Operator MODE_STATIQUE

1 Goal

To calculate static modes for a displacement, a force or a unit acceleration imposed. One can also calculate modes of couplings (modes of interface) to define a smaller generalized model.

A static mode is the static deformation of an isostatic or hyperstatic structure on which one imposes:

- in one **degree of freedom blocked** (node - component) a unit imposed displacement,
- in one **free degree of freedom** (node - component) a unit nodal force,
- in one **direction**, a unit imposed acceleration,
- in one **degree of freedom** (node - component) a unit imposed acceleration.

The modes of couplings correspond to the modes of under structure condensed statically on the interface. These modes, only definite on the interface, are then raised statically on the whole of under structure.

The operator allows to calculate the whole of the static modes corresponding to several couples node - component. The matrix of rigidity must be assembled by using a set of boundary conditions sufficient kinematics so that all the solid modes of body are removed (operators AFFE_CHAR_MECA [U4.44.01] or AFFE_CHAR_CINE [U4.44.03]). It is possible to ask only part of the static modes corresponding to these conditions kinematics.

The produced concept can be used to supplement a modal base of clean modes of vibration (operator DEFI_BASE_MODALE [U4.64.02] or DYNA_ALEA_MODAL [U4.53.22]), to determine the loadings necessary to the calculation of the movement of training under a seismic excitation (operator CALC_CHAR_SEISME [U4.63.01]) and to introduce displacements with anchorings multi-supports or the modes of correction in spectral analysis (operator COMB_SISM_MODAL [U4.84.01]).

Product a concept of the type mode_meca.

Contents

2 Syntax

```
R [mode_meca]    = MODE_STATIQUE (

    ♦  MATR_RIGI     =   rigi                            [matr_asse_DEPL_R]
    ◊  MATR_MASS     =   mass                            [matr_asse_DEPL_R]
    ♦  /   MODE_STAT     =   _F (
                         ♦  /   ALL    =    'YES'
                            /   GROUP_NO  = g_noeu         [l_Kn]
                         ♦  /   TOUT_CMP = 'YES'
                            /   AVEC_CMP = l_cmp           [l_Kn]
                            /   SANS_CMP = l_cmp           [l_Kn]
                         )
       /   FORCE_NODALE =   _F (
                         ♦  /   ALL =     'YES'
                            /   GROUP_NO = g_noeu          [l_gr_noeud]
                         ♦  /   TOUT_CMP = 'YES'
                            /   AVEC_CMP = l_cmp           [l_Kn]
                            /   SANS_CMP = l_cmp           [l_Kn]
                         )
       /   PSEUDO_MODE  =   _F (
                         ♦  /   AXIS = /   'X'
                                       /   'Y'
                                       /   'Z'
                            /  ♦  DIRECTION    =   to l_dir   [l_R]
                               ◊  NOM_DIR      =   to n_dir   [l_Kn]
                            /  ♦  /  ALL    =   'YES'
                                  /  GROUP_NO  =   g_noeu [l_gr_noeud]
                               ♦  /  TOUT_CMP  = 'YES'
                                  /  AVEC_CMP  = l_cmp    [l_Kn]
                                  /  SANS_CMP  = l_cmp    [l_Kn]
                         )
       /   MODE_INTERF =_F (
                         ♦  /   ALL =     'YES'
                            /   GROUP_NO = g_noeu          [l_gr_noeud]
                         ♦  /   TOUT_CMP = 'YES'
                            /   AVEC_CMP = l_cmp           [l_Kn]
                            /   SANS_CMP = l_cmp           [l_Kn]
                         ♦  /   NB_MODE = nb_mod           [I]
                            /   SHIFT = shift              [R]
                         )
       ◊   SOLVEUR      =   _F (see document [U4.50.01])
       ◊   TITLE        =   title                          [l_Kn]
       ◊   INFORMATION       =  /  1                             [DEFECT]
                            /   2
    );
```

3 Operands

3.1 Operand MATR_RIGI

♦ MATR_RIGI = rigi

Matrix of rigidity of the isostatic or hyperstatic structure.

3.2 Operand MATR_MASS

◊ MATR_MASS = mass

Matrix of mass of the isostatic or hyperstatic structure.

3.3 Nature of the requests applied

3.3.1 Keyword MODE_STAT

♦ / MODE_STAT

Keyword factor for the definition of the static modes with unit imposed displacement. These modes intervene to determine the loading due to the movement of training multi-supports under a seismic excitation (operator CALC_CHAR_SEISME [U4.63.01]) (cf reference [R4.05.01]) or to introduce displacements with anchorings multi-supports in spectral analysis (operator COMB_SISM_MODAL [U4.84.01]) (cf reference [R4.05.03]). See §4.1 example.

