SSNV510 - Uniaxial pressing of a Summarized multi-fissured

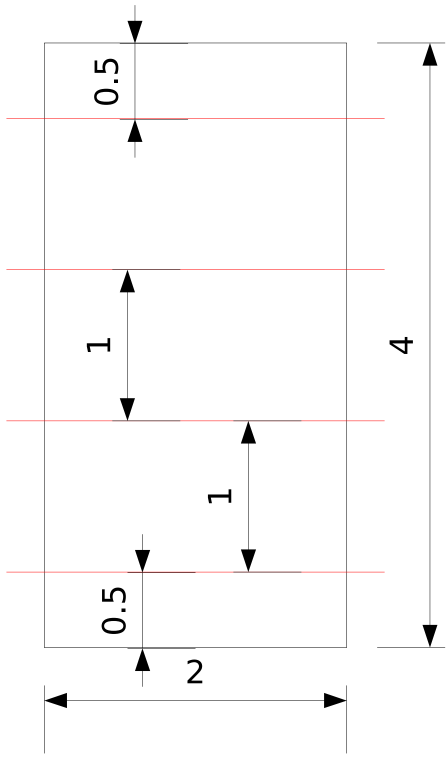
block:

This test makes it possible to validate the multi-Heaviside approach for the elements X-FEM. It is about a case test where one introduces several interfaces compressed laterally. The mesh is rather coarse so that meshes several cracks see. Some nodes also several cracks see. These nodes contain several Heaviside enrichments then. It is checked that these various enrichments are well taken into account at the kinematical level and that the stiffness matrixes associated with each zone between two interfaces make it possible to obtain the good deformed shapes. One adds also condition of contact on cracks.

1 Problem of reference

1.1 Geometry

the structure is a healthy rectangle into which four horizontal cracks are introduced, in red on the figure 1.1.a. dimensions of structure as well as the position of cracks are given on this figure in meters.



Appear 1.1-a: Geometry of structure and positioning of cracks.

