Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 *Page : 1/25*
Clé : U4.84.01 *Révision*   *:*
3ad2f58432c8

Operator `COMB_SISM_MODAL`

1 Goal

To calculate a dynamic response to single or multiple imposed movements.

In the case of the multiple excitation, the supports are animated different movements for a given direction. These movements can be either correlated between them, or perfectly décorrélés. These requests are represented by spectra of answer of oscillator representing an earthquake or a shock. These spectra of oscillator can be given starting from a accélérogramme of the seismic signal (real signal or synthetic signal) by the order `CALC_FONCTION` with the keyword factor `SPEC_OSCI` [U4.32.04].

The operator `COMB_SISM_MODAL` allows to determine, in any point of the structure, the maximum components of relative displacement, relative pseudovelocity, of absolute pseudo-acceleration, the maximum efforts generalized by element and the maximum reactions to the supports.

These maxima of answer are calculated starting from the maximum answer of a simple oscillator, associated with each real clean mode taken into account. Several rules of recombination of the contributions of each clean mode and the contributions in each direction are available.

Product a concept of the type `mode_meca`.

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 2/25
Clé : U4.84.01   Révision :
3ad2f58432c8

2   Syntax

```
R [mode_stat]  = COMB_SISM_MODAL

        ( ♦  MODE_MECA = mode                          [mode_meca]
          ◊  /  TOUT_ORDRE = 'YES'                     [DEFECT]
             /  NUME_ORDRE = l_ordre                   [l_I]
             /  LIST_ORDRE = lordre                    [listis]
             /  NUME_MODE  = l_mode                    [l_I]
             /  /  FREQ =       l_freq                 [l_R]
             /  LIST_FREQ = lfreqr8                     [listr8]
                  ◊  PRECISION =  /  1.D-3             [DEFECT]
                                  /  prec              [R]
                     ◊  CRITERION =     /  'RELATIVE'         [DEFECT]
                                        /  'ABSOLUTE'

          ◊  MODE_CORR = acce                           [mode_stat_acce]
          ◊  FREQ_COUP = freq                           [R]

          ♦  /  AMOR_REDUIT = amor                      [l_R]
             /  LIST_AMOR  = lamor                      [listr8]
             /  AMOR_GENE   = amogene                   [matr_asse_gene_R]

          ◊  MASS_INER     = mass_iner                  [tabl_mass_iner]

          ♦  /  MONO_APPUI = 'YES'
             /  MULTI_APPUI=' CORRELE'
             /  MULTI_APPUI=' DECORRELE'
          ♦  EXCIT =_F (♦ GROUP_NO  = lgrno            [l_gr_noeud]

                      ♦  /  ♦  AXIS      = (c1, c2, c3) [l_R]
                            ♦  SPEC_OSCI = spec         [tablecloth]
                            ◊  SCALE   = echel          [R]

                         /  ♦  TRI_AXE   = (p1, p2, p3) [l_R]
                            ♦  SPEC_OSCI = spec         [tablecloth]
                            ◊  SCALE   = echel          [R]

                         /  ♦  TRI_SPEC  = 'YES'        [KN]
                            ♦  SPEC_OSCI= (spe1, spe2, spe3) [l_fonction]
                            ◊  ECHELLE= (ech1, ech2, ech3)   [l_R]

                      ◊  NATURE =  /  'ACCE'            [DEFECT]
                                   /  'QUICKLY'
                                   /  'DEPL'
                        )

          ◊  CORR_FREQ =  /  'YES'
                          /  'NOT'                      [DEFECT]

          ♦  COMB_MODE =_F ( ♦  /  TYPE =    /  'GUPTA'
                                             /  'SRSS'
                                             /  'CQC'
                                             /  'DPC'
                                             /  'ABS'
                                             /  'DSC'
                          ◊  DURATION = S               [R]
                          ◊  FREQ_1 = Hz                [R]
                          ◊  FREQ_2 = Hz                [R]
                             )
```

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 3/25
Clé : U4.84.01   Révision :
3ad2f58432c8

```
◊    COMB_DIRECTION = _F (        ♦  /  TYPE = /  'QUAD'
                                            /  'NEWMARK'
                                     )


◊    COMB_MULT_APPUI = _F (
                                  ♦  / ALL = 'YES'
                                     / GROUP_NO =lgrno   [l_gr_noeud]
                                  ♦  / TYPE_COMBI =  / 'QUAD'
                                                     / 'LINE'

                                     )
◊    GROUP_APPUI = _F (
                                  ♦   GROUP_NO =lgrno [l_gr_noeud]

                                     )
◊    DEPL_MULT_APPUI = _F (
                                  ♦  NOM_CAS = nomcas
                                  ♦  NUME_CAS = numcas
                                  ◊  GROUP_NO_REFE = lgrno   [l_gr_noeud]
                                  ♦  MODE_STAT = stat     [mode_stat_depl]
                                  ♦  GROUP_NO = lgrno [l_gr_noeud]
                                  ♦  | DX =   dx          [R]
                                     | DY =   Dy          [R]
                                     | DZ =   dz          [R]
                                     )
◊    COMB_DEPL_APPUI = _F (
                                  ♦  /   ALL = 'YES'
                                     /  LIST_CAS = list [l_nume]
                                  ♦  /  TYPE_COMBI = / 'QUAD'
                                                     / 'LINE'
                                                      / 'ABS'
                                     )
            ♦  OPTION =        | 'DEPL'
                               | 'QUICKLY'
                               | 'ACCE_ABSOLU'
                               | 'SIGM_ELNO'
                               | 'SIEF_ELGA'
                               | 'SIPO_ELNO'
                               | 'EFGE_ELNO'
                               | 'REAC_NODA'
                               | 'FORC_NODA'
        ◊   TITLE = tit                                 [l_Kn]
        ◊   INFORMATION =   /  1                               [DEFECT]
                  /  2
        ◊   =_F IMPRESSION ( /  ALL= 'YES'          [DEFECT]
                               / LEVEL  =   | 'SPEC_OSCI'
                                            | 'MASS_EFFE'
                                            | 'MAXI_GENE'
                               )
        )
```

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017   Page : 4/25
Clé : U4.84.01   Révision :
3ad2f58432c8

3 Operands

3.1 Definition of the clean modes of the structure

3.1.1 Operand MODE_MECA

♦   MODE_MECA = mode

Name of the concept of the type mode_meca produced by the operator of modal analysis CALC_MODES [U4.52.02].

