Operator **DEFI_GLRC**

1 Drank

operator DEFI_GLRC allows to define the parameters of models GLRC_DAMAGE and GLRC_DM.

He makes it possible to determine the characteristics of the reinforced concrete homogenized starting from the properties of the concrete and several types of reinforcement (passive reinforcements, cables of prestressing, liner metal).

In this command, one informs the physical properties (elastic coefficients, yield stresses) and geometrical (steel section and positions) of the reinforced concrete. In output, one lays out of a concept “material”, which one can meshes assign then to different with command AFFE_MATERIAU.

It is important to note that before calling on DEFI_GLRC, it is necessary to use DEFI_MATERIAU to inform all the material parameters concerning the concrete and steel components.

Product Data format of type MATER

Contents

2 general Syntax

```
my [to subdue] =DEFI_GLRC      (

reuse=       mat,                                    [to subdue]
♦RELATION  =/GLRC_DM
# Definition of the parameters concrete
   ♦BETON  =   ( _F (♦MATER    =mat_beton   ,       [to subdue]
                    ♦EPAIS=          ep,              [R]
                 ),
# Definition of the parameters reinforcements
   ♦NAPPE  =   ( _F (♦MATER=      mat_acier,          [to subdue]
                    ♦OMX=         Wx,                 [R]
                    ♦OMY=         Wy,                 [R]
                    ♦RX=          X-ray,                 [R]
                    ♦RY=          ry,                 [R]
                 ),
   ◊RHO=rho                                              [R]
   ◊AMOR_ALPHA=amor_alpha                          [R]
   ◊AMOR_BETA=amor_beta                                  [R]
   ♦COMPR=/GAMMA                                      [DEFAULT]
                 ♦GAMMA_C=     gc,                 [R]
                 /SEUIL
                 ♦NYC=      nyc,                      [R]
   ♦PENTE=/RIGI_ACIER                                 [DEFAULT]
                 /PLAS_ACIER
                 /UTIL
                 ♦EPSI_MEMB=      EM,                 [R]
                 ♦KAPP_FLEX=      KF,                 [R]
   ♦CISAIL=/OUI
                 /NON                                 [DEFAULT]
   ♦METHODE_ENDO=/ENDO_INTER                          [DEFAULT]
                       /ENDO_NAISS
                       /ENDO_LIM
   ◊INFO=/1                                           [DEFAULT]
              /2

♦RELATION =/GLRC_DAMAGE
# Definition of the parameters concrete
   ♦BETON  =   ( _F (♦MATER=mat_beton          ,       [to subdue]
                    ♦EPAIS=ep        ,                [R]
                    ♦GAMMA=gamma        ,             [R]
                    ♦QP1=qp1                             [R]
                    ♦QP2=qp2            ,             [R]

                    ♦C1N1=c1n1          ,             [R]
                    ♦C1N2=c1n2          ,             [R]
                    ♦C1N3=c1n3          ,             [R]
                    ♦C2N1=c2n1          ,             [R]
                    ♦C2N2=c2n2          ,             [R]
                    ♦C2N3=c2n3          ,             [R]
                    ♦C1M1=c1m1          ,             [R]
                    ♦C1M2=c1m2          ,             [R]
                    ♦C1M3=c1m3          ,             [R]
                    ♦C2M1=c2m1          ,             [R]
                    ♦C2M2=c2m2          ,             [R]
                    ♦C2M3=c2m3          ,             [R]
```

```
                    ◊   BT1=bt1          ,             [R]
                    ◊BT2=bt2             ,             [R]

                    ◊EAT=eat             ,             [R]
                    ◊OMT=omt             ,             [R]

                    ◊MP1X=mp1x           ,             [l_R]
                    ◊MP1Y=mp1y           ,             [l_R]
                    ◊MP2X=mp2x           ,             [l_R]
                    ◊MP2Y=mp2y           ,             [l_R]

                    ◊MP1X_FO=mp1x_fo        ,       [l_R]
                    ◊MP1Y_FO=mp1y_fo        ,       [l_R]
                    ◊MP2X_FO=mp2x_fo        ,       [l_R]
                    ◊MP2Y_FO=mp2y_fo        ,       [l_R]
      ),

# Definition of the parameters passive reinforcements
   ♦NAPPE  =  ( _F (♦MATER=      mat_acier,         [to subdue]
                    ♦OMX=         Wxa,            [R]
                    ♦OMY=         Wya,            [R]
                    ♦RX=          rxa,               [R]
                    ♦RY=          rya,               [R]
             ),

# Definition of the parameters cables of prestressed
   ♦CABLE_PREC   =  ( _F (  ♦MATER=mat_cable       ,   [to subdue]
                       ♦OMX=Wxp            ,         [R]
                        ♦OMY=Wyp           ,         [R]
                       ♦RX=rxp             ,         [R]
                       ♦RY=ryp             ,         [R]
                       ♦PREX=precx         ,      [R]
                       ♦PREY=precy         ,         [R]
                ),

# Definition of the parameters liner metal
   ♦LINER  =  ( _F (  ♦MATER=mat_liner       ,       [to subdue]
                    ♦OML=W          L,            [R]
                    ♦RLR=rlr             ,           [R]
      ),

   ◊INFO   =/1                                      [DEFAULT]
            /2
                    )
```

