Operator DEFI_FOND_FISS

1 Drank

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

The definition of the bottom of crack can be done from entities (nodes or meshes) or from groups of entities. The nodes can be ordered in the meaning of the increasing curvilinear abscisses. If it is not the case and if the crack tip is given by a list of meshes or mesh groups, 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 taken into account for the definition of the direction of propagation and the lips.

This operator creates a concept of the fond_fiss `type` which is usable by operators `CALC_THETA` [U4.82.02], `CALC_G` [U4.82.03] and `POST_K1_K2_K3` [U4.82.05].

2 Syntax

```
FF [fond_fiss] = DEFI_FOND_FISS    (

♦MAILLAGE  = my  ,                                                  [mesh]
◊  INFO=/1                ,
[DEFAULT]
                    /2  ,

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

    # One defines a kind of bottom

    ◊  TYPE_FOND=/                "OUVERT",
[DEFAULT]
                            /   "FERME",
                            /   "INF",
                            /   "SUP",
    # Either one defines one nodes list already ordered

    ♦   /GROUP_NO      =lgrno    ,
[l_gr_noeud]
        /NOEUD         =lno      ,
[l_noeud]

    # Or one meshes defines a list of whose nodes can be already ordered or not

    ♦/GROUP_MA=lgrma            ,
[l_gr_maille]
        /MAILLE           =lma      ,
[l_maille]

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

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

    # In the case or GROUP_MA or MESH is defined and if the bottom is not closed, one can then
    define an end of the X-coordinates
    ◊   /NOEUD_EXTR       = No  ,                                 [l_noeud]
        /GROUP_NO_EXTR       = grno,
[l_gr_noeud]

    # In the case or GROUP_MA or MESH is defined and if the bottom is closed, one can then define an
    end of the X-coordinates
     ◊  /MAILLE_ORIG      =ma       ,
[l_maille]
        /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
◊/CONFIGURATION_INIT       = /   "COLLEE",
[DEFAULT]
                     /   "DECOLLEE",
```

Symmetry of structure

```
◊/SYME           = /   "NON",                                  [DEFAULT]
                   /   "OUI',
```

Definition of the upper lips

```
◊LEVRE_SUP    = _F (
   ♦/GROUP_MA=lgrma          ,                          [l_gr_maille]
      /MAILLE           =lma     ,                          [l_maille]
                 ),
```

If the structure is not symmetric, it is necessary to define the lower lip

```
♦LEVRE_INF    = _F (
      ♦/GROUP_MA=lgrma          ,
[l_gr_maille]
         /MAILLE           =lma     ,
[l_maille]
```

If the initial configuration is DECOLLEE : definition of norm

```
♦NORMALE=         (Nx, Ny, Nz)                                  [l_R]


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


)
```

3 Operands

3.1 Operand MAILLAGE

♦MAILLAGE = my

Name of the mesh on which one will define the crack tip and the lips.

3.2 Description of the crack tip

the crack tip is defined by all of the ordered nodes of the crack tip. If none key keys NOEUD_ORIG or GROUP_NO_ORIG is defined, the order of declaration of these nodes, via nodes list or of meshes segments, will define the meaning of path of the curvilinear abscisse of the crack tip. Load is thus left to the user compose an ordered list, within the meaning of the connectivity of the mesh, by increasing curvilinear abscisse.
It is also possible meshes to provide a list of segments without worrying about the order. The data of a node origin, provided that it corresponds well at an end of the path defined by meshes the segments, then makes it possible to order nodes list.

