Opérateur AFFE_CARA_ELEM

1 Drank

Affecter with structural elements of the geometrical and material characteristics. The affected geometrical data are complementary to the data of mesh.

Among the treated characteristics let us quote:

- for the elements of type shell: the thickness, a direction of reference in the tangent plane,
- for the elements of type beam: characteristics of the cross section and directional sense of the principal axes of inertia around neutral fiber, curvature of the curved elements,
- for the elements of the type discrete (spring, mass/inertia, damper): values of the stiffness matrixes, mass or damping to be affected directly or after directional sense,
- for the elements of the type bars or of type cables: the area of the cross section,
- for the elements of mediums continuous 3D and 2D: local axes by report in which the user will be able to define directions of anisotropy.

The command must be exhaustive for all the structural elements of the model.

This operator produces a structure of the cara_elem `type`.

Table des Matières

2 Syntaxe general

```
will cara [cara_elem] = AFFE_CARA_ELEM (
   ♦ MODELE=             Mo                                          [model]
   ◊ INFO=               / 1,                                       [DEFAUT]
                          / 2
   ◊ VERIF=              | "MESH",
                          | "NODE",

   ♦ | BARRE=            to see key word BARS                          [§66]

     | CABLE=            see key word CABLE                          [§1212]

     | COQUE=            see key word SHELL                            [§88]

     | POUTRE=           see key word BEAM                             [§99]
       ◊ ORIENTATION=    seeing key word DIRECTIONAL SENSE           [§1010]
       ◊ DEFI_ARC=       seeing key word DEFI_ARC                    [§1111]

     | MULTIFIBRE=       see key word MULTI_FIBRE                [§12.312.3]
       ◊ GEOM_FIBRE=     seeing key word GEOM_FIBRE              [§12.412.4]

     | DISCRET=          see key word DISCRET                        [§1313]
       ◊ ORIENTATION=    seeing key word DIRECTIONAL SENSE           [§1010]

     | DISCRET_2D=       see key word DISCRET_2D                     [§1313]
       ◊ ORIENTATION=    seeing key word DIRECTIONAL SENSE           [§1010]

     | MASSIF=           see key word MASSIF                         [§1414]

     | POUTRE_FLUI= see key word POUTRE_FLUI                         [§1515]

     |  GRILLE=          to see key word ROASTS                       [§ 16]

     | MEMBRANE        = see key word MEMBRANE                        [§ 17]

     | RIGI_PARASOL= see key word RIGI_PARASOL                       [§1818]

     | RIGI_MISS_3D=     see key word RIGI_MISS_3D                   [§1919]

     | MASS_AJOU=        to see key word MASS_AJOU                     [§20]

)
```

3 Opérandes Generals MODELE and VERIF

3.1 Opérande MODELE

♦ MODELE = Mo

Concept of the model type, produced by the operator AFFE_MODELE [U4.41.01] on whom are affected the characteristics of the elements. Let us note that models it must contain explicitly at least one of the structural elements, on which will carry the assignment (if not computation stops).

3.2 Operand VERIF

◊ VERIF = / "MESH"
"NODE"

Argument	Signification
"NETS"	Vérifie that the type of element supported by the meshes, to which one wants to affect a characteristic, is compatible with this characteristic (including the directional senses). In the contrary case, stop with error message.
"NODE" (only with DISCRET)	Vérifie which the nodes to which one wants to affect a nodal **characteristic** support a kind of element compatible with this characteristic. In the contrary case, stop with error message.

3.3 Operand INFO

◊ INFO = / 2 on file " MESSAGE", for all the elements, the list of values assigned to the elements Prints:

- orientation angles in degrees (beams and discrete),
- characteristics of the cross sections of beams and bars,
- printings of the elementary matrixes (discrete).

/ 1 does not print anything

4 Définition field of assignment

the choice of the elements of the model Mo to which the assignment relates is done in two stages:

- the choice of the type of element concerned with assignment (BEAM, DISCRET,…),
- meshes (of the type of definite element) to affect.

The choice of the key word factor defining the type of elements (BEAM, DISCRET,…) imply that there exists in the model the types of adapted elements (checking carried out systematically).
The types of elements concerned depend on the modelization:

- phenomenon MECANIQUE

Key word	Modelization
BARS	BAR
CABLE	CABLE, CABLE_POULIE
SHELL	COQUE_AXIS, COQUE_C_PLAN, COQUE_D_PLAN, DKT, DST, DKQ, DSQ, Q4G, COQUE_3D
DISCRET	DIS_T, DIS_TR, 2D DIS T, 2D_DIS_TR
BEAM	POU_D_E, POU_D_T, POU_C_T, POU_D_TG, POU_D_T_GD, FLUI_STRU, TUYAU_3M, TUYAU_6M, POU_D_TGM , POU_D_EM
MASSIF	3D, AXIS, AXIS_FOURIER, C_PLAN, D_PLAN, TUYAU_3M, TUYAU_6M
ROASTS	GRID, GRILLE_MEMBRANE
MEMBRANE	MEMBRANE
POUTRE_FLUI	3D_FAISCEAU
MULTI_FIBRE	POU_D_EM, POU_D_TGM
RIGI_PARASOL	DIS_TR
RIGI_MISS_3D	DIS_T

- THERMAL phenomenon

Key word	Modelization
SHELL	COQUE_AXIS, COQUE_PLAN, SHELL
MASSIF	3D, AXIS, PLANE

the assignment of the characteristics to the finite elements is done using the key words: "MESH", "NODE", "GROUP_MA", "GROUP_NO", according to the cases.

- If VERIF is not present: In a group or a list of meshes (or nodes), one assigns indeed the characteristics to the only elements for which they have a meaning. For the other elements, the characteristics are not affected.
- If VERIF is present: One checks moreover than all the elements of the group or of the list are of the good type, if not an error message is transmitted.

4.1 Operands NETS / GROUP_MA / NODE / GROUP_NO

Opérandes	Meaning
GROUP_MA = lgma	Affectation with all the elements of the specified mesh groups.
NET = lma	Affectation with all the elements of the specified meshes.
GROUP_NO = lgno	Affectation with all the nodes of the specified nodes groups (DISCRET only)
NODE = lno	Affectation with all the specified nodes (DISCRET only)

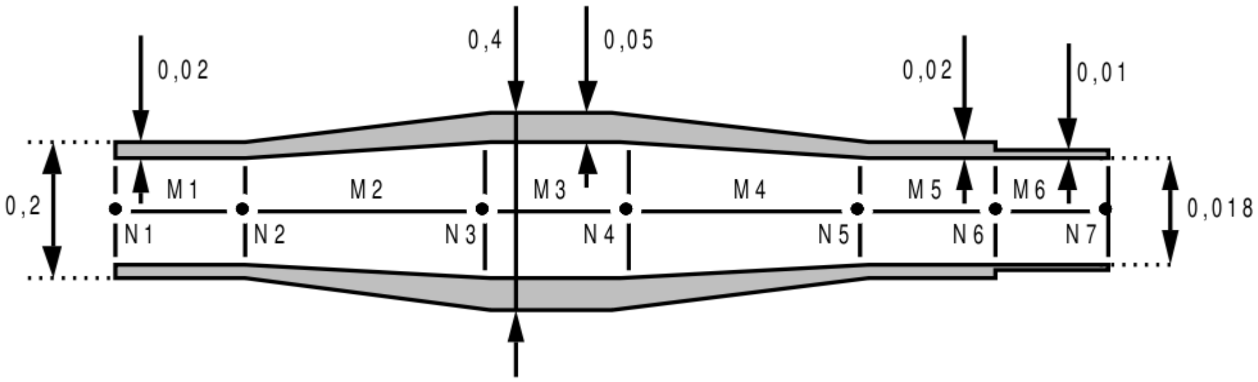
Comme in the other commands, the rule of overload applies [U1.03.00].

5 Assignment of values

Deux methods are usable to affect values of characteristics:

- common method: operand whose name evokes the treated characteristic followed by a value or a list of values. Examples:
  ```
  SHELL = _F (EPAIS = 1.E-2,  GROUP_MA = “G1”),
  SHELL = _F (ANGL_REP = (0. , 90.),    GROUP_MA = “G2”),
  ```
- for the assignments relating to BAR, BEAM and DISCRET, like DIRECTIONAL SENSE for the beam elements and the discrete elements, a large number of characteristics being able to be affected led to a better adapted syntax:
  CARA = (…) # lists names of characteristics
  VALE = (…) # lists values corresponding to the characteristics

One gives below an example to illustrate this case.



Description of the meshes:

```
SEG2
    M1 N1 N2
    m2 N2 N3
    m3 N3 N4
    M4 N5 N4
    M5 N5 N6
    M6 N6 N7
FINSF
```

Fichier of commands:

```
= AFFE_CARA_ELEM (POUTRE=
   (_F
       (SECTION= will cara'CERCLE”, CARA= (“R”, “EP”), VALE= (0.1, 0.02), MAILLE=
(“M1”, “M5”)),
     _F (SECTION='CERCLE”, CARA= (“R”, “EP”), VALE= (0.2, 0.05), MAILLE= “M3”),
     _F (SECTION='CERCLE”, CARA= (“R”, “EP”), VALE= (0.09, 0.01), MAILLE= “M6”),
      _F (SECTION='CERCLE”, CARA= (“R1”, “R2”), VALE= (0.1, 0.2), MAILLE= (“M2”,
“M4”)),
        _F (SECTION='CERCLE”, CARA= (“EP1”, “EP2”), VALE= (0.02, 0.05), MAILLE=
(“M2”, “M4”)),
     ),
)
```

It possible to use the functionalities of the language python. The example below recovers quantities computed by command MACR_CARA_POUTRE, for then affecting them. The use of python requires to put PAR_LOT='NON" in command DEBUT.

```
PRE_GIBI ()
SECTION = MACR_CARA_POUTRE (NOEUD= "N1", GROUP_MA_BORD= "EDGE")

II = 2
alpha0 = SECTION ["ALPHA", II]
cdgx0  = SECTION ["CDG_X", II]
cdgy0  = SECTION ["CDG_Y", II]
AIRE0  = SECTION ["AREA", II]
IY0    = SECTION ["IY_PRIN_G", II]
IZ0    = SECTION ["IZ_PRIN_G", II]
EY0    = SECTION ["EY", II]
EZ0    = SECTION ["EZ", II]
JX0    = SECTION ["CT", II]
JG0    = SECTION ["JG", II]
AY0    = SECTION ["AY", II]
AZ0    = SECTION ["AZ", II]
IYR20  = SECTION ["IYR2_PRIN_G", II]
IZR20  = SECTION ["IZR2_PRIN_G", II]


carelem=AFFE_CARA_ELEM (MODELE=mod,
  BEAM = (
    _F (GROUP_MA= ("POUT1", "POUT2"), SECTION='GENERALE",
       CARA= ("A",  "IY", "IZ", "AY", "AZ", "EY", "EZ", "JX", "JG", "IYR2", "IZR2"),
       VALE= (  AIRE0, IY0, IZ0, AY0, AZ0, EY0, EZ0, JX0, JG0, IYR20, IZR20),),
    )
)
```

If the mesh SECTION contains a surface group of mesh named "SQUARES', it is possible to use directly the array resulting from MACR_CARA_POUTRE in the following way:

```
SECTION = MACR_CARA_POUTRE (MAILLAGE=mail, NOEUD= "N1", GROUP_MA_BORD= "EDGE")

carelem=AFFE_CARA_ELEM (MODELE=mod,
  BEAM = (
    _F (GROUP_MA= ("POUT1", "POUT2"), SECTION='GENERALE",
       TABLE_CARA=SECTION, NOM_SEC='CARRE',
    )
)
```

6 Key word BARS

6.1 Caractéristiques allocatable

Permet to affect the characteristics of the cross sections of elements of the type **BARS**. One can treat three types of cross sections defined by operand SECTION.
A each type of section, it is possible to affect various characteristics identified by one or more names (operand CARA) to which one associates as many values (operand VALE). It is also possible to give the characteristics via an array in the case of the general section, to see the documentation of the command MACR_CARA_POUTRE.

6.2 Syntax

```
BARS = _F (
     ♦ / MAILLE=       lma,                                    [l_maille]
       / GROUP_MA=     lgma,                                [l_gr_maille]

     # constant section general
     ♦ / SECTION=      "GENERALE",
     ♦ / TABLE_CARA=   will tb_cara,                           [sd_table]
         NOM_SEC=      nom_sec,                                      [K8]
       / CARA=         "A",
         VALE=         goes,                                     [l_réel]
     # constant section right-angled
     / SECTION=        "RECTANGLE",
       ♦ CARA=         / ("H" | "EP"),
                        / ("HY" | "HZ" | "EPY" | "EPZ"),
       ♦ VALE=         go,                                       [l_réel]
     # constant section rings
     / SECTION=        "CERCLE",
       ♦ CARA=         ("R" | "EP"),
       ♦ VALE=         go,                                       [l_réel]
       ◊ FCX=                               fv,
      [FUNCTION]
),
```

Règle of use:
One cannot overload a kind of section (CERCLE, RECTANGLE, GENERALE) by another.

6.3 Operands

6.3.1 Opérande SECTION = "GENERALE"

the only characteristic required in this case is the area of the cross section of bar "A". It can be read in an array (key word TABLE_PARA and NOM_SEC, see § 9.4.3.1).

6.3.2 Operand SECTION = "CERCLE"

CARA	Valeur	Meaning by defect
R	Rayon external of Compulsory	tube
EP	Thickness in the case of a hollow tube	Tube full (EP=R)

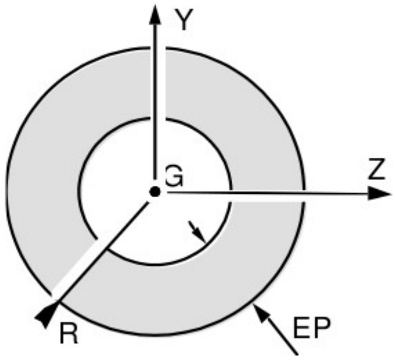


Figure 6.3.2-a : Section of the type CERCLE

These values are used for compute the area A of the section.

6.3.3 Operand SECTION = "RECTANGLE"

CARA	Valeur	Meaning by defect
/ HY	Dimension of the rectangle following GY	Obligatoire
HZ	Dimension of the rectangle following GZ	Obligatoire
/ H	Longueur of the edge (if the rectangle is square)	Compulsory
/ EPY	Thickness according to GY in the case of a hollow tube	HY/2
EPZ	Thickness according to GZ in the case of a hollow tube	HZ/2
/ EP	Thickness along the two axes in the case of a hollow tube	Tube full

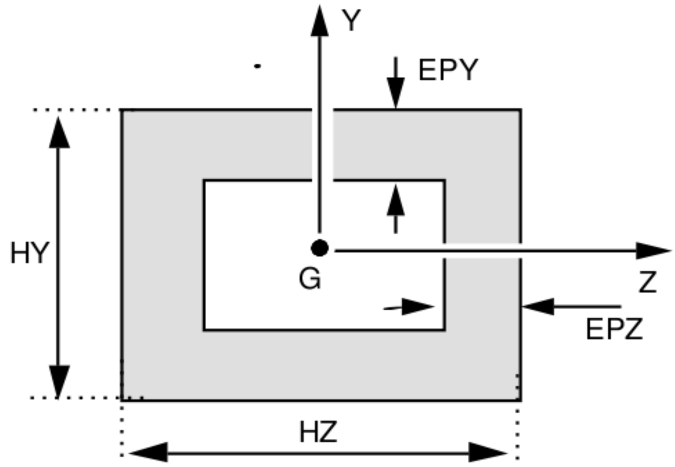


Figure 6.3.3-a : Section of the type RECTANGLE.

Rules of use: for a given mesh

- "H" is incompatible with "HZ" and "HY"
- "EP" is incompatible with "EPY" and "EPZ".

6.4 Operand "FCX `

◊ FCX = fv

Affectation of a function describing the dependence of the distributed force with respect to the relative velocity of wind (see for example [V6.02.118]).

7 Allocatable key word

7.1 CABLE Caractéristiques

Permet to assign a constant section to the elements of the type cables or cable-pulley.

7.2 Syntax

```
CABLE = _F (
      ♦ / MAILLE=       lma,                                    [l_maille]
        / GROUP_MA=     lgma,                                [l_gr_maille]
      ♦ SECTION=        area,                                    [reality]
      ◊ FCX=            fv,                                     [function]
      ♦ N_INIT=         / ninit,                                 [reality]
                         / 5000,                                  [defect]
),
```

7.3 Opérande "SECTION `

♦ SECTION = Permet

area to define the area of the cross section of the cable.

7.4 Operand "FCX `

◊ FCX = fv

Affectation of a function describing the dependence of the distributed force with respect to the relative velocity of wind (HM-77/01/046) see for example test SDNL102 [V5.02.102].

7.5 Operand N_INIT

Définit the initial tension in the cable, $5000\,N$ by defect for cables whose dimensions are defined in meters.

8 Key word SHELL

8.1 Caractéristiques allocatable

Les characteristics which one can affect on the shell elements or of shell are:

- for all the elements of this type, one thickness constant on each mesh, since the mesh represents only the average layer (or of diagram for offset),
- for all the elements of this type, the number of layers used for integration in the thickness,
- for all the elements of this type, the directional sense of the specific local coordinate system to each mesh,
- for certain models of shell, particular characteristics: shear coefficient, metric, eccentring, etc

8.2 Syntaxe

```
SHELL = _F (
      ♦ / MAILLE=          lma,                              [l_maille]
        / GROUP_MA=        lgma,                           [l_gr_maille]

      ♦ / EPAIS=           ep,                                [reality]
        / EPAIS_FO=        epfct                             [function]

      ◊ / ANGL_REP=        / (0. , 0.),                        [defect]
                            / ( α ,  β  ),                     [l_réel]
        / VECTEUR=         (vx, vy, vz),                       [l_réel]

      ◊ MODI_METRIQUE=     / "NON",                            [defect]
                            / "OUI",
      ◊ COEF_RIGI_DRZ=     / KRZ,                             [reality]
                            / 1.E-5,                           [defect]
      ◊ EXCENTREMENT=      E,                                 [reality]
                            0.0,                               [defect]
        EXCENTREMENT_FO=   efct                              [function]

      ◊ INER_ROTA=         "OUI",
      ◊ A_CIS=             / kappa,                           [reality]
                            / 0.8333333,                       [defect]
      ◊ COQUE_NCOU=        / N,                               [integer]
                            / 1,                               [defect]
)
```

8.3 Opérandes

8.3.1 Opérande EPAIS

```
♦ / EPAIS=    ep
  / EPAIS_FO= epfct
```

EPAIS represents the thickness of the shell which must be expressed in the same units as the coordinates of the nodes of the mesh.