3.1.2 Operands TOUT_ORDRE / NUME_ORDRE / NUME_MODE/LISTE_ORDRE

/   TOUT_ORDRE = 'YES'

Value by default which makes it possible to extract all the clean modes available in the concept mode.

/   NUME_ORDRE = l_ordre
/   NUME_MODE = l_mode

Extraction of the clean modes defined by a list l_ordre sequence numbers (NUME_ORDRE) or a list l_mode numbers of modes (NUME_MODE).

/   LIST_ORDRE = l_ordre

Idem NUME_ORDRE but of type listis (produced by DEFI_LIST_ENTI).

3.1.3 Operand FREQ / LIST_FREQ / PRECISION / CRITERION

/   FREQ = l_freq

Allows to extract the clean modes corresponding to a list from frequencies l_freq.

/   LIST_FREQ = lfreqr8

Allows to extract the clean modes corresponding to a list from frequencies lfreqr8, defined by the operator DEFI_LIST_REEL [U4.34.01] (lfreqr8 is thus a concept of the type listr8).

◊ | PRECISION = prec
     | CRITERION =

These operands make it possible to indicate that one searches all the clean modes whose frequency is in the interval $inst \pm prec$. By default $prec = 1.0D-3$.

According to the value of the keyword CRITERION :

'RELATIVE' : the interval of research is:

$$[inst(1-prec), inst(1+prec)]$$

'ABSOLUTE' : the interval of research is:

$$[inst-prec, inst+prec]$$

3.2 Definition of modal depreciation

Three possibilities exist to define modal depreciation: a list of reduced depreciation provided by the user in the form of list of realities (l_R) or of a concept of the type listr8 built by the operator DEFI_LIST_REEL [U4.34.01] or a matrix of damping generalized (matrix of damping projected on the basis of real clean mode).

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 5/25
Clé : U4.84.01 Révision :
3ad2f58432c8

Version
default

3.2.1 Operand AMOR_REDUIT

/ AMOR_REDUIT = amor

This operand makes it possible to provide the list of the depreciation reduced in the form of a list of realities (l_R). If the number of provided coefficients is lower than the numbers of clean modes taken into account, the last coefficient is allotted to the mode corresponding and the following modes.

3.2.2 Operand LIST_AMOR

/ LIST_AMOR = lamor

This operand makes it possible to provide the list of the depreciation reduced in the form of a concept of the type listr8. If the number of reduced depreciation is lower than the number of clean modes taken into account, the last coefficient is affected with the following modes.

Example:

        TOUT_ORDRE = 'YES'
        LIST_AMOR = ('0.01', '0.02')

first mode $\xi=0.01$ and for all the other modes $\xi=0.02$

3.2.3 Operand AMOR_GENE

/ AMOR_GENE = amogene

One gives the name of the matrix of generalized damping amogene produced by the operator PROJ_MATR_BASE [U4.63.12] or PROJ_BASE [U4.63.11].

Note:
> *For theoretical reasons (tallies of COMB_SISM_MODAL restricted with "classical" damping) the matrix of damping must be **diagonal**.*

3.3 Operand MASS_INER

To check the criterion of office plurality of the unit effective masses of the clean modes taken into account in each direction, it is necessary to know the total mass of the structure.

This one is calculated by the order POST_ELEM [U4.81.22] with the keyword MASS_INER. The operand MASS_INER allows to provide the name of the concept produced by this order.

3.4 Definition of the type of the excitation (mono or multi-supported)

Three configurations are possible:
- the structure is studied with the same movement of training in all the supports;
- the structure is studied with several different movements of training to the supports, all correlated between them;
- the structure is studied with several different movements of training to the supports, whose one can display groups perfectly décorrélés between them, the excitations inside the same group of supports being supposed correlated between them.

3.4.1 Operand MONO_APPUI

/ MONO_APPUI = 'YES'

The excitations all with the supports are equal.

3.4.2 Operand MULTI_APPUI

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017   Page : 6/25
Clé : U4.84.01   Révision   :
3ad2f58432c8

```
/ MULTI_APPUI=' CORRELE'
```

The excitations with the supports all are correlated between them (they can be different or equal).

```
/ MULTI_APPUI=' DECORRELE'
```

The excitations with the supports can be gathered so that one can display groups (possibly made up of only one support) perfectly décorrélés between them; inside the same group, the supports are supposed to be correlated between them.

3.5 Description of the excitation: keyword EXCIT

The seismic excitation is defined by one or more spectra of oscillators. Those are calculated as a preliminary by the order CALC_FONCTION [U4.32.04] or read on a file by the order LIRE_FONCTION [U4.32.02]. In both cases, the produced concept is of type function with two variables (tablecloth).

One uses for that the keyword factor

  ♦   EXCIT

and possibly the operand CORR_FREQ.

3.5.1 Operand GROUP_NO

One specifies with each occurrence of the keyword factor groups of nodes concerned with the described excitation.

3.5.2 Excitation along an axis

```
/  ♦   AXIS      = (c1, c2, c3)
   ♦   SPEC_OSCI = spec
   ◊   SCALE     = echel
```

In this case, one provides:

  • the cosine directors $(c1\,c2\,c3)$ axis of excitation in the reference mark TOTAL of definition of the grid: coefficients $c1, c2, c3$ are renormés by the order,
  • the operand SPEC_OSCI only one spectrum of oscillator waits where spec is the name of the tablecloth to be used,
  • the operand SCALE allows to define a scale factor echel to apply to all the points of the spectrum spec.

