Operator CALCUL

1 Goal

Compute stresses and the local variables for integration of a nonlinear constitutive law.

To calculate the elementary vect_elem internal forces and nodal vectors and the elementary matrixes `matr_elem` of a tangent matrix.

Product a data structure of the table_container `type`.

2 Syntax

```
table_container=        CALCUL
   (  ♦ MODELE=     Mo,                              [model]
      ♦ CHAM_MATER= chmat,                           [cham_mater]
      ◊ CARA_ELEM=  carac,                           [cara_elem]
      ♦ OPTION=       /“BEHAVIOR”                  [DEFAULT]
                      /“MATR_TANG_ELEM”
                      /“FORC_INT_ELEM”
                      /“FORC_NODA_ELEM”
      ♦ EXCIT=       _F (
              ♦ CHARGE  = chi,                       [char_meca]
              ◊ FONC_MULT =fi,                       [function/formula]
            ),
      ♦  |      COMP_INCR=_F (see the document [U4.51.11]),
         |      COMP_ELAS=_F (see the document [U4.51.11] .),
      ♦ DEPL=       depl,                            [cham_no]
      ♦ INCR_DEPL=  incdepl,                       [cham_no]
      ♦ SIGM=       sigm,                            [cham_elem]
      ♦ VARI=       vari,                            [cham_elem]
      ◊ TABLE=      counts,                          [table_container]
      ♦ INCREMENT=  _F (
              ♦ LIST_INST = litps,                   [listr8]
              ♦ NUME_ORDRE =nuini,                   [I]
            ),
      ◊ INFO=/1       ,                                [DEFAULT]
             /2,
   )
```

3 Operands

3.1 MODEL Operand

♦**MODELE** = Mo

Name of the defining concept the model whose elements are the object of computation.

3.2 Operand CHAM_MATER

♦**CHAM_MATER** = chmat

Name of the concept defining the affected material field on the model Mo.

3.3 Operand CARA_ELEM

◊CARA_ELEM = carac

Name of the concept defining the characteristics of the beam elements, shells, etc…

3.4 Key word EXCIT

♦ **EXCIT**

This key word factor makes it possible to for each occurrence describe a load (requests and boundary conditions), and possibly a multiplying coefficient and/or a kind of load.
This keyword is useful to produce the matrix of the dualized limiting conditions of Dirichlet which will be integrated in the matr_elem produced by the computation of the tangent matrix.

3.4.1 Operands CHARGE

♦ **CHARGE: CH** $_{\text{I}}$

chi is the mechanical loading (possibly comprising the evolution of a field of temperature) specified with i the ème occurrence of EXCIT.

3.4.2 Operand FONC_MULT

◊ **FONC_MULT: F** $_{\text{I}}$

fi is the multiplying function of the time of the loading specified with the ième occurrence of EXCIT.
The loading and the boundary conditions for n occurrences of the key word factor EXCIT are:

$$ch=\sum_{i=1}^{n} f_i . ch_i$$

For the conditions of Dirichlet, of course, only the specified value is multiplied by fi.
By default: fi=1.

3.5 Operand OPTION

```
♦   OPTION=/        "BEHAVIOR"     [default]
                    /"MATR_TANG_ELEM"
                    /"FORC_INT_ELEM"
                    /"FORC_NODA_ELEM"
```

Makes it possible to specify what one calculates:

- "BEHAVIOR" the constitutive law integrates and thus produces three objects: cham_elem of the stresses, cham_elem of the local variables and a cham_elem comprising the return code of the constitutive law.
- "MATR_TANG_ELEM" calculates the coherent tangent matrix (FULL_MECA in the language Aster) and thus produces four objects: cham_elem of the stresses, cham_elem of the local variables, a cham_elem comprising the return code of the constitutive law and a matr_elem of the tangent elementary matrixes.
- "FORC_INT_ELEM" calculates the vector of the internal forces after integration of constitutive law (RAPH_MECA in the language Aster) and thus produces four objects: cham_elem of the stresses, cham_elem of the local variables, a cham_elem comprising the return code of the constitutive law and a vect_elem of the elementary vectors of the internal forces.
- "FORC_NODA_ELEM" calculates the vector of the nodal forces starting from the stresses with Gauss points and produces a vect_elem of the elementary vectors of the nodal forces.