3 Description general of the reinforced concrete shell

One describes in this paragraph the geometry of the shell considered.

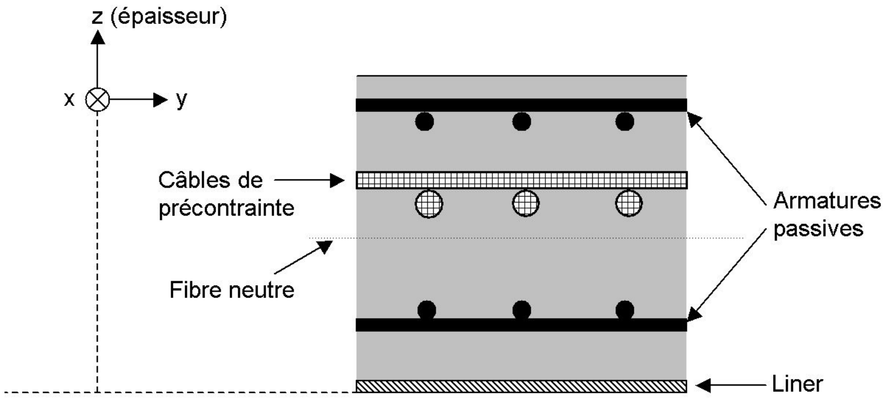


Figure 3-a : 3-a Current section of the reinforced concrete shell.

The basic section of a reinforced concrete slab (Figure 3-a : 3-a) is made up:
- concrete shell
- of passive reinforcements

and in the case of `GLRC_DAMAGE`, the section can contain moreover:
- cables of prestressed
- of a metal liner

the liner is a steel plate placed in intern skin of the enclosure guaranteeing
the sealing in the event of accidental escape in particular.

Prestressing makes it possible to compress the structural concrete of civil engineer. This prestressing is applied using cables of prestressed out of steel energized.

4 Operands RELATION = GLRC_DM

4.1 Key word BETON

the key word factor BETON makes it possible to define the geometrical characteristics and material of the concrete.

4.1.1 Operand MATER

```
MATER = mat_beton
```

Defines the name of the material produced by DEFI_MATERIAU used for the concrete. This operand makes it possible to check that the parameters associated with the behaviors with the concrete exist well in the material. One waits to find the properties: ELAS and BETON_ECRO_LINE.

4.1.2 Operand EPAIS

```
EPAIS = ep
```

Définit the thickness of the concrete plate. It is checked that $ep \geq 0$.

Note:
The value of this thickness must be identical to that given in AFFE_CARA_ELEM for the shell elements using the material mat_beton (defined by DEFI_GLRC).

