
Operator `DEFI_FISS_XFEM`

1 Drank

To define a crack or an interface 2D or 3D by the means of functions of levels.

For cracks, one defines two functions of levels (level sets) allowing to characterize an unspecified crack (crack planes or not). For the interfaces, only one level-set is necessary. The level sets can be defined in four different ways:

- maybe from two mesh groups (the mesh group of crack and the mesh group of the crack tip);
- maybe from two analytical functions.
- maybe from a catalog of preset forms.
- maybe by reading again fields at nodes already existing.

For the case 2D, meshes of the crack tip are meshes `POI`; they should not be given as a group of node but as a mesh group.

For 3D case, the crack tip is automatically directed. The ordered list of the points of the bottom is automatically displayed in the file of messages, during the transition in command `DEFI_FISS_XFEM`. The method of directional sense and the specific case where it does not function, are described in documentation [R7.02.12].

This operator does not allow to define a crack coinciding with an edge of structure.

The characteristics related to the contact on the lips of crack are not given here but in a specific contact load with operator `DEFI_CONTACT`.

The theoretical aspect of the method X-FEM is approached in [R7.02.12], and he is advised with the user who is not familiar with the use of the level sets of level sets. reading the few explanatory lines relating to the representation of surfaces by the method

Moreover, this operator is also used with cracks with a grid, in precondition to the computation of the stress intensity factors in 3D by the operator `CALC_G` [U4.82.03] with option `CALC_K_G`.

The operator produces a concept of the `fiss_xfem` type.

2 Syntax

```
[fiss_xfem] =DEFI_FISS_XFEM (
    ◆MODELE=mo , [model]
```

#Définition of a grid to be associated with the crack

```
    ◇/ MODELE_GRILLE=mogri , [model]
    /FISS_GRILLE= fiss_orig, [fiss_xfem]
```

#choix of a crack or an interface

```
    ◇TYPE_DISCONTINUITE=/ "FISSURES", [DEFAULT]
    / "INTERFACE"
```

#Définition of crack or interface

```
    ◆DEFI_FISS=_F (
```

#Soit one defines the mesh group of a lip and the mesh group of the crack tip:

```
    ◆/◆GROUP_MA_FISS=grma ,
[l_gr_maille]
    ◇GROUP_MA_FOND=grma ,
[l_gr_maille]
```

#Soit one defines two analytical functions; to characterize the surface of crack, and the other to characterize the crack tip:

```
    /◆FONC_LN=fonc , [function]
    ◇FONC_LT=fonc , [function]
```

#Soit one uses the shape of crack or of predefined interface and one gives the geometrical characteristics:

```
    /◆FORMES_FISS=formes , [K8]

    #Si forms = "ELLIPSE"
    ◆DEMI_GRAND_AXE=a , [R]
    ◆DEMI_PETIT_AXE=b , [R]
    ◆CENTER= (x0, y0, z0), [1_R]
    ◆VECT_X= (vxx, vxy, vxz), [1_R]
    ◆VECT_Y= (vyx, vyy, vyz), [1_R]
    ◇COTE_FISS=/ "IN", [DEFAULT]
    / "OUT",

    #Si forms = "RECTANGLE"
    ◆DEMI_GRAND_AXE=a , [R]
    ◆DEMI_PETIT_AXE=b , [R]
    ◇RAYON_CONGE=/0 [DEFAULT]
    /r , [R]
    ◆CENTER= (x0, y0, z0), [1_R]
    ◆VECT_X= (vxx, vxy, vxz), [1_R]
    ◆VECT_Y= (vyx, vyy, vyz), [1_R]
    ◇COTE_FISS=/ "IN", [DEFAULT]
    / "OUT",

    #Si forms = "CYLINDRE"
    ◆DEMI_GRAND_AXE=a , [R]
    ◆DEMI_PETIT_AXE=b , [R]
    ◆CENTER= (x0, y0, z0), [1_R]
```

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```

♦VECT_X= (vxx, vxy, vxz), [1_R]
♦VECT_Y= (vyx, vyy, vyz), [1_R]

#Si forms = "NOTCH"
♦DEMI_LONGUEUR=a ,
♦ RAYON_CONGE=r ,
♦CENTER= (x0, y0, z0),
♦VECT_X= (vxx, vxy, vxz),
♦VECT_Y= (vyx, vyy, vyz),

#Si forms = "DEMI_PLAN"
♦PFON= (x0, y0, z0), [1_R]
♦NORMALE= (vnx, vny, vnz), [1_R]
♦DTAN= (vtx, vty, vtz), [1_R]

#Si forms = SEGMENT'
♦PFON_ORIG= (x0, y0, z0), [1_R]
♦PFON_EXTR= (x1, y1, z1), [1_R]

#Si forms = "DEMI_DROITE"
♦PFON= (x0, y0, z0), [1_R]
♦DTAN= (vtx, vty, vtz), [1_R]

#Si forms = "RIGHT"
♦POINT= (x0, y0, z0), [1_R]
♦DTAN= (vtx, vty, vtz), [1_R]

),

#Soit one reads again already existing fields at nodes

/♦CHAM_NO_LSN=ch_lsn , [cham_no]
♦CHAM_NO_LST=ch_lst , [cham_no]

#Définition of the zone of enrichment

♦GROUP_MA_ENRI=grma ,
[1_gr_maille]
♦CHAM_DISCONTINUITE=' DEPL', [DEFAULT]
♦TYPE_ENRI_FOND=/ "TOPOLOGIQUE" [DEFAULT]
/ "GEOMETRIQUE"