3.6 Key word INCREMENT

♦ **INCREMENT**

Defines the intervals of time taken in the incremental method.

Times thus defined have physical meaning only for behavior models where time intervenes explicitly (viscoelastic or viscoplastic for example). In the other cases, they allow only indicer the increments of load and to parameterize the evolution of a possible field of temperature.

3.6.1 Operand LIST_INST

♦ **LIST_INST = litps**

times of computation is those defined in the concept litps by the operator DEFI_LIST_REEL [U4.34.01].

3.6.2 Operands NUME_ORDRE

♦ **NUME_ORDRE =numeric**

Makes it possible to define the sequence number (and thus time) for which will be calculated the quantities in **the table_container.**

3.7 Key word COUNTS

♦ **ARRAY**

Makes it possible to introduce a table_container NON-vacuum to supplement (with the adequate sequence number) with the new concepts calculated in the operand CALCUL.
If the array contains already fields for the sequence number claimed by keyword INCREMENT/NUMÉRIQUE_ORDRE , these chamsp is crushed and an alarm is emitted to warn the user.

3.8 Key key DEPL/INC_DEPL/SIGM/VARI

♦ **DEPL=depl , [cham_no],**
♦ **INCR_DEPL=incdepl , [cham_no],**
♦ **SIGM=sigm , [cham_elem],**
♦ **VARI=vari , [cham_elem],**

Makes it possible to introduce inputted fields to compute: the various fields by the command CALCUL :
•DEPL gives a field of displacement
•INCR_DEPL is the increment of the field of displacement since the beginning of time step

- the SIGM gives a stress field
- VARI gives a field of local variables

Note: it is necessary to take care to be coherent between the behavior requested by COMP_INCR and the size of the field of the local variables.

3.9 Operand INFO

◊ **INFO =inf**

Makes it possible to carry out in the message file various intermediate printings.

4 Use of CALCUL and the table_container

CALCUL produces only a table_container in which is stored for each sequence number one or more fields (forced, local variables, elementary vectors of the internal forces, elementary matrixes of the tangent matrix).

To extract these fields, it is advisable to use command EXTR_TABLE. For example, if one wants of the command the field of the stresses resulting CALCUL, one will make:

```
CONT=CALCUL (OPTION= (“BEHAVIOR”, “FORC_INT_ELEM”, “MATR_TANG_ELEM”),
            MODELE=MO,
            CHAM_MATER=CHMAT,
            INCREMENT=_F (LIST_INST=LISTE,
                         NUME_ORDRE=1),
            EXCIT=_F (CHARGE=CHARGE),
            DEPL=U,
            INCR_DEPL=DU,
            SIGM=SIGP,
            VARI=VARIP,
            COMP_INCR=_F (RELATION=' VMIS_ISOT_LINE',),
            INFO=2,);

SIGM=EXTR_TABLE (TYPE_RESU=' CHAM_GD_SDASTER',
                 TABLE=CONT,
                 NOM_PARA=' NOM_SD',
                 FILTRE=_F (NOM_PARA=' NOM_OBJET',
                           VALE_K=' SIEF_ELGA'),)
```

To compute: the second member of the external forces or other quantities (like the matrixes masses), one can use commands CALC_VECT_ELEM or CALC_MATR_ELEM.
The matr_elem or the vect_elem can be assembled via commands ASSE_VECTEUR and ASSE_MATRICE.

It should be noted that the MATR_ELEM of stiffness produced by CALCUL contain also the contribution resulting from the dualisation of the limiting conditions of Dirichlet (EXCIT).

An example of use of CALCUL is available in the pynl01a benchmark.