Macro-command CALC_GP

1 Drank

the object of this macro-command is to calculate, in postprocessing of a computation of nonlinear mechanics elastoplastic, the called energy parameter of fracture mechanics G_P. The energy approach based on this criterion is detailed in the document [R7.02.16].

This macro-command is usable in 2D and 3D.
In 2D, it makes it possible to use the approach with a specific mesh dedicated to the approach (presences of groups of elements forming of the called particular zones chips) or a sufficiently fine free mesh in which the zones are built by the macro-command.
In 3D, only a specific mesh dedicated to the approach including of the groups of elements forming of the slices of several chips is usable.

The macro-command turns over an array containing, for each time of required computation:

- the name of the zone of computation (chip) ZONE
- elastic strain energy in zone ENER_ELAS
- the length of zone (or surfaces in 3D) DELTA_L
- parameter GP
- an indicator specifying the place of the maximum per time MAX_INST

the user can also require a restricted array in which only the lines corresponding to the maximum per time are given. If the user would have used the automatic construction of the zones of chips, it can ask to obtain in output a field making it possible to visualize the zones and to check their good definition.

2 Syntax

```
[array]    = CALC_GP (
♦ RESULTAT=resumeca                                          ,    [result]

♦ LIST_INST=instant                                          ,    [l_R]
◊ PRECISION=/prec                                            ,    [R]
                  /1E-6                                           [DEFAULT]
◊ CRITERE=/       "ABSOLU"                                        [DEFAULT]
                  /"RELATIF"



◊ GPMAX=CO          ("TABGPMAX")                                  [CO]

#Pour the case 2D:
◊ TRANCHE_2D=_F     (
      ♦ ZONE_MAIL=/                                          "NON"
                        =  "OUI'


#SI ZONE_MAIL = "OUI':
      ♦ GROUP_MA=       l_group                                 [l_group_ma]
      ♦ TAILLE=l_taille                                           [l_R]


#Si ZONE_MAIL = "NON":
      ♦ TAILLE=          l_C                                    [R]
      ♦ CENTER=          CO                                      centers  [R,  R,
R
      ] ♦                R                                      RAYON= [R
      ] ♦                θ                                      ANGLE= [R
      ] ♦           NB_ZONE=                                     N [I
      ] ◊      CHAMP_VISU= ("FIELD")                             [CO]
                  )

#Pour 3D case:
◊ TRANCHE_3D=_F     (
       ♦ GROUP_MA       = l_group                               [l_group_ma]
                  )
#Si TRANCHE_2D:
♦ SYME=/          "OUI'
                  /"NON"
#SI TRANCHE_3D:
♦ FOND_FISS=fond                                                 [bottom]
                  )
```

3 Models elastoplastic fracture energy Gp

The model energy of prediction of the fracture in elastoplasticity is described more in detail in documentation of reference [R7.02.16].

The goal of this model is to consider the loading critical of starting of cleavage in an elastoplastic structure; it thus represents a deterministic alternative to the models based on the levels of principal stress which are Beremin or Bordet (also available in *Code_Aster*).

The model bases itself on a representation of the default by a notch; the principle of minimization of the potential energy of structure compared to the projection of default only makes it possible final to lead to a criterion on average elastic strain energy present in zones particular $C(l)$ downstream from the notch and commonly called chips. Figure 3-1 presents a definition of these zones, which are thus measured since the bottom of the notch until a distance l ; L_C represent the diameter of the notch here.

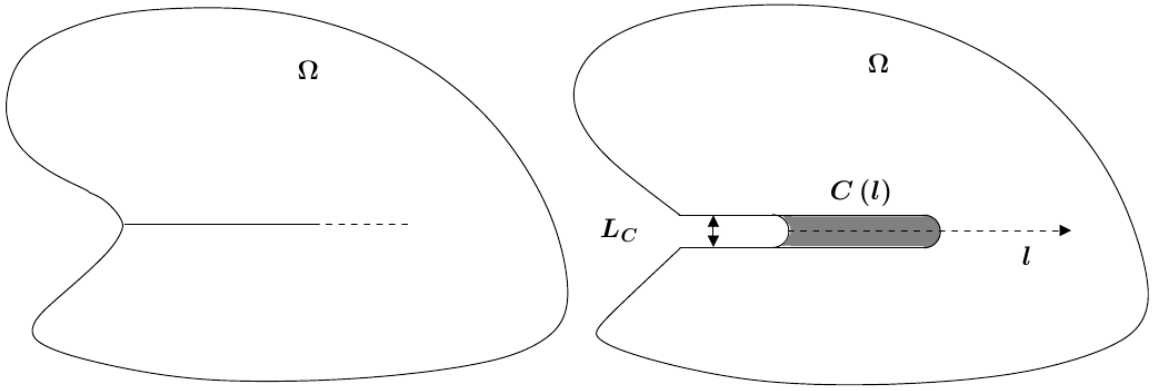

Figure 3-1 - Definition of the zone of interest.

