ZZZZ283 – Validation of the use of a grid with a crack X-FEM on a grid refined by Lobster

Summary:

This test validates calculation by `DEFI_FISS_XFEM` functions of level (level sets) of a crack X-FEM on a grid if the grid of the structure is refined by Lobster.

1 Problem of reference

1.1 Geometry

A parallelepiped of dimensions is considered $4\times4\times2\,mm$ with a plane crack:

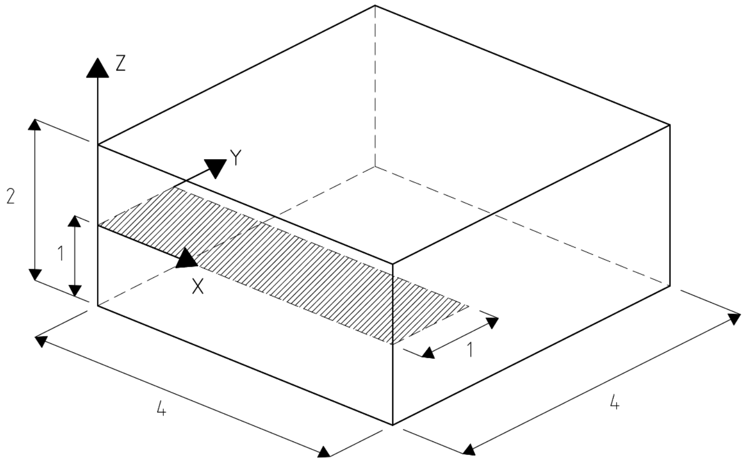

Figure 1.1-1: geometry of the crack

1.2 Boundary conditions and loadings

One will propagate the crack of the figure 1.1-1 by imposing the same angle of propagation β and the same projection Δa in each point of the bottom in way such as the bottom remains always right:

$\beta=5°$
$\Delta a=0.6\,mm$

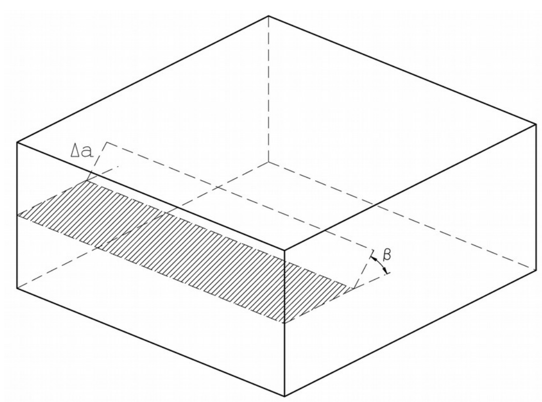

Figure 1.2-1: imposed propagation

2 Principle of the test

In DEFI_FISS_XFEM one can define the crack on a grid by one of the following methods:

1. by giving the grid of the grid to be used by MODELE_GRILLE,
2. by giving a crack with a grid already associated by FISS_GRILLE.

The second method was thought for the cases where one uses Lobster to refine the grid of the structure. In this case, the grid associated with the crack given by FISS_GRILLE is also associated with the new crack and the level sets already there definite is kept with the identical one. Information concerning the localization of the field of calculation and the use of an auxiliary grid is kept for the new crack, which makes it possible to correctly propagate it by PROPA_FISS. A contrario, the level sets on the grid are calculated by interpolation by Lobster and they passed directly to DEFI_FISS_XFEM by DEFI_FISS/CHAMP_NO_LS*.

To check the good performance of the two methods, one will propagate by PROPA_FISS the crack $FISS0$ figure 1.1-1 in three stages:

1. one propagates $FISS0$, crack with an associated auxiliary grid, which was defined by using the operand MODELE_GRILLE in DEFI_FISS_XFEM. One obtains $FISS1$.
2. one refines the grid of $FISS1$ by Lobster. Then one will define the same crack on the grid refined by keeping the auxiliary grid (operand FISS_GRILLE of DEFI_FISS_XFEM). One obtains $FISS1raff$, which coincides with $FISS1$ except at the place where grid more refined.
3. one propagates $FISS1raff$ and one obtains $FISS2$.

Same the values of angle of propagation and advanced crack are imposed in each point of the bottom of crack. These values are maintained constant between the two propagations. The propagated funds are thus always right and one knows a priori their position in the structure. If the two methods go correctly, the position of $FISS2$ must be coïncidente with that expected.

