Operator CALC_FERRAILLAGE

1 Goal

To calculate the densities of reinforcement in elements hulls and plates according to the requests: generalized efforts, obtained beforehand by the option EFGE_ELNO.

The order enriches the structure of data of the type result, provided under the keyword RESULT, of a field of size reinforcement, of which the components are described in chapter 4.

2 Syntax

```
resu [*] = CALC_FERRAILLAGE    (

        ♦ reuse     =  resu

        ♦ RESULTAT  =  resu            [evol_elas, evol_noli, dyna_trans]


        ♦ TYPE_COMB =  /   'ELS',
                       /   'ELECTED',

        ♦ #  Selection of the sequence number:
                       /  TOUT_ORDRE =     'YES',
                       /  NUME_ORDRE =     l_nuor ,              [l_I]
                       /  LIST_ORDRE =     l_nuor ,              [listis]
                       /  ♦   /  INST =    l_inst ,              [l_R]
                              /  LIST_INST =  / l_inst,          [listr8]
                              /  FREQ      =  / l_inst,          [listr8]
                              /  LIST_ FREQ = / l_freq,          [listr8]
                          ◊   |  PRECISION =  / prec,
                                              / 1.0E-6,          [DEFECT]
                              |  CRITERION =     / 'RELATIVE',       [DEFECT]
                                              / 'ABSOLUTE',


        ♦ AFFE   =   _F (  ♦   /  ALL = / 'YES'
                                        / 'NOT'
                              /  GROUP_MA = l_grma,              [l_gr_maille]
                              /  MESH   = l_maille,              [l_maille]

                          ♦ ENROBG     = enrobg,                 [R]

                          ◊ CEQUI      = cequi,                  [R]

                          ♦ SIGM_ACIER = sigaci ,                [R]

                          ♦ SIGM_BETON = sigbet,                 [R]

                          ◊ PIVA       = piva,                   [R]

                          ◊ PIVB       = pivb                    [R]

                          ◊ ES         = be                      [R]

                              )
```

3 Operands

3.1 Operand RESULT

♦ `RESULTAT = resu`

Name of a concept result of the type `result`. It is necessarily réentrant.

3.2 Operand TYPE_COMB

♦ / `'ELS'`

Reinforcement is parameterized for a calculation in Absolute limit of Service.

/ `'ELECTED'`

Reinforcement is parameterized for a calculation in Ultimate Absolute limit.

Note:

For the combinations of efforts, weightings are to be carried out before the call to the module `CALC_FERRAILLAGE`. With this intention, it is necessary to extract the field from the generalized efforts, beforehand obtained by the option `EFGE_ELNO`, by using the function `CREA_CHAMP` (operation `EXTR`) described in the document [U4.72.04].

```
MECA1=CALC_CHAMP (reuse =MECA1,
                  RESULTAT=MECA1,
                  CONTRAINTE=' EFGE_ELNO',);
EFFORTS1=CRÉA_CHAMP (TYPE_CHAM=' ELNO_SIEF_R',
                     OPERATION=' EXTR',
                     RESULTAT=MECA1,
                     NOM_CHAM=' EFGE_ELNO',);
```

Then, by re-using the function `CREA_CHAMP` (operation `ADZE`), one can add the fields extracted by balancing them by the desired coefficient.

```
PONDERE1=CRÉA_CHAMP (TYPE_CHAM=' ELNO_SIEF_R',
                     OPERATION=' ASSE',
                     MODELE=MODELE,
                     ASSE=_F (GROUP_MA=' BALCON',
                              CHAM_GD=EFFORTS1,
                              CUMUL=' OUI',
                              COEF_R=1.35,),);
```

Lastly, to be able to use the field of efforts balanced created in `CALC_FERRAILLAGE`, it should be transformed into a concept result of type result thanks to the function `CREA_RESU` described in the document [U4.44.12].

```
PONDER=CRÉA_RESU (OPERATION=' AFFE',
                  TYPE_RESU=' EVOL_ELAS',
                  NOM_CHAM=' EFGE_ELNO',
                  AFFE= (_F (CHAM_GD=PONDERE1,
                             MODELE=MODELE,
                             CHAM_MATER=MATE,
                             CARA_ELEM=CARA,
                             INST=1.0,),),);
```

3.3 Selection of the sequence numbers

Use of the keywords `TOUT_ORDRE, NUME_ORDRE, INST` is described in the document [U4.71.00].

