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## Operator CALC\_G

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### 1 Drank

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This operator calculates the following quantities of fracture mechanics, in 2D and 3D:

- rate of energy restitution by the method theta in the case of a linear thermoelastic problem or not linear [R7.02.01] and [R7.02.03], in static or dynamics [R7.02.02],
- the stress intensity factors  $K1$  ,  $K2$  and  $K3$  by the method of singular displacements in the case of a linear thermoelastic problem [R7.02.05],
- the bilinear form  $g$  , function of a series of displacements, such as  $g(u, u) = G(u)$  ,
- maximization of  $G$  and of  $K1$  under stresses limits.

This operator can be used as well for cracks with a grid (classical approach) as for cracks nonwith a grid (method X-FEM).

Before a first use, it is advised to refer to the reference documents and of corresponding advice of use, in particular the document [U2.05.01].

This operator generates a concept of the table\_sdaster type.

## 2 Syntax

```
[table_sdaster] =CALC_G

(

#Recuperation of result of mechanical computation
  ◆RESULTAT=resu          ,          / [evol_elas]
                               / [evol_noli]
                               / [dyna_trans]
                               / [mode_meca]
                               / [mult_elas]

  #Si RESULTAT of the evol_elas type, evol_noli or dyna_trans
    ◇/TOUT_ORDRE=' OUI',          [DEFAULT]
    /NUME_ORDRE      =l_ordre ,    [l_I]
    /LIST_ORDRE      =lis      ,    [listis]
    /INST             =l_inst  ,    [l_R]
    /LIST_INST       =l_reel  ,    [listr8]

  #Si RESULTAT of the mode_meca type
    ◇/TOUT_MODE      = ' OUI',    [DEFAULT]
    /NUME_MODE       =l_ordre ,    [l_I]
    /LIST_MODE       =lis      ,    [listis]
    /FREQ            =l_inst  ,    [l_R]
    /LIST_FREQ       =l_reel  ,    [listr8]

    ◇ CRITERE = "RELATIF",        [DEFAULT]
      ◇ accuracy = prec, [R]
        /1.E-6 , [DEFAULT]
      /"ABSOLU",
        ◆ accuracy =prec , [R]

# Recovery or creation of the field theta

  ◆ THETA=_F ( ◆ / ◆FOND_FISS = FF, [fond_fiss]
                ◇/R_INF      = R, [R]
                  /R_INF_FO = rz, [function]
                ◇/R_SUP      = R, [R]
                  /R_SUP_FO = rz, [function]
                ◇/MODULE     = m, [R]
                  /1, [DEFAULT]
                  /MODULE_FO = mz, [function]
                ◇DIRECTION   = (d1, d2, d3), [l_R]
                  ◇ DIRE_THETA = chamno [cham_no_sdaster]

  / ◆FISSURE = ffx, [fiss_xfem]
    ◇/R_INF      = R, [R]
      /R_INF_FO = rz, [function]
    ◇/R_SUP      = R, [R]
      /R_SUP_FO = rz, [function]
    ◇NUMÉRIQUE_FOND = 1, [DEFAULT]
      / N, [I]
    ◇NB_POINT_FOND = N, [I]

  / ◆ THETA = theta, [cham_no_sdaster]
    ◇SYME = "NON", [DEFAULT]
```

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.

```

                                /"OUI",
                                ),

#Chargement
  #Si RESULTAT of the type mult_elas
    ◊NOM_CAS =nom , [l_Kn]

  #Sinon
    ◊EXCIT = _F ( ◊ CHARGE=charge , [char_meca]
                  ◊ FONC_MULT=fmult , [char_cine_meca]
                  [function]
                  [formula]
                ),
  # Finsi

#Comportement
  ◊/COMP_ELAS=_F (
    ◊RELATION=/ "ELAS", [DEFAULT]
                / "ELAS_VMIS_LINE",
                / "ELAS_VMIS_TRAC",
                / "ELAS_VMIS_PUIS",
    ◊DEFORMATION=/ "PETIT", [DEFAULT]
                  / "GROT_GDEP",
    ◊/TOUT=' OUI', [DEFAULT]
    / | GROUP_MA=lgrma , [l_gr_maille]
      | MAILLE=lma , [l_maille]
    ),

  /COMP_INCR =_F (
    ◊RELATION=/ "ELAS", [DEFAULT]
                / "VMIS_ISOT_TRAC",
                / "VMIS_ISOT_LINE",
    ◊DEFORMATION=/ "PETIT" , [DEFAULT]
                  / "PETIT_REAC" ,
    ◊/TOUT=' OUI' , [DEFAULT]
    / | GROUP_MA=lgrma , [l_gr_maille]
      | MAILLE=lma , [l_maille]
    ◊SIGM_INIT=sig , [cham_elem,
cham_no]
    ),

#Méthode of discretization of theta in crack tip (3D local)
  ◊LISSAGE = _F (◊LISSAGE_THETA=/ "LEGENBRE"
[DEFAULT]
                / "LAGRANGE"
                / "LAGRANGE_REGU"
    ◊LISSAGE_G=/ "LEGENBRE"
[DEFAULT]
                / "LAGRANGE"
                / "LAGRANGE_NO_NO"
                / "LAGRANGE_REGU"
  # If LISSAGE_THETA = "LEGENBRE" or LISSAGE_G = "LEGENBRE":
    ◊DEGRE=/5 [DEFAULT]
    /0 , 1,2,3,4,6,7,

```

```
),  
  
#Option requested  
  ◆OPTION=/ "CALC_G" ,  
            / "CALC_G_GLOB" ,  
            / "CALC_K_G" ,  
            / "G_MAX" ,  
            / "G_MAX_GLOB" ,  
            / "CALC_K_MAX" ,  
            / "G_BILI" ,  
            / "G_BILI_GLOB" ,  
  
#Si OPTION = "G_MAX" or "G_MAX_GLOB"  
  ◇BORNES=_F ( ◆ NUME_ORDRE=num , [I]  
              ◆VALE_MIN= qmin , [R]  
              ◆VALE_MAX= qmax , [R]  
              ) ,  
#Si OPTION = "CALC_K_MAX"  
  ◇SIGNES=_F ( ◆ CHARGE_S =listS , [l_I]  
              ◆ CHARGE_NS= listNS , [l_I]  
              ) ,  
#Si OPTION = "CALC_G" or "CALC_G_GLOB"  
  ◇CALCUL_CONTRAINTE=' NON' ,  
  
  ◇TITER=titer , [l_Kn]  
  
#Impression of information  
  ◇INFO=/1 , [DEFAULT]  
  /2 ,  
)
```

## 3 Operands

### 3.1 Operand RESULTAT

/RESULTAT =resu

Name of a result concept of the evol\_elas type, evol\_noli, dyna\_trans, mode\_meca or mult\_elas. This operand makes it possible to recover the field of displacement (and velocity and of acceleration for a computation in dynamics).

The model and the material field, necessary to computation, are also extracted from data structure result. The possible computation options for each type of modelization are recalled in the table below.

	Computation of <i>G</i>	Computation of <i>K</i>
D_PLAN/C_PLAN D_PLAN_INCO, D_PLAN_INCO_UP	CALC_G	CALC_K_G
<i>Fissures with a grid</i>	G_MAX G_BILI	
D_PLAN/C_PLAN <i>Fissures nonwith a grid</i>	CALC_G	CALC_K_G
AXIS, AXIS_INCO, AXIS_INCO_UP	CALC_G	CALC_K_G
<i>Fissures with a grid</i>	G_MAX G_BILI	
AXIS <i>Fissures nonwith a grid</i>	CALC_G	CALC_K_G
3D, 3D_INCO, 3D_INCO_UP	CALC_G/CALC_G_GLOB	CALC_K_G
<i>Fissures with a grid</i>	G_MAX/G_MAX_GLOB G_BILI/G_BILI_GLOB	CALC_K_MAX
3D <i>Fissures nonwith a</i>	CALC_G	CALC_K_G  CALC_K_MAX

**Table 3.1: Availability, by modelization, of the computation options.**

#### Remarks on the properties material:

The characteristics of the material, recovered in the data structure resu, are the following ones:

- Poisson's ratio, Young modulus
- E NU,
- thermal coefficient of thermal expansion ALPHA (for a thermomechanical problem),
- elastic limit SY (for a nonlinear elastic problem),
- slope of curve of tension D\_SIGM\_EPSI (for a nonlinear elastic problem with linear isotropic hardening).

