SSNV201 – the purpose of Block with interface in contact slide with X-FEM

Summarized

This benchmark is testing and validating the features of the option SLIDE for the contact with X-FEM. It is mainly a question of proving that for an interface generated by X-FEM, on which one activates the contact with option SLIDE, one does not have separation of surfaces in contact, they can only slip one compared to the other.

This test brings into play a parallelepipedic block crossed by an interface modelled with X-FEM. The block is subjected to imposed displacements, which would have as a consequence the separation of structure when the option SLIDE is not activated and the sliding of the two parts of block, without separation, when this option is activated. Numerically, the activation of this option is made after the contact is established, either initial contact imposed by user (CONTACT_INIT=' OUI'), or natural contact, resulting from the kinematical evolution of structure.

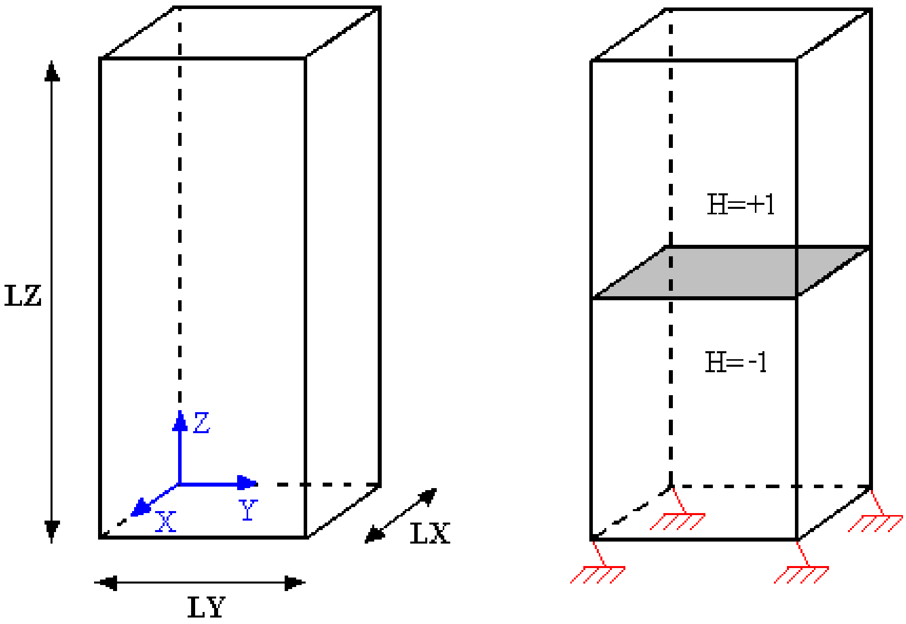
1 Problem of reference

1.1 Geometry

the structure is a right parallelepiped at rectangular and healthy base. Dimensions of the bar (see [Figure 1.1-1]) are: $LX=2\,m$, $LY=4\,m$ and $LZ=10\,m$.

The interface (Figure 1.1-2) is introduced by functions of level (level set directly noted LN norm into the command file using operator `DEFI_FISS_XFEM` [U4.82.08]. The interface is defined like a horizontal crack, in the middle of the block according to the direction OZ given by the following function of level:

$$\mathrm{LN}=Z-LZ/2 \qquad \textbf{éq 1-1}$$



1) **2)**

Figure 1.1 Geometry of the block and positioning of crack

No level set tangential is necessary since one uses key word `TYPE_DISCONTINUITE=' INTERFACE'`, which makes it possible to have structure completely cut in two parts.

1.2 Properties of the material

Modulus Young: $E=100\,MPa$

Poisson's ratio: $\nu=0.0$

Density: $\rho=7800\,kg/m^3$

1.3 Boundary conditions and loading

the nodes of the lower surface of the block are clamped (see Figures 1.1-1) by applying to the nodes group of surface a loading in imposed displacements:

$ENCASTR$: $DX=0$, $DY=0$ and $DZ=0$.