4.2 Key word THREE-DIMENSIONS FUNCTION

the key word factor THREE-DIMENSIONS FUNCTION makes it possible to define the geometrical characteristics and material of passive reinforcements. This key word can be defined only once. Indeed, under the hypothèse of isotropy of constitutive law GLRC_DM, all reinforcements are necessarily identical and to équidistance of neutral fiber.

4.2.1 Operand MATER

```
MATER = mat_acier
```

Defines the name of the material produced by DEFI_MATERIAU used for passive reinforcements.
This operand makes it possible to recover the material parameters used for passive reinforcements (Young modulus E_a , Poisson's ratio ν_a and yield stress σ_{ya}) which one finds in the properties: ELAS and ECRO_LINE.

4.2.2 Operands OMX and OMY

```
OMX = Wx
OMY = Wy
```

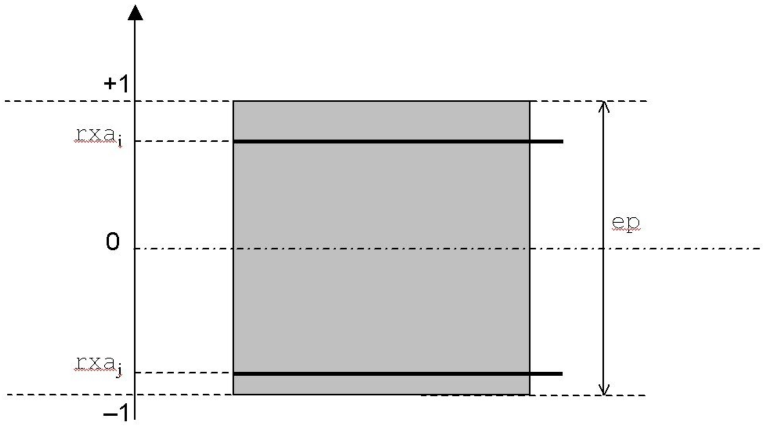
Définissent the steel sections Ω_x and Ω_y of a bed of reinforcements given according to the directions x and y (into m^2/m linear).
It is checked that $\Omega_x > 0$ and $\Omega_x = \Omega_y$.

4.2.3 Operands X-ray and RY

```
X-ray = X-ray
```

RY = ry

Définissent the position adimensionnée of a bed of reinforcements compared to the thickness of the concrete shell, given in the directions x and y ($-1 \leq rx \leq 1$ $-1 \leq ry \leq 1$, Appear 4.2.3-a).
It is checked that $rx = ry$.



Appear 4.2.3-a: Definition of the adimensionnée position of the beds of reinforcements.

4.3 Operand RHO

RHO = rho

Operand optional allowing the user to define the equivalent density of reinforced concrete slab. If the operand is not defined, the density is calculated in the following way:

$$\rho_{eq} = \rho_b + \frac{\rho_a}{h} \left(\Omega_x^{\sup} + \Omega_x^{\inf} + \Omega_y^{\sup} + \Omega_y^{\inf} \right)$$

Where ρ_a indicates the density of steel and is recovered in the concept mat_acier provided by operand MATER of the key word THREE-DIMENSIONS FUNCTION.
Where ρ_b indicates the density of the concrete and is recovered in the concept mat_beton provided by operand MATER of key word BETON .
Where h is the thickness provided by key word EPAIS.

4.4 Operands AMOR_ALPHA and AMOR_BETA

AMOR_ALPHA= optional
amor_alpha AMOR_BETA=

amor_beta Operand allowing the user to define the coefficients α and β which are used to build the matrix of the damping of Rayleigh.

$$C = \alpha K + \beta M$$

One will refer to the documents of modelization of the mechanical cushioning [U2.06.03] and [R5.05.04].

4.5 Key word COMPR

key word simple COMPR makes it possible to determine whether one uses the parameter of damage in compression γ_c or the threshold of damage in compression of concrete NYC to compute: the various parameters of the model. There exists a strong relation between these two quantities which is clarified in documentation of reference [R7.01.32].