Example:

For an excitation with 45° compared to the reference mark TOTAL, a spectrum of ground sol_0_1 fixed with $0.1\,g$ and a scale factor allowing to simulate a spectrum fixed with $0.25\,g$:

```
AXIS = (1. , 1. , 0.),
SPEC_OSCI=sol_0_1,
ECHELLE=2.5,
```

3.5.3 Triaxial excitation with only one spectrum

```
/  ♦   TRI_AXE   = (p1, p2, p3)
   ♦   SPEC_OSCI = spec
   ◊   SCALE     = echel
```

In this case, one provides:

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 7/25
Clé : U4.84.01 Révision :
3ad2f58432c8

- weighting coefficients $(p1\ p2\ p3)$ to apply to the spectrum of oscillator for each direction X, Y and Z,
- the operand SPEC_OSCI only one spectrum of oscillator waits where spec is the name of the tablecloth to be used,
- the operand SCALE allows to define a scale factor echel to apply to all the points of the spectrum spec, independently of the weighting coefficients of direction.

Example:

For an excitation with a weighting of $1.$ in X and in Y (horizontal plane) and 0.66 in Z (vertical), a spectrum of ground fixed with $0.1\,g$ and a scale factor allowing to simulate a spectrum fixed with $0,25\,g$:
TRI_AXE= (1. , 1. , 0.66),
SPEC_OSCI=sol_0_1,
ECHELLE=2.5,

3.5.4 Triaxial excitation with three different spectra

/ ♦ TRI_SPEC = 'YES'
   ♦ SPEC_OSCI = (spe1, spe2, spe3)
   ◊ SCALE   = (ech1, ech2, ech3)

In this case one provides:

- the operand TRI_SPEC: 'YES',
- the operand SPEC_OSCI expects three spectra of oscillators where (spe1 spe2 spe3) is the list of the tablecloths to be used in the three directions X, Y, Z.
- the operand SCALE allows to define three scale factors (ech1 ech2 ech3) to apply independently to all the points of each spectrum.

3.5.5 Operand **NATURE**

◊ NATURE

This operand makes it possible to specify the size of the spectrum of oscillator. By default, one uses a spectrum of acceleration 'ACCE'. It is possible D' to more rarely use of other sizes: speed 'QUICKLY'or displacement'DEPL'.

3.5.6 Operand **CORR_FREQ**

◊ CORR_FREQ

To calculate the components of answer of speed or in acceleration starting from a spectrum of oscillator of the size displacement (NATURE = 'DEPL'), one is led to multiply each value one or twice by ω_r pulsation of the real clean mode (oscillating not deadened). In any rigour the oscillator r is deadened and its own pulsation is $\omega_r\sqrt{1-\xi^2}$ and ω_r is only the own pseudo-pulsation. By default, one thus obtains:

$$
\begin{aligned}
vite_{max} &= \omega_r depl_{lu} = pseudo-vitesse\\
acce_{max} &= \omega_r^2 depl_{lu} = pseudo-accélération
\end{aligned}
$$

The operand CORR_FREQ: 'YES' allows to correct these values to take into account the damping of the clean mode:

$$
\begin{aligned}
vite_{max} &= \omega_r\sqrt{1-\xi^2}\,depl_{lu} = vitesse\\
acce_{max} &= \omega_r^2(1-\xi^2)\,depl_{lu} = accélération
\end{aligned}
$$

If one provides a spectrum of answer of speed (NATURE = 'QUICKLY') the operand CORR_FREQ will be necessary to correct $depl_{max}$ and $acce_{max}$ if necessary. In the same way for a spectrum of answer in acceleration (NATURE = 'ACCE') to correct $depl_{max}$ and $vite_{max}$.

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 *Page : 8/25*
Clé : U4.84.01 *Révision :*
3ad2f58432c8

In all the cases, one will take care not to use like data SPEC a spectrum pseudo - size.

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version default

Date : 07/12/2017 Page : 9/25
Clé : U4.84.01   Révision   :
3ad2f58432c8

3.6 Rules of combination

To evaluate one raising of the answer of the structure, one reasons size by size (displacement, speed or acceleration, internal efforts, constraints) starting from the modal values associated with the clean modes taken into account. For each size, one will treat **independently** each degree of freedom (fields to the nodes of displacement, speed or acceleration), or each component of torque (internal efforts) or constraint. It is what we call the answer R in the statement of the rules of combination.

Several levels of combinations are necessary:

- combination of the clean modes,
- static correction by pseudo-mode,
- combination according to the directions of earthquake.

In the case of an analysis multi-support, the rules of combination are modified to take account of the various excitations applied to groups of supports. It is also possible to separately calculate the primary and secondary components of the answer.

3.7 Rules of combination for an excitation mono-support

The answer **total** structure R is obtained by **combination of the directional answers** R_X where X represent one of the directions of the reference mark `TOTAL` of definition of the grid (X, Y, Z) or a particular direction (cf operand `AXIS`). The directional answer is given by:

$$R_X = \sqrt{R_d^2 + (R_t + R_{qs})^2 + R_e^2}$$

- R_d dynamic combined answer of the modal oscillators established by the keyword `COMB_MODE` [§ 3.7.1]
- R_t correction of the static effects of the neglected modes (pseudo-mode) [§ 3.7.2]
- R_{qs} quasi-static combined answer of the modal oscillators established by the keyword `COMB_MODE` (STANDARD = ' GUPTA') [§ 3.7.1.6]
- R_e contribution of the movement of training ($R_e = 0$ in mono-support)

The rule of combination of the directional answers is defined by the keyword `COMB_DIRECTION` [§ 3.6.3].

3.7.1 Combination of the clean modes: keyword COMB_MODE

♦   COMB_MODE

The answer of the structure R_d , **in a direction of earthquake**, is obtained by one of the possible combinations (defined by the operand `TYPE`) contributions of each clean mode taken into account. Each clean mode is regarded as an oscillator independent of answer R_r defined by (ω_r, ξ_r) . The answer is read by interpolation in the spectrum of oscillator of the signal of excitation in this direction.

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 10/25
Clé : U4.84.01 Révision :
3ad2f58432c8

For an excitation mono-support, the answer R_r oscillator r is given by:

$$R_r = \frac{p_r}{\omega_r^2} S_r \Phi_r$$

- Φ_r modal size (displacement, generalized effort, reaction) associated with the clean mode of index r
- P_r factor of modal participation associated with the mode r in the studied direction
- S_r value of the spectrum of answer, for example in pseudo-acceleration, for the oscillator r

Several rules of combination of the clean modes are available. They are chosen by the operand TYPE.