Two other loadings in imposed displacements, are applied to the nodes group of the upper surface of the block:

CHZ : $DZ=DEPZ$ and $DX=0$;
CHY : $DY=DEPY$.

The values of imposed displacements are: $DEPY=DEPZ=1.10^{-3} m$. The loadings are applied in three stages by means of the functions presented to [Figure 1.3-1].

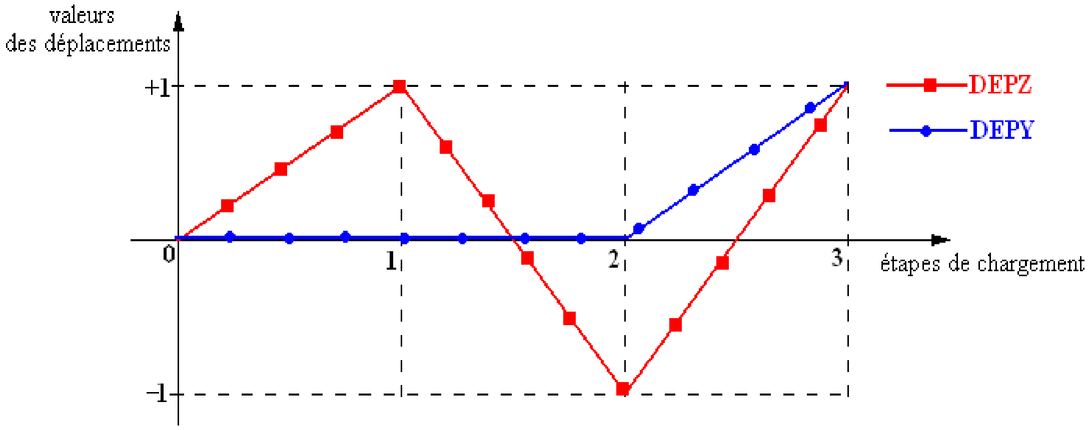


Figure 1.3-1: Variations of the loadings in displacements imposed

By imposing this kinematics of displacements to the upper part of the block, one wishes to show the dealing of the option SLIDE. In an initial state, the contact is not affected on the lips of crack (CONTACT_INI=' NON') and thus the two parts of the block will separate following the first stage from loading ($DZ=DEPZ$). They come to be restuck in the second phase when they are brought closer ($DZ=-DEPZ$). Once returned in contact, the option SLIDE activates and prevents separation according to the normal direction (OZ) during the third stage, in spite of imposed displacement ($DZ=DEPZ$), the tangential sliding on the level of the interface remains possible ($DY=DEPY$).

2 Quantities and

2.1 result reference solution of reference

the solution of such a problem is of course obvious.

Stage 1:

The two parts of structure are detached: the lower part has a null displacement and the upper part has an overall motion equal to the displacement imposed on the top of structure.

Stage 2:

There is no horizontal displacement. Vertically, the two parts of structure are dependant and behave like only one block in compression. Displacement with the interface is equal to moist displacement at the top of structure and the jump of displacement is null.

Stage 3:

Horizontally, the lower part has a null displacement and the upper part has an overall motion equal to the displacement imposed on the top of structure. Vertically, the two parts of structure are dependant and behave like only one block in tension. Displacement with the interface is equal to moist displacement at the top of structure and the jump of vertical displacement is null.

3 Modelization A

3.1 Characteristic of the modelization

One considers a modelization 3D X-FEM with taking into account of the contact. The interface is introduced into sane mesh by the operator DEFI_FISS_XFEM.

3.2 Characteristics of the mesh

One discretizes structure using finite elements HEXA8. According to the three directions of the reference system chosen, there are $2\times4\times9$ elements thus a total of 72 finite elements (see [Figure 3.2-1])
the interface will be introduced in the middle of the fifth stage of elements according to the direction OZ.