3.4 Operand AFFE

3.4.1 Selection of the meshs concerned with calculation

Keywords `ALL`, `GROUP_MA` and `MESH` allow the user to choose the meshs on which it wishes to do his elementary calculations of postprocessing.

/ `ALL = 'YES'`

All the meshs (carrying finite elements) will be treated. It is the value by default.

/ | `GROUP_MA = l_grma`
| `MESH = l_maille`

Only meshs included in `l_grma` and/or `l_maille` will be treated.

Note: If the model is not solely formed by elements of hull (3D, beams,…), the keyword should not be used `TOUT=' OUI'`. It is necessary to indicate the elements of hull using the keywords `GROUP_MA` and `MESH`.

3.4.2 Operand ENROBG

♦ `ENROBG = enrobg, [R]`

Distance enters the concrete surface and the axis of the reinforcements of reinforcement

Note:
The value of coating can be approximated to $0.1\,h$ with h the thickness of the section.

3.4.3 Operand CEQUI

◊ `CEQUI = cequi, [R]`

Coefficient of equivalence steel/concrete (calculation with the Absolute limit of Service, ELS)

Note:
The value usually used is $CEQUI=15$.

3.4.4 Operand SIGM_ACIER

♦ `SIGM_ACIER = sigaci`

Working stress in steel (`'ELS'`) or elastic limit of calculation of steel (`'ELECTED'`)

Note:
For the ELS, one uses in the regular manner:
$\mathrm{SIGM\_ACIER}=0.8\,f_e$
With f_e elastic limit of steel

For the ELECTED OFFICIAL, one uses in the regular manner:
$\mathrm{SIGM\_ACIER}=\frac{f_e}{\gamma_s}$ with $\gamma_s=1.15$ for accidental combinations if not $\gamma_s=1$

3.4.5 Operand SIGM_BETON

♦ `SIGM_BETON = sigbet`

Working stress of compression in the concrete (`'ELS'`) or resistance in compression of calculation of the concrete (`'ELECTED'`)

Note:
For the ELS, one uses in the regular manner:

$\text{SIGM\_BETON}=0.6 f_{cj}$

With f_{cj} resistance characteristic of the concrete to compression.

For the ELECTED OFFICIAL, one uses in the regular manner:

$$\text{SIGM\_BETON}=\frac{0.85 f_{cj}}{\theta \gamma_b}$$

with $\gamma_b=1.15$ for accidental combinations if not $\gamma_b=1.5$
and $\theta=1$ if the duration of loading is higher than 24:00, $\theta=0.9$ if the duration of loading lies between 1:00 and 24:00, if not $\theta=0.85$

3.4.6 Operands **PIVA/PIVB**

◊ `PIVA = piva,          [R]`

Valeur of pivot A (calculation with the Ultimate Absolute limit)

◊ `PIVB = pivb,          [R]`

Value of the pivot B (calculation with the Ultimate Absolute limit)

3.4.7 Operands **ES**

◊ `ES = be,          [R]`

Value of the Young modulus of steel (calculation to the Ultimate Absolute limit)

4 Composition of the produced field

The result is enriched by a new field (named ‘`REINFORCEMENT`‘in the structure of data) whose components are:

- a density of longitudinal reinforcement in the direction X element for the lower face of the element ($DNSXI$) ;
- the equivalent for the higher face ($DNSXS$) ;
- a density of longitudinal reinforcement in the direction Y element for the lower face of the element ($DNSYI$) ;
- the equivalent for the higher face ($DNSYS$) ;
- density of transverse reinforcement ($DNST$) ;
- the constraint in the concrete $SIGMBE$;
- deformation in the concrete $EPSIBE$.

The densities of reinforcement are calculated according to the method of CAPRA and MAURY [R7.04.05]. These densities are expressed in unit of area by linear length of hull. For example, if the grid is in meters (with data of characteristics elementary and material in coherence), the densities will be expressed in m^2/m .

The field of reinforcement is calculated for every moment specified by the user (by default: all). If one wants to calculate the field containing the values “max” during the transient, one can carry out the order:

```
FERMAX=CRÉA_CHAMP (  OPERATION=' EXTR', TYPE_CHAM=' ELEM_FER2_R',
                     NOM_CHAM=' FERRAILLAGE', RESULTAT=Solution,
                     TYPE_MAXI=' MAXI_ABS', TYPE_RESU=' VALE',
                        )
```

5 Examples of use

See the cases tests `ssls134a`, `ssls135a` and `sslx100d`.