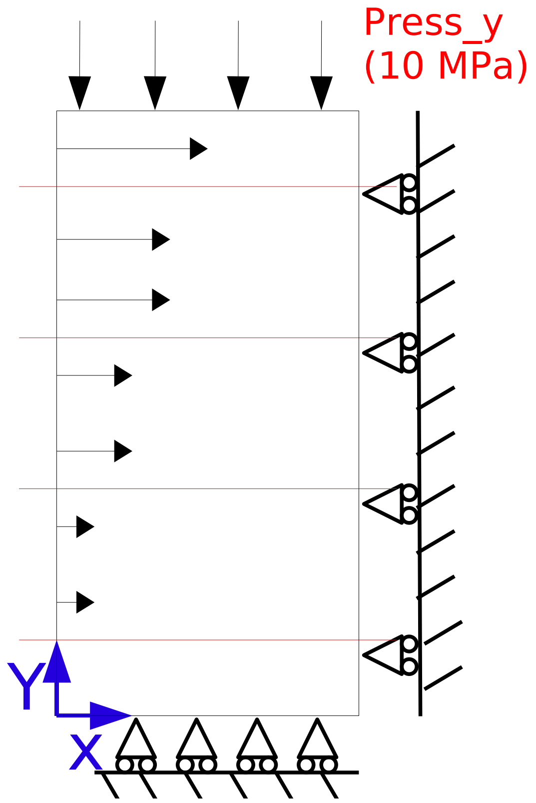
1.2 Properties of the material

Modulus Young: $100\,\mathrm{MPa}$

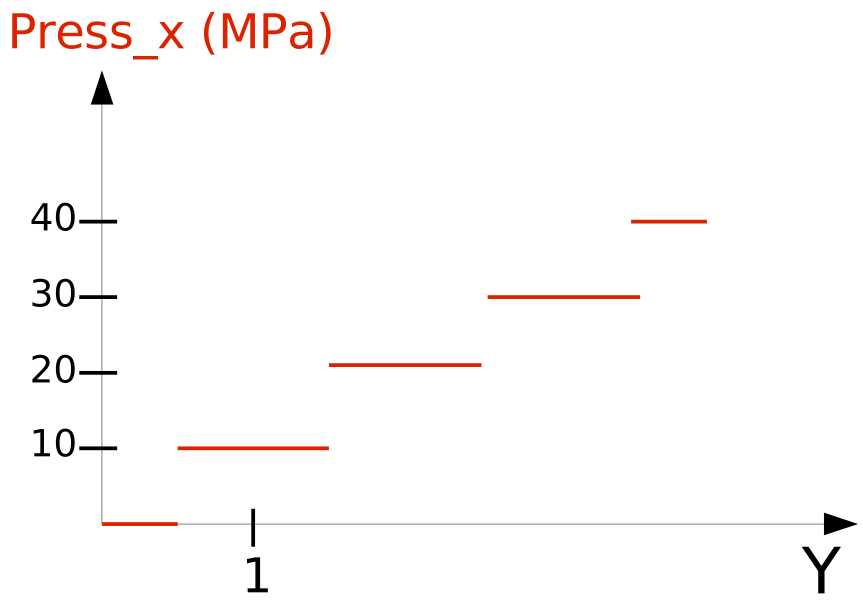
Poisson's ratio: 0.0

1.3 Boundary conditions and loadings

One blocks the component X of displacement on the right part of structure. One blocks the component Y of displacement on his lower part. One applies a loading in pressure according to X constant per piece to the left part, so as to obtain a staircase. This loading is represented figure 1.3-b. The contact is active on cracks, one applies a constant pressure to the upper part, so as to activate force of contact on the level as of cracks.



Appear 1.3-a: Illustration of the boundary conditions and the loadings.



Appear 1.3-b: Pressure imposed according to Y on left edge (in MPa).

2 Reference solution

the Poisson's ratio being null, one must find a uniform compression with each of the 4 stages of structure. In other words for a given stage, the displacement of structure is proportional to the position according to X and it depends on the Pressure which varies according to Y. Displacement according to Y depends only linearly on Y because the imposed pressure $Press_y$ is constant.

There is thus for all the points of structure the displacement which is worth :

$$Depl_X(X, Y)=(2-X)\frac{Press_x(Y)}{E}$$

éq 2.1-1

$$Depl_Y(Y)=(4-Y)\frac{Press_y}{E}$$

éq 2.1-2

3 Modelization A

3.1 Characteristic of the modelization

It acts of a modelization X-FEM, in plane strains, where the interfaces are defined by functions of level (level sets noted norms LN).

The equations of the functions of levels for three horizontal cracks are the following ones:

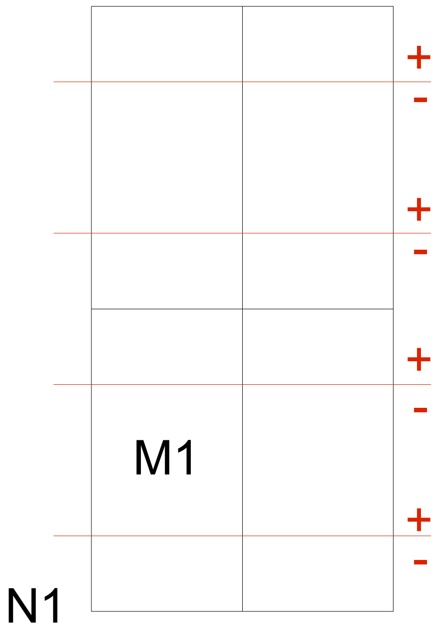
$$\mathrm{LN}\,1 = Y - 0.5$$ éq 3.1-1

$$\mathrm{LN}\,1 = Y - 1.5$$ éq 3.1-2

$$\mathrm{LN}2 = Y - 2.5$$ éq 3.1-3

$$\mathrm{LN}\,3 = Y - 3.5$$ éq 3.1-4

3.2 Characteristics of the mesh



Appears 3.2-a: The mesh of modelization A.