The criterion of cleavage is written then:

$$(\exists l>0)\tilde{G}_P(l)\geqslant G_{PC} \text{ with } \tilde{G}_P(l)=\frac{\int_{C(l)}\Phi_{el}\,d\,\Omega}{l},$$

where Φ_{el} is elastic strain energy and G_{PC} is a material parameter to be determined. In 3D, the distance l is replaced by the surface of the chip in the plane of propagation of the notch.

In order to carry out the computation of elastic strain energy in these zones called chips, two solutions exist in 2D:

- to have defined these zones in the mesh
- to define these zones a posteriori in the free mesh

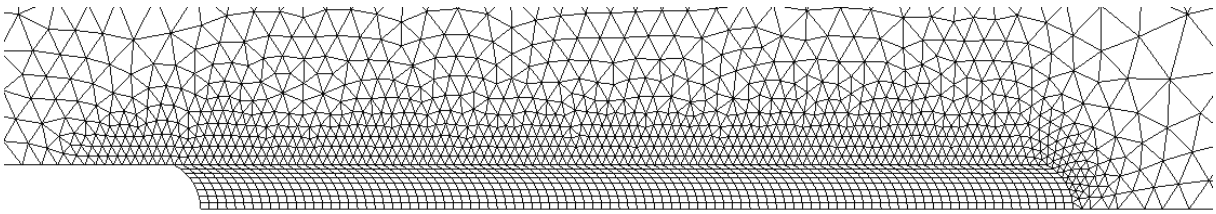

Figure 3-2 - Mesh classical with definition of the chips.

In the first case, Figure 3-2 presents a view of the mesh to be used. This mesh comprises 95 chips of small (with a grid each one by 8 quadrangular finite elements), then a zone of coarsening. A each chip must then be associated a mesh group.

In the second case, Figure 3-3 presents a possibility of mesh around the notch. This mesh must be sufficiently fine in this zone in order to allow a reliable computation of the parameter of the energy method.

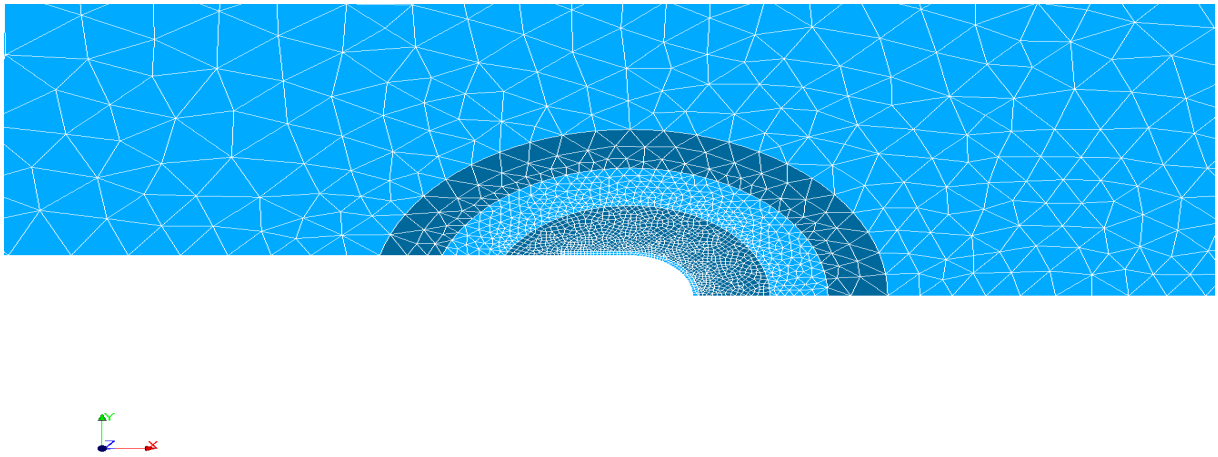

Figure 3-3 - Free mesh without definition of the chips.

