Operator CALC_ERC_DYN

1 Goal

In the case of linear dynamics, it makes it possible to obtain the fields solution of a problem of minimization of an energy functional calculus of standard error in relation in behavior (ERC) under a modal formulation.

In addition, it makes it possible to evaluate the functional calculus of error for the fields solution.

Product a structure of data of the type `mode_meca`.

2 Syntax

```
mode_meca [*]=  CALC_ERC_DYN
   (  ♦  MATR_MASS              =  m,       /  [matr_asse_DEPL_R]
      ♦  MATR_RIGI              =  K,       /  [matr_asse_DEPL_R]
      ♦  MATR_NORME             =  G,       /  [matr_asse_GENE_R]
      ♦  MATR_PROJECTION        =  H,       /  [corresp_2_mailla]
      ♦  MEASUREMENT                  =  me,      /  [mode_meca]
                                    /  [dyna_harmo]
      ◊  CHAMP_MESURE           =  |  'DEPL',   [DEFECT]
                                   |  'QUICKLY',
                                   |  'ACCE',
      ◊  /  FREQ                =  lf,          [l_R]
         /  LIST_FREQ           =  cf,          [listr8]
      ♦  ALPHA                  =  al,          [R]
      ♦  GAMMA                  =  ga,          [R]
      ◊   EVAL_FONC             =   |  'NOT',      [DEFECT]
                                    |  'YES',
      ◊  SOLVEUR                =  (
                                   . . to see [U4.50.01]….
                                   ),
      ◊  TITLE  =  tx,                          [l_Kn]
   );
```

3 Recalls

3.1 Problem of optimization associated with an energy functional calculus

This operator solves the following problem:

To find the triplet of acceptable fields (u, v, w) who minimize the functional calculus:

$$e_{\omega}^{2}(u, v, w)=\frac{\gamma}{2}(u-v)^{T}[K](u-v)+\frac{1-\gamma}{2}(u-w)^{T}\omega^{2}[M](u-w)+\frac{1-\alpha}{\alpha}(Hu-\hat{u})^{T}[Gr](Hu-\hat{u})$$

under the constraint:

$$[K]v-\omega^{2}[M]w=0$$

Where:

- K represent a matrix of real rigidity
- M represent a matrix of mass
- H represent a matrix of observation
- Gr represent a positive definite symmetrical matrix being used as standard of the errors within the space of observation
- $\omega=2\pi f$: pulsation of excitation
- $\hat{u}$ observation of displacements to the pulsation ω
- γ parameter of weighting of the errors $(u-v)$ and $(u-w)$
- α parameter of weighting of the functional calculus comparable to a term of regularization

3.2 Equations of resolution of the problem

Obtaining the triplet (u, v, w) associated with the problem under constraint higher brings, at each frequency considered, the resolution of the linear system of equations according to:

$$A l=b$$

with, for each own pulsation ω_i :

$$A_i=\begin{pmatrix}\gamma\left(K+\gamma/(1-\gamma)\omega_i^2 M\right) & -\gamma\left(K-\omega_i^2 M\right)\\ -\gamma\left(K-\omega_i^2 M\right) & (-2\alpha/(1-\alpha))H^T G_r H\end{pmatrix}$$; and $$b_i=\begin{pmatrix}0_n\\ (-2\alpha/(1-\alpha))H^T G_r \hat{u}_i\end{pmatrix}$$

For more details on the formulation, one will refer to the document [R4.10.07].

4 Operands

4.1 Operand MATR_MASS

♦ `MATR_MASS = m`

Name of the concept stamps assembled corresponding to the matrix of mass of the system.

4.2 Operand MATR_RIGI

♦ `MATR_RIGI = K`

Name of the concept stamps assembled corresponding to the matrix of rigidity of the system.

4.3 Operand MATR_NORME

♦ `MATR_NORME = G`

Name of the concept stamps assembled generalized corresponding to the positive definite symmetrical matrix being used as standard of the errors within the space of observation.

4.4 Operand MATR_PROJECTION

♦ `CHECHMATER_PROJECTION = H`

Name of the matrix of projection making it possible to make the geometrical correspondence enters the grid associated with the matrices with mass and rigidity with a side, and grid associated with the observations $\hat{u}$ on another side.
The matrix of projection H must result from a calculation with the operator `PROJ_CHAMP` `[U4.72.05]` with the method `'COLLOCATION'`.

