
Macro-order MACR_CARA_POUTRE

This macro order makes it possible to calculate the characteristics of a cross section of beam starting from a grid 2D of its cross section.

It makes it possible to build a table of values, usable by the order `AFFE_CARA_ELEM [U4.42.01]` to assign characteristics of cross-sections to all the finite elements of beam (modelings `POU_D_E`, `POU_D_T`, `POU_D_TG`, `POU_D_EM`, `POU_D_TGM`) or of bar (modeling `BAR`) of 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 grid, half grid with symmetry compared to Y or with Z , quarter of grid with two symmetries compared to Y and with Z),
- characteristics of torsion: ray of torsion, constant of rigidity in torsion, position and offsetting of the center of torsion for the coupling inflection-torsion,
- characteristics of shearing for the models with deformations of shearing action,
- characteristics of warping for the models of torsion of the nonsymmetrical opened sections.

The macro-order produces a concept of the type `table_sdaster` containing the characteristics of the section. The values contained in this table can be used, via Python, in the order `AFFE_CARA_ELEM` for a calculation of type beam or by informing the table produced in `AFFE_CARA_ELEM` via the keyword `WILL TABLE_CARA`.

1 Syntax

```
Tb[table_sdaster] = MACR_CARA_POUTRE (  
  
  ◇ / GRID = MY, [grid]  
  # If grid is not indicated  
  / ◇ UNIT = [IUNI (20)], [entirety (defect)]  
    ◇ FORMAT =/'MED' [defect]  
      / 'ASTER'  
  ◇ INFORMATION = [1, 2] [defect]  
  
  # Not by report to which inertias are calculated  
  ◇ ORIG_INER =/(YP, ZP), [l_réel]  
    / (0.0,0.0) [defect]  
  
  ◇ TABLE_CARA = ['YES' | 'NOT'] [defect]  
  
  # Conditions of symmetries  
  / ◇ SYME_Y = 'YES',  
    ◇ SYME_Z = 'YES',  
  # Groups (S) linear meshes, edge (S) of (S) section (S)  
  / ◇ GROUP_MA_BORD = lgb, [l_gr_maille]  
    ◇ GROUP_NO = lgn, [group_no]  
    ◇ GROUP_MA_INTE = lgi, [l_gr_maille]  
  
  # Calculation of the equivalent characteristics for disjointed sections  
  ◇ GROUP_MA = lgm, [l_gr_maille]  
  
  # Name of the section: If TABLE_CARA=' OUI' and nonwell informed GROUP_MA  
  ◇ NAME = NAME [txt_8]  
  
  # Characteristic of a network of beams between two floors  
  # SI GROUP_MA_BORD and GROUP_MA informed  
  ◇ LENGTH = h, [reality]  
  ◇ MATERIAL = to subdue, [to subdue]  
  ◇ CONNECTION = ['KNEECAP', 'EMBEDDING']  
)
```

2 Operands

2.1 Operand GRID

/ \diamond GRID

Name of the grid 2D of the section of beam which one will calculate the characteristics. If the name of the grid is not given, it is necessary to inform the key words according to so that the macro order carries out the reading by the order LIRE_MAILLAGE.

Note:

When the section consists of elements low thicknesses (tubes, reconstituted sections,...), it is necessary to have several meshes in this thickness to correctly calculate the characteristics related to torsion.

/ \diamond UNIT

Logical number of unit for the reading of the grid 2D of the section of beam which one will calculate the characteristics.

\diamond FORMAT

Format of the file of grid

Note:

If one must make several calls with MACR_CARA_POUTRE in the same command file de on the same grid or the different grids it is then necessary to change UNIT.

2.2 Operand TABLE_CARA

\diamond TABLE_CARA = 'YES'

When this option is present, the produced table contains only the parameters useful to AFFE_CARA_ELEM.

When the operand NAME is given (if GROUP_MA is not well informed), one Re finds to this you value in the column PLACE table. 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 well informed, the names of the groups of meshes are directly usable in AFFE_CARA_ELEM.