4.5.1 Operands GAMMA_C

GAMMA_C = gc

Définit the value of the parameter of damage in compression γ_c . It is checked that $0 \le gc \le 1$.

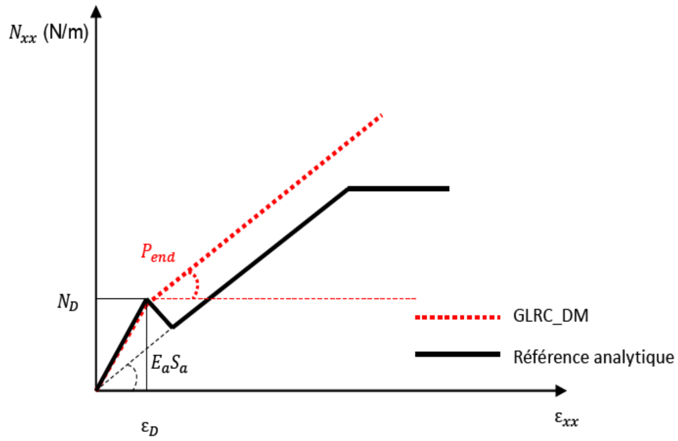
4.5.2 Operands NYC

NYC = nyc

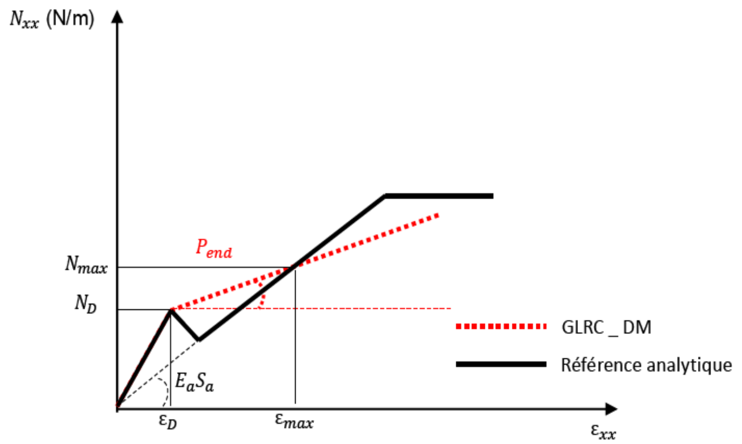
Defines the absolute value of the threshold of damage in compression of reinforced concrete slab (force by length).

4.6 Key word PENTE

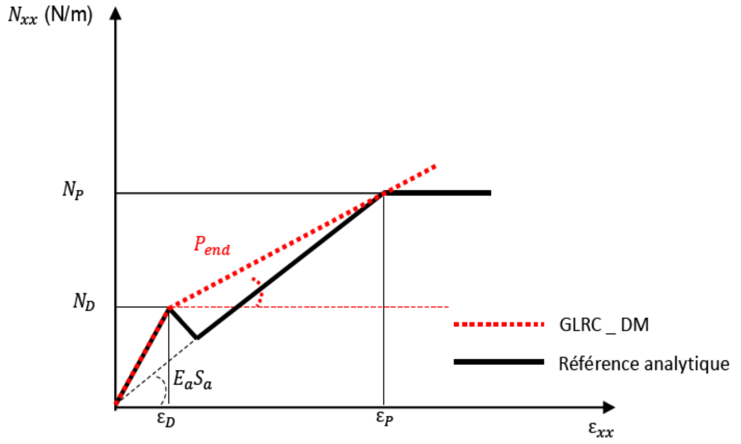
the key word factor PENTE makes it possible to define the méthode de calcul of the slope post-elastic. Indeed, it is possible of carried out this computation following three methods called RIGI_ACIER, PLAS_ACIER and UTIL. These three computations of slopes make it possible materials properties to set up three different methods of retiming according to well informed. If the yield stress of steels is not known, methods of retiming RIGI_ACIER, i.e slope post-elastic equal to the slope of resumption of stiffness of steels, and UTIL , i.e slope post-elastic cuts the slope of resumption of stiffness of steels to an imposed maximum strain, are accessible. If the elastic limit of steels is known, it is possible to use the method of retiming to the plastic limit of steels (PLAS_ACIER). The various methods of reclage are illustrated by the figures which follow. Appear