EPAIS_FO is a function which gives the thickness of the shell, in the same units as the coordinates of the nodes of the mesh. This function depends on geometry (X, Y, Z) and is evaluated at the center of gravity of the mesh.

8.3.2 Operands **ECCENTRING** / **EXCENTREMENT_FO**

```
◊ EXCENTREMENT=          / E,
                         / 0.0
  EXCENTREMENT_F0=EFCT
```

ECCENTRING: The distance between surface with a grid and mean surface defines, in the meaning of the norm (modelizations DKT, DST, GRID).
EXCENTREMENT_FO: Function which gives the distance between surface with a grid and mean surface, in the meaning of the norm (modelizations DKT, DST, GRID). This function depends on geometry (X, Y, Z) and is evaluated at the center of gravity of the mesh.

The taking into account of the eccentring influences the behavior of bending and possibly the behavior of membrane in the presence of coupling (there is no effect on the shears).

8.3.3 Operands **MODI_METRIQUE** / **COEF_RIGI_DRZ** / **INER_ROTA**

◊ MODI_METRIC = "NOT"
Fait the assumption that the thickness of the element is low. During integrations in the thickness one does not take account of the variation of the radius of curvature (default choice for all the shells).

◊ MODI_METRIC = "YES"
Pour modelizations of thick shells: COQUE_AXIS, COQUE_C_PLAN, COQUE_D_PLAN, COQUE_3D, integrations are done by taking of account the variations of the radius of curvature according to the thickness (see for example [R3.07.02], [R3.07.04]).

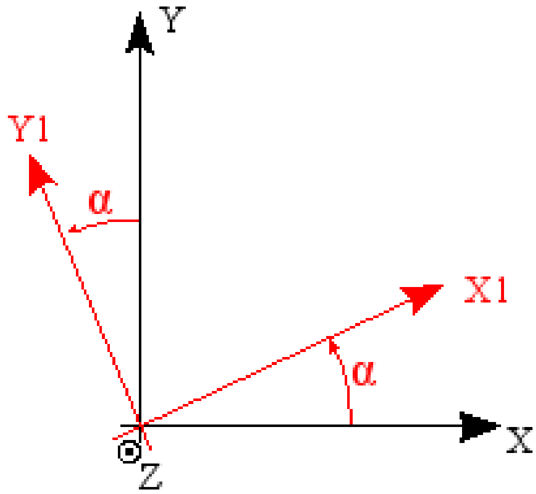
◊ INER_ROTA = "YES"
Prise in account of the inertia of rotation for modelization DKT, DST and Q4G. It is compulsory in the event of eccentring. One can omit this key word for thin shells, where the terms of inertia of rotation are negligible compared to different in the mass matrix [R3.07.03].

◊ COEF_RIGI_DRZ = KRZ,
KRZ is a coefficient of fictitious rigidity (necessarily small) on the degree of freedom of rotation around the norm with the shell. It is necessary to prevent that the stiffness matrix is singular, but must be selected smallest possible. The value by default (10^{-5}) is appropriate for most situations (it is a relative value: rigidity around the norm is equal to KRZ time the minor term diagonal of the stiffness matrix of the element).

Note:
Attention, in STAT/DYNA_NON_LINE, this coefficient can involve additional iterations of Newton (more than one iteration for a linear problem for example).

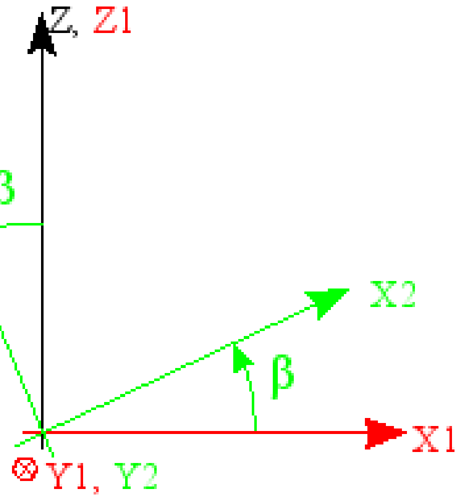
8.3.4 Operand **ANGL_REP** / **VECTOR**

◊ ANGL_REP = (α , β)
This key word is used for the definition of a local coordinate system in the tangent plane in any point of a shell.
The construction of the local coordinate system is done using the two "nautical" angles α and β (provided in degrees) which define a vector v whose projection on the tangent level with the shell fixes the direction x_l. If the key word VECTOR is present, it is VECTOR which defines the local coordinate system.
The vector V is defined in the total reference (O, X, Y, Z) by two rotations α and β :



Appear 8.3.4-a : Representation of the angle α .

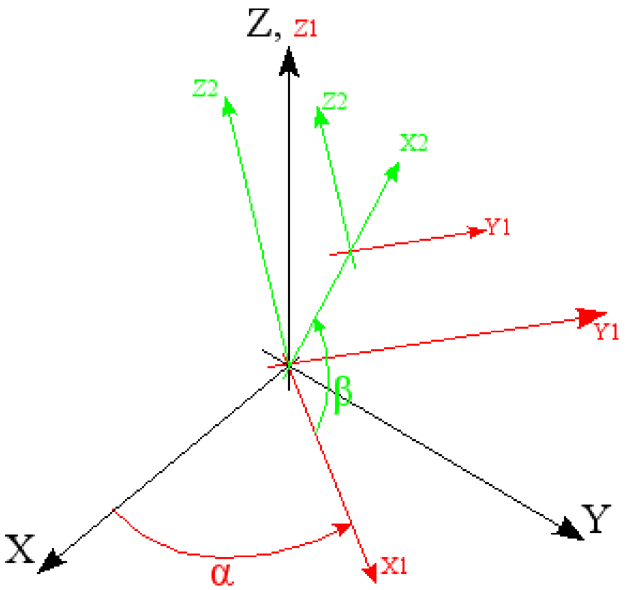
Rotation α around OZ transforms $(OXYZ)$ into (OX_1Y_1Z) with $Z_1 \equiv Z$.



Appear 8.3.4-b : Representation of the angle β .

Rotation β around OY_1 transforms OX_1 into OX_2 . Note: on the figure the angle β is negative.

In three-dimensional representation [Figure8.3.4-c].

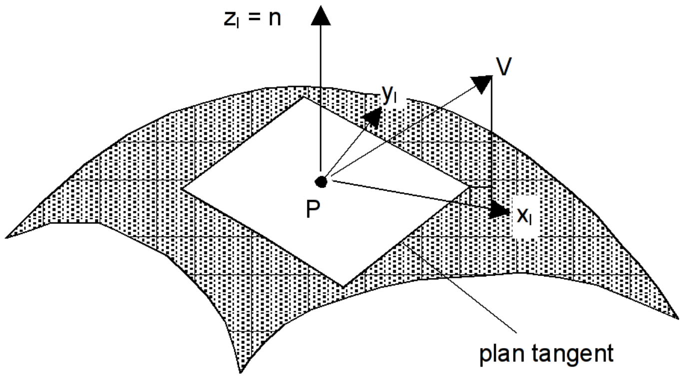


Appear 8.3.4-c : Representation 3D for `ANGLE_REP`.

One can define a single V vector for all structure, or one by area (key words `GROUP_MA` / `NET`). The construction of the local coordinate system in a point of a shell element is carried out from V , in the following way:

- the projection of V on the tangent level provides the axis x_l ,
- the norm with the tangent plane n is known for each element.

The local coordinate system is thus: (P, x_l, y_l, z_l) with: $z_l = n$ and y_l which supplements the trihedron.



◊VECTEUR = (vx, vy, vz)
This key word is used for the definition of a local coordinate system in the tangent plane in any point of a shell. The components of the vector are given in the total **reference**. One builds the local coordinate system (P, x_l, y_l, z_l) starting from the vector $V=(vx, vy, vz)$ in the same way as for key word ANGL_REP.

Note:
• The stresses and the strains computed on the shell are provided in the local coordinate system of each mesh.
• If none the key words above is indicated, it is thus the total axis X which determines, by projection on the tangent level of the shell, the local coordinate system of each mesh.
• The local coordinate system is also used for the definition of the directional sense of fibers in the composite shells (DEFI_COMPOSITE , [U4.42.03]).

8.3.5 Operand COQUE_NCOU

```
◊ COQUE_NCOU =  / N,        [integer]
                / 1,        [defect]
```

It acts amongst layers used for integration in the thickness of the shell. The number of layers also determines the number of subpoints of the stress field: $2n+1$.
Into nonlinear, it is necessary to use more than one layer to correctly integrate the stresses in the thickness (*cf* [U2.02.01]).

8.3.6 Operand A_CIS

```
◊ A_CIS = / kappa,        [reality]
          / 0.8333333,    [defect]
```

This parameter are to be used if one wishes, for a thick shell to be located in the frame of the model Coils-Kirchhoff. It is applicable only for modelizations COQUE_C_PLAN, COQUE_D_PLAN, COQUE_AXIS and COQUE_3D. For more detail the user will refer to the note [U2.02.01].

9 Key word Caractéristiques

9.1 BEAM allocatable

This key word makes it possible to affect the characteristics of the cross sections of elements of type **beam** (modelizations POU_D_E, POU_D_EM, POU_D_T, POU_C_T, POU_D_TG, POU_D_TGM, POU_D_T_GD, TUYAU_3M, TUYAU_6M). One can treat three types of cross sections defined by operand SECTION.

A each type of section, it is possible to affect various characteristics identified by one or more names (operand CARA) to which one associates as many values (operand VALE). It is also possible to give the characteristics via an array in the case of the general section, to see the documentation of the command MACR_CARA_POUTRE.

It is possible to treat beams of constant section (name of characteristic without suffix) or of variable section (name of characteristic with suffix 1 or 2). The mode of variation of the section is defined by key word VARI_SECT (cf [§9.4.119]). One then gives the characteristics of the section to the initial node (name with suffix 1) and to the final node (name with suffix 2) ("initial" and "final" compared to the dialup of the mesh support). One must also use this key word to define the constant of torsion for modelization (POU_D_EM).

9.2 Syntax

```
BEAM = _F (
     ♦ / MAILLE=            lma,                                  [l_maille]
       / GROUP_MA=          lgma,                              [l_gr_maille]
     # general section
     ♦ / SECTION=           "GENERALE",
         ◊ VARI_SECT=       / "CONSTANT"                            [DEFECT]
                             / "HOMOTHETIQUE"
     # constant general section
        /  ♦ TABLE_CARA=    will tb_cara,                         [sd_table]
             ♦ NOM_SEC=     nom_sec,                                   [K8]
       / ♦ CARA=            |'A'|'IY'|'IZ'|'AY'|'AZ'|'EY'|'EZ",
                             |'JX'|'AI'|'RY'|'RZ'|'RT",
                             |'JG'|'IYR2'|'IZR2",
         ♦ VALE=            go,                                     [l_réel]
     # general section homothetic
       / ♦ CARA=            |'A1'|'A2'|'IY1'|'IY2'|'IZ1'|'IZ2",
                             |'JX1'|'JX2'|'AY1'|'AY2'|'AZ1'|'AZ2',
                             |'JG1'|'JG2'|'EY1'|'EY2'|'EZ1'|'EZ2',
                             |'AI1'|'AI2'|'RY1'|'RY2'|'RZ1'|'RZ2',
                             |'RT1'|'RT2'|'IYR21'|'IZR21',
                             |'IYR22'|'IZR22',
         ♦ VALE=            goes,                                   [l_réel]
     # section right-angled
       / SECTION=           "RECTANGLE",
         ◊ VARI_SECT=       / "CONSTANT",                           [defect]
                             / "HOMOTHETIQUE",
                             / "AFFINE",
     # constant right-angled section
       / ♦ CARA=            / |'H'|'EP',
                             / |` HY'|'HZ'|'EPY'|'EPZ',
         ♦ VALE=            goes,                                   [l_réel]
     # right-angled section homothetic
       / ♦ CARA=            / |'H1'|'H2'|'EP1'|'EP2',
                             / |'HY1'|'HZ1'|'HY2'|'HZ2',
                               |'EPY1'|'EPY2'|'EPZ1'|'EPZ2',
         ♦ VALE=            goes,                                   [l_réel]
     # right-angled section closely connected
       / ♦ CARA=            |'HY'|'EPY'|'HZ1',
```

```
                              |'EPZ1'|'HZ2'|'EPZ2',
     ♦ VALE=                 goes,                                [l_réel]
   # section rings
     / SECTION=              "CERCLE",
       ◊ VARI_SECT=          / "CONSTANT"                         [defect]
                              / "HOMOTHETIQUE",
   # section rings constant
     / ♦ CARA=               |'R'|'EP',
       ♦ VALE=               goes,                                [l_réel]
   # section rings homothetic
     / ♦ CARA=               |'R1'|'R2'|'EP1'|'EP2',
       ♦ VALE=               goes,                                [l_réel]

   ◊                         MODI_METRIQUE= / "OUI",
                              / "NON",                            [defect]
   ◊                         TUYAU_NSEC= / nsec,                 [integer]
                              / 16,                               [defect]
   ◊                         TUYAU_NCOU= / ncou,                 [integer]
                              / 3,                                [defect]
   ◊ FCX=                    fv,                                [function]

   ◊                         PREC_AIRE= / precis,                [reality]
                              / 0.01,                             [defect]

   ◊                         PREC_INERTIE= / precis,
    [reality]
                              / 0.1,                              [defect]
),
```

9.3 Règles of Remarque

use:

The directional sense of the beam elements is done by the key word DIRECTIONAL SENSE *[§1026]. The angle of gimlet (which makes it possible to direct the cross-sectional area of the beam around its neutral fiber) is always given to direct the principal axes of the section what is not very practical because these axes are in general unknown before the computation of the geometrical characteristics of the section (cf* MACR_CARA_POUTRE *[U4.42.02]).*

- ***It is possible to provide via variables python, the characteristics of the sections (general) resulting from a computation with* MACR_CARA_POUTRE *. This is implemented in test* SSLL107F*.***
- *The various names of characteristic arguments of operand* CARA *are described further for each argument of operand* SECTION *.*
- For a given mesh:
  - *On cannot overload a kind of variation of section (constant or variable) by another.*
  - *On cannot overload a kind of section (*CERCLE, RECTANGLE, GENERALE*) by another.*
  - *Pour the beams non-prismatic, the names with suffix* 1 *or* 2 *are incompatible with the names without suffix. Example:* A *is incompatible with* A1 *and* A2.
  - 'H' *is incompatible with* "HZ" *and* "HY" *(like* H1 , H2 *,…)*
  - 'EP' *is incompatible with* "EPY" *and* "EPZ" *(like* EP1 , EP2 *,…).*
  - 'RY' , "RZ" *and* "RT" *intervene only for the computation of the stresses.*

9.4 Operands

9.4.1 Opérande VARI_SECT

Permet to define the type of variation of section enters the two nodes ends of the beam element (elements POU_D_E and POU_D_T [R3.08.01]).
The possibilities are:

Section	Affine	Homothétique
rings	not	yes
right-angled	yes (according to z)	yes
general	not	yes

- "Closely connected" means that the area of the section varies in a linear way between the two nodes. Dimensions in the direction are there constant (HY, EPY) and that in the direction z vary linearly (HZ1, HZ2, EPZ1, EPZ2).
- "Homothetic" means that 2 dimensions of the section vary linearly between the values given to the two nodes, the area of the section thus evolves in a quadratic way.

9.4.2 Operand MODI_METRIQUE

Permet to define for the elements PIPE the type of integration in the thickness (modelizations TUYAU_3M, TUYAU_6M):

- MODI_METRIQUE = "NON" results in assimilating in integrations the radius to the average radius. This is thus valid for the pipes of low thickness (compared to radius),
- MODI_METRIQUE = "OUI" implies a complete integration, more precise for thick pipework, but being able in certain cases to lead to oscillations of the solution.

9.4.3 Operand SECTION = "GENERALE"

9.4.3.1 Section constant

CARA	Valeur	Meaning by defect
A	Area of the section	Obligatoire
IZ	main geometrical Moment of inertia compared to GZ	Obligatoire
IY	main geometrical Moment of inertia compared to GY	Obligatoire
AY	Shear coefficient in the Obligatoire GY	direction if POU_D_T, POU_C_T, POU_D_TG 0. if POU_D_E
AZ	Shear coefficient in direction GZ	idem
EY	Eccentring of the center of torsion (component of CG following GY)	0.
EZ	Eccentring of the center of torsion (component of CG following GZ)	0.
JX	Compulsory Constante of	torsion
RY	Distance of an external fiber measured according to y	1.
RZ	Distance of an external fiber measured according to z	1.
RT	effective Rayon of torsion	1.
JG	Warping constant (POU_D_TG, POU_D_TGM)	
IYR2	Nécessaire with the computation of geometrical rigidity (POU_D_TG and POU_D_TGM)	
IZR2	Nécessaire with the computation of geometrical rigidity (POU_D_TG and POU_D_TGM)	
AI	Area of the bypass section of the fluid inside the beam.	compulsory for a modelization FLUI_STRU

Dans this precise case, the characteristics of section can be given by the key words WILL TABLE_CARA and NOM_SEC instead of WILL CARA and VALE. One can also give to TABLE_CARA an array resulting from the macro-command MACR_CARA_POUTRE while informing in key word NOM_SEC:
- the name of the mesh given to MACR_CARA_POUTRE , if the section corresponds to all the mesh
- the name of the mesh group to which the section corresponds

One can also give him an array resulting from the operator LIRE_TABLE . For that the array must be in the following way defined:

NOM_SEC	A	IY	IZ	AY	AZ
SEC_1	a1	iy1	iz1	ay1	az1
SEC_2	a2	iy2	iz2	ay2	az1

Les names of the columns are the names of the characteristics of the section. If a column contains nonreal values (excluded for column NOM_SEC), she will be ignored. If the name of a column is not in the list of the possible characteristics she will be ignored.
In this case NOM_SEC the value “sec_1 ″ OR ‟ sec_2 CAN TAKE″.

9.4.3.2 Homothetic section

One defines the characteristics for each mesh, with the two nodes.

