Operator DEFI_FOND_FISS

1 Goal

To define the geometric standards relative to a crack, in particular the bottom of crack and the upper lips and lower of this crack, in a grid 2D or 3D.

The definition of the bottom of the crack can be done starting from entities (nodes or meshs) or starting from groups of entities. The nodes can be ordered in the direction of the increasing curvilinear X-coordinates. If it is not the case and if the bottom of crack is given by a list of meshs or groups of meshs, the operator will order the nodes with the help of the definition of a node origin.

Two initial configurations of the upper lips and lower are takenS in account for the definition of the direction of propagation and the lips.

This operator creates a concept of the type fond_fiss who is usable by the operators CALC_G [U4.82.03] and POST_K1_K2_K3 [U4.82.05].

2 Syntax

```
FF [fond_fiss] = DEFI_FOND_FISS    (

♦  GRID = my ,                                                    [grid]
◊  INFORMATION         =  /  1,
   [DEFECT]
                       /  2,

# For the definition of a bottom of crack
♦  /  FOND_FISS = _F (

   # A kind of bottom is defined

   ◊  TYPE_FOND        =  /  'OPENED',                          [DEFECT]
                          /  'FIRM',

    # In 2D: one defines a group containing a single node

    ♦ /  GROUP_NO  =  lgrno,                                    [gr_noeud]

    # In 3D: one defines a list of meshs whose nodes can be already ordered or not

      /  GROUP_MA  =  lgrma,                                    [l_gr_maille]

    # In this last case it is then necessary to define an origin of the X-coordinates

     ◊ /  NOEUD_ORIG    = No   ,                                [l_noeud]
       /  GROUP_NO_ORIG= grno,                                  [l_gr_noeud]

    # If GROUP_MA is defined and if the bottom is not closed, one can then define an end of the X-coordinates
     ◊ GROUP_NO_EXTR= grno,                                     [l_gr_noeud]

    # If GROUP_MA is defined and if the bottom is closed, one can then define an end of the X-coordinates
     ◊ GROUP_MA_ORIG=  grma,                                    [l_gr_maille]


   ◊  /  DTAN_ORIG        =  (Drug addict, Toy, Toz),
   [l_R]
         DTAN_EXTR        =  (Tex, Tey, Tez),                  [l_R]
       / VECT_GRNO_ORIG   =  lgrno,                            [l_gr_noeud]
         VECT_GRNO_EXTR   =  lgrno,                            [l_gr_noeud]
                        ),

# For the definition of the initial configuration of the lips
◊  /  CONFIG_INIT = /  'COLLEE',                                [DEFECT]
                    /  'DECOLLEE',

# Symmetry of the structure
♦  SYME       = /   'NOT',
                /   'YES',
 # If the initial configuration is COLLEE : definition of the lips of the crack
♦  LEVRE_SUP = _F (
   ♦  GROUP_MA  =  lgrma,                                 [l_gr_maille]
                ),
```

If the structure is not symmetrical, the lower lip should be defined

♦ LEVRE_INF = _F (
♦ GROUP_MA = lgrma, [l_gr_maille]

If the initial configuration is DECOLLEE : definition of the normal
♦ NORMAL = (Nx, Ny, Nz) [l_R]

◊ PREC_NORM = / 1.E-1, [DEFECT]
/ epsi, [R]

)

3 Operands

3.1 Operand GRID

♦ GRID = my

Name of the grid on which one will define the bottom of crack and the lips.

3.2 Description of the bottom of crack

The bottom of crack is defined by the whole of the ordered nodes of the bottom of crack. If none the keywords NOEUD_ORIG or GROUP_NO_ORIG is not defined, the order of declaration of these nodes, via list of nodes or of meshs segments, the direction of course of the curvilinear X-coordinate of the bottom of crack will define. Load is thus left to the user compose an ordered list, within the meaning of the connectivity of the grid, by increasing curvilinear X-coordinate.
It is also possible to provide a list of meshs segments without worrying about the order. The data of a node origin, provided that it corresponds well at an end of the way defined by the meshs segments, then makes it possible to order the list of nodes.

