
Operator `MODE_ITER_INV`

1 Drank

That that is to study vibrations of a structure (possibly damped or revolving) or to search its buckling modes, the mechanic must often solve a modal problem: either **generalized (GEP)** [R5.01.01], or **quadratic (QEP)** [R5.01.02]. With this intention, *Code_Aster* proposes two core operators: `MODE_ITER_SIMULT` and `MODE_ITER_INV`.

The first operator is rather to use when one seeks a significant part of the spectrum (methods of subspace or global method). The second operator, who is the object of this note, is to be privileged when one is interested in only some eigen modes (typically a half-dozen) or when one wishes to refine some estimates (possibly coming from `MODE_ITER_SIMULT`).

`MODE_ITER_INV` determines the eigen modes in two stages: a preliminary phase of localization of the eigenvalues followed by a improvement of these estimates and computation of their associated eigenvectors.

The first stage is based only on evaluations provided by the user or refines them by the heuristic ones adapted: in GEP, by a technique of bisection possibly supplemented by a secant method; in QEP, by a method of Müller-Traub. **The second stage** implements an algorithm of the type powers opposite: in GEP, the standard method possibly accelerated by a coefficient of Rayleigh; in QEP, an alternative due to Jennings.

This operator produces a **concept** `mode_meca_*` (case dynamic) or `mode_flamb` (case buckling of Eulerian, only in GEP) according to the value indicated in key word `TYPE_RESU`. **The perimeter of use** of `MODE_ITER_INV` is limited to the GEP and to the QEP with real symmetric matrixes.

This document describes the parameters accessible from each method specific to operator `MODE_ITER_INV`.

For optimized performances CPU, this operator can be used with the parallelism of the linear solver MUMPS.

Contents

1	But1.....	
2	Syntaxe3.....	
3	Opérandes6.....	
3.1	Principles	6.3.2
	Operands MATR_RIGI/MATR_A/MATR_MASS/MATR_RIGI_GEOM /MATR_B/MATR_AMOR/ MATR_C8.....	
3.3	Key word TYPE_RESU9.....	
3.4	Key word CALC_FREQ9.....	
3.4.1	Operand FREQ10.....	
3.4.2	Operand AMOR_REDUIT10.....	
3.4.3	Operand NMAX_FREQ10.....	
3.5	Key word CALC_CHAR_CRIT10.....	
3.5.1	Operand CHAR_CRIT10.....	
3.5.2	Operand NMAX_CHAR_CRIT11.....	
3.6	Operands SEUIL_FREQ, SEUIL_CHAR_CRIT, PREC_SHIFT, NMAX_ITER_SHIFT11.....	
3.7	Operand OPTION12.....	
3.7.1	Operands of the bisection (if OPTION= 'SEPRE' or "ADJUSTS").....	12
3.7.2	Operands of the secant (if OPTION= 'AJUSTE').....	12
3.8	Key word factor CALC_MODE	
13.3.8.1	Operand OPTION	
13.3.8.2	Operand NMAX_ITER	
13.3.8.3	Operand PREC	13.3.9
	Factor key word SOLVEUR13.....	
3.10	Key word factor VERI_MODE	13
3.10.1	Operand STOP_ERREUR	14
3.10.2	Operand SEUIL	14
3.11	Operand INFO	14
3.12	Operand TITER	14
4	Phase of exécution15.....	
4.1	Vérification15.....	
4.2	Exécution15.....	
5	Parameters modal Normalizes modes Position modale16.....	
6	Printing of results	17
7	Exemples18.....	
8	Remarks of utilisation19.....	

