Macro-command MACR_CARA_POUTRE

This macro command makes it possible to calculate the characteristics of a cross section of beam from a 2D mesh of its cross section.

It makes it possible to build an array of values, usable by the command AFFE_CARA_ELEM [U4.42.01] to assign characteristics of cross-sections to all the finite elements of beam (modelizations POU_D_E, POU_D_T, POU_C_T, POU_D_TG, POU_D_EM, POU_D_TGM) or of bar (modelization BARS) unspecified section.

The characteristics necessary are defined in the note of reference [R3.08.03]. It is:
- the geometrical characteristics (which can be calculated on the complete mesh, half mesh with symmetry compared to Y or with Z, quarter of mesh with two symmetries compared to Y and with Z),
- characteristics of torsion: radius of torsion, constant of stiffness in torsion, position and eccentricity of the center of torsion for flexure-torsion coupling,
- characteristics of shears for the models with shear deformations,
- characteristics of warping for the models of torsion of the asymmetric sections “open”.

The macro-command produces a concept of the table_sdaster type containing the characteristics of the section. The values contained in this array can be used, via Python, in the command AFFE_CARA_ELEM for a computation of type beam or by informing the array produced in AFFE_CARA_ELEM via the key word WILL TABLE_CARA.

1 Syntax

```
Tb [table_sdaster] = MACR_CARA_POUTRE (

◊MAILLAGE=MA          ,
    [mesh]
# if mesh is not indicated
   /UNITE         =20 ,                                          [default]
   /FORMAT        =/ASTER                                        [default]
                   /MED
                   /IUNI,                                        [integer]
◊INFO=                /1                                        [default]
                   /2
◊ORIG_INER=           /(YP, ZP),                                 [l_réel]
                   /(0.0, 0.0)                                  [default]
◊TABLE_CARA=     /"OUI'
                   /"NON"                                       [default]

# Characteristic geometrical only
/◊      |         SYME_Y= "OUI',
        |         SYME_Z= "OUI',
   ◊GROUP_MA=                                                      LGM,
    [l_gr_maille]

# Characteristic geometrical and mechanics of a section
/◊GROUP_MA_BORD=                                                   LGB,
    [l_gr_maille]
   ◊/NOEUD=            LN,                                      [node]
       /GROUP_NO       = GN,                                  [group_no]
   ◊GROUP_MA_INTE=                                                 LGI,
    [l_gr_maille]
   # if WILL TABLE_CARA = "YES"
   ◊NOM=                                                           NAME
    [texte_8]

# Characteristic of a network of beams between two bottoms
/◊GROUP_MA_BORD=                                                   LGB,
    [l_gr_maille]
   ◊GROUP_MA=                                                      LGM,
    [l_gr_maille]
   ◊LONGUEUR=                                                        H,
    [reality]
   ◊MATERIAU=                                                    MATER,
    [to subdue]
   ◊LIAISON=          /"HINGE",
                        /"ENCASTREMENT",
)
```

2 Operands

2.1 Operand MAILLAGE

◊ MAILLAGE
Name of the mesh 2D of the section of beam which one will calculate them characteristics. If the name of the mesh is not given, it is necessary to inform the key keys according to so that the macro command carries out reading LIRE_MAILLAGE BY THE COMMAND.

◊ UNITE
logical Number of unit for the reading of the mesh 2D of the section of beam which one will calculate the characteristics.

◊ FORMAT
Format of mesh file

the Note::
If one must make several calls with MACR_CARA_POUTRE *in the same command file de on the same mesh or the different meshes UNITE should then* BE CHANGED *.*

2.2 Operand TABLE_CARA

◊TABLE_CARA=' OUI'
When this option is present, the produced array contains only the parameters useful to AFFE_CARA_ELEM.
When operand NOM is given (if GROUP_MA is not indicated), one Re finds to this you value in the column PLACE of the array. That makes it possible to the user to give a name to its section, which it can use in AFFE_CARA_ELEM . If GROUP_MA is indicated, the names of the mesh groups are directly usable in AFFE_CARA_ELEM .