In addition, in 3D, for a knot slip of the crack tip, the direction of propagation is defined as being the average of the norms to meshes the segments of the crack tip on its left and its right-hand side. For the nodes ends, the norm is calculated from one only mesh, and can thus be less precise.
The code thus envisages a correction of this norm in taking into account edges of structure. However, key DTAN_ORIG and DTAN_EXTR , optional keys, make it possible to the user to directly impose the directions of propagation at the origin and the end of the bottom.
In order to determine the meaning of the vector of direction of propagation when the structure is symmetric and when meshes of the upper lip are not defined with LEVRE_SUP (§3.3.33.3.3), key word DTAN_ORIG is then compulsory.
Key words DTAN_ORIG and DTAN_EXTR do not have any meaning in the case of a closed bottom and are 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 crack tip.

```
◊/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 Key word factor FOND_FISS

3.2.1.1 Key word TYPE_FOND

There are three possibilities to define the crack tip:

1) If the crack tip is defined by a curve open in opposition to the bottom defined by closed curve. It is then a question of informing TYPE_FOND = "OUVERT". This value is the value by default.
2) If the crack tip is defined by a closed curve. It is then a question of informing TYPE_FOND = "FERME".
3) If the crack tip is defined by two entities coïncidentes geometrically (in 2D and 3D). It is then a question of defining two basic types TYPE_FOND = "INF" and TYPE_FOND = "SUP".

3.2.1.2 Key word GROUP_NO

/♦/GROUP_NO = lgrno

List of nodes groups limited to 1 obligatorily ordered compared to the crack tip. In the case of a closed bottom, the first node must be also the last node of the group.

3.2.1.3 Key word NOEUD

/NOEUD = lno

Nodes list obligatorily ordered compared to the crack tip. In the case of a closed bottom, the first node must be also the last node of nodes list.

3.2.1.4 Key word GROUP_MA

/ ♦ /GROUP_MA = lgrma

List of mesh groups of the type SEG2 or SEG3, ordered or not compared to the crack tip. This key word can be used only in 3D.

3.2.1.5 Key word NETS

/MAILLE = lma

List of meshes, ordered or not, of type SEG2 or SEG3. This key word can be used only in 3D.

3.2.1.6 Key word NOEUD_ORIG

◊/♦/NOEUD_ORIG = single

No Node defining the origin. To be an end of the path defining the crack tip, it must rest on one and only one mesh of lgrma or lma . This key word can be defined only if MESH or GROUP_MA is defined. This key word can be used only in 3D.

3.2.1.7 Key word GROUP_NO_ORIG

/GROUP_NO_ORIG = grno

single Group of node, containing a single node. To be an end of the path defining the crack tip, it must rest on one and only one mesh of lgrma or lma . This key word can be defined only if MESH or GROUP_MA is defined. This key word can be used only in 3D.

3.2.1.8 Key word NOEUD_EXTR

◊ /NOEUD_EXTR = single

No Node defining the end. This data is optional and is only used to check that ending node 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 key word can be defined only if NOEUD_ORIG or GROUP_NO_ORIG is defined. This key word can be used only in 3D.