#Si TYPE_ENRI_FOND=' GEOMETRIQUE'
♦RAYON_ENRI=Renri , [R]

# If RAYON_ENRI = Nun
♦NB_COUCHES=/4 ,
[DEFAULT] =/N , [I]

#Définition of a junction on crack
# If (MODELE_GRILLE = Nun and FISS_GRILLE = Nun),

♦JONCTION=_F (

♦FISSURE= (fiss1, fiss2,..., fissi), [1_fiss_xfem]
♦POINT= (Pox, Poy, Poz), [1_R]

#Impression of information

```

```
◇INFO=/1  
      /2 ,  
      /3 ,  
      )
```

[DEFAULT]

3 Operands

3.1 Operand `MODELS`

◆`MODELE=mo`

`Mo` : name of the model on which one will define crack. This model is obligatorily a mechanical or thermal model (see key word `phenomenon` of operator `AFFE_MODELE` [U4.41.01]).

The definition of a crack by this operator is authorized only for the following modelizations:

if `Mo` is a mechanical model:

- 3D, `C_PLAN`, `D_PLAN`, `AXIS` for any type of meshes.

Attention, the quadratic elements X-FEM especially miss robustness (in 3D) and one advises to use linear elements X-FEM.

if `Mo` is a thermal model:

- 3D for meshes support `HEXA8`, `PENTA6`, `PYRA5`, `PLANE`
- `TETRA4` and `AXIS` for meshes support `QUAD4` and `TRIA3`

3.2 Definition of a grid to be associated with crack

One auxiliary grid can be associated with crack:

- either by giving a model roasts (see §3.2.15),
- or by giving a crack already associated with a preceding grid (see §3.2.25),

the use of the grid is strongly advised in the event of crack propagation because it makes it possible to reduce the computing times. In the case of use of the method upwind in `PROPA_FISS` (Doc. U4.82.11), its use is almost compulsory.

This key word is used typically following a refinement by Homard of the mesh where the crack was defined.

3.2.1 Operand `MODELE_GRILLE`

◇`MODELE_GRILL` = `mogri` [model]

`mogri` : name of the model of the grid to be associated with crack

This operand is used the model to associate grid `mogri` with crack. The two functions of level (level set) and their gradients are calculated at the same time on the model `Mo` given by `MODELE` (see §3.15) and on the model `mogri` according to the method chosen by `DEFI_FISS` (see §3.46) and they are stored with crack. Thus several cracks can be defined on the same grid `mogri`.

The model `mogri` is created by `AFFE_MODELE` by means of key word `GRILL`.

Auxiliary grid used must extend only on the zone envisaged from propagation from crack in order to correctly be able to represent the bottom of crack during all the simulation of the propagation. It can be partly outside the mesh model `Mo` (key word `MODEL`, to see §3.15) and no ratio does not exist between this mesh and that used to define grid `mogri` the `model`. In the presence of several cracks and with a use of different grid for each one, the grids are independent and can be superimposed partially or completely. In this case one could also use only one grid for all cracks.

3.2.2 Operand `FISS_GRILLE`

If one defined a crack on a mesh with an associated grid and where one wants to redefine it on another mesh without changing grid, one can save computing time while avoiding recomputing the functions of level on the grid. Indeed, in this case the functions of level defined on the grid do not change.

That is always the case when one uses Homard on the mesh where the crack was defined because the grid is not affected by the Homard modifications and the functions of level defined initially do not change. One can thus redefine same crack on the mesh refined with the same grid associated by calculating the functions with level only on the mesh and by keeping them with identical on the grid.

```
◇ FISS_GRILLE=      fiss_orig,                      [fiss_xfem]
```

One specifies the crack `fiss_orig` which was definite front. The grid already present is associated with new crack and the calculated fields at nodes which define the functions of level and their gradients are recopied on the grid for new crack. That is equivalent has by means of to define the crack `fiss_orig` on the new mesh always the same grid.

Note:

No checking can be made on the coherence between the crack which will be defined by DEFI_FISS (see § 6) and that which was defined on the grid of `fiss_orig`.

3.3 Operand TYPE_DISCONTINUITÉ

```
◇TYPE_DISCONTINUITÉ=/      "FISSURES",          [DEFAULT]  
/      "INTERFACE"
```

By default, one defines a crack. It is however possible to define an interface (to treat the case of 2 solids in contact, or under-thickness,...).

If `TYPE_DISCONTINUITÉ = "CRACK"`, the produced data structure is enriched by two named arrays "`FOND_FISS`" and recoverable "`NB_FOND_FISS`" by means of command `RECU_TABLE`. Array "`NB_FOND_FISS`" contains only one value corresponding to the number of crack tips. The array thus contains only one column (named `NOMBRE`) and only one line. Array "`FOND_FISS`" contains the list of the coordinates of the points of all the crack tip. This array 6 columns:

- the first column ("`NUME_FOND`") corresponds to the number of the crack tip,
- the following column ("`NUM_PT`") corresponds to the number of the point of the crack tip, this number is local with the crack tip running,
- the following column ("`ABSC_CURV`") corresponds to the value of the curvilinear abscisse along the current crack tip,
- the 3 following columns ("`COOR_X`" , "`COOR_Y`" and "`COOR_Z`") correspond to the coordinates of the point.

3.4 Key word DEFI_FISS

```
◆DEFI_FISS=_F
```

The factor key word `DEFI_FISS` makes it possible to define a crack or an interface in 4 different ways:

- maybe from two mesh groups (see §3.4.16);
- maybe from two analytical functions (see §3.4.27);
- maybe from a catalog of preset forms (see §3.4.38);
- maybe from existing fields (see §3.4.412).

3.4.1 Definition of crack by mesh groups

If there is a crack (or an interface) already with a grid, then one can define crack by giving two mesh group: `GROUP_MA_FISS` and `GROUP_MA_FOND`. This mesh can be independent of the mesh of structure.