2 Syntax

```
mode      [*] =MODE_ITER_INV

# TYPE OF PROBLEM
  ◊TYPE_RESU=/ "DYNAMIQUE"                                [DEFAULT]
                /"MODE_FLAMB" (only in GEP)
                /"GENERAL"

# IF TYPE_RESU= `DYNAMIQUE'

  (  ◊MATR_RIGI=A/                                         [matr_asse_DEPL_R]
                                           [matr_asse_PRES_R]
                                           [matr_asse_GENE_R]
    ◊MATR_MASS=B/                                         [matr_asse_DEPL_R]
                                           [matr_asse_PRES_R]
                                           [matr_asse_GENE_R]
    ◊MATR_AMOR=C      (only in QEP)                       [matr_asse_DEPL_R]

    ◊CALC_FREQ=_F ( ◊OPTION=      /"NEAR"      (not of multiple mode)
                    /"SEPARATE"    (only in GEP)
                    /"ADJUSTS"    [DEFAULT]
    ◊   FREQ=lfreq                [1_R]
    ◊   AMOR_REDUIT=lamor          [1_R]
    ◊   NMAX_FREQ=/0              [DEFAULT]
                                   /nf                [I]

    # IF OPTION= `SEPRE' or "ADJUSTS" (only in GEP)
    ◊ NMAX_ITER_SEPRE=/30          [DEFAULT]
                                   /nis                [I]
    ◊PREC_SEPRE=/1.E-4            [DEFAULT]
                                   /ps                [R]

    # IF OPTION= `AJUSTE'
    ◊NMAX_ITER_AJUSTE=/15         [DEFAULT]
                                   /nia                [I]
    ◊   PREC_AJUSTE=/1.E-4        [DEFAULT]
                                   /pa                [R]

# FOR PRE AND POSTPROCESSINGS
    ◊ SEUIL_FREQ=/1.E-2           [DEFAULT]
                                   /sf                [R]
    ◊   PREC_SHIFT=/0.05         [DEFAULT]
                                   /ps                [R]
    ◊   NMAX_ITER_SHIFT=/3       [DEFAULT]
                                   /ns                [I]

# IF TYPE_RESU= `MODE_FLAMB' (only in GEP)

  (  ◊ MATR_RIGI=A                                         [matr_asse_DEPL_R]
                                           [matr_asse_PRES_R]
                                           [matr_asse_GENE_R]
    ◊MATR_RIGI_GEOM=B/                                         [matr_asse_DEPL_R]
                                           [matr_asse_PRES_R]
                                           [matr_asse_GENE_R]

    ◊CALC_CHAR_CRIT=_F ( ◊ OPTION= /"NEAR"      (not of multiple mode)
                    /"SEPARATE"    (only in GEP)
                    /"ADJUSTS"    [DEFAULT]
```

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.

```

        ◆ CHAR_CRIT=lchar                [l_R]
        ◇ NMAX_CHAR_CRIT=/0              [DEFAULT]
                                          /nf      [I]

# IF OPTION= `SEPRE' or "ADJUSTS" (only in GEP)
        ◇ NMAX_ITER_SEPRE=/30            [DEFAULT]
                                          /nis     [I]
        ◇PREC_SEPRE=/1.E-4              [DEFAULT]
                                          /ps      [R]

# IF OPTION= `AJUSTE'
        ◇NMAX_ITER_AJUSTE=/15           [DEFAULT]
                                          /nia     [I]
        ◇ PREC_AJUSTE=/1.E-4           [DEFAULT]
                                          /pa      [R]

# FOR PRE AND POSTPROCESSINGS
        ◇ SEUIL_CHAR_CRIT=/1.E-2        [DEFAULT]
                                          /sf      [R]
        ◇ PREC_SHIFT=/0.05              [DEFAULT]
                                          /ps      [R]
        ◇ NMAX_ITER_SHIFT=/3            [DEFAULT]
                                          /ns      [I]

# IF TYPE_RESU= `GENERAL'
(   ◆MATR_A=A/                          [matr_asse_DEPL_R]
                                          /[matr_asse PRES_R]
                                          /[matr_asse_GENE_R]
        ◆MATR_B=B/                       [matr_asse_DEPL_R]
                                          /[matr_asse PRES_R]
                                          /[matr_asse_GENE_R]

        ◆CALC_CHAR_CRIT=_F ( ◇ OPTION= /"NEAR" (not to mode multiple)
                               /"SEPARATE" (only in GEP)
                               /"ADJUSTS" [DEFAULT]
        ◆ CHAR_CRIT=lchar                [l_R]
        ◇ NMAX_CHAR_CRIT=/0              [DEFAULT]
                                          /nf      [I]

# IF OPTION= `SEPRE' or "only ADJUSTS " ( in GEP)
        ◇ NMAX_ITER_SEPRE=/30            [DEFAULT]
                                          /nis     [I]
        ◇PREC_SEPRE=/1.E-4              [DEFAULT]
                                          /ps      [R]

# IF OPTION= `AJUSTE'
        ◇NMAX_ITER_AJUSTE=/15           [DEFAULT]
                                          /nia     [I]
        ◇ PREC_AJUSTE=/1.E-4           [DEFAULT]
                                          /pa      [R]

# FOR PRE AND POSTPROCESSINGS
        ◇ SEUIL_CHAR_CRIT=/1.E-2        [DEFAULT]
                                          /sf      [R]
        ◇ PREC_SHIFT=/0.05              [DEFAULT]
                                          /ps      [R]
        ◇ NMAX_ITER_SHIFT=/3            [DEFAULT]
                                          /ns      [I]