3.2.1.9 Key word 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 ending node 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

key word can be defined only if NOEUD_ORIG or GROUP_NO_ORIG is defined. This key word can be used only in 3D.

3.2.1.10 Operand DTAN_ORIG

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

Direction T_{or} at the origin of the crack tip directed in the meaning of the propagation of crack.

3.2.1.11 Operand VECT_GRNO_ORIG

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

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

3.2.1.12 Operand DTAN_EXTR

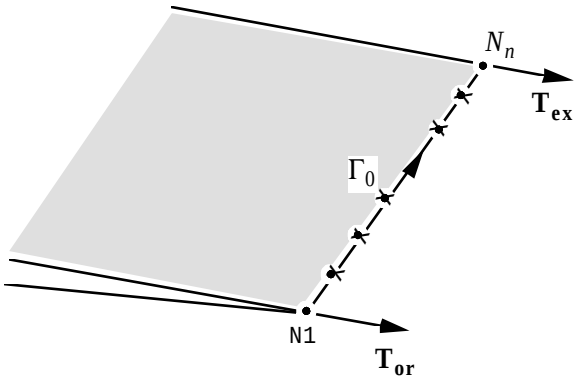
/DTAN_EXTR = vector (Tex, Tey, Tez)

Direction T_{ex} at the end of the crack tip in the meaning of the propagation of crack.

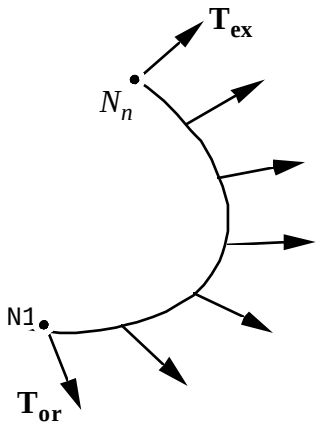
3.2.1.13 Operand VECT_GRNO_EXTR

/VECT_GRNO_EXTR = lgrno with lgrno list of two nodes groups 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 mesh is complete then the algorithm identifies meshes connected to the crack tip and the lips.
- if the mesh is to be supplemented by symmetry compared to the average plane of the lips then the algorithm requires the definition of the upper lips.

The direction of propagation of crack and the norm with the plane of crack are calculated for each node of the crack tip.

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

For a posterior use in POST_K1_K2_K3 (key word FOND_FISS), the knowledge of meshes 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 CALC_G then).

For nonplane cracks 3D, the direction of propagation of crack in any point of the crack tip is built in this operator and is used by operators CALC_THETA [U4.82.02] and CALC_G [U4.82.03].
Currently, computations of fracture mechanics per CALC_G, POST_K1_K2_K3 or other are not possible for defaults 3D not planes and whose lips are separated.

3.3.1 Key word CONFIG_INIT

the initial configuration is that described by the mesh. 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 computation factors of intensity of the stresses with operator POST_K1_K2_K3 [U4.82.05] *, or with options* "CALC_K_G" *or* "CALC_K_MAX" *of operator* CALC_G [U4.82.03] *, can be carried out only if* CONFIG_INIT=' COLLEE' *.*

3.3.2 Key word SYME

This key word makes it possible to specify if the modelization used takes account of a symmetry of structure compared to the average plane of the lips of crack (see Figure 3.1). If SYME = "OUI' , result will be automatically multiplied by 2.

If SYME = "OUI' and CONFIG_INIT=' COLLEE', it is then necessary either to define the upper lip of the crack (LEVRE_SUP, §3.3.33.3.3) or to give the direction of propagation to the point origin (DTAN_ORIG, §3.2.1.10), in order to know of which with dimensions of the bottom the crack is located.

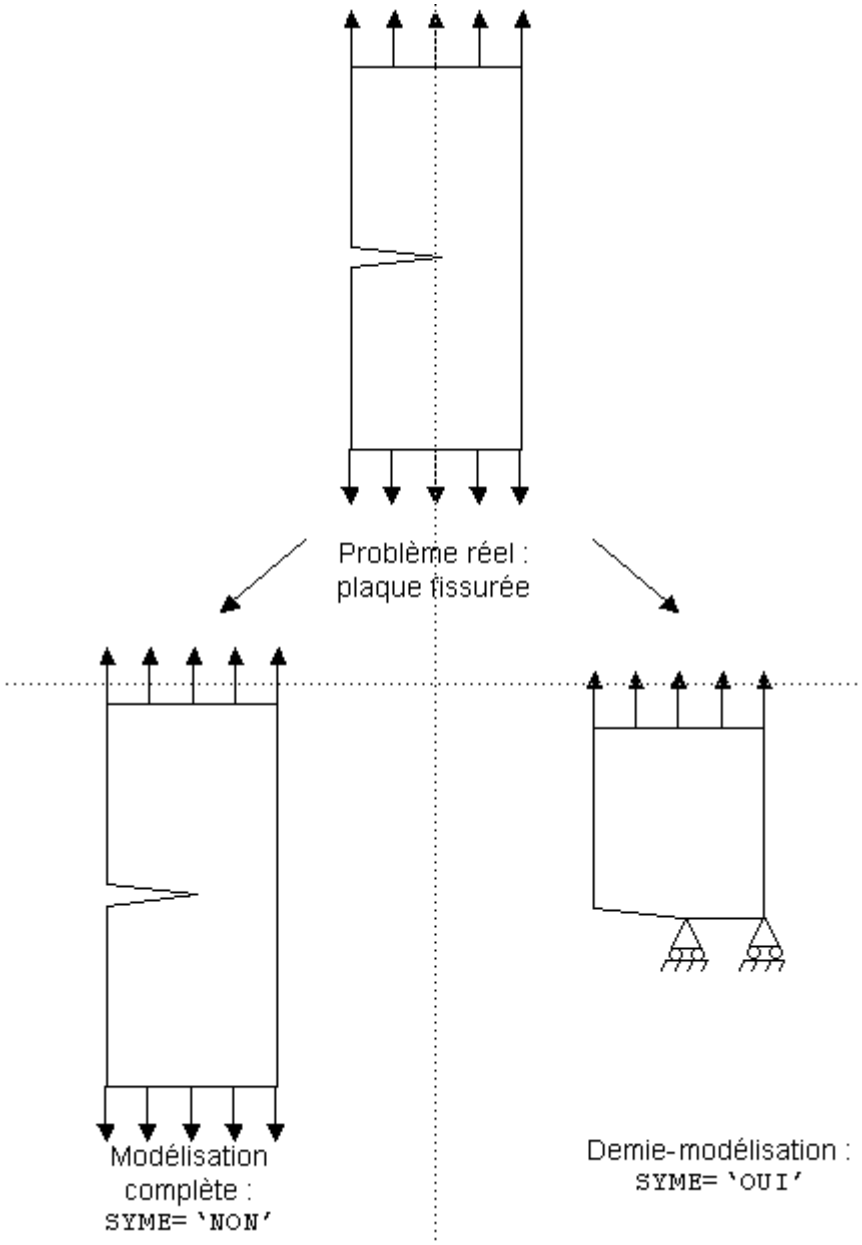


Figure 3.1 : Definition of symmetry.

3.3.3 Key word LEVRE_SUP

◊LEVRE_SUP =

Defines all the sides of the elements which lean on the upper lip of crack. The set of these sides is specified by the operands:

/GROUP_MA = lgrma list of mesh groups.