For the computation of restitution of energy, these characteristics can depend on the geometry (option "CALC\_G") and temperature (option "CALC\_G", "CALC\_G\_GLOB"). They must be independent of the temperature for the computation of the stress intensity factors.

Characteristics SY and D\_SIGM\_EPSI are treated only for one nonlinear elastic problem with hardening of Von Mises and the computation option of rate of energy restitution "CALC\_G\_GLOB". The computation coefficients of intensity of stresses is treated only in linear elasticity.

**Note:**

*For the computation of the stress intensity factors (option "CALC\_K\_G"), the characteristics must be defined on all the materials, including on the edge elements, because of méthode de calcul [R7.02.05]. To ensure itself so it is advised to make AFFE = \_F (TOUT = "OUI") in command AFFE\_MATERIAU [U4.43.03], since it is necessary to using the rule of overload then.*

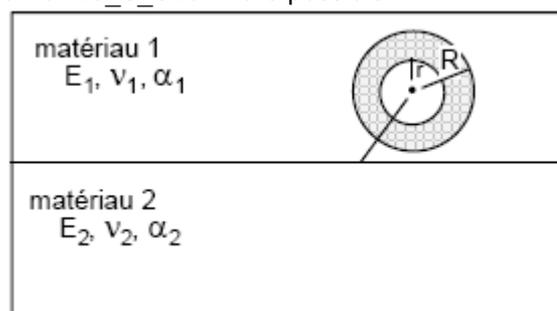
*For the incompressible elements (\_INCO, \_INCO\_UP), it is advised to use STAT\_NON\_LINE to get the results.*

*The factors of intensity of the stresses obtained with option CALC\_K\_G are calculated by evaluating the bilinear form of G with a purely mechanical singular solution (asymptotic solution of Westergaard). If a thermomechanical problem is solved, one then does not take counts the singularity due to the thermal field of it.*

*An indicator of the error due to this approximation can be obtained by evaluating the difference enters G and G\_IRWIN . In practice, one evaluates in any point of the crack tip the quantity  $\frac{|G - G_{irwin}|}{|G|}$ , and one makes of it then the arithmetic mean. If this average exceeds 50 %, it is estimated whereas one leaves the perimeter of validity of the approach, and an alarm message is transmitted.*

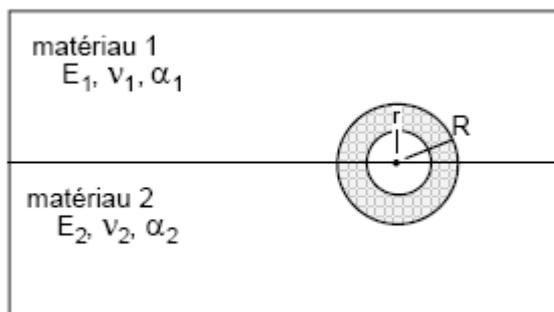
**Problem of the bi--material:**

**1st case :** There is a bi--material but the point of crack is in only one material, cf Appears 3.1-a. If one is assured that contour, definite between radius lower R\_INF and higher R\_SUP, has like support of the elements of the same material, computation is possible whatever the selected option. If not only options "CALC\_G" and "CALC\_G\_GLOB" are possible.



**Appear 3.1-a: Bi--material: 1st case**

**2nd case :** There is a bi--material where the point of crack is with the interface, cf Appears 3.1-b. To date, only the computation options of rate of energy restitution (options "CALC\_G\_GLOB" and "CALC\_G") are available. The computation of coefficients of intensity of stresses is not possible in this case.

Appear 3.1-b: Bi--material: 2<sup>Nd</sup> case

### 3.2 Operands

TOUT\_ORDRE/NUME\_ORDRE/LIST\_ORDRE/INST/LIST\_INST/TOUT\_MODE/NUME\_MODE/LIST\_MODE/FREQ/LIST\_FREQ/PRECISION/CRITERE

These operands are used with operand RESULTAT.

Operands TOUT\_ORDRE, NUME\_ORDRE, LIST\_ORDRE, INST, LIST\_INST are associated with the results of the evol\_elas type, evol\_noli or dyna\_trans. See [U4.71.00].

Operands TOUT\_MODE, NUME\_MODE, LIST\_MODE, FREQ, LIST\_FREQ are associated with the results of the mode\_meca type.

### 3.3 Operand NOM\_CAS

◇NOM\_CAS = name

operand NOM\_CAS is associated with the results of the mult\_elas type (produced by the operator MACRO\_ELAS\_MULT). Several loading cases can be listed behind this operand, with condition of course, to have been used in creation of result as mult\_elas type. If NOM\_CAS is not noted, all the loading cases are treated.

### 3.4 Key word EXCIT and operands CHARGE/FONC\_MULT

◇EXCIT = \_F ( ◇CHARGE=charge  
◇FONC\_MULT = fmult)

key word EXCIT makes it possible to recover a list of loadings charges, resulting from commands AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F [U4.44.01], and the possible associated multiplying coefficients fmult.

**Key word EXCIT is optional and does not have to be well informed in the general case.**

This key word is prohibited in the case of result of mult\_elas type, produces MACRO\_ELAS\_MULT by the operator. The loadings to be used are defined with operand NOM\_CAS.

Apart from this case, if key word EXCIT is absent of the command, the loading taken into account is that extracted from resu. If the loading is provided via EXCIT, then it is this loading which will be used in CALC\_G. If the loading provided in EXCIT is different from that present in resu (coherence of the name and amongst loads, of the couples load-function), an alarm is emitted and computation continues with the loadings indicated by the user. Attention, this use is valid only when result is created via operator CREA\_RESU. Indeed, as CREA\_RESU does not make it possible to apply loads, EXCIT gives the possibility of defining the loading directly in CALC\_G.

The loadings currently supported by the various modelizations and being able to have a meaning in fracture mechanics are the following ones:

*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.*

- Voluminal force: ROTATION, FORCE\_INTERNE, PESANTEUR.
- Surface force on the lips of crack: FORCE\_CONTOUR (2D), FORCE\_FACE (3D), PRES\_REP.
- Thermal thermal expansion: the temperature is transmitted via AFFE\_MATERIAU/AFFE\_VARC
- Predeformation: PRE\_EPSI (case only fissures with a grid, in 2D for all the options, and in 3D only for the option CALC\_G\_GLOB)

In the event of thermomechanical problem, the temperature is transmitted via the properties material (AFFE\_MATERIAU/AFFE\_VARC/EVOL). Thermal thermal expansion thus is automatically taken into account in computation with CALC\_G.

## Note:

*The loadings not supported by an option are ignored. To date, the following loadings being able to have a meaning in fracture mechanics are not treated:*

- FORCE\_NODALE
- FORCE\_ARETE
- DDL\_IMPOS<sub>sur</sub>                    *the lips of crack*
- FACE\_IMPO
- PRE\_EPSI<sub>en</sub>                    *3D for options CALC\_G and CALC\_K\_G*

It is important to note that the only loadings taken into account in a computation of fracture mechanics with the method  $\theta$  are those supported by the elements inside contour, where the field of vectors theta is non-zero (between R\_INF and R\_SUP [R7.02.01 §3.3]). **The only types of load likely to influence the computation of  $G$  are thus the voluminal loadings (gravity, rotation), a nonuniform field of temperature or forces applied to the lips of crack.**