In addition, in 3D, for a knot slip of the bottom of crack, the direction of propagation is defined as being the average of the normals to the meshs segments of the bottom of crack on its left and its right-hand side. For the nodes ends, the normal is calculated starting from one only mesh, and can thus be less precise.
The code thus envisages a correction of this normal by taking of account the edges of the structure. However, keywords DTAN_ORIG and DTAN_EXTR, optional, allow the user to directly impose the directions of propagation at the origin and the end of the bottom.
In order to determine the direction of the vector of direction of propagation when the structure is symmetrical and when the meshs of the upper lip are not defined with LEVRE_SUP (§3.3.3), the keyword DTAN_ORIG is then obligatory.
Keywords DTAN_ORIG and DTAN_EXTR no direction has in the case of a closed bottom and is then prohibited. Indeed, any node has then a mesh segment on its left and its right-hand side; nothing distinguishes the node origin and the direction from propagation in this point a current node from the bottom from crack.

```
 ◊ /   DTAN_ORIG        =   (Drug addict, Toy, Toz),          [l_R]
       DTAN_EXTR        =   (Tex, Tey, Tez),        [l_R]
    / VECT_GRNO_ORIG    =   lgrno  ,                   [l_gr_noeud]
VECT_GRNO_EXTR   =   lgrno  ,                  [l_gr_noeud]
```

3.2.1 Keyword factor FOND_FISS

3.2.1.1 Keyword TYPE_FOND

There is two possibilities to define the bottom of crack:
1) SI it bottom of crack is defined by an open curve (in opposition to the bottom defined by closed curve), one informs TYPE_FOND = 'OPEN'. This value is the value by default.
2) If the bottom of crack is defined by a closed curve, one inform TYPE_FOND = 'FIRM'.

3.2.1.2 Keyword GROUP_NO

/ ♦ GROUP_NO = grno

This keyword can be used only in 2D.

One expects a group containing a single node corresponding to the bottom of crack.
This keyword can be used only in 2D.

3.2.1.3 Keyword GROUP_MA

/ ♦ GROUP_MA = lgrma

This keyword can be used only in 3D.
List of groups of meshs of the type SEG2 or SEG3, ordinates or not compared to the bottom of crack.

3.2.1.4 Keyword GROUP_NO_ORIG

/ GROUP_NO_ORIG = grno

Single group of node, containing a single node. To be an end of the way defining the bottom of crack, it must rest on one and only one nets lgrma. This keyword can be defined only if GROUP_MA is defined. This keyword can be used only in 3D.

3.2.1.5 Keyword GROUP_NO_EXTR

/ GROUP_NO_EXTR = grno

Single group of node, containing a single node. This data is optional and is only used to check that the node end obtained by the operator is well that of which the user thinks. The code will stop in error if it is not the case. This keyword can be defined only if GROUP_NO_ORIG is defined. This keyword can be used only in 3D.

3.2.1.6 Operand DTAN_ORIG

◊ / DTAN_ORIG = vector (Drug addict, Toy, Toz)

Direction T_{or} at the origin of the bottom of crack directed in the direction of the propagation of the crack.

3.2.1.7 Operand VECT_GRNO_ORIG

/ VECT_GRNO_ORIG = lgrno with lgrno list of two groups of nodes containing each one only one node.

Direction T_{or} deduced from the data of two nodes.

3.2.1.8 Operand DTAN_EXTR

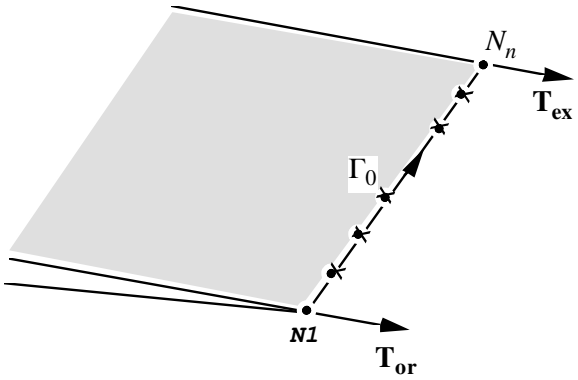
/ DTAN_EXTR = vector (Tex, Tey, Tez)

Direction T_{ex} at the end of the bottom of crack in the direction of the propagation of the crack.