2.1 Method of calculating

For each point of the bottom, on each step of propagation, one imposes the same angle of propagation β and the same projection Δa crack. One can thus calculate the coordinates of each point of the bottom after each step of propagation (figures 1.1-1 and 3.2-2):

$$Y_i = Y_{i-1} + \Delta a \cdot \cos(i \cdot \beta)$$
$$Z_i = Z_{i-1} + \Delta a \cdot sen(i \cdot \beta)$$

where $(0, Y_i, Z_i)$ and $(4, Y_i, Z_i)$ are the points end of the segment which coincides with the bottom of the crack $FISSi$. At the beginning, for the crack $FISS0$ (figure 1.1-1):

$$Y_0 = 1$$
$$Z_0 = 0$$

2.2 Sizes and results of reference

Coordinates of the points of end expected for the bottom $FISS2$ are thus the following ones:

$$X_2 = [0,4]$$
$$Y_2 = 2.189\, mm$$
$$Z_2 = 0.156\, mm$$

To check the effective position of the bottom $FISS2$ in the model finite elements, one uses the values of the level sets at the points of intersection between the segment defined by the two points of end above and the faces of the elements of the grid. If the position of the bottom after the propagation is calculated correctly, the value of both level sets must be equal to zero for all the found points of intersection because, by definition, the bottom of crack is formed by all the points where the level set tangent and normal are equal to zero.

The points of intersection and the value of the level sets in these points can be calculated by using the ordering of postprocessing `MACR_LIGN_COUPE`.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used 3D.

3.2 Characteristics of the grid

Grid 3D contains 100 elements of the type HEXA8 of dimension $0.4\times0.4\times0.2\,mm$:

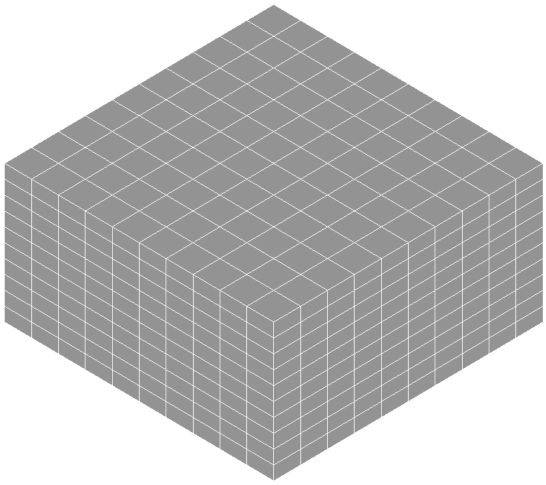

Figure 3.2-1: grid used

For the auxiliary grid, one uses a grid 3D containing 400 elements of the type HEXA8 of dimension $0.2\times0.2\times0.1\,mm$:

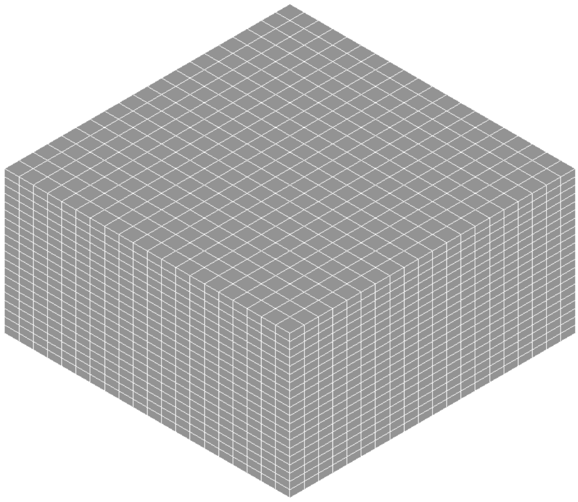

Figure 3.2-2: auxiliary grid

3.3 Sizes tested and results

After the two imposed propagations, one calculates the values of the level sets at the points of intersection between the segment connecting the points of end of the bottom $(0,2.189,0.156)$ and $(4,2.189,0.156)$ (see §2.2) and the faces of the elements of the grid and one will check that the values maximum and minimal obtained are equal to zero. By considering that the grid is coarse, one uses a tolerance equal to 15% length of the smallest edge of the grid, that is to say

$0.15 \cdot 0.2 mm = 0.03 mm$. Thus one accept the value of the level set at the point of the bottom considered if and only if it is in the interval $[-0.03, 0.03]$.

4 Summary of the results

The position of the crack $FISS2$ after the two steps of propagation coincides with that expected. That means that DEFI_FISS_XFEM allows well to define a crack at the same time on the grid and the auxiliary grid. Moreover, information on the localization of the field and the use of the auxiliary grid is well transferred by the operand FISS_GRILLE who was installation to allow the use of the grid for a crack defined on a grid refined by Lobster.