/MAILLE = lma list of meshes.

Meshes are thus surface so the model is 3D and linear so the model is 2D.

3.3.4 Key word LEVRE_INF

◊LEVRE_INF . =

3D Defines all the sides of the elements which lean on the lower lip of crack. If the crack is on a symmetry plane, this key word should not be indicated.

The set of these sides is specified by the operands:

/GROUP_MA = lgrma list of mesh groups.
/MAILLE = lma list of meshes.

Meshes are thus surface so the model is 3D and linear so the model is 2D.

3.3.5 NORMAL operand

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

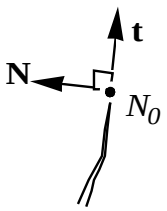
/♦NORMALE = (Nx, Ny, Nz)

the key word NORM makes it possible to introduce the components Nx, Ny, Nz in the total reference of a norm N to the plane of crack with the following convention of meaning:

- In 3D $\mathbf{n}=\Gamma_0 \wedge N$, where $\mathbf{n}$ is the norm external with crack in the plane of the lips, Γ_0 is the crack tip directed (defined by key word FOND_FISS),
- in 2D, the norm N is defined such that the reference $(N_0, \mathbf{t}, N)$ is direct, with:

  N_0 the node of the crack tip,

  $\mathbf{t}$ direction of propagation of 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 3D case for a crack defined from its lips (key words LEVRE_SUP and LEVRE_INF), before a computation with POST_K1_K2_K3 [U4.82.05].

Parameter PREC_NORM defines the accuracy used in the search of the nodes of the lips which are on normal directions with the crack tip: for the interpolation of the jumps of displacement, one indeed

uses the nodes whose distance *D* with the normal right 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 crack tip. To increase the value of PREC_NORM amounts increasing the number of nodes potentially retained for the computation of K in POST_K1_K2_K3.

4 Phase of checks

To the execution:

- checking of the membership of the entities (nodes and meshes) to the mesh,
- checking that the crack tip defined by the data of a list of mesh constitutes well a related path,
- checking which the NOEUD_ORIG belongs well to one of meshes and which it is well one of the two ends of the path defined by these meshes,
- in the case of a plane crack where the key word NORM was used, one checks the orthogonality of this norm with the 2 tangent vectors given by operands DTAN_ORIG and DTAN_EXTR,
- if the lips are defined by their mesh group, one checks that the meshes surface ones of the two lips are quite distinct and that the nodes of the crack tip belong well to at least a mesh of the lips.

In data structure produced by the operator are stored: the list of the nodes of the crack tip, the list of meshes of the lips, if definite tangents at the ends, if definite the norm with the plane of crack, and - if LEVRE_SUP / LEVRE_INF are used the list of the nodes of the lips belonging to the norms at the crack tip passing by each node of the bottom.

5 Examples

5.1 Fissures whole definite by various types of entities in 3D

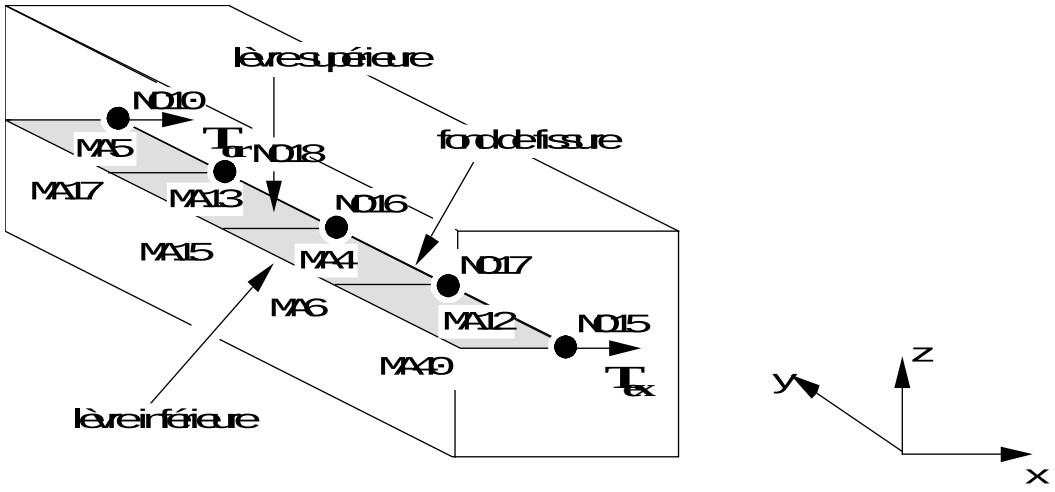
the crack tip is defined by a list of nodes groups, the upper lip by a list of meshes, the lower lip by a list of mesh groups.