In 3D, one introduces the notion of slice, each slice containing several chips. The slices follow one another while skirting the front of default, which is one line. In 2D, there is only one slice, the bottom of default being brought back to 1 point. One defines the chips of the 1st slice in the same way as in 2D, with the difference that meshes are voluminal and are obligatorily hexahedral; one continues the list by adding the chips of the 2nd slice in the same way; one obtains with final list $nb_{copeaux} \times nb_{tranches}$ mesh groups.

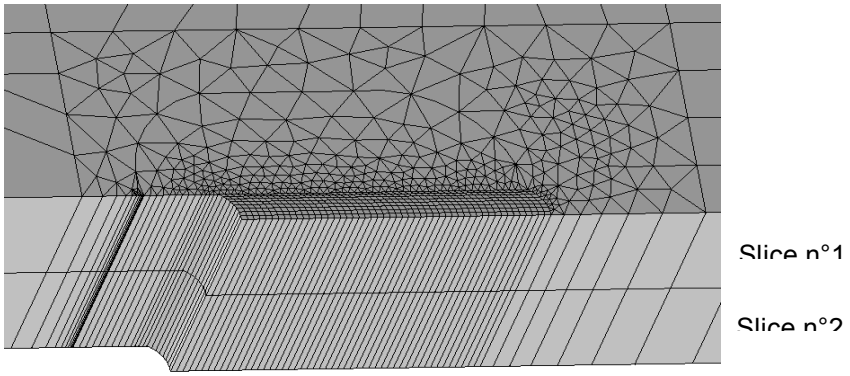

Figure 3-4 Definition of the slices

4 Operands

CALC_GP is a macro-command and thus calls in-house other commands of Code_Aster . Most key words are transmitted such as they are to the other commands. One will indicate thereafter in which (S) command (S) the key words are used.

4.1 Operand RESULTAT

♦ RESULTAT=resumeca , [result]

Indicates result thermomechanical computation for which one calculates the parameter G_P.
Used by POST_ELEM and CALC_CHAMP.

4.2 Operand LIST_INST

♦ LIST_INST=instant , [l_R]

List of times to which the parameter will be calculated.

Caution: the quantities from which the parameter G_P is calculated being nonlinear, no temporal extrapolation is allowed; if one time is specified, this one must be part of the list of times of archivage of thermomechanical computation.

Used by POST_ELEM, CREA_CHAMP and CALC_CHAMP .

4.3 Operand accuracy

◊ PRECISION=/prec , [R]
/1E-6 [DEFAULT]

Accuracy to which the list of times must be considered.

4.4 Operand CRITERE

◊ CRITERE=/ "ABSOLU" [DEFAULT]
/"RELATIF"

Indicates the type of accuracy for the determination of the list of times.

4.5 Operand GP_MAX

◊ GPMAX=CO ("TABGPMAX") [CO]

Indicates if the user wishes to obtain as a result a second array, restriction of the compulsory complete array containing only line place of the maximum of the parameter G_P for each time of computation.

4.6 Operand TRANCHE_2D

◊ TRANCHE_2D=_F (

```
                ♦ ZONE_MAIL=/                                   "NON"
                                =  "OUI'


          #Si ZONE_MAIL = "OUI':
                ♦ GROUP_MA=       l_group                       [l_group_ma]
                ♦ TAILLE=l_taille                                  [l_R]


          #Si ZONE_MAIL = "NON":
                ♦ TAILLE=         cuts                          [R]
                ♦ CENTER=         CO                             centers  [R,  R,
R
                ] ♦               R                            RAYON= [R
                ] ♦               θ                            ANGLE= [R
                ] ♦          NB_ZONE=                           N [I
                ] ◊     CHAMP_VISU= ("FIELD")                   [CO]
```

Indicate all the geometrical parameters necessary to the computation of the energy parameter.

4.6.1 Key word ZONE_MAIL

```
                ♦ ZONE_MAIL=/                                   "NON"
                                =  "OUI'
```

Indicates if the mesh represents the geometry of the zones of chips.
If "OUI', one is in the case of a mesh such as on Figure 3-2.

4.6.2 Case ZONE_MAIL = "OUI'

4.6.2.1 Key word GROUP_MA

```
♦ GROUP_MA=         l_group                                     [l_group_ma]
```

List of the mesh groups on which computations will be carried out. Each mesh group must correspond to a zone of chips.

Used by POST_ELEM.

4.6.2.2 Key word CUTS

```
♦ TAILLE=           l_taille                                    [l_R]
```

List of sizes of the zones. This list must be same size as the list of the groups of mesh.