## Caution:

- *If several loadings of comparable nature (for example volume force) appear in computation, they are combined between them for postprocessing. The weather is however not possible to date to be this combination so loadings of the FORMULA type are present : computation finishes then in error.*
- *One observes also a rule of exclusion at the time of the simultaneous presence of a field of predeformations (via "PRE\_EPSI" ) and of a stress field initial (see § 13)*
- *It is not possible to date to associate a load defined from a FORMULA and a multiplying coefficient ( FONC\_MULT ). In this case, computation finishes in error.*
- *Kinematical loads (AFFE\_CHAR\_CINE and AFFE\_CHAR\_CINE\_F), cannot be taken into account in computation.*
- *For the option CALC\_K\_G, if a loading is imposed on the lips of crack (PRES\_REP or FORCE\_CONTOUR), then it is obligatorily necessary to direct correctly meshes those (by means of ORIE\_PEAU\_2D or ORIE\_PEAU\_3D ) prior to computation of K (case only fissures with a grid).*
- *If one does a calculation in great transformations (key word DEFORMATION : "GROT\_GDEP" under the key word factor COMP\_ELAS or DEFORMATION = "PETIT\_REAC" under the key word factor COMP\_INCR) the supported loadings must be died loads, typically an imposed force and not a pressure [R7.02.03 §2.4]; these loads must be declared like nonfollowing in STAT\_NON\_LINE.*
- *It is noted that the computation of CALC\_G with modelization AXIS is not available for the results of thermomechanical computations in large deformation and large rotation.*

## 3.5 Key word THETA

the field theta is:

- 1) either calculated beforehand by the operator CALC\_THETA then transmitted by the key word factor THETA (cf §3.3.1),

- 2) or calculated in CALC\_G starting from key keys R\_INF/R\_INF\_FO, R\_SUP/R\_SUP\_FO, MODULE/MODULE\_FO, FOND\_FISS/FISSURE.

The various cases are described in the table below according to the computation option, the modelization (2D or 3D) and the type of crack (crack with a grid or not).

	CALC_G (G_MAX, G_BILI)	CALC_K_G	CALC_G_GLOB (G_MAX_GLOB, G_BILI_GLOB)
<b>2D - Crack with a grid</b>	◆/ THETA /◆ FOND_FISS ◆ R_INF.	◆/ R_INF, R_SUP... /THETA ◆ FOND_FISS	-
<b>2D - Crack nonwith a grid</b>	◇ R_INF, R_SUP... ◆ CRACK	◇ R_INF, R_SUP... ◆ CRACK	-
<b>3D - Crack with a grid</b>	◇ R_INF, R_SUP... ◆ FOND_FISS	◇ R_INF, R_SUP... ◆ FOND_FISS	◆/ THETA /◆ FOND_FISS ◇ R_INF.
<b>3D - Crack nonwith a grid</b>	◇ R_INF, R_SUP... ◆ CRACK	◇ R_INF, R_SUP... ◆ CRACK	-

### the Councils on the choice of contours (in CALC\_THETA or CALC\_G):

- To avoid using a theta field definite with a lower radius R\_INF null. The fields of displacements are singular in crack tip and introduce vague results in post - processing of fracture mechanics.
- It is advised to use successively command CALC\_G with at least three fields theta of different contours to make sure of the stability of the results. In the event of important variation (higher than 5-10%) it is necessary to wonder about the good taking into account of all the modelization.
- For the option CALC\_K\_G into 2D-axisymmetric, the radius of contours must be small in front of the radius of the crack's point having the best possible accuracy. It is prohibited to have contours of radius larger than the radius of the crack's point.

### 3.5.1 Operands THETA, FOND\_FISS, CRACK

```
◆/THETA=theta
  /FOND_FISS      =ff ,
  /FISSURE        =fiss ,
```

These operands make it possible to define to it (or them) fields theta. There are three possibilities:

1) If THETA is indicated:

The field theta is a field of vector in each node of the mesh. It is a concept of the cham\_no\_sdaster type. It is generally resulting of the command specific CALC\_THETA [U4.82.02] which makes it possible to affect the modulus, direction of the field theta and the radius of contour surrounding the crack tip. For more precise details to refer to [R7.02.01 §3].

2) If FOND\_FISS is indicated :

FF is the crack tip defined by the command DEFI\_FOND\_FISS [U4.82.01]. This key word can be used only if the crack is with a grid.

3) If CRACK is indicated :

fiss is crack defined by the command DEFI\_FISS\_XFEM [U4.82.08]. This key word is compulsory if the crack is not with a grid.

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### 3.5.2 Operands R\_INF, R\_INF\_FO, R\_SUP, R\_SUP\_FO, MODULE, MODULE\_FO, DIRECTION, DIRE\_THETA

These operands make it possible to calculate the field theta when this one was not beforehand given. They correspond respectively to radius lower and superior of contours (scalar or function, in 3D, of the curvilinear abscisse), to the modulus of the field theta and its direction.

The use of these operands is described in documentation of CALC\_THETA [U4.82.02]. Some advice is given above.

In 3D, when radius are not function of the curvilinear abscisse, operands R\_INF and R\_SUP are optional. If they are not indicated, they are automatically calculated starting from the maximum H of the sizes of meshes connected to the nodes of the crack tip. These sizes of meshes in each nodes of the bottom are calculated in command DEFI\_FOND\_FISS, in the case of a crack with a grid or DEFI\_FISS\_XFEM, in the case of a crack NON-with a grid, and are present respectively in the concept fond\_fiss [D4.10.01] or fiss\_xfem [D4.10.01]. It was selected to pose R\_SUP = 4:00 and R\_INF = 2:00. If one chooses the value automatically calculated for R\_SUP and R\_INF, it is advisable however to make sure that these values (displayed in the file .mess) are coherent with dimensions of structure.

Operands DIRECTION and DIRE\_THETA are usable that for cracks with a grid (presence of key word FOND\_FISS).

Attention, key word DIRECTION is optional, it should be used only in the basic of crack plane, curved or rectilinear case; indeed, it indicates the direction of the field theta, which must, so that computation is correct, being in the plane of propagation (but not necessarily normal with the bottom). It however is recommended to rather define the crack tip in DEFI\_FOND\_FISS by also giving the mesh groups of the lips.

In the case of a default initially opened and whose bottom is not plane, it is at present not possible to calculate rate of energy restitution.

### 3.5.3 Operands NUME\_FOND and NB\_POINT\_FOND

```
◇NUMÉRIQUE_FOND=n  
◇NB_POINT_FOND = nbnofo,
```

This whole of key key, optional, should be defined only for cracks nonwith a grid (modelization X-FEM), the key word FISSURES being thus indicated.

NUME\_FOND : it can arrive, for certain structures, that the crack tip is discontinuous. In the case of a crack defined by DEFI\_FISS\_XFEM the crack tip is then cut out in several parts.

The operand NUME\_FOND makes it possible to indicate on which of these under-parts of the crack tip one wishes to carry out computation. By default, computation is done on the first crack tip.

NB\_POINT\_FOND : by default, computation gives a report on the crack tip on all the, i.e all the points of intersection between the crack tip and the edges of the mesh. The points of the crack tip can then be very irregularly spaced, which can lead to awkward oscillations on the parameters or  $G(s)$  calculated  $K(s)$ .

Operand NB\_POINT\_FOND makes it possible to fix a priori the number of points of postprocessing, in order to improve the regularity of the results. The points nbnofo are équirépartis along the crack tip. Some advice is given in the §15.16

### 3.5.4 SYME ◇

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

key word SYME makes it possible to indicate if the loading is symmetric if one models only half of solid compared to the crack. Its presence is valid only if operand THETA is present. In the case SYME = "OUI" one multiplies by 2 the values of rate of energy restitution formulates  $G$  its possible derivative. Moreover, one multiplies by 2 the values of formula  $K_I$  one assigns formula 0 formula  $K_{II}$  formula  $K_{III}$  valid some is the option). Note:

## When

FOND\_FISS is present, information on the symmetry of the model is recovered directly in the concept melts \_fiss. Thus if the key word SYME = "OUI" is indicated in command DEFI \_FOND\_FISS, CALC\_G automatically takes into account the symmetry of the model. It

is not possible compared to to take into account the symmetry of the model crack when this one is not with a grid (case X-FEM). Key word

## 3.6 COMP\_ELAS $\diamond$

COMP\_ELAS = \_F (This

key word factor makes it possible to define an elastic behavior of the material. The computation rate of energy restitution  $G$  has meaning only in linear **elasticity** or not linéaire (COMP\_ELAS). It is however possible to calculate a parameter in elastoplasticity (see §13)13