3.7.1.1 Quadratic combination TYPE = 'SRSS'

This combination (Public garden Root of Sum of Squares) corresponds to the assumption of strict independence of the oscillators associated with each clean mode:

$$R_d = \sqrt{\sum_{r=1}^{nmod} R_r^2}$$

Let us note that this rule of combination, although very usually used, can be badly adapted when the assumption of independence is not checked for nearby clean modes or with important damping.

3.7.1.2 Complete quadratic combination TYPE = 'CQC'

The quadratic combination (established by DER KIUREGHIAN [bib1]) makes a correction to the preceding rule by introducing coefficients of correlation depending on depreciation and the distances between close clean modes (cf [R4.05.03]):

$$R_d = \sqrt{\sum_{r_1} \sum_{r_2} \rho_{r_1 r_2} R_{r_1} R_{r_2}}$$

with the coefficient of correlation:

$$\rho_{ij} = \frac{8\sqrt{\xi_i \xi_j \omega_i \omega_j}\left(\xi_i \omega_i + \xi_j \omega_j\right)\omega_i \omega_j}{\left(\omega_i^2 - \omega_j^2\right)^2 + 4\xi_i \xi_j \omega_i \omega_j\left(\omega_i^2 + \omega_j^2\right) + 4\left(\xi_i^2 + \xi_j^2\right)\omega_i^2 \omega_j^2}$$

3.7.1.3 Somme of the absolute values TYPE = 'ABS'

This combination corresponds to an assumption of complete dependence of the oscillators associated with each clean mode:

$$R_d = \sum_{r=1}^{nmod} |R_r|$$

Let us note that this rule of combination is to be disadvised, because it too strongly preserving and is led to a systematic oversizing.

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 11/25
Clé : U4.84.01 Révision :
3ad2f58432c8

3.7.1.4 Combination with rule of the 10% `TYPE = 'DPC'`

The close modes (of which the frequencies different from less than 10%) are initially combined by summation of the absolute values. The values resulting from this first combination are then combined quadratically. This method was proposed by American regulation U.S. Nuclear Regulatory Commission (Regulatory Guides 1.92 - February 1976) to attenuate the conservatism of the preceding method. It remains at fault for structures with a dense frequency spectrum clean.

3.7.1.5 Combination of ROSENBLUETH `TYPE = 'DSC'`

This rule (proposed by E. ROSENBLUETH and J. ELORDY [bib2]) introduced a correlation between modes, different from that of method CQC. The answers of the oscillators are combined by double nap (Double Sum Combination):

$$R_d = \sqrt{\sum_{r_1} \sum_{r_2} \rho_{r_1 r_2} R_{r_1} R_{r_2}}$$

It requires an additional data, the duration s "strong" phase of the earthquake defined by the operand `DURATION`.

The coefficient of correlation is then:

$$\rho_{ij} = \left(1 + \left(\frac{\omega'_i - \omega'_j}{\xi'_i \omega_i + \xi'_j \omega_j}\right)^2\right)^{-1}$$

$$où \quad \omega'_i = \omega_i \sqrt{1 - \xi_i^2} \quad et \quad \xi'_i = \xi_i + \frac{2}{s\,\omega_i}$$

3.7.1.6 Combination according to Gupta `TYPE = 'GUPTA'`

Gupta [NRC1.92], to take into account the correlations between modes due to the quasi-static part of the answer, introduced the rigid factor of answer, which varies from 0 to 1 the correlation between the modal answers of intermediate frequencies enters $FREQ_1$ and $FREQ_2$, two frequencies to be determined by the user.

Gupta breaks up each modal answer R_r in a dynamic part R_r^p and a quasi-static part R_r^{qs}:

$$R_r^{qs} = \alpha_r R_r \quad and \quad R_r^p = \sqrt{1 - \alpha_r^2} R_r$$

Thus, for each mode r, the rigid factor of answer is affected α_r with the modal answer R_r:

$$\alpha_r = 0 \quad for \quad f \leq f_1 \quad and \quad \alpha_r = 1 \quad for \quad f \geq f_2$$

α_r is estimated for the frequency f_r according to the following formula:

$$\alpha_r = \frac{\ln f_r / f_1}{\ln f_2 / f_1}$$

The dynamic combined answer of the modal oscillators is carried out according to the combination 'CQC':

$$R_d = \sqrt{\sum_{r_1} \sum_{r_2} \rho_{r_1 r_2} R_{r_1}^p R_{r_2}^p}$$

The quasi-static combined answer of the modal oscillators is carried out according to an algebraic combination:

$$R_{qs} = \sum_{r=1}^{nmod} R_r^{qs}$$

This combination according to GUPTA is available only in the case mono-support.

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 12/25
Clé : U4.84.01   Révision   :
                    3ad2f58432c8

3.7.2   Static correction by pseudo-mode: operand MODE_CORR

The modal base used is in general incomplete. The evaluation of raising answer to a seismic excitation requires, so a correction by a term representing the static contribution of the neglected clean modes, in each direction of earthquake.

For each direction of the earthquake, one carries out this correction, while adding to the modal base, a pseudo - mode ψ obtained starting from a static mode φ , field of displacements of the nodes of the structure subjected to a constant acceleration **in the direction considered** defined by:

$$K\,\varphi = M\,\delta$$

- • **K** matrix of rigidity of the structure
- • **M** matrix of mass of the structure
- • δ unit field in the direction of the earthquake

Pseudo-mode ψ is obtained by withdrawing the static contributions of the modes taken into account:

$$\Psi = \varphi - \sum_{r=1}^{nmod} \frac{p_r}{\omega_r^2} \Phi_r \quad \text{with:}$$

- • Φ_r clean mode of index r
  - • P_r factor of participation in the direction δ

In this direction δ , for each size, the contribution of the neglected modes is given by:

$$R_t = R_s - \sum_{r=1}^{nmod} R_r$$

R_s is the size associated with the static mode

◊   MODE_CORR = acce

This keyword makes it possible to provide it (S) field (S) of displacements ϕ nodes of the structure subjected to a constant acceleration in one (or several) direction (S), field (S) calculated (S) by the operator MODE_STATIQUE with the keyword PSEUDO_MODE [U4.52.14]. For specific needs, it is also possible to provide a concept resulting from CREA_RESU, while choosing TYPE_RESU=' MODE_MECA' and by informing the keyword AXIS of AFFE to indicate the direction corresponding to each field (defines by its sequence number) [U4.44.12]. For any direction of earthquake where the answer is calculated, one calculates a pseudo-mode if acce is provided.