CARA	Signification	Valeur by defect
A1 , A2	Area of the section	Obligatoire
IZ1 , IZ2	main geometrical Moment of inertia compared to GZ	Obligatoire
IY1 , IY2	main geometrical Moment of inertia compared to GY	Obligatoire
AY1 , AY2	Shear coefficient in the Obligatoire GY	direction if POU_D_T, POU_C_T, POU_D_TG 0. if POU_D_E
AZ1 , AZ2	Shear coefficient in direction GZ	idem
EY1 , EY2	Eccentring of the center of torsion (component of CG following GY)	0.
EZ1 , EZ2	Eccentring of the center of torsion (component of CG following GZ)	0.
JX1 , JX2	Compulsory Constante of	torsion
RY1 , RY2	Distance of an external fiber measured according to y	1.
RZ1 , RZ2	Distance of an external fiber measured according to z	1.
RT1 , RT2	effective Rayon of torsion	1.
JG1 , JG2	Warping constant (POU_D_TG)	
IYR21 , IYR22	Nécessaire with the computation of geometrical rigidity (POU_D_TG and POU_D_TGM)	
IZR21 , IZR22	Nécessaire with the computation of geometrical rigidity (POU_D_TG and POU_D_TGM)	
AI1 , AI2	Areas of the bypass section of the fluid inside the beam.	compulsory for a modelization FLUI_STRU

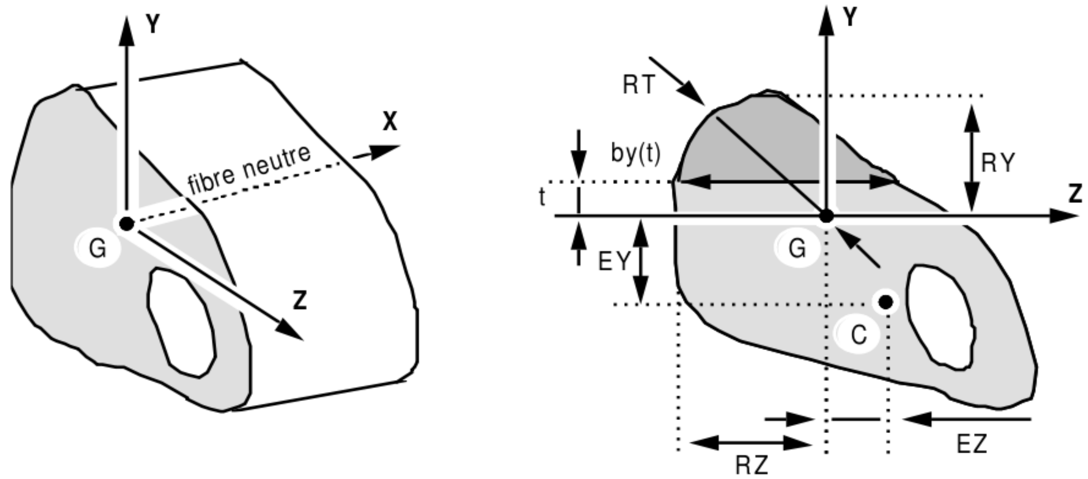


Figure 9.4.3.2-a : Section GENERALE.

Definition of the characteristics:

$IZ=\int_s y^2 ds$ $\qquad$ $IY=\int_s z^2 ds$

$$AY=\frac{A}{A_y^{'}}=\frac{A}{IZ^2}\int_{y_1}^{y_2}\frac{m_y^2(y)}{b_y(y)}dy \qquad AZ=\frac{A}{A_z^{'}}=\frac{A}{IY^2}\int_{z_1}^{z_2}\frac{m_z^2(z)}{b_z(z)}dz$$

with $m_y(y)=\int_y^{R_y} t.b_y(t)dt$ $\qquad$ $m_z(z)=\int_z^{R_z} t.b_z(t)dt$

$b_y(t)$ thickness according to z, in $z=t$ $\qquad$ $b_z(t)$ thickness according to y, in $y=t$

Avec:

$A_y^{'}$ $A_z^{'}$: sheared reduced areas.

$A_y^{'}=\frac{A}{AY}$ with $AY\geq 1$ or $A_y^{'}=k_y A$ with $k_y=\frac{1}{AY}\leq 1$

- the shear coefficients A_y, A_z are used by elements POU_D_T, POU_C_T and POU_D_TG, POU_D_TGM, for the computation of the stiffness matrixes and of mass and for the computation of the stresses [R3.08.01]. In particular, the shearing stresses transverse are expressed by:

$$\tau_{xz}=\frac{V_z}{K_z A}=V_z\frac{A_z}{A} \quad \tau_{xy}=V_y\frac{A_y}{A}$$

- in the case of the beams of Euler (POU_D_E) which do not take account of the transverse shears, one neglects the corresponding terms in the computation of rigidity and the mass while taking $A_y=A_z=0$. On the other hand, the stresses [R3.08.01] of shears are computed by:

$$\tau_{xz}=\frac{V_z}{A} \quad \tau_{xy}=\frac{V_y}{A}.$$

The characteristics RY RZ, RT are used with computation of torsion and bending stresses [R3.08.01] for options "SIGM_ELNO" or "SIPO_ELNO" as CALC_CHAMP [U4.81.04].

In bending $\sigma_{xx}=\frac{M_y}{I_y}.RZ-\frac{M_z}{I_z}.RY$

In Opérande $\tau_{xz} = \tau_{xy} = \frac{MT}{JX} . RT$

9.4.4 torsion SECTION = "RECTANGLE"

CARA	Valeurs	Meaning by defect
Section constant		
HY	Dimension of the rectangle following GY	Compulsory
HZ	Dimension of the rectangle following GZ	Compulsory
H	Dimension of square (if the rectangle is square)	Compulsory
EPY	Thickness following GY in the case of a hollow tube	HY/2
EPZ	Thickness following GZ in the case of a hollow tube	HZ/2
EP	Thickness along the two axes in the case of a hollow tube	Tube full
Section homothetic		
H1, H2	Dimension of the square at each end for a variable section	H1 = H2 = H
HY1 , HY2	Dimension of the rectangle following GY at each end for a variable section	HY1 = HY2 = HY
HZ1, HZ2	Dimension of the rectangle following GZ at each end for a variable section	HZ1 = HZ2 = HZ
EP1, EP2	Thickness along the two axes in the case of a hollow tube, at each end in the case of a variable section	EP1 = EP2 = EP
EPY1, EPY2	Thickness following GY in the case of a hollow tube, with each end in the case of a variable section	EPY1 = EPY2 = EPY
EPZ1, EPZ2	Thickness following GZ in the case of a hollow tube, at each end in the case of a variable section	EPZ1 = EPZ2 = EPZ

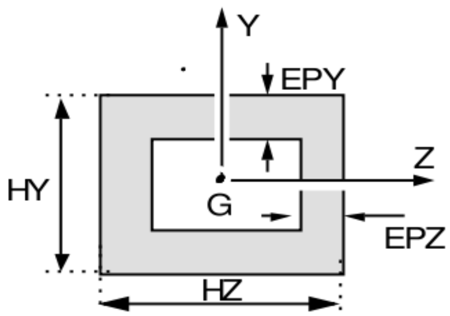


Figure 9.4.4-a : Section RECTANGLE.

The characteristics computed by *Code_Aster* are [R3.08.03]:

$$Iy = \frac{HY.HZ^3}{12} - \frac{(HY - 2.\mathrm{EPY}).(HZ - 2.\mathrm{EPZ})^3}{12}$$

$$Iz = \frac{HZ.HY^3}{12} - \frac{(HZ - 2.\mathrm{EPZ}).(HY - 2.\mathrm{EPY})^3}{12}$$

$$RY = \frac{HY}{2} \quad RZ = \frac{HZ}{2}$$

- If the tube is hollow:

$$JX = \frac{2.\mathrm{EPY}.\mathrm{EPZ}(HY - EPY)^2 (HZ - EPZ)^2}{HY.EPY + HZ.EPZ - EPY^2 - EPZ^2}$$

$$RT = \frac{JX}{2.\mathrm{EPZ}(HY - EPY)(HZ - EPZ)}$$

- If the tube is full, one poses:

$$a=\frac{HY}{2}\ ,\ b=\frac{HZ}{2}\ si\ HY>HZ$$
$$a=\frac{HZ}{2}\ ,\ b=\frac{HY}{2}\ si\ HZ>HY$$
$$J=ab^3\left(\frac{16}{3}-3.36\frac{b}{a}+0.28\frac{b^5}{a^5}\right)$$
$$RT=\frac{J(3\mathrm{a}+1.8\mathrm{b})}{8\mathrm{a}^2 b^2}$$

- Shear coefficients Ay and Az
  one poses $\alpha_y=\frac{HY-2\,EPY}{HY}$ $\alpha_z=\frac{HZ-2\,EPZ}{HZ}$
  Les values of AY and AZ are given by the table below: (Column, line)
  $AY=Tab(\alpha_y,\alpha_z)$ $AZ=Tab(\alpha_z,\alpha_y)$

Tab	0.00	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.95
0.00	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
0.05	1.200	1.209	1.212	1.217	1.220	1.221	1.220	1.217	1.212	1.207	1.202	1.201
0.10	1.200	1.229	1.236	1.247	1.252	1.253	1.249	1.241	1.230	1.217	1.206	1.202
0.20	1.200	1.300	1.317	1.339	1.348	1.345	1.332	1.309	1.280	1.247	1.217	1.206
0.30	1.200	1.413	1.442	1.477	1.489	1.479	1.451	1.408	1.354	1.295	1.238	1.214
0.40	1.200	1.577	1.621	1.671	1.683	1.662	1.614	1.545	1.460	1.366	1.272	1.230
0.50	1.200	1.803	1.866	1.936	1.949	1.913	1.838	1.733	1.608	1.469	1.325	1.256
0.60	1.200	2.115	2.207	2.309	2.324	2.267	2.154	2.000	1.818	1.619	1.409	1.301
0.70	1.200	2.561	2.704	2.866	2.894	2.810	2.640	2.409	2.140	1.848	1.541	1.378
0.80	1.200	3.265	3.520	3.830	3.907	3.790	3.524	3.154	2.720	2.252	1.771	1.517
0.90	1.200	4.715	5.358	6.216	6.536	6.401	5.916	5.186	4.300	3.331	2.338	1.841
0.95	1.200	6.689	8.194	10.294	11.236	11.189	10.375	9.014	7.296	5.372	3.367	2.371

Remark S :

- *The values of the table are given using a parametric study carried out with the command* `MACR_CARA_POUTRE`.
- *The interpolations on the values of the table are linear.*
- *For values of* $\alpha>0.95$ *, the user owes compute itself the values of the shear coefficients.*
- *The computed values can be printed with the key word* `INFO = 2`.

9.4.5 Operand `SECTION` = `"CERCLE"`

CARA	Valeur	Meaning by defect
Section constant		
R	Rayon external of Compulsory	tube
EP	Thickness in the case of a hollow tube	Tube full (EP=R)
Section variable		
R1, R2	Rayons outsides at the two ends for a variable section	R1 = R2 = R
EP1 , EP2	Thickness at the two ends in the case of a variable section	EP1 = EP2 = EP

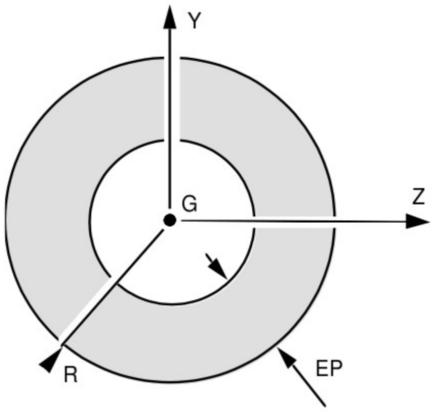


Figure 9.4.5-a : Section CERCLE.

The computed values by *Aster* are [R3.08.03]:

$$I_y = I_z = \frac{JX}{2} = \frac{\pi R^4}{4} - \frac{\pi (R-EP)^4}{4}$$
$$RT = RY = RZ = R$$

- Shear coefficients $Ay = Az$. O N poses $\alpha = \frac{R-EP}{R}$

α	0.00	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Ay=Az	1.167	1.174	1.199	1.289	1.419	1.563	1.700	1.815	1.902	1.960	1.991	2.000

Remarque S :

- *The values of the table are given using a parametric study carried out with the command MACR_CARA_POUTRE.*
- *The interpolations are linear.*
- *The computed values can be printed with the key word INFO = 2.*

9.5 Operand " FCX "

◊ FCX = fv

Affectation of a function describing the dependence of the distributed force with respect to the relative velocity of wind (see test SSNL118 [V6.02.118]). The loading of type wind is applicable on the elements of bar of cable and beam (modelizations POU_D_E, POU_D_T, POU_D_T, POU_D_TG, POU_D_TGD, POU_D_TGM).

9.6 Operands TUYAU_NSEC / TUYAU_NCOU

```
◊     TUYAU_NSEC=                  / nsec
          / 16                     [defect]
◊     TUYAU_NCOU=                  / ncou,
          / 3                      [defect]
```

Nombre of layers in the thickness (ncou by default = 3) and of sectors (nsec by default = 16) on the circumference used for integrations in the elements PIPE [R3.08.06]. The values by default (3 layers and 16 sectors) correspond to a necessary minimum to have a correct accuracy.

9.7 Operands PREC_AIRE / PREC_INERTIE

```
◊     PREC_AIRE=  / precis,
◊     PREC_INERTIE=  / precis,
```

the use of the multifibre beams (POU_D_EM or POU_D_TGM) requires to provide additional information, compared to key words VALE and CARA, key word MULTIFIBRE [§12].

The objective is to check the coherence of the information (AREA and INERTIA) provided on the one hand by the key word BEAM and on the other hand by key word MULTIFIBRE. The criterion of error is based on the error relative and is compared either with the default value or to that given by the user via key words PREC_AIRE and PREC_INERTIE.

If the criterion is not satisfied a fatal error is generated. The relative error is computed in the following way:

$$\frac{AIRE_{POUTRE}-(AIRE_{SECTION}+AIRE_{FIBRE})}{AIRE_{POUTRE}} \leq \mathrm{PREC\_AIRE}$$

$$\frac{INERTIE_{POUTRE}-(INERTIE_{SECTION}+INERTIE_{FIBRE})}{INERTIE_{POUTRE}} \leq \mathrm{PREC\_INERTIE}$$

Note:

- *AREA (FIBER), AREA (SECTION), INERTIA (SECTION), INERTIA (FIBER) are calculated starting from data structure describing fibers and defined under the key word GEOM_FIBRE . This data structure is created by the command DEFI_GEOM_FIBRE [U4.26.01].*
- *AREA (FIBER) is computed by making the sum of the areas of fibers, for all the groups of fibers defined by the key word GROUP_FIBRE of the operand FIBER of the command DEFI_GEOM_FIBRE.*
- *AREA (SECTION) is computed by making the sum of the areas of fibers defined by the key word GROUP_FIBRE of the operand SECTION of the command DEFI_GEOM_FIBRE .*
- *INERTIA (FIBER) is calculated by making the sum of $s.d^2$ fibers defined in all the groups of fibers defined by the key word GROUP_FIBRE of the operand FIBER of the command DEFI_GEOM_FIBRE. S: represent the surface of a fiber and D the distance between fiber and the axis defined by the key word CARA_AXE_POUTRE of the operand FIBER of the command DEFI_GEOM_FIBRE.*
- INERTIA (*SECTION*) *is calculated by making the sum of the s.d ² elements defined by key word* GROUP_FIBRE of *operand* SECTION *of command* DEFI_GEOM_FIBRE*. S: represent the surface of an element and D the distance between the center of gravity of the element and the axis defined by key word* CARA_AXE_POUTRE *of operand* SECTION *of command* DEFI_GEOM_FIBRE*.*

Note:

When the section is defined by a mesh (key word MAILLAGE_SECT under operand SECTION of command DEFI_GEOM_FIBRE) the computation of the total inertia of all the surface elements does not take account of inertia suitable for each element. It is thus necessary to define a sufficient number of fibers so that this error is weak and remains lower than PREC_INERTIE*.*

For example a rectangular section cut out uniformly in the height in n elements leads to the following errors, on the values of inertias:

Cutting	*2*	*3*	*4*	*5*	*6*
Erreur Inertie	*allocatable*	*25%*	*11.11%*	*6.25%*	*4.00%*

10 2.77% Key word

10.1 Caractéristiques DIRECTIONAL SENSE

This key word makes it possible to affect **the directional senses:**

- principal axes of the cross sections of the elements of type beam,
- **discrete elements** assigned to nodes or meshes of the type POI1 (nodal discrete elements) or to meshes of the type SEG2 (discrete elements of connection).

Note:

There exists always a local coordinate system by defect attached to the elements of the BEAM TYPE *or* DISCRET *even if the operand DIRECTIONAL SENSE* IS NOT USED. *It corresponds to* ANGL_VRIL *= 0 for the elements attached to a mesh SEG2 (beams or discrete) and* ANGL_NAUT *= (0.0, 0.0,0.0) for the nodal discrete elements.*

For the elements of the PIPE type, the key word DIRECTIONAL SENSE makes it possible to define a continuous generating line defining for each section the angular origin.

10.2 Syntax

```
DIRECTIONAL SENSE = _F (
     / GROUP_MA=       lgma,                                  [l_gr_maille]
     / MAILLE=         lma,                                      [l_maille]
     / GROUP_NO=       lgno,                                   [l_gr_noeud]
     / NOEUD=          lno,                                       [l_noeud]
     ♦ VALE=           langl,                                      [l_réel]
     ◊ CARA=           / "VECT_Y",
                        / "ANGL_VRIL",
                        / "VECT_X_Y",
                        / "ANGL_NAUT",
                        / "GENE_TUYAU",
     ◊ CRITERE=        / "RELATIF",                                [DEFECT]
                        / "ABSOLU",
     ◊ PRECISION=      / eps,                                     [reality]
                        / 1.E-4,                                   [DEFAUT]
)
```

10.3 Règles of use

the rule of overload is applied. The directional sense finally taken is the affected last.

Example:

```
ORIENTATION= (
   _F (CARA = "ANGL_NAUT", VALE = (1. , 1. , 1.), MESH = "P1"),
   _F (CARA = "ANGL_VRIL", VALE = 45.0,        MESH = "M1"),
   _F (CARA = "ANGL_VRIL", VALE = 90.0,        MESH = "M2"),
)
```

- to define the local coordinate system associated with a mesh of the type POI1 or a node (discrete element), either ANGL_NAUT should be used, or VECT_X_Y,
- to define the local coordinate system around the axis defined by a mesh SEG2 (beam or discrete), either ANGL_VRIL should be used, or VECT_Y,
- to define a generating line on the elements pipe, GENE_TUYAU should be used.