3.3.1.1 Operands TOUT/GROUP_NO

♦ / ALL = 'YES'

Calculation of the modes on all the nodes of the system which have blocked ddl.

/ GROUP_NO = g_noeu

Calculation of the modes on the groups of nodes g_noeu (subset of the blocked nodes).

3.3.1.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦ / TOUT_CMP = 'YES'

Calculation of the modes on all the components blocked with the nodes defined previously.

/ AVEC_CMP = l_cmp

Calculation of the modes on the components only quoted.

/ SANS_CMP = l_cmp

Calculation of the modes by excluding the quoted components.

3.3.2 Keyword FORCE_NODALE

/ FORCE_NODALE

Keyword factor for the definition of the static modes with unit imposed force. These modes intervene to supplement a modal base of clean modes of vibration (operator DEFI_BASE_MODALE [U4.64.02] or DYNA_ALEA_MODAL [U4.53.22]). Cf reference [R5.06.01] and to see §4.2 example.

3.3.2.1 Operand TOUT/GROUP_NO

♦ / `ALL = 'YES'`

Calculation of the modes on all the nodes of the system which have ddl **free** .

/ `GROUP_NO = g_noeu`

Calculation of the modes on the groups of nodes `g_noeu` .

3.3.2.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦ / `TOUT_CMP = 'YES'`

Calculation of the modes on all the components **free** with the nodes defined previously.

/ `AVEC_CMP = l_cmp`

Calculation of the modes on the components only quoted.

/ `SANS_CMP = l_cmp`

Calculation of the modes by excluding the quoted components.

3.3.3 Keyword PSEUDO_MODE

/ `PSEUDO_MODE`

Keyword factor for the definition of the static modes (or pseudo-modes) with unit imposed acceleration. These modes intervene to supplement a modal base of clean modes of vibration (operator `DEFI_BASE_MODALE` [U4.64.02] or `DYNA_ALEA_MODAL` [U4.53.22]) (cf reference [R5.06.01], to determine the modes of correction in spectral analysis (operator `COMB_SISM_MODAL` [U4.84.01], keyword `MODE_CORR`) (cf reference [R4.05.03]). One treats the case mono-support (operands `AXE/DIRECTION`, to see example §4.3) or multi-supports (operand `GROUP_NO` and `*CMP`, to see example §4.4).

3.3.3.1 Operands AXE/DIRECTION/NOM_DIR

♦ / `AXIS = l_axe`

Calculate modes along the axes of the total reference mark given (`l_axe`), these axes being $'X'$, $'Y'$ and $'Z'$.

/ ♦ `DIRECTION = to l_dir`

Calculate the mode according to the direction given (`to l_dir`)
(`to l_dir`) : directing vector with 3 components.

◊ `NOM_DIR = to n_dir`

Name user which one wishes to give to the mode calculated in the direction (n_{dir}).
By default the name is `DIR_N` , N being the number of the static mode.

3.3.3.2 Operands TOUT/GROUP_NO

♦ / `ALL = 'YES'`

Calculation of the modes on all the nodes of the system.

/ `GROUP_NO = g_noeu`

Calculation of the modes on the groups of nodes `g_noeud` .

3.3.3.3 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦ / `TOUT_CMP = 'YES'`

Calculation of the modes on all the components with the nodes defined previously.

/ `AVEC_CMP = l_cmp`

Calculation of the modes on the components only quoted.

/ `SANS_CMP = l_cmp`

Calculation of the modes by excluding the quoted components.

3.3.4 Keyword MODE_INTERF

/ `MODE_INTERF`

Keyword factor for the definition of the modes of coupling. These modes intervene to supplement a modal base of clean modes of vibration (operator `DEFI_BASE_MODALE` [U4.64.02] or `DYNA_ALEA_MODAL` [U4.53.22]). Cf reference [R5.06.01] and to see §4.2 example.

3.3.4.1 Operand TOUT/GROUP_NO

♦ / `ALL = 'YES'`

Calculation of the modes on all the nodes of the system which have degrees of freedom **blocked** .

/ `GROUP_NO = g_noeu`

Calculation of the modes on the groups of nodes `g_noeu` .

3.3.4.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦ / `TOUT_CMP = 'YES'`

Calculation of the modes on all the components blocked with the nodes defined previously.

/ `AVEC_CMP = l_cmp`

Calculation of the modes on the components only quoted.

/ `SANS_CMP = l_cmp`

Calculation of the modes by excluding the quoted components.