2.3 Operands SYME_Y / SYME_Z

◊ | SYME_Y
Specifies that the mesh provided by the user corresponds to a half mesh. The computation characteristics of the cross-section takes account of a symmetry compared to $Y=0$.
| SYME_Z
Specifies that the mesh provided by the user corresponds to a half mesh. The computation characteristics of the cross-section takes account of a symmetry compared to $Z=0$.
The simultaneous use of the two options makes it possible to provide only one quarter of the mesh.
The properties of symmetry are used to accelerate the computation of the geometrical characteristics.

Note:
Key keys SYME_Y *and* SYME_Z *are used only for the computation of the geometrical characteristics. The mechanical characteristics (constant of torsion, warping constant, shear coefficients) do not take account of it. To calculate them, it is thus necessary to net the section in integer. This is why* SYME_Y *and* SYME_Z *cannot be simultaneously indicated with* GROUP_MA_BORD *.*

2.4 Computation of the mechanical characteristics

◊ GROUP_MA_BORD = lgb
lgb indicates one (or several) mesh group (SEG2 or SEG3) describing the contour (closed) of the section with a grid. It is the presence of this key word which involves the computation of the mechanical characteristics of the section (cf [U4.42.01] AFFE_CARA_ELEM, key word POUTRE).

◊ GROUP_MA_INTE = lgi
lgi indicates one or more mesh groups describing hole contours possible. This data is used with computation of the constant as torsion.

◊GROUP_MA = lgm

lgm corresponds to a list of mesh groups for which the computation of the characteristics must be carried out independently. This functionality makes it possible in particular to search the characteristics of beam equivalent to several disjoined sections. If one wishes the computation of the mechanical characteristics for each group of mesh, it is then necessary to give a mesh group of edge per section (using key word GROUP_MA_BORD). The lists lgb and lgm must then correspond.

◊ORIG_INER = (YP, zp)
This key word defines the point where the inertial characteristics of the section are calculated. The values of the main moments of inertia are then provided in this point and to the center of gravity of the section (for all the mesh or for each group of mesh if GROUP_MA is specified).

◊NOEUD = ln,
GROUP_NO = lgn,
For the computation of the shear coefficients (if key word GROUP_MA_BORD is present), one is brought to solve a thermal problem on the section (or each group of the list lgm), with for only boundary condition a source term. This can produce alarm messages due to the presence of null pivots, without the quality of result being affected. To avoid these alarm messages, it is possible to give a node or a nodes group (or one nodes list or of nodes group if lgm is given) for which the temperature is imposed.

◊NOM = name,
When NAME is indicated and that TABLE_CARA=' OUI' the name of the section is indicated in the column PLACE of the array. That makes it possible to the user to directly use the array in AFFE_CARA_ELEM to assign the mechanical magnitudes to various linear elements.