4.6-a 4.6-a (GLRC_DM vs Référence) Retiming PENTE = RIGI_ACIER Appears



4.6-b 4.6-b (GLRC_DM vs Référence) Retiming PENTE = UTIL Appears



4.6-c 4.6-c (GLRC_DM vs Référence) Retiming PENTE = PLAS_ACIER In

the case of retiming to the maximum strain (PENTE=UTIL), it is necessary to inform the maximum strain out of membrane (EPSI_MEMB) and the maximum curvature in bending (KAPP_FLEX). Operand

4.6.1 EPSI_MEMB EPSI_MEMB

= Definite EM

T the value of the maximum strain out of membrane in case PENTE =UTIL. Operand

4.6.2 KAPP_ FLEX KAPP_

FLEX = Definite KF

T the value of the maximum curvature in bending (opposite a length) in case PENTE =UTIL. Key word

4.7 CISAIL key word

simple CISAIL makes it possible to determine whether the homogenized elastic parameters are those calculated by standard homogenization (CISAIL=NON) or those calculated in order to respect the fact when pure shears the stiffness of steels do not intervene (CISAIL=OUI). Key word

4.8 METHODE_ENDO From

the knowledge of the slopes post-elastics, several methods are available to go back to the values of the parameters of damage, and γ_t. γ_c γ_f The detail of the various methods can be found in [R7.01.32]: ENDO_INTER

- is the method by default (and advised) and corresponds to a ratio of slope ENDO_NAISS
- corresponds to the case of the assumption of the damage incipient ENDO_LIM
- corresponds to the case of the assumption of the infinite damage Key word

4.9 INFO Printing

with result format of the list of the homogenized parameters used in entry of the model of behavior GLRC_DM . Operands

5 RELATION = GLRC_DAMAGE Key word

5.1 BETON the key word

factor BETON makes it possible to define the geometrical characteristics and material of the concrete. Operand

5.1.1 MATER MATER

= mat_beton Defines

the name of the material produced by DEFI_ MATERIAU used for the concrete. This operand makes it possible to check that the parameters associated with the behaviors chosen under key words ECOULEMENT , ECRO_ISOT , ECRO_CINE and ELAS exist well in the material. Operand

5.1.2 EPAIS EPAIS

= ep Définit

the thickness of the concrete plate. It is checked that. Note: $ep \geq 0$

The value
of this thickness must be identical to that given in AFFE_CARA_ELEM for the shell elements using the material mat_beton (defined by DEFI_ GLRC) . Operand

5.1.3 GAMMA GAMMA

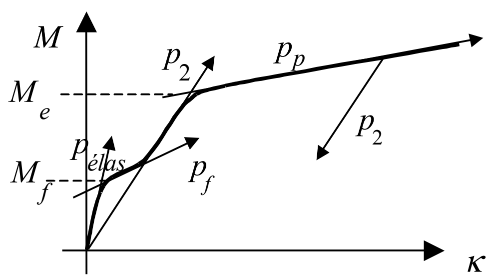
= gamma Defines

the parameter of damage which characterizes the slope of the curved moment – curvature during the cracking of the concrete (figure 2). can $gamma$ be regarded as being the relationship between the slope lasting cracking on the elastic slope. If, $gamma > 0$ the slope is positive. If, $gamma < 0$ the slope decrease and stability is not guaranteed any more. In all the cases, we must have and. $gamma < QP1$ $gamma < QP2$ The value by default is 0. This parameter is used only for the computation of the damage: With

$$\gamma = \frac{p_f}{p_{élas}}$$

: : GAMMA

- γ : elastic
- $p_{élas}$ slope: slope
- p_f during cracking Figure



5.1.3 5.1.3-a moment – curvature of the behavior of a reinforced concrete plate in bending. Operands