◊   FREQ_COUP = fcoup

This keyword makes it possible to provide the frequency where one will read on the SRO the value which will be used for the static level of correction. This frequency corresponds normally to the cut-off frequency of the seismic signal, i.e that where the SRO reached (in acceleration) an asymptote.
This key word is particularly useful when the last frequency of the modal base does not reach the cut-off frequency of the seismic signal although it is nevertheless sufficient to take into account all the dominating modes for the answer of the structure.

3.7.3   Combination according to the directions: keyword COMB_DIRECTION

◊   COMB_DIRECTION

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version default

Date : 07/12/2017 Page : 13/25
Clé : U4.84.01 Révision :
3ad2f58432c8

Two rules of combination of the directional answers are available. They are chosen by the operand `TYPE`.

3.7.3.1 Quadratic combination: `TYPE = 'QUAD'`

This combination corresponds to the assumption of strict independence of the answers in each direction:

$$R = \sqrt{R_X^2 + R_Y^2 + R_Z^2}$$

3.7.3.2 Combination of NEWMARK: `TYPE = 'NEWMARK'`

For each direction $i(X, Y, Z)$, the 8 values are calculated:

$$R_i = \pm R_X \pm 0{,}4\, R_Y \pm 0{,}4\, R_Z$$

What leads, by circular shift, with 24 values and

$$R = max(Ri)$$

3.8 Case of an excitation multi-support

Two treatments are envisaged [feeding-bottle 3]:

- Calculation of the total answer
- Calculation of the primary and secondary components of the answer

In the case of the multiple excitation, these supports are animated different movements for a given direction. 2 distinct cases then are distinguished:

- that is to say these movements all are correlated between them (case correlated excitations),
- either one can display at least 2 groups of perfectly décorrélés supports, the supports constitutive of the same group being correlated between them (case décorrélées excitations).

3.8.1 Calculation of the total answer

Compared to the mono-support, an additional combination is necessary. The flow diagram for treatment differs according to whether the excitations are correlated or décorrélées.

3.8.1.1 Correlated excitations

- For each mode of index j, the modal directional answers are calculated R_{Xj} by combination of the modal directional answers of support R_{Xij}. The rule of combination is defined by the keyword `COMB_MULT_APPUI` [§ 3.8.3].

- The directional answers are calculated R_X defined by:
$$R_X = \sqrt{R_{Xd}^2 + R_{Xt}^2 + R_{Xe}^2}$$
  - R_{Xd} is the combined answer of the modal directional answers established by the keyword `COMB_MODE` [§ 3.7.1];
  - R_{Xt} represent the static correction of the neglected modes. This term is obtained by algebraic office plurality of the pseudo-modes of support;
  - R_{Xe} represent the movement of training. This term is obtained by algebraic combination of the movements of training of support.
- The total answer R structure is obtained by combination of the directional answers R_X. The rule of combination is defined by the keyword `COMB_DIRECTION` [§ 3.7.3].

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 14/25
Clé : U4.84.01   Révision   :
*   3ad2f58432c8*

3.8.1.2 Décorrélées excitations

- One defines the possible groups of supports using the keyword GROUP_APPUI. The answers of the modal oscillators of the same group of supports are combined linearly (not choice left to the user for this office plurality intra-group).

- For each support or groups supports subscripted by i, subjected to a different excitation, one calculates the directional answers of supports R_{Xi} defined by:

$$R_{Xi} = \sqrt{R_{Xdi}^2 + R_{Xti}^2 + R_{Xei}^2}$$

  - R_{Xdi} is the combined answer of the modal oscillators established by the keyword COMB_MODE [§ 3.7.1].
  - R_{Xti} represent the correction of the static effects of the neglected modes. The term differs from the case mono-support. Similar but is calculated to intervene the field of displacements of the structure subjected to a unit acceleration of support I in direction X [bib3];
  - R_{Xei} is the contribution of the movement of training of the support i ($R_{ei} \neq 0$ in multi-support) established by the keyword DEPL_MULT_APPUI [§ 3.8.5].

- The directional answers are calculated R_X by combination of the directional answers of supports R_{Xi}. The groups of supports being supposed décorrélés between them, the directional answers of supports are combined quadratically (not choice left to the user).

  - The total answer R structure is obtained by combination of the directional answers R_X. The rule of combination is defined by the keyword COMB_DIRECTION [§ 3.7.3].

3.8.2 Partition of the components primary and secondary of the answer

For the seismic analysis of multimedia pipings, the partition of the components inertial and quasi-static of the answer can prove to be necessary for a postprocessing RCC-M [bib3].

3.8.2.1 Inertial primary component

It is the inertial answer induced by the accelerations imposed on anchorings (SRO). One renews the treatment adopted for the total answer by removing the contribution of the movement of training.
The order of the combinations to be carried out differs according to whether the excitations of the supports all are correlated between them or that they set up groups décorrélés between them.

- Correlated supports

  - For each modal oscillator j, the modal directional answers are calculated (office plurality on the supports) $R_{IXj} = \sqrt{R_{dj}^2 + R_{tj}^2}$ with:
    - R_{dj} combined modal answer of the modal oscillators (office plurality on the supports). The rule of combination is defined by the keyword COMB_MULT_APPUI [§ 3.8.3].
    - R_{tj} contribution of the static correction of the neglected modes (pseudo-mode of support)
  - The directional answers are calculated R_{IX} by combination of the modal directional answers R_{IXj}, using the keyword COMB_MODE [§ 3.7.1].

- Groups décorrélés of supports

  - One defines the possible groups of supports using the keyword GROUP_APPUI. The answers of the modal oscillators of the same group of supports are combined linearly (not choice left to the user for this office plurality intra-group).