2.3 Operands SYME_Y / SYME_Z

\diamond | SYME_Y

Specify that the grid provided by the user corresponds to a half grid. The calculation of the characteristics of the cross-section takes account of a symmetry compared to $Y=0$.

| SYME_Z

Specify that the grid provided by the user corresponds to a half grid. The calculation of the 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 grid.

The properties of symmetry are used to accelerate the calculation of the geometrical characteristics.

Note:

Keywords SYME_Y and SYME_Z NE are used that for the calculation of the geometrical characteristics. The mechanical characteristics (constant of torsion, constant of warping, coefficients of shearing) do not take account of it. To calculate them, it is thus necessary to net the section in entirety. This is why SYME_Y ET SYME_Z NE cannot be simultaneously indicated with GROUP_MA_BORD.

2.4 Calculation of the mechanical characteristics

◇ GROUP_MA_BORD = **lgb**

lgb indicate one (or several) groups meshes (SEG2 or SEG3) describing the contour (closed) of the section with a grid. It is the presence of this keyword which involves the calculation of the mechanical characteristics of the section (cf. [U4.42.01] AFFE_CARA_ELEM, keyword BEAM).

◇ GROUP_MA_INTE = **lgi**

lgi indicate one or more groups of meshes describing contours of possible holes. This data is used with calculation of the constant as torsion.

◇ GROUP_MA = **lgm**

lgm corresponds to a list of groups of meshes for which the calculation of the characteristics must be carried out independently. This functionality makes it possible in particular to search the characteristics of beam equivalent to several disjointed sections. If one wishes the calculation of the mechanical characteristics for each group of mesh, it is then necessary to give a group of meshes of edge by section (using the keyword GROUP_MA_BORD). Lists **lgb** and **lgm** must then correspond.

◇ ORIG_INER = (YP, zp)

This keyword defines the point where the inertial characteristics of the section are calculated. The values of the moments of inertia are then provided in this point and to the centre of gravity of the section (for all the grid or for each group of mesh if GROUP_MA is specified).

◇ GROUP_NO = **lgn**

For the calculation of the coefficients of shearing (if the keyword 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 messages of alarm due to the presence of worthless pivots, without the quality of the result being affected. To avoid these messages of alarm, it is possible to give a group of Nœuds or a list of group of nodes (in the same way cardinal than **lgm**) for which the temperature is imposed. Each GROUP_NO must contain one node.

◇ NAME = name

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

2.5 Case of network of beams

◆ LENGTH = H,

◆ MATERIAL = to subdue,

◆ CONNECTION = [' KNEECAP', 'ENCASTREMENT'],

These three keywords allow the calculation of the coefficients of shearing equivalent to a set of parallel beams (posts) located between two floors, distant the length h. the sections of these beams are defined by the keyword GROUP_MA.

They all are made up of same linear elastic material (keyword MATERIAL). The connection with the lower floor is of standard "embedding". That with the higher floor is indicated by the keyword CONNECTION.

3 Definition of the produced sizes

3.1 Reference marks used for the geometrical characteristics

Two reference marks are used:

- the reference mark OYZ of description of the grid 2D;
- the principal reference mark of inertia G_{yz} cross-section, whose denomination corresponds to that used with the description of the elements of neutral fibre beam G_x [U4.42.01].