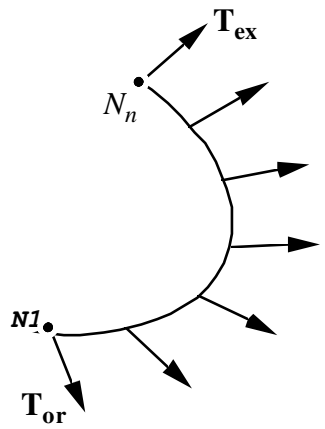
3.2.1.9 Operand VECT_GRNO_EXTR

/ VECT_GRNO_EXTR = lgrno with lgrno list of two groups of nodes containing each one only one node.

Direction T_{ex} deduced from the data of two nodes.



Example 1: case of a rectilinear plane crack:



Example 2: case of a crack planes curve:

Note:

T_{or} and T_{ex} are normalized automatically.

3.3 Description of the lips

Two initial configurations are treated:

1) if the lips are stuck
2) if the lips are separated

In the case of stuck lips, two cases are distinguished:

- if the grid is complete then the algorithm require the definition of the upper lips and lower.
- if the grid is to be supplemented by symmetry compared to the average plan of the lips then the algorithm requires only definition DE the upper lip.

Direction of propagation of the crack and the normal with the plan of the crack are calculatedS for each node of the bottom of crack.

In the case of separated lips, it is necessary to give the normal to the plan of the crack using the operand NORMAL (2D and 3D for the plane cracks only).

For a posterior use in POST_K1_K2_K3 (keyword FOND_FISS), the knowledge of the meshs of the lips is essential. Those are calculated in the case of stuck lips but not in the case of separated lips (one will use then CALC_G).

For the nonplane cracks 3D, the direction of propagation of the crack in any point of the bottom of crack is built in this operator and is used by the operator CALC_G [U4.82.03].
Currently, calculations of breaking process by CALC_G, POST_K1_K2_K3 or other are not possible for defects 3D not plans and whose lips are separated.

