Operator CALCULATION

1. Goal

For mechanics:
- Calculate internal constraints and variables for the integration of a non-linear law of behavior;
- Calculate elementary vectors vect Elem internal and nodal forces and elementary matrices matr Elem of a tangent matrix;
- Calculate R elementary vectors vect Elem forces corresponding to the variables of order.

For thermics:
- To calculate the elementary vectors vect Elem residues of balance and matrices elementary matr Elem of a thermal matrix of rigidity;
- Calculate R elementary vectors vect Elem forces corresponding with the non-linear thermal loadings.

Product a structure of data of the type table_container.
2 Syntax

table_container = CALCULATION

(  ♦ MODEL = Mo,  [model]
  ♦ CHAM_MATER = chmat,  [cham_mater]
  ♦ CARA_ELEM = carac,  [cara_elem]
  ♦ TABLE = table,  [table_container]
  ♦ INCREMENT = F (  
    ♦ LIST_INST = litps,  [litr8]
    ♦ NUME_ORDRE = nuini,  [I]
  ),
  ♦ PHENOMENON = '/MECHANICAL'  [DEFECT]
    '/THERMAL'

If PHENOMENON = 'MECHANICAL'
{
  ♦ OPTION = '/BEHAVIOR'  [DEFECT]
    '/MATR_TANG_ELEM'
    '/FORC_INT_ELEM'
    '/FORC_NODA_ELEM'
    '/FORC_VARC_ELEM_M'
    '/FORC_VARC_ELEM_P'
  ♦ EXCIT = F (  
    ♦ LOAD = chi,  [char_meca]
    ♦ FONC_MULT = fi,  [fonction/formule]
  ),
  ♦ BEHAVIOR = F (see the document [U4.51.11]),
  ♦ SCHEMA_THM = F (see the document [U4.51.11]),
  ♦ DEPL = depl,  [cham_no]
  ♦ INCR_DEPL = incdepl,  [cham_no]
  ♦ SIGM = sigm,  [cham_elem]
  ♦ VARI = vari,  [cham_elem]
  ♦ MODE_FOURIER = nh ,  [I]
}

If PHENOMENON = 'THERMICS'
{
  ♦ OPTION = '/CHAR_THER_ELEM'
    '/MATR_TANG_ELEM'
    '/CHAR_EVOL_ELEM'
    '/RESI_THER_ELEM'
  ♦ EXCIT = F (  
    ♦ LOAD = chi,  [char_ther]
    ♦ FONC_MULT = fi,  [fonction/formule]
  ),
  ♦ TEMP = temp,  [cham_no]
  ♦ INCR_TEMP = Inctemp,  [cham_no]
  ♦ BEHAVIOR = F (see the document [U4.54.02]),
  ♦ PARM_THETA = theta,  [R]
    /0.57,
  ♦ INCR_TEMP = Inctemp,  [cham_no]
}

◊ INFORMATION = /1,  [DEFECT]
/2,
3 Operands commun runs

3.1 Keyword PHENOMENON

◊ PHENOMENON =/ ‘MECHANICAL’ / ‘THERMAL’ [DEFECT]

Allows to choose the phenomenon which will be calculated.

3.2 Keyword TABLE

♦ TABLE

Allows to introduce one table_container not-vacuum to supplement (with the adequate sequence number) with the new concepts calculated in the operand CALCULATION.

If the table contains already fields for the sequence number claimed by the keyword INCREMENT/NUMÉRIQUE_ORDRE, these fields are crushed and an alarm is emitted to warn the user.

3.3 Keyword MODEL

♦ MODEL = Mo

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

3.4 Keyword CHAM_MATER

♦ CHAM_MATER = chmat

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

3.5 Keyword CARA_ELEM

◊ CARA_ELEM = carac

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

3.6 Keyword INCREMENT

♦ INCREMENT

Defines the time intervals taken in the incremental method.

In mechanics, Lurgent be thus defined have physical direction only for relations of behavior 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

The moments of calculation are those defined in the concept litps by the operator DEFI_LIST_REEL [U4.34.01].

3.6.2 Operands NUME_ORDRE

♦ NUME_ORDRE = digital

Allows to define the sequence number (and thus the moment) for which will be calculated the sizes in table_container.