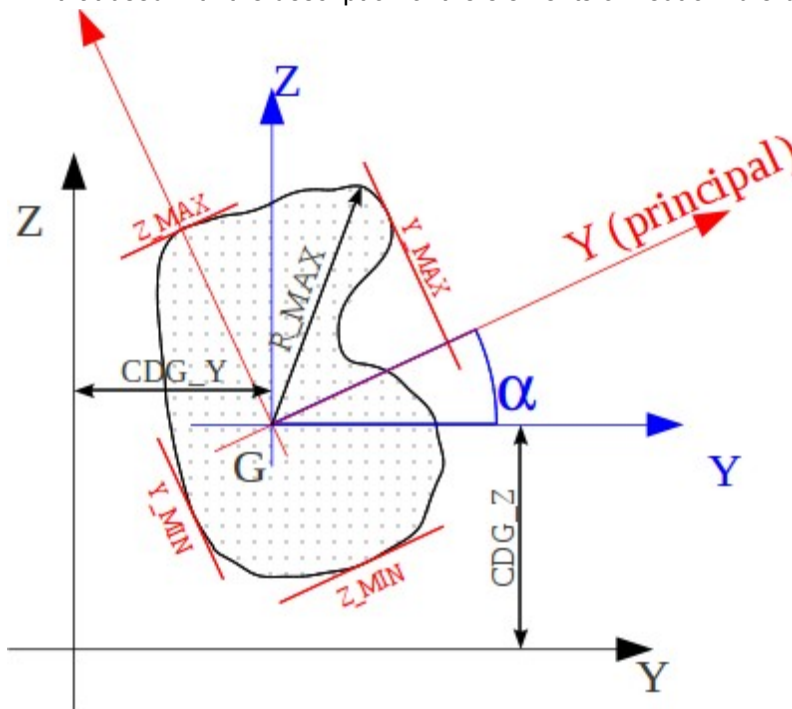


Figure 3.1-a : Definition of the geometrical magnitudes relative to a section of beam.

3.2 Sizes available in the produced table

3.2.1 Geometrical characteristics

These characteristics are given in the table for all the grid and each group of the list **lgm** (which can correspond to a half or a quarter of the section if the keywords `SYME_Y` or `SYME_Z` are present).

3.2.1.1 Characteristics of the grid read

- surface: `A_M`
- position of the centre of gravity: `CDG_Y_M`, `CDG_Z_M`
- moments and product of inertia of surface, in the centre of gravity G in the reference mark GYZ :

`IY_G_M` `IZ_G_M` `IYZ_G_M`

3.2.1.2 Characteristics of the section of beam

- surface: `WITH`
- position of the centre of gravity: `CDG_Y`, `CDG_Z`
- moments and product of inertia of surface, in the centre of gravity G in the reference mark GYZ :

`IY_G` `IZ_G` `IYZ_G`

- principal moments of inertia of surface in the reference mark G_{yz} , usable for the calculation of the rigidity of inflection of the beam: IY and IZ
- angle of flow of the reference mark GYZ with the principal reference mark of inertia G_{yz} : ALPHA
- characteristic distances, compared to the centre of gravity G section for calculations of maximum constraints: Y_MAX , Y_MIN , Z_MAX , Z_MIN and R_MAX .
- RY and RZ : maximum of Y_MIN and Y_MAX and of Z_MIN and Z_MAX .
- Y_P , Z_P : not calculation of the geometrical moments of inertia
- IY_P , IZ_P , IYZ_P : geometrical moments of inertia in the reference mark PYZ
- IY_P , IZ_P : moments of inertia in the reference mark P_{yz} .
- $IYR2_G$, $IZR2_G$, $IYR2$, $IZR2$, $IXR2_P$, $IYR2_P$: useful characteristics for the geometrical matrix of rigidity of the elements POU_D_TG and POU_D_TGM . For more detail on the definition of the sizes 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 table for all the grid and each group of mesh of the list [lgm](#).

3.2.2.1 Characteristics of torsion

- constant of torsion: JX
The resolution of a stationary thermal problem of unknown factor ϕ allows to determine the constant of torsion and shear stresses.
Note:
When the section consists of elements low thicknesses (tubes, reconstituted sections,...), it is necessary to have several meshes in this thickness for Calculer correctly characteristics related to torsion.
The characteristics of torsion are obtained by the resolution of $\Delta\phi$ on the section, it is necessary thus that the grid makes it possible to solve this equation.
It is necessary to have more three linear meshes or two meshes quadratic in the thickness to solve correctly $\Delta\phi$. In case of doubt about the found value, it is possible to obtain an approached value from it, in applying the formula given in [1, pp. 200, table 3.6.5].
- ray of torsion: RT
The ray of torsion Rt can vary along external contour; indeed, for an unspecified section, shearings due to torsion vary on the edge. One chooses to take the value of Rt leading to shearings maxima on the external edge, i.e. the maximum value of Rt (in absolute value) on external contour. Moreover, if the section is alveolate, there are several “several rays of torsion”: $Rt = 2 * A(k) / L(k)$ (where $A(k)$ represent the surface of the cell k and $L(k)$ its perimeter).
If one is satisfied to search the maximum value of shearing, it is necessary to take the maximum of the values Rt obtained on the external edge and the cells.
- Position of the center of torsion (not C) in the reference mark GYZ : $PCTY$ and $PCTZ$. One from of deduced offsetting from the center of torsion (component from CG in the principal reference mark of inertia G_{yz}): EY and EZ .
- Constant of warping (usable for modelings POU_D_TG and POU_D_TGM with 7 degrees of freedom): JG .