```
Fiss1 = DEFI_FOND_FISS (MAILLAGE = my,
             FOND_FISS =_F (GROUP_NO = ("GRN1", "GRN2", "GRN3"),
                            DTAN_ORIG =   (1. , 0. , 0.),
                            DTAN_EXTR =   (1. , 0. , 0.),),
             LEVRE_SUP =_F (MESH = ("MA5", "MA13", "MA4", "MA12"),),
             LEVRE_INF =_F (GROUP_MA = ( " GRM1 " , " GRM2 " ),),
                           )
```

with the following groups defined in the mesh my :

```
GRN1:  {N010  N018}          GRN2: {N018  N016  N017}
GRN3:  {N017  N015}
GRM1:  {MA17  MA15  MA6}     GRM2: {MA40}
```

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

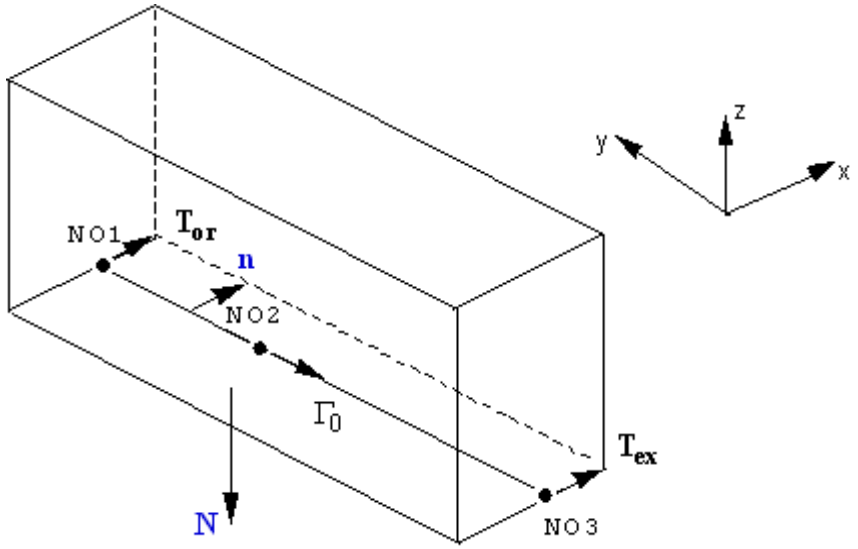


5.2 Use of the NORMAL operand (crack planes in 3D)