```
/◆      GROUP_MA_FISS=grma  
with grma single mesh group.
```

This mesh group corresponds to only one of the lips of the crack (lower lip or higher). This mesh group must be directed. In the case of lips which would not be stuck perfectly, the fact of privileging a side will

have a light influence on the basis of local crack tip, influences all the more large as the angle between the two lips is important. For the case 2D, the program sorts meshes `GROUP_MA_FISS` in order to have a mesh group contiguous whatever the starting group. It is thus not necessary to give a mesh group which is followed.

◇ `GROUP_MA_FOND=grma`

with `grma` single mesh group.

This operand is used to define the crack tip. For the interfaces, `GROUP_MA_FOND` is not with informing.

In 2D, `GROUP_MA_FOND` is a mesh group not.

3.4.2 Definition of crack by analytical functions

the principal interest of this operator is the possibility of defining a crack without this one not being inevitably with a grid. In this case, one defines crack using two functions of levels (level sets). The first level set (known as level set "norm") is that which makes it possible to characterize the surface of crack. One thus informs `FONC_LN` with a function real of X , Y and Z definite as a preliminary by the operator `FORMULA`. The surface of crack will be then the Iso-zero of this function. The second level set (known as level set "tangent") is that which makes it possible to characterize the crack tip. One thus informs `FONC_LT` with a function real of X , Y and Z definite as a preliminary by the operator `FORMULA`. The trace of the Iso-zero of `FONC_LT` in the plane of cracking is the crack tip. The points of crack are then characterized by `FONC_LN = 0` and `FONC_LT < 0`, whereas the crack tip is characterized by `FONC_LN = 0` and `FONC_LT = 0`.

For the interfaces, `FONC_LT` is not with informing.

/◆`FONC_LN=fonc`

with `fonc` a function or a formula defined before.

◇`FONC_LT=fonc`

with `fonc` a function or a formula defined before.

Note:

For a crack, it is paramount that the level sets are the true functions distances, one cannot thus define an elliptic crack by:

`LN=FORMULE (NOM_PARA= ("X", "Y", "Z"), VALE=' Z-H')`

`LT=FORMULE (NOM_PARA= ("X", "Y", "Z"), VALE=' (X/a) ^ 2 + (Y/b) ^ 2 - 1')`

where a and B would be the equatorial radius and half-small axis of the ellipse. Indeed, the function `LT` is not the distance to the ellipse. The function distance to an ellipse is not expressed using usual functions. For introduced such a crack, the 3rd method should be used: predefined forms.

For the interfaces, any function level set is possible, and it is not useful to introduce the true function outdistances.

Note:

To date nothing would prohibit to have a level set which defines several closed crack tips (for example several cracks of the type "Penny-shaped"). Under these conditions, a call to `DEFI_FISS_XFEM` could then define several cracks. This possibility is prohibited: each command `DEFI_FISS_XFEM` defines only one crack. It is thus not possible to define several closed funds OR a bottom closed more one or more open funds.

Note:

Attention with the sign of `FONC_LT`, always to remember that the crack is defined on the side `FONC_LT < 0`.

3.4.3 Definition of crack by a catalog of form predefined

There exists a catalog of predefined forms of crack/interface. The choice of the form depends on the dimension of the mesh (2D or 3D). The possible choices are indexed in Table 3.4.3-1.

	Cracks	Interfaces
2D	SEGMENT, DEMI_DROITE	RIGHT , ELLIPSE , RECTANGLE , NOTCH
3D	ELLIPSE, RECTANGLE, CYLINDRE, DEMI_PLAN	

Table 3.4.3-1: Catalogue predefined forms

For each form, it is necessary to give the specific geometrical characteristics.

```
/♦FORMES_FISS=formes ,
```

3.4.3.1 FORM_FISS = "ELLIPSE"

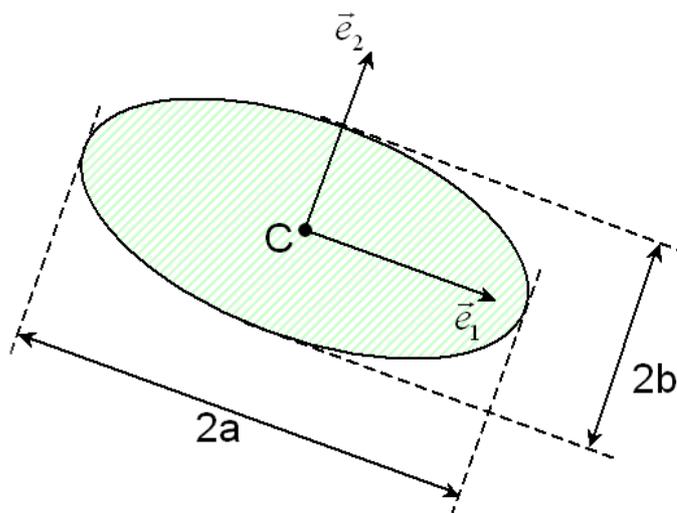
Case of an elliptic plane crack in 3D or of an elliptic inclusion of form in 2D. It is necessary by the key word to inform the length of equatorial radius DEMI_GRAND_AXE and the length of half-small axis by the key word DEMI_PETIT_AXE. To characterize the plane of the ellipse, one must by the key word inform the center of ellipse CENTER and the reference of the plane by key word VECT_X and VECT_Y. Vector VECT_X corresponds to the axis of the ellipse the length which one defines the length a given under key word DEMI_GRAND_AXE, and vector VECT_Y corresponds to the axis of the ellipse the length which one defines the length b under key word DEMI_PETIT_AXE.

Note:

That one chooses $0 < b \leq a$ or $0 < a \leq b$, VECT_X remains always associated with DEMI_GRAND_AXE and VECT_Y remains always associated with DEMI_PETIT_AXE .

In the case of a crack, one can moreover specify of which with dimensions is crack (inside or outside the ellipse) by the key word COTE_FISS . 3.4.3.1-1 represents an elliptic crack/inclusion, of equatorial radius a , half-small axis b and center C . The vector \vec{e}_1 corresponds to the key word VECT_X and the vector \vec{e}_2 corresponds to the key word VECT_Y .