3.3.1 Keyword CONFIG_INIT

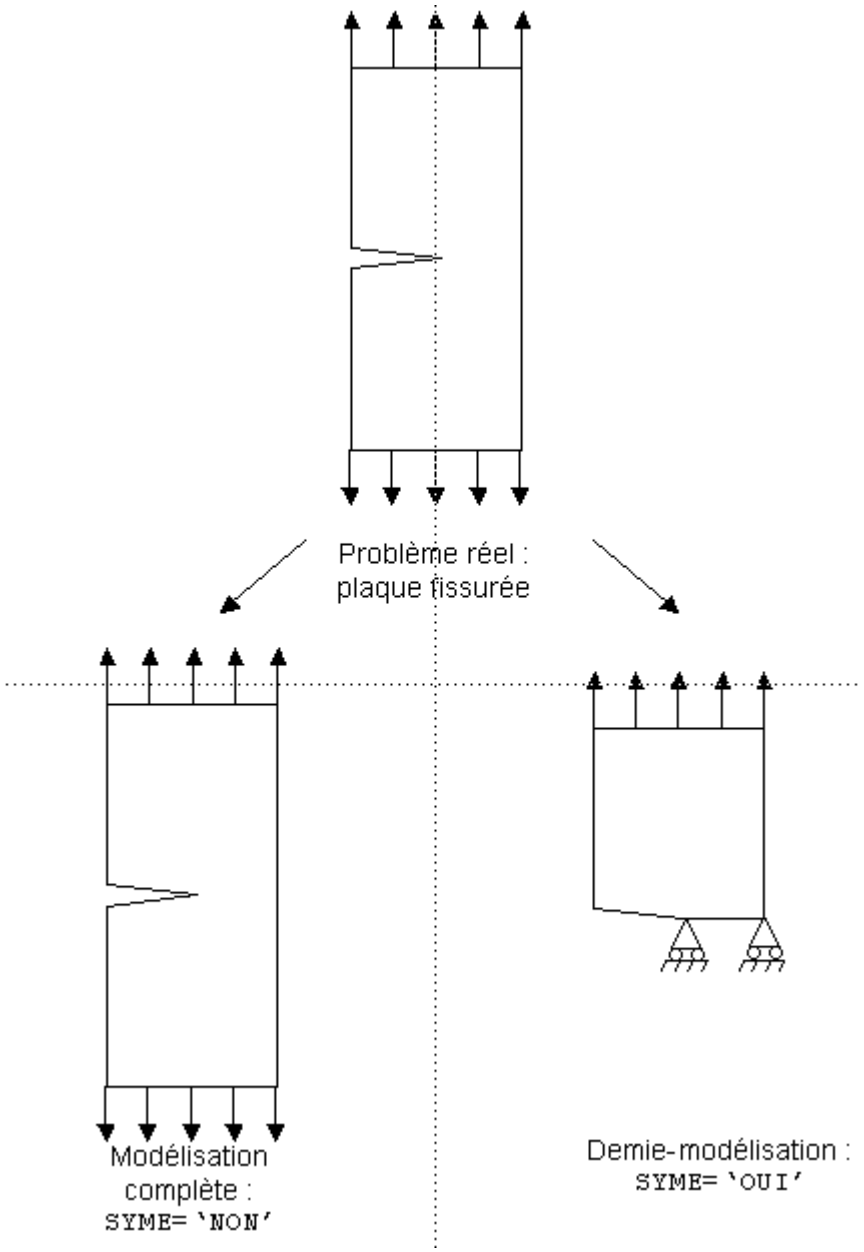
The initial configuration is that described by the grid. The lips are:
1. stuck if the angle between the 2 lips is lower or equal to 5°;
2. taken off in the contrary case.

Note: The calculation of the factors of intensity of the constraints with the operator POST_K1_K2_K3 [U4.82.05] *, or with L'option* 'CALC_K_G' *of the operator* CALC_G [U4.82.03] *, can be carried out only if* CONFIG_INIT=' COLLEE' *.*

3.3.2 Keyword SYME

This keyword makes it possible to specify if modeling used takes account of a symmetry of the structure compared to the average plan of the lips of the crack (see Figure 3.1). If SYME = 'YES' , the value of the rate of refund of energy G (S) and those of the factors of intensity of the constraints corresponding to the mode of symmetry will be automatically multiplied by 2 and that of G_Irwin by 4 (see [U4.82.03] for CALC_G and [U4.82.05] for POST_K1_K2_K3).

If SYME = 'YES' and CONFIG_INIT=' COLLEE', it is necessary then is to define the upper lip of the crack (LEVRE_SUP, §3.3.3) that is to say to give the direction of propagation to the point origin (DTAN_ORIG, § 3.2.1.6), in order to know of which with dimensions of the bottom the crack is located.



3.3.3 Keyword LEVRE_SUP

◊ LEVRE_SUP =

The whole of the faces of the elements defines which are pressed on the upper lip of the crack. The whole of these faces is specified by the operands:

GROUP_MA = lgrma list of groups of meshs.

The meshs are thus surface if the model is 3D and linear if the model is 2D.

3.3.4 Keyword LEVRE_INF

◊ LEVRE_INF = .

The whole of the faces of the elements 3D defines which are pressed on the lower lip of the crack. If the crack is on a symmetry plane, this keyword should not be indicated.

The whole of these faces is specified by the operands:

/ GROUP_MA = lgrma list of groups of meshs.

The meshs are thus surface if the model is 3D and linear if the model is 2D.

3.3.5 Operand NORMAL

This operator is to be defined only in the case of a crack in the separated lips. That relates to the cases of open defect or notch.
The keyword NORMAL is used to specify the normal vector with the plan of these lips, therefore with the crack itself. This vector is used in any point of the bottom of crack to determine the direction of propagation and thus supposes that the crack is plane. The normal is then not the normal with the lips, but with the plan of propagation (symmetry plane).