2.5 Cases of network of beams

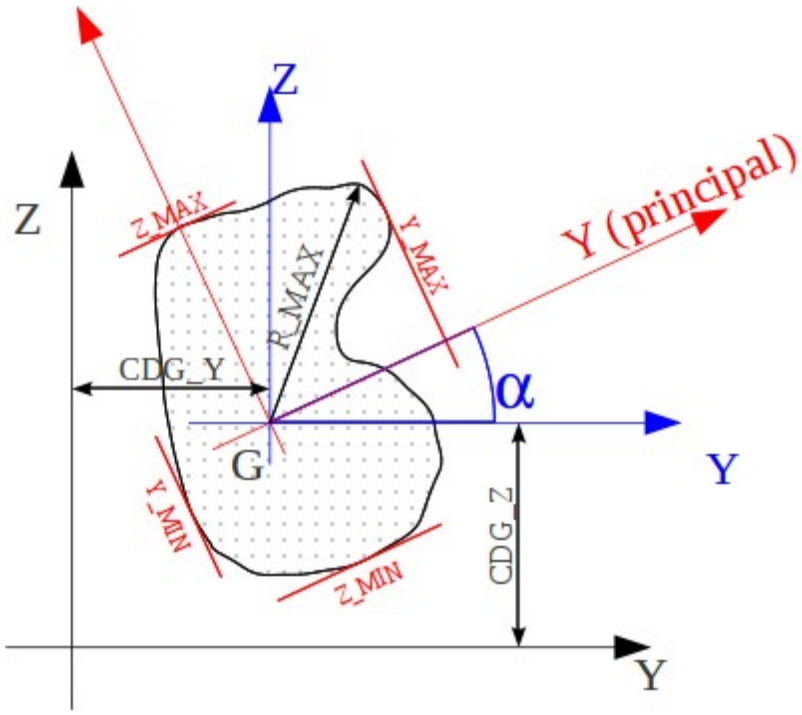
◊LONGUEUR= H,
MATERIAU= to subdue,
LIAISON= /"HINGE",
/"ENCASTREMENT",
These three key words allow the computation of the shear coefficients equivalent to a set of parallel beams (columns) located between two bottoms, distant the length h. the sections of these beams are defined by the key word GROUP_MA.
They all are made up of the same linear elastic material (key word MATERIAU). Connection with lower bottom is of standard “fixed support”. That with higher bottom is indicated by the key word LIAISON.

3 of the produced quantities

3.1 References used for the geometrical characteristics

Two references are used:

- the reference OYZ of description of the mesh 2D;
- the principal reference of inertia Gyz. cross-section, whose denomination corresponds to that used with the description of the neutral fiber beam elements Gx [U4.42.01].



Appear 3.1-aDefinition of the geometrical magnitudes relative to a section of beam.

3.2 Quantities available in the produced array

3.2.1 Characteristic geometrical

These characteristics are given in the array for all the mesh and each group of the list `lgm` (which can correspond to a half or a quarter of the section if key keys `SYME_Y` or `SYME_Z` are present).

3.2.1.1 Characteristics of the mesh read

- area: `A_M`
- position of the center of gravity: `CDG_Y_M, CDG_Z_M`
- moments and product of inertia of area, at the center of gravity G in the reference GYZ :
  `IY_G_M IZ_G_MIYZ_G_M`

3.2.1.2 Characteristic of the section of beam

- area: `A`
- position of the center of gravity: `CDG_Y, CDG_Z`
- moments and product of inertia of area, at the center of gravity G in the reference GYZ :
  `IY_G IZ_G IYZ_G`
- principal main moments of inertia of area in the reference Gyz, usable for the computation of the flexural rigidity of beam: `IY` and `IZ`
- angle of flow of the reference GYZ to the principal reference of inertia Gyz : `ALPHA`
- characteristic distances, compared to the center of gravity G of the section for computations of maximum stresses: `Y_MAX`, `Y_MIN`, `Z_MAX`, `Z_MIN` and `R_MAX`.

- RY and RZ: maximum of Y_MIN and Y_MAX and Z_MIN and Z_MAX.
- Y_P, Z_P : not computation of the geometrical main moments of inertia
- IY_P, IZ_P, IYZ_P : geometrical main moments of inertia in reference PYZ
- IY_P, IZ_P : main moments of inertia in the reference Pyz .
- IYR2_G, IZR2_G, IYR2, IZR2, IXR2_P, IYR2_P : useful characteristics for the geometrical stiffness matrix of elements POU_D_TG and POU_D_TGM. For more detail on the definition of the quantities to see [R3.08.04]:

$$I_{yr}^2=\int_S y(y^2+z^2)\,dS \quad I_{zr}^2=\int_S z(y^2+z^2)\,dS$$

3.2.2 "Mechanical" characteristics

These characteristics are provided in the array for all the mesh and each group of mesh of the list lgm.