```

#PARAMETRAGE PHASE Inverse iterations

```
    ◇CALC_MODE=_F ( ◇OPTION=/ "DIRECT"                                [DEFAULT]
                    /"RAYLEIGH" (only in GEP)
                    ◇NMAX_ITER=/30
[DEFAULT]
                    /nim                                             [I]
                    ◇PREC=/1.E-5                                     [DEFAULT]
                    /pm                                             [R]
                    )
```

#POUR VERIFICATION FINALE

```
    ◇VERI_MODE=_F ( ◇STOP_ERREUR=/ "OUI"                               [DEFAULT]
                    /"NON"
                    ◇SEUIL=/1.E-2                                     [DEFAULT]
                    /r                                              [R]
                    )
```

#DIVERS

```
    ◇INFO=/1                                                         [DEFAULT]
        /2
    ◇TITER=ti                                                         [I_Kn]
);
```

#RESULTATS OF PROBLEM MODAL

```
    SiTYPE_RESU= `MODE_FLAMB'           then [*] - >mode_flamb
    SiTYPE_RESU= `GENERAL'              then [*] - >mode_flamb
    SiMATR_AMOR or MATR_C= [matr_asse_DEPL_R] then [*] - >mode_meca_c
    SiMATR_RIGI or MATR_A= [matr_asse_DEPL_R] then [*] - >mode_meca
    SiMATR_RIGI or MATR_A= [matr_asse_PRES_R] then [*] - >mode_acou
    SiMATR_RIGI or MATR_A= [matr_asse_GENE_R] then [*] - >mode_gene
```

3 Operands

3.1 Principles

This operator solves **the problem generalized (GEP)** with the eigenvalues according to [R5.01.01]:

To find (λ, \mathbf{x}) formula $\mathbf{A} \mathbf{x} = \lambda \mathbf{B} \mathbf{x}$ formula $\mathbf{x} \neq 0$ formula, \mathbf{A} formula \mathbf{B} formula are real matrixes, symmetric. To model a hysteretic damping in the study of free vibrations of a structure, the matrix \mathbf{A} can be complex symmetric [U2.06.03] [R5.05.04].

This kind of problem corresponds, in mechanics, in particular with:

- **The study of free vibrations of an undamped** and nonrevolving structure. For this structure, one searches the smallest eigenvalues or those which are in an interval given to know if an exiting force can create a resonance. In this case, the matrix \mathbf{A} is the material stiffness matrix, noted \mathbf{K} , symmetric real (possibly increased geometrical stiffness matrix noted \mathbf{K}_g , if the structure is prestressed), and \mathbf{B} is the mass matrix or of noted inertia \mathbf{M} (symmetric real). The eigenvalues obtained are the squares of the pulsations associated with the sought frequencies. The system to be solved can be written

$$\underbrace{(\mathbf{K} + \mathbf{K}_g)}_{\mathbf{A}} \mathbf{x} = \lambda \underbrace{\mathbf{M}}_{\mathbf{B}} \mathbf{x}$$

where $\lambda = (2\pi f)^2$ is the square of the pulsation ω , f the eigenfrequency formulates and \mathbf{x} the associated clean displacement vector. The handled eigen modes (λ, \mathbf{x}) are with actual values. This kind of problems are activated by the key word `TYPE_RESU='DYNAMIQUE'` and generate a data structure *Aster* of the mode_meca type, mode_acou or mode_gene (according to the type of the data input).

- **The search for linear mode of buckling.** In the frame of the linearized theory, while supposing *a priori* that the phenomena of stability are suitably described by the system of equations obtained by supposing the linear dependence of displacement compared to the level of critical load, the search of the mode of buckling x associated on this level with critical load $\mu = -\lambda$, is brought back to a problem generalized to the eigenvalues of the form

$$(\mathbf{K} + \mu \mathbf{K}_g) \mathbf{x} = 0 \Leftrightarrow \underbrace{\mathbf{K}}_{\mathbf{A}} \mathbf{x} = \lambda \underbrace{\mathbf{K}_g}_{\mathbf{B}} \mathbf{x}$$

with \mathbf{K} material stiffness matrix and \mathbf{K}_g geometrical stiffness matrix. The handled eigen modes (λ, \mathbf{x}) are with actual values. This kind of problems are activated by the key word `TYPE_RESU='MODE_FLAMB'` and generate a data structure *Aster* of the mode_flamb type.