10.4 Operands ANGL_NAUT / VECT_X_Y

/ CARA = "ANGL_NAUT", VALE = (α β , γ)

Les nautical angles α β , γ provided in degrees, are the angles making it possible to pass from the total reference of definition of the coordinates of the nodes (P, X, Y, Z) to the local coordinate system (P, X_3, Y_3, Z_3) . The aforementioned is obtained by 3 rotations:

- a rotation of angle α around Z, transforming (XYZ) into $(X_1 Y_1 Z_1)$ with $Z_1 \equiv Z$ [Figure10.4-a]
- a rotation of angle β around Y_1, transforming $(X_1 Y_1 Z_1)$ into $(X_2 Y_2 Z_2)$ with $Y_2 \equiv Y_1$ [Figure10.4-b]
- a rotation of angle γ around X_2, transforming $(X_2 Y_2 Z_2)$ into $(X_3 Y_3 Z_3)$ with $X_3 \equiv X_2$ [Figure10.4-c]

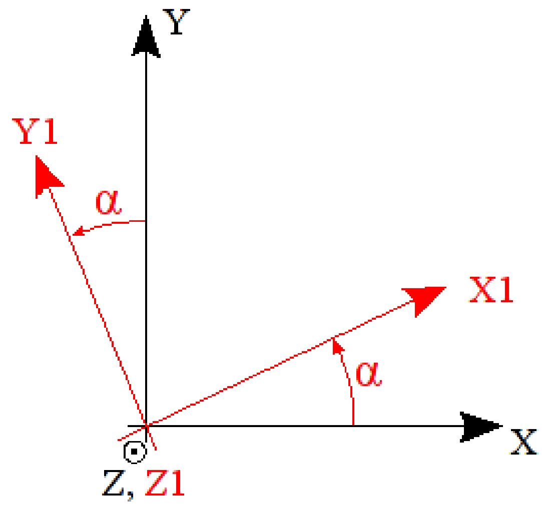
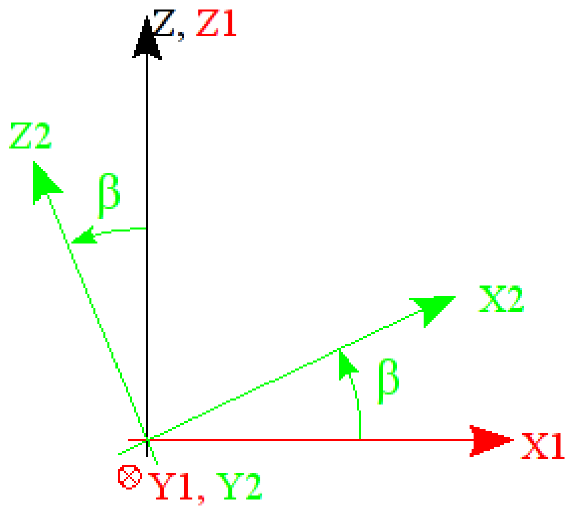
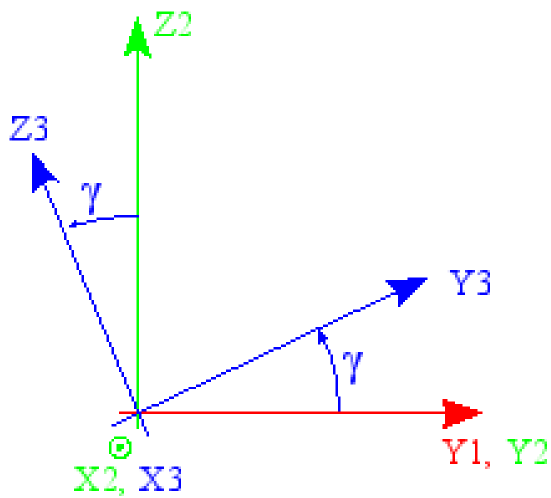


Figure 10.4-a : angle α .



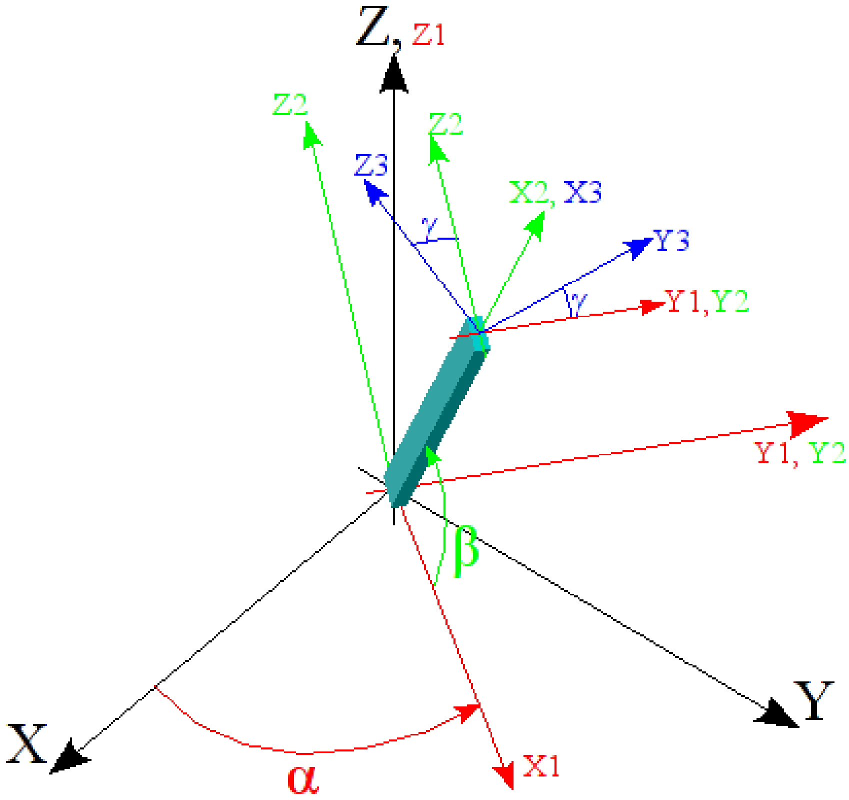
Appear 10.4-b : angle β .

Note: for the figure 10.4-b, the swing angle β is negative.



Appear 10.4-c : angle γ .

The local coordinate system is: $(X_3 Y_3 Z_3)$



Appear 10.4-d : Representation of the references total and local.

/ WILL CARA = "VECT_X_Y", VALE $= \left(x_1^l, x_2^l, x_3^l, y_1^d, y_2^d, y_3^d\right)$

x_1^l, x_2^l, x_3^l are the 3 components, in the total reference, of a vector defining the local axis X_3.

y_1^d, y_2^d, y_3^d are the 3 components, in the total reference, of a vector Y^d, whose projection on the orthogonal level with X_3 will provide the local axis Y_3. The local axis Z_3 supplements the reference then so that the trihedron (P, X_3, Y_3, Z_3) is direct [Figure 10.4-e].

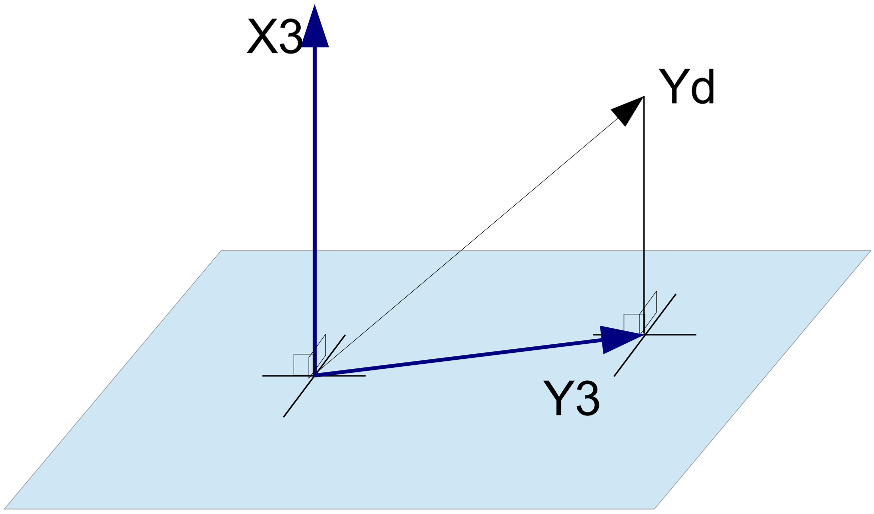


Figure 10.4-e : Definition of VECT_X_Y.

10.5 Operand ANGL_VRIL / VECT_Y

Dans the case of meshes SEG2, the axis X_3 is already carried by the mesh (the meaning of X_3 is defined by the classification of two nodes of the mesh, it can be changed by MODI_MAILLAGE/ORIE_LIGNE, [U4.23.04]). It is thus enough to define Y_3 and Z_3, either by rotation around X_3 (key word ANGL_VRIL) or by defining a vector (key word VECT_Y).

/ CARA = "ANGL_VRIL", VALE = γ

γ is the angle (in degrees) of rotation around X_3, transforming (P, X_3, Y_2, Z_2) into (P, X_3, Y_3, Z_3) [Figure 10.4-c].

/ CARA = "VECT_Y", VALE = y_1^d, y_2^d, y_3^d

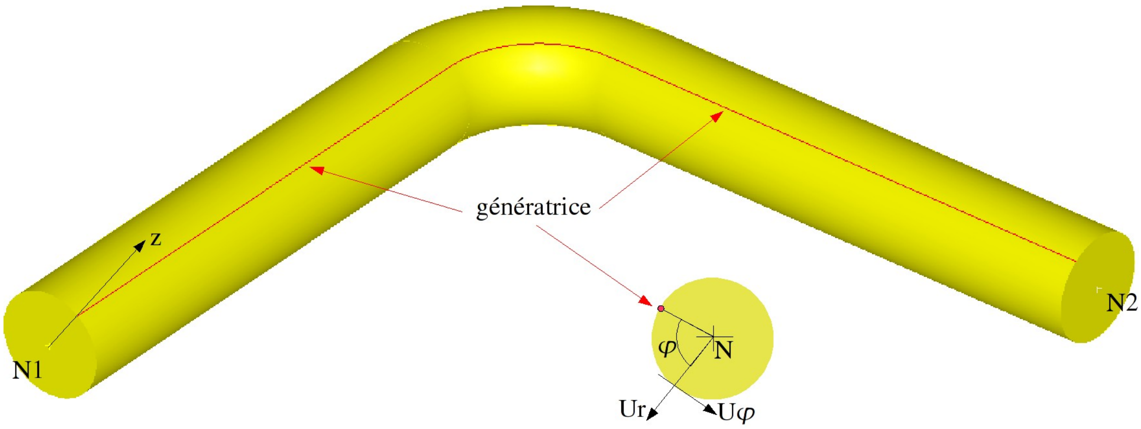
y_1^d, y_2^d, y_3^d are the 3 components of a vector Y^d whose projection on the orthogonal level with X_3 will provide the local axis Y_3 [Figure 10.4-e]. The axis Z_3 is such as (P, X_3, Y_3, Z_3) is direct.

10.6 Operand "GENE_TUYAU"

relates to only the elements PIPE (modelizations TUYAU_3M or TUYAU_6M).

VALE $=(Z_1, Z_2, Z_3)$ then contains the 3 components of a vector z directing the generator of the pipe (continuous line traced on the pipe, defining for each element the origin of the angle φ used to express ovalization and warping).

This vector must be defined in a node or A GROUP_NO end of the pipe. The geometry is then built automatically for all the related elements of PIPE.



10.7 Operands PRECISION / CRITERE

Cette accuracy is used for the construction of the generator like defining the limit between a right pipe section and a curved element (distinction based on the alignment of the 3 or 4 nodes of the element).

11 Allocatable key word

11.1 DEFI_ARC Caractéristiques

Permet to assign to curved beams (POU_C_T) (elements with 2 nodes) of the characteristics related to the curvature of the element (radius of curvature and directional sense of the plane of the arc). Those can be defined with the choice by the key words: POIN_TANG, CENTRE or (ORIE_ARC and RAYON).

11.2 Remarque

Les key words of DEFI_ARC are used to define the geometrical characteristics (radius of curvature and plane of the elbow) of the curved beam element. The main reference of inertia is not defined here, and must be given as for the straight beams by the key word DIRECTIONAL SENSE (ANGL_VRIL / VECT_Y), by supposing that the element is right (segment $N_i N_J$).

11.3 Syntax

```
DEFI_ARC = _F (
     ♦ / MAILLE=              LMA,                        [l_maille]
       /                     GROUP_MA= LGMA,             [l_gr_maille]
     ♦ /                     POIN_TANG= (XT, YT, ZT),
      [l_réel]
       / NOEUD_POIN_TANG=      NO,                             [node]
       / GROUP_NO_POIN_TG=     GNO,                         [gr_noeud]
       / CENTRE=               (XC, YC, ZC),                  [l_réel]
       /                     NOEUD_CENTRE= NO,                 [node]
       / GROUP_NO_CENTRE=      GNO,                         [gr_noeud]
       / ♦ ORIE_ARC=           G_ARC,                        [reality]
         ♦ RAYON=              R,                            [reality]
     ◊ / COEF_FLEX=            CFLEX,                        [reality]
       / ♦ COEF_FLEX_XY=       CFLEX_XY,                     [reality]
         ♦ COEF_FLEX_XZ=       CFLEX_XZ,                     [reality]
     ◊ / INDI_SIGM=            ISIGM,                        [reality]
       / ♦ INDI_SIGM_XY=       ISIGM_XY,                     [reality]
         ♦ INDI_SIGM_XZ=       ISIGM_XZ,                     [reality]
     ◊ PRECISION=              / EPS,                        [reality]
                                / 1.0E-03,                    [defect]
     ◊ CRITERE=                / "ABSOLU",
                                / "RELATIF",                  [defect]
)
```

11.4 Opérandes POIN_TANG / NOEUD_POIN_TANG / GROUP_NO_POIN_TG

/ POIN_TANG= (xt, yt, zt)
/ NOEUD_POIN_TANG= "NT"
/ GROU P_NO_POIN_TG= "GNT"

Définit the point of intersection T of the tangents to the arc in its two ends (intersection of the lines of diagram), either by its coordinates (xt, yt, zt) in the total reference, or by the name of the node located in this point ("NT"), or by the name of a nodes group ("GNT") container only one node corresponding to this point.

11.5 Operands CENTRE / NOEUD_CENTRE / GROUP_NO_CENTRE

```
/ CENTRE=              (xc, yc, zc)
/  NOEUD_CENTRE= "NC",
/ GROUP_NO_CENTRE=       "GNC",
```

Définit the center of curvature C of the element. The angle (C, N_j, N_i) must be strictly lower than 2.

The point C is defined either by its coordinates (xc, yc, zc) in the total reference, or by the node located in C given by its name ("NC") or by the name of a group ("GNC") containing only this node.

11.6 Operands PRECISION / CRITERE

Définit accuracy for the checking that C is well the center of the arc of circle $N_i N_J$:

$$C N_i - C N_j < eps \qquad (CRITERE:'ABSOLU')$$
$$C N_i - C N_j < eps\, C N_i \qquad (CRITERE:'RELATIF')$$

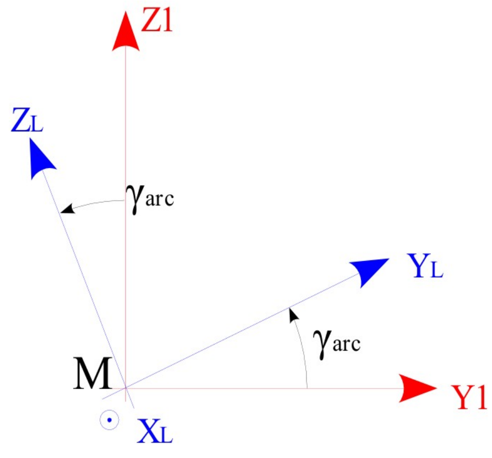
11.7 Operands RAYON / ORIE_ARC

♦ ORIE_ARC = γ_{arc}

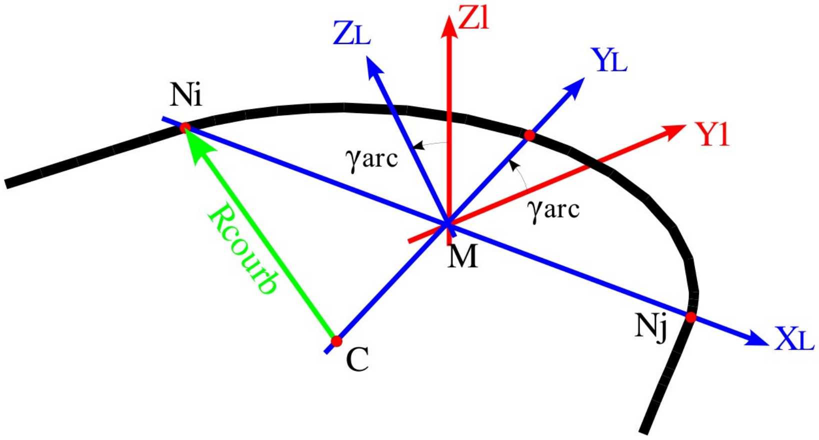
Orientation angle of the arc of the element (in degrees). The angle γ_{arc} defines rotation around the local axis x_l (determined by the two ends of the arc N_i and N_j) making it possible to pass from $(M, x_l, y_{1,} z_1)$ to (M, x_l, y_l, z_l) [Figure11.7-a].

♦ RAYON = rcourb

Radius of curvature of the element. It allows of compute the center C of the arc [Figure11.7-b].



Appear 11.7-a : Radius of curvature in the local coordinate system of the element.



Appear 11.7-b : Radius of curvature in the total reference.

Note:

- *the reference* (M, x_l, y_1, z_1) *is calculated automatically from* N_i, N_j *, ends of the meshes belonging to* `lma` *or* `lgma` *, following the same principle as for the key word* `DIRECTIONAL SENSE` *[Figure10.4-a] and [Figure10.4-b],*
- *the local axis* y_l *is directed of* C *worms* M *.*

11.8 Operand COEF_FLEX , COEF_FLEX_XZ , COEF_FLEX_XY : coefficients of compliance

◊ COEF_FLEX = $cflex$
◊ COEF_FLEX_XZ = $cflex_{xz}$
◊ COEF_FLEX_XY = $cflex_{xy}$

Pour the modelization of the elbows of pipework the representation by elements of a steel ring is insufficient to represent the compliance of a thin shell. The coefficient of compliance corrects the geometrical data (geometrical moments of inertia) in accordance with the rules of construction. For example, rules RCC_M result in making the computation of flexural rigidity with one geometrical moment of inertia:

$$I_{y,z}=\frac{I_{y,z}(tube)}{cflex} \text{ with } cflex>1.0$$

conventional Une value of $cflex$, for a pipework of thickness e and average radius R_{moy} , is given by:

$$cflex=\frac{1.65}{\lambda} \text{ with } \lambda=\frac{e\,R_{courb}}{R_{moy}^2}$$

Cette value can be computed directly in the command file (see for example test FORMA01A [V7.15.100]).

If 2 coefficients are given, one obtains: $I_y=\frac{I_y(tube)}{cflex_{xz}}, I_z=\frac{I_z(tube)}{cflex_{xy}}$

By default, $cflex=cflex_{xz}=cflex_{xy}=1$ (not of amendment of geometrical inertias).