3.3.4.3 Operand NB_MODE

♦ `NB_MODE = nbmod`

Many modes to be calculated. It is not, for the moment, possible to specify a waveband of interest, or the frequency maximum of the modes to be calculated. The user must thus estimate by him even the number of mode to be taken into account. The list of the frequencies associated with the modes with interface makes it possible to determine the number of modes to take into account in calculation for the scale model.

3.3.4.4 Operand SHIFT

♦ SHIFT = shift

Frequency of shift (shift) used for the calculation of the modes of interface. The choice of this value makes it possible to improve the precision of the calculation of the modes. One will be able to choose a value of shift corresponding to 10% of the first Eigen frequency expected for the modes of coupling. The arbitrary value by default is fixed at $1\,Hz$.

3.4 Keyword SOLVEUR

◊ SOLVEUR =…

This keyword factor is optional: it makes it possible to choose the linear solvor used in certain part of the algorithm. Syntax being common to several orders, please consult the handbook [U4.50.01].

Note: for the keyword MODE_INTERF, one must solve system linear but for those, the solvor is selected in “hard” in programming (LDLT if there is very few ddls and MUMPS if there is more).

3.5 Operand TITLE

◊ TITLE = title

Attache with the concept produced by this operator [U4.03.01].

3.6 Operand INFORMATION

◊ INFORMATION

Indicate the level of impression of information on the file “ MESSAGE ”:

1: no impression
2: impression of the calculated static modes.

4 Examples

4.1 Calculation of the static modes in unit imposed displacement

Calculation static modes in unit imposed displacement.

mode Ψ solution of

$$\begin{cases}\Psi = -K^{-1} \cdot {}^t B^{-1} \cdot \lambda_i \\ B \cdot \Psi = V_i\end{cases}$$

with

K : matrix of rigidity

V_i : being worth vector $1.$ for the components DX and DY group of nodes bases.

λ_i : reactions of support on the connection B group of nodes bases.

```
mstat = MODE_STATIQUE (   MATR_RIGI = rigidity,
                          MODE_STAT =_F (GROUP_NO = 'bases',
                                   (AVEC_CMP = ('DX', 'DY'),),
                        );
```

4.2 Calculation of the static modes in unit imposed force

Calculation static modes in unit imposed force.

mode $\Psi = K^{-1} F_i$ with

K : matrix of rigidity

F_i : being worth vector $1.$ for the components DX and DY group of nodes bases.

```
mstat = MODE_STATIQUE (   MATR_RIGI = rigidity,
                          FORCE_NODALE =_F (GROUP_NO = 'bases',
                                     (AVEC_CMP = ('DX', 'DY'),),
                        );
```

4.3 Calculation of the static modes (or pseudo-modes) in unit constant acceleration in the 3 directions

Calculation static modes in unit constant acceleration in the 3 directions.

mode $\Psi = K^{-1}(M\,A_i)$ with

K : matrix of rigidity

M : matrix of mass

A_i : unit vector in the direction i.

```
mstat = MODE_STATIQUE  (   MATR_RIGI = rigidity,
                           MATR_MASS = mass,
                           PSEUDO_MODE=_F (AXE= ('X', 'Y', 'Z'),),
                        );
```

4.4 Calculation of the static modes (or pseudo-modes) in unit imposed acceleration

Calculation static modes in unit imposed acceleration.

mode $\Psi = K^{-1}(M A_i)$	with	K	:	matrix of rigidity
		M	:	matrix of mass
		A_i	:	unit vector for the components DX and DY group of nodes $base$

```
mstat = MODE_STATIQUE  (  MATR_RIGI = rigidity,
                          MATR_MASS = mass,
                          PSEUDO_MODE=_F   (GROUP_NO = 'bases',
                                            (AVEC_CMP = ('DX', 'DY'),),
                       ) ;
```

4.5 Calculation of the modes of coupling

Modes of couplings $\Psi = T\,\Phi$ are the static raising of the modes Φ reduced problem

$$[T^T(K-\omega^2 M)T]\Phi=0\,, \qquad (1)$$

where T are the static modes in imposed displacement. One does not calculate obviously explicitly T in this case there. The modes are calculated by an approximate method detailed in the reference [R4.06.02].

```
minter = MODE_STATIQUE (  MATR_RIGI = rigidity,
                          MATR_MASS = mass,
                          MODE_INTERF=_F   (GROUP_NO = 'bases',
                                             AVEC_CMP = ('DX', 'DY'),
                                             NB_MODE=10,
                                             SHIFT=1.,
                                           ),
                       ) ;
```