Caution:

- In the code, one treats only the eigenvalues of the generalized problem, the variables λ . To obtain the true critical loads, the variables μ , it should be multiplied par. -1
- In GEP, for dealing with problems with complex modes (asymmetric matrixes and/or with complex values), it is necessary to use `MODE_ITER_SIMULT (METHODE='SORENSEN'/'QZ')`.

This operator allows also the study of **the dynamic stability of a structure in the presence of depreciation and/or gyroscopic effects**. That led to the resolution of a modal problem of a nature higher, known as quadratic (QEP) [R5.01.02]. Complex values and eigenvectors then are searched (l, \mathbf{x}) .

- The problem consists in finding $(\lambda, \mathbf{x}) \in (C, C^N)$ such as

$$(\lambda^2 \mathbf{B} + \lambda \mathbf{C} + \mathbf{A}) \mathbf{x} = \mathbf{0}$$

where typically, in linear mechanics, \mathbf{A} will be the stiffness matrix, \mathbf{B} the mass matrix and \mathbf{C} the damping matrix. The matrixes \mathbf{A} , \mathbf{B} and \mathbf{C} are symmetric and real matrixes. The complex eigenvalue λ is connected to the eigenfrequency f and with reduced damping ξ by $\lambda = \xi(2\pi f) \pm i(2\pi f)\sqrt{1-\xi^2}$. This kind of problems are activated by the key word `TYPE_RESU='DYNAMIQUE'` and generate a data structure *Aster* of the mode_meca_c type .

Caution:

- In QEP, for dealing with problems with asymmetric matrixes and/or complex values, it is necessary to use `MODE_ITER_SIMULT (METHODE=' SORENSEN'/"QZ")`.
- Buckling (`TYPE_RESU=' MODE_FLAMB '`) is not licit in QEP.
- The test of Sturm type is operative only in GEP with real symmetric matrixes. Outside this frame (QEP, GEP with asymmetric real matrixes or symmetric \mathbf{A} formules formules complex), the option "TAPE" is proscribed and the post-checking based on Sturm type is not activated (inoperative parameter " VERI_MODE/STURM).

To solve these generalized or quadratic modal problems, *Code_Aster* proposes various approaches. Beyond their numerical specificities and functional calculuses which are included in the documents [R 5.01.01/02], one can synthesize them in the shape of the table below (the default values are materialized in fat).

Operator Perimeter D" application	Algorithm	Key word	Advantages	Disadvantages
MODE_ITER_INV				Only symmetric reality (GEP and QEP).
<i>1st phase (heuristic)</i>				
Computation of some Bisection	modes (without object in QEP).	"SEPARATE"		
Computation of some modes	Bisection+ Secant (GEP) or Müller-Traub (QEP).	"ADJUSTS"	Better accuracy	Cost computation
Improvement of some Initialization	estimates by the user	"NEAR"	Taken again eigenvalues estimated by another process. Cost computation of this phase almost zero	No capture of multiplicity
<i>2nd phase (method of the powers opposite)</i>				
basic Method	Powers opposite	"DIRECT"	Very good construction of eigenvectors	Not very robust
Option of acceleration	Quotient of Rayleigh (without object in QEP)	"RAYLEIGH"	Improves convergence	Cost computation

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Operator Perimeter D” application	Algorithm	Key word	Advantages	Disadvantages
MODE_ITER_SIMULT				
Computation of part of the spectrum	Bathe & Not very	<i>robust</i> Wilson “		JACOBI” Only symmetric reality (GEP)
	Lanczos (Newman-Pipano in GEP and Jennings in QEP)	“TRI_DIAG”	Detection specific of the rigid modes.	Only symmetric reality (GEP and QEP)
	IRAM (Sorensen)	“SORENSEN”	increased Robustness. Better complexities computation and memory. Quality control of the modes.	Method by default. Range into asymmetric and with A complexes symmetric.
Computation of all the spectrum then filtering of a part.	QZ	“QZ”	Method of reference in term of robustness.	Very expensive in CPU and memory. A to reserve for the small cases (<103 dofs). Range into asymmetric and with A complexes symmetric.

Table 3.1-1. Summary of the modal methods of Code_Aster

When it is a question of determining some well discriminated simple eigenvalues or of refining some estimates, operator `MODE_ITER_INV` (heuristic + power reverses), is often clearly shown. On the other hand, to capture a part significant of the spectrum, one has resorts to `MODE_ITER_SIMULT`, via the methods of subspace (Lanczos, IRAM, Jacobi) or the total method QZ (very robust but expensive method; to reserve for the small cases).

It is the second class of method which will interest us here.