11.9 Operands `INDI_SIGM` / `INDI_SIGM_XZ` / `INDI_SIGM_XY` : Intensification of the stresses

◊ `INDI_SIGM=` $isigm$

◊ `INDI_SIGM_XZ=` $isigm_{xz}$

◊ `INDI_SIGM_XY=` $isigm_{xy}$

Pour the computation of bending stresses in the curved beam elements of tubular section, one can take account of a coefficient of intensification due to ovalization.
The stresses are written then:

$$\sigma_{xx}=\frac{M_y . R}{I_y}\times isigm \text{ or } \sigma_{xx}=\frac{M_z . R}{I_z}\times isigm \text{ with } isgim\geq 1$$

Dans le cas où 2 indices are given, one a:

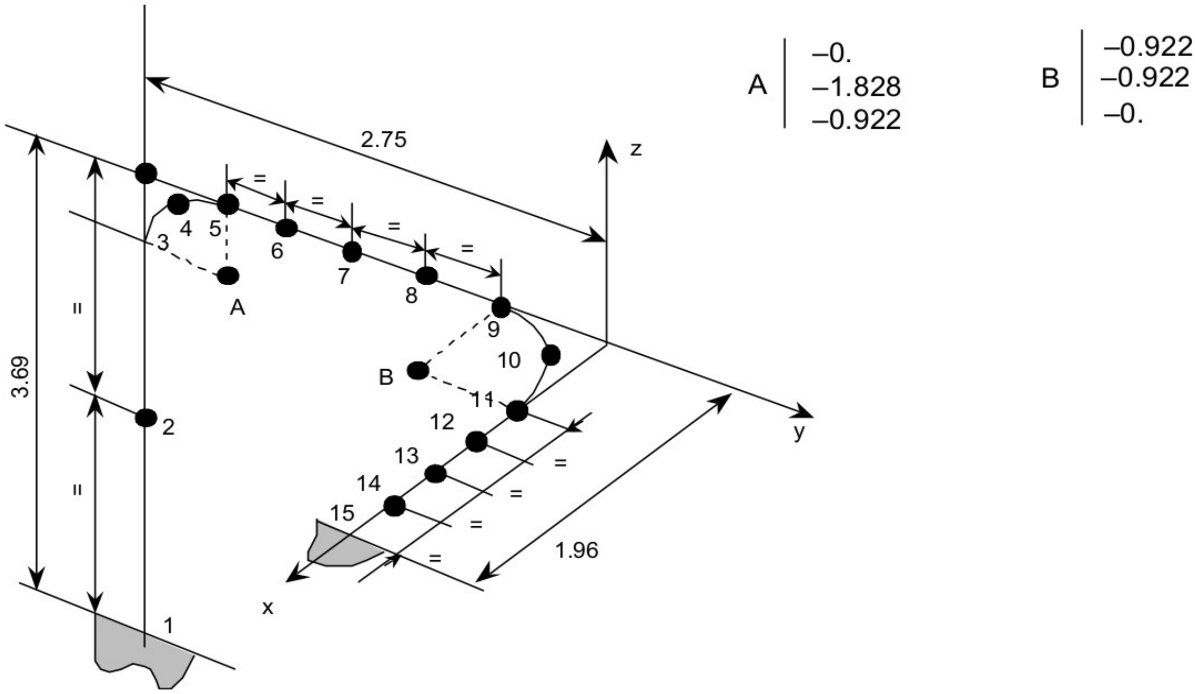
$$\sigma_{xx}=\frac{M_y . R}{I_y}\times isigm_{xz} \text{ or } \sigma_{xx}=\frac{M_z . R}{I_z}\times isigm_{xy}$$

11.10 Remarque

It is possible to check the characteristics of the curved beam elements (angle, radius of curvature) in the file "messages" while giving `INFO = 2`.

11.11 Example of Pipework

use comprising two elbows (problem of Hoovgaard resulting from test `SSLL101B`).



- diameter external of the pipe: $0.185\,m$
- thickness of the pipe: $6.12\,mm$
- radius of curvature of the elbows: $0.922\,m$

The 2 elbows are formed by the elements:
- $E3$ (nodes 3 and 4) $E4$ (nodes 4 and 5)
- $E9$ (nodes 9 and 10) $E10$ (nodes 10 and 11)

Les values of (α , β) are:

```
NOMTYPEALPHABETA
E1         MECA_POU_D_T0.000000E+00-0.900000E+02
E2         MECA_POU_D_T0.000000E+00-0.900000E+02
E5         MECA_POU_D_T0.900000E+020.000000E+00
E6         MECA_POU_D_T0.900000E+020.000000E+00
E7         MECA_POU_D_T0.900000E+020.000000E+00
E8         MECA_POU_D_T0.900000E+020.000000E+00
E11        MECA_POU_D_T0.000000E+000.000000E+00
E12        MECA_POU_D_T0.000000E+000.000000E+00
E13        MECA_POU_D_T0.000000E+000.000000E+00
E14        MECA_POU_D_T0.000000E+000.000000E+00
E3         MECA_POU_C_T0.900000E+02-0.675050E+02
E4         MECA_POU_C_T0.900000E+02-0.224950E+02
E9         MECA_POU_C_T0.675050E+020.000000E+00
E10        MECA_POU_C_T0.224950E+020.000000E+00
```

```
CARA_ELE = AFFE_CARA_ELEM (
     MODELE =  model,
     INFO   =  2,
     BEAM = (
        _F (GROUP_MA    =  "SEC_1",
           SECTION     =  "GENERALE",
           # right pipe
           CARA        = ("A", "IZ", "IY", "AY", "AZ", "JX", "EZ", "EY",
                          "RY", "RZ", "RT"),
           VALE        = (3.4390E-3, 2*1.3770E-5,
                          2*2.0, 2.7540E-5, 2*0.0, 3*1.0),
        ),
        _F (GROUP_MA    =  "SEC_2",
           # elbows
           VALE        = (3.4390E-3,  2*5.8870E-6,
                          2*2.,  2.7540E-5,  2*0.0,  3*1.0),
        ),
     ),
     DEFI_ARC = (
        _F (MESH      = ("E9", "E10"),
           POIN_TANG   = (0.0, 0.0,0.0),
           PRECISION   =  1.E-3,
           CRITERE     =  "RELATIF",
        ),
        _F (MESH      = ("E3", "E4"),
           CENTRE      = (0. ,  -1.8280,-0.9220  ),
           PRECISION   =  1.E-3,
           CRITERE     =  "RELATIF",
        ),
      ),
)
```

Les computed values by `AFFE_CARA_ELEM` are:

```
Key word FACTEUR "DEFI_ARC" (meshes E9 E10)
Key word "NETS",     RCOURB:     0.9219999999999899
KEY WORD "NETS",     ORIE_ARC:   0.
KEY WORD "NETS",     ANGLE_ARC:  90.
KEY WORD "NETS",     CENTRE:     0.921999999999864, -0.921999999999864, 0.0
Key word FACTEUR "DEFI_ARC" (meshes E3 E4)
Key word "NETS",     RCOURB:     0.9219999999999828
KEY WORD "NETS",     ORIE_ARC:  90.
KEY WORD "NETS",     ANGLE_ARC:  90.00000000000091
KEY WORD "NETS",     CENTRE:     0.0, -1.82799999999996, -0.92199999999997
```

12 key Words GEOM_FIBRE / MULTIFIBRE

12.1 Syntaxe

```
GEOM_FIBRE = gfibre                                             [geom_fibre]

MULTIFIBRE = _F (
      ♦ / GROUP_MA=     lgrma,                                 [l_gr_maille]
        / MAILLE=       lma                                       [l_maille]
      ♦ GROUP_FIBRE=    gfbr,                                    [l_gr_fibre]
)
```

key Mots used to define the section of the multifibre beams, (modelizations POU_D_EM or POU_D_TGM) while assigning to the element beam (mesh SEG2) of the groups of fibers defined using operator DEFI_GEOM_FIBRE (U4-26.01).

12.2 Goal

Dans the frame of a modelization of the multifibre type, there are two “levels” of modelization. There is the modelization known as “longitudinal” which will be represented by a beam (geometrical support SEG2) and a plane modelization of the section (perpendicular to the SEG2). Key word MULTIFIBRE makes it possible to associate groups of fibers (defined beforehand by operator DEFI_GEOM_FIBRE) with an element beam. GEOM_FIBRE makes it possible to give the name of the concept created by DEFI_GEOM_FIBRE containing the description of all the groups of fibers.

Note:

For elements POU_D_EM, it is necessary to affect all the groups of fibers defining the cross-section on only one element beam (see R3.08.08). On the other hand for elements POU_D_TGM, one can affect currently one group of fiber per element beam. If one wants to treat heterogeneous cases of section with elements POU_D_TGM, operator CREA_MAILLAGE allows to duplicate support SEG2 so that there is one material by support.

Caution:

The contained informations in the groups of fibers allow of compute some of the integrated characteristics of the cross-sections (area, statical moments and quadratic). In spite of that, for elements POU_D_TGM, it is necessary to give coherent values for the operands A , IY , IZ under the key word BEAM. A checking is carried out on the coherence of these quantities. If the relative error is too important (Confer key words PREC_AIRE, PREC_INERTIE) a fatal error is emitted.

12.3 Key word MULTIFIBRE

♦ MULTIFIBRE

Définit entities of the mesh of beams concerned and the sections which are affected for them.

12.3.1 Operands NETS and GROUP_MA

♦ / NET
  / GROUP_MA

Ces operands make it possible to define the entities of the mesh of beams (elements SEG2) which are concerned with the occurrence of the key word factor:

Operands	Contained / Meaning
NETS	Affectation with a list of meshes
GROUP_MA	Affectation to a list of mesh groups

12.3.2 Opérande GROUP_FIBRE

♦ GROUP_FIBRE
Ces operands make it possible to define the groups of fibers (among all those defined in the concept geometry of fibers given by key word GEOM_FIBRE) which are assigned to the elements beams of this occurrence of

12.4 Key word GEOM_FIBRE

♦ GEOM_FIBRE
Définit the concept created by DEFI_GEOM_FIBRE [U4.26.01], containing the description of all the groups of fibers of the study.

13 Key word DISCRET and allocatable

13.1 DISCRET_2D Caractéristiques

Ces key words make it possible to assign directly to entities (meshes or nodes), which support elements of the type DIS_T, DIS_TR (DISCRET) or 2D DIS T, 2D_DIS_TR (DISCRET_2D), **stiffness matrixes** , of **mass** or **damping**.

On all the entities one can only affect matrixes corresponding to the degrees of freedom of (T) translation or the degrees of freedom of translation and rotation (TR). The matrixes can be diagonal (D) or full (symmetric or not symmetric).
In all the cases (symmetric, diagonal, complete matrixes) **the convention of dialup of the terms is imposed** :

- for symmetric matrixes, one will provide only triangular the higher, **with a convention imposed for the dialup of the terms** (see examples).
- for diagonal matrixes, one will provide only the terms of the diagonal, **with a convention imposed for the dialup of the terms** (see examples).
- for matrixes not-symmetric, one will provide all the terms, **with a convention imposed for the dialup of the terms** (see examples).

The matrixes can be affected:

- with nodes or meshes of the types POI1; they are then known as nodal matrixes (N),
- with meshes of the type SEG2; they are then known as matrixes of connection (L).

In the event of assignment of matrixes to meshes or nodes, the type of discrete element must be affected, au préalable, with this meshes or these nodes by operator AFFE_MODELE [U4.41.01].

13.2 Syntax

```
DISCRET and DISCRET_2D = _F (
     ♦ / MAILLE=       lma,                                  [l_maille]
       / GROUP_MA=     lgma,                              [l_gr_maille]
       / NOEUD=        lno,                                   [l_noeud]
       / GROUP_NO=     lgno,                               [l_gr_noeud]
     ◊ SYME=          / "OUI",                                 [defect]
                       / "NON"
     # stiffness matrixes
     ♦ / CARA=        |'K_T_D_N'|'K_TR_D_N'|'K_T_D_L'|'K_TR_D_L",
                       |'K_T_N'|'K_TR_N'|'K_T_L'|'K_TR_L",
     # mass matrixes
       / CARA=        |'M_T_D_N'|'M_TR_D_N',|'M_T_D_L',|'M_TR_D_L'
                       |'M_T_N'|'M_TR_N'|'M_T_L'|'M_TR_L',
     # damping matrixes
       / CARA=        |'A_T_D_N'|'A_TR_D_N'|'A_T_D_L'|'A_TR_D_L',
                       |'A_T_N'|'A_TR_N'|'A_T_L'|'A_TR_L',
     ♦ / VALE=        lva,                                     [l_réel]

     ◊ REPERE=        / "LOCAL",
                       / "GLOBAL",                             [defect]

     ◊ AMOR_HYST=     / 0.0,                                   [defect]
                       / amnh,                                [reality]
)
```

13.3 Opérandes

13.3.1 Règles of use

- RIGIDITY or DAMPING and SYME='OUI' (default value)

CARA	CARA	ENTITE	DIS_* VALE	2D_DIS_* VALE
“K_T_D_N”	“A_T_D_N”	node or POI1	3 terms	2 terms
“K_T_D_L”	“A_T_D_L”	SEG2	3 terms	2 terms
“K_TR_D_N”	“A_TR_D_N”	node or POI1	6 terms	3 terms
“K_TR_D_L”	“A_TR_D_L”	SEG2	6 terms	3 terms
“K_T_N”	“A_T_N”	node or POI1	6 terms	3 terms
“K_T_L”	“A_T_L”	SEG2	21 terms	10 terms
“K_TR_N”	“A_TR_N”	node or POI1	21 terms	6 terms
“K_TR_L”	“A_TR_L”	SEG2	78 terms	21 terms

- RIGIDITY or DAMPING and SYME='NON'

CARA	CARA	ENTITE	DIS_* VALE	2D_DIS_* VALE
“K_T_N”	“A_T_N”	node or POI1	9 terms	4 terms
“K_T_L”	“A_T_L”	SEG2	36 terms	16 terms
“K_TR_N”	“A_TR_N”	node or POI1	36 terms	9 terms
“K_TR_L”	“A_TR_L”	SEG2	144 terms	36 terms

- MASS and SYME='OUI' (default value)

CARA	ENTITE	DIS_* VALE	2D_DIS_* VALE
“M_T_D_N”	node or POI1	1 (mass)	1 (mass)
“M_TR_D_N”	node or POI1	10 (mass/inertia)	nonavailable
“M_T_N”	node or POI1	6 (mass/inertia)	3 (mass/inertia)
“M_T_L”	SEG2	21 (mass/inertia)	10 (mass/inertia)
“M_T_D_L”	SEG2	1 (mass/inertia)	1 (mass/inertia)
“M_TR_N”	node or POI1	21 (mass/inertia)	6 (mass/inertia)
“M_TR_D_L”	SEG2	4 (mass/inertia)	4 (mass/inertia)
“M_TR_L”	SEG2	78 (mass/inertia)	21 (mass/inertia)

- MASS and SYME='NON'

CARA	ENTITE	DIS_* VALE	2D_DIS_* VALE
“M_T_N”	node or POI1	9 (mass/inertia)	4 (mass/inertia)
“M_T_L”	SEG2	36 (mass/inertia)	16 (mass/inertia)
“M_TR_N”	node or POI1	36 (mass/inertia)	9 (mass/inertia)
“M_TR_L”	SEG2	144 (mass/inertia)	36 (mass/inertia)

13.3.2 Opérandes VALE

♦ / VALE= lva

One finds in VALE the list of the values making it possible to define the elementary matrix of the discrete element. The size of this list depends on the type of element.

Key word VALE is used if effector a standard computation is wanted. The arguments of this key word are realities.

13.3.3 Operands K_ (stiffness matrixes) or A_ (damping matrixes)

K_T_D_N / A_T_D_N and SYME='OUI' (default value)
for a mesh of the type POI1 or a node, one finds in correspondence in VALE 3 values k_x k_y, k_z in DIS_T and 2 values k_x, k_y 2D DIS T such as:

$$K\ ou\ A=\begin{array}{c} \begin{array}{ccc} U_x & U_y & U_z \end{array} \\ \begin{bmatrix} k_x & 0 & 0 \\ 0 & k_y & 0 \\ 0 & 0 & k_z \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{cc} U_x & U_y \end{array} \\ \begin{bmatrix} k_x & 0 \\ 0 & k_y \end{bmatrix} \end{array}$$

K_T_D_L / A_T_D_L and SYME='OUI' (value by default)
for a mesh of the type SEG2, K being the matrix previously definite:

$$\begin{array}{c} \begin{array}{cc} \mathit{Noeud1} & \mathit{Noeud2} \end{array} \\ \begin{bmatrix} K & -K \\ -K & K \end{bmatrix} \end{array}$$

it is thus enough to provide 3 values k_x k_y, k_z

K_TR_D_N / A_TR_D_N and SYME='OUI' (default value)
for a mesh of the type POI1 or node, one finds in correspondence in VALE 6 values k_x k_y k_z k_{rx} k_{ry}, k_{rz} in DIS_TR or 3 values k_x k_y, k_{rz} 2D_DIS_TR such as:

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccc} U_x & U_y & U_z & R_x & R_y & R_z \end{array} \\ \begin{bmatrix} k_x & 0 & 0 & 0 & 0 & 0 \\ 0 & k_y & 0 & 0 & 0 & 0 \\ 0 & 0 & k_z & 0 & 0 & 0 \\ 0 & 0 & 0 & k_{rx} & 0 & 0 \\ 0 & 0 & 0 & 0 & k_{ry} & 0 \\ 0 & 0 & 0 & 0 & 0 & k_{rz} \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{ccc} U_x & U_y & R_z \end{array} \\ \begin{bmatrix} k_x & 0 & 0 \\ 0 & k_y & 0 \\ 0 & 0 & k_{rz} \end{bmatrix} \end{array}$$

K_TR_D_L / A_TR_D_L and SYME='OUI' (value by default)
for a mesh of the type SEG2, K being the matrix previously definite:

$$\begin{array}{c} \begin{array}{cc} \mathit{Noeud1} & \mathit{Noeud2} \end{array} \\ \begin{bmatrix} K & -K \\ -K & K \end{bmatrix} \end{array}$$

it is enough to give the 6 values above.