4.6.3 Case ZONE_MAIL = "NON"

In this case, a geometrical zone of computation is built by the macro one. The following parameters make it possible to define it. Figure 4-1 presents the parameters of definition of these zones; it represents a notch of center C_{ent}, of R; the third zone $C_3(l)$ length $3\times l_C$ is hatched.

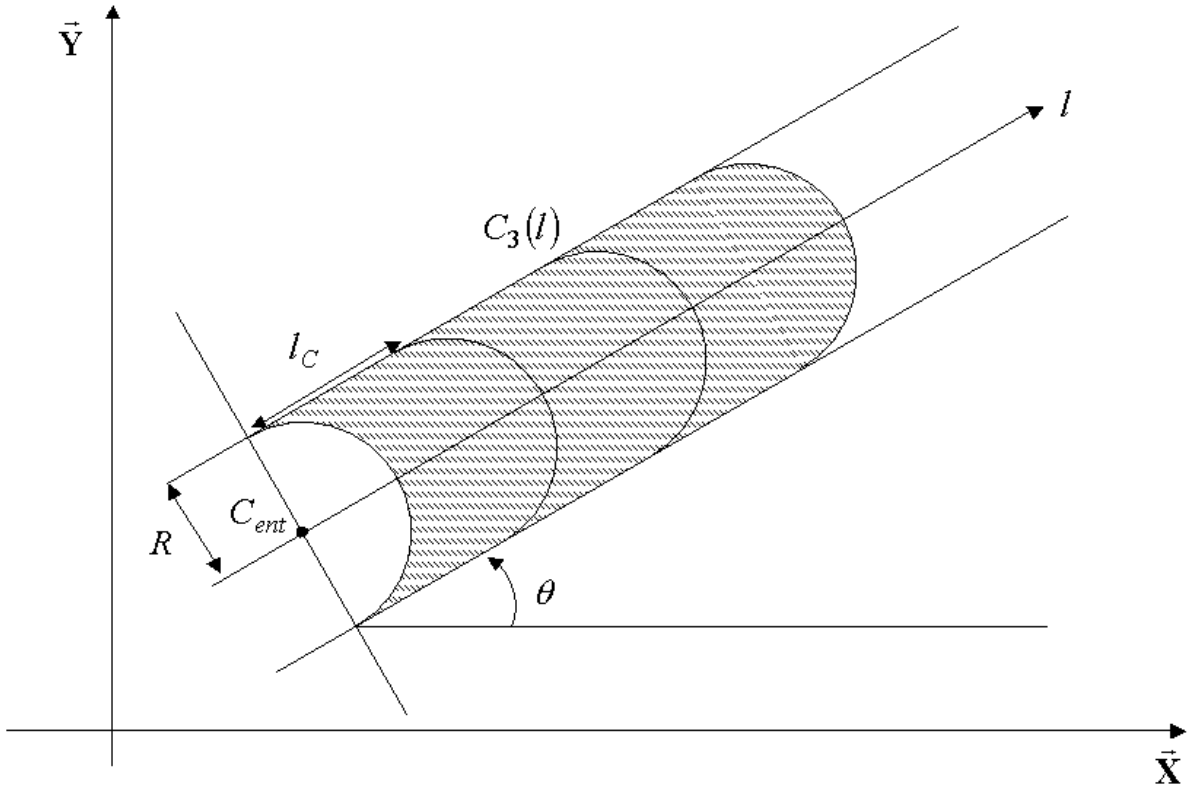

Figure 4-1 - Definition geometrical of the zones in the case nonwith a grid.

4.6.3.1 Key word CUTS

♦ TAILLE= l_C [R]

Increment of the size of the zones. Zone N is thus of size n* l_C .

Used by FORMULA.

4.6.3.2 Key word CENTER

♦ CENTER= centers [R, R, R]

Indicates the coordinates of the center of the notch C_{ent} in the total reference.

Used by FORMULA.

4.6.3.3 Key word RADIUS

♦ RAYON= R [R]

Indicates the radius of the notch.

Used by FORMULA.

4.6.3.4 Key word ANGLE

♦ ANGLE= θ [R]

Indicates the angle formed between the direction of the notch and the axis $\vec{X}$ of the total reference. The angle must be given in degrees and measured in the trigonometrical meaning.

Used by FORMULA

4.6.3.5 Key word NB_ZONE

♦ NB_ZONE= N [I]

the number of zones (chips) considered in computation Indicates.