For the methods of subspace, it consists in projecting the problem on a space whose size is higher than the number of desired eigenvalues but much lower than that of the problem. One arranges oneself so that this problem has a spectrum very close to that of the initial problem and that it takes a canonical form (tridiagonal, Hessenberg etc). Then one applies a total modal solver (Jacobi for Bathe & Wilson, QR for Lanczos/IRAM) to this simplified problem. Finally one converts the modes obtained within the space of initial work.

As for the total method QZ, it résoud directly and entirely the initial problem (GEP or linearized QEP) to improve the robustness of the process. It presents however the disadvantage of computation all the spectrum. It is thus to hold for the small cases ($< 10^3$ degrees of freedom).

It is completely recommended besides to benefit from the strong points of the two classes of method by refining the eigenvectors obtained by `MODE_ITER_SIMULT`, via `MODE_ITER_INV` (OPTION=' PROCHE '). That will make it possible to reduce the norm of the final residue (cf §3.6.2).

Note:

One strongly advises a preliminary reading of documentations of reference [R5.01.01] [R5.01.02]. It gives and to the user the properties limitations, theoretical and practical, of the modal methods

approached while connecting these considerations, which can sometimes appear a little ethereal, to a precise parameter setting of the options.

3.2 Operands MATR_RIGI/MATR_A/MATR_MASS/MATR_RIGI_GEOM /MATR_B/MATR_AMOR/ MATR_C

the table below represents the operands to be used according standard to key word TYPE_RESU.

TYPE_RESU		
"DYNAMIQUE"	"MODE_FLAMB"	"GENERAL"
◆ MATR_RIGI = A	◆ MATR_RIGI = A	◆ MATR_A = A
◆ MATR_MASS = B	◆ MATR_RIGI_GEOM = B	◆ MATR_B = B
◇ MATR_AMOR = C	Without object	Except current perimeter

- ◆MATR_RIGI or MATR_A=A
Stamps assembled (symmetric real) of type [matr_asse*_R] of the GEP/QEP to solve.
- ◆MATR_MASS or MATR_RIGI_GEOM or MATR_B=B
Stamp assembled (symmetric real) of type [matr_asse*_R] of the GEP/QEP to solve.
- ◇MATR_AMOR or MATR_C=C
Stamps assembled (symmetric real) of type [matr_asse*_R] of the QEP to solve.

3.3 Key word TYPE_RESU

◇TYPE_RESU=/ "DYNAMIQUE" [DEFAULT]
/ "MODE_FLAMB"
/ "GENERAL"

This key word makes it possible to define the nature of the modal problem in treating: search for frequencies of vibration (classical case of dynamics with or without gyroscopic damping and effects) or search for critical loads (case of the theory of linear buckling, only in GEP) or search of eigenvalues and the modes associated with a general matric system.

According to this class of membership, the results are displayed and stored differently in data structure:

- **In dynamics**, the frequencies are ordered by order ascending of the modulus of their variation to the shift (cf [R 5.01.01/02] §3,8/2.5). It is the value of the variable of access NUME_ORDRE of data structure. The other variable of access, NUME_MODE, is equal to the true modal position in the spectrum of the eigenvalue (determined by the test of Sturm type cf §3.6 [R5.01.01]). This test of Sturm type is licit only in GEP with real modes (real symmetric matrixes), in the other cases, GEP with complex modes and QEP, one poses NUME_MODE=NUMÉRIQUE_ORDRE.
- **In buckling** and in the general case, the eigenvalues are stored by order ascending algebraic. Variables NUME_ORDRE and NUME_MODE take the same value equal to this order.

TYPE_RESU=' GENERAL' makes it possible to solve value problems in the case of clean a **general matric system**. For time its perimeter is restricted in GEPs standards (symmetric real matrixes). Its only difference with MODE_FLAMB is thus only in the denomination of the matrixes: MATR_A/B rather than MATR_RIGI/MATR_RIGI_GEOM.

3.4 Key word `CALC_FREQ`

- ◆ `CALC_FREQ=_F` (...
Factor key word for the definition of the parameters of the first phase of computation (localization of the eigenvalues).
Apart from the "CLOSE" option, for the GEP, the localization of the eigenvalues is generally carried out by a dichotomic separation of the frequencies (for the options "ADJUSTS" and "SEPARATE"), followed by a secant method (for the option: "ADJUSTS"). For the QEP, this localization is carried out by a method of Müller-Traub (for the option: "ADJUSTS").