K_T_N / A_T_N and SYME='OUI' (default value)
for a mesh of the type POI1 or a node, one finds in correspondence in VALE 6 values k_1, k_2 … k_6 in DIS_T or 3 values k_1 k_2, k_3 2D DIS T such as:

$$K\ ou\ A=\begin{array}{c} \begin{array}{ccc} U_x & U_y & U_z \end{array} \\ \begin{bmatrix} k_1 & k_2 & k_4 \\ & k_3 & k_5 \\ & & k_6 \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{cc} U_x & U_y \end{array} \\ \begin{bmatrix} k_1 & k_2 \\ & k_3 \end{bmatrix} \end{array}$$

`K_T_N` / `A_T_N` and `SYME='NON'`
`for` a mesh of the type `POI1` or a node, one finds in correspondence in `VALE` 9 values k_1 , k_2 … k_9 in `DIS_T` or 4 values k_1 k_2 ,… k_4 in `2D DIS T` such as:

$$K\ ou\ A=\begin{array}{c} \begin{array}{ccc} U_x & U_y & U_z \end{array} \\ \begin{bmatrix} k_1 & k_4 & k_7 \\ k_2 & k_5 & k_8 \\ k_3 & k_6 & k_9 \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{cc} U_x & U_y \end{array} \\ \begin{bmatrix} k_1 & k_3 \\ k_2 & k_4 \end{bmatrix} \end{array}$$

`K_T_L` / `A_T_L` and `SYME='OUI'` (default value)
for a mesh of the type `SEG2`, one finds in correspondence in `VALE` 21 values k_1 , k_2 … k_{21} in `DIS_T` or 10 values k_1 , k_2 … k_{10} in `2D DIS T` and the following stiffness matrix will be affected:

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccc} U_{x1} & U_{y1} & U_{z1} & U_{x2} & U_{y2} & U_{z2} \end{array} \\ \begin{bmatrix} k_1 & k_2 & k_4 & k_7 & k_{11} & k_{16} \\ & k_3 & k_5 & k_8 & k_{12} & k_{17} \\ & & k_6 & k_9 & k_{13} & k_{18} \\ & & & k_{10} & k_{14} & k_{19} \\ & & & & k_{15} & k_{20} \\ & & & & & k_{21} \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{cccc} U_{x1} & U_{y1} & U_{x2} & U_{y2} \end{array} \\ \begin{bmatrix} k_1 & k_2 & k_4 & k_7 \\ & k_3 & k_5 & k_8 \\ & & k_6 & k_9 \\ & & & k_{10} \end{bmatrix} \end{array}$$

`K_T_L` / `A_T_L` and `SYME='NON'`
for a mesh of the type `SEG2`, one finds in correspondence in `VALE` 36 values k_1 , k_2 … k_{36} in `DIS_T` or 16 values k_1 , k_2 … k_{16} in `2D DIS T` and the following stiffness matrix will be affected:

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccc} U_{x1} & U_{y1} & U_{z1} & U_{x2} & U_{y2} & U_{z2} \end{array} \\ \begin{bmatrix} K_1 & K_7 & K_{13} & K_{19} & K_{25} & K_{31} \\ K_2 & K_8 & K_{14} & K_{20} & K_{26} & K_{32} \\ K_3 & K_9 & K_{15} & K_{21} & K_{27} & K_{33} \\ K_4 & K_{10} & K_{16} & K_{22} & K_{28} & K_{34} \\ K_5 & K_{11} & K_{17} & K_{23} & K_{29} & K_{35} \\ K_6 & K_{12} & K_{18} & K_{24} & K_{30} & K_{36} \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{cccc} U_{x1} & U_{y1} & U_{x2} & U_{y2} \end{array} \\ \begin{bmatrix} k_1 & k_5 & k_9 & k_{13} \\ k_2 & k_6 & k_{10} & k_{14} \\ k_3 & k_7 & k_{11} & k_{15} \\ k_4 & k_8 & k_{12} & k_{16} \end{bmatrix} \end{array}$$

`K_TR_N` / `A_TR_N` and `SYME='OUI'` (default value)
for a mesh of the type `POI1` or a node, one finds in correspondence in `VALE` 21 values k_1 , k_2 … k_{21} in `DIS_TR` or 6 values k_1 , k_2 … k_6 in `2D_DIS_TR` such as:

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccc} U_x & U_y & U_z & R_x & R_y & R_z \end{array} \\ \begin{bmatrix} k_1 & k_2 & k_4 & k_7 & k_{11} & k_{16} \\ & k_3 & k_5 & k_8 & k_{12} & k_{17} \\ & & k_6 & k_9 & k_{13} & k_{18} \\ & & & k_{10} & k_{14} & k_{19} \\ & & & & k_{15} & k_{20} \\ & & & & & k_{21} \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{array}{ccc} U_x & U_y & R_z \end{array} \\ \begin{bmatrix} k_1 & k_2 & k_4 \\ & k_3 & k_5 \\ & & k_6 \end{bmatrix} \end{array}$$

K_TR_N / A_TR_N and SYME='NON'
for a mesh of the type POI1 or a node, one finds in correspondence in VALE 36 values k_1, k_2 … k_{36} in DIS_TR or 9 values k_1, k_2 … k_9 in 2D_DIS_TR such as:

$$K\ ou\ A=\begin{array}{c} \begin{matrix} U_x & U_y & U_z & R_x & R_y & R_z \end{matrix} \\ \begin{bmatrix} k_1 & k_7 & k_{13} & k_{19} & k_{25} & k_{31} \\ k_2 & k_8 & k_{14} & k_{20} & k_{26} & k_{32} \\ k_3 & k_9 & k_{15} & k_{21} & k_{27} & k_{33} \\ k_4 & k_{10} & k_{16} & k_{22} & k_{28} & k_{34} \\ k_5 & k_{11} & k_{17} & k_{23} & k_{29} & k_{35} \\ k_6 & k_{12} & k_{18} & k_{24} & k_{30} & k_{36} \end{bmatrix} \end{array} \qquad K\ ou\ A=\begin{array}{c} \begin{matrix} U_x & U_y & R_z \end{matrix} \\ \begin{bmatrix} k_1 & k_4 & k_7 \\ k_2 & k_5 & k_8 \\ k_3 & k_6 & k_9 \end{bmatrix} \end{array}$$

K_TR_L / A_TR_L and SYME='OUI' (default value)
for a mesh of the type SEG2, one finds in correspondence in VALE 78 values k_1, k_2 … k_{78} in DIS_TR.

$$K\ ou\ A=\begin{array}{c} \begin{matrix} U_{x1} & U_{y1} & U_{z1} & R_{x1} & R_{y1} & R_{z1} & U_{x2} & U_{y2} & U_{z2} & R_{x2} & R_{y2} & R_{z2} \end{matrix} \\ \begin{bmatrix} k_1 & k_2 & k_4 & k_7 & k_{11} & k_{16} & k_{22} & k_{29} & k_{37} & k_{46} & k_{56} & k_{67} \\ & k_3 & k_5 & k_8 & k_{12} & k_{17} & k_{23} & k_{30} & k_{38} & k_{47} & k_{57} & k_{68} \\ & & k_6 & k_9 & k_{13} & k_{18} & k_{24} & k_{31} & k_{39} & k_{48} & k_{58} & k_{69} \\ & & & k_{10} & k_{14} & k_{19} & k_{25} & k_{32} & k_{40} & k_{49} & k_{59} & k_{70} \\ & & & & k_{15} & k_{20} & k_{26} & k_{33} & k_{41} & k_{50} & k_{60} & k_{71} \\ & & & & & k_{21} & k_{27} & k_{34} & k_{42} & k_{51} & k_{61} & k_{72} \\ & & & & & & k_{28} & k_{35} & k_{43} & k_{52} & k_{62} & k_{73} \\ & & & & & & & k_{36} & k_{44} & k_{53} & k_{63} & k_{74} \\ & & & & & & & & k_{45} & k_{54} & k_{64} & k_{75} \\ & & & & & & & & & k_{55} & k_{65} & k_{76} \\ & & & & & & & & & & k_{66} & k_{77} \\ & & & & & & & & & & & k_{78} \end{bmatrix} \end{array}$$

or 21 values k_1, k_2 … k_{21} in 2D_DIS_TR such as :

$$K\ ou\ A=\begin{array}{c} \begin{matrix} U_{x1} & U_{y1} & R_{z1} & U_{x2} & U_{y2} & R_{z2} \end{matrix} \\ \begin{bmatrix} k_1 & k_2 & k_4 & k_7 & k_{11} & k_{16} \\ & k_3 & k_5 & k_8 & k_{12} & k_{17} \\ & & k_6 & k_9 & k_{13} & k_{18} \\ & & & k_{10} & k_{14} & k_{19} \\ & & & & k_{15} & k_{20} \\ & & & & & k_{21} \end{bmatrix} \end{array}$$

K_TR_L / A_TR_L and SYME='NON'
for a mesh of the type SEG2, one finds in correspondence in VALE 144 values k_1, k_2 … k_{144} in DIS_TR.

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccccccccc} U_{x1} & U_{y1} & U_{z1} & R_{x1} & R_{y1} & R_{z1} & U_{x2} & U_{y2} & U_{z2} & R_{x2} & R_{y2} & R_{z2} \end{array} \\ \begin{bmatrix} k_1 & k_{13} & k_{25} & k_{37} & k_{49} & k_{61} & k_{73} & k_{85} & k_{97} & k_{109} & k_{121} & k_{133} \\ k_2 & k_{14} & k_{26} & k_{38} & k_{50} & k_{62} & k_{74} & k_{86} & k_{98} & k_{110} & k_{122} & k_{134} \\ k_3 & k_{15} & k_{27} & k_{39} & k_{51} & k_{63} & k_{75} & k_{87} & k_{99} & k_{111} & k_{123} & k_{135} \\ k_4 & k_{16} & k_{28} & k_{40} & k_{52} & k_{64} & k_{76} & k_{88} & k_{100} & k_{112} & k_{124} & k_{136} \\ k_5 & k_{17} & k_{29} & k_{41} & k_{53} & k_{65} & k_{77} & k_{89} & k_{101} & k_{113} & k_{125} & k_{137} \\ k_6 & k_{18} & k_{30} & k_{42} & k_{54} & k_{66} & k_{78} & k_{90} & k_{102} & k_{114} & k_{126} & k_{138} \\ k_7 & k_{19} & k_{31} & k_{43} & k_{55} & k_{67} & k_{79} & k_{91} & k_{103} & k_{115} & k_{127} & k_{139} \\ k_8 & k_{20} & k_{32} & k_{44} & k_{56} & k_{68} & k_{80} & k_{92} & k_{104} & k_{116} & k_{128} & k_{140} \\ k_9 & k_{21} & k_{33} & k_{45} & k_{57} & k_{69} & k_{81} & k_{93} & k_{105} & k_{117} & k_{129} & k_{141} \\ k_{10} & k_{22} & k_{34} & k_{46} & k_{58} & k_{70} & k_{82} & k_{94} & k_{106} & k_{118} & k_{130} & k_{142} \\ k_{11} & k_{23} & k_{35} & k_{47} & k_{59} & k_{71} & k_{83} & k_{95} & k_{107} & k_{119} & k_{131} & k_{143} \\ k_{12} & k_{24} & k_{36} & k_{48} & k_{60} & k_{72} & k_{84} & k_{96} & k_{108} & k_{120} & k_{132} & k_{144} \end{bmatrix} \end{array}$$

or 36 values k_1, k_2 … k_{36} in 2D_DIS_TR such as :

$$K\ ou\ A=\begin{array}{c} \begin{array}{cccccc} U_{x1} & U_{y1} & R_{z1} & U_{x2} & U_{y2} & R_{z2} \end{array} \\ \begin{bmatrix} k_1 & k_7 & k_{13} & k_{19} & k_{25} & k_{31} \\ k_2 & k_8 & k_{14} & k_{20} & k_{26} & k_{32} \\ k_3 & k_9 & k_{15} & k_{21} & k_{27} & k_{33} \\ k_4 & k_{10} & k_{16} & k_{22} & k_{28} & k_{34} \\ k_5 & k_{11} & k_{17} & k_{23} & k_{29} & k_{35} \\ k_6 & k_{12} & k_{18} & k_{24} & k_{30} & k_{36} \end{bmatrix} \end{array}$$

13.3.4 Operands M_ Mass matrixes

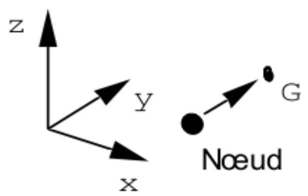
M_T_D_N and SYME='OUI' (default value)
for a mesh of the type POI1 or a node, one finds in correspondence in VALE 1 value m. The following mass matrix will be affected:

$$M=\begin{array}{c} \begin{array}{ccc} U_x & U_y & U_z \end{array} \\ \begin{bmatrix} m & 0 & 0 \\ 0 & m & 0 \\ 0 & 0 & m \end{bmatrix} \end{array}$$

M_TR_D_N and SYME='OUI' (default value, nonavailable in 2D_DIS_TR)
for a mesh of the type POI1 or a node, one finds in correspondence in VALE a value of mass m, 6 values of the tensor of inertia (mass): $I_{xx}, I_{yy}, I_{zz}, I_{xy}, I_{yz}, I_{xz}$ and 3 components of the vector of eccentring of the mass compared to its node: e_x, e_y, e_z. The following mass matrix will be affected:

$$M=\begin{array}{c} \begin{array}{cccccc} U_x & U_y & U_z & R_x & R_y & R_z \end{array} \\ \begin{bmatrix} m & 0 & 0 & 0 & -m.e_z & -m.e_y \\ & m & 0 & m.e_z & 0 & -m.e_x \\ & & m & -m.e_y & m.e_x & 0 \\ & & & V_{xx} & V_{xy} & V_{xz} \\ & & & & V_{yy} & V_{yz} \\ & & & & & v_{zz} \end{bmatrix} \end{array}$$

$$V_{xx}=I_{xx}+m(e_y^2+e_z^2)$$
$$V_{yy}=I_{yy}+m(e_x^2+e_z^2)$$
$$V_{zz}=I_{zz}+m(e_x^2+e_y^2)$$
$$V_{xy}=I_{xy}-m\,e_x e_y$$
$$V_{yz}=I_{yz}-m\,e_y e_z$$
$$V_{xz}=I_{xz}-m\,e_x e_z$$



Caution:

The eccentring must be expressed in the total reference: coordinates of the vector NG (eccentring) directed node towards the mass.

M_T_N and SYME='OUI' (default value)
for a mesh of the type POI1 or node, one finds in correspondence in VALE 6 values M_1 M_2,… M_6 in DIS_T or 3 values M_1 M_2, M_3 in 2D DIS T and the following mass matrix will be affected:

$$M=\begin{array}{c} \begin{array}{ccc} U_x & U_y & U_z \end{array} \\ \begin{bmatrix} M_1 & M_2 & M_4 \\ & M_3 & M_5 \\ & & M_6 \end{bmatrix} \end{array} \qquad M=\begin{array}{c} \begin{array}{cc} U_x & U_y \end{array} \\ \begin{bmatrix} M_1 & M_2 \\ & M_3 \end{bmatrix} \end{array}$$

See for example test SDLD27 [V2.01.027].

M_T_N and SYME='NON'
for a mesh of the type POI1 or node, one finds in correspondence in VALE 9 values M_1 M_2,... M_9 in DIS_T or 4 values M_1 M_2,... M_4 in 2D DIS T and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{ccc}U_x & U_y & U_z\end{array}\\ \begin{bmatrix} M_1 & M_4 & M_7\\ M_2 & M_5 & M_8\\ M_3 & M_6 & M_9\end{bmatrix}\end{array} \qquad M=\begin{array}{c}\begin{array}{cc}U_x & U_y\end{array}\\ \begin{bmatrix} M_1 & M_3\\ M_2 & M_4\end{bmatrix}\end{array}$$

M_TR_N and SYME='OUI' (default value)
for a mesh of the type POI1 or node, one finds in correspondence in VALE 21 values M_1 M_2,... M_{21} in DIS_TR or 6 values M_1 M_2,... M_6 in 2D_DIS_TR and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cccccc}U_x & U_y & U_z & R_x & R_y & R_z\end{array}\\ \begin{bmatrix} M_1 & M_2 & M_4 & M_7 & M_{11} & M_{16}\\ & M_3 & M_5 & M_8 & M_{12} & M_{17}\\ & & M_6 & M_9 & M_{13} & M_{18}\\ & & & M_{10} & M_{14} & M_{19}\\ & & & & M_{15} & M_{20}\\ & & & & & M_{21}\end{bmatrix}\end{array} \qquad M=\begin{array}{c}\begin{array}{ccc}U_x & U_y & R_z\end{array}\\ \begin{bmatrix} M_1 & M_2 & M_4\\ & M_3 & M_5\\ & & M_6\end{bmatrix}\end{array}$$

M_TR_N and SYME='NON'
for a mesh of the type POI1 or node, one finds in correspondence in VALE 36 values M_1 M_2,... M_{36} in DIS_TR or 9 values M_1 M_2,... M_9 in 2D_DIS_TR and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cccccc}U_x & U_y & U_z & R_x & R_y & R_z\end{array}\\ \begin{bmatrix} M_1 & M_7 & M_{13} & M_{19} & M_{25} & M_{31}\\ M_2 & M_8 & M_{14} & M_{20} & M_{26} & M_{32}\\ M_3 & M_9 & M_{15} & M_{21} & M_{27} & M_{33}\\ M_4 & M_{10} & M_{16} & M_{22} & M_{28} & M_{34}\\ M_5 & M_{11} & M_{17} & M_{23} & M_{29} & M_{35}\\ M_6 & M_{12} & M_{18} & M_{24} & M_{30} & M_{36}\end{bmatrix}\end{array} \qquad M=\begin{array}{c}\begin{array}{ccc}U_x & U_y & R_z\end{array}\\ \begin{bmatrix} M_1 & M_4 & M_7\\ M_2 & M_5 & M_8\\ M_3 & M_6 & M_9\end{bmatrix}\end{array}$$

M_T_L and SYME='OUI' (default value)
for a mesh of the type SEG2, one finds in correspondence in VALE 21 values M_1 M_2,... M_{21} in DIS_T or 10 values M_1 M_2,... M_{10} in 2D DIS T and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cccccc}U_{x1} & U_{y1} & U_{z1} & U_{x2} & U_{y2} & U_{z2}\end{array}\\ \begin{bmatrix} M_1 & M_2 & M_4 & M_7 & M_{11} & M_{16}\\ & M_3 & M_5 & M_8 & M_{12} & M_{17}\\ & & M_6 & M_9 & M_{13} & M_{18}\\ & & & M_{10} & M_{14} & M_{19}\\ & & & & M_{15} & M_{20}\\ & & & & & M_{21}\end{bmatrix}\end{array} \qquad M=\begin{array}{c}\begin{array}{cccc}U_{x1} & U_{y1} & U_{x2} & U_{y2}\end{array}\\ \begin{bmatrix} M_1 & M_2 & M_4 & M_7\\ & M_3 & M_5 & M_8\\ & & M_6 & M_9\\ & & & M_{10}\end{bmatrix}\end{array}$$

M_T_D_L and SYME='OUI' (default value)
for a mesh of the type SEG2, one finds in correspondence in VALE 1 value, in DIS_T and in 2_DIS_T, the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cc} \scriptstyle Noeud1 & \scriptstyle Noeud2 \end{array}\\ \begin{bmatrix} M & \\ & M \end{bmatrix}\end{array}$$

the matrix M has the same definition as that given for the M_T_D_N.