```
      fiss = DEFI_FOND_FISS    ( MAILLAGE          =ma    ,
                                 FOND_FISS =_F (NOEUD= ("NO1", "NO2",
"NO3"),
                                                DTAN_ORIG =   (1. , 0. , 0.),
                                                DTAN_EXTR =   (1. , 0. ,
0.),),
                                 CONFIG_INIT=' DECOLLEE',
                                 NORM          =   (0. , 0. , - 1.),
                               )
```

One defines the norm N in the plane of crack.

The direction $\mathbf{n}$ of the norm to the crack tip in the plane of the lips of crack is given par. $\mathbf{n}=\Gamma_0 \wedge N$



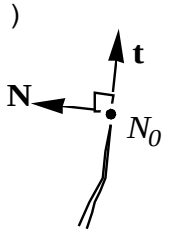
5.3 Fissures in 2D

the crack tip is defined by the N10 node of the mesh my. The groups of meshes of the lips are respectively noted GMSUP and GMINF. The crack can be defined is from the norm:

```
fiss = DEFI_FOND_FISS    ( MAILLAGE=ma      ,
                           FOND_FISS=_F      (NOEUD = "N10"),
                           CONFIG_INIT = "DECOLLEE",
                           NORMALE=       (- 1. , 1. , 0.),
                         )
```

are starting from meshes lips:

```
fiss = DEFI_FOND_FISS    ( MAILLAGE=ma      ,
                           FOND_FISS=_F      (NOEUD = "N10"),
                           LEVRE_SUP=        `GMSUP',
                           LEVRE_INF=        `GMINF',
                         )
```

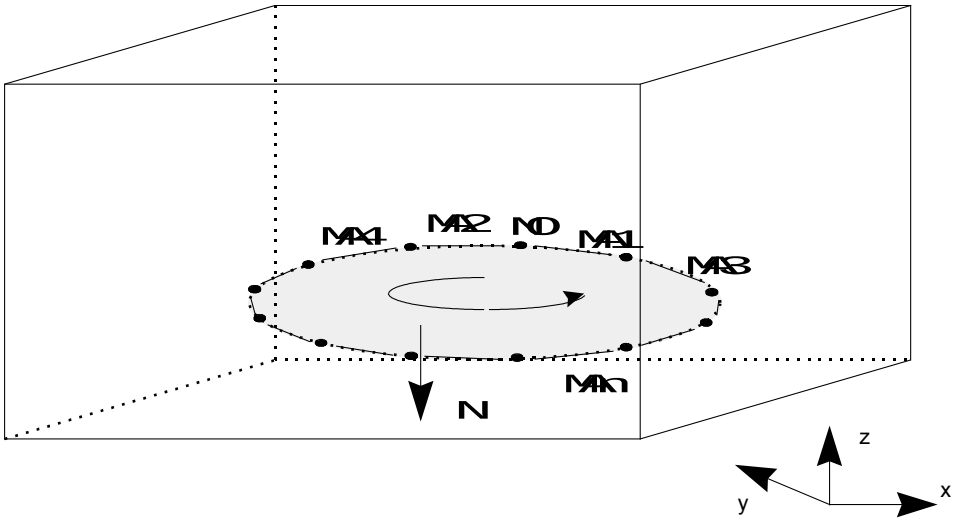


5.4 Crack tip closed with scheduling of the nodes

```
fiss = DEFI_FOND_FISS (MAILLAGE    =ma  ,
                       FOND_FISS=_F (TYPE_FOND=' FERME',
                                     MAILLE= ("MA3", "MA1", "MA2"…),
                                         GROUP_NO_ORIG=' NO',
                                         MAILLE_ORIG=' MA2'     ),
                       CONFIG_INIT = "DECOLLEE",
                       NORM       =   (0. , 0. , - 1.),
                         )
```

One defines the norm $\mathbf{N}$ in the plane of crack. The direction $\mathbf{n}$ of the norm to the crack tip in the plane of the lips of crack is given par. $\mathbf{n}=\Gamma_0 \wedge N$

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



5.5 Crack tip defines by two coïncidents nodes groups

the crack tip of the mesh my is defined by 2 nodes groups:
1) "FONDINF" : nodes group pertaining to the lower lip.
2) "FONDSUP" : nodes group pertaining to the upper lip whose nodes coincide geometrically with those of group "FONDINF"

```
fiss = DEFI_FOND_FISS (MAILLAGE = my,
                       FOND_FISS=_F (TYPE_FOND=' INF',
                                     GROUP_NO=' FONDINF',
                                     DTAN_ORIG= (0. , 1. , 0.),
                                     DTAN_EXTR= (1. , 0. , 0.),),
                       FOND_FISS=_F (TYPE_FOND=' SUP',
                                     GROUP_NO=' FONDSUP'
                                     DTAN_ORIG= (0. , 1. , 0.),
                                     DTAN_EXTR= (1. , 0. , 0.),),
                       LEVRE_INF=_F (GROUP_MA=' LEVINF'),
                       LEVRE_SUP=_F (GROUP_MA=' LEVSUP'),
                       )
```