3.4.1 Operand `FREQ`

- ◇ `FREQ=lfreq`
For a problem of search for eigenvalue of dynamic type (`TYPE_RESU= "DYNAMIQUE"`), this key word corresponds to the list of the frequencies of which the use depends on the `OPTION` selected.
If `OPTION=' PROCHE'` is retained: it is the list of the frequencies whose one seeks the mode nearest. The list has at least 1 element and is ordered by ascending order.
If `OPTION=' SEPRE'` or "ADJUSTS": they are the limits of intervals of search
$$FREQ= (f_1, f_2, \dots, f_{n-1}, f_n)$$

One will seek to separate the frequencies in the intervals
$$[F_1, F_2], [F_2, F_3] \dots [F_{N-2}, F_{N-1}], [F_{N-1}, F_N]$$

the list has at least two elements. The frequencies are positive. It is checked that the frequencies are given in the ascending order.

3.4.2 Operand `AMOR_REDUIT`

- ◇ `AMOR_REDUIT=lamor`
For QEP of the dynamic type (`TYPE_RESU= 'DYNAMIQUE'`) and if the `CLOSE` option were selected, one can initialize the method of the inverse iterations from a complex initial eigenvalue. To build this complex value, one uses the list of the arguments given under the key - key `FREQ` (list of frequencies) and `AMOR_REDUIT` (list of depreciation).
These two lists must have the same number of arguments.

3.4.3 Operand `NMAX_FREQ`

- ◇ `NMAX_FREQ=nf 0 [DEFAULT]`
Number maximum of eigenvalues to calculating. This operand is ignored for the option "NEAR". For the other options, if the user does not inform this key word, all the eigenvalues contained in the intervals specified by the user are calculated. If not, the `NMAX_FREQ` first eigenvalues, therefore lowest, are calculated

3.5 Key word `CALC_CHAR_CRIT`

- ◆ `CALC_CHAR_CRIT=_F` (...
Factor key word for the definition of the parameters of the first phase of computation (localization of the critical loads).
Apart from the "CLOSE" option, for the GEP, the localization of the eigenvalues is generally carried out by a dichotomic separation of the critical loads (for the options "ADJUSTS" and "SEPARATE"), followed by a secant method (for the option: "ADJUSTS"). For the QEP, this localization is carried out by a method of Müller-Traub (for the option: "ADJUSTS").

So during these shifts, the shift takes a value lower (in modulus) than sf , then one imposes the value to him $\lambda = -sf$. This parameter corresponds to a value threshold below which one considers that one has a value numerically null. This imposition thus makes it possible to distinguish these rigid modes moreover spectrum.

This value sf is also used during to detect the quasi-null eigenvalues the postprocessing of checking on the norm of the residue (cf [R 5.01.01/02] algorithm n^2/n^1).

Note:

During the first transitions, it is strongly advised not to modify these parameters which rather relate to the mysteries of the algorithm and which are initialized empirically with values standards.

3.7 Operand OPTION

“ CLOSE

” \diamond OPTION=

One searches the mode to which the eigenvalue is closest to a given value. This value is indicated by:

- the argument `lfreq` of key word `FREQ` for GEP of a dynamic type (`TYPE_RESU= `DYNAMIQUE'`).
- the argument `lcharc` of key word `CHAR_CRIT` for a GEP of type linear buckling (`TYPE_RESU= `MODE_FLAMB'`).
- the arguments `lfreq` and `lamor` of key word `FREQ` and `AMOR_REDUIT` for QEP of a dynamic type (`TYPE_RESU= `DYNAMIQUE'`).

There are as many searches of modes than of terms in this list (or these lists). If one wishes to calculate a multiple mode, this option should not be used because one mode will be found.

“SEPARATE”

One separates the eigenvalues by a method of bisection based on the criterion from Sturm type. The limits of the interval of search are:

- arguments of the list `lfreq` of key word `FREQ` for a generalized or quadratic problem of dynamic type (`TYPE_RESU= `DYNAMIQUE'`).
- arguments of the list `lcharc` of key word `CHAR_CRIT` for a generalized problem of standard linear buckling (`TYPE_RESU= `MODE_FLAMB'`).

“ADJUSTS” [DEFAULT]

After having separated the eigenfrequencies via the option “SEPARATE” (in GEP only), one carries out additional iterations either by secant method (GEP) or by the method of Müller-Traub (QEP) to obtain a better accuracy on the eigenvalue.

3.7.1 Operands of the bisection (if OPTION= `SEPARATE' or `ADJUSTS')

\diamond NMAX_ITER_SEPARATE=nis (30) [DEFAULT]

\diamond PREC_SEPARATE=ps (1.10-4) [DEFAULT]

Parameters of adjustment amongst iterations and the accuracy of separation for the dichotomizing search. These operands are ignored for the option “NEAR” (cf [R5.01.01] §4.2).

