A ‘quasi-discrete’ model of fracture in geomaterials

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Motivation

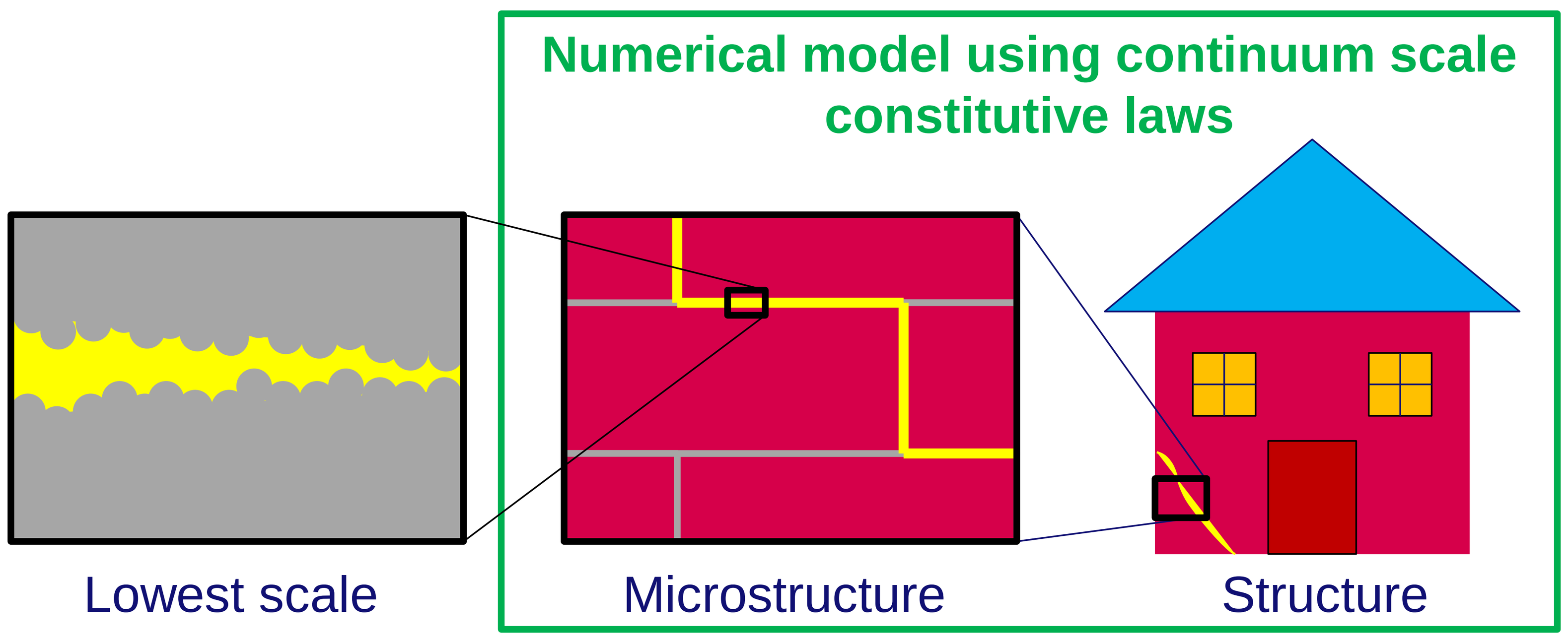
A large variety of **geomaterials** used in civil engineering exhibits a quasi-brittle behavior. The understanding and the **prediction of** the cracking and the **failure** behavior of these materials in construction and building applications are of the highest interest in order to ensure their **structural safety** and to estimate the **load bearing capacity** of existing historical buildings.