```
♦DEMI_GRAND_AXE=a ,
♦DEMI_PETIT_AXE=b ,
♦CENTER= (Cx, Cy, Cz),
♦VECT_X= (e1x, e1y, e1z),
♦VECT_Y= (e2x, e2y, e2z),
♦COTE_FISS=/ "IN",
/ "OUT",
```



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nd inaccurate in whole or in part

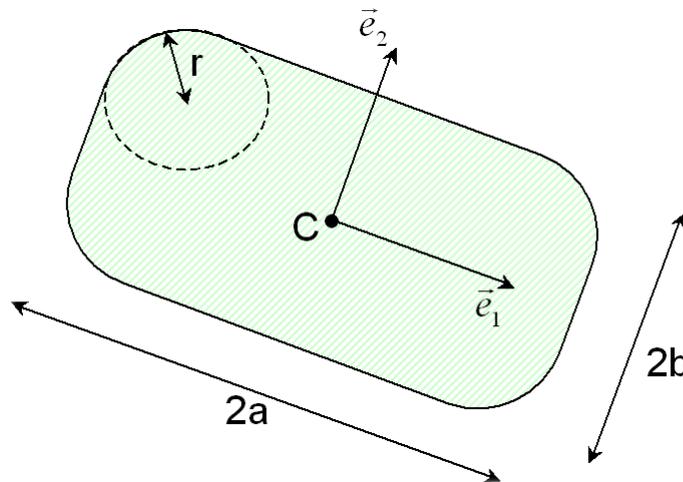
3.4.3.1 3.4.3.1-1: Diagram of an elliptic crack/inclusion

3.4.3.2 FORM_FISS = "RECTANGLE"

Case of a crack planes of rectangular form in 3D, or a rectangular inclusion of form in 2D, with possibility of corners rounded. It is a form similar to the ellipse, it is necessary to inform the same key word: the value of equatorial radius (or half-length) by the key word `DEMI_GRAND_AXE` and the value half-small axis (or half-width) by the key word `DEMI_PETIT_AXE`. To characterize the plane of the rectangle, one must by the key word inform the center of rectangle `CENTER` and the reference of the plane. The equatorial radius corresponds to vector `VECT_X` and the half-small axis with vector `VECT_Y`. Moreover, in the case of a crack, one can specify of which with dimensions crack (inside or outside the rectangle) is by the key word `COTE_FISS`. The only key word in compared to the form ellipse is that being used to give the value of the radius of fillet for the corners rounded (`RAYON_CONGE`). 3.4.3.2 3.4.3.2-1 represents a crack/rectangular inclusion of form to corners rounded, equatorial radius a , half-small axis b and center C . The vector \vec{e}_1 corresponds to the key word `VECT_X` and the vector \vec{e}_2 corresponds to the key word `VECT_Y`. The radius of fillet of the corners rounded is r . By default the radius of fillet is null.

```

◆DEMI_GRAND_AXE=a           ,
◆DEMI_PETIT_AXE=b          ,
◇RAYON_CONGE=r             ,
◆CENTER=                   (Cx, Cy, Cz),
◆VECT_X=                   (e1x, e1y, e1z),
◆VECT_Y=                   (e2x, e2y, e2z),
◇COTE_FISS=/               "IN",
                           / "OUT",
    
```



3.4.3.2 3.4.3.2-1: diagram of a rectangular crack/inclusion with corners rounded

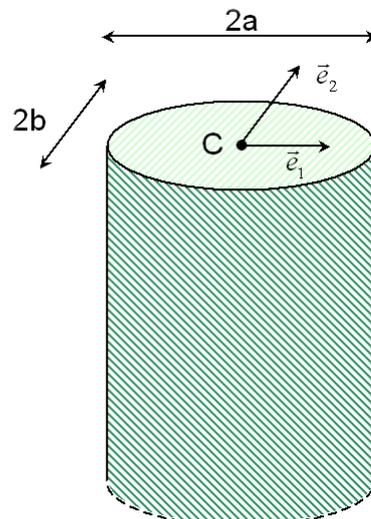
3.4.3.3 FORM_FISS = "CYLINDRE"

Case of a cylindrical three-dimensional crack with elliptic section. To characterize the bottom (elliptic) crack, it is necessary by the key word to inform the length of equatorial radius `DEMI_GRAND_AXE` and the length of half-small axis by the key word `DEMI_PETIT_AXE`. One must also inform the center of ellipse by the key word `CENTER` as well as the reference of plane (`VECT_X`, `VECT_Y`). Note: the equatorial radius corresponds to vector `VECT_X` and the half-small axis with vector `VECT_Y`. The generator of the cylinder and the direction of potential propagation of crack are given by the cross product of `VECT_X` by `VECT_Y`. This cylinder is semi-infinite along this axis. Appears 3.4.3.3-1 a crack of the type rolls equatorial radius a , of half-small axis b and center C . The vector \vec{e}_1 corresponds to the key word `VECT_X` and the vector \vec{e}_2 corresponds to the key word `VECT_Y`.

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```

♦DEMI_GRAND_AXE=a          ,
♦DEMI_PETIT_AXE=b         ,
♦CENTER=                   (x0, y0, z0),
♦VECT_X=                   (vxx, vxy, vxz),
♦VECT_Y=                   (vyx, vyy, vyz),
    
```