### By

- default (if neither COMP\_ELAS nor COMP\_INCR is indicated), the constitutive law used in CALC\_G is identical to that used for mechanical computation (via MECA\_STATIQUE or STAT\_NON\_LINE) Nothing
- prohibits to affect a behavior the different during computation of displacements (for example elastoplastic) then to carry out this postprocessing with another relation (for example elastic nonlinear). A checking of coherence is carried out on the behaviors used for computation and postprocessing, and an alarm message is transmitted if there is a difference; the user is responsible for the interpretation of the got results [R7.02.03]. For example
- , if the loading is perfectly radial monotonous, computations in nonlinear elasticity and elastoplasticity lead to the same results.
- Only the command variable (see [U 4.43.03]: operator AFFE\_MATERIAU , key word AFFE\_VARC ) authorized for the computation of rate of energy restitution is temperature "TEMP ". The same applies when key word COMP\_INCR is indicated. For

more precise details, to refer to [U2.05.01]. Operand

### 3.6.1 RELATION RELATION

- =

the possible behavior models ("ELAS", "ELAS\_VMIS\_LINE ", "ELAS\_VMIS\_TRAC ", "ELAS\_VMIS\_PUIS ") are detailed in [U4.51.11]. /"

ELAS " (DEFAULT) linear

elastic Behavior model i.e. the relation between the strains and the forced considered is linear [R7.02.01 §1.1]. /"

ELAS\_VMIS\_LINE" nonlinear

elastic Behavior model, of Von Mises with linear isotropic hardening. The data materials necessary of the field material are provided in operator DEFI \_MATERIAU (cf operator

STAT\_NON\_LINE [U 4.51.03] and key word VMIS\_ISOT\_LINE ) [R7.02.03 §1.1] and [R5.03.20]. /"

ELAS\_VMIS\_TRAC" nonlinear

elastic Behavior model, of Von Mises with nonlinear isotropic hardening. The data materials necessary of the field material are provided in operator DEFI\_MATERIAU (cf operator STAT\_NON\_LINE [U 4.51.03] and key word VMIS\_ISOT\_TRAC ) [R7.02.03 §1.1] and [R5.03.20]. /"

ELAS\_VMIS\_PUIS" nonlinear

elastic Behavior model, of Von Mises with nonlinear isotropic hardening defined by a model power. The data materials necessary of the field material are provided in operator DEFI\_MATERIAU (cf operator STAT\_NON\_LINE [U 4.51.03] and key word VMIS\_ISOT\_PUIS ) [R7.02.03 §1.1] and [R5.03.20]. Operand

### 3.6.2 DEFORMATION This

key word makes it possible to define the assumption used for the computation of the strains. In a general way, to see paragraph DEFORMATION of [U4.51, 11]. ◇

DEFORMATION =/"

PETIT " : the strains used in the behavior model are the linearized relations. That means that one remains in Assumption Small Disturbances: small displacements, small rotations and small strains. This option is the only possible one for cracks nonwith a grid. /"

GROT\_GDEP " : the strains used in the behavior model are the strains of Green - Lagrange [R7.02.03 §2.1], which makes it possible to treat large rotations and large displacement, but while remaining in small strains. Caution:

- *The loadings supported in large displacement are those supported out of linear elastic provided that they are dead loads: charge imposed or nonfollowing pressure.*
- *Displacements and the rotations can be large but it is essential to be limited to small strains if one wishes a coherence with the actual material. For more precise details to refer to [R7.02.03 §2.5]. Behavior model*

### 3.6.3 available for each option "CALC\_G

"ELAS	" "PETIT	" "CALC_K_G	" COMP_ELAS
		" "GROT_GDEP	"
		" "PETIT	"ELAS_VMIS_LIN
			E
	" "ELAS_VMIS_TRAC	" "GROT_GDEP	disp. Table
	" "ELAS_VMIS_PUIS	" not	
	" "PETIT		

#### 3.6.4-a: Availability, by option, of the behavior models. Operand

### 3.6.4 CALCUL\_CONTRAINTE ◇

CALCUL\_CONTRAINTE = 'NON' This

operand is found that in the presence of COMP\_ELAS and only for cracks with a grid, without initial state and for options "CALC\_G " and "CALC\_G\_GLOB ". By default, the stresses are recomputed in operator CALC\_G , starting from the field of displacement and of the constitutive law. If CALCUL\_CONTRAINTE = "NON ", then G is

calculated without recomputing the stresses starting from solution displacements (one directly uses those present in data structure result). Note:

If

*the constitutive laws used for mechanical computation and postprocessing are the same ones - what constitutes the normal practice - then the results with or without recalculation of the stresses are identical.*

*A usual practice to take into account plasticity however consists in doing an elastoplastic mechanical computation, followed by a nonlinear elastic postprocessing for the computation of*

*G. If one remains well in the field of validity of the computation of (radial  $G$  and monotonous loading), then the results with or without recalculation of the stresses are identical. As soon as one leaves this field of validity, the variation grows. This*

*option, to hold to the informed users, thus makes it possible to check a posteriori that one remains well on the design assumptions of.  $G$  Operands*

### 3.6.5 TOUT /GROUP\_MA/MESH ◇

```
/TOUT=' OUI'           , / |
GROUP_MA=lgrma        , |NET
=lma                   , Specifies
```

meshes or the nodes on which the behavior model is used. Key word

### 3.7 COMP\_INCR ◇

COMP\_INCR =

the behavior model elastoplastic is associated with a criterion of Von Mises with isotropic or kinematical hardening. It is possible to calculate in elastoplasticity a parameter,  $G$  called and  $G_{TP}$  defined then as total flux of energy (plasticity and fracture) through the default. In the case of elastoplasticity, the default must be modelled by a notch. ◇

RELATION =/"

ELAS " incremental

elastic Behavior model [U4.51.03]. With this relation, it is possible to define a non-zero state of initial stresses. /"

VMIS\_ISOT\_LINE" Von Mises

with linear isotropic hardening ([U4.51.03] and [R5.03.20]). /"

VMIS\_ISOT\_TRAC" Von Mises

with isotropic hardening given by a curve of tension [U4.51.03]. This behavior model cannot be used in CALC\_G in the presence of thermal. ◇

DEFORMATION = This

key word makes it possible to define the assumption used for the computation of the strains. In a general way, to see paragraph DEFORMATION of [U4.51, 11]. /"

PETIT " :

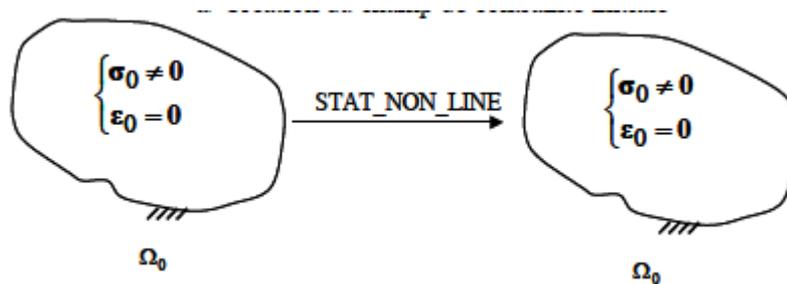
the strains used in the behavior model are the linearized relations. This option is the only possible one for cracks nonwith a grid. /"

PETIT\_REAC " :

the increments of strains are calculated in the current geometry (reactualized) but the behavior remains writes under the assumption of the small strains [U 4.51.11]. ◊

TOUT /GROUP\_MA/MESH: specify meshes on which the incremental behavior model is used. ◊

SIGM\_INIT : In the case of an incremental elastic behavior model, it is possible to define a non-zero stress state initial. Only option CALC\_G can take into account this stress state initial. Taking into account the difficulty of validation of the formulation established in CALC\_G , it is not currently licit to cumulate a predeformation (via key word PRE\_EPSI of operator AFFE\_CHAR\_MECA ) and an initial stress. The provided stress field initial can be of type SIEF\_ELGA , SIEF\_ELNO or SIEF\_NOEU (possibility of creating them from CREA\_CHAMP in particular). In all the cases, this stress field initial must be car - **balanced**, in absence of crack, with the only conditions limiting. The user will be able (would have...) to check that its stress field initial is licit by applying it in key word ETAT\_INIT of operator STAT\_NON\_LINE , with an incremental elastic behavior (COMP\_INCR, RELATION = "ELAS"), with the only limiting conditions; the result mechanical one must be the same stress field without additional strains (see Figure 3.1 3.1Figure