Note:

During the first transitions, it is strongly advised not to modify these parameters which rather relate to the mysteries of the algorithm and which are initialized empirically with values standards.

3.7.2 Operands of the secant (if OPTION= `AJUSTE')

\diamond NMAX_ITER_AJUSTE = denied (15) [DEFAULT]

- ◇ `PREC_AJUSTE=` Pa (1.10-4) [DEFAULT]
Parameters of adjustment amongst iterations and the accuracy of separation for the secant method. These operands are not useful that with the option "ADJUSTS" (cf [R5.01.01] §4.2).

Note:

During the first transitions, it is strongly advised not to modify these parameters which rather relate to the mysteries of the algorithm and which are initialized empirically with values standards.

3.8 Key word factor `CALC_MODE`

- ◇ `CALC_MODE=_F` (...)
Factor key word for the definition of the parameters of computation of the second phase of computation (method of the powers opposite).

3.8.1 Operand `OPTION`

◇`OPTION=`
Definition of the method of the powers opposite (confer [R 5.01.01/02] §4.3/3.3):
"DIRECT" standard method in GEP or alternative of Jennings in QEP.
[DEFAULT]
"RAYLEIGH" Acceleration via the quotient of Rayleigh (only in GEP)

3.8.2 Operand `NMAX_ITER`

◇`NMAX_ITER=nim` (30) [DEFAULT]
maximum Number of iterations of the method of the powers opposite for the search of the eigen modes.

3.8.3 Operand `PREC`

◇ `PREC=pm` (1.10-5) [DEFAULT]
Test of stop of the method of the powers opposite.

3.9 Factor key word `solver`

◇`SOLVEUR=_F` (),

One has access to all the parameters of the direct linear solvers (`METHODE='LDLT'/'MULT_FRONT'/'MUMPS'`).

In parallel mode, one advises parameter setting `22METHODE=' MUMPS' and RENUM=' QAMD' .`

For more details on the solvers, one will be able to consult the document [U4.50.01]. Concerning parallelism, one returns to the document [U2.08.06] and the dedicated paragraph of the document [U2.06. 01].

3.10 Key word factor `VERI_MODE`

◇`VERI_MODE=_F` (...)

2 In order to at least reduce the cost in time of the phase of analysis (sequential) of MUMPS. This parameter setting is done however to the detriment of memory consumption. But this overcost quickly proves compensated by the distribution of the data on the processors which parallelism implies.

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.

Key word factor for the definition of the parameters of the checking of the eigen modes ([R 5.01.01/02] §3.8/2.5).

Note:

- During the first transitions, it is strongly advised not to modify these parameters which rather relate to the mysteries of the algorithm and which are initialized empirically with values standards.
- Contrary to its alter-ego, `MODE_ITER_SIMULT`, this factor key word does not comprise a key word of the `STURM TYPE` type and `PREC_SHIFT`. The phase of postprocessing and checking does not comprise indeed a test of Sturm type which would be redundant with the first heuristic part. The methods of type "power" being less robust than those of standard "subspace", the value by default of the threshold R is less demanding (10^{-2} instead of 10^{-6}).

3.10.1 Operand `STOP_ERREUR`

◇`STOP_ERREUR`=/ "OUI" [DEFAULT]
/"NON"

Makes it possible to indicate to the operator if it must stop ("OUI") or continue ("NON") if one of criteria `SEUIL` or `STURM TYPE` (only with `MODE_ITER_SIMULT`) is not checked.
By default the concept of output is not produced.

3.10.2 Operand `SEUIL`

◇`SEUIL`=r (1.10-2) [DEFAULT]

tolerance Level for the error norm relative of the mode to the top of which he is regarded as forgery or too approximated (cf [R 5.01.01/02] algorithm n^2/n^1).

3.11 Operand `INFO`

◇`INFO`=/1 [DEFAULT]
/2

Indicates the level of printing in the message file (.mess).

- 1 Printing on the file "MESSAGE" of the eigenvalues, their modal position, reduced damping, the error norm *a posteriori* and certain useful parameters to follow the course of computation.
- 2 Printing more provided rather reserved to the developers.

3.12 Operand `TITER`

◇`TITER`=ti
Title attached to the product concept by this operator [U4.03.01].