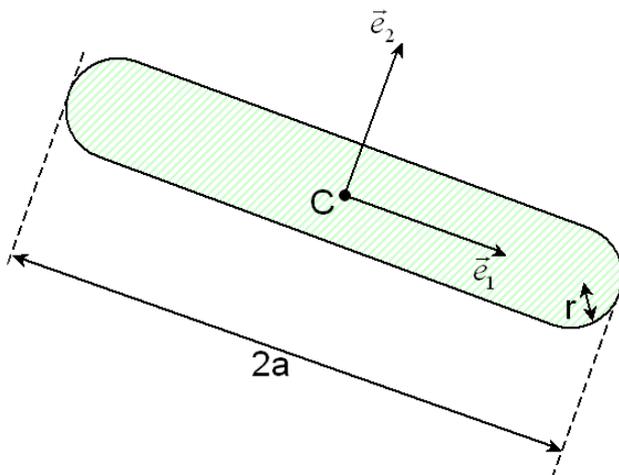
Appears 3.4.3.3-1: Diagram of a crack rolls

3.4.3.4 FORM_FISS = "NOTCH"

Case of an inclusion of the type notches in 2D. It is a typical case of inclusion of the right-angled type to corners rounded in where the half-height is equal to the radius of fillet. To define the notch it is necessary to inform by the key word the value of half-length `DEMI_LONGUEUR`, the value of the radius of fillet by the key word `RAYON_CONGE` and the center of notch by the key word `CENTER`. Moreover, the direction of the notch is given by key words `VECT_X` and `VECT_Y`. Appears 3.4.3.4-1 represents an inclusion of the type notches, half-length a , radius of fillet r and center C . The vector \vec{e}_1 corresponds to the key word `VECT_X` and the vector \vec{e}_2 corresponds to the key word `VECT_Y`.

```

♦DEMI_LONGUEUR=a          ,
♦RAYON_CONGE=r           ,
♦CENTER=                  (Cx, Cy, Cz),
♦VECT_X=                  (e1x, e1y, e1z),
♦VECT_Y=                  (e2x, e2y, e2z),
    
```

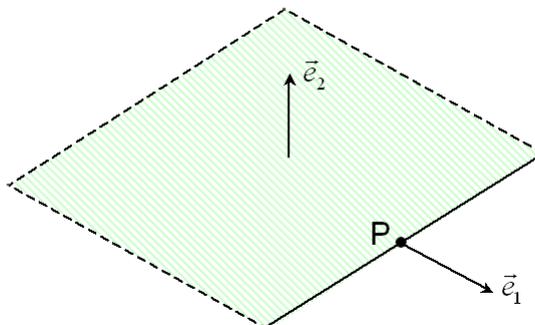


Appears 3.4.3.4-1: diagram of a rectangular crack/
inclusion with corners rounded

3.4.3.5 FORM_FISS = "DEMI_PLAN"

Case of a crack defined by a half-plane. PFON indicates a point of the crack tip. NORM defines the norm in the half-plane of crack and DTAN provides a vector in the plane of crack, orthogonal to bottom and directed in the direction of potential propagation. Appears 3.4.3.5-1 represents a crack of half-plane defined by P a point of the bottom, the vector \vec{e}_1 corresponds to the key word DTAN and the vector \vec{e}_2 corresponds to the key word NORMAL.

- ◆PFON= (Px, Py, Pz),
- ◆DTAN= (e1x, e1y, e1z),
- ◆NORMALE= (e2x, e2y, e2z),



Appears 3.4.3.5-1: diagram of a
crack half-plane

3.4.3.6 FORM_FISS = "SEGMENT"

Case of a crack 2D defines by a segment. PFON_ORIG and PFON_EXTR indicate the ends of the segment. Appears 3.4.3.6-1 presents a crack 2D standard segment where $P1$ indicates the point of origin PFON_ORIG and $P2$ the point end PFON_EXTR .

- ◆PFON_ORIG= (P1x, P1y, P1z),
- ◆PFON_EXTR= (P2x, P2y, P2z),



Appears 3.4.3.6-1:
diagram of a crack 2d
of type segment

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3.4.3.7 FORM_FISS = "DEMI_DROITE"

Case of a crack 2D defined by a half-line. PFON indicates the point of the crack tip. DTAN corresponds to a directing vector of the half-line directed in the direction of potential propagation. Appears 3.4.3.7-1 presents a crack 2D standard half-line for which P of the bottom (PFON is the point) and of directing vector \vec{e}_1 (DTAN).

```

♦PFON=                (x0, y0, z0),
♦DTAN=                (e1x, e1y, e1z),
    
```



Appears 3.4.3.7-1: diagram of a crack 2D of standard half-line

```
if forms = RIGHT
```

Case of a right interface in a structure 2D definite. POINT a point of the interface indicates. DTAN corresponds to a directing vector of the right. The directional sense is not important.

```

♦POINT=                (x0, y0, z0),
♦DTAN=                (vtx, vty, vtz),
    
```

3.4.4 Definition of crack by relecture of already existing fields at nodes

```

/♦CHAM_NO_LSN=ch_lsn                ,                [cham_no]
♦CHAM_NO_LST=ch_lst                ,                [cham_no]
    
```

the fields `ch_lsn` and `ch_lst` are already existing fields at nodes. They must be created on the same mesh that attached to the model as starter (cf §3.13.1).

