Operator DEFI_COMPOR

1 Goal

To define the behavior of a monocrystal, a polycrystal or a beam multifibre.

For the behavior of a monocrystal or a polycrystal, one allows the user to choose the components of the single-crystal law of behavior.

One gives, according to this definition, only the name of the crystallographic structure, knowing that the directions of the systems of slip of each family of systems of slip are defined once and for all in the code-source.

In the case of a beam multifibre, this operator makes it possible to associate with a group of fibres an incremental behavior.

2 Syntax

```
Comp1 [compor] = DEFI_COMPOR (
  ♦/MONOCRYSTAL = _F (
      ♦ MATER = mat1,                                          [to subdue]
      ♦ ELAS =/'ELAS'
              /'ELAS_ORTH'
      ♦/FLOW = ['MONO_VISC1'|' MONO_VISC2']
          ♦ ECRO_ISOT = ['MONO_ISOT1'|' MONO_ISOT2']
          ♦ ECRO_CINE = ['MONO_CINE1'|' MONO_CINE2']
          ♦ FAMI_SYST_GLIS = ['OCTAHEDRAL'|'CUBIQUE1'|' CUBIQUE2'|
                              'BCC24'|' ZIRCONIUM'|' UNIAXIAL',|
                              'USER']
        /FLOW = 'MONO_DD_KR'
          ♦ FAMI_SYST_GLIS = ['BCC24'|' UTILISATEUR']              [DEFECT]
        /FLOW = ['MONO_DD_CFC'|' MONO_DD_CFC_IRRA']
          ♦ FAMI_SYST_GLIS = ['OCTAHEDRAL'|' UTILISATEUR']         [DEFECT]
        /FLOW = 'MONO_DD_FAT'
          ♦ FAMI_SYST_GLIS = ' OCTAHEDRAL',                        [DEFECT]
        /FLOW = ['MONO_DD_CC'|' MONO_DD_CC_IRRA']
          ♦ FAMI_SYST_GLIS = ['CUBIQUE1'|' UTILISATEUR']           [DEFECT]
        # If FAMI_SYST_GLIS = 'USER'
          ◊ TABL_SYST_GLIS= tabsys,                                 [table]
    ),
    # If MONOCRYSTAL
      ◊ MATR_INTER = tabinter,                                      [table]
      ◊ ROTA_RESEAU = ['NOT'|' POST'|' CALC']                      [DEFECT]

    /POLYCRYSTAL = _F (
      ♦ MONOCRYSTAL = comp1,                                       [compor]
      ♦ FRAC_VOL     = fvol,                                            [R]
      ♦ /ANGL_REP    = (has, B, c),                                   [l_R]
        /ANGL_EULER = (phi1, phi, phi2),                              [l_R]
    ),
    # If POLYCRYSTAL
      ♦ MU_LOCA = mu_loca,                                             [R]
      ◊ LOCALIZATION = ['BZ'|' BETA',]
      # If LOCALIZATION = 'BETA',
        ♦ DL = dl,                                                     [R]
        ♦ DA = da,                                                     [R]

    /MULTIFIBRE = _F (
      ♦ GROUP_FIBRE =liste_group_fibres,                           [l_TXM]
      ♦ MATER = mat1,                                          [to subdue]
      ◊ RELATION = (see the document [U4.51.11]),
    ),
    # So MULTIFIBRE
      #  concept  gathering  the  groups  of  fibres  (resulting  from
DEFI_GEOM_FIBRE)
      ◊ GEOM_FIBRE = gfibre,                                       [gfibre]
      # material for the characteristics homogenized on the section
      ◊ MATER_SECT = to subdue,                                [to subdue]
)
```

3 Operands

3.1 Keyword MONOCRYSTAL

An occurrence of the keyword factor MONOCRYSTAL allows to define a single-crystal law of behavior elastoviscoplastic. This is to be repeated as many times as one has different single-crystal laws of behavior [R5.03.11].

3.1.1 Operand MATER

The name of material produced defines by DEFI_MATERIAU used for the monocrystal. This operand makes it possible to check that the parameters associated with the behaviors chosen under the keywords FLOW, ECRO_ISOT, ECRO_CINE and ELAS exist well in material.

3.1.2 Operand FLOW

The viscoplastic type of flow used in the definition of the law of behavior defines MONOCRYSTAL.

3.1.3 Operand ECRO_ISOT

The isotropic type of work hardening used in the definition of the law of behavior defines MONOCRYSTAL.

3.1.4 Operand ECRO_CINE

The kinematic type of work hardening used in the definition of the law of behavior defines MONOCRYSTAL.

3.1.5 Operand ELAS

The type of the elastic behavior used in the definition of the law of behavior defines MONOCRYSTAL.