3.1 3.1 Checking of the initial validity of the stress field. Operand

## 3.8 OPTION ◊

```
OPTION = "CALC_G", / "
        CALC_G_GLOB", / "
        CALC_K_G", / "
        G_MAX", / "
        G_MAX_GLOB", / "
        CALC_K_MAX", / "
        G_BILI", / "
        G_BILI_GLOB", OPTION
```

### 3.8.1 = "CALC\_G" [R 7.02.01] and [R7.02.03] It

allows the computation of the rate of refund of energy by  $G$  the method theta in 2D or 3D local for a linear thermoelastic problem or not linear. In 2D, for modelization AXIS , it is necessary to divide result obtained by the radius into crack tip, cf §4.24.2

### 3.8.2 = "CALC\_G\_GLOB" [R 7.02.01] and [R7.02.03] It

G allows the computation of the rate of refund of energy by the method theta in 3D total for a linear thermoelastic problem or not linear. It is necessary to divide the gross amount of data  $G$  by Code\_Aster by the length of crack, cf §4.34.3

### 3.8.3 = "CALC\_K\_G" [R 7.02.05] This

option calculates in **2D and 3D** the rate of refund and the  $G$  coefficients of intensity of stresses,  $K_1$  and  $K_2$  in  $K_3$  plane linear thermoelasticity by the method of the singular fields (use of the bilinear form of,  $G$  [R7.02.05]). Note:

For

- *this option, only the linear elastic designs without initial state are available. For*
- *this option in 2D, if INFO is worth 2, one generates the computation and the printing (in the message file ) of the angle of propagation of crack. This angle, calculated according to 3 criteria (or  $K1$  maximum  $G$  , minimal  $K2$  ) according to the formulas of AMESTOY, BUI and DANG-VAN [R7.02.05 §2.5], is given with a margin of 10 degrees. If*
- *crack is with a grid (i.e if key word FOND\_FISS is indicated ), the computation of this option is possible only if the lips are initially stuck (CONFIGURATION \_INIT='COLLEE' in DEFI\_FOND\_FISS [U4.82.01]). OPTION*

### 3.8.4 = "G\_BILI" or " G\_BILI\_GLOB " [R7.02.01] For

a series of displacements, this  $(U_1, \dots, U_n)$  option allows the computation of the bilinear form for  $g(U_i, U_j)$  ; so  $i \geq j$  then  $i = j$  .  $g(u, u) = G(u)$  The results are stored in an array comprising two indices and in  $i$  reference  $j$  to displacements and are ordered  $U_i U_j$  in the list contained in data structure result under key word RESULTAT . Option

"G\_BILI " corresponds to computations 2D and 3D local; option "G\_BILI\_GLOB " corresponds to the computation of rate of energy restitution 3D total. Caution:

In 3D

*local, only combinations of discretization of and  $G(s)$  field cf [  $\theta$  §Error - LEGENDRE or LAGRANGE - LAGRANGE are available for this option. This computation option is valid only for linear elastic designs where the superposition of loading by linear combination is possible. OPTION*

### 3.8.5 = "G\_MAX" or " G\_MAX\_GLOB " [R7.02.05] This

option relates to the maximization of in 2D  $G$  and 3D local (option "G\_MAX ") or in 3D total ("G\_MAX\_GLOB") under stresses limits [R7.02.05]. It is necessary to provide the value of the stresses limits behind the key word BORNES , cf § 3.10. 3.10, this option does not make it possible to distinguish the loadings leading to an opening or a closing from crack, contrary to option CALC\_K\_MAX . OPTION

### 3.8.6 = "CALC\_K\_MAX" This

option relates to the maximization of in 3D  $K_1$  local in the presence of signed and not signed loadings. It is necessary to provide the sign of the loadings behind the key word SIGNES , cf §3.11. 3.11 to options G\_MAX and G\_MAX\_GLOB , this option makes it possible well to distinguish opening and closing from crack. Note:

if

*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.*

*crack is with a grid (i.e if key word FOND\_FISS is indicated ), the computation of this option is possible only if the lips are initially stuck (CONFIG\_INIT = ' COLLEE' in DEFI \_FOND\_FISS [U4.82.01 ]).* Key word

### 3.9 LISSAGE the domained'application

of this key word is limited to 3D case local. Operand

#### 3.9.1 LISSAGE\_THETA ◇ LISSAGE\_THETA

```
= "LEGENDRE      " [DEFAULT]          /\LAGRANGE
      /\LAGRANGE_REGU
      " the trace
```

of the field theta on the crack tip can be discretized either according to the base of the first  $N$  polynomials of Legendre ("LEGENDRE"), or according to the shape functions associated with the discretization with the crack tip ("LAGRANGE" or "LAGRANGE\_REGU") [R7.02.01]. LISSAGE\_THETA

= ' LEGENDRE': is discretized  $\theta(s)$  on a basis of polynomials of Legendre of degree  $\gamma_j(s)$  () where  $j$  is  $0 < j < Deg_{max}$  the maximum  $Deg_{max}$  degree given under key word DEGRE (between 0 and 7). LISSAGE\_THETA

= ' LAGRANGE': is discretized  $\theta(s)$  on the shape functions of the node of the crack tip  $k$  :. LISSAGE\_THETA  $\varphi_k(s)$

= ' LAGRANGE\_REGU': form regularized lissage of LAGRANGE , consisting in taking linear shape functions systematically and extending the support of each field theta on 4 meshes consecutive (against 2 with "LAGRANGE") . Operand

#### 3.9.2 LISSAGE\_G LISSAGE\_G

```
= "LEGENDRE      ", [DEFAULT]          /\LAGRANGE
      /\LAGRANGE_NO_NO
      /\LAGRANGE_REGU
      " can be
```

$G(s)$  discretized either according to the polynomials of Legendre ("LEGENDRE"), or according to the shape functions of the nodes of the crack tip ("LAGRANGE"). Method "LAGRANGE\_NO\_NO " is resulting from method LAGRANGE - LAGRANGE but it is simplified [R7.02.01]. In the same way, "LAGRANGE\_REGU " is a regularized version of the method LAGRANGE , which can be useful for the crack tips with a grid irregularly or with quadratic elements. If the lissage

of theta by polynomials of Legendre were retained with the preceding key word, then the lissage of must also  $G$  be of Legendre type. In the same way, if a lissage of theta of the type "LAGRANGE\_REGU " were retained with the preceding key word, then the lissage of must also  $G$  be of type "LAGRANGE\_REGU ". The options

available in Aster are summarized in the following table: Theta Polynomials

of LEGENDRE Shape functions	Polynomials
-----------------------------	-------------

$G(s)$	of LEGENDRE THETA= LISSAGE_ LISSAGE_G = "LEGENDRE" LISSAGE_	"LEGENDRE" THETA=' LAGRANGE' LISSAGE_ G= "LEGENDRE" Shape functions
LISSAGE_TH ETA	= "LAGRANGE" LISSAGE_G = "LAGRANGE" or "LAGRANGE_NO_NO " LISSAGE_THETA = "LAGRANGE_REGU" LISSAGE_G = "LAGRANGE_REGU" Operand	

### 3.9.3 DEGRE $\diamond$ DEGRE

=n is the maximum

$n$  degree of the polynomials of Legendre used for the decomposition of the field in crack tip  $\theta$  [§3.12] (when LISSAGE\_THETA = ' LEGENDRE'). By default

is assigned  $n$  to 5. The value of must be  $n$  ranging between 0 and 7. If one retains

the discretizations LISSAGE\_THETA = ' LAGRANGE' and LISSAGE\_G = "LEGENDRE", one must have, where is  $n < NNO$  the number  $NNO$  of nodes in crack tip [R7.02.01 §2.3]. The Councils