These nodal fields can be obtained successively by the reading of an array (LIRE_TABLE), then by the creation of the field by extraction of array (CRÉA_CHAMP/OPERATION=' EXTR').

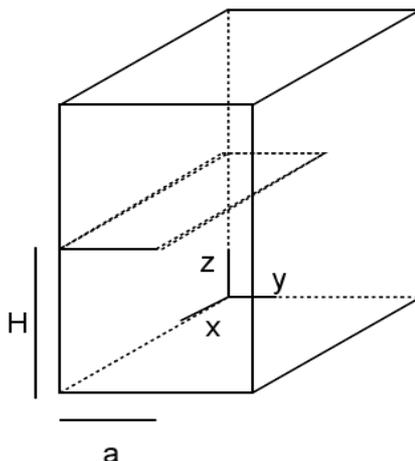
They could also be generated in a stage of refinement of mesh (MACR_ADAP_MAIL/MAJ_CHAM).

3.4.5 Examples

•if one wishes to define a bar fissured right through in his plane in the height $z=H$ (see [Figure 3.2-a], on which the crack is hatched):

```

LN=FORMULE (NOM_PARA= ("X", "Y", "Z"), VALE=' z-H');
LT=FORMULE (NOM_PARA= ("X", "Y", "Z"), VALE=' Y-a');
    
```



Apppear 3.2-a: Fissured bar

•if one wishes to define an elliptic crack in an infinite solid mass in a plane in the height $z = H$ (see [Figure 3.2-b], on which the crack is hatched):

```

DEFI_FISS=_F      (          FORMES_FISS=' ELLIPSE',
                   DEMI_GRAND_AXE=a      ,
                   DEMI_PETIT_AXE=b      ,
                   CENTER=                (0, 0, H),
                   VECT_X=                (1, 0, 0),
                   VECT_Y=                (0, 1, 0),
                   COTE_FISS=' IN',),

```

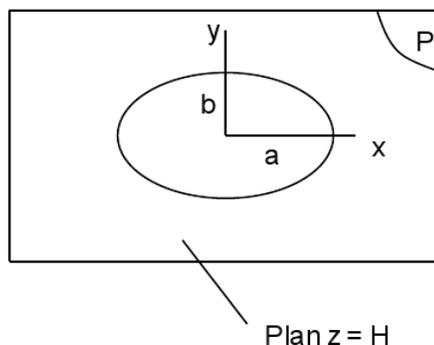


Figure 3.2-b: Elliptic crack

3.5 Operand GROUP_MA_ENRI

```

◇GROUP_MA_ENRI=grma      ,
[1_gr_maille]

```

This operand makes it possible to know the zone on which the procedure of enrichment will be carried out. The nodes nouveau riches must belong to this group of mesh.

If GROUP_MA_ENRI is not indicated, then the procedure of enrichment will be carried out on all the mesh associated with the model.

A use of this key word thus makes it possible to delimit the zone of enrichment, therefore crack. The following example presents an elliptic crack of form in a hollow roll. The crack is defined by the data of mesh groups (key words GROUP MA FISS and GROUP MA FOND). Two level sets are deduced from

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

it, by considering a prolongation of the crack tip by continuity. If the zone of enrichment contains all structure, that led then to a crack in the right part of the cylinder, which is not at all what one wishes. To solve this problem, it is enough to limit the zone of enrichment and to inform key word GROUP_MA_ENRI with meshes of the left half of the cylinder for example.

3.6 Operand CHAM_DISCONTINUITE

```
◇CHAM_DISCONTINUITE=' DEPL', [DEFAULT]
```

This key word makes it possible to choose the type of fields to enriching. For the moment, only the field of displacement can be enriched.

3.7 Operands TYPE_ENRI_FOND, RAYON_ENRI, NB_COUCHES

```
◇TYPE_ENRI_FOND=/ "TOPOLOGIQUE" [DEFAULT]  
/ "GEOMETRIQUE"
```

This key word makes it possible to choose the type of enrichment in crack tip. Topological enrichment is activated (only one layer) if TYPE_ENRI_FOND = " TOPOLOGIQUE" (by default). Geometrical enrichment is activated (several layers) if TYPE_ENRI_FOND = " GEOMETRIQUE" (for more information concerning the effects of enrichment on quality of the results, to see [R7.02.12] and [U2.05.02]). Geometrical enrichment is controlled by key words RAYON_ENRI and NB_COUCHES . This kind of enrichment is not advised at all with quadratic meshes (under penalty of null pivot).

```
◇ RAYON_ENRI = Renri, [R]
```

This key word can be indicated only if TYPE_ENRI_FOND = "GEOMETRIQUE" . If this operand is indicated, it makes it possible to specify a geometrical criterion Renri such as all the nodes whose distance to the crack tip is lower than this criterion will be enriched by the singular functions. This enrichment is called "geometrical". Studies showed that such an enrichment largely improved the accuracy of computations, in particular when the mesh is refined in crack tip. It is advised to choose Renri approximately equal to 1/10 the length of crack. The disadvantage is that a too large radius of enrichment can deteriorate the conditioning of the system and generate difficulties of convergence.