3.1.6 Operand FAMI_SYST_GLIS

The surname of the systems of slip defines on which one defined the law of behavior MONOCRYSTAL. The orientations of the normals to the slip surfaces and the directions of slip are calculated automatically by the code starting from the surname.

3.1.7 Operand TABL_SYST_GLIS

Allows to provide to a family of systems of slip “user”, read in a table. One must give for each line of the table (correspondent to a system of slip) the 3 components in the reference mark of the crystal of the vectors $\boldsymbol{n}$ (normal with the slip surface) and $\boldsymbol{m}$ (direction of slip). Example (see also the test ssnd112c) :

$$n_x(s_1), n_y(s_1), n_z(s_1), m_x(s_1), m_y(s_1), m_z(s_1)$$
$$n_x(s_2), n_y(s_2), n_z(s_2), m_x(s_2), m_y(s_2), m_z(s_2)$$
$$etc...$$

Limitations : this functionality is active only for the behavior MONOCRYSTAL, and on condition that defining only one family of systems (only one occurrence of MONOCRYSTAL). It is not available for the behavior POLYCRYSTAL.

3.1.8 Operand MATR_INTER

Allows to provide a matrix of interaction (single) between the systems of slip of a monocrystal, read in a table. It is a square, symmetrical table of which dimension is the number of systems of total slip. Example (see also the test ssnd112c) :

0,124	0,124	0,124	0,625	0,137	0,137	0,137	0,122	0,070	0,137	0,070	0,122
0,124	0,124	0,124	0,137	0,070	0,122	0,625	0,137	0,137	0,137	0,122	0,070
0,124	0,124	0,124	0,137	0,122	0,070	0,137	0,070	0,122	0,625	0,137	0,137
0,625	0,137	0,137	0,124	0,124	0,124	0,122	0,137	0,070	0,122	0,070	0,137
0,137	0,070	0,122	0,124	0,124	0,124	0,070	0,137	0,122	0,137	0,137	0,625
0,137	0,122	0,070	0,124	0,124	0,124	0,137	0,625	0,137	0,070	0,122	0,137
0,137	0,625	0,137	0,122	0,070	0,137	0,124	0,124	0,124	0,122	0,137	0,070
0,122	0,137	0,070	0,137	0,137	0,625	0,124	0,124	0,124	0,070	0,137	0,122
0,070	0,137	0,122	0,070	0,122	0,137	0,124	0,124	0,124	0,137	0,625	0,137
0,137	0,137	0,625	0,122	0,137	0,070	0,122	0,070	0,137	0,124	0,124	0,124
0,070	0,122	0,137	0,070	0,137	0,122	0,137	0,137	0,625	0,124	0,124	0,124
0,122	0,070	0,137	0,137	0,625	0,137	0,070	0,122	0,137	0,124	0,124	0,124

Limitations : this functionality is active for the behavior MONOCRYSTAL and for the behavior POLYCRYSTAL, on condition that using one type of MONOCRYSTAL).

3.1.9 Operand ROTA_RESEAU

• ROTA_RESEAU=' CALC' EPRmet to calculate the rotation of the crystal lattice and to take it into account in the resolution of the law of behavior MONOCRYSTAL, into implicit only. The orientations of the normals to the slip surfaces and the directions of slip are put up to date automatically by the code at every moment of calculation, and the corresponding internal variables are added (see their significance in [R5.03.11].
• ROTA_RESEAU=' POST' EPRmet to calculate the rotation of the crystal lattice, without taking it into account in the resolution, and to display the values in the internal variables, has ends of postprocessings.

Validity and limitations:
This approximation is to be used in the presence of small deformations DEFORMATION=' PETIT' under BEHAVIOR, for RELATION=' MONOCRISTAL' [U4.51.11]. It must be thus used for moderate deformations (about 10% at the most). Beyond, and for a complete taking into account of the great deformations, it is necessary to use an adapted resolution, without using the keyword ROTA_RESEAU : DEFORMATION=' SIMO_MIEHE' in STAT_NON_LINE/COMPORTMENT.

3.2 Keyword POLYCRYSTAL

An occurrence of the keyword factor POLYCRYSTAL allows to define a phase of the polycrystalline behavior, starting from the data of a single-crystal behavior, voluminal fraction of this phase, and orientation of this phase. This is to be repeated as many times as one has different single-crystal phases. Moreover, one rule of localization, commune to all the phases, is defined by the keyword LOCALIZATION [R5.03.11].

3.2.1 Operand MONOCRYSTAL

The name of the structure of data defines compor defining the monocrystal, produced by a call former to DEFI_COMPOR.