#### on the lissage: it is difficult

- to give a preference to one or the other method of lissage. In theory both give equivalent numerical results. Nevertheless the lissage of the type "LAGRANGE " is little more expensive in TEMPS CPU than the lissage of the type "LEGENDRE "; the lissage
- of the type "LEGENDRE " is sensitive to the maximum degree of the selected polynomials. The maximum degree must be defined according to the number of nodes in crack tip NO. If is too  $n$  large taking into consideration result  $NNO$  are poor [U2.05.01 §2.4]; oscillations
- can appear with the lissage of the type "LAGRANGE ", in particular if the mesh comprises quadratic elements or if the crack is not with a grid. If the mesh is radiant in crack tip (crack with a grid), it is then recommended to define contours R\_INF and R\_SUP coinciding with the borders of the elements. A lissage of the type "LAGRANGE\_NO\_NO " or "LAGRANGE\_REGU " makes it possible to limit these oscillations; for
- cracks nonwith a grid (method X-FEM), when one uses a lissage of the type "LAGRANGE " it is recommended to use operand NB\_POINT\_FOND to guarantee an equal distribution of the points of computations in crack tip. The choice of a ratio of about 5 between the total number of points in crack tip (to be sought in the information printed in message file by the command DEFI\_FISS\_XFEM ) and the number of points of computation seems suitable to limit the oscillations; the use
- of at least two types of lissage with several integration contours and the comparison of the results are essential **in order to check the validity of the model**. Key word

### 3.10 BORNES $\diamond$ BORNES

= This key word

factor is compulsory if one uses options "G\_MAX" and "G\_MAX\_GLOB ". If not it is not used. It makes it possible to define couple stresses limits for each  $(q_i^-, q_i^+)$  sequence number of data structure result . One then seeks to define the combination of loading more penalizing in term of rate of energy restitution: where are

$$\max_{q_i^- \leq q_i \leq q_i^+} G(\sum_i q_i Q_i) = \max_{i,j=1}^N \sum G_{ij} q_i q_j Q_i$$
 the unit  $N$  loadings associated with the various displacements contained  $U_i$  in data structure result , and the bilinear  $G_{ij} = g(U_i, U_j)$  form of. ♦NUMÉRIQUE  $G_$

ORDRE=num Sequence number

in data structure result associated with the values of stresses limits. ♦VALE\_

minimal MIN=qmin Value

of the coefficient applied to the loading associated with result stored in the sequence number num with the data structure resu. ♦ VALE\_

MAX=qmax maximum Value

of the coefficient applied to the loading associated with result stored in the sequence number num with the data structure resu. Note:

### The user

- must as many give couples of limits than of sequence numbers contained in data structure result under penalty of fatal error. This computation option
- is valid only for linear elastic designs where the superposition of loading by linear combination is possible. An example
- of use of this option to maximize in the presence of  $G$  signed and not signed loadings is given in the §5.3. Key word5.3

## 3.11 SIGNES ♦ BORNES

= This key word

factor is compulsory if one uses option "CALC\_K\_MAX ". If not it is not used. It makes it possible to define, for each sequence number of data structure result , the type of loading, i.e if the loading is signed or not signed. ♦CHARGE\_S

=listS List of the sequence numbers

of data structure result associated with signed loadings. ♦CHARGE\_NS

=listNS List of the sequence numbers

of data structure result associated with not signed loadings. This option

makes it possible to distinguish opening and closing from crack: An example

$$K^{max} = \sum_{CHARGE\_S} K(u_i) + \sum_{CHARGE\_NS} K(u_i) \cdot sign(K_I(u_i))$$

of use of this option is given in the 5.3. Operand5.3

## 3.12 TITER ♦TITER =titer

[U4.03.01 ] .

Operand

### 3.13 INFO $\diamond$ INFO =

/1, [DEFAULT ] /2 , Level  
 of messages

in the file "MESSAGE". Count produced

### 3.14 command

CALC\_G generates a concept of the type counts. This one contains  
 : in 2D or 3D

- total: rate of energy restitution then possibly, according to the options, its derivative or factors of intensity of the stresses. in 3D local
- : for the option CALC\_G, this array contain, for each node of the crack tip: the name of the node
- , its curvilinear abscisse
- along the crack tip, the value of
- room to the node  $G$  . For the option

CALC\_K\_G, the array contain: (in 3D)

- the number of the point of the crack tip, (in 3D) its
- curvilinear abscisse along the crack tip, the value of
- the factors of intensity of the stresses, and  $K_1$  the room  $K_2$  ( $K_3$ ) in each  $G$  point (in 3D),
- the value of the angle  $BETA$  of propagation of crack. the value of
- the rate of energy restitution calculated from  $G_{IRWIN}$  the factors of intensity of the stresses. is obtained

$G_{IRWIN}$  starting from the factors of intensity of the stresses and (and)  $K_1$  with  $K_2$   $K_3$  the following formulas: in plane stresses

$$G_{IRWIN} = \frac{1}{E} (K_I^2 + K_{II}^2) \text{ in plane strains}$$

$$G_{IRWIN} = \frac{(1-\nu^2)}{E} (K_I^2 + K_{II}^2) \text{ and axisymmetric in 3D with}$$

$$G_{IRWIN} = \frac{(1-\nu^2)}{E} (K_I^2 + K_{II}^2) + \frac{K_{III}^2}{2\mu} \text{ Young's modulus}$$

$E$  and Poisson's ratio  $\nu$  and. The comparison  $\mu = \frac{E}{2(1+\nu)}$  enters and allows  $G$  S  $G_{IRWIN}$  "to ensure of the coherence of the results: a too important variation must result in checking the parameters of computation (refinement of the mesh, choice of contours for theta, lissage in 3D...). L" angle

of propagation  $BETA$  in 3D is calculated according to the following formula (cf [R7.02 .12]): In 2D, the angle of propagation of the crack

$$BETA = 2 \operatorname{atan} \left( \frac{1}{4} \left( \frac{K_I}{K_{II}} - \operatorname{sign}(K_{II}) \sqrt{\left( \frac{K_I}{K_{II}} \right)^2 + 8} \right) \right)$$

is indicated in the message file if INFO=2 (cf example in paragraph 5.1). Command 5.1

IMPR\_TABLE [U4.91.03] makes it possible to print the results with the desired format.  
Standardization

## 4 of the total rate of refund G 2D plane stresses

### 4.1 and plane strains In dimension

2 (plane stresses and plane strains), the crack tip is tiny room to a point and value resulting of the command  $G(\theta)$  CALC\_G is independent of the choice of the field: Axisymetry  $\theta$

$$G = G(\theta) \quad \forall \theta \in \Theta$$

### 4.2 Into axisymmetric

it is necessary to standardize the value obtained with  $G(\theta)$  Aster for options CALC\_G, G\_MAX and G\_BILL : where is

$$G = \frac{1}{R} G(\theta)$$

the distance  $R$  from the crack tip to the axis of symmetry [R7.02.01 §2.4.4]. For the option

CALC\_K\_G, the values of and provided  $G$  in  $K$  the table result are directly the local values, it thus should not be standardized. 3D In dimension

### 4.3

3, the value of for a given  $G(\theta)$  field is  $\theta$  such as: By default

$$G(\theta) = \int_{\Gamma_0} G(s) \theta(s) \cdot \mathbf{m}(s) ds$$

, the direction of the field in crack tip  $\theta$  is the norm with the crack tip in the plane of the lips. By choosing a unit field in  $\theta$  the vicinity of the crack tip, one has then: and: That is to say

$$\theta(s) \cdot \mathbf{m}(s) = 1$$

the total

$$G(\theta) = \int_{\Gamma_0} G(s) ds$$

rate  $G$  of refund of energy, to have the value from unit of length  $G$ , it is necessary to divide the value obtained by the length of crack: . Symmetry  $l$

$$G = \frac{1}{l} G(\theta) \text{ of}$$

### 4.4 the model If one models

only half of solid compared to the crack: that is to say to specify

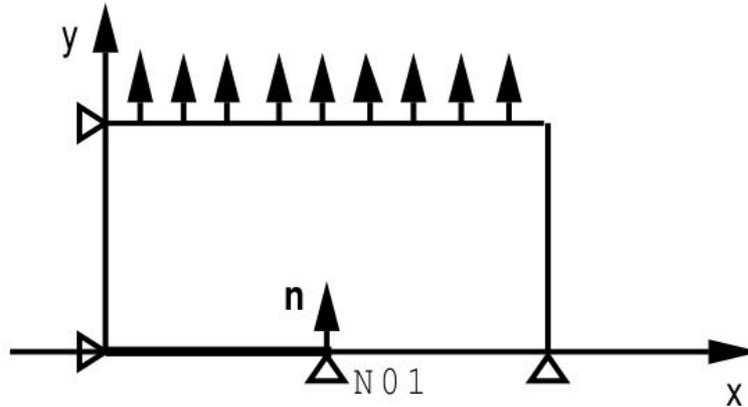
- the key word SYME = "OUI" in the commands concerned; that is to say

- not to forget to multiply by 2, values of rate of energy restitution or and by  $G$  4 those  $G(s)$  of.