To avoid the nuisances caused by a too large radius of enrichment, one proposes to define the zone to be enriched by stipulating the number of layers of elements to enriching around the crack tip instead of radius by enrichment.

```
# If RAYON_ENRI=None  
◇ NB_COUCHES = /4 , [DEFAULT]  
/N , [I]
```

If RAYON_ENRI is not indicated (and that TYPE_ENRI_FOND = "GEOMETRIQUE"), then NB_COUCHES is the number of layers of elements to enriching (4 per default). Generally, 7 layers is the limit not to exceed to avoid the null pivots during the resolution.

3.8 Operand JONCTION

```
# If MODELE_GRILLE = Nun,  
◇JONCTION =_F (  
    ◆FISSURE= (fiss1, fiss2, ..., fissi), [l_fiss_xfem]  
    ◆ POINT = (Px, Py, Pz), [l_R]
```

Note:

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The functionalities associated with this operand are available only for the mechanical models (see the paragraph dedicated to the operand `MODELS` page 5).

This operand makes it possible to define one or more junctions between a crack and other already existing cracks. These other cracks are then regarded as cracks mothers: they should have been already beforehand defined by calls to `DEFI_FISS_XFEM`.

One informs a crack mothers list in the key word `FISSURES`. All these cracks mothers will be taken into account at the time of the definition of current crack. The key word `POINT` must be given in the field where it is wished that the crack be defined. An example is provided figure 3.7-a. One considers on this figure that crack 3 was defined at the beginning to cut the field vertically. One introduces key word `JUNCTION` in order to connect it on cracks 1 and 2. One can `POINT` obtain the three configurations of the figure according to the choice of the position given in the key word.

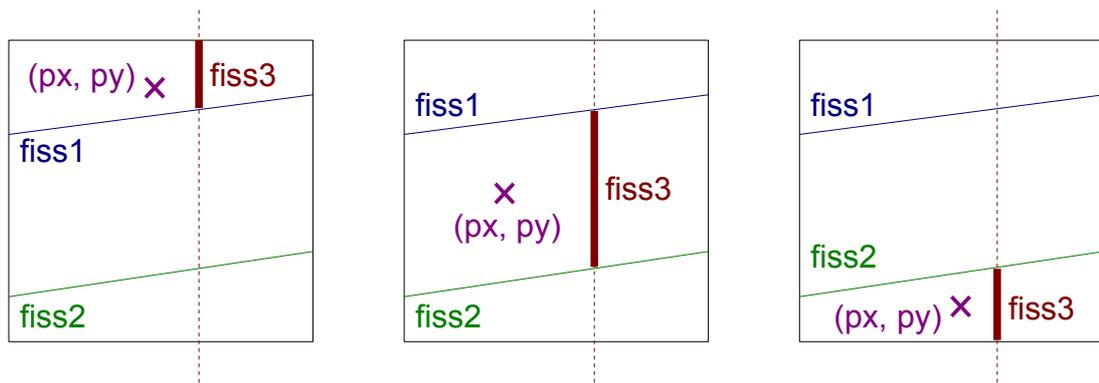


Figure 3.8-1 : Example of definition of the crack `fiss3`, for the cracks mothers `fiss1` and `fiss2`, according to the selected (px, py) point.

It should well be paid attention when operand `JUNCTION` is used: the crack then will not be only any more represented by its level sets norm and tangent, but it will also depend on the cracks mothers. That can pose problem if one wishes to use operators like `RAFF_XFEM`, which take into account only the notion of level sets like mode of definition of crack. In the same way the chart of the Iso-zero of the level sets is not sufficient, it is preferable to pass by postprocessing operations via operator `POST_MAIL_XFEM`.

An example of configuration is presented Figure 3.8-2. On this example one identifies the cracks on which another crack comes to connect. Thus for crack $N=3$, one has $K=2$ where K is all the cracks on which 3 connects. In the same way for crack $N=5$, one deduces $K=[3,4]$. Crack 5 is thus defined from the operand junction and of two cracks 3 and 4. Crack 3 is itself before definite from the operand junction acting on crack 2, itself definite from the operand junction acting on crack 1. The shaft of hierarchy of Figure 3.8-2 is thus used to us to establish the order of definition of the various cracks (2 from 1,3 from 2,4 from 1 and 5 from 3 and 4).

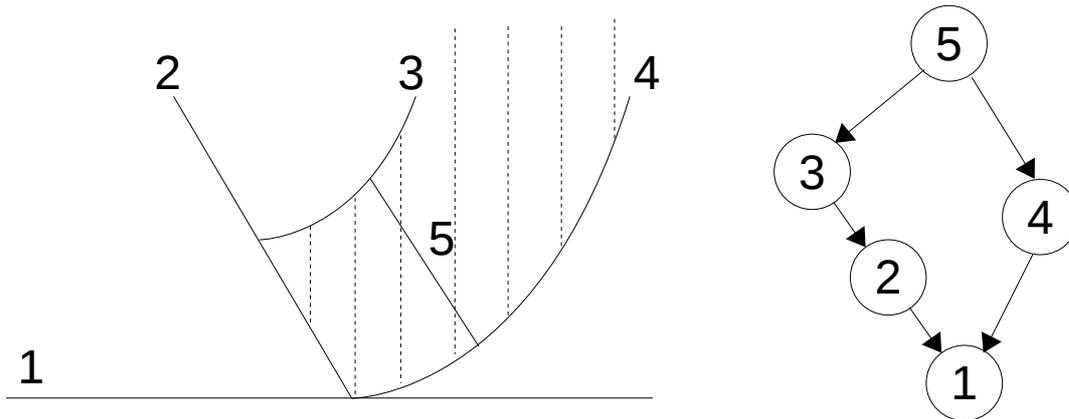


Figure 3.8-2 : Network of cracks on the left, shaft of hierarchy on the right indicating which connects and allowing to establish the relations of order for the definitions of crack and the use of the operand JONCTION.