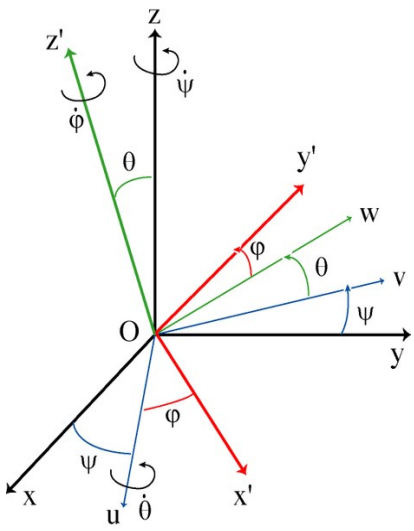
3.2.2 Operand FRAC_VOL

The voluminal fraction of the phase in progress defines. The sum of the whole of the values of fvol must be equal to 1.

3.2.3 Operand ANGL_REP/ANGL_EULER

Defines the 3 nautical angles (provided in degrees) [U4.42.01] or the 3 angles of Euler (provided in degrees) which make it possible to direct the monocrystal corresponding to the phase defined by the current occurrence of POLYCRYSTAL. The angles of Euler are defined in a conventional way, one passes from the fixed reference frame $Oxyz$ with the reference frame related to the solid $Ox'y'z'$ by three successive rotations:

- The precession ψ, around the axis Oz, makes pass from $Oxyz$ with the reference frame $Ouvz$.
- Nutation θ, around the axis Or, makes pass from $Ouvz$ with $Ouwz'$.
- Clean rotation φ, around the axis Oz', makes pass from $Ouwz'$ with the reference frame related to the solid $Ox'y'z'$.



3.2.4 Keyword LOCALIZATION

The name of the rule of localization used for the polycrystal defines.

3.2.5 Keyword MU_LOCA

The coefficient defines μ^{loca} to use in the rules of localization.

3.2.6 Operands DL and DA

If the rule of localization is 'BETA', two real parameters should be provided: dl and da. The rule of localization is in [R5.03.11].

3.3 Keyword MULTIFIBRE

This keyword makes it possible to associate with a group of fibres an incremental behavior.

3.3.1 Operand GROUP_FIBRE

Allows to define, for each occurrence of the keyword factor MULTIFIBRE, names of the groups of fibres associated with the selected relation of behavior. These groups of fibres were defined as a preliminary by the order DEFI_GEOM_FIBRE, of which the resulting concept is specified by the keyword GEOM_FIBRE below.

3.3.2 Operand MATER

This keyword makes it possible to specify the name of material containing the parameters associated with the selected behavior.

3.3.3 Operands RELATION

These keywords make it possible to define the relation of behavior associated with the groups with fibres defined by GROUP_FIBRE. The relations of behavior are described in [U4.51.11]. Let us announce however that the list of the behaviors usable with the multifibre beams is restricted compared to [U4.51.11]. The authorized relations are:
ELAS, CORR_ACIER, GRANGER_FP, GRAN_IRRA_LOG, MAZARS_GC, VISC_IRRA_LOG, VMIS_CINE_GC, VMIS_CINE_LINE, VMIS_ISOT_LINE, VMIS_ISOT_TRAC.

3.3.4 Notice on the behaviors 1D

Multifibre modelings of beams (like those of bars, of grids of reinforcements) use for each fibre an one-way behavior. If the selected law of behavior is available in 1D, this integration directly is used. If not, method of DEBORST generalized with the cases of the behaviors 1D [R5.03.09] allows to add the condition of uniaxial constraint to all the behaviors available for modelings 3D under BEHAVIOR (for more detail to see documentation [R5.03.09]). The assumption of the uniaxial constraints is checked with convergence. One recommends to rather often use and reactualize the tangent matrix (all the one with three iterations) in the method of Newton (MATRIX = 'TANGENT', REAC_ITER = 1 to 3).

3.4 Keyword GEOM_FIBRE

◊ GEOM_FIBRE = gfibre
This keyword makes it possible to specify the name of the concept gathering the groups of fibres resulting from DEFI_GEOM_FIBRE .

3.5 Keyword MATER_SECT

◊ MATER_SECT = to subdue
Definition of the material which them characteristic rubber bands homogenized of the section (thus under the keyword ELAS), used for calculation:
- rigidity of torsion .
- damping.
- thermal dilation (ALPHA).
- calculation of DEGE_ELNO (E and NAKED).