4.5 Operand MEASUREMENT

♦ `MEASUREMENT = me`

Name of the concept of the type `mode_meca` or `dyna_harmo` telling the fields which will be used as an observation. This concept must contain sequence numbers as many than the number of frequencies which will be studied at the time of the call of the operator (operands FREQ/LISTE_FREQ).
In addition, fields contained in `me` do not have to comprise degrees of freedom of the Lagrange type.

The dimension of the fields contained in this concept must be coherent with the dimension of the matrix normalizes `G` informed under the operand `MATR_NORME`.

The use of the operator `OBSERVATION` [U4.90.03] can be a suitable means to condition a concept of the type `mode_meca` or `dyna_harmo` as a measurement `me`.

4.6 Operand CHAMP_MESURE

```
◊  FIELD _MESURE =   |  'DEPL',   [DEFECT]
                     |  'QUICKLY',
                     |  'ACCE',
```

Choice of the fields determining the type of field contained in measurement `me`.

4.7 Operands FREQ/LISTE_FREQ

◊ / `FREQ = lf`

List of all the frequencies of calculation: (`f1, f2,…, fn`).

/ `LIST_FREQ = cf`

Name of the concept of the type `listr8` containing the list of the frequencies of calculation.

4.8 Operand **ALPHA**

♦ `ALPHA = al,`

Value of the parameter of weighting assimilable functional calculus at the end of regularization.

4.9 Operand **GAMMA**

♦ `GAMMA = ga,`

Value of the parameter of weighting of the errors $(u-v)$ and $(u-w)$ functional calculus.

4.10 Operand **EVAL_FONC**

```
◊  EVAL_FONC   =  |  'YES',    [DEFECT]
                  |  'NOT',
```

Choice determining if the value of the functional calculus for the optimal triplet of fields will be evaluated and stored in the result.
In the affirmative one, the operator will store under the dedicated parameter `'ERC_EVAL_FONC'` computed values.

The storage of the value of `'ERC_EVAL_FONC'` is made in the following way in the outgoing concept mode_meca:

For I^{ème}- frequency of calculation, two values of `'ERC_EVAL_FONC'` are stored:

- in (2* (i-1) +1)^{ème} nume_ordre of the outgoing concept one stores the value of $e^2_{\omega_i}(u,v,w)$
- in (2* (i-1) +2)^{ème} nume_ordre of the outgoing concept one stores the value associated at the end of the fields with error $(u-v)$ and $(u-w)$ according to:

$$\frac{\gamma}{2}(u-v)^T[K](u-v)+\frac{1-\gamma}{2}(u-w)^T\omega^2[M](u-w)$$

4.11 Operands **SOLVEUR**

◊ `SOLVEUR`

This keyword factor is optional. It makes it possible to define the method of resolution of the system. Syntax is described in the document [U4.50.01].
In the current version, the solveurs available are MUMPS (defect) and LDLT.

4.12 Operand **TITLE**

◊ `TITLE = tx`

Title attached to the concept produced by this operator [U4.03.01].

5 Storage of the fields solution

Operator CALC_ERC_DYN produces a concept result of the type `mode_meca`.

With each desired frequency, it calculates the fields solution u and $(u-v)$ who are stored in the following way:

For I[ème]- frequency of calculation, are stored:

- in (2* (i-1) +1)[ème] nume_ordre of the outgoing concept is stored the field u
- in (2* (i-1) +2)[ème] nume_ordre of the outgoing concept is stored the field $(u-v)$

One is reminded that the field $(u-w)$ is not calculated directly because can be obtained by the scalar relation:

$$(u-w)=\frac{-\gamma}{1-\gamma}(u-v)$$

6 Example of use

```
# CONSTRUCTION OF THE MATRICES OF THE MECHANICAL MODEL

ASSEMBLY (MODELE=MODNUM,
           CARA_ELEM=CARE,
           CHARGE=CHARGE_L,
           NUME_DDL=CO (“NAKED”),
           SOLVEUR=_F (METHOD = ‘MUMPS’),
           MATR_ASSE= (_F (  MATRIX = CO (“K”),  OPTION = ‘RIGI_MECA’),
                      _F (  MATRIX = CO (“M”),  OPTION = ‘MASS_MECA’),),
           );

# CONSTRUCTION OF THE REDUCED MATRIX OF GUYAN BEING USED AS MATRICE_NORME

# CL FOR THE CONSTRUCTION OF THE REDUCED MATRIX OF GUYAN

CHAR_G=AFFE_CHAR_MECA (MODELE=MODNUM, DDL_IMPO= (_F (  GROUP_NO =
‘OBSPOINT’,  DX=0.  ),),);

ASSEMBLY (MODELE=MODNUM,
           CARA_ELEM=CARE,
           CHARGE= (CHAR_G, CHARGE_L),
           NUME_DDL=CO (“NU_G”),
           SOLVEUR=_F (METHOD = ‘MUMPS’),
           MATR_ASSE= (_F (  MATRIX = CO (“K1”),  OPTION = ‘RIGI_MECA’),
                      _F (  MATRIX = CO (“M1”),  OPTION = ‘MASS_MECA’),),
           );

MOD_STA=MODE_STATIQUE (MATR_RIGI=K1,
                      MATR_MASS=M1,
                      MODE_STAT= (_F (GROUP_NO=' OBSPOINT',
                                   AVEC_CMP= (‘DX’,),),),);

NUME_RED=NUMÉRIQUE_DDL_GENE (BASE=MOD_STA, STOCKAGE=' PLEIN');

MA_RE=PROJ_MATR_BASE (BASE=MOD_STA, NUMÉRIQUE_DDL_GENE=NUMÉRIQUE_RED,
MATR_ASSE=M);
K_RE=PROJ_MATR_BASE (BASE=MOD_STA, NUMÉRIQUE_DDL_GENE=NUMÉRIQUE_RED,
MATR_ASSE=K);

# ONE CHOOSES (for example) the MATRIX NORMALIZES LIKE a COMBINATION OF
# REDUCED MATRICES OF MASS AND STIFFNESS
```

```
G_GUY=COMB_MATR_ASSE (COMB_R= (_F (MATR_ASSE = MA_RE, COEF_R = 1.),
                               _F (MATR_ASSE = K_RE, COEF_R = 1.),),);


## CALCULATION OF the MATRIX OF PROJECTION BETWEEN DIGITAL AND EXPERIMENTAL
MODEL ## (concept corresp_2_mailla)
## OBLIGATORY METHOD COLLOCATION FOR CALC_ERC_DYN

MATPROJ = PROJ_CHAMP (METHODE=' COLLOCATION',
                      PROJECTION=' NON',
                      MODELE_1=MODNUM,
                      MODELE_2=MODEXP);

### CONDITIONNEMENET OF MEASUREMENTS (concept MODES) ON the DDL WHICH US
### INTERESTS
OBS = OBSERVATION (RESULT = MODES,
                   MODELE_1 = MODNUM,
                   MODELE_2 = MODEXP,
                   PROJECTION = 'YES',
                   TOUT_ORDRE = 'YES',
                   MATR_RIGI = KASEXP,
                   MATR_MASS = MASEXP,
                   NOM_CHAM = 'DEPL',
                   FILTER = _F (GROUP_MA = 'MEASUREMENT',
                                NOM_CHAM = ('DEPL'),
                                DDL_ACTIF = ('DX',),),);

### RESOLUTION OF THE PROBLEM OF THE ERC

# CHOICE OF THE FREQUENCIES ON WHICH ONE WILL SOLVE THE ERC:
LFREQ=DEFI_LISTE_REEL (VALE= [0.12181191980055407,
1.25*0.22507907903927654],);

# CHOICE OF THE FREQUENCIES ON WHICH
ERC=CALC_ERC_DYN (EVAL_FONCTIONNELLE=' OUI',
                  MATR_PROJECTION=MATPROJ,
                  MESURE=OBS,
                  CHAMP_MESURE=' DEPL',
                  MATR_MASS=M,
                  MATR_RIGI=K,
                  MATR_NORME=G_GUY,
                  LIST_FREQ=LFREQ,
                  GAMMA=0.5,
                  ALPHA=0.5,
                  INFO=1,
                  SOLVEUR=_F (METHODE=' MUMPS',),);
```