M_T_L and SYME='NON'
for a mesh of the type SEG2, one finds in correspondence in VALE 36 values M_1 M_2,... M_{36} in DIS_T or 16 values M_1 M_2,... M_{16} in 2D DIS T and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cccccc} U_{x1} & U_{y1} & U_{z1} & U_{x2} & U_{y2} & U_{z2} \end{array}\\ \begin{bmatrix} M_1 & M_7 & M_{13} & M_{19} & M_{25} & M_{31} \\ M_2 & M_8 & M_{14} & M_{20} & M_{26} & M_{32} \\ M_3 & M_9 & M_{15} & M_{21} & M_{27} & M_{33} \\ M_4 & M_{10} & M_{16} & M_{22} & M_{28} & M_{34} \\ M_5 & M_{11} & M_{17} & M_{23} & M_{29} & M_{35} \\ M_6 & M_{12} & M_{18} & M_{24} & M_{30} & M_{36} \end{bmatrix}\end{array} \qquad M=\begin{array}{c}\begin{array}{cccc} U_{x1} & U_{y1} & U_{x2} & U_{y2} \end{array}\\ \begin{bmatrix} M_1 & M_5 & M_9 & M_{13} \\ M_2 & M_6 & M_{10} & M_{14} \\ M_3 & M_7 & M_{11} & M_{15} \\ M_4 & M_8 & M_{12} & M_{16} \end{bmatrix}\end{array}$$

M_TR_L and SYME='OUI' (default value)
for a mesh of the type SEG2, one finds in correspondence in VALE 78 values M_1 M_2,... M_{78} in DIS_TR and the following mass matrix will be affected:

$$M=\begin{array}{c}\begin{array}{cccccccccccc} U_{x1} & U_{y1} & U_{z1} & R_{x1} & R_{y1} & R_{z1} & U_{x2} & U_{y2} & U_{z2} & R_{x2} & R_{y2} & R_{z2} \end{array}\\ \begin{bmatrix} M_1 & M_2 & M_4 & M_7 & M_{11} & M_{16} & M_{22} & M_{29} & M_{37} & M_{46} & M_{56} & M_{67} \\ & M_3 & M_5 & M_8 & M_{12} & M_{17} & M_{23} & M_{30} & M_{38} & M_{47} & M_{57} & M_{68} \\ & & M_6 & M_9 & M_{13} & M_{18} & M_{24} & M_{31} & M_{39} & M_{48} & M_{58} & M_{69} \\ & & & M_{10} & M_{14} & M_{19} & M_{25} & M_{32} & M_{40} & M_{49} & M_{59} & M_{70} \\ & & & & M_{15} & M_{20} & M_{26} & M_{33} & M_{41} & M_{50} & M_{60} & M_{71} \\ & & & & & M_{21} & M_{27} & M_{34} & M_{42} & M_{51} & M_{61} & M_{72} \\ & & & & & & M_{28} & M_{35} & M_{43} & M_{52} & M_{62} & M_{73} \\ & & & & & & & M_{36} & M_{44} & M_{53} & M_{63} & M_{74} \\ & & & & & & & & M_{45} & M_{54} & M_{64} & M_{75} \\ & & & & & & & & & M_{55} & M_{65} & M_{76} \\ & & & & & & & & & & M_{66} & M_{77} \\ & & & & & & & & & & & M_{78} \end{bmatrix}\end{array}$$

or 21 values $M_1 \quad M_2, \ldots \quad M_{21}$ in 2D_DIS_TR

$$M = \begin{array}{cccccc} U_{x1} & U_{y1} & R_{z1} & U_{x2} & U_{y2} & R_{z2} \\ \end{array}$$
$$M = \begin{bmatrix} M_1 & M_2 & M_4 & M_7 & M_{11} & M_{16} \\ & M_3 & M_5 & M_8 & M_{12} & M_{17} \\ & & M_6 & M_9 & M_{13} & M_{18} \\ & & & M_{10} & M_{14} & M_{19} \\ & & & & M_{15} & M_{20} \\ & & & & & M_{21} \end{bmatrix}$$

M_TR_D_L and SYME='OUI' (default value)
for a mesh of the type SEG2, one finds in correspondence in VALE 4 values $M1 \quad M2, \ldots \quad M4$ in DIS_TR and the following mass matrix will be affected:

$$\begin{array}{cccccccccccc} U_{x1} & U_{y1} & U_{z1} & R_{x1} & R_{y1} & R_{z1} & U_{x2} & U_{y2} & U_{z2} & R_{x2} & R_{y2} & R_{z2} \end{array}$$
$$M = \begin{bmatrix} M_1 &&&&&&&&&&& \\ & M_1 &&&&&&&&&& \\ && M_1 &&&&&&&&& \\ &&& M_2 &&&&&&&& \\ &&&& M_3 &&&&&&& \\ &&&&& M_4 &&&&&& \\ &&&&&& M_1 &&&&& \\ &&&&&&& M_1 &&&& \\ &&&&&&&& M_1 &&& \\ &&&&&&&&& M_2 && \\ &&&&&&&&&& M_3 & \\ &&&&&&&&&&& M_4 \end{bmatrix}$$

or 2 values $M1$, $M2$ in 2D_DIS_TR

$$\begin{array}{cccccc} U_{x1} & U_{y1} & R_{z1} & U_{x2} & U_{y2} & R_{z2} \end{array}$$
$$M = \begin{bmatrix} M_1 &&&&& \\ & M_1 &&&& \\ && M_2 &&& \\ &&& M_1 && \\ &&&& M_1 & \\ &&&&& M_2 \end{bmatrix}$$

`M_TR_L` and `SYME='NON'`
`for` a mesh of the type `SEG2`, one finds in correspondence in `VALE` 144 values $M_1 \quad M_2 ,\ldots \quad M_{144}$ in `DIS_TR` and the following mass matrix will be affected:

$$\begin{array}{cc} & \begin{array}{cccccccccccc} U_{x1} & U_{y1} & U_{z1} & R_{x1} & R_{y1} & R_{z1} & U_{x2} & U_{y2} & U_{z2} & R_{x2} & R_{y2} & R_{z2} \end{array} \\ M= & \begin{bmatrix} M_1 & M_{13} & M_{25} & M_{37} & M_{49} & M_{61} & M_{73} & M_{85} & M_{97} & M_{109} & M_{121} & M_{133} \\ M_2 & M_{14} & M_{26} & M_{38} & M_{50} & M_{62} & M_{74} & M_{86} & M_{98} & M_{110} & M_{122} & M_{134} \\ M_3 & M_{15} & M_{27} & M_{39} & M_{51} & M_{63} & M_{75} & M_{87} & M_{99} & M_{111} & M_{123} & M_{135} \\ M_4 & M_{16} & M_{28} & M_{40} & M_{52} & M_{64} & M_{76} & M_{88} & M_{100} & M_{112} & M_{124} & M_{136} \\ M_5 & M_{17} & M_{29} & M_{41} & M_{53} & M_{65} & M_{77} & M_{89} & M_{101} & M_{113} & M_{125} & M_{137} \\ M_6 & M_{18} & M_{30} & M_{42} & M_{54} & M_{66} & M_{78} & M_{90} & M_{102} & M_{114} & M_{126} & M_{138} \\ M_7 & M_{19} & M_{31} & M_{43} & M_{55} & M_{67} & M_{79} & M_{91} & M_{103} & M_{115} & M_{127} & M_{139} \\ M_8 & M_{20} & M_{32} & M_{44} & M_{56} & M_{68} & M_{80} & M_{92} & M_{104} & M_{116} & M_{128} & M_{140} \\ M_9 & M_{21} & M_{33} & M_{45} & M_{57} & M_{69} & M_{81} & M_{93} & M_{105} & M_{117} & M_{129} & M_{141} \\ M_{10} & M_{22} & M_{34} & M_{46} & M_{58} & M_{70} & M_{82} & M_{94} & M_{106} & M_{118} & M_{130} & M_{142} \\ M_{11} & M_{23} & M_{35} & M_{47} & M_{59} & M_{71} & M_{83} & M_{95} & M_{107} & M_{119} & M_{131} & M_{143} \\ M_{12} & M_{24} & M_{36} & M_{48} & M_{60} & M_{72} & M_{84} & M_{96} & M_{108} & M_{120} & M_{132} & M_{144} \end{bmatrix} \end{array}$$

or 36 values $M_1 \quad M_2 ,\ldots \quad M_{36}$ in `2D_DIS_TR`

$$\begin{array}{cc} & \begin{array}{cccccc} U_{x1} & U_{y1} & R_{z1} & U_{x2} & U_{y2} & R_{z2} \end{array} \\ M= & \begin{bmatrix} M_1 & M_7 & M_{13} & M_{19} & M_{25} & M_{31} \\ M_2 & M_8 & M_{14} & M_{20} & M_{26} & M_{32} \\ M_3 & M_9 & M_{15} & M_{21} & M_{27} & M_{33} \\ M_4 & M_{10} & M_{16} & M_{22} & M_{28} & M_{34} \\ M_5 & M_{11} & M_{17} & M_{23} & M_{29} & M_{35} \\ M_6 & M_{12} & M_{18} & M_{24} & M_{30} & M_{36} \end{bmatrix} \end{array}$$

Remarque:

Options `M_T_L`*,* `M_TR_L`*,* `M_T_D_L`*,* `M_TR_D_L` *do not correspond in general to an option of modelization having a mechanical meaning. They are available to import in Code_Aster of the mass matrixes discretized on a mesh of the type* `SEG2` *determined by another software. Indeed, one affects usually values of specific mass and inertia (mesh* `POI1` *) by* `M_T_D_N` *or* `M_TR_D_N`*.*

13.3.5 Operand `AMOR_HYST`

◊ `AMOR_HYST = amorh`

Permet to assign to a discrete element a coefficient to build a complex stiffness matrix (modelization of hysteretic damping) the built matrix is:

$$\left(1+j.amor_h\right).K$$

where K is the K_* `matrix` whose values are provided in the same occurrence of key word `DISCRET`. The complex stiffness matrix will be actually built at the time of a call to `CALC_MATR_ELEM` [U4.61.01] with option `AMOR_HYST` (see test `SDLD313`) and [R5.05.04].

13.3.6 Operand `REPERE`

```
◊ REPERE=     / "LOCAL",
              / "GLOBAL",
```

Par defect the values of the matrixes provided for the discrete elements are used to express the corresponding quantities in `REPERE = "GLOBAL"`.

If one wishes to define a particular reference in a node (or nets of type POI1) one will specify REPERE = "LOCAL" by defining this reference by the key word DIRECTIONAL SENSE [§1026].

For a matrix defined on a mesh of the type SEG2 the operand REPERE = "LOCAL" makes it possible to refer to the local coordinate system attached to the mesh (initial node, final node) supplemented if necessary of an angle of gimlet defined by the key word DIRECTIONAL SENSE [§1026].

14 Allocatable key word

14.1 MASSIF Caractéristiques

Permet to assign to elements 3D or 2D of the local axes (which can be for example used to define directions of orthotropy (cf DEFI_MATERIAU [U4.43.01], DEFI_ COMPOR [U4.43.06]). These local axes are defined by the key words:

- ANGL_REP (3 nautical angles) or (ANGL_AXE and ORIG_AXE) or ANGL_EULER (3 angles) in 3D.
- ANGL_REP (1 only angle) in 2D.

14.2 Syntax

```
MASSIF = _F (
      ♦ / MAILLE=        lma,                              [l_maille]
        / GROUP_MA=      lgma,                             [l_gr_maille]

      ♦ / ANGL_REP=      (α  β,  γ),                       [l_réel]
        / ANGL_EULER=    (Ψ  θ,  φ),                       [l_réel]
        / ♦ ANGL_AXE=    (α,  β),                          [l_réel]
          ♦ ORIG_AXE=    (x1, x2, x3),                     [l_réel]
)
```

14.3 Opérande ANGL_REP

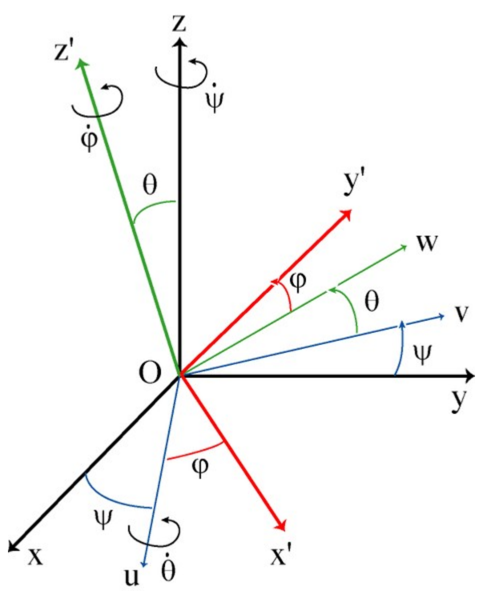
α β , γ are the 3 nautical angles (as for the key word DIRECTIONAL SENSE, cf [§2626]) defining the local axes (x, y, z) , which correspond to the reference of orthotropy (L, T, N) . In 2D, it is necessary to only give α what defines the reference (LT) in the plane.

14.4 Operand ANGL_EULER

Définit the 3 Eulerian angles which make it possible to direct the local coordinate system with the element. The Eulerian angles are in the following way defined:

one passes from the fixed reference frame $Oxyz$ to the reference frame related to solid $Ox'y'z'$ by three successive rotations.

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

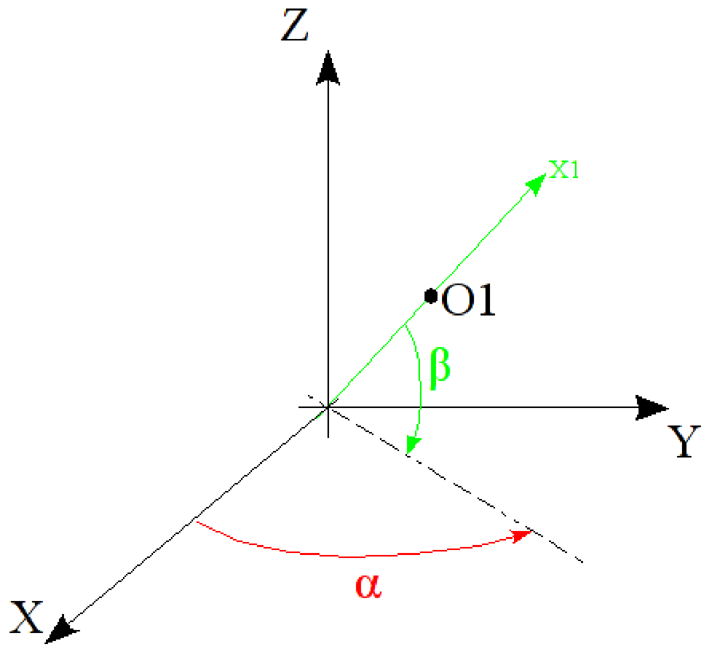


14.5 Operands ANGL_AXE / ORIG_AXE

Ces key words are to be given in 3D only to define local axes for which one will use a property of symmetry of revolution, or of transverse isotropy (for example: structure with orthotropic cylindrical symmetry).

ANGL_AXE = (α , β) defines the axis of revolution $x1$, (α, β) being the first two nautical angles,

ORIG_AXE = (x1, x2, x3) defines a point $O1$ of the axis.



15 Key word POUTRE_FLUI

15.1 Syntax

```
POUTRE_FLUI = _F (
      ♦ / GROUP_MA=     lgma,                        [l_gr_maille]
        / MAILLE=       lma,                            [l_maille]
      ♦ B_T=            LT,                                  [R]
      ♦ B_N=            bn,                                  [R]
      ♦ B_TN=           btn,                                 [R]
      ♦ A_FLUI=         aflui,                               [R]
      ♦ A_CELL=         acell,                               [R]
      ♦ COEF_ECHELLE=   ech,                                 [R]
)
```

15.2 Caractéristiques allocatable

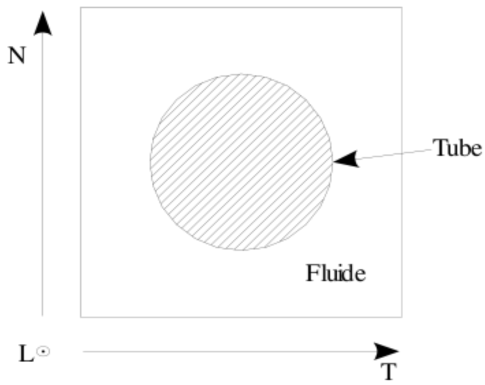
This key word factor makes it possible to define the characteristics of the finite elements (hexahedron with 8 or 20 nodes) associated with modelization "3D_FAISCEAU" (cf command AFFE_MODELE [U4.41.01]). This modelization relates to the representation of a periodic network of tubes bathed by an incompressible fluid (cf [R4.07.05]). An example is given in test SDLV111 [V2.04.111].

15.3 Operand GROUP_MA / NET

Lieu of assignment of the elementary characteristics:
- list the meshes (key word NETS),
- list mesh groups (key word GROUP_MA).

15.4 Operands A_FLUI / A_CELL / COEF_ECHELLE

the periodic cell of the medium to be homogenized is two-dimensional.
The basic periodic cell which is used for compute the homogenized coefficients is obtained by homothety starting from the real periodic cell of the medium.



♦ A_FLUI : Area of the part occupied by the fluid in the periodic cell basic

♦ A_CELL : Area of the periodic cell basic

♦ COEF_ECHELLE: Coefficient of homothety allowing to transform the real periodic cell into the periodic cell basic

15.5 Opérandes B_T / B_N / Homogenized

B_TN Coefficients of the problem fluid-structure calculated in the reference (T, N) [R4.07.05].
The directional sense of this reference is fixed by the key word factor DIRECTIONAL SENSE. The direction L is inevitably parallel to the beam axis of tubes.

16 Key word ROASTS

16.1 Syntax

```
ROASTS = _F (
     ♦ / MAILLE=           lma,                              [l_maille]
       / GROUP_MA=         lgma,                          [l_gr_maille]
     ♦ SECTION=            S1,                                      [R]
       SECTION_FO=         S1fct                             [function]
     ◊ / ANGL_REP=         ( α , β )                              [l_R]
       / AXE=              (vx, vy, vz)                           [l_R]
     ◊ EXCENTREMENT=       ez,                                      [R]
       EXCENTREMENT_FO=    ezfct                             [function]

     ◊ COEF_RIGI_DRZ=      / kz,                                    [R]
                            / 1.E-10,                          [defect]
)
```

16.2 Caractéristiques allocatable

Permet to define characteristics of a mesh wire, modelization of three-dimensions function of reinforcements for the reinforced concrete shells, (see for example test SSNS100 [V6.05.100]), affected with modelizations GRILLE_EXCENTREE or GRILLE_MEMBRANE.
These characteristics are used to define a shell element orthotropic, usable only, or more often superimposed with a concrete shell element.