The mesh 4 meshes type QUAD4 comprises, represented on the figure 3.2-a.
One notices on this figure for example that the node $N1$ sees 2 cracks. It must thus be enriched 2 times and it has the kinematical degrees of freedom then DX, DY, H1X, H1Y, H2X and H2Y. The contact being active, the node $N1$ has also the degrees of Lagrange LAGS_C and LAG2_C.
In addition it is noticed for example that the mesh $\mathrm{M1}$ "sees" 4 cracks. The element associated with this mesh will thus store the fields of four cracks, independently of the degrees of freedom which are associated with its nodes.

3.3 Features tested

One tests operator MODI_MODELE_XFEM in the case as of meshes which sees several cracks. One then activates the multi-storage of the data structures X-FEM during the concatenation of cracks in the model. All the cracks seen by the mesh are then taken into account in the corresponding element

One tests AFFE_CHAR_MECA with option DDL_IMPO on multi-Heaviside nodes and option PRESS_REP on elements multi-Heaviside edge.

One tests the assembly of the Heaviside degrees of freedom on the level as of matrixes and of the second members of the elements multi-Heaviside for the option COMP_ELAS in STAT_NON_LINE.
One tests the contact for the multi-Heaviside approach in small sliding, with option XFEM under operand FORMULATION of operator DEFI_CONTACT.

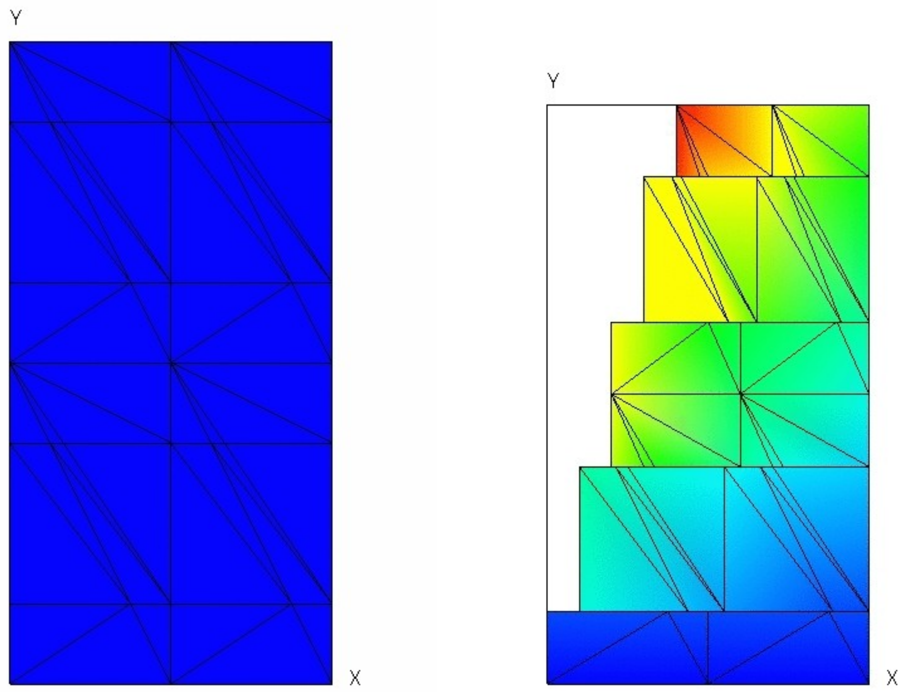
One in the case of validates also postprocessing X-FEM multi-Heaviside, with operators POST_MAIL_XFEM and POST_CHAM_XFEM .

3.4 Quantities tested and results

One tests displacements on the level as of lips of crack. DX displacement must follow the function $Depl\_X$ of equation 2.1-1. Displacement DY must follow the function $Depl\_Y$ of equation 2.1-2. One obtains the deformed shape in staircase of the figure 3.4-a.

Identification	*Reference*
SOMM_ABS for DX- $Depl\_X$ (with dimensions Master)	0
SOMM_ABS for DY $Depl\_Y$ (with dimensions Master)	0
SOMM_ABS for DX- $Depl\_X$ (with dimensions slave)	0
SOMM_ABS for DY $Depl\_Y$ (with dimensions slave)	0

Table 3.4-1



Appears 3.4-a: Deformed shape of structure.