4 Stage of execution

4.1 Checking

matrixes **A** , **B** and **C** , arguments of keywords (MATR_A/MATR_RIGI) , (MATR_MASS/MATR_RIGI_GEOM/MATR_B) and (MATR_AMOR/MATR_C) , must be coherent between them (i.e. to lean on the same classification and the same mode of storage). The operator checks that for the options "SEPARATE" and "ADJUSTS" , the list of the values of the arguments of key word `FREQ` or `CHAR_CRIT` has, at least, two terms.

It checks also a certain coherence of the parameters of the various algorithms.

4.2 Execution

For the option "ADJUSTS" , if the separation is not possible and that in a given interval there is more than one value of eigenvalue, one does not apply the method of adjustment with this interval. On the other hand, one will during carry out the computation of the modes of the reorthogonalisations compared to the preceding modes contained in the interval (this makes it possible to calculate modes associated with a multiple eigenvalue).

For the option "SEPARATED" , having obtained an interval determining an eigenvalue, one takes for the computation of the mode the medium of the interval. During the computation of the mode, the value of the eigenvalue is still refined. It is result of the inverse iteration itself one.

5 Modal parameters Normalizes modal Position modes

In output of this operator, the eigen modes real or complex are standardized with largest of the components which is not a multiplier of Lagrange. To choose another norm, it is necessary to use command `NORM_MODE` [U4.52.11].

In the case of a dynamic computation, the data structure `mode_meca_*`, contains, besides the frequencies of vibration and of the associated modal deformed shapes, of the modal parameters (generalized mass, generalized stiffness, participation factor, effective mass). One will find the definition of these parameters in [R5.01.03].

In the case of a linear computation of buckling, the data structure `mode_flamb`, contains only the associated critical loads and the deformed.

In the case of a dynamic computation with real modes (real symmetric matrixes), the modal position of the modes corresponds to the position of the mode in the group of the spectrum defined by the matrixes and **A B**.

In the case of a linear computation of buckling, the modal positions of the critical loads are allotted of 1 to nf (nf being the number of calculated critical loads) by classifying the critical loads by order ascending in absolute value. All the modal positions are thus positive.

For the option `NEAR`, the modal positions are allotted of 1 to nf (nf being the number of calculated eigenvalues), by taking the eigenvalues in the order of the list indicated under `FREQ` or `CHAR_CRIT`.

6 Printing of results

to display the modal parameters associated with each mode and the coordinated with the modes, it is necessary to use operator `IMPR_RESU` [U4.91.01] in the following way:

- Display of the modal parameters only in the form of array:

```
IMPR_RESU ( RESU=_F ( RESULTAT=mode,  
                    TOUT_PARA= `OUI',  
                    TOUT_CHAM= `NON' ) );
```

- Display of the modal parameters and the eigenvectors:

```
IMPR_RESU ( RESU=_F ( RESULTAT=mode,  
                    TOUT_PARA= `OUI',  
                    TOUT_CHAM= `OUI' ) );
```

7 Examples

Are `mass` and `stiffness` two matrixes beforehand assembled by the operator `ASSE_MATRICE` from elementary matrixes of mass (`OPTION= `MASS_MECA'`) and of stiffness (`OPTION= `RIGI_MECA''`).

One calculates the modes of eigenfrequency understood in the tape 50Hz with 150Hz operator `MODE_ITER_INV` as follows:

```
mode=MODE_ITER_INV
      (  MATR_RIGI=rigidite,
        MATR_MASS=masse,
        CALC_FREQ=_F (OPTION=' AJUSTE',
                     FREQ= (50. , 150.))
      )
```

One calculates the modes of eigenfrequency closest to the frequencies 20Hz and 50Hz with operator `MODE_ITER_INV` as follows:

```
mode=MODE_ITER_INV
      (  MATR_RIGI=rigidite,
        MATR_MASS=masse,
        CALC_FREQ=_F (  OPTION=' PROCHE',
                     FREQ= (50. , 150.)),
        CALC_MODE=_F (OPTION=' RAYLEIGH')
      )
```

the acceleration of convergence by means of the coefficient of Rayleigh was selected.

8 Remarks of use

the cost of this operator can be high because:

- each dichotomy requires a factorization (if `OPTION=' SEPRE'`),
- each iteration of secant or Müller-Traub (if `OPTION=' AJUSTE'`) requires also a factorization.

It can be more judicious to make:

- a search for eigenvalues by the operator `MODE_ITER_SIMULT` [U4.52.03],
- then by means of to refine the results got by `MODE_ITER_INV` the option `"CLOSE"` to `CALC_FREQ` or `CALC_CHAR_CRIT` and option `"RAYLEIGH"` of `CALC_MODE` to improve the eigenvectors.