Bruxelles, 'Notre-Dame au Sablon' start of construction XIII century

Crack in a longitudinal section due to differential settlements (soil)

Numerical challenge

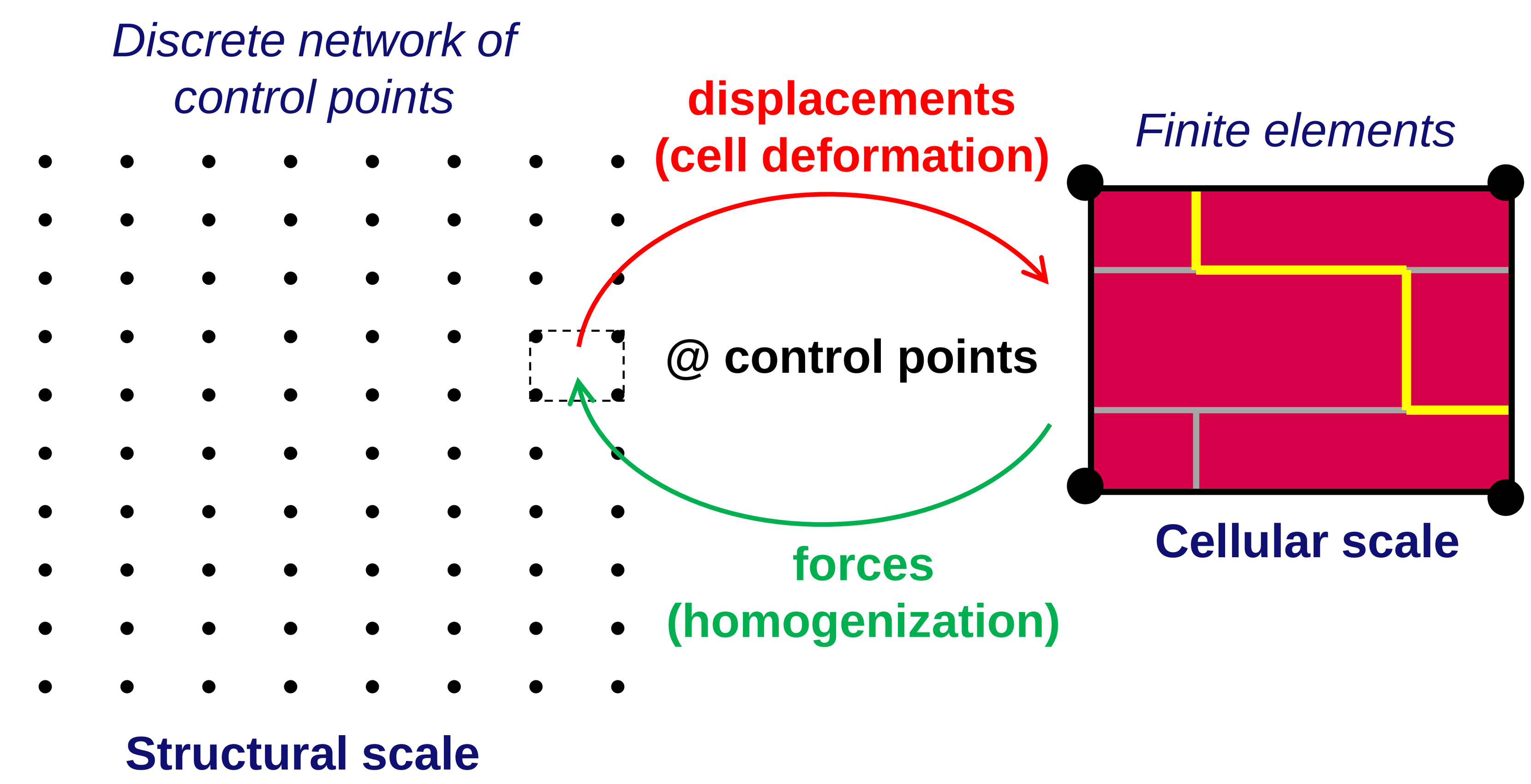
Fracture is a phenomenon bridging **multiple scales**.