3.5 Remarks

One gets very good results for this test, the raised error corresponding to the numerical residue.

4 Modelization B

4.1 Characteristic of the modelization

It is acted of the same modelization as the modelization A, but as plane stresses.

4.2 Characteristics of the mesh

The mesh is the same one as that of modelization A.

4.3 Grandeurs tested and results

the quantities tested are identical to those described in modelization A. One obtains the deformed shape in staircase of the figure 3.4-a.

Identification	*Reference*
SOMM_ABS for DX- $\mathrm{Depl\_X}$ (with dimensions Master)	0
SOMM_ABS for DY $\mathrm{Depl\_Y}$ (with dimensions Master)	0
SOMM_ABS for DX- $\mathrm{Depl\_X}$ (with dimensions slave)	0
SOMM_ABS for DY $\mathrm{Depl\_Y}$ (with dimensions slave)	0

Table 4.3-1

4.4 Remarks

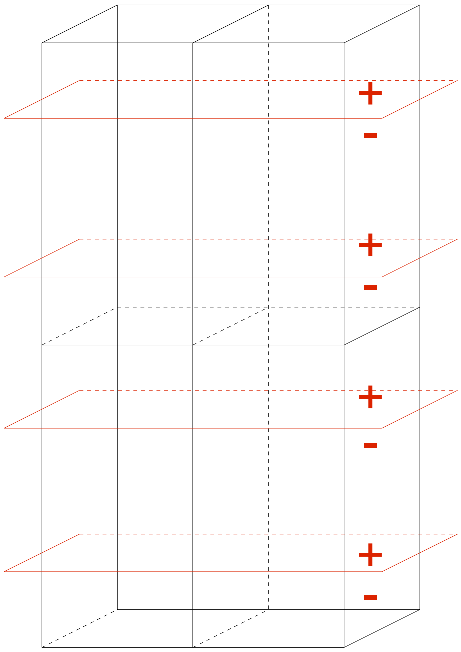
One gets very good results for this test, the raised error corresponding to the numerical residue.

5 Modelization C

5.1 Characteristic of the modelization

It acts of the same modelization as the modelization A, but in 3D.

5.2 Characteristics of the mesh



Appears 5.2-a: The mesh of the modelization C.

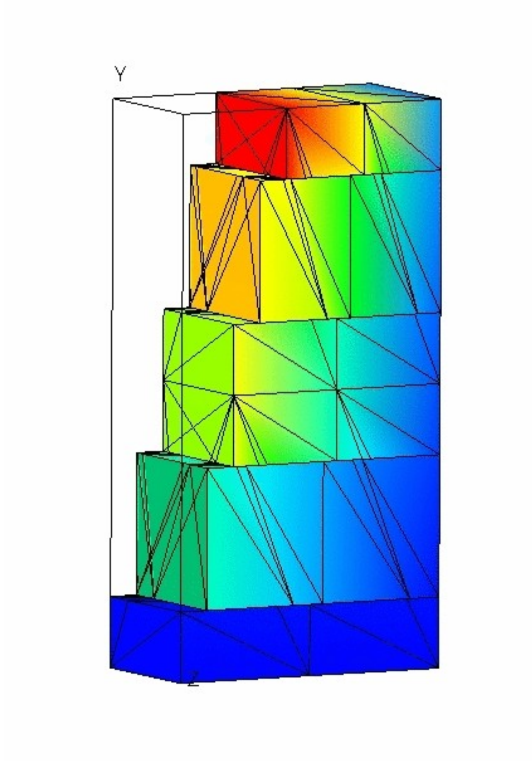
The mesh 4 meshes type HEXA8 , represented on the figure 5.2-a comprises.
Even notices that for the mesh of modelization A. Some meshes “see” 2 cracks, they have the degrees of freedom kinematics DX, DY, DZ, H1X, H1Y, H1Z, H2X and H2Y, H2Z as well as the degrees of freedom of Lagrange LAGS_C and LAG2_C. others “see” 4 cracks, they have also kinematical degrees of freedom H3X, H3Y, H3Z, H4X and H4Y, H4Z as well as the degrees of freedom of Lagrange LAG3_C and LAG4_C.