5.1.4 QP1 and `QP` 2 QP `1 =`

```
qp1 QP2 =
qp2 Define
```

ratios of slopes for a positive or negative bending. The ratio is supposed to be the ratio of the slope of the curved curvature – moment after cracking on the elastic slope. They are used only for the computation of the damage: With

$$Q_P = \frac{p_2}{p_{élas}}$$

: : ratio

- Q_p of the slopes: elastic
- $p_{élas}$ slope: slope
- p_2 after cracking One checks

that. Operands $0 < QPi < 1$

5.1.5 C1N1/ `C1N2/C1N3/C2N1/C2N2/C2N3 C1N1`

```
= c1n1 C1N2
= c1n2 C1N3
= c1n3 C2N1
= c2n1 C2N2
= c2n2 C2N3
= c2n3 plastic strains
```

Define the components of the tensor of kinematic hardening of Prager binding the tensors of membrane with the forces of kinematical membrane of recall. With

$$N = CN_1 \epsilon_1^p + CN_2 \epsilon_2^p$$

: and are

- $CN_1 = \begin{pmatrix} C1N1 & 0 & 0 \\ 0 & C1N2 & 0 \\ 0 & 0 & C1N3 \end{pmatrix}$
- $CN_2 = \begin{pmatrix} C2N1 & 0 & 0 \\ 0 & C2N2 & 0 \\ 0 & 0 & C2N3 \end{pmatrix}$
- ϵ_1^p ϵ_2^p the strain tensors membrane plastic for plasticity criterion 1 and 2. It is checked

that. Operands $CiNj \geq 0$

5.1.6 C1M1/ `C1M2/C1M3/C2M1/C2M2/C2M3 C1M1`

```
= c1m1 C1M2
= c1m2 C1M3
= c1m3 C2M1
= c2m1 C2M2
= c2m2 C2M3
= c2m3 Define
```

the components of the tensor of kinematic hardening of Prager binding the tensors of the plastic curvatures with the moments of kinematical recall. With

$$M = CM_1 \kappa_1^p + CM_2 \kappa_2^p$$

: and are

- $CM_1 = \begin{pmatrix} C1M1 & 0 & 0 \\ 0 & C1M2 & 0 \\ 0 & 0 & C1M3 \end{pmatrix}$
- $CM_2 = \begin{pmatrix} C2M1 & 0 & 0 \\ 0 & C2M2 & 0 \\ 0 & 0 & C2M3 \end{pmatrix}$
- $\kappa_1^p \quad \kappa_2^p$ the tensors of plastic curvature for plasticity criterion 1 and 2. The computation

by means of $C_i M_j$ MOCO is carried out. With

$$C_i M_j = \frac{p_{élas} p_p}{p_{élas} - p_p}$$

: : elastic

- $p_{élas}$ slope: plastic
- p_p slope One checks

that. Operands $C_i M_j \geq 0$

5.1.7 BT1/BT 2 and EAT /OMT BT1 =

```
bt1 BT2 =
bt2 EAT =

eat OMT =
omt If
```

the finite elements support the computation of the shears, these operands are used to define the elastic matrix of transverse shear stiffness. The shears formula V are connected to the distortions formulates γ formulate

$$V = \begin{bmatrix} BT1 & 0 \\ 0 & BT2 \end{bmatrix} : \gamma$$

the user then informs the Young modulus of transverse steels EAT as well as the steel section transverse per linear meter OMT one deduces the coefficients from the stiffness matrix by the following relation: formulate

$$bt_i = \frac{5}{6} \frac{ep}{2} \left(\frac{eb}{1+nub} + eat \times omt \right)$$

cannot inform at the same time BT1, BT2 and the parameters EAT, OMT One checks

that these operands are strictly positive realities. Operands

5.1.8 MP1X/ MP1Y/MP2X/MP2Y and MP 1X_FO/MP1Y_FO/MP2X_FO/MP2Y_FO MP1X

```
= mp1x MP1Y
= mp1y MP2X
= mp2x MP2Y
= mp2y MP1X_

FO = mp1x_fo MP1Y_
FO = mp1y_fo MP2X_
FO = mp2x_fo MP2Y_
FO = mp2y_fo Define
```

the limiting plastic moments of the generalized criterion of Johansen used in the model of behavior GLRC_ RAMMED. They can be defined are by constant values are by functions. It is not possible to mix functions and constants. Moreover as soon as one of the operands is indicated, it is compulsory all to inform them. When those are not specified, they are calculated in an automatic way. Key word