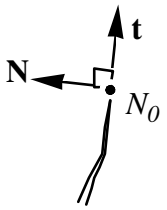
/ ♦ NORMAL = (Nx, Ny, Nz)

The keyword NORMAL allows to introduce the components Nx, Ny, Nz in the total reference mark of a normal N with the plan of the crack with the following convention of direction:

- In 3D, $n=\Gamma_0 \wedge N$, where n is the normal external with the crack in the plan of the lips, Γ_0 is the bottom of crack directed (defined by the keyword FOND_FISS),
- in 2D, the normal N is defined such as the reference mark (N_0, t, N) that is to say direct, with:

  N_0 the node of the bottom of crack,

  t direction of propagation of the crack.



In all the cases, N is normalized automatically. It is necessary to give the three components of the vector even in 2D.

3.4 Operand PREC_NORM

This operand is useful only in the case 3D for a crack defined starting from its lips (keywords LEVRE_SUP and LEVRE_INF), before a calculation with POST_K1_K2_K3 [U4.82.05].

The parameter PREC_NORM the precision used in the research of the nodes of the lips defines which are on normal directions at the bottom of crack: for the interpolation of the jumps of displacement, one indeed uses the nodes of which the distance *D* with the normal right-hand side at the bottom and passing by a node of this bottom checks:

$$d < \text{PREC\_NORM} \, . \, l_f$$

where l_f is the minimal distance between two successive nodes of the bottom of crack. To increase the value of PREC_NORM come down to increase the number of nodes potentially retained for the calculation of K in POST_K1_K2_K3.

4 Phase of checks

With the execution:

- checking of the membership of the entities (nodes and meshs) to the grid,
- checking that the bottom of crack defined by the data of a list of mesh constitutes a related way well,
- checking that it NOEUD_ORIG belongs well to one of the meshs and that it is well one of the two ends of the way defined by these meshs,
- in the case of a crack planes where the keyword NORMAL was used, one checks the orthogonality of this normal with the 2 tangent vectors given by the operands DTAN_ORIG and DTAN_EXTR,
- if the lips are defined by their group of meshs, it is checked that the surface meshs of the two lips are quite distinct and that the nodes of the bottom of crack belong well to at least a mesh of the lips.

In the structure of data produced by the operator are stored: the list of the nodes of the bottom of crack, the list of the meshs of the lips, if definite tangents at the ends, if definite the normal with the plan of the crack, and - if LEVRE_SUP / LEVRE_INF are used the list of the nodes of the lips belonging to the normals at the bottom of crack passing by each node of the bottom.

5 Examples

5.1 Whole crack defined by various types of entities in 3D

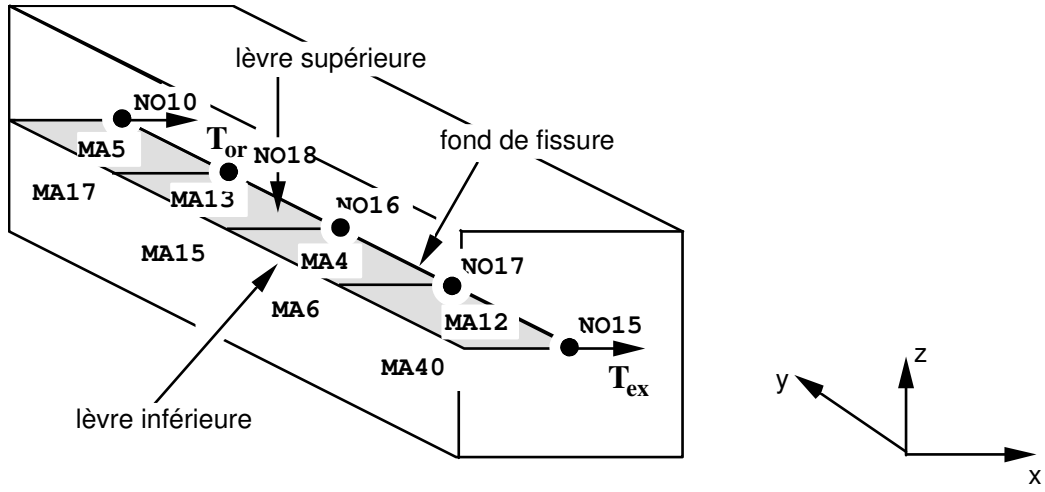
The bottom of crack is defined by a list of groups of nodes, the upper lip by a list of meshs, the lower lip by a list of groups of meshs.

```
Fiss1 = DEFI_FOND_FISS (GRID = my,
             FOND_FISS =   _F (GROUP_NO = ('GRN1', 'GRN2', 'GRN3'),
                               DTAN_ORIG =   (1. , 0. , 0.),
                               DTAN_EXTR =   (1. , 0. , 0.),),
             LEVRE_SUP =   _F (GROUP_MY = ('GM123'),),
             LEVRE_INF =   _F (GROUP_MA = ( 'GRM1' , 'GRM2' ),),
                           )
```