The operator junction allows to establish a relation of order for a mesh which sees N cracks. One will thus distinguish on Figure 3.8-3 two shafts from hierarchy from right. In the shaft on the right, cracks 1 and 2 are sufficiently close so that a mesh seeing crack 3, sees also cracks 1 and 2: one thus decides to connect crack 3 on cracks 2 and 1, but to use as the operand junction to indicate as crack 2 is connected to crack 1. For the other shaft, a mesh sees with more 2 cracks (no mesh sees then at the same time cracks 1,2 and 3) and in this case crack 3 connects simply on the cracks 2 and 1 which are not connected any more between them.

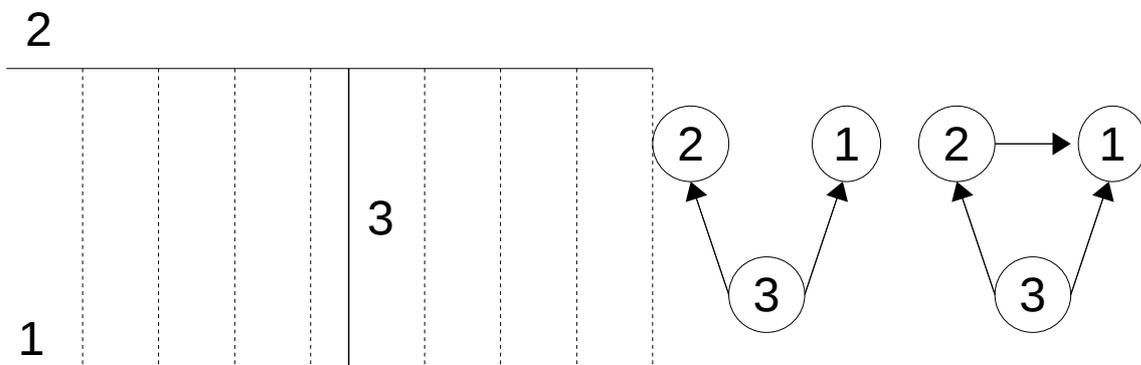


Figure 3.8-3 : Network of cracks on the left, shafts of hierarchy on the right.

The shaft of hierarchy on the right indicates that crack 2 cannot be defined independently of crack 1 because too near to the latter (a mesh seeing crack 3 then sees also cracks 1 and 2).

3.9 Operand INFO

- /1 : printing on the file "MESSAGE"
- 1) amongst points of the crack tip;
 - 2) amongst crack tips;
 - 3) ordered list of the coordinates of the points of the bottom like their curvilinear abscisse, for each crack tip.

- /2 : same printings as 1 + printings
 - 1) amongst level sets readjusted;
 - 2) amongst meshes of the zone of crack;
 - 3) amongst meshes containing the crack tip
 - 4) amongst meshes Heaviside type, Ace-tip and Heaviside Ace-tip.
- /3 : even printing that 2 + printings
 - 5) of the stages of computation;
 - 6) fields level sets and their gradients;
 - 7) statute of the nodes;
 - 8) numbers of meshes enriched.

4 Examples

4.1 With analytical formulas

```
LN=FORMULE      ( NOM_PARA= ("X", "Y", "Z"), VALE=' Z-12.5' )
LT=FORMULE      ( NOM_PARA= ("X", "Y", "Z"), VALE=' X-10' )

FISS=DEFI_FISS_XFEM ( MODELE=MODELEIN
                      ,
                      DEFI_FISS=_F ( FONC_LT=LT
                                     ,
                                     FONC_LN=LN
                                     , )
                      ,
                      GROUP_MA_ENRI=' VOL'
                      ,
                      INFO=2
                      )
```

4.2 With mesh groups

```
FISS=DEFI_FISS_XFEM ( MODELE=MODELEIN
                      ,
                      DEFI_FISS=_F (          GROUP_MA_FISS='
LEVSUP'
                      ,
                      GROUP_MA_FOND   =   ' FONFIS'
                      ,
                      GROUP_MA_ENRI   =   ' VOL'
                      ,
                      INFO=3
                      )
```

4.3 With the catalog of preset forms

Case of a cylindrical crack:

```
FISS=DEFI_FISS_XFEM (MODELE=MODELEIN,
DEFI_FISS=_F (
FORM_FISS = "CYLINDRE",
DEMI_GRAND_AXE = R,
DEMI_PETIT_AXE = R,
CENTER      = (0. , l_fiss, 0.),
VECT_X      = (0. , 0. , 1.),
VECT_Y      = (1. , 0. , 0.),
),
GROUP_MA_ENRI=' VOL',
INFO=1,
);
```

Case of a crack defined by a half-plane:

```
FISS=DEFI_FISS_XFEM (MODELE=MODELEIN,
INFO=1,
DEFI_FISS=_F (
FORM_FISS = "DEMI_PLAN",
PFON      = (0. , 5. , 15.),
NORM      = (0. , 0. , 1.),
DTAN      = (0. , - 1. , 0.),
GROUP_MA_ENRI=' VOL');
```