5.2 ARMED the key word

factor ARMED makes it possible to define the geometrical characteristics and material of passive reinforcements. Operand

5.2.1 MATER MATER

```
= mat_acier Defines
```

the name of the material produced by DEFI_ MATERIAU used for passive reinforcements. This operand
makes it possible to recover the material parameters used for passive reinforcements (Young modulus, Poisson's ratio E_a and yield stress ν_a). Operands σ_{ya}

5.2.2 OMX and OMY OMX =

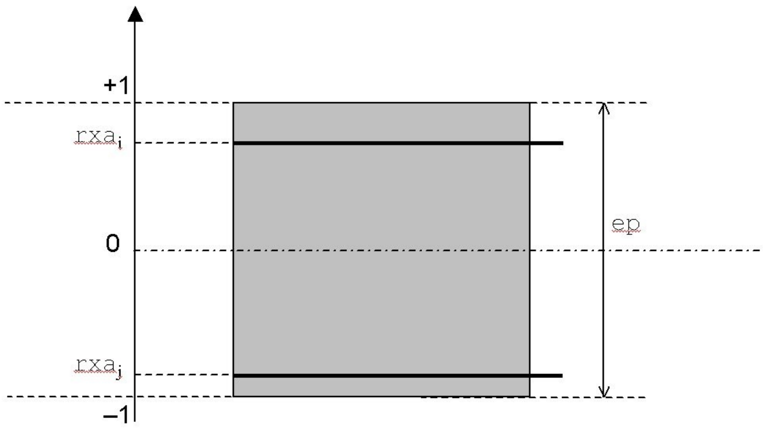
```
Wxa OMY =
Wya Define
```

the steel sections of a bed of reinforcements given according to the directions and (x into y linear m^2/m). It is checked
that and. $Wxa \geq 0$ Operands $Wya \geq 0$

5.2.3 X-ray and RYS X-ray =

```
rxa RY =
rya Define
```

the position adimensionnée of a bed of reinforcements compared to the thickness of the concrete shell, given in the directions and (x , y figure $-1 \leq rxa \leq 1$ $-1 \leq rya \leq 1$ 3). Figure



5.2.3 5.2.3-a of the adimensionnée position of the beds of reinforcements. Key word

5.3 CABLE_PREC the key word

factor CABLE_PREC makes it possible to define the geometrical characteristics and material of the cables of prestressed as well as the prestressing force used. Operand

5.3.1 MATER MATER

= mat_cable Defines

the name of the material produced by DEFI_ MATERIAU used for the cables of prestressing. This operand
makes it possible to recover the material parameters used for the cables of prestressed (Young modulus, Poisson's ratio E_p and yield stress ν_p). Operands σ_{yp}

5.3.2 OMX and OMY OMX =

W xp OMY =
W YP Define

the steel sections of a bed of cables of prestressing given according to the directions and (x into y linear m^2/m). It is checked
that and. $Wxp \geq 0$ Operands $Wyp \geq 0$

5.3.3 X-ray and RYS X-ray =

rxp RY =
ryp Define

the adimensionnée position of a bed of cables of prestressed compared to the thickness of the concrete shell, given in the directions and (x ,) y . $-1 \leq rxp \leq 1$ Operands $-1 \leq ryp \leq 1$

5.3.4 PREX and PREY PREX

= precx, PREY
= precy, Define

the forces of prestressed (in Newton) in the directions and (x they y must be normally negative because one applies a compressive force). Key word