with the following groups defined in the grid my :

```
GRN1:  {N010  N018}        GRN2: {N018  N016  N017}
GRN3:  {N017  N015}
 GRM123: {MA5, MA13, MA4, MA12}
GRM1:  {MA17  MA15  MA6}   GRM2: {MA40}
```

The bottom of crack is made up here by the nodes N010, N018, N016, N017, N015 in an ordered way.



5.2 Use of the operand NORMAL (crack planes in 3D)

```
      fiss = DEFI_FOND_FISS  (  GRID         =  my,
                                FOND_FISS =_F (GROUP_NO=' GNOF',
                                              DTAN_ORIG =  (1. , 0. , 0.),
                                              DTAN_EXTR =  (1. , 0. ,
0.),),
                                CONFIG_INIT=' DECOLLEE',
                                NORMAL          =   (0. , 0. , - 1.),
                             )
```

The normal is defined N with the plan of the crack.

Direction n normal at the bottom of crack in the plan of the lips of the crack is determined by $n=\Gamma_0 \wedge N$ ·

with GRNOF: {NO1, NO2, NO3}

5.3

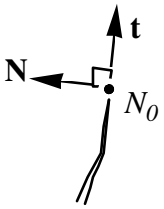
5.4 Crack in 2D

The bottom of crack is defined by the node N10 grid my. The groups of the meshs of the lips are noted respectively GMSUP and GMINF. The crack can be defined is starting from the normal:

```
      fiss = DEFI_FOND_FISS  (  GRID   =  my,
                                 FOND_FISS   =  _F (GROUP_NO = 'N10'),
                                CONFIG_INIT = 'DECOLLEE',
                                NORMAL =   (- 1. , 1. , 0.),
                             )
```

maybe starting from the meshs of the lips:

```
      fiss = DEFI_FOND_FISS  (  GRID   =  my,
                                FOND_FISS =   _F (GROUP_NO = 'N10'),
                                LEVRE_SUP =   'GMSUP',
                                LEVRE_INF =   'GMINF',
                             )
```



5.5 Fund of crack closed with scheduling of the nodes

```
fiss = DEFI_FOND_FISS (GRID    = my,
                       FOND_FISS=_F (TYPE_FOND=' FERME',
                                     GROUP_MA=' GMA',
                                     GROUP_NO_ORIG =   'NO',
                                     GROUP_MA_ORIG =   'GMA2'    ),
                       CONFIG_INIT = 'DECOLLEE',
                       NORMAL      =   (0. , 0. , - 1.),
                          )
```

with GMA: {MA1, MA2, MA3,…}, GMA2: {MA2}

The normal is defined $\mathbb{N}$ with the plan of the crack. Direction $\mathbb{n}$ normal at the bottom of crack in the plan of the lips of the crack is determined by $n=\Gamma_0 \wedge N$.

The order of declaration of the meshs in the list does not have any importance. The operator checks that the node NO belongs well to the mesh MA2 and that the whole of the meshs segments provided form well a closed related curve. The order of the nodes in the produced concept will be that given by the arrow of the drawing below, on the basis of NO.