Moreover  $G_{Irwin}$  values of the factors of intensity of the stresses corresponding to the mode of symmetry must also be multiplied by 2. Example examples

## 5 of use

### 5.1 in 2D Figure 5.1 -



a: Computation of the stress intensity factors. ma=LIRE\_MAILLAGE

```
( ) mo=AFFE_MODELE
(MAILLAGE=ma, AFFE =_F (TOUT
= "OUI" , PHENOMENE = ' MECANIQUE', MODELISATION
= "D_PLAN")) ff=DEFI_FOND

_FISS (NOEUD=' N01' , SYME=' OUI'
NORMALE= (0.
1.),) theta=CALC_

THETA ( MODELS = Mo , THETA_2D =_F
(NOEUD=' N01', MODULE=1 ,
R_INF=2.0 ,
R_SUP=3.0 ),
DIRECTION= (
1. 0.),) G0=CALC_G (RESULTAT

=resu , THETA=_F (THETA
= theta , SYME=' OUI',
), OPTION=' CALC
_G' INFO = 2,)
GK0=CALC_G (

RESULTAT = resu, THETA =_F (THETA
= theta , FOND_FISS=ff
), OPTION=' CALC
_K_G' INFO = 2,)
IMPR_TABLE (

ARRAY =G4) One calculates
```

the stress intensity factors and on the model  $K_1$   $K_2$   $M_0$ , with displacement depl solution of the elastic problem with: the material field

- chma produced by AFFE\_MATERIAU , the load
- CH produced by the command AFFE\_CHAR\_MECA . One recovers

node the basic N01 crack and the norm with crack by the concept fond\_fiss. In G0, it is specified that the total loading is symmetric compared to the crack thanks to key word SYME. It is not necessary to add SYME in GK0 because the concept fond\_fiss holds already information on symmetry thanks to key word SYME in DEFI\_FOND\_FISS . As INFO

is worth 2 , the angle of propagation of the crack is also calculated, and result is printed in the message file with the following format: Basic crack

node: N01 Coordinated

of the basic crack node: 0. 0. Coordinates

of the norm to crack: 0. 1. ( IRWIN ) 2.14364

$K_1$	$K_2$	$G$ E+01
0.0000E+00	1.14880E-	03 Rates of energy restitution

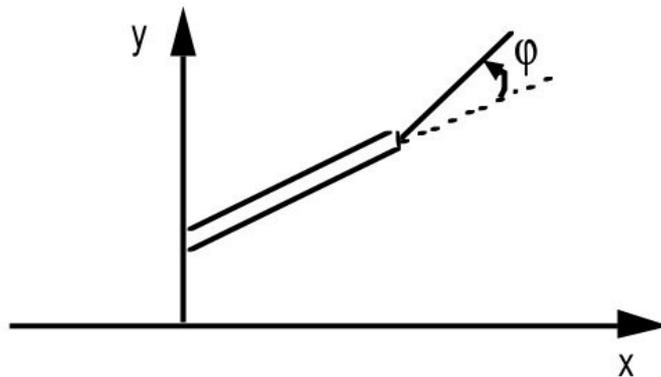
: 1.14907E-  $G$  03 Direction of

the deviation of crack (in degrees): According to the maximum

**criterion: 0  $K_1$  with max** : 2.14364  $K1$  E+ 01 According to the null  
**criterion: 0 with  $K_2$  no one** : 0.0000  $K2$  E+00 According to the maximum  
**criterion: 0  $G$  with:** 1.1 E  $G_{max}$  03 From  
 48  
 8

the stress intensity factors and, one can  $K_1$  indeed  $K_2$  calculate the coefficients and corresponding  $K_1^*$   $K_2^*$  with a crack propagation given (according to works of AMESTOY, BUI and DANG-VAN [R7.02.05 §2.5]). The direction

of the deviation of crack is calculated according to these results and according to 3 criteria maximum, no one  $K_1^*$  and maximum  $K_2^*$  .  $G^*$  The angle of propagation, given in degree, is calculated compared to the prolongation of crack. Figure 5.1 -



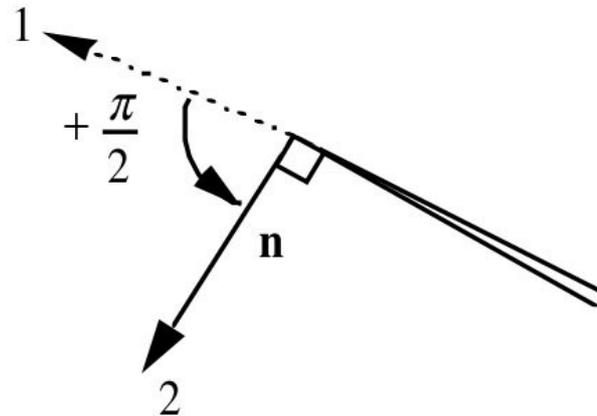
**b: Angle of propagation Note:**

**For a thermal**

- loading, the coefficients characteristic of the material must be  $(E, \nu, \dots)$  independent of the temperature. Attention with

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- the directional sense of the norm to crack. Figure 5.1 -



C: Directional sense of the norm to the crack Example of

## 5.2 use in 3D Let us take

the case of a crack with a grid: The crack tip

is defined in DEFI\_FOND\_FISS : ff=DEFI\_FOND

```
_FISS (MAILLAGE=MA, FOND_FISS=_
      F (GROUP_MA = "LFF"),) Examples
of
```

computation of the rate of refund of energy in 3D (local or total): G1LOC=CALC\_

```
G (OPTION=      \  CALC_G'      , RESULTAT=resu
  , THETA      = _F
  (FOND_FISS   =ff , R_INF=1      . , R
                _SUP=2      . ,),
    LISSAGE=_F
  (    LISSAGE_G=' LAGRANGE'      LISSAGE_THETA
    = ' LAGRANGE')      ,) G1GLOB=CALC
```

```
_G (OPTION=      \  CALC_G_GLOB', RESULTAT=resu
  , THETA      = _F
  (FOND_FISS   =ff , R_INF=1      . , R
                _SUP=2      . ,),
    ) Example      of
```

computation of the factors of intensity of the stresses in 3D: KLOC=CALC\_G

```
(OPTION=      \  CALC_K_G' , RESULTAT=resu
  , THETA      = _F
  (FOND_FISS   =ff , R_INF=1      . , R
                _SUP=2      . ,),
    LISSAGE=_F
  (    LISSAGE_G=' LAGRANGE'      LISSAGE_THETA
    = ' LAGRANGE')      ,) One can
find
```

examples of use in the following tests: SSLV110 [V3.04

- .110] Fissures semi-elliptic in infinite medium SSLV112 [V3.04
- .112] Fissures circular in infinite medium HPLV103 [V7.03
- .103] Thermoelasticity with circular crack in infinite medium Maximization

## 5.3 of G and of K in the presence of not signed stresses the purpose of This example

is specifying how to maximize the rate of refund of energy for a linear problem with at the same time of the signed stresses (inertia loading, pressure interns) and of the stresses which one does not know the sign a priori (seisme). The studied problem is in modelization 3D, with a linear elastic behavior. Two types of options are usable: that is to say options

1. G\_MAX/G\_MAX\_GLOB (maximization of rate of energy restitution); that is to say the option
2. CALC\_K\_MAX which, based on the computation of, makes it possible KI to distinguish opening and closing from crack. In both

cases, the contact on the lips of crack is not taken into account. Let us suppose for example

