Operator MODE_STATIQUE

1 Drank

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

A static mode is the static deformed shape of a statically determinate or hyperstatic structure on which one imposes:

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

The operator allows to calculate all the static modes corresponding to several couples node - component. The stiffness matrix must be assembled by means of a set of kinematical boundary conditions sufficient so that all the modes of solid bodies 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 kinematical conditions.

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

Product a concept of the mode_meca type.

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Contents

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2 Syntax

```
R [mode_meca]    = MODE_STATIQUE (

   ♦MATR_RIGI=rigi
[matr_asse_DEPL_R]
   ◊MATR_MASS=masse
[matr_asse_DEPL_R]
   ♦/MODE_STAT=_F                  (
                        ♦/TOUT=                  "/NOEUD
                           OUI'           =    noeu           [l_Kn]
                           /GROUP_NO      = g_noeu         [l_Kn]
                        ♦/TOUT_CMP        = "/AVEC_CMP
                           OUI'    = l_cmp              [l_Kn]
                           /SANS_CMP  = l_cmp             [l_Kn]
                        )
      /FORCE_NODALE =_F    (
                        ♦/TOUT      =      "/NOEUD
                           OUI'    =    noeu              [l_noeud]
                           /GROUP_NO  = g_noeu         [l_gr_noeud]
                        ♦/TOUT_CMP        = "/AVEC_CMP
                           OUI'    = l_cmp              [l_Kn]
                           /SANS_CMP  = l_cmp             [l_Kn]
                        )
      /PSEUDO_MODE      =_F   (
                        ♦/AXE       =      "X"
                                    /   "Y"
                                    /   "Z"
                           to/♦DIRECTION=l_dir                  [l_R]
                              to ◊NOM_DIR=n_dir                 [l_Kn]

                                                /♦/TOUT=' OUI'
                              /NOEUD         =noeu     [l_noeud]
                              /GROUP_NO      =g_noeu       [l_gr_noeud]
                              ♦/TOUT_CMP=           "/AVEC_CMP
                                 OUI'       = l_cmp   [l_Kn]
                                 /SANS_CMP      = l_cmp   [l_Kn]
                        )
      /MODE_INTERF  =_F    (
                        ♦/TOUT      =      "/NOEUD
                           OUI'    =    noeu              [l_noeud]
                           /GROUP_NO  = g_noeu         [l_gr_noeud]
                        ♦/TOUT_CMP        = "/AVEC_CMP
                           OUI'    = l_cmp              [l_Kn]
                           /SANS_CMP  = l_cmp             [l_Kn]
                        ♦/NBMOD        = nb_mod            [I]
                           /SHIFT  = shift                [R]
                        )
      ◊   SOLVEUR=_F          (see document [U4.50.01])
      ◊TITER=titer                                          [l_Kn]

      ◊INFO=/1                                              [DEFAULT]
                        /2
```