4 Examples

4.1 Examples of use for crystalline materials

The following example corresponds to a classical use of MONOCRYSTAL. It is resulting from the test SSNV171B.

```
STEEL = DEFI_MATERIAU (
  ELAS=_F (E=145200.0, NU=0.3,),
  MONO_VISC2=_F (N=10.0, K=40.0, C=1.0, D=36.68, A=10.0,),
  MONO_ISOT2=_F (R_0=75.5, Q1=9.77, B1=19.34, H=0.5, Q2=-33.27, B2=5.345,),
  MONO_CINE1=_F (D=36.68,),
)

COMPORT = DEFI_COMPOR (
  MONOCRISTAL=_F (MATER=ACIER, ELAS=' ELAS',
                  ECOULEMENT=' MONO_VISC2',
                  ECRO_ISOT=' MONO_ISOT2',
                  ECRO_CINE=' MONO_CINE1',
                  FAMI_SYST_GLIS=' OCTAEDRIQUE',),
)
```

The following example, implementing POLYCRYSTAL, is resulting from test SSNV171B:

```
MATPOLY = DEFI_MATERIAU (
  ELAS=_F (E=192500.0, NU=0.3,),
  MONO_VISC2=_F (N=10.0, K=40.0, C=6333.0, D=36.68, A=72.21,),
  MONO_ISOT2=_F (R_0=75.5, Q1=9.77, B1=19.34, H=2.54, Q2=-33.27, B2=5.345,),
  MONO_CINE1=_F (D=36.68,),
)

MONO1 = DEFI_COMPOR (
  MONOCRISTAL=_F (MATER=MATPOLY, ELAS=' ELAS',
                  ECOULEMENT=' MONO_VISC2',
                  ECRO_ISOT=' MONO_ISOT2',
                  ECRO_CINE=' MONO_CINE1',
                  FAMI_SYST_GLIS=' OCTAEDRIQUE',),
)

POLY1 = DEFI_COMPOR (
  POLYCRISTAL= (
    _F (MONOCRISTAL=MONO1, FRAC_VOL=0.025,
       ANGL_REP= (- 149.67, 15.61, 154.67,),),
    _F (MONOCRISTAL=MONO1, FRAC_VOL=0.025,
       ANGL_REP= ( - 481.7,35.46, 188.7),),
  ),
  MU_LOCA = 82500
  LOCALISATION=' BETA', DL=321.5, DA=0.216,
)
```

4.2 Example of use for the multifibre ones

The orders below make it possible to illustrate the use of DEFI_COMPOR for a multifibre behavior (see for example the test SSNL119B).

```
GF = DEFI_GEOM_FIBRE (
  FIBRE = _F (GROUP_FIBRE=' SACI', CARA = 'DIAMETER',
      COOR_AXE_POUTRE = (0. , 0. ,),
       VALE = (0.066,-0.218,32.E-3,
               0.066,-0.218,32.E-3,
                0.066,0.218,8.E-3,
               0.066,0.218,8.E-3,),),
  ),
  SECTION = _F (GROUP_FIBRE=' SBET', MAILLAGE_SECT = MASEC,
      TOUT_SECT = 'YES',
      COOR_AXE_POUTRE = (0. , 0. ,),
  ),
)

MOPOU = AFFE_MODELE (
    MAILLAGE=MAPOU,
    AFFE=_F    (TOUT='    OUI',    PHENOMENE='    MECANIQUE',    MODELISATION='
POU_D_EM',),
)

# Concrete
EB = 37272.0E+06
CONCRETE = DEFI_MATER_GC (
    MAZARS=_F (UNITE_LONGUEUR = 'M', FCJ=40.963E+06, EIJ=EB,
              EPSI_C=1.75754E-03, AT=1.0, NU=0.2,),
    RHO=2400.0, INFO=2,
)

ACIER=DEFI_MATER_GC (
    ACIER=_F (E = 2.0E+11, D_SIGM_EPSI=3.28E+9, SY=4.E+8,),
    RHO=7800.0,
)

MATOR=DEFI_MATERIAU (ELAS=_F (E=2.E11, NU=0.0, RHO=7800.0,) )

POUCA = AFFE_CARA_ELEM (
    MODELE=MOPOU,
    POUTRE=_F (GROUP_MA=' POUTRE', SECTION=' RECTANGLE',
              CARA= ('HY', 'HZ'), VALE= (0.2, 0.5),
              PREC_AIRE=5.0, PREC_INERTIE=10.0,),
    ORIENTATION=_F (GROUP_MA=' POUTRE', CARA=' ANGL_VRIL', VALE=-90.0,),
    GEOM_FIBRE=GF,
    MULTIFIBRE=_F (GROUP_MA=' POUTRE', GROUP_FIBRE= ('SBET', 'SACI')),
)

COMPPMF = DEFI_COMPOR (GEOM_FIBRE=GF, MATER_SECT=MATOR,
    MULTIFIBRE= (
      _F (GROUP_FIBRE=' SACI', MATER=ACIER, RELATION=' VMIS_CINE_LINE'),
      _F (GROUP_FIBRE=' SBET', MATER=BETON, RELATION='MAZARS_GC'),
    ),
)
```