3.2.2.1 Characteristics of torsion

- constant of torsion: JX
  the resolution of a steady thermal problem of unknown phi makes it possible to determine the constant of torsion and the shearing stresses.
- radius of torsion: RT
  the radius of torsion Rt can vary along external contour; indeed, for an unspecified section, the shears due to torsion vary on edge. One chooses to take the value of Rt leading to the shears maximum on external edge, it has to say the maximum value of Rt (in absolute value) on external contour. Moreover, if the section is alveolate, there is several "several radius torsion": $Rt=2*A(k)/L(k)$ (where $A(k)$ the area of the cell and k its $L(k)$ perimeter represents).
  If one is satisfied to search the maximum value of the shears, it is necessary to take the maximum of the values Rt obtained on external edge and the cells.
- Position of the center of torsion (not C) in reference GYZ : PCTY and PCTZ. One from of deduced eccentricity from the center of torsion (component of CG in the principal reference of Gyz inertia): EY and EZ.
- Warping constant (usable for modelizations POU_D_TG and POU_D_TGM with 7 degrees of freedom): JG.

3.2.2.2 Characteristics of shears

the shear coefficients are given, in the principal reference of inertia Gyz , in the form of the ratio (>1) of the total area to the actually sheared area: AY and AZ.

3.3 Assignment of the quantities in AFFE_CARA_ELEM

the characteristics contained in this array and which can be used in AFFE_CARA_ELEM have the same names as the characteristics expected under key word CARA of the command AFFE_CARA_ELEM.
The results calculated by MACR_CARA_POUTRE can be transmitted simply to AFFE_CARA_ELEM via key word TABLE_CARA.

4 Examples of use

4.1 Characteristic of a section in angle with equal wings

$(50\times 50\times 8)$ treaty by test SSLL107A [V1.01.105].

4.1.1 Studied section

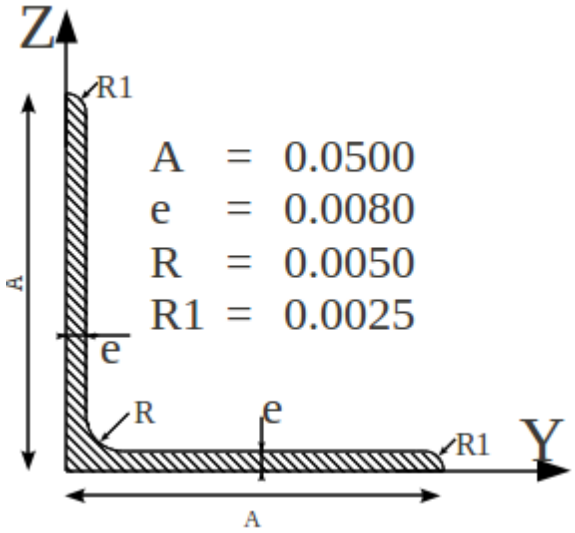


Figure : Angle with equal wings 50x50x8.

4.1.2 Command file

TCARA = MACR_CARA_POUTRE (GROUP_MA_BORD = "LSURF", NOEUD = "N1", INFO = 2) or LSURF is the group of meshes linear contour of the section.

4.1.3 Geometrical characteristics obtained

the characteristics of the mesh are identical to those of the section. They are in conformity with those found in the "Catalog of iron and steel products OTUA: Condition of uses in steel construction - 1959"

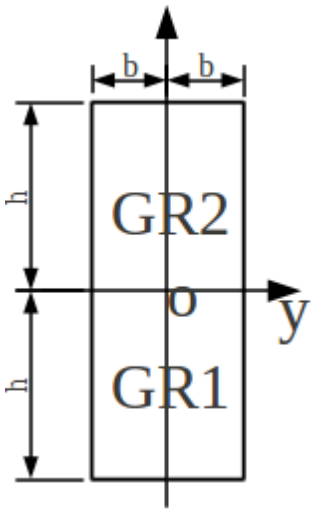
```
A_M=A=7.39E-4
CDG_Y_M=CDG_Y=1.53148E-02
CDG_Z_M=CDG_Z=1.53148E-02
IY_G_M=IY_G=1.64141E-07
IZ_G_M=IZ_G=1.64141E-07
IYZ_G_M=IYZ_G=-9.48843E-08
IY=2.59025E-07
IZ=6.92568E-08

ALPHA=45°
OG==2.166E-02
Y_MIN=-OG=-2.166E-02
Y_MAX      ==1.465E-02
Z_MIN      ==-3.536E-02          -A cos(α/4)
Z_MAX      ==3.536E-02           A cos(α/4)
R_MAX      Characteristic
==3.792E-02
RY=-Y_MIN=2.166E-02
```