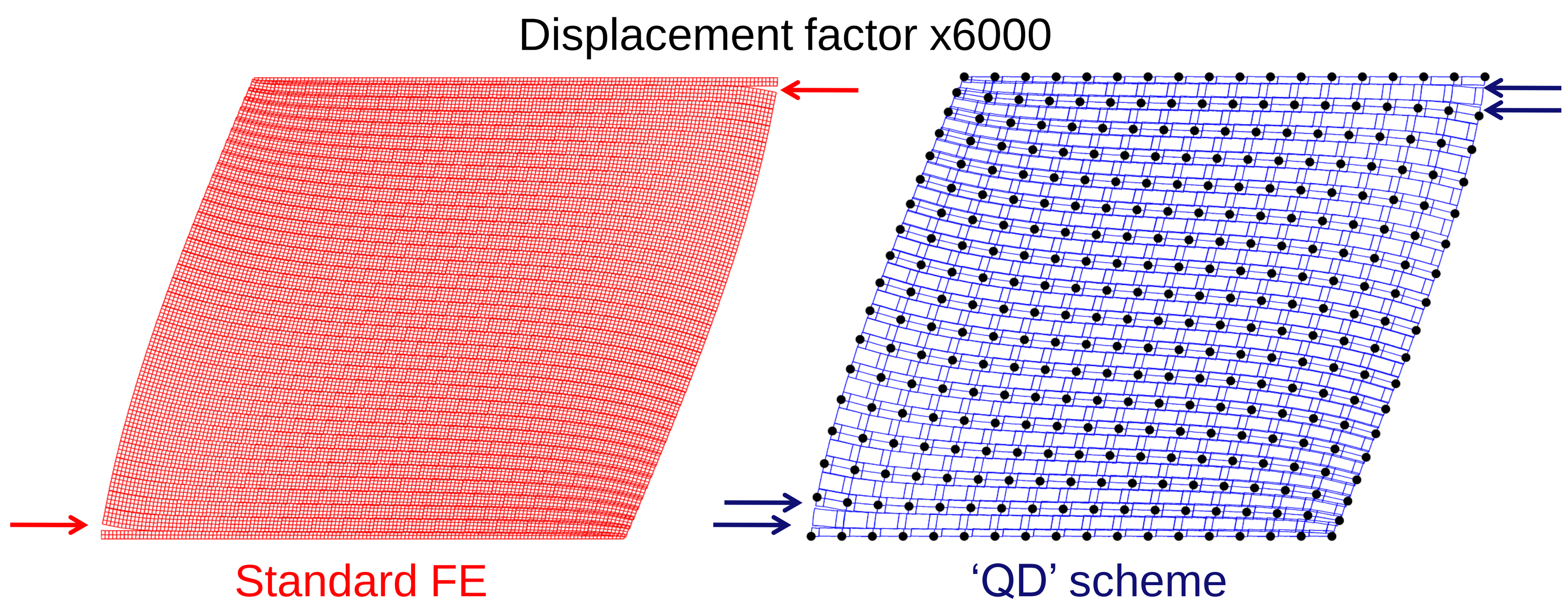
Most numerical models for quasi-brittle fracture using continuum scale constitutive laws remain limited by their high complexity or computational cost. The prime **purpose** of this project is to **propose** a **multi-scale scheme** which bears high **efficiency** coupled to **simplicity** to attenuate these common drawbacks.

A 'quasi-discrete' approach

The principle of the proposed formulation is a **coupling** between **numerical scale transition** techniques and a **discrete description of equilibrium** on the structural level. The structure is composed of assembled **cells** (unit volume of microstructure) in both **behavioral and geometrical** sense. The deformation of a cell is imposed by the displacements of its **control points**, which are the only representation of a cell that appears on the structural scale. Different **cellular boundary conditions** can be considered to allow realistic **crack propagation and branching** in the cell and on the structural level (cross-talk between neighboring cells).



Application to masonry



Deformed configuration of a compressed, sheared masonry wall. (Only the brick contours are plotted for QD, the underlying FE mesh of each cell is omitted for the sake of clarity.) Crack initiation is shown by arrows. Load-displacement curves agree well.

Conclusions and outlook

The proposed scheme benefits from a **natural representation of fracture on the structural scale** (simplicity) and from a potential **easy adaptivity** of this discrete network of points as a function of crack propagation in the underlying microstructure (efficiency).
Adaptivity on the macroscale based on force-displacement type relations will be investigated in a future work. As a first step a **selectivity** condition will be defined which leads to conduct a cell computation only when a particular cell exhibits a nonlinear response. The 'quasi-discrete' approach is first applied to periodic microstructures (masonry) with the ultimate goal to extend it to **heterogeneous random microstructures** (concrete).
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