3.2.2.2 Characteristics of shearing

The coefficients of shearing are given, in the principal reference mark of inertia G_{yz} , in the form of the report (> 1) total surface with the actually sheared surface: AY and AZ .

3.3 Assignment of the sizes in AFFE_CARA_ELEM

The characteristics contained in this table and which can be used in AFFE_CARA_ELEM the same names have as the characteristics expected under the keyword CARA order AFFE_CARA_ELEM. Results calculated by MACR_CARA_POUTRE can be transmitted simply to AFFE_CARA_ELEM via the keyword TABLE_CARA.

4 Examples of use

4.1 Characteristic of a section in angle with equal wings

(50×50×8) treaty by test SSSL107A [V1.01.105].

4.1.1 Studied section

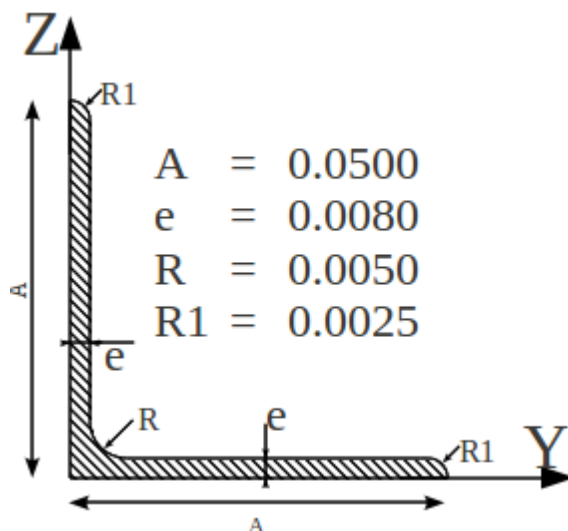


Figure 4.1.1-a : Angle with equal wings 50x50x8.

4.1.2 Command file

```
TCARA = MACR_CARA_POUTRE (
  GROUP_MA_BORD = 'LSURF', GROUP_NO = 'G N1', INFORMATION = 2)
```

or LSURF is the group of the linear meshes of the contour of the section.

4.1.3 Geometrical characteristics obtained

The characteristics of the grid are identical to those of the section. They are in conformity with those found in the "Catalogue of iron and steel products OTUA: Condition of uses in metal structure - 1959"

```
A_M           = With           = 7.39E-04
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
```

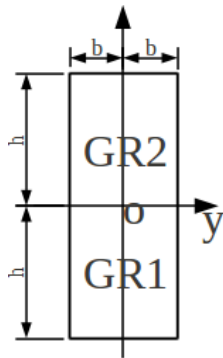
```
ALPHA         =                 = 45°
OG            =                 = 2.166E-02
Y_MIN         = - OG            = -2.166E-02
Y_MAX         =                 = 1.465E-02
Z_MIN         = -A cos(α/4)     = -3.536E-02
Z_MAX         = A cos(α/4)      = 3.536E-02
R_MAX         =                 = 3.792E-02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


4.1.4 Mechanical characteristics

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 Full rectangle (treaty by test SSSL107G)

4.2.1 Studied section



$$b = 0.01$$

$$h = 0.025$$

3 groups of meshes are defined:

GR1 part $y \leq 0$

GR2 part $y \geq 0$

LR1 linear meshes of contour

4.2.2 Order

TCARS = MACR_CARA_POUTRE (GROUP_MA_BORD = 'LR1', GROUP_NO = 'GN64')

4.2.3 Geometrical characteristics 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	WITH	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

5 References

- [1] J.L. BATOZ, G. DHATT. Modeling of the structures by finite elements, vol. 2– HERMES.