Figure 2: Flow characteristics in a fractured, deforming ionised porous medium

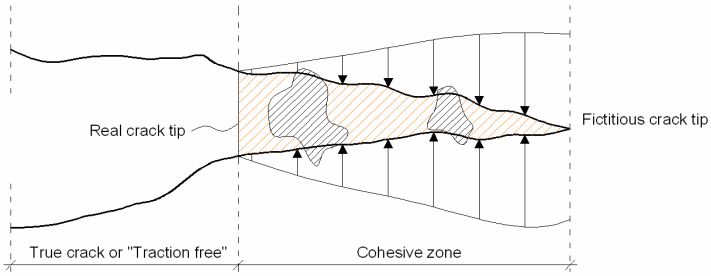

Figure 3: Schematic representation of the cohesive surface approach to fracture

Flows computed by MHFE are guaranteed to be continuous across the inter-element boundaries because normal flux fields are taken into account as degree of freedom inside the formulation (Fig.4).

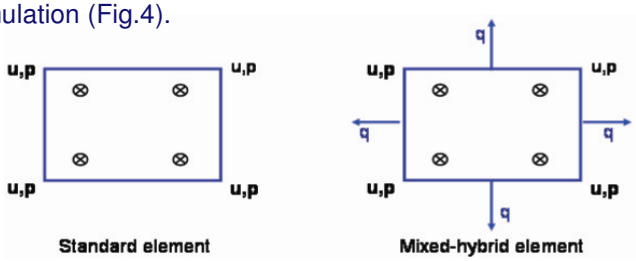

Figure 4: A mixed hybrid element takes the flow into account

Future work

First Partition of Unity formulation is integrated with Mixed Hybrid FE to deal with mode II of fracture mechanics. In later phases extending to mode I is considered as well as the development of a micro model of the crack tip.

References

1 *J.J.C. Remmers, Comp. Mech.,* ***31****, 2003*
2 *Y. Lanir, Biorheology,* ***24****, 1987*
3 *F. Kraaijeveld et al., Engng. Frac. Mech., accepted*
4 *K. Malakpoor, ESAIM,* ***41****(4), 2007*