4.1.4 RZ=Z_MAX=3.536E-02 mechanical

```
JX=1.596E-8
RT=1.164E-2
PCT_Y=4.665E-3
PCT_Z=4.665E-3
              EY=1.51E- 0 2
EZ=0.00
AY=2.174
AZ=2.174
```

4.2 Right-angled full (treated by test SSLL107G)

4.2.1 studied Section



$b=0.01$
$h=0.025$
One defines 3 mesh groups:
$GR1$ to the part corresponds $y \leq 0$
$GR2$ to the part corresponds $y \geq 0$
$LR1$ to meshes linear of contour Orders

4.2.2 TCARS

```
corresponds = MACR_CARA_POUTRE (GROUP_MA_BORD = "LR1", NOEUD = "N64")
```

4.2.3 Characteristic geometrical obtained

PLACE	A_M	CDG_Y_M	CDG_Z_M	IY_G_M	IZ_G_M	IYZ_G_M
0.000003	1.00E-03	4.24E-18	-3.39E-18	2.08E-07	3.33E-08	2.65E-23
GR1	5.00E-04	2.20E-17	-1.25E-02	2.60E-08	1.67E-08	3.97E-23
GR2	5.00E-04	-8.47E-18	1.25E-02	2.60E-08	1.67E-08	5.62E-23

PLACE	A	CDG_Y	CDG_Z	IY_G	IZ_G	IYZ_G
0.000003	1.00E-03	4.24E-18	-3.39E-18	2.08E-07	3.33E-08	2.65E-23
GR1	5.00E-04	2.20E-17	-1.25E-02	2.60E-08	1.67E-08	3.97E-23
GR2	5.00E-04	-8.47E-18	1.25E-02	2.60E-08	1.67E-08	5.62E-23

PLACE	IY	IZ	Y_P	Z_P	IY_P	IZ_P
0.000003	3.33E-08	2.08E-07	0.00E+00	0.00E+00	2.08E-07	3.33E-08
GR1	1.67E-08	2.60E-08	0.00E+00	0.00E+00	1.04E-07	1.67E-08
GR2	1.67E-08	2.60E-08	0.00E+00	0.00E+00	1.04E-07	1.67E-08

PLACE	IYZ_P	IY_PRIN_P	IZ_PRIN_P	Y_MAX	Z_MAX	Y_MIN
0.000003	2.65E-23	3.33E-08	2.08E-07	2.50E-02	1.00E-02	-2.50E-02
GR1	-9.79E-23	1.67E-08	1.04E-07	2.50E-02	2.25E-02	-2.50E-02
GR2	3.31E-24	1.67E-08	1.04E-07	2.50E-02	-2.50E-03	-2.50E-02

PLACE	Z_MIN	R_MAX	JX	AY	AZ	EY
0.000003	-1.00E-02	2.69E-02	-	-	-	-
GR1	2.50E-03	3.36E-02	3.43E-08	1.20E+00	1.20E+00	9.00E-17
GR2	-2.25E-02	3.36E-02	3.43E-08	1.20E+00	1.20E+00	-4.03E-17

PLACE	EZ	PCTY	PCTZ	RT	ALPHA
0.000003	-	-	-	1.93871E-2	9.00E+01
GR1	-3.97E-18	2.60E-17	-1.25E-02	1.56391E-2	9.00E+01
GR2	1.19E-16	-1.27E-16	1.25E-02	1.56391E-2	9.00E+01