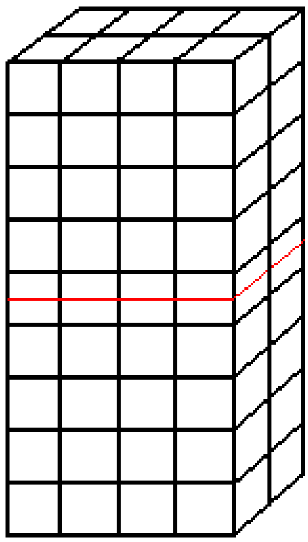


Figure 3.2-1: Mesh of the modelization A

3.3 Quantities tested and results

operator POST_MAIL_XFEM makes it possible to net cracks represented by the method X-FEM. Operator POST_CHAM_XFEM then allows to export the X-FEM results on this new mesh. These two operators are to be used only in a posterior way with computation at sights of postprocessing. They make it possible to generate nodes right in lower part and with the top of the interface and to display their displacements.

One thus tests the values of displacement right in lower part and with the top of the interface after convergence of the iterations of operator STAT_NON_LINE. The following table is obtained:

Not	IdentificationRéférenceTolérance1
	DY for all the nodes right below the interface0.001.0E-161
	DY for all the nodes right with the top of the interface0.001.0E-161
	DZ for all the nodes right below the interface0.001.0E-161
	DZ for all the nodes right with the top of the interface1.0E-031.0E-09%2
	DY for all the nodes right below the interface0.001.0E-162
	DY for all the nodes right with the top of the interface0.001.0E-162
	DZ for all the nodes right below the interface-5.0E-41.0E-09%2
	DZ for all the nodes right with the top of the interface-5.0E-41.0E-09%3
	DY for all the nodes right below the interface0.001.0E-163
	DY for all the nodes right with the top of the interface1.0E-031.0E-09%3
	DZ for all the nodes right below the interface5.0E-41.0E-09%3
	DZ for all the nodes right with the top of the interface5.0E-41.0E-09%

to test all the nodes in only once, one tests the minimum and the maximum of column.

4 Modelization B

4.1 Characteristic of the modelization

It is acted of the same modelization as the modelization A, but as great slidings.

4.2 Characteristics of the mesh

It is the same mesh as that of the modelization A (see [Figure 3.2-1])

4.3 Quantities tested and results

One thus tests the values of displacement right in lower part and with the top of the interface after convergence of the iterations of operator `STAT_NON_LINE`. The following table is obtained:

Not	Identification	Reference	Tolerance
1	DY for all the nodes right below the interface	0.00	1.0E-16
1	DY for all the nodes right to the top of the interface	0.00	1.0E-16
1	DZ for all the nodes right below the interface	0.00	1.0E-16
1	DZ for all the nodes right with the top of the interface	1.0E-03	1.0E-09%
2	DY for all the nodes right below the interface	0.00	1.0E-15
2	DY for all the nodes right with the top of the interface	0.00	1.0E-15
2	DZ for all the nodes right below the interface	-5.0E-4	1.0E-09%
2	DZ for all the nodes right with the top of the interface	-5.0E-4	1.0E-09%
3	DY for all the nodes right below the interface	0.00	1.0E-6
3	DY for all the nodes right with the top of the interface	1.0E-03	1.0E-01%
3	DZ for all the nodes right below the interface	5.0E-4	1.0E-01%
3	DZ for all the nodes right with the top of the interface	5.0E-4	1.0E-01%

to test all the nodes in only once, one tests the minimum and the maximum of column.

5 Summary of the results

One once notices that the activation of `the option` SLIDE had the effect envisaged, the contact established at stage 2, i.e. the absence of separation following the direction OZ at stage 3, in spite of the imposition of a displacement following this direction, with a structure in tension. Discontinuity according to OZ , on the level of the interface, is null at the end of stages 2 and 3 and the upper part of the block slips according to the direction OY with the specified value.