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version default

Date : 07/12/2017 Page : 15/25
Clé : U4.84.01 Révision :
3ad2f58432c8

- For each support or groups supports subscripted by i, subjected to a different excitation, one calculates the directional answers of primary education supports R_{IXi} defined by:

$$R_{IXi} = \sqrt{R_{di}^2 + R_{ti}^2}$$

- R_{di} combined answer of the modal oscillators established by the keyword COMB_MODE [§ 3.7.1]
- R_{ti} represent the correction of the static effects of the neglected modes. The term differs from the case mono-support. Similar but is calculated to intervene the field of displacements of the structure subjected to a unit acceleration of support I in direction X [bib3].
- The directional answers are calculated R_{IX} by combination of the directional answers of supports R_{IXi}. The groups of supports being supposed décorrélés between them, the directional answers of supports are combined quadratically (not choice left to the user).

The primary total answer R_I structure is obtained by combination of the directional answers R_{IX}. The rule of combination is defined by the keyword COMB_DIRECTION [§ 3.7.3].

3.8.2.2 Differential secondary component

It is the static answer induced by seismic differential displacements of anchorings (movement of training):

- Calculation of the contribution R_{ei} movement of training of the support i established by the keyword DEPL_MULT_APPUI [§ 3.8.5]

- Combinations of the various definite contributions of support R_{ei} by the keyword COMB_DEPL_APPUI [§ 3.8.6].

    It is thus possible to reconstitute:

- lawful loading cases corresponding to:
  - an overall movement of part of the supports in a given direction
  - a displacement mentioned in a local reference mark different from the total reference mark of inertial seismic request;
- directional answers by combining the adequate contributions of supports;
- the total secondary answer.

Examples are proposed in [§ 3.8.6.6].

3.8.3 Keyword COMB_MULT_APPUI (case MULTI_APPUI=CORRELE)

◊ COMB_MULT_APPUI

The occurrences of this key word make it possible to define:
- combinations of the modal directional answers of support to form the modal directional answers (case of the correlated excitations);
- combinations of the directional answers of support to form the directional answers structure (case of the décorrélées excitations).
If occurrences of the key word COMB_MULT_APPUI is present, it is the primary component of the answer which is treated.

The combination of the contributions of each movement of support can be combined various manners, defined by the operand TYPE_COMBI :

- quadratic combination
- linear combination

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 16/25
Clé : U4.84.01   Révision   :
3ad2f58432c8

3.8.3.1 Operands `ALL`/`GROUP_NO`

♦ /   `ALL = 'YES'`

Allows to choose that all the supports are combined with the rule defined by `TYPE`

/ `GROUP_NO = lgrno`   `[l_group_no]`

Allows to define the list of the supports which are combined with the rule defined by the operand `TYPE_COMBI` in the same occurrence of the keyword `COMB_MULT_APPUI`.

3.8.3.2 Quadratic combination `TYPE = 'QUAD'`

$$R_X = \sqrt{\sum R_{Xj}^2}$$

It is advised to use this combination only when the movements of support are décorrélés.

3.8.3.3 Linear combination `TYPE = 'LINE'`

$$R_X = \sum R_{Xk}$$

3.8.3.4 Different rules of combination on the various supports

The rule of combination can be the same one for all the supports [§ 3.7.3.1] or differentiated according to the supports or groups of supports defined by an occurrence of the keyword factor `COMB_MULT_APPUI`. In this case the total answer - or the primary component of the answer if `COMB_DEPL_APPUI` is present - is obtained by:

$$R = \sqrt{\sum R_{Xj}^2 + \left(\sum R_{Xk}\right)^2}$$

where j indicate the supports combined quadratically and k linearly combined supports.

3.8.4 Keyword `GROUP_APPUI` (case `MULTI_APPUI=DECORRELE`)

◊ `GROUP_APPUI`

If this keyword is absent, all the supports are regarded as décorrélés between them.
This keyword is used only if one can display one or more groups of supports décorrélés between them, the supports constitutive of a group being correlated between them. A group can be made up of only one support.
The occurrences of this keyword make it possible to define the groups of supports. The supports not belonging to a group are regarded as décorrélés between them and décorrélés of the definite groups.

The combination of the contributions of each movement of support inside a group can be realized only in a linear way. The combination of the contributions of each group of supports can be realized only in a quadratic way (not of choice left to the user).

3.8.4.1 Operands `ALL` / `GROUP_NO`

◆   `GROUP_NO = lgrno`   `[l_group_no]`

Allows to define the list of the groups of supports.

3.8.5 Keyword `DEPL_MULT_APPUI`

◊   `DEPL_MULT_APPUI`

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 17/25
Clé : U4.84.01 Révision :
3ad2f58432c8

The movement of training of the structure not being uniform this keyword makes it possible to define the contribution to the total answer of a list of supports or groups of supports. This one is established starting from the static modes of the structure:

$$R_{ei} = \Phi_{si} \delta_{i\,max}$$

with:

Φ_{si} static mode for the support i

$\delta_{i\,max}$ maximum displacement of the support i compared to a support of reference (for which $\delta_{i\,max} = 0$)

If this keyword is not indicated, then the contribution of the static modes of the structure is worthless. In other words, this is equivalent to inform $\delta_{i\,max} = 0$.

3.8.5.1 Operand NOM_CAS/NUMÉRIQUE_CAS

♦   NOM_CAS = nomcas
Character string defining the name of the loading case

• NUME_CAS = numecas
     Number of the loading case

3.8.5.2 Operand MODE_STAT

◊   MODE_STAT = stat

Name of the static modes Φ_{si}, concept of the type mode_stat product by the operator MODE_STATIQUE [U4.52.14].

3.8.5.3 Operand GROUP_NO_REFE

◊   GROUP_NO_ REFE = grno
Group containing Nœud of reference by report to which relative displacements of the supports are defined (the group given should contain one node) .
If this operand is present, the maximum displacement applied to the support i is worth $\delta_{i\,max} - \Delta$ where Δ is affected displacement with node of reference noeu in the direction considered.

3.8.5.4 Operand GROUP_NO

♦   GROUP_NO = lgrno

List of the names ofS groups of nodes corresponding to the supports concerned with the occurrence of the keyword factor DEPL_MULT_APPUI.