3.7 Operand INFORMATION

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

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◊ INFORMATION = inf

Allows to carry out in the file message various intermediate impressions.
4 Operands for mechanics

4.1 Keyword EXCIT

◊ EXCIT

This keyword factor makes it possible to describe with each occurrence 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 `matr_elem` product by the calculation of the tangent matrix.

4.1.1 Operand LOAD

◊ LOAD: CH

CH is the mechanical loading (possibly comprising the evolution of a field of temperature) specified with \( i \) \( \text{ème} \) occurrence of EXCIT.

4.1.2 Operand FONC_MULT

◊ FONC_MULT: F

\( F \) is the multiplying function of the time of the loading specified with \( i \) \( \text{ème} \) occurrence of EXCIT.

The loading and boundary conditions for \( n \) occurrences of the keyword factor EXCIT are:

\[
ch = \sum_{i=1}^{n} f_i \cdot ch_i
\]

For the conditions of Dirichlet, of course, only the specified value is multiplied by \( F \).

By default: \( F = 1 \).

4.2 Operand OPTION

◊ OPTION = /

‘BEHAVIOR’ [defect]

‘MATR_TANG_ELEM’

‘FORC_INTE_ELEM’

‘FORC_NODA_ELEM’

‘FORC_VARC_ELEM_M’

‘FORC_VARC_ELEM_P’

Allows to specify what one calculates:

• ‘BEHAVIOR’ integrate the law of behavior and thus produces three objects: `cham_elem` constraints, `cham_elem` internal variables and one `cham_elem` comprising the code return of the law of behavior;

• ‘MATR_TANG_ELEM’ calculate the coherent tangent matrix (option `FULL_MECA`) and thus produces four objects: one `cham_elem` constraints, one `cham_elem` internal variables, one `cham_elem` comprising the code return of the law of behavior and one `matr_elem` tangent elementary matrices;

• ‘FORC_INTE_ELEM’ calculate the vector of the internal forces after integration of the law of behavior (RAPH_MECA in the language Aster) and thus produces four objects: one `cham_elem` constraints, one `cham_elem` internal variables, one `cham_elem` comprising the code return of the law of behavior and one `vect_elem` elementary vectors of the internal forces;

• ‘FORC_NODA_ELEM’ calculate the vector of the nodal forces starting from the constraints at the points of Gauss and produces one `vect_elem` elementary vectors of the nodal forces.

• ‘FORC_VARC_ELEM_M’ calculate the vector of the forces corresponding to the variables of orders at previous time (given by `LIST_INST` ). See the related paragraph in the theoretical documentation of `STAT_NON_LINE` [R5.03.01].

• ‘FORC_VARC_ELEM_P’ calculate the vector of the forces corresponding to the variables of orders at time running (given by `LIST_INST` ). See the related paragraph in the theoretical documentation of `STAT_NON_LINE` [R5.03.01].
4.3 Keyword DEPL/INCR_DEPL/SIGM/VARI

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

Allows to introduce inlet limits to calculate the various fields by the order CALCULATION:
- DEPL give a field of displacement;
- INCR_DEPL is the increment of the field of displacement since the beginning of the step of time;
- SIGM give a stress field;
- VARI give a field of internal variables.

Note:
It is necessary to take care to be coherent between the behavior requested by BEHAVIOR and field of the internal variables cuts it.
The field of the constraints being used to calculate the option FORC_NODA_ELEM is not the same one according to calculations requested. Indeed, if one integrates the law of behavior (options BEHAVIOR, MATR_TANG_ELEM, FORC_INTE_ELEM), then the stress field taken in the calculation of the option FORC_NODA_ELEM will be that calculated afterwards the integration of the behavior. In this case, SIGM is the tensor of the constraints initial and will not be that employed in the calculation of FORC_NODA_ELEM. On the other hand, if only the option FORC_NODA_ELEM is asked, then one will use the field of the constraints directly given by SIGM.

4.4 Operand MODE_FOURIER

- MODE_FOURIER = nh

Positive or null entirety indicating the harmonic of FOURIER on whom one calculates the elementary vector for an axisymmetric model 2D.
5 Operands for thermics

5.1 Keyword EXCIT

◊ EXCIT

This keyword factor makes it possible to describe with each occurrence 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 matr_elem product by the calculation of the matrix of thermal rigidity.