4.6.3.6 Key word CHAMP_VISU

◊ CHAMP_VISU= CO ("FIELD") [CO]

If the user wishes it, it can ask for the output of a field Gauss points representing the chips. The value of this field is 1 in the zone of chip and 0 elsewhere. Figure 4-2 presents a visualization of this field for the mesh presented of Figure 3-3.

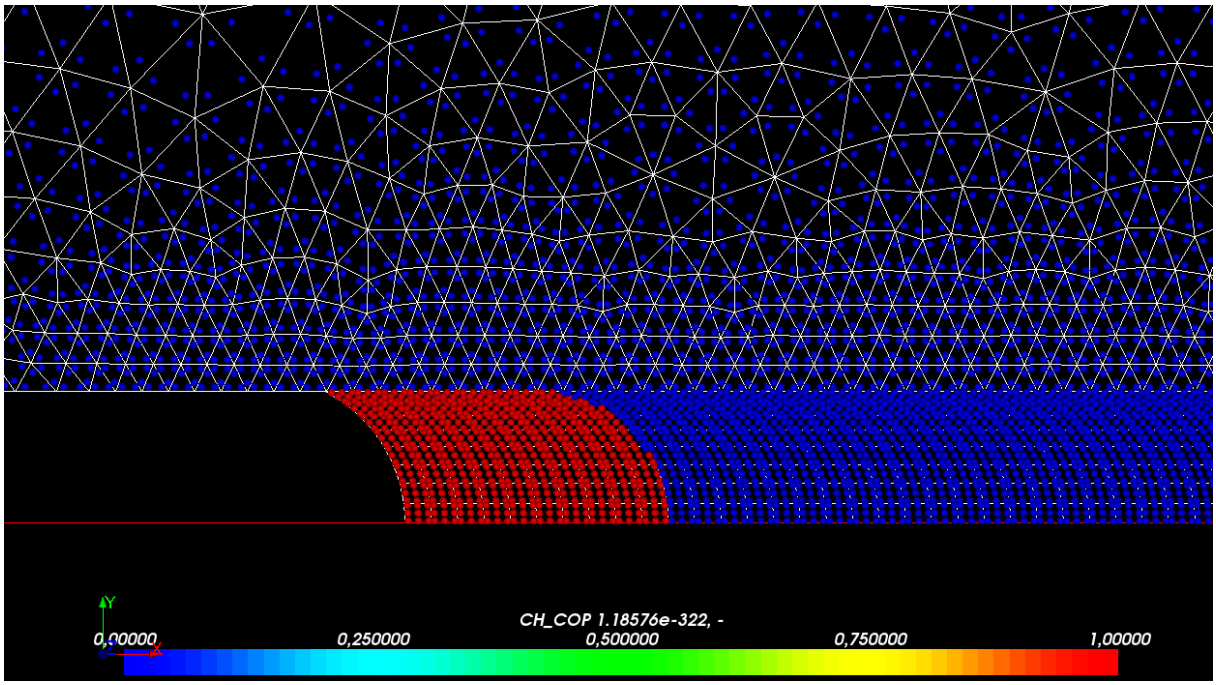

Figure 4-2 - Field of visualization of the chips.

4.7 Operand TRANCHE_3D

◊ TRANCHE_3D=_F (
♦ GROUP_MA = l_group [l_group_ma]
)

4.7.1 Key word GROUP_MA

♦ GROUP_MA= l_group [l_group_ma]

List of the mesh groups on which computations will be carried out.
Each mesh group must correspond to a zone of chips.
Each list of mesh group corresponds to a given slice; the mesh groups with the interor of each list must correspond to the chips and be ordered nearer to the bottom of default to most distant.

Used by POST_ELEM.

4.8 Operand SYME

```
#Dans the case 2D
♦ SYME=/           "OUI'
                   /"NON"
```

Informs if a symmetry of structure compared to the notch made it possible to carry out a mesh only half of structure. On figures 3-2 and 3-3, only the part of structure higher than the notch is defined; in this case, the user will inform SYME=' OUI' and result indicated in the array account of symmetry will take (multiplied by two).

4.9 Operand FOND_FISS

```
#Si TRANCHE_3D:
♦ FOND_FISS=fond                                          [bottom]
```

In 3D, the user must define a crack tip beforehand, with separated lip (since the default is represented by a notch).
This crack tip allows in particular the calculation of the areas (denominator of the computation of G_p).

5 Examples of use

One will find examples in the cases test SSNV218a, SSNP131a and SSNP131b.