3.8.5.5 Operands DX / DY / DZ

♦ | DX = dx
   | DY = Dy
  | DZ = dz

Value of maximum relative displacement of the supports concerned, direction by direction.

3.8.6 Keyword COMB_DEPL_APPUI

◊   COMB_DEPL_APPUI

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 18/25
Clé : U4.84.01 Révision :
  3ad2f58432c8

Version
default

The occurrences of this key word define the combinations of the lawful loading cases intervening in the secondary component of the answer.

3.8.6.1 Operands `ALL/LISTE_CAS`

♦ / `ALL = 'YES'`

All loading cases defined under the occurrences of `DEPL_MULT_APPUI` are combined with a single rule specified by `TYPE`

/ `LISTE_CAS = list`

Numbers of the loading cases combined with the rule specified by `TYPE`

3.8.6.2 Quadratic combination `TYPE = 'QUAD'`

$$R_e = \sqrt{\sum R_{ej}^2}$$

3.8.6.3 Linear combination `TYPE = 'LINE'`

$$R_e = \sum R_{ek}$$

3.8.6.4 Combination in absolute value `TYPE = 'ABS'`

$$R_e = \sum |R_{el}|$$

Version
default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 *Page : 19/25*
Clé : U4.84.01   *Révision   :*
                    3ad2f58432c8

3.8.6.5 Different rules of combination on the various loading cases

The rule of combination can be the same one for all the cases of displacement of anchoring or differentiated according to the groups of cases defined by an occurrence of the keyword factor COMB_DEPL_APPUI. In this case the secondary total answer is obtained by:

$$R_{II} = \sqrt{\sum R_{ej}^2 + \left(\sum R_{ek}\right)^2 + \left(\sum |R_{el}|\right)^2}$$

where j indicate the supports combined quadratically, k linearly combined supports and l supports combined in absolute value.

3.8.6.6 Examples of application

• Displacement expressed in a local reference mark $R_{loc}(x, y, z)$ different from the total reference mark $R_{glob}(X, Y, Z)$

Axes x, y and z of R_{loc} are built by 3 successive rotations of angle α, β and γ around the axes X, Y and Z of R_{glob}.

To simplify the example, it is considered that R_{loc} results from R_{glob} by a single rotation around the axis X and of angle α and that local displacement u_x support S located with the node NS is given along the axis x of R_{loc}.

This loading case results from the linear combination of 2 static modes and results in the algebraic summation of the 2 following loadings:

• displacement $DX = u_x \cos\alpha\, depl\, X$ along the axis X
• displacement $DY = u_x \sin\alpha\, depl\, Y$ along the axis Y

Static modes of support following the directions X and Y are calculated beforehand.
The taking into account of the loading case is written with following syntax:

```
DEPL_MULT_APPUI= (
        _F (
          NOM_CAS=' uxcos',
          NUME_CAS=1,
          MODE_STAT=modstat,
          GROUP_NO= 'GNS',
          DX=deplX,
          ),
        _F (
          NOM_CAS=' uxsin',
          NUME_CAS=2,
          MODE_STAT=modstat,
          GROUP_NO= 'GNS',
          DY=deplY,
          ),
            ),
    COMB_DEPL_APPUI= (
        _F (
          LIST_CAS= ('1', '2'),
          TYPE_COMBI = 'LINE'
          ),
```

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 20/25
Clé : U4.84.01 Révision :
3ad2f58432c8

- Overall movement in a direction

Let us consider a line anchored on 3 supports $S1$, $S2$ and $S3$. An overall movement U is applied to the supports $S1$, $S2$ in the direction X. The support $S3$ dependent on the crossing of a building is supposed to be fixed.
Static modes of support in the direction X on the level as of supports $S1$ and $S2$ are calculated beforehand.
The taking into account of the loading case is written with following syntax:

```
DEPL_MULT_APPUI= (
            _F (NOM_CAS=' depl_S1_X',
                NUME_CAS=1,
                MODE_STAT=modstat,
                GROUP_NO= 'GNS1',
                DX=U,
                ),
            _F (NOM_CAS=' depl_S2_X',
                NUME_CAS=2,
                MODE_STAT=modstat,
                GROUP_NO= 'GNS2',
                DX=U,
                ),),
    COMB_DEPL_APPUI= (
      _F (
        LIST_CAS= ('1', '2'),
        TYPE_COMBI = 'LINE'
        ),
```

- Answer by direction and total secondary office plurality

Let us consider a line anchored on 2 supports $S1$ and $S2$ and following seismic differential displacements:

- support $S1$: $U1$, $V1$ and $W1$ in the directions X, Y and Z
- support $S2$: $U2$, $V2$ and $W2$ in the directions X, Y and Z

The 6 static modes of support are calculated beforehand.

The seizure of the various loading cases is carried out under the occurrences of DEPL_MULT_APPUI :

```
        DEPL_MULT_APPUI= (
                #support S1 with node NS1
                _F (
                    NOM_CAS=' depl_S1_X',
                    NUME_CAS=1,
                    MODE_STAT=modstat,
                    GROUP_NO= 'GNS1',
                    DX=U1,
                    ),
                _F (
                    NOM_CAS=' depl_S1_Y',
                    NUME_CAS=2,
                    MODE_STAT=modstat,
                    GROUP_NO= 'GNS2',
                    DY=V1,
                    ),
                _F (
                    NOM_CAS=' depl_S1_Z',
```

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 21/25
Clé : U4.84.01   Révision :
3ad2f58432c8

```
                                NUME_CAS=3,
                                MODE_STAT=modstat,
                                GROUP_NO= 'GNS1',
                                DZ=W1,
                                ),
                        #support S2 with node NS2
                        _F (
                                NOM_CAS=' depl_S2_X',
                                NUME_CAS=4,
                                MODE_STAT=modstat,
                                GROUP_NO= 'GNS2',
                                DX=U2,
                                ),
                        _F (
                                NOM_CAS=' depl_S2_Y',
                                NUME_CAS=5,
                                MODE_STAT=modstat,
                                GROUP_NO= 'GNS2',
                                DY=V2,
                                ),
                        _F (
                                NOM_CAS=' depl_S2_Z',
                                NUME_CAS=6,
                                MODE_STAT=modstat,
                                GROUP_NO= 'GNS2',
                                DZ=W2,
                                ),
                        ),
```