5.1.1 Operand LOAD

◊ LOAD: CH

Concept of the type load product by AFFE_CHAR_THER or by AFFE_CHAR_THER_F [U4.44.02].

Notice important:

For each occurrence of the keyword factor EXCIT various concepts tank used must be built on the same model Mo.

5.1.2 Operand FONC_MULT

◊ FONC_MULT: F

Multiplicative coefficient function of time (concept of the type function, tablecloth or formula) applied to the load.

Notice important:

The concomitant use of FONC_MULT with a load containing of the thermal loadings depending on the temperature is prohibited; i.e. for loadings of the type ECHANGE_, RADIATION, SOUR_NL or FLUNL.

5.2 Operand OPTION

◊ OPTION = '/CHAR_THER_ELEM'

Allows to specify what one calculates:

- 'CHAR_THER_ELEM' calculate them vect_elem corresponding to the non-linear thermal loadings (SOURCE_NL, RADIATION and FLUX_NL). For the linear loadings, it will be necessary to use CALC_VEC_MAT_ELEM;
- 'MATR_TANG_ELEM' calculate the matrix DE non-linear thermal rigidity and thus produces matr_elem elementary matrices. These matrices comprises the voluminal terms of the variational form but also the terms coming from the contribution of the loadings\(^1\): EXCHANGE, ECHANGE_PAROI, RADIATION, FLUX_NL and SOUR_NL. If the loadings understand conditions of the Dirichlet type (AFFE_CHAR_THER/DDL_IMPO), one has also matrices of dualisation coming from the multipliers of Lagrange;
- 'TANK_EVOL_ELEM' calculate Lbe vect_elem elementary vectors corresponding to the resolution of the transitory problem in time;
- 'TANK_RESI_ELEM' calculate Lbe vect_elem elementary vectors corresponding to the deficit of balance of the residues for the non-linear coefficients of the thermal parameters (conductivity thermics for example).

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\(^1\) For FLUX_NL and SOUR_NL only if the coefficients are functions
5.3 **Keyword TEMP/INCR_TEMP**

- TEMP = temp, [cham_no],
- INCR_TEMP = Inctemp, [cham_no],

Allows to introduce inlet limits to calculate the various fields by the order **CALCULATION**:
- TEMP give a field of temperature;
- INCR_TEMP is the increment of the field of temperature since the beginning of the step of time;

5.4 **Operand PARM_THETA**

- PARM_THETA = theta

The argument theta is the parameter of the theta-method applied to the evolutionary problem. It must be ranging between 0 (explicit method) and 1 (completely implicit method). In the absence, keyword, the value used is \( \theta = 0.57 \), a little higher than \( \theta = 0.5 \) corresponds to the diagram of Crank-Nicholson. The incidence of the choice of theta on the stability of the method is detailed in [R5.02.02].
Use of \texttt{CALCULATION} and of \texttt{table\_container}

\texttt{CALCULATION} only a \texttt{table\_container} produces in which is stored for each sequence number one or more fields (forced, internal variables, elementary vectors of the internal forces, elementary matrices of the tangent matrix).

To extract these fields, it is advisable to use the order \texttt{EXTR\_TABLE}. For example, if one wants the field of the constraints resulting from the order \texttt{CALCULATION}, one will make:

\begin{verbatim}
CONT=CALCUL (OPTION= (‘BEHAVIOR’, ‘FORC\_INTE\_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,
COMPORTEMENT=_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’),)
\end{verbatim}

To calculate the second member of the external forces or other quantities (like the matrices masses), one can use the orders \texttt{CALC\_VECT\_ELEM} or \texttt{CALC\_MATR\_ELEM}.

\texttt{matr\_elem} or \texttt{vect\_elem} can be assembled via the orders \texttt{ASSE\_VECTEUR} and \texttt{ASSE\_MATRICE}.

It should be noted that \texttt{MATR\_ELEM} of rigidity produced by \texttt{CALCULATION} contain also the contribution resulting from the dualisation of the limiting conditions of Dirichlet (\texttt{EXCIT}).

An example of use of \texttt{CALCULATION} for mechanics EST available in the CAS-test pynl01a.