5.3 Quantities tested and results

the quantities tested are identical to those described in modelization A. One obtains the deformed shape in staircase of the figure 5.4-a.

Identification	*Reference*
SOMM_ABS for DX- Depl_X (with dimensions Master)	0
SOMM_ABS for DY Depl_Y (with dimensions Master)	0
SOMM_ABS for DX- Depl_X (with dimensions slave)	0
SOMM_ABS for DY Depl_Y (with dimensions slave)	0

Table 5.3-1



Appears 5.4-a: Deformed shape of structure.

5.4 Remarks

One gets very good results for this test, the raised error corresponding to the numerical residue.

6 Modelization D

6.1 Characteristic of the modelization

It acts of the same modelization as the modelization A, but the contact in great sliding is activated.

6.2 Characteristics of the mesh

The mesh is the same one as that of modelization A.

6.3 Fonctionnalités tested

Idem modelization A. One tests this time the contact for the multi-Heaviside approach in great sliding, using option REAC_GEOM of operator DEFI_CONTACT. One thus passes by a phase of pairing of elements before you calculate the contribution of contact.

6.4 Quantities tested and results

the quantities tested are identical to those described in modelization A. One obtains the deformed shape in staircase of the figure 3.4-a.

Identification	***Reference***
SOMM_ABS for DX- $Depl\_X$ (with dimensions Master)	0
SOMM_ABS for DY $Depl\_Y$ (with dimensions Master)	0
SOMM_ABS for DX- $Depl\_X$ (with dimensions slave)	0
SOMM_ABS for DY $Depl\_Y$ (with dimensions slave)	0

Table 6.4-1

6.5 Remarks

One gets very good results for this test, the raised error corresponding to the numerical residue.

7 Modelization E

7.1 Characteristic of the modelization

It is acted of the same modelization as the modelization D, but as plane stresses.

7.2 Characteristics of the mesh

The mesh is the same one as that of modelization A.

7.3 Grandeurs tested and results

the quantities tested are identical to those described in modelization A. One obtains the deformed shape in staircase of the figure 3.4-a.

Identification	*Reference*
SOMM_ABS for DX- Depl_X (with dimensions Master)	0
SOMM_ABS for DY Depl_Y (with dimensions Master)	0
SOMM_ABS for DX- Depl_X (with dimensions slave)	0
SOMM_ABS for DY Depl_Y (with dimensions slave)	0

Table 7.3-1

7.4 Remarks

One gets very good results for this test, the raised error corresponding to the numerical residue.

8 Modelization F

8.1 Characteristic of the modelization

It acts of the same modelization as the modelization D, but in 3D.

8.2 Characteristics of the mesh

The mesh is the same one as that of the modelization C.

8.3 Quantities tested and results

the quantities tested are identical to those described in modelization A. One obtains the deformed shape in staircase of the figure 5.4-a.

Identification	***Reference***
SOMM_ABS for DX- $\mathrm{Depl\_X}$ (with dimensions Master)	0
SOMM_ABS for DY $\mathrm{Depl\_Y}$ (with dimensions Master)	0
SOMM_ABS for DX- $\mathrm{Depl\_X}$ (with dimensions slave)	0
SOMM_ABS for DY $\mathrm{Depl\_Y}$ (with dimensions slave)	0

Table 8.3-1

8.4 Remarks

One gets very good results for this test, the raised error corresponding to the numerical residue.

9 Summary of the results

This test makes it possible to activate multi-Heaviside for the elements X-FEM. One shows that one is able to differentiate the number of cracks “seen” by mesh, of that “seen” by node. In the example of this case test, some nodes to the maximum 2 cracks see whereas meshes 4 see some. One also shows that it is possible to take into account conditions of contact on the interfaces, the nodes then are also enriched by multiple degrees of freedom by Lagrange.

The approach was validated in `D_PLAN`, `C_PLAN` and `3D`, for the small and the great slidings.