

# Simulia Academic Seminar 2010

Simplified modelling of cracks

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- RESEARCH TOPICS
- DISCRETE CRACKING

COUPLING MATLAB/ABAQUS

DUPLICATION OF THE NODE

#### CASE STUDIES

- 3D BEAMS
- MAGDALENE CHURCH
- OUR-LADY CATHEDRAL

POSSIBLE IMPROVEMENTS

## Introduction

### Research topics

- Structural analyses on patrimonial buildings by using ABAQUS.
- Those buildings often suffer from pathologies :
  - Soil instabilities (settlements, etc.)
  - Structural elements failure (cracks)
- The structures are highly redundant and it is interesting to have an overview of the stress redistribution due to the introduction of cracks.
- That's why a simplified tool for automatically introducing discrete cracking phenomena in the models was developed (coupling MatLab/ABAQUS).
- This tool is intended for engineering offices and is therefore simplified in order to be more easily and efficiently used.

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## Introduction

### **Discrete cracking**

- The introduction of a discrete crack consists in creating a crack as a geometrical discontinuity.
- In opposition to a smeared cracking phenomenon for which the crack is simulated through a local modification of the material mechanical properties (reduction of the Young modulus).





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## Coupling MatLab/ABAQUS

### Criterion

 We essentially studied masonry buildings and we have made some approximations about the material : elastic, isotropic material with a tensile strength σ<sub>max</sub> and a infinite compression strength.



 A Rankine criterion is used for determining the location of the failure of the material. This criterion compares the maximal principal stress (SP3) in the model to the tensile strength of the material σ<sub>max</sub>. The vector representing the maximal principal stress gives us the orientation of the crack plane.

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# Coupling MatLab/ABAQUS

### Discrete cracking

- As we are dependent on the morphology of the mesh, a fictitious crack plane is chosen as close as possible to the real one.
- If SP3  $\geq \sigma_{max}$ , then introduction of a crack.
- When there is no more stresses higher than the tensile strength, the program stops.





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# Coupling MatLab/ABAQUS



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# Coupling MatLab/ABAQUS

Duplication of the node



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# Coupling MatLab/ABAQUS

Process

- The first (uncracked) model must be created under ABAQUS/CAE for introducing the geometry, the material, the loads, the boundary conditions and the mesh.
- MatLab is used for analysing the results provided by ABAQUS. It detects the location of the crack and models it by duplicating nodes
- Then for managing the cracked models, MatLab launches automatically ABAQUS for calculating the stresses

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Possible improvements

### **Case Studies**

# **3D Beams (only flexion)**



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### **Case Studies**



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### **Case Studies**

### Magdalene Church (Tournai, BE)





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### Our-Lady Cathedral(Tournai, BE)



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## **Case Studies**

### Our-Lady Cathedral(Tournai, BE) Cracks 11 11 Introduced 11 11 11 01 2 2 2 2 2 11 1111 A. A. A. A.

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#### **POSSIBLE IMPROVEMENTS**

### **Possible Improvements**

- The tool developed here is a simple one which gives quite good qualitative results. It can, of course, be improved !
- With this tool, it is not possible to take into account the cracks due to shear stresses. This could be implemented in the MatLab routines
- Another criterion (e.g. Mohr Coulomb) could be implemented for studying other materials
- Cycle loads could be analysed if the contact between the faces of the cracks was introduced

# Thank you for your attention !