5.4 LINER the key word

factor LINER makes it possible to define the geometrical characteristics and material of the metal liner. Operand

5.4.1 MATER MATER

= mat_liner Defines

the name of the material produced by DEFI_ MATERIAU used for the metal liner. This operand makes it possible to recover the material parameters used for the metal liner (Young modulus, Poisson's ratio E_l and yield stress ν_l). Operand σ_{yl}

5.4.2 OML OML =

Wl Définit

the thickness of the liner (in meters). It is checked
that. Operand $Wl \geq 0$

5.4.3 RLR RLR =

rlr, Defines

the adimensionnée position of the liner compared to the thickness of the concrete shell (in practice, or, $rlr=-1$ because $rlr=1$ the metal liner is laid out opposite lower or higher the concrete shell). Key word

5.5 INFO Printing

with result format of the list of the homogenized parameters used in entry of the model of behavior GLRC_DAMAGE . Example

6 of use the following

example is resulting from test SDNS106A: MAT =

```
DEFI_GLRC (RELATION = GLRC_DAMAGE, BETON
                   = _F (MATER
                     = MAT_B, EPAIS
                     = EP, GAMMA
                     = 0.0, QP1 =
                     0.15, QP2 =
                     0.15, C1N1

                     = 87.3E6, C1N2 = 87.3E6, C1N3 = 87.3E6, C2N1
                     = 87.3E6, C2N2 = 87.3E6, C2N3 = 87.3E6, C1M1
                     = 14.8E6, C1M2 = 14.8E6, C1M3 = 14.8E6, C2M1
                            = 14.8E6, C2M2 = 14.8E6, C2M3 = 14.8E6,), THREE-
DIMENSIONS FUNCTION

                   = (_F (MATER
                  = MAT_A1, OMX =
                     5.65E-4, OMY =
                     5.65E-4, X-ray =
                     0.95, RY =
                     0.95,), _F (MATER

                  = MAT_A1, OMX =
                     5.65E-4, OMY =
                     5.65E-4, X-ray =
                     -0.95, RY =
                     -0.95,),), LINER

                   = _F (MATER
                    = MAT_A2, OML =
                    6.E-3, RLR =
                    -1. ,), CABLE_PREC

                   = _F (MATER
                     = MAT_A2, OMX =
                     4.56E-3, OMY =
                     1.35E-2, X-ray =
                     0.0, RY =
                     0.0, PREX
                     = -3.0E6, PREY
                     = -3.0E6,), INFO

                    = 2,); Note:
```

In

this example, 3 different materials are used: MAT_B (concrete), MAT_A 1 (passive reinforcements) and MAT_A 2 (liner metal and cables of prestressed). Before defining the parameters of DEFI_ GLRC, it is compulsory to use DEFI_ MATERIAU to inform all the parameters concerning these materials: MAT_B

```
=DEFI_MATERIAU (ELAS
                    = _F (E =
                              30000     . E6, NU =
                              0.2   ,  RHO
                              = 2500.0    ,), BETON_ECRO_LINE
```

```
                    = _F (D_SIGM_EPSI
                               = 0.0, SYT
                               = 5th   6,  SYC
                               = -35    . E6,),); MAT_A
1=DEFI_MATERIAU (ELAS
                    = _F (E =
                               2.    E11  , NU =
                               0.0   ,)  , ECRO_LINE
                    = _F (D_SIGM_EPSI
                               = 0.0, SY =
                               3.   E9,  ),); MAT_A

2=DEFI_MATERIAU (ELAS
                    = _F (E =
                               2.    E11  , NU =
                               0.3   ,)  , ECRO_LINE
                    = _F (D_SIGM_EPSI
                               = 0.0, SY =
                               5.   E8,  ),); Although
```

the formulas of homogenization used in DEFI_ GLRC exploit only the threshold values SY for ECRO_LINE and SYT , SYC for BETON_ECRO_LINE of DEFI _ MATERIAU, one is obliged to also inform values D_SIGM_EPSI as indicated above, since they are compulsory key words.