16.3 Description of the following

Les operands given geometrical are necessary to modelize the three-dimensions function of reinforcements:

◊ ECCENTRING = e_z
EXCENTREMENT_F0= ezfct

ECCENTRING : The eccentring e_z (constant for all the nodes of the mesh) of the three-dimensions function of reinforcements compared to the mesh support (distance measured on the norm of the mesh support), (modelization GRILLE_EXCENTREE only).
EXCENTREMENT_F0 : Function which gives the eccentring (constant for all the nodes of the mesh) of the three-dimensions function of reinforcements compared to the mesh support (distance measured on the norm of the mesh support), (modelization GRILLE_EXCENTREE only). This function depends on geometry (X, Y, Z) and is evaluated at the center of gravity of the mesh.

♦ SECTION= S_1
SECTION_F0= S1fct

SECTION: Section of reinforcements in direction 1, by unit of length. It thus corresponds to the section cumulated over a width unit. If there is a section s all $1/5\text{ème}$ unit, the cumulated section is $5\times s$.
SECTION_FO: Function giving the section of reinforcements in direction 1, by unit of length. It thus corresponds to the section cumulated over a width unit. This function depends on geometry (X, Y, Z) and is evaluated at the center of gravity of the mesh.

◊ COEF_RIGI_DRZ = see key word SHELL [§8].

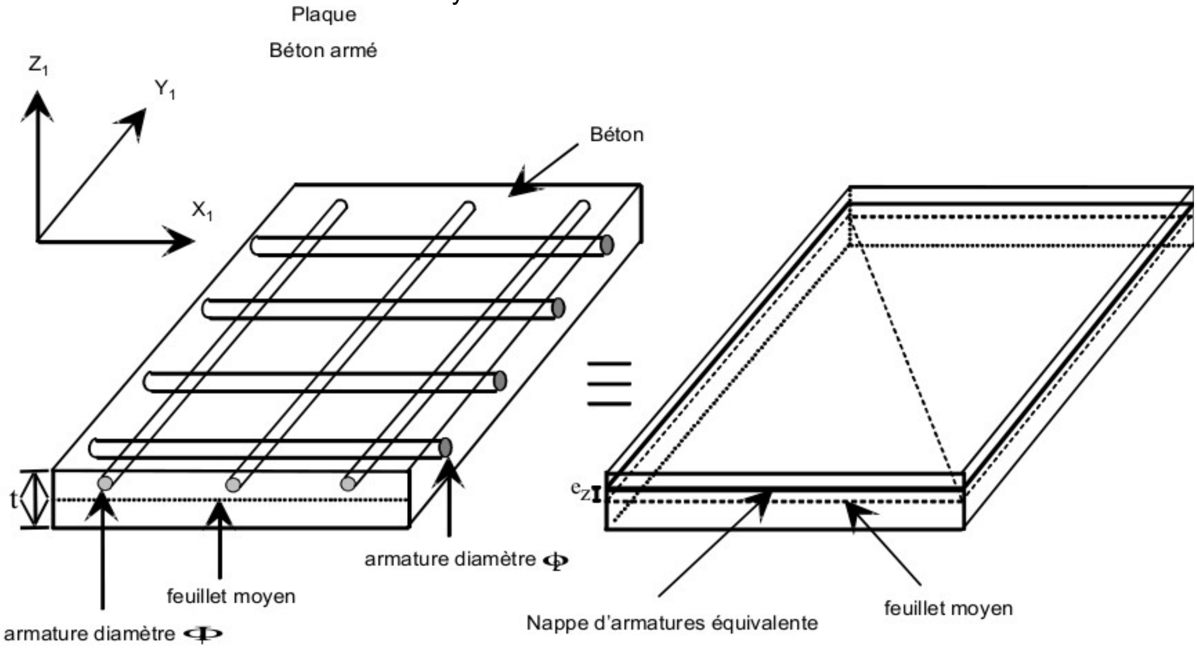
◊ /ANGL_REP = see key word SHELL [§8].

This key word makes it possible to define the reference axis (x_1) . It defines also the reference in which the strains are computed, stresses, curvatures,…

/ AXE= (vx, vy, vz)

Tout comme ANGL_REP, this key word makes it possible to fix the local coordinate system of the element. The projection of the vector indicated via key word AXE defines the local y vector, whereas ANGL_REP determines the local x vector.

For example, in the case of a cylindrical geometry, it makes it possible to define the directions of reinforcements in a circonférencielle way.



Appear 16.3-a : Representation of reinforcements by an equivalent three-dimensions function.

To define a grid or the section of reinforcements in the longitudinal meaning and the transverse one are different, it is necessary to create 2 layers of elements (command CREA_MAILLAGE, key word CREA_GROUP_MA), a layer of element for the longitudinal direction and a second layer of elements for the transverse direction:

```
GRILLE= (
   _F (GROUP_MA = "GEOL",
      SECTION = 0.02,
      ANGL_REP = (0.0, 0.0,),
      ECCENTRING = 0.0,
   ),
   _F (GROUP_MA = "GEOT",
      SECTION = 0.01,
      ANGL_REP = (90.0, 0.0,),
      ECCENTRING = 0.01,
   ),
)
```

17 Key word MEMBRANE

17.1 Syntax

```
MEMBRANE= _F (
     ♦ / MAILLE=       lma,                       [l_maille]
       / GROUP_MA=     lgma,                      [l_gr_maille]
     ◊ / ANGL_REP=     ( α , β )                  [l_R]
       / AXE=          (vx, vy, vz)               [l_R]
)
```

17.2 Caractéristiques allocatable

Permet to define the characteristics of an anisotropic membrane.

17.3 Description of the operands

◊ / ANGL_REP = see key word SHELL [§8].
This key word defines the local coordinate system related to the anisotropic behavior of the membrane, in which the strains and the stresses are computed.

```
/ AXE=        (vx, vy, vz)
```

Tout comme ANGL_REP, this key word makes it possible to fix the local coordinate system of the element. The projection of the vector indicated via key word AXE defines the vector y local, whereas ANGL_REP determines the vector x local.
For example, in the case of a cylindrical geometry, it makes it possible to lay down the directional sense of the membranes in a circonférencielle way.

18 Key word RIGI_PARASOL

18.1 Syntaxe

```
RIGI_PARASOL = _F (
     # Meshes being used to distribute the characteristics of discrete
     ♦ GROUP_MA=          l_gma,                                [l_group_ma]
     # Meshes of the type POI1 corresponding to discrete
     the ◊ / GROUP_MA_POI1=                    gmapoi1,
      [group_ma]
     # Meshes of the type SEG2 corresponding to the discrete ones
      / GROUP_MA_SEG2=    l_gma,                                [l_group_ma]
     # Functions of distribution
     ♦ / FONC_GROUP=      l_fg,                                 [l_fonction]
       / COEF_GROUP=      l_cg,                                     [l_réel]
     # total Stiffness to distribute
     ♦ CARA=              / |'K_TR_D_N'|'K_T_D_N'|
                             |'K_TR_D_L'|'K_T_D_L'|
                             |'A_TR_D_N'|'A_T_D_N'|
                             |'A_TR_D_L'|'A_T_D_L'                   [l_txm]
     ♦ VALE=              l_val,                                    [l_réel]
     ◊ REPERE=            / "LOCAL",
                           / "GLOBAL",                              [defect]
     # Center of gravity
     ♦ / GROUP_NO_CENTRE= gno,                                    [group_no]
       / NOEUD_CENTRE=    Nd,                                         [node]
       / COOR_CENTRE=     l_xyz,                                    [l_réel]
     # EuroPlexus
     ◊ EUROPLEXUS=        / "NON",                                  [defect]
                           / "OUI"
     # Unité of output
     ◊ UNITE=             links,                                   [integer]
),
```

18.2 Caractéristiques allocatable

Cette functionality corresponds to a methodology used to determine the characteristics of discrete elements (springs of translation and/or rotation) to apply to the nodes a basemat starting from results obtained by code PARASOL.
This option is available in 3D and 2D. In case 3D to erase it will be modelized by a surface, in case 2D it will be modelized by a line (test SSNL130 [V6.02.130]). In case 2D the discrete ones are "2D_DIS_TR" or "2D DIS T".

One must affect modelization "DIS_TR" or "DIS_T" in 3D, on the nodes group which compose to erase it. The meshes which compose to erase it (pertaining to the l_gma groups) carry when to them a modelization of plate (DKT, DST) or a modelization of face of 3D (test SDLS108 [V2.03.108]).

It is necessary to distinguish a mesh group for erasing it, to declare behind key word GROUP_MA of the key word factor RIGI_PARASOL, and a mesh group with 1 node which lean on the nodes this basemat which it is necessary to modelize and declare in AFFE_MODELE, either in the form of late meshes behind GROUP_NO, or in the form of specific meshes of type POI1. If the meshes are of type POI1, it should be indicated using key word GROUP_MA_POI1 of the key word factor RIGI_PARASOL.
The use of specific meshes of type POI1 is necessary for the assignment of constitutive laws in the operators of nonlinear computation.

18.3 Description of the operands

♦ `GROUP_MA`
Liste of the mesh groups which compose to erase it.

◊ `GROUP_MA_POI1`
Liste of the groups of points including the nodes of the mesh groups defined by `GROUP_MA`. That makes it possible to declare the nodes of a foundation defined by meshes like meshes specific `POI1` in order to affect characteristics RIGI_PARASOL `TO THEM`. That makes it possible to affect to them materials or behaviors for the use of a nonlinear operator. If it is not present, the nodes are regarded as late meshes for a strictly linear study.

♦ `FONC_GROUP / COEF_GROUP`
Liste of functions or real coefficients. There are as many arguments in this list than there are mesh groups which compose to erase it (definite under key word `GROUP_MA)`. The functions must have as a X-coordinate the distance to the center of gravity (key word defined by `GROUP_NO_CENTRE` / `NOEUD_CENTRE` / `COOR_CENTRE)`.

♦ `CARA / VALE`
Les total stiffness of ground, resulting from code `PARASOL` are provided by the user using key words `CARA` and `VALE` as for the discrete elements. One can also select the nature of the reference (total or local) in which one defines the characteristics of springs (key word `REPERE`). Stiffness or the depreciation only defined in translation can also be distributed (`K_T_D_N` or `A_T_D_N` , not of stiffness in rotation), in this case it is only necessary to give 3 values behind $VALE=(k_x, k_y, k_z)$.

```
♦ / GROUP_NO_CENTRE=   gno
  / NOEUD_CENTRE=      Nd
  / COOR_CENTRE=       l_xyz
```
Pour to define the center of the basemat (calculated by code `PARASOL)`, one can either give the coordinates (three realities given behind key word `COOR_CENTRE)`, or to give the name of a node of the mesh (for more facility, one accepts also the name of a nodes group but the aforementioned should contain one node: key word `GROUP_NO_CENTRE` or `NOEUD_CENTRE)`.

◊ `EUROPLEXUS`
If this key word is `OUI`, *Code_Aster* creates a structure of data exploited by macro command `CALC_EUROPLEXUS`. For more detail to see documentation associated with Europlexus and the case test `PLEXU01A` which implements this functionality.

◊ `UNITE`
If this key word is present, Code_Aster creates a file, corresponding to the number of unit, which contains the stiffness of discrete affected with the various nodes.

18.4 Principle of determination of the characteristics of the discrete elements

the document [R4.05.01] “ seismic Response by transient analysis ” gives theoretical information on the method employed.
In 3D, to erase it is represented by a set of surface elements of center of gravity O . Using code `PARASOL`, one obtains 6 total quantities which characterize the coupling ground-to erase: three stiffness of translation K_x, K_y, K_z and three stiffness of rotation Kr_x, Kr_y, Kr_z .
In each node of the mesh of the basemat, *Code_Aster* seeks the characteristics in stiffness of a discrete element of the type `K_TR_D_N` $(k_x, k_y, k_z, kr_x, kr_y, kr_z)$ cf [R4.05.01].
To determine the stiffness of translation, one forces that they are proportional to the surface represented by the node and a function of distribution depending on the distance to the center of gravity of the basemat. That is to say $S(P)$ the surface attached to the node P and $f(r)$ the function of distribution where r is the distance from the node P to the node O .

For the stiffness of rotation, one distributes the remainder in the same way (what remains after having removed the contributions due to the translations) that the translations.

If one computes the forces and the moments resulting at the point O due to the distribution from springs in each node of the mesh of the basemat and if one identifies them with the values obtained by PARASOL, one obtains the following formulas:

$$k_x = K_x / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_x(p) = k_x S(p) f(op)$$

$$k_y = K_y / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_y(p) = k_y S(p) f(op)$$

$$k_z = K_z / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_z(p) = k_z S(p) f(op)$$

$$k_{rx} = \left(K_{rx} - \sum_p \left(k_z(p) y_{op}^2 + k_y(p) z_{op}^2 \right) \right) / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_{rx}(p) = k_{rx} S(p) f(op)$$

$$k_{ry} = \left(K_{ry} - \sum_p \left(k_x(p) z_{op}^2 + k_z(p) x_{op}^2 \right) \right) / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_{ry}(p) = k_{ry} S(p) f(op)$$

$$k_{rz} = \left(K_{rz} - \sum_p \left(k_x(p) y_{op}^2 + k_y(p) x_{op}^2 \right) \right) / \left(\sum_p S(p) f(op) \right) \quad ; \quad k_{rz}(p) = k_{rz} S(p) f(op)$$

If the key word `INFO = 2`, the computed values above are written in file `MESSAGE` with the format of the commands of *Code_Aster*.

Notice 1 :

Calculation of the area attached to the point P.
For each surface mesh of the basemat, one computes surface, one divides it by the number of tops of the mesh and one affects this contribution to each node of the mesh. One ensures then:

$$S_{radier} = \sum_p S(p)$$

Notice 2:

It is considered that one can apply the same formulas to carry out a distribution of discrete elements of damping.

18.5 Example of use

Exemple n°1

```
carac = AFFE_CARA_ELEM (
   RIGI_PARASOL = _F (GROUP_MA = erase,
                      COEF_GROUP = 2. ,
                      CARA = ("K_TR_D_N", "A_TR_D_N"),
                      VALE = (6 realities, 6 realities),
                      NOEUD_CENTRE = "P1",
                   ),
)
```

Exemple n°2: `INFORMATION = 2`

```
carelem=AFFE_CARA_ELEM (INFO =2,
   MODELE=model,
   RIGI_PARASOL=_F (GROUP_MA='PAVE',
                  GROUP_MA_POI1='ARISES',
                  COEF_GROUP=1.0,
                  REPERE='GLOBAL',
                  CARA='K_T_D_N',
                  VALE= (10000.0, 10000.0, 10000.0,),
                  GROUP_NO_CENTRE='PCDG',),
)
```

an extract of the display in the output file:

```
PAS DE REPARTITION EN ROTATION POUR DES K_T_D_N

 _F (NOEUD='N1      ", CARA='K_T_D_N",
    VALE= (  1.56250E+02,  1.56250E+02,  1.56250E+02,),
    REPERE='GLOBAL'),
 _F (NOEUD='N2      ", CARA='K_T_D_N",
    VALE= (  1.56250E+02,  1.56250E+02,  1.56250E+02,),
    REPERE='GLOBAL'),
 _F (NOEUD='N3      ", CARA='K_T_D_N",
    VALE= (  3.12500E+02,  3.12500E+02,  3.12500E+02,),
    REPERE='GLOBAL'),
```

19 Key word RIGI_MISS_3D

19.1 Syntaxe

```
RIGI_MISS_3D = _F (
     ♦ GROUP_MA_POI1=      l_gma,                    [l_group_ma]
     ◊ GROUP_MA_SEG2=      l_gma,                    [l_group_ma]
     ♦ FREQ_EXTR=          freq,                     [R]
     ◊ UNITE_RESU_IMPE=    / links,                  [I]
                            / 30,                    [DEFAUT]
)
```

19.2 Caractéristiques allocatable

the use of this key word is dedicated to problems of separation of foundation in order to better take into account the carpet of springs of ground than RIGI_PARASOL does IT which proportionally distributes 6 total stiffness under a foundation on the surfaces of the elements surrounding its nodes.

This key word will affect the exact terms of a matrix of impedance computed by MISS3D for every degrees of freedom of application interface (3 times the number of nodes) and for frequency of extraction given. The assignment of these terms (modelization "DIS_T") is then made with specific meshes POI1 nodes of the surface foundation and possibly with the lines of the network of SEG2 superimposed on the foundation to represent transverse connections between nodes.

19.3 Description of the operands

SPECIFIC ♦
GROUP_MA_POI1 Mesh group of the nodes of the foundation.

◊ GROUP_MA_SEG2
Mesh group of SEG2 connecting the nodes of the foundation transversely.

♦ FREQ_EXTR
Frequency of extraction of the matrix of impedance.

LOGICAL ◊
UNITE_RESU_IMPE Unité of the matrix of impedance calculated by MACRO_MISS_3D option MISS_IMPE.

20 Key word MASS_AJOU

20.1 Syntaxe

```
MASS_AJOU = _F (
     ♦ GROUP_MA=          l_gma,                               [l_group_ma]
     ♦ GROUP_MA_POI1=     l_gma,                               [l_group_ma]
     ♦                    FONC_GROUP= l_fg,                    [l_fonction]
)
```

20.2 Caractéristiques allocatable

the objective of this key word is to take into account simply the added mass of fluid in the problems of stoppings without having to modelize the fluid as in MACRO_MATR_AJOU and to preserve only structure for nonlinear dynamic studies.
The idea is thus, in a new option of AFFE_CARA_ELEM, to distribute characteristics of point mass to the nodes of the application interface fluid-structure of the face upstream without adding degrees of freedom apart from structure.

One is inspired thus by the distribution by total characteristics by rigidity or damping by option RIGI_PARASOL by AFFE_CARA_ELEM.

In this new option MASS_AJOU, one distributes with the nodes of the interface fluid-structure with characteristics "M_T_N" of the elementary values of directional mass obtained by integration of the normal pressure to each element starting from functions of distribution of this normal pressure depending on the coordinates - in particular of altitude - in order to express relations of Westergaard for example or more simply the statement of the hydrostatic pressure.

The assignment of these terms (modelization "DIS_T" to declare in AFFE_MODELE) is then made with specific meshes POI1 nodes of the interface fluid-structure using key word GROUP_MA_POI1 of the key word factor MASS_AJOU.

It is necessary to distinguish this specific meshes from the surface mesh groups for the interface fluid-structure, to declare behind key word GROUP_MA .

20.3 Description of the operands

SURFACE ♦
GROUP_MA Mesh groups of the interface fluid-structure.

SPECIFIC ♦
GROUP_MA_POI1 Mesh group of the nodes of the interface fluid-structure.

♦ FONC_GROUP
Liste of functions of distribution of this normal pressure depending on the coordinates. There are as many arguments in this list than there are mesh groups which compose the interface fluid-structure (definite under key words GROUP_MA or GROUP_MA_POI1). The functions must be homogeneous with one density surface of mass, that is to say a pressure divided by the acceleration of gravity.