, that besides the boundary conditions of blocking CHCL, there is a loading of pressure signed CHPRESS, and two not signed loadings applying to mesh groups distinct from the model, CH\_NS1 and CH\_NS2 : CHCL =AFFE \_CHAR

```
_MECA (MODELE=MO, DDL_IMPO= (_F
                                (GROUP_NO = "SSUP_S", DZ = 0.), _F (GROUP_NO
                                = "SLAT_S", DX = 0.), _F (GROUP_NO
                                = "SAV_S", DY = 0.),), ) CHPRES=AFFE

_CHAR_MECA (MODELE=MO, PRES_REP=_F
            (GROUP_MA = "SINF", NEAR = -1.E6),) CH_NS1=AFFE

_CHAR_MECA (MODELE=MO, FORCE_NODALE
            =_F (GROUP_NO = "SLAT", FZ = 1540),) CH_NS2=AFFE

_CHAR_MECA (MODELE=MO, FORCE_NODALE
            =_F (GROUP_NO = "SINF", FX = 2100),) One
calculates
```

the solution problem associated with each one of these loadings by defining multiplying functions: F0=DEFI\_FONCTION

```
(NOM_PARA=' INST', PROL_GAUCHE
          = ' LINEAIRE', PROL_DROITE
          = ' CONSTANT', VALE= (1. ,
          1. , 2. , 0. , 3. , 0. ,),) F1=DEFI _FONCTION

(NOM_PARA=' INST', PROL_GAUCHE
          = ' LINEAIRE', PROL_DROITE
          = ' CONSTANT', VALE= (1. ,
          0. , 2. , 1. , 3. , 0. ,),) F2=DEFI _FONCTION

(NOM_PARA=' INST', PROL_GAUCHE
          = ' LINEAIRE', PROL_DROITE
          = ' CONSTANT', VALE= (1. ,
          0. , 2. , 0. , 3. , 1. ,),) LISTE=DEFI _LISTE

_REEL (DEBUT=0.E+0, INTERVALLE=
```

```

        _F (JUSQU_A = 3. , NOMBRE = 3),)
    RESU=MECA_STATIQUE
    
```

```

(MODELE=MO, CHAM_MATER=
    CHMAT, EXCIT= (_F (CHARGE
    = CHCL), _F (CHARGE =
        CHPRES, FONC_MULT = F0), _F (CHARGE =
        CH_NS1, FONC_MULT = F1), _F (CHARGE =
        CH_NS2, FONC_MULT = F2)),), LIST_INST =
    LISTE,) One defines
    
```

the crack tip and contour theta for the computation of: FOND=DEFI G \_FOND

```

    _FISS (MAILLAGE=MA, FOND_FISS=_
        F (GROUP_MA = "LFF"),) THETA=CALC
    -
    THETA (MODELE=MO, FOND_FISS=FOND
        , THETA_3D=_F
        (TOUT = "OUI" , MODULE = 1.
            , R_INF = 0.2
            , R_SUP = 0.5
            ),) the maximization
    
```

of are done by G option G\_MAX\_GLOB (in 3D total ) or by option G\_MAX (in 3D local ) of CALC\_G. The coefficient of the signed loading is worth 1, the coefficients of the not signed loadings vary between - 1 and 1: G\_MAX\_G =CALC

```

    _G (THETA=_F (THETA ,), RESULTAT=RESU
        , BORNES= (_F
            (NUME_ORDRE = 1, VALE_MIN =
                1. , VALE_MAX = 1.), _F (NUME_ORDRE
                    = 2, VALE_MIN =
                        -1. , VALE_MAX = 1.), _F
                            (NUME_ORDRE
                                = 3, VALE_MIN =
                                    -1. , VALE_MAX = 1.),), OPTION='
    G_MAX
        _GLOB',) IMPR_TABLE (
    ARRAY = G_MAX_G) G_MAX_L =CALC
    _G (RESULTAT=RESU , THETA = _F (
        FOND_FISS=FOND , R_INF=0.2,
            R_SUP=0.5 ,
            MODULE=1.0,
            ), BORNES= (_F
                (NUME_ORDRE = 1, VALE_MIN =
                    1. , VALE_MAX = 1.), _F
                        (NUME_ORDRE
                            = 2, VALE_MIN =
                                -1. , VALE_MAX = 1.), _F
                                    (NUME_ORDRE
                                        = 3, VALE_MIN =
                                            -1. , VALE_MAX = 1.),), OPTION='
    G_MAX
        ",) IMPR_TABLE (
    
```

ARRAY = G\_MAX\_L) the array produced

by CALC\_G option " G\_MAX\_GLOB " is the following one :#ASTER 8.02

```
.01 CONCEPT   GMAX_G LE CALCULATES 12/21/2005 A 15:49: 17 FROM TYPE
#TABLE_SDASTER
Q_1 Q_2 Q
_3 G          G_MAX          1.00000          E+00
1.00000E+00 -1.00000E+00 3.91703E+03 3.91703E+03 1.00000E+00
1.00000E+00 -1.00000E+00 3.91703E+03 3.91703E+03 1.00000E+00
-1.00000E+00 -1.00000E+00 3.63507E+03 - 1.00000E+00
-1.00000E+00 -1.00000E+00 3.63507E+03 - 1.00000E+00
-1.00000E+00 1.00000E+00 2.92029E+03 - 1.00000E+00
-1.00000E+00 1.00000E+00 2.92029E+03 - 1.00000E+00
1.00000E+00 1.00000E+00 2.68007E+03 - 1.00000E+00
1.00000E+00 1.00000E+00 2.68007E+03 - Thus, the maximum
```

rate of refund is obtained for the combination of the loading of pressure with CH\_NS1 with a sign "+" and CH\_NS2 with a sign "-". Options G\_MAX/G\_MAX\_GLOB do not make it possible to distinguish the loadings tending to open crack of those which tend to close it: it can thus happen that the maximum of found corresponds G to a reclosing of crack. To also maximize

the stress intensity factors one uses L" option CALC\_K\_MAX : K\_MAX =CALC

```
_G (RESULTAT=RESU , THETA = _F (
FOND_FISS =FOND, R_INF=0.2,
R_SUP=0.5 ,
MODULE=1.0 ,
), SIGNES= F (CHARGE
_S = ( 1, ), CHARGE_NS =
(2,3), ), OPTION=' CALC_K_MAX
",) IMPR_TABLE (
```

ARRAY = K\_MAX) In the table

result produced by this option, one finds successively: the factors

1. D" intensity of the stresses, and K1 K2 associates K3 with G each loading (functions of the curvilinear abscisse); factors
2. of maximum intensity of the stresses, the maximum and the G associated coefficients of the loads (1 for the signed loadings, the not ±1 signed loadings). #K\_MAX AVEC

```
R_INF = 0.2 AND R_SUP = 0.5 Q_1 Q_2 Q
_3 NUM _PT AB _CURV K1 K2 K3 G 1 0 0 1
2 0.00000 E +00 8.46799E+05 -3.39509E+05 1.65142E+03 5.85407E+00 1 0 0
3.92069 E - 01 8.51341E+05 -3.48645E+05 2.89982E+03 5.85097E+00 ... 0 1
0
1 0.00000 E +00 5.20948E+05 -2.31674E+05 -2.01759E+04 2.19826E+00 0 1 0
2 3.92069 E - 01 5.25149E+05 -2.42255E+05 -7.40016E+03 2.19755E+00 ... 0 0
1
0 0.00000 E +00 - 1.97960E+05 8.03611E+04 - 1.61407E+04 1.52288E+01 0 0
1 0 3.92069 E - 01 - 1.99557E+05 9.20569E+04 -5.92013E+03 1.52227E+01 ... 1
1 -1
1 0.00000 E +00 1.56571E+06 -6.59219E+05 -2.38376E+03 7.64144E+01 1 1 -1
2 3.92069 E - 01 1.57605E+06 -6.82957E+05 1.41979E+03 7.63789E+01 ... For
other
```

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.

examples, one can refer to the case test SSLV134E/F [V3.04.134].