The directional answers are established under the occurrences of COMB_DEPL_APPUI :

```
        COMB_DEPL_APPUI= (
        #cumul according to X
                        _F (
                        LIST_CAS= ('1', '4'),
                        TYPE_COMBI = 'QUAD',
                                ),
        #cumul according to Y
                        _F (
                        LIST_CAS= ('2', '5'),
                        TYPE_COMBI = 'QUAD',
                                ),
        #cumul according to Z
                        _F (
                        LIST_CAS= ('3', '6'),
                        TYPE_COMBI = 'QUAD',
                                ),
                        ),
```

The secondary total answer is formed by the quadratic office plurality of the directional answers. It is calculated automatically.
If the impression of the directional answers is not necessary, the total answer can be calculated directly under only one occurrence of COMB_DEPL_APPUI :

```
        COMB_DEPL_APPUI= (
        #réponse total
                        _F (
                        TOUT=' OUI',
                        TYPE_COMBI = 'QUAD',
```

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version default

Date : 07/12/2017 Page : 22/25
Clé : U4.84.01 Révision :
3ad2f58432c8

),

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version default

Date : 07/12/2017 Page : 23/25
Clé : U4.84.01 Révision :
3ad2f58432c8

3.9 Option of calculation: operand OPTION

♦ OPTION

List of the sizes (options of calculation) modal which one wants to determine the combined answer:

'DEPL'	relative displacement
'QUICKLY'	relative speed
'ACCE_ABSOLU'	absolute acceleration = relative acceleration + acceleration of training
'SIGM_ELNO'	constraints by elements with the nodes
'SIEF_ELGA'	constraints by elements at the points of integration
'SIPO_ELNO'	constraints in the section of beam broken up into contributions of each generalized effort
'EFGE_ELNO'	efforts generalized by elements with the nodes
'REAC_NODA'	reactions to the supports
'FORC_NODA'	internal efforts

Note:

For the calculation of the options of efforts or constraints on part of the model defined by groups of meshs, it is possible to connect a calculation on the concept mode produced by the operator CALC_CHAMP.

3.10 Operand TITLE

◊ TITLE = T

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

3.11 Operand INFORMATION

◊ INFORMATION

/1: impression on the file "message" of following information:

• name of the modal base used,
• many clean vectors selected,
• rule of modal combination chosen,
• options of calculation requested.

/2: idem 1

3.12 Keyword IMPRESSION

◊ IMPRESSION

Impression on the file "result" of following information:

/ ALL = 'YES'
/ LEVEL =

'SPEC_OSCI'	Values of the excitation corresponding to the various modes
'MASS_EFFE'	modal sizes in the direction of the excitation and office plurality of the effective mass
'MAXI_GENE'	Maximum generalized contributions

With ALL = 'YES', one obtains the impressions corresponding to the whole of the 3 levels defined above.

Code_Aster

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Version
default

Date : 07/12/2017 Page : 24/25
Clé : U4.84.01 Révision :
3ad2f58432c8

The impression in the file "result" of the computed fields is carried out via the orders `IMPR_RESU` [U4.91.01] or `POST_RELEVE_T` [U4.81.21] by specifying the suitable sequence numbers.

For an excitation mono-support according to the 3 directions X, Y and Z:
• directional answers [§3.7]:
    sequence numbers 1.2 and 3 for the answers according to X, Y and Z
• combination of the directional answers if `COMB_DIRECTION` is present [§3.7.3]:
    sequence number 4

For an excitation multi-support according to the 3 directions X, Y and Z:
• If the keyword `COMB_DEPL_APPUI` is absent, the components primary and secondary of the answer are cumulated:
    • directional answers [§3.8.1]:
        sequence numbers 1.2 and 3 for the answers according to X, Y and Z
    • combination of the directional answers if `COMB_DIRECTION` is present [§3.7.3]:
        sequence number 4
• If the keyword `COMB_DEPL_APPUI` is present, the components primary and secondary of the answer are separate:
    • primary component:
        • directional answers [§3.8.3]:
            sequence numbers 1.2 and 3 for the answers according to X, Y and Z
        • combination of the directional answers if `COMB_DIRECTION` is present [§3.673]:
            sequence number 4
    • secondary component [§3.8.2]:
        • fields resulting from the combinations of loading case of displacement indicated under N occurrences from `COMB_DEPL_APPUI` [§3.8.6]
            sequence number 200 for occurrence 1
            sequence number $200+i-1$ for the occurrence i
            sequence number $200+n-1$ for the occurrence n
        • total quadratic office plurality
            sequence number $200+n$

4 Concept at exit

The operator `COMB_SISM_MODAL` product, for practical reasons of visualization, a concept of the type `mode_meca`. However it is advisable to pay attention to the fact that the result is not a mechanical clean mode. In particular, one should not make postprocessing on this concept (cf paragraph 4.8 of Doc. [R4.05.03]).
In addition in parameter 'FREQ', one stores the seismic number of direction, in accordance with paragraph 3.12:
1 ↔ direction X
2 ↔ direction Y
3 ↔ direction Z
4 ↔ office plurality on the directions (if asked in calculation)

5 Bibliography

• "With answer spectrum method for random vibrations" Carryforward UCB/EERC - 80/15 Berkeley (1980)

Code_Aster

Version default

Titre : Opérateur COMB_SISM_MODAL
Responsable : BOYERE Emmanuel

Date : 07/12/2017 Page : 25/25
Clé : U4.84.01 Révision :
3ad2f58432c8

- "Answer of linear systems to some transient disturbances" Proceedings, Fourth World conference one earthquake engineering - Santiago of Chile (1969)

- Seismic answer by spectral method [R4.05.03]

- [NRC1.92] U.S. Nuclear Regulatory Commission, Regulatory Guides 1.92 – Modal Combining Answers and Space Components in Seismic Answer Analysis (July 2006)

- Expertise on the seismic analysis of the EPR Flammanville by COMB_SISM_MODAL and developmental perspectives, CR-AMA-11.210, E. Boyère, I. Zentner (7/15/2011)