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```
                )  ;
```

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3 Operands

3.1 Operand MATR_RIGI

♦MATR_RIGI =rigi

Stiffness matrix of statically determinate or hyperstatic structure.

3.2 Operand MATR_MASS

◊MATR_MASS = mass

Mass matrix of statically determinate or hyperstatic structure.

3.3 Nature of the requests applied

3.3.1 Key word MODE_STAT

♦/MODE_STAT

Key word factor for the definition of the static modes to unit imposed displacement. These modes intervene to determine the loading due to the motion of training multi-bearings under a seismic excitation (operator CALC_CHAR_SEISME [U4.63.01]) (cf reference [R4.05.01]) or to introduce displacements with the anchorages multi-bearings 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/NOEUD/GROUP_NO

♦/TOUT=' OUI'

Computation of the modes on all the nodes of the system which have d.o.f. blocked.

/NOEUD =noeu

Computation of the modes on all the nodes noeu (subset of the blocked nodes).

/ GROUP_NO=g_noeu

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

3.3.1.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦/TOUT_CMP=' OUI'

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

/ AVEC_CMP=l_cmp

Computation of the modes on the components only quoted.

/SANS_CMP =l_cmp

Computation of the modes by excluding the quoted components.

3.3.2 Key word FORCE_NODALE

/FORCE_NODALE

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Key word factor for the definition of the static modes with unit imposed force. These modes intervene to supplement a modal base of eigen 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/NOEUD/GROUP_NO

♦/TOUT = "OUI'

Computation of the modes on all the nodes of the system which have free **d.o.f** .

/NOEUD = noeu

Computation of the modes on all the nodes noeu.

/ GROUP_NO = g_noeu

Computation of the modes on the g_noeu nodes groups .

3.3.2.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦/TOUT_CMP = "OUI'

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

/AVEC_CMP = l_cmp

Computation of the modes on the components only quoted.

/SANS_CMP = l_cmp

Computation of the modes by excluding the quoted components.

3.3.3 Key word PSEUDO_MODE

/PSEUDO_MODE

Key word factor for the definition of the static modes (or pseudo-modes) with unit imposed acceleration. These modes intervene to supplement a modal base of eigen 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], key word MODE_CORR) (cf reference [R4.05.03]). One treats the case mono-bearing (operands AXE/DIRECTION, to see §4.3 example) or multi-bearings (operands NOEUD/GROUP_NO and *CMP, to see §4.4 example).

3.3.3.1 Operands AXE/DIRECTION/NOM_DIR

♦/AXE = l_axe

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

/♦DIRECTION = to l_dir

Calculates 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.

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3.3.3.2 Operands TOUT/NOEUD/GROUP_NO

♦/TOUT = "OUI'

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

/NOEUD = noeu

Computation of the modes on all the nodes noeu.

/GROUP_NO = g_noeu

Computation of the modes on the g_noeud nodes groups .

3.3.3.3 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦/TOUT_CMP = "OUI'

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

/AVEC_CMP = l_cmp

Computation of the modes on the components only quoted.

/SANS_CMP = l_cmp

Computation of the modes by excluding the quoted components.

3.3.4 Key word MODE_INTERF

/MODE_INTERF

Key word factor for the definition of the modes of coupling. These modes intervene to supplement a modal base of eigen 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/NOEUD/GROUP_NO

♦/TOUT = "OUI'

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

/NOEUD = noeu

Computation of the modes on all the nodes noeu.

/ GROUP_NO = g_noeu

Computation of the modes on the g_noeu nodes groups .

3.3.4.2 Operands TOUT_CMP/AVEC_CMP/SANS_CMP

♦/TOUT_CMP = "OUI'

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

/AVEC_CMP = l_cmp

Computation of the modes on the components only quoted.

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/SANS_CMP = l_cmp

Computation of the modes by excluding the quoted components.

3.3.4.3 Operand NBMOD

♦ NBMOD = nbmod

Many modes to calculating. It is not, for time, possible to specify a waveband of interest, or the frequency maximum of the modes to calculating. 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 computation for the model reduced.

3.3.4.4 Operand SHIFT

♦SHIFT = shift

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

3.4 Key word solver

◊ solver =…

This key word factor is optional: it makes it possible to choose another solver of resolution of system. Syntax being common to several commands, please consult the handbook [U4.50.01].

3.5 Operand TITER

◊TITER = title

Attached to the product concept by this operator [U4.03.01].

3.6 Operand INFO

◊INFO

Indicates the level of printing of information on the file "MESSAGE ":

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

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4 Computation

4.1 examples of the static modes in displacement imposed unit

Computation of the static modes in unit imposed displacement.

solution Ψ mode of $\begin{cases} \Psi = -K^{-1} \cdot {}^{t}B^{-1} \cdot \lambda_i \\ B \cdot \Psi = V_i \end{cases}$ with

K : stiffness matrix

V_i : vector applying $1.$ to the components DX and DY of the nodes group bases.

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

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

4.2 Computation of the static modes in imposed force unit

Computation of the static modes in unit imposed force.

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

K : stiffness matrix

F_i : vector applying $1.$ to the components DX and DY of the nodes group bases.

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

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

Computation of the static modes in unit constant acceleration in the 3 directions.

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

K : stiffness matrix

M : mass matrix

A_i : unit vector in the direction i .

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

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

Computation of the static modes in unit imposed acceleration.

mode Ψ = $K^{-1}\left(M\, A_i\right)$ with K : stiffness matrix

M : mass matrix

A_i : unit vector for the components DX and DY of the mstat $base$

```
nodes group = MODE_STATIQUE   (  MATR_RIGI = stiffness,
                              MATR_MASS = mass,
                              PSEUDO_MODE=_F    (GROUP_NO = "bases",
                                                 (AVEC_CMP = ("DX", "DY"),),
                           );
```

4.5 Computation of the modes of coupling

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

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

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 = stiffness,
                          MATR_MASS = mass,
                          MODE_INTERF=_F    (GROUP_NO = "bases",
                                             AVEC_CMP = ("DX", "DY"),
                                             NBMOD=10,
                                             SHIFT=1.,
                                            ),
                       );
```

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